AD-A043 735   ARMY COMMUNICATIONS COMMAND FORT HUACHUCA ARIZ   F/G 17/2
PRODUCT ASSURANCE, OPERATIONAL QUALITY ASSURANCE, SATELLITE SYS--ETC(U)
MAY 77

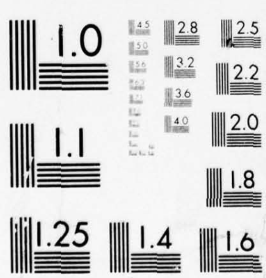
UNCLASSIFIED   ACC-CCP-702-2   NL

1 OF 7
AD
A043 735

SIFIED

1 OF 7

AD A043735



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

14 ACC - CCP-702-2

12 mc

9 Communications Command pamphlet.

USACC

VOICE OF THE ARMY

6 Product Assurance,

OPERATIONAL QUALITY ASSURANCE

SATELLITE SYSTEMS TECHNICAL EVALUATION.

11 31 MAY 1977

12 649p.

DISTRIBUTION STATEMENT

Approved for public release. Distribution unlimited.

HEADQUARTERS 408 562

U. S. ARMY COMMUNICATIONS COMMAND

FORT HUACHUCA, ARIZONA 85613

DISPOSITION INSTRUCTIONS

Destroy this document when no longer needed. Do not return it to the originator.

AVAILABILITY STATEMENT

This publication is available for public sale through the Defense Documentation Center, Cameron Station, Alexandria, VA 22314.

DISCLAIMER

The contents of this document are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

The use of trade names in this document does not constitute an official endorsement or approval of the use of such commercial hardware or software. This document may not be cited for purpose of advertisement.

NOTICE

The procedures contained in this document have not been tested in the field. Comments and recommendations of team members actually engaged in testing are solicited. Comments should be submitted in accordance with paragraph 1-7.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER CCP-702-2 / 2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SATELLITE SYSTEMS TECHNICAL EVALUATION, Operational Quality Assurance	5. TYPE OF REPORT & PERIOD COVERED Communications Command Pamphlet 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) US Army Communications Command ATTN: CC-OPS-O Fort Huachuca, AZ 85613	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Communications Command ATTN: CC-OPS-O Fort Huachuca, AZ 85613	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Communications Command ATTN: CC-PA-AMP Fort Huachuca, AZ 85613	12. REPORT DATE 31 May 1977 13. NUMBER OF PAGES 692
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

This publication is available for public sale through the Defense Documentation Center, Cameron Station, Alexandria, VA 22314.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Line of sight link
Tropospheric scatter link
Earth terminal
Common long haul system
Tactical communication system
Frequency conversion subsystem

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This pamphlet contains the responsibilities and duties, and the administrative and logistical procedures governing the functions of a satellite test team. Calculation worksheets and tutorial information on test techniques and data analysis as well as equipment specifications and extracts of technical literature are included to aid in the assessment of a link and terminal. Test procedures for the radio system and pertinent audio series tests are furnished from which to determine the quality of customer service being provided.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED 408562

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
HEADQUARTERS, US ARMY COMMUNICATIONS COMMAND
FORT HUACHUCA, ARIZONA 85613

USACC Pamphlet
No. 702-2

31 May 1977

Product Assurance

OPERATIONAL QUALITY ASSURANCE

SATELLITE SYSTEMS TECHNICAL EVALUATION

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Page

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1-1. GENERAL.

a. This pamphlet is designed to aid in the technical evaluation of satellite earth terminals, equipment, and circuits. The technical evaluation program (TEP) for satellite systems was pioneered by US Army Communications Command (USACC) when the first comprehensive test procedures were developed and tested by the USACC Technical Evaluation Detachment (TED) in early 1974. Since that time, the procedures have been revised a number of times and are continually being refined to improve test techniques, data collection, application of the test data for systems improvements, and methods of accomplishing the evaluations more effectively. In this respect, it is anticipated that the tests contained in this pamphlet and subsequent analysis of the test data will be accomplished almost entirely by calculator-controlled techniques. This improved method will reduce onsite test time, improve data accuracy, and permit more efficient scheduling of resources.

b. The material contained in this pamphlet is basically a compendium of instructional notes developed or compiled by the USACC satellite test team. The procedures, contained in chapters 6 through 75, pertaining to satellite evaluations are essentially the same as those developed for the Defense Communications Agency (DCA) by USACC. While these procedures were developed for evaluating the defense satellite communications system (DSCS), they should also be applicable to non-defense communications systems (DCS) satellites as they are deployed. It is anticipated that some changes to the test procedures and test techniques will be required to adapt them to new and more sophisticated satellite systems.

c. The method used to perform an evaluation of a satellite system will vary depending on the number of test teams available and system configuration. The most desirable method, of course, would be to employ a test team at the nodal point with other teams located at each of the stations when the system is configured in the fan mode as shown in figure 1-1. This may not be practicable due to the number of test teams that would be required and the affect such a test arrangement would have on all customers served by the multiple destination approach. Recognizing this, the test procedures contained in this pamphlet and the method used by the test team is to primarily evaluate the system through a satellite loopback. This approach has its limitations since it does not fully characterize the overall network in a system configuration as is commonly used on terrestrial radio links. Considering all factors, the loopback approach appears to be the most cost-effective and efficient method of conducting the satellite evaluation program. The audio series tests, chapters 57 through 74 of this pamphlet, could be performed on a link basis, however, which would be indicative of the service quality being provided the customer, as well as the need to evaluate other stations in the network.

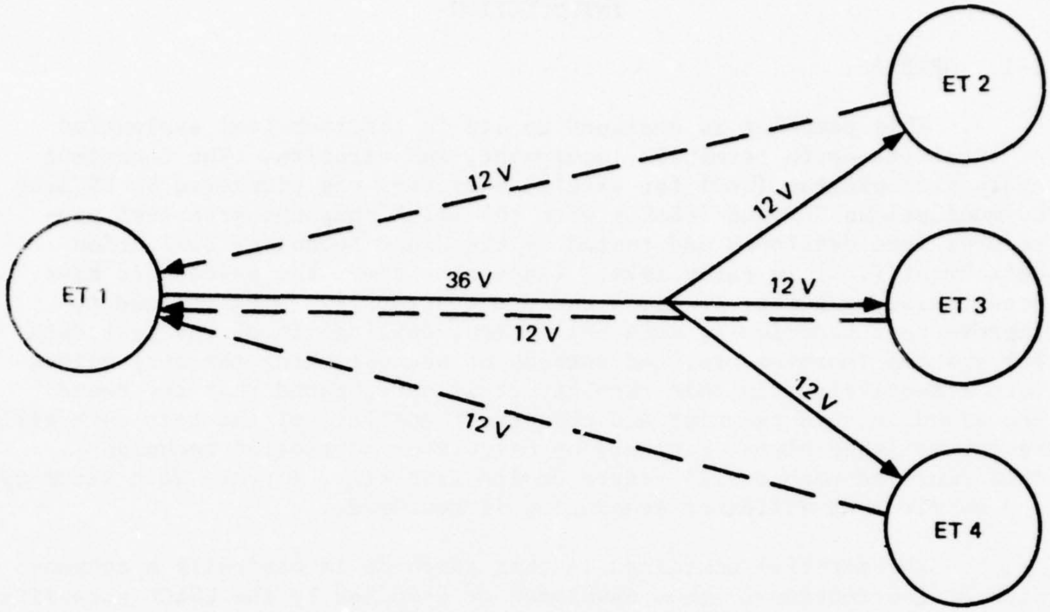


Figure 1-1. Fan mode.

d. The basic test procedures and test techniques contained in this pamphlet should also be used when testing newly installed terminals. This will establish a baseline for ongoing operations as well as provide empherical data on which to compare the data collected by the TEP teams.

e. System downtime to accomplish all required test sequences normally involves a minimum of 24 hours of downtime. This can be divided into three 8-hour blocks or segments of six 4-hour blocks when necessary. This 24-hour requirement is predicated on testing and minor onsite adjustments only, and any major maintenance or repair actions that may be necessary could extend the downtime requirements. If the total downtime requirement cannot be provided due to high priority circuit requirements or lack of adequate alternate-route capability, the test team will accomplish as many of the key tests as time permits. The final test report will include all pertinent data on denial of the downtime along with information on the nonavailability of circuit alternate-route capability. This lack of alternate-route capability may indicate a serious weakness in system configuration and could have catastrophic effect on critical communications service. During system downtime, the test team will insure that the system can be restored to its normal operating condition within 20 minutes of notification.

f. The technical nature and the complexity of the systems that are to be evaluated necessitates that the test teams be highly proficient, self-motivated, and extensively experienced in the fundamentals of satellite transmission systems and equipment. The frequent and extended periods of temporary duty (TDY) that will be required of the test teams also necessitates that the team members not only be professional in their specialty but totally dedicated to systems improvements.

1-2. SCOPE. The following information is contained in this pamphlet:

a. Responsibilities and duties of the satellite test team (chap 2).

b. Administrative and logistical procedures (chap 2).

c. Calculation worksheets and tutorial information on test techniques and data analysis (chap 3).

d. Equipment specifications and extracts of technical literature that may assist test engineers in assessing the performance of a link and terminal (app B).

e. Test procedures for the radio system and pertinent audio series tests that can be used to determine the quality of customer service (chap 6 through 75).

f. Reporting requirements and report preparation (app C).

1-3. PURPOSE. The purpose of this pamphlet is to:

a. Establish standardized test procedures and test criteria for evaluating the operational performance of satellite earth terminal equipment, systems, and circuits.

b. Provide a compendium of pertinent information that will aid TEP personnel in performing a technical evaluation of a system and that can be used as an instructional guide for onsite maintenance personnel.

c. Provide information to the operation and maintenance (O&M) commands having primary responsibility for the O&M of satellite earth terminals that can be used by their personnel in evaluating the effectiveness of their quality assurance programs.

d. Prescribe a standard reporting format for the recording and reporting of the test data collected by the TEP field test teams.

1-4. PROGRAM OBJECTIVES. The objectives of the technical evaluation program are to:

a. Identify those systems that may require replacement, modification, or upgrade.

b. Standardize and improve onsite operations, maintenance, logistical service, and customer service.

c. Establish a baseline of equipment and system performance that can be used by the O&M command in monitoring the effectiveness of onsite O&M.

d. Develop a technical data base of equipment and system performance characteristics that can be used for cost-effective, time-phased modernization of USACC facilities and equipment.

e. Provide over-the-shoulder training and assistance to onsite personnel as required.

f. Improve the quality of service being provided the customer through a systematic and detailed evaluation of equipment and facilities operated and maintained by USACC. This is the most important objective of the program since it provides commanders with an impartial and comprehensive evaluation of equipment potential, operating level, and recommendations for improvements.

1-5. REFERENCES.

a. DCAC 300-175-9, DCS Operating-Maintenance Electrical Performance Standards.

b. DCAC 310-70-1, Supplement 1 to Volume II, DCS Technical Control Test Descriptions.

c. DCAC 310-70-57, Supplement 1, DCS Quality Assurance Program Technical Evaluation of Line-of-Sight and Tropospheric Scatter Links.

d. DCAC 310-70-57, Supplement 6, Performance-Measurement Procedures for Satellite Communications Systems with draft Annex A, Subsystem Performance Parameters.

e. MIL-STD-188/100, Common Long Haul and Tactical Communication System Technical Standards.

f. TM 11-5805-507-15/1, Service: Multiplexer Set AN/UCC-4(V) (Lenkurt) AF 30(602)-4135.

g. TM 11-5895-389-34/3, Direct Support (DS) and General Support (GS) Maintenance Manual: Satellite Communications Terminal AN/TSC-54 (Functional Diagrams).

h. TM 11-5895-389-50/4, Depot Maintenance Manual: Satellite Communication Terminal AN/TSC-54 (Alignment Procedures and Depot Overhaul Standards).

i. DTM 11-5820-803-12, Operator Manual, Modem, Digital Data, MD-921/G.

j. DTM 11-5820-819-12, Operator Manual, Amplifier, Parametric AM-6676/TSC-54.

k. DTM 11-5820-819-34, Amplifier, Parametric (AM-6676/TSC-54).

l. TM 11-5895-539-12, Operator and Organizational Maintenance Manual, Parts 1 and 2, Satellite Communications Terminal (AN/MSC-46(V)).

m. DTM 11-5895-539-34-1, Frequency Conversion Subsystem for Satellite Communications (AN/MSC-46(V)).

n. DTM 11-5895-796-34-1, Modular OM-46(V)/TCC-78, -79, DS/GS and Depot Maintenance Manual, Multiplexer Sets, AN/TCC-78, AN/TCC-79 and Non-Nodal.

o. DTM 11-5895-833-12, Frequency Conversion Subsystem for Satellite Communications Terminal (AN/TSC-54).

p. TM 11-5895-903-34, Operator and Maintenance Manual: Parametric Amplifier Group OG-133/G for AN/FSC-78.

q. CCR 702-1-3, US Army Communications Command (USACC) Quality Assurance Program for Operational Communications-Electronics (C-E) Systems and Facilities.

r. CCP 105-5, Introduction to Satellite Communications.

s. CCP 702-1, Wideband Radio Analysis.

1-6. DISCUSSION.

a. Prior to conducting a technical evaluation, a test notification message will be provided the command that is scheduled to be evaluated. This notification message will also be addressed to all applicable action and information addressees and will as a minimum contain:

(1) Period of the evaluation.

(2) Test team composition and security clearance status of test team members.

(3) Primary and alternate date(s) and time(s) for system downtime.

(4) Designated point of contact for the test team activities including telephone numbers.

(5) Test team travel arrangements and arrival time.

(6) Test schedule for multiple link or system evaluations.

(7) Requirement for the O&M command to provide a qualified technician during the evaluation to work with and assist the test team.

(8) Requirement for O&M point of contact and telephone number.

(9) Logistical support will consist of the following:

(a) Quarters and rations requirements. Any unusual situations that would preclude using government facilities should be included in the test notification message.

(b) Power requirement for the test sets, especially for the AN/TSM-125.

(c) Equipment security requirements.

(d) Onsite augmentation of test team test, measurement, and diagnostic equipment (TMDE) that may be required.

(e) Transportation requirements for the test team and equipment. This should include any known requirement for materials handling equipment or other specialized equipment.

b. On receipt of the test notification message, the O&M command personnel will perform all required maintenance, optimize system performance, and arrange for the logistical support required by the test teams in accomplishing their test objectives. The O&M command will notify the TED, CC-OPS-OQ, of:

(1) Name and telephone number of the local point of contact for the evaluation.

(2) The status of quarters, rations, and logistical support identified in the test notification message.

(3) Any renovation, reconfiguration, or maintenance actions that may be scheduled or in process that could influence the test results.

c. Upon arrival at the station to be evaluated, the team chief will brief the site personnel and the senior C-E commander on the scope of the evaluation, delineating the long range and immediate goals of the evaluation.

d. The initial station evaluation should consist of a general walk-through and familiarization of station layout, facilities available, and orientation of site personnel. A suitable working location for the test team will be established in coordination with onsite personnel. The working location should be selected in such a manner that interference with the site personnel and their mission is minimized.

e. Successful accomplishment of the evaluation and, consequently, the test objectives will depend to a large degree on the participation of site personnel throughout the evaluation. Therefore, the test team members are expected to work hand-in-hand with the local personnel and understand their problems in operating and maintaining the system.

f. At the conclusion of the evaluation, the test team chief will provide site personnel and the senior C-E commander with an informal exit briefing. In the case of DCS's, the local DCA representative will be invited to participate as an observer. As a minimum the briefing will include:

(1) A summary of test results in nontechnical terms whenever possible. The use of charts and graphs is encouraged since the information can be better presented and understood by management personnel.

(2) Significant deficiencies noted during the evaluation that were corrected by the test team or site personnel.

(3) Deficiencies requiring ongoing corrective actions at the site and command level, along with technical recommendations that must be taken to improve system performance. The deficiencies should be presented in such a manner that they can be directly related to the quality of service being provided by the terminal. All technical recommendations must be based on sound engineering and maintenance practices and represent a reasonable and logical cost-effective solution to the problem.

(4) In addition to the informal exit briefing, the senior C-E commander and site personnel will be provided a written list of ongoing corrective actions and the test team's recommendations for system improvement. The O&M commander will also be advised that a response to identified deficiencies will be required upon receipt of the finalized test report.

g. The test team members will refrain from any action that can be interpreted as establishment of policy or changing either local or USACC policy. Any questions that may arise during the course of the evaluation that may involve policy will be referred to the TED.

1-7. COMMENTS. Users of this pamphlet are invited to submit recommendations to improve the pamphlet. Comments should be keyed to the specific page, paragraph, and line of the text. Rationale should be provided for each comment to insure understanding and complete evaluation of the recommended change. Comments should be submitted on DA Form 2028 (Recommended Changes to Publications and Blank Forms) and addressed to Commander, US Army Communications Command, ATTN: CC-OPS-O, Fort Huachuca, Arizona 85613. (Copies of DA Form 2028 are provided at the end of this pamphlet.)

CHAPTER 2

SATEP TEAM MEMBER RESPONSIBILITIES

2-1. GENERAL.

a. This chapter delineates the responsibilities and duties of the satellite technical evaluation program (SATEP) team members. The test teams assigned to accomplish the program objectives will not normally be diverted to other missions except when an emergency situation arises (CCR 702-1-3).

b. The test teams will be deployed based on a master test schedule, and the period of deployment will vary depending on the complexity of the system, transportation problems, and the amount of effort required to optimize the equipment and system. It is anticipated that a satellite evaluation should not exceed 20 days in duration, with an objective of 15 days. This time will also be influenced by the effectiveness of local maintenance programs, proficiency of test team members, and availability of required test equipment and associated hardware.

c. During the time the test teams are not on TDY performing evaluations of satellite systems in accordance with (IAW) the master test schedule, they will be involved in analyzing the raw test data, reviewing test procedures, developing procedures for new systems, preparing revisions to existing procedures, and preparing O&M procedures to improve onsite techniques. Additionally, the systems located in the proximity of the test team's home station will be scheduled for a cyclic evaluation when the teams are not TDY to other geographical areas.

d. Although this pamphlet is primarily technical in nature, the test team may examine other nontechnical areas such as facility manning, adequacy of logistical support, environmental conditions, safety practices, and operational procedures. This is based on the fact that problems encountered by the test team in the technical area may be directly attributed to a deficiency in the nontechnical areas. A nontechnical evaluation would normally be conducted by a performance evaluation program (PEP) team rather than a TEP team; however, in the interest of economy of resources, the TEP and PEP may be conducted at the same time.

e. Checklists and guidelines for conducting a performance evaluation of a satellite facility will be published as an appendix to this pamphlet as they are developed. These checklists will provide for a comprehensive examination of all facets of station operation. They will be objective rather than subjective insofar as possible. They will be developed in such a manner that O&M commanders can use the same information in evaluating the performance of onsite personnel, maintenance, and procedures.

2-2. TEST TEAM COMPOSITION.

a. The SATEP test team will be comprised of the following:

TITLE	GRADE	MOS	QUANTITY
Team Chief	WO	286A0	1
Team NCOIC	E7	26Y40C4	1
Sr Satellite Rpmn	E6	26Y40C4	2
Sr Microwave Rpmn	E7	26V40C4	1

b. The above represents the standardized test team structure for an evaluation of a satellite terminal. The number of personnel and the specialties to be included in the team will depend on the mission of the team. At times, it is possible that additional specialties such as power, environmental control, electromagnetic, or other type engineering specialties will be included in the test team to resolve a particular problem.

c. Personnel selected to man the test teams must be satellite trained as well as proficient in systems evalaution techniques. They should also have long-term retainability to reduce training cost and to insure that the evaluations are conducted in a minimum of time without sacrificing the quality of service being provided.

2-3. TEST TEAM RESPONSIBILITIES. The basic responsibilities of the test team and personnel comprising the team are contained in subsequent paragraphs. The responsibilities of the O&M command scheduled to be evaluated are contained in CCR 702-1-3 and paragraphs 1-6b, 2-4, and 2-5 of this pamphlet.

a. Team Chief.

(1) Supervises the test team activities and insures that all data is collected and analyzed on a daily basis and required reports are prepared.

(2) Implements deviations from established test procedures as may be required to insure that the test data is complete, valid, and in compliance with established directives. When deviations are used, they must be fully explained, and the team chief will insure that the data elements are essentially unchanged.

(3) Assists the test technicians in setting up the test instrumentation, assuring that the test configuration is IAW established procedures.

(4) Insures that all assigned test instrumentation and associated hardware is accounted for and properly maintained.

(5) Provides technical assistance and over-the-shoulder training to onsite personnel in improving system performance.

(6) Insures that the completed test data package and summary of test results are provided to the TEP detachment analysis section within 7 working days after the evaluation has been completed.

(7) Provides an entrance briefing to the O&M commander and other designated personnel, covering the scope of the evaluation (immediate and long range goals); provides O&M commander with a milestone chart covering all phases of the evaluation.

(8) Provides the operating unit, site personnel, and O&M commander with an exit briefing at the conclusion of the evaluation. The local DCA representative will also be given the opportunity to participate in the briefing when DCS terminals are involved. The exit briefing will include those items outlined in paragraph 1-6f of this pamphlet.

(9) Directs diagnostic testing as necessary to isolate a problem or potential problem and provides recommendations to correct any deficiencies noted.

(10) Advises the detachment headquarters directly of any problems encountered which would influence the test results or necessitate a change to the test schedule.

(11) Assumes responsibility for the health, welfare, morale, and conduct of assigned team members when in test status.

(12) Assures adherence of all team members to locally published dress standards and policies within the host command.

(13) Requests and coordinates system downtime as required.

(14) Performs onsite analysis and reduction of the test data and provides a draft of the test report to the analysis section.

(15) Provides the detachment in-country coordinator of the desired date and time that the exit briefing can be given. The in-country coordinator will make all arrangements to insure that appropriate personnel are in attendance and that adequate facilities are available. In the absence of a detachment in-country coordinator, all arrangements will be made through the local command's primary point of contact.

(16) Maintains a journal throughout the test period that reflects all significant items occurring during the evaluation. As a minimum, the journal will include:

(a) Start and stop time for all test sequences.

(b) Acquisition of systems or circuits for testing; and release of the user or time of notification to the technical controller or site personnel that the test sequence has been completed.

(c) Arrival and departure time of test personnel at the terminal to be evaluated.

(d) Difficulties encountered in technical, logistical, or administrative areas that impact on the evaluation program.

(e) A record of total hours worked by each team member on a daily basis. This is extremely important when computing overtime or compensatory time for test team members.

(17) Reviews and submits team travel vouchers to the detachment commander within 3 working days after the TDY has been completed.

(18) Other duties as assigned.

b. Team NCOIC.

(1) Assists the team chief in accomplishing the mission to characterize the performance of an earth terminal or satellite link.

(2) Provides guidance and training to team members and site personnel on an as-required basis.

(3) Provides technical, personal, administrative, and operational observations to the team chief.

(4) Insures that the test equipment is calibrated, operational, and securely packed in the isopods prior to shipment to the field.

(5) Performs the duties of the SATEP team chief during his or her absence.

c. Senior Satellite Repairman (rpmn).

(1) Performs the tests and measurements IAW the procedures and requirements contained in this pamphlet.

(2) Completes the required data elements for all test data collected and insures that the data is valid, legible, and representative of system performance.

(3) Initiates corrective adjustment, maintenance, and/or alignment of satellite radio and multiplex equipment within the capabilities of the test team.

(4) Insures that test equipment is functioning properly whenever data is being collected.

(5) Other duties as assigned.

d. Senior Microwave Repairman.

(1) Performs tests and measurements IAW the procedures and requirements contained in this pamphlet.

(2) Completes the required data elements for all test data collected insuring that the data is valid, legible, and representative of system performance.

(3) Initiates corrective adjustment, maintenance, and/or alignment of microwave radio and multiplex equipment within the capabilities of the test team.

(4) Insures that the test equipment is functioning properly when data is being collected.

(5) Insures that the interconnecting microwave system is not degrading the satellite communications service.

(6) Other duties as assigned.

2-4. ADMINISTRATIVE REQUIREMENTS.

a. All personnel are required to comply with the uniform standards outlined in DA regulations as may be amended by local command policies and directives within the geographical test area. The appropriate uniform will be worn during normal duty hours unless civilian clothing is prescribed or encouraged for wear by the host command.

b. All TDY orders will be prepared and processed by the TEP detachment in sufficient time to permit orderly planning by affected personnel. The orders will normally require that personnel utilize, to the maximum extent possible, government quarters, mess, and transportation to include Military Airlift Command facilities. When it is impracticable to use these facilities or their use would directly affect the test team's mission, the orders will be appropriately annotated. In the event that quarters and rations are available in a particular area and the team chief determines that the use of such facilities would adversely affect the mission, the team chief will prepare and submit a written certification so that an appropriate amendment to the original orders can be initiated.

c. An inventory of all blank forms and test data sheets will be performed at the conclusion of the evaluation; and replenishments requisitioned as required to insure that the basic load of these items are maintained with the test set.

d. The team chief will insure that the detachment headquarters is provided a telephone number at which all team members can be reached during normal and off-duty hours. The local O&M command's primary point of contact will also be provided this information.

e. USACC subordinate commands will provide telephone and message service for the detachment in-country coordinator and the test team as may be required during the evaluation.

2-5. LOGISTICAL SUPPORT.

a. USACC subordinate commanders are responsible for logistical support of the TEP test team while deployed within their geographical area of responsibility. This support includes but is not limited to:

(1) Transporting of personnel and equipment to and from the test site.

(2) Arranging for billeting and messing facilities. In this respect, considerations must be given to the fact that the test teams are expected to work during nonduty hours, holidays, and weekends in accomplishing the test objectives. Test personnel are also expected to reduce and analyze the test data during the time that testing is not being accomplished.

(3) Arranging for test equipment repair and calibration within the capabilities of the area maintenance supply facility (AMSF) and for A level calibration and repair as may be required by the test teams.

(4) Providing security for the test instrumentation during periods that the test teams are not onsite.

(5) Augmenting the test equipment organic to the TEP team as required and within local capabilities.

(6) Providing qualified maintenance technicians to assist the test team throughout the evaluation. These individuals may be site personnel or technicians from the local AMSF; however, they should be made available on a full-time basis for maximum exposure to the test procedures, cross training, and effectiveness of required corrective actions.

b. When the USACC TEP detachment is scheduled to perform a technical evaluation of satellite earth terminals operated and maintained by other military departments or services, coordination with the appropriate level of command will be effected to insure that the required support is available.

CHAPTER 3

PREDICTED PERFORMANCE AND TUTORIAL DATA

3-1. GENERAL.

a. Prior to an evaluation of a satellite earth terminal and its associated communications system, certain calculations must be performed so that predicted performance levels can be established. These predicted levels may be accomplished by the test team or obtained from the agency who engineered and installed the system. Whenever possible, the original engineering data should be obtained and used as a basis for comparing the measured test results with design parameters and the values calculated by the test team.

b. Equipment specifications as contained in the appropriate technical manuals and manufacturer's specifications should also be reviewed prior to any onsite evaluation to insure that equipment performance can be compared to its design parameters during applicable test sequences.

c. Appendix B contains the subsystem performance parameters for various types of satellite earth terminals. It may be found during an evaluation, however, that the specification for a particular test sequence is not included in this data. In this case, it may be necessary to review all available literature in order to establish the performance parameter. This information should then be forwarded to the detachment so that the appendix can be updated.

d. The test team should also review the performance monitoring data, communications resource equipment data site synopsis report, and other operational information pertaining to the site to be evaluated prior to departure from their home station. A review of this data will provide the test team with an indication of the quality of service and reliability being provided by the terminal, as well as identify possible areas requiring corrective action.

3-2. PREDICTED PERFORMANCE WORKSHEETS.

a. The link performance worksheets as shown in figures 3-1 through 3-4; USACC Forms 406-R (Test), 407-R (Test), 408-R (Test), and 409-R (Test) should be completed by the test team chief prior to arrival onsite. This may not be possible in some cases since site personnel may be unaware of waveguide (WG) lengths or some other pertinent parameter necessary to complete the worksheets. The data from these worksheets is to be used throughout the technical evaluations to ascertain that measured test results compare favorably with the predicted or design performance.

b. The data elements contained in the worksheets are based on engineering design principles and proven techniques for determining system performance. Many of the elements are common to wideband transmission systems while others are unique to satellite terminal transmission characteristics. The symbols used and their definitions are contained in appendix F of CCP 702-1 or are explained in the accompanying text.

c. Calculations performed to determine the predicted performance level of a satellite earth terminal must always consider the design specification of the equipment. As an example, when white noise loading the baseband of a system, peak operational performance cannot be expected if the design limits are exceeded. The formula for white noise loading as contained in the link calculation worksheets is based on -1 +4 log N (where N equals the design number of channels). During the course of the evaluation, it is also desirable to determine the system performance at other loading levels, especially in the current operational configuration. A practice used during the wideband evaluations (CCP 702-1) is to load the system at some level below the number of channels installed to at least the design capability. This method provides a valid indication of how well the system will perform should the loading levels be increased or decreased.

d. The completed performance worksheet will be included in the final test report and will be used during the detailed analysis performed by the TED.

3-3. TRANSMITTER DEVIATION.

a. The information listed in the subsequent paragraphs has been extracted from CCP 702-1 as tutorial information for the satellite test teams. The information pertains primarily to the wideband radio systems; however, some of the data is also applicable to the satellite terminal equipment.

b. The proper amount of carrier deviation to be used on any particular radio system is established during system design, and depends upon the balance between thermal noise and intermodulation distortion to be permitted in the system. Before proceeding further, it is necessary to remember that the frequency modulated (FM) systems, noise of thermal origin appearing in the baseband after frequency demodulation is inversely proportional to the received radio frequency (RF) carrier level and the square of carrier deviation. Similarly, baseband noise appearing as intermodulation products increases with the square of deviation. The absolute value of these intermodulation products depends upon equipment linearity, feeder echo distortion, and frequency selective fast fading due to multipath propagation. This simply means that for any specific carrier level (received signal level (RSL)), equipment configuration, and path geometry, thermal noise <u>decreases</u> with increasing deviation, and intermodulation products <u>increase</u> with increasing deviation. This would suggest that some optimum deviation exists at which the sum total of thermal and intermodulation noise is minimum. It is a proven fact that for second order terms, the sum of thermal and intermodulation noise is minimized when they are equal to each other (fig. 3-6). Thus to achieve the minimum amount of noise for the maximum period of time, it is the usual practice of FM system designers to calculate the test tone deviation which results in equal contribution of thermal and intermodulation noise in the presence of some specified RF signal level, usually the expected or median value. When a specific optimum carrier deviation has been established, it is a problem for the technician to set and periodically check that the deviation is of the proper value. Remembering that all test tone power levels in the system are proportional to the square of deviation, it should be apparent that all system levels (and consequently channel noise) are critically dependent upon carrier deviation.

c. The method used by the wideband TEP test teams to set deviation is the first carrier dropout method. It is characteristic of all frequency or phase modulated radio systems that for certain frequencies of modulation tones, the carrier (in the modulated signal) will disappear. This disappearance is due to phase cancellation of certain components produced during modulation and always occurs with mathematical precision. The mathematical relationships describing this phenomenon are termed "Bessel Functions." Specifically of interest here is the relationship:

$$M = \frac{D_p}{f_t}$$

This defines the modulation index and indicates that it equals the ratio of peak per channel carrier deviation to the frequency of the tone used to produce it. When the modulation index (this ratio of carrier deviation to test tone modulation frequency) equals 2.41, the carrier will disappear. Knowing the carrier disappears when the modulating index equals 2.41, the desired optimum deviation D_p can be substituted and the above equation solved for f_t, the so-called, Bessel dropout test tone frequency. This frequency at a level of zero dbm0 will produce the required deviation if the system does not have preemphasis. However, a number of the systems encountered by the TEP teams during an evaluation will have preemphasis networks. The problem can be summarized as follows: If modulator deviation is adjusted using the test tone (f_t) above with a level of zero dbm0 in a preemphasized system, the actual baseband traffic will not be represented. The amount of preemphasis (and consequently, deviation) will be different for other baseband frequencies because of the preemphasis. Therefore, some baseband frequency must be found at which the net preemphasis effect is zero. This frequency is called the pivot frequency, or in some references, mean baseband frequency. Below this frequency, the modulator input level is less and above this frequency, the input level is greater. A formal definition of pivot frequency would be that frequency in baseband for which the root mean square (rms) deviation in an emphasized system with white noise loading is equal to that of a flat system when the rms power input (modulating white noise level) to the modulator is the same in both cases. The problem now becomes one of determining the pivot frequency and the test tone level that must be used to set deviation in an emphasized system. The first step in solving this problem is to determine the type of preemphasis in the system. There are basically three types of preemphasis that may be encountered in the field. These three types are discussed in the succeeding paragraphs.

d. One particular type of preemphasis provides a 12-db boost to the top baseband frequency. The characteristic curve for this type of preemphasis is shown in figure 3-7. Figure 3-7 is plotted for any baseband configuration. The abscissa is the normalized frequency (f/f_{max}) where f is the baseband frequency of interest and f_{max} is the maximum baseband frequency. The following equation is used to derive this curve:

$$I_p = 10 \log \; 1 + 15\,(f/f_{max})^2$$

where:

I_p = preempahsis for the frequency of interest

f = the baseband frequency of interest

f_{max} = maximum baseband frequency

The pivot frequency for this type of preemphasis can be found by using the following relationship:

$$\text{Preemphasis improvement } (I_p) \text{ at pivot frequency} = 10 \log \left[\frac{\int_{R_1}^{R_2} (I_p \text{ linear})\, dR}{\int_{R_1}^{R_2} dR} \right]$$

where:

I_p linear = the linear portion of the preemphasis equation

$$1 + 15\,(f/f_{max})^2$$

$R_1 = f/f_{max}$ = lowest baseband frequency divided by the maximum baseband frequency

$R_2 = f_{max}/f_{max}$ = maximum baseband frequency divided by the maximum baseband frequency = 1

As an example let's assume a 24-channel system with a baseband of 12 kHz to 108 kHz.

$$I_p = 10 \log \left[\frac{\int_{R_1}^{R_2} (I_p \text{ linear})\, dR}{\int_{R_1}^{R_2} dR} \right]$$

$$= 10 \log \left[\frac{\int_{R_1}^{R_2} (1 + 15R^2)\, dR}{\int_{R_1}^{R_2} dR} \right] \quad \text{where } R = f/f_{max}$$

$$= 10 \log \left[\frac{\int_{R_1}^{R_2} dR + 15 \int_{R_1}^{R_2} R^2\, dR}{\int_{R_1}^{R_2} dR} \right]$$

$$= 10 \log \left[\frac{R \Big]_{R_1}^{R_2} + 15 \frac{R^3}{3} \Big]_{R_1}^{R_2}}{R \Big]_{R_1}^{R_2}} \right]$$

$$= 10 \log \left[\frac{(R_2 - R_1) + 5\,(R_2^3 - R_1^3)}{R_2 - R_1} \right]$$

but

$R_1 = 12 \times 10^3/108 \times 10^3 = 0.11$

$R_2 = 108 \times 10^3/108 \times 10^3 = 1.0$

$$I_p = 10 \log \left[\frac{1.00 - 0.11 + 5 \left\{(1)^3 - (0.11)^3\right\}}{1.00 - 0.11} \right]$$

$$= 10 \log \left[\frac{0.98 + 5\,(0.998669)}{0.89} \right]$$

$$= 10 \log \left| \overline{6.61} \right|$$
$$= 8.2 \text{ db} = \text{preemphasis improvement at the pivot frequency}$$

In every case where this type preemphasis is used, this integration will yield approximately 8 db. Therefore, the pivot frequency for any baseband can be found from the preemphasis curve by finding the frequency corresponding to 8 db. Now that the pivot frequency is known, the level used to set deviation can be found. The rms (or peak) deviation per channel can usually be found in the equipment technical manual or manufacturer's specifications. This value is stated for the pivot frequency. With this per channel rms deviation value and the pivot frequency obtained from the above calculations, the test tone level can be determined from the following equation:

$$L_n(\text{dbm0}) = 20 \log \left[\frac{2.4\, f_p}{\sqrt{2}\, D_{rms}} \right]$$

where:

$L_n(\text{dbm0})$ = required test tone level

f_p = modulating (pivot) frequency

D_{rms} = rms per channel deviation desired

Using the pivot frequency at the test tone level calculated above, the correct deviation can be set on a modulator with this type preemphasis.

e. Probably the most common type of preemphasis is that recommended by International Radio Consultive Committee (CCIR). The characteristic curve for CCIR preemphasis is shown in figure 3-8. Once again the preemphasis improvement is plotted versus f/f_{max}. The CCIR preemphasis curve is defined by:

$$I_p = 5 - 10 \log \left[1 + \frac{6.9}{1 + \left(\frac{5.25}{(f_r/f - f/f_r)^2} \right)} \right]$$

where:

f_r = circuit resonant frequency = 1.25 f_{max}

f_{max} = the highest baseband frequency

f = the frequency of interest

The pivot frequency is once again found by the integration method used on the typical preemphasis curve. In the case of CCIR preemphasis, I_p - linear, would be:

$$I_p \text{ linear} = \left[1 + \frac{6.9}{\left(1 + \frac{5.25}{(f_r/f - f/f_r)^2}\right)}\right]$$

If the integration is performed in the same manner as with the typical preemphasis, the result would be that the pivot frequency would occur at the frequency corresponding to zero db on the curve. As in the typical preemphasis case, the test tone level is found using the formula:

$$L_n(\text{dbm0}) = 20 \log \left[\frac{2.4f_p}{\sqrt{2}\ D_{rms}}\right]$$

Using the pivot frequency and the level calculated by the formula above, the deviation can be set correctly on systems utilizing preemphasis networks recommended by CCIR.

f. Sometimes a system will have a time constant that differs from that of the typical preemphasis curve, in which case, the preemphasis curve will not accurately define the preemphasis effects. Therefore, a method is needed to plot a preemphasis curve, if only the preemphasis circuit time constant is known. If this is the case, the following relationship can be used.

$$I_p = 10 \log (1 + 39.5\ f^2\ \tau^2)$$

where:

f = any baseband frequency in Hz

τ = preemphasis circuit time constant

The preemphasis improvement at the pivot frequency can be found by the same integration method that was used for the typical preemphasis curve. I_p linear in this case would be:

$$I_p = 1 + 39.5\ f^2\ \tau^2$$

If the results of this integration is equated to $I_p = 10 \log (1 + 39.5\ f^2\ \tau^2)$, a general formula can be derived to find the pivot frequency. This formula is:

$$f_p = \sqrt{\frac{f_{max}{}^3 - f_o{}^3}{3\ (f_{max} - f_o)}}$$

where:

f_p = pivot frequency

f_{max} = maximum baseband frequency

f_o = lowest baseband frequency

The test tone level can be calculated in the same manner as it was for CCIR and the typical preemphasis curves.

g. It should be made clear that sometimes a technical manual will prescribe a frequency and level other than the pivot frequency at the appropriate level. There is nothing wrong with this as long as the difference in preemphasis between the pivot frequency and the new frequency is taken into account in the new level. It is clear that the equipment technical specifications should be consulted to determine if special techniques are used to set deviation.

h. Additional information as it pertains to deviation for the satellite modems is contained in the appropriate test procedures.

3-4. SYSTEM TEMPERATURE VS NOISE FIGURE.

a. One of the major factors determining the capacity of a satellite link is the ratio of the received signal strength to the noise present within the receiving systems. The noise in the receiver originates from two principal sources -- the internal noise associated with the electron flow within the system and the external noise contributed by various sources. The receiving system noise temperature is the equivalent noise temperature of the system as applied to the input of the parametric amplifier (para-amp). It is composed of the noise temperature of the total of all components preceding and including the para-amp, noise contributed by the WG, and the noise temperature of the antenna. This system noise temperature is commonly referred to as the SNT which includes the contribution of noise from all sources. It may also be referred to as the system operating noise temperature.

b. Noise figure (NF) is used to express the noise introduced in relative terms by comparing the actual noise output of the receiver with the receiver input noise. This input noise is thermal shot-noise generated within the signal source and is proportional to the absolute temperature of the source. Conventionally, when defining the NF, this temperature has been accepted to be 290 degrees K. Noise figure readings must be corrected when operating devices where signal sources are at very low temperatures. The temperature of the sky area to which the receiver antenna is pointed may be the problem. To circumvent such corrections, the term system temperature has been introduced, by which the noise performance of receiving systems may be described, regardless of the input noise conditions.

c. System temperature expresses the noise conditions in a receiving system in a more fundamental way than NF since the thermal shot-noise at the input is proportional to temperature (degrees K). It is then appropriate to identify temperature with noise level, thus determining an absolute amount of noise. System temperature expresses how much the input noise level would have to be raised (and, hence, the associated source noise temperature increased) to produce the actual noise level at the output. The increase of source noise temperature is defined as receiver noise temperature. The system temperature represents the total noise level at the system output referred to the receiver input. If the source noise temperature is subtracted from the systems temperature, the receiver noise temperature will be obtained.

d. System temperature is an absolute figure and describes the amount of noise added to the input signal noise by a system (receiver or network). The total noise in a system, T_s, can be separated into two elements as shown below:

$$T_s = N_g + N_r \tag{1}$$

where:

N_g = noise produced by a signal source at the receiver input.

N_r = noise produced within the receiver, referred to receiver input as an equivalent noise source

Expressing the noise levels of equation (1) as corresponding temperatures we obtain the following:

$$kBT_s = kBT_g + kBT_r \tag{2}$$

where:

k = Boltzmann's constant (1.38×10^{-23} watt sec/^oK)

B = receiver (or equivalent noise) bandwidth (3 db down points) in Hz

T_s = SNT in ^oK

T_g = temperature of generator (input termination, signal source, etc)

T_r = equivalent receiver noise temperature referred to the receiver input

After eliminating factor kB, a simple relationship for the system temperature is obtained by the following:

$$T_s = T_g + T_r \tag{3}$$

For the interpretation of the system temperature T_s, the terms, T_g (generator temperature) and T_r (receiver temperature) need further expansion.

(1) Generator temperature T_g: Generator temperature T_g is the actual, absolute temperature of the signal source at the receiver input. However, this temperature does not coincide with the ambient room temperature in all cases.

(a) T_g below room temperature (T_o): Cooled transmission line terminations for measurements on para-amps may have temperatures of 200 degrees K or less, which introduces less noise at the amplifier input. In radio astronomy it may be the temperature of the sky area to which the receiver antenna is pointed (approximately 10 degrees K or less).

(b) T_g *above room temperature:* Excess noise sources (gas discharge tubes or temperature limited thermionic diodes have temperatures on the order of 9,000 degrees K, or 10,000 degrees K).

(c) T_g equal to room temperature: Input terminations or receiver antennas for terrestrial communications have a generator temperature which is 290 degrees K, for all practical purposes.

(2) Receiver temperature T_r: The receiver temperature T_r and its relationship to the NF is obtained from the general definition of the noise factor (F) or NF respectively.

$$F = \frac{\text{actual available output noise}}{\text{ideal available amplifier input noise}} \tag{4}$$

(The word available in the above formula indicates that the source must always be matched to the load.)

$$NF_{actual} = 10 \log F \tag{5}$$

The NF for a receiver (gain G, noise factor F) which is terminated at the input by a signal source (T_g) may be written as:

$$NF_{actual} = 10 \log \frac{GkBT_g + (F - 1)\, GkBT_g}{GkBT_g} \tag{6}$$

Introducing the receiver temperature T_r, equation (6) will become:

$$NF_{actual} = 10 \log \frac{GkBT_g + GkBT_r}{GkBT_g} \qquad (7)$$

Comparing equations (6) and (7) it is possible to obtain the expression for T_r.

$$T_r = T_g \ (F-1) \qquad (8)$$

It is recognized that for a receiver which does not add any noise (F-1), the receiver temperature becomes zero degree K; however, this situation may never be encountered. Finally, equation (8) may be solved for F as follows:

$$F = \frac{T_r + T_g}{T_g} = \frac{T_s}{T_g} \qquad (9)$$

Interpreting equation (1), the system temperature is the generator temperature multiplied by the noise factor (F) of the receiver. For a noiseless receiver, the system temperature T_s equals the generator temperature T_g.

$$NF_{actual} = 10 \log T_s - 10 \log T_g \qquad (10)$$

In order to convert from system temperature to NF, the generator temperature must be known. The receiver temperature is obtained from the system temperature which is directly related to the temperature of the generator. Rewriting equation (3), the receiver temperature T_r becomes:

$$T_r = T_s - T_g \qquad (11)$$

e. By convention, the definition of the NF relates the actual available noise output power to the amplified available noise input power. The noise input power is thermal noise generated in the input termination at 290 degrees K. The NF, based on the preceding definition, is called the system operating NF. Equation (6) can be rewritten as follows:

$$NF_{operating} = 10 \log \frac{GkBT_g + (F-1)\ GkBT_g}{GkBT_o} \qquad (12)$$

where:

T_o = 290 degrees K

T_g = generator noise temperature

When using signal sources of very low temperature, the operating NF will not indicate the actual NF as defined in equation (6). A correction factor relating the operating NF to the actual NF is obtained from equation (12).

$$NF_{operating} = 10 \log \frac{GkBT_g + (F-1)\ GkBT_g}{GkBT_o} \quad (13)$$

$$NF_{operating} = NF_{actual} + 10 \log \frac{T_g}{T_o} \quad (14)$$

Solving for NF_{actual}:

$$NF_{actual} = NF_{operating} + 10 \log \frac{T_o}{T_g} \quad (15)$$

Noise figure meters usually indicate only the value $NF_{operating}$. The meter reading should then be corrected by equation (15). Only when T_o = T_g does the meter indicate NF_{actual}.

f. For a typical SNT measurement configuration, see figure 3-9.

3-5. EARTH STATION RECEIVE ANTENNA GAIN (G)/SYSTEM TEMPERATURE (T_s).

a. Due to the high gain of these large antennas, in the order of 60 db, it is not usually practicable to provide a known signal source from a boresight tower or atop a mountain to use in calibrating the receive antenna gain. Instead, the well-known radio energy emanating from Cassiopeia-A, Taurus-A, or Cygnus-A can be used as a signal source in the far-field. The gain can then be measured directly by means of a radiometer, or indirectly by measuring both G/T_s and T_s (system temperature) by means of the so-called Y-factor technique. In principle, both techniques should yield equal results. In practice, when both techniques are available, the radiometer can yield higher accuracy and repeatability than the Y-factor technique for gain, and the opposite is true for G/T_s.

b. The Y-factor technique employs a noise source such as an argon lamp for which the noise temperature has been established for both cold (turned off) and hot (turned on) conditions. The Y-factor measurement can be made using the basic configuration shown in figure 3-10.

c. With the noise source off, the equivalent cold temperature at the receiver input (T_{ce}) is composed of the cold temperature of the source (T_c) modified by the isolation and filter unit. With the noise source turned on, the equivalent hot temperature at the receiver input (T_{he}) is composed of the hot temperature of the source (T_h) modified by the isolation and filter unit.

d. To determine the Y-factor as shown in figure 3-10, a reference is set at zero db. The noise source is turned on and the attenuator is adjusted so that the power meter is set on the reference point again. The attenuator setting is the Y-factor in db. The noise source shown in figure 3-10 can represent the star selected for the measurement. The tracking antenna is peaked on the star, and an indication meter is set at a convenient reference. This meter measures the received power after suitable low-noise amplification, in some finite but arbitrary bandwidth. The antenna is then taken off the star, and a precision RF attenuator located ahead of the meter is adjusted to restore the original indicator reading. The change in attenuator setting is the Y-factor in db for a particular elevation angle and frequency. This Y-factor is then related to the system G/T_s through the following equation:

$$G/T_s = 8\pi k\ (Y-1)\ k_1 k_2/s\lambda^2 \qquad (16)$$

$$G/T_s\ (db) = 10 \log 8\pi k/s\lambda^2 + 10 \log (Y-1) + 10 \log k_1 k_2 \qquad (17)$$

where:

k = Boltzmann's constant (1.3×10^{-23} Joules/^{o}K)

s is the spectral flux density for the star used

k_1 is a correction for atmospheric attenuation and is a function of elevation angle. A suitable approximation to k_1, usable for $\Theta_{EL} \geq 5^{o}$ is given by:

$$10 \log k_1 = 0.04/\sin\Theta_{EL}$$

k_2 is a correction for the angular extent of the radio star and is a function of antenna beamwidth

λ is speed of light $\div$ frequency

e. To complete the Y-factor measurement, the system temperature, T_s, must be measured. The receiver temperature T_r is first measured. This is done by measuring the factor Y, which is the ratio of power at the meter when the input to the receiver is first connected to an ambient (T_a) matched load, and then to a cryogenically cooled load T_c. The factor is obtained as the db difference reading of the RF attenuator.

Then:

$$T_r = \frac{T_a - Y_1 T_c}{Y_1 - 1} \tag{18}$$

System temperature T_s is then obtained by measuring Y_2 which is the ratio (db difference) of powers appearing at the low-noise receiver output when the input is first connected to the ambient load and then to the antenna.

Then:

$$T_s = \frac{T_a + T_r}{Y_2} \tag{19}$$

From the above, the antenna gain can easily be calculated. This method has two distinct disadvantages. First, there is the uncertainty of being properly peaked on the moving radio star. Secondly, the finite time required for each of these measurements leaves room for error due to gain changes in the low-noise receiver during the measurement. Both of these disadvantages are minimized by repeating the measurement several times. Another consideration that must be given when using this method is that all systems may be unable to use Cassiopeia-A as a source. This is typical of the AN/TSC-54 terminals. Also the measured results may be questionable on other type terminals due to the small Y-factors that may be involved.

f. The radiometer technique eliminates the zero drift errors in gain measurements by translating the signal to a modulated frequency, usually on the order of 30 Hz. In this technique, the deflection of the meter or strip chart is directly proportional to the power received, which in turn is directly related to the antenna gain. Thus, only the scale factor needs to be calibrated. This is accomplished by switching between the ambient temperature and a cold load at a fast rate of about 30 Hz.

3-6. EARTH STATION TRANSMIT ANTENNA GAIN.

a. Earth station transmit antenna gains could be measured in a manner similar to the receive gain using the Y-factor technique if a low-noise receiver in the 7.2 to 8.4 GHz band were readily available. Alternately, if the equipment configuration permitted, a radiometer could be used. However, neither of these are generally available. Therefore, transmit antenna gain is generally measured by comparing the output of a small standard gain horn antenna with the gain of the unknown antenna. In this technique, two sources of error must be taken into account. The small standard gain horn sees considerable ground interference, and the large antenna is being measured in the near-field. The ground interference can generally be accounted for by sweeping the standard gain horn in elevation and tracing out the interference pattern. If there is one main source of interference, as is usually the case, it can be calculated out and the interference-free received signal can be found to compare with that due to the large antenna. Similarly, near-field factors can be computed for the large antenna from standard antenna theory.

b. The basic transmission equations as used in figures 3-1 through 3-4 will provide a close approximation of system gains and losses. If the earth station transmitter power is radiated by an isotropic antenna, the power per unit area at a given distance from the transmitter antenna is equal to the transmitter power (P_t) divided by the surface area ($4\pi R^2$) of an imaginary sphere having a specified distance (R). This is illustrated in figure 3-11.

where:

$$W_L = \frac{P_t}{4\pi R^2}$$ - surface area of a sphere's radius in meters

Since the transmit antennas are usually directional there will be a gain associated with the transmitting antenna. Then the power per unit area or power density (W_L) at a distance from a directional antenna is given by:

$$W_L = \frac{P_t G_t}{4\pi R^2} \tag{20}$$

where:

P_t is transmitted output power of the ground station

G_t is gound station transmitting antenna gain

The receiving antenna captures a portion of the transmitted power, giving a received power (P_r) based on the effective cross sectional area of the receiving antenna equal to A_R.

$$P_R = \frac{P_t G_t A_R}{4\pi R^2} \tag{21}$$

Antenna theory gives the relationship between antenna gain (G) and the effective cross sectional area (A) as:

$$G = \frac{4\pi A}{\lambda^2} \tag{22}$$

where:

π is the transmitted wavelength

Solving equation (22) for A and substituting in equation (22) gives:

$$P_R = \frac{P_t G_t G_R \lambda^2}{4\pi R^2} \tag{23}$$

c. Antennas can be designed to radiate much more in one direction than in others. The ratio of the power density at the peak of the antenna pattern to what the power density would have been for an isotropic antenna (W_L) is called gain. The numerical value of an antenna gain can be expressed as a ratio of the powers or it can be expressed in db by taking ten times the common logarithm of the power ratio. Some very precise mathematical relationships exist between beamwidth, gain, wavelength, and antenna area during antenna design. High gain antennas with very narrow beam angles must be accurately pointed for maximum efficiency. However, it must be remembered that large antennas are prone to deformations in shape which change the shape of the radiation pattern, reduce the antenna gain, and deflect the center beam away from its intended direction. The relationship of antenna beamwidth, gain, wavelength, and antenna area during design can be expressed as:

A = antenna area (aperture area) in square meters

Θ_B = half-power beamwidth in radians

G = gain (power ratio)

λ = wavelength in meters = $\frac{G}{R}$

F = frequency in Hz

C = speed of light (3×10^8 meters/sec)

d = parabola diameter in fact

Then for a parabolic antenna common to microwave applications the following relationship exists:

$$G = \frac{4\pi A}{\lambda^2} = \frac{4\pi AF}{C^2} \simeq \frac{4\pi}{\Theta_B{}^2} \tag{24}$$

d. Typically, most parabolic antennas have an efficiency of 55 to 60 percent. This accounts for such factors as aperture blockage, antenna misalignment, and imperfections in the antenna surface. The above gain formula then becomes:

$$G = \frac{4\pi}{\Theta_B{}^2}\, n\, \frac{(2.2)\ \pi}{\Theta_B{}^2} \tag{25}$$

n = antenna efficiency

or in terms of decibels:

$$G\ (db) = 20 \log d + 20 \log F - 172.5 \tag{26}$$

The beamwidth can also be expressed as a function of frequency and antenna size:

$$\Theta_B{}^2 = \frac{\lambda^2}{A} \text{ or } \frac{(68,700)\ 10^6}{F_d} \tag{27}$$

e. The gain in figure 3-12 is shown in db while the beam angle is shown in radians. The graph reveals that antenna gain increases rapidly with both an increase in diameter (or aperture area A) and frequency (F). Also gain (G) increases as beamwidth Θ_B decreases.

f. Atmospheric disturbances, during bad weather, prevent beam angles from being less than 1 milliradian; hence, antenna gains of more than 72 db for all-weather use cannot generally be achieved.

g. The gain figures discussed are only valid for the far-field (many wavelengths away from the antenna). Gain figures change with distance and are considerably different in the near-field.

h. Normally, the gain of the antennas will be specified during design and this information should be consulted whenever possible. In the event this data is not available, consult the government acceptance data or manufacturer's literature to establish the antenna gain used during the calculation process. If none of this data is available, the information can be calculated from the preceding information which will provide a close approximation of overall antenna gain.

3-7. LOSS FACTORS.

a. RF Considerations.

(1) Major factors in RF considerations, as applied to satellite communications, are those of propagation and transmission loss.

(2) When P_{tc} is defined as the RF carrier power output delivered to the transmission line leading to the duplexer (either in earth terminal or aboard the satellite) and P_{rc} is defined as the carrier power delivered to the receiver amplifier input at either the earth terminal or satellite receiver, the ratio T_c/P_{rc} can be called the transmission loss (L_t) of a single communications space link.

$$L_t = \frac{P_{tc}}{P_{rc}} \quad L_t\ (db) = 10 \log^{10} \left(\frac{P_{tc}}{P_{rc}} \right) \tag{28}$$

It is convenient to divide L_t into the sum of five losses for further study, thus:

$$L_t = L_s + L_a + L_r + L_t + L_{exr} \tag{29}$$

where:

L_s = an isotropic space loss (db)

L_t = the loss between the output of the transmitter power amplifier and the antenna (db)

L_a = absorption loss due to normal (clear) weather (db)

L_{exr} = excess atmospheric absorption loss during periods of rain (db)

L_r = loss between the receiver antenna input and the receiver amplifier (db)

b. Isotropic Free Space Loss.

(1) For any free space link, the ratio of the power radiated by transmitter antenna P_t to the power absorbed by the receiving antenna P_r (if both antennas are assumed to be isotropic and in free space) is called the isotropic free space loss (L_s).

$$L_s = \frac{P_t}{P_r} \tag{30}$$

$$L_s \text{ (db)} - 10 \log^{10} \left(\frac{P_t}{P_r}\right)$$

(2) This isotropic free space loss is related quantitatively to the distance between the transmitter and receiver and to the frequency or wavelength of the signal. The isotropic loss L_s increases as the square of both distance and frequency is expressed:

$$L_s = \left(\frac{4\pi D_r}{\lambda}\right)^2 \tag{31}$$

$$L_s \text{ (db)} = -79.3 + 20 \log F +2 \log D_r$$

where:

F is frequency in Hz

D_r is path length in km

c. Atmospheric and Rain Loss.

(1) The atmosphere has a selective absorption of radiation in the microwave millimeter portions of the spectrum between 10^9 and 10^{11} Hz, as shown in figure 3-13. The right-hand curves represent absorption by oxygen and water vapor which occurs under ideal atmospheric conditions. The left-hand curves represent excess rain loss in the atmosphere when rain or fog formations are dominate factors. The curves of figure 3-13 have been theoretically derived and experimentally verified.

(2) The amount of absorption due to water vapor and excess rain loss (L_{exr}) varies considerably depending on the weather. Both excess rain loss and clear weather atmospheric loss (L_a) are dependent to some extent on antenna elevation pointing angle. This is because, at low elevation angles, the radio signal traverses a longer path through the earth's atmosphere than at high elevation angles. At an antenna elevation angle of 5 degrees, the path length through the atmosphere is approximately 50 km in length. The constituents of atmospheric absorption and how they vary with frequency in the case of a 50-km path length are shown in figure 3-13. Figure 3-14 shows the total one-way, clear weather absorption as a function of frequency for different antenna elevation angles.

(3) Since excess rain loss becomes a factor only during periods of rain or fog, it is expressed as a percentage of time that it exceeds a certain value.

d. Transmitter Antenna Line Loss.

(1) It is convenient to specify the RF power of a transmitter P_t as that delivered by the power amplifier to the transmission line leading to the duplexer. The RF power that is actually radiated is less than P_t. P_t is multiplied by a fractional transmitter loss (L_t) to give the radiated power. This loss, composed of losses due to the duplexer, network coupling, and factors concerning the antenna beam, is practically unavoidable although every effort is made to minimize these losses as much as possible during equipment design.

(2) The loss in the network stems from the duplexer itself, and to the transmission lines connecting the duplexer to the power amplifier and to the antenna. The potential transmission line loss can be considerably reduced by the choice of high quality, low-loss transmission line material, and arrangement of the antenna-duplexer-power amplifier locations to require the minimum length of line. The duplexer loss depends on its design, but can be reduced by using a greater separation between the transmitted and received frequencies. The same isolation is required, but more freedom in design is allowed so that, generally, a lower loss duplexer (filter-isolator) results. Well-designed duplexers exhibit a loss of the order of 1 db, depending on rated power.

(3) The antenna beam loss is a composite group of loss factors which, when divided into the antenna gain (G), reduces the theoretical gain to an effective operating antenna gain. The antenna beam loss group is composed of an illumination loss and a pointing error loss. The illumination loss occurs with beams formed by concave antenna dishes which are illuminated by a point or a subreflector, in the case of a Cassegrainian feed system, at the dish's focal point. Due to practical considerations in design, not all energy from the feed point is intercepted by the dish surface. That which is not intercepted is lost and this may be referred to as the illumination loss factor which is usually in the order of 2 to 3 db. Inaccuracies in pointing the transmitting antenna can cause a pointing error (tracking error) loss ranging from a fraction of a db to several db's.

e. Polarization Loss.

(1) Electromagnetic radiation oscillates in a plane at right angles to its direction of propagation. To illustrate, consider a rope tied to a post while the other end is moved up and down vertically. Vertical waves will be created which will travel down the rope from the source of vibration toward the fixed terminal. The waves in the rope will occur in only one plane and, since in this case the plane is vertical, the waves are termed vertically polarized waves. In a similar illustration, if the rope is vibrated from side to side and no gravity is present, the waves in the rope will occur in a horizontal plane and will be horizontally polarized. Polarized radiation is generated in a manner similar to this illustration. A receiving antenna and its transmission line coupling network can be designed to accept, with only negligible loss, radiation which is polarized in a plane and to reject any radiation which is polarized in a plane at right angles to it. If the rope passed through a narrow slotted picket fence, horizontal oscillations (analogous to horizontally polarized waves) would be stopped abruptly at the slot. Varying degrees of hindrance would be observed if the angle of polarization were rotated from zero (vertical) through 90 degrees (horizontal). Thus, a plane-polarized receiver antenna is similar to the picket fence and when aligned to the polarization plane of the transmitter, it can deliver the radiated power intercepted by the antenna to the antenna transmission line. As the angular misalignment (short of 90 degrees) between the transmitter and receiver antenna increases, the polarization loss will become greater. When the receiver polarization plane is at right angles to the transmitter polarization plane (a condition called cross polarization) the loss, theoretically, is infinite. In practice, cross polarization loss is not infinite, but it does approach the order of 30 db or a factor of 1,000 to 1.

(2) A more sophisticated scheme of polarization is called circular polarization. This is a wave whose plane of polarization rotates through 360 degrees as it progresses forward. The rotation can be clockwise or counterclockwise (CCW). Circular polarization is created by combining equal magnitudes of vertical and horizontal plane polarized waves, with a phase difference of 90 degrees. Depending on the phase relationship,

this creates rotation either in one direction or the other. If the phase-time relation between the horizontal or vertical components is not exactly 90 degrees or if the magnitudes are not equal, a right-hand or left-hand elliptical polarization results. The magnitude of the radiated wave varies in a cyclical manner.

(3) A receiving antenna designed for circular polarization in one rotational sense (right-hand, for example) will pass all intercepted right-hand circularly polarized radiations to the transmission line. Conversely, an antenna designed for one rotational sense will exhibit a high rejection of radiation polarized in the opposite rotational sense. Theoretically, this loss is infinite, but again in practice, it is more on the order of 30 db.

(4) There are two outstanding reasons for using circular polarization rather than plane polarization in ground-to-satellite and satellite-to-ground communications. Ground station receivers can reject circularly polarized radiation emitted from their own transmitters and back-scattered from reflecting layers in the atmosphere (rain, fog, and clouds) far more effectively than if the reflected radiation is plane polarized. Additionally, the use of circular polarization makes the use of a polarization alignment control unnecessary. For example, suppose a linearly polarized wave were rotated 90 degrees as the result of rotation of the satellite's transmitting antenna or because of atmospheric phenomena, linearly polarized receiving antenna would then have to be rotated simultaneously through 90 degrees to avoid a large loss (as much as 30 db) of signal. With circular polarization there would be, in theory, no loss of signal strength as the result of the 90 degrees rotation of the transmitted wave. In practice, there might be as much as a 3-db loss resulting from a 90-degree rotation of the wave with circular polarization. On the other hand, a circularly polarized antenna is more complicated than a plane polarized antenna and the polarization will always have some ellipticity in practice.

(5) Even when employing circularly polarized antennas, some polarization loss occurs. This is due to the fact that actual antennas are never exactly circularly polarized and polarization is affected by the ionosphere. These factors give rise to slightly elliptical rather than pure circular polarization. When the elliptical polarization seen by the receiving antenna is not exactly matched by the antenna polarization, a polarization loss occurs. This polarization loss is typically on the order of 1 or 2 db.

f. Receiver Antenna Loss.

(1) As in the case of the transmitter power ratios, the ratio of the single channel RF power -- intercepted by the receiving antenna (P_r) -- to the power delivered to the input of the receiver amplifier for that channel (P_{rc}) is the receiver antenna loss (L_r). This loss is also compounded by increments of network loss and antenna loss.

(2) Both the network and composite pointing error losses are similar in magnitude and occur for reasons similar to those described for the transmitter losses.

3-8. SIGNAL-TO-NOISE (S/N) RATIO, CARRIER-TO-NOISE (C/N) RATIO.

a. Noise in a satellite communications system is made up largely of thermal, sky, excess rain, and satellite intermodulation noise.

b. Although, ultimately, the S/N ratio of the output signal from the earth station receiving system is of prime importance, the C/N at several intermediate points between the transmitting earth station and the receiving earth station should be considered. The power ratios at the following points are of particular interest:

(1) At the input to the satellite transponder (C/N).

(2) At the input to the earth station receiving system (C/N).

(3) At the output of the earth station receiving system, as measured in the individual voice or data channels (S/N, C plus noise-to-noise (N/N)).

c. This paragraph describes the various factors that must be taken into consideration in computing S/N at the points of interest.

(1) Effective radiated power.

(a) Effective isotropic radiated power (E_{irp}) is a term that has been found convenient to use in describing the radiated power from the satellite. E_{irp} is the product of the actual RF transmitter power output and the antenna gain. For instance, a satellite transponder with a 10-watt final amplifier and an antenna with a gain of 10 would have an E_{irp} of 100 watts or 20 dbw. The E_{irp} of a satellite can be calculated providing that certain parameters (readily available at the earth station) are obtained. These parameters are antenna elevation, slant range to the satellite, weather, ground antenna net gain, SNT, C/N (or C/kTB) of the receiver, and bandwidth of the receiver or measuring device (whichever is narrower). The received signal strength (S_r) at the ground station (referred to the para-amp input) is given by:

$$S_r = E_{irp} - L_{fs} - L_a + G_{ga(net)} \qquad (32)$$

where:

S_r is received signal strength (referred to para-amp input)

L_{fs} is free space loss

L_a is atmospheric attenuation

$G_{ga(net)}$ is antenna net gain - to include radome loss (when applicable), tracking (crossover) loss, polarization (ellipticity) loss, and feed loss (including WG lines) to para-amp input

Based on the above, it can be seen that by transposing the equation, E_{irp} is expressed by:

$$E_{irp} = S_r + L_{fs} + L_a - G_{ga(net)} \tag{33}$$

(b) Once the major parameters are stated, it is simply a matter of addition and subtraction to determine E_{irp}.

(2) Multiple access backoff.

(a) Multiple access backoff is a term that has come into use in connection with frequency division multiple access (FDMA).

(b) Multiple access backoff refers to the satellite output power that is lost due to the necessity for backing off on the earth station radiated power to avoid generating excessively high intermodulation products in the satellite. Multiple access backoff will normally amount to between 1 and 2 db.

(3) Noise bandwidth.

(a) A figure for C/N is meaningless unless the noise bandwidth associated with the C/N is known. The noise bandwidth of interest varies, depending on which C/N is being determined.

(b) The only noise of concern in the earth terminal receiving output signal is the noise that falls within the output voice or data channel. In the case of a voice channel, this noise bandwidth will normally be 4 kHz.

(c) At the input to the earth station receiving system we are concerned with the C/N in the intermediate frequency (IF) bandwidth. The C/N in this bandwidth determines whether or not the signal is strong enough to be above receiver threshold. Knowing the C/N in the IF bandwidth, the C/N in the output channel can be calculated.

(d) At the input to the satellite receiver, there are two noise bandwidths of interest: the C/N in the entire transponder passband and C/N in the RF signal bandwidth. The ratio of the S/N power in the entire transponder passband largely determines how the output power of the satellite will divide between the desired signal and the noise signal. Also, the satellite power lost to intermodulation products must be considered. The C/N in the RF signal bandwidth determines how much noise power will be contained in the output signal that will ultimately fall within the IF passband of the earth station receiving system.

(4) Carrier-to-noise density.

(a) In the C/N density expression (C/kT), C refers to the ratio of the RF signal level, or carrier level, of the received signal at the earth terminal receiving system. Boltzmann's constant is k and T is the receiving SNT, kT is the noise power in a bandwidth of 1 Hz; hence the term, noise density.

(b) The significance of this expression comes from the fact that formulas for computing the capacity of satellite communications links show that this factor is basic to determining the channel capacity of the system. It suffices to say, however, that once the arbitrary factors such as desired channel C/N and modulation index have been determined, then channel capacity can be determined from C/kT. Figure 3-15 shows how the number of voice channels varies as a function of C/kT under set conditions.

(c) Because C/kT is fundamental to so many link performance calculations, manufacturers of satellite receiving equipment generally describe the performance of their equipment based on the C/kT of the received signal.

(5) Antenna gain-to-noise (G/T) temperature.

(a) The antenna G/T temperature ratio may be thought of as a figure-of-merit for an earth receiving station. G refers to the gain of the earth station antenna in the receive mode, and T is the equivalent noise temperature of the receiving system.

(b) To understand the importance of G/T, recall that C/kT determines the capacity of a satellite communication link. C, in the expression C/kT, corresponds to P_r and is expressed as:

$$C = \frac{P_t G_t G_r \lambda^2}{(4\pi R)^2} \tag{34}$$

Equation (34) indicates that any increase in the receive antenna gain G_r will bring about a corresponding increase in the value of C/kT.

(c) The equivalent noise temperature T in the expression C/kT is based on the total amount of noise in the received signal. This includes sky, excess rain, and satellite intermodulation noise, as well as the earth terminal receiving SNT. However, the earth terminal receiving SNT is usually the major component of the total noise in the receive system and reducing it will automatically reduce T in the C/kT expression; thereby increasing the value of C/kT. There is a direct relationship between an increasing value of G/T and an improvement in C/kT. Satellite earth equipment designers always strive for as high a ratio of G/T as possible.

(d) The measurement of G/T is a difficult procedure because of the problem of finding a suitable reference and measurement procedure.

(6) Signal-to-noise ratio.

(a) Four sets of computations must be performed to determine the S/N ratio of the earth receiving station output signals to the ultimate user of the link. The four sets of computations are:

1. An uplink power budget analysis.

2. A computation of how the signal power divides in the satellite between signal power and noise power.

3. A downlink power budget analysis to determine C/kT.

4. A computation of the number and quality of voice channels based on C/kT.

(b) The uplink power budget analysis may be performed by solving the equation for the free space loss.

$$L_s = \frac{P_t}{P_r}$$

$$L_s \text{ (db)} = 10 \log \left(\frac{P_t}{P_r} \right)$$

where:

L_s = isotropic free space loss

P_t = ratio of power radiated by the transmitter to the power absorbed by the receiving antenna

P_r = power absorbed by the P_t antenna

To the free space loss must be added the atmospheric absorption loss. The total loss consisting of free space loss, plus atmospheric absorption, determines the amount of power received by the satellite from the earth station. Excess rain and sky noise can be ignored in the uplink analysis because they will be very small in relation to the thermal noise introduced by the satellite receiver.

(c) The computation to determine how the signal power in the satellite divides, when FDMA is used, is best explained by going through a simple example calculation. Let us assume that the satellite has a rated power output of 25 watts and that there are four stations all of equal power accessing the satellite. Let us further assume that the accessing stations are small tactical stations so that the signal strength from each station reaching the satellite is equal to the thermal noise power of the satellite receiver. The 25 watts of output would, therefore, be divided equally into five parts, one part to each of the four signals it is repeating and one part to noise, so that each output carrier would be 5 watts.

(d) The 5-watt carriers, however, must be reduced by the amount of multiple access backoff that is required. In a typical satellite repeater this will amount to -1.5 db, or a factor of 1 to 1.41, resulting in 3.5 watts per carrier.

(e) In computing the split between satellite signal power and thermal noise power, the noise power in the entire passband of the satellite has to be considered. Of the noise power leaving the satellite, however, we need be concerned only with the noise in the RF carrier bandwidth. For ease of computation, assume that the total satellite bandwidth is 200 MHz and that the RF carrier bandwidth is 2 MHz. The thermal noise power within each carrier passband will be one-hundredth of 5 watts or 0.05 watt.

(f) The satellite intermodulation noise must be added to the thermal noise power. In a typical satellite repeater, the intermodulation noise will be about the same magnitude as the thermal noise. Therefore, to complete this example of how the power divides within the satellite, we can assume that the output from the satellite would consist of 3.5 watts of signal power and 0.1 watt of noise power.

(g) An accurate downlink power budget analysis is somewhat more complicated than the uplink analysis. Free space loss and atmospheric absorption loss must be applied to both the satellite signal power output and the satellite noise power output to determine how much signal power and how much noise power reach the earth station antenna. The sky noise must be added to the noise power received from the satellite. The total noise in the receiving system may be calculated by adding the receiving SNT to the noise from the satellite. The ratio of the signal power reaching the earth to the total noise power is C/N. Multiplying by 1/B gives the C/N density C/kT.

(h) To determine the C/kT during high precipitation conditions, apply the excess rain loss to both the satellite signal and noise power. Also, add the excess rain noise to the noise from the satellite and sky noise. This will give a new figure for total received signal and noise. By adding the receiving system equivalent noise temperature to the received equivalent noise temperature of the total received noise, C/kT under rain conditions can be obtained.

(i) The number and quality of voice and data channels that a given satellite communications link can support, can be determined from C/kT by using equipment curves such as shown in figure 3-15.

(7) Required signal-to-noise ratio. While the S/N ratio gives a measure of the performance of a communications link, the decision as to whether a particular S/N ratio is good or bad is still somewhat subjective although various standards have been established. An S/N ratio that would be intolerable on a military system might be perfectly acceptable on a commercial system, or vice versa.

(8) Other noise considerations.

(a) The major galactic sources of noise (sky noise) are the sun, Milky Way, and scattered hydrogen clouds. The sun is the most intense source, having a noise temperature T_{sun} as high as 1,000,000°K at 300 MHz, although this decreases to 6,000°K for frequencies higher than 10 GHz, as shown by the line labeled T_{sun} in figure 3-16. If an antenna beam has a beam angle width Θ_B, which is identical to the angle subtended by the sun from the earth, then when the beam is pointed at the center of the sun the antenna beam temperature TB will be exactly the sun temperature as shown in figure 3-16. If the antenna beamwidth θ_B is larger than the angle subtended by the sun θ_S, then with the beam again pointed at the center of the sun, the beam temperature T_B is less than the sun temperature. During the most active years in the sunspot activity cycle, the temperature T_{sun} can be as much as 10,000 times that shown in figure 3-16. However, by insuring that a high gain antenna does not point within ten beamwidths of the sun, the beam temperature T_B of an isotropic antenna resulting from the sun's radiation at its high bust intensity will not exceed that given by the line marked sunburst noise in figure 3-16.

1. The most intense galactic noise comes from our own galaxy, the Milky Way, in the direction of the constellation Sagittarius. For antenna beams sufficiently narrow (fraction of a degree) T_B is given approximately by the galactic noise line in figure 3-16. There are isolated clusters of hydrogen in space that also radiate noise. High gain antennas with narrow beamwidths, when pointed at these sources, have been temperatures of about 100°K, as shown by the hydrogen noise line in figure 3-16. For larger-than-fractional-degree antenna beamwidths, the beam antenna noise temperature would be less than 100°K.

2. Satellite antennas with a beamwidth narrow enough to be completely subtended by the earth would have an antenna beam temperature equal to the earth or earth's atmospheric thermal temperature (approximately 290°K), as shown by the line marked earth noise. The antenna beam noise would be less than 290°K for antennas with beam angle widths larger than the angle subtended by the earth.

3. In general, the antenna beam background noise temperature can be anything from 1,000,000°K to a few degrees K, depending on narrowness of beamwidth angle, frequency, and direction of pointing. Both isotropic and high gain antenna beam noise are minimized by choosing frequencies higher than 1 GHz. High gain antennas must avoid pointing at discrete noise sources such as the sun, Milky Way, hydrogen clouds, and the earth.

4. Despite the high sky noise temperatures that can be encountered, the amount of sky noise entering the antenna under normal conditions does not present a severe problem. For an antenna pointed slightly downward so that it is actually looking at the earth, the noise temperature will be approximately the temperature of the earth, or $290^{\circ}K$; as the antenna pointing elevation is raised, the temperature rapidly drops off to something less than $10^{\circ}K$ at an elevation angle of 15 degrees and continues to drop off as the antenna is raised. This is shown in figure 3-17.

(b) During periods of heavy rainfall, the antenna is in effect pointed at a large mass of material in the form of countless raindrops. Excessive rainfall noise energy in the form of blackbody radiation will be received by the antenna. Since the raindrops do not form a solid mass, the noise equivalent temperatures of the rain fall will be somewhat lower than the actual temperature of the rain.

1. If the rain is occurring some distance away from the antenna, the rainfall probably will not extend through the entire cross section area of the antenna beamwidth. This will have the effect of reducing the noise equivalent temperature further.

2. Since excess rain temperature is present only during periods of rain, it is expressed as a percentage of time that it exceeds a certain value in the same manner that excess rain loss is expressed. A typical distribution curve of excess rainfall attenuation is shown in figure 3-18.

(c) The receiver portion of the satellite transponder generates a certain amount of thermal noise in the same manner as any other receiver. The amount of thermal noise generated is dependent upon the NF or equivalent noise temperature of the satellite receiver.

1. This noise is added to the signal received from the earth station and is rebroadcast by the transmitter portion of the satellite transponder with the desired signal. The amount of satellite thermal noise in the rebroadcast signal will depend on the ratio of received signal strength to satellite thermal noise.

2. A typical satellite transponder receiver will have an equivalent noise temperature of $3{,}000^{\circ}K$. The amount of noise power generated by a 3,000-degree receiver having a 50-MHz bandpass can be calculated to be:

$$\begin{aligned} N &= kTB \\ &= 1.38 \times 10^{-23} \times 3 \times 10^{3} \times 5 \times 10^{7} \qquad (35) \\ &= 2.07 \times 10^{-12} \text{ watts} \end{aligned}$$

3. Most communications satellites employ automatic gain control (AGC) so that as the received signal decreases in strength, the gain of the satellite increases. This insures that, regardless of receiver signal strength, the satellite transmitter is driven to saturation or near saturation. In the event that no signal is received, the noise generated by the receiver will constitute the signal that drives the satellite transmitter.

4. The amount of satellite thermal noise in the output signal can vary anywhere from constituting the entire output signal (no-received-signal condition) to a small portion of the output signal (strong-received-signal condition).

(d) Since all satellite repeater transponders built to date have been nonlinear devices, they generate intermodulation noise. Intermodulation noise consists of the sum and difference signals that are produced whenever two or more signals are amplified in any device that is not exactly linear (output signal directly proportional to input signal) in its operation. The amount of intermodulation noise that is added to the signal by the satellite transponder is dependent to some extent upon the type of multiple access that is employed. There is no accurate way of calculating the amount of intermodulation noise contributed by the satellite.

3-9. INJECTED REFERENCE CARRIER TECHNIQUE. The signal strength received from a satellite at the earth station's antenna flange ranges from about -85 dbm to -120 dbm. These weak signals must be amplified by a low-noise receiver in order to be visible on a typical microwave spectrum analyzer or measurable by other techniques. In order to make accurate signal strength measurements at the output of the receiver, it is necessary to cancel out gain variations of the receiver itself. One technique for doing this is to inject ahead of the receiver a continuous wave (CW) signal whose power level is calibrated and adjustable to be within the range of the satellite's signal. The injected signal can thus be made equal in power and close in frequency to the unknown signal, as displayed on a spectrum analyzer. In this way, both the power level and the frequency of the unknown signal can be measured accurately. The injected carrier is generated by a signal generator or equivalent instrument. Its level is monitored by the reference signal power meter and adjusted by the downlink reference attenuator. It is injected ahead of the para-amp by means of a calibrated directional coupler and displayed together with the satellite's signal on the spectrum analyzer. Note that by using this technique the noise seen on both the satellite and injected signals is about the same. This is largely due to the para-amp. Eye observations are used to distinguish the noise as seen on the spectrum analyzer display while the measurement is actually done on a noise-free injected signal. Also, all receiver or analyzer gain variations affect both signals simultaneously and are thus integrated out by the observer.

3-10. SPECIAL INFORMATION RELATING TO THE PROPERTIES OF CAS A

Information contained herein was extracted from Technical Report No. ACC-ACO-2-74

2.1 Early Measurements

The radio emission known as Cas A was discovered in 1948 by Ryle and Smith (7) while measuring rf emissions from the Constellation of Cygnus discovered two years earlier. In 1954 Baade and Minkowski (8) identified the newly discovered radio source with faint optical nebulosities located near the Constellation of Cassiopeia. From optical measurements of the nebulosities Minkowski (9, 10, 11) concluded: that they are traveling radially outward at a speed of 7440 km/sec; that they are approximately 11,000 light years from the earth, and that they are remnants of a supernova explosion, the visual evidence of which probably reached the earth about 1700 A.D. Subsequent rf measurements (12, 13) made in 1952 to determine the center and angular size of Cas A helped Baade and Minkowski to positively identify the emission with the nebulosities.

Since these first observations, many measurements of Cas A have been made to determine its flux density and spectral distribution, angular shape, polarization, and stability. The following subsections contain discussions of the results of these measurements as they pertain to the use of Cas A as a standard source of rf noise power for the measurement of the parameters of large antennas.

2.2 The Location of Cas A

2.2.1 The Equatorial and Galactic Coordinate System

The equatorial coordinate system is the most commonly used system for locating the position of celestial bodies. It is the one used in most star catalogues and will be discussed in detail in this subsection. The galactic coordinate system is often used in conjunction with the equatorial system in locating broad regions of cosmic background radiation and will therefore also be treated to some extent here.

Equatorial Coordinate System (6)

In the equatorial system the plane of the earth's equator is the plane of reference, the center of the earth is to coordinate origin, and the earth's geographic north pole is the northern direction. The reference direction in the reference plane is defined in conjuction with the celestial sphere, figure 2-1. This sphere is an

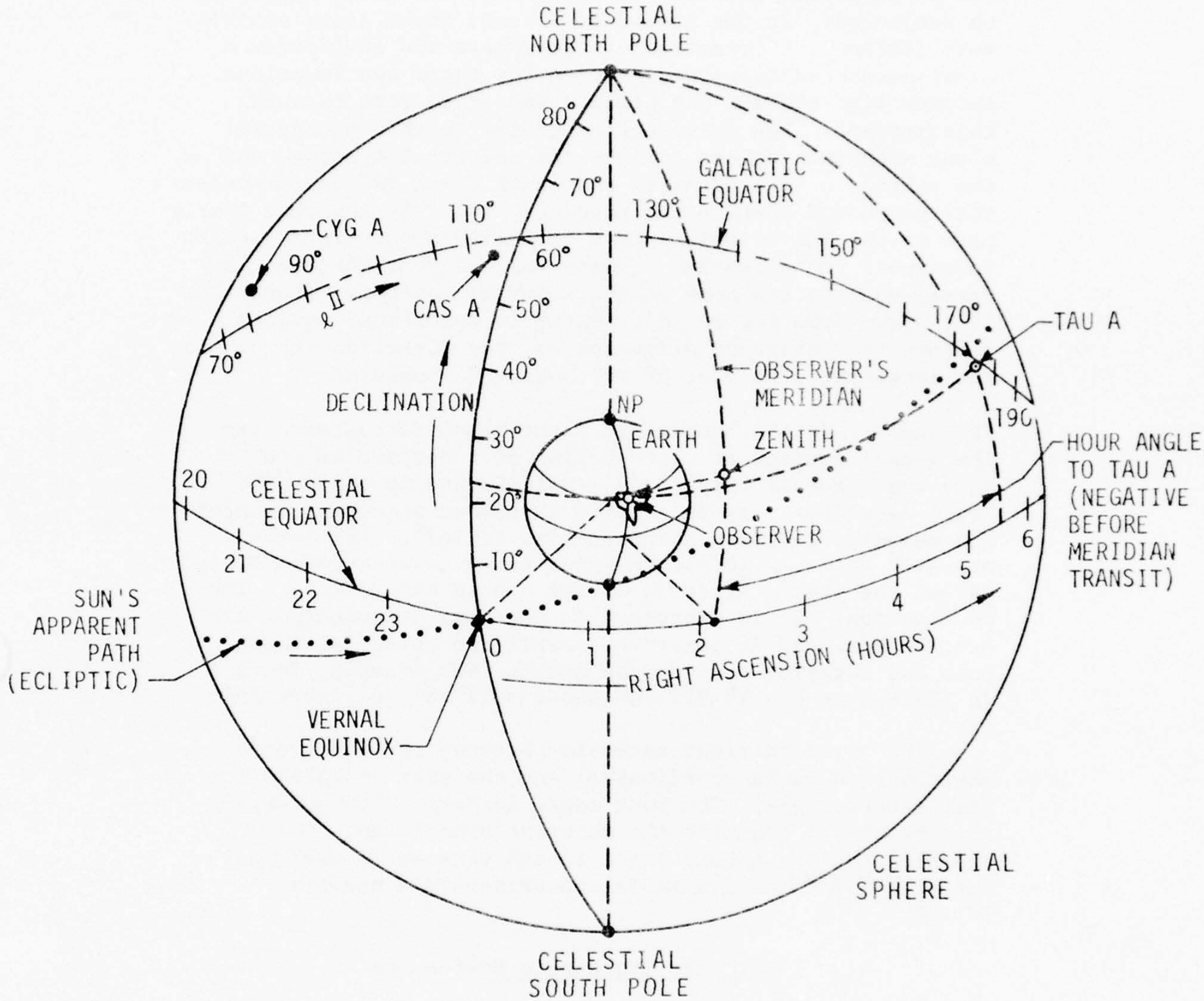


Figure 2-1. The equatorial and galactic coordinate systems superimposed onto the celestial sphere.

imaginary spherical surface of arbitrarily large radius with the earth as its center, and onto which the stars appear to be projected. In the period of a year, these stars exhibit very little angular motion on the sphere and so provide a quasi-permanent reference pattern for their own locations. Objects like the sun and planets appear to move through this pattern. The intersection of the earth's equatorial plane with this sphere defines the celestial equator, and the earth's projected north and south poles define the celestial north and south poles respectively. The apparent yearly path of the sun on this sphere is called the ecliptic, which intersects the celestial equator twice a year, once at the vernal equinox and once at the autumnal equinox. Then, the line drawn from the earth's center to the vernal equinox defines the reference direction, or the direction from which the longitude of a star of the sphere is measured.

The angle α in the equitorial plane measured eastward from the vernal equinox to a projection of a particular star onto the plane is the star's longitude and is called the right ascension. It is usually expressed in hours, minutes, and seconds; 24 hours corresponding to 360^{o}. The angle δ measured from the reference plane to the star's position is called the star's latitude on the sphere and is called the declination. It is expressed in degrees, arc minutes, and arc seconds, and is positive towards the celestial north pole and negative towards the south. For example, Tau A is located at $\alpha = 5^{h}\ 31^{m}\ 30^{s}$ and $\delta = 21^{o}58'$ in figure 2-1.

The angle in right ascension between the observer's meridian (in earth coordinates) and the star is called the star's hour angle. The hour angle is defined to be negative before it transits the observer's meridian. For example, the Tau A hour angle to the observer's meridian (at $\alpha = 2^{h}\ 11^{m}$) in figure is approximately a negative $3^{h}\ 20^{m}$.

Galactic Coordinate System (6)

Since 1958, the galactic coordinate system is defined as follows. The origin is defined by the intersection of the plane of our galaxy and the line through the center of the earth perpendicular to this plane. Angles of galactic longitude (ℓ^{II}) are measured in this plane, and angles of galactic latitude (b^{II}) are measured from this plane. The reference direction in the galactic plane is from the origin to the center of the galaxy in the plane.

The apparent intersection of the galactic plane with the celestial sphere is called the galactic equator (fig. 2-1) and provides a convenient reference circle (not a great circle) on that sphere. The north galactic pole is the intersection ($\alpha = 12^{h}\!.7$ and $\delta = 28^{o}$) of the perpendicular from the origin with the northern hemisphere of the celestial sphere.

2.2.2 The Precession of the Earth's Axis (6)

Since the earth is not a perfect sphere, the gravitational pull exerted upon it by the sun causes a gradual precession of the earth's axis around the pole of the ecliptic, one cycle being completed in approximately 26000 years. This gradual motion shifts both the celestial equator and the celestial poles with respect to the star pattern, causing an apparent shift in the positions of the stars. Therefore, when specificing the right ascension and declination of a star, it is important to specify a date (epoch) to which they refer. The difference in the right ascension and declination referred to AD 1950.0 are given by

$$\Delta\alpha = m + n \sin\alpha \tan\delta \text{ per year}$$
$$\Delta\delta = n \cos\alpha \text{ per year}$$

where α and δ are the right ascension and declination for 1950.0.

$m = 3.07327$ seconds

and $n = 1.33617$ seconds of arc = 20.0426 seconds of arc

2.2.3 Cas A

Through a detailed study of the shape of Cas A (14) the center of its rf emission is placed at

$$\alpha = 23^{h}\ 21^{m}\ 11^{s}$$

and $$\delta = 58^{o}32'40''$$

at the epoch of 1950.0. For comparison, the optical center of the expanding nebulosities mentioned in subsection 2.2.1 is located at (15) $23^{h}\ 21^{m}\ 11.4^{s}$ right ascension, and $58^{o}32'18.9''$ declination.

Cas A, though not visible, is located (fig. 2-2) just west (11^{o}) of β Cas. The effect of the earth's precessional motion upon the apparent position of the stars from 1900 AD to 2000 AD is also indicated in figure 2-2. The location of Cas A in our galaxy is shown in figure 2-3.

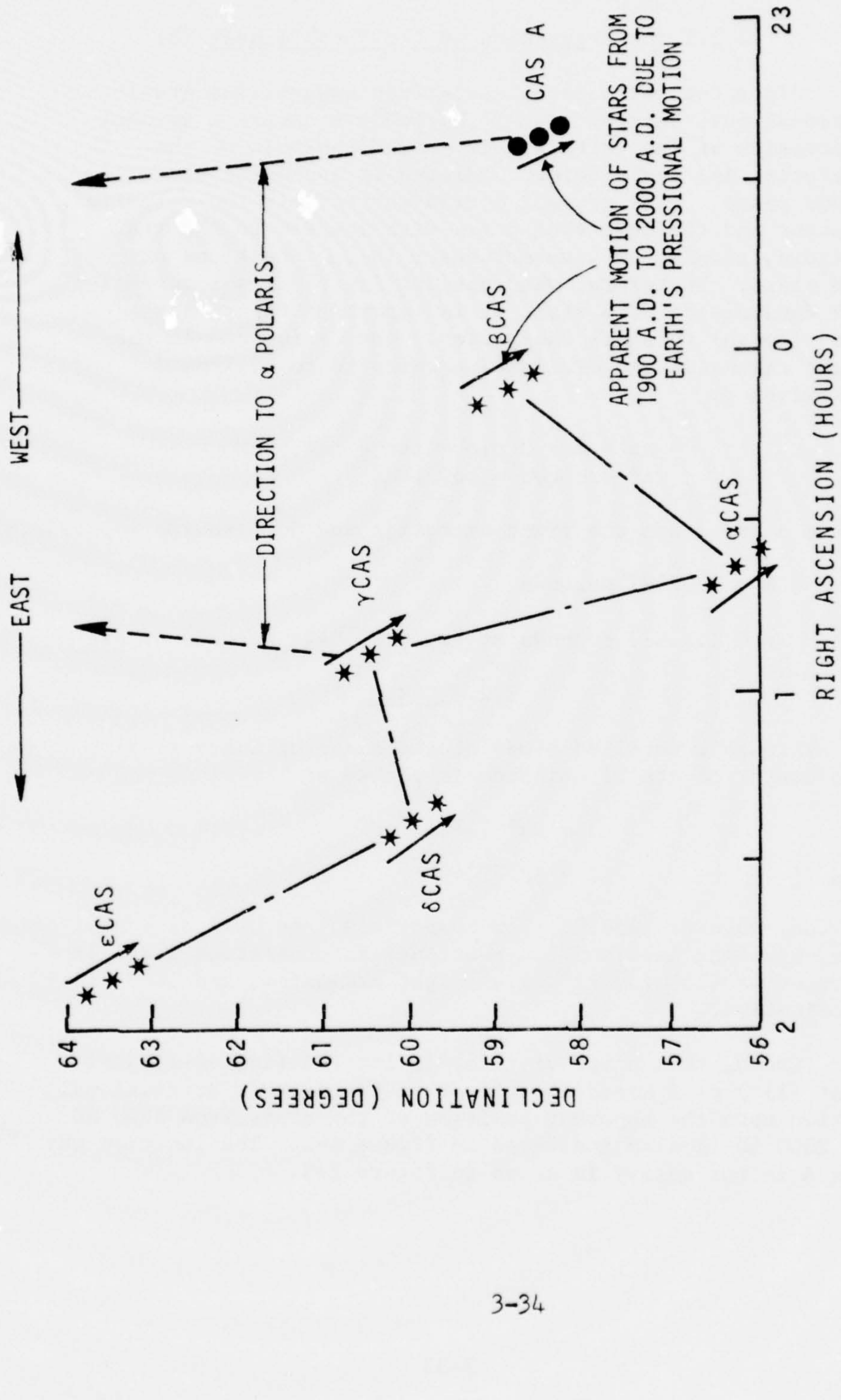


Figure 2-2. The position of the radio source Cas A relative to the visible stars in the constellation of Cassiopeia.

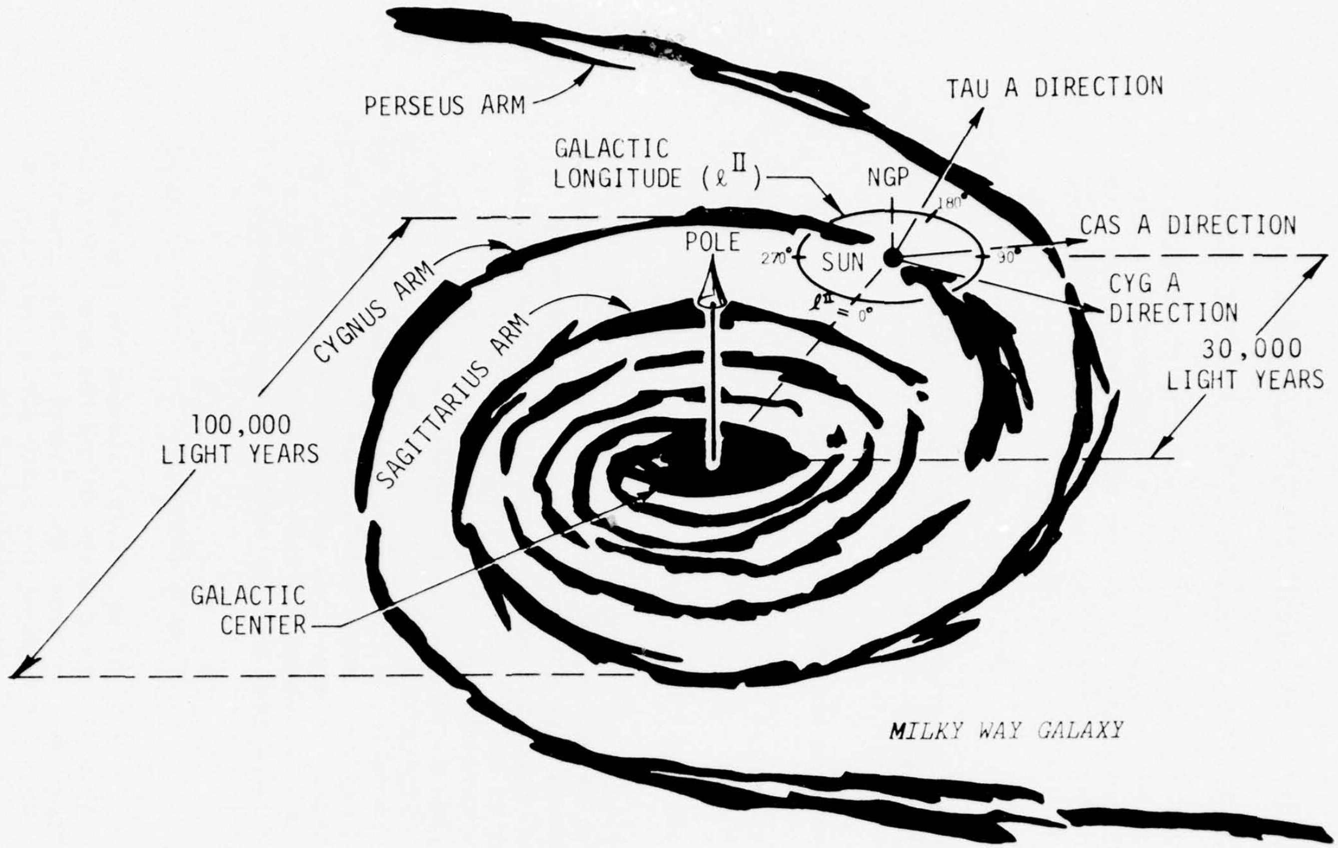


Figure 2-3. An artist's sketch of the position of the sun, and the directions to Cas A, Tau A, and Cyg A relative to the Milky Way Galaxy.

2.3 Flux Density and Spectral Index

2.3.1 Brightness, Brightness Temperature, and Flux Density (6)

The intensity measure of radiation from the celestial sphere is called the brightness. The brightness of a small surface on the celestial sphere can be related to the flux density, S, at an antenna on the earth. This relationship will now be developed. From figure 2-4

$$dw' = B\, dA\, d\Omega' \tag{2.1}$$

where dw' = spectral power (power per unit bandwidth) emitted by the incremental surface dA into the solid angle $d\Omega'$, watts/Hz

B = surface brightness, watts/($rad^2 \cdot m^2 \cdot Hz$)

dA = elemental surface area on the celestial sphere, m^2

$d\Omega'$ = elemental solid angle, rad^2

Thus B is a brightness whose magnitude depends upon its location on the celestial sphere, and which varies in a roughly continuous manner over the sphere except for occasional "bright spots" which correspond to highly localized or discrete sources of radio emissions. The broad continuous brightness is referred to as "background radiation," and the bright spots as radio "stars." Cas A is one of these radio stars. Figure 2-5 is a representation of the celestial sphere with the earth at its center, and with the size of the earth represented by a point (e) relative to the radius of the celestial sphere. As seen from the earth the elemental surface area dA on the sphere (of radius r) subtends a solid angle $d\Omega$, where the area and the solid angle are related via the equation

$$dA = r^2 d\Omega. \tag{2.2}$$

The spectral power (dw' of eq. (2.1)) leaving the surface dA proceeds within the solid angle $d\Omega'$ to the earth, becoming spread uniformly over the area dA'. Therefore the elemental flux density (dS) that reaches the earth after radiating from dA equals this spectral power divided by the elemental area dA'. That is

$$dS = \frac{dw'}{dA'}. \tag{2.3}$$

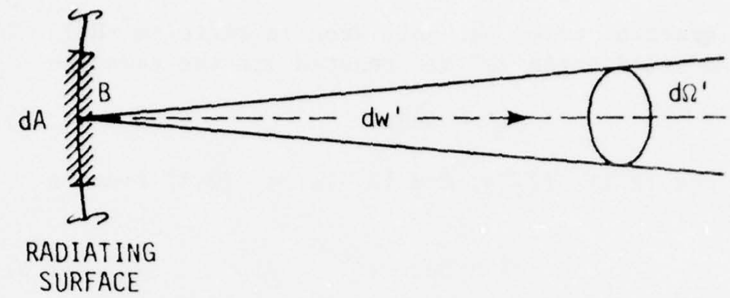


Figure 2-4 Brightness B of an elemental radiating surface dA

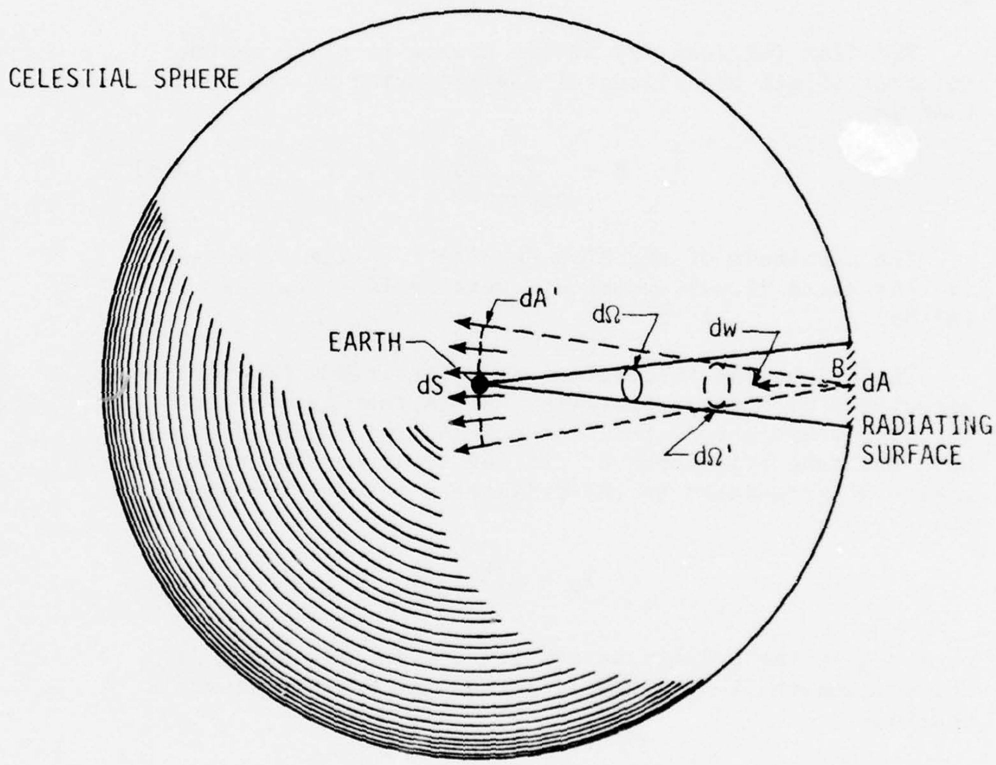


Figure 2-5 Elemental radiating surface dA on the celestial surface

where dS = spectral power per unit area in watts/($m^2 \cdot Hz$). The area dA' and solid angle $d\Omega'$ are related via the equation

$$dA' = r^2 d\Omega'. \tag{2.4}$$

Then using eqs (2.1), (2.2), and (2.4); eq. (2.3) reduces to

$$dS = B d\Omega. \tag{2.5}$$

This is the fundamental equation relating the elemental flux density (dS) arriving at the earth to the brightness B of the area of the sphere subtended by the solid angle $d\Omega$.

The flux (S) from any finite source is given by the integral of all the elemental fluxes making up the source, that is

$$S = \int_{\text{source}} B d\Omega \tag{2.6}$$

The magnitude of the flux density is often expressed in flux units (f.u.), where one unit is 10^{-26} watts/($m^2 \cdot Hz$).

The brightness temperature is a fictitious temperature associated with the brightness. It is that temperature to which a black-body radiator must be raised in order to have the same brightness B. In the low frequency approximation it is related to the brightness through the equation (6)

$$T_B = \frac{\lambda^2 B}{2k} \tag{2.7}$$

where T_B is the brightness temperature in kelvins, λ is the wavelength of interest in meters and K is Boltzmann's constant.

2.3.2 Flux Density and Spectral Index of Cas A

Among other things the flux density of Cas A is both a function of frequency and time. Therefore the time and the frequency of its measurement must be specified. For example, the flux density of Cas A at 7.5 GHz for the time (epoch) AD 1965.0 is approximately 618 f.u. and is decaying at approximately 1% per year. One f.u. or flux unit is 10^{-26} w/m^2/Hz.

It has been found that the frequency dependence of the flux density follows the equation

$$S(f) = S_1 f^{\alpha} \tag{2.8}$$

where S_1 is the flux density at 1 GHz, α is a constant called the "spectral index" and is defined by eq. (2.8), and f is the frequency in GHz (the symbol α is also used to denote right ascension). The flux density of Cas A around 7.5 GHz is given in table 2-1 and figure 2-6. The flux densities were transferred (see section 2.4) from the epochs in which they were measured (column three) to the epoch AD 1965.0 (column four) by using a decay rate of 1.1% per year.

Table 2-1

Frequency (GHz)	Epoch (AD)	Flux Density (f.u.)	AD 1965.0 Flux Density (f.u.)
5	1964.4	910 (16)	905
5.68	1968.5	740 (17)	766
6.66	1965	684 (18)	684
8	1964	590 (19)	584
9.36	1961.5	520 (20)	502
9.375	1962.7	514 (21)	502
9.38	1968.5	510 (17)	528

Figure 2-6 is a log-log plot of the AD 1965.0 flux densities in table 2-1. The line drawn through the points is a least squares fit to these points and conforms in the interval from 5 to 10 GHz to the spectral equation

$$S(f) = 3604\ f^{-0.875} \tag{2.9}$$

where the flux density is given in flux units and the frequency is in GHz. From this equation the flux density at 7.5 GHz is found to be 618 f.u., with a corresponding brightness temperature of 336 kelvins. A method such as this is often used over a much wider frequency range to determine S at a frequency where it has not been measured, and/or to obtain a higher accuracy in S based upon the assumption that eq. (2.8) is a correct description of how S varies with frequency. In this context it should

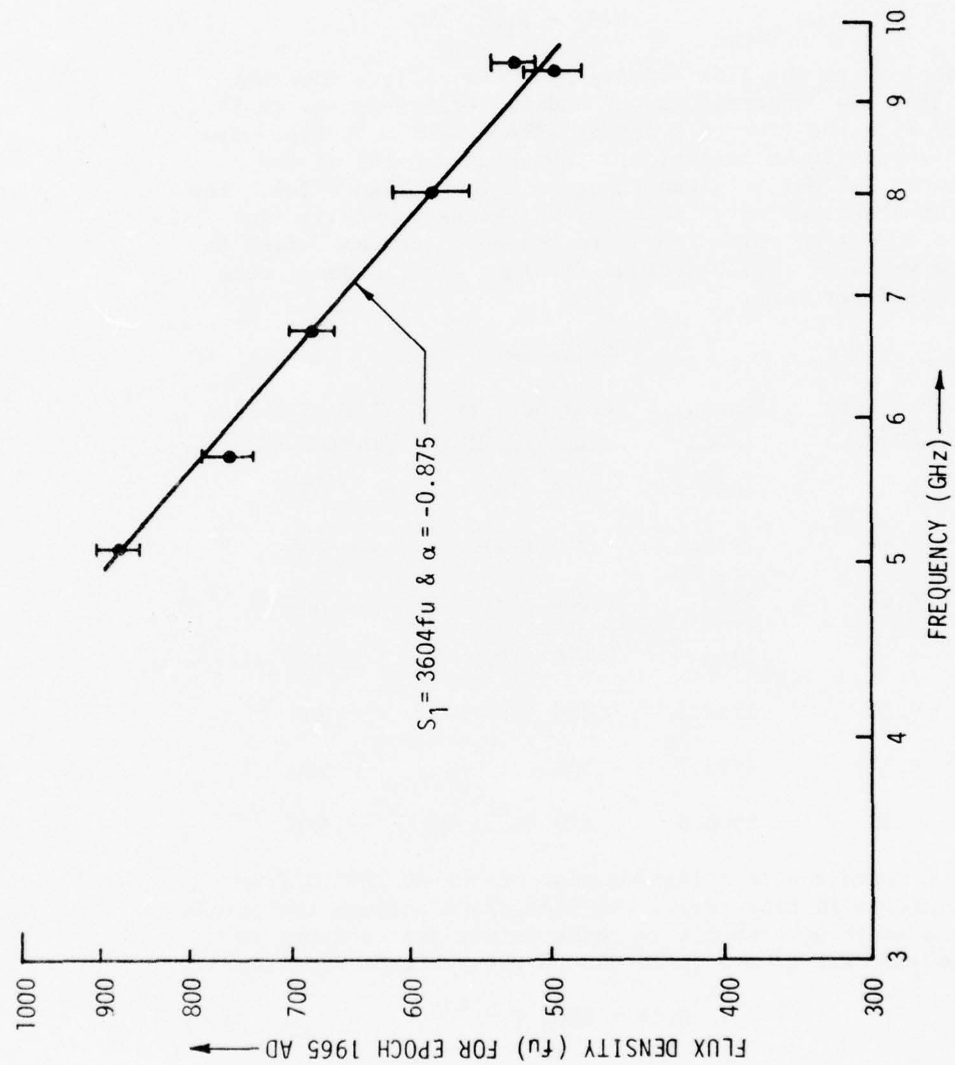


Figure 2-6. The flux density of Cas A around 7 GHz.

CCP 702-2

be pointed out that the value of α (-0.875) and S_1 (3604 f.u.) found from this table using only data over the restricted frequency range do not agree with α's and S_1's generally found in the literature. This disagreement reopens the question of whether the flux density (at 7.5 GHz for example) can actually be more accurately determined by a curve fitting process on a number of measured points close to 7.5 GHz as done in figure 2-5, by a curve fitting process over a wider frequency range or by direct measurement of G/T at 7.5 GHz. The curve fitting process for finding α and S over the wider frequency range correspondingly requires α to be constant over this larger range, a requirement that may not be met (22).

The characteristics (spectral index, polarization, decay rate, intensity distribution, and shape) for Cas A are explained to first order (23) by an expanding shell model wherein the rf emission is assumed to come from synchrontron radiation within the shell. One of the predictions of this model will be used in the next subsection where the Cas A decay rate is discussed.

2.4 Secular Decay

2.4.1 Decay Rate

The shell model (23) of Cas A predicts its flux density S at its age t. According to this model S can be calculated from the measured flux density S_o measured at age t_o from the equation

$$S = S_o(t_o/t)^{\beta} \qquad (2.10)$$

Where β is a decay constant that is related to the spectral index α through the equation ($\alpha < o$)

$$\beta = 2(1-2\alpha) \qquad (2.11)$$

Based on eq. (2.10) the flux density S from Cas A should decay with time as roughly indicated in figure 2-7. The (normalized) differential decay rate, r, can be found by differentiating eq. (2.10) and is

$$r = -\frac{1}{S}\frac{dS}{dt} = \frac{\beta}{t} \qquad (2.12)$$

The decay rate calculated for Cas A using epoch AD 1950.0 from eqs. (2.11) and (2.12) is 2%, while the measured value is closer to 1%. Minkowski's (10) birthday (AD 1700) for Cas A has been used in this calculation along with a spectral index equal to -0.8. It is interesting to note in this regard that Brosche (24) has drawn attention to some Korean records that indicate a "guest star" in the region of Cassiopeia around AD 1592, which "star" if it were the birth of Cas A would yield a decay rate (AD 1950.0) of 1.3% per year, much closed to the measured values than the rate given by Minkowski's data.

While the shell model is not a perfect description of the Cas A decay, it indicates in a rough way (fig. 2-7) how the flux density should decay with time. As will be seen, the time dependence of r as indicated in eq. (2.12) shows that more care should be exercised in the application of average decay rates measured over long periods.

The decay rate predicted by eq. (2.12) decreases with time. At the present time insufficient receiver sensitivity, coupled with the small yearly decrease in the flux of Cas A, prevents a short term measurement of the Cas A decay rate. One is forced therefore to compare the flux from Cas A over long periods of time, a process which yields an average decay rate instead of the differential rate. It can be seen from figure 2-8 that this average decay rate, R, where ($\Delta t = t - t_o$)

$$R = \frac{S_o - S}{S\Delta t} \tag{2.13}$$

is related to the differential decay rate, r, at age t to first order in $\Delta t/t_o$ by

$$r \simeq R(1 - \Delta t/t_o) \tag{2.14}$$

and that the differential rate is always less than the average rate. An estimate of the magnitude of $\Delta t/t_o$, or the relative correction needed to reduce R to r, can be obtained by taking the birth of the radio star to be AD 1700, t_o to be AD 1948, and Δt to be 25 years. The resulting $\Delta t/t_o$ is 0.1. In other words the differential decay rate is 10% less than the average decay rate measured over the 25 year period, a difference that should not be ignored when using the decay rate to predict the flux density of Cas A. Therefore, the model, while not perfect, does indicate that the average decay rate (R)

CCP 702-2

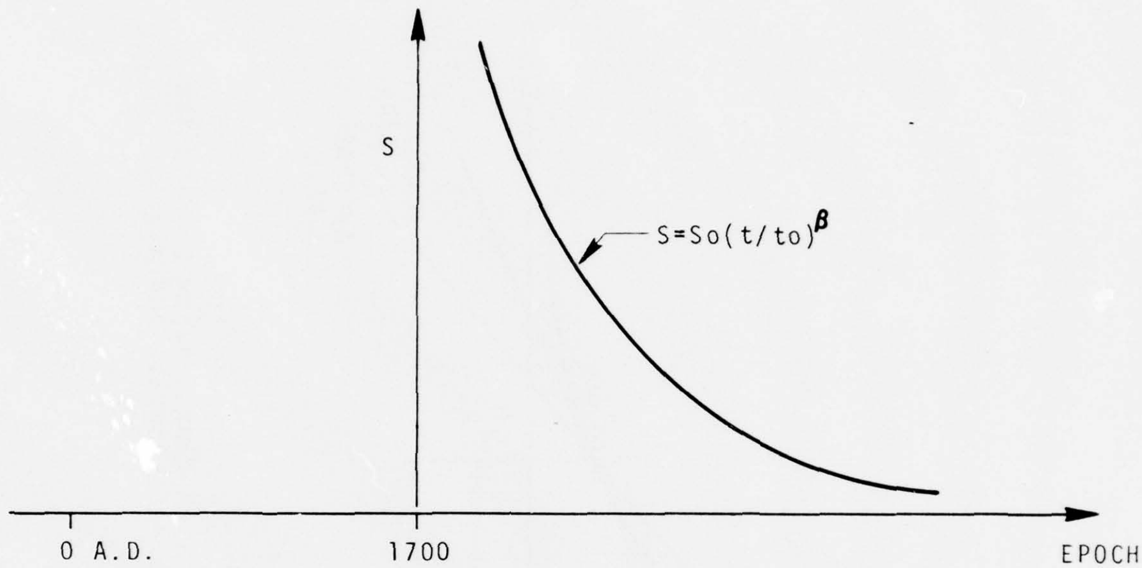


Figure 2-7. Decay curve of the Cas A flux density as calculated from the shell model.

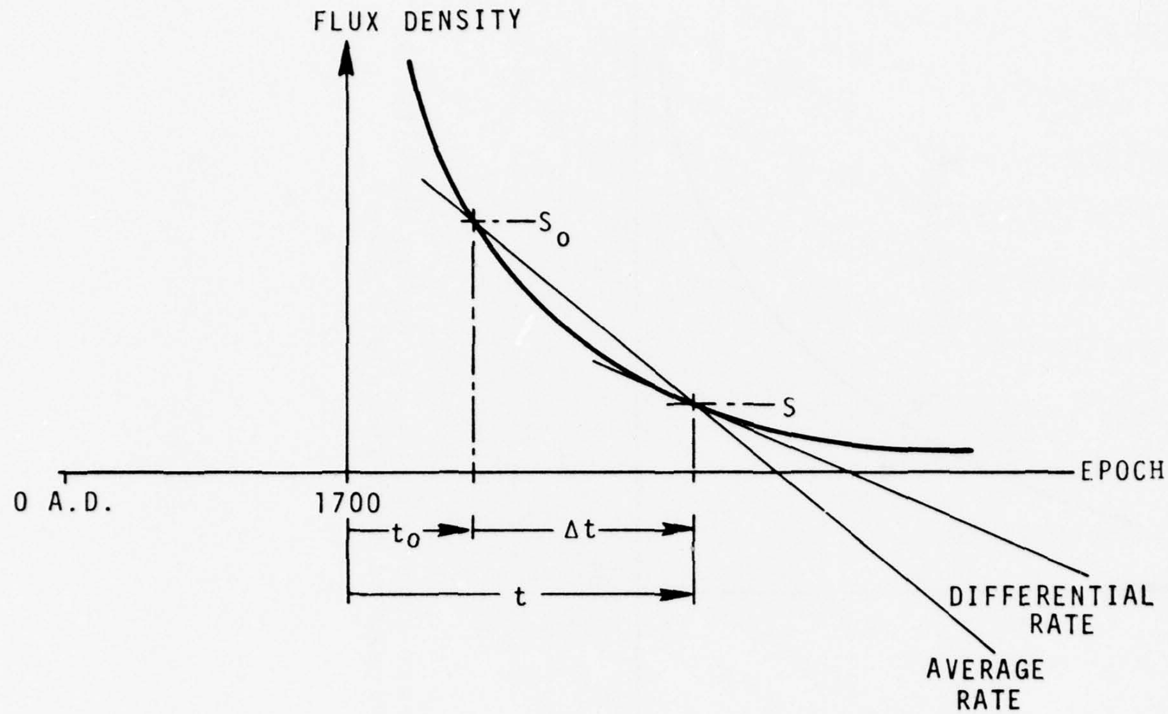


Figure 2-8. Decay curve of the Cas A flux density showing the relation between the differential and average decay ratio.

used in the literature to transfer flux densities from one epoch to another should probably be reduced, in some cases possibly by as much as 10%. Moreover, if it is assumed that the shell velocity has not increased since the explosion that gave rise to Cas A, then it can be easily shown that the star birth cannot be earlier than AD 1700 under certain simplifying assumptions in which case it can be conjectured that the difference between the average and differential decay rates is probably greater than 10% for a 25 year measurement period. In any case, these results derived from the shell model do strongly suggest that the practice of using the average decay rate to transfer flux densities from one epoch to another should be examined more closely if a high accuracy in the resulting flux densities are desired.

Flux densities are deduced in the literature from known values by use of the following equation

$$S = S_1(1-R)^{\Delta t} \tag{2.15}$$

where S_1 is the flux measured at age t_1, R is the average decay rate discussed above, and Δt is the time difference between t_1 and the time of interest t. From the preceding discussion it is seen that a better approximation to S is obtained when one uses r instead of R, that is

$$S = S_1(1-r)^{\Delta t}, \tag{2.16}$$

where r is calculated from R by using eq. (2.14). Even eq. (2.16) is not exact in the sense that it is equivalent to eq. (2.10). However, it is a sufficiently good approximation for even the most accurate of today's measurements and has the great advantage that β need not be known and only a rough estimate of the star's birthday need be used in calculating r from eq. (2.14).

2.4.2 Some Measured Values of R

Some measured values of the average decay rate R are shown in table 2-2.

Table 2-2

Freq. GHz	Decay Rate (percent)	Error in Decay Rate (percent)	Epochs Used	Year Span	Reference
0.082	1.06	13	1948-1960	12	Högben (25)
0.082	1.29	6	1948-1969	21	Scott (26)
3.2	1.14	23	1953.9-1962.7	8.8	Mayer (27)
1.4	1.38	11	1965-1971	11	Findlay (28)
1-3	0.90	11	1960-1971	15	Baars (29)

These results indicate that the average decay rate is not known to a high degree of accuracy. Add to this the fact that the rates used are possibly 5% to 10% high, and that the rate possibly changes with frequency (30) and it is easily seen that the state of knowledge concerning decay rate is not at a very high level and that much more work along this line needs to be done.

2.5 Polarization

2.5.1 Polarization and Faraday Rotation

Polarization (6)

The emission from a celestial radio source extends over a wide frequency range and therefore within any finite band-width consists of the super-position of many statistically independent waves of various polarizations. Generally these emissions are partially polarized, some sources tending towards complete nonpolarization and others toward a significant degree of polarization. Partially polarized emission can be decomposed into a completely random wave plus completely polarized waves. The degree of polarization d is then defined as the ratio of the power contained in the polarized wave to the total power in all the wave. It is this total power, or the power contained in both the random and polarized waves, that is proportional to the source flux density.

The "position angle" of the polarization of a source is measured relative to the northerly direction from the source on the celestial sphere, increasing in the eastwardly direction. The manner in which the antenna polarization and the linear source polarization effect the available power antenna output port is shown in table 2-3, on the assumption that the antenna is pointed directly at the source, and that the source is a point source.

Table 2-3

Type of Antenna Polarization	Spectral Power at Antenna Waveguide Port
Linear	$1/2\ SA_e(1 + d\ \mathrm{Cos}\ 2\theta)$
Right or Left Circular	$1/2\ SA_e$

The first column of the table shows the type of antenna polarization assumed for the antenna receiving flux from the sources. The second column shows the power per unit bandwidth available at the antenna waveguide port as a result of the source flux impinging on the antenna aperture. A_e is the effective antenna aperture (2), d is the degree of linear polarization of the source, and θ is the angular difference between the source's polarization position angle and the antenna's linear polarization angle measured relative to the source's north.

Faraday Rotation (6,31)

Much of the galactic medium between the earth and Cas A is ionized and contains a small magnetic field roughly parallel to the direction between them. Because of the presence of the magnetic field, this medium is an isotropic and causes the direction of polarization of a polarized wave traveling through it to rotate as the wave proceeds. This rotation is proportional to the square of the wavelength of the polarized wave. Therefore, as the observed wavelength is increased, the observed position angle of the source polarization will increase or decrease according to whether the proportionality constant is positive or negative respectively. This proportionality constant is called the "rotation measure," and in the direction of Cas A is thought to be (14) approximately -130 rad./m^2.

2.5.2 Measured Polarization of Cas A

The literature (14,32,33,34) suggests that above 1 GHz the linear polarization of Cas A is approximately 1%, and that below 1 GHz the polarization falls to zero. Table 2-4 is representative of the values reported, and shows that the degree of polarization and the position angle are not accurately known.

Table 2-4

Frequency (GHz)	Polarization (%)	Position Angle (Degree)	Reference
1	< 1	--	32
3	< 1	--	32
5	1.4 ± 0.5	37 ± 15*	14
8.25	0.5 ± 0.2	114 ± 15	33
10	1.5	40*	32
14.5	1.2 ± 0.5	41 ± 9*	35
15.25	1.9 ± 0.2	71 ± 3*	33
15.75	2.2 ± 0.3	79 ± 3	33
19.4	1	31*	34

*Indicates values used in figure 2-9.

The scheme depicted in figure 2-9 might be used to obtain usable values of position angle versus frequency. The position angle values in the table identified by an asterisk have been plotted against wavelength in the figure. The wavelength is indicated on a squared scale so that the data should fall along a straight line assuming the position angle is proportional to wavelength squared. Then the least squares fit linear curve, curve (a) in the figure, gives at least an idea of the position angle as a function of wavelength that might be used in calculations involving linearly polarized antennas. Curve (b) is included in the figure to indicate the slope that corresponds to the measured (14) rotation measure (-130 rad./m^2).

2.6 High Resolution Maps

For the purpose of this report Cas A is considered to be a discrete source with a single value assigned to its flux density, spectral index, degree polarization and position angle, and secular decay rate for a given epoch and frequency of observation. However, there have been a number (14,34,36) of investigations made into the detailed structure of this source which, from our point of view, are worth examining for several reasons: 1) they aid in understanding the nature of the background radiation in the neighborhood of Cas A, and therefore in the interpretation

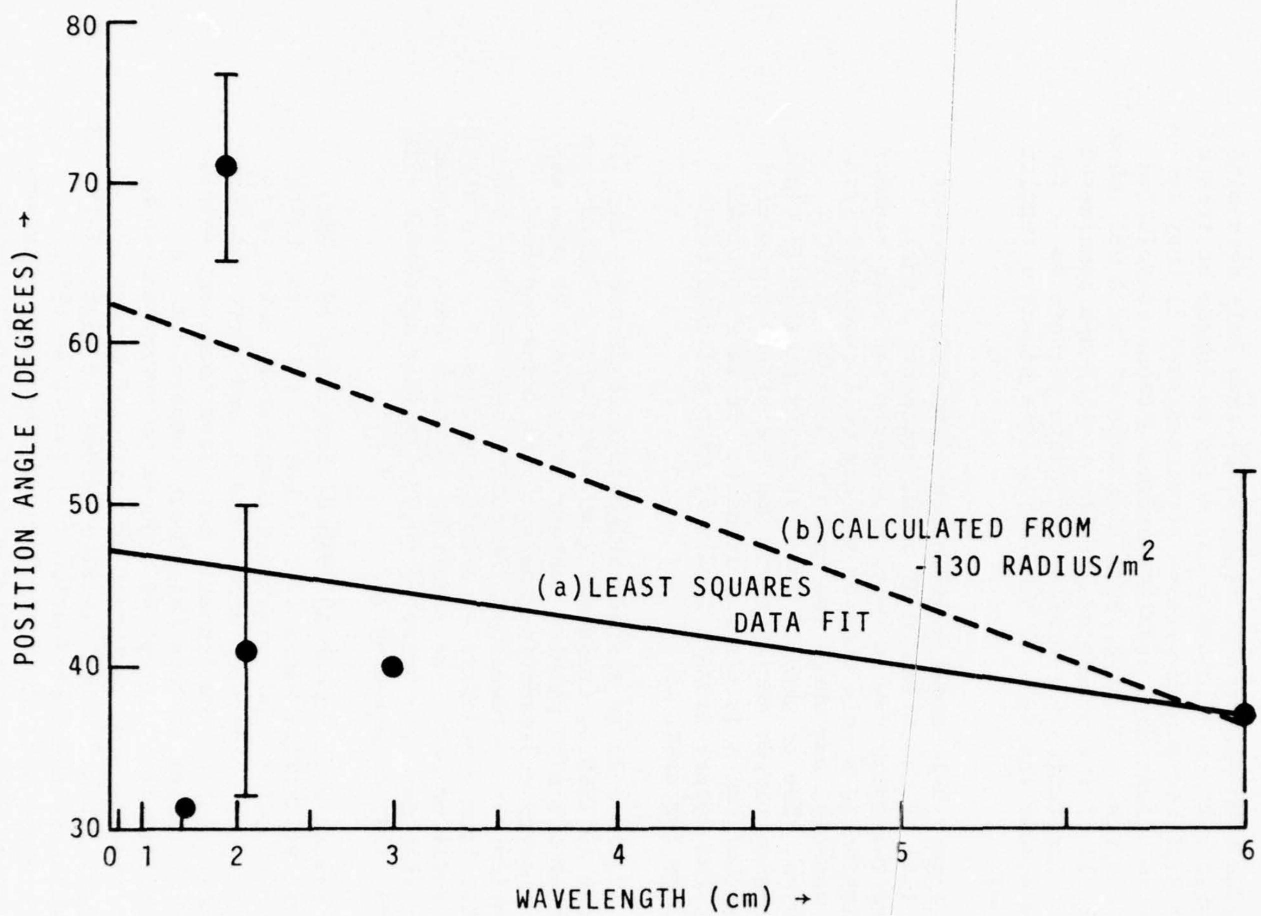


Figure 2-9. Hypothetical position angle curve for the linearly polarized flux from Cas A.

of broadbeam measurement results; 2) they help determine at what antenna resolution Cas A can no longer be treated as a discrete source with no structure; and 3) they can be used to obtain more accurate source-antenna convolution corrections. The high resolution maps of Cas A will show that all of the parameters of Cas A which are considered to be constants in the broad beamwidth picture do in fact vary across the face of the source in a highly irregular manner.

Figure 2-10 shows a brightness temperature contour map (14) of Cas A (epoch AD 1950, frequency 5 GHz), where the thick dashed curve represents the zero contour (relative to a cold area of the sky well separated from the source), and where the contour interval is 200 kelvins. The brightness temperature is plotted in right ascension versus declination, and the highly structured nature of Cas A is clearly evident. It is also clear that the source is well localized with a slight bulge towards the east.

Figure 2-11 is another brightness temperature map (14) (epoch AD 1968.4, frequency 1.407 GHz) with a dashed zero contour and 6700 kelvins contour intervals. On this map the numbers representing the spectral index and their locations are noteworthy. It can be seen that the index varies from a negative -0.5 to a negative -1.2 in a highly irregular manner. The resulting spectral index averaged over this map is a negative -0.75, in fair agreement with Baars' (29) negative -0.787.

Figure 2-12 (epoch AD 1966.8, frequency 19.4 GHz) shows two profile views (34) of Cas A, curve (a) being proportional to the brightness temperature relative to the uniform background around Cas A, and curve (b) being proportional to the linearly polarized component (amplified 20 times) of this brightness temperature. A characteristic "valley" of reduced polarization can be seen running from southwest to northeast across the source. This "valley" is also evident in figure 2-13 which shows the distribution (14) (epoch AD 1950, frequency 5 GHz) of this polarized component. The bars in figure 2-13 are oriented along the electric vector position angles, the longest bar corresponding to a brightness temperature of about 100 kelvins. The degree of polarization averages about 5% around the rim of the shell, with peaks of about 10% in the southeast region and of about 6% in the northwest region. Towards the central part of the shell the polarization falls to 1% or less. The average polarization over this map is 1.4% at a position angle of 37°.

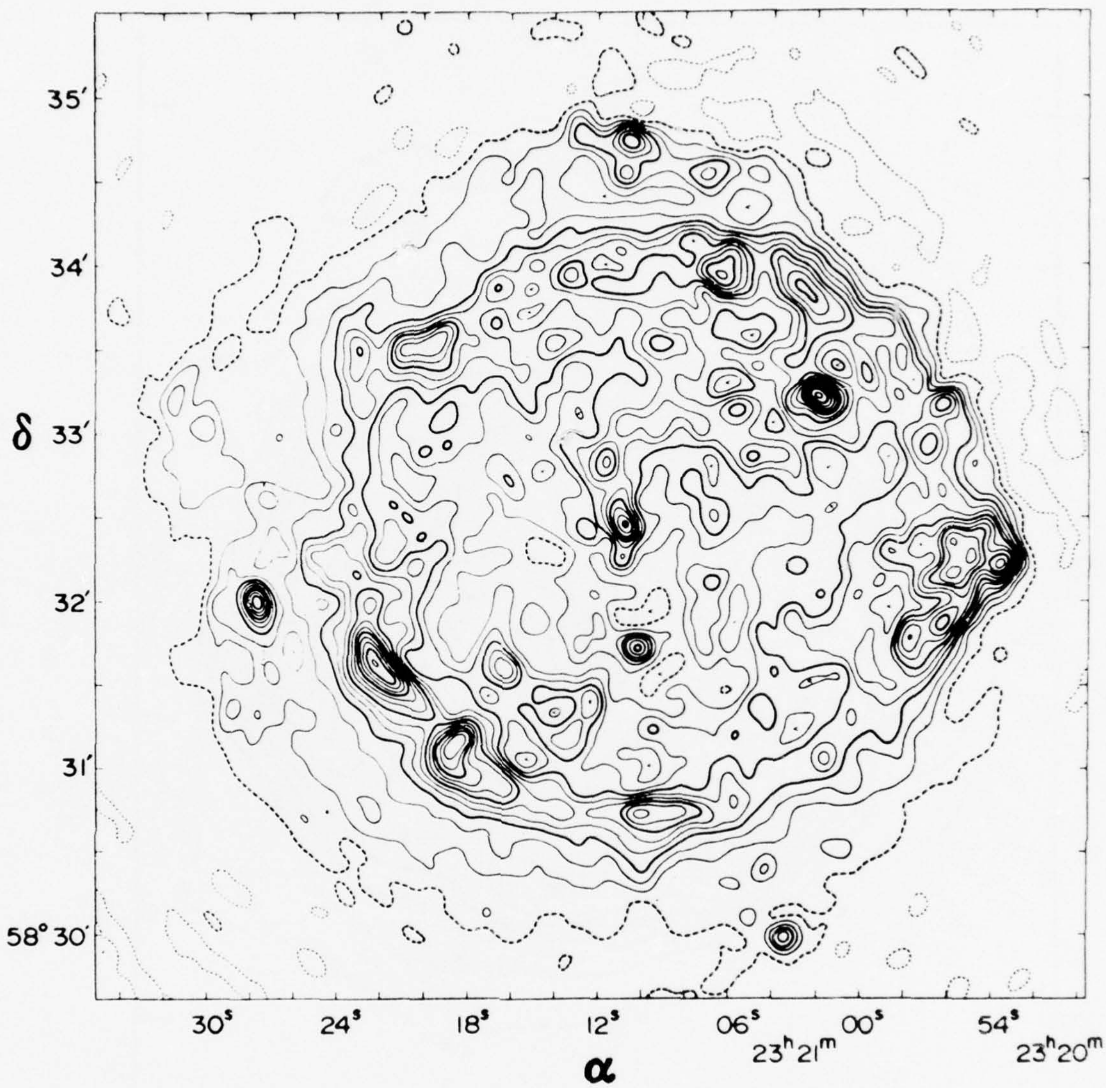


Figure 2-10. Brightness temperature contour map of Cas A (Epoch AD 1950.0, 5.0 GHz). (Courtesy of Monthly Notices of the Royal Astronomical Society, Vol. 151, No. 1, p. 112, 1970.)

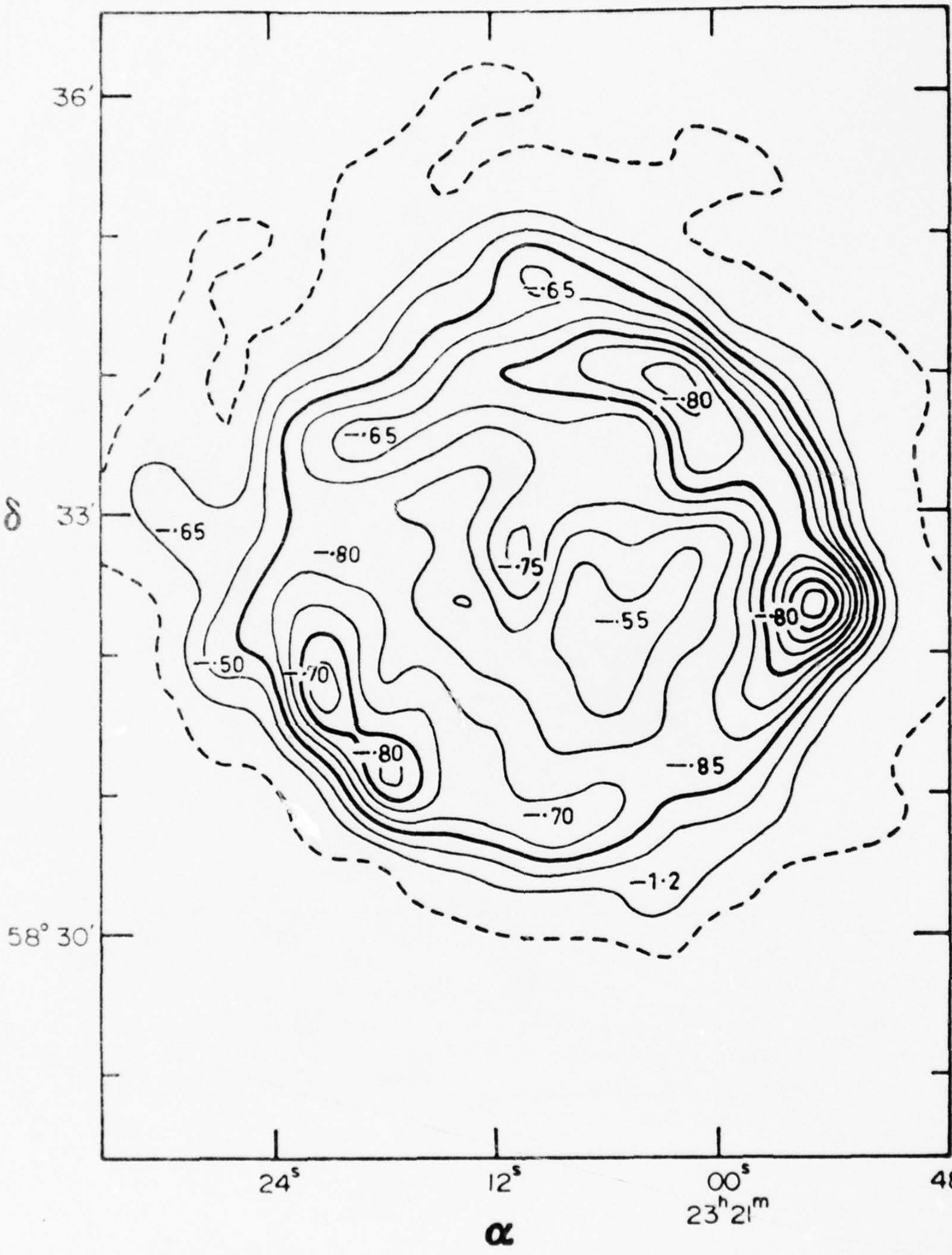


Figure 2-11. Brightness temperature contour map of Cas A (Epoch 1968.4, 1.4 GHz) showing the variation of the spectral index across the source. (From Monthly Notices of the Royal Astronomical Society, Vol. 151, No. 1, p. 114, 1970.

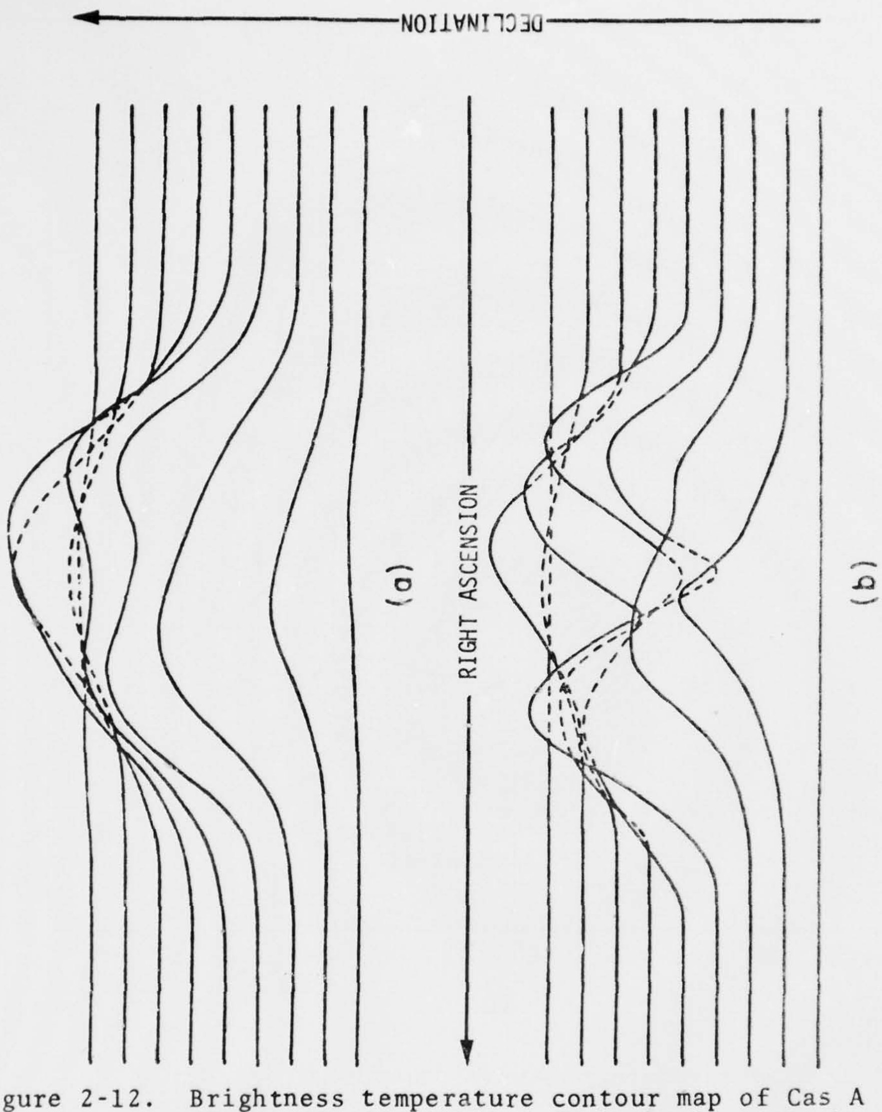


Figure 2-12. Brightness temperature contour map of Cas A (Epoch AD 1966.8, 19.4 GHz) showing (a) the brightness temperature, (b) the linearly polarized component of (a) amplified 20 times. (Courtesy of Astrophysical Journal, Vol. 151, p. 56, 1968; C.H. Mayer and I.P. Hollinger; University of Chicago Press.)

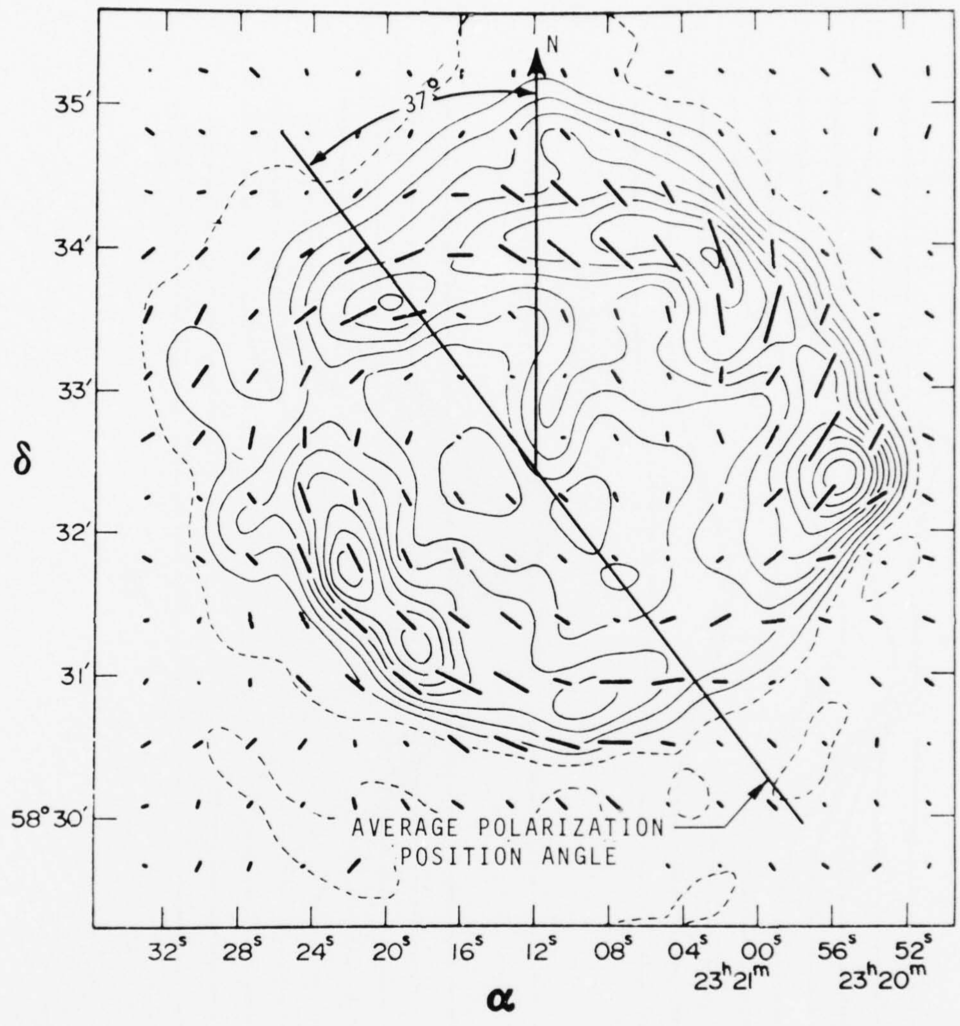


Figure 2-13. Brightness temperature contour map of Cas A (Epoch 1950.0, 5.0 GHz) showing the distribution of polarized emission across the source with the average position angle of the electric vectors superimposed. (Courtesy of Monthly Notices of the Royal Astronomical Society, Vol. 151, No. 1, p. 116, 1970.)

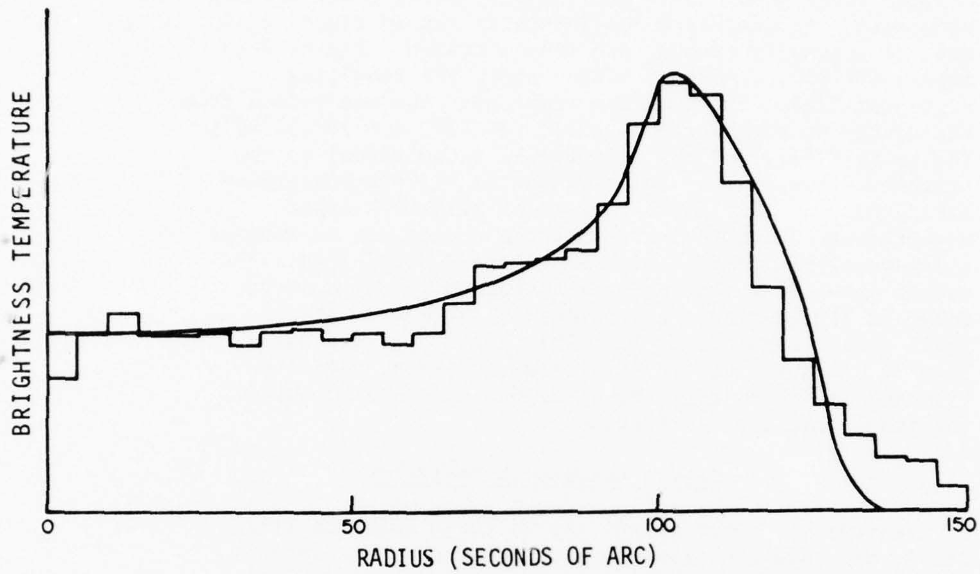


Figure 2-14. Mean brightness temperature profile from the center of Cas A outward (Epoch AD 1950.0, 5.0 GHz). (From Monthly Notices of the Royal Astronomical Society, Vol. 151, No. 1. p. 118, 1970).

To get an idea of the average shape of the Cas A, annular rings about the center of the source 5 arc seconds wide were extracted from the intensity map in figure 2-10, and the intensity around each ring averaged. Figure 2-14 (epoch AD 1950, frequency 5 GHz) shows the resulting histogram (14). The abscissa represents the arc radius from the center of the source ($\alpha = 23^h\ 21^m\ 11^s$, $\delta = 58^o,32'40''$, (Epoch AD 1950), and the ordinate is proportional to the brightness temperature relative to the uniform background around Cas A. This histogram agrees well with other measurements which indicate that the source has an average shape resembling a disk with an enhanced outer ring. The smooth curve drawn through the histogram is the best-fit curve predicted from the spherical shell model with a small radial magnetic field. This curve, or some curve like it drawn through the histogram, could be convolved with the main beam of broad beamwidth antennas to obtain the usual star size correction.

2.7 Cosmic Background Radiation

Besides the discrete sources of radio emission like Cas A, the cosmic or extraterrestrial radio sky contains a more or less continuous background of radiation which consists of a thermal and a nonthermal component. In the context of this report one needs to know this background radiation because 1) this background radiation contributes to total system temperature of any satellite ground station -- the contribution depending upon where the satellite is; 2) the background around Cas A may be different from the background around the satellite; and 3) the background around the calibrating source (Cas A) determines where the antenna should be pointed in the course of performing G/T ratio measurements.

2.7.1 Nature of the Cosmic Radio Background

The origin of the continuous cosmic radio background radiation is still open to question, and it appears that a number of measurements in the microwave region and above remain to be done.

Kraus (6) distinguishes three sources of continuous background radiation, extragalactic and galactic nonthermal (synchrotron) radiation, and galactic thermal radiation originating in the galactic HII (ionized hydrogen) regions. The nonthermal synchrotron radiation predominates below about 1 GHz with a spectral index of from about -0.2 to -0.5, and the thermal radiation predominates about 1 GHz. From a review of the literature one receives the impression that above 1 GHz it is not clear what the source of the continuous thermal radiation is. Some of the references suggest that the radiation comes from the galactic HII (ionized hydrogen) regions, while others suggest a cosmic black-body origin (to be discussed). In what follows it will be seen that the radio background maps support the latter conclusion.

A radio map (6) of the cosmic radiation at 20 MHz is shown in figure 2-15. The contours are at 6 kelvin intervals above the coldest parts of the sky which are at a temperature of about 80 kelvins. Since the dotted line represents the galactic equator it is seen that the background peaks up in the galactic plane and falls off from this plane. Since the measurements were done at 250 MHz, the contours are predominantly nonthermal in nature (see fig. 2-16). Furthermore, since the contour lines run parallel to the galactic equator, it can be implied, consistent with remarks in the preceding paragraph, that the nonthermal radiation has a strong component associated with the galactic plane. In the following it will be seen that the same conclusion does not appear to be applicable to the thermal radiation above 1 GHz.

In addition to the three sources of continuous radio emission mentioned earlier there is mention in the literature of a possible fourth (37) source, cosmic black-body radiation. According to hypothesis it originated when the universe was in a highly condensed and heated state, and as the universe expanded, the cosmological red shift cooled the radiation while preserving its thermal character. A number of measurements (38,39,40) of the absolute cosmic background tend to support this idea, the most convincing of which is the set taken at Princeton (39). Referring again to figure 2-15, the eleven numbered points along the 40th declination represent positions where the Princeton measurements (9.375 GHz) were made. Table 2-5 gives the values of these measurements which, although they should be considered to be the same within the ± 0.5 kelvin experimental error, are listed in order of descending magnitude.

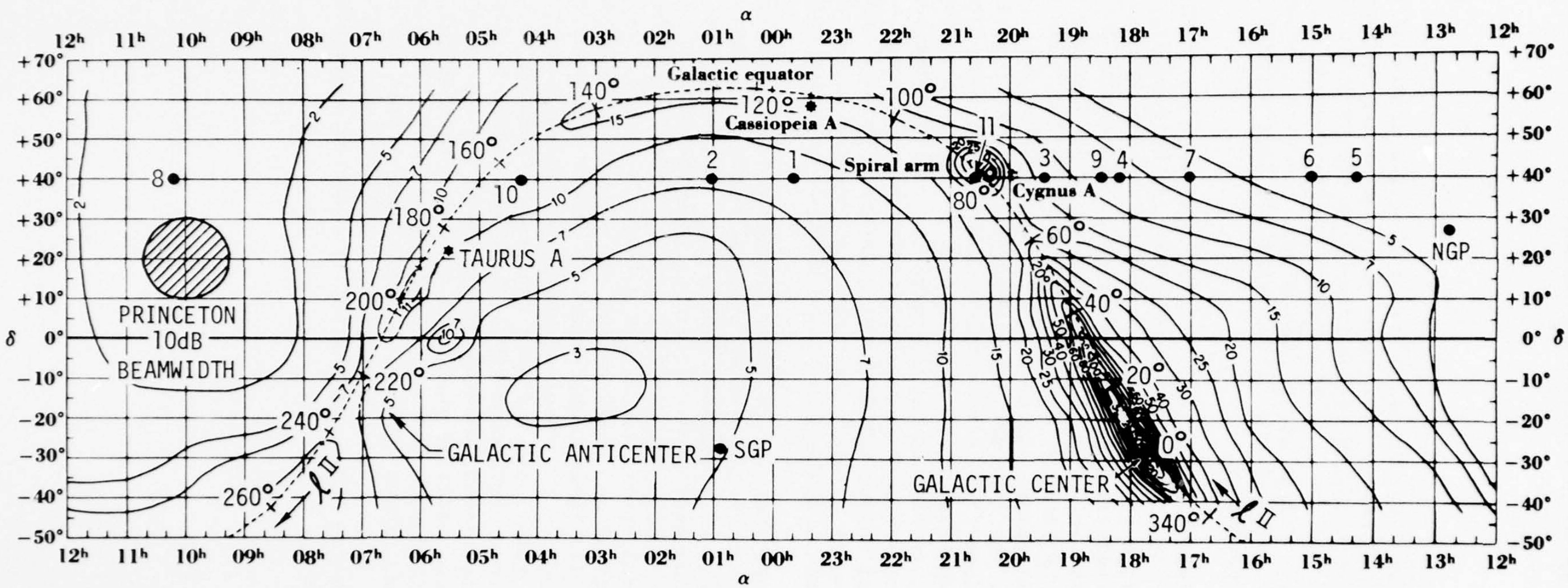


Figure 2-15. The cosmic radio sky at 250 MHz. (From Sky and Telescope, Vol. 16, p. 160, 1957).

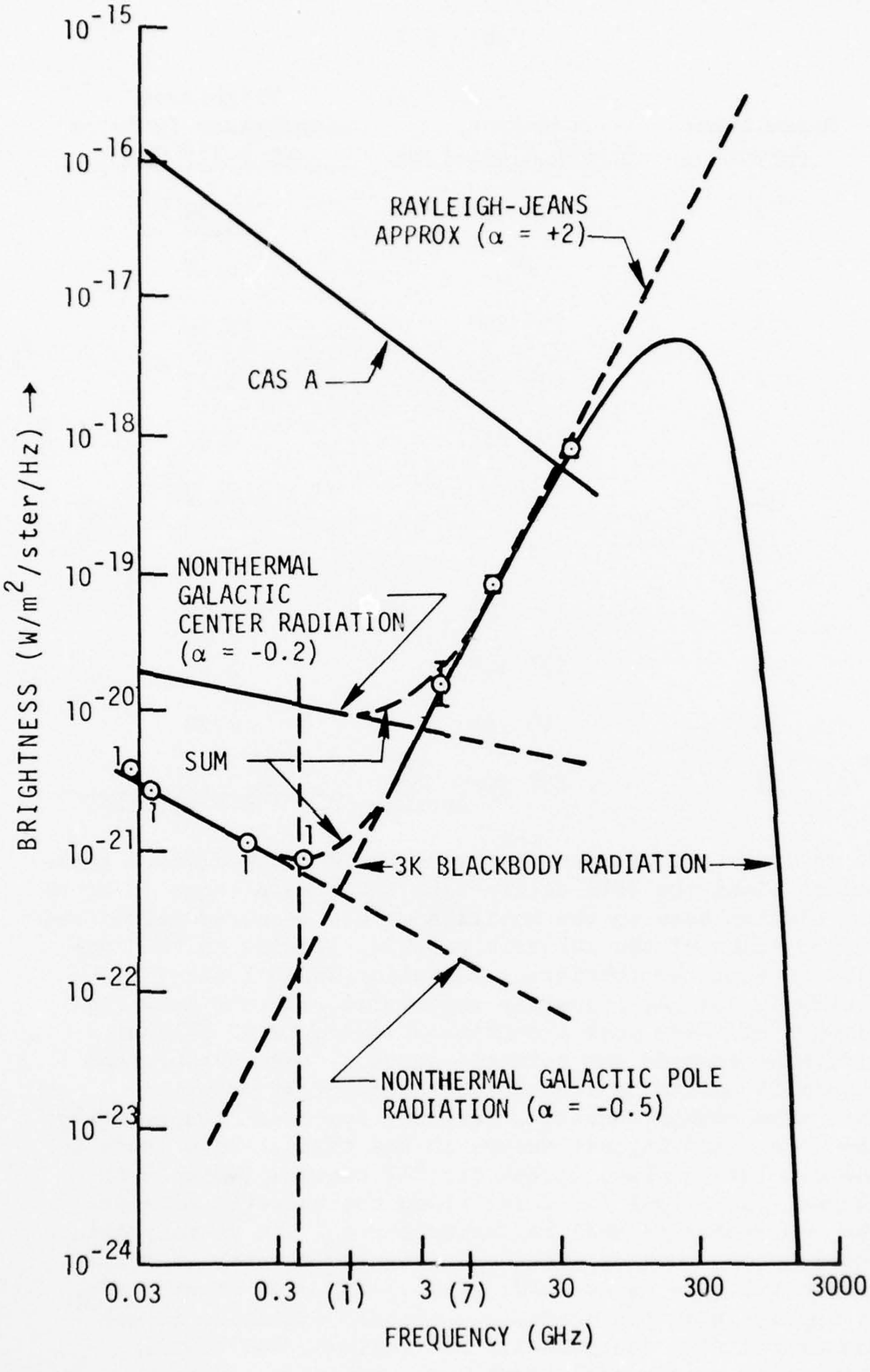


Figure 2-16. Brightness spectrum of the continuous cosmic radiation as deduced from the literature.

Table 2-5

Measurement Number	Location (Right Ascension)	Brightness Temperature (kelvins) at 9.375 GHz
1	$23^h\ 40^m$	3.32
2	1^h	3.16
3	$19^h\ 30^m$	3.14
4	$18^h\ 10^m$	3.12
5	$14^h\ 20^m$	3.07
6	15^h	3.02
7	17^h	2.98
8	$10^h\ 10^m$	2.89
9	$18^h\ 30^m$	2.80
10	$4^h\ 20^m$	2.78
11	$20^h\ 30^m$	2.76
	Average	3.0 ± 0.5 kelvins

It is important to note that from the distribution of these points along the 40th declination that there seems to be no correlation between the position of the measured values and the position of the galactic equator, leading to the conclusion that the continuous radiation above 1 GHz is isotropic and not primarily associated with the galactic plane. If there were a continuous increase of thermal radiation towards the galactic equator, then measurement number 11 should be considerably greater in magnitude than measurement number 1, yet they represent respectively the lowest and highest values in the table. This leads to the conclusion that, except for HII regions (which emit thermal radiation) localized along the galactic equator, the continuous thermal radiation above 1 GHz is isotropic and does not peak-up along the galactic equator like the nonthermal case below 1 GHz (fig. 2-15). In other words, it appears that the continuous thermal radiation is not associated with the galactic HII regions, but that it stems from a universal black-body radiation and is spread uniformly over the celestial sphere. This conclusion is further supported by the contour maps to follow.

In addition to the Princeton measurement, Penzias and Wilson (38) and Roll et al. (39) have made measurements averaging the absolute cosmic background along declinations close to the 40th declination which agree with the Princeton measurements, and are summarized in table 2-6.

Table 2-6

Frequency GHz	Brightness Temperature (kelvins)
4.08	3.1 ± 1 (38)*
9.375	3.0 ± 0.5 (39) (average of Princeton measurements)
32.5	3.16 ± 0.2 (40)

*The value quoted by Penzias and Wilson (38) is 3.5 ± 1 kelvin. A later measurement by the same authors with a modified horn feed mentioned by Roll et al. (39) gave the lower (and presumably better) value reported in table 2-6.

The preceding remarks lead to the following picture (fig. 2-16) of the continuous cosmic radio background. Below approximately 1 GHz the brightness (c.f. section 2.3.1) consists mainly of synchrotron radiation (6) lying in magnitude between that emanating from the galactic center and that from the galactic pole, and peaking up along the galactic equator. Above 1 GHz the brightness consists of isotropic black-body radiation at 3 kelvins. Superimposed on this continuous radiation are numerous localized HII regions of thermal radiation associated with the galaxy. For reference the brightness of Cas A is included in figure 2-16. While this picture of the continuous background seems to be consistent with the available data and radio maps, many more measurements, primarily in the microwave region and above, need to be performed to adequately justify it. It is nevertheless the most consistent picture that can be pieced together from the available literature. With figure 2-16, the positions of the contours with respect to the galactic equator in the maps to follow can be easily understood and lend further support to the conclusions drawn.

In addition to the map shown in figure 2-15 (250 MHz), figures 2-17 (30), 2-18 (41), 2-19 (42), and 2-20 (43) show radio maps around Cas A at 404 MHz, 960 MHz, 1.4 GHz, and 3.2 GHz respectively, with the galactic equator drawn in, and lend support to the previously drawn conclusions concerning the nature of the thermal radiation above 1 GHz. It is apparent that in the 250 MHz, 404 MHz, and 960 MHz maps the contours run predominantly parallel to the galactic equator, while in the 1.4 GHz and 3.2 GHz maps this is not the case. In fact the contours in the 1.4 GHz and 3.2 GHz maps arise from localized HII regions around Cas A, and in the frequency region above 1 GHz where the synchrontron radiation is expected to die out (fig. 2-16), the distinct absence of contour lines parallel to the galactic equator indicates a lack of continuous thermal radiation emanating from the galactic plane. In other words, at about 1 GHz, consistent with figure 2-6, the continuous synchrotron radiation dies out leaving only the isotropic black body component with the HII radiation manifesting in localized regions only.

2.7.2 Cosmic Background Contribution to the System Noise Temperature

Assuming the validity of the above conclusions, the contribution to the cosmic background on the system noise temperature can now be predicted. When an antenna is pointed at a stationary satellite, the satellite appears to describe a path on the celestial sphere along one of the celestial declinations. In the process, the antenna beam and sidelobes pick up cosmic radiation along this path which, in the microwave region, is a uniform 3 kelvin black-body radiation on which the occasional localized HII regions are superimposed. The contribution to the system noise temperature from this backgound radiation varies along this path in a corresponding manner. For example, consider what happends when the antenna beam encounters the various HII regions along the 60th declination in figure 2-19. The contour intervals are designated by integers which are multiples of 0.8 kelvins above a uniform background, presumably the 3 kelvin black-body radiation. As the beam (assumed small compared to the distances between the contours) traverses the contours along the 60th declination from right to left the antenna temperature is increased from 3 kelvins by 1.6, 2.4, 3.2, 3.2, 2.4, 1.6, and 0.8 kelvins in succession. This gives an idea of the possible variation of the antenna temperature for a narrow beam antenna as it traverses a localized HII region. To know this variation in detail a radio map along the declination

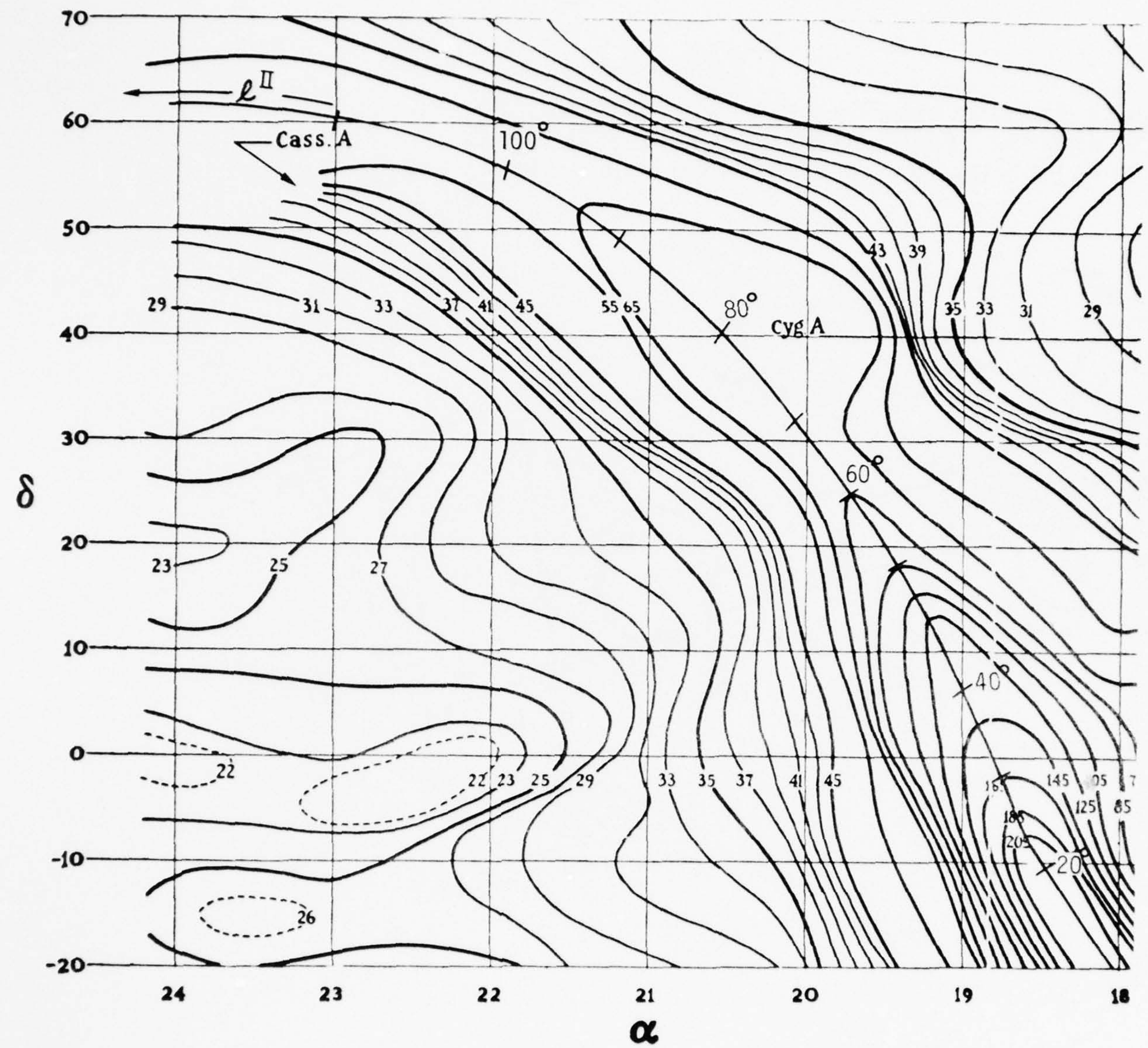


Figure 2-17. Cosmic radio background at 404 MHz. (From Monthly Notices of the Royal Astronomical Society, Vol. 124, No. 1, p. 74A, 1962.)

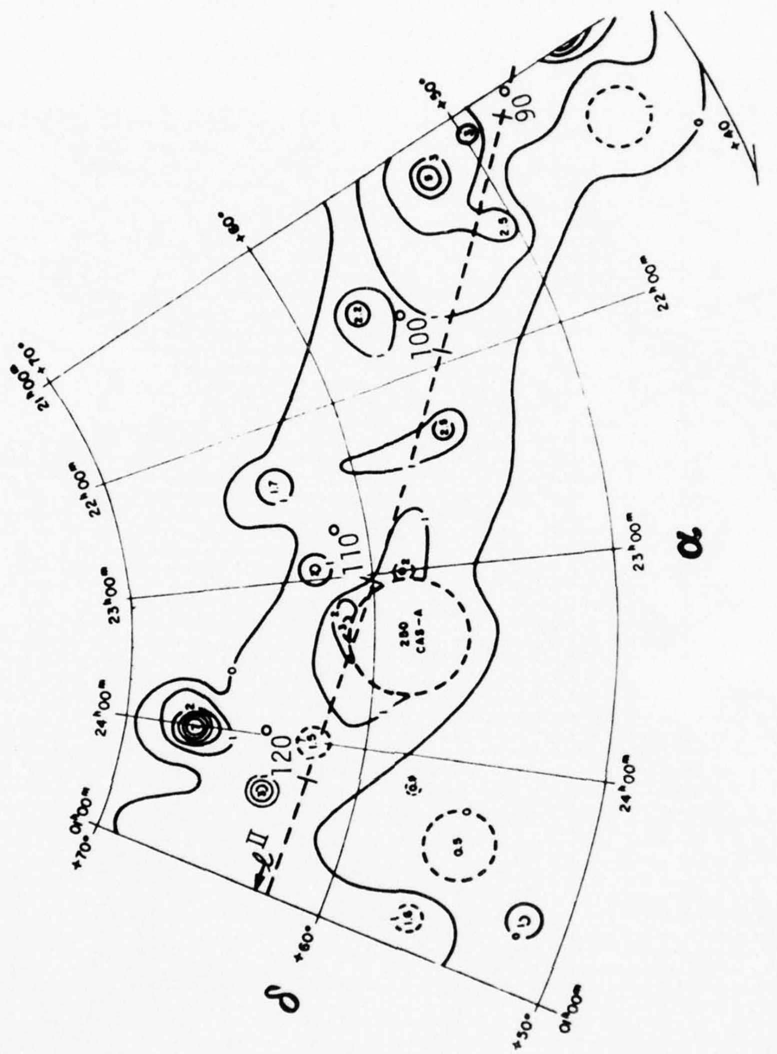


Figure 2-18. Cosmic radio background at 960 MHz. (From Publications of the Astronomical Society of the Pacific, Vol. 72, No. 428, p. 336, 1960.)

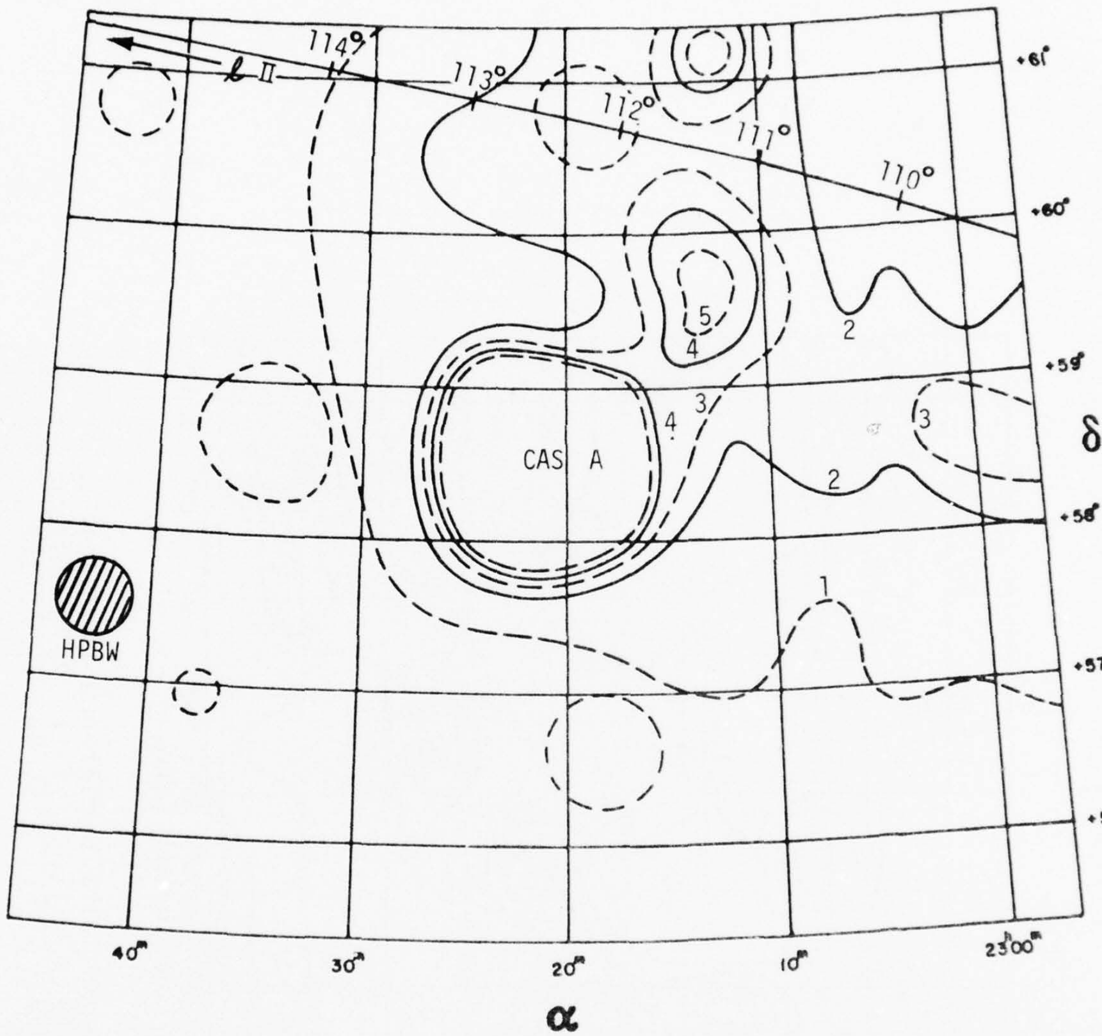


Figure 2-19. Cosmic radio background at 1.4 GHz. (From Publications of the National Radio Astronomy Observatory, Vol. 1, No. 3, p. 55, 1961.)

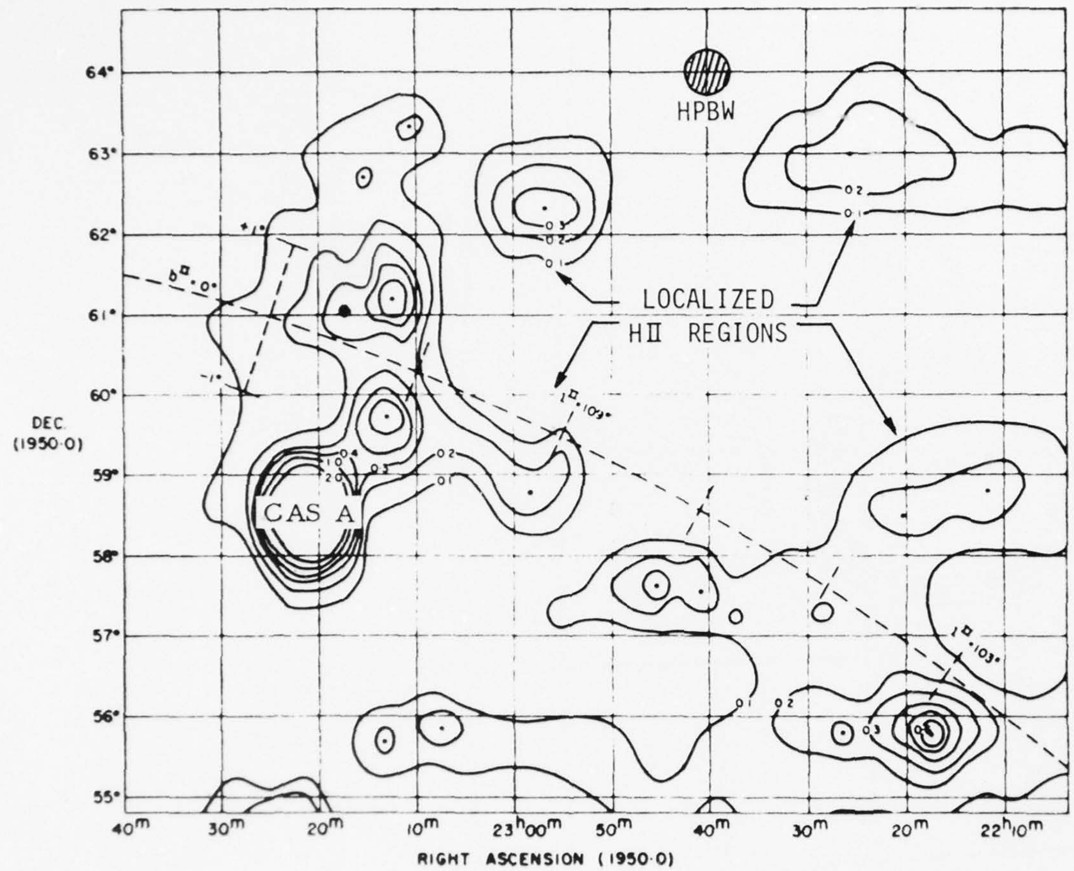


Figure 2-20. Cosmic radio background at 3.2 GHz. (From Monthly Notices of the Royal Astronomical Society, Vol. 129, No. 2, p. 166, 1965.)

AD-A043 735 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA ARIZ F/G 17/2

PRODUCT ASSURANCE, OPERATIONAL QUALITY ASSURANCE, SATELLITE SYS--ETC(U)

MAY 77

UNCLASSIFIED ACC-CCP-702-2 NL

2 OF 7

AD

A043735

SIFIED

2 OF 7

AD
A043735

1.0 4.5 2.8 2.5 5.0 3.2 2.2 3.6 4.0 2.0 1.1 1.8 1.25 1.4 1.6

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

traversed by the satellite for the frequency in use is clearly necessary.

For the greatest accuracy, the preceding implies that when measuring the ground station G/T using the direct radio star method described in section 1.4, the offsets from Cas A used to establish P_2 or the system noise temperature should be made to an area of the celestial sphere free from localized HII radiation. These regions are apparent from figures 2-19 and 2-20. Furthermore, since figures 2-19 and 2-20 indicate that there is some HII radiation surrounding Cas A, the contribution of this radiation to the system noise temperature should be subtracted when Cas A is used as a calibrating source. In order to do this, a good map of the HII radiation around Cas A is needed. Figures 2-19 and 2-20 give an idea of the problems involved in obtaining such maps at a given frequency. The symmetry of contour lines around Cas A in these figures strongly suggests that the high synchrotron radiation from Cas A in the sidelobes of the antenna used to determine these contours has distorted the resulting picture of the HII radiation, and one is tempted to replace the maps with a (hopefully) "corrected" map that might look like figure 2-21. When this is done at 1.4 GHz, Cas A appears to be bathed in HII radiation approximately equal to 1.2 kelvins (1.5 x 0.8) above the 3 kelvin black-body level. Since the brightness for the HII regions is expected (6) to be flat above 1.4 GHz this leads to 0.04 kelvin (using eq. (2.8)) increased at 7.25 GHz. Thus, given the validity of the assumptions made in arriving at 0.04 kelvins, the HII background around Cas A at this frequency should cause negligible error (less than 0.01 dB) in the use of Cas A as a calibrating source.

In summary, it appears that there are many gaps in the literature concerning the cosmic background in general, and the background around Cas A in particular.

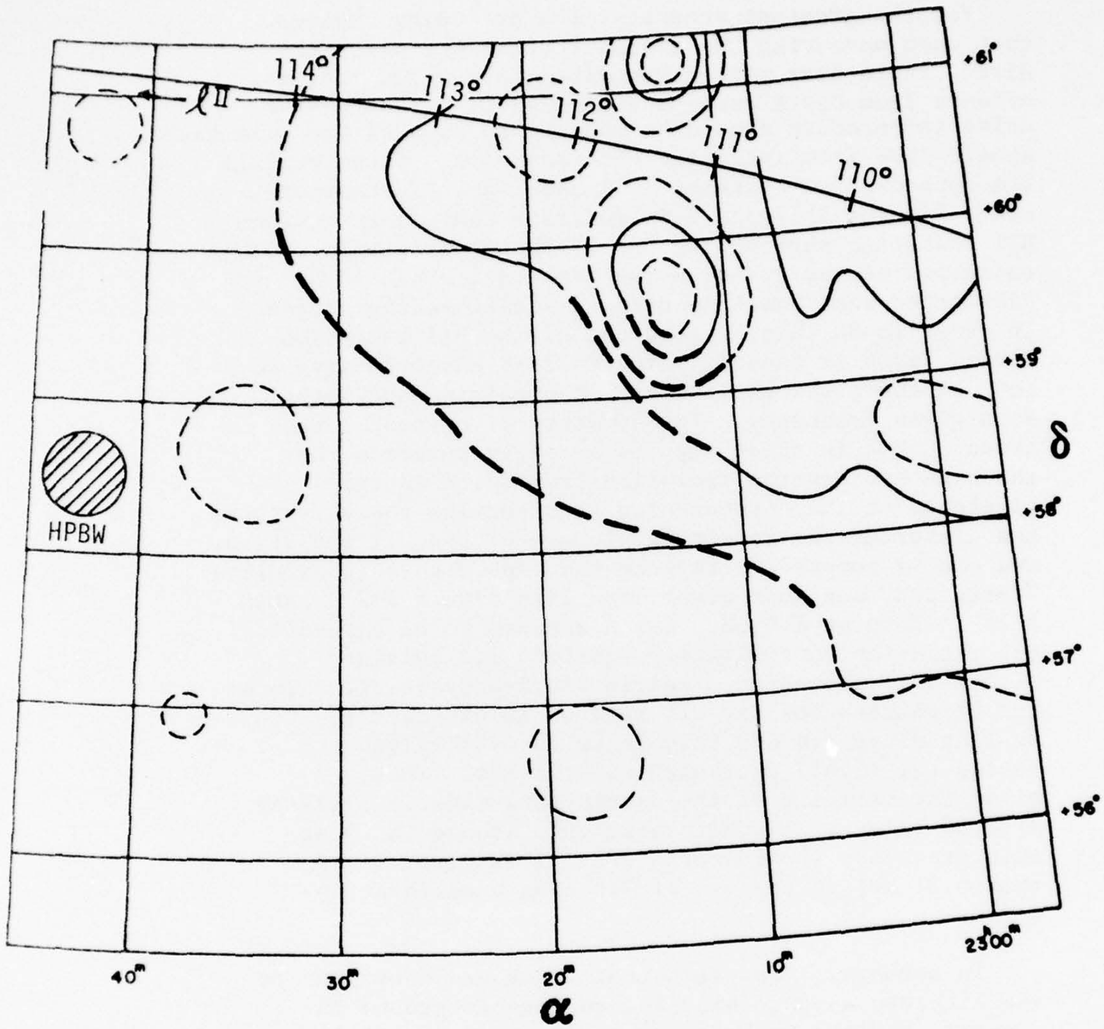


Figure 2-21. Hypothetical cosmic radio background at 1.4 GHz with effect of Cas A removed.

UPLINK NOISE PERFORMANCE WORKSHEET (CCR 702-1-3)			TEST ENGR SIGNATURE
LINK NO.	STATIONS UNDER TEST ______ TO ______		
DEFINITION	SYMBOL	VALUE	REFERENCE/EQUATION
Path distance (earth terminal to satellite)	d	______km	
Carrier frequency	f	______MHz	
Free space loss	L_{bf}	______db	20 log f + 20 log d + 32.45
Atmospheric absorption	A_a	______db	
Antenna coupling loss (losses in satellite in coupling of transmitter to antenna)	L_{gp}	______db	
Tracking error loss	L_t	______db	
Polarization loss	L_p	______db	
Basic median transmission loss	L	______db	$L_{bf} + A_a + L_{gp} + L_{ta} + L_p$
Transmitter power (nominal)	P_t	______dbm	10 log P_t (milliwatts)
Antenna diameter (transmit)	D_t	______m	
Antenna diameter (receive)	D_r	______m	
Free space antenna gain (transmit) relative to isotropic radiator	G_t	______db	Manufacturer's specifications or 20 log D_t + 20 log f - 52.5 d
Free space antenna gain (receive) relative to isotropic radiator	G_r	______db	Manufacturer's specifications or 20 log D_r + 20 log f - 52.5 d
Path antenna gain	G_p	______db	$G_t + G_r$
Median receive carrier power	P_{rc}	______dbm	$P_t + G_p - L$
Receiving system noise temperature	T_s	______°K	From receiving system noise temperature worksheet or manufacturer's data

USACC FORM 406-R (TEST)
1 MAY 77

Page 1

Figure 3-1. Uplink noise performance worksheet.

UPLINK NOISE PERFORMANCE WORKSHEET

DEFINITION	SYMBOL	VALUE	REFERENCE/EQUATION
Boltzmann's constant	k	-198.6 dbm/kHz	(1.38044±0.00007) x 10^{-16} erg deg^{-1}
Number of VF channels	N	______	
Top baseband frequency	f_m	______kHz	
Required IF bandwidth	B	______MHz	$2\ \Delta f + 2\ f_m$
Peak composite deviation	Δf	______kHz	$\sqrt{2}\ d_{rms} \log^{-1} (P_n/20)$
Carrier-to-noise ratio C/N = C/kTB	C/N	______db	$C - k - 10 \log T_s - 10 \log B$
RMS per channel deviation	d_{rms}	______kHz	
White noise loading	P_n	______dbm0	$-1 + 4 \log N$
Preemphasis improvement for top channel	I_p	______db	
FM improvement for top channel	I_{fm}	______db	$20 \log d_{rms} - 20 \log f_m + 10 \log B + I_p + 25.1$ db
Unweighted median channel-to-thermal noise ratio for top channel	S/N(t)	______db	$C/N + I_{fm}$
C-message weighted thermal noise power	$N(t)_1$	______pWC0	$\text{Log}^{-1} \{0.1[88.5 - S/N(t)]\}$

USACC FORM 406-R (TEST) Page 2
1 MAY 77

Figure 3-1. Uplink noise performance worksheet. (continued)

RECEIVING SYSTEM NOISE TEMPERATURE WORKSHEET (CCR 702-1-3)			TEST ENGR SIGNATURE
LINK NO	STATION UNDER TEST ______ TO ______		
DEFINITION	SYMBOL	VALUE	REFERENCE/EQUATION
Equivalent antenna noise temperature at antenna output flange	T_a	______ °K	Based on antenna position and frequency
Transmission line loss between the antenna output flange and the receiver input flange	L_1	______ db	Measured or calculated value
Ambient temperature	T_o	290 °K	
Noise figure of the receiver first stage, for low noise systems, NF_2 is taken for parametric amplifier	NF_2	______ db	Measured or manufacturer's specifications
Noise temperature of the receiver first stage	T_2	______ °K	For a low noise receiver system $T_2 = (F_2 - 1)\ T_o$ where $F_2 = \log^{-1}\left(\frac{NF_2}{10}\right)$
Power gain of the receiver first stage	G_2	______ db	
Noise figure of the second stage of the receiver	NF_3	______ db	Measured or manufacturer's specifications
Noise temperature of the second stage of the receiver	T_3	______ °K	$T_3 = (F_3 - 1)\ T_o$ where $F_3 = \log^{-1}\left(\frac{NF_3}{10}\right)$
Loss between first stage and second stage	L_2	______ °K	
System noise temperature	T_s	______ °K	$T_s = T_a + (L_1 - 1)\ T_o + L_1\ T_2 + \frac{L_1 T_3}{G_2}$

USACC FORM 407-R (TEST)
1 MAY 77

Figure 3-2. Receiving system noise temperature worksheet.

DOWNLINK NOISE PERFORMANCE WORKSHEET (CCR 702-1-3)			TEST ENGR SIGNATURE
LINK NO.	STATIONS UNDER TEST ____ TO ____		
DEFINITION	SYMBOL	VALUE	REFERENCE/EQUATION
Basic median transmission loss	L	____ d	From uplink noise performance worksheet
Effective isotropic radiated power of satellite	E_{irp}	____ dbm	Power output (dbm) + antenna gain (db) or manufacturer's specifications
Receiving system antenna gain relative to isotropic radiator	G	____ db	
Median receive carrier power	C	____ dbm	E_{irp} - L + G
Receiving system noise temperature	T_s	____ °K	From receiving system noise temperature worksheet or measured results
Boltzmann's constant	k	-198.6 dbm/kHz	$(1.38044 \pm 0.00007) \times 10^{-16}$ erg deg^{-1}
Number of VF channels	N	____	
Top baseband frequency	f_m	____ kHz	
Requi[illegible] bandwidth	B	____ MHz	$(2\ \Delta f + 2\ f_m)$
Peak [illegible]te deviation	Δf	____ kHz	$\sqrt{2}\ d_{rms}\ \log^{-1}\ (P_n/20)$
Carrier-to-noise ratio C/N = C/kTB	C/N	____ db	C - k - 10 log T_s - 10 log B
RMS per channel deviation	d_{rms}	____ kHz	
White noise loading	P_n	____ dbm0	-1 +4 log N
Preemphasis improvement for top channel	I_p	____ db	
FM improvement for top channel	I_{fm}	____ db	20 log d_{rms} - 20 log f_m + 10 log B + I_p + 25.1 db

USACC FORM 408-R (TEST) Page 1
1 MAY 77

Figure 3-3. Downlink noise performance worksheet.

DOWNLINK NOISE PERFORMANCE WORKSHEET

DEFINITION	SYMBOL	VALUE	REFERENCE/EQUATION
Unweighted median channel-to-thermal noise ratio for top channel	S/N(t)	________db	$C/N + I_{fm}$
C-message weighted thermal noise power	$N(t)_2$	______pWCO	$\text{Log}^{-1}\ \{0.1 \mid 88.5 - S/N(t) \mid\}$
Equipment noise power ratio at operating	NPR	________db	Manufacturer's specifications
C/kT ratio white noise loading	P_n	______dbm0	-1 +4 log N
White noise bandwidth	B_n	________kHz	
Equivalent channel signal-to-intermodulation noise ratio	S/N(i)	________db	
C-message weighted intermodulation noise power	N(i)	______pWCO	$\text{Log}^{-1}\ \{0.1 \mid 88.5 - S/N(i) \mid\}$
C-message weighted thermal noise power (uplink)	$N(t)_1$	______pWCO	From uplink noise performance worksheet
C-message weighted equipment intermodulation noise power	N(i)	______pWCO	From equipment intermodulation distortion worksheet
C-message weighted feeder echo noise	$N_{(fe)}$	______pWCO	From echo distortion worksheet
Total weighted noise power	$N_{(total)}$	______pWCO	$N(t)_1 + N(t)_2 + N(i) + N_{(fe)}$
DCA median allocation	$N_{(DCA)}$	______pWCO	
Design margin		________db	$10 \log \left[N_{(DCA)}/N_{(total)}\right]$

USACC FORM 408-R (TEST) Page 2
1 MAY 77

Figure 3-3. Downlink noise performance worksheet. (continued)

ECHO DISTORTION WORKSHEET (CCR 702-1-3)				TEST ENGR SIGNATURE
LINK NO.	STATIONS UNDER TEST ______ TO ______			
DEFINITION	SYMBOL	VALUE TRANSMIT STATION	VALUE RECEIVE STATION	REFERENCE/EQUATION
VSWR at point A		______	______	Manufacturer's specs or measurement
Return loss A	L_a	______db	______db	$20 \log \left\lvert \frac{VSWR+1}{VSWR-1} \right\rvert$
VSWR at point B		______	______	Manufacturer's specs or measurement
Return loss B	L_b	______db	______db	$20 \log \left\lvert \frac{VSWR+1}{VSWR-1} \right\rvert$
Transmission distance	D	______m	______m	
Attenuation constant	α	______dbm	______dbm	Manufacturer's data
Transmission loss A to B	L_t	______db	______db	αD
Velocity of propagation	ν	______m/μs	______m/μs	Manufacturer's data
Echo delay	T	______μs	______μs	$2D/\nu$
RF signal-to-RF echo power ratio	S/E	______db	______db	$L_a + L_b + 2L_t$
Number of VF channels	N	______	______	
Top baseband frequency	f_m	______MHz	______MHz	
Per channel deviation (rms)	d_{rms}	______MHz	______MHz	Manufacturer's standard or measurements
Baseband white noise power	P_n	______dbm0	______dbm0	
White noise bandwidth	B_n	______MHz	______MHz	
System deviation (rms)	σ	______MHz	______MHz	$d_{rms} \log^{-1}(0.05P_n)$
Deviation ratio	σ/f_m	______	______	
Top baseband frequency times echo delay	$f_m T$	______	______	
Interference ratio	K	______db	______db	Figure 3-5

USACC FORM 409-R (TEST)
1 MAY 77

Page 1

Figure 3-4. Echo distortion worksheet.

ECHO DISTORTION WORKSHEET

DEFINITION	SYMBOL	VALUE TRANSMIT STATION	VALUE RECEIVE STATION	REFERENCE/EQUATION
Emphasis improvement	I_p	______db	______db	3 db for CCIR emphasis
Noise power ratio due to echo	NPR	______db	______db	$S/E + K + I_p$
Channel signal-to-noise ratio due to echo	S/N	______db	______db	$NPR - P_n + 10 \log B_n + 25.1$
Channel echo noise	N_e	______pWCO	______pWCO	$\text{Log}^{-1}[0.1\ (88.5\text{-}S/N)]$
Link channel echo noise		____________________pWCO		Sum of noise powers due to echos at both stations

COMMENTS

USACC FORM 409-R (TEST) Page 2
1 MAY 77

Figure 3-4. Echo distortion worksheet. (continued)

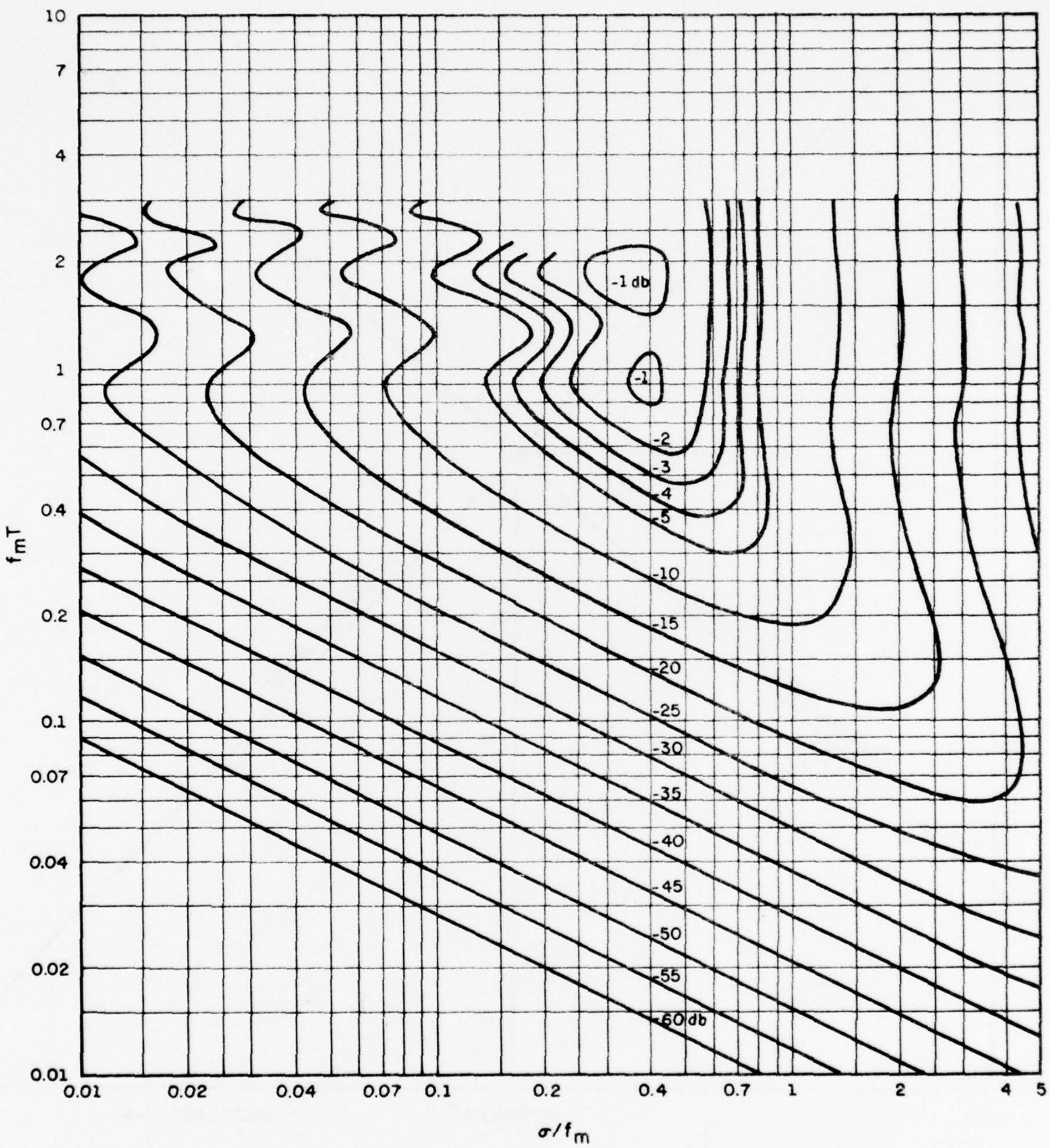


Figure 3-5. Contours of constant interference in the top channel of a multichannel FM system.

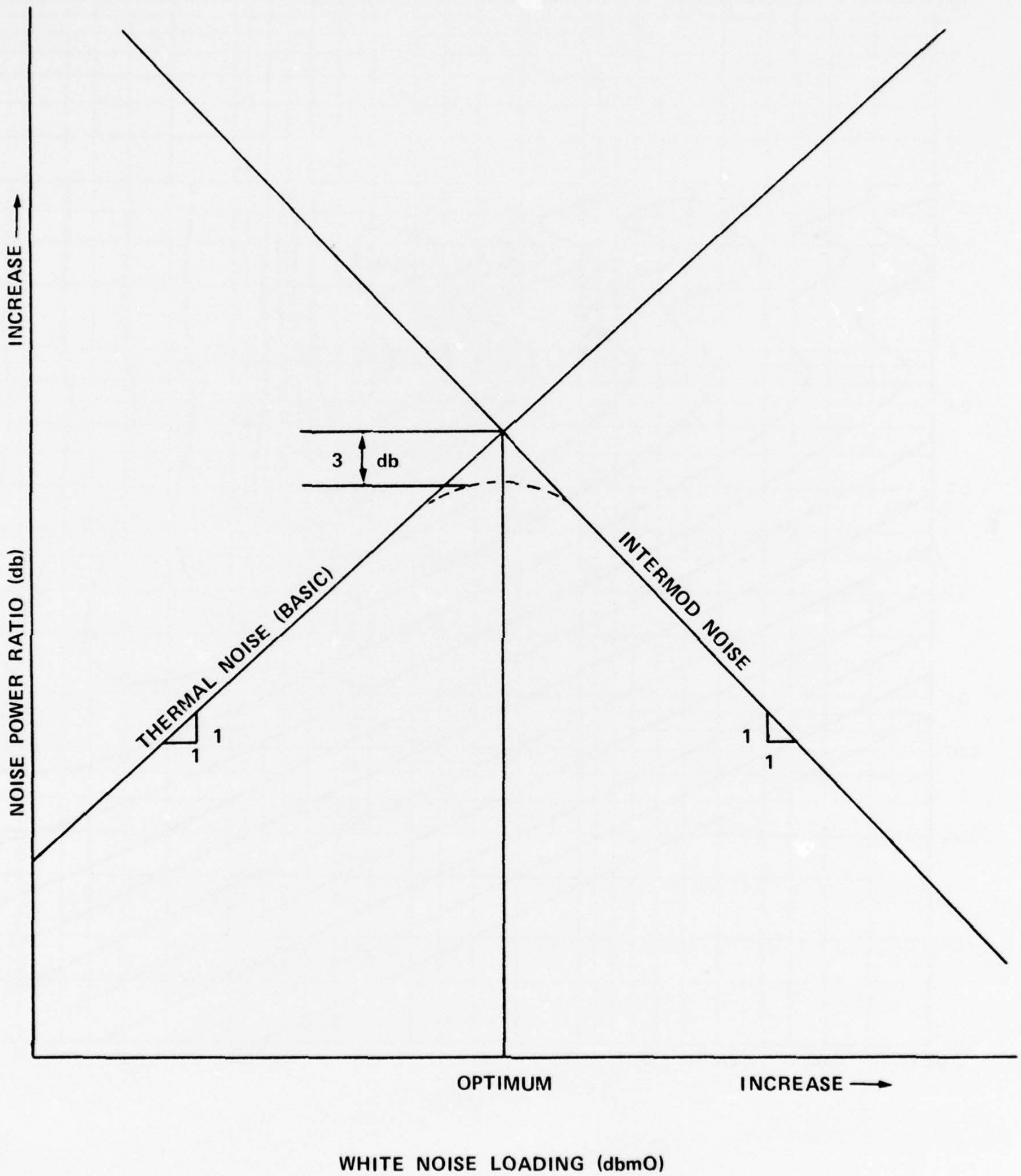


Figure 3-6. Carrier deviation.

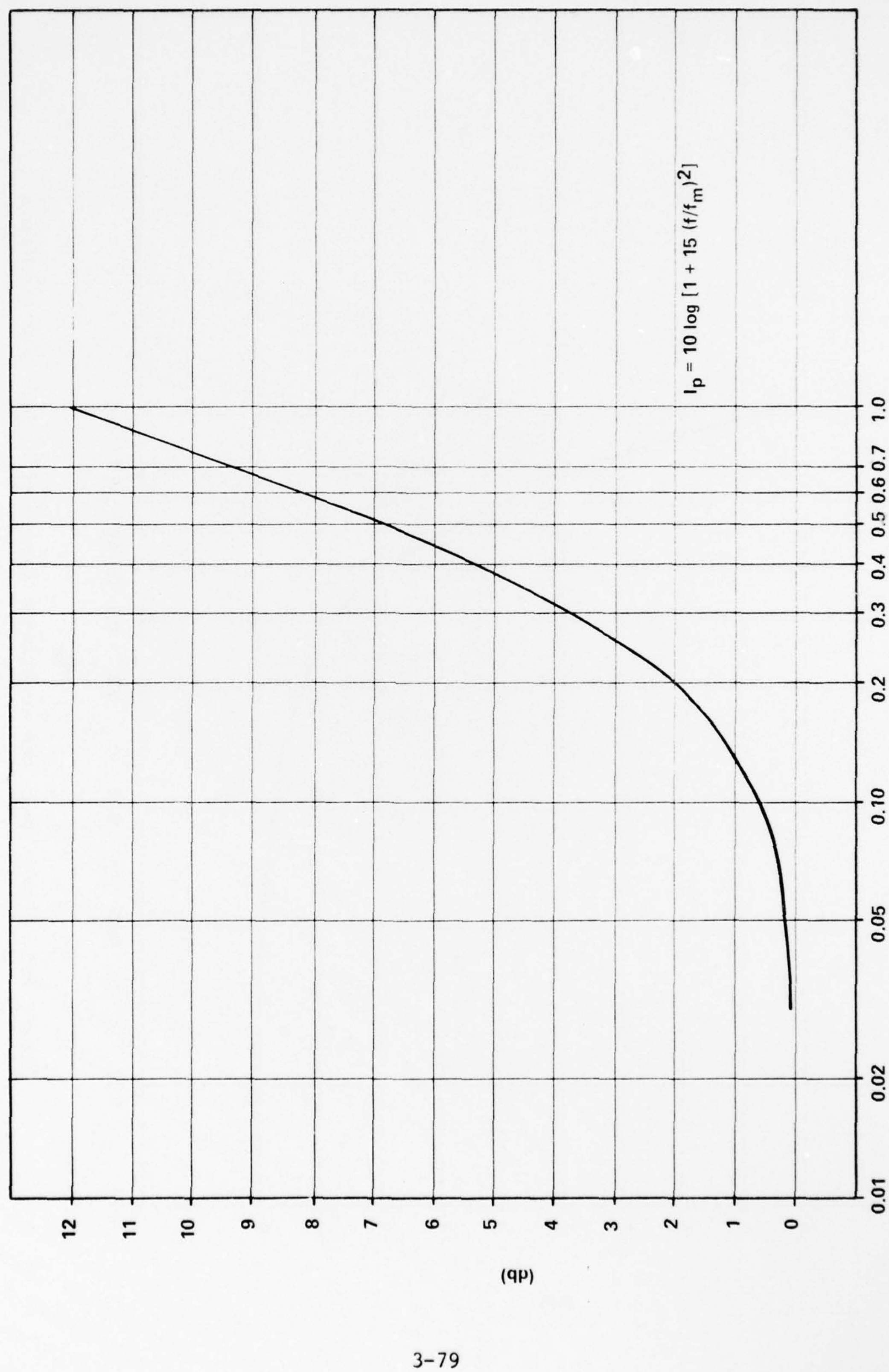


Figure 3-7. Typical preemphasis curve.

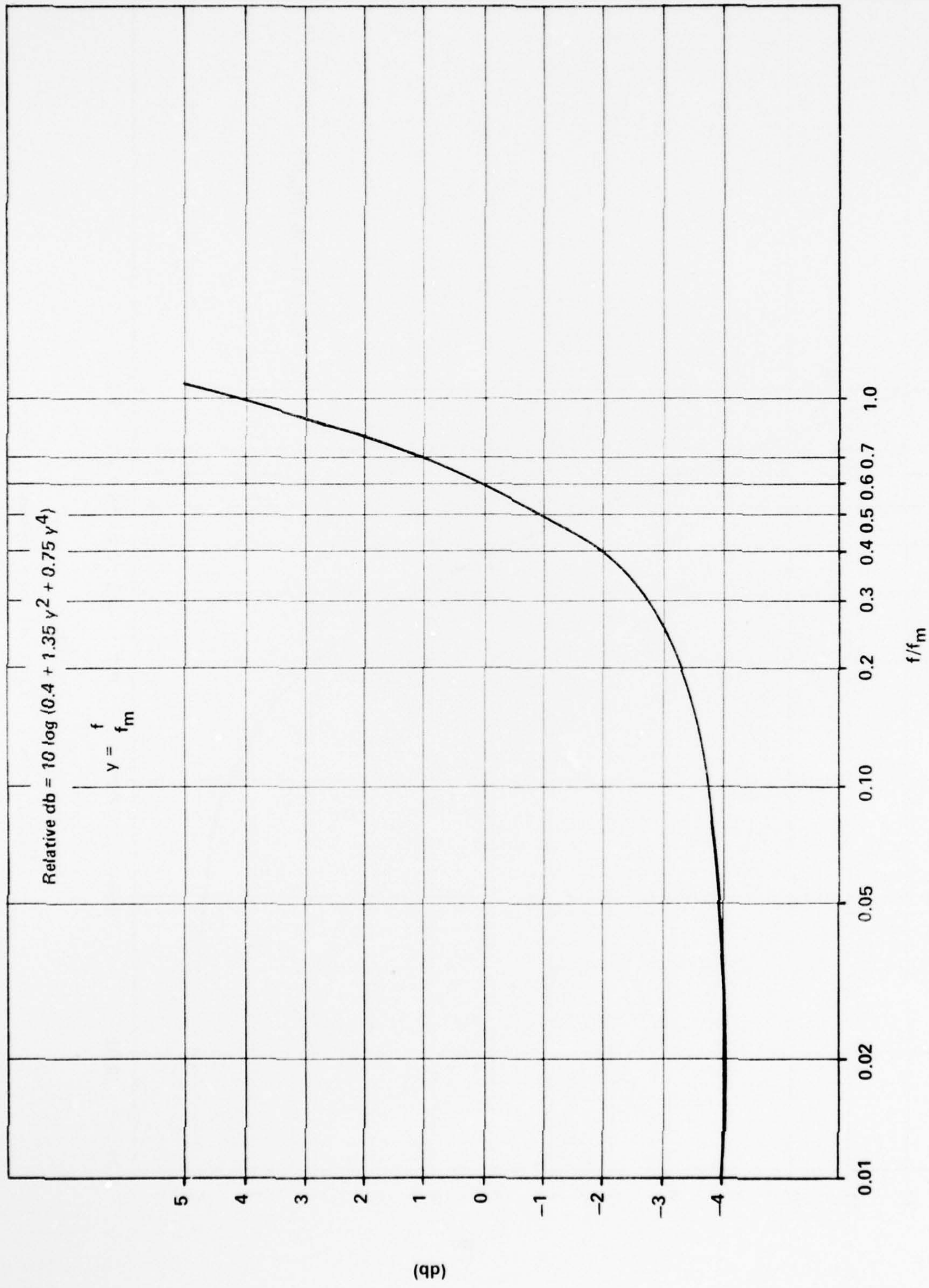


Figure 3-8. Preemphasis characteristic for multichannel communications.

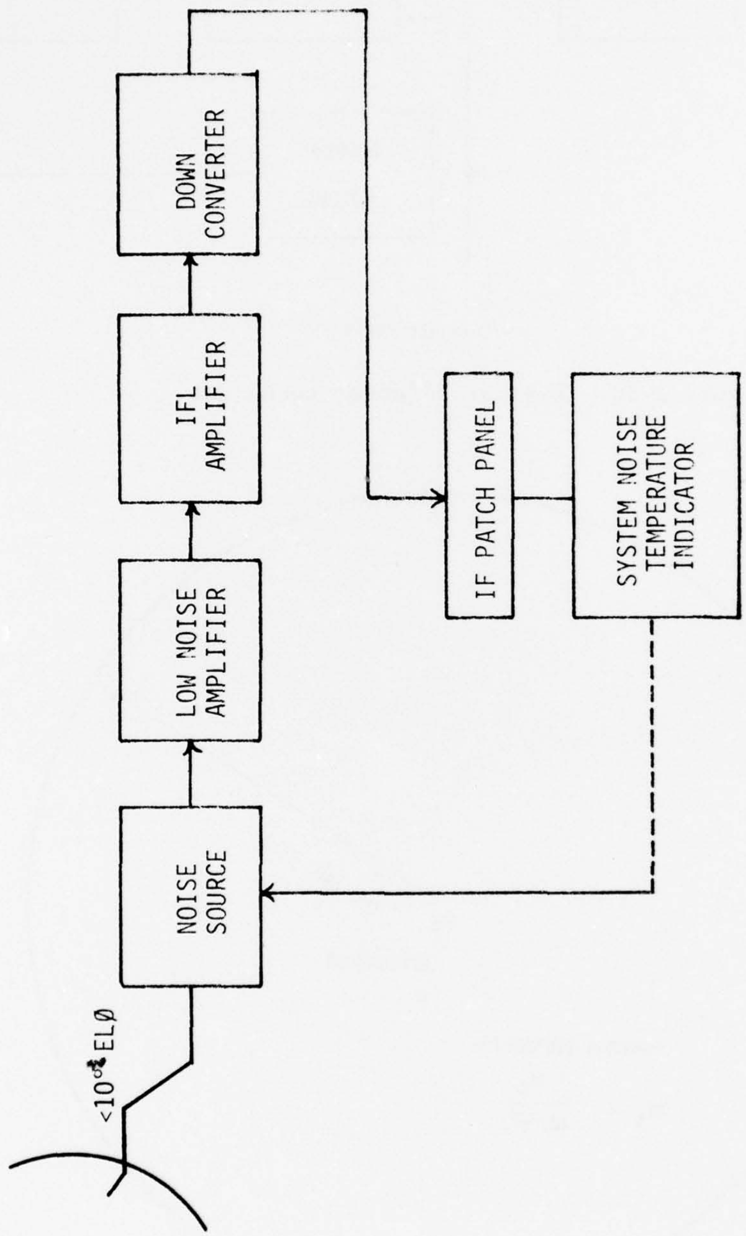


Figure 3-9. Typical SNT measurement configuration.

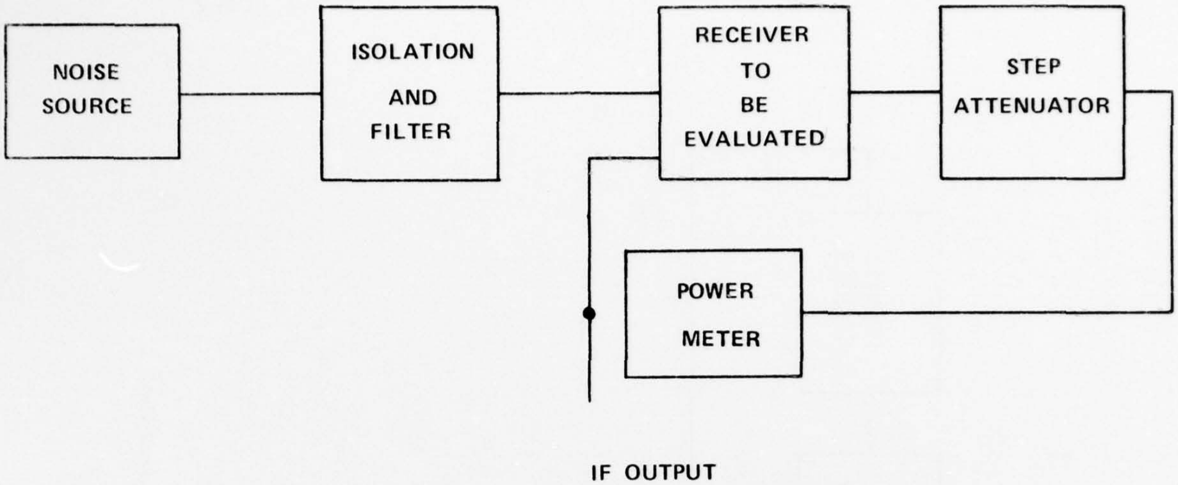


Figure 3-10. Typical Y-factor technique.

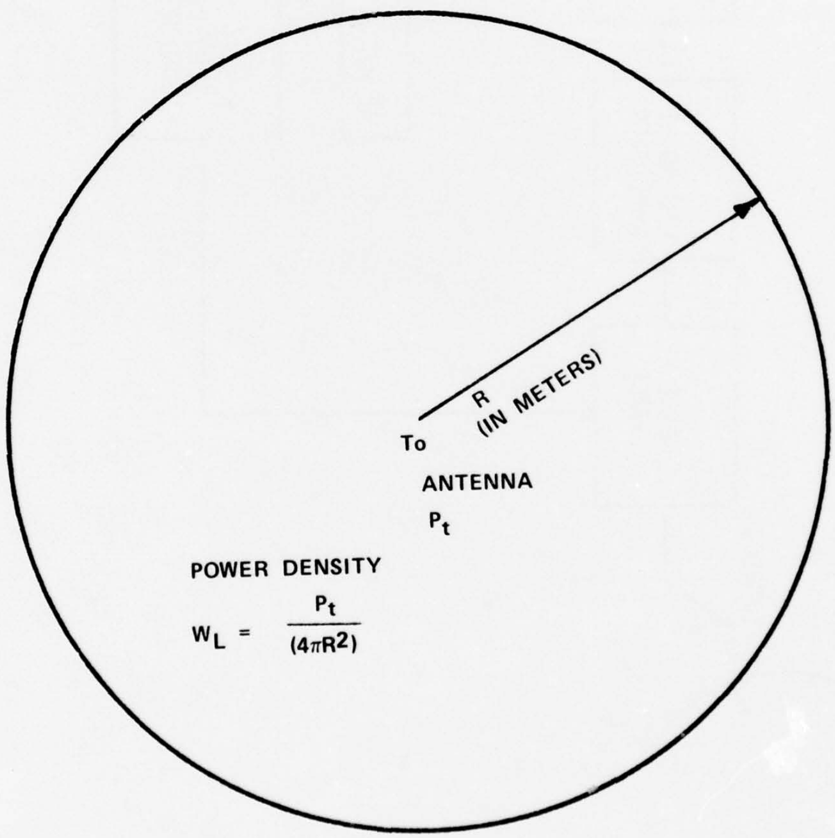


Figure 3-11. Typical isotropic antenna pattern.

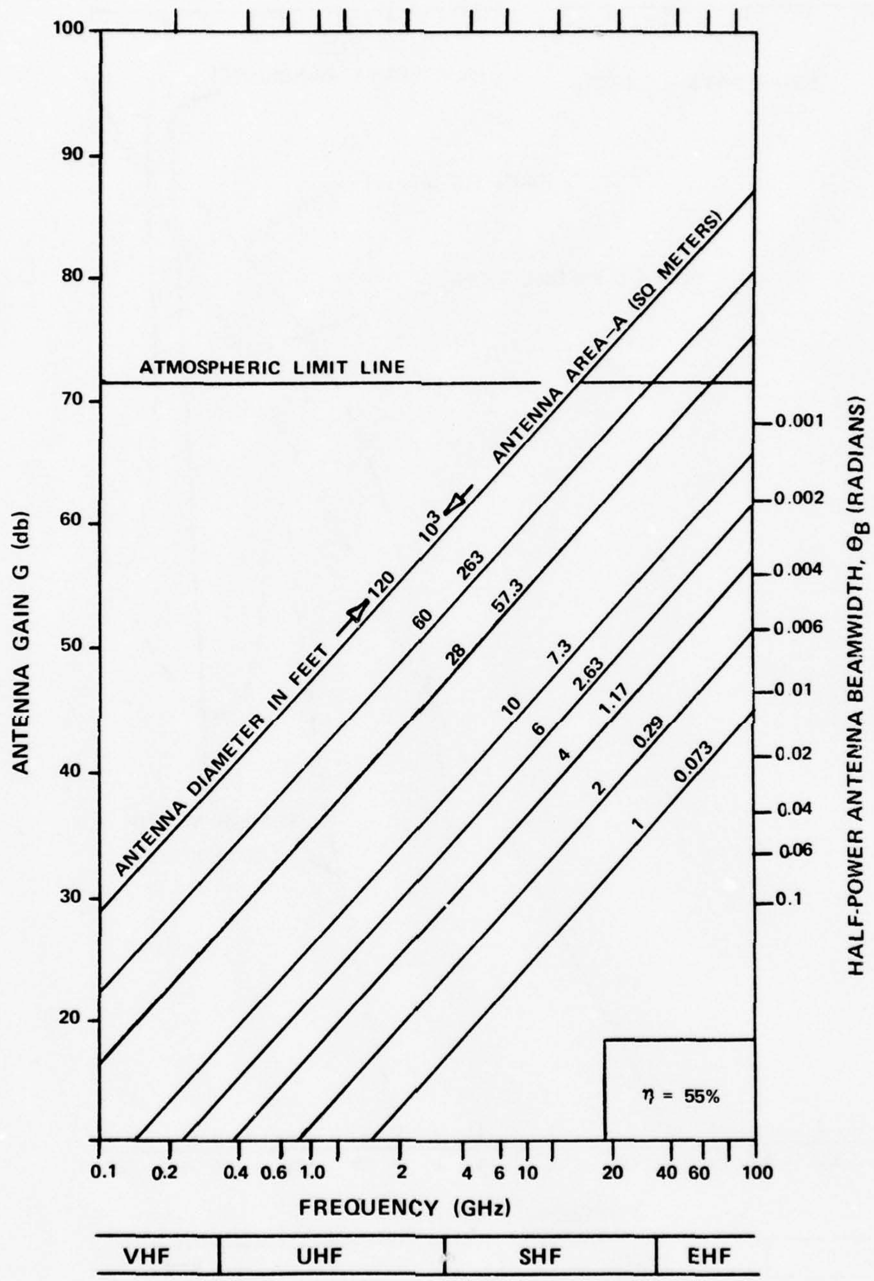


Figure 3-12. Antenna gain vs wavelength graph.

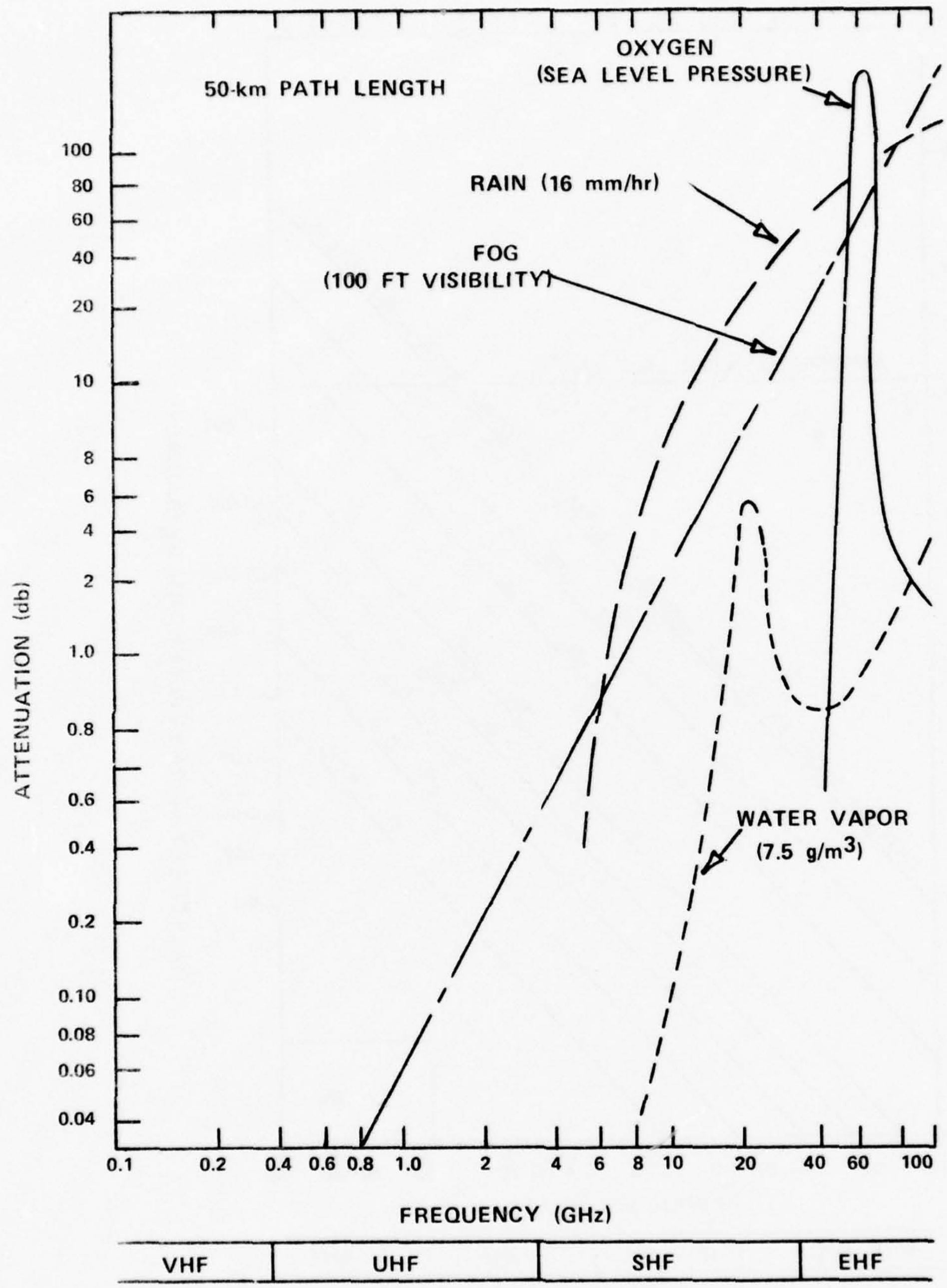


Figure 3-13. Atmospheric absorption graph.

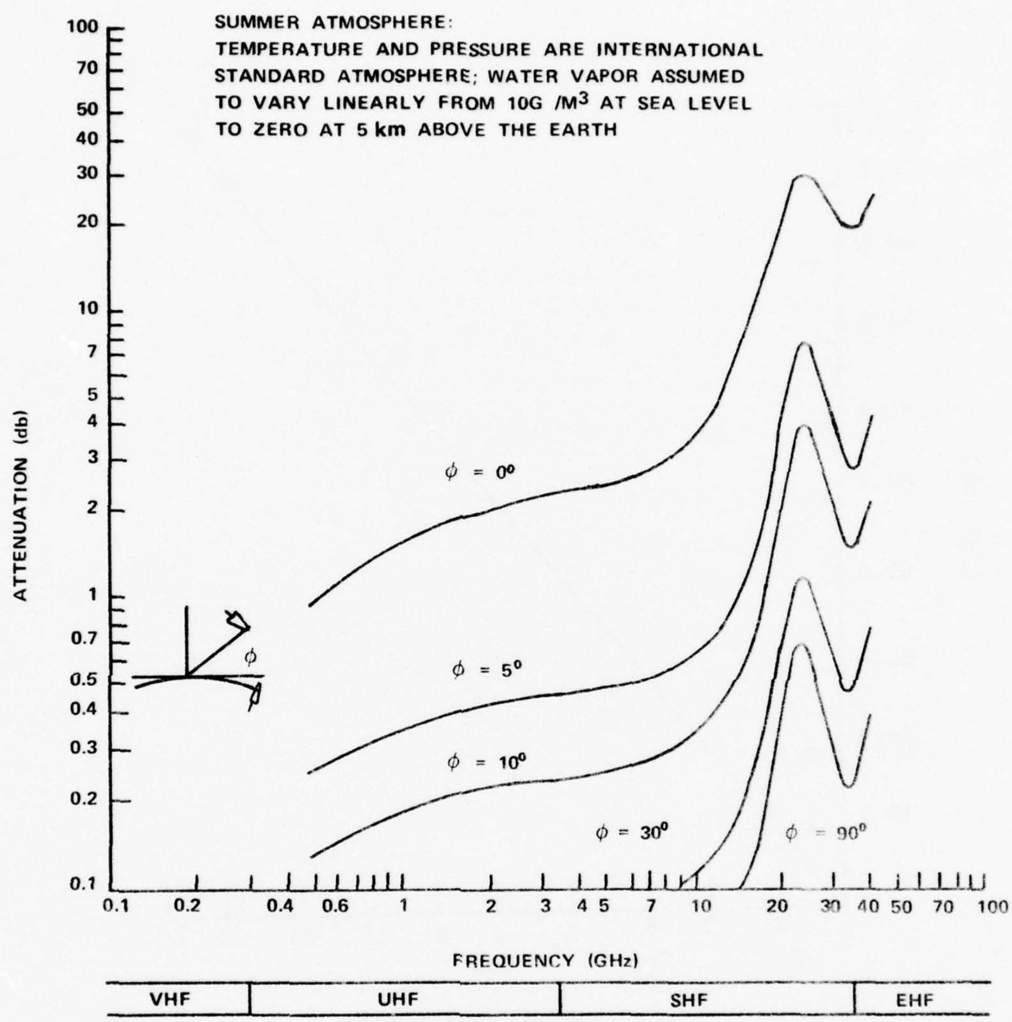


Figure 3-14. Clear weather atmospheric absorption graph.

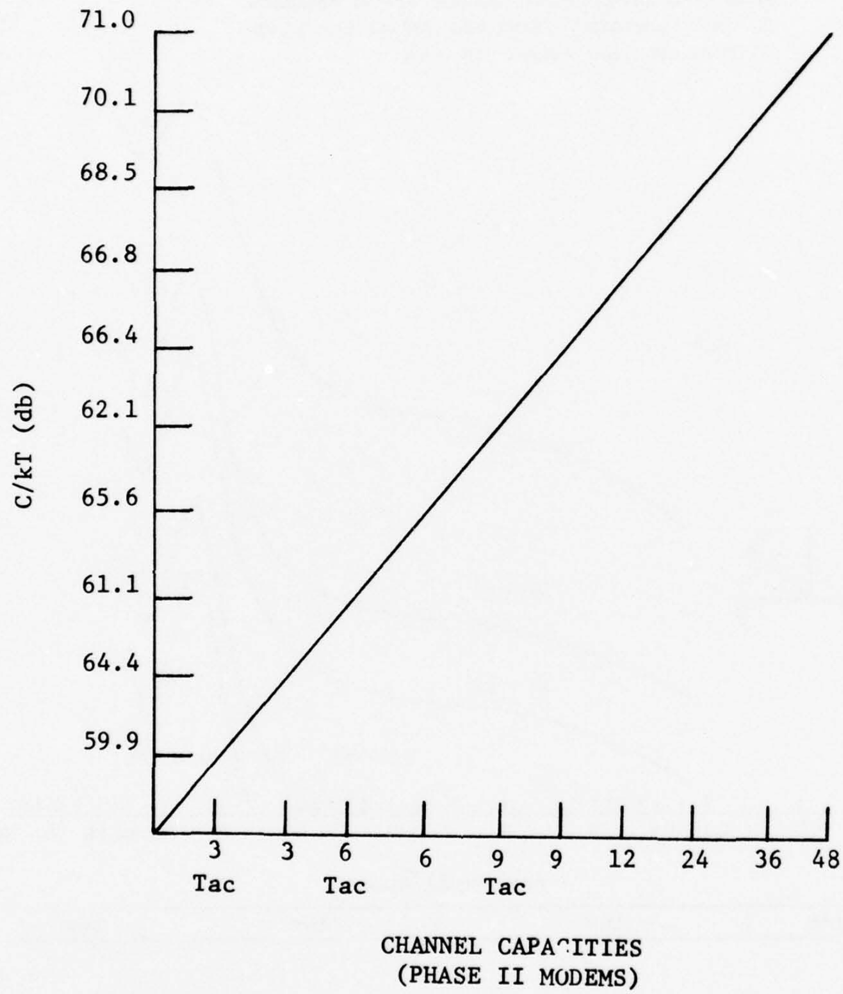


Figure 3-15. Channel capacity graph in relation to C/kT.

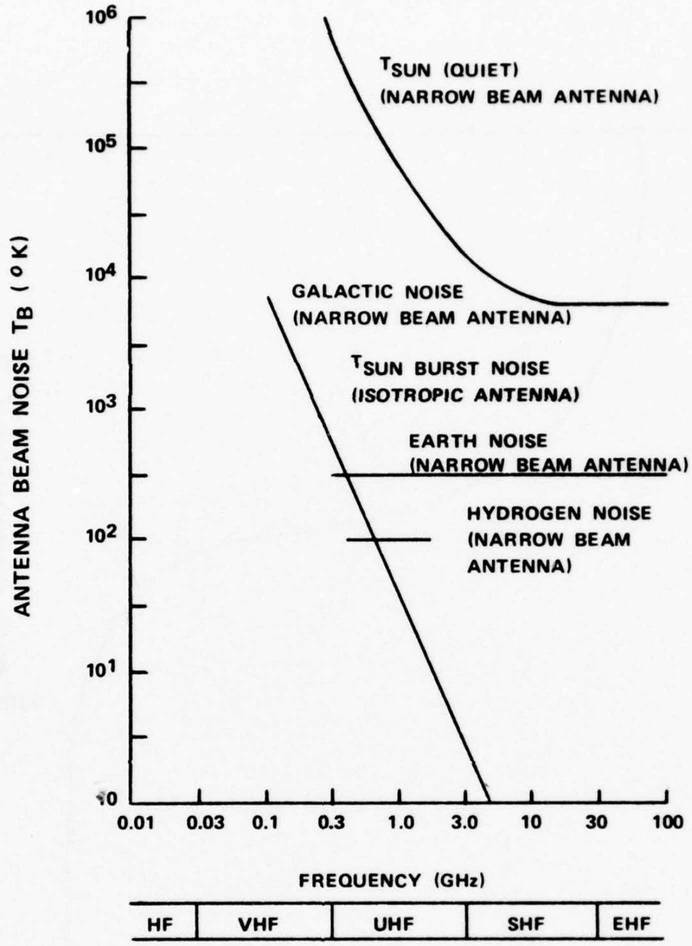


Figure 3-16. Antenna beam noise graph.

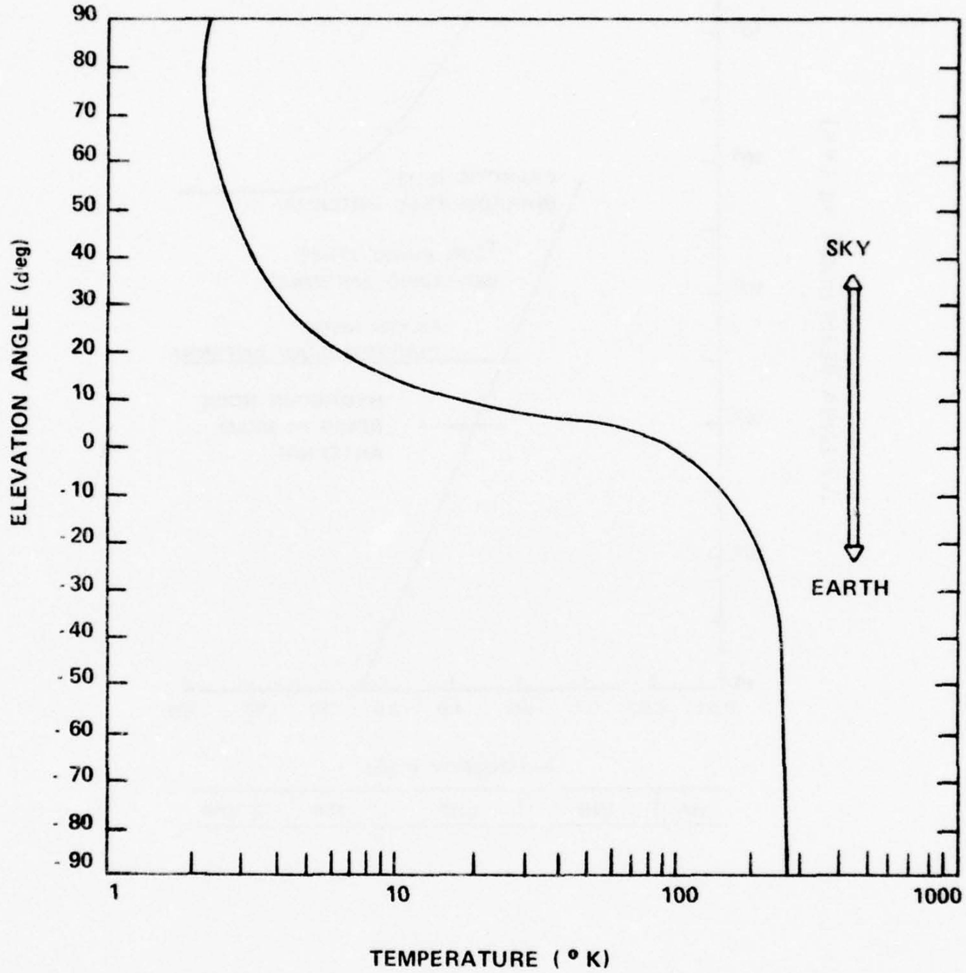


Figure 3-17. Space noise temperature graph as a function of elevation angle at 4 GHz.

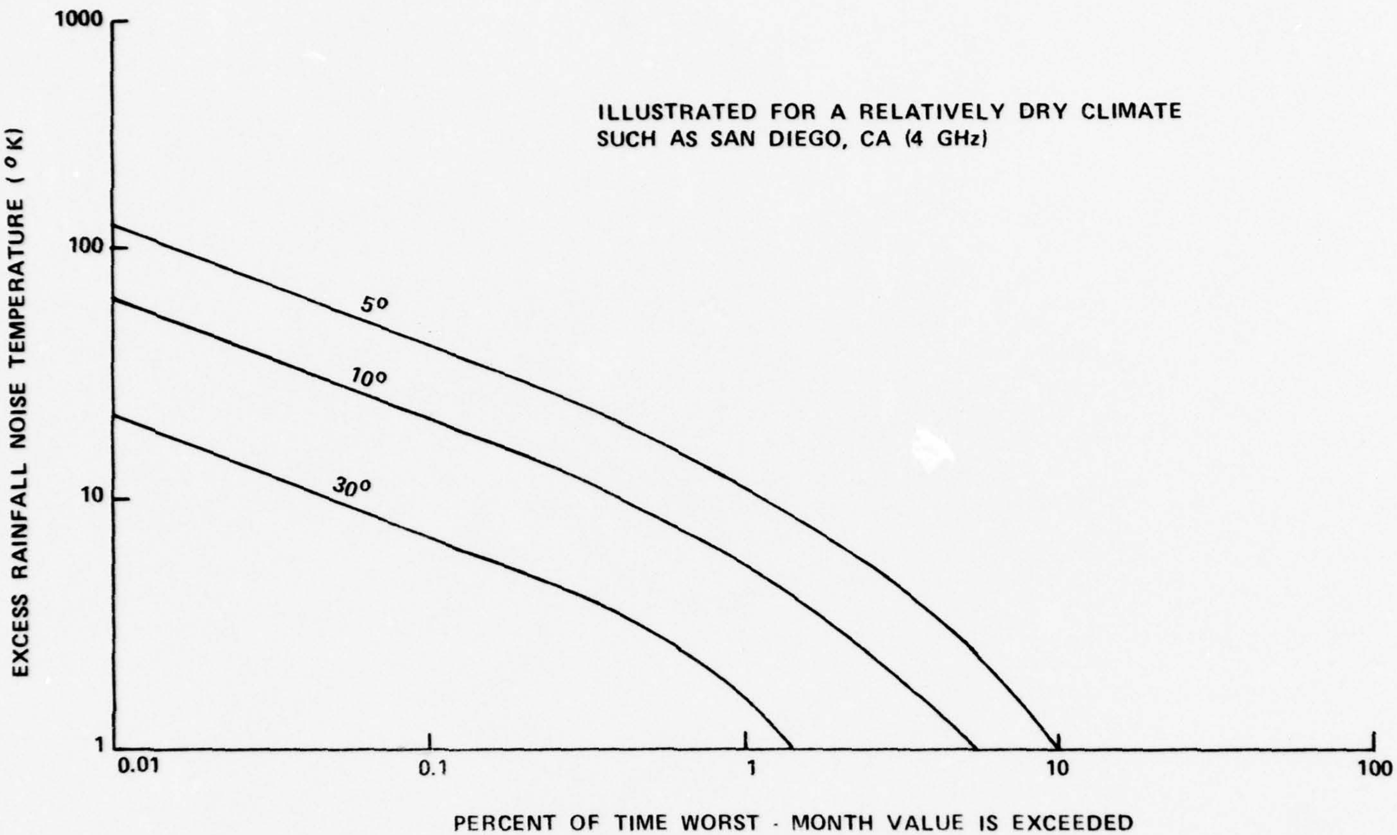


Figure 3-18. Distribution graph of worst month excess rainfall and temperature.

Preceding Page Blank - NOT FILMED

CHAPTER 4

TESTING PHILOSOPHY

4-1. GENERAL.

a. As discussed in chapter 1, the most cost-effective method of evaluating a satellite earth terminal appears to be by use of a satellite loopback. The test procedures contained in chapters 6 through 59 of this pamphlet are basically those tests necessary to fully characterize the equipment and terminal operation.

b. A logical test sequence must be followed during the evaluation since the results of one particular test may impact on one or more succeeding test sequences. The test sequence can be divided into three elements, that is, testing of individual items of equipment, testing of a subsystem, and finally, a complete systems test.

c. Equipment testing can be defined as that testing required to determine if a particular piece of equipment is performing within its design specifications. Those items of equipment found to be deficient should be repaired or adjusted as required to bring their performance within specifications. This is necessary since their peak operational performance is required to insure that system performance parameters are within specifications. In other words, deficiencies in individual pieces of equipment that are left uncorrected may impact on the service being provided to the customer.

d. As the satisfactory testing of individual items of equipment progresses, subsystems will gradually evolve. A subsystem is that grouping of equipment designed to perform as a functional part of the complete system. Assuming individual items of equipment have been proved to be within specifications, the subsystem testing will determine how well the items perform when combined into a subsystem. During this phase of testing, emphasis should be placed on functional performance rather than the performance of individual pieces of equipment. This phase should reveal any unusual problems with interfacing of equipment items to form a subsystem. Such things as level incompatibility and impedance mismatches should be evident during subsystem testing.

e. System testing consists of those test techniques required to evaluate the individual items of equipment and the subsystem's performance when installed as a completed system. Tests for the entire system should be designed to determine the ability of the system to meet its overall design specifications. The system tests must consider the desired system end product, encompass the functions of the subsystems, and yield an evaluation of the composite function of the system. The design of these tests will be predicated, to some degree, on the availability of equipment and facilities. The system tests on operational systems will also be limited due to the constraints contained in chapter 1 of this pamphlet.

f. The audio test series listed in chapters 57 through 74 of this pamphlet should be performed on a systems basis whenever possible. Since a complete radio systems test is impractical, especially on an operational system, the audio series will provide a good indicator of customer service.

4-2. SYSTEM MEASUREMENTS.

a. Correct measurement techniques are usually acquired through a combination of formal training and field experience. Extensive experience is not required, however, to avoid many of the mistakes commonly made by the test teams. Some of the most common mistakes are contained in subsequent paragraphs.

b. Improper terminations, lack of a termination, or mismatched impedances are common errors which result in erroneous test data. The individual performing the tests must examine the data while the test is in progress to insure the results are valid. In this respect, it is essential that the individual be familiar with the manufacturer's specifications and design standards in order to ascertain that the test data is within required parameters.

c. Lack of adequate grounding, no ground at all, or ground loops will result in invalid test data. The station ground of the system being evaluated should be checked by the test teams before proceeding to the individual test sequences. This check should also include the potential between subsystems and adjacent equipment areas. The test leads used by the test team should be fabricated and used in such a manner as to preclude introducing unwanted ground loops. As an example, the test leads for the selective voltmeter should be constructed so that 80- to 100-db attenuation is provided for all frequencies and levels external to the systems being evaluated.

d. Technical manuals or manufacturer's literature should always be consulted to obtain the test level points (TLP) and the impedance at the point at which the measurement is to be taken. This information should be entered on the appropriate test form to aid in the analysis process.

e. One guideline should definitely be followed by the test team. If the test data does not correlate with expected performance levels, the test should be rerun to insure that the test techniques are valid or to isolate the cause for the disparity in measured performance versus the design specifications. This must be accomplished while the test team is onsite since it would not be cost-effective for the teams to rerun the test after departure from the terminal.

f. When measured results depart from the expected value, the test team must isolate the cause for the discrepancy and implement the necessary corrective action. Those areas not corrected while onsite must be identified as to the specific problem and recommended corrective action. Whenever possible, the test team must refrain from using such terms as it may be caused by or it may be influenced by. Sufficient diagnostic testing must be accomplished to isolate the problem to specific equipment items or subsystem so that the O&M command can initiate corrective action.

4-3. TESTS TO BE PERFORMED.

a. Table 4-1 provides a list of tests that are required to be performed by the test teams as well as some optional tests that may be conducted, time permitting. This information has been extracted from DCAC 310-70-57 since certain data elements are required by DCA on all DSCS terminals. The same data is also applicable to non-DCS terminals.

b. Additional diagnostic routines may have to be performed by the test team. In such cases, the appropriate technical literature should be consulted.

c. Table 4-2 reflects those test sequences that may or may not require system outage time. Since downtime will be limited on all operational systems, the test team must use a system of priorities in evaluating a terminal. The priorities should be arranged so that the most significant tests are accomplished during system downtime.

Table 4-1. Test Organization and Requirements

TEST NUMBER	TEST TITLE	DCA O&M REQUIRED	O&M PRIORITY	OUTAGE REQUIRED			
				SYSTEM		CHANNEL	
				YES	NO	YES	NO
ST-1	Antenna Tracking and Pointing Accuracy	X	6	X			
ST-2	Antenna Focusing, Beamwidth, and Side Lobe	X		X			
ST-3	Earth Terminal Figure-of-Merit	X	4	X			
ST-4	SNT vs Antenna Elevation Angle	X	3	X			
ST-5	WG Return Loss or Voltage Standing Wave Ratio (VSWR)	X		X			
ST-6	WG Insertion Loss	X		X			
ST-7	Para-amp Frequency Response and Gain	X		X			
ST-8	Para-amp Noise Temperature			X			
ST-9	Para-amp Dynamic Range (0.5-db Compression Point)			X			
ST-10	Para-amp VSWR			X			
ST-11	Para-amp Pump Source Power Output Level and Frequency			X			
ST-12	Interfacility Link Amplifier (IFLA) NF			X			

Table 4-1. Test Organization and Requirements (continued)

TEST NUMBER	TEST TITLE	DCA O&M REQUIRED	O&M PRIORITY	OUTAGE REQUIRED			
				SYSTEM		CHANNEL	
				YES	NO	YES	NO
ST-13	IFLA Frequency Response and Gain	X		X			
ST-14	IFLA VSWR					X*	
ST-15	Down Converter VSWR					X*	
ST-16	Down Converter Spurious Output					X*	
ST-17	Down Converter Frequency Response and Gain	X				X*	
ST-18	Down Converter NF	X				X*	
ST-19	Up Converter/Exciter Frequency Response and Power Output	X				X*	
ST-20	Up Converter Spurious Output					X*	
ST-21	Uplink IFLA and Intermediate Power Amplifier (IPA) Frequency Response and Gain	X					X
ST-22	IPA VSWR						X
ST-23	Power Output, VSWR, and Reflectometer Calibration; and Power Amplifier (PA) Frequency Response	X				X*	

*Depending on equipment availability and redundancy of terminal equipment.

Table 4-1. Test Organization and Requirements (continued)

TEST NUMBER	TEST TITLE	DCA O&M REQUIRED	O&M PRIORITY	OUTAGE REQUIRED			
				SYSTEM		CHANNEL	
				YES	NO	YES	NO
ST-24	PA Intermodulation, Spurious Radiation, and Hum Modulation	X	8			X*	
ST-25	Terminal Multiple Uplink Carrier Operation, Control, and Stability	X	10			X*	
ST-26	PA Power Output Control, Stability, and Noise	X	9			X*	
ST-27	Track Receiver Automatic Gain Control (AGC) Voltage vs C/kT	X	11		X		
ST-28	Track Receiver IF Amplifier Dynamic Range				X		
ST-29	Track Receiver IF Filter Noise Bandpass				X		
ST-30	Track Receiver Voltage Controlled Oscillator (VCO) Frequency Accuracy and Power Output				X		
ST-31	FM Modem Deviation, Deviation Linearity, Dispersion, and Frequency Response	X				X*	
ST-32	FM Demodulator IF Bandpass Characteristics	X				X*	
ST-33	Demodulator IF Amplifier Dynamic Range					X*	

*Depending on equipment availability and redundancy of terminal equipment.

Table 4-1. Test Organization and Requirements (continued)

TEST NUMBER	TEST TITLE	DCA O&M REQUIRED	O&M PRIORITY	OUTAGE REQUIRED			
				SYSTEM**		CHANNEL	
				YES	NO	YES	NO
ST-34	Test-Tone-to-Noise Ratio (TTNR) and Idle Noise Power Ratio (NPR) vs C/kT Ratio	X	7	X			
ST-35	Stability of Out-of-Band Noise (OBN) vs TTNR	X				X*	
ST-36	NPR vs Baseband Loading	X	1			X*	
ST-37	FM Modulator Power Output and Frequency Accuracy	X				X*	
ST-38	Wideband (Digital) Modem	X	2	X			
ST-39	Spread Spectrum Modem	X	5		X		
ST-40	Frequency Synthesizer Internal Frequency Standard				X		
ST-41	Local Oscillator (LO) Multiplication Check and Power Output					X*	
ST-42	Transmit-to-Receive Isolation			X			
ST-43	Crossover Intermodulation	X		X			
ST-44	System Phase Linearity	X		X			

*Depending on equipment availability and redundancy of terminal equipment.

**System outage not required; however, individual channels used for testing must be taken out of service.

Table 4-1. Test Organization and Requirements (continued)

TEST NUMBER	TEST TITLE	DCA O&M REQUIRED	O&M PRIORITY	OUTAGE REQUIRED			
				SYSTEM**		CHANNEL	
				YES	NO	YES	NO
ST-45	System Phase Noise	X		X			
ST-46	Dispersion Generator Range and Threshold Level					X*	
ST-47	Uplink and Downlink Equipment Net Frequency Response	X	3	X			
T-3	Inservice Customer Levels	X	1		X		
T-4	1-kHz Test Tone Signal Levels	X	3		X		
T-5	Voice Channel Impedance (Automatic Sweep)	Opt***			X		
T-6	Voice Channel Impedance (Manual Sweep)	Opt***			X		
T-7	Voice Channel Longitudinal Balance	Opt***			X		
T-8	Idle Channel Noise	X	2		X		
T-9	Idle Channel Impulse Noise	X	5		X		
T-10	Voice Channel Frequency Response (Manual Sweep)	X	7		X		

*Depending on equipment availability and redundancy of terminal equipment.

**System outage not required; however, individual channels used for testing must be taken out of service.

***Optional tests are IAW supplement 1 to DCAC 310-70-57.

Table 4-1. Test Organization and Requirements (continued)

TEST NUMBER	TEST TITLE	DCA O&M REQUIRED	O&M PRIORITY	OUTAGE REQUIRED			
				SYSTEM**		CHANNEL	
				YES	NO	YES	NO
T-11	Voice Channel Frequency Response (Automatic Sweep)	X	7		X		
T-12	Voice Channel Envelope Delay Distortion (Manual Sweep)	X	8		X		
T-13	Voice Channel Envelope Delay Distortion (Automatic Sweep)	X	8		X		
T-14	Voice Channel Harmonic Distortion	X	4		X		
T-15	Voice Channel Frequency Translation	X	9		X		
T-16	Voice Channel Spurious Phase Jitter and Hits (Meter Method)	X	10		X		
T-17	Voice Channel Phase Jitter (Oscilloscope Method)	X	10		X		
T-18	Voice Channel Crosstalk	X	6		X		
T-19	Data Error Rate	Opt***			X		
T-21	Voice Channel Intermodulation Distortion	X			X		

**System outage not required; however, individual channels used for test must be taken out of service.

***Optional tests are IAW supplement 1 to DCAC 310-70-57.

Table 4-2. Test Sequence

SEQUENCE OF TESTS REQUIRING AN OUTAGE	ANTENNA	WG	PARA-AMP	IFLA	DOWN CONVERTER	UP CONVERTER	IPA	PA	TRACK RECEIVER	FM MODEM	WIDEBAND MODEM	SPREAD SPECTRUM MODEM	FREQUENCY GENERATION	SYSTEM	AUDIO CHANNELS
9														ST 34 (LINK)	
8														ST 34 (BACK-TO-BACK)	
7		ST 5,6													
6													ST 41	ST 42,43, 44,45	
5										ST 31, 32,33,34, 35,36,37					
4								ST 23,24, 25,26							
3						ST 19,20									
2					ST 15,16, 17,18										
1	ST 1,2, 3,4														
NO OUTAGE			ST 7,8, 9,10,11	ST 12,13,14	ST 15,16, 17,18	ST 19,20	ST 21,22	ST 23,24, 25,26	27,28, 29,30	ST 31,32,33, 35,36,37	ST 38	ST 39	ST 41		ALL

CHAPTER 5

ANALYSIS OF DATA

5-1. GENERAL. This chapter is intended to provide insight into the meaning of data recorded during a technical evaluation. Each individual test performed provides information as to system quality and certain faults that may exist in the radio or multiplex subsystem. Analysis of the test results collectively can result in expeditious fault isolation and correction, and the elimination of unnecessary and time-consuming trial and error procedures. Every test performed has a definite relationship to one or more of the other tests in the sequence. This chapter will examine the key individual tests performed by the TEP team and their relationships. The test results will be examined as possible troubleshooting aids based on engineering information and past experience.

5-2. IDLE CHANNEL NOISE RECORDINGS. Idle channel noise (ICN) is a key parameter in system analysis. The ICN readings usually provide the first indication that a problem exists in a system. The ICN is the composite noise frcm all subsystems as shown below:

ICN = thermal noise + equipment intermodulation
and residual noise + feeder echo distortion
+ RF interference + multiplex noise

a. The ICN recordings performed by the TEP teams will provide the median system noise during normal traffic loading conditions. This considers the TLP and the data obtained during the NPR test. Due to the low C/kT normally encountered, in two satellite systems, multiplex noise contributions are usually insignificant and have little effect if any on the composite ICN. The predominant source of noise in the system is thermal.

b. It should be pointed out that although ICN is a valuable parameter in system analysis it does not provide a great deal of information as to the cause of a problem. When ICN is high, the system should be checked to determine whether the fault can be attributed to radio problems. Noise isolation can be accomplished by measuring the noise output of the receiver in a 3.1 kHz slot at the respective input receive C/kT ratio and comparing this figure with calculated values. Noise spikes or interfering tones which may be the cause of the high ICN may be identified by use of a frequency selective voltmeter (FSVM). In addition, NPR tests may be conducted to further isolate the noise problem. The increased ICN may be attributable to many factors, and many tests may have to be conducted before a solution is found. Receiver quieting checks (C/kT versus baseband TTNR and/or channel TTNR), transmitter deviation, and baseband frequency response are but a few of the tests which may be required.

5-3. NPR VERSUS BASEBAND LOADING (ST-36).

a. The NPR test is a special testing technique employing white noise loading of amplifiers, transmitters, and transmission systems to determine or verify equipment and system performance. This technique is widely used in testing and evaluating wideband terrestrial links; however, its application to satellite links is somewhat limited.

b. The most common application of NPR testing normally encountered in the DSCS and other communications systems is in the testing of broadband transmission facilities. The technique may be applied in testing of radio or multiplex noise performance under various loading conditions. It is also possible to test overall system performance from audio breakout to audio breakout by use of special white noise generators designed to load individual channels of frequency division multiplex (FDM) system. The following discussion will be limited to applications in testing satellite systems looped at IF, RF, or satellite from baseband to baseband since most terminals are not equipped with NPR test sets.

c. NPR testing developed out of a need to measure equipment and transmission system performance under actual operating conditions. When a transmission system is developed, the design is based on providing a particular noise performance under maximum load conditions. Obviously it becomes impractical or impossible to test the noise performance under normal operating conditions, because the instantaneous loading is continually changing and there is no practical method by which to control the channel's activity to insure that all channels are in use simultaneously and that all levels are correct. This problem has been overcome by use of what is termed white noise to simulate a fully loaded system. White noise is random noise which has a flat power distribution across the frequency spectrum. White noise statistically has the same characteristics as a complex signal composed of a multiple number of voice and data signals. Figure 5-1 shows the difference between the peak and rms values of complex and sine wave signals. The peak-to-average value in db for a sine wave is readily calculated as 3 db (20 log 1.414). Calculating the peak-to-average value of a complex waveform is more difficult and becomes more of a statistical study. As may be seen from the figure, there are many peaks occurring at various amplitudes. The important point in determining the peak-to-average value of a complex signal is to define the percentage of time a certain level is exceeded rather than the number of peaks or the maximum peak level. In this respect it has been determined that for a peak-to-average value of 13 db, the complex signal will not exceed the specific level of 0.001 percent of the time. This is further illustrated in figure 5-2. As may be seen, the peak-to-average value of voice signals varies from approximately 19 db for one channel to about 13 db for approximately 60 channels. Data signals, however, start at 3 db for a single tone (sine wave) increasing to about 13 db at a loading of about 18 tones. White noise then can be used to simulate multichannel baseband signals for testing purposes.

d. When white noise is used to simulate a baseband signal, it must occupy the same frequency spectrum as the bandwidth of the baseband signal, and be adjusted to the design level of the system fully loaded. Figure 5-3 delineates the required levels for testing different channel capacities.

e. References in various technical publications give definitions or descriptions of NPR as:

(1) Signal-to-noise ratio in db in a particular channel or slot of the baseband of an amplifier, transmission equipment, or transmission path for some specified white noise loading condition.

(2) Intermodulation noise for some specified loading condition.

Both of the above properly describe NPR but fall far short of providing an easily understood explanation of what NPR is and how NPR test results may be used and interpreted. To obtain maximum benefits from NPR testing, a good understanding of decibels and their logarithmic function is also required.

f. Figure 5-4 shows a typical setup for white noise testing of a transmission system or components of a system to determine its NPR performance capability. The transmission system may be a complete satellite link or simply a self-test translator (STT) RF loopback of transmitters and receivers. In any case, the point of interface is the baseband input and output. As shown in the diagram, the output of the white noise generator is connected to the system or device under test through the appropriate high pass and low pass filter combination to band limit the spectrum of white noise to that of the normal baseband signal. The level of noise is then adjusted to simulate design load conditions based on the NLR formula (-1 +4 log N). At the receive station, the noise level in a 3.1-kHz slot, at the frequency of interest, is measured and used as a reference. Next, a band-reject filter is inserted into the receiver circuitry at the same reference frequency and the noise is measured again. The NPR is the difference in db between the two readings. For example, if the two readings were -16 dbm and -71 dbm, the NPR is 55 db. It is normal practice to perform this measurement at three different slots (preferably high, mid, and low) in the baseband. The level of white noise loading is also varied, usually ranging from -10 dbm0 to 10 dbm0 while operating at the maximum allowable C/kT ratio (6 db above FM threshold). The results are then drawn on a graph for analysis.

g. Another measurement that is made during the analysis of the NPR is the basic noise ratio (BNR) or basic intrinsic noise ratio (BINR). Normally, on satellite terminals, the NPR and BNR are equal. Figure 5-5 shows how BNR is measured. The slot noise is measured under loaded conditions. The noise reading becomes the reference. The white noise is removed and the remaining noise measured. If the reading with white noise is -16 dbm and the reading is -76 dbm when the white noise is removed, the BNR is 60 db. There are some NPR test sets that give measurements in terms of S/N ratio in db for a voice channel instead of NPR.

h. The question is sometimes raised as to what effect the bandwidth of the noise slot measured has on the test results. This involves what is termed bandwidth ratio (BWR) and is illustrated in figure 5-6. BWR in db is simply 10 times the log of the ratio of the two bandwidths involved. It is easily understood that if a slot that is Y-cycles wide admits a certain amount of noise then a slot 2Y cycles wide will admit twice as much noise power or 3 db more power (10 log 2 = 3 db). It is important then to know the bandwidth when determining the S/N ratio of channels, but not during NPR testing. Figure 5-7 demonstrates this fact very simply. The figure assumes a 1-kHz slot for taking measurements. If the bandwidth is widened to 2 kHz, twice as much noise is measured and the levels are 3 db higher than those measured with 1-kHz slot. The NPR remains the same because it is the difference between the two levels. The S/N of a channel, however, is another matter because the reference is made to the zero TLP, single-channel test tone (SCTT), or zero dbm0 point and the S/N's are therefore 76 and 73 db respectively. Hence the 3 db difference is due to the bandwidth of the noise slot measured.

5-4. AUDIO TEST RESULTS.

a. If the radio subsystem has been cleared as a source of problems, the audio series tests should provide further information as to an appropriate solution. In most cases, the effects of out-of-specification data is evident. However, each of the tests will be discussed briefly with emphasis placed on a few of the tests where results may require clarification and/or interpretation. Comments for each test should be provided on the test data forms and should include a comparison of measured results to the manufacturer's and/or MIL-STD specifications.

b. Idle channel noise, delay distortion, and impulse noise tests must be performed on identical channels at both ends of the link in order to obtain a more meaningful correlation of these parameters within the system.

5-5. INSERVICE CUSTOMER LEVELS (T-3).

a. This test should be performed as early in the test phase as possible since it may indicate that a complete alignment of the multiplex may be required. It may also reveal specific equipment problems that must be corrected before proceeding with the complete evaluation.

b. Proper customer levels and level discipline is essential to quality communications over a satellite transmission system. Hot levels can cause a degradation of the entire system through intermodulation products and the fact that additional satellite power may be used.

5-6. 1-kHz TEST TONE SIGNAL LEVELS (T-4).

a. This test measures and evaluates the voice signal level characteristics end-to-end across the satellite link including the multiplex and earth terminal's conditioning components. If during the preliminary testing the measurements are not within the specified tolerances, corrective action should be taken to insure that final data is accurate. Test tone levels that exceed the prescribed level may result in overloading of the baseband and intermodulation products created. In some cases, the hot levels will also cause adjacent channel crosstalk and degradation of the subscriber service.

b. In some equipment, provisions have not been incorporated for adjusting the group (GP) and supergroup (SG) levels. In such cases, only the channel and baseband levels can be adjusted. If these adjustments do not correct the level disparity at the GP and SG test points, troubleshooting of the individual circuits may be necessary to isolate the problem. In most cases, this particular situation would be indicative that changes in component values have occurred.

5-7. IDLE CHANNEL NOISE (T-8). This test measures and evaluates the degree of interference and noise introduced into a voice frequency (VF) channel. This parameter and its affect on system performance as related to the radio equipment and path have been discussed previously. Additional noise contributions and isolation procedures are discussed below.

a. Some major contributors to a high noise level in the channels are: in-station wiring, carrier leak, improper or ineffective grounding systems, and unbalanced power distribution systems. In the event the measured ICN departs from the predicted value by more than 2 or 3 db, it may be necessary to investigate all of the possible factors to isolate and correct the problem.

b. When a difference of 2 db or more exists between ICN measurements obtained using flat as opposed to C-message weighting, the cause is usually attributed to alternating current (AC) power interference. The AC power interference usually results from improper grounding or induction. Sometimes the additional noise can be attributed to carrier leak, extraneous signals, or mixing of signals which result in unwanted components falling into the VF spectrum. The first step in isolating these interfering components is to sweep the VF channel bandwidth with a wave analyzer. Audio detection will be useful in determining the type of signal being introduced.

5-8. IDLE CHANNEL IMPULSE NOISE (T-9).

a. The purpose of this test is to measure and evaluate the degree of interference being introduced into a VF channel by random impulse noise hits. Impulse noise can be introduced into a VF channel at any point in a system. It can be generated in the equipment itself, induced from powerlines or generated in the environment, and radiated into the station. Excessive impulse noise can have a detrimental affect on teletype and data circuits. If excessive impulse noise is measured during the evaluation, additional measurements should be performed at the group, supergroup, and baseband of the equipment in an effort to isolate the problem.

b. The above procedures are helpful in isolating the source of impulse noise and verifying whether the radio, multiplex, or path is the cause of the problem. If these have been eliminated as potential sources, it will be necessary to perform additional tests to determine the cause of the impulse noise. The isolation process must consider all those factors listed in paragraph 5-2 to include verification that the instrumentation is not being affected by the test connections.

5-9. VOICE CHANNEL CROSSTALK (T-18).

a. The purpose of this test is to measure the total amount of crosstalk within a voice channel from all sources and assess its impact on normal communications. Whenever crosstalk is measured in a VF channel, the test results must be analyzed and compared to the manufacturer's specifications and MIL-STD.

b. Intelligible crosstalk may be caused by an impedance mismatch in the circuit or capacitive and inductive coupling between disturbing and disturbed channels. These conditions can occur at any point in a communications system. Crosstalk can also result from improper filtering within the multiplex and maladjusted channel and carrier levels.

c. One of the first steps during the preliminary evaluation of a system or station is to isolate crosstalk entry into the network. To accomplish this, measurements may have to be performed between the various test points (TP-1 through TP-12). Once isolated to high levels, improper filtering, wiring or cabling, the team chief can then determine the necessary course of corrective action.

d. To obtain accurate crosstalk measurements, considerable attention to detail is required. Particular care must be exercised to insure the adequacy of the grounds, effectiveness of the shielding, and correctness of terminations in order to avoid ground loops and to insure that the measured data is accurate.

5-10. VOICE CHANNEL FREQUENCY RESPONSE (T-10).

a. This test, also referred to as an insertion loss and amplitude versus frequency response test, may be performed on any VF transmission path. Its purpose is to measure the amount of attenuation incurred in the path at various frequencies within the audio spectrum. This test basically measures the level of a received test signal at each of the voice frequencies of interest. The loss at each frequency is then compared to the loss at 1 kHz or some other reference frequency to determine the response of the channel under test.

b. The results of the frequency response tests are used to determine if the VF channel equipment is operating properly. When the VF channel performance has been verified, additional tests must be performed on the equalizers or ringing equipment to verify their performance in the system.

5-11. VOICE CHANNEL ENVELOPE DELAY DISTORTION (T-12).

a. The purpose of this test is to determine the relative delay time of the frequencies from 250 Hz to 3400 Hz. This is to compare the delay of the frequencies in the channel spectrum with the delay of a reference frequency (usually 2 kHz). In this way, while the absolute delay (the actual transmit time from send to receive) is not determined, the time differential across the receive audio path is measured.

b. The results of the delay measurements are used to determine whether the multiplex equipment on the path is operating properly and to ascertain if external equalizers are necessary to meet circuit parameters. When delay equalizers are installed, the test must be performed at the equalizer input and output to determine if the equalizers are operating properly.

c. On some systems, fixed type equalizers may be installed which limit onsite adjustments. On these systems, the test team should pay particular attention to the operation of the equalizers. Deterioration of components or local configuration of the equalizers may necessitate that the fixed type limits be replaced with an adjustable type.

5-12. VOICE CHANNEL PHASE JITTER (T-17).

a. This test is used to measure the incremental changes in the phase of a single frequency transmitted on a VF channel over a system. Since phase jitter has little impact on voice communications, minimum attention has been given to this parameter during earlier evaluations. Today, with the increasing use of high-speed data circuits, phase jitter has become one of the primary indicators of measuring system performance. As transmission speeds increase, data pulses become narrower with extremely short time intervals between pulses. As this happens, it is possible that the jitter would be seen as a pulse by the receiving equipment and result in message errors. This situation is highly undesirable and could have serious consequences.

b. Phase jitter on data transmissions systems can be defined as an unwanted change in the phase or frequency of the transmitted signal due to modulation products from another system or source. The modulation process that causes phase jitter may be either phase or frequency modulation depending on the source, which is generally in the terminal equipment. In multiplex units, phase jitter results from incidental phase modulation of oscillators used for frequency translation of the signals. This incidental modulation is caused by noise and line related ripple of office batteries and on power and bias supplies. It may also occur within timing circuits of FDM systems. This modulation is transferred to the multiplex signal during frequency translations and,generally, the greater the number of translations, the greater the phase jitter.

c. Measurements have indicated that for long-haul, multilink systems, the most serious components of incidental phase modulation are powerline related, both as harmonics and subharmonics of the line frequency. If excessive phase jitter is measured during an evaluation, the sources discussed above should be investigated.

5-13. VOICE CHANNEL HARMONIC DISTORTION (T-14).

a. The purpose of this test is to determine whether any appreciable nonlinearities exist within the equipment during the evaluation. The nonlinear operation of amplifiers, filters, channel modulators, or group modulators can all contribute harmonic distortion and result in degraded service.

b. Should the harmonic distortion measured during an evaluation exceed the equipment specifications, an investigation should be accomplished to determine which component is causing the problem. From past experience, it has been found that the primary cause for high harmonic distortion was attributed to the channel modulators and demodulators. High levels of harmonic distortion could influence the ICN readings taken during test T-8.

c. Analysis of the test data must include a comparison of the measured results with the equipment specifications and the applicable DCA standard. Moreover, a conclusion must be drawn as to the capability of the equipment to meet specifications and, whenever possible, a concise description of the problem along with recommended corrective action should be documented.

5-14. VOICE CHANNEL FREQUENCY TRANSLATION (T-15).

a. This test will determine whether there is a frequency error present in any of the carrier frequency oscillators of the multiplex equipment. If a carrier oscillator is off frequency, the received signal will also be shifted in frequency. Small errors of a few Hz are not noticeable on normal voice circuits, but digital transmissions are extremely sensitive to any frequency errors.

b. The send and receive frequencies are compared and the difference is stated as the frequency translation of change in audio frequency. This amount in Hz is compared to the maximum allowable change in audio frequency criterion for the circuit. Should the measurement exceed the applicable DCA standard, it will be necessary to measure and adjust the master oscillator frequency on all multiplex equipment on the link/system.

5-15. VOICE CHANNEL INTERMODULATION DISTORTION (T-21).

a. This test evaluates the intermodulation products when a two-tone signal of different frequencies is applied to the VF channel input. This test requires a higher input level than the standard -10 dbm0 test tone level; therefore, it should be performed only during nontraffic periods.

b. Since the level of the required test tone may interfere with customer service, the harmonic distortion test (T-14) will normally be used instead of T-21.

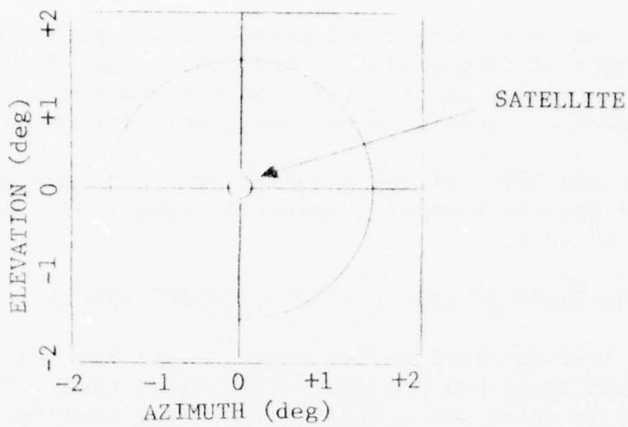
5-16. ANTENNA TRACKING AND POINTING ACCURACY (ST-1).

a. This test consists of two parts. They are the angular threshold of the tracking receivers and the -6 db offset test. The former defines the threshold at which the track receivers remain effective with respect to deviation in look angles from the actual location of the satellite. The data obtained should be reduced and tabulated on figure 6-4; USACC Form 351-R (Test) as shown in the example below:

	LOST LOCK (THRESHOLD)			REGAINED LOCK (THRESHOLD)	
DIRECTION	ANGULAR DEV (AVERAGE)	C/kT db	DIRECTION	ANGULAR DEV (AVERAGE)	C/kT db
+AZ	$+1.50^{\circ}$	44	+AZ	$+1.40^{\circ}$	51
-AZ	-1.55°	47	-AZ	-1.45°	50
+EL	$+1.20^{\circ}$	46	+EL	$+1.15^{\circ}$	47
-EL	-1.30°	45	-EL	-1.25°	44

NOTE: The angular deviation is determined by obtaining the difference in degrees from the pointing angles to the satellite and the angle at which a loss of lock or acquisition occurs. The above chart depicts average values calculated arithmetically.

b. The angular deviation at which the threshold events occurred should be graphically represented as shown below:



c. The -6 db offset test measures the servo system's ability to automatically return the antenna to the look angle of the satellite after being manually moved off the satellite to where the receive C/N density ratio decreases 6 db.

d. Most military FM satellite systems operate at a C/kT ratio that is 4 to 6 db above FM threshold. As the C/kT is varied, the TTNR varies directly, db for db. Consequently, the information attained will define the maximum allowable tracking error with respect to the threshold or TTNR requirements. The -6 db offset usually occurs before the antenna has been moved 0.5 degree in any direction from the satellite look angle.

NOTE: The tracking error should never exceed 10 percent of the -3 db beamwidth of the antenna.

e. When test results are found to be substandard the most probable causes are defective track receivers, defective servo control system, misaligned azimuth and elevation phase shifters, mechanical backlash, antenna feed assembly alignment, dirty dielguide horns, or any combination of these causes.

5-17. ANTENNA FOCUSING, BEAMWIDTH, AND SIDE LOBE (ST-2).

a. The results of this measurement will provide data related to the actual focusing of the feed assembly. If the test results are found to be substandard, the earth terminal will experience one or a combination of the following conditions:

(1) Low figure-of-merit.

(2) Excessive tracking error.

(3) Out-of-tolerance link phase distortion.

(4) Low TTNR's.

b. Substandard antenna focusing may be corrected by erecting a boresight tower and adjusting the feed assembly and/or phasers, as required, to attain in-tolerance test results. Usually, the antenna manufacturer will provide the MILDEP facility with required alignment procedures and TMDE. In most instances, the TMDE required to correct antenna focusing is not readily available to test personnel and, consequently, the problem should be addressed separately.

c. Sometimes a terminal may be operating severely below the design requirements. Therefore, as an interim measure, the team chief should employ a modified alignment procedure that uses an unmodulated signal from the satellite to readjust the feed assembly or phasers, as required, to improve the earth terminal performance. This procedure will require repeated adjustments and extensive communications outage time. When it has been determined that an alignment is required, the technical manual on the particular terminal should be consulted.

5-18. EARTH TERMINAL FIGURE-OF-MERIT (ST-3).

a. Earth terminals that fail to meet the G/T specifications will usually require excessive amounts of power in order to meet user circuit quality requirements and, subsequently, place heavy power requirements on the satellite repeater.

b. The three most likely causes of a low figure-of-merit (G/T) are the antenna gain, equipment noise temperature, and WG component power losses between the antenna feed assembly and the front end of the low noise amplifier (LNA).

c. The antenna gain is determined by its diameter and the operating frequency with the assumption being that the feed horn is properly positioned. If it is determined that the antenna gain is low, test personnel should perform adjustments on the feed assembly to achieve the required gain. Another cause for a low G/T ratio may be attributed to excessive power loss between the input to the LNA and the feed assembly. This occurs when there are severe impedance mismatches and high loss in the WG line. Lastly, excessive SNT will degrade the G/T ratio. Although several factors (line and equipment) govern the G/T ratio, the most significant and controllable cause is the poor performance of the first LNA. Normally a para-amp is employed at the earth terminal facilities.

d. Based on the above discussion, it is apparent that corrective measures required to improve the G/T ratio are limited primarily to antenna alignment, antenna maintenance, and maintaining the specified or a lower SNT.

e. In cases where the anomalies cannot be corrected in a cost-effective manner or where extensive reengineering would be required, the team chief should recommend that the uplink power levels from the distant terminals be increased or decreased accordingly. Consideration should be given to system configuration inasmuch as power adjustments on fan systems could affect the user performance levels at other stations. Furthermore, the team chief should keep in mind that the power adjustments should be made using the frequencies at which the G/T ratio was measured.

f. The team chief should reduce the measured results to arithmetic averages for each of the three RF center frequencies at which the figure-of-merit was measured. The process for calculating the figure-of-merit is outlined in the SATEP handbook; therefore, only the basic formula is shown below:

$$\frac{G}{T}\ (\text{numeric}) = \frac{8\pi K\ (Y-1)}{S_{\lambda}2}$$

$$\frac{G}{T}\ (\text{db}) = 10 \log \frac{8\pi K}{S_{\lambda}2} + 10 \log (Y-1) + 10 \log K_1 K_2$$

where:

G is gain

T is SNT

K^o is 1.38×10^{-23} Joules/^oK

S is spectural flux density of the star in W/m^2

K_1 is atomospheric attenuation respective to elevation look only in db

K_2 is correction for angular extent of Cassiopeia-A and is a function of antenna beamwidth at -3 db power points

Y is power ratio between on-star and quiet space

g. The information attained from this test should also be used to compute the system path characteristics and to compare expected noise performance levels with measured noise levels.

5-19. SNT VERSUS ANTENNA ELEVATION ANGLE (ST-4).

a. The SNT is a function of the intrinsic noise of the equipment, sky noise, atmospheric attenuation, antenna noise, and extraneous noise sources such as electromagnetic interference. The SNT usually varies inversely with the elevation look angles. The greater the elevation look angle the lower the SNT.

b. The greatest degree of latitude in controlling the SNT lies in control of the C-E components since the celestial and terrestrial sources of noise are not subject to control. The first stage of low noise amplification is normally the predominant factor. However, substandard noise temperatures of the IFLA's, down converters, poor grounds, and loose RF fields also contribute to the overall noise temperature or NF of the system. A convenient method to overcome the effects of substandard SNT is to increase the transmit power level at the distant station. However, this adjustment has a few restrictions that limit the power allocated to other terminals accessing the satellite. Therefore, it is imperative that the SATEP team identify substandard stages of amplification and initiate the necessary corrective actions required to improve the SNT. Supplement 6 to DCAC 310-70-57 and this pamphlet provide detailed procedures for measuring NF's and/or noise temperatures of downlink components. The noise temperature or NF may be measured on the individual C-E components without requiring extensive communications outages. In some cases, only the noise temperature of one or two components need be measured. The NF or noise temperature can be calculated by employing either the tandem NF or temperature formulas and transposing the formulas as required to solve for unknown values. The basic formulas are shown below:

$$\text{NF (total)} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \cdots + \frac{F_n - 1}{G_1 G_3 \cdots G(n-1)}$$

where:

F_n is the NF of the n^{th} stage

and G_n is the gain of the n^{th} stage

$$T_r = T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2} + \cdots + \frac{T_n}{n-1}$$

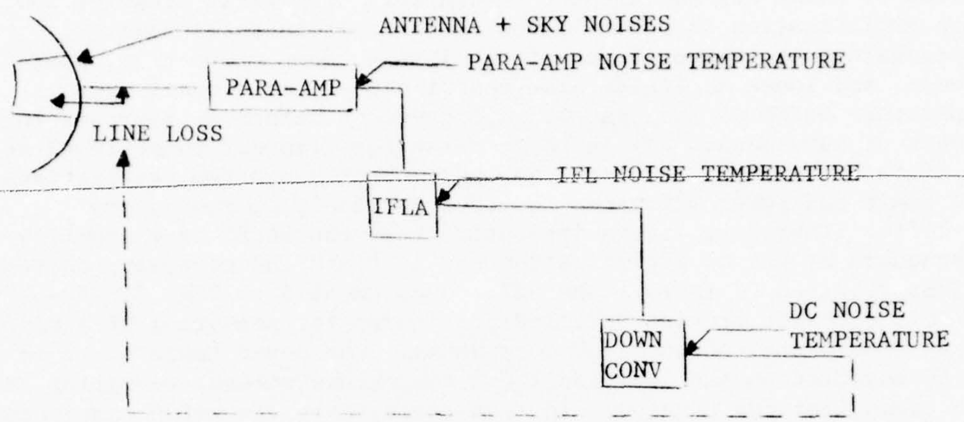
where:

T_r is composite SNT

T_n is SNT of the n^{th} stage

and G_n is the gain of the n^{th} stage

c. To further clarify this iiscussion, a diagram depicting the points where the noise temperatures may be measured is shown below:



d. The data obtained from this test may be used to calculate the threshold performance levels based on measured parameters which should be compared to the predicted threshold values. As a result of this comparison, a conclusion may be reached as to whether a module within the terminal would have to optimized.

5-20. WG RETURN LOSS OR VSWR (ST-5).

a. This test provides information concerning the magnitude of the reflected power on the transmit and receive transmission lines. The data acquired should be compared to specified performance levels. Where the VSWR is not specified, the test should be conducted with the line terminated into a standard or calibrated WG termination and with the line terminated into the equipment (normal system configuration). The test results from these two configurations should be compared with respect to frequency and the two impedances to determine if anomalies exist in the WG system.

b. Multiple problems may arise as a result of excessive VSWR on the transmit line. One problem is excessive feeder echo distortion noise. However, feeder echo distortion noise is not significant in the voice channels since thermal noise predominates on most links. The team chief should also keep in mind that other problems may arise when substantially high VSWR's are noted. These are substandard phase distortion and non-linearities that could increase the amplitude of RF intermodulation distortion products.

c. Standing waves are usually caused by discontinuities in a transmission line. These anomalies are a result of dents, bends, splices, punctures, and foreign matter within the transmission line. Most military terminals employ WG lines greater than 80 feet in length. As a result, fault location on the line could be simplified by using a time domain reflectometry test. As an alternate, fault isolation may be accomplished by performing frequency domain reflectometry or VSWR measurements at intermediate points or sections along the line. On active terminals, an authorized outage (AO) is required for troubleshooting the WG runs.

d. ST-5 measurements should be performed in conjunction with ST-6 since excessive line losses will tend to mask or obscure the ST-5 test results.

5-21. WG INSERTION LOSS (ST-6).

a. Excessive WG insertion loss may require substantial increases in uplink power to meet effective isotropic radiated power (E_{irp}) requirements and in some isolated cases may affect the receive SNT. Previous experience has shown that when the insertion loss was notably out of tolerance on the receive line, the terminal's ability to autotrack was greatly impaired along with indications of RF phase shift symptoms and increased impulse noise counts.

b. The calculated WG loss, L in db per foot, is a function of the physical characteristics, the operating frequency, and conductor resistivity as shown below:

$$L = \frac{0.01107}{a^{3/2}} \left\{ \frac{\frac{a}{2b}\left(\frac{f}{f_c}\right)^{3/2} + \left(\frac{f}{f_c}\right)^{-\frac{1}{2}}}{\left(\frac{f}{f_c}\right)^{2} - 1^{\ \frac{1}{2}}} \right\} \text{db/ft}$$

where:

f_c is frequency cutoff in MHz

f is operating frequency in MHz

a is width of WG in cm

b is height of WG in cm

NOTE: The above formula is for copper WG's. Attenuation due to dielectric loss is not considered. In order to compute loss for WG's other than copper, multiply (L) by the square root of ratio of resistivity of the new material (R_{nm}) to copper (R_{cu})

$$\sqrt{\frac{R_{nm}}{R_{cu}}} \times (L) \text{ where } R_{cu} \text{ is } 1.72 \times 10^{-6}\ \Omega/\text{cm}$$

c. Previous experience has shown that the most common causes of out-of-tolerance conditions are moisture accumulation, foreign matter in the line, misaligned WG windows and seals, loose connections, and in general, any irregularities in the uniform line.

5-22. PARA-AMP FREQUENCY RESPONSE AND GAIN (ST-7).

a. The operating condition of the para-amp will have a significant affect on the overall system noise performance of the terminal. Therefore, it is critical that the LNA (para-amp) be maintained in optimum condition. The gain of the para-amp should be held within the maximum and minimum limitations to preclude any oscillations and jitter which could become noticeable at the user VF levels. A substantially degraded gain response would affect the terminal's ability to maintain an in-tolerance figure-of-merit (G/T ratio) throughout the 500-MHz downlink bandwidth and may also degrade the VF channel noise performance levels.

b. The most common causes of low gain and frequency response are substandard pump power, pump output frequency, or misadjusted varactor bias voltages. The first stage of amplification is supercooled to provide low noise amplification. Variations in temperature may have an adverse affect on the stability of the para-amp.

c. Typical state-of-the-art para-amps are multistaged, single-pump amplifiers and are generally equipped with switches that enable maintenance personnel to bypass individual stages for analytic testing. Varactor bias, pump power, gain, and frequency adjustments are usually available to improve degraded conditions.

d. The data collected from this test will be used to identify substandard net gain or loss and net frequency response performance levels when the overall net response measurements fail to meet specifications.

5-23. PARA-AMP NOISE TEMPERATURE (ST-8).

a. This test is conducted for diagnostic purposes. The results will indicate the effect of the para-amps on the overall SNT.

b. The most common causes of excessive noise temperature are high input VSWR and failure of oven or refrigeration units. Excessive varactor bias will cause para-amp oscillations and an increase in noise temperature. In general, any anomalies that affect ambient temperature, bandwidth, and gain of the para-amp will affect the SNT.

c. Routine and preventive maintenance on the cryogenic cooling system, ovens, and alignment of the para-amps will tend to reduce the noise temperature. The input VSWR's may be improved by replacing input components and/or matching the input impedance to the output impedance of the preceding stage, that is, antenna feed assembly to input of para-amp.

5-24. PARA-AMP DYNAMIC RANGE (0.5-db COMPRESSION POINT) (ST-9).

a. This test will demonstrate the para-amp's ability to maintain a constant gain for various levels of input signal. DCAC 310-70-57 requires a minimum RF input level of -50 dbm. This signal level is significantly greater than the normal operating power level. Consequently, the dynamic range at signal levels lower than -50 dbm is usually not checked. Whenever necessary, the dynamic range below -50 dbm may be evaluated by using the attenuator substitution technique. An SHF signal generator and a calibrated attenuator are used to obtain a suitable reference display on a spectrum analyzer. The calibrated output from the signal generator should be on the order of -10 to -20 dbm. After injecting the signal into the para-amp, the attenuator is adjusted as required to reestablish the reference level.

b. When dynamic range requirements are not met, the problem is generally attributed to a defective varactor diode, improper varactor bias, or excessive pump power.

c. The dynamic range is measured at three RF frequencies: 7250, 7500, and 7750 MHz in the RF bandpass. The input and output levels of the para-amp are recorded. The difference between the two levels is equal to gain in db.

$$G = P_o - P_i$$

where:

P_o = power output in dbm

P_i = power input in dbm

d. The maximum or rated input levels are shown in the appropriate maintenance manual. At the rated or higher input level, the device under test will tend to compress the gain, resulting in very little gain.

e. This test and assessment is also applicable to field effect transistors and tunnel diodes.

5-25. PARA-AMP PUMP SOURCE POWER OUTPUT LEVEL AND FREQUENCY (ST-11).

a. This is a diagnostic test and should be performed when the gain or bandwidth is found to be out of tolerance.

b. Should the test results fall below specified performance levels, it will be necessary to adjust either the pump or Gunn oscillators IAW the manufacturer's maintenance manuals. In some cases, it will be necessary to replace or repair defective components such as klystrons and power supplies.

c. For additional information relating to the pump oscillator's affect on the varactor diode and subsequent affects on the gain of the para-amp, refer to chapter 2, TM 11-5895-903-34.

5-26. IFLA NF (ST-12).

a. The data obtained from this test may be used to determine the IFLA's noise contribution to the overall SNT. Theoretically, the IFLA noise contribution will be minimal. Therefore, this test should not be conducted unless the SNT requirements were not met and previous diagnostic tests did not reveal any conclusive results.

b. In most cases, there are no adjustments which can be made on the IFLA. Therefore, the amplifier should be replaced if it is determined that unsatisfactory service is being provided. However, power supply hum and grounding NF's are not considered sufficient reasons for amplifier replacement.

c. Based on the above, corrective measures may have to be implemented IAW appropriate maintenance manuals.

5-27. MULTIPLE FREQUENCY RESPONSE AND GAIN.

a. This paragraph pertains to the following tests:

TEST	DESCRIPTION
ST-13	IFLA Frequency Response and Gain
ST-17	Down Converter Frequency Response and Gain
ST-19	Up Converter/Exciter Frequency Response and Power Output
ST-21	Uplink IFLA and IPA Frequency Response and Gain

b. Substandard frequency response of the uplink and downlink components will have serious affects on the overall net gains, losses, and frequency response of the system. Therefore, it is essential that anomalies within each major component be corrected prior to performing the overall net gain and frequency response measurements whenever possible. It should be noted that net RF and IF phase response problems are usually apparent when the net frequency response is below minimum performance levels.

c. The two most common causes of such substandard conditions are:

(1) Excessive voltage standing waves due to mismatching of impedances.

(2) Degraded power supplies, amplifiers, and components.

d. In general, most of the uplink and downlink equipment such as the IFLA's and IPA's have no or very few adjustments that will aid in attaining in-specification conditions. Therefore, the components should probably be replaced. In cases related to the up and down conversion systems, it has been found that the majority of the problems are due to the following:

(1) Defective amplifiers.

(2) Misaligned filters.

(3) Misadjusted attenuators.

(4) Loose coaxial connections.

e. Prior to any troubleshooting effort, a visual inspection should be made to ascertain that all connections are secured. Faults can normally be isolated by employing the automatic swept frequency technique to measure the gain, loss, and bandwidth of integral modules or subcomponents of the up and down converters.

5-28. MULTIPLE VSWR.

a. This paragraph pertains to the following tests:

TEST	DESCRIPTION
ST-10	Para-amp VSWR
ST-14	IFLA VSWR
ST-15	Down Converter VSWR
ST-22	IPA VSWR
ST-23	Power Output, VSWR, and Reflectometer Calibration; and PA Frequency Response

b. VSWR tests conducted on IFLA's para-amps, up and down converters, and associated equipment are normally performed for diagnostic purposes. However, previous evaluations have shown that an excessive VSWR will have adverse affects on amplitude response and phase distortion in the system. Also, if the input VSWR on receive components is abnormal, an increase in system or equipment noise temperatures may be noted dependent upon the severity of the standing waves.

c. Therefore, the VSWR should be considered when determining and correcting system phase linearity, net frequency response, and net gain anomalies. Additional discussion on VSWR may be found in chapter 3.

5-29. DOWN CONVERTER (ST-16) AND UP CONVERTER (ST-20) SPURIOUS OUTPUT.

a. In the discussion of spurious signals, intermodulation products will be covered in a subsequent paragraph. However, it is recognized that in some cases, spurious signals and intermodulation are directly related and may be caused by the symptoms discussed in that subsequent paragraph.

b. Spurious signals may be either broadband or narrowband and their affect on the communications quality will depend on their amplitude and relationship to the frequency of the normal carrier and traffic signals. Depending on this relationship, spurious signals can result in high bit error rates (BER), impulse noise, and ICN which generally degrade the quality of service. These spurious signals may also require the use of additional terminal RF output power over and above that allocated to minimize their effects on communications quality. Since the proper management of RF output power is the key to successful satellite transmission, it is essential that spurious signals which exceed the specified level be identified and corrected. Spurious signals may also obscure receiver quieting characteristics and, in satellite communications, special frequency allocations and control measures must be implemented to avoid the affects of these signals. Unwanted signals also tend to increase the SNT. Therefore, if spurious signals are noted, the source should be identified and, corrective action taken. If corrective action is not taken, the affect that the spurious signals have on the system should be determined and appropriate recommendations provided in the final report.

c. The sources of spurious signals are divided into two categories, internal and external. Internal sources include harmonically or unharmonically related signals generated within the earth terminal equipment which, in most cases, can be controlled or reduced to an acceptable level. The external sources of spurious signals are either natural phenomena or manmade which are generated external to the earth terminal's equipment. Generally, these are: propagation conditions resulting in the reception of unwanted RF signals, ducting, rain, galactic or earth noise, and signals generated by terrestrial communications systems, factories, machinery, and powerlines. All of these sources, whether narrowband or wideband, can have a detrimental affect on the communications quality. The degree of degradation caused by these signals will depend on their amplitude, frequency, and duration. As an example of this, in the earlier days of satellite transmission, it was found that signals radiating from nearby microwave links were causing antenna tracking and noise problems which reduced the effectiveness of the satellite system. In each case, the spurious signals had to be identified and corrected before satisfactory service could be expected from the terminal equipment.

d. The magnitude of spurious signals is normally expressed in db relative to a known signal level; however, on occasion, it may be expressed in units of power. The attenuator substitution method uses a spectrum analyzer to determine the magnitudes of these signals in db.

e. The SATEP team will be responsible for pinpointing the origin of spurious signals and submitting technical recommendations to effectively reduce or eliminate these signals. Frequently, corrective measures may not be cost-effective or may be extremely difficult, at which time it will be incumbent upon the test team to evaluate the affects on the terminal's operation and recommend alternative means for nullifying the effects of the signals.

f. Previous satellite evaluations have revealed that the FM modulators and LO's in the up and down converters have produced more spurious signals than any other source within the terminal equipment. Through the proper selection of the terminal location, the affects of external spurious signals can be controlled or minimized.

5-30. DOWN CONVERTER NF (ST-18).

a. The total NF of the down converter under normal conditions is composed of the NF of the stripline mixers, IF amplifiers, and the power losses of the devices that precede the NF controlling device. These may be expressed as shown below:

$$NF_T = NF_1 + \frac{NF_2-1}{G_1} + \frac{NF_3-1}{G_1G_2} + \cdots + \frac{NF_1-1}{G_1G_2\cdots G_{NF_n}-1}$$

where:

NF_T is the composite NF

NF_n is the NF of the n^{th} stage

G_n is the NF of the n^{th} stage

b. Any attenuation or coaxial cable power losses between the noise source and the input to the down converter should be subtracted from the NF as indicated below:

$NF_{actual} = NF - (C_L + A)$

NF_{actual} = NF considering external losses (db)

NF = measured NF (db)

C_L = coaxial cable losses (db)

A = attenuation (db)

c. It was noted during previous evaluations that the NF increases substantially when the phase lock loop circuitry of the LO's are maladjusted and when the LO's are emitting spurious signals. Another factor that contributes to the total NF is the power output level of the LO's and, therefore, these should be maintained at specified levels. When substandard conditions exist, the items previously mentioned should be checked pursuant to appropriate maintenance instructions. As previously mentioned, the condition of the first mixer and amplifier will have the predominant affect on the overall NF.

5-31. PA INTERMODULATION, SPURIOUS RADIATION, AND HUM MODULATION (ST-24) AND CROSSOVER INTERMODULATION (ST-43).

a. Intermodulation distortion products result from mixing two or more signals within devices that have amplitude nonlinearities or where amplitude and phase modulation conversion occurs. Some of the significant sources of intermodulation are: antenna feed assemblies, transmit amplifiers, klystrons, loose WG connections, and overdriven amplying devices.

b. It should be noted that the magnitude of intermodulation varies with changes in carrier amplitude. However, changes in amplitude do not necessarily result in a proportional change of the intermodulation. Therefore, it will be incumbent upon the SATEP team to define the relationship of the multiple carriers, input drive level (uplink) frequencies, and the affect that each of these variables has on system operations. The team chief must submit recommendations that are required to reduce the level of the intermodulation.

c. The intermodulation may be detected and measured by using a spectrum analyzer, and employing the attenuation substitution technique to measure the amplitude and magnitude of the intermodulation with changes in carrier levels. Measurements should be taken when the device under test has saturated power output levels of 3, 6, and 9 db below the rated level. These measurements will show the carrier-to-intermodulation frequency relationship and the amplitude-to-carrier relationship. This information will establish the basis for determining the maximum allowable carrier drive level and the number of carriers to be used at a terminal. The above discussion is directed toward uplink equipment. The intermodulation distortion products, present on the downlink, are generated at the satellite, at the distant terminal's transmitters, or at the crossover from the transmit end of the antenna feed assembly. Often, these are third order intermodulation products which may be present in the usable downlink frequency spectrum.

d. Intermodulation distortion products will be noticeable at all terminals tested that use multiple carriers. However, the levels should not exceed specified tolerances. If it is determined that devices such as traveling wave tube (TWT) PA's, klystrons, or loose WG connections are producing high intermodulation distortion products, those devices should be replaced or corrected as required. In some instances, alignment or tuning may improve conditions.

e. Intermodulation distortion products resulting from amplitude and phase modulation conversion should be reduced to a minimum by restricting the level of amplitude modulation that is produced from the FM modulator (normally in the order of -40 db). These products are common to nonlinearities in phase-lock loop detectors and other FM derivative circuitry. The test team must insure that nonlinearities are noted and corrected, and that the frequency gain response levels of the transmitters are within specified tolerances.

5-32. FM MODEM DEVIATION, DEVIATION LINEARITY, DISPERSION, AND FREQUENCY RESPONSE (ST-31).

a. The FM deviation and linearity measurements are two of the most important tests made during the SATEP evaluation. Substandard performance levels will probably affect the VF users and may also limit the terminal's capabilities.

b. When FM deviation is properly adjusted, the noise performance of the system will be optimal with respect to thermal and intermodulation noise. This phenomena will be explained in greater detail.

c. The modulator input level (M_i in dbm0) at which the carrier null occurs is a function of the peak FM deviation (ΔF in kHz) and the recommended rms SCTT deviation ($\Delta SCTT$ in kHz) as follows:

$$M_i = 20 \log \frac{\Delta F}{\Delta_{SCTT} \sqrt{2}}$$

d. The peak FM deviation may be calculated from the n^{th} order Bessel function (J_oN) and the highest modulating frequency (F_m in kHz) as follows:

$$\Delta F = 0.608 \, J_oN \, F_m$$

e. The value of J_oN may be extracted from the Bessel function tabulated below:

J_o1	2.405	J_o6	18.071
J_o2	5.520	J_o7	21.212
J_o3	8.654	J_o8	24.352
J_o4	11.792	J_o9	27.493
J_o5	14.931	J_o10	30.635

f. The constant 0.608 is based on CCIR parameters for pivot frequency. As an example, for a 24-channel system, F_m will be 108 kHz. For first carrier null:

$$\Delta F = 0.608 \, (2.405) \, 108$$

$$= 157.768$$

In this particular example, the ΔSCTT taken from the manufacturer's specification is 125 Hz rms. The modulator input level for first carrier null on this 24-channel system is then:

$$M_i = 20 \log \frac{157.768}{125\sqrt{2}}$$

$$= -0.988 \text{ dbm0}$$

If the zero dbm0 input level to the modulator is -20 dbm, the first carrier dropout should be at a level of -20.988 dbm0.

5-33. FM DEMODULATOR IF BANDPASS CHARACTERISTICS (ST-32).

a. If the bandpass characteristics, bandwidth, and frequency response of the IF filters are substandard, they will generally have adverse affects on the overall noise threshold and intermodulation distortion within the system.

NOTE: Substandard frequency response does not always affect the phase delay.

b. Theoretically, the noise threshold degrades logarithmically as the bandwidth of the filter increases. That is, if the bandwidth is doubled, the noise threshold of the system would degrade by 3 db. To overcome this degradation, the transmit power at the distant station would have to be increased by 3 db which levies heavier power requirements on the satellite. Conversely, if the bandwidth is decreased, the noise threshold would improve. However, reducing the bandwidth while the distant station maintains a constant FM deviation ratio may result in an increase in phase distortion which subsequently results in lower noise power ratios. The minimum IF bandwidth (B_{IF} in MHz) that is required on any given system is determined as follows:

$$B_{IF} = 2\,\Delta F + f_m$$

where:

ΔF is the frequency deviation in MHz

f_m is the highest modulating baseband frequency in MHz

c. The degraded condition of the IF filter may be improved by employing the swept frequency technique and tuning the filter as required to attain in-tolerance results. After alignment and prior to returning the system to normal operating condition, the NPR test should be performed to insure that the system is optimized. Should the NPR's fail to meet the required levels, the delay and linearity of the filter must be measured. Accordingly, adjustments of the delay equalizers may be required to obtain in-tolerance test results. Due to error introduced by detectors, delay test sets, and test cables, the NPR's should be remeasured following this adjustment. To assist team personnel in performing delay and linearity measurements, a procedure has been extracted from DTM 11-5895-796-34-1 and included in this discussion.

d. The affects that the alignment will have on the overall noise threshold of the system under test may be determined by performing C/kT versus TTNR or NPR measurements. The curve obtained from these measurements will indicate the FM threshold. The measured FM threshold will then be compared to the calculated value.

NOTE: This procedure should be implemented when all other C-E equipment that could affect the threshold is operating at specified performance levels or better.

e. Any change in the measured IF bandwidth from specifications will have a direct affect on the threshold level. For example, on a 24-channel system the typical IF bandwidth is 2.1 MHz. If the actual measured bandpass was 2.9 MHz, the increase in bandwidth will result in a degradation in threshold level as indicated:

$$\text{Change in } T_{FM} \text{ (db)} = 10 \log \frac{\text{measured IF bandwidth}}{\text{predicted IF bandwidth}}$$

$$= 10 \log \left(\frac{2.9}{2.1}\right)$$

$$= 1.4 \text{ db}$$

NOTE: The AGC circuitry of the IF amplifiers cause misloading measurements and invalidate the test results. Therefore, the AGC circuitry should be disabled or the test signal should be injected at a power level at which the AGC circuitry has virtually no affect.

EXTRACT FROM DTM 11-5895-796-34-1

Group Delay Equalization (70 MHz only)

a. Connect the test equipment to the IF bandpass filter module as shown in figure ST-32-1.

b. On the transmission generator, make the following control settings:

CONTROL	SETTING
Mode	BB + Sweep
IF Frequency (MHz) Coarse	70
IF Frequency (MHz) Fine	0
BB Frequency (kHz)	500
Deviation (kHz RMS)	200

c. On transmission generator, set the ATTENUATION (dB) pushbuttons to provide 4.0 dB attenuation.

d. On the demodulator display, make the following control settings:

CONTROL	SETTING
Display	IF
Marker Offset (MHz)	2.9 (72 channels)
	2.1 (48 channels)
	1.7 (36 channels)
	1.3 (24 channels)
Calibration (dB)	1

e. On the demodulator display, adjust IF LEVEL attenuator pushbuttons to zero the IF/BB LEVEL meter.

f. On the group delay detector, make the following control settings:

CONTROL	SETTING
BB Frequency (kHz)	500
Demod Input	INT
Delay Output	Normal
Ret Loss/Ref/Delay (rear panel)	Delay

g. On group delay detector, adjust SET LEVEL control until PHASE LOCK/LEVEL meter indicates in green zone.

h. Set DELAY CALIBRATION (ns) control of group delay detector to 1.

i. The group delay of the 70 MHz IF bandpass filter module shall be as follows:

72 channels	less than 40 ns	2.9 MHz bandwidth
48 channels	less than 60 ns	2.1 MHz bandwidth
36 channels	less than 80 ns	1.7 MHz bandwidth
24 channels	less than 120 ns	1.3 MHz bandwidth

These figures are based on 60 percent of the 3 dB bandwidth. Adjust circuit elements, if necessary, to obtain this value. No equalization is required in 10.7 MHz filters. (Refer to figure ST-32-2, part J for 36 channel presentation).

REPAIR: In general, there are no special techniques required to repair this module. Standard techniques of soldering and unsoldering electronic parts are required. The IF bandpass filter circuit card assembly provides mounting for all circuit components, except connectors J1 and J2. The circuit card itself is mounted in the module casing using 4L-brackets. Module covers are mounted on 5 hexagonal posts and fastened by cross-slotted screws.

PrecedING Page BLANK - FILMed

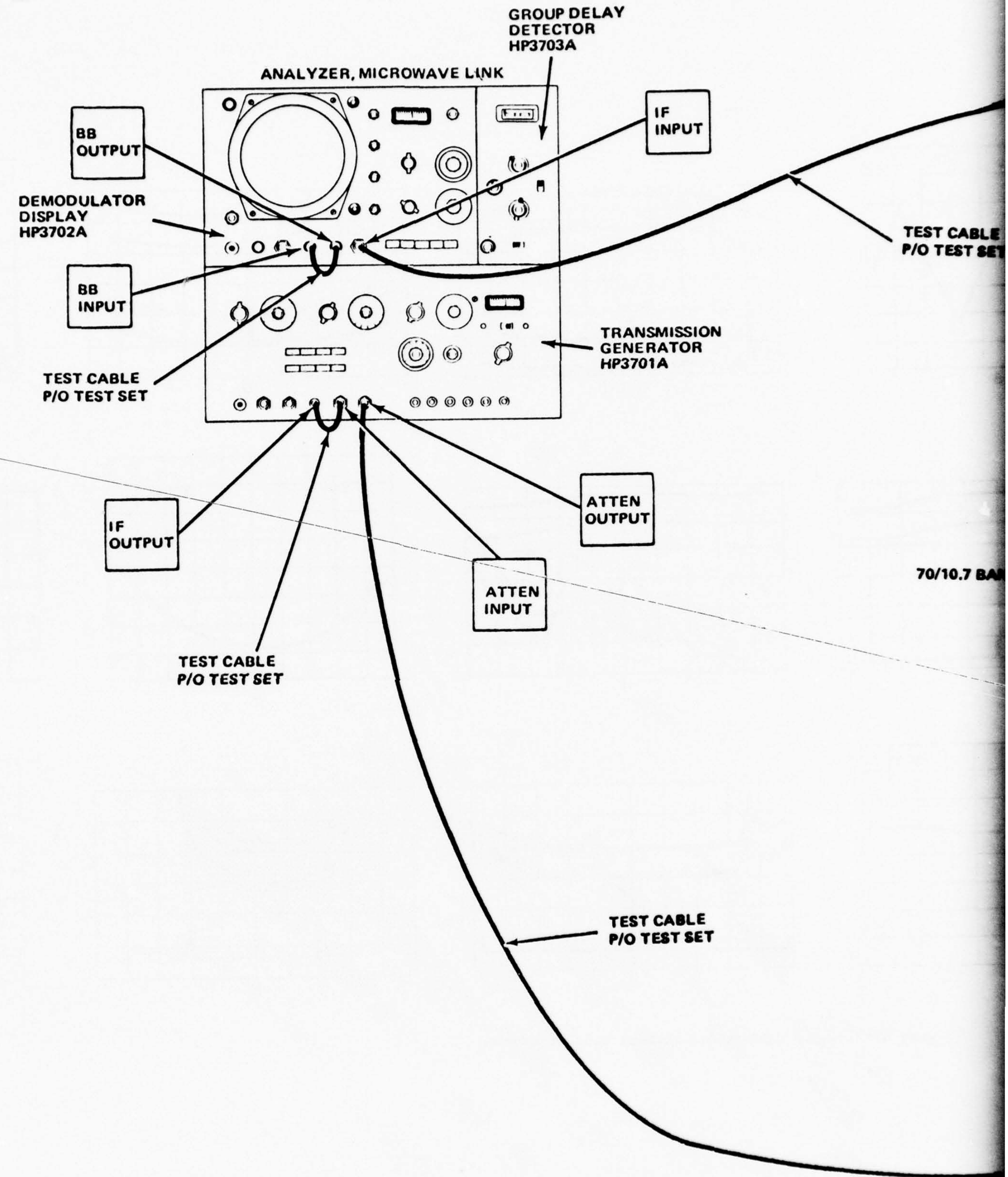
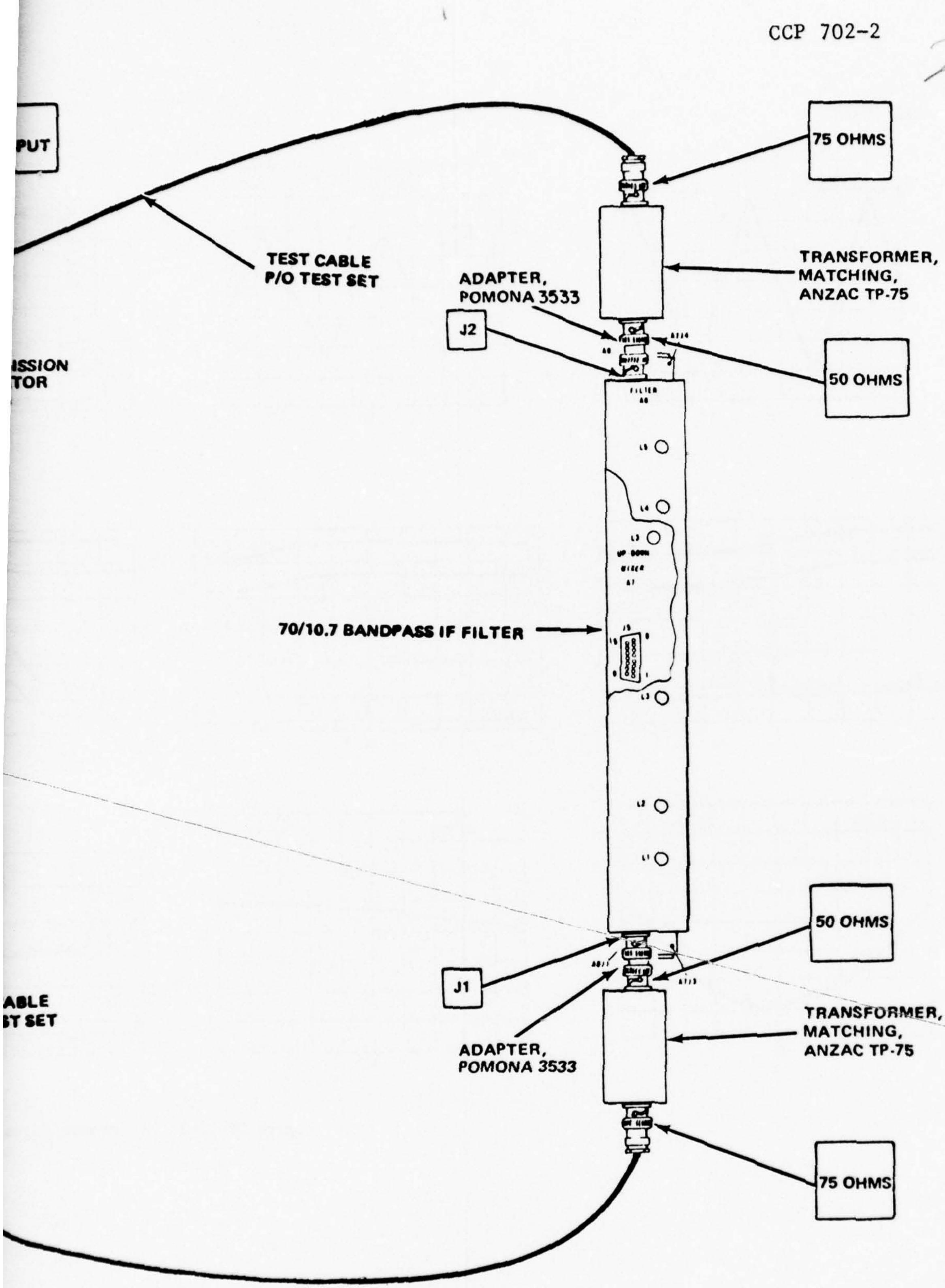


Figure ST-32-1. IF baseband filter group delay, test equi

2



filter group delay, test equipment setup.

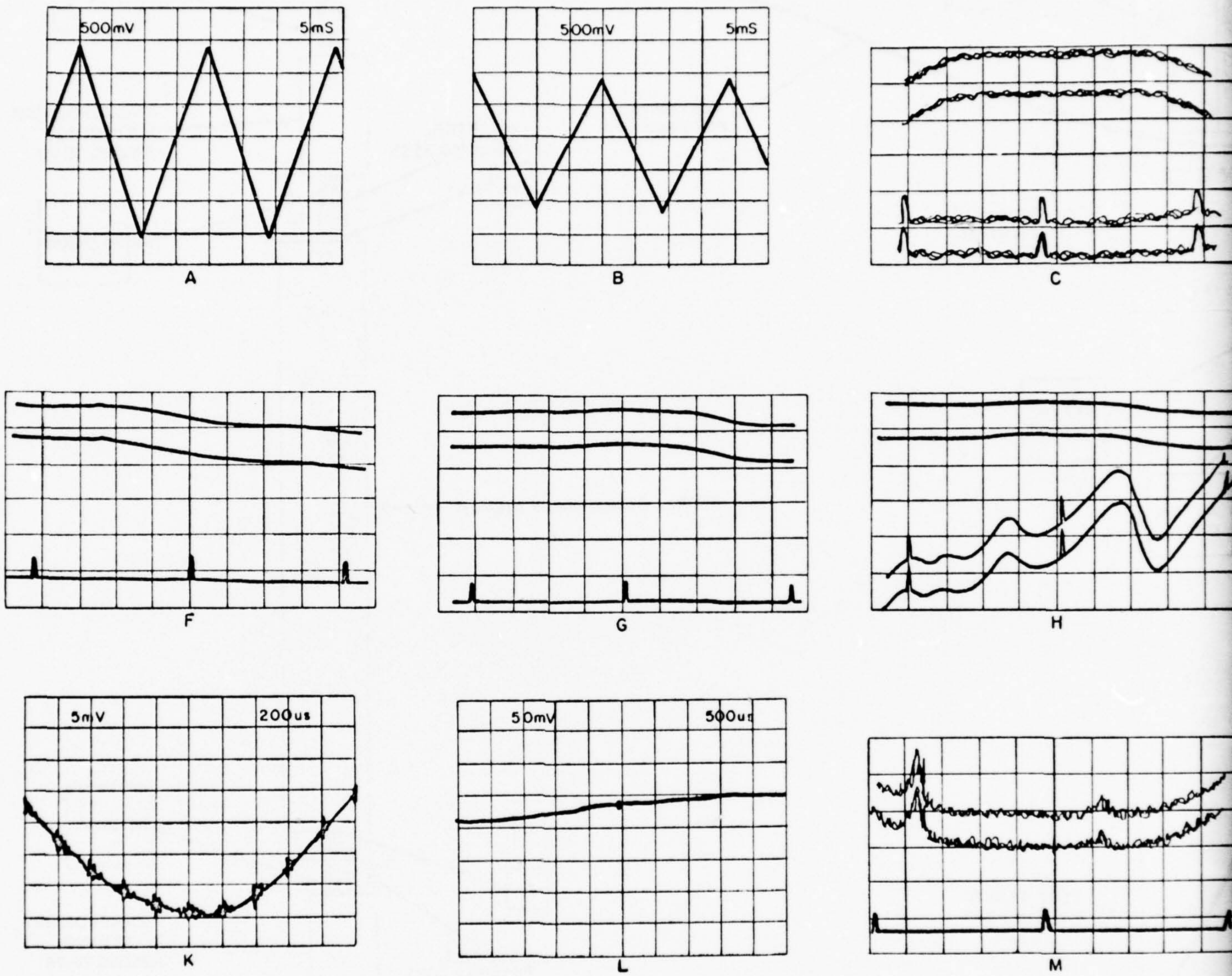
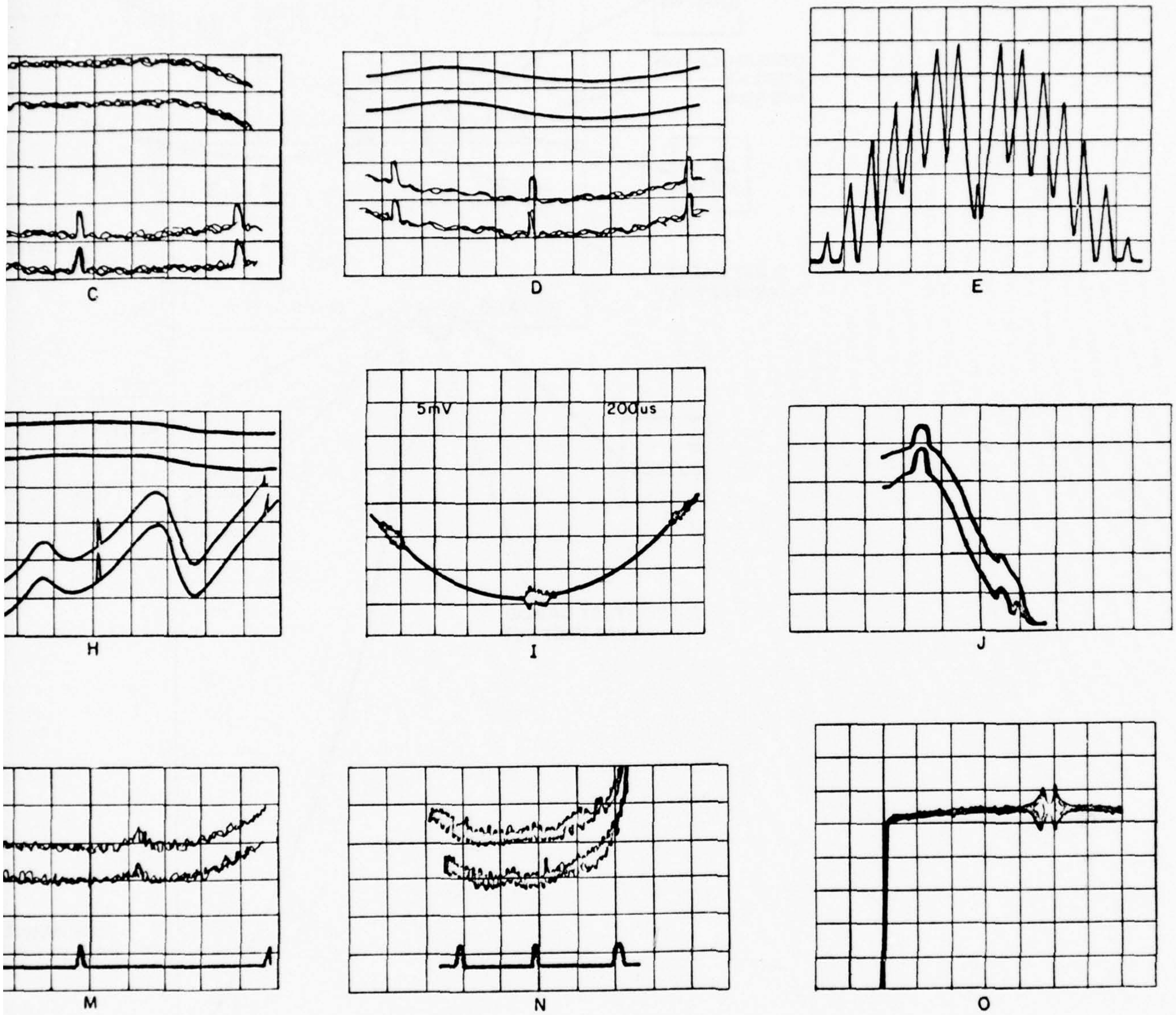


Figure ST-32-2. Alignment/adjustment test waveforms.

2



adjustment test waveforms.

5-34. TTNR AND IDLE NPR VERSUS C/kT RATIO (ST-34).

a. The performance of an earth terminal is determined by its ability to provide quality communications to the users. The key factor used to indicate this quality of performance is the TTNR versus the C/N referred to as 1-Hz bandwidth (C/kT). The TTNR refers to a baseband slot of 3.1 kHz or a nominal voice channel. Measurements are made of both the loaded and idle channel TTNR as C/kT is varied. The resulting data is compared to calculated values in order to provide the basis for technical recommendations.

b. The key quality factor, TTNR or S/N ratio, as a function of C/N or C/kTB may be expressed as:

$$S/N = C/kTB + 20 \log \frac{\Delta F}{F_m} + 10 \log \frac{B}{B_{CH}} + I_{im}$$

where:

ΔF is the peak FM deviation in kHz

F_m is the highest modulating frequency in kHz

B is the IF bandwidth in Hz

B_{CH} is the channel bandwidth (nominal $3.1X10^3$ Hz)

I_{im} is the emphasis improvement in db (nominal 4 db)

c. For a given system, the last three parameters listed above are essentially constant. Therefore, the S/N will depend almost entirely on the value C/kTB. This ratio may be further simplified for a given system to C/kT since the B or IF bandwidth will be constant. It is important to determine the S/N for an operational value of C/kT which is some value above FM threshold. This operating point is typically 6 db above the FM threshold of the terminal. This threshold may be calculated from the product kTBF where:

k is Boltzmann's constant or -198.6 dbm

T is the ambient temperature in $^{\circ}$K or for 290°K 24.6 db

B is the IF bandwidth in Hz

F is the NF obtained from the SNT

d. A typical value for SNT of 175°K will yield an NF (F) of 2 db. For a 24-channel system with an IF bandwidth of 2.1 MHz or 63.2 db, a typical noise threshold would be -198.6 dbm + 24.6 db + 63.2 db + 2 db or -108.8 db. This would represent a calculated value. The actual FM threshold should be 10 db higher than the noise threshold and, using this example, would occur at -98.8 dbm. If the measured FM threshold coincided with our calculated value, the operating point would be about 6 db above this level or -98.8 dbm. The S/N obtained for this value will be the key performance factor. An S/N of about 40 db may be expected.

e. In actual testing, the range of receive C/kT will be established (typically 3 db below to 6 db above FM threshold which is considered 10 db above noise threshold) and the uplink power will be adjusted to obtain the desired receive C/kT ratio. The TTNR's in the high, mid, and low baseband slots should then be measured and the results compared to calculated values.

f. No consideration has been given to nonlinear noise generated by intermodulation distortion. This type of noise results when the amplifiers are overloaded, when severe discontinuities exist in the WG, or when RF or IF spurious signals are present.

g. Generally, in earth terminals, the effects of intermodulation distortion cannot be detected because of masking due to predominating noise. In any event, it will be incumbent upon the SATEP team to determine the source of the excessive noise when TTNR's are found to be substandard and when all RF C-E components have met specified performance levels.

h. It has been found that the best way to make such a determination is to measure the baseband noise in a given channel noise slot and to see whether the noise level compares favorably with the calculated value. If they do, the multiplex equipment and coaxial cables located between the FM modem input and output points and the multiplex equipment input and output points may be the cause for the degraded channel performance. The source of radio noise is usually determined by making the TTNR measurements with the system looped back through the RF and/or IF equipment. Consideration should be given to actual power level required to attain the desired C/kT ratios to preclude any compensation for equipment abnormalities.

i. The plot of the NPR as a function of the baseband loading of a satellite station provides useful information concerning the composite effects of thermal noise and intermodulation noise for various levels of baseband loading. The maximum NPR is achieved when the thermal and intermodulation noise components are equal as shown in figure 3-6. The corresponding baseband loading at this crossover point is considered the optimum. Since the calculated baseband loading is usually a fixed value for a given system, it may be necessary to achieve the ideal operating point by shifting the composite NPR curve. This may be accomplished by changing the modulation index and by decreasing or increasing the deviation ratio. However, this is not usually accomplished on active earth terminals.

j. The NPR's are measured at the predicted loading level (-1 +4 log N) to ascertain optimum noise performance of the equipment. Ideally, this test should be performed at both the FM threshold and at the operating C/kT level.

k. The data obtained from this test may also be used to calculate the TTNR's which may then be compared to predicted values and used as a basis for diagnostic information. The noise as a result of intermodulation distortion may be defined as follows:

$$S/N\ (db) = NPR + 10 \log \frac{B_{Bw}}{B_{wc}} - NLR$$

where:

NPR = noise power ratio (db)

B_{Bw} = baseband width in Hz

B_{wc} = bandwidth of voice channel (3100 Hz)

NLR = noise loading factor based on -1 +4 log N (dbm0)

l. The data obtained from the 48-hour recordings of baseband traffic levels should be compared to data obtained in this test to insure that actual baseband traffic levels are commensurate with design standards.

m. The most common cause of substandard conditions are improperly deviated FM modulators or noise contribution from other sources. Additional information on NPR and baseband loading is contained in paragraph 5-3 and chapter 3 respectively.

5-35. FM MODULATOR POWER OUTPUT AND FREQUENCY ACCURACY (ST-37).

a. The FM deviation should be centered at 70 MHz to insure that it is linear within the -3 db points of the distant end IF bandpass filter. If the deviation pattern is found to be in the nonlinear portion of the IF bandpass, excessive distortion will probably result in degraded performance to the subscribers. Therefore, it is imperative that the output frequency of the FM modulator remain within specified tolerances.

b. Substandard conditions are usually attributed to misadjusted deviator modules, defective AGC circuitry, improper B+ voltage supplies, and excessive baseband loading traffic levels.

c. The power output level is not as critical as frequency. However, intermodulation distortion products may be generated when excessively high power levels exist at the input to the up converters. Low output levels are normally coupled with an increase in the output noise floor which may result in lower uplink C/kT levels.

d. Power output level anomalies are generally attributed to a substandard deviator and/or 70-MHz PA modules.

5-36. SPREAD SPECTRUM MODEM (ST-39).

a. Only a limited amount of discussion is provided on this test since any information concerning the operational characteristics of antijamming is classified.

b. Previous evaluations have shown that inaccurate measurements result when other stations are accessing the satellite at the same frequency. Therefore, test personnel should insure that no other station has access to the satellite during the performance of this test. It was also noted that error rates generally increase when operating the C/kT ratio close to threshold. Therefore, for evaluation purposes the BER measurements should be made in 1-db steps from 6 db above threshold to 2 db below. Timing circuits and threshold controlling devices are usually the cause of substandard conditions.

c. For additional information relating to advantages and operation of spread spectrum systems and equipment, consult the training document prepared by the manufacturer under government contract.

5-37. WIDEBAND (DIGITAL) MODEM (ST-38).

a. The most common cause of excessive error counts is high thermal noise within the system. Therefore, in order to provide specified user performance levels, it is imperative that a phase shift keying (PSK) system operate at or above the specified C/kT level. Other sources that would degrade the quality of communications are phase distortion in C-E components, amplitude nonlinearities, IF feed over from the keyer to receiver, poor ground systems, and defective coaxial cables. Also, if timing circuits fail, the system will normally experience an increase in error rates.

b. A discussion on the PSK system bit error performance as extracted from DTM 11-5820-803-12 is quoted below. This discussion applies specifically to the Digital Data Modem MD-921/G.

EXTRACT FROM DTM 11-5820-803-12

CODING/DECODING OPTIONS

a. The transmission of digital data over a satellite communications link typically results in random errors in the data sent to the digital user from the PSK Modem receiver. These errors are primarily caused by the noise inherent in the satellite link. The performance of a digital communication link is generally measured in terms of the average bit error rate at the digital output of the link. Average bit error rate is determined by dividing the number of bit errors occurring in a large number of bits by the total number of bits in the sample. The resulting number is the probability of error associated with each bit. For example, if it is determined that 40 errors have occurred in a total of 10,000 bits, the average bit error rate (or bit error probability) is 40/10,000 or 4×10^{-3}.

b. The bit error rate produced by a satellite communications link is a function of the data rate and the signal-to-noise ratio present at the PSK Modem receiver input. If a noise bandwidth equal to the bit rate is always used as a reference, the bit error rate as a function of signal-to-noise ratio (E_b/N_o) for any data rate can be shown on one curve (figure ST-39-1). As shown in figure ST-39-1, if only differential coding is used, the signal-to-noise ratio (E_b/N_o) required to obtain a low bit error rate is higher than that required to obtain the same error rate with the internal or external coder. For example, if a digital user requires an error rate equal to or less than 1×10^{-5}, the minimum signal-to-noise ratio (E_b/N_o) needed to support this requirement using only differential coding is +9.8 db. If internal coder/decoder is used, the signal-to-noise ratio required is reduced by 2.7 dB to +7.1 dB. If an external Viterbi coder/decoder is used, the signal-to-noise ratio required is further reduced an additional 2.6 dB to +4.5 dB.

c. The requirement for use of error correctin (correction) coding equipment is determined by several factors. These factors are the signal-to-noise density ratio (C/kT) provided by the communications link, the implementation loss of the PSK Modem, the data rate, the bit error rate required by the digital user, and the link margin required. To aid in understanding how these factors enter into the determination, consider the case in which a digital communications system must support a 50 kb/s digitized voice link. The link margin required is 1.0 dB, and the digital user needs a worst-case bit error rate of 1×10^{-3}. The signal-to-noise density ratio (C/kT) provided by the system, which is determined by the earth terminal figure of merit, geographical location at the terminal, implementation losses of the terminal equipment, and power capability or allocation of the satellite, must first be determined. Further assuming that analysis of the system indicates an available C/kT of 57.1 dB-Hz, the effective C/kT may than (then) be determined by subtracting the link margin and the PSK Modem implementation loss as follows:

Effective C/kT = System C/kT - (Link Margin + PSK Modem Implementation Loss)

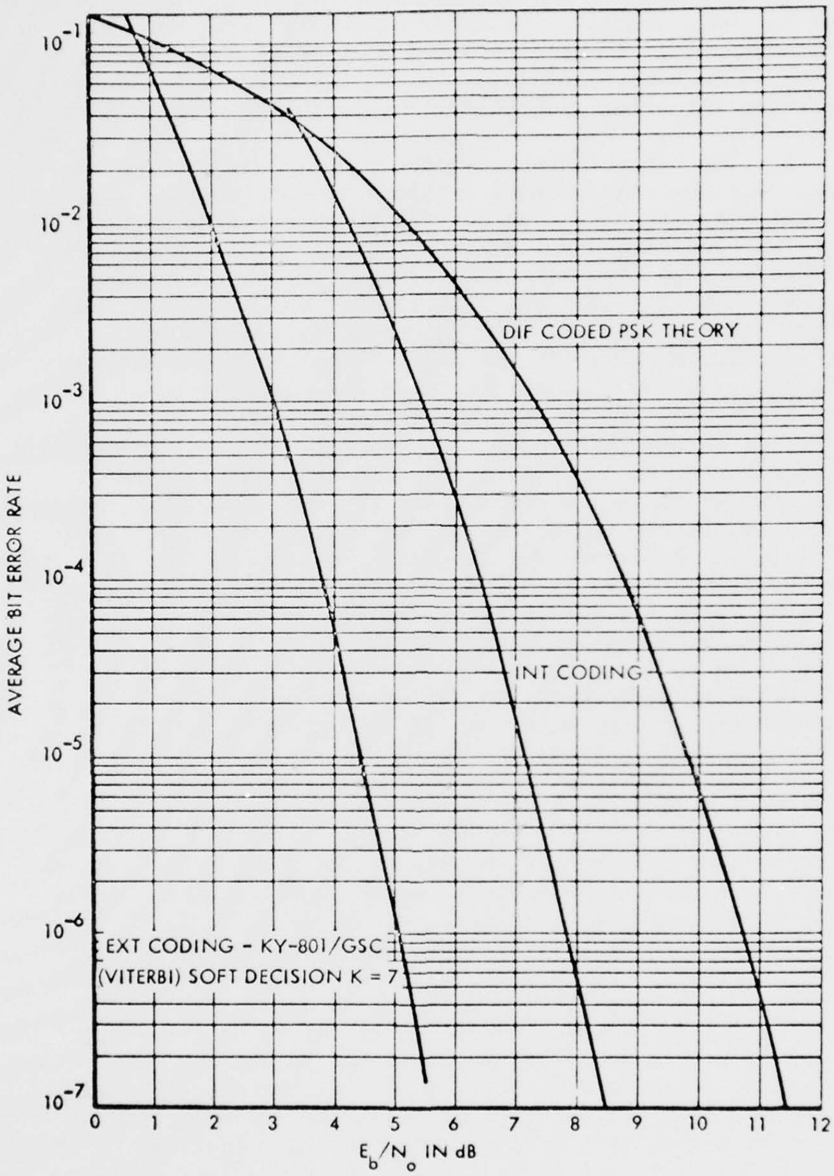


Figure ST-39-1. PSK modem theoretical bit error rate performance for various coding configurations (best case performance).

Effective C/kT = 57.1 - (1.0 + 1.1) = 55 dB-Hz .

Knowing the data rate (50 kb/s), the equivalent signal-to-noise ratio (E_b/N_o) referenced to a noise bandwidth equal to the data rate (R_D) can be determined from the formula:

E_b/N_o = C/kT - 10 Log R_D

This function is plotted for convenience in figure ST-39-2. The resulting E_b/N_o is +8 dB. As shown in the performance curves of figure ST-39-1, the PSK Modem operating only with differential coding will provide an error rate of 4×10^{-4} at E_b/N_o = 8 dB. Error-correcting coding would therefore, not be required to provide a bit error rate of less than 1×10^{-3}.

d. However, should the digital user require a minimum bit error rate of 1×10^{-5} instead of 1×10^{-3}, operation with differential coding only would not provide an acceptable bit error rate. In this case, using the internal coder/decoder would result in an acceptable bit error rate of 4.4×10^{-6} as indicated in figure ST-39-1.

e. Assuming that the digital user's data rate is changed to 100 kb/s, that he still requires 1×10^{-5} maximum bit error rate, but the satellite will not support any increase in the C/kT, then the following situation exists. Operating with the same link parameters, the resulting E_b/N_o from figure ST-39-2 (for an effective C/kT of 55 dB and a data rate of 100 kb/s) is now 5 dB. Referring to the performance curves of figure ST-39-1 the resulting error rates for the various options are:

(1)	Differential coding only	1.2×10^{-2}
(2)	Internal coder/decoder	4.3×10^{-3}
(3)	External Viterbi coder/decoder	1.3×10^{-6}

Therefore, the only option which satisfies the requirements is the use of an external Viterbi coder/decoder.

5-38. FREQUENCY SYNTHESIZER INTERNAL FREQUENCY STANDARD (ST-40) AND LO MULTIPLICATION CHECK AND POWER OUTPUT (ST-41).

a. The frequency synthesizers provide time bases to attain the required radio frequency local oscillator (RFLO) and intermediate frequency local oscillator (IFLO) stability. This stability and accuracy minimizes translation error since any significant translation could adversely affect the noise performance of the system. BER's on digital systems and impulse noise counts may become excessive at the VF user level under degraded conditions.

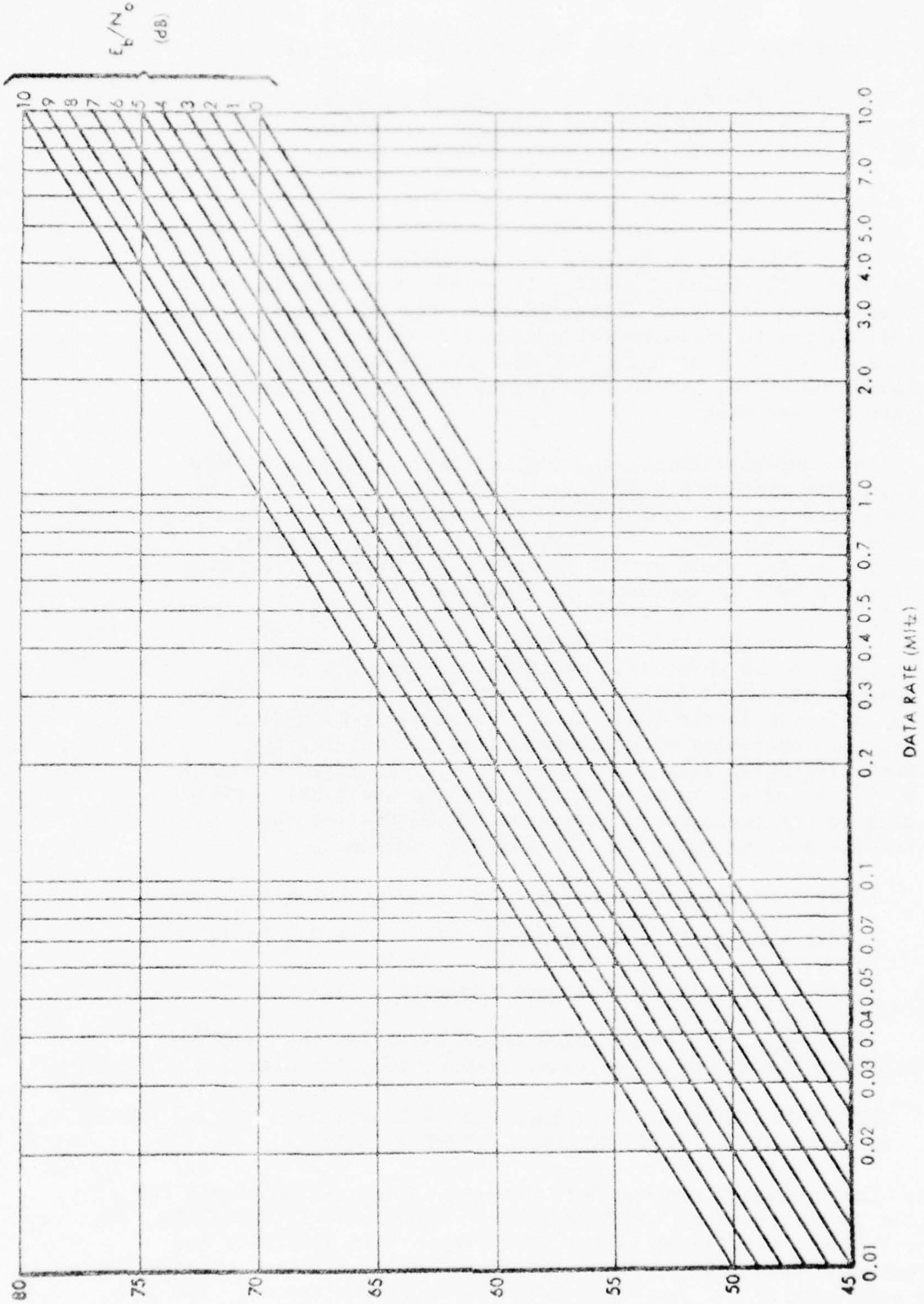


Figure ST-39-2. E_bN_o = C/kT - 10 log R_D

b. The primary cause of frequency error is faulty synthesizers and/ or phase lock loop circuitry on the IFLO's and RFLO's. In some instances, the abnormal conditions may be attributed to poor grounding or AC power instability.

c. The synthesizer output is multiplied 50 times and phase-locked to the RFLO while a 10-MHz time base is provided to stabilize or phase-lock the IFLO. The RFLO is normally 700 MHz below the assigned channel while the IFLO provides a 630-MHz signal which is added or subtracted, depending on the system, from the 70-MHz IF signal.

5-39. DISPERSION GENERATOR RANGE AND THRESHOLD LEVEL (ST-46).

a. The results of this test will provide SATEP personnel with information relating to the operation of the dispersion circuitry.

b. In essence, the dispersion generator operation holds constant the amount of intermodulation distortion in a baseband channel under low traffic loading conditions. Intermodulations that result from multicarrier operation and extraneous sources mix with other modulated carriers and their resultant carriers are sometimes seen as signals in the baseband. The dispersal generator insures that the system is always operating under properly loaded conditions, thereby canceling out the peak carriers or dispersing them so that the effects of the RF intermodulation products may be considered as flat baseband noise. A secondary purpose is to maintain a constant deviation ratio based on -1 +4 log N which should provide the optimum noise performance levels for varying baseband traffic levels.

c. Improper dispersal operation normally results in extraneous carriers that may be measured in the baseband and, in turn, will interfere with operation of selected baseband channels. When improper dispersal operation is found, the cause can generally be attributed to the frequency of the modulating sawtooth waveform, improper dispersal threshold adjustments, or low dispersion output levels.

CCP 702-2

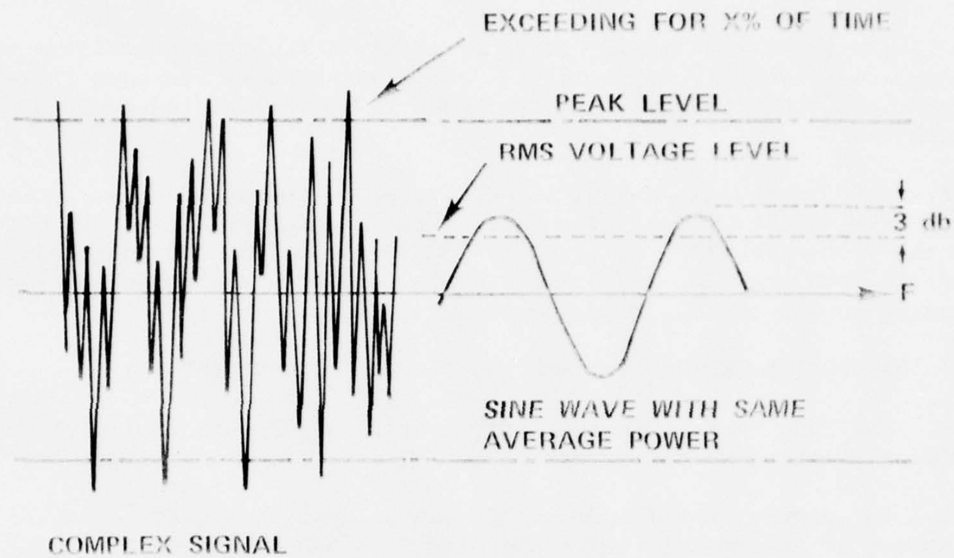


Figure 5-1. Peak/rms measurements.

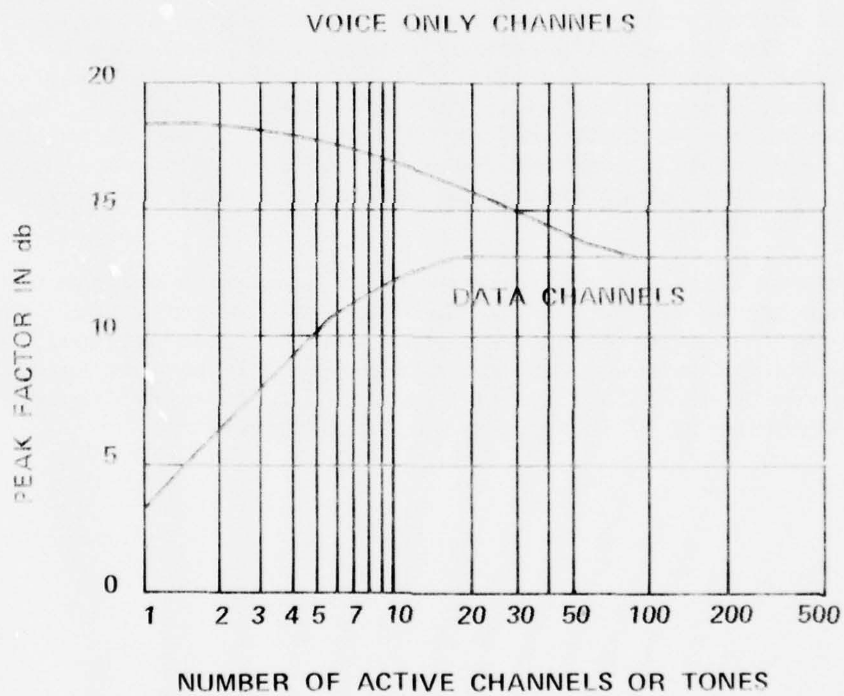
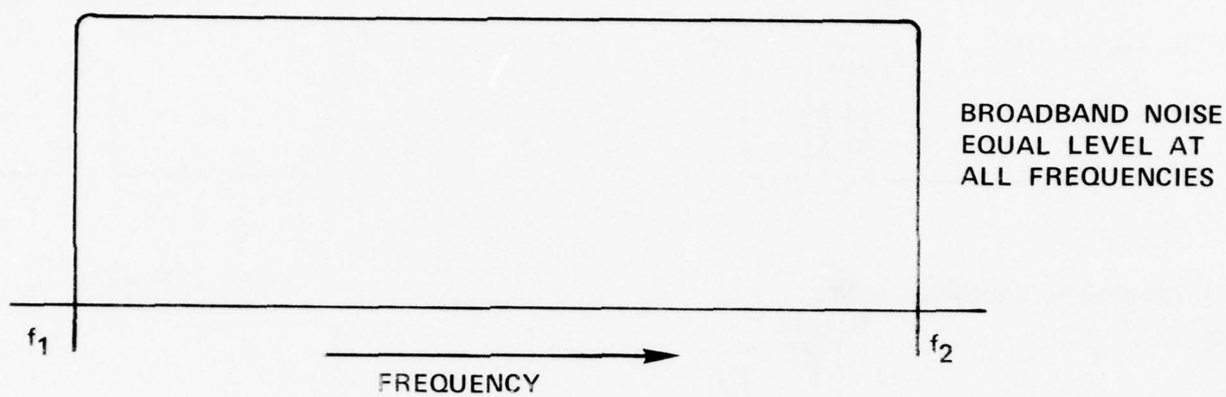


Figure 5-2. Peak-to-average values.



NLR = −1 + 4 LOG N   N < 240

CHANNEL CAPACITY	LOADING LEVEL (dbm0)
3	0.9
6	2.1
12	3.3
24	4.5
36	5.2

Figure 5-3. White noise loading -- NLR.

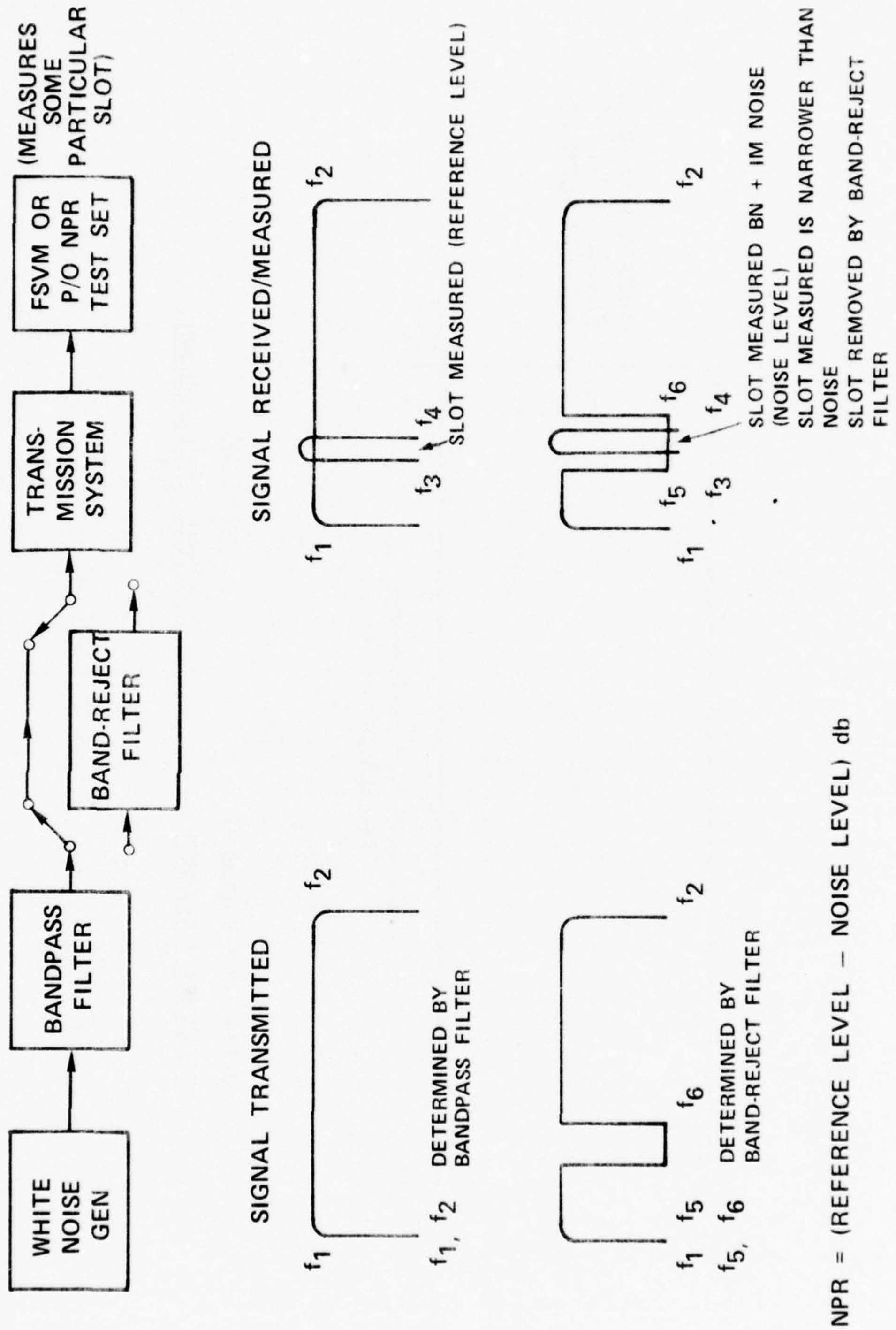
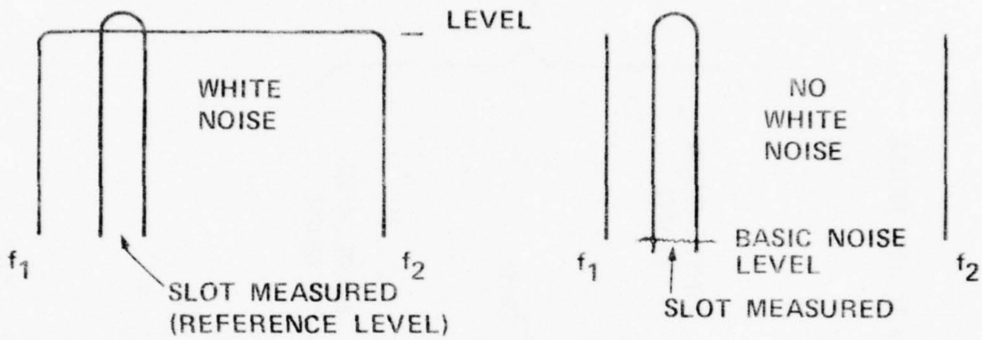


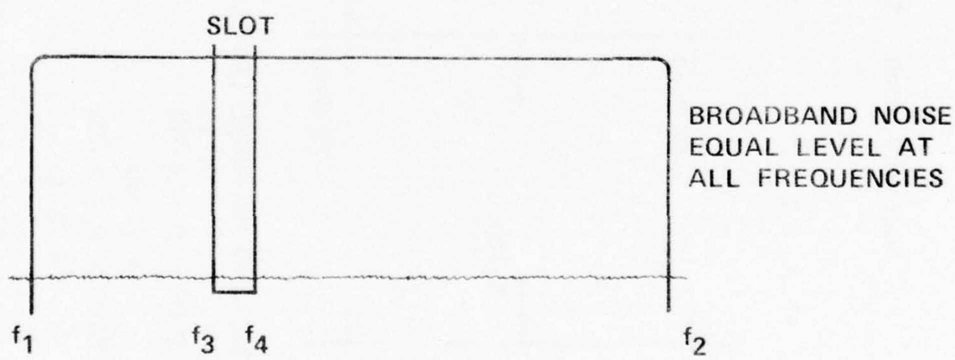
Figure 5-4. NPR test configuration.

RATIO OF NOISE IN A TEST CHANNEL WITH ALL CHANNELS LOADED TO THE NOISE PRESENT WITH NO LOADING



BNR = (REFERENCE LEVEL – BASIC NOISE LEVEL) db

Figure 5-5. BNR/BINR measurement techniques.



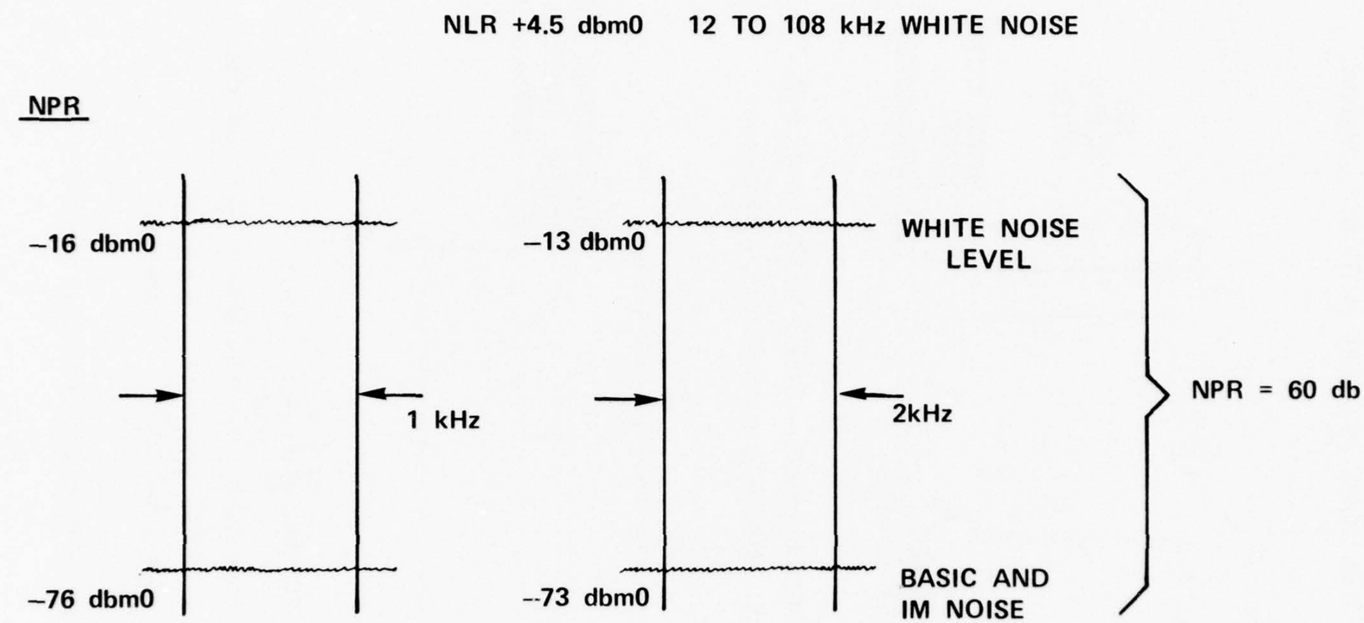
$$\text{BWR} = 10 \text{ LOG } \frac{f_2 - f_1}{f_4 - f_3}$$

NLR = +4.5 dbm0 $\quad f_1 = 12$ kHz $\quad f_2 = 108$ kHz

SLOT = 3.1 kHz

$$\text{BWR} = 10 \log \frac{108 - 12}{3.1} = 14.9 \text{ db}$$

Figure 5-6. BWR measurement techniques.



S/N 0 – (BASIC AND IM NOISE LEVEL)

1 kHz SLOT = 0 – (–76)
= 76 db

2 kHz SLOT = 0 – (–73)
= 73 db

Figure 5-7. Slot bandwidth -- NPR and S/N.

CHAPTER 6

ANTENNA TRACKING AND POINTING ACCURACY (ST-1)

6-1. GENERAL.

a. The purpose of this test is to evaluate the satellite earth terminal's ability to autotrack the satellite and to determine the angular threshold of the tracking receivers.

b. This test will be conducted on each tracking receiver, as applicable. In order to minimize communications outage time, the test personnel should insure that the para-amps, tracking receivers, tracking down converters, and all other equipment that would adversely affect the receiver tracking threshold capability meet the minimum performance specifications.

c. This is an out-of-service test and requires an AO.

6-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

6-3. TEST EQUIPMENT REQUIRED.

a. Frequency selective voltmeter.

b. Crystal mixer.

c. Signal generator.

d. Coupler.

e. Frequency counter.

6-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 6-1. Tune the beacon signal down converter to the appropriate beacon frequency.

b. This test will determine the angular difference to the right of, to the left of, above, and below the satellite over which the track receiver is effective.

c. Measure the beacon C/kT ratio while autotracking the designated satellite.

d. Manually track the satellite.

e. Without changing the elevation look angle, manually adjust the antenna azimuth in a clockwise direction until a loss-of-lock condition exists. Measure and record the beacon signal C/kT ratio and the deviation in degrees in reference to the original azimuth angle reading. Slowly adjust the antenna in a CCW direction until lock is regained. Record the angle and beacon C/kT on figure 6-2; USACC Form 410-R (Test).

f. Repeat paragraph 6-4e nine more times.

g. Manually adjust the antenna in a CCW direction without changing the elevation look angle until a loss-of-lock condition exists. Measure and record the deviation in degrees in reference to the original azimuth angle and the beacon C/kT ratio. Slowly adjust the antenna in a clockwise direction until lock is regained. Record the angle and beacon C/kT on figure 6-2; USACC Form 410-R (T_{est}).

h. Repeat paragraph 6-4g nine more times.

i. Manually adjust the antenna to the orignal azimuth and elevation look angles.

j. Without changing the azimuth look angle, adjust the antenna in the UP direction until a loss-of-lock condition exists. Measure and record the beacon C/kT ratio and the deviation angle in reference to the original elevation look angle reading. Adjust the antenna in the downward direction until the system has regained lock. Record the angle and beacon C/kT on figure 6-2; USACC Form 410-R (Test) and repeat nine more times.

k. Manually adjust the antenna to the orignal azimuth and elevation look angles and repeat paragraph 6-4j in the down direction ten times.

l. Tune the beacon signal down converter to a communication downlink signal that is frequency modulated with voice channels. This signal must be transmitted from another terminal that shall be in the autotrack mode for the duration of this test.

m. Repeat paragraph 6-4 c through k and record the test data on figure 6-2; USACC Form 410-R (Test).

n. Tune the beacon down converter to the beacon signal frequency and measure the beacon C/kT ratio.

o. Autotrack the designated satellite repeater and record the azimuth and elevation look angles on figure 6-2; USACC Form 410-R (Test). Manually track the satellite repeater and increase the elevation angle until the beacon C/kT decreases 6 db. Record the elevation angle on figure 6-2; USACC Form 410-R (Test).

p. Autotrack the designated satellite repeater. Measure and record the azimuth and elevation angles on figure 6-2; USACC Form 410-R (Test). Manually track the satellite repeater and increase the azimuth angle until the beacon signal C/kT decreases 6 db. Record the azimuth angle on figure 6-3; USACC Form 411-R (Test).

q. Autotrack the designated satellite repeater. Measure and record the elevation angle on figure 6-3; USACC Form 411-R (Test). Manually track the satellite repeater and decrease the elevation angle until the beacon signal C/kT decreases 6 db. Record the elevation angle on figure 6-3; USACC Form 411-R (Test).

r. Autotrack the designated satellite repeater. Measure and record the azimuth angle on figure 6-3; USACC Form 411-R (Test). Manually track the satellite and decrease the azimuth angle until the beacon signal C/kT decreases 6 db. Record the azimuth angles and deviations on figure 6-3; USACC Form 411-R (Test).

s. Repeat paragraphs 6-4 o through r five additional times.

t. Autotrack the designated satellite and record the azimuth and elevation look angles on figure 6-3; USACC Form 411-R (Test).

u. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

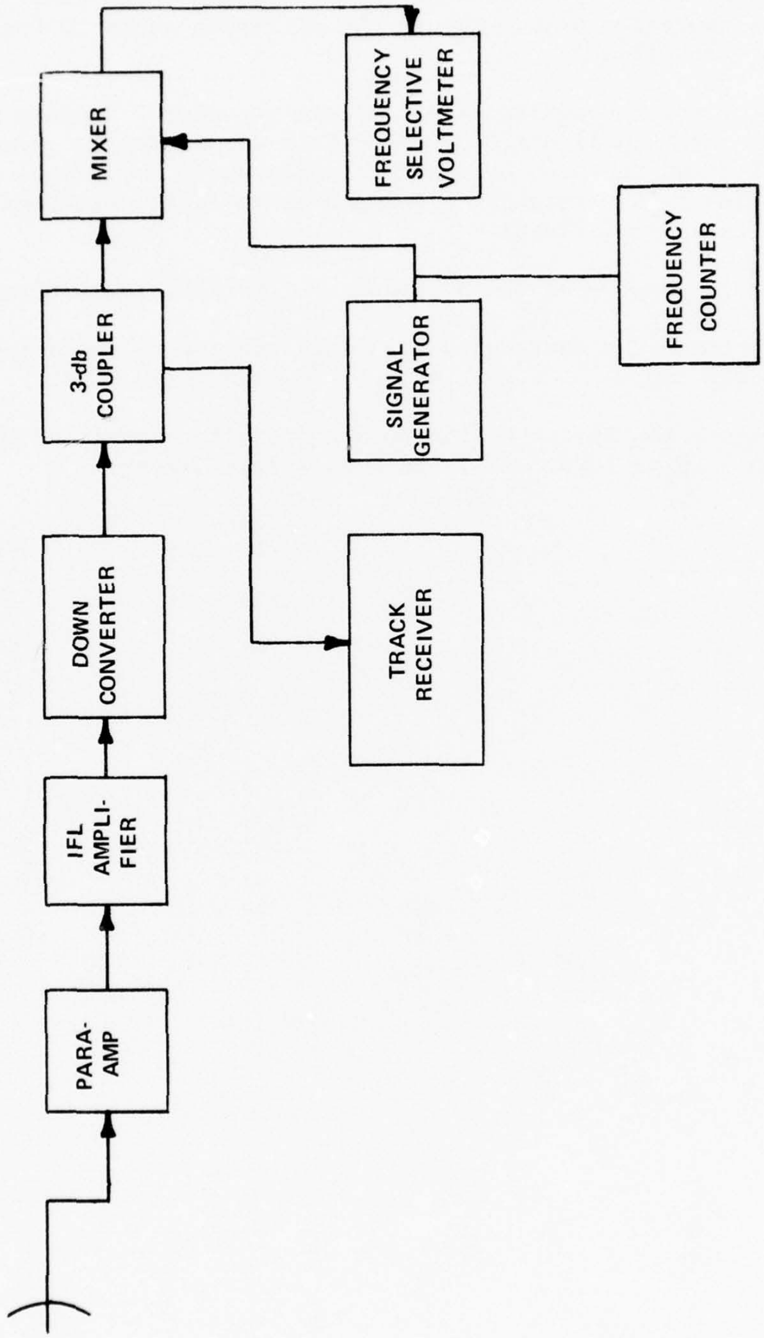


Figure 6-1. Tracking and pointing accuracy measurement test configuration.

SATELLITE ACQUISITION AND TRACKING CAPABILITY (CCR 702-1-3) DATA SHEET					PAGE OF PAGES			
TERMINAL ID		DOWN CONVERTER			DATE (DAY, MONTH, YEAR)			
SATELLITE ID		SATELLITE MODE			WIND VELOCITY			
PRECIPITATION		TIME Z	PRETEST BEACON C/kT		☐ COMM SIG TRACK ☐ BEACON SIG TRACK			
☐ AZ ☐ EL	LOST LOCK				REGAIN LOCK			
TEST RUN NO.	C (dbm)	kT (dbm–Hz)	C/kT (db–Hz)	Δ ANGLE (deg)	C (dbm)	kT (dbm–Hz)	C/kT (db–Hz)	Δ ANGLE (deg)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
COMMENTS								
TYPED NAME, GRADE, AND TITLE					TEST ENGR SIGNATURE			

USACC FORM 410-R (TEST)
1 MAY 77

Figure 6-2. Satellite acquisition and tracking capability data sheet.

ANTENNA TRACKING AND POINTING ACCURACY (CCR 702-1-3) DATA SHEET		PAGE OF PAGES
TERMINAL ID	SSN	DATE (DAY, MONTH, YEAR)
COMM C/kT	BEACON C/kT	SATELLITE ID
WIND VELOCITY	CHANNEL CAP	AZ LOOK ANGLE deg
EL LOOK ANGLE deg	TYPE BEACON	VF CHANNEL NO.

TEST RUN NO.	TIME (Z)	ANGLES (°)		-6db OFFSET		DEVIATION (deg)	TEST TONE
		AZ	EL	AZ	EL		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 411-F (TEST)
1 MAY 77

Figure 6-3. Antenna tracking and pointing accuracy data sheet.

TEST COVER PAGE	☐ PRELIMINARY ☐ FINAL	DATE
DATA SHEET		

FACILITY TESTED	DISTANT FACILITY
THROUGH FACILITIES:	
TEST PERFORMED: ☐ AS SPECIFIED IN TEST PROCEDURES	☐ WITH MINOR MODIFICATIONS ☐ WITH MAJOR MODIFICATIONS (Explain below)
COMMENTS	
STANDARDS/SPECIFICATIONS	

TEAM LEADER CERTIFICATION		
NAME (Typed)	GRADE	SIGNATURE

USACC FORM 351-R (TEST)
1 OCT 76

Figure 6-4. Test cover page data sheet.

Preceding Page Blank - NOT FILMED

CHAPTER 7

ANTENNA FOCUSING, BEAMWIDTH, AND SIDE LOBE (ST-2)

7-1. GENERAL.

a. The purpose of this test is to measure the antenna focusing and beamwidth at the -1 and -3 db power points, and the relative (main lobe) amplitude of the side lobes.

b. This is normally an out-of-service test and therefore requires an AO.

c. Misalignment in the antenna focusing normally would reduce the G/T ratio of the terminal and could increase the tracking error and/or crosstalk, resulting in subsequent excessive channel impulse noise counts, BER, and degraded TTNR.

7-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

7-3. TEST EQUIPMENT REQUIRED.

a. Signal generator.

b. Power meter.

c. Mixer.

d. Frequency counter.

e. Frequency selective voltmeter.

7-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 7-1. Tune the down converter to the frequency of the beacon signal.

b. Tune the FSVM for 500 kHz at a bandwidth of 3.1 kHz.

c. Tune the signal generator to 70.5 MHz as read on the frequency counter at an output power level of zero dbm. Adjust the frequency control on the FSVM until a peak indication is obtained at 500 kHz.

d. Fine tune the azimuth and elevation controls until a peak indication is obtained on the FSVM.

NOTE: It may be necessary to retune the FSVM for a peak indication.

e. Record the azimuth and elevation look angles indicated on the synchro readout on figure 7-2; USACC Form 412-R (Test).

f. Rotate the azimuth of the antenna in a clockwise direction until the peak indication on the FSVM decreases by 1 db. Monitor the angle as indicated on the synchro readout and subtract the original azimuth look angle from the angle in which the signal amplitude decreased by 1 db. Record the difference between the two angles on figure 7-2; USACC Form 412-R (Test).

g. Continue to rotate the antenna in a clockwise direction until the peak indication on the FSVM decreases by 3 db. Observe the angle indicated on the synchro readout and subtract the original azimuth look angle from the angle at which the signal amplitude decreased by 3 db. Record the difference between the two angles on figure 7-2; USACC Form 412-R (Test).

h. Continue to rotate the antenna in a clockwise direction until a second peak indication is displayed on the FSVM. Record the amplitude of the side lobe in reference to the amplitude of the main beam on figure 7-2; USACC Form 412-R (Test).

i. Repeat paragraphs 7-3 d through i, while rotating the antenna in the CCW, up (increase elevation), and down (decrease elevation) directions.

j. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

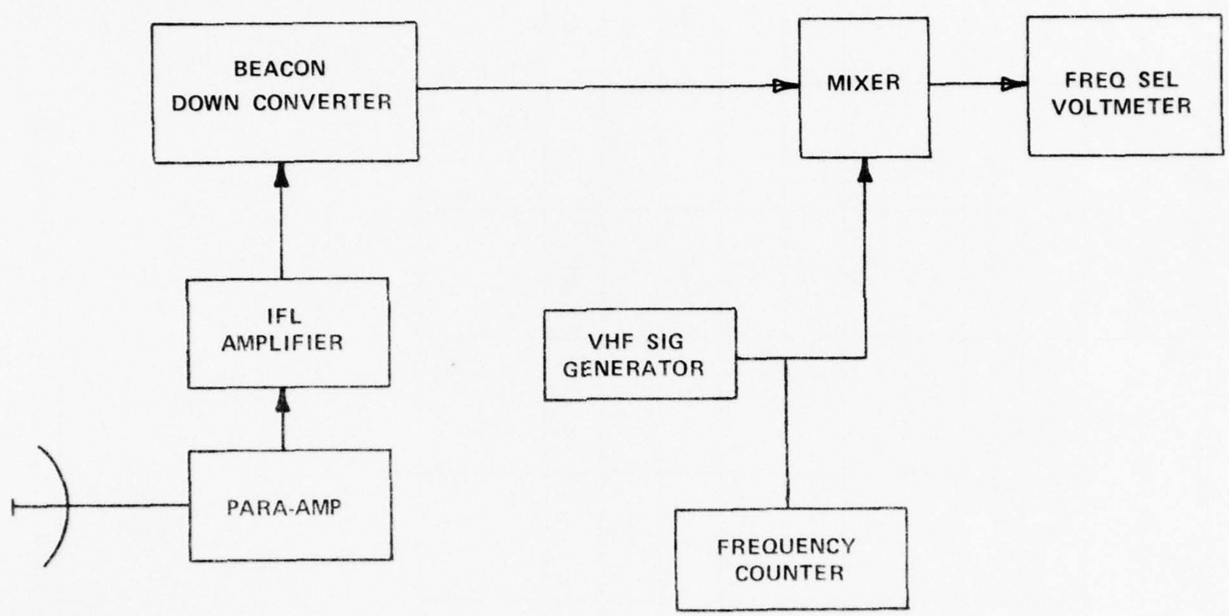


Figure 7-1. Antenna focusing, beamwidth, and side lobe test configuration.

ANTENNA FOCUSING, BEAMWIDTH, AND SIDE LOBE (CCR 702-1-3) DATA SHEET							PAGE OF PAGES
LINK NO.		TERMINAL ID				DATE (DAY, MONTH, YEAR)	
AZ LOOK ANGLE deg				EL LOOK ANGLE deg			
FEED TYPE				PEAK INDICATION db			
BEACON FREQUENCY MHz				C/kT			
CLOCKWISE		COUNTERCLOCKWISE		UP		DOWN	
DEVIATION		DEVIATION		DEVIATION		DEVIATION	
db	ANGLE	db	ANGLE	db	ANGLE	db	ANGLE
−1.0		−1.0		−1.0		−1.0	
−2.0		−2.0		−2.0		−2.0	
−3.0		−3.0		−3.0		−3.0	
−4.0		−4.0		−4.0		−4.0	
−5.0		−5.0		−5.0		−5.0	
−6.0		−6.0		−6.0		−6.0	
SIDE LOBE (db)							
COMMENTS							
TYPED NAME, GRADE, AND TITLE				TEST ENGR SIGNATURE			

USACC FORM 412-R (TEST)
1 MAY 77

Figure 7-2. Antenna focusing, beamwidth, and side lobe data sheet.

CHAPTER 8

EARTH TERMINAL FIGURE-OF-MERIT (ST-3)

8-1. GENERAL.

a. The purpose of these procedures is to measure the figure-of-merit (G/T) of a satellite earth terminal. These procedures are applicable to the AN/FSC-78, AN/FSC-79, AN/MSC-60, AN/MSC-46, AN/FSC-9, and AN/TSC-54.

b. Those terminals having a G/T of less than 30 db will employ the sun as a known source of celestial energy. Terminals having a figure-of-merit greater than 30 db will use the supernova remnant, Cassiopeia-A, as a calibrated source of celestial energy.

c. The procedures require that the antenna be pointed ON and OFF the signal source in order to obtain the Y-factor which is used to calculate the actual figure-of-merit.

d. An alternate method is to transfer the G/T from a calibrated terminal to an uncalibrated terminal involving the satellite as described for the AN/TSC-54.

e. Terminology used in these procedures are:

(1) ON-STAR -- where the antenna is pointed at the celestial object used for the noise source.

(2) OFF-STAR -- any antenna orientation, except that which is on the radio star. Cassiopeia-A is considered off-star.

(3) QUIET ZONE -- at the operational frequencies of the terminal, the entire sky, except regions of certain radio stars, is a quiet zone and can be used for measurement of sky noise. The movement of the antenna of approximately 1 degree off-star, Cassiopeia-A, is adequate to achieve the quiet zone.

f. These tests must be performed under ambient conditions of pressure, temperature, and humidity. The sky should be clear and the radome dry.

g. Personnel performing these tests must exercise normal precautions in connecting and using electrical test equipment.

h. A selected amount of tutorial data has been included in these procedures to aid in accomplishing the data collection and review.

8-2. SPECIFICATIONS.

a. The test data obtained during these tests shall be compared to the performance limits delineated in appendix B. The appropriate manufacturer's literature and the technical manual should also be consulted when comparing the test data to the specifications.

b. Paragraph 3.2.1.3a of SC-SS-1001 defines the minimum terminal G/T figure-of-merit for the AN/FSC-78, AN/FSC-79, and AN/MSC-60 as:

$$G/T = 39 \text{ db} + 20 \log \frac{F}{7.25 \text{ GHz}}$$

where:

F is the test frequency in GHz

8-3. TEST EQUIPMENT REQUIRED.

a. SNT meter and driver.

b. DC power supply.

c. Smoothing filter.

d. Strip chart recorder.

e. SNT meter HP-344A (BITE) as applicable.

f. SNT meter HP-340A (BITE) as applicable.

8-4. G/T MEASUREMENTS FOR THE AN/FSC-78, AN/FSC-79, AND AN/MSC-60.

a. This test will be performed following alignment of the equipment IAW the alignment instructions contained in the instruction manual. In particular, the para-amp performance should be optimized prior to conducting this test. This measurement will be performed at previously tuned frequencies on existing subsystem units.

b. The noise temperature monitor will be used to accomplish this test. Disconnect the cable at the back of the console at 14A22J10. Connect the output of the down converter at the IF patch panel to this jack.

c. The variable attenuators in the noise temperature monitor unit must be calibrated. This calibration data will be noted for reference purposes.

d. The normally accepted method of obtaining G/T includes determining the NF by attenuator substitution which in this test provides a measurement resolution of approximately 0.1 db. Since the change in noise level between on-star and off-star measurements is approximately 1 db, the measurement resolution needs to be expanded to increase the measurement accuracy. By calibrating the step attenuators, the measurement resolution can be interpolated to 0.02 db.

e. Ephemeris data is required for Cassiopeia-A, the test data, and the coordinates of the antenna location. This data can be obtained from the Air Force Satellite Control Facility, Sunnyvale, California.

f. Insure that both receive para-amps are properly aligned before beginning the test. Select the receive para-amp (IFLA) and down converter series to be tested and switch the antenna to the para-amp input.

g. Place the scanner in the random mode (not bypass).

h. Select an up converter, and place the transmitters in the combined mode. The transmitters will radiate at full power with a single carrier during this test.

i. Allow the equipment to warm up at least 30 minutes.

j. Check the on-line receive subsystem on the spectrum display to verify that no extraneous interfering carriers are present within the 40-MHz passband at the test frequencies. It may be necessary to change the test frequency to avoid such interfering carriers.

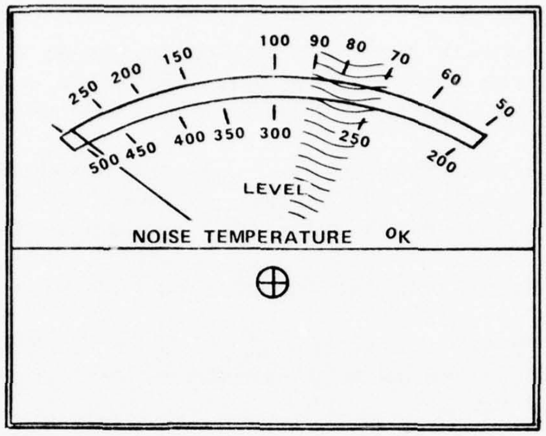
k. The LOW EL/REFL DR XMIT LIM SW must be jumpered to perform this test (SM-F-715415).

l. The following steps are used for determining the Y-factor.

(1) Configure the test equipment as illustrated in figure 8-1. Tune the down converter to 7.275 GHz.

(2) Tune up converter #1 to 8150 MHz and switch to on-line. With both transmitters operating at rated power, select the combined mode and switch the output to the antenna.

(3) The mode switch on the noise temperature monitor should be in MANUAL OFF. With the antenna pointing away from the star in a quiet zone, adjust the noise temperature monitor meter sensitivity so that a 1-db increase in system noise deflects the meter needle at least 15 percent of full scale. Adjust the attenuator or the REFERENCE ADJUST on the noise temperature monitor meter to position the needle so that the deflection falls into the area of the meter as depicted below by the shaded region. Insure that the noise temperature monitor has at least 1.5 db of attenuation in use. Record this attenuation on figure 8-2; USACC Form 413-R (Test).



NOISE TEMPERATURE MONITOR METER

(4) Manually adjust the antenna to the radio star and mark the maximum meter reading on the face of the meter using a felt tip pen, and record the maximum value for use in the next step.

(5) Move the antenna off the star to a quiet zone. Immediately decrease the attenuation in the noise temperature monitor until the reading on the meter obtained from the on-star measurement is equaled

NOTE: This measurement, paragraphs 8-4ℓ (4) and (5), must be made within 1 minute to eliminate meter drift and gain fluctuations.

Most likely the measurement will fall between two 0.1-db steps of the precision attenuator. Should this occur, take the high and low readings that bracket the on-star measurement and quickly mark them on the face of the meter. Estimate the percent of the bracket that the attenuation substitution should have been. Record these values on the data sheet. Using the data on the precision attenuators, interpolate the Y-factor in db as accurately as possible. Accuracy to the nearest 0.02 db should be possible.

(6) Repeat this procedure five times to average out the effects of system gain fluctuations. Average the Y-factors in db and, using table 8-1, record the G/T on figure 8-2; USACC Form 413-R (Test) and figure 6-4; USACC Form 351-R (Test).

Table 8-1. G/T Normalized to 7.250 GHz

Y-FACTOR (db)	FREQUENCY (GHz)							
	7.275	7.325	7.400	7.5	7.550	7.625	7.725	7.750
0.80	38.67	38.75	38.88	39.04	39.12	39.24	39.40	39.43
0.85	38.96	39.04	39.17	39.33	39.40	39.53	39.68	39.72
0.90	39.24	39.32	39.45	39.60	39.68	39.81	39.96	40.00
0.95	39.50	39.58	39.71	39.86	39.94	40.07	40.22	40.26
1.00	39.75	39.83	39.95	40.11	40.19	40.31	40.47	40.51
1.05	39.98	40.06	40.19	40.35	40.43	40.55	40.71	40.74
1.10	40.21	40.29	40.42	40.58	40.65	40.78	40.93	40.97
1.15	40.43	40.51	40.64	40.80	40.87	41.00	41.15	41.19
1.20	40.64	40.72	40.85	41.01	41.00	41.21	41.36	41.40

(7) To determine the system noise between the noise of the quiet zone at the elevation angle of the radio star and the quiet zone at an elevation angle of 7.5 degrees, lower the antenna to 7.5 degrees and, using the azimuth drive, traverse 360 degrees to find the quietest zone. Record this value and the azimuth reading for future use in this test.

(8) Elevate the antenna to a quiet zone near the star elevation without changing the azimuth angle. Reduce attenuation in the noise temperature monitor as before and match the reading obtained at 7.5 degrees elevation.

NOTE: These paragraphs 8-4ℓ (7) and (8), must also be done within 1 minute. Interpolate a db value for system noise by using the calibration data in the same manner as in paragraph 8-4ℓ(5). Enter the value on figure 8-2; USACC Form 413-R (Test) and figure 6-4; USACC Form 351-R (Test). Subtract system noise from the G/T measurement as indicated on figure 6-4; USACC Form 351-R (Test).

(9) Repeat paragraphs 8-4ℓ (5) through (8) with the down converter tuned to 7.5 GHz.

(10) Switch the down converter and repeat paragraphs 8-4ℓ (5) through (8) with the down converter tuned to 7.725 GHz.

(11) Switch para-amps, IFLA's, and down converters and repeat the test.

(12) Disconnect the test equipment and return the equipment to a normal operating condition.

Table 8-2. Decibels to Power Ratio

Y-FACTOR db	Y-FACTOR POWER RATIO	Y-FACTOR db	Y-FACTOR POWER RATIO
0.75	1.1885	1.05	1.2735
0.80	1.2023	1.08	1.2823
0.85	1.2162	1.10	1.2832
0.88	1.2246	1.12	1.2942
0.90	1.2303	1.15	1.3032
0.92	1.2360	1.18	1.3122
0.95	1.2445	1.20	1.3183
0.98	1.2531	1.22	1.3244
1.00	1.2589	1.25	1.3335
1.02	1.2647	1.30	1.3490

The following formula was used to generate the above table 8-2 which may be used to calculate G/T for frequencies and Y-factors not in the table.

$$G/T = 40 + 10 \log \left[0.06868^{*}\, f_o^{2}\, (Y-10)\right] + 3.21 \left[\frac{f_o - 7.25\ \text{GHz}}{7.25\ \text{GHz}}\right]\ ^{**}$$

* This number was true at the beginning of the year 1975. The number increases by approximately 1.1 percent per year. See table 8-3 for correction factor information.

** This correction factor for frequency corresponds to the 0.0443 db/100 MHz as per table 8-3.

where:

f_o is the measurement frequency in GHz

NOTE: In this equation, Y is a power ratio (not in db). Use this table as an interpolation guide to translate Y in db to Y power ratio.

m. An example of data reduction for a typical set of measurements for f_o = 7.275 GHz follows. In paragraphs 8-4ℓ (4) through (6), five runs of on-star and off-star measurements are made and recorded.

RUN NO.	ATTENUATION MEASUREMENT START	ATTENUATION MEASUREMENT END
1	3.3	2.1 2.2 80%
2	3.3	2.2 2.3 30%
3	3.3	2.2
4	3.3	2.2 2.3 10%
5	3.3	2.1 2.2 90%

The two readings and the percent value in the END column represent the percent of the bracket readings as per paragraph 8-4ℓ(5).

NOTE: The attenuation substitution in run 3 equals the on-star measurement.

Using the test data supplied, the measurements are corrected per the attenuator calibration values. A portion of the calibration data for serial number 179 is shown below for information and as a means of illustration only.

ATTENUATOR 0-10		ATTENUATOR 0-1.0	
DIAL SET	ATTEN (db)	DIAL SET	ATTEN (db)
1	1.00	0.1	0.11
2	1.99	0.2	0.22
3	2.99	0.3	0.30

In run 1:

2.2 corresponds to 2.21 calibrated
2.1 corresponds to 2.10 calibrated
difference = 0.11

80% of the difference = 0.088 rounded off to 0.09
2.10 + 80% of difference = 2.10 + 0.09 = 2.19

Runs 2 through 5 are similarly done

RUN NO.	ATTENUATION MEASUREMENT		ATTENUATION PER CALIBRATION	
	START	END	START	END
1	3.3	2.1 2.2 80%	3.29	2.19
2	3.3	2.2 2.3 30%	3.29	2.23
3	3.3	2.2	3.29	2.21
4	3.3	2.2 2.3 10%	3.29	2.22
5	3.3	2.1 2.2 90%	3.29	2.20

To find Y-factor in db, subtract these calibrated values and enter on figure 8-2; USACC Form 413-R (Test). Average these values and enter this information on figure 8-2; USACC Form 413-R (Test).

ATTENUATION PER CALIBRATION		Y-FACTOR (db)
START	END	
3.29	2.19	1.10
3.29	2.23	1.06
3.29	2.21	1.08
3.29	2.22	1.07
3.29	2.20	1.09
AVERAGE Y-FACTOR		1.08

AD-A043 735 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA ARIZ F/G 17/2

PRODUCT ASSURANCE, OPERATIONAL QUALITY ASSURANCE, SATELLITE SYS--ETC(U)

MAY 77

UNCLASSIFIED ACC-CCP-702-2 NL

3 OF 7

AD A043735

OF 7

3735

Table 8-1 is now used to determine the G/T for this frequency.

Y-FACTOR (db)	FREQUENCY (GHz)	
	7.250	7.325
1.05	39.95	40.06
1.10	40.17	40.29

At the test frequency of 7.275 GHz, interpolation is necessary to use table 8-1. The 7.275 test frequency is one-third of the interval from 7.250 to 7.325. The new values from this interpolation:

Y-FACTOR (db)	FREQUENCY (GHz)
1.05	39.98
1.10	40.21

The Y-factor 1.08 is 60 percent of the interval from 1.05 to 1.10. This results in a G/T for this frequency of 40.12. This value is entered on figure 8-2; USACC Form 413-R (Test) and on figure 6-4; USACC Form 351-R (Test).

In paragraphs 8-4ℓ (7) and (8), the 7.5-degree elevation sky noise is calculated. The method is the same as that previously utilized.

ATTENUATION MEASUREMENT		ATTENUATION PER CALIBRATION		Y-FACTOR (db)
START	END	START	END	
3.3	2.5 50% 2.6	3.29	2.55	0.74

From the data for the attenuators:

0.5 corresponds to 0.50
0.6 corresponds to 0.62
difference = 0.12

50% of difference = 0.06
2.5 + 50% of difference = 2.49 + 0.06 = 2.55

Subtract these calibrated values to arrive at the system noise. Enter this information on figure 6-4; USACC Form 351-R (Test). The final average G/T at 7.5 degrees is found by subtracting the increased system noise at 7.5 degree elevation from the average G/T. Enter this number on figure 6-4; USACC Form 351-R (Test).

Average G/T	40.12 db
System noise	- 0.74 db
Average G/T 7.5°	39.38 db

Due to the low Y-factor and correspondingly degraded measurement accuracy it is necessary to take the average of repeated Y-factor measurements. The number of values required (n) is such that $\sigma y = 0.02$ db which is the standard deviation of Y from the mean. This will result in a Y-factor related random error in G/T on the order of 0.1 db rms. Table 8-3 outlines the value and the basis for each factor.

For measurements taken in years other than 1976, the correction factor K_4 must be determined from:

$$K_4 = (1 - 0.11)^{-n} \tag{1}$$

$$= \frac{1}{\{1 - (0.011)\}^n}$$

where: n is the number of years since 1968

Measurements at frequencies other than 7.25 GHz may be accommodated by using equation (4) and correcting the resulting G/T value by 0.0443 db per 100 MHz offset for small offsets from 7.25 GHz. This corrects for the fall in Cassiopeia-A flux density at increasing frequencies and gives a value which is referred to 7.25 GHz.

EXAMPLE: Measurement at 7.75 GHZ

G/T according to equation (4)	= 38.75 db
Actual G/T	= 38.75 + 0.221
	= 38.97 db

from which:

$$G/T = \frac{K}{F\mu}(Y - 1) \tag{2}$$

The value to be used for μ is given by:

$$\mu = \frac{c^2}{4f^2} = \frac{3 \times 10^8}{4\ f_o^2\ 10^9} = \frac{7.16 \times 10^{-3}}{f_o^2}$$

where:

f_o is the test frequency in GHz

The value to be used for F is given by:

$$F = \frac{F}{K_1 K_2 K_3 K_4} \qquad (3)$$

where:

F_o = 0.683×10^{-23} $W/m^2/Hz$ for Cassiopeia-A* at 7.25 GHz

K_1 = 1.013 correcting for atmospheric attenuation

K_2 = 2.0 correcting for reception of randomly polarized celestial noise by a circularly (or linearily) polarized antenna

K_3 = 1.10 correcting for the bandwidth of the H_t antenna which is comparable to the angular diameter of Cassiopeia-A*

K_4 = 1.092 correcting at the beginning of the year 1976, for the approximately 1.1 percent per year decline in flux density of Cassiopeia-A. Where F_o is based on a January 1968 datum

Consequently, $F = 2.807 \times 10^{-24}$ $W/m^2/Hz$ at 7.25 GHz and

$$G/T = 10 \log_{10} \left[6.868 \times 10^2 \ f_o{}^2 \ (Y-1)\right] \text{db}$$

$$G/T = 40 + 10 \log_{10} \left[0.06868 \ f_o 2 \ (Y-1)\right] \text{db} \qquad (4)$$

Correspondingly, for G/T's in the range of 39 to 40 db/^{o}K the Y-factor to be anticipated will be:

$$Y = 0.89 \text{ to } 1.09 \text{ db} \qquad (5)$$

Assuming the measurement error equal to a power factor of 1, the maximum error would then be ±1.187. This results in a measurement error of:

$$E_{G/T} = \pm 0.75 \text{ db}$$

n. G/T is determined directly from a Y-factor measurement (star noise plus background noise versus background noise alone) obtained by centering the antenna beam on the celestial source and swinging off a fraction of a degree. The resulting noise powers referred to the para-amp input are:

***ICSC/T-23-16E W/1/68 and figures 8-9 and 8-10 of this pamphlet.**

$$P_1 = \frac{\lambda^2}{4\pi} + KTS \qquad (6)$$

$$P_o = KTB \qquad (7)$$

where:

F = flux density of celestial source, corrected for polarization, secular variation, beamwidth, and atmospheric attenuation (in watts/m^2/Hz)

G = antenna gain from aperture to para-amp input

B = RF measurement noise bandwidth

$\mu = \frac{\lambda^2}{4\pi}$ = effective aperture of an isotropic radiator wavelength (λ in meters)

where:

$$\lambda = \frac{c}{f}$$

where:

F is the test frequency

k = Boltzmann's constant (1.38047×10^{-23} Joules/deg)

T = system noise temperature referenced to para-amp input

thus

$$Y = \frac{P_1}{P_o} = \frac{FGM}{KT} + 1 \qquad (8)$$

If the interpolation method is not used, the information can be calculated using the same data in table 8-2, an average Y-factor (db) of 1.08 equals 1.2823 Y-factor (power ratio). Inserting these values into the equation yields:

$$\text{Average G/T} = 40 + 10 \log \left[0.06868\ (7.275)^2\ (1.2823^{-1})\right] + 3.21 \left[\frac{7.275 - 7.25}{7.25}\right] \qquad (9)$$

$$= 4012 \text{ db}$$

The data reduction is then continued by the method listed above.

o. The primary error sources are uncertainties in corrected star flux and the accuracy of the precision attenuator. System gain fluctuations are also a potentially serious error source; however, this error source may be minimized by obtaining a sufficient number of readings and deriving an average value. The flux density uncertainty is on the order of ±12.5 percent and the Y-factor error is approximately 0.05 db (1.2 percent). Assuming a nominal Y-factor of 0.95 db (1.24 power factor), the probable measurement error, $E_{G/T}$, is found to be:

$$\begin{aligned} E_{G/T} &= \pm E_{flux} + \frac{Y}{Y-1} E_{Y\text{-factor}} \\ &= \pm 0.125 + \frac{1.24}{0.24}(0.012) \qquad (10) \\ &= \pm 0.187 \text{ power factor error} \end{aligned}$$

p. The following figures and tables are included in this procedure to aid in determining the figure-of-merit for the satellite earth terminals.

(1) Figure 8-3, Figure-of-merit alternate test configuration.

(2) Figure 8-4, Sample SNT meter calibration.

(3) Figure 8-5, Sample antenna gain histogram.

(4) Figure 8-6, Sample Gaussian beam shape (also refer to fig. 8-10).

(5) Table 8-3, Radio Star G/T Measurement Considerations.

(6) Table 8-4, Antenna Beam Shape Correction Factors.

(7) Table 8-5, Atmospheric Absorption Loss Correction Factor (also refer to fig. 8-9).

8-5. G/T MEASUREMENT FOR THE AN/TSC-54 AND EQUIVALENT TERMINALS.

a. The receiver subsystem will be turned on at least 30 minutes prior to performing the measurement.

b. This measurement will be performed at a minimum sun elevation angle of 30 degrees and preferably greater than 60 degrees.

c. Plot the flux density on figure 8-7; USACC Form 396-R (Test) for a 3-day period. Date each curve during the test period to demonstrate the daily variations in flux density from nearby parallel lines with the variations of other days. This plot serves two functions:

(1) To demonstrate a quiet sun condition exists at the time of measurement.

(2) To give credence to the frequency-of-interest interpolation from the 4995- and 8800-MHz references.

d. The flux density required for this test can be obtained from:

Environmental Science Service Administration (ESSA)
Space Disturbance Forecast Center
Boulder, Colorado 80303
Phone: (303) 499-1000 Ext. 3204

e. The following steps are required to obtain the terminal figure-of-merit.

(1) Configure the test equipment as illustrated in figure 8-8 and allow for a 30-minute warmup and stabilization period.

(2) Tune a down converter to one of the following listed frequencies:

7250 MHz
7500 MHz
7750 MHz

(3) Set precision attenuator on the precision receiver for zero db and adjust the manual gain control for a convenient meter indication.

(4) Manually rotate the antenna onto the sun until a peak indication is noted on the receiver power meter, and adjust the precision attenuator until the reference level established in paragraph 8-5e(1) above is reattained. Record the attenuator setting on figure 8-2; USACC Form 413-R (Test).

(5) Manually rotate the antenna off the sun by at least three widths in the elevation direction and return the precision attenuator zero db. Continue to rotate the antenna in this general vicinity while observing the power meter to insure that this area is a quiet location.

(6) Readjust the manual gain control on the precision receiver to attain the reference level established in paragraph 8-5e(1) above.

(7) Rotate the antenna onto the sun until a peak indication is attained, and adjust the precision attenuator until the established reference level is indicated on the power meter.

NOTE: The difference between the attenuator setting on-sun and off-sun is equal to the Y-factor in db. Record the attenuator setting and elevation look angles on figure 8-2; USACC Form 413-R (Test).

(8) Repeat paragraphs 8-5e (3) through (7) five more times.

(9) If applicable, manually position the antenna onto the sun. Turn the scanner off. Record the increase in the precision attenuator setting on figure 6-4; USACC Form 351-R (Test). The difference between the scanner on Y-factor and scanner off Y-factor is equal to the modulation loss caused by the scanner and should be considered when calculating the G/T ratio.

(10) Repeat paragraphs 8-5e (3) through (9) at 7500 and 7750 MHz.

(11) Record the G/T on figure 8-2; USACC Form 413-R (Test). The G/T ratio is calculated as follows:

$$G/T = \frac{8\pi\ K\ell}{S\lambda^2}\ (Y - 1) + \frac{b}{\sin_\theta} + \ (Y_2 - Y_3)$$

where:

b is the atmospheric attenuation in db for a one-way transmission at an elevation angle of 90 degrees

$b/\sin_\theta$ is the elevation correction and is valid only above 30 degrees elevation angle. See figure 8-9 for b at the frequency-of-interest

ℓ is the correction factor for the ratio of the source diameter (sun) (θ_d) to the antenna half-power beamwidth (θ_H)

This correction factor has been plotted for different ratios and is shown in figure 8-10. Whereas the ratio of θ_d/θ_H is equal to one or less, ℓ may be calculated from:

$$\ell = 1 + 0.38 \left(\frac{\theta_d}{\theta_H}\right)^2 \quad \text{with less than 2\% error}$$

λ = wavelength at the frequency of measurement in meters

k = Boltzmann's constant (1.38×10^{-23} Joules/$^{\circ}$K)

Y = average numeric Y-factor measured on the sun

Y_2 = Y-factor in db with scanner off (if applicable)

Y_3 = Y-factor in db with scanner on (if applicable)

Obtain the flux density reading for the day of Y-factor measurements and calculate the flux density for the frequency of interest from the equation.

$$\text{Log S } (F_x) = \frac{\log \frac{F_x}{F_1}}{\log \frac{F_2}{F_1}} \left(\text{Log } \frac{SF_2}{SF_1}\right) + \text{Log } SF_1$$

where:

S = flux density at the frequency of interest, F_x, in W/m^2 and is solved from the reported density at F_1, 4995 MHz and F_2 at 8800 MHz at the time of measurement

(12) Once the test data is obtained, the G/T value may then be calculated using the program as shown in figure 8-11 providing an HP 9100 calculator or an equivalent is available. If no calculator is available, G/T value may be calculated using a slide rule or mathematical tables.

8-6 G/T MEASUREMENT FOR AN/MSC-46, AN/FSC-9, AND EQUIVALENT TERMINALS.

a. Subparagraphs (1) through (13) below shall be used to determine the G/T_s from Cassiopeia-A.

(1) Prepare an active smoothing filter as shown in figure 8-3 and connect to the SNT meter, power supply, and strip chart as shown in figure 8-1.

(2) The sky should be clear, the radome dry, all test equipment calibrated and thoroughly stabilized and Cassiopeia-A as close to zenith as possible when this test is conducted. Predicted pointing angles, for each terminal using Cassiopeia-A for G/T_s measurement, are required and can be obtained from the US Army Satellite Communications Agency, Fort Monmouth, New Jersey 07703.

(3) The terminal under test will acquire Cassiopeia-A. Insure that the transmitter is switched off.

(4) Make R_1 as large a resistance as possible without affecting the accuracy of the SNT meter. Vary R_2 and C for a range of integration time constants from 2 to 8 seconds while allowing Cassiopeia-A to drift through the main lobe of the earth terminal antenna pattern to determine which values of R_2 and C yield optimal smoothing.

(5) Connect the floating power supply in series polarity opposition so that its voltage will offset the direct current (DC) voltage, leaving the voltage variations to be recorded. Adjust the strip chart recorder gain setting for maximum deflection on peaks. Record the bias voltage

and strip chart recorder gain so that the deflection can be calculated in millivolts (mv). This value will then be converted to ΔT in degrees Kelvin (K) by use of the calibration curve. Figure 8-4 is a sample curve of the SNT calibration. The calibration consists of feeding a DC voltage into the meter from point C with R_1 disconnected and noting the voltage at point C and the meter reading in T degrees K. Repeat with the resistor R_1 (a low value) connected. Read the voltage at C and the meter reading, and make sure that the meter reading has not changed for the same voltage. Read the voltages at A and D, and make sure that these are equal by adjusting the gain of the operational amplifier. Draw the curve of the noise meter readings in degrees K versus mv at A.

(6) Record the off-star background sky and system noise deflection at the elevation of Cassiopeia-A for about 2 minutes on figure 8-12; USACC Form 414-R (Test).

(7) Make a statistical estimate of G (fig. 8-5) by weighting each result by the number of times maximum deflection is reached in each measurement.

(8) The correction factor to be added to G based upon the beamwidth and beam shape of the particular antenna being tested is obtained from figure 8-6 and table 8-4. The measurement on Cassiopeia-A utilizes the Gaussian beam shape corrections as shown in figure 8-6.

(9) To correct for the variation in atmospheric losses due to air humidity and path length, G must also be corrected by the appropriate value from table 8-5.

(10) Table 8-1 is a sample of a gain versus system noise temperature increase for the year 1976 as a function of receive frequency from the radio star. Antenna receive gain (G), as shown on figure 8-2; USACC Form 413-R (Test), equals the appropriate gain value from figure 8-5 plus the ΔT, in db, value from figure 8-2; USACC Form 413-R (Test).

(11) G/T is determined by subtracting the measured value of T at a particular elevation angle from the G obtained from Cassiopeia-A (statistical mean value plus correction factors from paragraphs 8-6a (8) and (9) above).

(12) Continue to measure the on-star and off-star temperatures until approximately pairs of readings are obtained at each test frequency. Check repeatability of the results by running the test on successive days if possible. Determine noise temperature on and off Cassiopeia-A from the deflection in mv and the calibration curve.

(13) Enter the calculated values on figure 8-2; USACC Form 413-R (Test), calculate the statistical mean, and enter the mean on the top of this data sheet.

b. To measure the G/T through an active satellite, use the following procedure.

(1) Using a terminal calibrated from radio star measurements, have the calibrated terminal and all other terminals to be calibrated acquire the same satellite beacon. The beacon utilized should be from a satellite carrying no operational traffic as the beacon is suppressed by varying amounts depending upon the amount of signal power being received from earth terminals.

(2) Request all stations measure and record the receiver output carrier level. Simultaneous readings are required.

(3) Each station will then swing off the satellite by 5 degrees and the idle sky receiver noise output and receiver SNT will be measured.

(4) Repeat paragraphs 8-6b (2) and (3) once per minute for 30 minutes. Record all data on figure 8-12; USACC Form 414-R (Test).

(5) Make a statistical estimate of the uncalibrated terminal's G/T. The C/kT of the calibrated terminal is determined by the relationship

$$C/kT_S = G/T_S + Q$$

where Q includes Boltzmann's constant, spacecraft effective radiated power (erp), path attenuation, atmospheric losses, and radome losses (if any), G and T_S, and the previously determined and recorded values. The G/T_S of the other terminals are determined by the relationship

$$G/T_S = G/kT_S - Q$$

where C/kT_S is determined statistically from the recorded measurements of the beacon, and Q is obtained from the calibrated terminal. The G/T_S thus determined is relative to the calibrated terminal. An independent G/Ts figure for each terminal is determined by using correction factors for each particular terminal using table 8-5 as a guide.

c. Restore all terminal equipment to normal operation and summarize the test results on figure 6-4; USACC Form 351-R (Test).

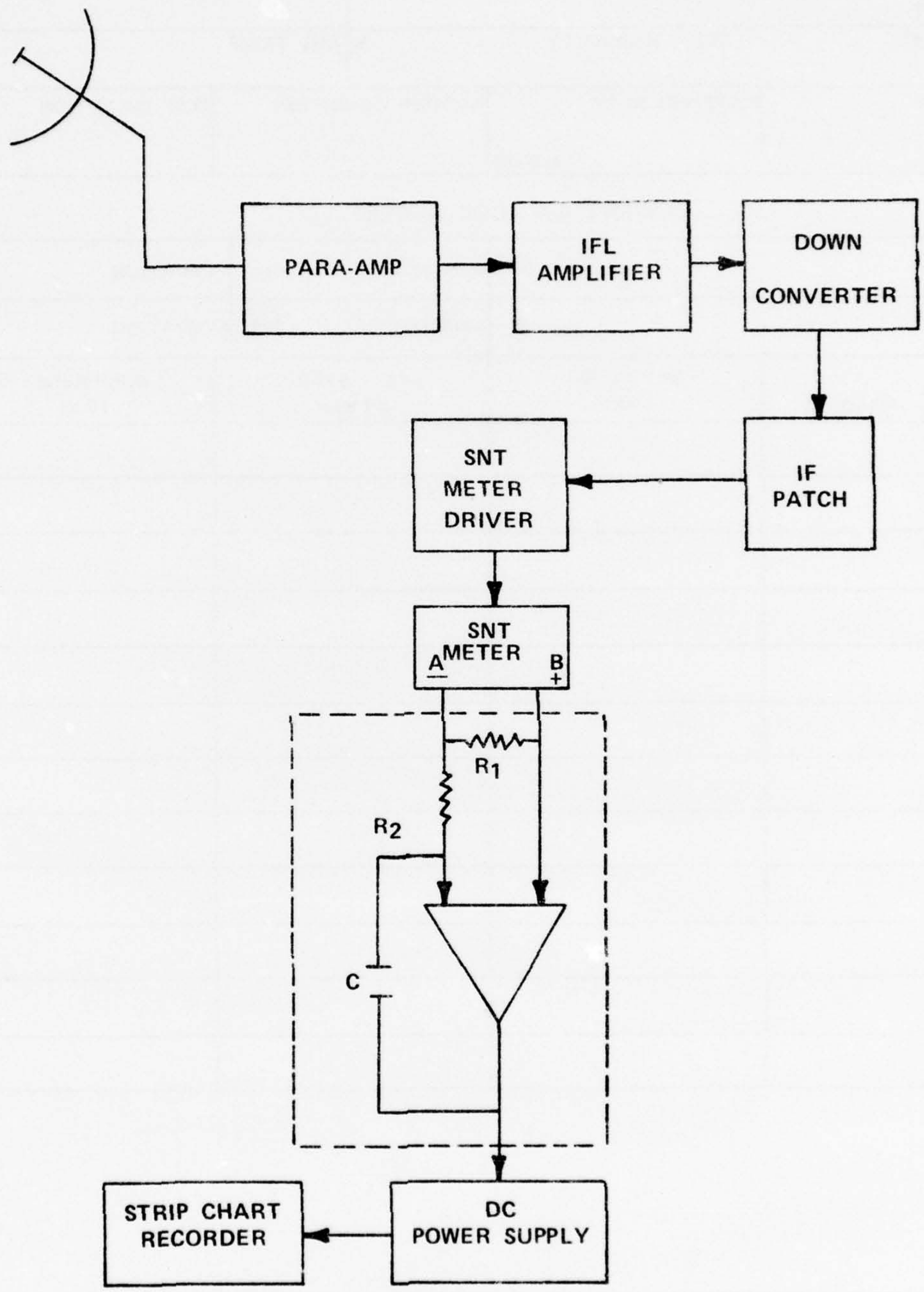


Figure 8-1. Y-factor test configuration.

TERMINAL RECEIVE G/T RATIO (CCR 702-1-3) DATA SHEET			PAGE OF PAGES	
			DATE (DAY, MONTH, YEAR)	
TERMINAL ID	REL HUMIDITY %		AIR TEMP deg	
CLOUD COVER	WIND VELOCITY KNOTS	RADOME CONDITION	TEST CONDITION	
CASSIOPEIA-A LOOK ANGLES				
START TIME Z		AZIMUTH deg	ELEVATION deg	
STOP TIME Z		AZIMUTH deg	ELEVATION deg	
TEST RUN NO.	READING	SKY TEMP (°K)	SKY + STAR (°K)	DIFFERENCE (°K)
COMMENTS				
TYPED NAME, GRADE, AND TITLE		TEST ENGR SIGNATURE		

USACC FORM 413-R (TEST)
1 MAY 77

Figure 8-2. Terminal receive G/T ratio data sheet.

Table 8-3. Radio Star G/T Measurement Considerations

ITEM	ASSUMED VALUE	BASIS
Flux distribution correction factor	1.10	Derived from ICSC data
Secular variation correction factor	1.0797	Value for 1975.0. Based on widely accepted 1.1 percent year decline from 1968.0 epoch
Atmospheric absorption correction factor	1.013	0.063 db at $\approx 45^{o}$ elevation based on average of Haroules and Brown, Mumford and Hogg, and ICSC data
Polarization correction factor	2.0	Standard correction for any polarization
Flux density	0.683×10^{-23} W/m^2/Hz	At 7.25 GHz for 1968.0 epoch
Flux density value	0.2807×10^{-23} W/m^2/Hz	0.0683 x (1.10) x (1.092) x (1.013) x (2.0)
Elevation angle	40^{o} to 45^{o}	Optimum for midday measurement with minimum Θ at 1975.0
Spectral index	-0.74	Commonly used value. (Value not critical once a value is assumed for flux at 7.25 GHz)
Measurement basis		Use above value and correct all readings by 0.0443 db/100 MHz to refer value back to 7.25 GHz

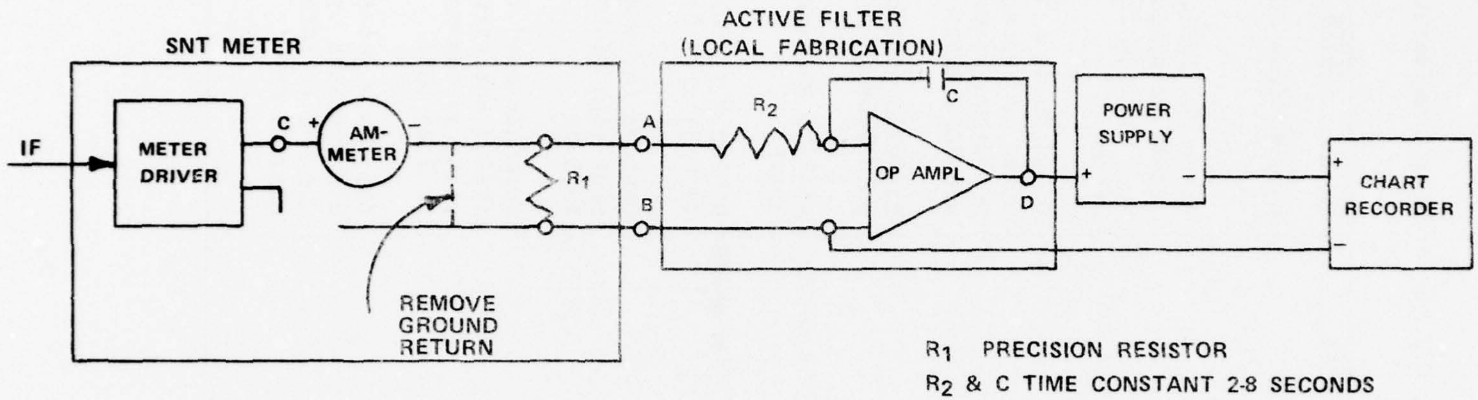


Figure 8-3. Figure-of-merit alternate test configuration.

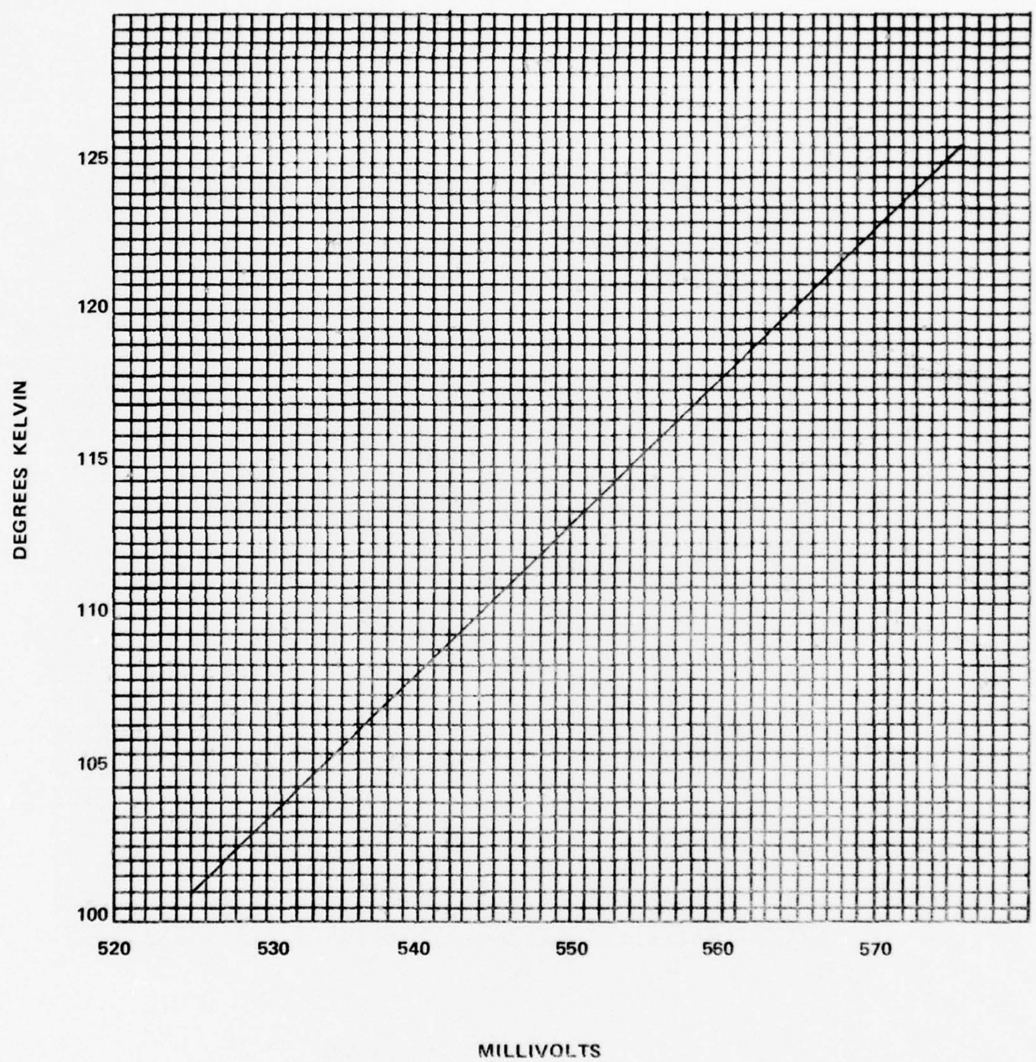


Figure 8-4. Sample SNT meter calibration.

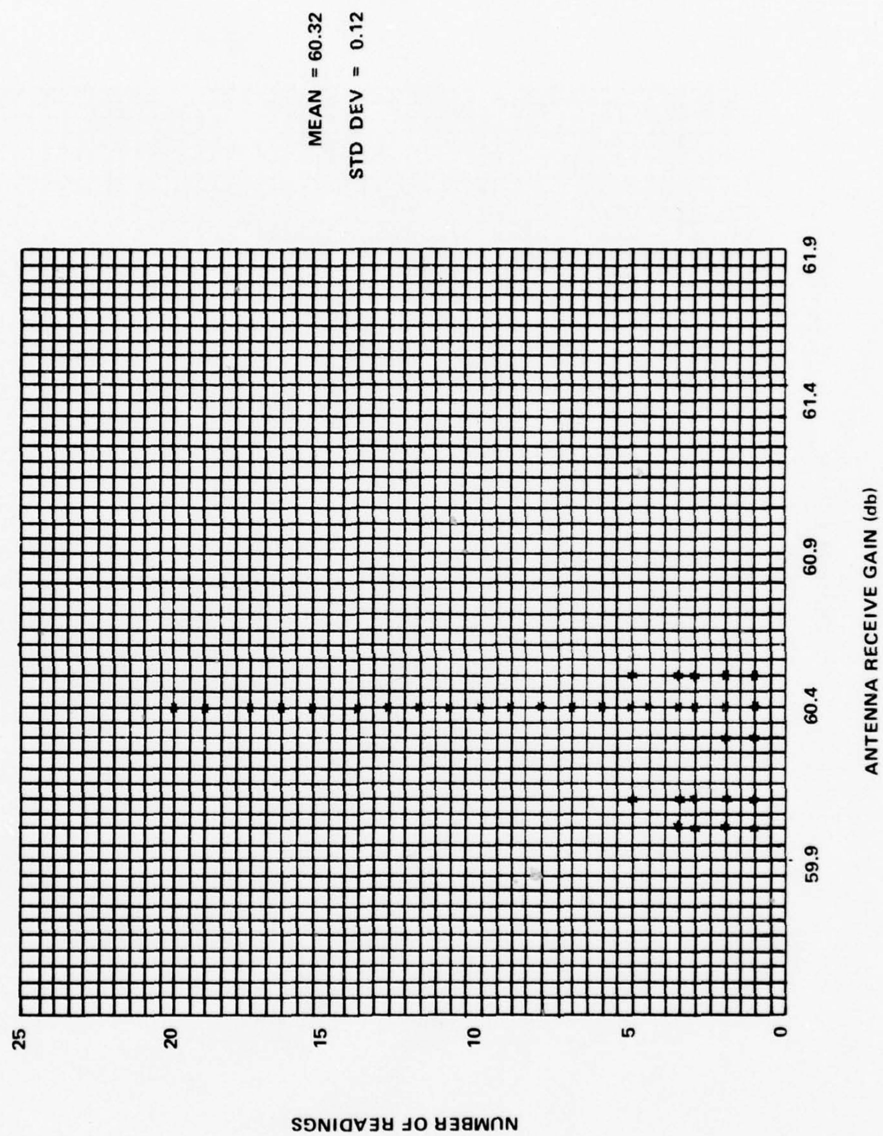


Figure 8-5. Sample antenna gain histogram.

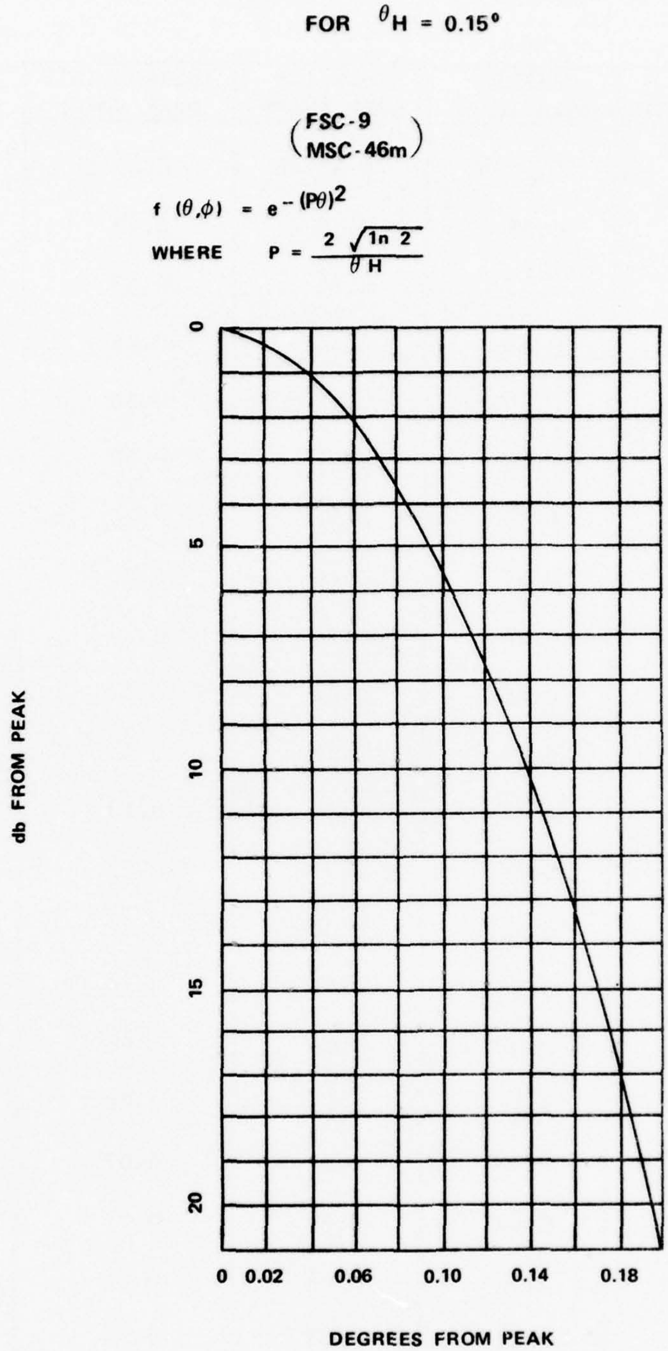


Figure 8-6. Sample Gaussian beam shape.

Table 8-4. Antenna Beam Shape Correction Factors

3-db BEAMWIDTH	GUASSIAN BEAM SHAPE	BESSELIAN BEAM SHAPE	INTERMEDIATE BEAM SHAPE
0.10	0.75 db	0.91 db	0.83 db
0.11	0.62	0.68	0.63
0.12	0.53	0.53	0.53
0.13	0.45	0.42	0.43
0.14	0.39	0.33	0.36
0.15	0.34	0.27	0.30
0.16	0.30	0.22	0.26
0.17	0.27	0.19	0.23
0.18	0.24	0.16	0.20
0.19	0.21	0.14	0.17
0.20	0.19	0.12	0.15
0.21	0.17	0.10	0.13
0.22	0.16	0.09	0.12
0.23	0.15	0.08	0.11
0.24	0.13	0.07	0.10
0.25	0.12	0.06	0.09
0.26	0.11	0.05	0.08
0.27	0.10	0.05	0.07
0.28	0.10	0.04	0.07
0.29	0.09	0.04	0.06
0.30	0.09	0.03	0.06

Table 8-5. Atmospheric Absorption Loss Correction Factors

ELEVATION ANGLE TO STAR (DEGREES OF ARC)	CORRECTION TO BE ADDED (db)		
	VERY DRY	AVERAGE	HUMID
10	0.24	0.29	0.50
20	0.12	0.15	0.26
30	0.08	0.10	0.20
40	0.07	0.08	0.16
50	0.06	0.07	0.14
60	0.05	0.06	0.12
70	0.04	0.05	0.11
80	0.04	0.05	0.10
90	0.04	0.05	0.09

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3) DATA SHEET			PAGE NUMBER	NUMBER OF PAGES
			DATE (DAY, MONTH, YEAR)	
LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE	
TITLE OF PERFORMANCE PLOTTED				TEST NO.

USACC Form 396-R (Test)
1 April 1977

Figure 8-7. General purpose graph paper data sheet.

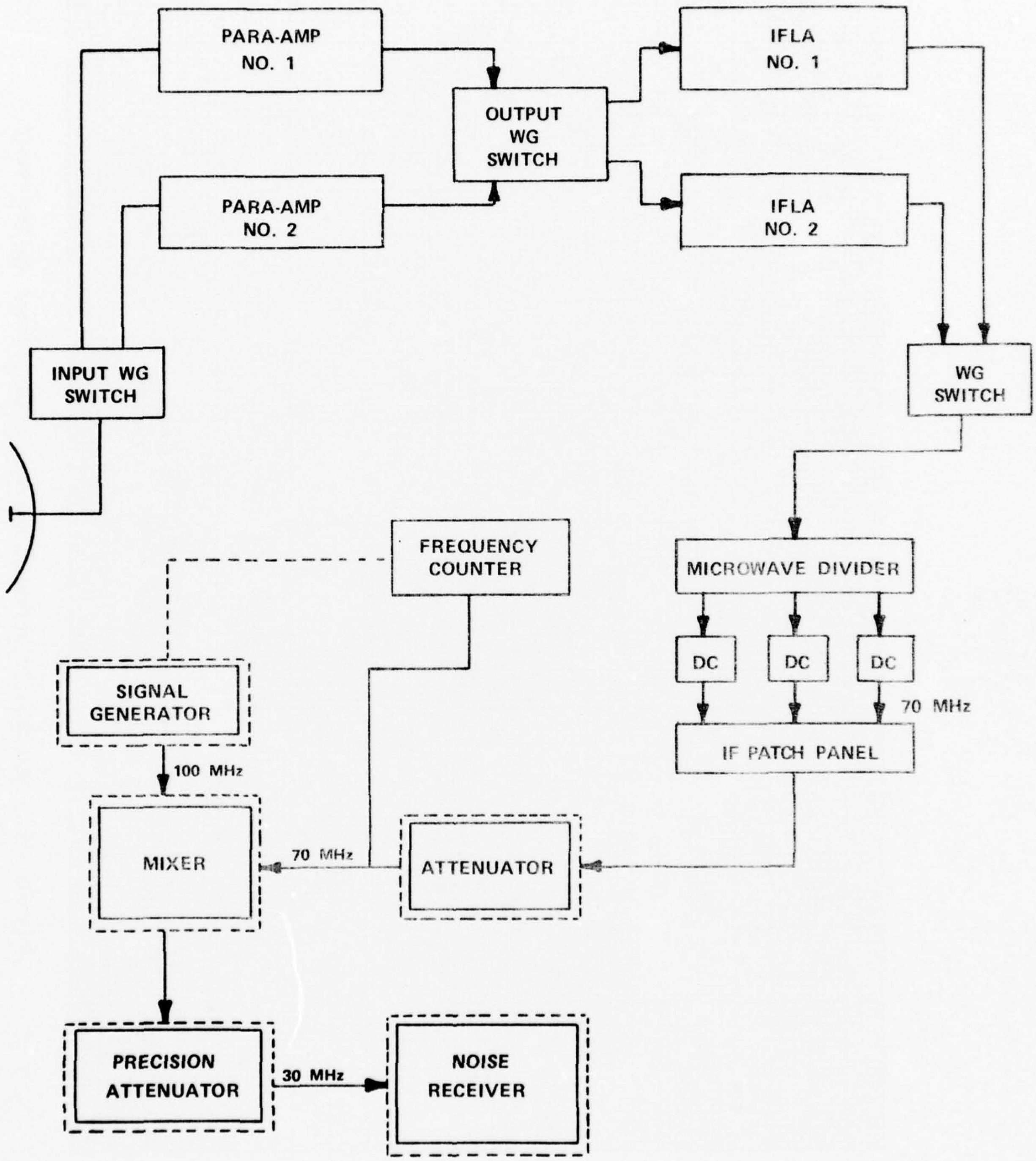


Figure 8-8. Test configuration for AN/MSC-46 and AN/FSC-9.

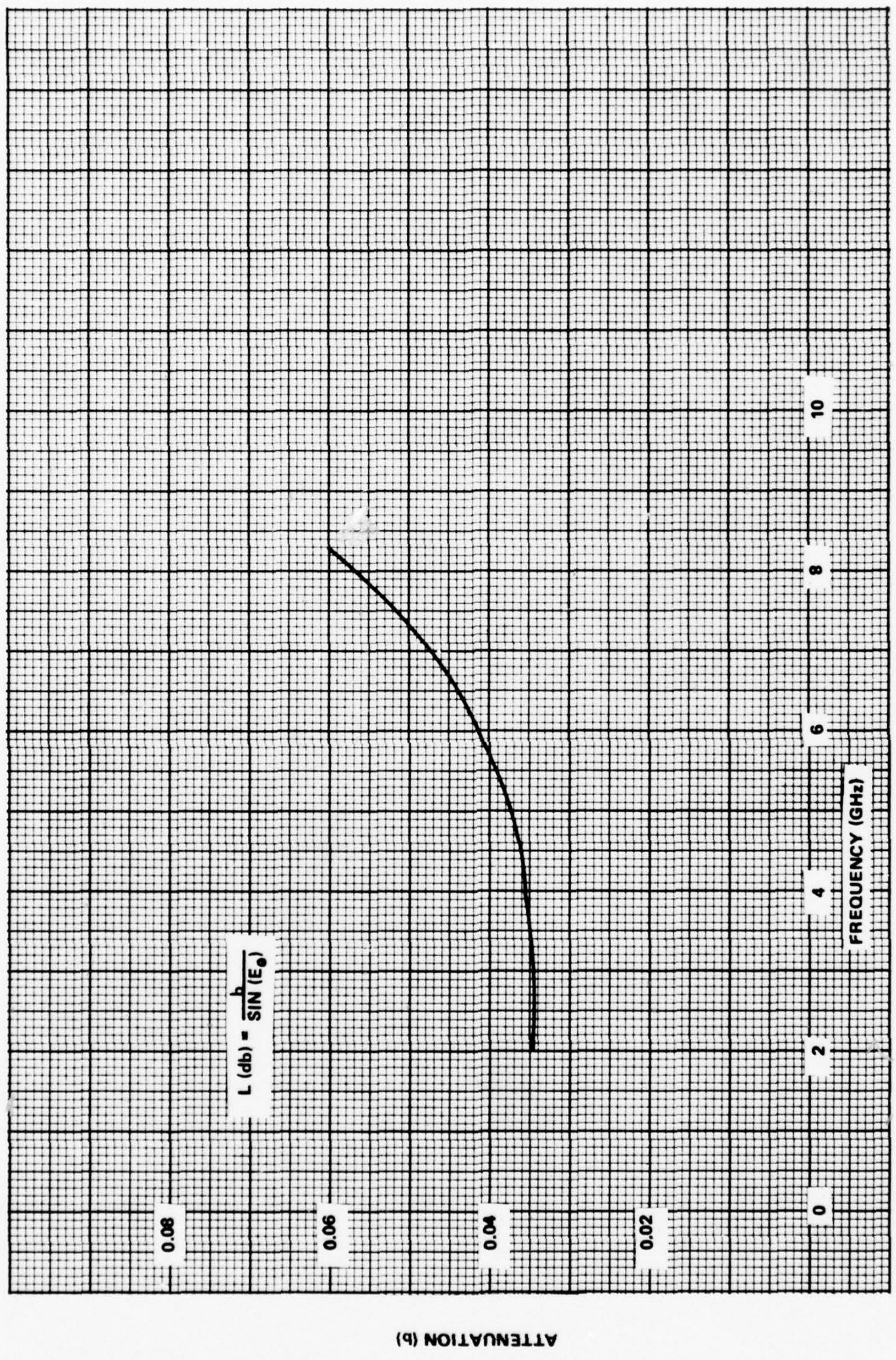


Figure 8-9. Atmospheric attenuation correction factor vs frequency.

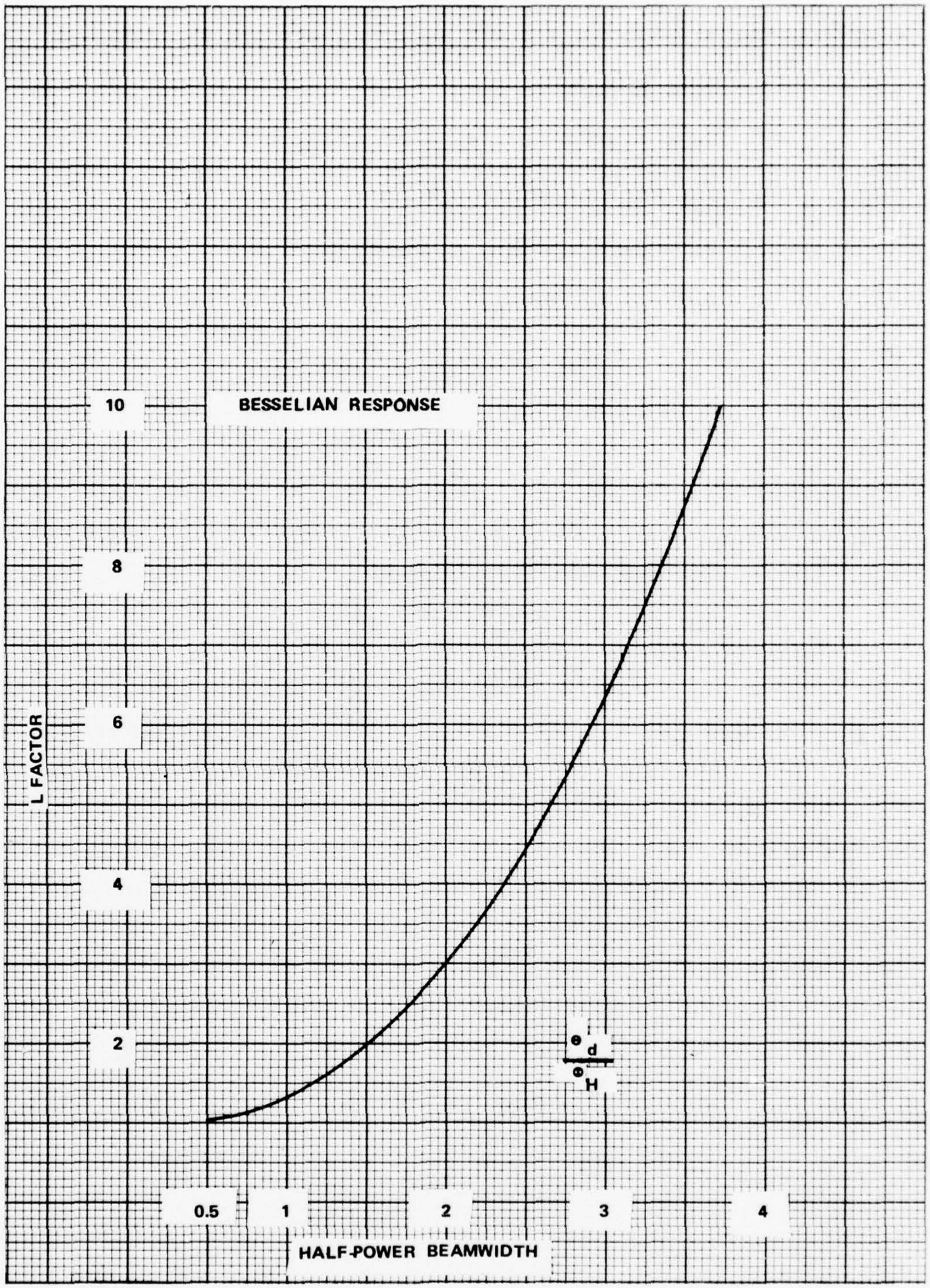


Figure 8-10. Correction factor vs ratio of source diameter to half-power beamwidth.

To program the HP 9100 for the G/T equation, perform the following steps:

1. Turn HP 9100 to ON
2. Turn PRINTER ON - Select Y print
3. Set PROGRAM-RUN to RUN
4. Set FLOATING-FIXED to FLOATING
5. Key the following:

   CLEAR

   GO TO

   0

   0

6. Set PROGRAM-RUN to PROGRAM
7. Key the following:

1. CLEAR
2. STOP "f2"
3. $\uparrow$
4. STOP "f1"
5. X $\rightarrow$ ( )
6. f
7. $\div$
8. $\downarrow$
9. Log $_x$
10. $\uparrow$
11. STOP "fx"
12. $\uparrow$
13. f
14. $\div$
15. $\downarrow$
16. Log$_x$
17. R$\overset{\uparrow}{\text{O}}$LL
18. $\div$
19. STOP "SF2"
20. $\uparrow$
21. STOP "Sf_1"
22. X $\rightarrow$ ( )
23. e
24. $\div$
25. $\downarrow$
26. Log$_x$
27. $\uparrow$
28. R$\overset{\uparrow}{\text{O}}$LL
29. X (multi)
30. e

Figure 8-11. G/T equation computer program.

31. log$_x$
32. +
33. 1
34. e^x
35. Log$_x$
36. ÷
37. ↓
38. e^x
39. ↑
40. STOP "λ"
41. ↑
42. X (Multi)
43. ROLL↓
44. X
45. Y →( )
46. f
47. STOP "Y"
48. ↑
49. 1
50. -
51. 3
52. 4
53. 6
54. 7
55. ENT EXP
56. CHG SIGN
57. 2
58. 2
59. X (Multi)
60. f
61. ÷
62. STOP "L"
63. X (Multi)
64. ↓
65. Log$_x$
66. ↑
67. 1
68. 0
69. X (Multi)
70. STOP "$Y^2 - Y^3$"
71. +
72. Y →( )
73. f
74. STOP "b"
75. ↑
76. STOP "θ"
77. Sin x
78. ÷
79. f
80. +
81. PRINT
82. END

Figure 8-11. G/T equation computer program. (continued)

The program is now entered. To enter the variables perform the following steps.

a. Set PROGRAM-RUN to RUN

Key: GO TO

0

0

Continue

b. Program is now stopped at F2. Enter F2. (An example of how F2 is entered is: Let F2 = 8800 MHz (8.8×10^9).)

Key 8

Key 8

ENTER EXP

Key 9

c. Key CONTINUE

d. Program is now stopped at F1. Enter F1. (An example of how F1 is entered is: Let F1 - 4995 MHz (4.995×10^9).)

Key 4

Key 9

Key 9

Key 5

ENTER EXP

Key 9

e. Key CONTINUE

f. Program is now stopped at Fx. Enter Fx. (An example is: Let Fx = 500 MHz (7.5×10^9).)

Key 7

Key 5

ENTER EXP

Figure 8-11. G/T equation computer program. (continued)

Key 9

g. Key CONTINUE

H. Program is now stopped at SF2. Enter SF2. (An example is: Let SF2 = 7.5×10^{-19}.)

Key 7

Key 5

ENTER EXP

CHG SIGN

Key 1

Key 9

i. Key CONTINUE

j. Program is now stopped at SF1. Enter SF1. (An example is: Let 8.0×10^{-20}.)

k. Key CONTINUE

l. Program is now stopped at λ. Enter λ. (An example os how λ is entered is: Let $\lambda = 0.04$ meters.)

Key DECIMAL POINT

Key 0

Key 4

m. Key CONTINUE

n. Program is now stopped at Y. Enter Y. (An example of how Y is entered is: Let Y = 15.8 numeric.)

Key 1

Key 5

Key DECIMAL POINT

Key 8

o. Key CONTINUE

Figure 8-11. G/T equation computer program. (continued)

p. Program is now stopped at L. Enter L. (Example L = 1.85.)

q. Key CONTINUE

r. Program is now stopped at Y2 - Y3. Enter Y2 - Y3 product. (Example Y2 - Y3 = (0.1).)

s. Key CONTINUE

t. Program is now stopped at "b." Enter "b." (Example .053.)

u. Key CONTINUE

v. Program is now stopped at "θ." Enter "θ." (Example 85°.)

w. Key CONTINUE

Answer for G/T is printed out on tape.

If the examples given above are used the printout should read:

1.187 - - - - - - - - - - - - - - - - 01

This gives a G/T of 11.87 db

Figure 8-11. G/T equation computer program. (continued)

TERMINAL RECEIVE G/T_S
(CCR 702-1-3)

DATA SHEET

PAGE OF PAGES

DATE (DAY, MONTH, YEAR)

LINK NO.			TERMINAL ID			SPECIFICATION					MEAN G/T_S = db				
TIME (z)	OFFSET VOLTAGE	RUN NO.	PRESKY (mv)	POSTSKY (mv)	AVG SKY (mv)	DRIFT DIFF (mv)	STAR (mv)	DRIFT T (°K)	SKY T (°K)	STAR T (°K)	ΔT (°K)	ΔT (db)	UNCORR G (db)	CORR G (db)	G/T_S (db)

TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 414-R (TEST)
1 MAY 77

Figure 8-12. Terminal receive G/T_S data sheet.

PrecedING Page BLank - FILMed

CHAPTER 9

SYSTEM NOISE TEMPERATURE VERSUS ANTENNA ELEVATION ANGLE (ST-4)

9-1. GENERAL.

a. The purpose of this test is to measure the earth terminal's SNT vs antenna elevation angle.

b. This is normally an out-of-service test and requires an AO.

9-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

9-3. TEST EQUIPMENT REQUIRED. The SNT meter is in most cases part of the terminal built-in test equipment (BITE). In cases where either the BITE is not installed or its performance level is suspected of being substandard, the listed test equipment will be used.

a. GR adapter.

b. Amplifier.

c. Noise generator.

d. VHF signal generator.

e. Mixer.

f. Receiver.

g. WG adapter.

h. Frequency counter.

9-4. TEST PROCEDURES.

a. This procedure will be used on those earth terminals in which BITE is not installed or its accuracy is suspect.

(1) Configure the test equipment and earth terminal as illustrated in figure 9-1.

(2) Energize test equipment and allow for a 30-minute warmup and stabilization period.

(3) Tune the selected down converter to 7.25 GHz and connect the cold termination of the generator to the input para-amp WG switch. Select the para-amp to be tested.

(4) Adjust the precision variable attenuator for a convenient on-scale meter indication on the receiver and record both the attenuator setting and meter indication on figure 9-2; USACC Form 415-R (Test).

(5) Transfer the input of the WG switch to the hot termination on the noise generator. The meter indication should increase. Increase the variable attenuator setting until the meter indicates the reference level established in paragraph 9-4a(4) above and record the new setting. The difference between the two attenuator settings is equal to the Y-factor which will be used to calculate the SNT.

(6) Repeat paragraphs 9-4a (3) through (5) two more times.

(7) Tune the down converter to 7500 and 7750 MHz and repeat paragraphs 9-4a (3) through (6).

(8) The subsystem noise temperature can be calculated by using the following formula:

$$T_R = \frac{T_{Hc} - (Y_R)\ (T_{cc})}{Y_R - 1}$$

where:

T_{Hc} = effective hot standard temperature corrected for loss

T_{cc} = effective cold standard temperature corrected for loss

Y_R = Y-factor of receive system (numeric)

(9) The following information is provided to facilitate the deviations of the effective hot and cold temperatures.

$$T_{Hc} = \frac{T_H}{L} + \frac{(L-1)\ (T_L)}{L}$$

where:

T_{Hc} = effective hot standard temperature corrected for loss

T_H = hot temperature corrected for frequency and RF loss per AIL reference manual

T_L = ambient temperature of coax and coax to WG cable (295^oK assumed)

L = measured loss of interconnecting WG to coax adapter and coax cable converter to numeric

$$T_{cc} = \frac{T_c}{L} + \frac{(L-1)(T_L)}{L}$$

where:

T_{cc} = effective cold standard temperature correct for loss

T_c = cold temperature corrected for frequency and RF loss per AIL reference manual

T_L = ambient temperature of coax and coax to WG cable (295^oK assumed)

L = measured loss of interconnecting WG to coax adapter and coax cable converted to numeric

(10) Record the calculated noise temperatures on figure 9-2; USACC Form 415-R (Test).

b. This procedure is applicable to the AN/MSC-46 and AN/FSC-9 earth terminals.

(1) Prior to conducting this test, insure that the antenna is not pointing in the direction of any satellite, known signal sources (microwave and/or VHF towers), the sun or other celestial noise sources.

(2) Calibrate the BITE SNT meter IAW manufacturer's manual.

(3) Energize the SNT test set and allow for a 5-minute warmup and stabilization period (fig. 9-3). Adjust the performance monitor frequency selector switch, located on the power distribution panel, for a dial indication of 080.5.

(4) Adjust the elevation angle of the antenna until 50 degrees is attained and calibrate the SNT meter in the INF and ZERO positions. Turn the control switch to the SNT position.

(5) Record the SNT on figure 9-2; USACC Form 415-R (Test).

(6) Switch to the standby para-amp and repeat paragraphs 9-4b (4) and (5).

(7) Decrease the elevation angle in 10-degree steps and repeat paragraphs 9-4b (3) through (6) until an elevation angle of 10 degrees is attained.

(8) Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

c. This procedure is applicable to AN/FSC-78 earth terminals and will be performed using the BITE.

(1) Energize the noise temperature monitor and allow for a 30-minute warmup and stabilization period.

(2) Set the mode selector switch to LEVEL and verify that the noise temperature reads in the LEVEL zone.

(3) Set the alarm threshold selector switch to 350 degrees K and mode selector switch to MANUAL OFF.

(4) At the RF plate, set the variable attenuator AT-1 in the cold position by pulling the attenuator ADJUST straight out.

(5) On the noise temperature monitor, set the two IF attenuators to zero db of attenuation.

(6) Select the off-line Para-amp by activating the para-amp indicator switch at the noise temperature indicator for an off-line indication.

(7) Set the reference adjust control for a midscale reading on the noise temperature degrees K meter (approximately 100 degrees K on the upper scale of the meter).

(8) At the RF plate, set the variable attenuator AT-1 for 30 db (hot load) by pushing the attenuation ADJUST straight in.

(9) Adjust the attenuators on the noise temperature degrees K meter until the meter indicates the reference level established in paragraph 9-4c(7) above. Record the attenuator setting on figure 9-2; USACC Form 415-R (Test).

(10) Repeat paragraphs 9-4c (2) through (9) two more times. Switch para-amps and repeat the test procedure on the other para-amp.

(11) The attenuator setting or Y-factor between the hot load and cold load is related to noise temperature as follows:

Y-FACTOR (db)	SNT (°K)	Y-FACTOR (db)	SNT (°K)
2.0	425	3.8	178
2.1	400	3.9	171
2.2	377	4.0	165
2.3	356	4.1	158

Y-FACTOR (db)	SNT (^{o}K)	Y-FACTOR (db)	SNT (^{o}K)
2.4	337	4.2	152
2.5	319	4.3	157
2.6	303	4.4	142
2.7	288	4.5	137
2.8	274	4.6	132
2.9	262	4.7	127
3.0	250	4.8	123
3.1	239	4.9	119
3.2	228	5.0	115
3.3	218	5.1	111
3.4	209	5.2	108
3.5	201	5.3	104
3.6	193	5.4	101
3.7	185	5.5	97
5.6	94	6.6	70
5.7	91	6.7	58
5.8	89	6.8	66
5.9	86	6.9	64
6.0	83	7.0	62
6.1	81	7.1	60
6.2	78	7.2	58
6.3	76	7.3	57
6.4	74	7.4	55
6.5	72	7.5	54

(12) Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

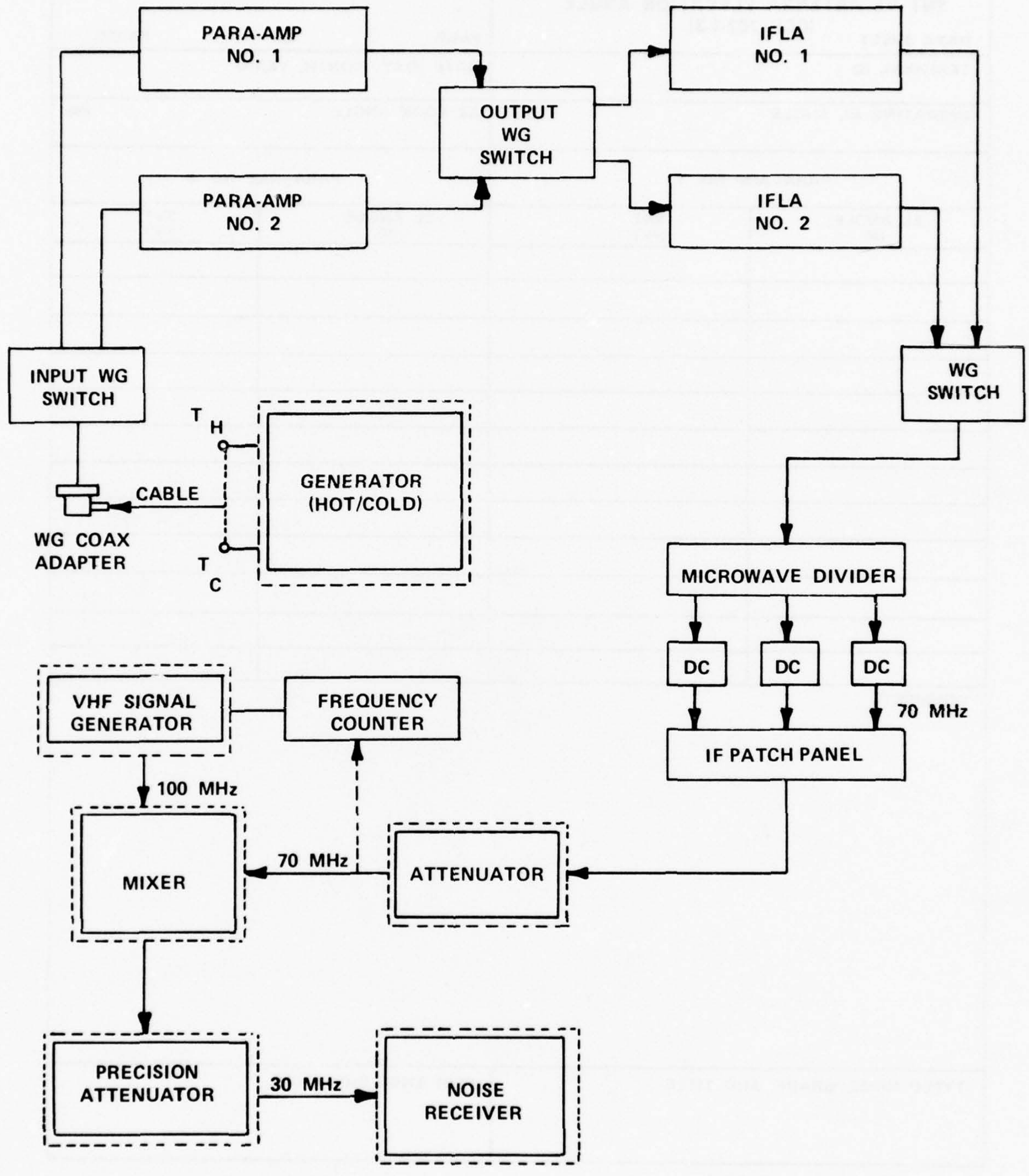


Figure 9-1. SNT vs antenna elevation angle (non-BITE) test configuration.

SNT VS ANTENNA ELEVATION ANGLE (CCR 702-1-3) DATA SHEET		PAGE OF PAGES	
TERMINAL ID		DATE (DAY, MONTH, YEAR)	
OPERATING EL ANGLE deg		AZ LOOK ANGLE deg	
PARA-AMP NO. 1		PARA-AMP NO. 2	
EL ANGLE (°)	SNT (°K)	EL ANGLE (°)	SNT (°K)
COMMENTS			
TYPED NAME, GRADE, AND TITLE		TEST ENGR SIGNATURE	

USACC FORM 415-R (TEST)
1 MAY 77

Figure 9-2. SNT vs antenna elevation angle data sheet.

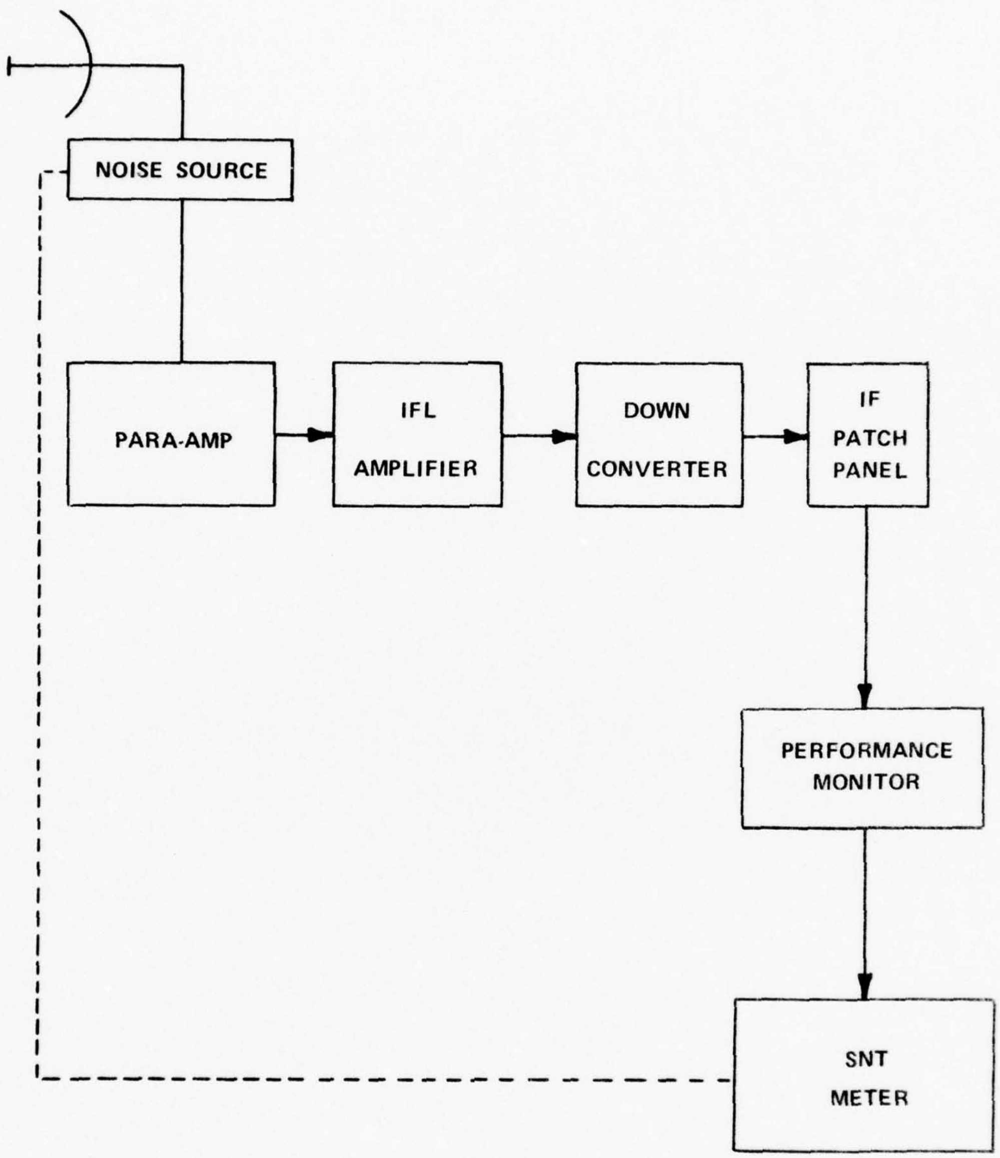


Figure 9-3. SNT vs antenna elevation angle (BITE) test configuration.

Preceding Page Blank - Not Filmed

CHAPTER 10

WAVEGUIDE RETURN LOSS OR VSWR (ST-5)

10-1. GENERAL.

a. The purpose of this test is to measure the return loss of the transmit and receive WG. This test should be performed after completion of test number ST-6 in order to determine the effect that line loss may have on the final test results.

b. This is an out-of-service test and requires an AO.

c. This procedure applies primarily to the manually swept frequency technique; however, the automatic swept frequency technique may be used as an alternate test method.

10-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

10-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. SHF generator.

c. Power meter.

d. Directional coupler.

e. WG to coaxial adapters.

10-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 10-1.

b. Energize the test equipment and allow for a 30-minute warmup and stabilization period.

c. This test will normally be performed with the far-end of the WG runs terminated into the normal load (feed assembly or IFLA's). For diagnostic purposes, it may be necessary to terminate the far-end of the WG with a precision WG termination.

d. Tune the SHF signal generator to 8150 MHz at an output power level of zero dbm.

e. Measure and record (on figure 10-2; USACC Form 416-R (Test)) the forward and reverse power levels as indicated on the power meter connected to the respective coupling port.

f. The difference between the forward and reverse power levels in dbm is equal to the return loss in db.

g. Repeat paragraphs 10-4 c and d above at the following listed frequencies:

FREQUENCY	(MHz)
7900	8200
7950	8250
8000	8300
8050	8400
8100	

h. Connect the test equipment to the receive WG and repeat paragraphs 10-4 b through g at the following listed test frequencies:

FREQUENCY	(MHz)
7250	7550
7300	7600
7350	7650
7400	7700
7450	7750
7500	

i. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

j. This portion of the test refers to the return loss from output of the PA looking toward the antenna feed assembly. In some cases (transmit WG only), due to physical construction of the earth terminal, it will be difficult to connect the test equipment to the WG. In such instances, the transmitter will be put on-line and the forward and reverse power levels will be read at the forward and reverse ports of the PA's output directional coupler.

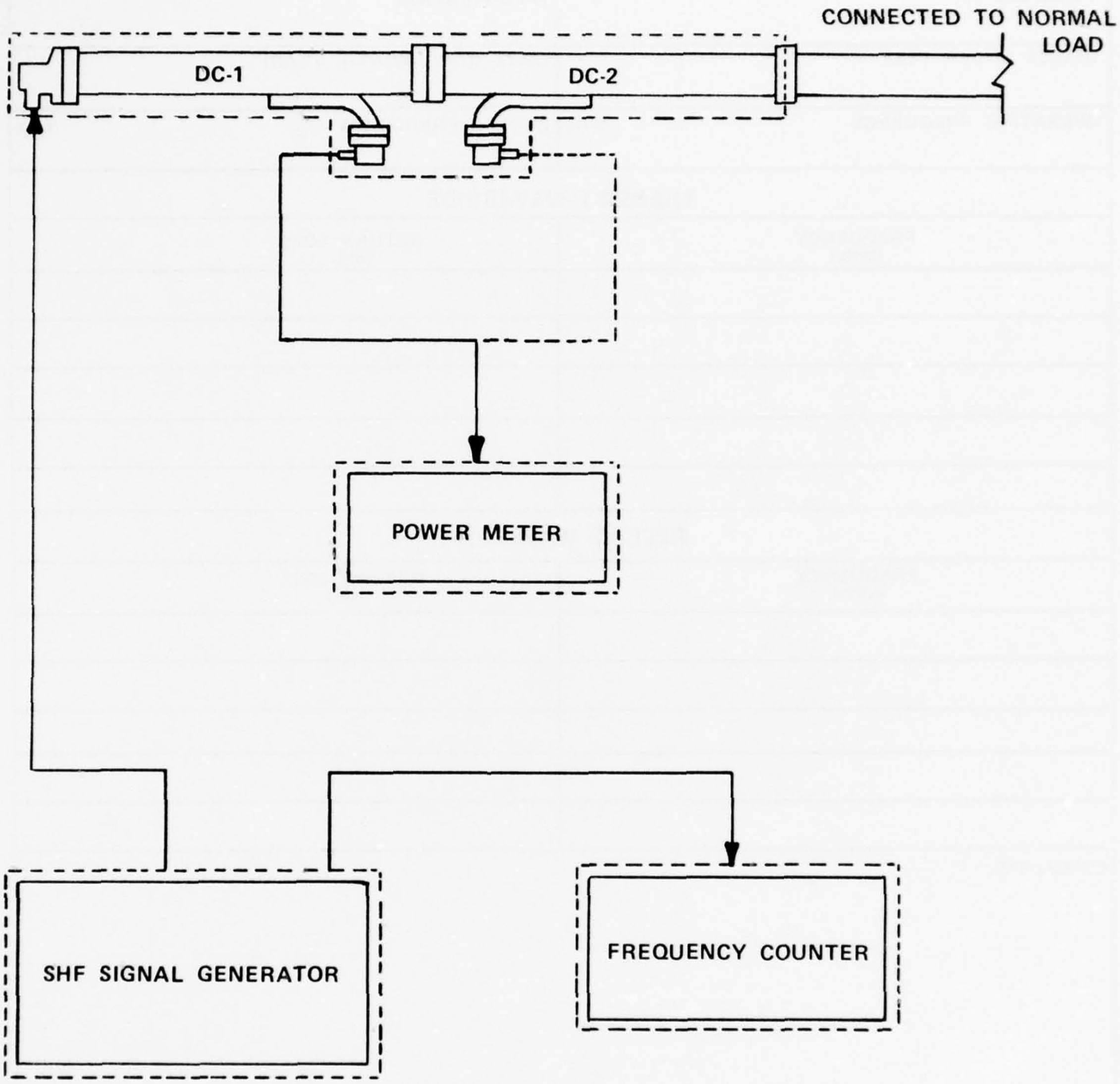


Figure 10-1. WG return loss or VSWR test configuration.

WG RETURN LOSS (MANUAL) (CCR 702-1-3) DATA SHEET	PAGE OF PAGES
TERMINAL ID	SPECIFICATION
DEVICE UNDER TEST	DATE (DAY, MONTH, YEAR)
OPERATING FREQUENCY MHz	CENTER FREQUENCY (F_c) MHz

TRANSMIT WAVEGUIDE

FREQUENCY (MHz)	RETURN LOSS (db)

RECEIVE WAVEGUIDE

FREQUENCY (MHz)	RETURN LOSS (db)

COMMENTS

TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 416-R (TEST)
1 MAY 77

Figure 10-2. WG return loss (manual) data sheet.

CHAPTER 11

WAVEGUIDE INSERTION LOSS (ST-6)

11-1. GENERAL.

a. The purpose of this test is to measure the RF power losses of the receive and transmit WG's. The test data obtained should be compared to the results of ST-5 in order to determine if excessive line losses have obscured the test data of ST-5.

b. This is normally an out-of-service test and requires an AO.

11-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

11-3. TEST EQUIPMENT REQUIRED.

a. Sweep generator.

b. Plug-in (8 to 12.4 GHz).

c. Plug-in (4 to 8 GHz).

d. Power meter.

e. Thermistor mount.

f. WG adapter.

g. Frequency counter.

h. Directional coupler.

11-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 11-1 and allow for a 30-minute warmup and stabilization period.

b. Tune the signal generator to the lowest frequency in the frequency band of interest. Record the input and output power meter readings on figure 11-2; USACC Form 417-R (Test). The RF insertion loss can be determined by subtracting the output power from the input power. Consideration should be given to all cable, adapter, and coupler losses utilized in the test configuration.

c. Repeat paragraph 11-4b in 50-MHz steps across the frequency band of interest (normally 7.25 to 7.75 GHz receive and 7.9 to 8.4 GHz transmit).

d. This test will be performed on both the transmit and receive W/G lines.

e. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

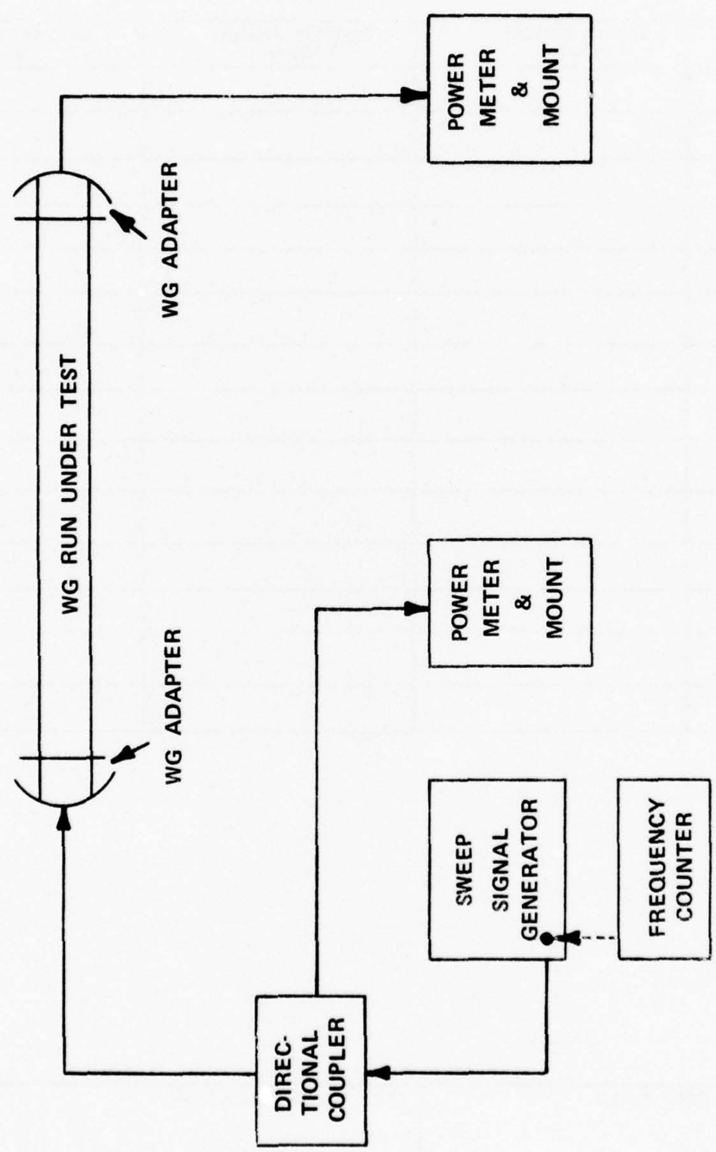


Figure 11-1. WG insertion loss test configuration.

WG INSERTION LOSS (CCR 702-1-3) DATA SHEET		PAGE OF PAGES	
TIME Z		DATE (DAY, MONTH, YEAR)	
TYPE WG		F_c INSERTION LOSS db	
LENGTH		TERMINAL ID	
FREQUENCY (MHz)	INPUT POWER (dbm)	OUTPUT POWER (dbm)	INSERTION LOSS (db)
COMMENTS			
TYPED NAME, GRADE, AND TITLE		TEST ENGR SIGNATURE	

USACC FORM 417-R (TEST)
1 MAY 77

Figure 11-2. WG insertion loss data sheet.

CHAPTER 12

PARA-AMP FREQUENCY RESPONSE AND GAIN (ST-7)

12-1. GENERAL.

a. The purpose of this test is to measure the frequency response and gain of the para-amps.

b. This is normally an inservice test and requires no communications outage time provided the standby para-amp is operational. The standby para-amp under test must be removed from service. This test will be performed in either the manual or automatic sweep mode.

c. Unless otherwise specified, the half-power bandwidth is understood to be between frequencies where the gain drops 3 db below the center frequency (F_c) gain and is within the required RF spectrum bandwidth. The bandwidth will also be measured at the ±1.0 db power points.

d. When applicable, insure that power losses in test cables and WG sections are taken into consideration.

e. This test will be performed on each amplifier.

12-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

12-3. TEST EQUIPMENT REQUIRED.

a. WG attenuator.

b. Crystal detector.

c. Sweep generator.

d. Counter.

e. Oscilloscope.

f. Power meter.

g. Thermistor mount.

h. Plug-in.

i. Directional coupler.

j. Camera oscilloscope.

k. WG adapter.

12-4. TEST PROCEDURES.

a. Para-amp Gain and Bandwidth, Manual Mode.

(1) Configure the test equipment as illustrated in figure 12-1 (reference connection) and allow for a 30-minute warmup and stabilization period.

(2) Adjust the signal generator to the center frequency of the nominal passband, and to a level of -40 dbm at the output of the variable attenuator.

NOTE: The maximum or minimum power levels to para-amps are shown in the equipment maintenance manuals.

(3) Configure the test equipment as illustrated in figure 12-1 (test connection). Measure and record the output of the para-amp on figure 12-2; USACC Form 418-R (Test).

(4) Vary the frequency in 50-MHz steps above and below the center frequency until the specified passband (500 MHz) has been tested.

(5) Record the test results on figure 12-2; USACC Form 418-R (Test) and plot a frequency versus gain or frequency response curve as applicable on figure 8-7; USACC Form 396-R (Test). This data should be compared to the manufacturer's specifications and/or the equipment maintenance manuals.

b. Para-amp Gain and Bandwidth, Automatic Mode.

(1) Configure the test equipment as illustrated in figure 12-3 (reference connection). Set the sweep generator to obtain a -10 dbm output and the variable attenuator to zero db of attenuation.

(2) Adjust the sweep signal generator and oscilloscope to obtain a convenient indication as illustrated in figure 12-4.

(3) Configure the test equipment as illustrated in figure 12-3 (test connection). Insure that the sweep generator output level remains at -10 dbm. Set the variable attenuator to obtain 30 db of attenuation.

(4) Photograph the display and note all frequencies within the specified bandpass that are not within gain response or ripple tolerances.

(5) Mount the photographs on figure 12-5; USACC Form 397-R (Test). Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

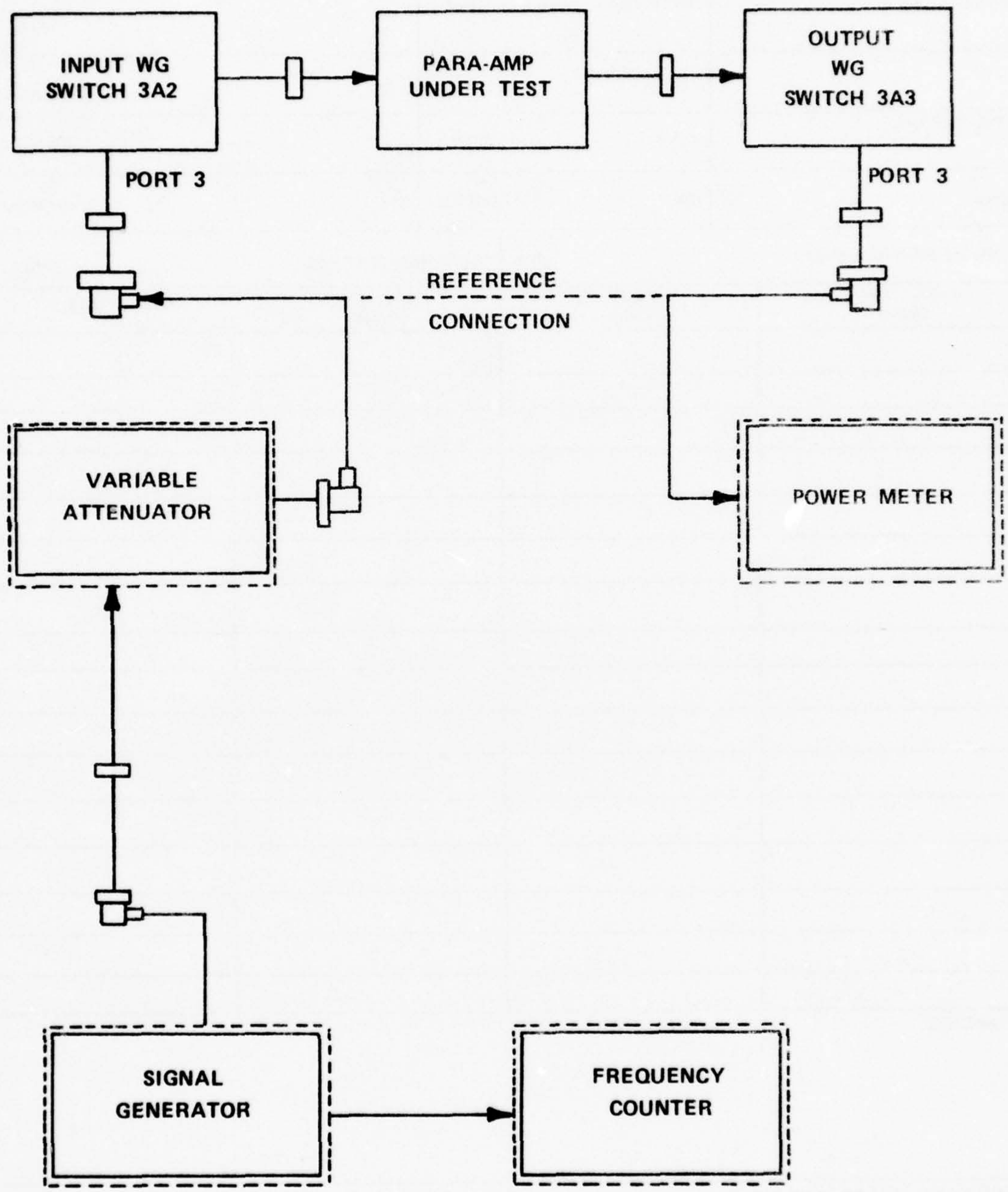


Figure 12-1. Para-amp frequency response and gain (manual mode) test configuration.

PARA-AMP GAIN AND BANDWIDTH (CCR 702-1-3) DATA SHEET		PAGE OF PAGES
TERMINAL ID	DATE (DAY, MONTH, YEAR)	F_c GHz
	$+\Delta F$ −1db(MHz)	$+\Delta F$ −0.5db(MHz)
PARA-AMP NO.	$-\Delta F$ −1db(MHz)	$-\Delta F$ −0.5db(MHz)
GAIN db	BW −3db(MHz)	BW −0.5db(MHz)

INPUT SIGNAL LEVEL dbm		REFERENCE LEVEL dbm	
FREQUENCY (MHz)	AMPLITUDE (dbm)	FREQUENCY (MHz)	AMPLITUDE (dbm)

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 418-R (TEST)
1 MAY 77

Figure 12-2. Para-amp gain and bandwidth data sheet.

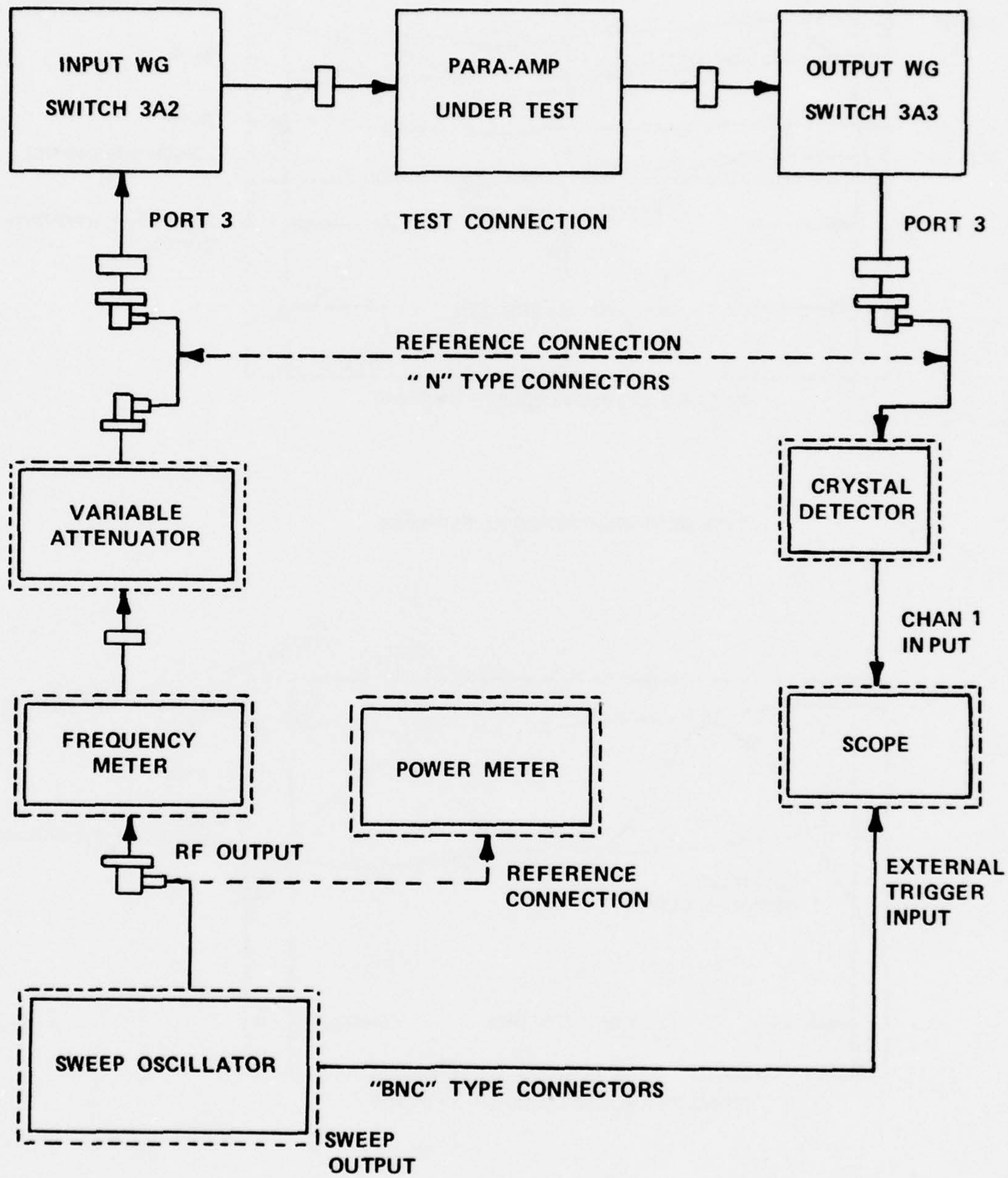
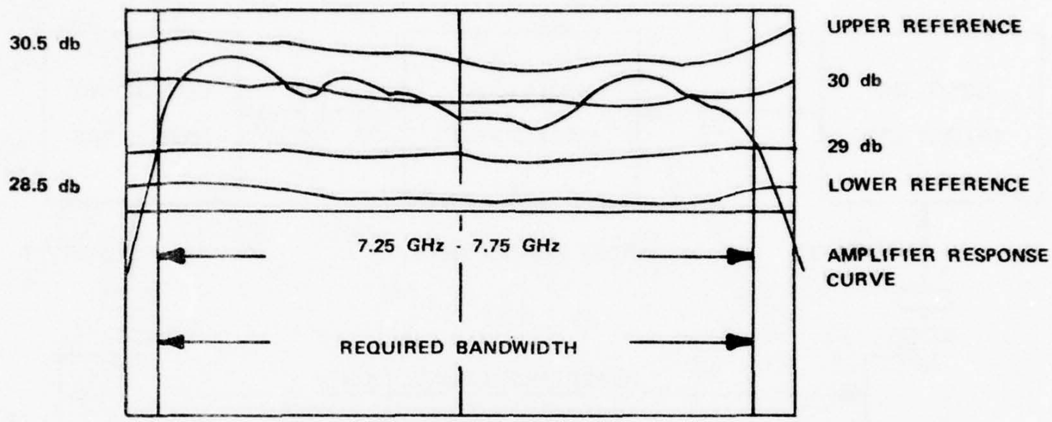
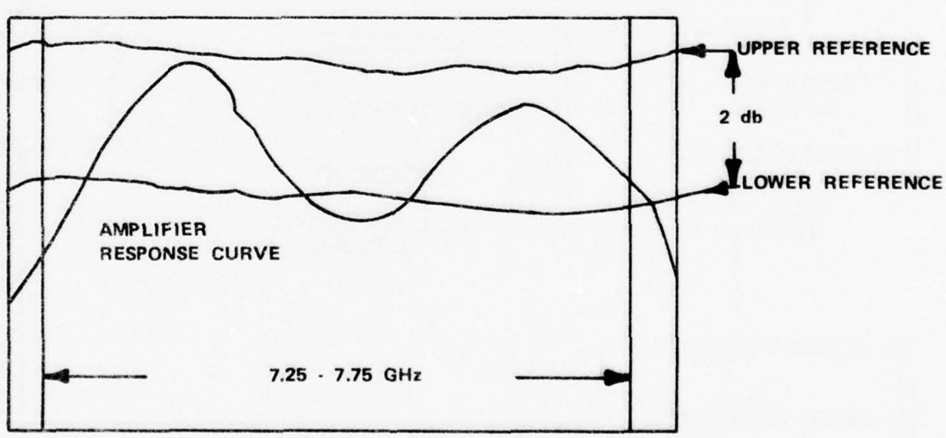


Figure 12-3. Para-amp frequency response and gain (automatic mode) test configuration.



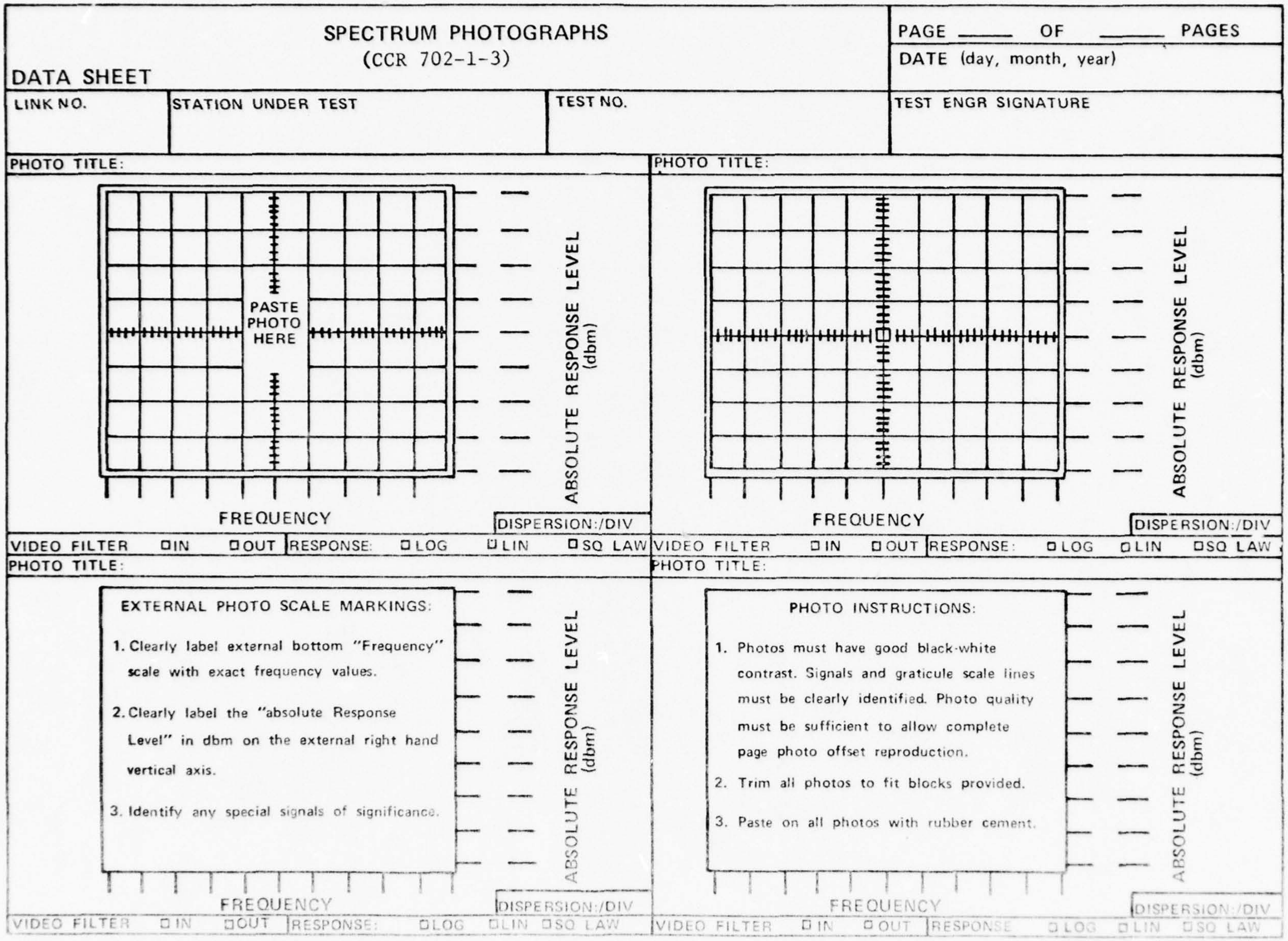
(TRACING OF OSCILLOSCOPE DISPLAY)

TYPICAL GAIN-BANDWIDTH RESPONSE



(TRACING OF OSCILLOSCOPE DISPLAY)

Figure 12-4. Out-of-tolerance gain bandwidth response.



DATA SHEET

SPECTRUM PHOTOGRAPHS
(CCR 702-1-3)

PAGE ____ OF ____ PAGES

DATE (day, month, year)

LINK NO.	STATION UNDER TEST	TEST NO.	TEST ENGR SIGNATURE

PHOTO TITLE:

PASTE PHOTO HERE

ABSOLUTE RESPONSE LEVEL (dbm)

FREQUENCY

DISPERSION:/DIV

VIDEO FILTER ☐IN ☐OUT RESPONSE: ☐LOG ☐LIN ☐SQ LAW

PHOTO TITLE:

ABSOLUTE RESPONSE LEVEL (dbm)

FREQUENCY

DISPERSION:/DIV

VIDEO FILTER ☐IN ☐OUT RESPONSE: ☐LOG ☐LIN ☐SQ LAW

PHOTO TITLE:

EXTERNAL PHOTO SCALE MARKINGS:

1. Clearly label external bottom "Frequency" scale with exact frequency values.
2. Clearly label the "absolute Response Level" in dbm on the external right hand vertical axis.
3. Identify any special signals of significance.

ABSOLUTE RESPONSE LEVEL (dbm)

FREQUENCY

DISPERSION:/DIV

VIDEO FILTER ☐IN ☐OUT RESPONSE: ☐LOG ☐LIN ☐SQ LAW

PHOTO TITLE:

PHOTO INSTRUCTIONS:

1. Photos must have good black-white contrast. Signals and graticule scale lines must be clearly identified. Photo quality must be sufficient to allow complete page photo offset reproduction.
2. Trim all photos to fit blocks provided.
3. Paste on all photos with rubber cement.

ABSOLUTE RESPONSE LEVEL (dbm)

FREQUENCY

DISPERSION:/DIV

VIDEO FILTER ☐IN ☐OUT RESPONSE: ☐LOG ☐LIN ☐SQ LAW

USACC Form 397-R (Test)
1 April 1977

Figure 12-5. Spectrum photographs data sheet.

Preceding Page BLANK - NOT FILMED

CHAPTER 13

PARA-AMP NOISE TEMPERATURE (ST-8)

13-1. GENERAL.

a. The purpose of this test is to measure the noise temperature of the parametric or low noise amplifiers.

b. This is an inservice test and normally will not require a communications outage; however, the standby amplifier will have to be removed from service.

c. Techniques for measuring the noise temperature of the para-amp by employing the Y-factor may be found in chapter 54.

13-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

13-3. TEST EQUIPMENT REQUIRED.

a. GR adapter.

b. Amplifier.

c. Noise generator.

d. Signal generator.

e. Mixer.

f. Receiver.

g. WG adapter.

h. Frequency counter.

13-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 13-1 and allow for a 30-minute warmup and stabilization period.

b. Before conducting this test, insure that the components and controls of the amplifier are all operational and that the vacuum vessel's normal operating pressure is correct, as specified by the manufacturer. Verify that the operating temperature of the cooled stage is correct and within the parameters specified by the manufacturer.

c. Fill the noise generator's thermos container with liquid nitrogen.

d. Select a test frequency (F_c) that is located in the center of the passband (7250, 7500, and 7750 MHz). Adjust the RF signal generator to a frequency 30 MHz below the test frequency and adjust the power level for 0.5 ma of crystal current as indicated on the receiver.

e. Set the receiver attenuator to 10 db and record the meter indication.

f. Change the GR adapter connection from the cold to the hot terminal of the noise generator.

g. Increase the receiver attenuation to obtain the same meter indication recorded in paragraph 13-4e. The difference in the two attenuator settings is equal to the Y-factor.

h. The losses between the GR adapter and WG adapter at the input to the WG switch should be measured and then subtracted from the Y-factor. The adapter loss correction plot is shown in figure 13-2.

i. To increase the accuracy of the measurement, repeat paragraphs 13-4 b through h five times and take an average of the five readings (fig. 13-2 and 13-3 for noise temperature to Y-factor conversion and noise temperature corrected versus noise temperature uncorrected). Record the test results on figure 13-4; USACC Form 419-R (Test).

j. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

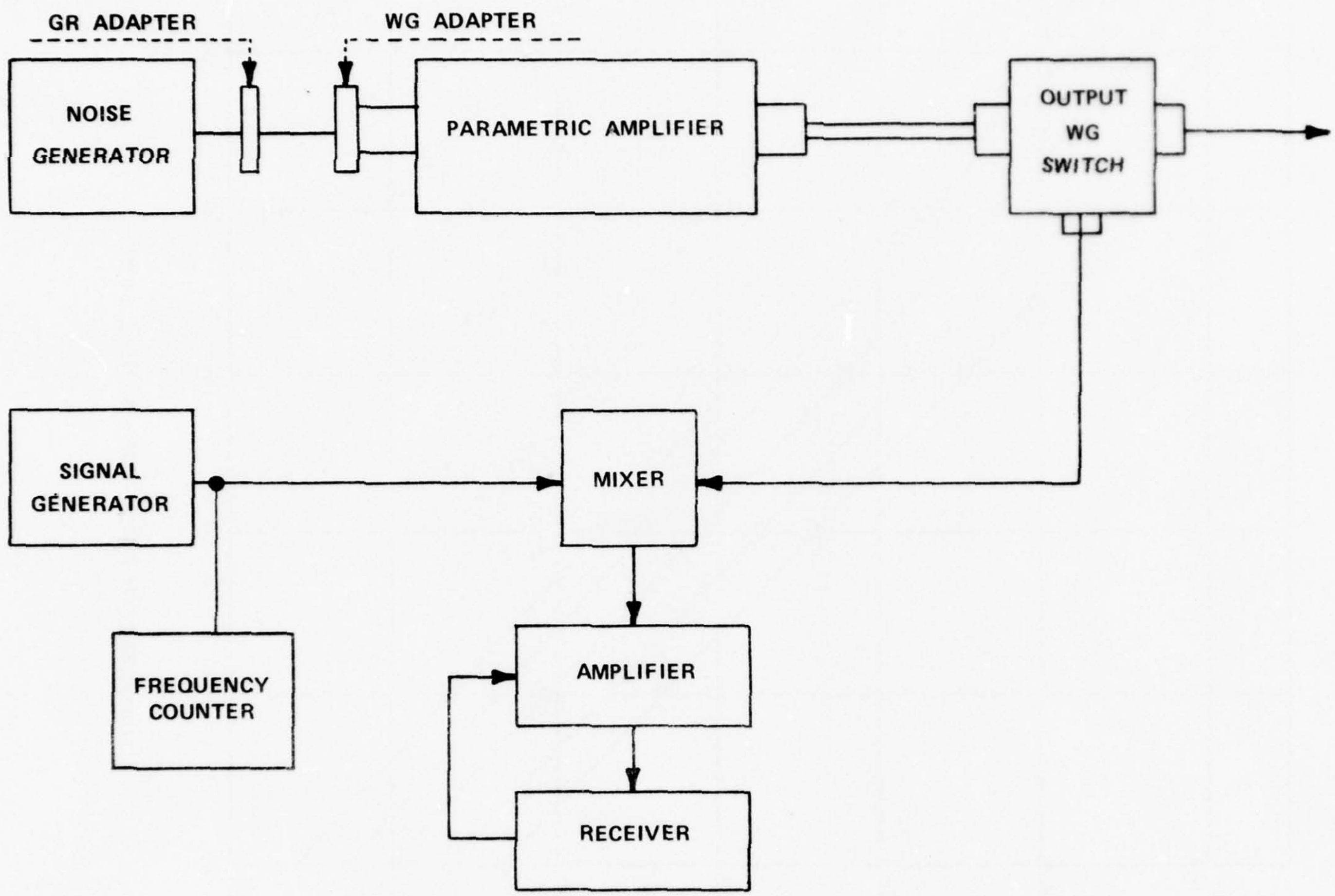


Figure 13-1. Para-amp noise temperature test configuration.

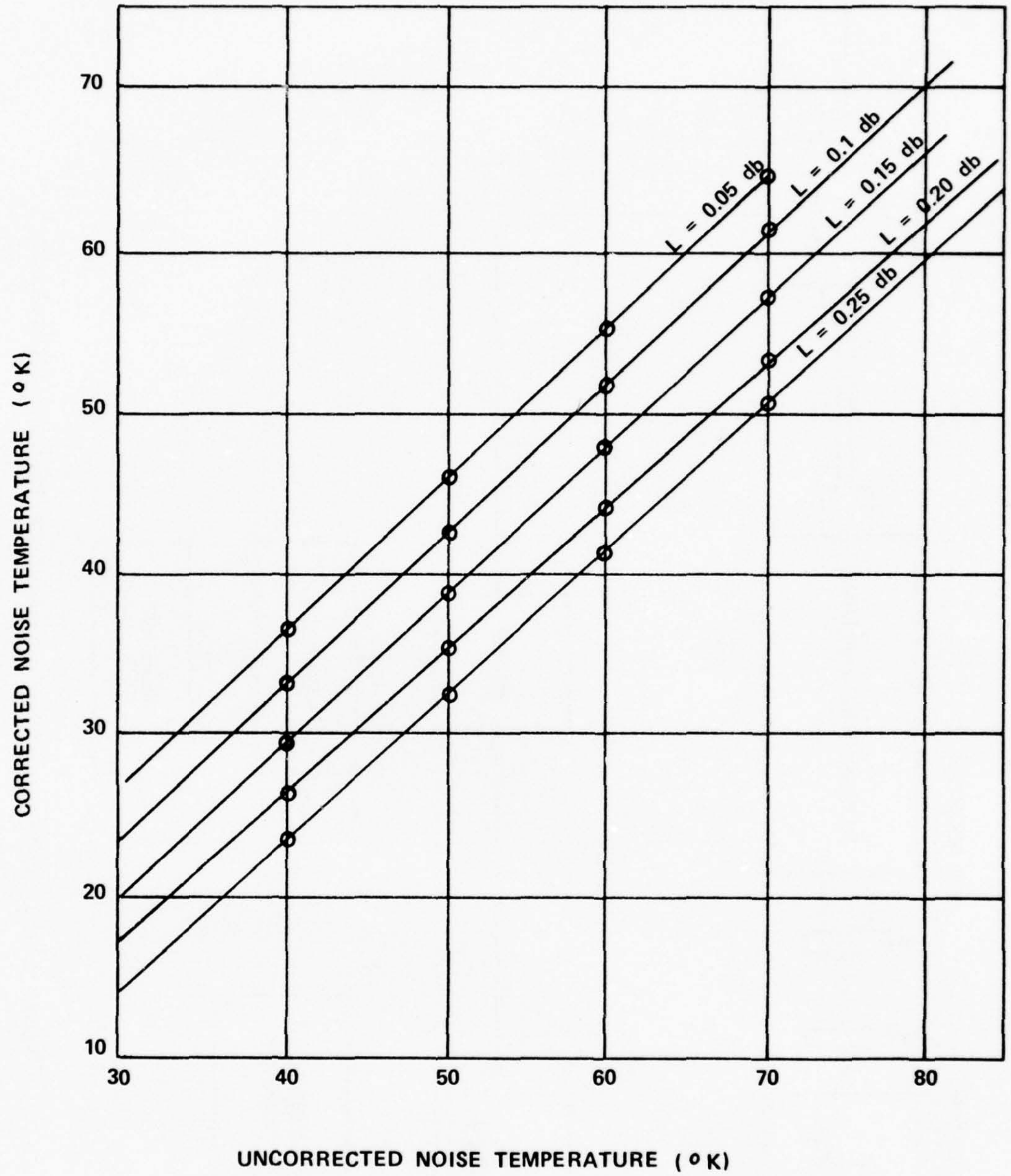


Figure 13-2. Adapter loss noise temperature correction plot.

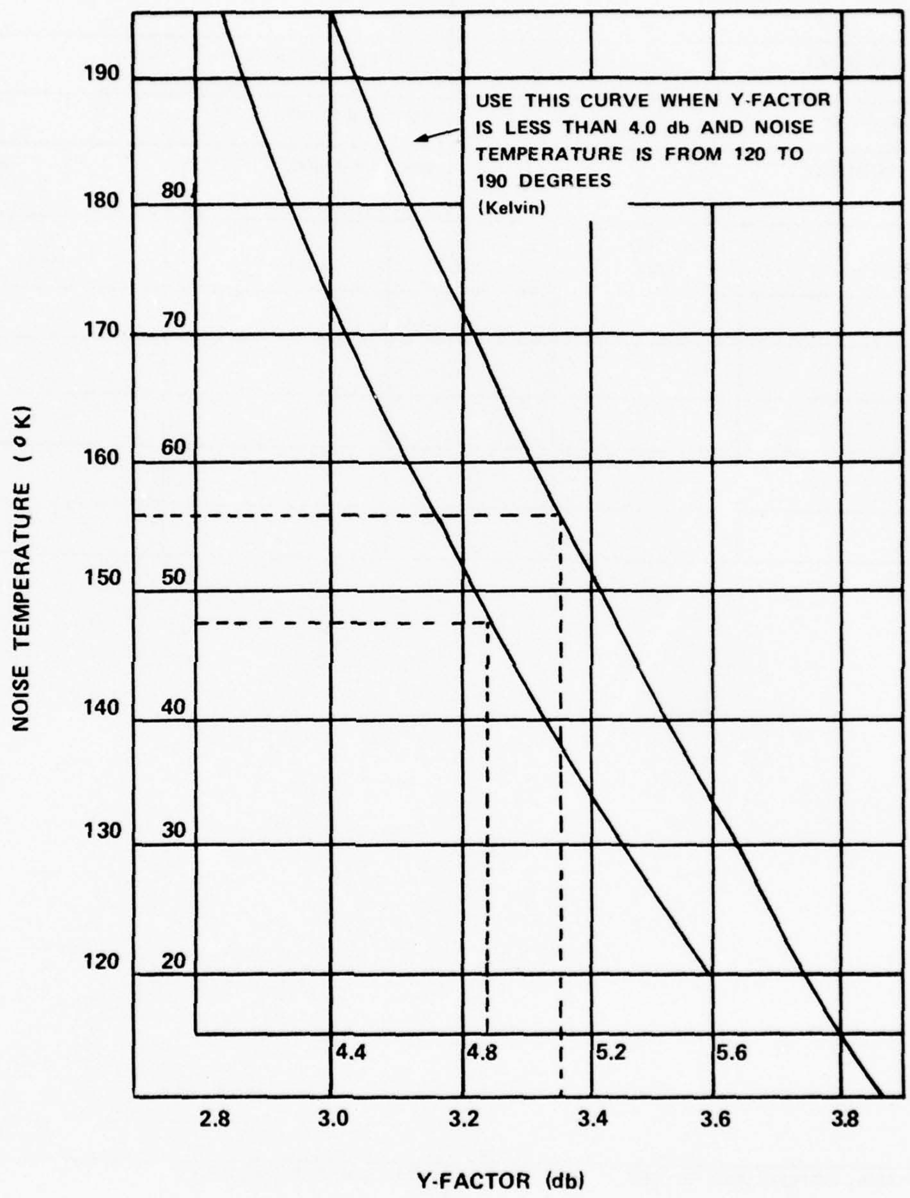


Figure 13-3. Para-amp Y-factor vs noise temperature.

PARA–AMP NOISE TEMPERATURE (CCR 702-1-3) DATA SHEET	PAGE OF PAGES
TERMINAL ID	DATE (DAY, MONTH, YEAR)
VACUUM PRESSURE	ADAPTER LOSSES db
OPERATING TEMP deg K	AMPLIFIER NO.
CRYSTAL CURRENT	SPECIFICATION deg K

STARTS	COLD (db)	HOT (db)	Y (db)	T (°K)
1				
2				
3				
4				
5				

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 419-R (TEST)
1 MAY 77

Figure 13-4. Para-amp noise temperature data sheet.

CHAPTER 14

PARA-AMP DYNAMIC RANGE (0.5-db COMPRESSION POINT) (ST-9)

14-1. GENERAL.

a. The purpose of this test is to measure the dynamic range and amplification threshold of the para-amp.

b. This is an inservice test and does not require a communications outage; however, the standby para-amp will have to be removed from service.

c. This test will be conducted using three different frequencies of the passband frequency spectrum as listed below.

(1) F_c 7500 MHz

(2) F_1 7750 MHz

(3) F_2 7250 MHz

14-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

14-3. TEST EQUIPMENT REQUIRED.

a. Signal generator.

b. Counter.

c. Power meter.

d. Thermistor mount.

e. Frequency counter.

14-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 14-1 and allow for a 30-minute warmup period.

b. Adjust the output attenuator located on the SHF signal generator to maximum attenuation.

c. Tune the SHF signal generator to a frequency of 7500 MHz at an output power level of -30 dbm. Connect the power meter to the output WG switch.

d. Measure the output power level and compute the gain difference between the measured output and the input levels. Decrease the input signal level in 2-db steps until a level of -50 dbm is reached. Measure the input and output power levels and compute the gain at each step.

e. Repeat paragraphs 14-4 c and d at 7250 MHz and 7750 MHz, respectively. Plot a gain versus input signal level curve on figure 8-7; USACC Form 396-R (Test). The amplifier gain should be plotted in db on the vertical axis of the form while the input level in dbm is plotted on the horizontal axis.

f. Record the test results on figure 14-2; USACC Form 420-R (Test).

g. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

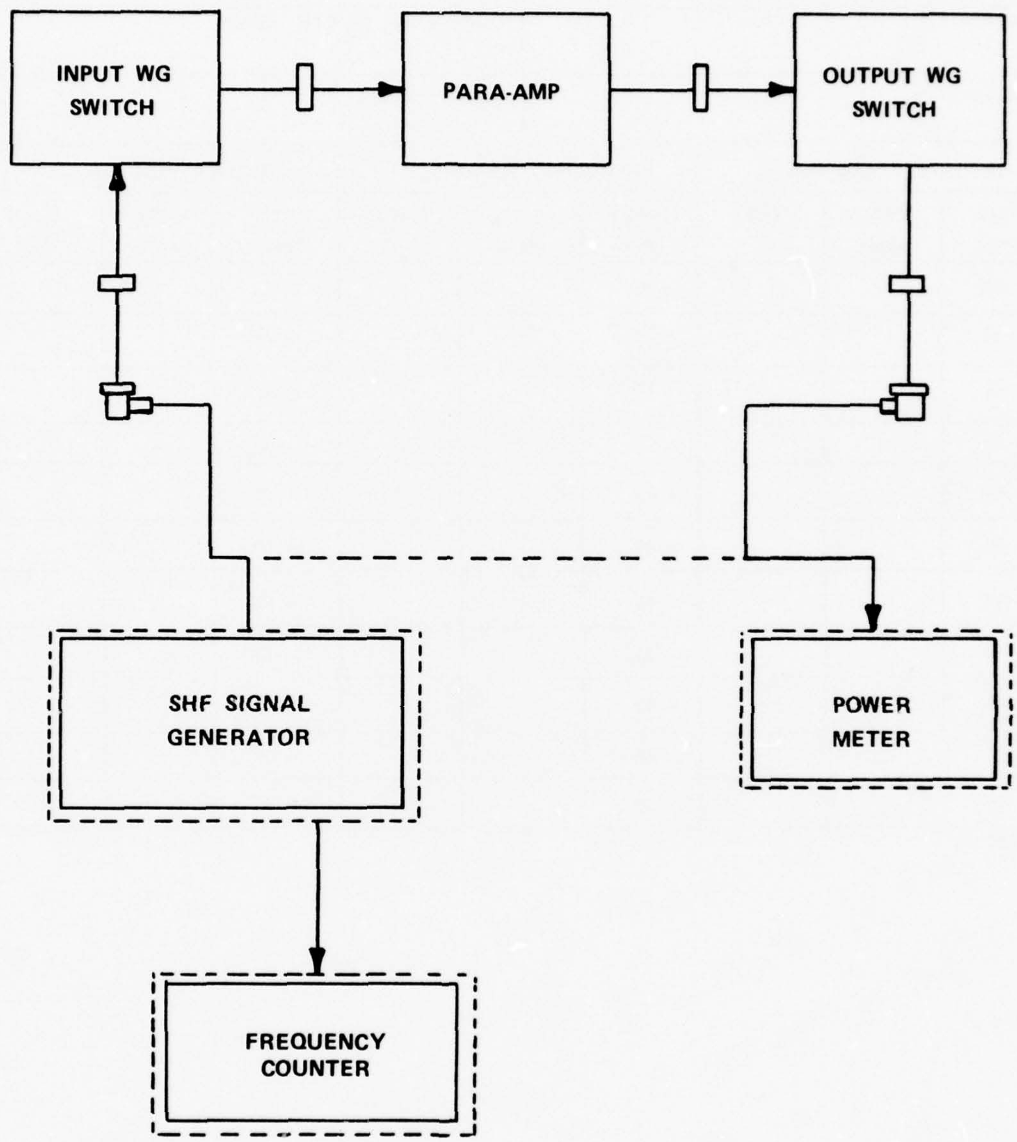


Figure 14-1. Para-amp dynamic range test configuration.

PARA-AMP DYNAMIC RANGE (0.5-db COMPRESSION POINT) DATA SHEET (CCR 702-1-3)	PAGE OF PAGES
TERMINAL ID	DATE (DAY, MONTH, YEAR)
PARA-AMP ID	SPECIFICATION db

FREQUENCY 7500 MHz			FREQUENCY 7250 MHz			FREQUENCY 7750 MHz		
INPUT (dbm)	OUTPUT (dbm)	GAIN (db)	INPUT (dbm)	OUTPUT (dbm)	GAIN (db)	INPUT (dbm)	OUTPUT (dbm)	GAIN (db)
– 30			– 30			– 30		
– 32			– 32			– 32		
– 34			– 34			– 34		
– 36			– 36			– 36		
– 38			– 38			– 38		
– 40			– 40			– 40		
– 42			– 42			– 42		
– 44			– 44			– 44		
– 46			– 46			– 46		
– 48			– 48			– 48		
– 50			– 50			– 50		

COMMENTS

TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 420-R (TEST)
1 MAY 77

Figure 14-2. Para-amp dynamic range (0.5-db compression point) data sheet.

CHAPTER 15

PARA-AMP VSWR (ST-10)

15-1. GENERAL.

a. The purpose of this test is to measure the VSWR at the input and output ports of the para-amps.

b. Although all terminals are equipped with a redundant parametric IFLA, the test will have to be performed out of service to prevent exposure of personnel to radiation hazards. An AO is required.

c. This test will be conducted using 10 different frequencies equally distributed over the specified bandpass.

d. Techniques for performing both VSWR and return loss measurements may be found in chapter 55.

15-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

15-3. TEST EQUIPMENT REQUIRED.

a. Thermistor mount.

b. Power meter.

c. Counter.

d. WG attenuator.

e. VSWR indicator.

f. Slotted line carriage.

g. Slotted line probe.

h. Slotted line.

i. Plug-in.

j. Sweep generator.

k. Directional coupler.

l. WG adapters.

15-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 15-1 (para-amp input) and allow for a 30-minute warmup and stabilization period.

b. Tune the RF sweep signal generator to a CW frequency of 7500 MHz at an output power level of -10 dbm. Push the internal square wave switch to the IN position.

c. Adjust the variable attenuator to a setting of 20-db attenuation.

d. Adjust the handcrank located on the slotted line carriage until a maximum indication is obtained on the square law indicator.

e. Calibrate the square law indicator to read on the 1-standing wave ratio (SWR) meter range. Adjust the handcrank located on the slotted line carriage until a minimum indication is observed on the square law indicator. Record the VSWR indication on figure 15-2, USACC Form 421-R (Test).

f. Repeat paragraphs 15-4 c through e at the following frequencies:

FREQUENCY (MHz)		
7250	7450	7650
7300	7500 (F_c)	7700
7350	7550	7750
7400	7600	

Specified Bandpass: 500 MHz
Center Frequency: 7500 MHz

g. Configure the test equipment as illustrated in figure 15-3 and measure the VSWR at the output port of the para-amp.

h. Record the test results on figure 15-2; USACC Form 421-R (Test). and summarize the test results on figure 6-4; USACC Form 351-R (Test).

i. Plot a frequency versus VSWR curve of the para-amp on figure 8-7; USACC Form 396-R (Test).

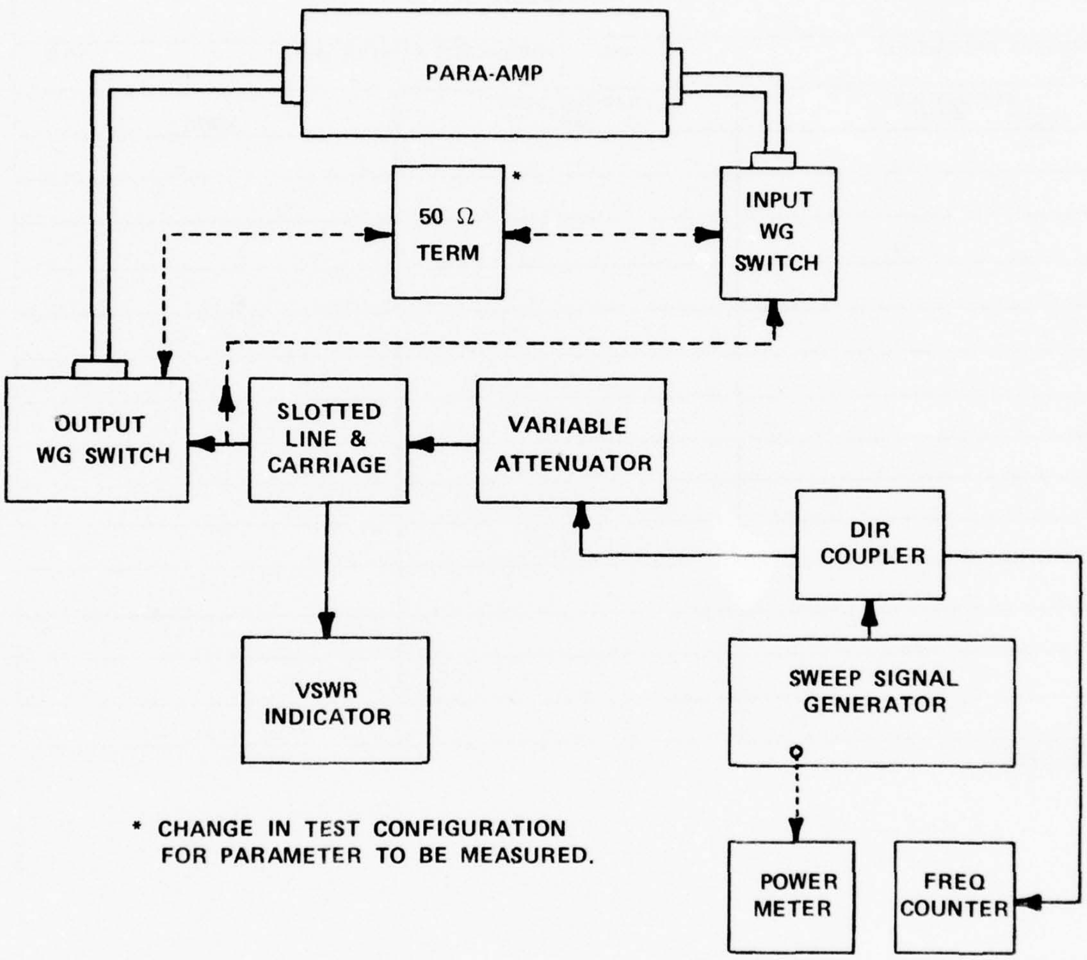


Figure 15-1. Para-amp input/output VSWR test configuration.

PARA-AMP VSWR (CCR 702-1-3) DATA SHEET	PAGE OF PAGES
TERMINAL ID	DATE (DAY, MONTH, YEAR)
PARA-AMP UNDER TEST	SPECIFICATION
OPERATING FREQUENCY MHz	FREQUENCY CENTER (F_c) MHz

FREQUENCY (MHz)	RETURN LOSS (db)	VSWR

COMMENTS

TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 421-R (TEST)
1 MAY 77

Figure 15-2. Para-amp VSWR data sheet.

CHAPTER 16

PARA-AMP PUMP SOURCE POWER OUTPUT LEVEL AND FREQUENCY (ST-11)

16-1. GENERAL.

a. The purpose of this test is to measure the pump oscillator power output and frequency. This test should not be performed unless the bandwidth and gain requirements do not meet specifications (nominally, 30±0.5 db).

b. This is an inservice test and does not require a communications outage; however, the standby para-amp will have to be removed from service.

16-2. SPECIFICATIONS. The test data obtained during this test shall be compared to performance limits delineated in appendix B.

16-3. TEST EQUIPMENT REQUIRED.

a. Coupler.

b. Frequency meter.

c. Thermistor mount.

d. Power meter.

e. Termination.

16-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 16-1 and allow for a 30-minute warmup and stabilization period.

b. Insure that all additional pump signal source outputs are terminated into the appropriate impedance.

c. Tune the frequency meter until a sharp null indication is observed on the power bridge. The frequency meter should indicate 42.00±0.024 GHz, unless otherwise specified.

d. Observe the power meter for a minimum indication as specified. Consider the 20-db directional coupler loss.

e. Record the test results on figure 16-2; USACC Form 422-R (Test).

f. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

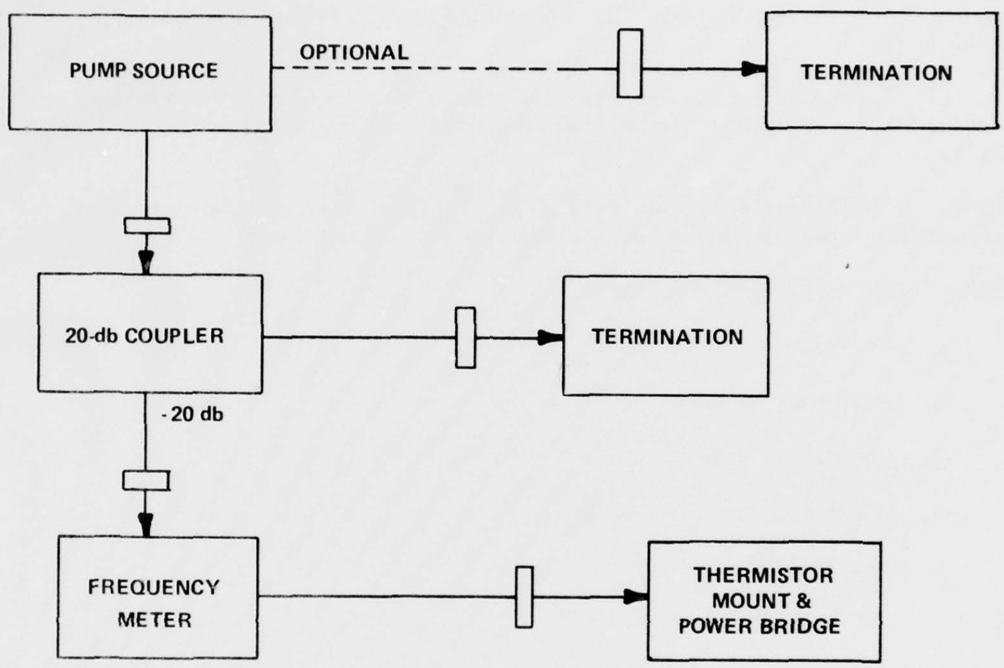


Figure 16-1. Para-amp pump source power output level and frequency test configuration.

PARA-AMP PUMP SOURCE POWER OUTPUT LEVEL AND FREQUENCY DATA SHEET (CCR 702-1-3)			PAGE OF PAGES		
TERMINAL ID			DATE (DAY,MONTH,YEAR)		
SPECIFIED FREQ MHz			SPECIFIED POWER OUTPUT W		
AMPLIFIER NO.			SPECIFIED FREQ TOLERANCE ±MHz		
POWER OUTPUT			FREQUENCY		
STAGE	WATTS	dbm	REQUIRED (MHz)	MEASURED (MHz)	ACCURACY (%)
COMMENTS					
TYPED NAME, GRADE, AND TITLE			TEST ENGR SIGNATURE		

USACC FORM 422-R (TEST)
1 MAY 77

Figure 16-2. Para-amp pump source power output level and frequency data sheet.

Preceding Page Blank - NOT FILMED

CHAPTER 17

IFLA NF (ST-12)

17-1. GENERAL.

a. The purpose of this test is to measure the NF of the IFLA.

b. Although all terminals are equipped with a redundant parametric IFLA, the test will have to be performed out of service to prevent exposure of personnel to radiation hazards. An AO is required.

c. This test will be conducted in the manual or automatic mode.

d. Techniques for measuring the noise temperature of the receive IFLA by employing the Y-factor may be found in chapter 54.

17-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

17-3. TEST EQUIPMENT REQUIRED.

a. Noise source.

b. Noise figure indicator.

c. SHF signal generator.

d. Power meter.

e. Thermistor mount.

f. Frequency counter.

g. RF voltmeter.

h. Variable attenuator.

i. Mixer.

j. Fixed attenuator.

17-4. TEST PROCEDURES.

a. Manual Mode.

(1) Configure the test equipment as illustrated in figure 17-1 and allow for a 30-minute warmup and stabilization period.

(2) Terminate the input to the IFLA with a 50-ohm termination plug.

(3) Adjust the SHF signal generator for an output power level of zero dbm at a frequency of 7500 MHz.

(4) Adjust the variable attenuator to obtain a convenient indication on the RF voltmeter. Record the RF voltmeter reading and the attenuator setting.

(5) Adjust the noise source for an indication of 200 ma or a current indication that relates to the appropriate noise source discharge temperature (typical 10, 100 degrees K).

(6) Adjust the variable precision attenuator to obtain the original reading as in paragraph 17-4a(4), and record the new attenuator setting. The difference between the original attenuator setting and the new setting is equal to the Y-factor in db.

(7) The arithmetical difference between the Y-factor and 15.28 db is equal to the NF. Record the NF on figure 17-2; USACC Form 423-R (Test).

(8) Subtract 10 db plus any cable loss from the NF and record the corrected NF.

(9) Repeat paragraphs 17-4a (5) through (8) five more times and compute an arithmetical average NF.

(10) Restore the system to normal operating condition.

b. Automatic Mode.

(1) Configure the test equipment as illustrated in figure 17-3 and allow for a 30-minute warmup and stabilization period.

(2) Tune the signal generator to 7500 MHz at an RF output power level of zero dbm.

(3) Calibrate the noise source and the NF indicator as specified in the operating instructions.

(4) Place the mode switch in the automatic position and record the NF.

(5) Subtract 10 db and any cable loss (in db) from the NF indication. Repeat paragraphs 17-4a (2) through (5) five more times and compute the arithmetical average NF. Record the test results on figure 17-2; USACC Form 423-R (Test).

(6) Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

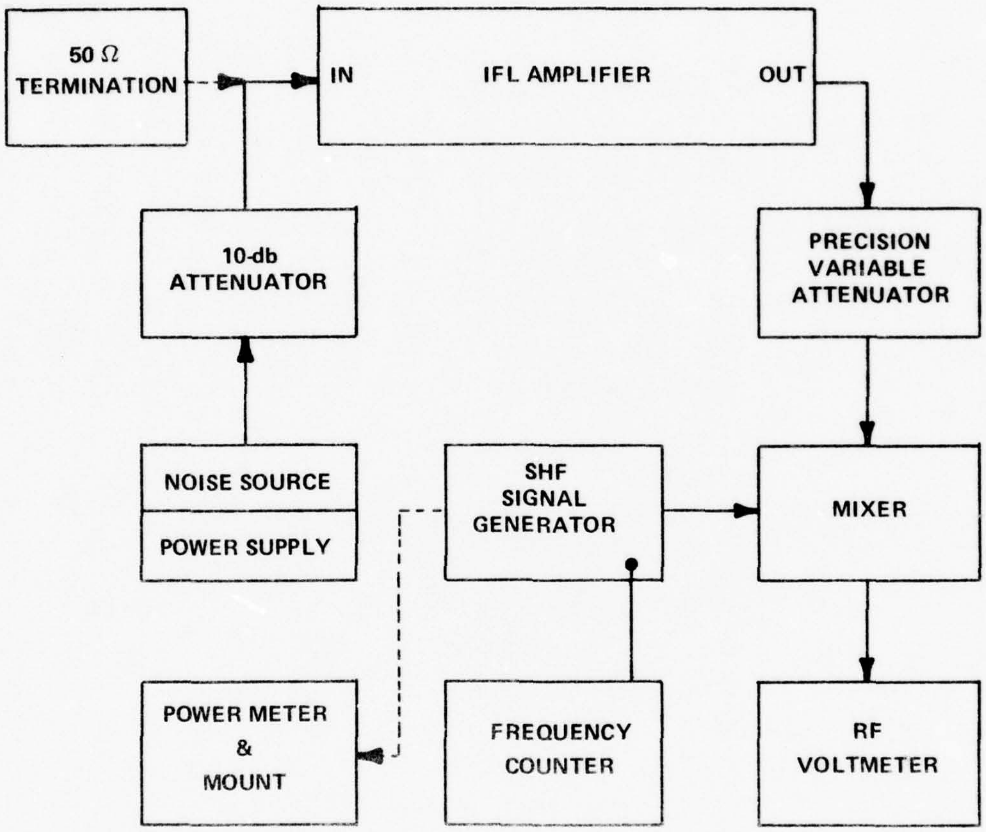


Figure 17-1. IFLA NF (manual mode) test configuration.

<table>
<tr><td colspan="3">IFLA NF
(CCR 702-1-3)
DATA SHEET</td><td colspan="2">PAGE OF PAGES</td></tr>
<tr><td colspan="3">TERMINAL ID</td><td colspan="2">DATE (DAY, MONTH, YEAR)</td></tr>
<tr><td colspan="3">AVERAGE NF</td><td colspan="2">CABLE LOSS db</td></tr>
<tr><td colspan="3">SOURCE CURRENT</td><td colspan="2">SPECIFICATION</td></tr>
<tr><td colspan="3">MODE ☐ MANUAL ☐ AUTO</td><td colspan="2">ORIGINAL METER INDICATION</td></tr>
<tr><td colspan="3">ATTENUATOR SETTINGS
(db)</td><td rowspan="2">Y-FACTOR
(db)</td><td rowspan="2">NOISE FIGURE
(db)</td></tr>
<tr><td>STARTS</td><td>COLD</td><td>HOT</td></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td></td><td></td><td></td><td></td></tr>
<tr><td>6</td><td></td><td></td><td></td><td></td></tr>
<tr><td>7</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">COMMENTS</td></tr>
<tr><td colspan="3">TYPED NAME, GRADE, AND TITLE</td><td colspan="2">TEST ENGR SIGNATURE</td></tr>
</table>

USACC FORM 423-R (TEST)
1 MAY 77

Figure 17-2. IFLA NF data sheet.

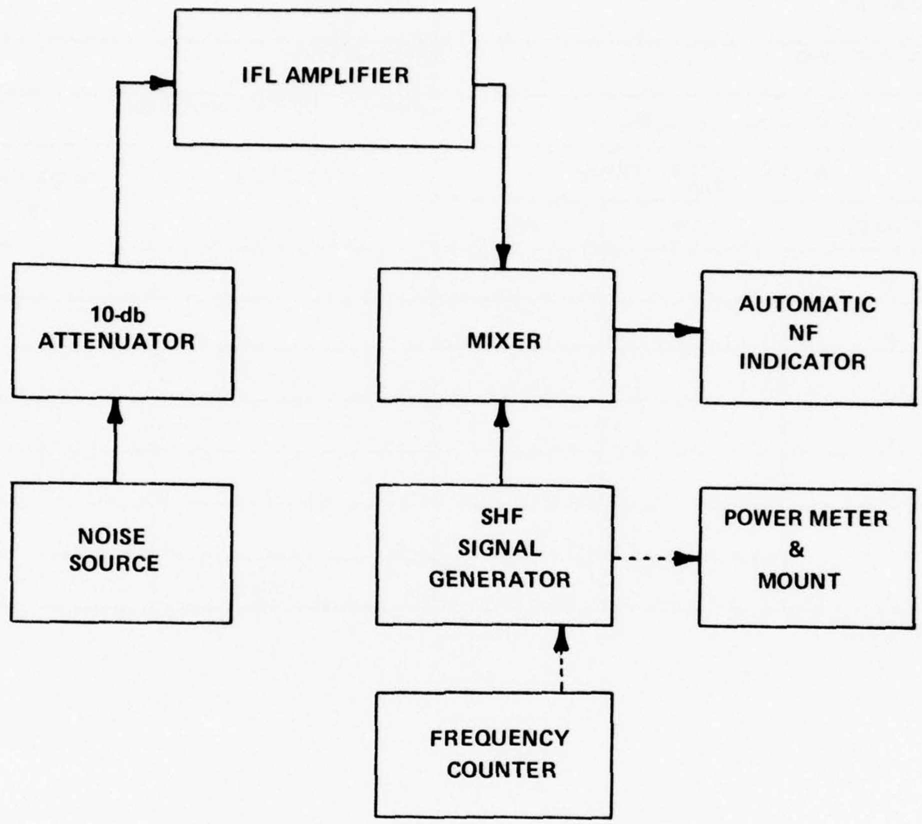


Figure 17-3. IFLA NF (automatic mode) test configuration.

CHAPTER 18

IFLA FREQUENCY RESPONSE AND GAIN (ST-13)

18-1. GENERAL.

a. The purpose of this test is to measure the IFLA traveling wave tube amplifier (TWTA) signal gain at a finite and specified bandwidth.

b. This is normally an inservice test and does not require a communications outage; however, the amplifier under test must be removed from service.

c. This test will be performed in the manual sweep mode.

d. The input and output test points are the appropriate ports on the input and output WG switches or, in cases where a switch-redundant IFLA is installed, the input and output ports of the amplifier.

e. This test is performed once per amplifier and on each amplifier.

18-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

18-3. TEST EQUIPMENT REQUIRED.

a. Sweep generator.

b. Plug-in.

c. Power meter.

d. Thermistor mount.

e. WG attenuator.

f. Fixed attenuator.

g. Directional coupler.

h. WG adapters.

i. Frequency counter.

18-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 18-1 and allow for a 30-minute warmup and stabilization period.

b. Adjust the variable WG attenuator to a setting of zero db. Tune the sweep signal generator to a CW frequency of 7500 MHz at an output power level of -10 dbm as indicated on the power meter.

c. Adjust the variable WG attenuator to a setting of 30 db. Configure the test equipment as illustrated in figure 18-2. Set WG switches, located on the back of the IFLA panel, in the respective positions for the amplifier to be tested.

d. The power meter should indicate a minimum of -10 db. Compute and record the gain on figure 18-3; USACC Form 424-R (Test).

e. Repeat paragraphs 18-4 c and d above, at the following listed frequencies:

FREQUENCY (MHz)		
7200	7400	7650
7250	7450	7700
7300	7500 (F_c)	7750
7350	7550	7800
	7600	

f. Plot a gain versus frequency curve on figure 8-7; USACC Form 396-R (Test). The gain (db/ref gain at F_c) should be entered on the vertical axis of the form and the frequency in MHz on the horizontal axis.

g. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

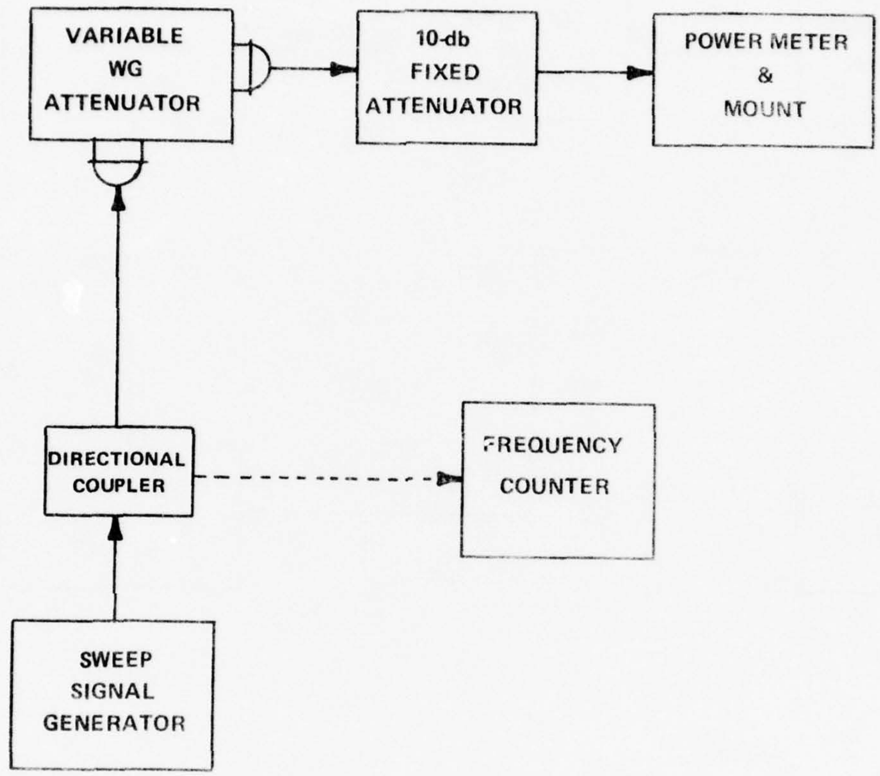


Figure 18-1. IFLA frequency response and gain (WG attenuator at zero db) test configuration.

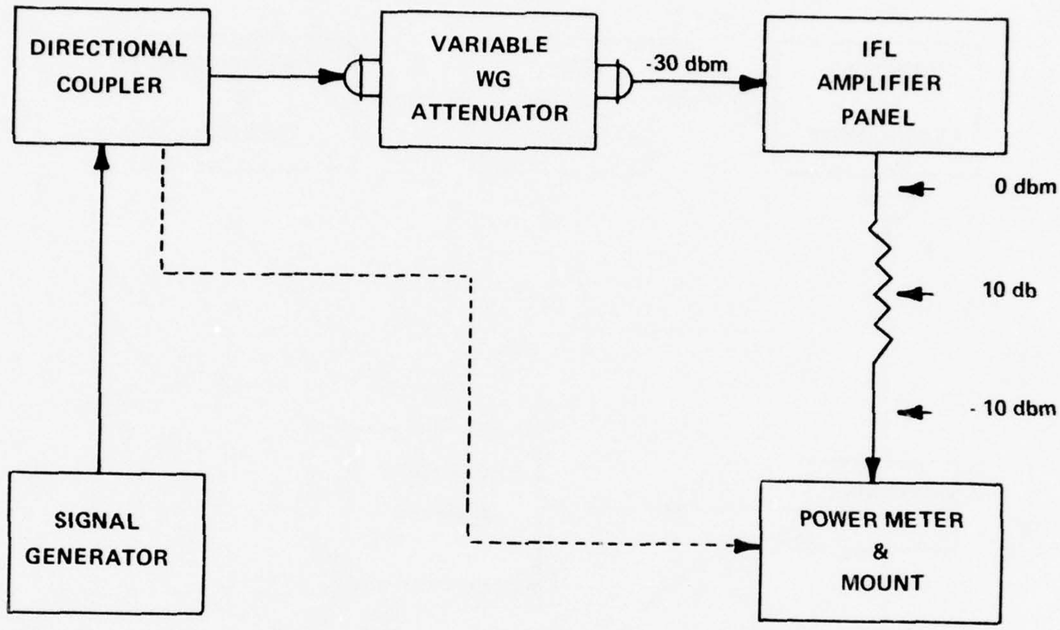


Figure 18-2. IFLA frequency response and gain (WG attenuator at 30 db) test configuration.

IFLA FREQUENCY RESPONSE AND GAIN DATA SHEET (CCR 702-1-3)		PAGE OF PAGES
TERMINAL ID		DATE (DAY, MONTH, YEAR)
TWTA NO.		SPECIFICATION db
INPUT LEVEL dbm	OUTPUT LEVEL dbm	REFERENCE FREQ (F_c) MHz
FREQUENCY (MHz)		GAIN (db) IN REF (F_c)
COMMENTS		
TYPED, NAME, GRADE, AND TITLE		TEST ENGR SIGNATURE

USACC FORM 424-R (TEST)
1 MAY 77

Figure 18-3. IFLA frequency response and gain data sheet.

Preceding Page BLank - FILMed

CHAPTER 19

IFLA VSWR (ST-14)

19-1. GENERAL.

a. The purpose of this test is to measure the input and output VSWR of the IFLA's.

b. This is normally an inservice test for the transmit IFLA; however, the standby amplifier will be removed from service. Although all terminals are equipped with a redundant para-amp IFLA, the test may have to be performed out of service to prevent exposure of personnel to radiation hazards. In which case, an AO is required.

c. Techniques for performing both VSWR and return loss measurements may be found in chapter 55.

19-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

19-3. TEST EQUIPMENT REQUIRED.

a. Slotted line carriage.

b. Slotted line probe.

c. Slotted line.

d. Power meter.

e. Frequency counter.

f. VSWR indicator.

g. WG attenuator.

h. Thermistor mount.

i. WG adapters.

j. Sweep generator.

k. Plug-in.

l. Directional coupler.

19-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 19-1 and allow for a 30-minute warmup and stabilization period.

b. Tune the RF sweep signal generator to a CW frequency of 7500 MHz at an output power level of zero dbm. Push the internal square wave switch to the IN position.

c. Adjust the variable WG attenuator to a setting of 20 db.

d. Adjust the handcrank located on the slotted line carriage until a maximum indication is obtained on the square law indicator of the SWR meter. Calibrate the square law indicator for an indication of 1 on the SWR meter.

e. Adjust the handcrank on the slotted line until a minimum indication is obtained. Record the SWR indication on figure 19-2; USACC Form 425-R (Test).

f. Tune the sweep signal generator to the following frequencies and repeat paragraphs 19-4 d and e.

FREQUENCY (MHz)		
7200	7450	7700
7250	7500	7750
7300	7550	8000
7350	7600	
7400	7650	

g. Plot a VSWR versus frequency curve on figure 8-7; USACC Form 396-R (Test).

h. Terminate the input of TWTA under test and connect the test equipment to the output test jack of the amplifier under test.

i. Repeat paragraphs 19-4 d through g.

j. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

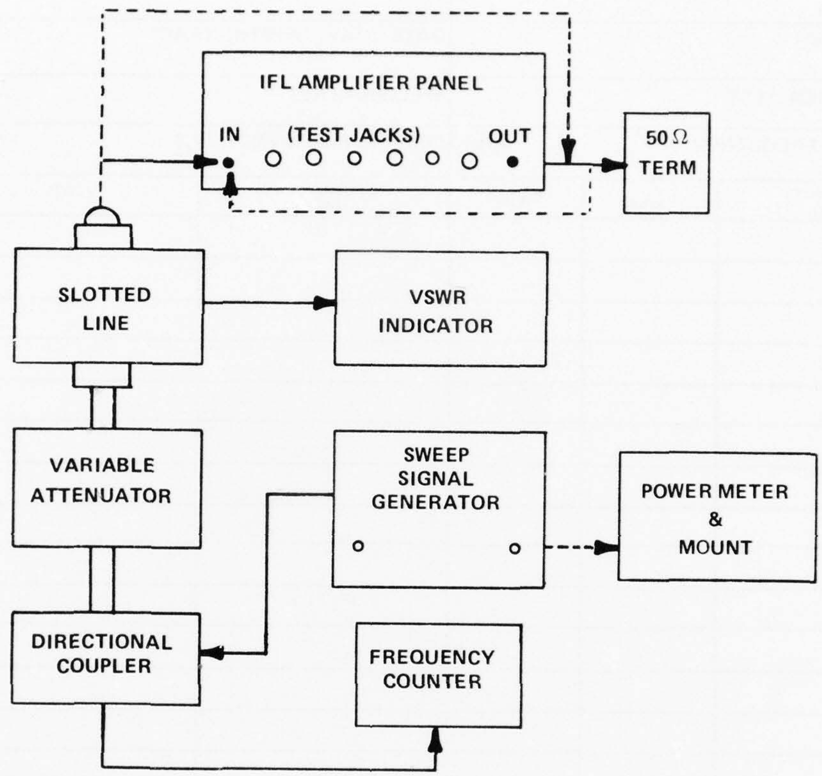


Figure 19-1. IFLA input/output VSWR test configuration.

IFLA VSWR (CCR 702-1-3) DATA SHEET			PAGE OF PAGES	
TERMINAL ID			DATE (DAY, MONTH, YEAR)	
DEVICE UNDER TEST			SPECIFICATION	
OPERATING FREQUENCY MHz			CENTER FREQUENCY (F_c) MHz	
FREQUENCY (MHz)	E_{max}	E_{min}	RETURN LOSS (db)	VSWR
COMMENTS				
TYPED NAME, GRADE, AND TITLE			TEST ENGR SIGNATURE	

USACC FORM 425-R (TEST)
1 MAY 77

Figure 19-2. IFLA VSWR data sheet.

CHAPTER 20

DOWN CONVERTER VSWR (ST-15)

20-1. GENERAL.

a. The purpose of this test is to measure the input VSWR of the down converter.

b. This is an inservice test and does not require an AO; however, the down converter must be removed from service.

c. Techniques for performing both VSWR and return loss measurements may be found in chapter 55.

20-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

20-3. TEST EQUIPMENT REQUIRED.

a. Slotted line carriage.

b. Slotted line probe.

c. Slotted line.

d. Sweep generator.

e. Plug-in.

f. Frequency counter.

g. VSWR indicator.

h. WG adapters.

i. WG attenuator.

j. Directional coupler.

k. Power meter.

l. Thermistor mount.

20-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 20-1. Remove the coaxial cable from the input of the down converter. (Turn off the AC power to the down converter under test.)

b. Tune the RF sweep signal generator for a frequency output of 7500 MHz at an output power level of zero dbm. Push the internal square wave switch to the IN position and set the variable attenuator to 20-db attenuation.

c. Adjust the slotted line to obtain a maximum deflection (E_{max}) and calibrate the SWR meter on the 1-SWR range.

d. Adjust the slotted line to obtain a minimum indication (E_{min}) on the SWR indicator. Record the VSWR indication on figure 20-2; USACC Form 426-R (Test).

e. Repeat paragraphs 20-4 b through d using the following frequencies:

FREQUENCY (MHz)		
7200	7400	7650
7250	7450	7700
7300	7500	7750
7350	7550	7800
	7600	

f. Plot a frequency versus VSWR curve on figure 8-7; USACC Form 396-R (Test).

g. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

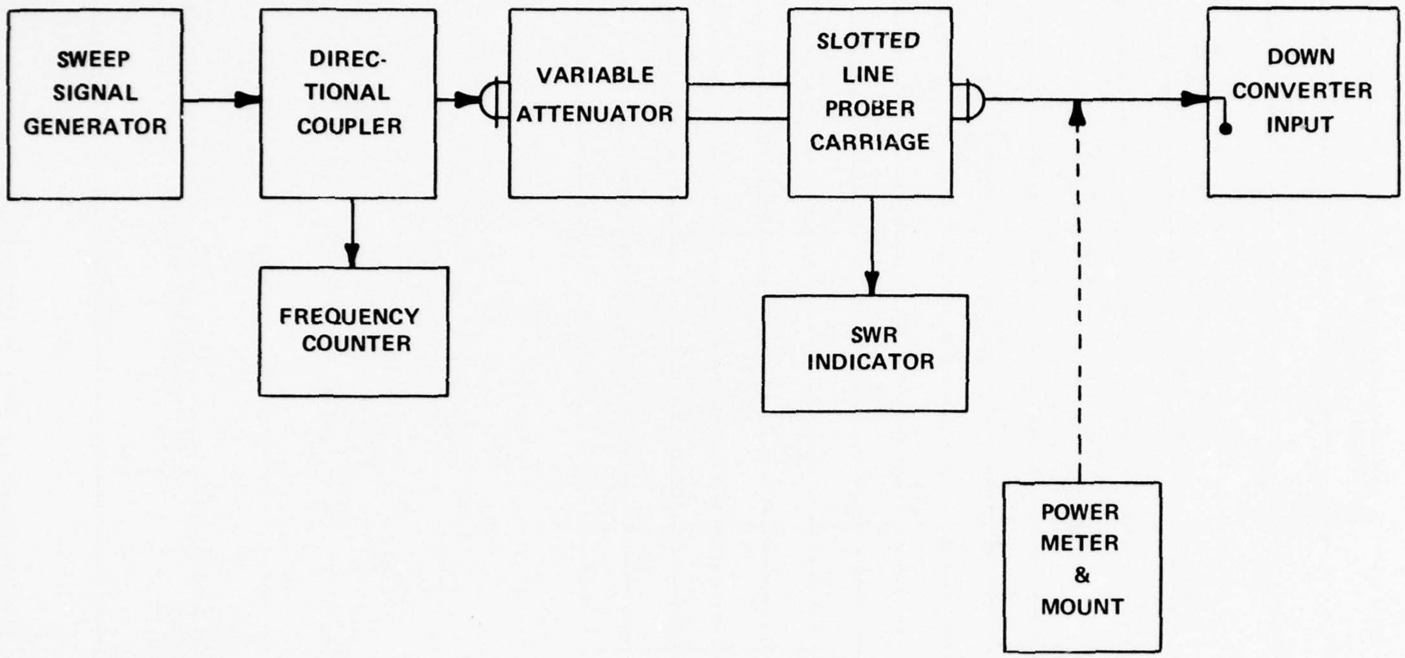


Figure 20-1. Down converter VSWR test configuration.

DOWN CONVERTER VSWR (CCR 702-1-3) DATA SHEET				PAGE OF PAGES
TERMINAL ID			DATE (DAY, MONTH, YEAR)	
DEVICE UNDER TEST			SPECIFICATION	
OPERATING FREQUENCY MHz			DOWN CONVERTER ID	
FREQUENCY (MHz)	E_{max}	E_{min}	RETURN LOSS (db)	VSWR
COMMENTS				
TYPED NAME, GRADE, AND TITLE			TEST ENGR SIGNATURE	

USACC FORM 426-R (TEST)
1 MAY 77

Figure 20-2. Down converter VSWR data sheet.

CHAPTER 21

DOWN CONVERTER SPURIOUS OUTPUT (ST-16)

21-1. GENERAL.

a. The purpose of this test is to measure the spurious output radiations of the down converter and to determine what effect the spurious signals would have on the quality of communications.

b. This is normally an inservice test for those earth terminals that are equipped with one or more standby down converters. However, this is an out-of-service test for those terminals that are not equipped with a standby down converter. An AO is required.

c. This test will be conducted in either the manual or automatic swept frequency mode.

21-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

21-3. TEST EQUIPMENT REQUIRED.

a. Spectrum analyzer.

b. SHF signal generator.

c. 40-db fixed attenuator.

d. 20-db fixed attenuator.

e. Frequency counter.

f. Power meter.

g. Thermistor mount.

h. 1-db step attenuator.

i. 10-db step attenuator.

j. Fixed attenuator.

k. Oscilloscope camera.

21-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 21-1 and allow for a 30-minute warmup and stabilization period.

b. Tune the RF signal generator to the normal operating channel frequency of the down converter under test at an output power level of zero dbm. The power meter will indicate -20 dbm.

c. Decrease the output power by 23 db by increasing the signal generator's output level attenuator 23 db.

d. Configure the test equipment as illustrated in figure 21-2 and adjust the variable attenuators of the RF signal generator to zero db of attenuation. Adjust the spectrum analyzer to obtain a convenient display.

e. Tune the spectrum analyzer 25 MHz above and below the 70 MHz intermediate frequency and observe the display on the spectrum analyzer. Measure and record the amplitude and frequency of any spurious radiations that are displayed on the oscilloscope. The amplitude is measured by increasing the variable attenuation until the amplitude of the carrier is equal to that of the spurious signal. The amplitude of the radiation in reference to the carrier will be equal to the total variable attenuation settings.

f. Photograph the display and mount the photograph on figure 12-5; USACC Form 397-R (Test). Record the test results on figure 21-3; USACC Form 427-R (Test).

g. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

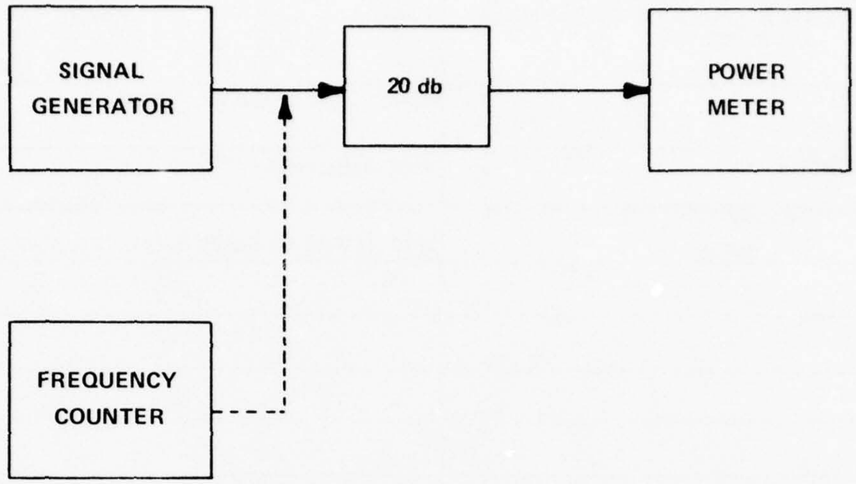


Figure 21-1. Equipment calibration test configuration.

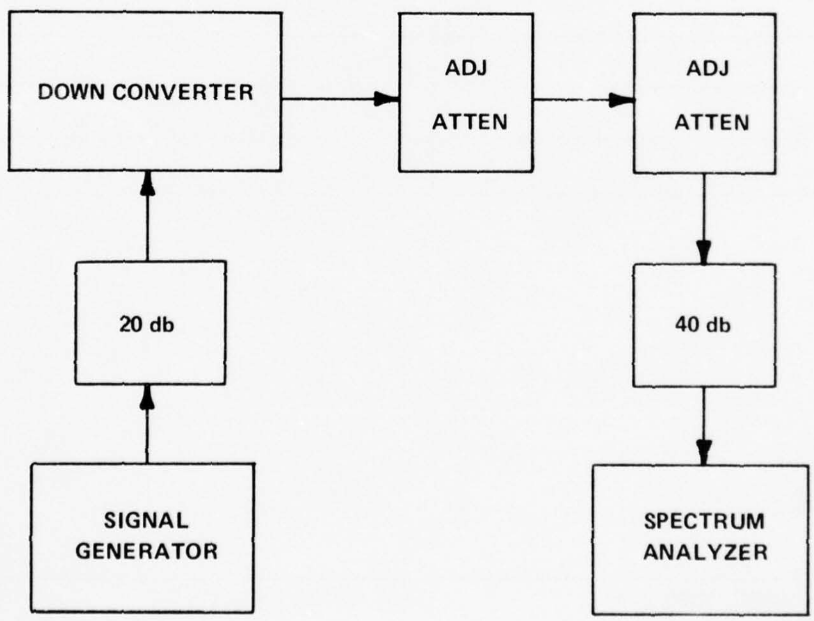


Figure 21-2. Down converter spurious output test configuration.

DOWN CONVERTER SPURIOUS RADIATIONS (CCR 702-1-3) DATA SHEET	PAGE OF PAGES
TERMINAL ID	DATE (DAY, MONTH, YEAR)
DOWN CONVERTER ID	SPECIFICATION

FREQUENCY (MHz)	AMPLITUDE IN REFERENCE TO CARRIER

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 427-R (TEST)
1 MAY 77

Figure 21-3. Down converter spurious radiation data sheet.

CHAPTER 22

DOWN CONVERTER FREQUENCY RESPONSE AND GAIN (ST-17)

22-1. GENERAL.

a. The purpose of this test is to measure the down converter frequency response and gain. The bandwidth will be defined at the ±0.5 and ±1.0 db power points.

b. This is normally an inservice test for those earth terminals with redundant capabilities. However, it is an out-of-service test for terminals not equipped with a standby down converter and will require an AO.

c. This test will be conducted in either the manual or automatic swept frequency mode.

d. Techniques for measuring relative/actual amplitudes and frequencies of spurious or extraneous emissions by means of attenuator substitution may be found in chapter 53.

22-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

22-3. TEST EQUIPMENT REQUIRED.

a. WG attenuator.

b. Fixed attenuator.

c. SHF sweep generator.

d. Plug-in.

e. Frequency counter.

f. Power meter.

g. Thermistor mount.

h. 10-db directional coupler.

i. 3-db directional coupler.

j. Adapter.

k. RF detector.

l. X-Y recorder.

m. Power divider.

22-4. TEST PROCEDURES.

a. Manual Mode.

(1) Energize the test equipment and allow for a 30-minute warmup and stabilization period.

(2) If required, tune the selected down converter to the normal operating channel (7500 MHz will be used for discussion and illustration purposes).

(3) Tune the SHF signal generator to 7500 MHz and adjust the output power level to zero dbm. Insure that external coaxial cable losses are considered when establishing the reference output power levels.

(4) Adjust the microwave attenuator to 43 db and configure the test equipment as illustrated in figure 22-1.

(5) Record the power meter indication on figure 22-2; USACC Form 428-R (Test). The power meter should indicate zero dbm ±0.5 db unless otherwise specified in the equipment maintenance manual.

(6) Increase and decrease the SHF signal generator frequency in 1-MHz steps until 5 MHz above and below the selected channel frequency is attained. Record test results on figure 22-2; USACC Form 428-R (Test).

NOTE: At each test frequency, insure that the input level to the down converter is maintained at -43 dbm.

(7) Increase and decrease the SHF signal generator frequency in 5-MHz increments until 25 MHz above and below the selected channel frequency is attained while maintaining a constant input level of -43 dbm at input to the down converter. Record the test results on figure 22-2; USACC Form 428-R (Test).

(8) Continue to vary the output frequency of the SHF signal generator while maintaining a constant input level to the down converter until the ±0.5 and ±1.0 db power points have been identified. Record the ±0.5 and ±1.0 db bandwidths on figure 22-2; USACC Form 428-R (Test).

NOTE: The ±0.5 and ±1.0 db power points are relative to the down converter output power level at the selected channel frequency.

(9) Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

b. Automatic Mode.

(1) Configure the test equipment as illustrated in figure 22-1 and

tune the sweep signal generator to 7500 MHz (CW). The input to the microwave attenuator should be zero dbm.

(2) If required, tune the down converter to the normal operating frequency (7500 MHz will be used for discussion and illustration purposes). Energize the test equipment and allow for a 30-minute warmup and stabilization period.

(3) Measure and record the down converter output level on figure 22-2; USACC Form 428-R (Test). The power meter should indicate zero ±0.5 db.

(4) Configure the test equipment as illustrated in figure 22-3 and adjust the test instrumentation as follows:

Sweep Signal Generator:

Start Frequency:	7470 MHz
Stop Frequency:	7530 MHz

Output Power Level at Input to Microwave:

Attenuator:	zero dbm
Sweep Mode:	manual
Manual Frequency:	to read 7500 MHz on frequency counter
Microwave Attenuator:	-3 db

(5) Manually (manual frequency adjust) calibrate the X-Y recorder for a suitable display on the X-axis for a bandwith of 60 MHz. Adjust the X-axis direct current (DC) gain control as required on the X-Y recorder to obtain a suitable display. Insure that the sweep generator is operating at the slowest sweep speed.

(6) Adjust the X-Y recorder DC gain controls as required to obtain an upper 3/4-scale resolution on the Y-axis as displayed on the graph paper.

NOTE: Use figure 8-7; USACC Form 396-R (Test) for the X-Y recorder with the gain (db ref at F_c) on the vertical axis and the frequency in MHz on the horizontal axis.

(7) Adjust the microwave attenuator to -2.5 db and press the X-Y recorder pen to establish contact with the graph paper. Set the sweep generator mode switch to trigger and the X-Y recorder pen to down.

AD-A043 735 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA ARIZ F/G 17/2

PRODUCT ASSURANCE, OPERATIONAL QUALITY ASSURANCE, SATELLITE SYS--ETC(U)

MAY 77

UNCLASSIFIED ACC-CCP-702-2 NL

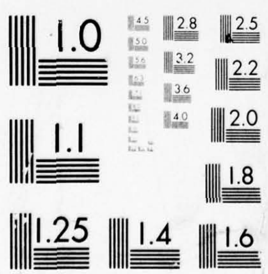
4 OF 7

AD A043 735

SIFIED

4 OF 7

AD
A043735



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(8) Push the trigger switch in and release when the recorder begins to sweep.

(9) Adjust the microwave attenuator to the following settings and repeat paragraphs 22-4 b (6) and (7) above.

ATTENUATOR SETTING (db)	
1.0 (2.0)	3.5 (-0.5)
1.5 (1.5)	4.0 (-1.0)
2.0 (1.0)	4.5 (-1.5)
2.5 (0.5)	5.0 (-2.0)
3.0 (0)	6.0 (-3.0)

(10) Raise the X-Y recorder pen, switch sweep generator mode to manual, and adjust the manual frequency control, if required, to read 7500 MHz on the frequency counter.

(11) Configure the test equipment as illustrated in figure 22-4 and adjust the microwave attenuator until -3 dbm is observed on the power meter. The pen on the X-Y recorder should be centered on the zero db (-3.0) reference line established in paragraph 22-4b(9) above.

(12) Set the sweep generator mode switch to trigger, the X-Y recorder pen to down, and press the trigger switch.

(13) Restore the system to the normal operating condition and summarize the test results on USACC FORM 351-R (Test).

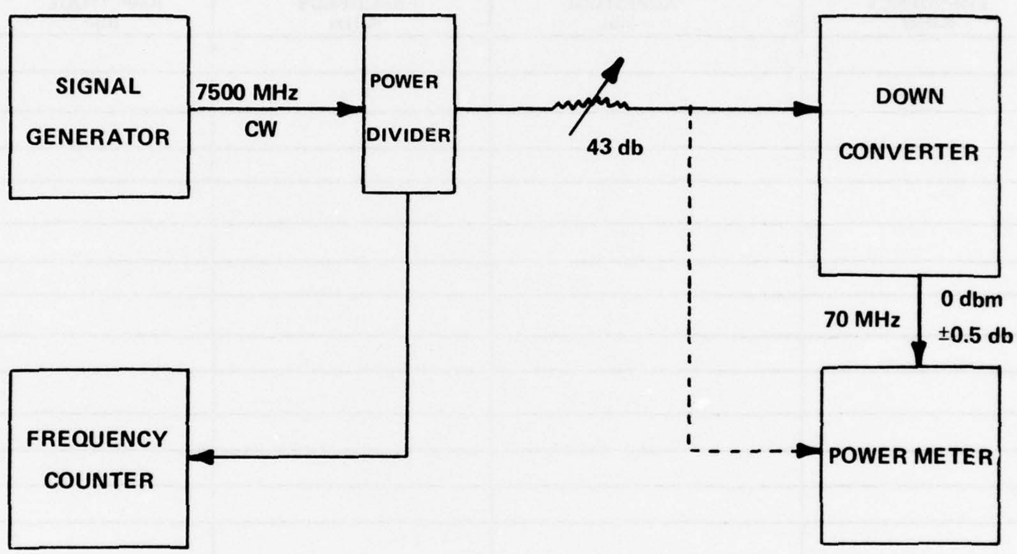


Figure 22-1. Down converter frequency response and gain (manual mode) test configuration.

DOWN CONVERTER FREQUENCY RESPONSE AND GAIN (CCR 702-1-3) DATA SHEET		PAGE OF PAGES
TERMINAL ID	DATE (DAY,MONTH, YEAR)	F_c GHz
DOWN CONVERTER ID	$+\Delta F$ (MHz) -3db	$+\Delta F$ (MHz) -0.5 db
SUBASSEMBLY	$-\Delta F$ (MHz) -3db	$-\Delta F$ (MHz) -0.5 db
GAIN db	BW (MHz) -3db	BW (MHz) -0.5 db
INPUT SIG LEVEL dbm	OUTPUT SIG LEVEL dbm	REF LEVEL db

FREQUENCY (MHz)	AMPLITUDE (db)	FREQUENCY (MHz)	AMPLITUDE (db)

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 428-R (TEST)
1 MAY 77

Figure 22-2. Down converter frequency response and gain data sheet.

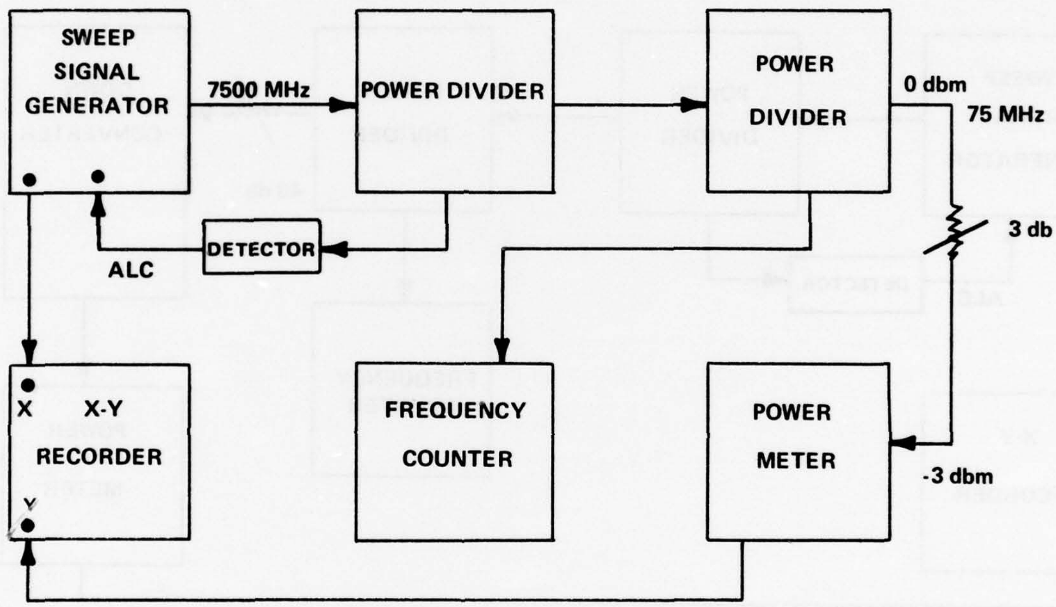


Figure 22-3. Down converter equipment calibration (automatic mode) test configuration.

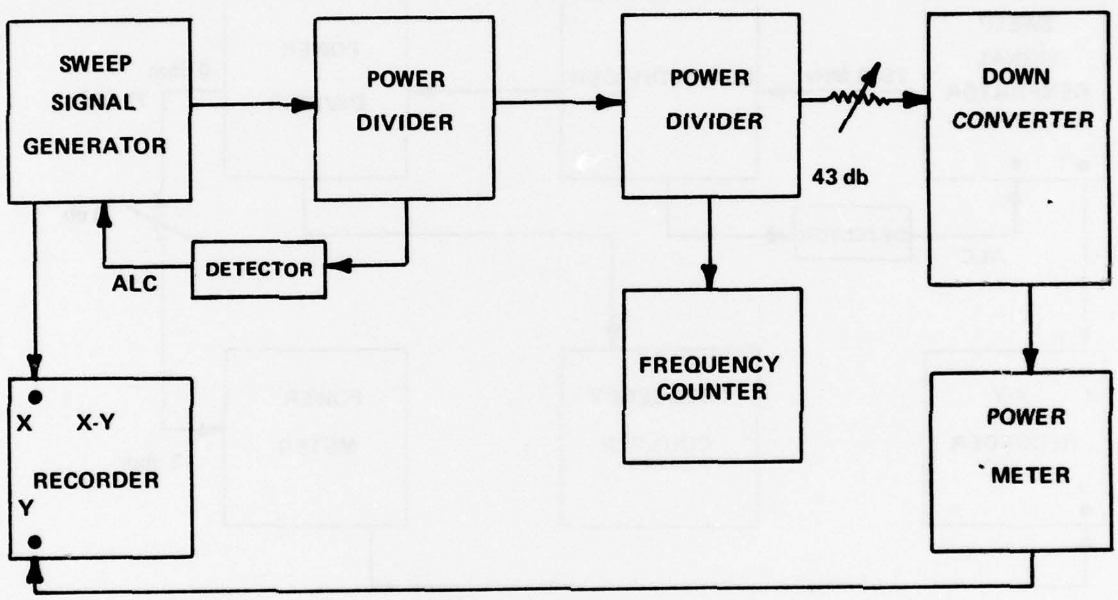


Figure 22-4. Down converter frequency response and gain (automatic mode) test configuration.

CHAPTER 23

DOWN CONVERTER NOISE FIGURE (ST-18)

23-1. GENERAL.

a. The purpose of this test is to measure the NF of the down converters.

b. This test will be performed in the automatic or manual mode depending on the availability of equipment. The signal generator method will not be employed due to the high probability of error unless no other means of performing the NF measurement is available.

c. This is normally an inservice test for those earth terminals that are equipped with one or more standby down converters.

23-2. SPECIFICATIONS. The test date obtained during this test shall be compared to the performance limits delineated in appendix B.

23-2. TEST EQUIPMENT REQUIRED.

a. Noise source.

b. NF test set.

c. 1-db attenuator.

d. 10-db attenuator.

23-4. TEST PROCEDURES.

a. Automatic Mode.

(1) Configure the test equipment as illustrated in figure 23-1.

(2) Energize the test equipment and allow for a 30-minute warmup and stabilization period.

(3) Set the AUTO-MANUAL switch located on the rear of the NF indicator to AUTO.

(4) Set the meter function switch to the 4-ma position. Adjust the gas tube current control until the NF indicator reads 200 ma.

(5) Set the meter function switch to zero and adjust the potentiometer until the NF meter indicates zero.

(6) Turn the meter function switch to INF and adjust the potentiometer until the NF indicator reads INF. Insure that the NF indicator input IF selector is set to 70 MHz. (If the NF indicator does not calibrate on INF, this measurement cannot be performed in the automatic mode.)

(7) Set the meter function switch to the NOISE FIGURE position and read the down converter NF indicated.

(8) Measure the power loss of any coaxial cable that is located between the noise source and item under test. Subtract the cable loss in db from the NF and record the required information on figure 23-2; USACC Form 429-R (Test).

(9) Analyze the test results and restore the system to its normal operating condition.

b. Manual Mode.

(1) Configure the test equipment as illustrated in figure 23-3.

(2) Energize the test equipment and allow for a 30-minute warmup and stabilization period.

(3) Set the IF input switch to 70 MHz.

(4) Set the meter function switch to 4 ma and the noise source switch to ma x 100. Adjust the gas tube current control until 200 ma is indicated on the NF meter.

(5) Turn the noise source switch to OFF and the meter function switch to NOISE FIGURE.

(6) Set the variable attenuators for a convenient current scale reading on the lower one-quarter of the meter scale (I_{min}).

(7) Set the noise source switch to the GAS TUBE position and read the current scale (I_{max}).

(8) Insure that any cable losses between the noise source and test device have been considered.

NOTE: Noise figure - 15.2 db - 10 log $\left[\left(\frac{I_{max}}{I_{min}}\right)\right] - 1$

(9) Summarize the test results on figure 6-4; USACC Form 351-R (Test).

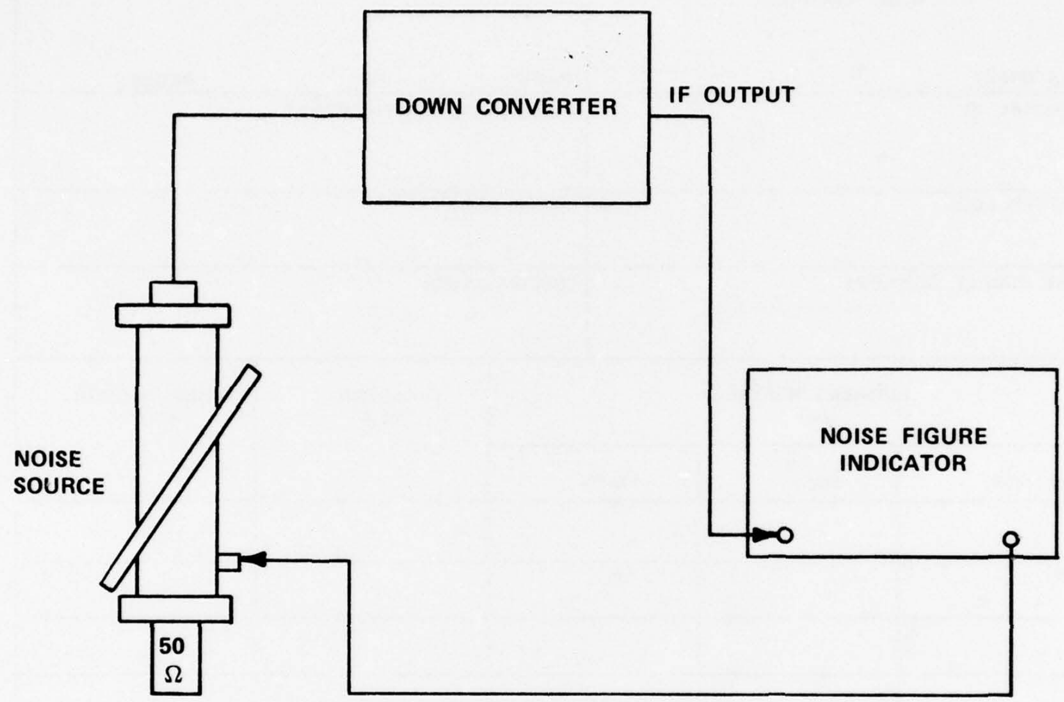


Figure 23-1. Down converter NF (automatic mode) test configuration.

DOWN CONVERTER NOISE FIGURE (CCR 702-1-3) DATA SHEET			PAGE OF PAGES	
TERMINAL ID			DATE (DAY, MONTH, YEAR)	
ADAPTER LOSS db			CABLE LOSS db	
NOISE SOURCE CURRENT			SPECIFICATION	
CURRENT READING (ma)			Y-FACTOR (db)	NOISE FACTOR (db)
STARTS	I_{min}	I_{max}		
1				
2				
3				
4				
5				
COMMENTS				
TYPED NAME, GRADE, AND TITLE			TEST ENGR SIGNATURE	

USACC FORM 429-R (TEST)
1 MAY 77

Figure 23-2. Down converter NF data sheet.

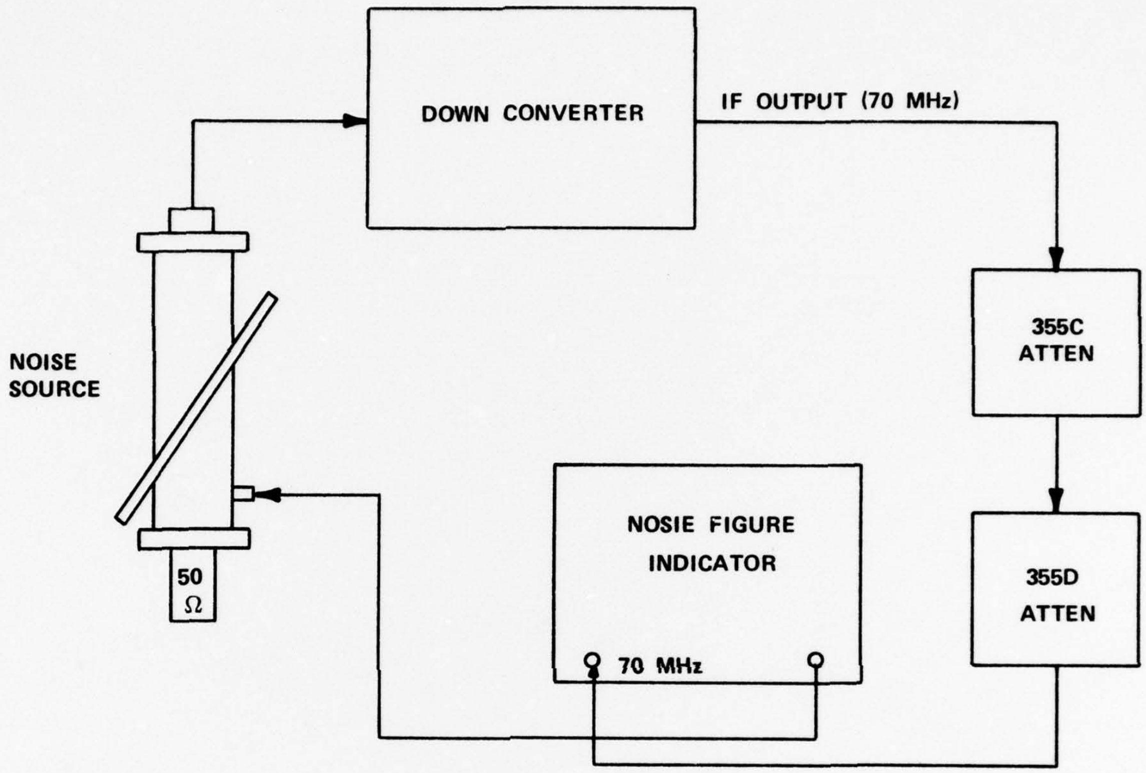


Figure 23-3. Down converter NF (manual mode) test configuration.

Preceding Page Blank - Filmed

CHAPTER 24

UP CONVERTER/EXCITER FREQUENCY RESPONSE AND POWER OUTPUT (ST-19)

24-1. GENERAL.

a. The purpose of this test is to measure the frequency response and the power output of the up converter/exciter. The frequency response will be determined at the ±0.5, ±1.0, and the -3.0 db power points.

b. This is an inservice test for earth terminals equipped with one or more standby up converters/exciters. However, this is an out-of-service test for those terminals that are not equipped with the standby converters/exciters.

c. This test may be conducted in either the automatic or manual sweep mode, centered on the assigned channel frequency of the particular up converter/exciter under test.

24-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

24-3. TEST EQUIPMENT REQUIRED.

a. Power meter.

b. Thermistor mount.

c. Frequency counter.

d. Signal generator.

e. Plug-in.

f. Power divider.

g. 10-db attenuator.

h. Crystal detector.

i. Oscilloscope.

j. Oscilloscope camera.

24-4. TEST PROCEDURES.

a. Manual Mode.

(1) Configure the test equipment as illustrated in figure 24-1 and allow a 15-minute warmup and stabilization period. Place the up converter to be tested off-line and set the input attenuators in zero db.

(2) Tune the RF sweep signal generator to a CW frequency of 70 MHz at an output power level of zero dbm.

(3) Configure the test equipment as illustrated in figure 24-2. Adjust the output level attenuator, located on the up converter, until the power meter indicates -3 dbm. Record the reference level at the 70 MHz (F_c) on figure 24-3; USACC Form 430-R (Test).

(4) Tune the RF sweep signal generator to a CW frequency of 41 MHz at a power output level of zero dbm. Record the up converter output power level in reference to the F_c of 70 MHz.

(5) Repeat paragraph 24-4a(4) in 1-MHz increments at frequencies 42 MHz through 56 MHz, and in 2-MHz increments at frequencies 56 MHz through 96 MHz.

(6) Plot an amplitude versus frequency response curve on figure 8-7; USACC Form 396-R (Test), and annotate the -1 and -3 db power points on the curve. The gain in db in reference to F_c will be plotted on the vertical axis and the frequency (MHz) on the horizontal axis.

b. Automatic Mode.

(1) Configure the test equipment as illustrated in figure 24-4 and allow for a 15-minute warmup and stabilization period.

(2) Adjust the IF sweep signal generator for a sweep width of 40 MHz centered on 70 MHz and adjust the output power level control until the power meter indicates zero dbm.

(3) Adjust the oscilloscope as necessary to obtain a suitable display. Observe the oscilloscope display for 1 minute and record all amplitude variations that exceed ±1 db at 40 MHz bandwidth or ±0.5 db at 10 MHz bandwidth (reference at 70 MHz).

(4) Photograph the oscilloscope display and mount the photographs on figure 12-5; USACC Form 397-R (Test).

c. Manual/Automatic Mode. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

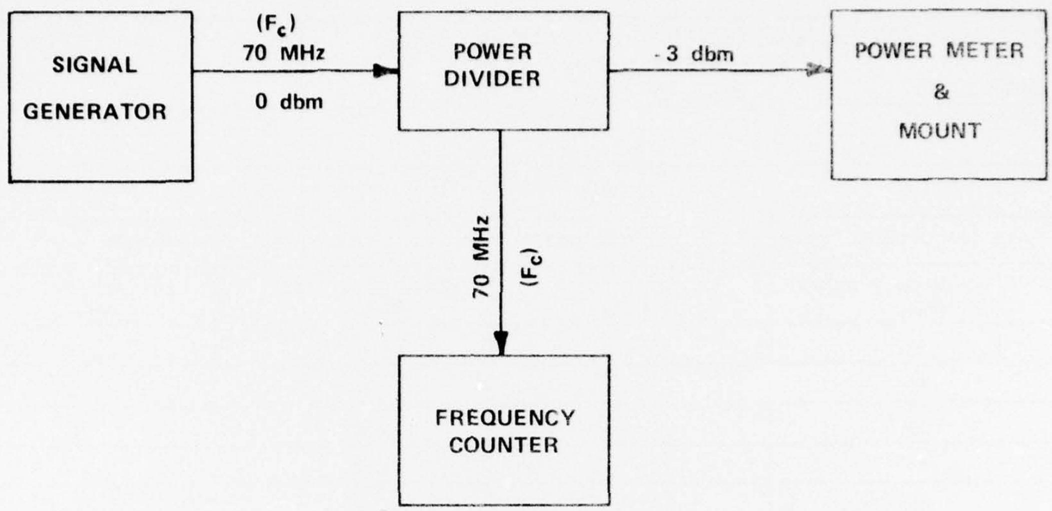


Figure 24-1. Up converter/exciter equipment calibration.

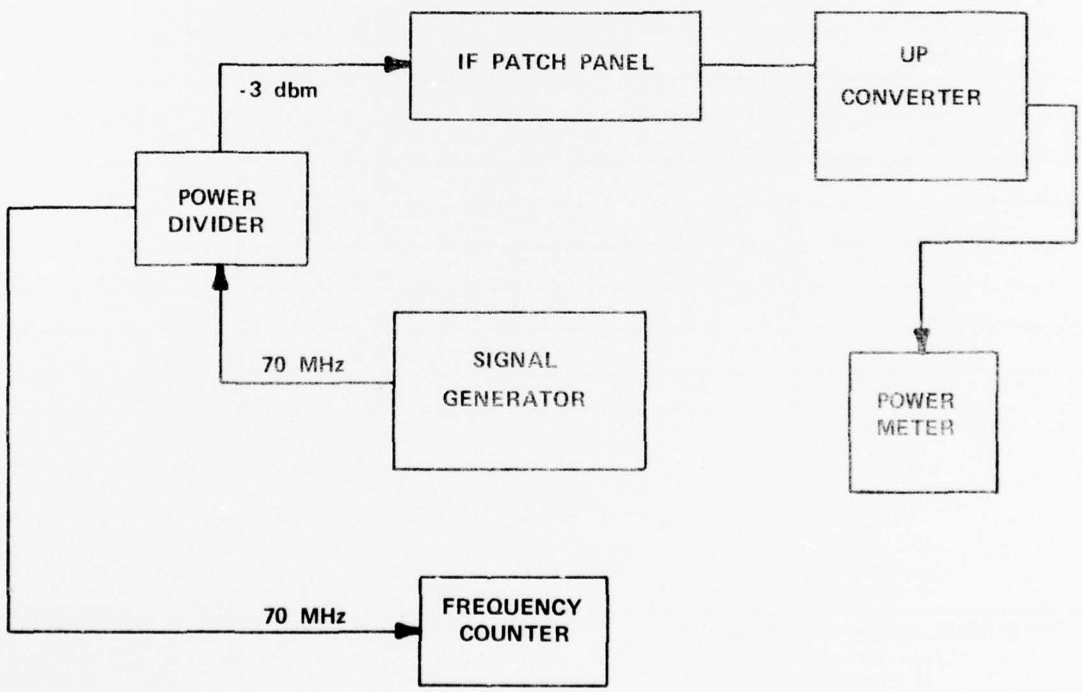


Figure 24-2. Up converter/exciter frequency response and power output (manual mode) test configuration.

UP CONVERTER/EXCITER FREQUENCY RESPONSE AND POWER OUTPUT DATA SHEET (CCR 702-1-3)		PAGE OF PAGES
TERMINAL ID	−1 db BW MHz	$+\Delta F_c$ MHz−1 db
UP CONVERTER ID	−3 db BW MHz	$-\Delta F_c$ MHz−1 db
DATE (DAY,MONTH, YEAR)	PWR OUTPUT dbm	F_c MHz

FREQUENCY INPUT (MHz)	AMPLITUDE (± db)	FREQUENCY INPUT (MHz)	AMPLITUDE (± db)
41		72	
42		74	
43		76	
44		78	
45		80	
46		82	
48		84	
50		86	
52		88	
54		90	
56		92	
58		94	
60		95	
62		96	
64		97	
66		98	
68		99	
70		100	

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 430-R (TEST)
1 MAY 77

Figure 24-3. Up converter/exciter frequency response and power output data sheet.

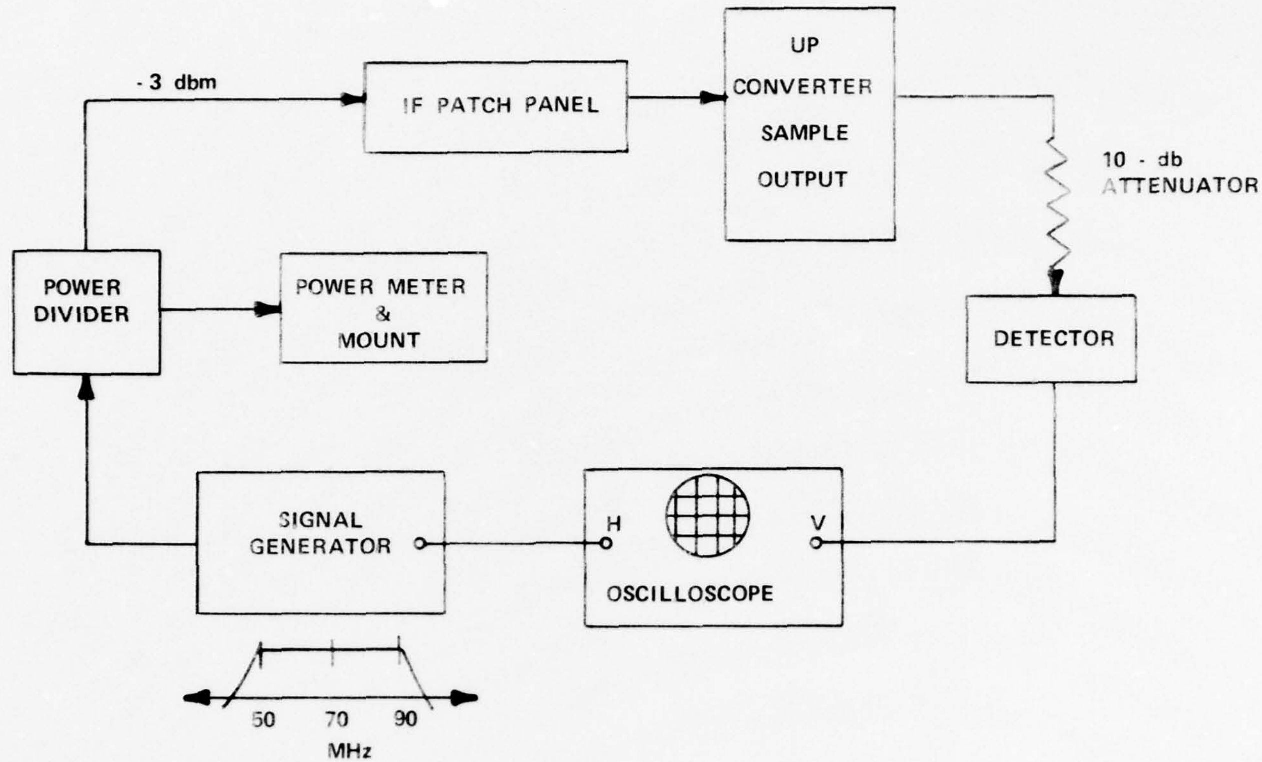


Figure 24-4. Up converter/exciter frequency response and power output (automatic mode) test configuration.

Preceding Page Blank - Not Filmed

CHAPTER 25

UP CONVERTER SPURIOUS OUTPUT (ST-20)

25-1. GENERAL.

a. The purpose of this test is to measure the spurious output radiations of the up converter and to determine the effects the spurious signals would have on the quality of communications.

b. The nominal output level of the up converter is -1 dbm. This test will be conducted with the spectrum analyzer input connected to the test jack through a 40-db attenuator.

c. This is normally an inservice test for those earth terminals that are equipped with one or more standby up converters; however, this is an out-of-service test for earth terminals not equipped with a standby up converter, in which case an AO is required.

d. Techniques for measuring relative/actual amplitudes and frequencies of spurious or extraneous emissions by means of attenuator substitution may be found in chapter 52.

25-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

25-3. TEST EQUIPMENT REQUIRED.

a. Spectrum analyzer.

b. Fixed attenuator.

c. Step attenuator.

d. Oscilloscope camera.

25-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 25-1. Set all the variable attenuators to zero db attenuation, and allow for a 30-minute warmup and stabilization period.

b. Tune the up converter to one of the frequencies stipulated in paragraph 25-4d. Tune the spectrum analyzer until the up converter output frequency appears on the analyzer. Adjust the spectrum analyzer frequency control 50 MHz above and below the carrier frequency while looking for any spurious emissions. Measure and record the amplitude of any spurious signals.

c. The relative amplitude of any spurious signal can be measured by increasing the variable attenuation until the amplitude of the carrier is equal to that of the spurious signal. The attenuation setting of the variable attenuator will be equal to the amplitude of the spurious signal in relation to the main carrier. Record the test results on figure 25-2; USACC Form 431-R (Test).

d. Repeat paragraphs 25-4 b and c for all of the following frequencies:

FREQUENCY (MHz)		
7925	8075	8275
7975	8125	8325
8025	8175	8375
	8225	

e. Photograph the spectrum analyzer display and mount the photograph on figure 12-5; USACC Form 397-R (Test).

f. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

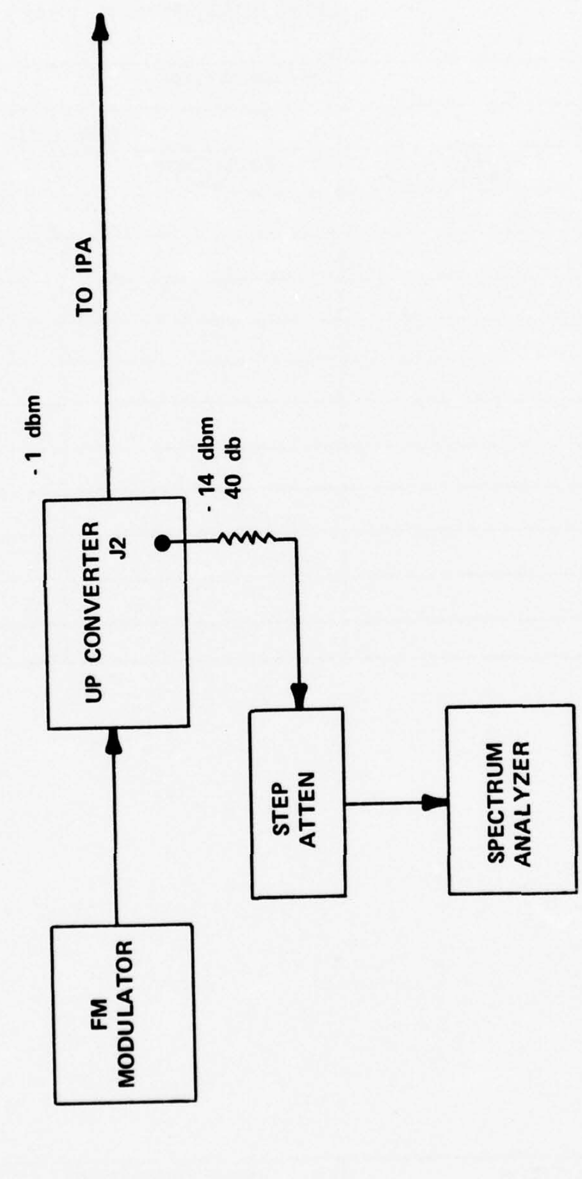


Figure 25-1. Up converter spurious radiations test configuration.

UP CONVERTER/EXCITER RF SPURIOUS RADIATIONS (CCR 702-1-3) DATA SHEET		PAGE OF PAGES	
TERMINAL ID		DATE (DAY, MONTH, YEAR)	
UP CONVERTER ID		SPECIFICATION	
CARRIER		SPURIOUS	
FREQUENCY (MHz)	LEVEL (dbm)	FREQUENCY (MHz)	LEVEL (db REF CARRIER)
COMMENTS			
TYPED NAME, GRADE, AND TITLE		TEST ENGR SIGNATURE	

USACC FORM 431-R (TEST)
1 MAY 77

Figure 25-2. Up converter spurious radiations data sheet.

CHAPTER 26

UPLINK IFLA AND IPA FREQUENCY RESPONSE AND GAIN (ST-21)

26-1. GENERAL.

a. The purpose of this test is to measure the gain and frequency response of the uplink IFLA's or IPA's as required.

b. This is normally an inservice test for those earth terminals that are equipped with standby IFLA's. However, it is an out-of-service test for terminals that do not have redundant capabilities and requires an AO.

26-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

26-3. TEST EQUIPMENT REQUIRED.

a. SHF signal generator.

b. Power meter.

c. Frequency counter.

d. Attenuator set.

26-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 26-1 or 26-2 to conform to the type of earth terminal under test.

b. Energize the test equipment and allow for a 30-minute warmup and stabilization period.

c. Tune the SHF signal generator to 8150 MHz and adjust the output power level to zero dbm.

d. Adjust the IPA drive attenuator for maximum attenuation.

e. Decrease the input drive attenuation until a peak indication is observed on the power meter. Record this indication on figure 26-3; USACC Form 432-R (Test).

NOTE: The IPA gain is determined by calculating the arithmetic difference in dbm between the peak power level (dbm) and the signal generator output level (zero dbm), also any coupling, attenuator, etc, power loss must be taken into consideration in the calculation.

f. Decrease the input drive attenuation until a dip in power is observed on the power meter (IPA saturation).

f. Increase the input drive attenuation until the power meter indicates at least 3 db below the saturation level.

g. Tune the signal generator to 8200 MHz and adjust the output power level as required to zero dbm. Record the IPA output power level on figure 26-3; USACC Form 432-R (Test). Repeat paragraph 26-4g at the following listed test frequencies:

FREQUENCY (MHz)		
7900	8050	8250
7950	8100	8300
8000	8150	8350
	8200	8400

h. Switch IPA's and repeat this test if applicable.

i. Plot a frequency versus relative amplitude response curve, relative to 8150 MHz, on figure 8-7; *USACC Form 396-R (Test)*. The IPA gain should be plotted in db referenced to 8150 MHZ (F_c) on the vertical axis and the frequency in MHz on the horizontal axis of the data sheet.

j. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

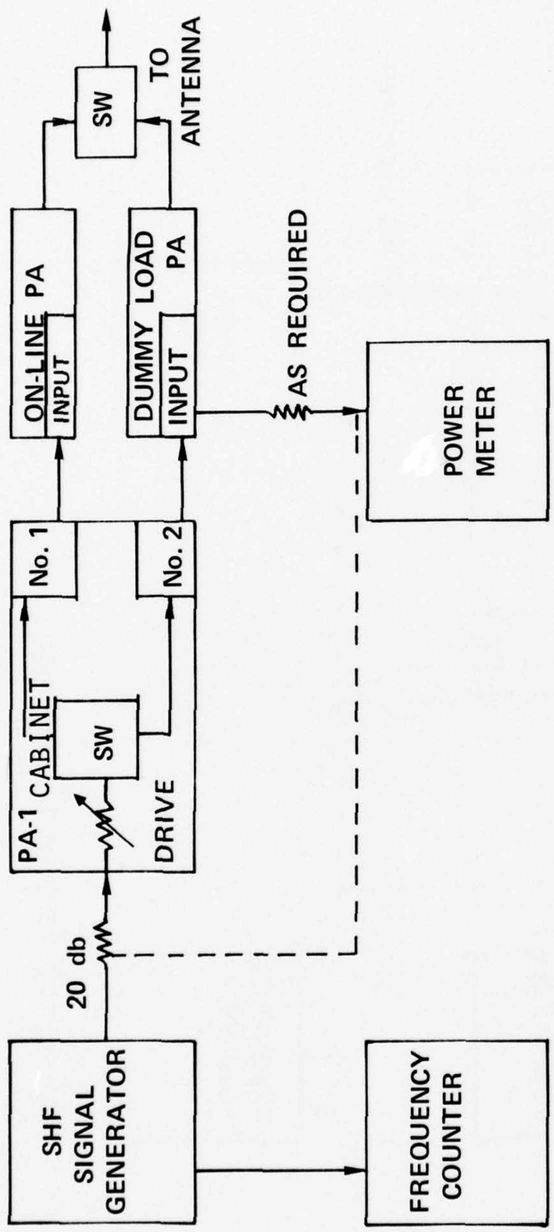
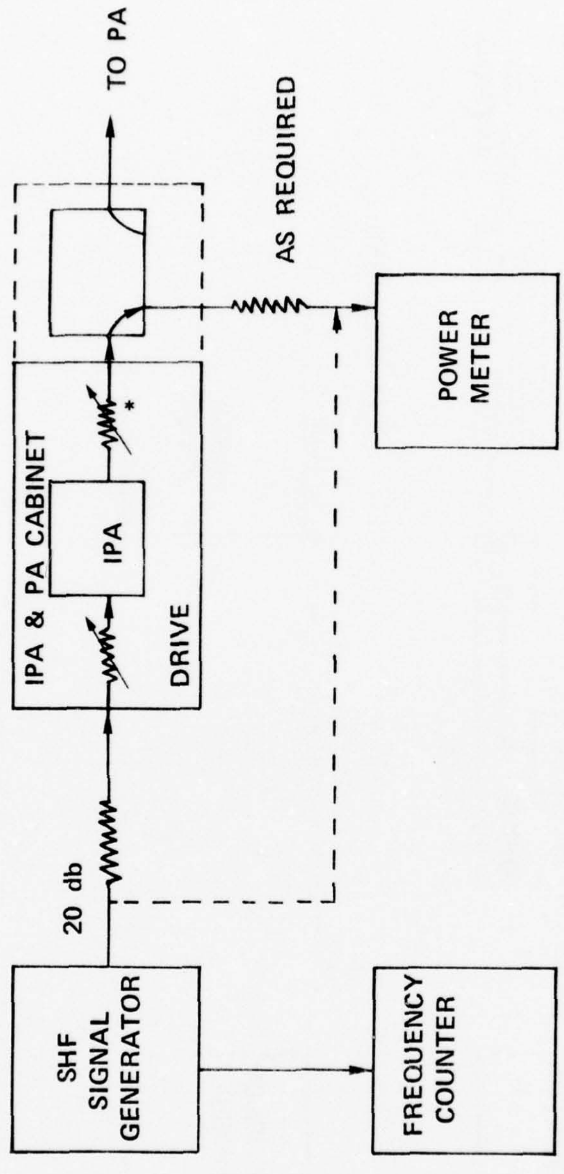


Figure 26-1. Uplink IFLA (standby) and IPA frequency response and gain test configuration.



* ADJUST TO ZERO db DURING TEST.

Figure 26-2. Uplink IFLA and IPA frequency response and gain test configuration.

UPLINK IFLA AND IPA FREQUENCY RESPONSE AND GAIN (CCR 702-1-3) DATA SHEET			PAGE OF PAGES
TERMINAL ID		DATE (DAY, MONTH, YEAR)	
AMPLIFIER ID		OPERATING FREQUENCY MHz	
INPUT LEVEL dbm	OUTPUT LEVEL dbm	GAIN db	

FREQUENCY (MHz)	AMPLITUDE (± db)	FREQUENCY (MHz)	AMPLITUDE (± db)
7900		8200	
7950		8250	
8000		8300	
8050		8350	
8100		8400	
8150			

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 432-R (TEST)
1 MAY 77

Figure 26-3. Uplink IFLA and IPA frequency response and gain data sheet.

Preceding Page Blank - NOT FILMED

CHAPTER 27

IPA VSWR (ST-22)

27-1. GENERAL.

a. The purpose of this test is to measure the input and output VSWR of the IPA.

b. This is an inservice test and does not require an AO; however, the standby IPA must be removed from service.

c. Techniques for performing both VSWR and return loss measurements may be found in chapter 55.

27-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

27-3. TEST EQUIPMENT REQUIRED.

a. Power meter.

b. Thermistor mount.

c. Slotted line carriage.

d. Slotted line probe.

e. Slotted line.

f. Sweep signal generator.

g. Plug-in.

h. VSWR indicator.

i. WG adapter.

j. Variable attenuator.

k. Frequency counter.

l. Directional coupler.

27-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 27-1 and allow for a 30-minute warmup and stabilization period.

b. Adjust the RF sweep signal generator for an output power level of zero dbm at the nominal operating CW frequency of the particular earth terminal under test. Remove the AC power from the IPA that is to be tested. Push the internal square wave switch to the IN position.

c. Adjust the slotted line until a maximum peak indication (E_{max}) is observed on the square law indicator. Calibrate the VSWR indicator on the 1-SWR range.

d. Adjust the slotted line to obtain a minimum indication (E_{min}). Record the VSWR indication on figure 27-2; USACC Form 433-R (Test).

e. Repeat paragraphs 27-4 c and d at the frequencies listed below, and plot a frequency versus VSWR curve on figure 8-7; USACC Form 396-R (Test).

FREQUENCY (MHz)	
7900	8200
7950	8250
8000	8300
8050	8350
8100	8400
8150	

f. Configure the test equipment as illustrated in figure 27-3; and repeat paragraphs 27-4 b through e for an IPA output VSWR measurement.

g. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

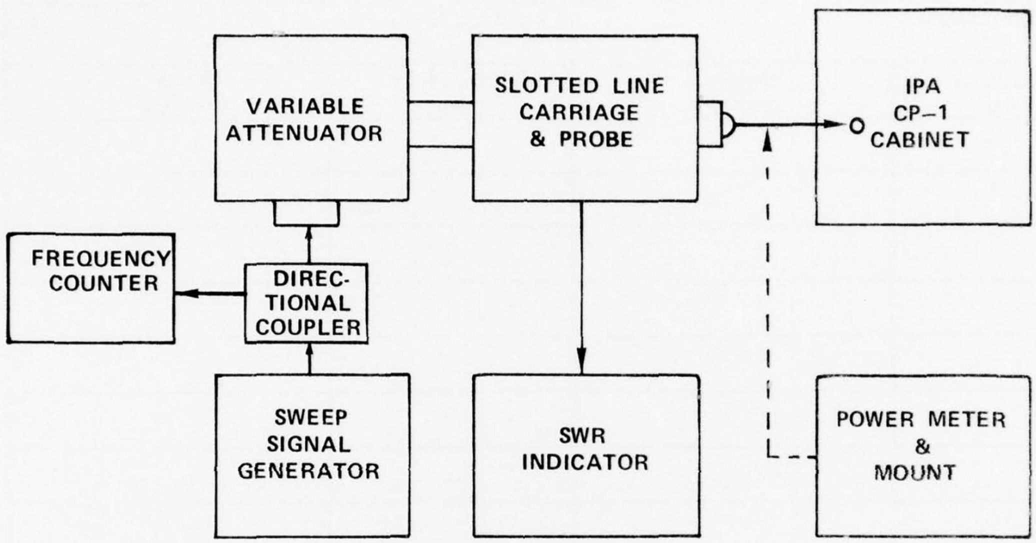


Figure 27-1. IPA input VSWR test configuration.

IPA INPUT AND OUTPUT VSWR (CCR 702-1-3) DATA SHEET		PAGE OF PAGES	
TERMINAL ID		DATE (DAY, MONTH, YEAR)	
AMPLIFIER ID		OPERATING FREQUENCY MHz	
VSWR (DUMMY LOAD)		SPECIFICATION	
VSWR (ANTENNA)		ANTENNA TYPE	
FREQUENCY (MHz)	VSWR INPUT	FREQUENCY (MHz)	VSWR OUTPUT
COMMENTS			
TYPED NAME, GRADE, AND TITLE		TEST ENGR SIGNATURE	

USACC FORM 433-R (TEST)
1 MAY 77

Figure 27-2. IPA input/output VSWR data sheet.

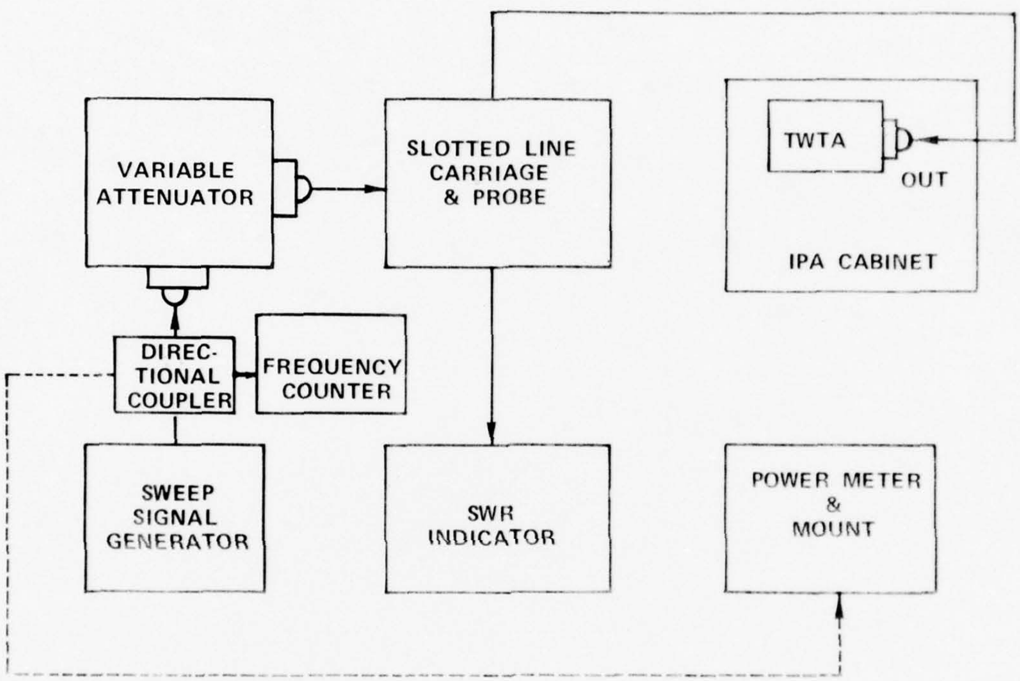


Figure 27-3. IPA output VSWR test configuration.

Preceding Page Blank - Not Filmed

CHAPTER 28

POWER OUTPUT, VSWR, AND REFLECTOMETER CALIBRATION; AND PA FREQUENCY RESPONSE (ST-23)

28-1. GENERAL.

a. The purpose of this test is to calibrate the PA (low power amplifier (LPA) and high power amplifier (HPA), if applicable) power output, VSWR, and reflectometer; and to measure the amplitude versus frequency response.

b. This is an inservice test for terminals that have redundant PA chains. However, this is an out-of-service test for terminals with parallel TWT PA's.

c. The tests must be coordinated with the satellite communications (SATCOM) controller since switchover between PA's causes short transmission interruptions.

28-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

28-3. TEST EQUIPMENT REQUIRED.

a. Power meter.

b. Thermistor mount.

c. Attenuator set.

d. Frequency counter.

e. Sweep signal generator.

f. Plug-in.

g. Directional coupler.

h. WG attenuator.

28-4. TEST PROCEDURES.

a. Power Output Measurement and BITE Forward and Reverse Power Meter Calibration.

(1) Insure that the PA under test is in the dummy load position. Configure the test equipment as illustrated in figure 28-1, and allow for a 30-minute warmup and stabilization period.

(2) Tune the SHF sweep signal generator to a CW frequency in the center of the passband or klystron channel. Set the signal generator output to zero dbm as determined on the power meter.

(3) Adjust the input attenuator, located on the IPA, for the maximum attenuation.

(4) Decrease the IPA attenuator in 3-db steps, and record the power meter readings at the IPA input and the PA output forward and reverse power ports until maximum power has been reached. Record this data on figure 28-2; USACC Form 434-R (Test).

(5) Repeat paragraphs 28-4a (3) and (4) with the BITE meters connected. Readjust the BITE meter sensitivity if necessary and record the BITE meter readings after readjustment. Change the BITE scale where required and adjust individual scales as may be necessary.

b. Power Output to Antenna Calibration.

(1) Configure the terminal and test equipment as shown in figure 28-3.

(2) Adjust the uplink power to the normal operating level for the terminal being evaluated.

(3) Measure the forward and reverse power with the test power meter.

(4) Measure the forward and reverse power with the BITE power meter.

(5) Record the data on figure 28-2; USACC Form 434-R (Test).

c. Amplitude Versus Frequency Response.

(1) This test will be performed on the LPA, HPA, and the parallel TWT's if so equipped. The last configuration is an out-of-service test. The steps described apply to each configuration.

(2) Configure the terminal and test equipment as shown in figure 28-1.

(3) Tune the SHF signal generator to the frequencies listed below. Measure and record the amplitude of each radio frequency in reference to 8150 MHz (F_c).

NOTE: TWT only. The forward and reverse power can be obtained at DC-4 in the LPA cabinet.

TEST FREQUENCY (MHz)	(TWT ONLY)
7900	8200
7950	8250
8000	8300
8050	8350
8100	8400
8150	

(4) Tune the HPA to the operating channel frequency and measure the power output level in 10-MHz steps until a bandwidth of 160 MHz has been measured, that is, 80 and -80 MHz in reference to the F_c.

(5) Record the results on figure 28-4; USACC Form 435-R (Test). Plot a frequency versus amplitude curve on figure 6-4; USACC Form 396-R (Test) and annotate the -1 and -3 db points. Plot the output power relative to the measured power at F_c (db) on the vertical axis and the frequency on the horizontal axis.

(6) Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

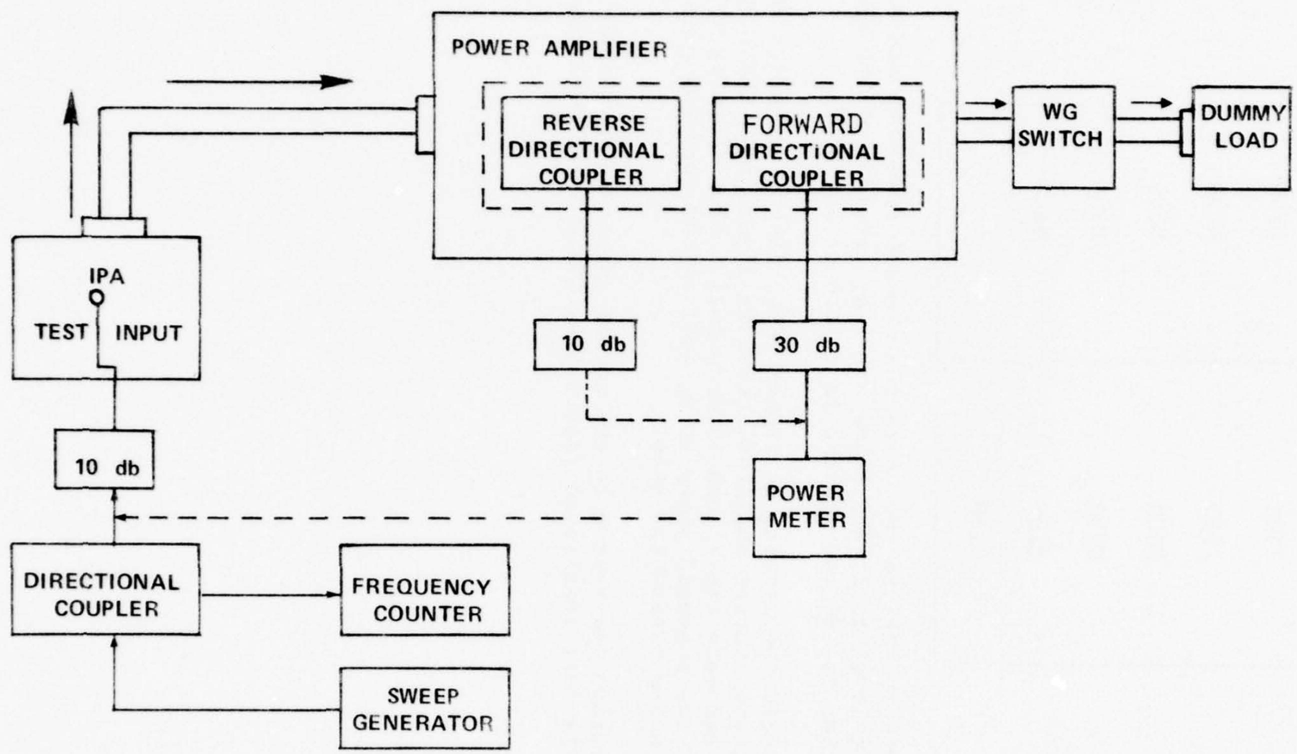


Figure 28-1. PA power output, VSWR, and reflectometer calibration; and PA frequency response test configuration.

PA POWER METER CALIBRATION (CCR 702-1-3) DATA SHEET	PAGE OF PAGES
TERMINAL ID	DATE (DAY, MONTH, YEAR)
AMPLIFIER ID	OP FREQ (ANTENNA) MHz
GAIN db	TEST FREQ (DUMMY LOAD) MHz

INPUT POWER (dbm)	CALIBRATION METER		BITE METER	
	FWD (dbm)	RVSE (dbm)	FWD (dbm)	RVSE (dbm)

COMMENTS

TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 434-R (TEST)
1 MAY 77

Figure 28-2. PA power meter calibration data sheet.

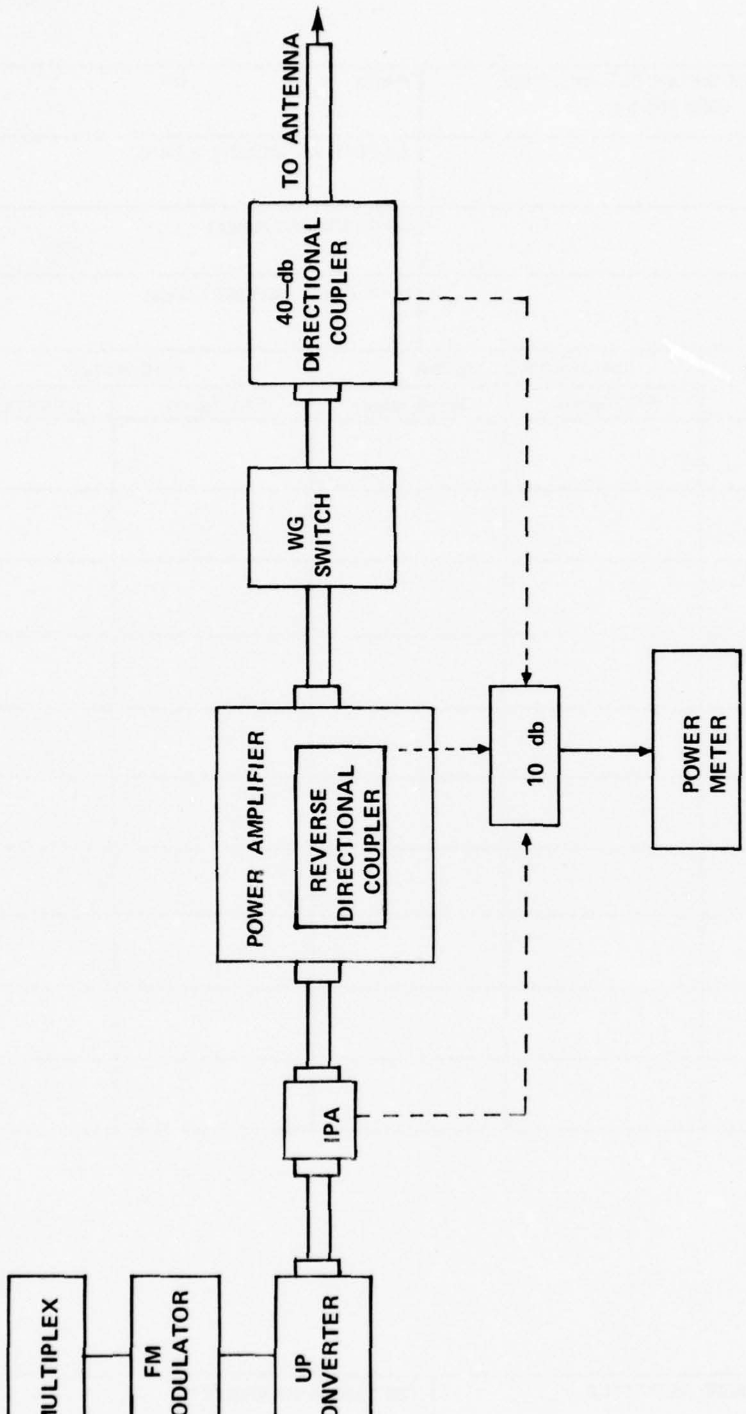


Figure 28-3. PA power output to antenna calibration test configuration.

PA FREQUENCY RESPONSE CHARACTERISTICS DATA SHEET (CCR 702-1-3)		PAGE OF PAGES	
TERMINAL ID		DATE (DAY, MONTH, YEAR)	
AMPLIFIER NO.		CENTER FREQUENCY (F_c) MHz	
IPA NO.		BW -3db MHz	
OUTPUT POWER W		SPECIFIED BANDPASS MHz	
OUTPUT V S W R		REFLECTED POWER W	
DIR COUPLER LOSS db		ATTENUATION db	
FREQUENCY (MHz)	AMPLITUDE (±db)	FREQUENCY (MHz)	AMPLITUDE (±db)

COMMENTS

BEAM VOLTS ______

BEAM CURRENT ______

BODY CURRENT ______

RF INPUT POWER ______

RF OUTPUT POWER ______

TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 435-R (TEST)
1 MAY 77

Figure 28-4. PA frequency response characteristics data sheet.

CHAPTER 29

PA INTERMODULATION, SPURIOUS RADIATION, AND HUM MODULATION (ST-24)

29-1. GENERAL.

a. The purpose of this test is to measure the intermodulation products caused by multiple carriers, spurious radiation, and hum modulation.

b. This is an inservice test for those earth terminals that are equipped with one or more standby PA's. However, for those terminals not equipped with a standby PA, an AO will be required. The PA under test must be removed from service.

c. Since the signal generator output is limited to zero dbm, the tests will be performed on the PA and IPA combined in order to provide sufficient drive level to the PA.

29-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

29-3. TEST EQUIPMENT REQUIRED.

a. SHF signal generator.

b. Frequency counter.

c. Power meter.

d. Thermistor mount.

e. WG attenuator.

f. Spectrum analyzer.

g. Power combiner.

h. Detector crystal.

i. Oscilloscope.

j. Step attenuator.

k. WG adapter.

29-4. TEST PROCEDURES.

a. Measurement of Intermodulation Distortion and Spurious Radiation.

(1) Configure the test equipment as shown in figure 29-1 and allow for a 30-minute warmup and stabilization period.

(2) Connect the power meter to the output of the power combiner.

(3) Tune the SHF signal generator #1 to 8.14 GHz and generator #2 to 8.16 GHz. Set both output attenuators to minimum output.

(4) Increase the output level from SHF generator #1 until the power meter reads -3 dbm. Record the attenuator's setting and return to minimum output.

(5) Repeat paragraph 29-4a(4) for SHF generator #2.

(6) Return both SHF generator outputs to the recorded settings of paragraph 29-4a(4).

(7) Set the variable WG attenuator to maximum attenuation.

(8) Connect the output of the power combiner to the input of the attenuator.

(9) Decrease the WG attenuator setting until the PA reaches rated power.

(10) Observe the spectrum analyzer for intermodulation and spurious signals.

(11) Increase the WG attenuator by 3 db and observe the spectrum analyzer for intermodulation and spurious signals.

(12) Reduce the output level from SHF generator #1 to minimum.

(13) Decrease the WG attenuator by 3 db.

(14) Repeat paragraphs 29-4a (10) through (12).

(15) Photograph any displays that show spurious and/or intermodulation products and mount the scope photographs on figure 12-5; USACC Form 397-R (Test).

(16) Record the test results on figure 29-2; USACC Form 436-R (Test).

(17) Summarize the test results on figure 6-4; USACC Form 351-R (Test).

b. Measurement of Hum Modulation.

(1) Reconfigure the test equipment as shown in figure 29-3.

(2) Tune the SHF generator to 8150 MHz.

(3) Connect the power meter to the output of the directional coupler.

(4) Adjust the level to -3 dbm with the SHF generator output control and WG attenuator set to zero db.

(5) Increase the WG attenuator to maximum.

(6) Connect the WG attenuator output to the IPA input.

(7) Decrease the WG attenuator until the PA reaches rated power.

(8) Adjust the time base of the oscilloscope to a value that permits the display of at least two full cycles of a 360-Hz frequency.

(9) Switch the input of the oscilloscope to DC.

(10) Adjust the gain and RF attenuator for a near full-scale deflection. The oscilloscope gain control should be at least 50 db below maximum gain.

(11) Record the DC deflection as displayed on the oscilloscope.

(12) Switch the input of the oscilloscope to AC.

(13) Adjust the gain to obtain a nearly full-scale deflection and record the peak-to-peak deflection of the hum waveform.

(14) Compute the hum modulation as follows:

$$\left(20 \log \frac{\text{AC deflection}}{2 \times \text{DC deflection}}\right) - \text{Gain change (db)}$$

(15) Record all settings and readings on figure 29-4; USACC Form 437-R (Test) and mount scope photographs on figure 12-5; USACC Form 397-R (Test).

(16) Restore the normal operating condition of the terminal and summarize the results on figure 6-4; USACC Form 351-R (Test).

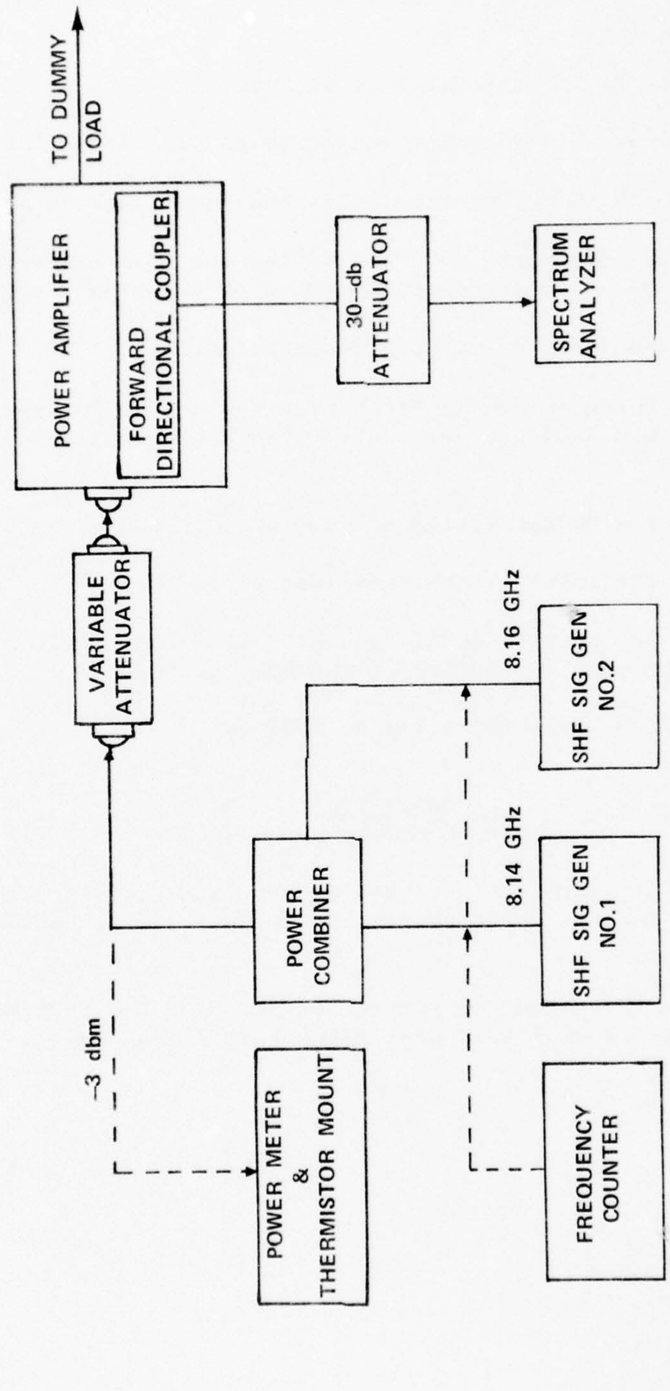


Figure 29-1. PA distortion and spurious radiation test configuration.

PA INTERMODULATION AND SPURIOUS RADIATION (CCR 702-1-3) DATA SHEET	PAGE OF PAGES
TERMINAL ID	DATE (DAY, MONTH, YEAR)
LINK NO.	PA ID
POWER OUTPUT W	NO. OF CARRIERS

DUMMY LOAD

FREQUENCY (MHz)	AMPLITUDE (± db)

FEED ASSEMBLY

FREQUENCY (MHz)	AMPLITUDE (± db)

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 436-R (TEST)
1 MAY 77

Figure 29-2. PA intermodulation and spurious radiation data sheet.

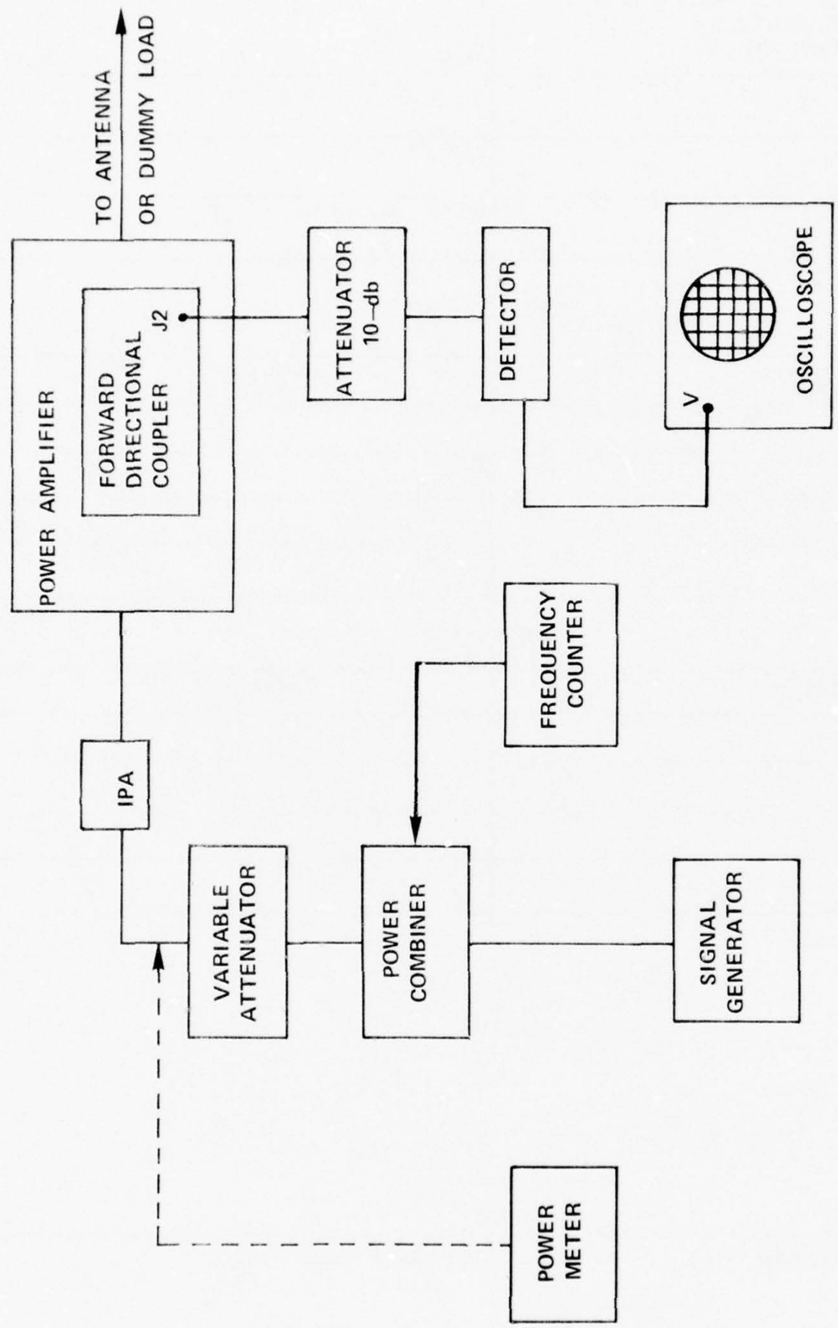


Figure 29-3. PA hum modulation test configuration.

PA HUM MODULATION (CCR 702-1-3) DATA SHEET				PAGE OF PAGES		
TERMINAL ID		TIME Z		DATE (DAY, MONTH, YEAR)		
AMPLIFIER ID		IPA ID		SPECIFICATION		
DIR COUPLER ATTENUATION (db)	ATTENUATOR VALUE (db)	POWER OUTPUT (W)	DEFLECTION (VDC)	DEFLECTION (VAC)	GAIN CLEAR (db)	HUM MODULATION (db)
COMMENTS						
TYPED NAME, GRADE, AND TITLE			TEST ENGR SIGNATURE			

USACC FORM 437-R (TEST)
1 MAY 77

Figure 29-4. PA hum modulation data sheet.

CHAPTER 30

TERMINAL MULTIPLE UPLINK CARRIER OPERATION, CONTROL, AND STABILITY (ST-25)

30-1. GENERAL.

a. The purpose of this test is to determine the interaction of individual FM carrier power level adjustments in the nodal terminals. The stability and adjustability of the power will also be monitored and recorded.

b. Prior to commencing this test, insure that the power output stability and intermodulation products of the exciters, up converters, and/or IPA's are within the manufacturer's specifications.

c. This is an inservice test for terminals with redundant PA's and an out-of-service test for terminals with a single PA.

30-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

30-3. TEST EQUIPMENT REQUIRED.

a. Power meter.

b. Thermistor mount.

c. Directional coupler.

d. Spectrum analyzer.

e. Attenuator.

30-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 30-1 and allow for a 15-minute warmup and stabilization period.

b. The PA must be adjusted for its nominal output power rating with three input carriers of equal level. The carriers will then be varied with respect to each other and the levels recorded on figure 30-2; USACC Form 438-R (Test). Power adjustability and level stability will be observed and recorded several times throughout the testing period.

c. Terminate the earth terminal transmitter into a dummy load. Choose the three carrier frequencies to be tested from the tabulation below depending upon the earth terminal's normal operating range.

FREQUENCY RANGE (MHz)	CARRIER FREQUENCY (MHz)
7895 - 8065	7976, 7985, 8023
8065 - 8235	8095, 8150, 8200
8235 - 8405	8260, 8339, 8396
7900 - 8400	8002, 7925, 8299

d. After choosing three frequencies from the above tabulation, bring the three carriers up until maximum amplifier power is obtained. Use the spectrum analyzer to balance the three carriers. Record the attenuator settings, power output, and the relative power levels of the carriers on figure 30-2; USACC Form 438-R (Test). Any intermodulation products observed on the spectrum analyzer display should be noted and recorded.

e. Increase the lowest frequency carrier attenuator 1 db and record the power output, attenuator settings, and relative power levels as observed on the spectrum analyzer.

f. Repeat paragraph 30-4e for levels 2, 3, 5, 10, 20, 25, and 30 db below the initial level as set in paragraph 30-4d.

g. Return the attenuator to the position determined in paragraph 30-4d, then repeat paragraphs 30-4 e and f for carriers 2 and 3.

h. Reduce carrier #1 by 20 db.

i. Increase carrier #2 until the power output is the same as in paragraph 30-4d. Record the attenuator settings, power output, and relative power levels of the three carriers on figure 30-2; USACC Form 438-R (Test).

j. Reduce carrier #3 by 1 db and record the same data as in paragraph 30-4i.

k. Repeat paragraph 30-4j for 2, 3, 5, 10, and 20 db more attenuation of carrier #3.

l. Record all data taken in paragraphs 30-4 d through k on figure 30-2; USACC Form 438-R (Test).

m. Establish initial test conditions to check for system drift. Set the three carriers as in paragraph 30-4d and observe for a period of 15 minutes to check the level stability. Note any variation or drift.

n. Lower the three carriers by 10 db each (from maximum power) and balance the carrier power levels as observed on the spectrum analyzer. Record the data and the time required to set the carrier levels.

o. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

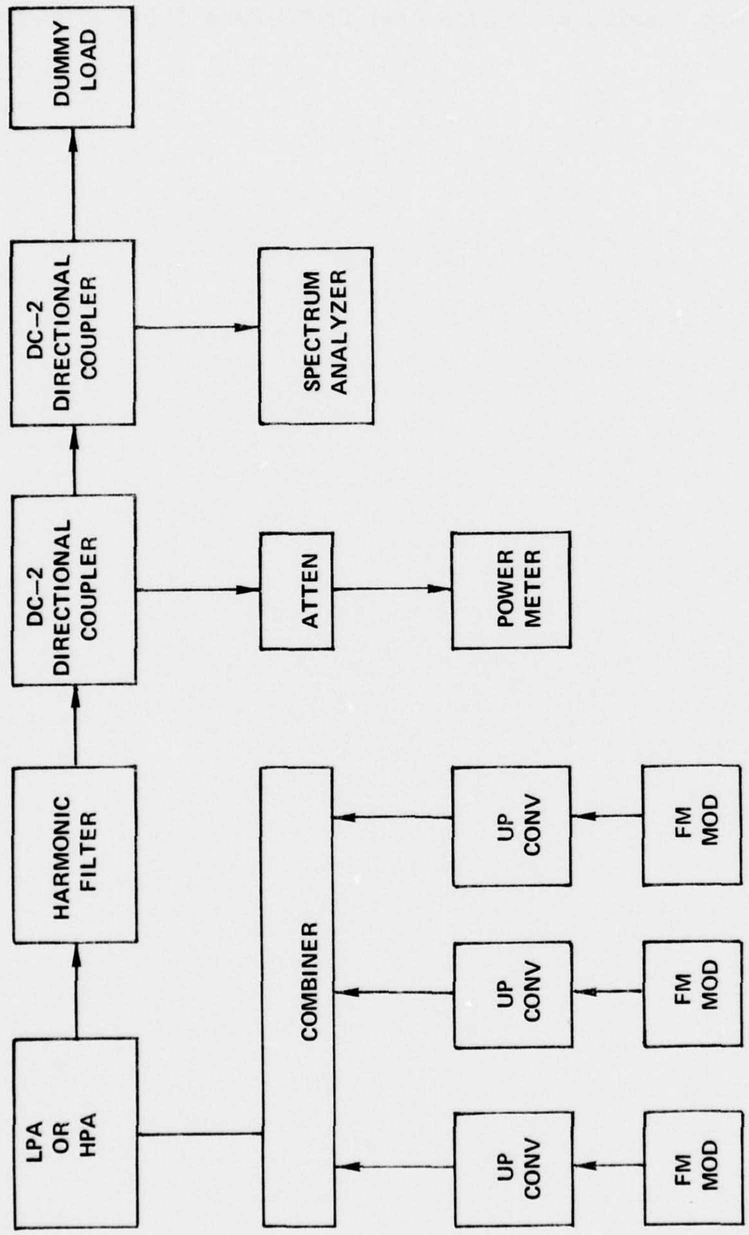


Figure 30-1. PA transfer characteristics test configuration.

PA TRANSFER CHARACTERISTICS (CCR 702-1-3) DATA SHEET				PAGE OF PAGES		
TERMINAL ID	DATE (DAY, MONTH, YEAR)			TIME Z		
TUBE	TERMINAL TYPE			F_1 db	F_2 db	F_3 db
F_1 GHz	F_2 GHz			F_3 GHz		
TOTAL POWER OUTPUT (w)	ATTEN F_1	LEVEL (dbm)	ATTEN F_2	LEVEL (dbm)	ATTEN F_3	LEVEL (dbm)
COMMENTS						
TYPED NAME, GRADE, AND TITLE		TEST ENGR SIGNATURE				

USACC FORM 438-R (TEST)
1 MAY 77

Figure 30-2. PA transfer characteristics data sheet.

CHAPTER 31

PA POWER OUTPUT CONTROL, STABILITY, AND NOISE (ST-26)

31-1. GENERAL.

a. The purpose of this test is to establish the characteristics of each type of PA used in the DSCS earth terminals with the exception of the nonnodal terminals.

b. This is an out-of-service test and requires a communications outage for terminals that do not have redundant uplink chains.

31-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

31-3. TEST EQUIPMENT REQUIRED.

a. VHF signal generator.

b. Frequency counter.

c. Power meter.

d. Strip chart recorder.

e. Variable WG attenuator.

f. Thermistor mount.

31-4. TEST PROCEDURES.

a. Configure the test equipment as shown in figure 31-1 and allow 15 minutes warmup time. Insure that the power meters are calibrated before each reading and annotate the terminal type, date, time, and terminal number on the strip chart paper for later identification and data analysis.

b. Testing one HPA and LPA at each terminal, determine the settling time for levels 1, 2, 3, 5, 10, 20, 25, 30, and 40 db below maximum power output and the power stability at 3, 5, 10, 20, and 25 db below maximum power output.

c. Terminate the PA output into a dummy load and set the test frequency to the center of the amplifier's passband. This test will be performed using both base and local generator power on those earth terminals equipped with motor/generator sets.

d. Adjust for nominal PA output and record the power readings of both the external power meter and the operations control van (OCV) power meter.

e. Reduce the power output by 1 db on the OCV power meter and record time required for the power to settle. Record the reading obtained on the external RF power meter at this power level.

f. Repeat paragraphs 31-4 d through f for power levels 2, 3, 5, 10, 20, 25, and 30 db below rated power output. Record all data on figure 31-2; USACC Form 439-R (Test).

g. Repeat paragraphs 31-4 d and e at least twice.

h. Calibrate the strip chart by running the chart for 2 or 3 inches at the power levels of paragraph 31-4f. Raise the level by 1 db and run the chart for an additional 3 inches. Lower the level to 1 db below the power level for the test to provide a scale for later data evaluation.

i. Adjust the power output to 3 db below maximum and record the level on the strip chart for a period of 4 hours. After 4 hours, repeat the calibration procedures in paragraph 31-4h.

j. Repeat paragraphs 31-4 h and i for 5, 10, 20, and 25 db below maximum power output.

k. Repeat paragraphs 31-4 h through j for each type of PA at the terminal.

l. Adjust the power output to 50 watts. Record the RF power meter reading and the RF attenuator setting. Decrease the drive to the PA to a minimum.

m. Remove all attenuation on the RF attenuator. Record the power meter reading on the lowest readable scale with the minimum attenuator setting. If necessary, bypass the RF attenuator to get an adequate deflection on the power meter.

n. Remove the drive to the PA entirely by turning off the modulator to measure the noise output.

o. Repeat paragraphs 31-4 m and n.

p. Repeat paragraphs 31-4 ℓ through o with the output power adjusted to 20 watts.

q. Record all test data on figure 31-2; USACC Form 439-R (Test).

r. Restore the system to normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

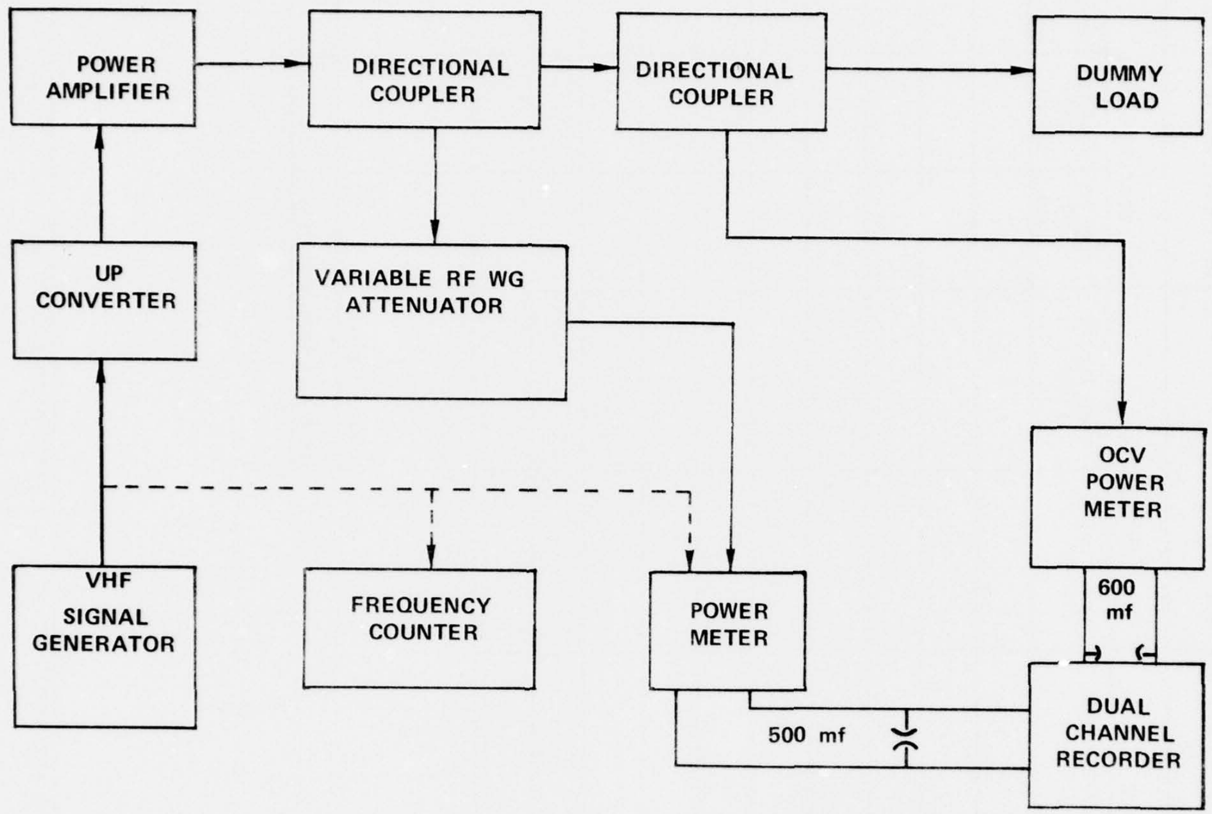


Figure 31-1. PA power output control, stability, and noise test configuration.

PA POWER OUTPUT CONTROL, STABILITY, AND NOISE (CCR 702-1-3) DATA SHEET				PAGE OF PAGES		
TERMINAL ID		TIME Z		DATE (DAY, MONTH, YEAR)		
AMPLIFIER TYPE		FREQUENCY		STATION POWER		
POWER LEVEL (db)	POWER LEVEL (dbw) (ocv)	POWER LEVEL (dbw) RF	TIME TO SET 1 (sec)	TIME TO SET 2 (sec)	TIME TO SET 3 (sec)	TIME TO SET avg (sec)
MAX						
1						
2						
3						
4						
5						
10						
20						
25						
30						
COMMENTS					50 watts	20 watts
			NOISE WO DRIVE			
			NOISE OUT WITH MIN DRIVE			
TYPED NAME, GRADE, AND TITLE			TEST ENGR SIGNATURE			

USACC FORM 439-R (TEST)
1 MAY 77

Figure 31-2. PA power output control, stability, and noise data sheet.

CHAPTER 32

TRACK RECEIVER AGC VOLTAGE VERSUS C/kT (ST-27)

32-1. GENERAL.

a. The purpose of this test is to calibrate the track receiver AGC voltage versus the C/kT and to determine the C/kT ratio at which the track receiver will not maintain lock.

b. This is an inservice test and does not require a communications outage; however, the tracking receiver under test must be taken out of service.

c. Techniques for measuring receive C/kT ratio may be found in chapter 56.

32-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

32-3. TEST EQUIPMENT REQUIRED.

a. VHF signal generator.

b. Amplifier.

c. Frequency selective voltmeter.

d. Mixer.

e. Frequency counter.

f. Power meter.

g. Attenuator.

h. Thermistor mount.

i. Directional coupler.

32-4. TEST PROCEDURES.

a. Configure the system for an RF loopback, and configure the test equipment as illustrated in figure 32-1.

b. Energize the test equipment and allow for a 30-minute warmup and stabilization period.

c. Adjust the PA output power level until a C/kT of 70 db is obtained. Record the C/kT ratio and the AGC voltage of both track receivers as displayed on the operations control panel (fig. 32-2; USACC Form 440-R (Test)).

d. Repeat paragraph 32-4c above in 3-db steps until a C/kT of 35 db is obtained. Note the C/kT ratio at which each track receiver fails to maintain lock. Record on figure 32-2; USACC Form 440-R (Test).

e. Plot an AGC voltage versus C/kT curve on figure 8-7; USACC Form 396-R (Test) and annotate the point at which each track receiver loses lock on the curve. The AGC voltage should be plotted on the vertical axis and the C/kT (db Hz) on the horizontal axis.

f. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

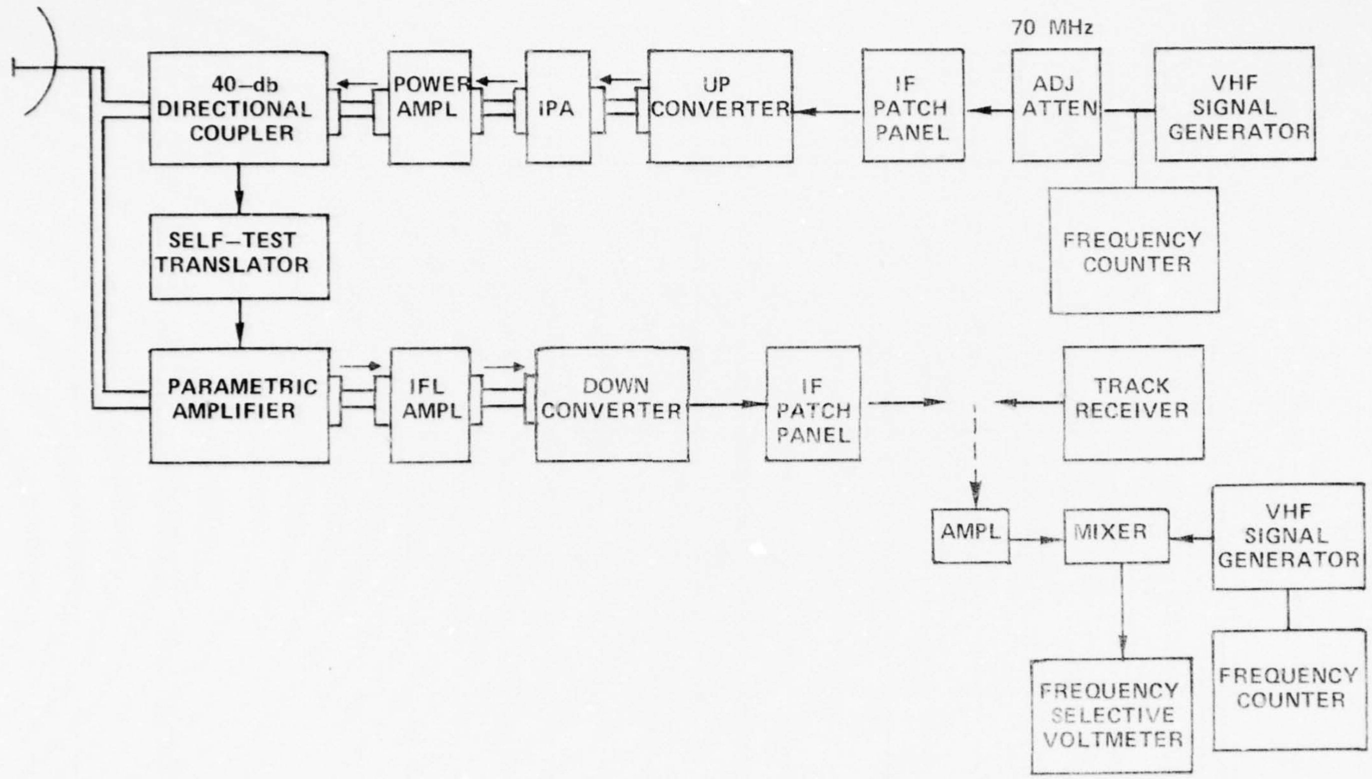


Figure 32-1. Track receiver AGC voltage vs C/kT test configuration.

TRACK RECEIVER AGC VOLTAGE VS C/kT (CCR 702-1-3) DATA SHEET						PAGE OF PAGES	
TERMINAL ID			TIME Z			DATE (DAY, MONTH, YEAR)	
TRACKING RCVR ID			TRACKING FREQ MHz			SPECIFICATION	
C/kT INPUT LEVEL (db–Hz)	AGC LEVEL (V)	C/kT INPUT LEVEL (db–Hz)	AGC LEVEL (V)	C/kT INPUT LEVEL (db–Hz)	AGC LEVEL (V)	C/kT INPUT LEVEL (db–Hz)	AGC LEVEL (V)
COMMENTS							
TYPED NAME, GRADE, AND TITLE				TEST ENGR SIGNATURE			

USACC FORM 440-R (TEST)
1 MAY 77

Figure 32-2. Track receiver AGC voltage vs C/kT data sheet.

CHAPTER 33

TRACK RECEIVER IF AMPLIFIER DYNAMIC RANGE (ST-28)

33-1. GENERAL.

a. The purpose of this test is to measure the dynamic range of the tracking receiver IF amplifier.

b. This is an inservice test and does not require a communications outage; however, the tracking receiver under test must be taken out of service.

33-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

33-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. VHF signal generator.

c. Power meter.

d. Thermistor mount.

e. Attenuator.

33-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 33-1. Energize the test equipment and allow for a 30-minute warmup and stabilization period.

b. Tune the signal generator to 70 MHz at an output power level of zero dbm. Adjust the signal generator output level attenuator to a setting of 86 db.

c. Connect the test equipment to the input of the desired track receiver as shown in figure 33-1 and record the track receiver input level and the IF amplifier output level on figure 33-2; USACC Form 441-R (Test).

d. Increase the RF power input level in 5-db steps and repeat paragraph 33-4c until a level of -21 dbm has been obtained.

e. Set the signal generator output level attenuator to 86 db and restore the IF amplifier to its normal operating configuration. Monitor and record the AGC voltage as displayed on the operations control panel.

f. Increase the output power level of the signal generator in 5-db steps and repeat paragraphs 33-4 c and d. Return the track receiver to the normal configuration and repeat paragraphs 33-4 a through d on all standby track receivers.

g. Record the IF input, RF output, and AGC voltage obtained during each step on figure 33-2; USACC Form 441-R (Test).

h. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

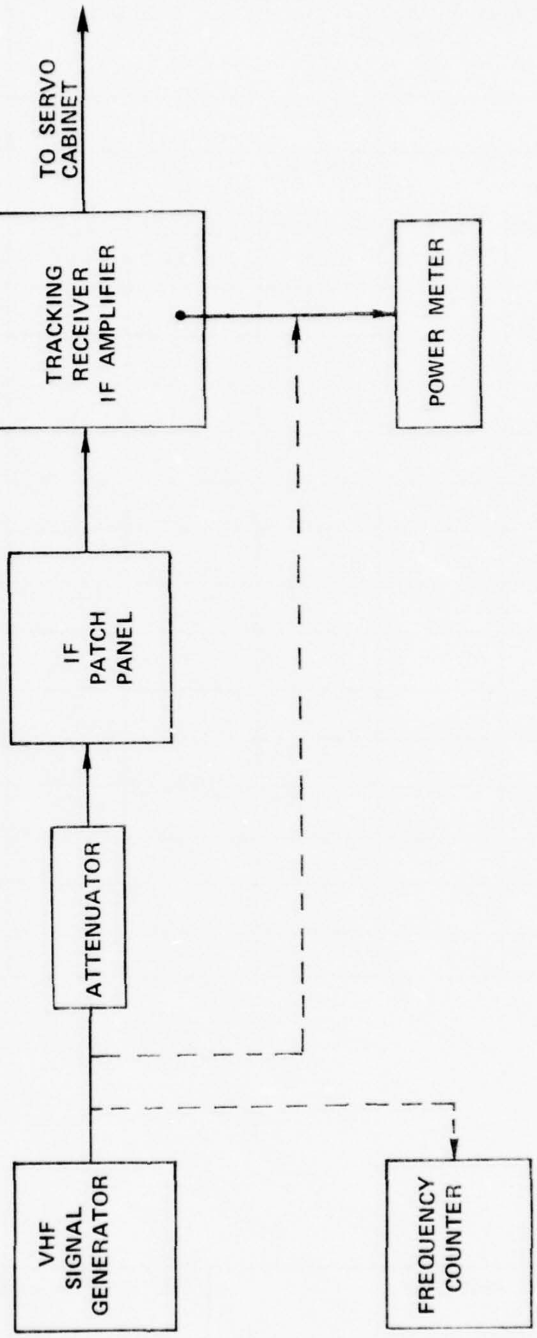


Figure 33-1. Track receiver IF amplifier dynamic range test configuration.

TRACK RECEIVER IF AMPLIFIER DYNAMIC RANGE (CCR 702-1-3) DATA SHEET						PAGE OF PAGES		
TERMINAL ID			TIME Z			DATE (DAY, MONTH, YEAR)		
ITEM ID			LINK NO.			IF AMPL OUTPUT dbm REFERENCE db		
IF INPUT (dbm)	IF OUTPUT (± db)	AGC (V)	IF INPUT (dbm)	IF OUTPUT (± db)	AGC (V)	IF INPUT (dbm)	IF OUTPUT (± db)	AGC (V)
COMMENTS								
TYPED NAME, GRADE, AND TITLE				TEST ENGR SIGNATURE				

USACC FORM 441-R (TEST)
1 MAY 77

Figure 33-2. Track receiver IF amplifier dynamic range data sheet.

CHAPTER 34

TRACK RECEIVER IF FILTER NOISE BANDPASS (ST-29)

34-1. GENERAL.

a. The purpose of this test is to determine the IF filter noise bandpass of the track receiver.

b. This is an inservice test and does not require a communications outage. The track receiver under test must be taken out of service.

34-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

34-3. TEST EQUIPMENT REQUIRED.

a. Spectrum analyzer.

b. VHF signal generator.

c. Power meter.

d. Thermistor mount.

e. Frequency counter.

f. Oscilloscope camera.

g. Attenuator set.

34-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 34-1. Energize the test equipment and allow for a 30-minute warmup and stabilization period.

b. Tune the signal generator to 50 MHz at an output power level of zero dbm. Adjust the signal generator output power level attenuator for a setting of -40 dbm.

c. Tune the spectrum analyzer for a desirable dispersion and measure the track receiver noise bandpass.

d. The signal should be centered on the noise bandpass as displayed on the spectrum analyzer (fig. 34-2).

e. Photograph the spectrum analyzer display and mount the photographs on figure 12-5; USACC Form 397-R (Test).

f. Restore the track receiver under test to the normal configuration and repeat paragraphs 34-4 a through e on all track receivers.

g. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

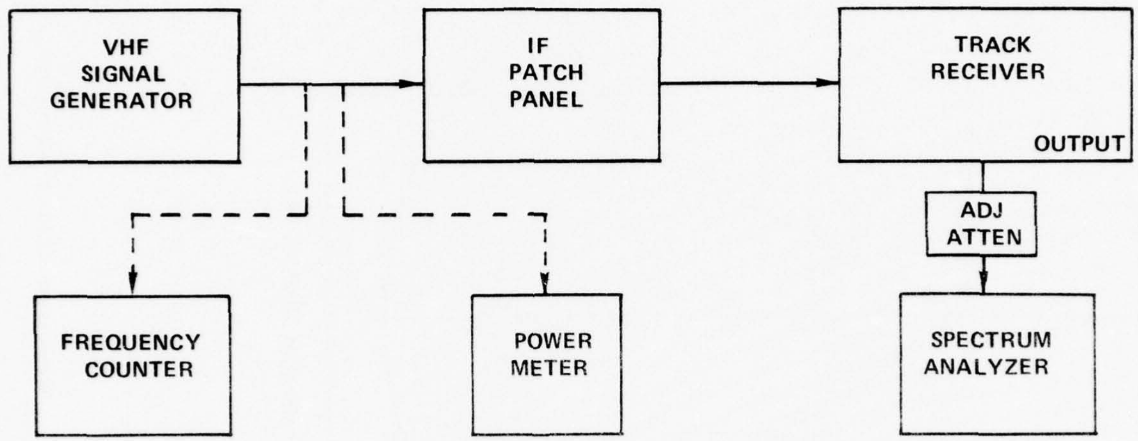


Figure 34-1. Track receiver IF filter noise bandpass test configuration.

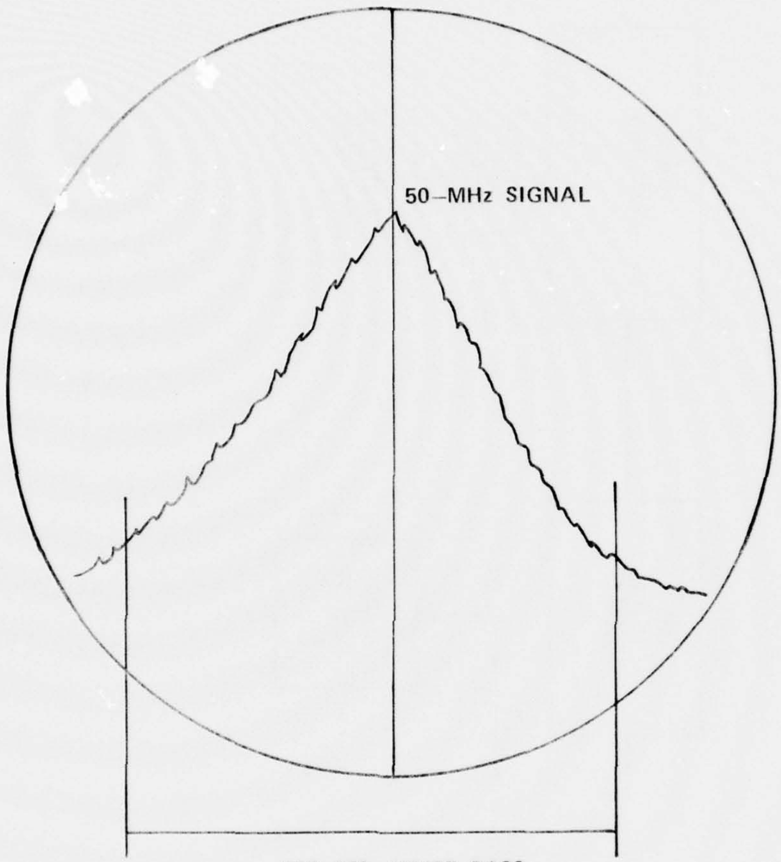


Figure 34-2. Bandpass filter waveform.

CHAPTER 35

TRACK RECEIVER VCO FREQUENCY ACCURACY AND POWER OUTPUT (ST-30)

35-1. GENERAL.

a. The purpose of this test is to determine the track receiver VCO frequency accuracy and power output level.

b. This is an inservice test and does not require a communications outage. The tracking receiver being tested must be taken out of service for the duration of the test.

35-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

35-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. Power meter.

c. Thermistor mount.

d. Digital printer.

35-4. TEST PROCEDURES.

a. Configure the test equipment as shown in figure 35-1 and allow for a 15-minute warmup and stabilization period. Remove the plugs from the VCO input and output jacks. Connect the frequency counter to the VCO output jack and observe the output frequency as read on the frequency counter. Record the output frequency on figure 35-2; USACC Form 442-R (Test).

b. Connect the power meter to the VCO output jack. Observe the power meter reading and record the test results on figure 35-2; USACC Form 442-R (Test). Connect the plug to the VCO input jack and observe the frequency as displayed on the frequency counter. Record the plus and minus variations on figure 35-2; USACC Form 442-R (Test).

c. If the test equipment is available, the preferred method would be to connect the frequency counter output to a digital recorder and record the frequency for approximately 15 minutes.

d. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

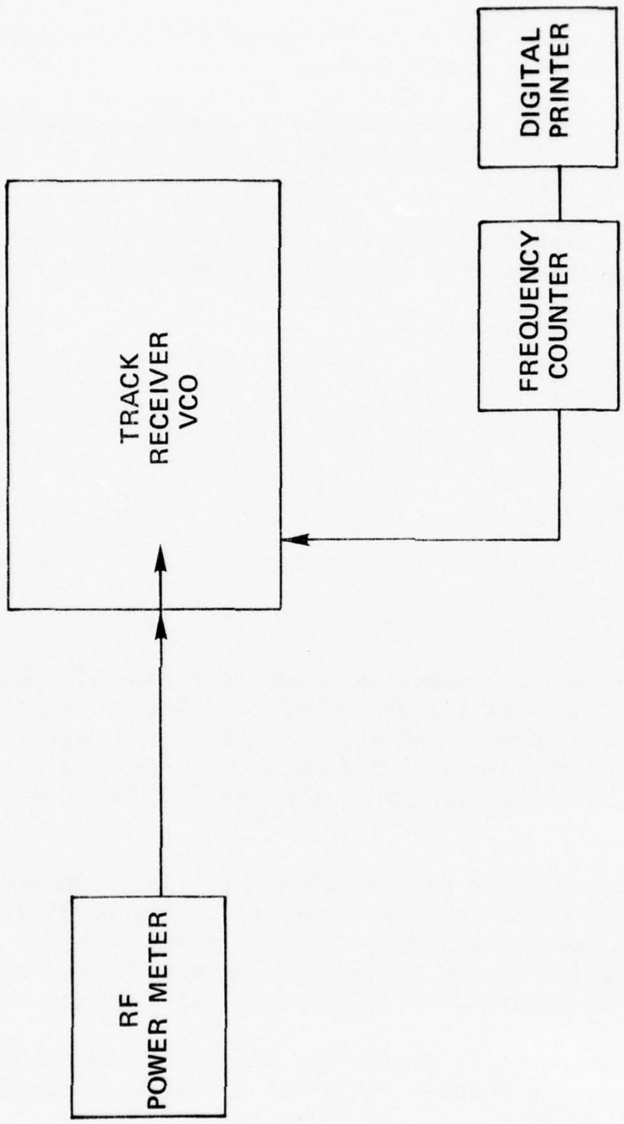


Figure 35-1. Track receiver VCO frequency accuracy and power output test configuration.

DATA SHEET — TRACK RECEIVER VCO FREQUENCY ACCURACY AND POWER OUTPUT (CCR 702-1-3)			PAGE OF PAGES
TERMINAL ID	TIME Z		DATE (DAY, MONTH, YEAR)
TRACK RCVR ID	VCO FREQ MHz		SWEEP RANGE 82±4kHz
ASSIGNED FREQUENCY (MHz)	MEASURED FREQUENCY (MHz)	ACCURACY (%)	POWER OUTPUT (dbm)
COMMENTS			
TYPED NAME, GRADE, AND TITLE		TEST ENGR SIGNATURE	

USACC FORM 442-R (TEST)
1 MAY 77

Figure 35-2. Track receiver VCO frequency accuracy and power output data sheet.

Preceding Page Blank - NOT FILMED

CHAPTER 36

FM MODEM DEVIATION, DEVIATION LINEARITY, DISPERSION, AND FREQUENCY DEVIATION RESPONSE (ST-31)

36-1. GENERAL.

a. The purpose of this test is to measure the frequency deviation, deviation linearity, dispersion, and frequency response of the FM modem.

b. This is an inservice test for those earth terminals that are equipped with a standby modem and an out-of-service test for earth terminals not equipped with a standby modem.

36-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

36-3. TEST EQUIPMENT REQUIRED.

a. Test oscillator.

b. RMS voltmeter.

c. Spectrum analyzer.

d. Frequency counter.

e. Step attenuator.

36-4. TEST PROCEDURES.

a. This test will normally be conducted with the FM modulator configured for the normal operating channel capacities. The 12-channel configuration is used in this procedure for illustration purposes only.

b. Configure the test equipment as illustrated in figure 36-1 and allow for a 30-minute warmup and stabilization period. (Insure that emphasis circuitry has been activated.)

c. Tune the baseband oscillator to 65.8 kHz as observed on the frequency counter. Adjust the vernier and coarse level controls on the baseband oscillator for a minimum output level.

d. Tune the spectrum analyzer for a suitable display at 70 MHz.

NOTE: If sidebands appear on the spectrum analyzer display, disconnect the output of the baseband oscillator from the input to the deviator module. This is to determine if sidebands are being caused by extraneous baseband signals or the output level of the baseband oscillator.

e. On the baseband oscillator, adjust the vernier and coarse output level controls until a first carrier null is observed on the spectrum analyzer.

f. The rms voltmeter should indicate 6.8 mv. If this requirement is not met, it will be necessary to adjust the output level of the baseband oscillator to 6.8 mv and adjust resistor R-2 for a first carrier null. Record the final results on figure 36-2; USACC Form 443-R (Test).

g. Configure the test equipment and the FM modulator as illustrated in figure 36-3 and deactivate the dispersal generator.

h. Adjust the output level of the baseband oscillator until the first null occurs as observed on the spectrum analyzer. This should occur at 19 mv as read on the true rms voltmeter. Record the information on figure 36-2; USACC Form 443-R (Test).

i. Continue to increase the output level of the baseband oscillator and observe and record the level at which each successive carrier null occurs until the first ten nulls have been completed. The following is a list of predictions at which each carrier null should occur:

CARRIER NULL	BESSEL FUNCTION	ΔFM (kHz)	MOD INPUT LEVEL		
			mv	dbm	METER dbm
1	2.4	87.552	19	-23.2	-32.2
2	5.52	201.369	43	-16.0	-25.3
3	8.65	315.552	68	-12.1	-21.4
4	11.79	430.099	93	- 9.4	-18.7
5	14.93	544.646	117	- 7.4	-16.7
6	18.08	659.658	142	- 5.7	-15.0
7	21.21	773.740	167	- 4.3	-13.6
8	24.35	888.288	191	- 3.1	-12.4
9	27.49	1002.835	216	- 2.7	-11.3
10	30.64	1117.747	240	1.1	- 8.2

NOTE: Figure 36-4 is typical of predicted carrier dropout levels for channel capacities other than 12.

j. Summarize the test results on figure 6-4; USACC Form 351-R (Test) and plot an FM deviation versus modulator input level curve on figure 8-7; USACC Form 396-R (Test). The deviation (ΔF kHz) should be plotted on the vertical axis and the input voltage (V_i mv) on the horizontal axis.

k. Repeat paragraphs 36-4 b through j, as applicable, for the normal operating channel capacity of the terminal being evaluated. Pivot frequencies and levels applicable to the various channel configurations are tabulated below.

CHANNEL CAPACITY	PIVOT FREQUENCY (KHz)	
	SPECIFIED	CALCULATED
3	13.000	14.592
3 (Tac)	13.000	14.592
6	19.000	21.888
6 (Tac)	19.000	21.888
9	25.000	29.184
9 (Tac)	25.000	29.184
12	36.500	36.480
24	65.660	65.664
36	94.850	94.848
48	124.000	124.032

l. Reduce the input level to the FM modulator until the true rms voltmeter indicates -29.03 dbm, and configure the test equipment as illustrated in figure 36-1.

m. Adjust the baseband amplifier attenuator (FM demodulator) to obtain a demodulator output level of -29.0 dbm.

n. Without adjusting the demodulator baseband output level, repeat paragraph 36-4m above at the following listed test frequencies:

12-Channel Capacity:

Frequency (kHz): 4, 8, 12, 16, 20, 24, 28, 30, 32, 36, 40, 44, 48, 50, 52, 56, 60, 64, and 68.

CCP 702-2

The following test frequencies are to be used on those systems configured for other than 12 channels.

CHANNEL CAPACITIES	TEST FREQUENCIES (kHz)
3 or 3 Tac	4, 8, 12, 16, 18, 20, 24, 28, 32
6 or 6 Tac	4, 8, 12, 15, 19, 22, 25, 28, 31, 33, 36, 40, 44, 48, 52
9 or 9 Tac	4, 8, 12, 16, 20, 24, 28, 30, 34, 38, 40, 44, 48, 52, 56, 60, 64
24	4, 8, 12, 16, 20, 24, 28, 30, 32, 36, 40, 44, 48, 50, 52, 56, 60, 64, 68, 70, 80, 90, 100, 104, 108, 112, 116, 120
36	4, 8, 12, 16, 20, 24, 28, 30, 34, 38, 40, 44, 48, 50, 54, 58, 60, 64, 68, 70, 80, 90, 100, 110, 120, 125, 130, 140, 150, 156, 160, 170
48	4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64, 68, 72, 76, 80, 90, 100, 110, 120, 125, 130, 140, 150, 160, 170, 180, 190, 204, 214, 224, 234

o. Plot a frequency versus relative amplitude curve in reference to the pivot frequency level (-29.03 dbm) on figure 8-7; USACC Form 396-R (Test). Summarize the test results on figure 6-4; USACC Form 351-R (Test).

p. Connect a BNC "Tee" at the input to the deviator module and configure the test equipment as illustrated in figure 36-1.

q. Tune the baseband oscillator to 36.5 kHz and adjust the output level to -29.0 dbm as indicated on true rms voltmeter #1.

r. Observe and record on figure 6-4; USACC Form 351-R (Test) the level indicated on true rms voltmeter #2, then remove the test tone. Activate the dispersal generator and record the level indicated on true rms voltmeter #2. The level should be 3.32 db above the test tone level.

s. Reinsert the test tone and gradually increase the output level of the baseband oscillator until a sharp meter movement is noted on true rms voltmeter #2. Record this level on figure 6-4; USACC Form 351-R (Test).

t. Gradually decrease the output level of the baseband oscillator until the dispersal generator automatically activates. Record the level indicated on true rms voltmeter #1 (the input level at which the dispersal generator activated) on figure 6-4; USACC Form 351-R (Test).

u. Plot a frequency response curve on figure 8-7; USACC Form 396-R (Test) and summarize the test results on figure 6-4; USACC Form 351-R (Test).

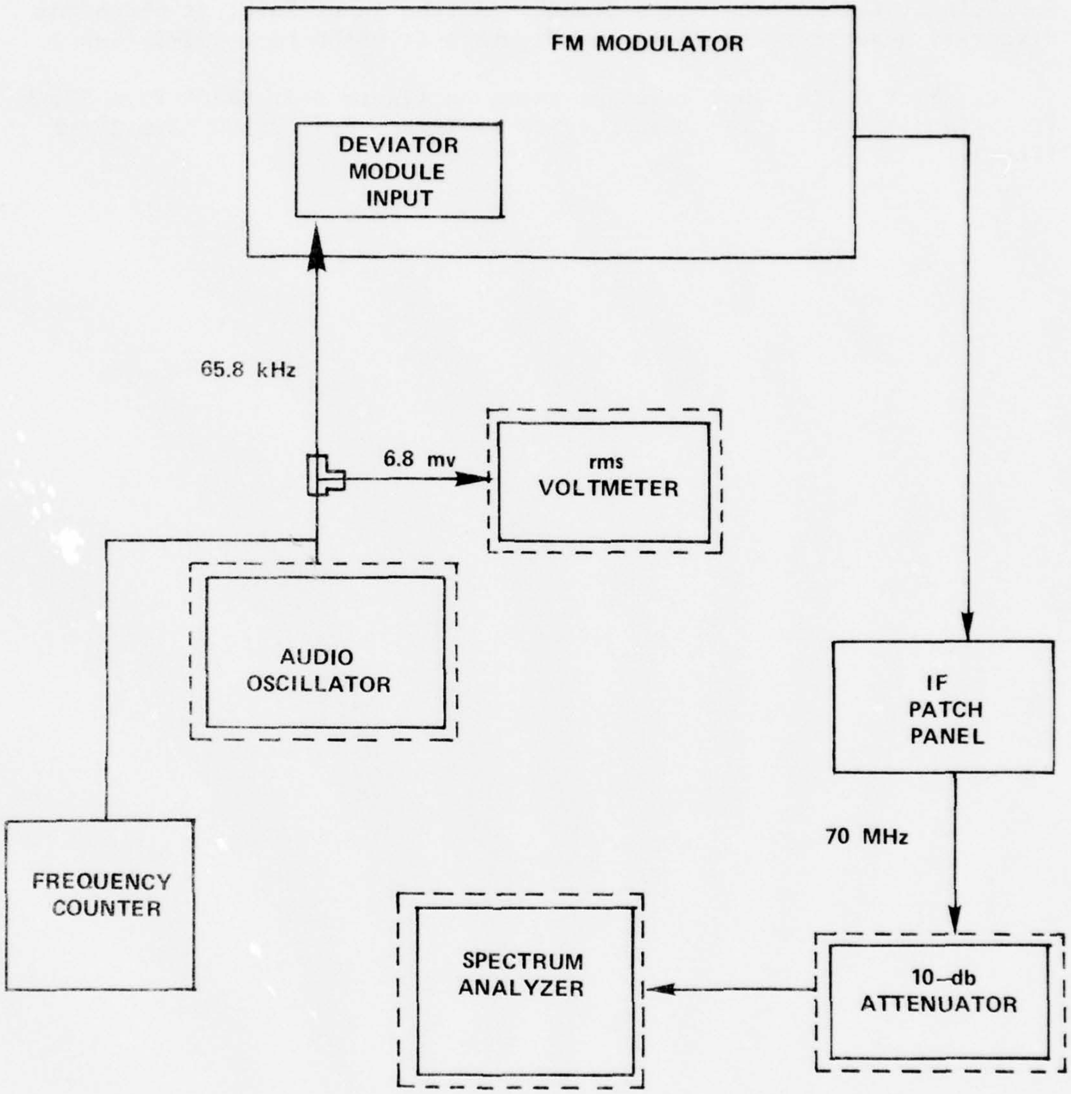


Figure 36-1. FM modem deviation (12 channel) test configuration.

FM MODEM DEVIATION LINEARITY (CCR 702-1-3) DATA SHEET		PAGE OF PAGES
TERMINAL ID	LOCATION	DATE (DAY, MONTH, YEAR)
MOD ID	MOD SN	SUBSYSTEM
SCCT LEVEL dbm	TLP dbm	PIVOT FREQ kHz

CARRIER NULL	BESSEL FUNCTION	Δ FM (kHz)	MOD INPUT LEVEL		
			mv	dbm	mtr dbm
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

COMMENTS

BASE BAND BW ____________ TO ________________ kHz

CHAN CAPACITY ______________________________

SCCT rms DEV ___________________________ kHz

TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 443-R (TEST)
1 MAY 77

Figure 36-2. FM modem deviation linearity data sheet.

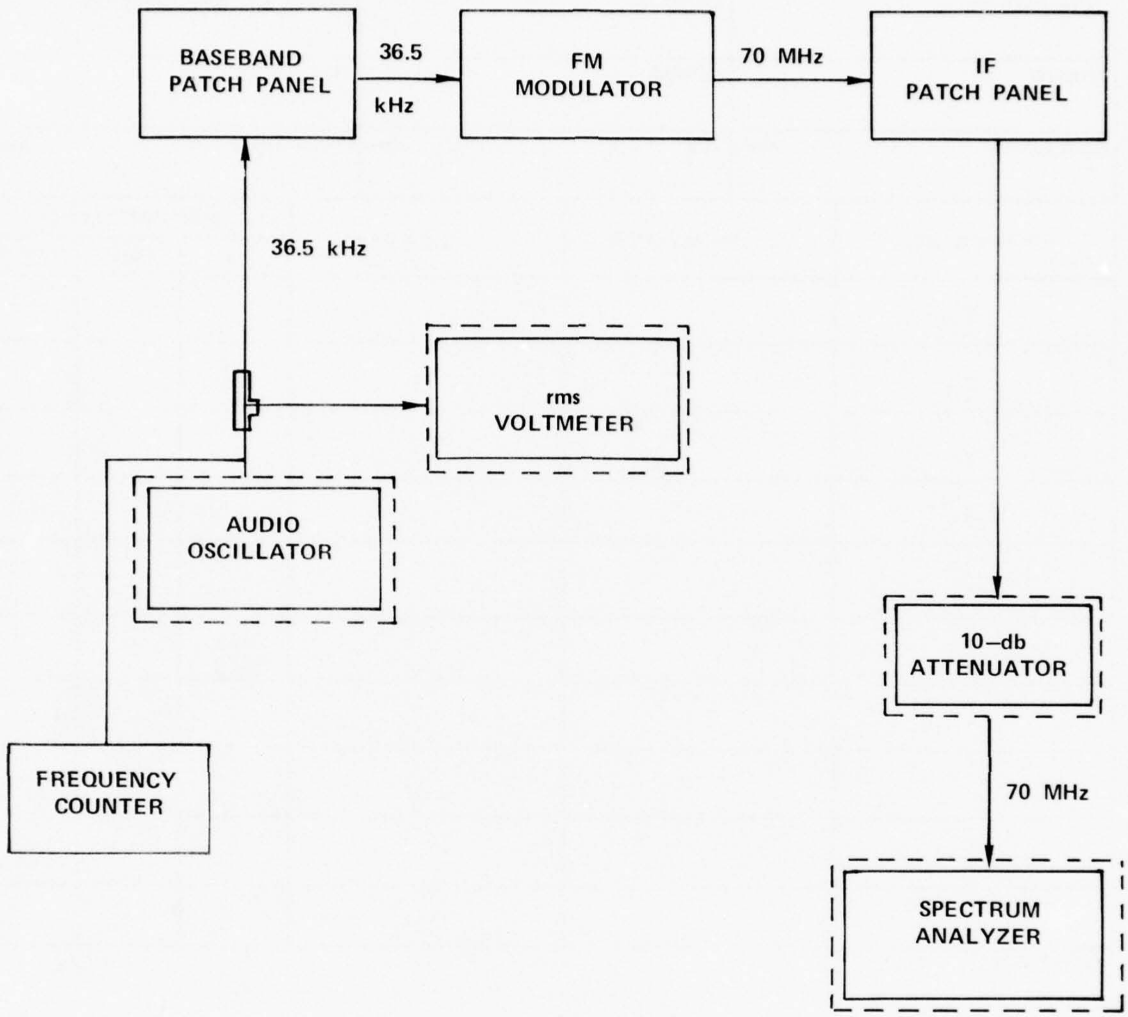


Figure 36-3. FM modem deviation (12 channel without dispersal generator) test configuration.

FM MODEM DEVIATION LINEARITY (CCR 702-1-3) DATA SHEET		PAGE 1 OF 1 PAGES
TERMINAL ID: Futema	LOCATION: Okinawa	DATE (DAY, MONTH, YEAR): 3 May 72
MOD ID: 1A8	MOD SN: 061	SUBSYSTEM: 78F306
SCCT LEVEL: -20 dbm	TLP: -20 dbm	PIVOT FREQ: 25 kHz

CARRIER NULL	BESSEL FUNCTION	△ FM (kHz)	MOD INPUT LEVEL mv	MOD INPUT LEVEL dbm	MOD INPUT LEVEL mtr dbm
1	2.4048	60.12	12.8		
2	5.5201	138	29.37		
3	8.6537	216.343	46.05		
4	11.7915	294.788	62.74		
5	14.9309	373.273	79.45		
6	18.0711	451.778	96.16		
7	21.2116	530.290	112.87		
8	24.3525	608.813	129.58		
9	27.4935	687.338	146.29		
10	30.6346	765.865	163.0		

COMMENTS

BASE BAND BW 12 TO 48 kHz

CHAN CAPACITY 9

SCCT rms DEV 91 kHz

Calculated pivot frequency: 29.184 kHz
Specified pivot frequency: 25 kHz

TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE
JOHNS, MARY E., CW3	Mary E. Johns CW3

USACC FORM 443-R (TEST)
1 MAY 77

Figure 36-4. FM modem predicted carrier dropout levels for channel capacities other than 12.

Preceding Page BLANK - NOT FILMed

CHAPTER 37

FM DEMODULATOR IF BANDPASS CHARACTERISTICS (ST-32)

37-1. GENERAL.

a. The purpose of this test is to measure the IF bandpass at the -3 db points unless otherwise specified.

b. This is an inservice test for those earth terminals that are equipped with two or more standby demodulators. For terminals equipped with only one demodulator, this will be an out-of-service test and will require an AO.

37-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

37-3. TEST EQUIPMENT REQUIRED.

a. SHF signal generator.

b. Plug-in.

c. Frequency counter.

d. Crystal detector.

e. Oscilloscope.

f. Power meter.

37-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 37-1. Energize the test equipment and allow for a 30-minute warmup and stabilization period.

b. Tune the VHF sweep signal generator to a CW frequency of 70 MHz and an output power level of zero dbm.

c. Measure and record the output power level at the IF filter.

d. Repeat paragraphs 37-1 b and c above in 50-kHz steps for tactical configurations and in 100-kHz steps for a nontactical system until the -1 and -3 db power points have been identified.

e. Record the test results on figure 37-2; USACC Form 444-R (Test) and plot an amplitude versus frequency curve on figure 8-7; USACC Form 396-R (Test). The response curve will be in reference to 70 MHz for 24 channels and above, and 10.7 MHz for 12 channels and below.

f. Configure the test equipment as illustrated in figure 37-3. Using the following tabulation, adjust the start and stop frequency controls to the bandwidth that is required to measure the 3-db bandwidth of the IF filter. Figure 37-4 depicts typical response curve of the phase II stage 1b FM modem obtained during an evaluation.

CHANNEL CAP	BANDWIDTH IN MHz			
	MAXIMUM	NOMINAL	MINIMUM	F_c (MHz)
3 Tac	0.320	0.352	0.288	10.7
6 Tac	0.430	0.473	0.387	10.7
9 Tac	0.460	0.500	0.414	10.7
3	0.800	0.880	0.720	10.7
6	1.050	1.155	0.945	10.7
9	1.25	1.375	1.125	10.7
12	1.32	1.452	1.188	10.7
24	2.1	2.205	1.995	70
36	2.90	3.045	2.755	70
48	3.50	3.675	3.325	70

g. Set the sweep signal generator mode switch to the automatic mode position. Adjust the oscilloscope and sweep signal generator to obtain a suitable display.

h. Remove the detector from the test loop and configure the test equipment as illustrated in figure 37-5.

i. Readjust the vertical deflection of the oscilloscope to obtain a suitable display.

NOTE: The phase lock detector crossover should occur at 70 MHz and the curve should be linear throughout the -3 db bandwidth of the IF section. If it is found that the IF amplifier AGC circuitry obscures the display, it will be necessary to connect the output of the sweep generator directly to the input of the phase lock detector.

j. Photograph each of the displays and mount the photographs on figure 12-5; USACC Form 397-R (Test).

k. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

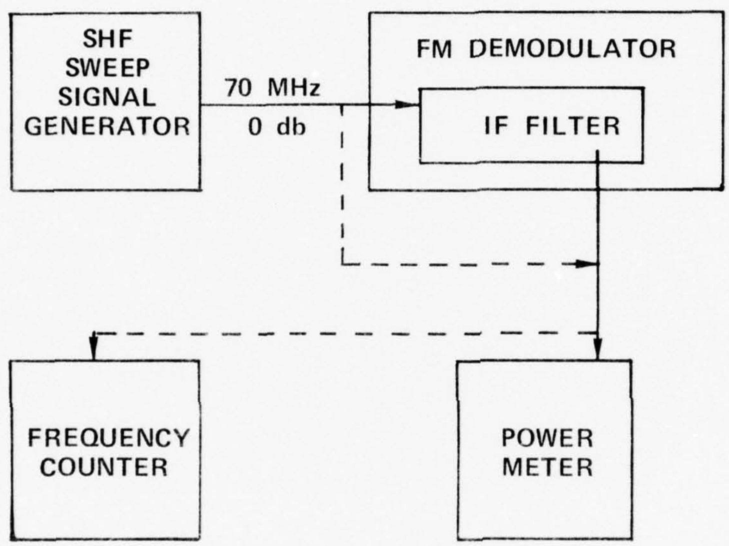


Figure 37-1. IF bandpass output power test configuration.

IF BANDPASS CHARACTERISTICS (CCR 702-1-3) DATA SHEET			PAGE OF PAGES
TERMINAL ID		GAIN db AT 70 MHz	
DEMOD ID		OUTPUT LEVEL (dbm)	
BW–3db △ +F	BW–3db △ –F	BW–3db	MHz
FREQUENCY (MHz)	BANDWIDTH (± db)	FREQUENCY (MHz)	BANDWIDTH (± db)
COMMENTS			
TYPED NAME, GRADE, AND TITLE		TEST ENGR SIGNATURE	

USACC FORM 444-R (TEST)
1 MAY 77

Figure 37-2. IF bandpass characteristics data sheet.

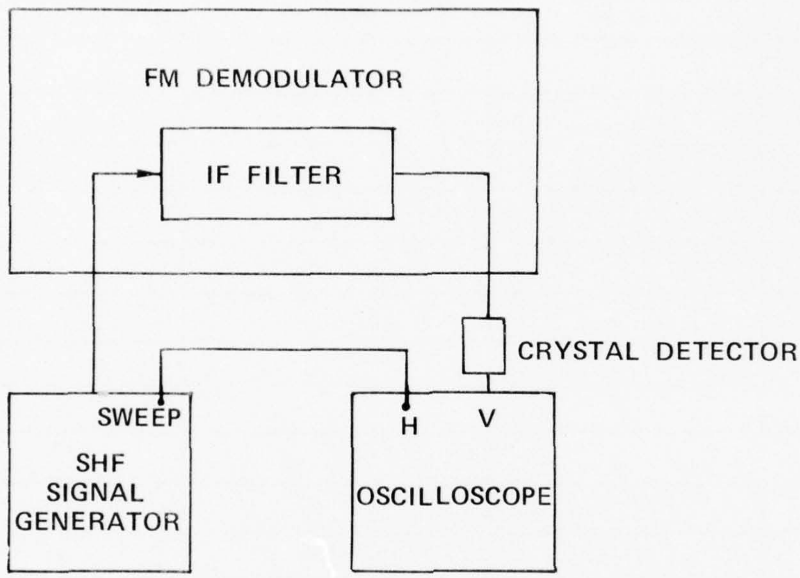
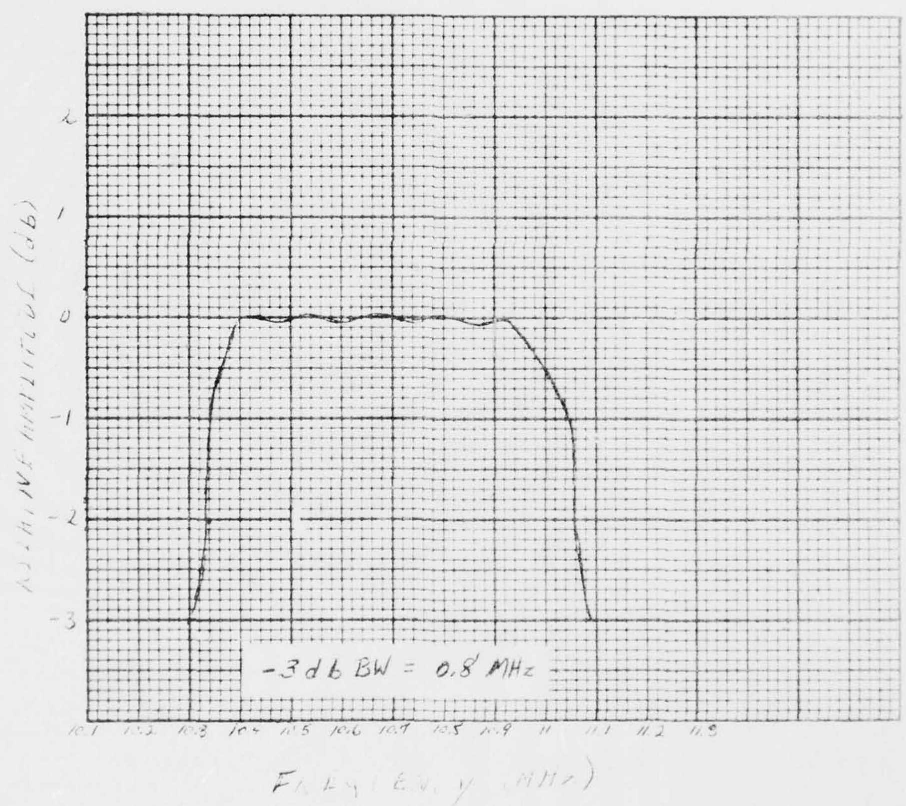


Figure 37-3. IF bandpass 3-db bandwidth test configuration.

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3) DATA SHEET			PAGE NUMBER: 1	NUMBER OF PAGES: 1
			DATE (DAY, MONTH, YEAR): [illegible]	
LINK NO.: [illegible]	STATION UNDER TEST: Site Y	DISTANT STATION: Site X	TEST ENGR SIGNATURE: [illegible]	
TITLE OF PERFORMANCE PLOTTED: [illegible]				TEST NO.: [illegible]



USACC Form 396-R (Test)
1 April 1977

Figure 37-4. Typical response curve of phase II stage 1b FM modem.

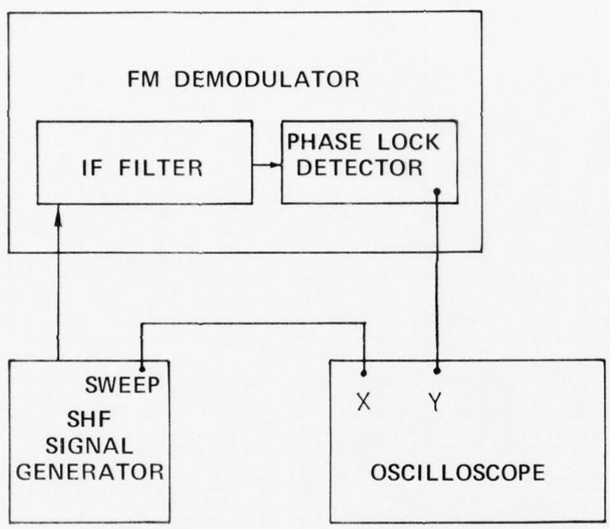


Figure 37-5. IF bandpass 70-MHz crossover test configuration.

CHAPTER 38

DEMODULATOR IF AMPLIFIER DYNAMIC RANGE (ST-33)

38-1. GENERAL.

a. The purpose of this test is to determine the dynamic range of the demodulator.

b. This is an inservice test for terminals with spare modulators and demodulators.

38-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

38-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. RF voltmeter.

c. 1-db step attenuator.

d. 10-db step attenuator.

e. Coupler.

g. Signal generator.

h. DC measuring set.

38-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 38-1 and allow for a 30-minute warmup and stabilization period.

b. Adjust the attenuators to obtain a level of -5 dbm at the patch panel FM demodulator in the receiver jack.

c. Place a BNC "Tee" connector at the output (J-1) of the IF amplifier and connect the RF voltmeter. Set the measuring set to -DC and connect to TP-1. Note and record the attenuator setting of AT-1.

d. Record the data on figure 38-2; USACC Form 445-R (Test).

e. Increase attenuation in 5-db steps, until a level of -55 dbm has been reached and record the IF output level of each step.

f. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

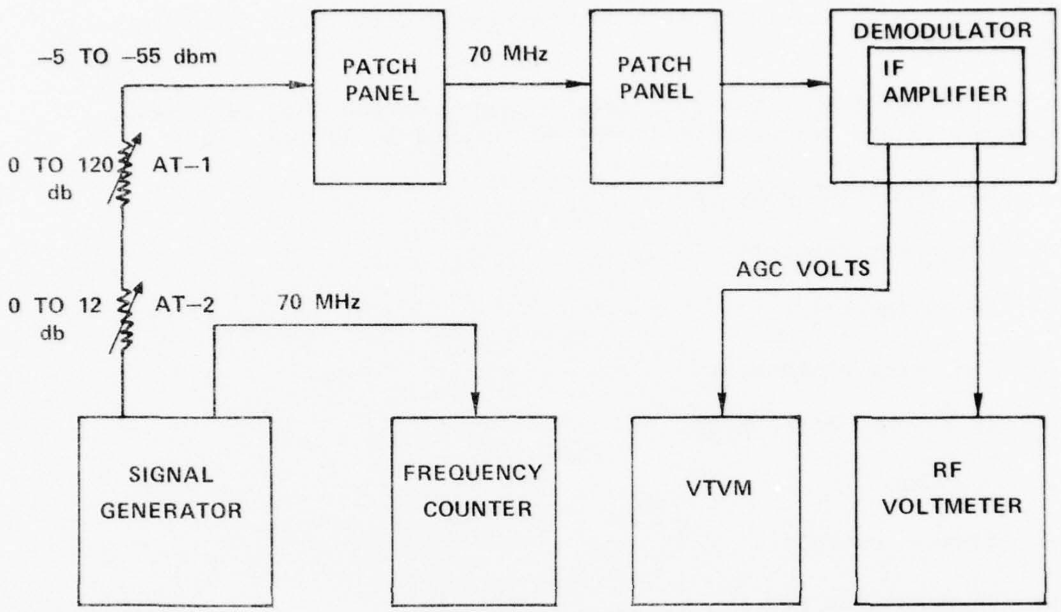


Figure 38-1. Demodulator dynamic range test configuration.

DEMODULATOR IF AMPLIFIER DYNAMIC RANGE (CCR 702-1-3) DATA SHEET		PAGE OF PAGES
TERMINAL ID	TIME Z	DATE (DAY, MONTH, YEAR)
ITEM ID	SPECIFICATION	IF AMPL INPUT dbm REFERENCE db

INPUT LEVEL (dbm)	ATTENUATOR SETTING	IF AMPL OUTPUT (J–1) (V_{rf})	AGC (–DC) (TP–1)
-5			
–10			
–15			
–20			
–25			
–30			
–35			
–40			
–45			
–50			
–55			

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 445-R (TEST)
1 MAY 77

Figure 38-2. Demodulator IF amplifier dynamic range data sheet.

Preceding Page Blank - NOT FILMED

CHAPTER 39

TTNR AND IDLE NPR VERSUS C/kT RATIO (ST-34)

39-1. GENERAL.

a. The purpose of this test is to measure the TTNR and idle NPR versus C/kT ratio.

b. This is normally an out-of-service test and requires an AO; however, a communications outage will not be required on those earth terminals with redundant capabilities, providing that the transmitted test signal does not interfere with the satellite repeater operation. Loopback and link tests employing the satellite repeater will be coordinated with DSCS SATCOM controllers and distant-end earth terminal personnel.

c. This test will provide an FM improvement curve, and the noise loading levels will be based on CCIR standards -1 +4 log N (for 240 channels and less).

d. Techniques for measuring receive C/kT ratio may be found in chapter 56.

39-2. SPECIFICATIONS. The test data obtained as a result of this test shall be compared to the performance limits delineated in appendix B.

39-3. TEST EQUIPMENT REQUIRED.

a. RMS voltmeter.

b. Noise loading test set.

c. 1-db attenuator.

d. 10-db attenuator.

e. VHF amplifier.

f. LF amplifier, baseband 75 ohm.

g. Directional coupler.

h. Noise measuring set.

i. Coaxial attenuator set.

j. Test oscillator.

k. VHF signal generator.

l. Mixer.

m. Selective voltmeter.

n. Digital voltmeter.

o. Frequency counter.

39-4. TEST PROCEDURES.

a. General.

(1) Prior to commencing this test insure that test ST-31 has been completed and that the results are within the performance standards as outlined in equipment maintenance manuals.

(2) Table 39-1 lists the parameters for all channel capacities. The required TTNR's for systems at FM threshold are 25 db for tactical and 39 db for nontactical configurations.

Table 39-1. NPR Parameters for FM Modem

CHANNEL CAPACITY	LOADING LEVELS (dbmO)	FILTERS HIGH PASS	FILTERS LOW PASS	NOTCH FILTERS LOW	NOTCH FILTERS MID	NOTCH FILTERS HIGH	BANDPASS FILTERS LOW	BANDPASS FILTERS MID	BANDPASS FILTERS HIGH
3 Tac	0.9	12	24	14		22	14		22
6 Tac	2.0	12	36	14		34	14		34
9 Tac	2.8	12	48	14		40	14		40
3	0.9	12	24	14		22	14		22
6	2.0	12	36	14		34	14		34
9	2.8	12	48	14		40	19		40
12	3.3	12	60	14	34	66	14	34	56
24	4.5	12	108	14	56	105	14	56	105
36	5.2	12	156	14	70	105	14	70	105
48	5.7	12	204	14	105	185	14	105	185

(3) Figures 39-1 through 39-8 depict typical NPR and TTNR versus C/kT ratio performance curves for a stage 1b FM modem.

b. NPR Test.

(1) Configure the FM modem for an IF loopback as shown in figure 39-9 and allow for a 15-minute warmup and stabilization period. Insure that the baseband input and output levels are adjusted to the required SCTT level at the appropriate test points.

NOTE: The 48-channel configuration will be used for illustrative purposes.

(2) Adjust the variable attenuators in conjunction with the noise amplifiers to obtain a C/kT of 77 db. Insure that the RSL level is of sufficient magnitude to provide for normal demodulator performance (turn off the dispersal generator).

(3) Adjust the noise power test set filters as required to establish a white noise baseband from 12 to 204 kHz. Adjust the output power level of the noise generator to attain a power level of -23.38 dbm as indicated by true rms voltmeter #1. True rms voltmeter #2 should also indicate the same level.

(4) Calibrate the noise receiver to obtain a reference level in the 14-kHz noise slot. Push the 14-kHz notch filter switch on the noise generator to IN position and adjust the attenuators on the noise receiver to obtain the reference level. The amount of attenuation required to attain the reference level is the NPR. Record the NPR on figure 39-10; USACC Form 446-R (Test).

(5) Push the 14-kHz switch located on the noise generator notch filter to the OUT position. Repeat paragraphs 39-4b (3) and (4) above, measuring the NPR's in the 105- and 185-kHz noise slots.

(6) Increase the output level of the noise generator in 2-db steps above and below -23.33 dbm (from minimum input level of -29.33 to maximum of -17.3 dbm) and repeat paragraphs 39-4b (3) through (5) at each step. Record the test results on figure 39-10; USACC Form 446-R (Test).

(7) Decrease the receive C/kT ratio in 2-db steps and repeat paragraphs 39-4b (3) through (5) at each step until a C/kT ratio of 67 db has been attained.

(8) Table 39-1 shows the filters to be used for all channel capacities while table 39-2 depicts the required NPR's in the high noise slot, in respect to FM threshold.

Table 39-2. FM Modem Threshold Performance

CHANNEL CAPACITY	C/kT RATIO (db)	NOISE SLOT (kHz)	NPR (db)
3 Tac	59.9	22	18.5
6 Tac	61	34	16.7
3	64.4	22	32.5
6	65.6	34	30.5
12	66.77	105	29.1
24	68.5	105	26.5
36	70.1	105	25.5
48	71	185	24.5

(9) Plot an NPR versus C/kT curve on figure 8-7; USACC Form 396-R (Test).

c. TTNR Test.

(1) Disconnect the NPR test set and configure the modem and multiplex equipment as shown in figure 39-11. It may be necessary to perform a multiplex equipment alignment to insure that the VF channel input and output test tone levels are correct.

(2) Activate the dispersal generator and terminate the transmit side of channels 1, 24, and 48 with 600-ohm terminations.

(3) Adjust the receive C/kT ratio to 77 db and measure the TTNR using a 3.1 kHz flat weighting network on channels 1, 24, and 48. Disable the dispersal generator and remeasure the TTNR's. Record the test results on figure 39-12; USACC Form 447-R (Test).

(4) Continue to repeat paragraphs 39-4c (2) and (3) at the C/kT ratios of: 75, 73, 71, 69, and 67 db, then plot a TTNR (loaded) versus C/kT curve on figure 8-7; USACC Form 396-R (Test).

d. OBN Test.

(1) Configure the test equipment as illustrated in figure 39-13. Tune the FSVM to 208 kHz at a bandwidth of 3.1 kHz. Insure that the input to the FSVM is set to the 75-ohm bridging position.

(2) Measure the OBN at the baseband patch panel and the corresponding DC mv between TP-2 and TP-5 on the OBN module. Record both indications on figure 39-14; USACC Form 448-R (Test).

(3) Increase the C/kT ratio in 2-db steps until a C/kT of 77 db is attained (67 to 77 db) and repeat paragraphs 39-4d (1) and (2) for each step. Plot an OBN and DC mv versus C/kT curve on figure 8-7; USACC Form 396-R (Test).

(4) Table 39-3 lists the OBN frequency slots to be employed for other channel configurations. Figures 39-15 through 39-17 show the OBN with respect to DC mv at TP-5.

Table 39-3. OBN Frequency Slots

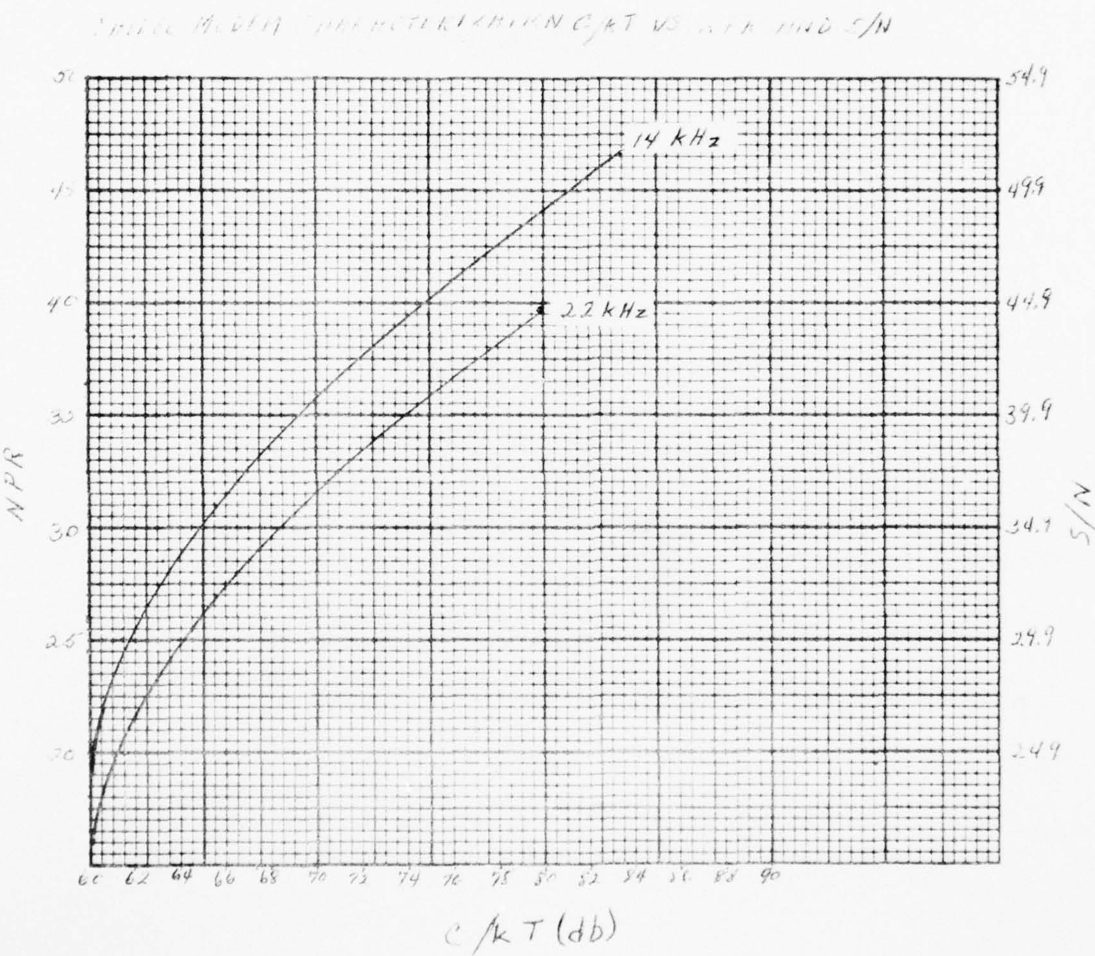
CHANNEL CAPACITY	NOISE SLOT (kHz)
3 or 3 Tac	38
6 or 6 Tac	40
9 or 9 Tac	52
12	64
24	112
36	160
48	208

(5) Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

(6) Configure the test equipment for RF equipment and satellite loop as illustrated in figures 39-18 and 39-19 respectively, and repeat paragraphs 39-4d (1), (2), (3), and (5) above. Insure that the downlink down converter is tuned 725 MHz below the uplink frequency.

NOTE: The inherent noise of the system and equipment noise will be used to establish KTB/Hz. Also the transmit RF carrier power level will be adjusted as necessary in order to establish the desired C/kT ratios.

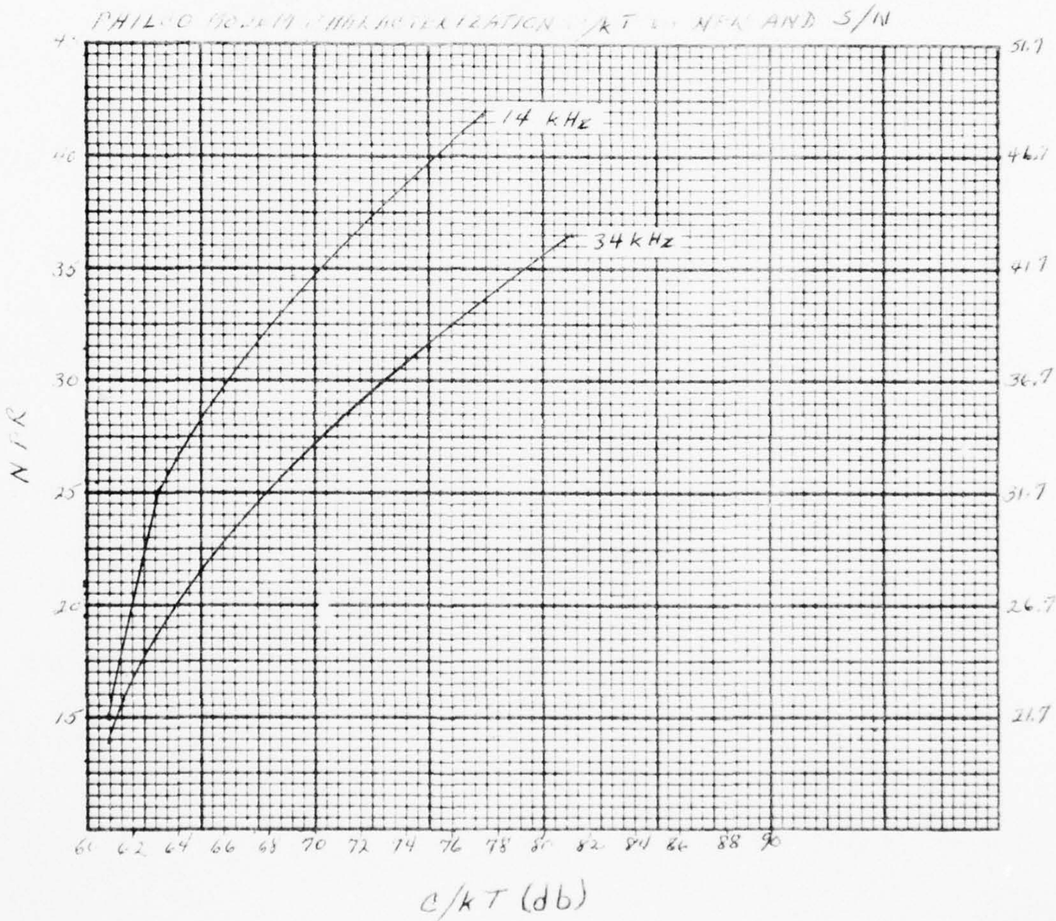
GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3)		PAGE NUMBER	NUMBER OF PAGES
		1	1
DATA SHEET		DATE (DAY, MONTH, YEAR)	
		16 Sep 76	
LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE
S-CCCC	Site Y	Site X	
TITLE OF PERFORMANCE PLOTTED			TEST NO.
... DEVIATION BACK-TO-BACK 3 TACTICAL CHAN			ST-34



USACC Form 396-R (Test)
1 April 1977

Figure 39-1. Typical noise vs deviation (3 tactical channels).

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3)		PAGE NUMBER	NUMBER OF PAGES
		1	1
DATA SHEET		DATE (DAY, MONTH, YEAR)	
		16 Sep 76	
LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE
5-0000	Site Y	Site X	[illegible]
TITLE OF PERFORMANCE PLOTTED			TEST NO.
NOISE VERSUS DEVIATION BACK-TO-BACK 6 TACTICAL CHAN			ST-34



USACC Form 396-R (Test)
1 April 1977

Figure 39-2. Typical noise vs deviation (6 tactical channels).

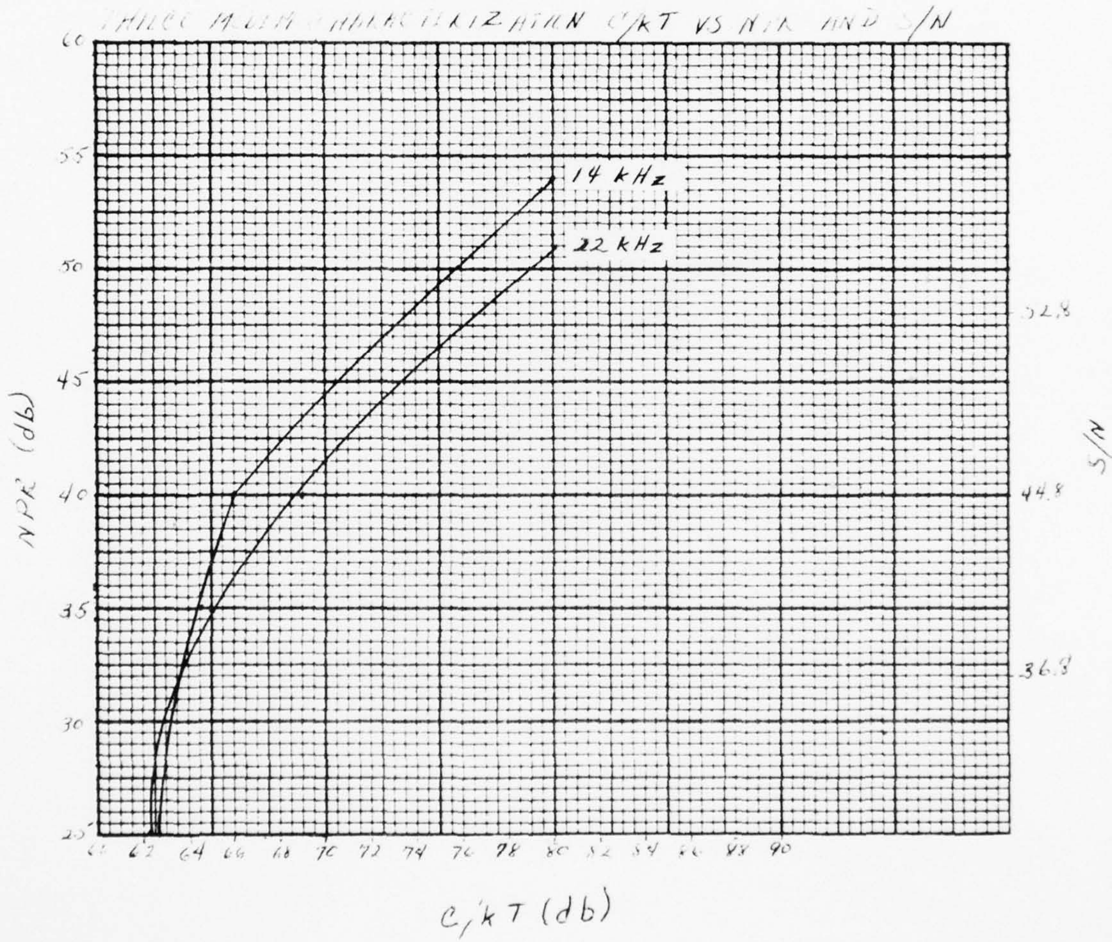
CCP 702-2

BEST AVAILABLE COPY

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3)	PAGE NUMBER	NUMBER OF PAGES
	1	1
DATA SHEET	DATE (DAY, MONTH, YEAR)	
	16 ... 78	

LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE
S-CCCC	Site Y	Site X	[illegible]

TITLE OF PERFORMANCE PLOTTED	TEST NO.
NOISE VS DEVIATION BACK-TO-BACK 3 CHAN	ST-34



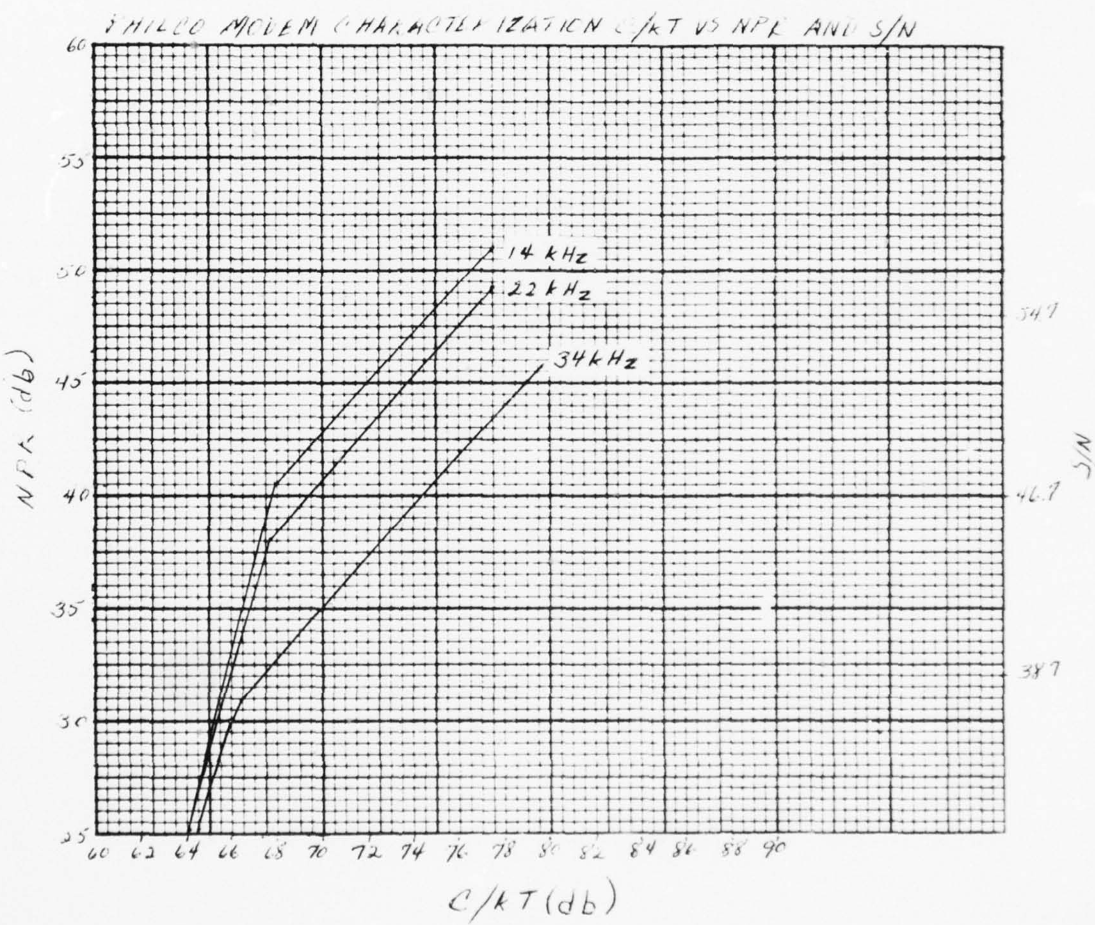
USACC Form 396-R (Test)
1 April 1977

Figure 39-3. Typical noise vs deviation (3 channels).

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3) DATA SHEET	PAGE NUMBER 1	NUMBER OF PAGES 1
	DATE (DAY, MONTH, YEAR) 16 Sep 76	

LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE
S-0000	Site Y	Site X	[illegible]

TITLE OF PERFORMANCE PLOTTED	TEST NO.
NOISE VS DEVIATION BACK-TO-BACK 6 CHAN	57-54



USACC Form 396-R (Test)
1 April 1977

Figure 39-4. Typical noise vs deviation (6 channels).

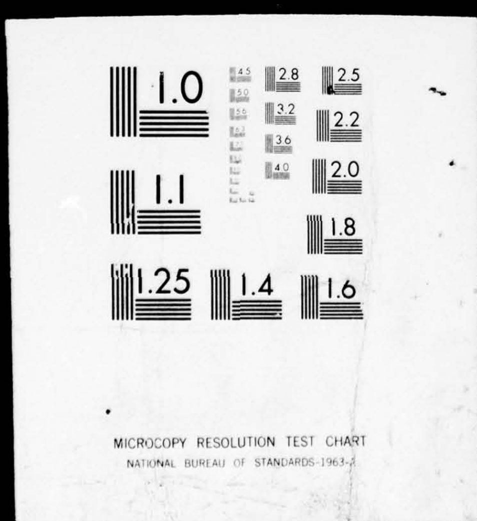
AD-A043 735 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA ARIZ F/G 17/2
PRODUCT ASSURANCE, OPERATIONAL QUALITY ASSURANCE, SATELLITE SYS--ETC(U)
MAY 77

UNCLASSIFIED ACC-CCP-702-2 NL

5 OF 7
AD
A043735

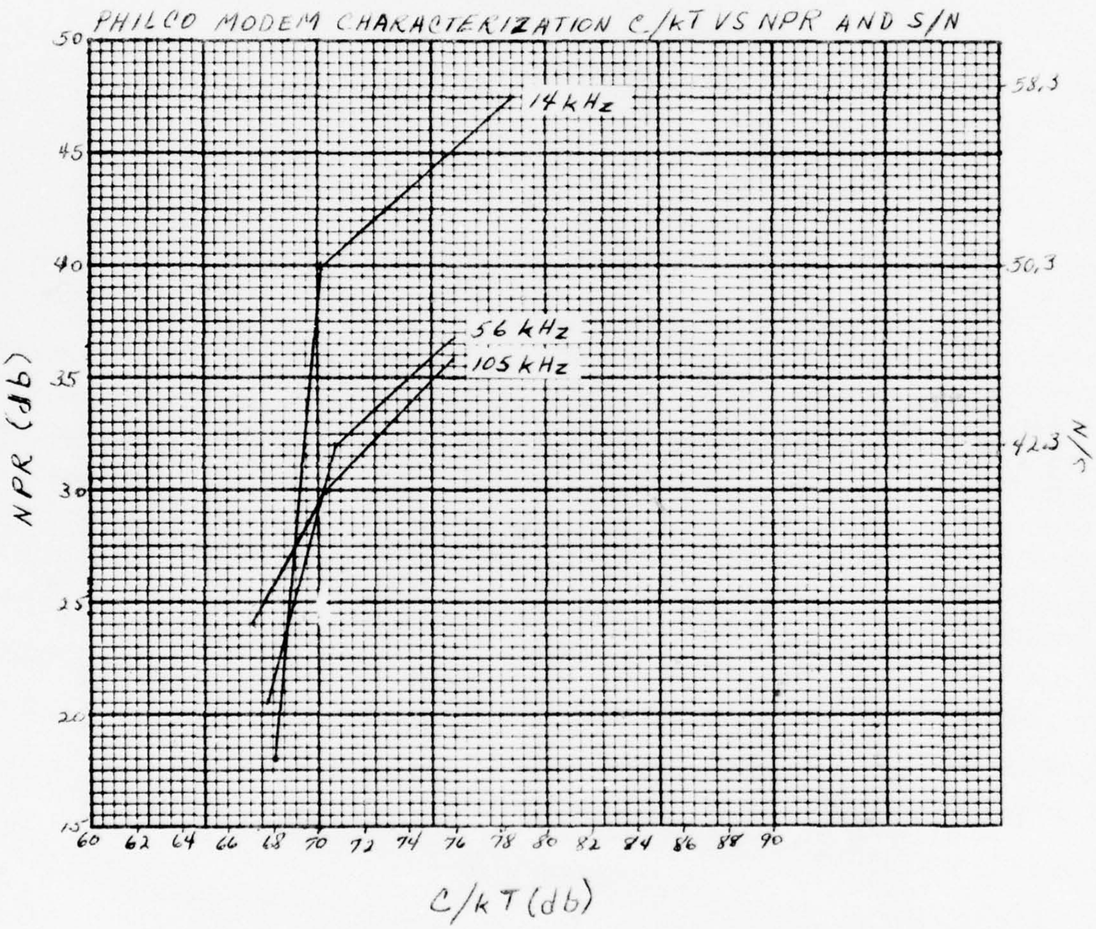
5 OF 7

AD
A043735



BEST AVAILABLE COPY

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3) DATA SHEET		PAGE NUMBER	NUMBER OF PAGES
		1	1
		DATE (DAY, MONTH, YEAR) 16 Sep 76	
LINK NO. S-0000	STATION UNDER TEST Site Y	DISTANT STATION Site X	TEST ENGR SIGNATURE [signature]
TITLE OF PERFORMANCE PLOTTED NOISE VS DEVIATION BACK-TO-BACK 24 CHAN			TEST NO. ST-34

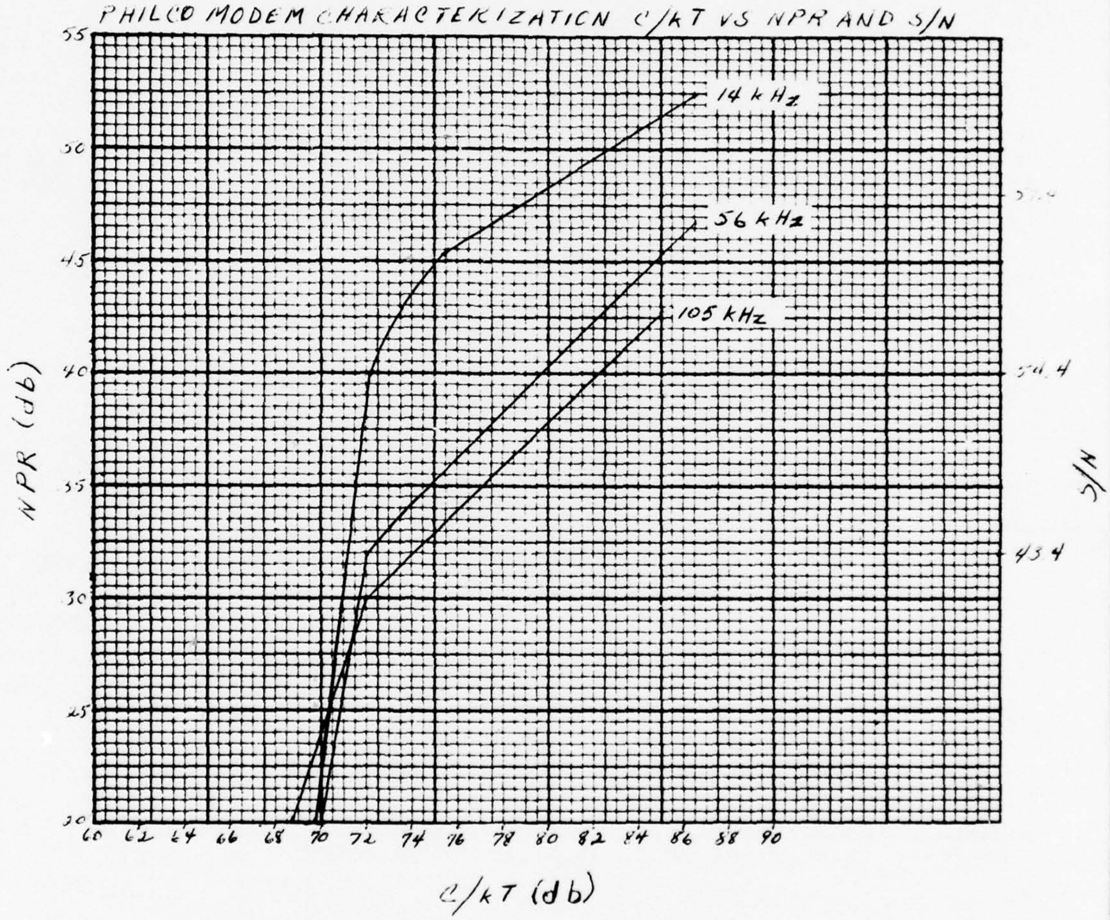


USACC Form 396-R (Test)
1 April 1977

Figure 39-5. Typical noise vs deviation (24 channels).

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3) DATA SHEET		PAGE NUMBER	NUMBER OF PAGES
		1	1
		DATE (DAY, MONTH, YEAR)	
		16 Sep 76	
LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE
S-0000	Site Y	Site X	[illegible], CW3
TITLE OF PERFORMANCE PLOTTED			TEST NO.
NOISE VS DEVIATION BACK-TO-BACK 36 CHAN			ST-34

PHILCO MODEM CHARACTERIZATION C/kT VS NPR AND S/N

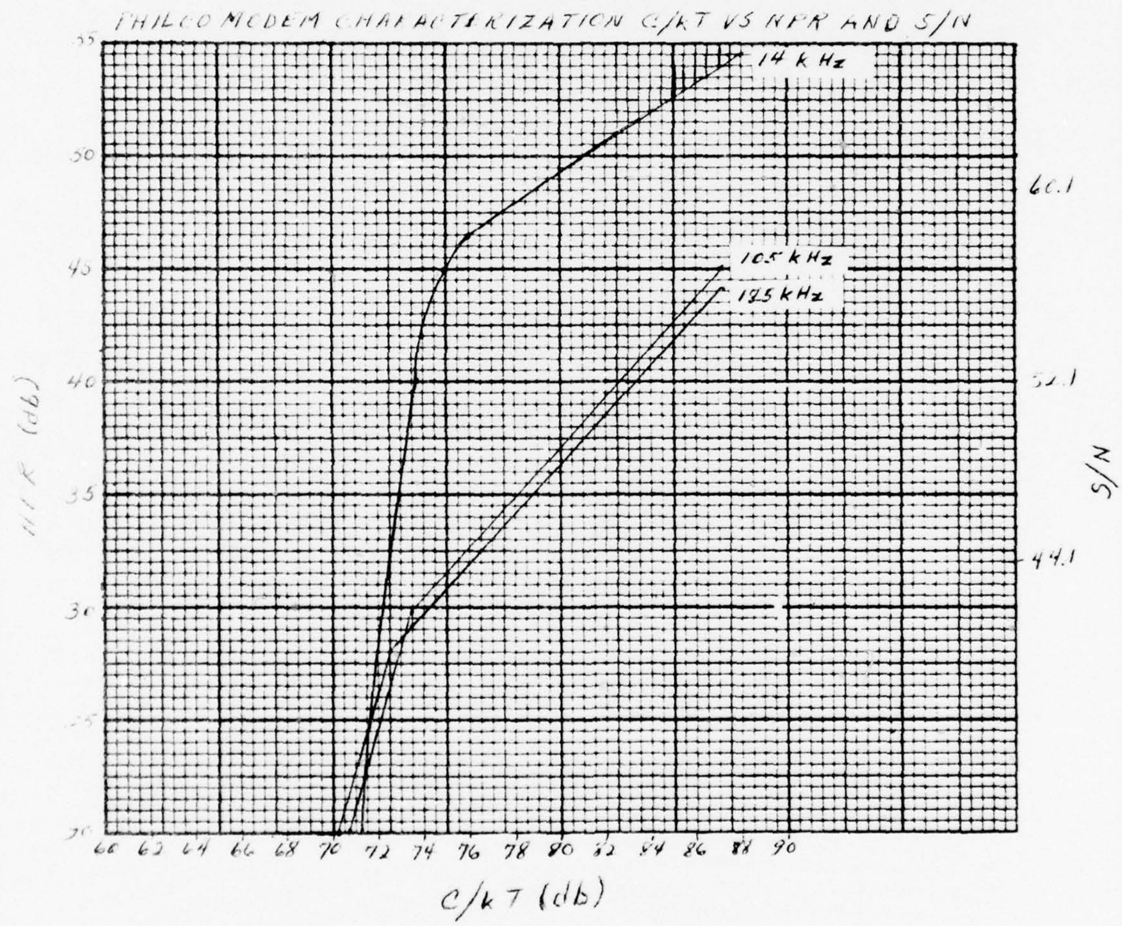


USACC Form 396-R (Test)
1 April 1977

Figure 39-6. Typical noise vs deviation (36 channels).

CCP 702-2 **BEST AVAILABLE COPY**

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3)		PAGE NUMBER	NUMBER OF PAGES
		1	1
DATA SHEET		DATE (DAY, MONTH, YEAR) 16 Sep 76	
LINK NO. S-CCCC	STATION UNDER TEST Site Y	DISTANT STATION Site X	TEST ENGR SIGNATURE [illegible], CW3
TITLE OF PERFORMANCE PLOTTED: NOISE VS DEVIATION BACK-TO-BACK 48 CHAN			TEST NO. ST-34



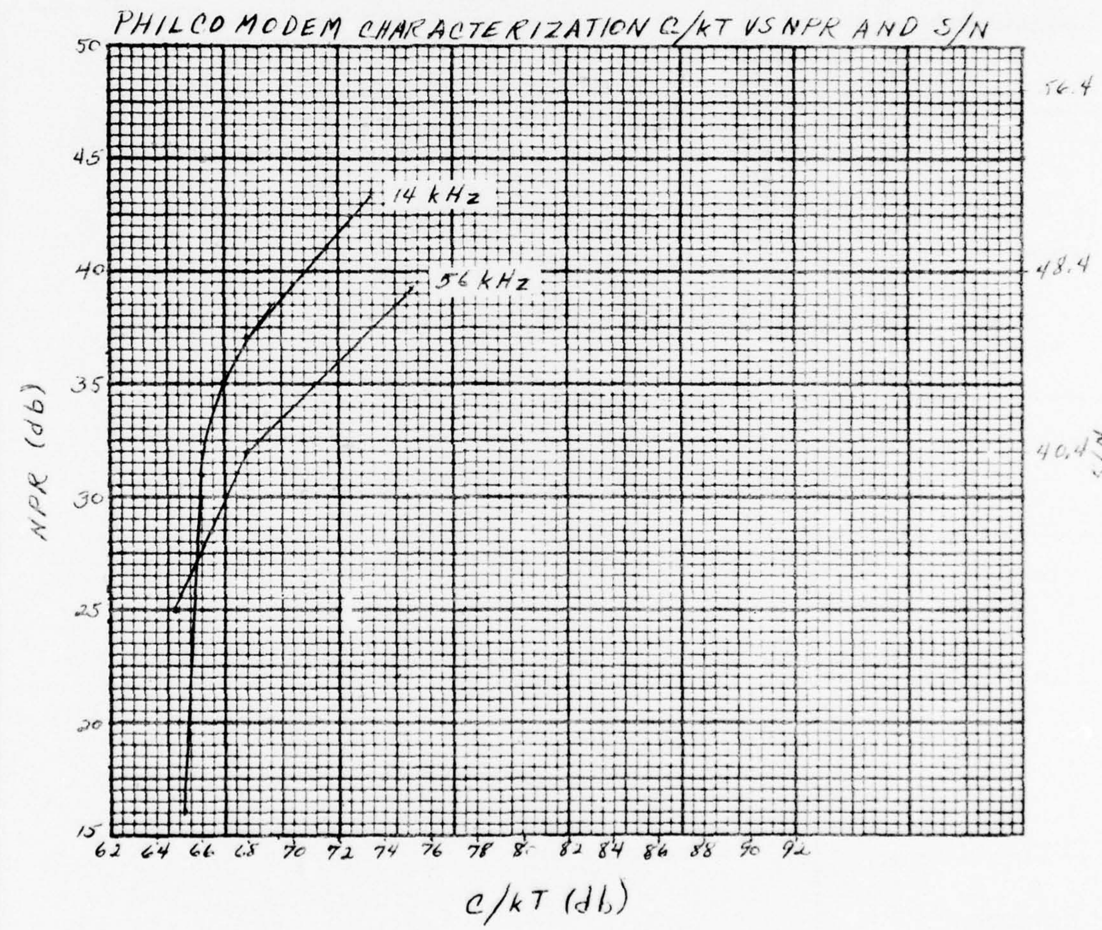
USACC Form 396-R (Test)
1 April 1977

Figure 39-7. Typical noise vs deviation (48 channels).

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3) DATA SHEET	PAGE NUMBER	NUMBER OF PAGES
	1	1
	DATE (DAY, MONTH, YEAR) 16 Sep 76	

LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE
S-0000	Site Y	Site X	Mary E. Johns, CW3

TITLE OF PERFORMANCE PLOTTED	TEST NO.
RF EQUIPMENT (NPR/BNR) CkT VS NPR 12 CHAN	ST-34



USACC Form 396-R (Test)
1 April 1977

Figure 39-8. RF equipment C/kT vs NPR (12 channels).

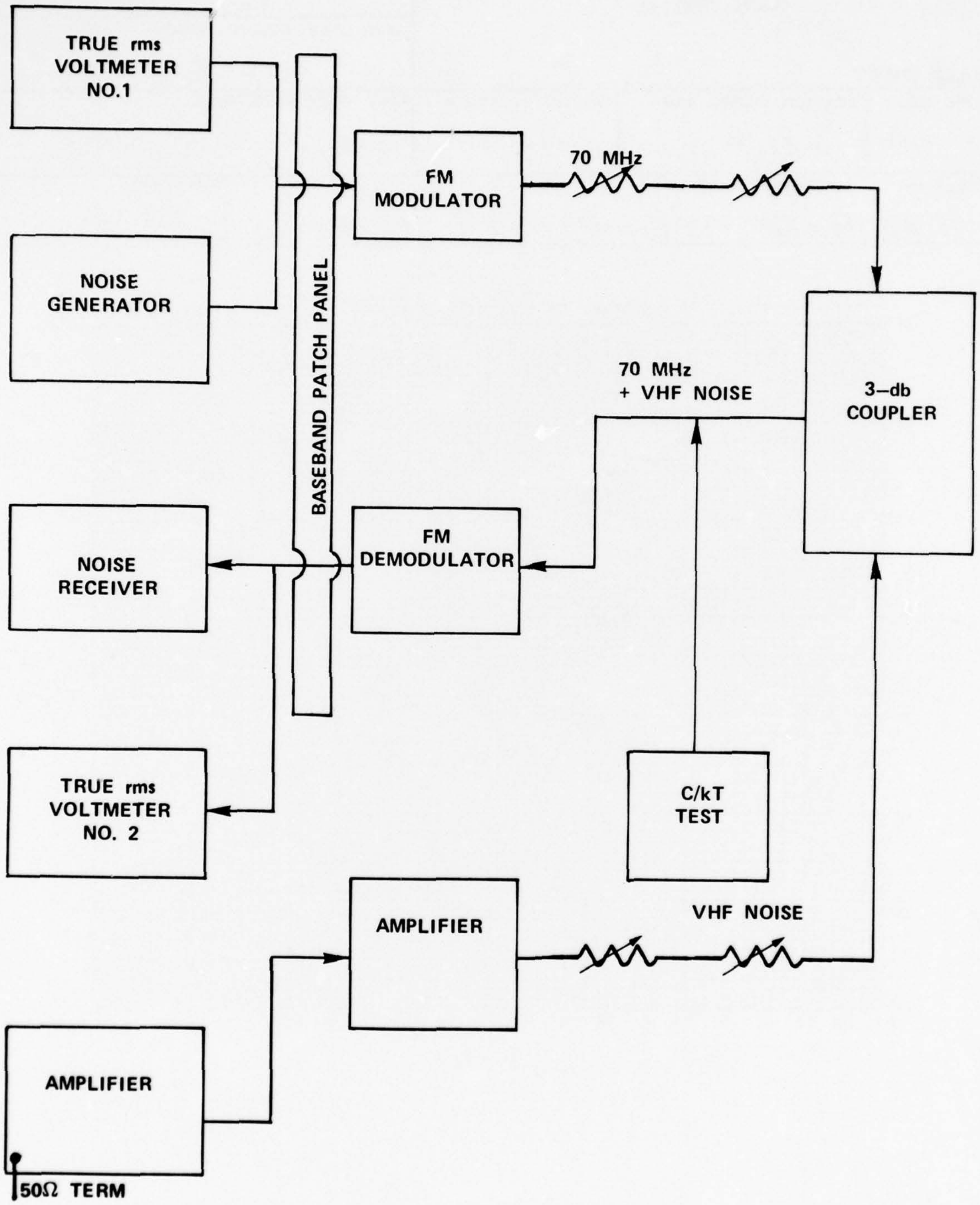


Figure 39-9. NPR test configuration.

NPR AND BNR VS C/kT (CCR 702-1-3) DATA SHEET			PAGE OF PAGES		
LINK NO.	TERMINAL ID		DATE (DAY, MONTH, YEAR)		
TEST MODE	TIME Z		SPECIFICATION		

C/kT RATIO (db-Hz)	NOISE POWER (db) IN BASEBAND SLOT					
	kHz		kHz		kHz	
	BNR	NPR	BNR	NPR	BNR	NPR

COMMENTS	
TYPES NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 446-R (TEST)
1 MAY 77

Figure 39-10. NPR and BNR vs C/kT data sheet.

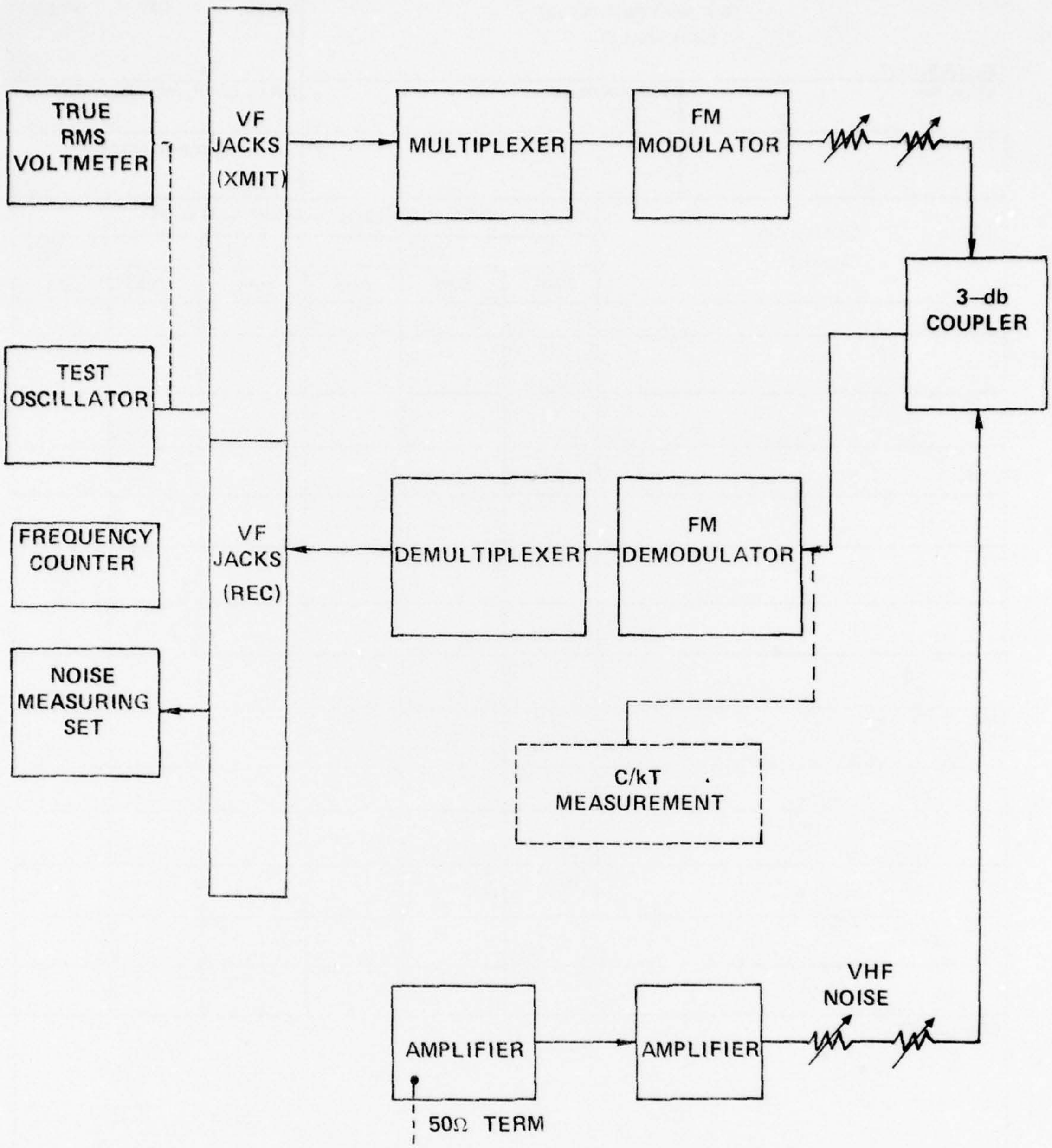


Figure 39-11. IF loopback for TTNR test configuration.

TTNR VS C/kT RATIO (CCR 702-1-3) DATA SHEET				PAGE OF PAGES	
TERMINAL ID		BASIC GROUP		DATE (DAY, MONTH, YEAR)	
CHANNEL CAP		SUPER GROUP		C/kT	

CHANNEL NO.	TEST TONE LEVEL		TTNR IDLE		TTNR LOADED	
	ABSOLUTE (dbm)	CORRECTED (dbm0)	ABSOLUTE (dbm)	CORRECTED (dbm0)	ABSOLUTE (dbm)	CORRECTED (dbm0)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 447-R (TEST)
1 MAY 77

Figure 39-12. TTNR vs C/kT ratio data sheet.

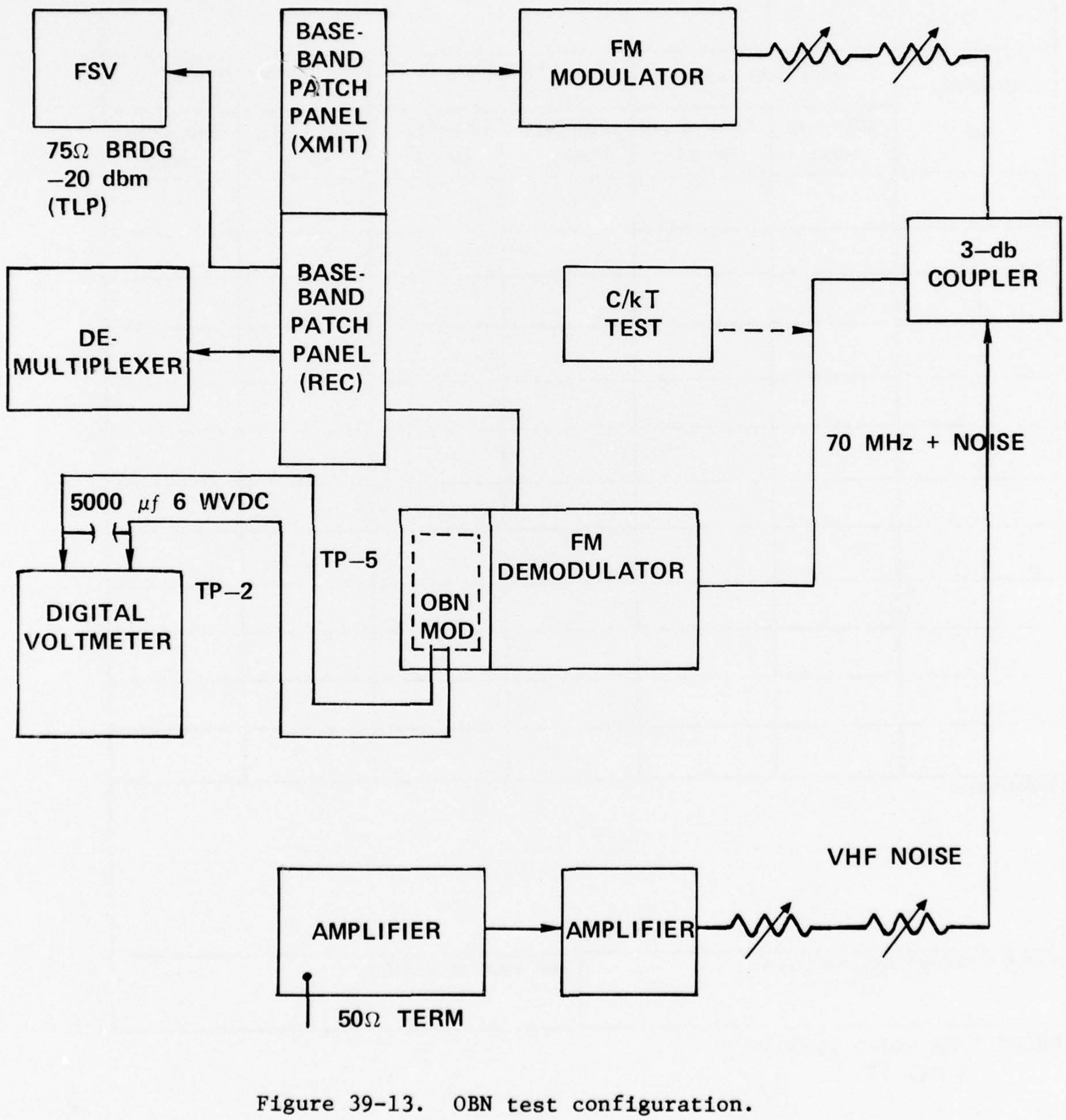


Figure 39-13. OBN test configuration.

OBN VS C/kT (CCR 702-1-3) DATA SHEET		PAGE OF PAGES
TERMINAL ID	CHANNEL CAP	DATE(DAY,MONTH,YEAR)

C/kT (db-Hz)	OBN	
	(mv)	(dbm0)

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 448-R (TEST)
1 MAY 77

Figure 39-14. OBN vs C/kT data sheet.

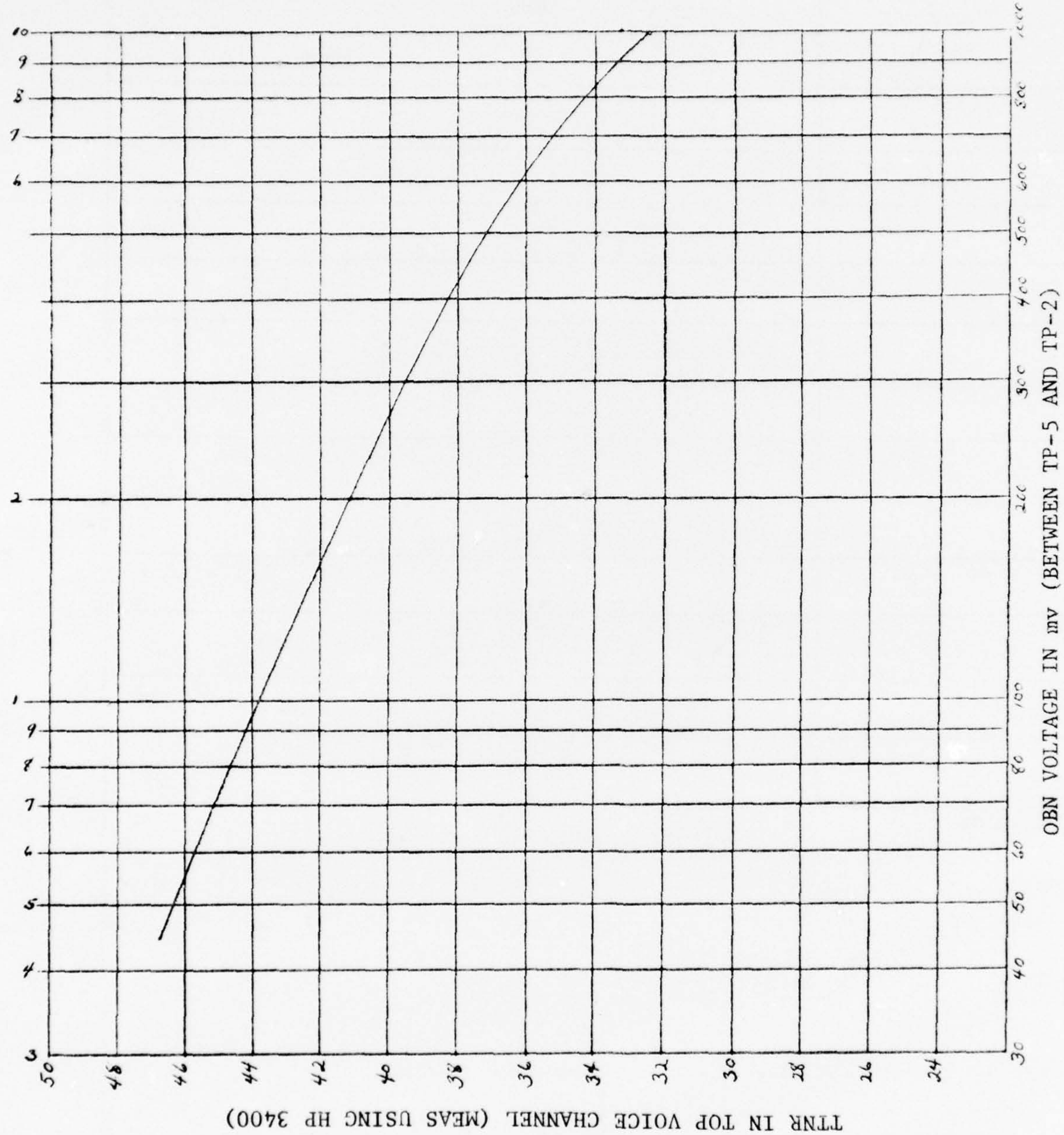


Figure 39-15. Normal performance OBN vs TTNR for Philco FM modem.

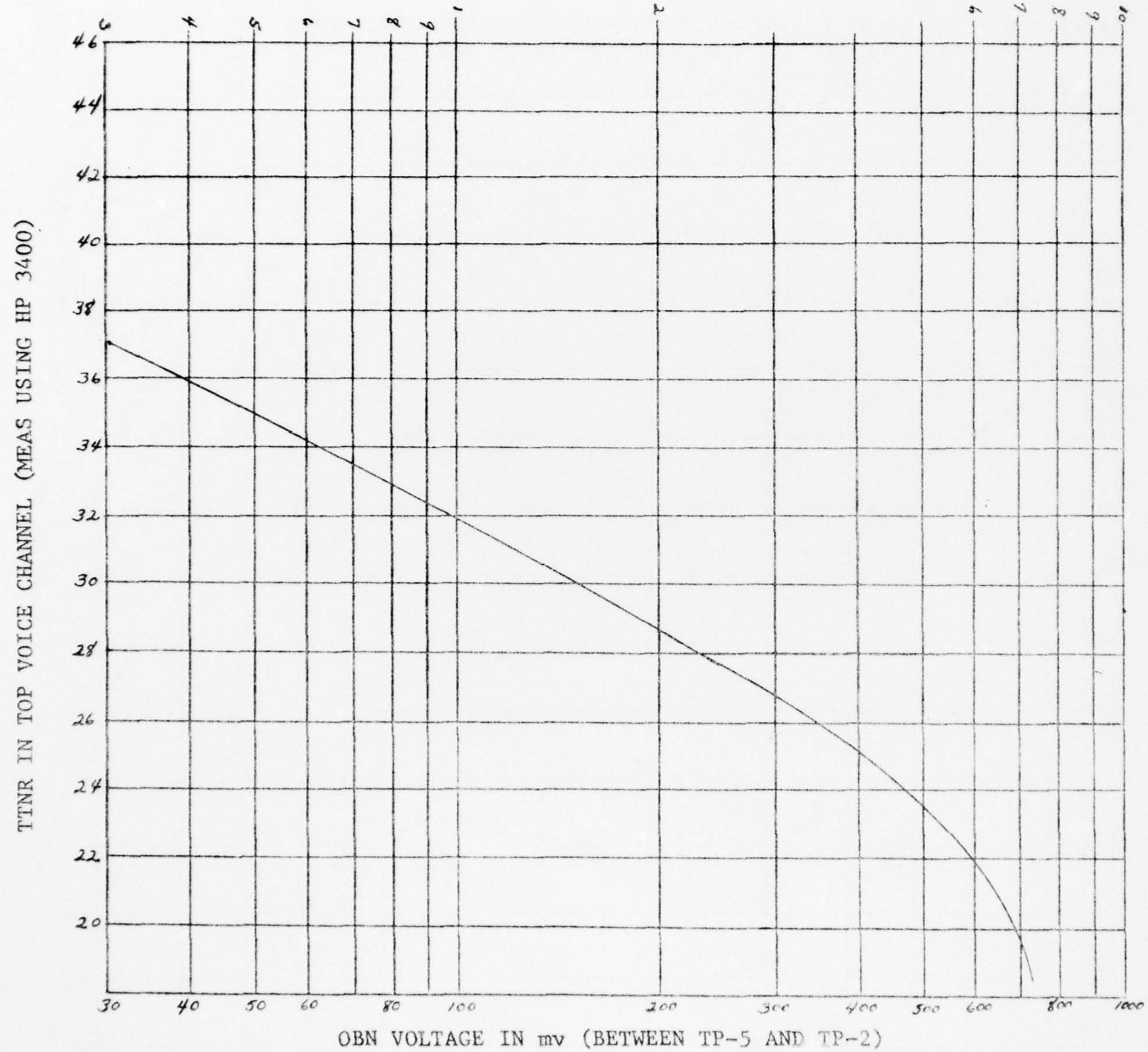


Figure 39-16. Normal performance OBN vs TTNR for Philco FM modem -- tactical.

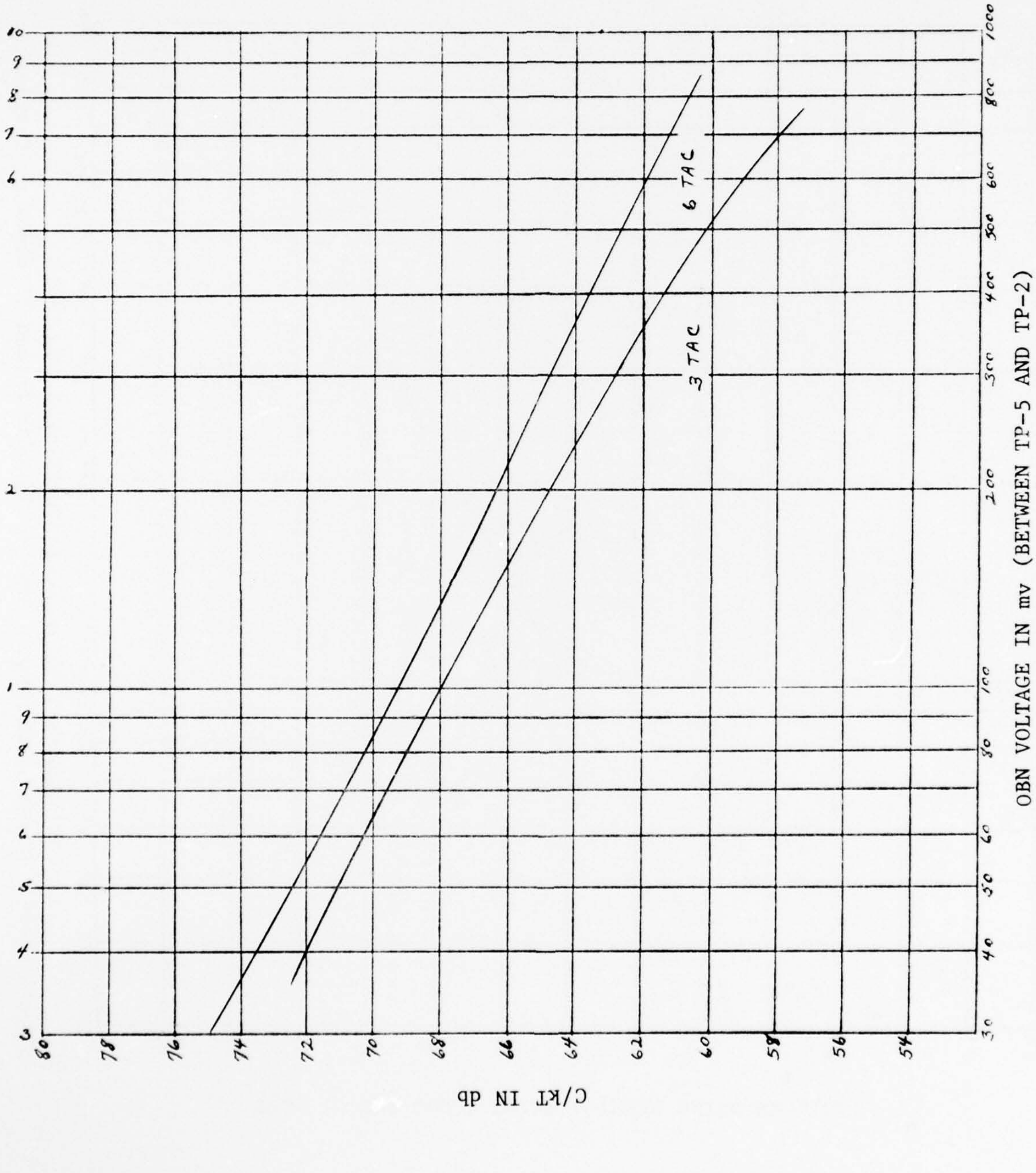


Figure 39-17. Normal performance OBN vs C/kT for Philco FM modem -- tactical.

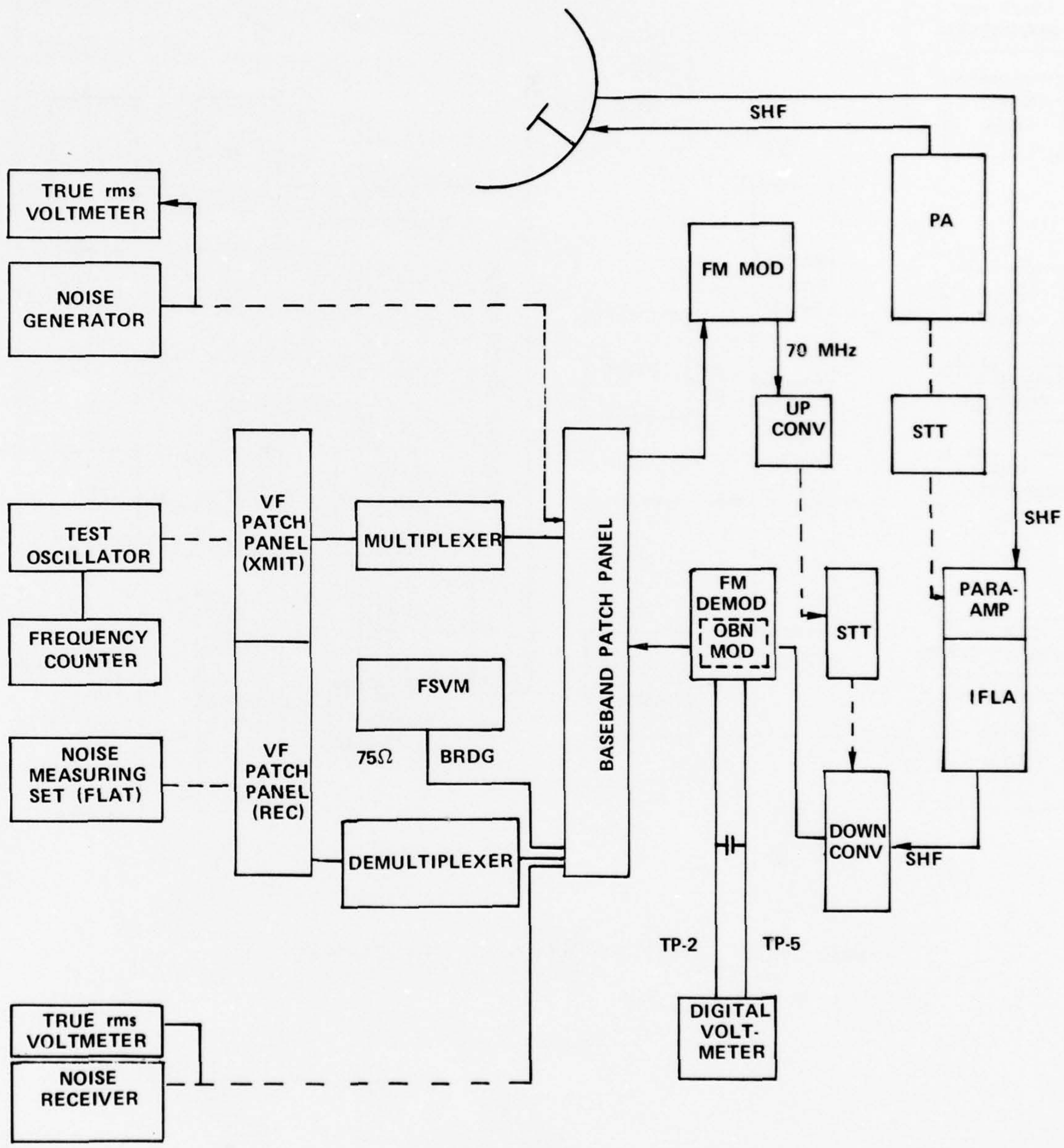


Figure 39-18. RF equipment loop test configuration.

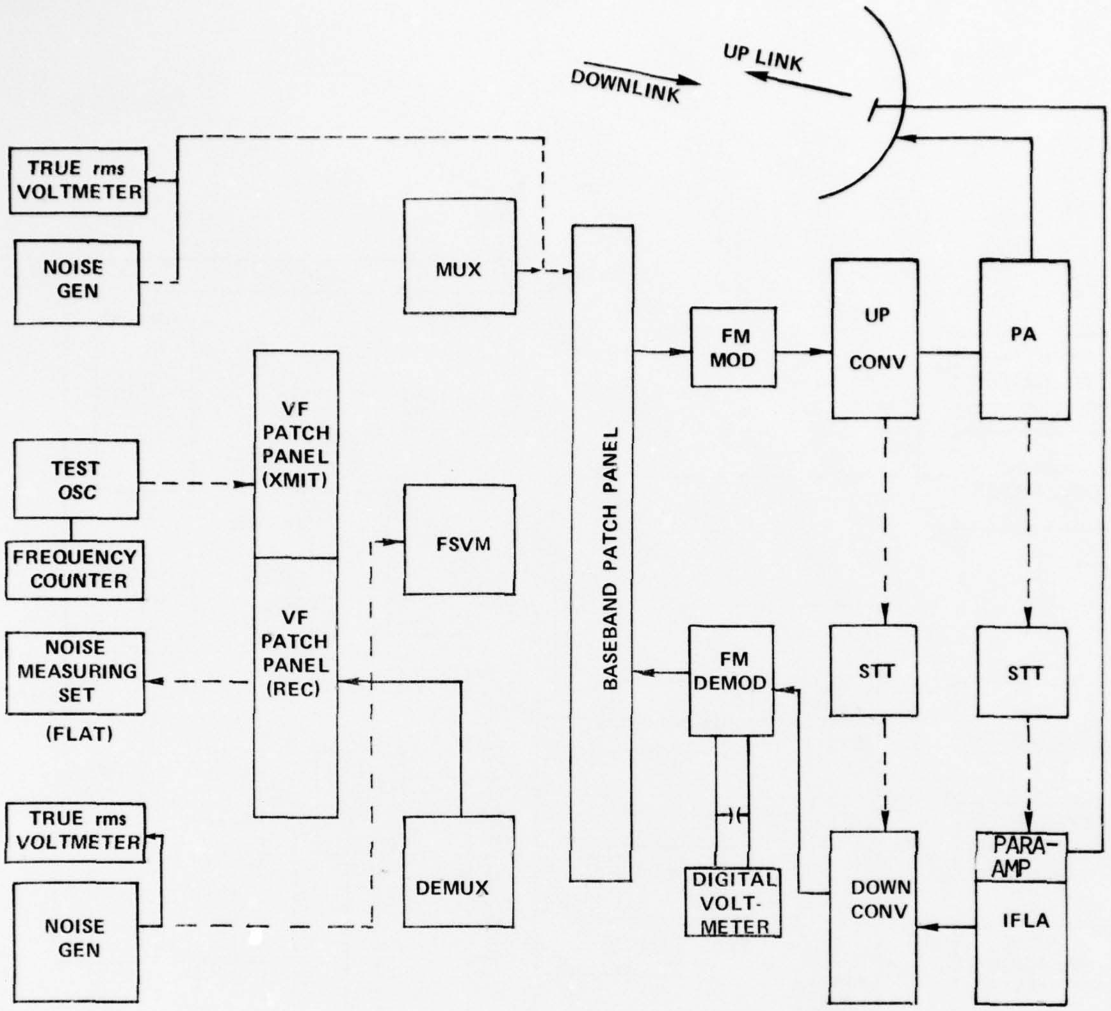


Figure 39-19. Satellite loop test configuration.

CHAPTER 40

STABILITY OF OBN VERSUS TTNR (ST-35)

40-1. GENERAL.

a. The purpose of this test is to determine the stability of the OBN versus the TTNR in a voice channel.

b. Test procedures for ST-34 must be performed prior to starting this test.

c. This is an inservice test except for the time required for test equipment calibration.

40-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

40-3. TEST EQUIPMENT REQUIRED.

a. True rms voltmeter.

b. Chart recorder.

c. Log/lin amplifier.

d. Step attenuator.

e. FSVM.

f. Digital voltmeter.

g. Noise measuring set.

h. Attenuator set.

40-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figures 40-1 and 40-2.

b. Energize test equipment and allow for a 30-minute warmup and stabiiization period.

c. Request the local technical control to provide a VF channel at the high end of the baseband for connection of the rms voltmeter.

d. Coordinate with the SATCOM controller to take the baseband out of service during the time that the recorder is being calibrated as in paragraph 40-4e below.

e. Tune the down converter to an unused frequency. Calibrate four recorder channels by reading the three rms voltmeters and the OBN meter. Vary the noise by stepping the adjustable attenuator and mark the strip chart for all four channels at each level. This calibrates the recorder input for later analysis of the collected data.

f. Retune the down converter to the operational traffic frequency. All multiplex (mux) VF channels remain in traffic during this test, with the exception of the channel under test.

g. Operate the strip chart recorder for 88 hours using the lowest chart speed and repeat paragraphs 40-4 e and f every 24 hours if bridging the rms voltmeter across the input indicates a requirement for recalibrating the chart recorder. At the end of the recording period, perform a recalibration sequence to verify the recorded data and to aid in the analysis process.

h. Summarize the test results on figure 6-4; USACC Form 351-R (Test).

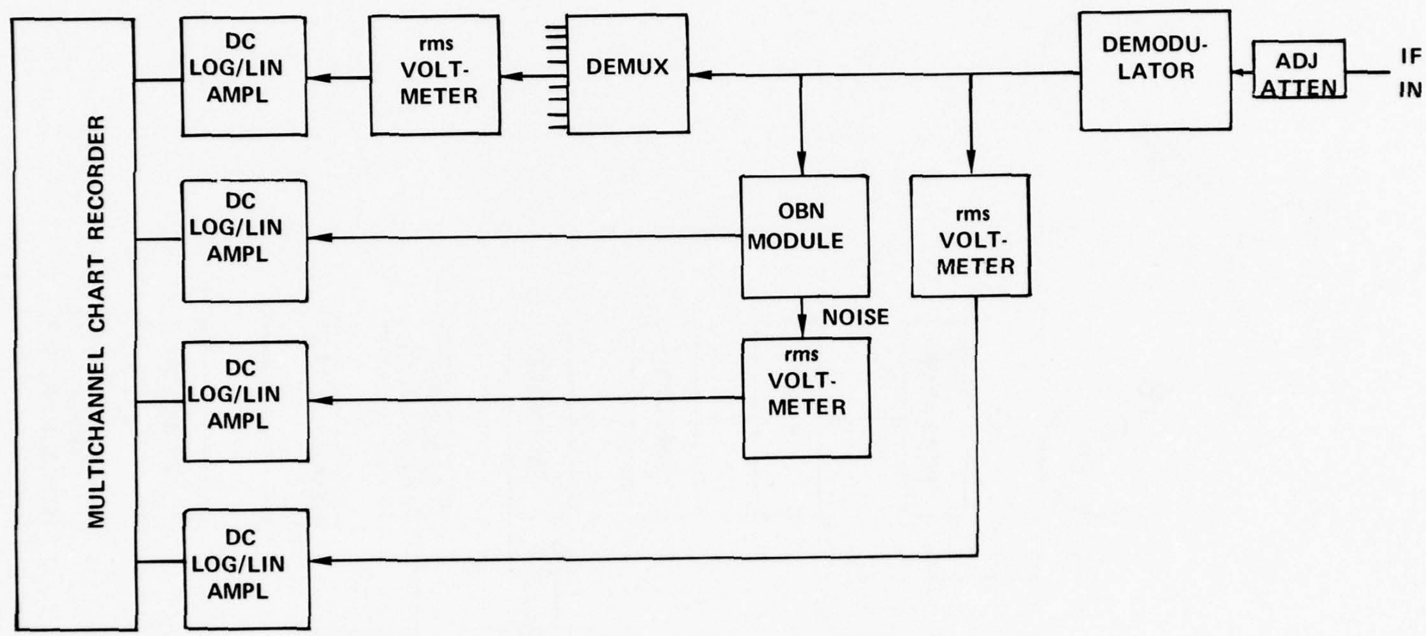


Figure 40-1. Stability of OBN vs TTNR test configuration.

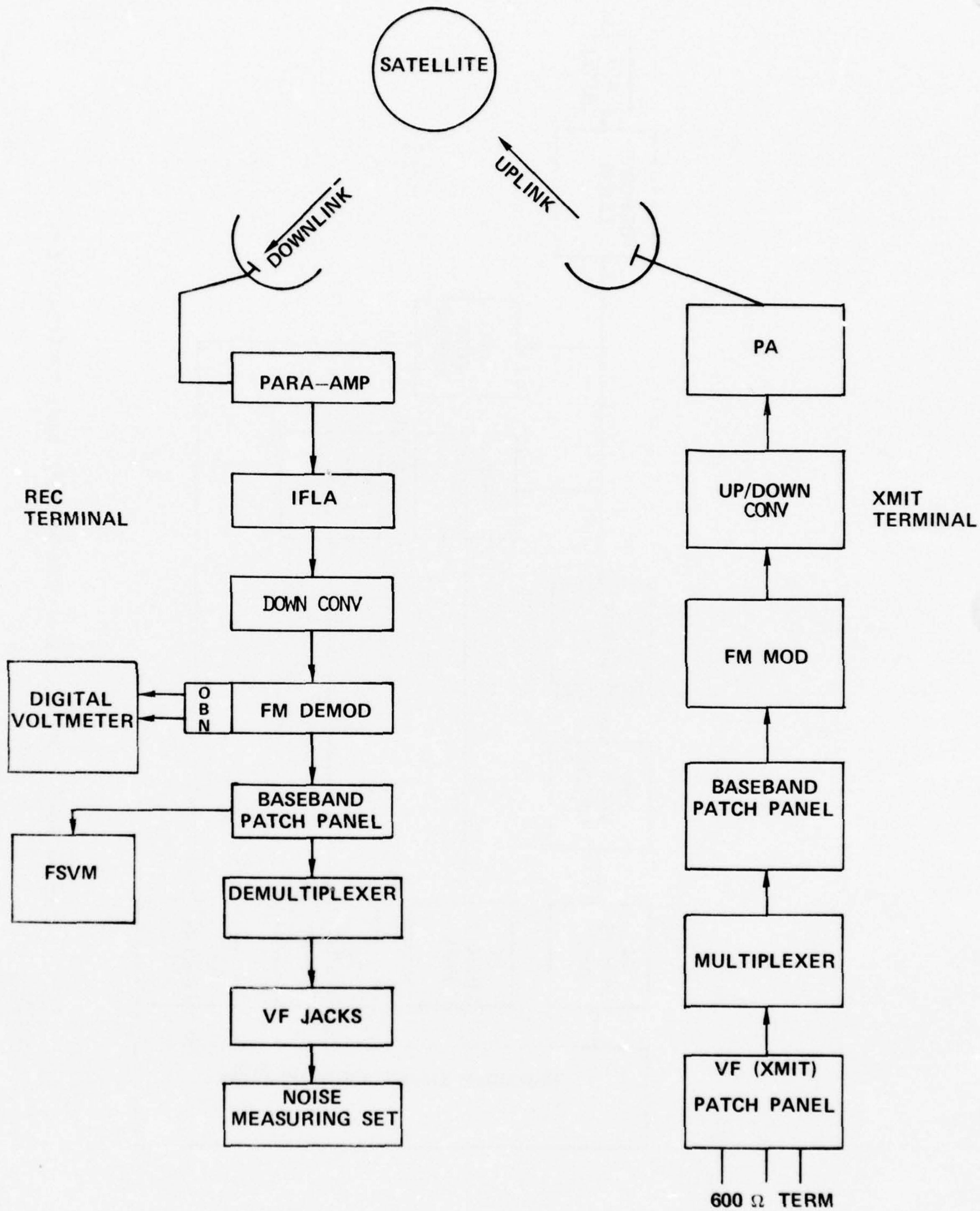


Figure 40-2. TTNR and OBN over-the-link test configuration.

CHAPTER 41

NPR VERSUS BASEBAND LOADING (ST-36)

41-1. GENERAL.

a. The purpose of this test is to measure the intermodulation noise contribution to the total baseband noise as a function of FM deviation with the modulator in a loopback configuration at IF and RF. This test is to be performed on satellite earth terminals utilizing 3, 6, and 9 channel capacities (para 41-4a) and for 12 or more channels (para 41-4b).

b. This is an inservice test for terminals with spare modulators and demodulators. In order to minimize communications outage time, the test should be performed at the normal operating channel capacity of the system being evaluated.

c. This test should be performed as close to the circuit end line segment as possible to insure that all VF channel circuit conditioning equipment is included within the test loop.

d. Prior to commencing this test, insure that test ST-31 has been completed and that the test results are within specifications.

e. Loading levels will be based on CCIR standards (-1 +4 log N dbm0 for 240 channels and less).

f. Coordinate satellite loopback tests with the SATCOM controller.

41-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

41-3. TEST EQUIPMENT REQUIRED.

a. RMS voltmeter.

b. Noise loading test set.

c. Frequency counter.

d. VF noise loading test set.

e. 1-db attenuator.

f. 10-db attenuator.

g. VHF amplifier.

h. LF amplifier.

i. Directional coupler.

j. Noise measuring set.

k. Coaxial attenuator set.

l. Test oscillator.

m. VHF signal generator.

n. Mixer.

o. Selective voltmeter.

41-4. TEST PROCEDURES.

a. Terminal Operating with Less Than 12 Channels.

(1) Configure the test equipment as indicated in figure 41-1 (3, 6, or 9 channel).

(2) Inject a 1-kHz test tone (transmit multiplex channel) at a level of -10 dbm0 at the point of testing, on each channel under test. Measure and record the receive demultiplex test tone level in reference to the TLP. Remove the test tone and insert a 600-ohm, nonreactive termination plug into the jack.

(3) Adjust the attenuators located at the output of the modulator and the noise injection set to establish the reference C/kT (table 41-1). Insure that the power output from the modulator is sufficient to lock the demodulator so that it functions properly.

Table 41-1. Parameters for (Philco) Stage 1b Modem

C/kT (db-Hz)	CHANNEL CAPACITY	COMPOSITE NOISE LOAD (dbm0)	BASEBAND (kHz)	NPR SLOTS (kHz)		
				LOW	MID	HIGH
59.9	3 Tac	0.9	12-24	14		22
61.3	6 Tac	2.0	12-36	14		34
62.1	9 Tac	2.8	12-48	14		40
64.4	3	0.9	12-24	14		22
65.6	6	2.0	12-36	14		34
66.4	9	2.8	12-48	14		40
66.7	12	3.3	12-60	14	34	56

Table 41-1. Parameters for (Philco) Stage 1b Modem (continued)

C/kT (db-Hz)	CHANNEL CAPACITY	COMPOSITE NOISE LOAD (dbm0)	BASEBAND (kHz)	NPR SLOTS (kHz)		
				LOW	MID	HIGH
68.9	24	4.5	12-108	14	56	105
70.1	36	5.2	12-156	14	56	105
71.0	48	5.7	12-204	14	105	185
72.5	72	6.4	12-300	14	185	270

NOTE: The TTNR's (flat) for above C/kT's are: (1) 39 db for nontactical and (2) 25 db for tactical.

(4) Measure and record the TTNR indicated on the transmission test set. Use a 3-kHz flat weighting network for line weighting. Make the necessary corrections for the TLP, test tone, and TTNR readings. Measure and record the OBN reading. Repeat paragraphs 41-4a (2) and (4) on all other channels under test.

(5) Connect the required number of channels of the 12-channel noise generator to the multiplex IN jacks of the channels under test. Monitor and adjust the input to each channel for the composite loading at baseband input as listed in table 41-1.

(6) Remove the patch cord from channel 1 and insert a 600-ohm nonreactive termination plug into the transmit side of the channel.

(7) Measure and record the composite loading level on the true rms voltmeter at the input of the modulator. (Disable all pilots and dispersal generators.)

(8) Measure and record the noise power level on the receive output jack of channel 1.

(9) Connect the noise generator to channel 1 and repeat paragraphs 41-4a (4) through (8) for the remaining channels.

(10) Increase the loading level by adjusting the external input attenuators in 2-db steps, from a -10 dbm0 to 10 dbm0. Repeat paragraphs 41-4a (4) through (9).

(11) Configure the test equipment as indicated in figure 41-2 and repeat paragraphs 41-4a (2) through (10) minus step (3) for RF STT or satellite loopback.

NOTE: Adjust the power out at the up converter or power amplifier input drive to obtain the required C/kT ratio, and tune the down converter for the appropriate down translation frequency.

(12) Record the test results on figure 41-3; USACC Form 450-R (Test) and plot the test results on figure 8-7; USACC Form 396-R (Test).

(13) Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

b. Terminal Operating with 12 Channels or More.

(1) Configure the test equipment as illustrated in figure 41-4 for an IF loopback.

(2) Adjust the output noise generator to the appropriate loading level and bandwidth (12, 24, 36, and 48 channel capacities) as indicated on the true rms voltmeter. Insure that corrections have been made for all impedance mismatches.

(3) Adjust the attenuators on the output of the modulator in conjunction with the attenuators on the output of noise amplifiers to obtain the reference C/kT ratio (table 41-1). Insure that an adequate amount of signal power is available from the modulator to lock the demodulator ON so that it functions properly.

(4) Terminate the receive baseband output in the appropriate output impedance, and monitor the receive noise loading level to insure that the receive loading level is correct.

(5) Remove the termination from the receive baseband under test, and connect the receiver output to the noise receiver input. Connect the rms voltmeter to the T-connector on the output of the noise generator, and monitor the noise loading level.

(6) Measure and record the BNR and the NPR in the low, mid, and high 3.1-kHz bandwidth slots (table 41-1) and the OBN.

(7) Adjust the output of the noise generator for an output level of -10 dbm0. Repeat paragraphs 41-4b (4) through (6) in 2-db steps until a level of 10 dbm0 has been obtained.

NOTE: Measure the BNR at the normal loading level only.

(8) During RF loopback test (STT or satellite), configure the equipment as indicated in figure 41-5 and adjust the up converter or exciter for the reference C/kT ratio (table 41-1). Repeat paragraphs 41-4b (2) and (4) through (7).

(9) Record the test results on figure 41-6; USACC Form 451-R (Test) and graphically plot the test results on figure 8-7; USACC Form 396-R (Test).

(10) Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

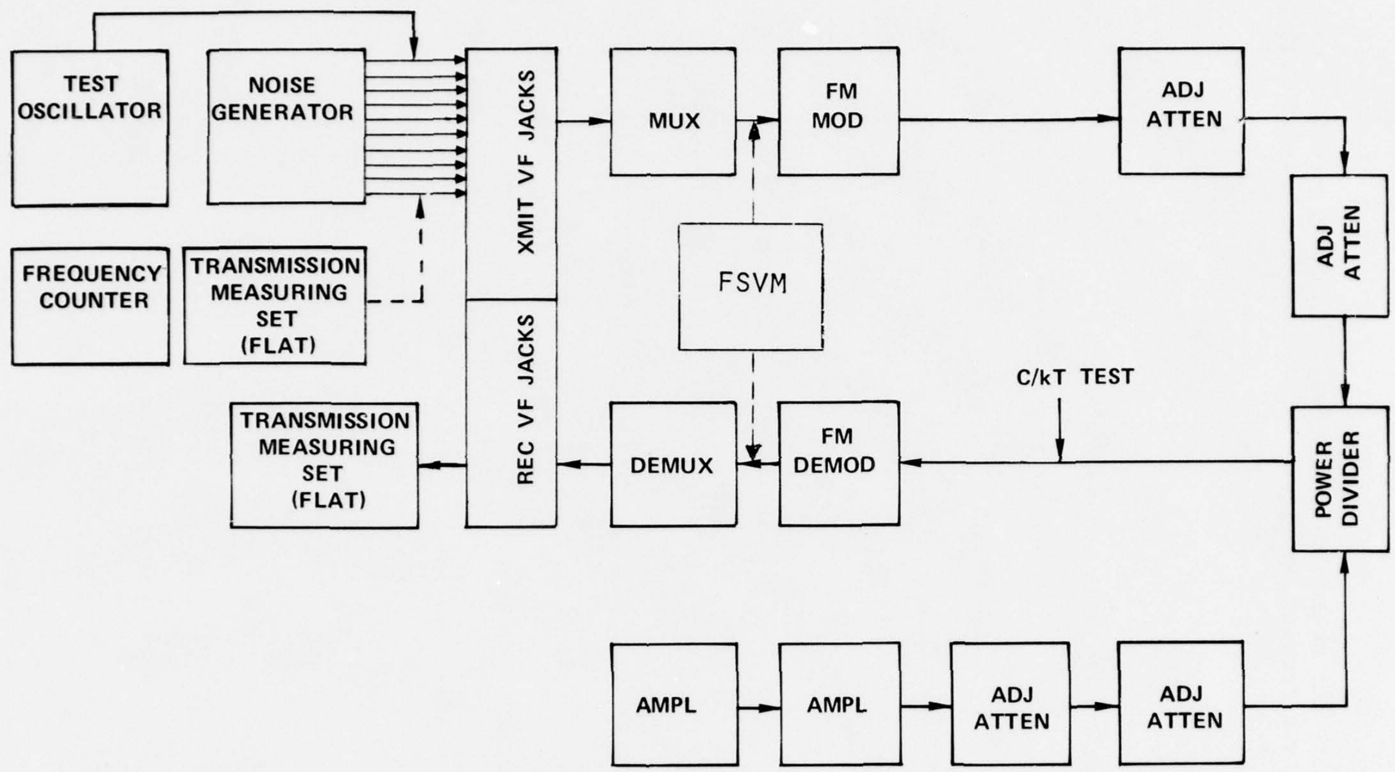


Figure 41-1. Noise vs baseband loading (below 12 channels)
IF loop test configuration.

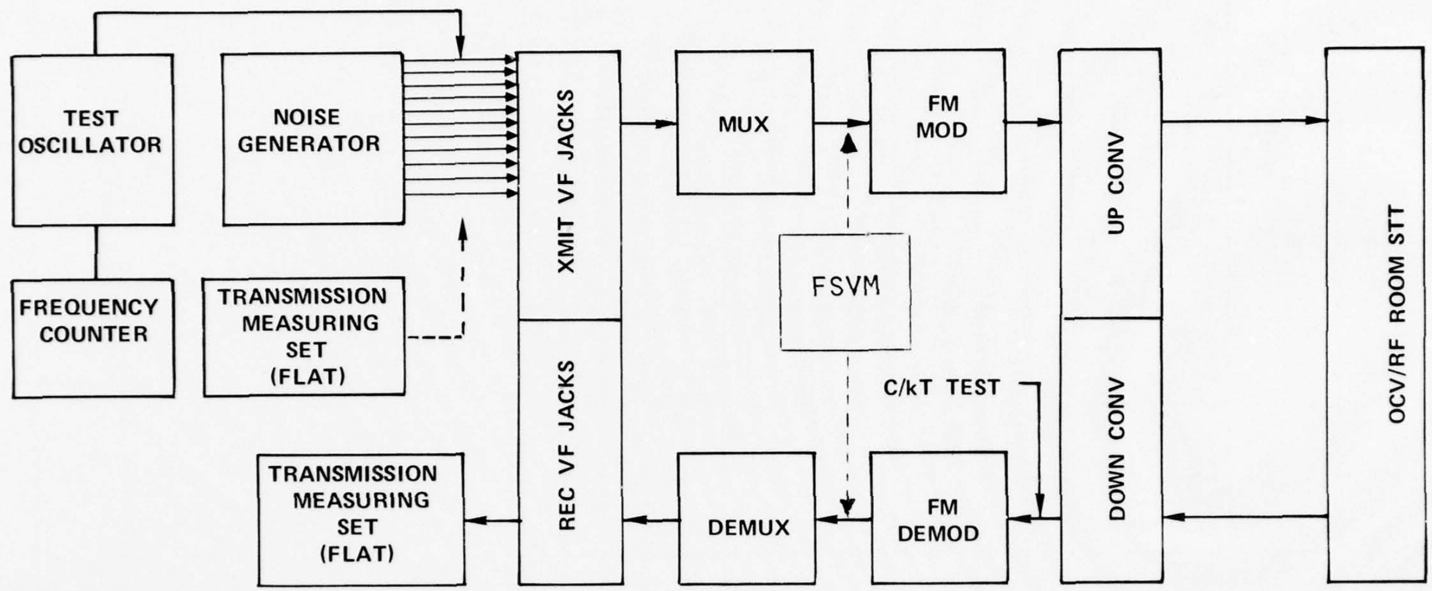


Figure 41-2. Noise vs baseband loading (below 12 channels) RF loop test configuration.

NOISE VS BASEBAND LOADING (BELOW 12 CHANNELS) (CCR 702-1-3) DATA SHEET					PAGE OF PAGES	
TERMINAL ID		NOMINAL C/kT		TEST LOOP	SPECIFICATION	
CHANNEL CAP		MODULATOR TLP		DATE(DAY,MONTH, YEAR)		
CHANNEL NO.	RECEIVE TEST TONE (dbmO) LEVEL	DRIVE LEVEL (dbm)	C/kT (db)	CORR TTNR NOISE LOADED (db)	CORR TTNR IDLE (db)	OBN (dbmO)
COMMENTS						
TYPED NAME, GRADE, AND TITLE			TEST ENGR SIGNATURE			

USACC FORM 450-R (TEST)
1 MAY 77

Figure 41-3. Noise vs baseband loading (below 12 channels) data sheet.

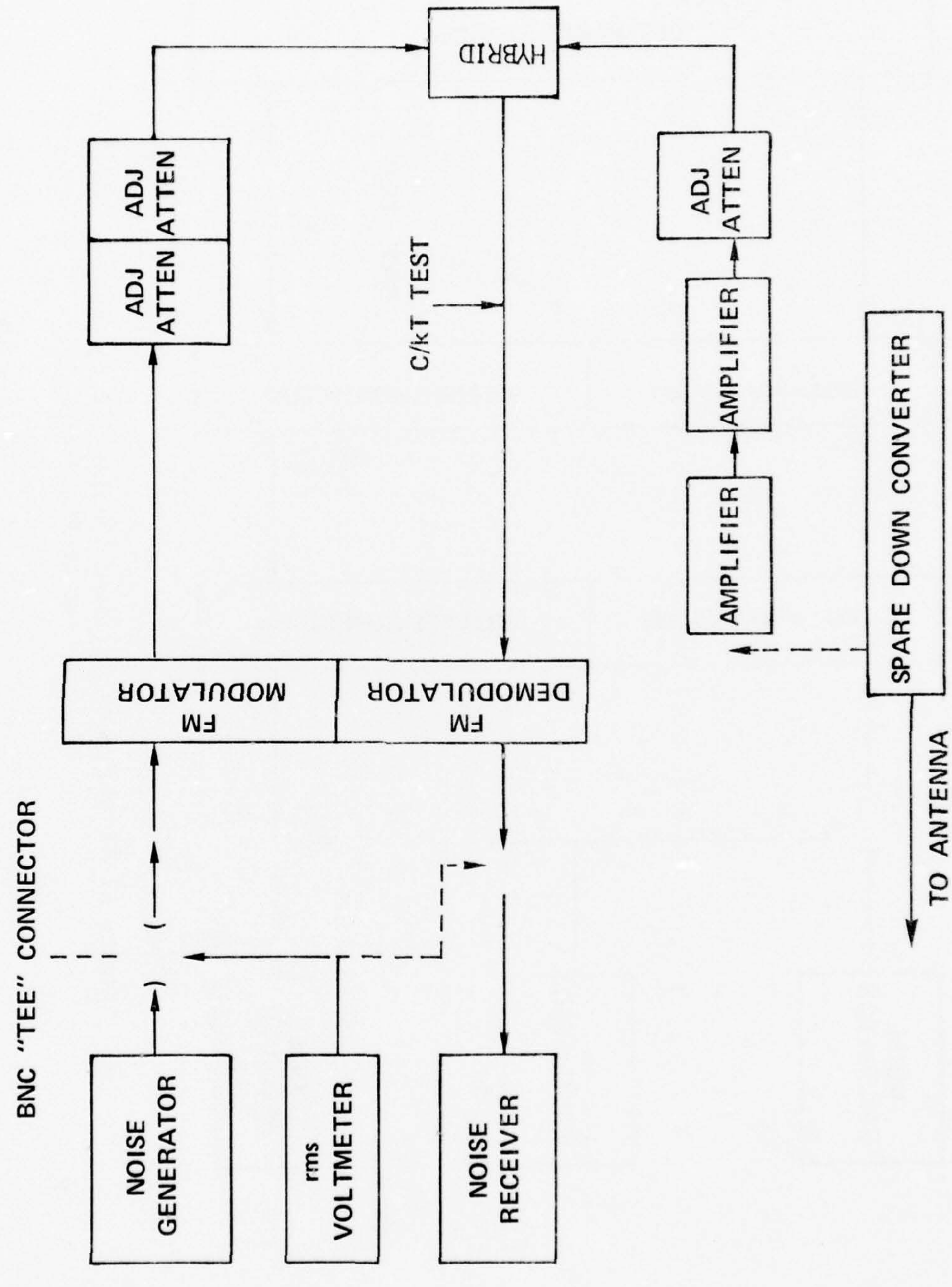


Figure 41-4. Noise vs baseband loading (12 channels or more) IF loop test configuration.

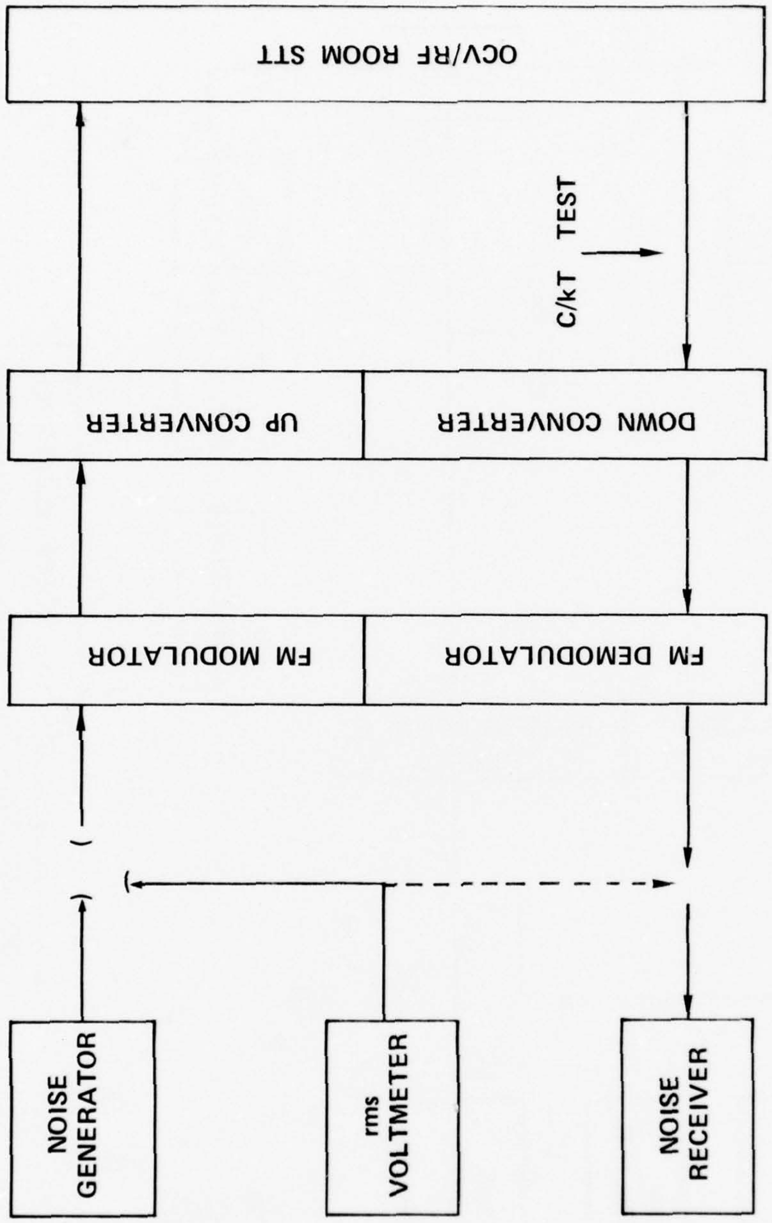


Figure 41-5. Noise vs baseband loading (12 channels or more)
RF loop test configuration.

NOISE VS BASEBAND LOADING (12 CHANNELS OR MORE) DATA SHEET (CCR 702-1-3)								PAGE OF PAGES
LINK NO.			TERMINAL ID			DATE (DAY, MONTH, YEAR)		
MOD ID			MOD MODE			C/kT	AGC V	
REC TLP			XMIT TLP			TEST MODE		
NOISE LEVEL (dbmC)	SLOT FREQ kHz		SLOT FREQ kHz		SLOT FREQ kHz			
	BNR	NPR	BNR	NPR	BNR	NPR	OBN (dbmO)	
-12								
-10								
- 8								
- 6								
- 4								
- 2								
0								
2								
4								
6								
8								
10								
COMMENTS								
TYPED NAME, GRADE, AND TITLE				TEST ENGR SIGNATURE				

USACC FORM 451-R (TEST)
1 MAY 77

Figure 41-6. Noise vs baseband loading (12 channels or more) data sheet.

Preceding Page BLank - NOT FILMed

CHAPTER 42

FM MODULATOR POWER OUTPUT AND FREQUENCY ACCURACY (ST-37)

42-1. GENERAL.

a. The purpose of this test is to measure the output power level and to determine the frequency accuracy of the FM modulator.

b. This is an inservice test for those earth terminals equipped with one or more standby modulator. However, for those terminals not equipped with a standby modulator, this will be an out-of-service test and will require an AO.

c. The power output level will be measured with the dispersal generator IN and OUT. If the modulator does not have a dispersal generator, insert a 1-kHz test tone (zero dbm0) on channel 6 of any basic group. After completing the measurement with the 1-kHz test tone injected, disconnect the multiplex equipment input and measure the power output. Record both measurements.

42-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

42-3. TEST EQUIPMENT REQUIRED.

a. Test oscillator.

b. Power meter.

c. Thermistor mount.

d. Frequency counter.

e. Fixed attenuator.

f. Digital printer.

42-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 42-1a. Adjust AT-1 to 3 db and allow for a 10-minute warmup and stabilization period.

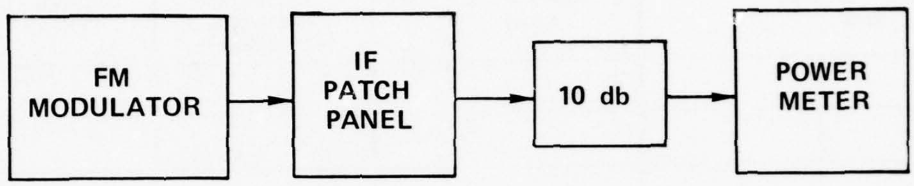
b. Turn the dispersal generator on and measure the power output. Record the power output level on figure 42-2; USACC Form 452-R (Test).

c. Turn the dispersal generator off and disconnect any multiplex or modulation from the input to the modulator. Measure and record the power level on figure 42-2; USACC Form 452-R (Test).

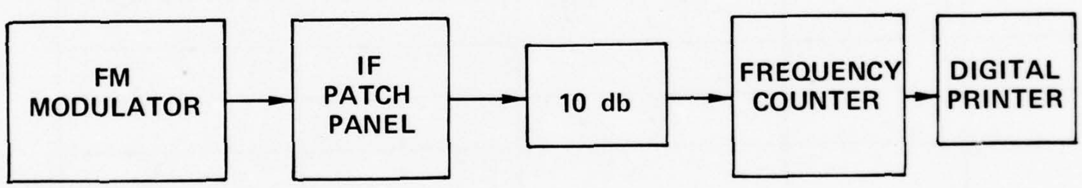
d. Configure the test equipment as illustrated in figure 42-1b and allow for a 10-minute warmup period.

e. Measure and record the frequency as indicated on the frequency counter. Compute the frequency accuracy and record this data on figure 42-2; USACC Form 452-R (Test).

f. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).



a. POWER OUTPUT.



b. FREQUENCY ACCURACY.

Figure 42-1. FM modulator power output and frequency accuracy test configuration.

FM MODULATOR POWER OUTPUT AND FREQUENCY ACCURACY DATA SHEET (CCR 702-1-3)				PAGE OF PAGES
TERMINAL ID				DATE (DAY, MONTH, YEAR)
MODULATOR ID				SPECIFICATION
POWER OUTPUT (dbm)		ASSIGNED FREQUENCY (MHz)	MEASURED FREQUENCY (MHz)	DEVIATION PERCENTAGE
COMMENTS				
TYPED NAME, GRADE, AND TITLE			TEST ENGR SIGNATURE	

USACC FORM 452-R (TEST)
1 MAY 77

Figure 42-2. FM modulator power output and frequency accuracy data sheet.

CHAPTER 43

WIDEBAND (DIGITAL) MODEM (ST-38)

43-1. GENERAL.

a. The purpose of this test is to measure the performance of the wideband modem in terms of BER versus E_b/N_o.

b. This is an out-of-service test for all terminals not equipped with a redundant digital modem.

43-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

43-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Amplifier.

c. Filter.

d. 1-db attenuator.

e. 10-db attenuator.

f. Coupler.

g. RF voltmeter.

h. Digital printer.

43-4. TEST PROCEDURES.

a. Configure the modem and test equipment as shown in figure 43-1 and allow for a 15-minute warmup and stabilization period.

b. Set the modem to the highest operational data rate for this terminal and no coding.

c. Set the attenuators at the modem output to zero and the attenuators at the noise amplifier's output to maximum (132 db).

d. Measure the modem output with the RF voltmeter.

e. Set the attenuators at the noise amplifier's output to zero and the attenuators at the modem output to maximum (132 db).

f. Measure the noise output. The noise density is determined by subtracting 10 log B from the measured noise power where B is the noise bandwidth of the filter in MHz.

g. Set the C/N density ratio (C/kT) for a value resulting in E_b/N_o = 10 db.

$$C/kT = 10 \log R + E_b/N_o$$

where:

R = bit rate in bps

The carrier C should be set for a value in the middle of the dynamic range of the demodulator. The noise attenuators are then set to the value required for the calculated C/kT.

h. Read the BER on the BER test set and adjust the modulator output attenuators to obtain a BER $\approx 10^{-6}$.

i. Take five error rate samples and record C/kT, E_b/N_o, and BER on figure 43-2; USACC Form 453-R (Test).

j. Repeat paragraph 43-3i for a reduced C/kT in steps of 1 db until the modem breaks lock.

k. Repeat paragraphs 43-1 i and j with the internal error correction coder.

l. Repeat paragraphs 43-4 i and j with the external error correction coder.

m. Plot the BER versus E_b/N_o curves on figure 43-2; USACC Form 453-R (Test).

n. Repeat paragraphs 43-4 h through m for 100 kbps data rate.

o. Repeat paragraphs 43-4 h through m for 4 Mbps data rate.

p. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

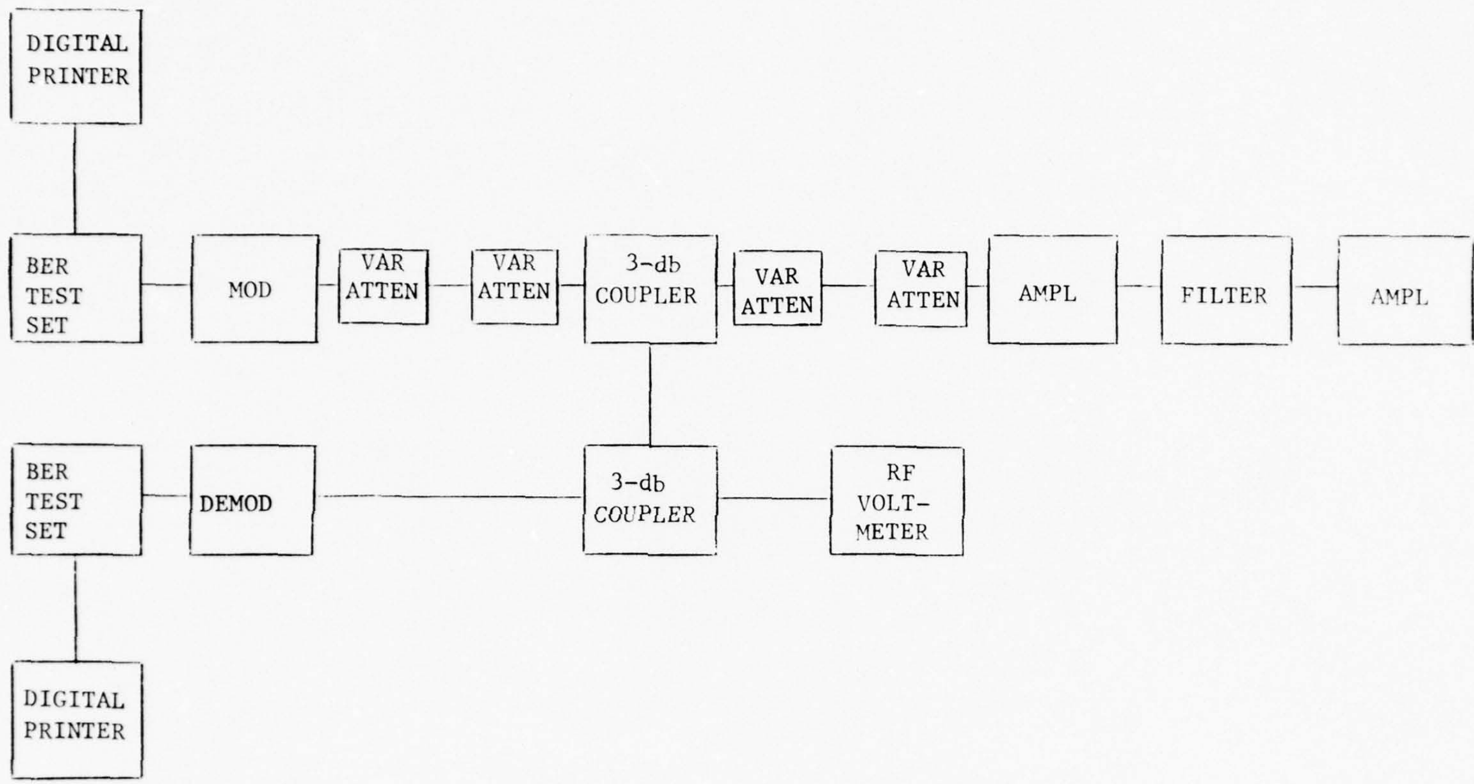


Figure 43-1. Wideband digital modem BER vs E_b/N_o test configuration.

Preceding Page Blank - Filmed

WIDEBAND (DIGITAL) MODEM (CCR 702-1-3) DATA SHEET		PAGE OF PAGES
TERMINAL ID	TERMINAL TYPE	DATE (DAY, MONTH, YEAR)
MODEM ID	DATA RATE baud	SPECIFICATION
LINK NO.	TRUNK NO.	NORMAL OP C/kT db

C/kT (db)	E_b/N_o (db)	BER					AVERAGE BER

COMMENTS

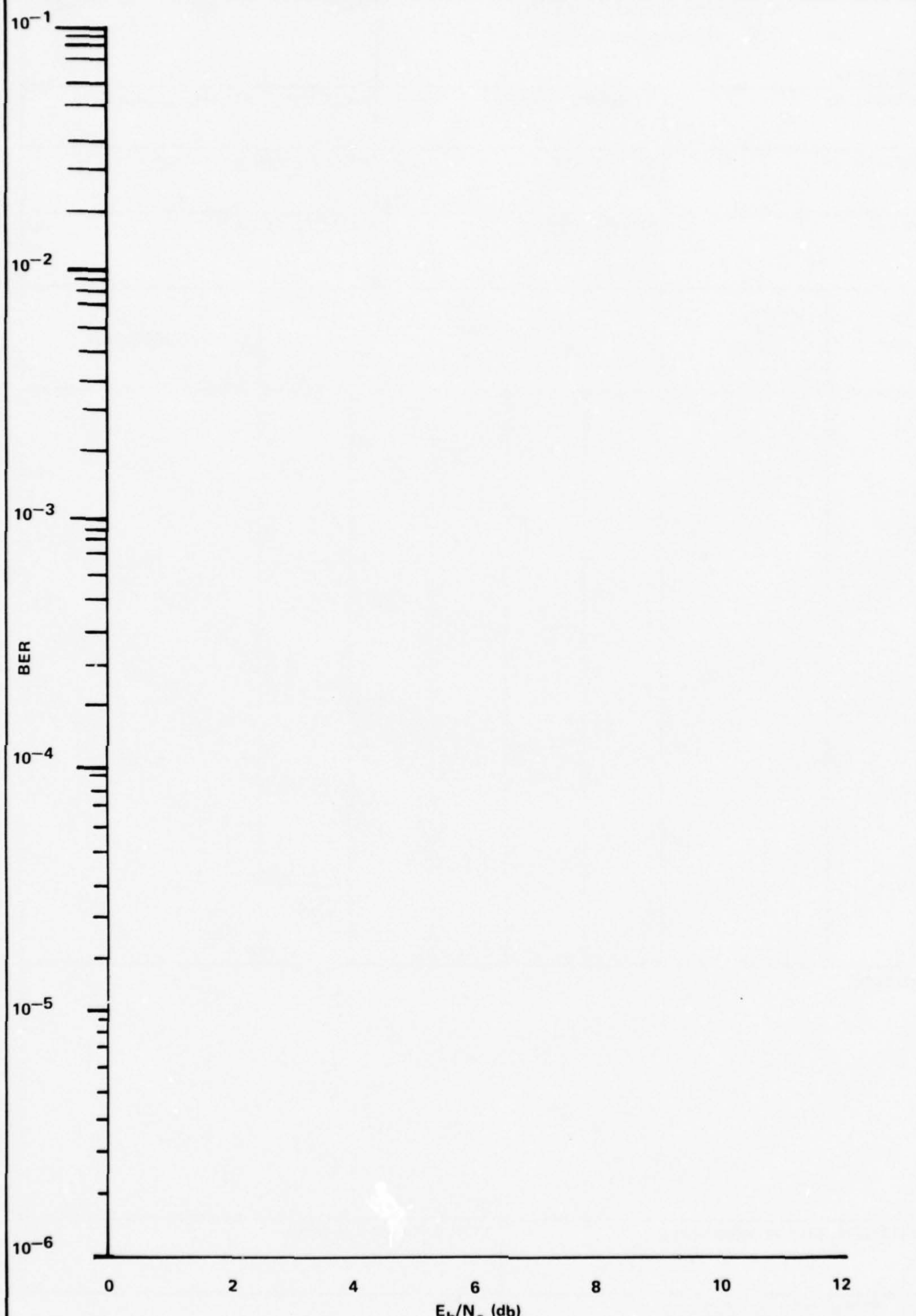
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 453-R (TEST)
1 MAY 77

PAGE 1

Figure 43-2. Wideband (digital) modem data sheet.

DIGITAL MODEM BER VS E_b/N_o	PAGE OF PAGES



PAGE 2

USACC FORM 453-R (TEST)
1 MAY 77

Figure 43-2. Wideband (digital) modem data sheet. (continued)

CHAPTER 44

SPREAD SPECTRUM MODEM (ST-39)

44-1. GENERAL.

a. The purpose of this test is to determine the performance of the spread spectrum modem in terms of acquisition time, TTNR, and BER performance.

b. All test results revealing the performance of the modem are classified SECRET and must be treated IAW the security regulations governing the handling, storage, transmittal, and reproduction of classified information.

c. Personnel tasked with testing of the spread spectrum modem must have the appropriate clearances required for access to the modem.

d. This test procedure is UNCLASSIFIED including the blank data sheets. The data sheets become classified SECRET at the time the test data is being entered.

44-2. SPECIFICATIONS. These specifications are classified SECRET; refer to the modem manuals.

44-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Amplifier.

c. Filter.

d. 1-db attenuator.

e. 10-db attenuator.

f. Coupler.

g. RF voltmeter.

h. Test oscillator.

i. Distortion analyzer.

j. LF selective voltmeter.

k. SHF voltmeter.

l. Frequency counter.

m. Wave analyzer.

n. Signal generator.

o. Mixer.

p. Noise test set.

q. Digital printer.

44-4. TEST PROCEDURES.

a. General. The spread spectrum modem is an antijam modulator/demodulator that obtains its jamming resistance by spreading the signal over a bandwidth larger than required for data transmission. The spread bandwidth is referred to as ASW. The ratio of jammer power, J, to the signal power, S, is J/S. The relationship between J/S and C/kT is J/S = W:C/kT for a noise jammer. Or, in db, J/S db = W db-C/kT db. In these tests, thermal noise will be used as a noise jammer and in the satellite test the conversion from the measured C/kT to J/S must be made to compare performance against the specified requirements.

b. Synchronization Test.

(1) Configure the modem and test equipment as shown in figure 44-1 and allow for a 30-minute warmup and stabilization period.

(2) Adjust the transmitter and both receiver PN-codes to a test code (see code book).

(3) Set the modem for 4,800 bps data on the transmitter and both receivers and adjust the BER test set for 4,800 bps. Dial in a 45-km range.

(4) Set the attenuators at the noise amplifiers to zero and the attenuators at the modem output to maximum (132 db). Measure and record the noise power output.

(5) Set the attenuators at the noise amplifiers to maximum (132 db) and the attenuators at the modem output to zero. Measure and record the signal power output.

(6) Use the filter bandwidth to calculate kT (noise density) and W to calculate S_o (the spread signal density) and set up for J/S = zero db at a suitable level of S at the demodulator input.

(7) Vary J/S by varying the noise attenuators.

(8) Acquire loop synchronization on both receivers at a low value of J/S in the reset mode.

CCP 702-2

(9) Increase the J/S in 1-db steps until the data light on one receiver goes out and record the J/S on figure 44-2; USACC Form 454-R (Test).

(10) Continue to increase J/S until both data lights and both sync lights are out and record the J/S at which each light went out on figure 44-2; USACC Form 454-R (Test).

(11) Repeat paragraphs 44-4b (8) through (10) twice.

(12) Adjust the J/S to the value specified for this operating mode.

(13) Actuate the reset start and measure the time for each of the sync and data lights to come on. Record these times on figure 44-2; USACC Form 454-R (Test).

(14) Repeat paragraph 44-4b(13) four more times.

c. VF Channel TTNR Test.

(1) Configure the modem and test equipment as shown in figure 44-1 and allow for a 30-minute warmup and stabilization period.

(2) Adjust the transmitter and both receiver PN-codes to a test code (see code book).

(3) Set the modem for 1-VF channel operation at deviation factor 2. Adjust the test oscillator to 1 kHz at the specified level. Dial in a 45-km range.

(4) Set the attenuators at the noise amplifiers to zero and the attenuators at the modem output to maximum (132 db). Measure and record the noise power output.

(5) Set the attenuators at the noise amplifiers to maximum (132 db) and the attenuators at the modem output to zero. Measure and record the signal power output.

(6) Use the filter bandwidth to calculate kT (noise density) and W to calculate S_o (the spread signal density) and set up for J/S = zero db at a suitable level of S at the demodulator input.

(7) Vary J/S by varying the noise attenuators.

(8) Acquire loop synchronization on both receivers at a low value of J/S in the reset mode.

(9) Tune the distortion analyzer to minimum deflection and the selective voltmeter to maximum deflection. The TTNR is read as the difference in the dbm readings of both meters. Correct for the bandwidth of the LF selective voltmeter if required.

NOTE: If this bandwidth is 30 Hz or less, no connection is required.

(10) Decrease the J/S from a resulting value of TTNR = 10 db until the TTNR does not increase anymore.

(11) Plot the data on figure 8-7; USACC Form 396-R (Test). The TTNR in db should be plotted on the vertical axis and J/S in db on the horizontal axis.

(12) Repeat paragraphs 44-4c (10) and (11) in the 4-VF channel mode (channel 4).

(13) Record the data on figure 44-3; USACC Form 455-R (Test).

d. Digital Channel Test.

(1) Configure the modem and test equipment as shown in figure 44-1 and allow for a 30-minute warmup and stabilization period.

(2) Adjust the transmitter and both receiver PN-codes to a test code (see code book).

(3) Set the modem for 4,800 bps data on transmitter and both receivers and adjust the BER test set for 4,800 bps. Dial in a 45-km range.

(4) Set the attenuators at the noise amplifiers to zero and the attenuators at the modem output to maximum (132 db). Measure and record the noise power output.

(5) Set the attenuators at the noise amplifiers to maximum (132 db) and the attenuators at the modem output to zero. Measure and record the signal power output.

(6) Use the filter bandwidth to calculate kT (noise density) and W to calculate S_0 (the spread signal density) and set up for J/S = zero db at a suitable level of S at the demodulator input.

(7) Vary J/S by varying the noise attenuators.

(8) Acquire loop synchronization on both receivers at a low value of J/S in the reset mode.

(9) Record the J/S and BER on figure 44-4; USACC Form 456-R (Test).

(10) Increase J/S in 1-db steps until the data light goes off and record J/S and BER on figure 44-4; USACC Form 456-R (Test) for each J/S setting.

(11) Plot the data on figure 44-4; USACC Form 456-R (Test).

(12) Repeat paragraphs 44-4d (9) through (11) for 75 bps.

(13) Repeat paragraphs 44-4d (9) through (11) for 1,200 bps.

e. Satellite Loop Tests.

(1) Configure the modem and test equipment as shown in figure 44-5 and allow for a 30-minute warmup and stabilization period.

(2) Adjust the transmit power to the normal transmit power for this terminal and modem.

(3) Adjust the terminal up and down converters to the normal operating frequencies.

(4) Adjust the range to the satellite ephemeris range.

(5) Reduce the uplink power by 10 db.

(6) Set the noise amplifier attenuators to maximum.

(7) Switch the modem to CW and measure C/kT with the selective voltmeter.

(8) Decrease the noise amplifier attenuators until the J/S derived from the measured C/kT by using W reaches the specified value for acquisition at 4,800 bps.

(9) Switch the modem to spread and 4,800 bps.

(10) Increase the uplink power by 10 db (normal setting).

(11) Dial in a test code in the transmitter and both receivers.

(12) Actuate reset start and determine the time for each of the sync and data lights to come on. Record the data on figure 44-2; USACC Form 454-R (Test) and repeat twice.

(13) Adjust the C/kT until the BER is approximately 10^{-3} and take five samples at this setting.

(14) Adjust the C/kT 1 db up and 1 db down and take five BER samples at each reading.

(15) Enter the data from paragraphs 44-4e (13) and (14) on figure 44-4; USACC Form 456-R (Test).

(16) Repeat paragraphs 44-4e (13) through (15) for 75 bps.

(17) Repeat paragraphs 44-4e (13) through (15) for 1,200 bps.

(18) Restore the modem and terminal to their normal operating condition.

f. Radio Set AN/URC-61 Tests.

NOTE: This is an alternate test procedure and should be employed on AN/URC-61 radio sets when BER test sets are not available.

(1) Configure the radio set and TMDE as illustrated in figure 44-6 and allow for a 15-minute warmup and stabilization period.

(2) Tune the wave analyzer to 18.6 MHz and measure the receive C/kT ratio.

(3) The AN/URC-61 should be configured for data operation, narrow-band mode with a space injected.

(4) Adjust the attenuators on the noise amplifier to attain the desired C/kT ratio (J/S) for 4,800 bps (see applicable technical manuals).

(5) Measure the BER and the time required to reset the radio set as follows:

(a) Connect the test equipment as illustrated in figure 44-7.

(b) Adjust the frequency counter as follows:

1. Set the time base switch to EXT.

2. Set the sensitivity switch to 0.1 volt.

3. Set the function switch-to-switch to 100K under period average.

4. Adjust sample rate to HOLD.

5. Push the reset switch to start the test.

6. Multiply the number of errors by Z.

(c) Repeat paragraphs 44-4 a through d at data rates of 2,400, 1,200, 600, 300, 150, and 75.

(d) Perform this test at the specified data rates 1 db above and below the specified jamming ratios.

(6) Record and plot the data on figures 44-2 through 44-4; USACC Forms 452-R (Test), 453-R (Test), and 454-R (Test).

(7) Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

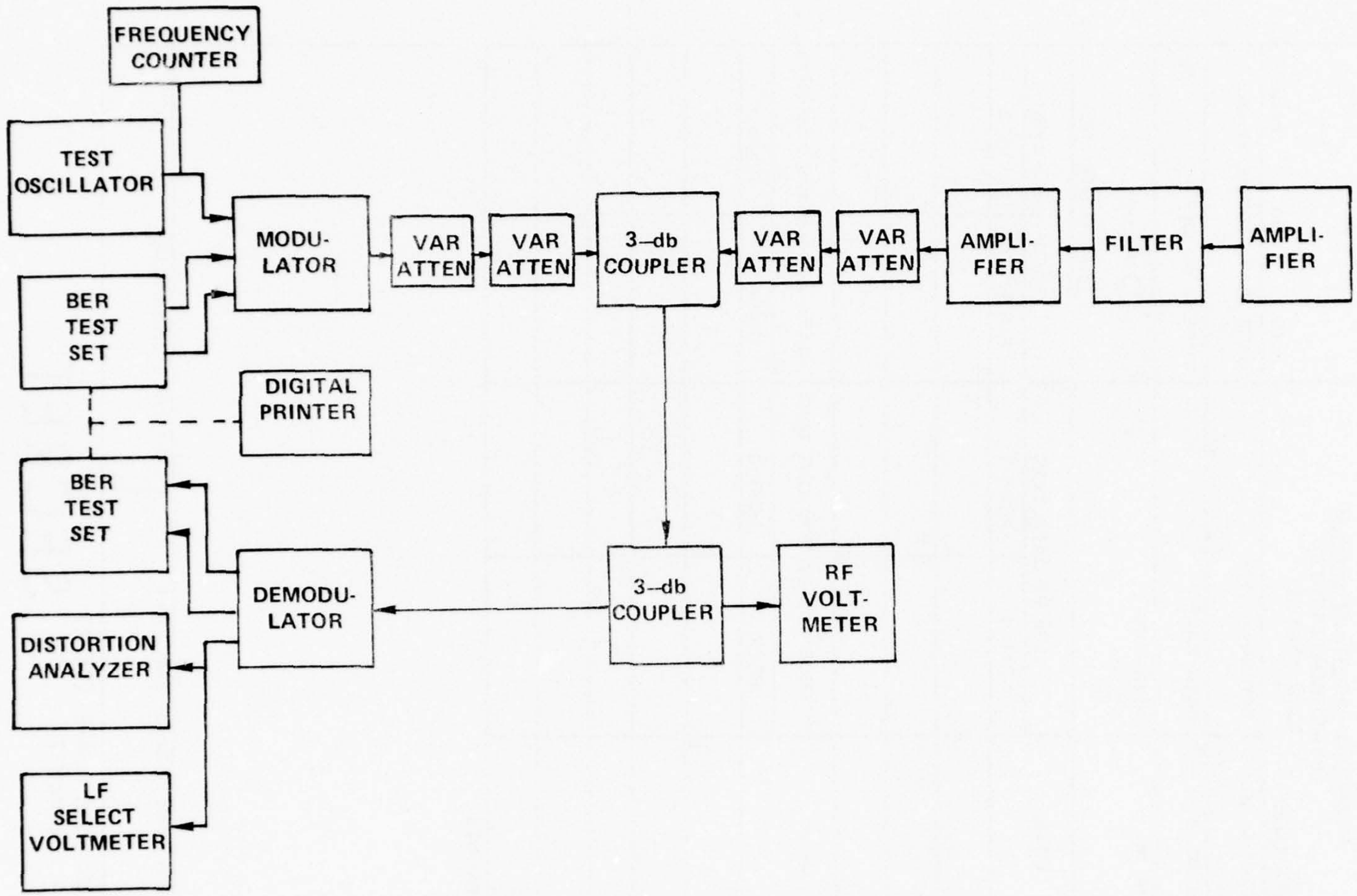


Figure 44-1. Spread spectrum modem (synchronization, VF, TTNR, and digital) test configuration.

SPREAD SPECTRUM MODEM (SYNCHRONIZATION) (CCR 702-1-3) DATA SHEET		PAGE OF PAGES
TERMINAL ID	TERMINAL TYPE	DATE (DAY, MONTH, YEAR)
MODEM ID	DATA RATE baud	NORMAL OP C/kT db
LINK NO.	TRUNK NO.	☐ IF LOOP ☐ SATELLITE LOOP

J/S(db)	LOSS OF DATA SYNC		LOSS OF CODE SYNC	
	RCVR 1	RCVR 2	RCVR 1	RCVR 2

J/S(db)	CODE ACQUISITION TIME (SEC)		DATA ACQUISITION TIME (SEC)	
	RCVR 1	RCVR 2	RCVR 1	RCVR 2

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 454-R (TEST)
1 MAY 77

Figure 44-2. Spread spectrum modem (synchronization) data sheet.

SECRET

SPREAD SPECTRUM MODEM (VF TTNR) (CCR 702-1-3) DATA SHEET		PAGE OF PAGES
TERMINAL ID	TERMINAL TYPE	DATE (DAY, MONTH, YEAR)
MODEM ID	DEVIATION FACTOR	NORMAL OP C/kT db
LINK NO.	TRUNK NO.	☐ IF LOOP ☐ SATELLITE LOOP
J/S(db)	TTNR (db) SIGNAL VF CHANNEL	TTNR (db) 4 VF CHANNELS in CHANNEL 4

COMMENTS

TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 455-R (TEST)
1 MAY 77

SECRET

(CLASSIFIED WHEN FILLED IN)

Figure 44-3. Spread spectrum mode (VF TTNR) data sheet.

SPREAD SPECTRUM MODEM (BER) (CCR 702-1-3) DATA SHEET		PAGE OF PAGES
TERMINAL ID	SPECIFICATION	DATE (DAY, MONTH, YEAR)
MODEM ID	DATA RATE baud	NORMAL OP C/kT db
LINK NO.	TRUNK NO.	☐ IF LOOP ☐ SATELLITE LOOP

C/kT (db)	J/S (db)	E_b/N_o (db)	BER					AVERAGE BER

COMMENTS	
TYPED NAME, GRADE, AND TITLE	TEST ENGR SIGNATURE

USACC FORM 456-R (TEST)
1 MAY 77

PAGE 1

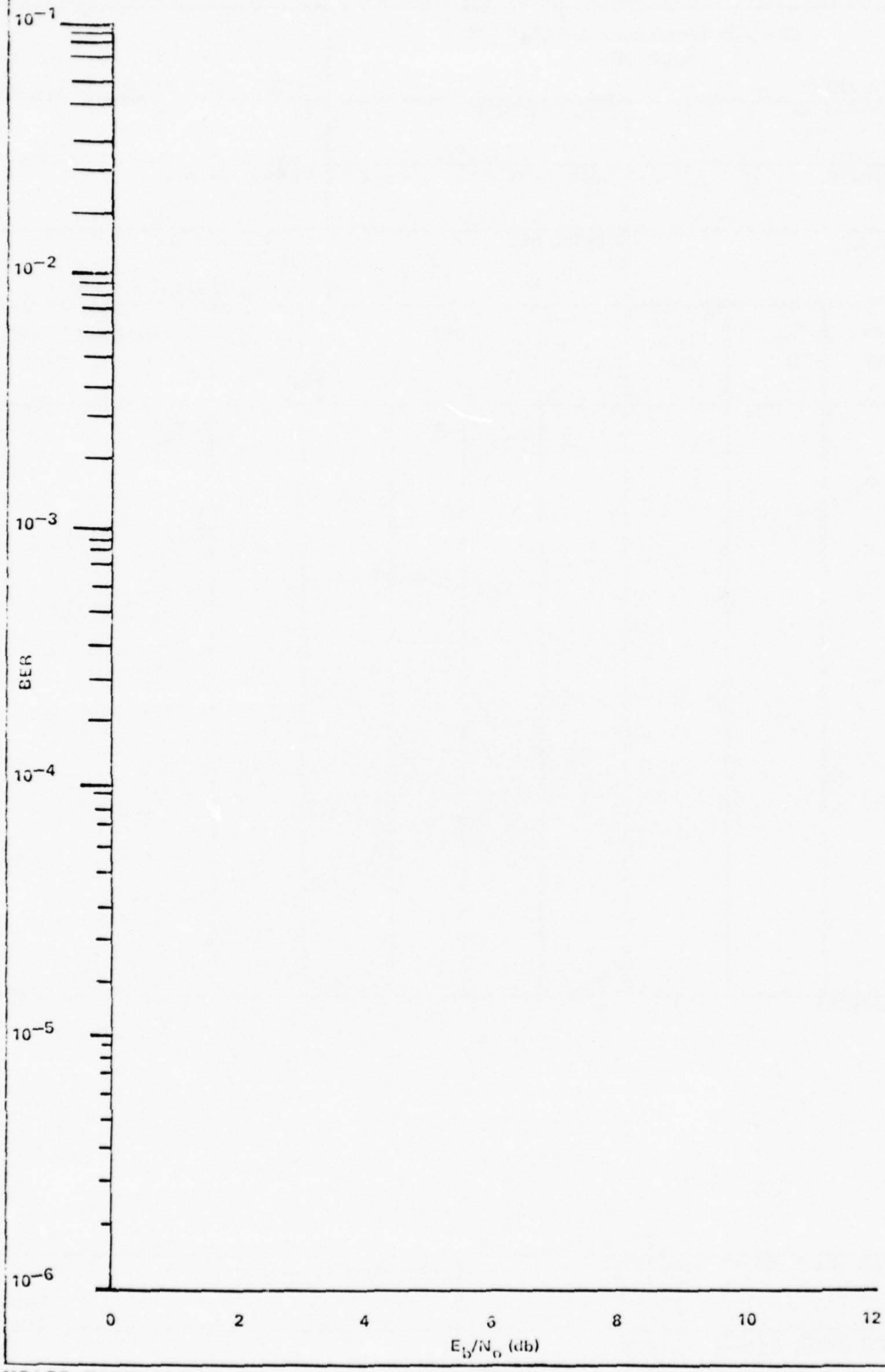
SECRET

(CLASSIFIED WHEN FILLED IN)

Figure 44-4. Spread spectrum modem (BER) data sheet.

SECRET

DIGITAL MODEM BER VS E_b/N_o | PAGE OF



USACC FORM 456-R (TEST)
1 MAY 77

PAGE 2

SECRET

(CLASSIFIED WHEN FILLED IN)

Figure 44-4. Spread spectrum modem (BER) data sheet. (continued)

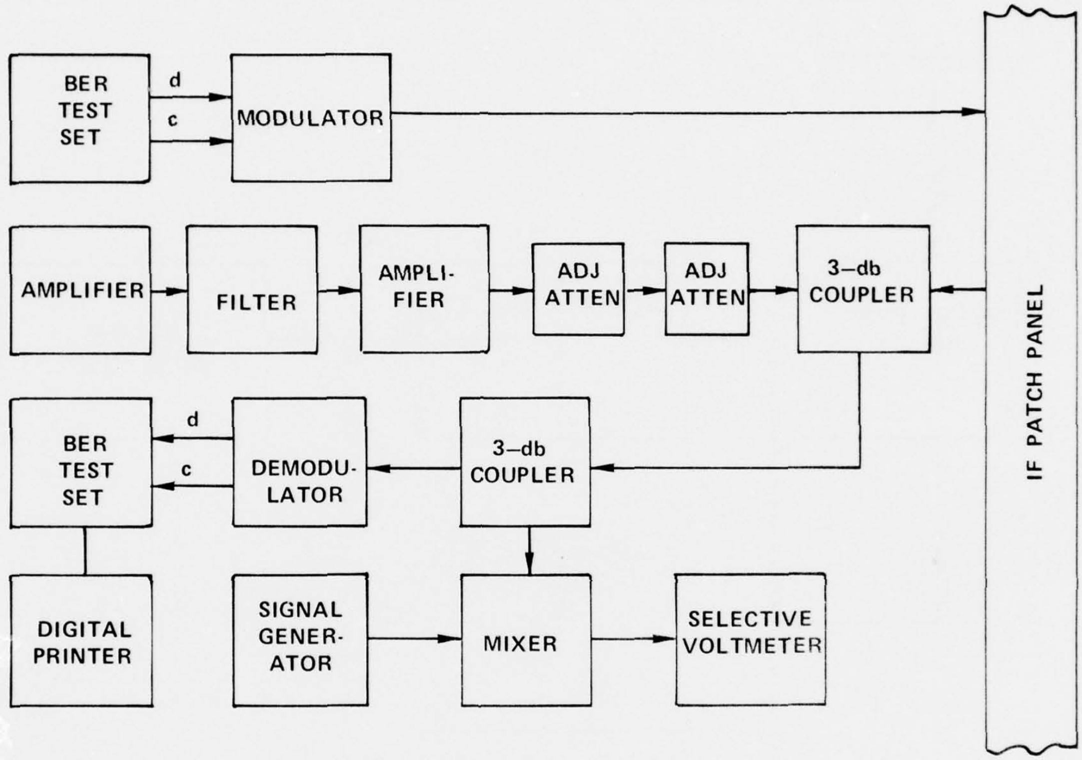


Figure 44-5. Spread spectrum modem (satellite loop) test configuration.

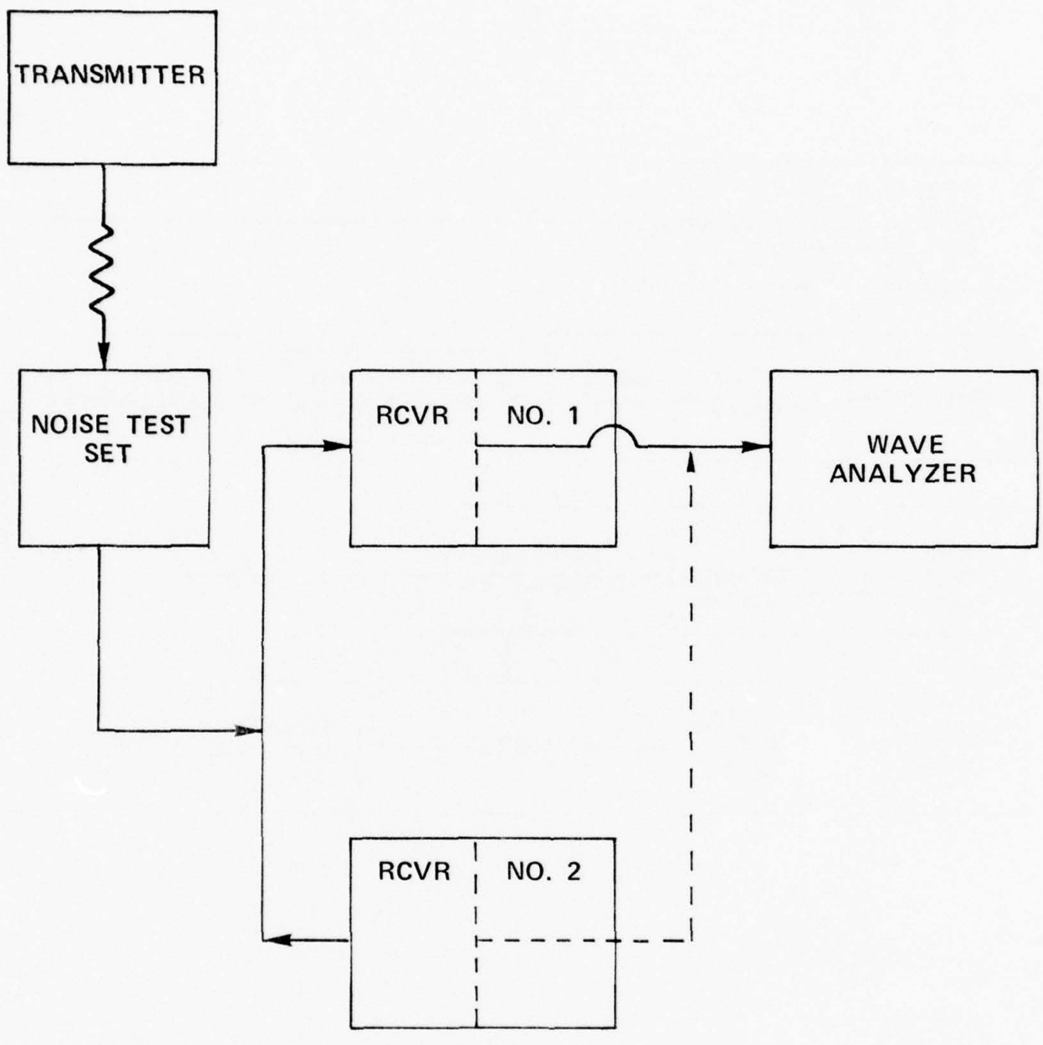


Figure 44-6. Spread spectrum modem BER vs C/kT (equipment calibration) alternate test configuration.

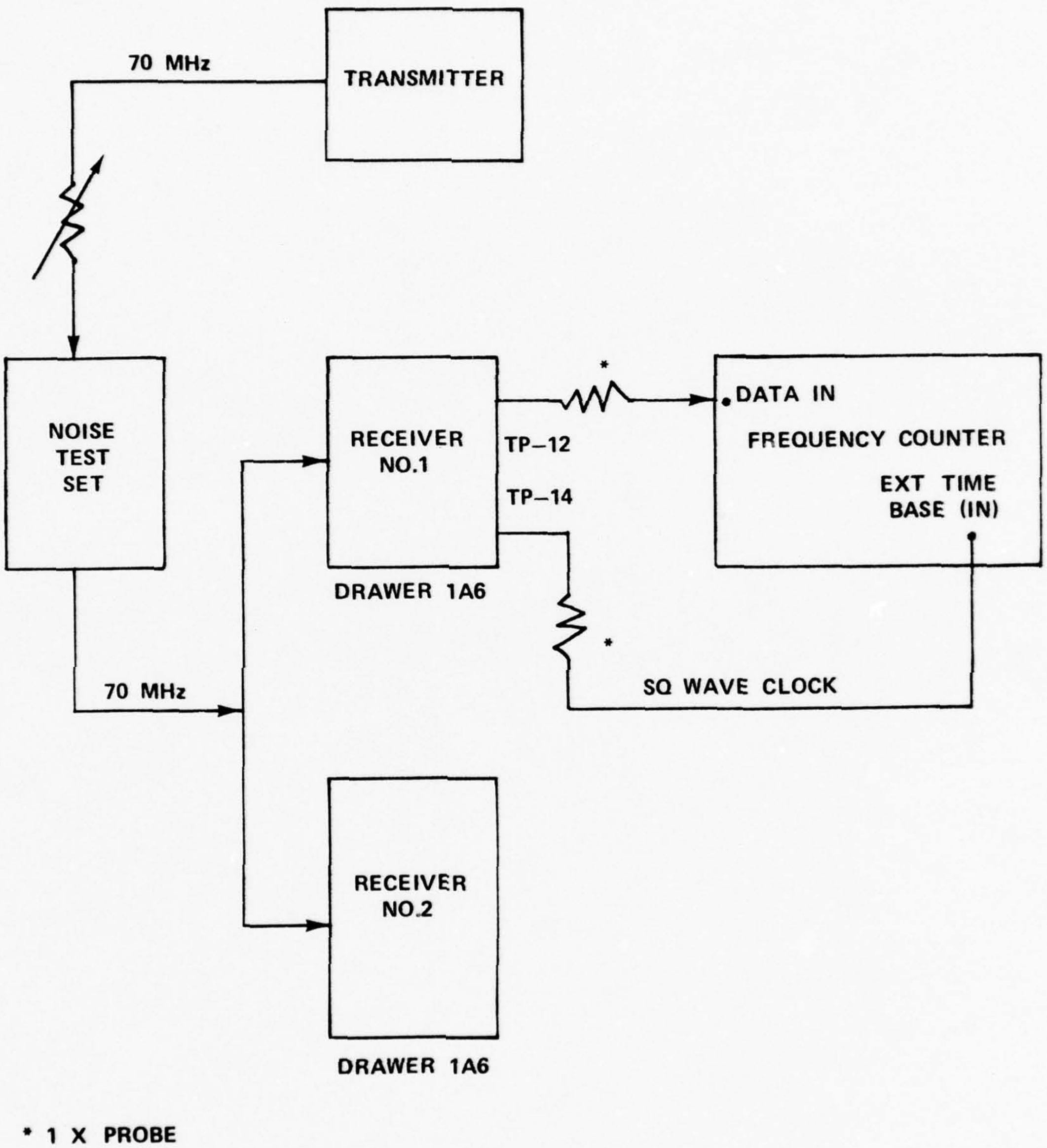


Figure 44-7. Spread spectrum modem BER vs C/kT alternate test configuration.

Preceding Page Blank - Filmed

CHAPTER 45

FREQUENCY SYNTHESIZER INTERNAL FREQUENCY STANDARD (ST-40)

45-1. GENERAL.

a. The purpose of this test is to measure the accuracy of the internal frequency standard of the frequency synthesizers.

b. Under conditions where the station frequency standard fails, the internal synthesizer standard automatically activates and must be sufficiently accurate. The synthesizer multiplication accuracy is tested in ST-41.

c. This is an inservice test.

45-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

45-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. RF voltmeter.

c. Amplifier.

d. Adjustable attenuator.

e. Doubler.

f. Mixer.

45-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 45-1.

b. Set the internal 1.0-MHz standard switch located on the rear of the frequency counter to EXT.

c. Adjust the amplifier gain to 20 db and the variable attenuator until a level of between 0.5 and 1 volt is indicated on the RF voltmeter.

d. Connect the amplifier output to the 1.0-MHz external standard terminal on the frequency counter.

e. Configure the test equipment as illustrated in figure 45-2 and measure the four synthesizer frequency outputs. Record the data on figure 6-4; USACC Form 351-R (Test).

NOTE: The sample out (J-5) frequency x 50 + 700 MHz should equal the corresponding up/down converter channel frequency.

f. Connect the frequency counter to the sample out (J-5) terminal on the synthesizer under test. Set the corresponding up/down converter channel selector to the channels listed in table 45-1.

g. Record the results on figure 6-4; USACC Form 351-R (Test) and calculate the frequency accuracy.

h. Repeat paragraphs 45-4 c through g on all synthesizers.

i. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

Table 45-1. Up/Down Converter Channel and Synthesizer Frequencies

DOWN CONVERTER		UP CONVERTER	
CHANNEL FREQUENCY (MHz)	SYNTHESIZER SAMPLE OUT (J-5) REQUIRED FREQUENCY (MHz)	CHANNEL FREQUENCY (MHz)	SYNTHESIZER SAMPLE OUT (J-5) REQUIRED FREQUENCY (MHz)
7250	131	7900	144
7300	132	7950	145
7350	133	8000	146
7400	134	8050	147
7450	135	8100	148
7500	136	8150	149
7550	137	8200	150
7600	138	8250	151
7650	139	8300	152
7700	140	8350	153
7750	141	8400	154

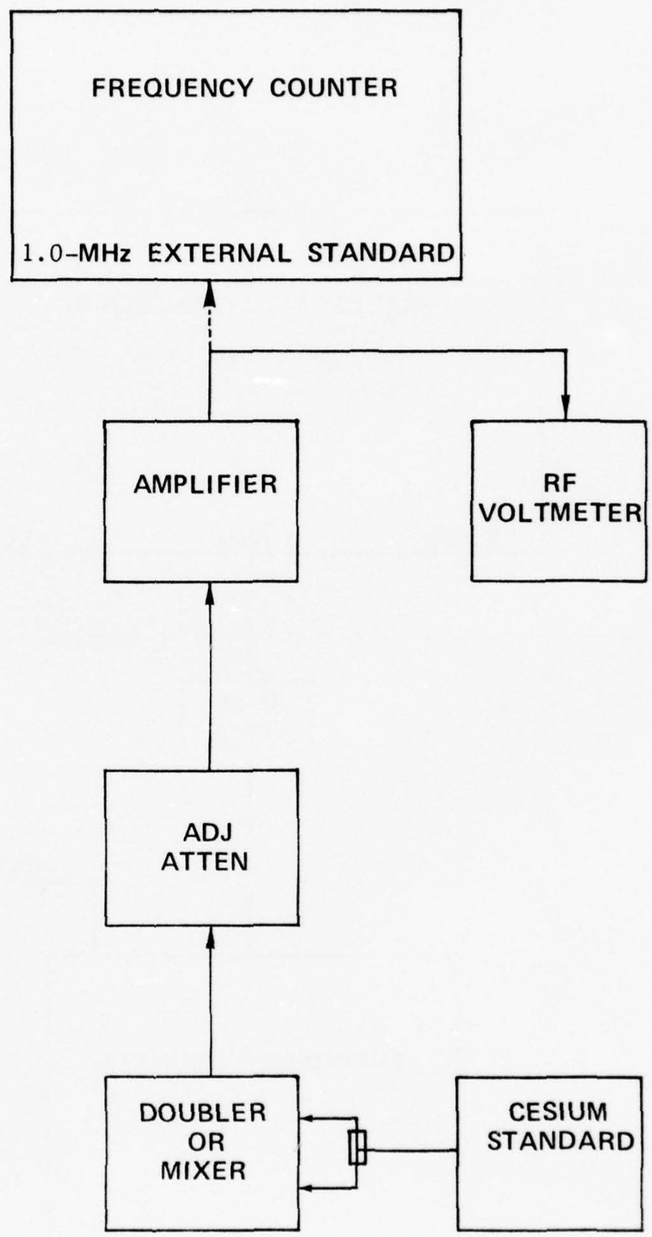
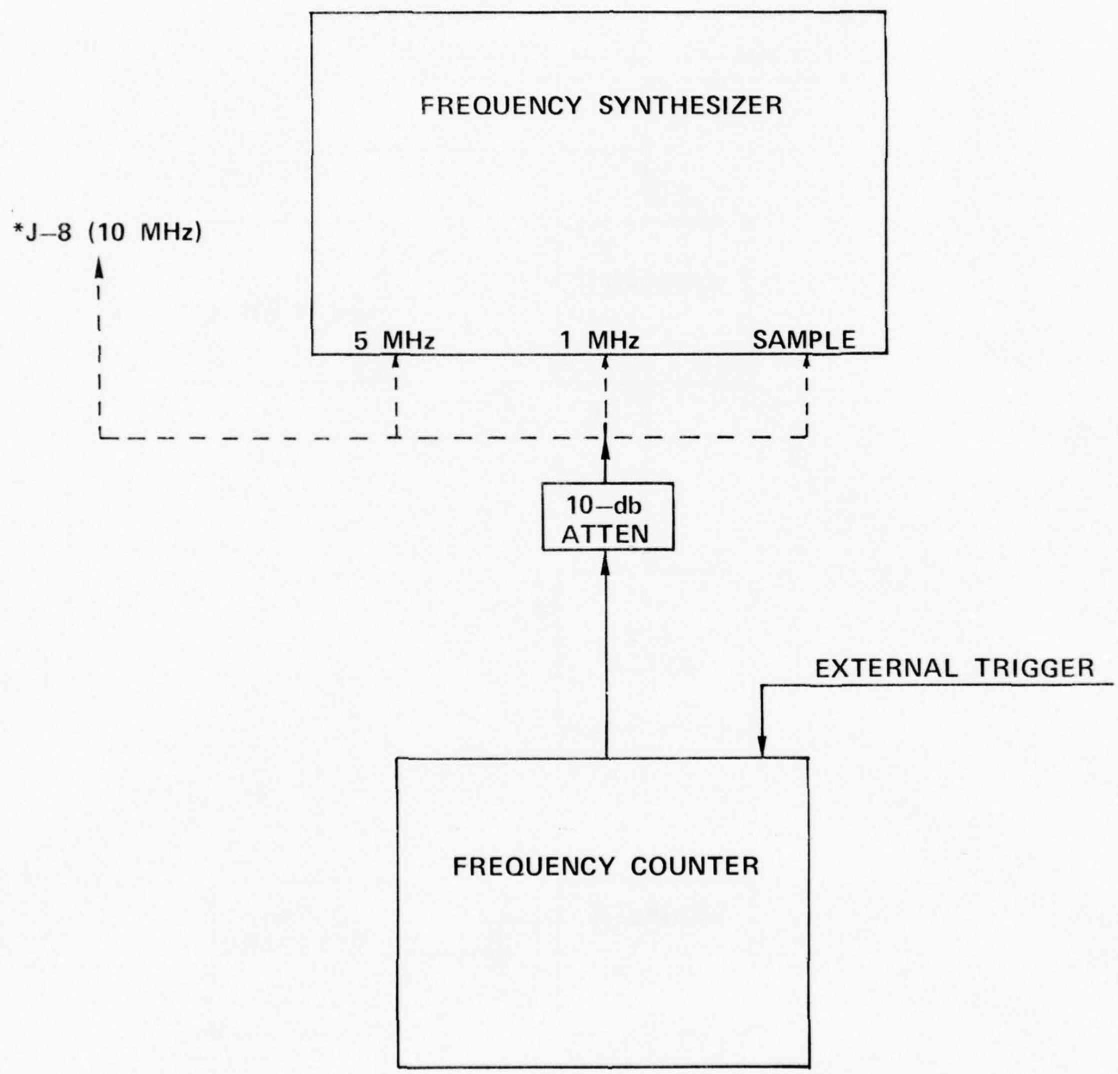


Figure 45-1. Frequency synthesizer equipment calibration test configuration.



* READING TAKEN FROM CABLE CONNECTED TO J–8 IN REAR OF UP/DOWN CONVERTER.

Figure 45-2. Frequency synthesizer test configuration.

CHAPTER 46

LO MULTIPLICATION CHECK AND POWER OUTPUT (ST-41)

46-1. GENERAL.

a. The purpose of this test is to check the output frequency of the LO's referenced to the frequency standard and the power output level of the LO's.

b. The LO frequencies are derived from the station cesium beam frequency standard. There is no easy way to measure the accuracy and stability of this standard, but failures normally result in gross errors or greatly reduced output. Both failure modes are immediately apparent during normal operation of the station. The actual LO frequencies are phase locked to the synthesizer's 10 MHz and synthesized output. The most probable failure mode of the synthesizer is either no output or a decade error. The most probable failure mode of the phase lock multipliers is loss-of-lock which results in a gross frequency error and instability. This test therefore measures the LO frequencies against the cesium beam frequency. The readings will either have a zero error, with equal occurrence probability of a 1-count error on the least significant digit displayed or a gross error that requires corrective maintenance.

c. This is an inservice test for terminals with redundant up and down converters and IF converters, and for converters that allow power measurement inservice.

46-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

46-3. TEST EQUIPMENT REQUIRED.

a. Power meter.

b. Thermistor mount.

c. Fixed attenuator.

d. Frequency counter.

e. RF voltmeter.

f. Amplifier.

g. Variable attenuator.

h. Doubler.

i. Mixer.

46-4. TEST PROCEDURES.

a. Configure the test equipment as shown in figure 46-1.

b. Adjust the amplifier gain to 20 db and the variable attenuator until the input voltage on the back of the counter (external time base) reads between 0.5 and 1 volt rms.

c. Set the counter to external time base.

d. Measure the frequency of the LO sample and record data on figure 46-2; USACC Form 457-R (Test).

e. Measure the power level of the LO input to the converter with the power meter and record on figure 46-2; USACC Form 457-R (Test).

f. Repeat paragraphs 46-4 d and e for all up and down converters.

g. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

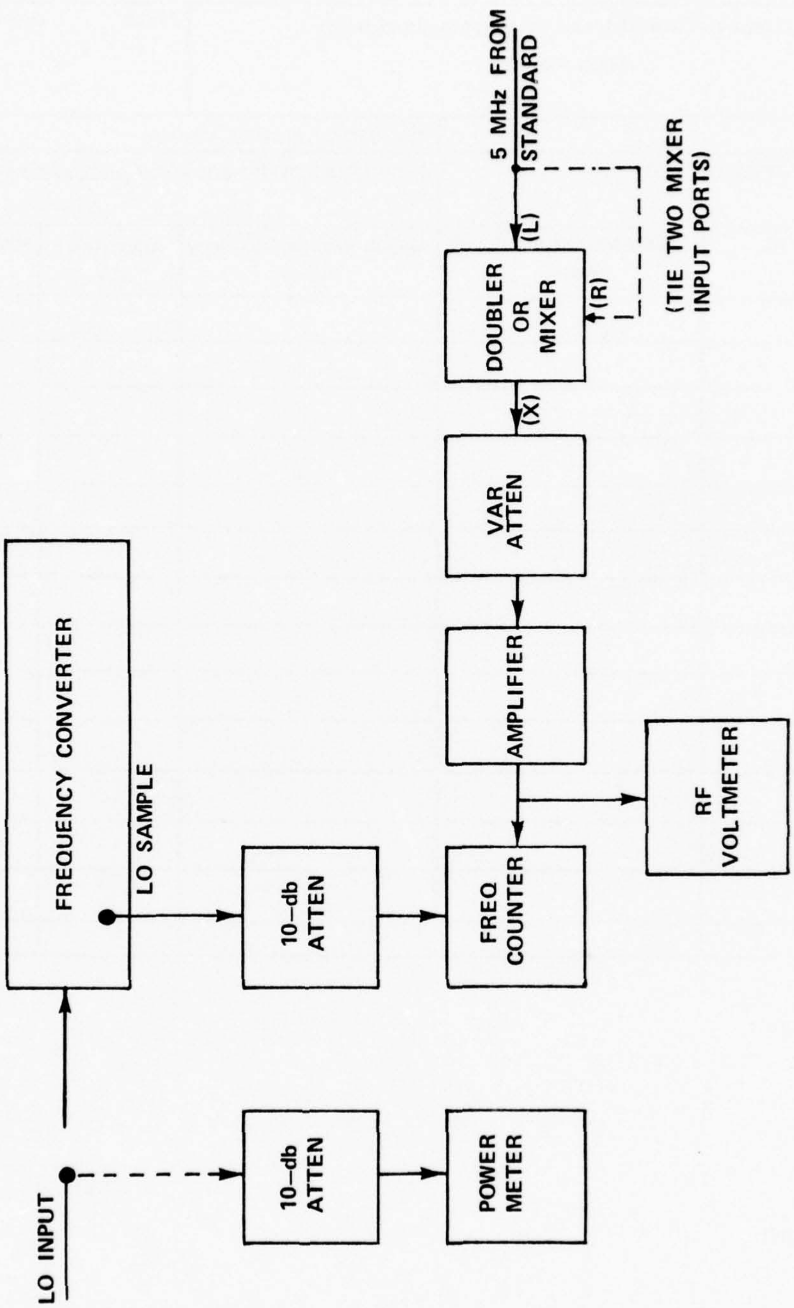


Figure 46-1. LO multiplication check and power output test configuration.

LO MULTIPLICATION CHECK AND POWER OUTPUT (CCR 702-1-3) DATA SHEET			PAGE OF PAGES	
TERMINAL ID		DATE (DAY, MONTH, YEAR)		
SPECIFICATION (POWER OUTPUT)		SPECIFICATION (FREQUENCY ACCURACY)		
CONVERTER ID	ASSIGNED FREQUENCY (MHz)	MEASURED FREQUENCY (MHz)	ACCURACY (%)	POWER OUTPUT (dbm)
COMMENTS				
TYPED NAME, GRADE, AND TITLE		TEST ENGR SIGNATURE		

USACC FORM 457-R (TEST)
1 MAY 77

Figure 46-2. LO multiplication check and power output data sheet.

CHAPTER 47

TRANSMIT-TO-RECEIVE ISOLATION (ST-42)

47-1. GENERAL.

a. The purpose of this test is to measure the RF isolation between the receive and transmit links of the satellite earth terminal.

b. This is an out-of-service test and requires an AO.

c. Terminals, for which the transmit-to-receive isolation has been specified in terms of noise temperature, must be measured IAW test ST-4 with the power amplifier on and off. This test applies to terminals for which the isolation is specified in db.

47-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

47-3. TEST EQUIPMENT REQUIRED.

a. Step attenuator.

b. Spectrum analyzer.

c. Oscilloscope camera.

47-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 47-1. Point the antenna away from the satellite.

b. Adjust the output of the power amplifier to the rated output power level.

c. Adjust the variable attenuator for maximum attenuation and tune the spectrum analyzer to the desired frequency.

d. Calibrate the vertical deflection of the spectrum analyzer display for a suitable reference.

e. Disconnect the spectrum analyzer from the 40-db directional coupler and configure the test equipment as illustrated in figure 47-2.

f. Decrease the variable attenuation on the spectrum analyzer and attenuator until the amplitude of the transmit signal is equal to that of paragraph 47-4d.

g. Account for the gain of the para-amp as measured in ST-7 and record the transmit-to-receive isolation on figure 47-3; USACC Form 458-R (Test).

h. Apply modulation to the system and repeat paragraphs 47-4 b through h.

i. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

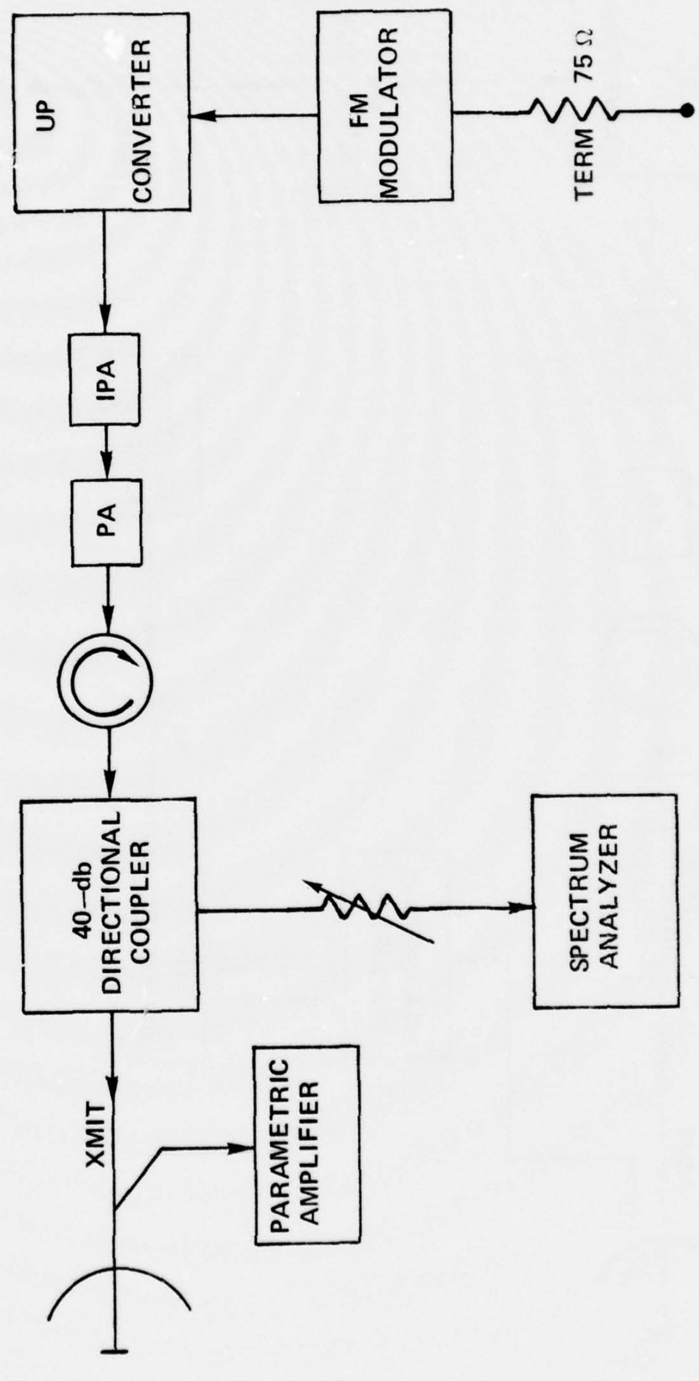


Figure 47-1. Transmit-to-receive isolation (calibration) test configuration.

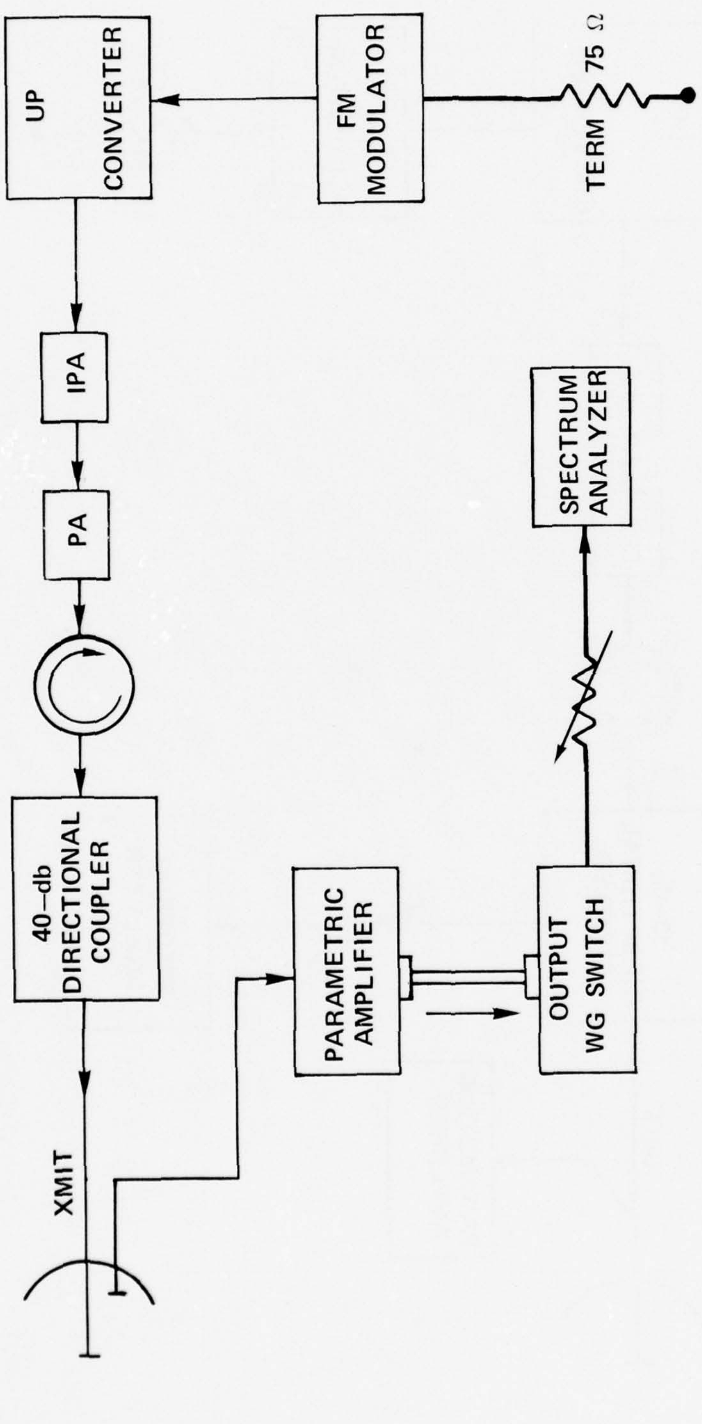


Figure 47-2. Transmit-to-receive isolation test configuration.

<table>
<tr><td colspan="5">EARTH TERMINAL XMIT-TO-REC ISOLATION
(CCR 702-1-3)
DATA SHEET</td><td colspan="4">PAGE OF PAGES</td></tr>
<tr><td colspan="3">TERMINAL ID</td><td colspan="2">TIME Z</td><td colspan="4">DATE (DAY, MONTH, YEAR)</td></tr>
<tr><td colspan="3">LINK NO.</td><td colspan="2">FREQUENCY MHz</td><td colspan="4">POLARIZATION
XMIT REC</td></tr>
<tr><td rowspan="2">EQUIPMENT</td><td colspan="2">DIRECTIONAL COUPLER
ATTEN db</td><td colspan="2">INITIAL VALUE
ATTEN db</td><td colspan="2">FINAL VALUE
ATTEN db</td><td colspan="2">ISOLATION
(db)</td></tr>
<tr><td>MOD ON</td><td>MOD OFF</td><td>MOD ON</td><td>MOD OFF</td><td>MOD ON</td><td>MOD OFF</td><td>MOD ON</td><td>MOD OFF</td></tr>
<tr><td>HPA</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>LPA</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>OTHER</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>RECEIVER</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">COMMENTS</td></tr>
<tr><td colspan="4">TYPED NAME, GRADE, AND TITLE</td><td colspan="5">TEST ENGR SIGNATURE</td></tr>
</table>

USACC FORM 458-R (TEST)
1 MAY 77

Figure 47-3. Earth terminal xmit-to-rec isolation data sheet.

Preceding Page Blank - NOT Filmed

CHAPTER 48

CROSSOVER INTERMODULATION (ST-43)

48-1. GENERAL.

a. The purpose of this test is to measure the level of intermodulation products between multiple uplink carriers that fall in the receive band. This test does not apply to terminals configured for a single uplink carrier.

b. This is an out-of-service test that requires the terminal antenna to be pointed away from the satellite. An AO is required.

c. This test is performed at maximum uplink power, as well as at authorized uplink power. It is performed at carefully selected and listed frequencies, as well as at DSCS assigned operating frequencies.

48-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

48-3. TEST EQUIPMENT REQUIRED. Spectrum analyzer.

48-4. TEST PROCEDURES.

a. Configure the test equipment and terminal as shown in figure 48-1.

b. Connect two up converters in the uplink chain.

c. Terminate the input to two modulators in their characteristics impedance.

d. Point the antenna to a quiet spot in the sky.

e. Measure the SNT.

f. Tune the up converters to a set of frequencies given in the following tabulation.

TRANSMIT F_1 (MHz)	TRANSMIT F_2 (MHz)	RECEIVE (MHz)
7950	8050	7.750
8243.2	8343.2	7743.2
7900	8000	7700

g. Tune the down converter to the corresponding frequencies given in the above tabulation.

h. Tune the spectrum analyzer to 70 MHz and 1 MHz/cm dispersion.

i. Bring up the power amplifier to maximum power, equal level per carrier.

j. Measure the SNT and measure intermodulation products on the spectrum analyzer in terms of C/kT and frequency.

k. Scan the receive 500 MHz with the spectrum analyzer tuned to 70 MHz and 5 MHz/cm dispersion by tuning the down converter in 40-MHz steps from 7260 to 7740 MHz.

l. Record all measured data on figure 48-2; USACC Form 459-R (Test).

m. Repeat paragraphs 48-4 e through ℓ for the next set of frequencies in the tabulation until all three sets have been measured; then turn the transmit power down.

n. Tune all operational up converters to the operational frequencies.

o. Bring up the power amplifier to maximum power.

p. Repeat paragraphs 48-4 j through ℓ and record the data on figure 48-2; USACC Form 459-R (Test).

q. Reduce the transmit power to the operational transmit power per carrier.

r. Measure the intermodulation product level at the frequencies found under the conditions specified in paragraph 48-4o.

s. Measure the SNT.

t. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

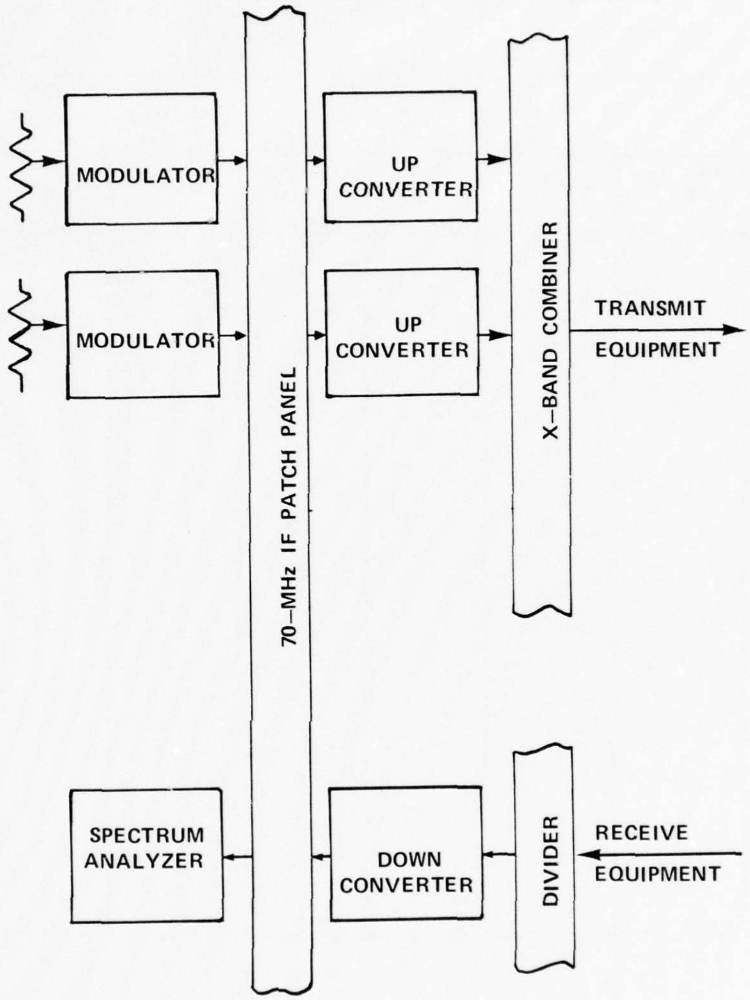


Figure 48-1. Crossover intermodulation test configuration.

CROSSOVER INTERMODULATION
(CCR 702-1-3)

DATA SHEET		PAGE OF PAGES
TERMINAL ID	NO. UPLINK CARRIERS	DATE (DAY, MONTH, YEAR)
LINK NO.	ASGD UPLINK PWR W	SPECIFICATION

XMIT F_1 (MHz)	XMIT F_2 (MHz)	P TOTAL (W)	REC F (MHz)	REC LEVEL C/kT (db)	SNT P=O (°K)	SNT P=W (°K)	Δ SNT (°K)

COMMENTS

TYPED NAME, GRADE AND TITLE	TEST ENGR SIGNATURE

USACC FORM 459-R (TEST)
1 MAY 77

Figure 48-2. Crossover intermodulation data sheet.

Preceding Page Blank - Filmed

CHAPTER 49

SYSTEM PHASE LINEARITY (ST-44)

49-1. GENERAL.

a. The purpose of this test is to measure the phase linearity of the satellite earth terminal.

b. This is an out-of-service test and requires an AO.

49-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

49-3. TEST EQUIPMENT REQUIRED.

a. X-Y recorder.

b. Vector voltmeter.

c. Sweep signal generator.

d. Plug-in.

e. Variable attenuator.

f. Coaxial attenuator set.

g. Power meter.

h. Directional coupler.

i. Frequency counter.

49-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 49-1. Energize the test equipment and allow for a 30-minute warmup and stabilization period.

b. Tune the sweep generator for an F_c of 70 MHz at an output level of zero dbm. Set the variable attenuator to 10 db of attenuation.

c. Set the vector voltmeter frequency range control to the 50- to 90-MHz position and calibrate the X-Y recorder sweep width for 4 MHz per inch on the X-axis.

d. Calibrate the X-axis by zeroing the phase reading on the vector voltmeter and then by setting the recorder pen to the bottom of the Y-axis. Then increment the meter offset switch on the vector voltmeter by 180 degrees and adjust the Y-axis for a 5-inch deflection. Label

CCP 702-2

the Y-axis of the graph paper starting with zero at the bottom on a scale of 36 degrees per inch. Label the X-axis starting with 50 MHz at the left on a scale of 4.0 MHz per inch.

e. Configure the terminal for an STT loopback and arrange the test equipment as illustrated in figure 49-2.

f. Adjust the variable attenuator so that channels A and B read within 10 db of each other on the vector voltmeter.

g. With the pen of the X-Y recorder lifted, trigger the sweep signal generator. Adjust the start position of the pen so that the lowest point in the curve traced by the pen is just above the baseline. Lower the pen and trigger the sweep signal generator to plot phase shift versus frequency on figure 8-7; USACC Form 396-R (Test).

h. Draw a straight line through the plot to determine the phase linearity.

i. Repeat paragraphs 49-4 f through k with the up and down converter frequency dial set to other selected frequencies for a total of three frequencies.

j. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

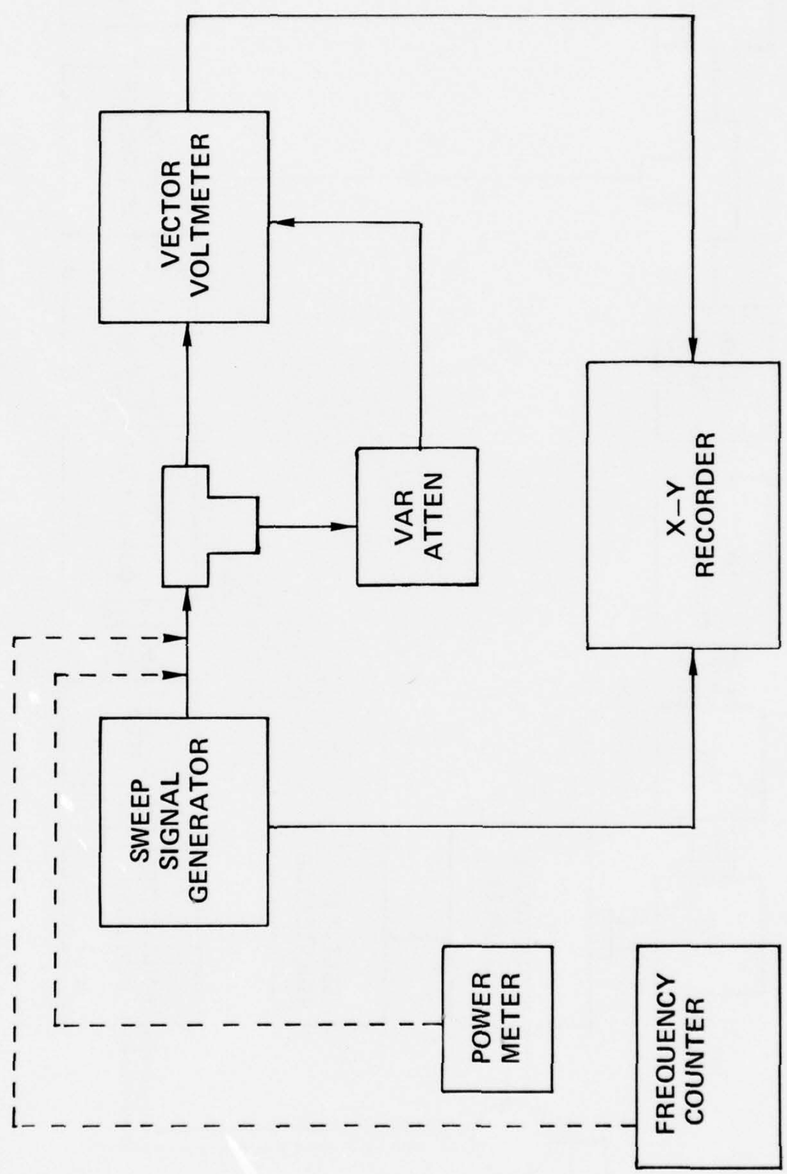


Figure 49-1. System phase linearity (calibration) test configuration.

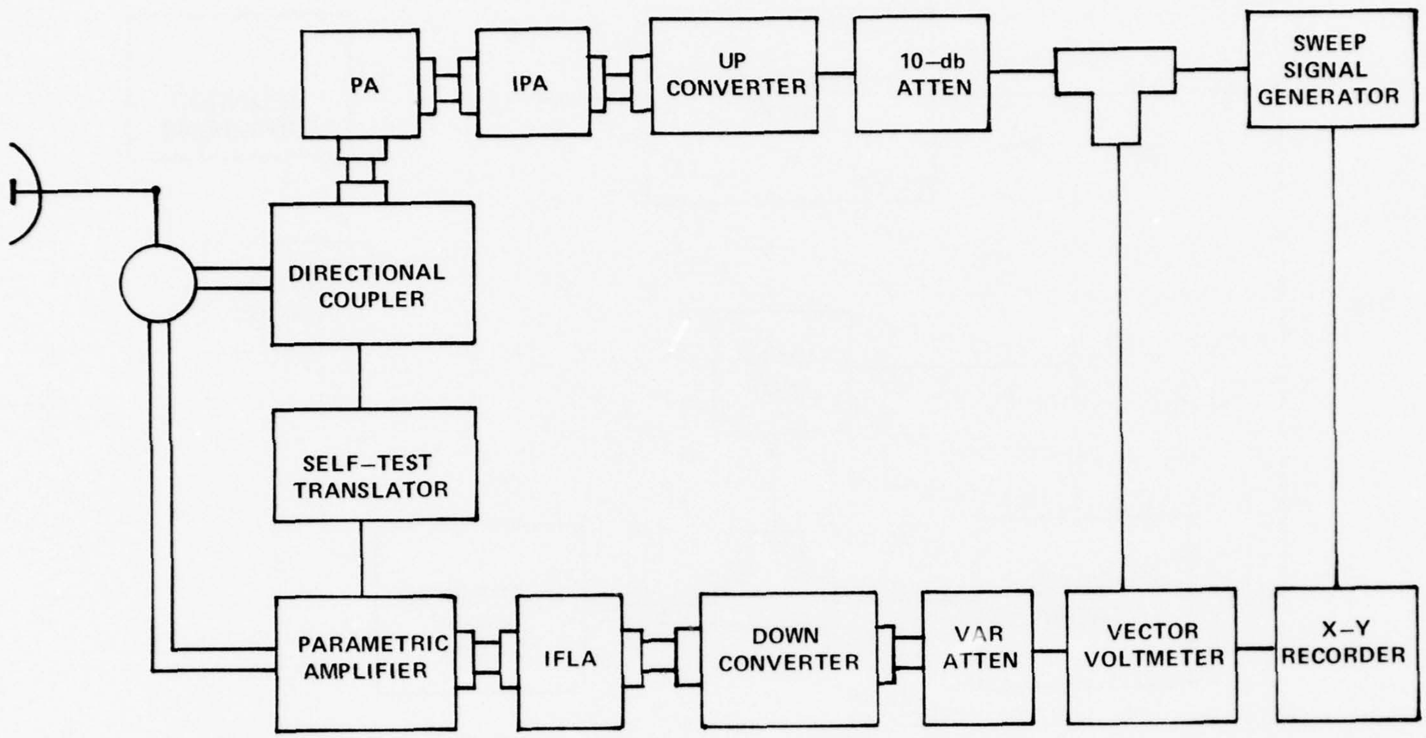


Figure 49-2. System phase linearity test configuration.

CHAPTER 50

SYSTEM PHASE NOISE (ST-45)

50-1. GENERAL.

a. The purpose of this test is to determine the spurious phase noise content of the LO's in the up and down converters.

b. This is an out-of-service test and requires an AO.

c. The LO phase noise is added to the signal carrier, and thus degrades the performance of phase modulated transmissions.

d. This test requires the use of an extremely low phase noise signal source. The measurement does not recognize the source of the noise and, consequently, it may result in the measurement of the noise on the signal source rather than the measurement of the noise added by the terminal.

NOTE: Do not substitute the required signal generator with one having excessive or unknown phase noise since the test results would be invalid.

e. Extreme care must be taken to avoid ground loops between the signal generator, the terminal, and the spectrum analyzer. Connecting the equipment solely through the outer conductor of the coaxial cables may render the test results invalid. Make certain that the terminal prime power supply and the test equipment prime power supply are connected to the same distribution transformer secondaries. This will provide common moding cancellation of the supply frequency components.

f. Do not use a spectrum analyzer that does not have a resolution of $\leq$10 Hz.

50-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

50-3. TEST EQUIPMENT REQUIRED.

a. Spectrum analyzer.

b. Signal generator.

50-4. TEST PROCEDURES.

a. Configure the terminal and test equipment as shown in figure 50-1.

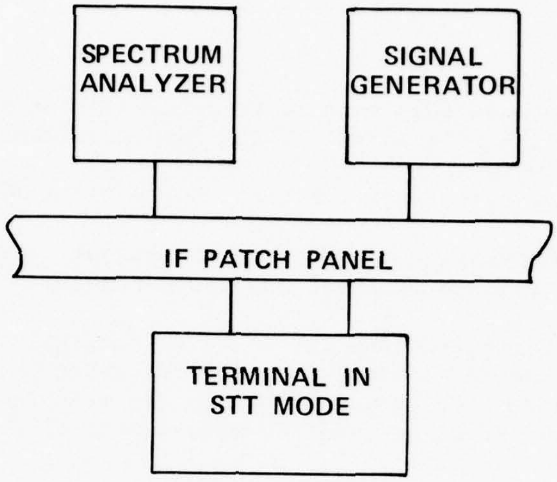


Figure 50-1. System phase noise test configuration.

b. Allow the signal generator and spectrum analyzer at least a 4-hour warmup and stabilization period before performing the test.

c. Tune the uplink and downlink converter to a convenient frequency to establish an STT loop. (Normal operating frequencies can be used.)

d. Adjust the uplink power for the highest C/kT achievable without causing danger to the para-amp. Saturation of the para-amp is acceptable for the purpose of this test.

e. Tune both the signal generator and the spectrum analyzer to 70 MHz.

f. Adjust the spectrum analyzer bandwidth (resolution) to 10 Hz (or less).

g. Adjust the spectrum analyzer scanwidth (dispersion) to 50 kHz/division.

h. Measure and record the noise level indication on the analyzer relative to the carrier level at frequencies displaced from the carrier by 0.05, 0.1, 0.5, 1, 5, 10, 50, and 100 kHz. Increase the analyzer bandwith to 100 Hz when it becomes necessary in order to determine the frequency displacement.

i. Measure and record single frequency signals on figure 50-2; USACC Form 460-R (Test).

j. Plot the recorded data on figure 8-7; USACC Form 396-R (Test) with the frequency on the horizontal axis referenced to 70 MHz. The db below carrier level should be plotted on the vertical axis.

k. Repeat paragraphs 50-4 h through j for different combinations of up and down converters if more than one of each are available.

<table>
<tr><td colspan="6">DATA SHEET
SYSTEM PHASE NOISE
(CCR 702-1-3)</td><td colspan="6">PAGE OF PAGES</td></tr>
<tr><td colspan="3">TERMINAL ID</td><td colspan="5">ADJUSTED C/kT db</td><td colspan="4">DATE (DAY, MONTH, YEAR)</td></tr>
<tr><td colspan="3">LINK NO.</td><td colspan="5">TERMINAL TYPE</td><td colspan="4">SPECIFICATION</td></tr>
<tr><td rowspan="2">UP CONVERTER NO.</td><td rowspan="2">DOWN CONVERTER NO.</td><td colspan="8">NOISE ENVELOPE RELATIVE TO CARRIER IN (db) OFFSET kHz</td><td colspan="2">SINGLE FREQ REL TO CARRIER</td></tr>
<tr><td>0.05</td><td>0.1</td><td>0.5</td><td>1</td><td>5</td><td>10</td><td>50</td><td>100</td><td>(kHz)</td><td>(db)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="12">COMMENTS</td></tr>
<tr><td colspan="6">TYPED NAME, GRADE, AND TITLE</td><td colspan="6">TEST ENGR SIGNATURE</td></tr>
</table>

USACC FORM 460-R (TEST)
1 MAY 77

Figure 50-2. System phase noise data sheet.

CHAPTER 51

DISPERSION GENERATOR RANGE AND THRESHOLD LEVEL (ST-46)

51-1. GENERAL.

a. The purpose of this test is to determine the operating range and the threshold level at which the dispersion generator engages.

b. This is normally an inservice test for those earth terminals that are equipped with a standby modulator. This is an out-of-service test for earth terminals not equipped with a standby modulator and an AO is required.

51-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

51-3. TEST EQUIPMENT REQUIRED.

a. RMS voltmeter.

b. Selective voltmeter.

c. Test oscillator.

d. Test set noise loading.

e. Frequency counter.

51-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 51-1 and allow for a 30-minute warmup and stabilization period.

b. Set the input dbm - volt attenuator to CAL and the input impedance switch to CAL - 75-ohm on the FSVM. Set the selectivity switch to narrow and the function main tuning mode selector in the lock position. Fine adjust the main tuning megacycles control until the locked lamp illuminates at 1 MHz. Adjust the incremental kHz dial for a peak meter indication. It may be necessary to adjust the cursors until the hair-line indicators are centered on the respective 1 MHz and zero kHz dial graticules.

c. Adjust the audio oscillator for a 1-kHz test tone output and inject the test tone into the input of a VF channel that lies in the center of the transmit baseband frequency spectrum. The input test tone level should be equal to the recommended manufacturer's engineered level.

d. Measure and record the test tone level with the FSVM connected to the input of the modulator on figure 51-2; USACC Form 461-R (Test) Record the test tone level measured at TP-1 on the deviator module and configure the test equipment as illustrated in figure 51-3.

e. Adjust the noise generator output level to obtain a level 10 db higher than the test tone level measured at TP-1 on the deviator module (consider all impedance irregularities).

f. Decrease the output of the noise generator in 2-db steps by adjusting the output step attenuators and wait 10 seconds prior to recording the level indicated on the true rms voltmeter connected to TP-1 on the deviator module (fig. 51-2; USACC Form 461-R (Test).

g. Continue to decrease the noise generator output level in 2-db steps until the noise generator output is equal to that of the test tone measured in paragraph 51-4d above.

h. The loading level at the input to the deviator module should remain constant ±0.5 db in respect to recommended CCIR loading levels below. (Input loading levels that exceed those stated below are not of interest during this measurement.)

CHANNEL CAPACITY	LOADING LEVEL (dbm0)
12	3.3
24	4.5
36	5.2
48	5.7
72	6.4

i. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

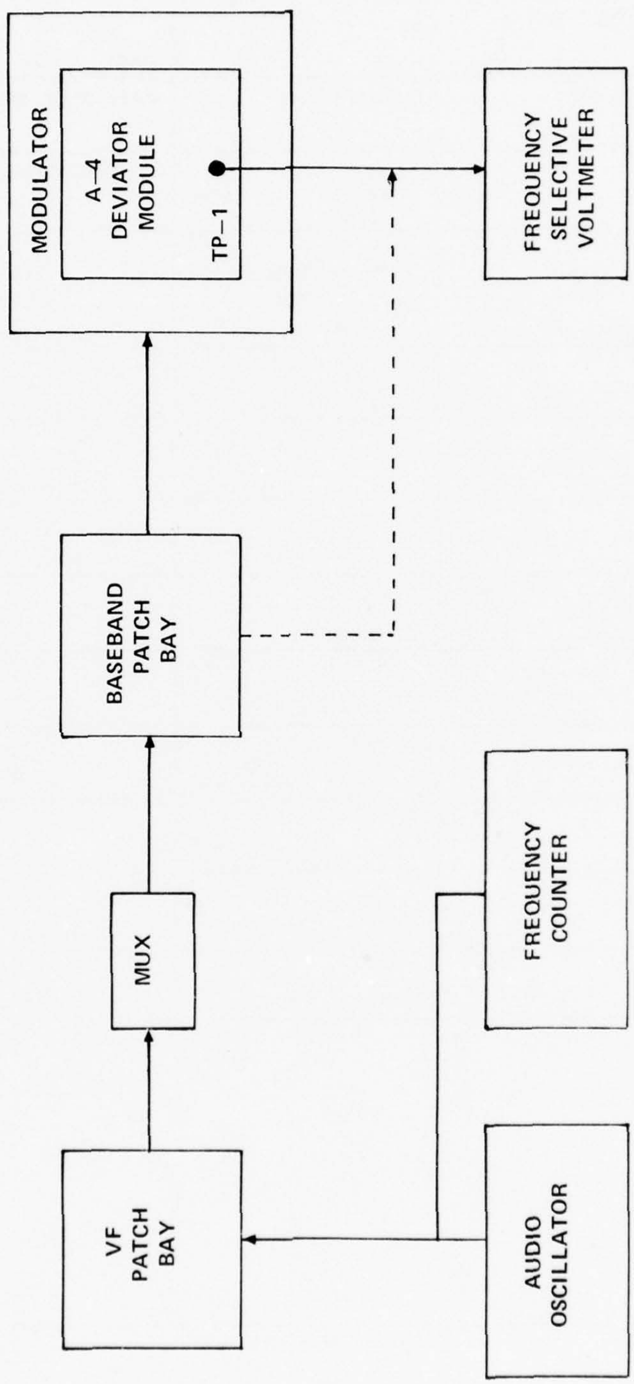


Figure 51-1. Dispersion generator (calibration) test configuration.

DISPERSION GENERATOR RANGE AND THRESHOLD LEVEL (CCR 702-1-3) DATA SHEET			PAGE OF PAGES
TERMINAL ID	MODEM ID	CHANNEL CAP	DATE (DAY, MONTH, YEAR)
TT IN CHAN NO. dbm	TT IN dbm	TT@TP–1 dbm	SPECIFICATION
NOISE GEN OUT (dbm)	TP–1 (dbm)	NOISE GEN OUT (dbm)	TP–1 (dbm)
COMMENTS			
TYPED NAME, GRADE, AND TITLE		TEST ENGR SIGNATURE	

USACC FORM 461-R (TEST)
1 MAY 77

Figure 51-2. Dispersion generator range and threshold level data sheet.

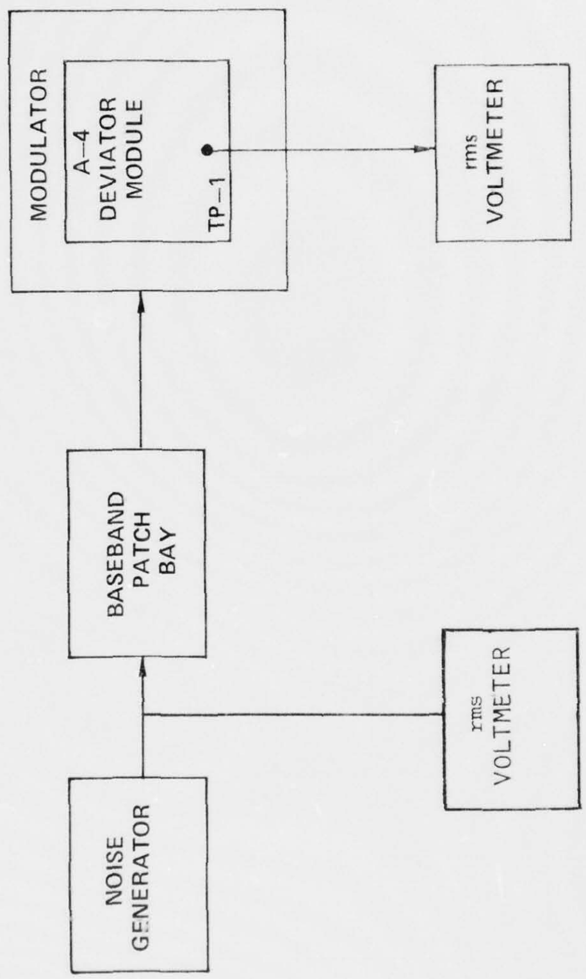


Figure 51-3. Dispersion generator test configuration.

Preceding Page Blank - Filmed

CHAPTER 52

UPLINK AND DOWNLINK EQUIPMENT NET FREQUENCY RESPONSE (ST-47)

52-1. GENERAL.

a. The purpose of this test is to measure the uplink and downlink equipment net frequency response.

b. On an active system, this is an out-of-service test requiring 2 to 4 hours of AO depending on system configuration.

52-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

52-3. TEST EQUIPMENT REQUIRED.

a. Sweep generator.

b. Plug-in (0.4 to 110 MHz).

c. Plug-in (4 to 8 GHz).

d. Frequency counter.

e. Power meter.

52-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 52-1. Energize the equipment and allow for a 30-minute warmup and stabilization period.

b. Adjust the sweep generator output power for zero dbm at a frequency of 70 MHz as read on the power meter with the output terminated into a resistor equal to the input impedance of the IF patch. The external attenuator, as shown in figure 52-1, should be adjusted to zero db attenuation during calibration. Manually adjust the sweep frequency of the generator between 50 and 90 MHz while observing the power meter to insure that the generator output level is flat over the 50- to 90-MHz range. Once the calibration has been verified, disconnect the load resistor and connect the sweep generator output through the attenuator to the IF patch/up converter input.

c. Tune the sweep generator to 70 MHz and the up converter to 7920 MHz. Record the power level as read on the power meter connected at the output of the PA.

d. Without changing the power level, adjust the sweep generator frequency in 4-MHz steps until the entire 50- to 90-MHz bandpass has been tested.

e. Tune the up converter to the frequencies listed below and repeat paragraph 52-4d for each frequency listed.

FREQUENCY (MHz)			
7920	8060	8200	8360
7960	8100	8240	8400
8000	8120	8280	
8020	8160	8320	

f. Configure the test equipment as illustrated in figure 52-2. Switch RF plug-in units on the sweep generator and tune the generator for a manual swept output frequency of 7270 MHz at a power level of zero dbm.

g. Adjust the WG attenuator to 50 db and record the level indication on the power meter at the output of the selected down converter.

h. Repeat paragraph 52-4 f and g in 4-MHz steps until a bandwidth of 40 MHz has been tested (20 MHz above and below the center frequency).

i. Repeat paragraphs 52-4 f through h at the frequencies listed below.

FREQUENCY (MHz)			
7310	7530	7650	7750
7350	7570	7690	7770
7390	7610	7730	

j. In the event that trunk jacks are available, the net frequency response may be tested by employing the automatic swept frequency technique. This method will reduce the amount of AO time required to complete this test.

k. Record the data collected on figure 6-4; USACC Form 351-R (Test).

l. Plot a curve on figure 8-7; USACC Form 396-R (Test).

m. Summarize the test results on figure 6-4; USACC Form 351-R (Test).

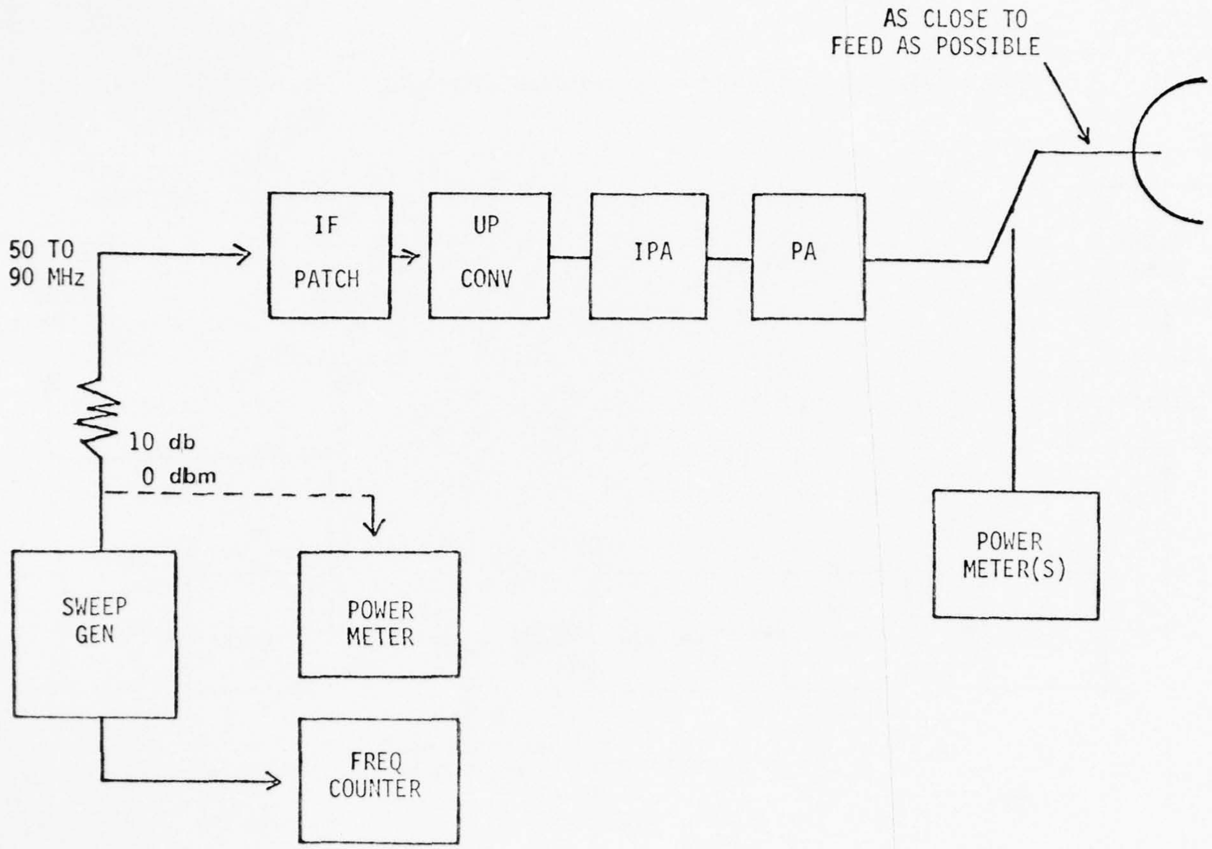


Figure 52-1. Frequency response (uplink) test configuration.

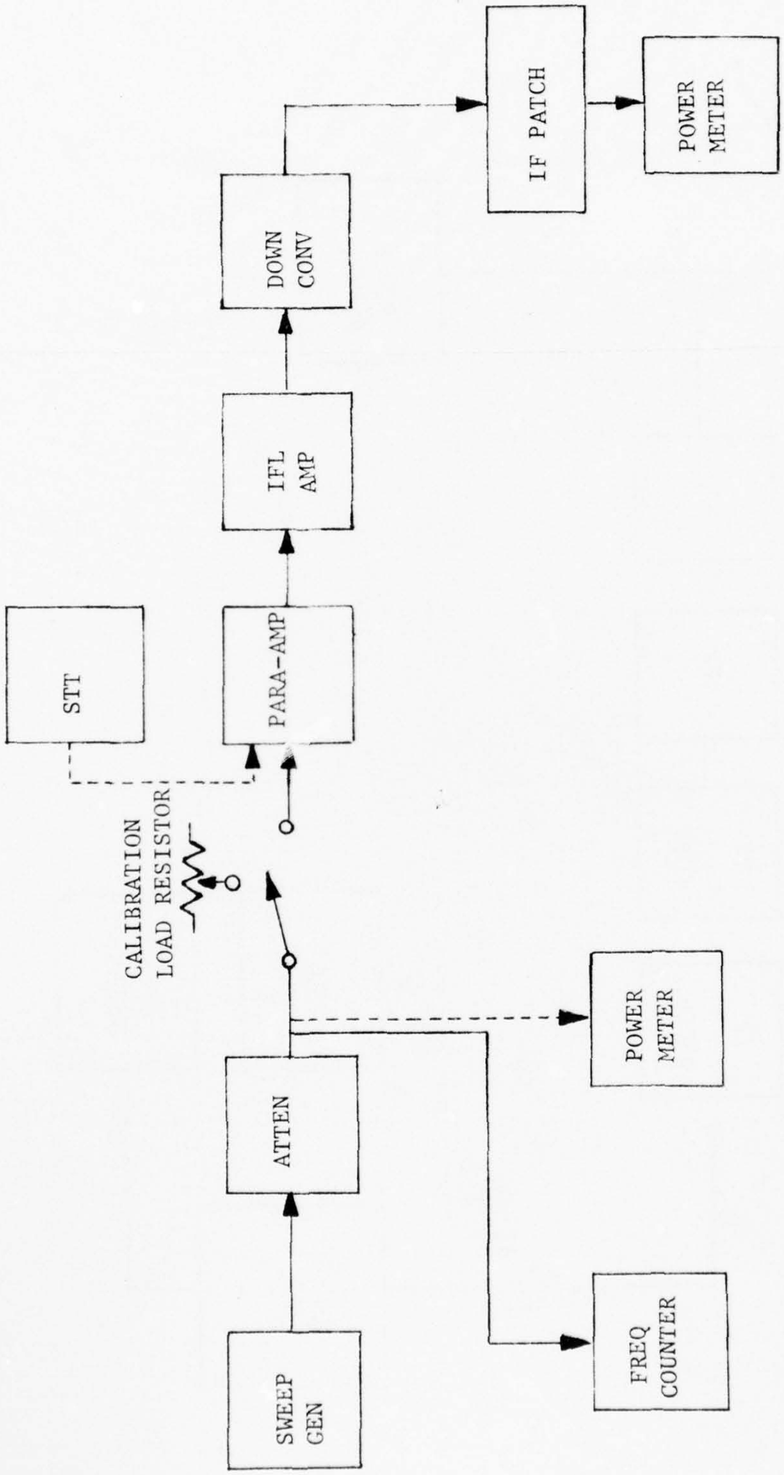


Figure 52-2. Frequency response (downlink) test configuration.

CHAPTER 53

RELATIVE/ACTUAL AMPLITUDES AND FREQUENCIES OF SPURIOUS EMISSIONS

53-1. GENERAL.

a. The purpose of this test is to provide the techniques for measuring the relative/actual amplitudes and frequencies of spurious or extraneous emissions by means of attenuator substitution.

b. This procedure is applicable to ST-16 and ST-20 and should be performed within the frequency bandwidth of the device under test. Up and down converters -- assigned channels ±20 and ±62.5 MHz.

c. Normally this is an inservice test. However, an AO will be required for those earth terminals in which redundant or standby capabilities are not available.

53-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

53-3. TEST EQUIPMENT REQUIRED.

a. Power meter.

b. Frequency counter.

c. SHF signal generator.

d. VHF signal generator.

e. Spectrum analyzer.

53-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 53-1 and allow for a 30-minute warmup and stabilization period. Insure that the IF attenuators on the spectrum analyzer are set to the IN position.

b. An up converter operating at 8150 MHz (F_c) employing a 40-MHz bandpass will be used as an example.

c. Insure that the up converter to be tested is off-line. Tune the VHF generator to 70 MHz and adjust the output power level to zero dbm.

d. Configure the test equipment as illustrated in figure 53-2 and tune the frequency control on the spectrum analyzer until the 8150-MHz signal is centered on the analyzer display scope. Adjust the gain and attenuation controls as required to obtain a suitable reference level.

NOTE: The spectrum analyzer should be set up for a disposition of not less than 60 MHz (6 MHz per cm) and operated in the logarithmic mode.

e. Adjust the frequency dial 30 MHz above and below 8150 MHz several times while observing the spectrum analyzer display for spurious emissions. Because of their relatively low levels, it may be necessary to remove some attenuation.

f. If a spurious signal is seen, remove the IF attenuation until the spurious signal is equal to the amplitude of the reference level established in paragraph 53-4d above. The arithmetic difference between the original and new IF attenuation setting in db is equal to the ratio of spurious signal to reference carrier level.

g. An alternate method of measuring the relationship of reference carrier to spurious signal amplitude is as follows:

(1) Tune the SHF signal generator to 8150 MHz at an output power level of zero dbm. Insure that the RF attenuator is calibrated for zero db attenuation while the output power level is zero dbm.

(2) Adjust the spectrum analyzer dispersion control to present both the spurious and reference signal on the scope (fig. 53-3).

(3) Mark the amplitude of each signal on the scope display with a grease pencil. Configure the test equipment as illustrated in figure 53-4.

(4) Adjust the SHF signal generator attenuator until the signal amplitude is equal to that of the reference carrier and record the attenuator setting.

(5) It may be necessary to recalibrate the SHF signal generator's output attenuator and power level.

(6) The frequency counter will indicate the frequency of the spurious signal. The arithmetic difference between the SHF signal generator attenuator setting in paragraph 53-4g(4) above and the new setting reflect the relative strength of the spurious signal to the carrier in db.

(7) In certain instances, it may be necessary to express extraneous signal levels in dbm. This is accomplished by noting the SHF signal generator attenuator setting and algebraically subtracting the setting from zero dbm. For example:

Attenuator set at 35 db

0 dbm - 35 db = -35 dbm - (40) db = -75 dbm

40 db is value of external attenuator

NOTE: In some cases, the 40-db attenuator may have to be replaced with a lower value in order to obtain a suitable display.

h. Photograph the display and mount the photographs on figure 12-5; USACC Form 397-R (Test).

i. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

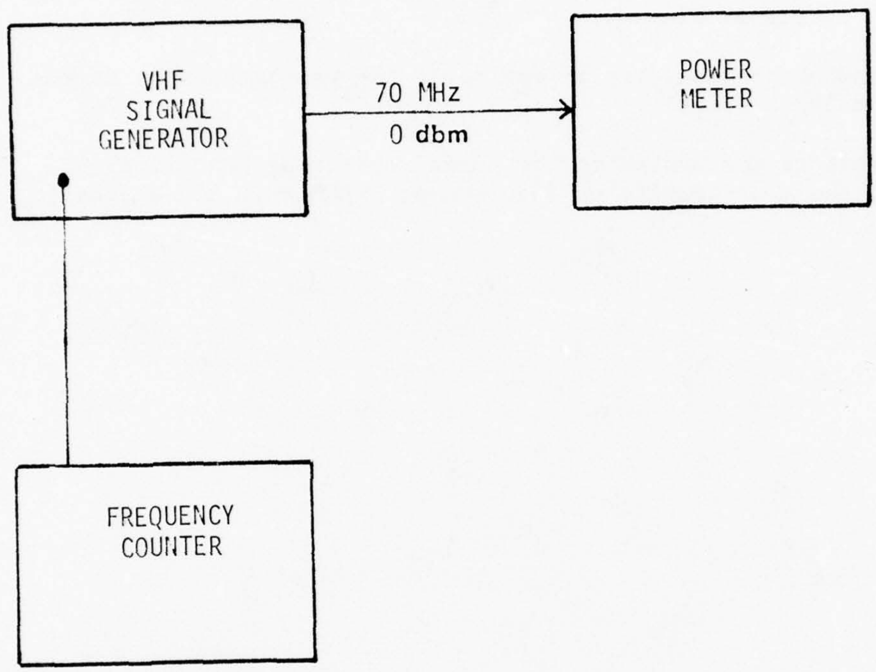


Figure 53-1. VHF signal generator output calibration.

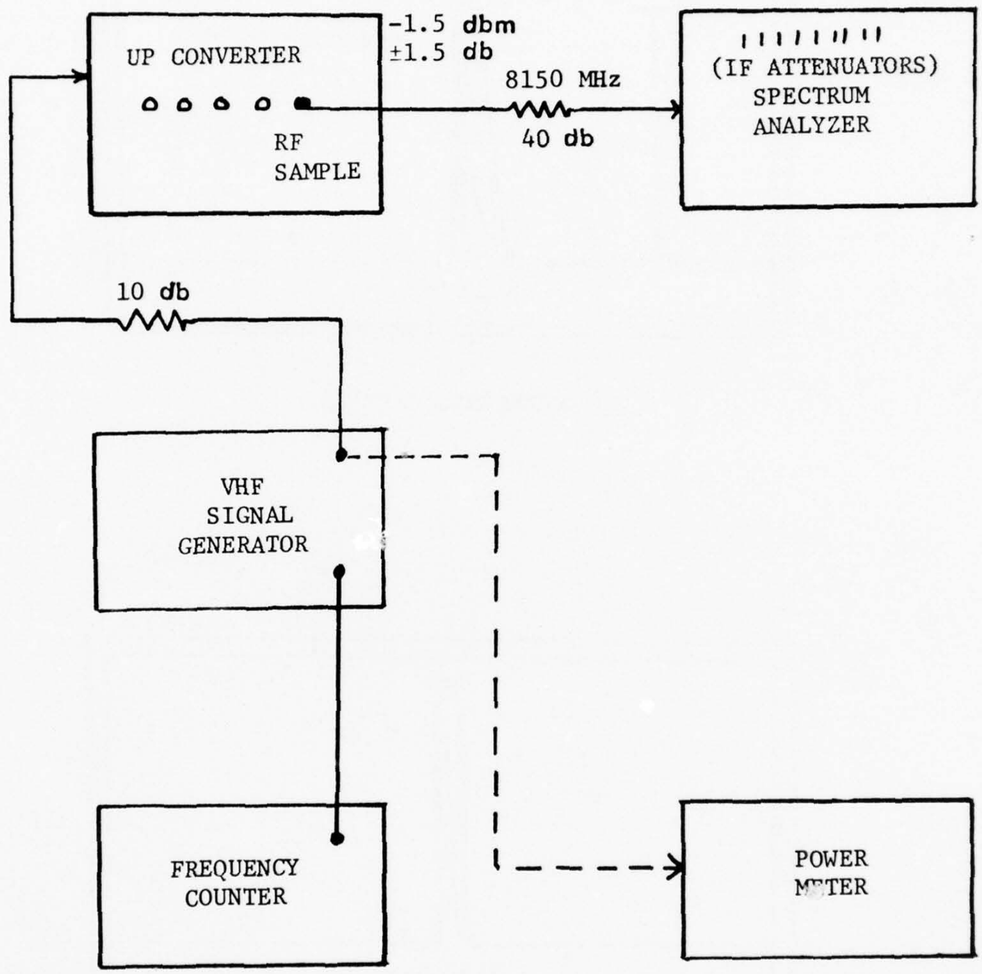
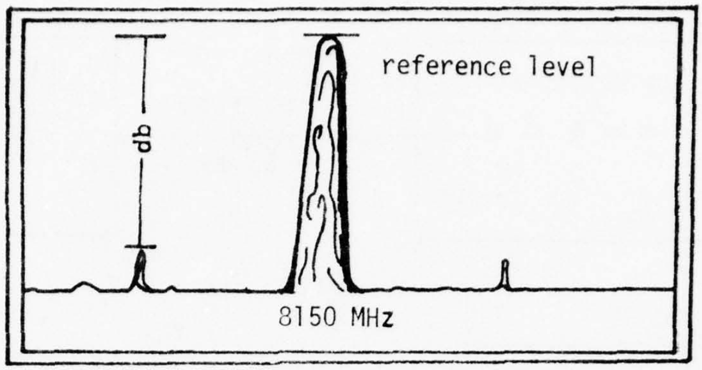
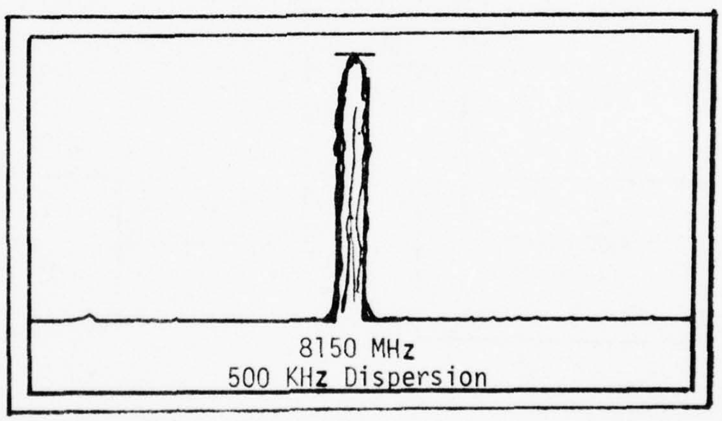


Figure 53-2. Spurious emissions amplitude test configuration.



a. REFERENCE CARRIER



b. REFERENCE CARRIER PLUS SPURIOUS

Figure 53-3. Typical scope displays of reference carrier to spurious signal amplitude.

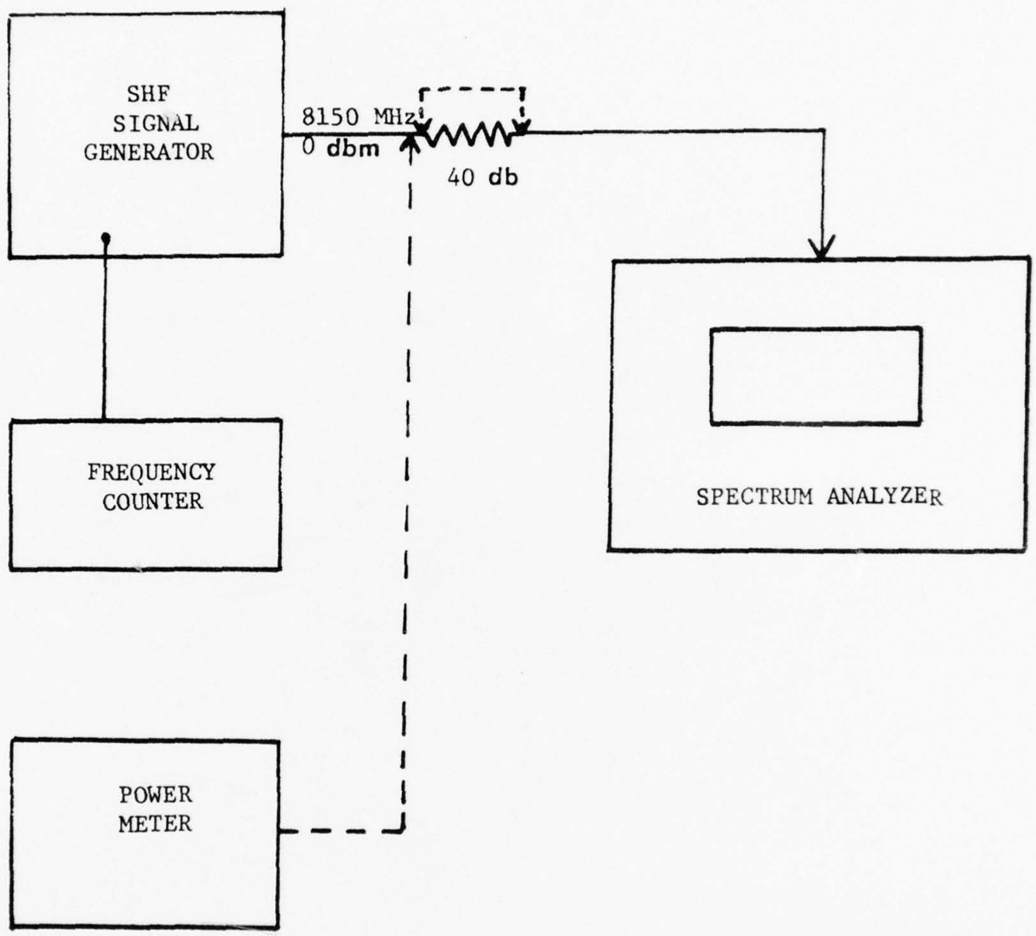


Figure 53-4. Relative/actual amplitudes and frequencies of spurious emissions equipment calibration.

Preceding Page Blank - NOT Filmed

CHAPTER 54

EARTH TERMINAL EQUIPMENT NOISE TEMPERATURE

54-1. GENERAL.

a. The purpose of this test is to provide a technique for measuring the noise temperature of the para-amp and receive IFLA by employing the Y-factor technique.

b. This procedure is applicable to ST-8 and ST-12. Normally this is an inservice test. However, an AO will be required for those earth terminals that do not have redundant capabilities.

54-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

54-3. TEST EQUIPMENT REQUIRED.

a. Mixer.

b. Adapter.

c. Amplifier.

d. Noise generator.

e. Receiver.

f. Signal generator.

g. Power meter.

h. Frequency counter.

54-4. TEST PROCEDURES.

a. Energize the test equipment and allow for a 30-minute warmup and stabilization period.

NOTE: Use extreme caution when handling liquid nitrogen. Severe injuries will result if liquid nitrogen contacts the skin.

b. After the oven temperature on the noise generator has stabilized, fill the flask with liquid nitrogen. Initially violent boiling will occur, but will diminish as the flask wall temperature approaches the liquid nitrogen temperature.

c. Refill the flask after the nitrogen settles and allow for a 15 minute temperature stabilization of the cold load.

d. Tune the SHF generator to 7470 MHz and an output power level of zero dbm.

e. Configure the test equipment as illustrated in figure 54-1. Readjust the output power level of the signal generator until 0.5 ma is observed on the receiver crystal current meter.

f. Set the receiver's variable attenuator to 10 db. Note and record the crystal current meter indication on the appropriate test data sheet.

g. Disconnect the test cable and GR adapter from cold load and reconnect it to the hot load.

h. On the noise receiver, increase the attenuation to attain the same crystal current reading as outlined in paragraph 54-4f above. The difference between the attenuator setting in paragraph 54-4f above and the new setting is equal to the Y-factor in db. The Y-factor may be used to calculate the actual noise temperature in degrees K.

i. Repeat paragraphs 54-4 f through h three more times. Tune the SHF signal generator to 7220 and 7730 MHz and repeat paragraphs 54-4 d through i.

j. Measure the power losses on the cables and adapters that are connected between the input of the test device and the output of the noise source. This information will be used as correction factors. The cable losses in db should be subtracted from the NF in order to obtain accurate test results.

k. The NF may be calculated as follows:

$$NF = \frac{\frac{T_2}{T_o} - Y\frac{T_1}{T_o}}{Y-1}$$

where: $T_2 = 373.2^oK$

$T_1 = 77.3^oK$

$T_o = 290^oK$

Y = Y-factor expressed as power ratio

or

$$NF\ (db) = 10 \log \left(\frac{T_2 - T_{1Y}}{290\ (Y-1)} \right)$$

AD-A043 735 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA ARIZ F/G 17/2

PRODUCT ASSURANCE, OPERATIONAL QUALITY ASSURANCE, SATELLITE SYS--ETC(U)

MAY 77

UNCLASSIFIED ACC-CCP-702-2 NL

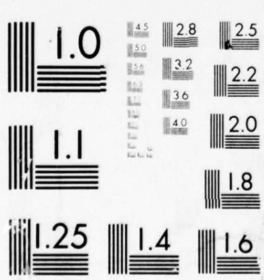
6 OF 7

AD

A043 735

6 OF 7

AD
A043735



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

l. In some cases it will be necessary to express measured results in terms of effective input noise temperature. The effective noise temperature, T_e, may be expressed as follows:

$$T_e = \frac{T_2 - T_1 Y}{Y-1}$$

where:

$T_2 = 373.2^{o}K$

$T_1 - 77.3^{o}K$

Y = Y-factor (power ratio)

m. Table 54-1 shows a few calculated NF's and noise temperatures respective to measured Y-factors. This table may be used by test team personnel when analyzing and summarizing the test results. The table assumes that the temperatures of the cold and hot loads are 77.3 degrees K and 373.2 degrees K, respectively.

n. Figure 54-2 shows the RF correction factor for losses between the actual terminations and the front panel connections caused by the conductivity of the transmission system between the two points. Figure 54-3 depicts error in NF as a function of error in the hot and cold temperatures. The worst case error should be used to calculate the actual NF or noise temperatures.

o. Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test).

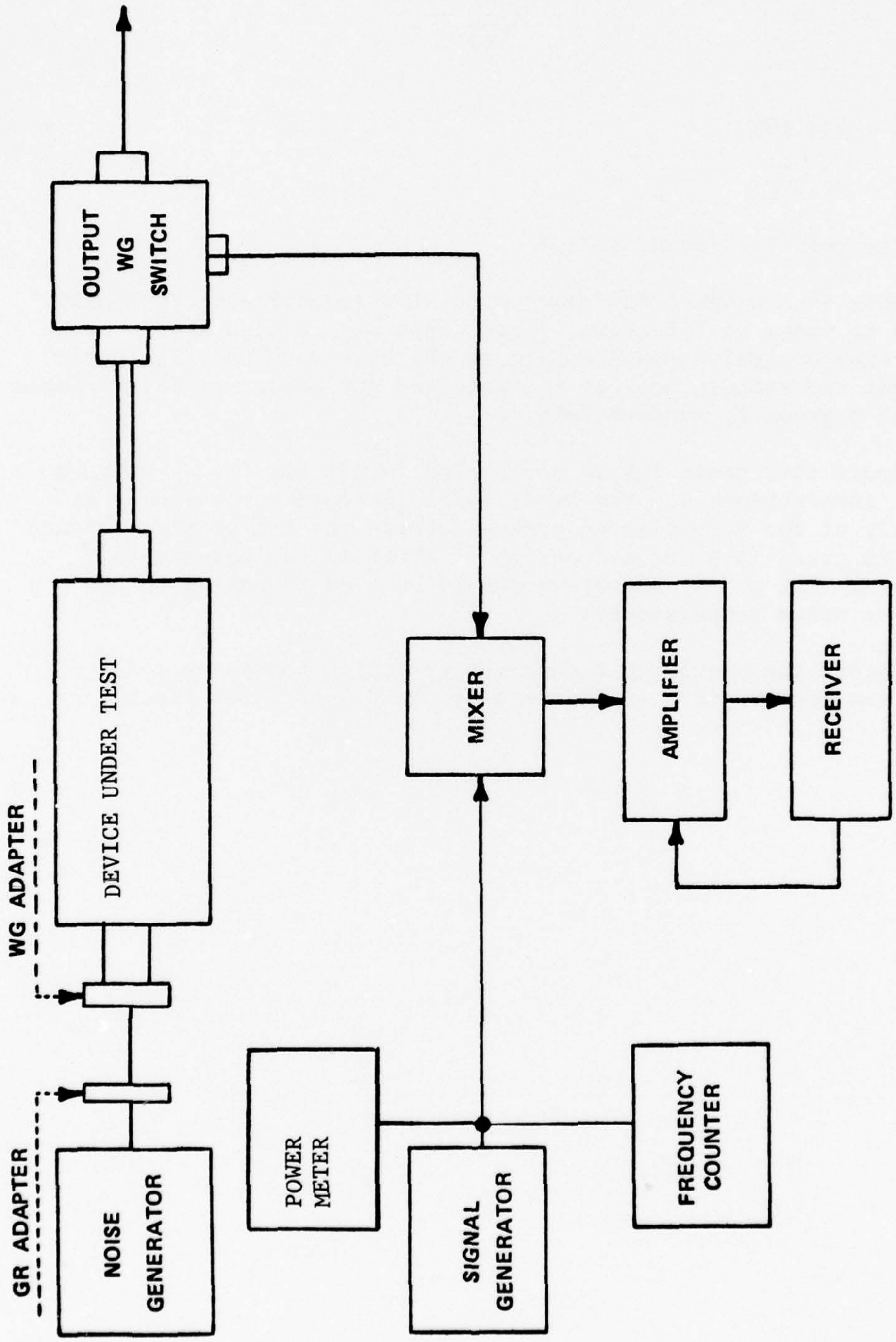


Figure 54-1. Equipment noise temperature test configuration.

Table 54-1. RF Correction Factor

Y-FACTOR (db)	NOISE FIGURE (db)	NOISE TEMPERATURE (°K)
10	0.7220	44.42
9	0.5532	34.68
8	0.3357	21.56
7	0.0531	3.52
6	0.3170	21.96
5	0.8131	59.55
4	1.4880	118.4
3	2.4520	220.0
2	3.9440	429.25
1	6.7090	1069.3
0.9	7.134	1622.6
0.8	7.161	1387.4
0.7	8.171	1622.8
0.6	8.823	1921.9
0.5	9.588	2348.0
0.4	10.554	3004.6

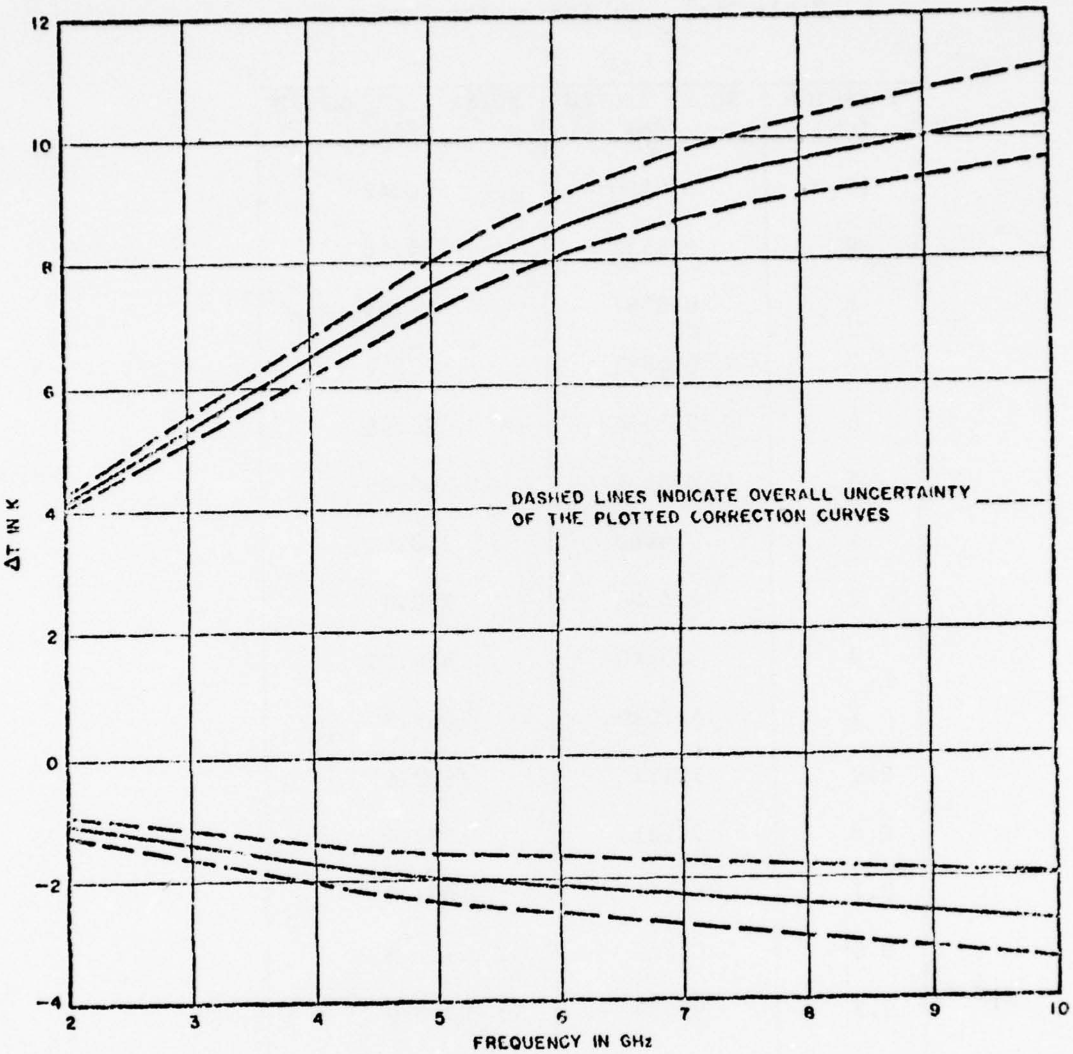


Figure 54-2. Corrections in hot and cold termination temperatures due to internal RF losses.

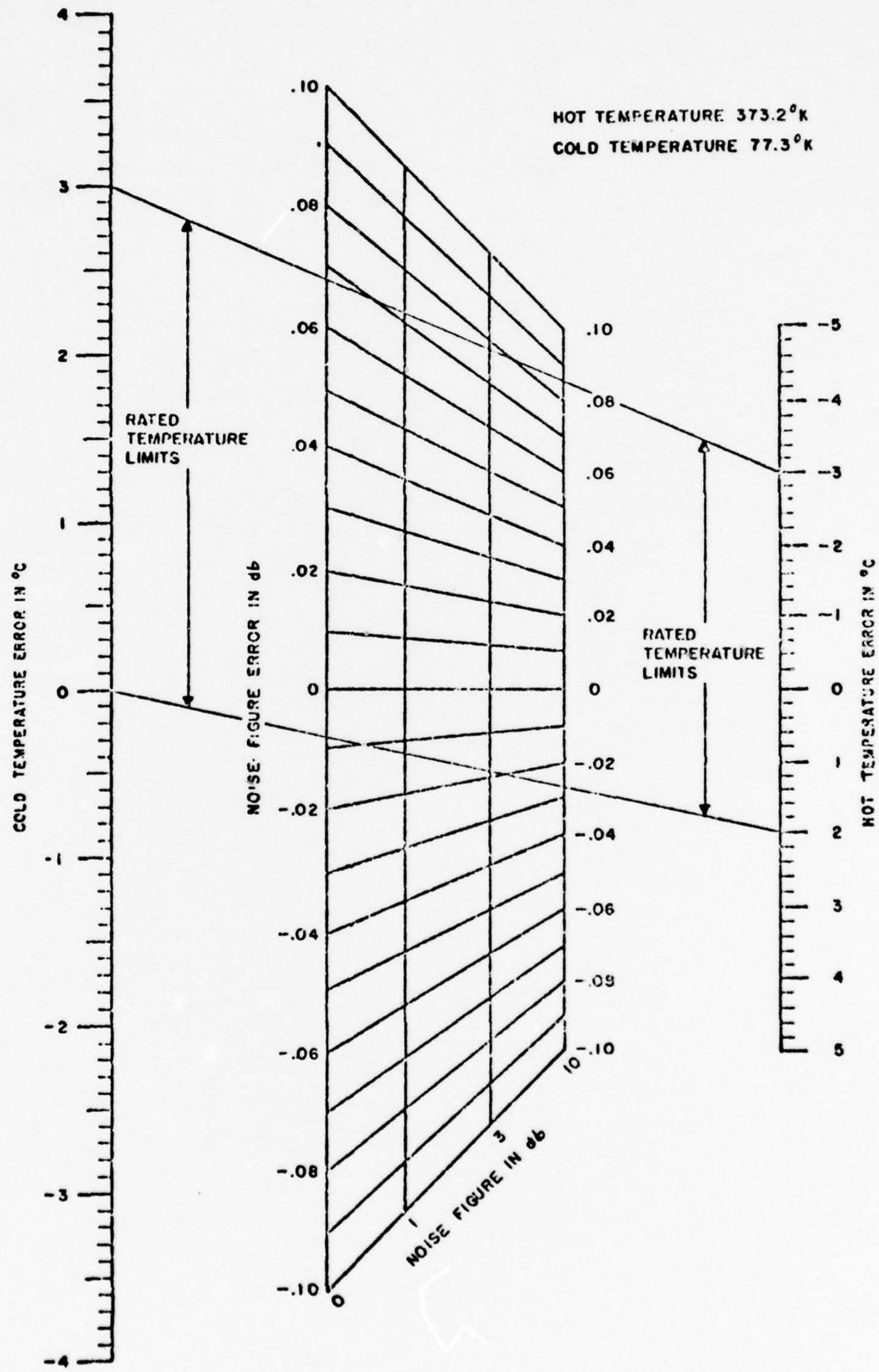


Figure 54-3. Determining error in NF as a function of error in hot and cold temperatures.

Preceding Page Blank - NOT FILMED

CHAPTER 55

VSWR AND RETURN LOSS

55-1. GENERAL.

a. The purpose of this test is to provide techniques for performing both VSWR and return loss measurements.

b. This procedure is applicable to ST-10, ST-14, ST-15, and ST-22.

c. Consideration should be given to the adaptability of test equipment to those listed in paragraph 55-3. In those cases where WG adapters are used between the test equipment and the devices under test, the manual or automatic return loss techniques should be employed in lieu of the slotted line technique.

55-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

55-3. TEST EQUIPMENT REQUIRED.

a. Slotted line.

b. Slotted line carriage.

c. Probe.

d. VSWR indicator.

e. SHF signal generator.

f. Directional coupler.

g. WG to coaxial adapters.

h. Sweep signal generator.

i. Microwave WG attenuator.

j. Microwave amplifier.

k. Detectors.

l. X-Y recorder.

m. Power meter.

n. WG short.

o. Frequency counter.

55-4. TEST PROCEDURES.

a. Automatic Mode.

(1) Configure the test equipment as illustrated in figure 55-1 and adjust the microwave attenuator to 30 db.

(2) Energize the test equipment and allow for a 30-minute warmup and stabilization period.

NOTE: It may be necessary to amplify the reflected signal by connecting the microwave amplifier in the test loop.

(3) Set up the sweep signal generator for the applicable frequency range shown below and adjust the output power level to zero dbm.

(a) Receive WG: 7.25 to 7.75 GHz.

(b) Para-amp's: 7.25 to 7.75 GHz.

(c) IFLA's: 7.25 to 7.75 GHz.

(d) Down converters: Any 40 or 125 MHz portion of 7.25 to 7.75 GHz.

(e) IPA's: 7.9 to 8.4 GHz.

(f) Antenna feed assembly: 7.9 to 8.4 GHz.

(4) Manually adjust the sweep generator and X-Y recorder as required to display the selected frequency range on the X-axis. Divide the frequency range by ten and identify each tenth of the bandwidth on the X-axis.

NOTE: The down converter will be tested at 40 or 125 MHz bandwidths respective to the assigned or normal operating channel.

(5) Adjust the RF attenuator to 25 db and the DC gain controls on the X-Y recorder to obtain a suitable deflection on the Y-axis.

(6) Adjust the sweep spread to 0.01 milliseconds and trigger the sweep generator.

NOTE: The pen should be in the down position.

(7) Adjust the microwave attenuator in 5-db steps and repeat paragraph 55-4a(6) until a setting of zero db is reached on the sweep signal generator (excluding adjust of the DC gain controls). Insure that the attenuator remains at zero db during the actual measurement.

(8) Disconnect the WG short and connect the test equipment to the device under test as illustrated in figure 55-2.

(9) Trigger the sweep signal generator. The test results obtained should be compared with the performance standards that are established in appendix B.

(10) In some instances the specifications are stated in VSWR. Therefore, it will be necessary to convert the return loss measurements to VSWR. The conversion can be accomplished by application of the following formula:

$$VSWR = \frac{1+ \frac{Lr}{20} \log^{-1}}{1- \frac{Lr}{20} \log^{-1}}$$

where:

VSWR = voltage standing wave ratio and Lr stands for return loss in db

b. Manual Mode.

(1) The downlink frequency bandwidth will be used for illustrative purposes.

(2) Configure the test equipment as illustrated in figure 55-3a for input measurements or 55-3b for output measurements and allow for a 30-minute warmup and stabilization period.

(3) Tune the SHF signal generator to 7500 MHz and adjust the output power level to -10 dbm as indicated on the power meter. The power meter should be connected to the coupling port of the forward power directional coupler.

(4) Connect the power meter to the coupling port of the reverse power directional coupler and record the power meter indication on the appropriate data sheet. The arithmetic difference in db between the forward and reverse power levels is equal to the return loss.

(5) Repeat paragraphs 55-4b (3) through (5) in 50-MHz steps until the bandpass of 7.25 through 7.75 GHz has been tested.

(6) Restore the system to the normal operating condition and summarize the test results on figure 6-4; USACC Form 351-R (Test). The VSWR may be computed as illustrated in paragraph 55-4a(10).

NOTE: The applicable bandwidth and intervals pertaining to specific C-E components are listed in paragraph 55-4a(4) above.

(7) Plot a frequency versus return loss curve on figure 8-7; USACC Form 396-R (Test).

c. Slotted Line Mode.

(1) Insure that a power level of zero dbm throughout the frequency range of 7.25 to 8.4 GHz will not damage the device under test. Information related to the maximum input levels is normally found in the applicable maintenance manuals.

(2) Configure the test equipment as illustrated in figure 55-4 and calibrate the test equipment IAW the respective operator's manual.

(3) A test frequency of 7500 MHz will be used as an example. After the test equipment has stabilized, tune the SHF signal generator to 7500 MHz at an output power level of zero dbm. Adjust the pulse rate controls for 1000 Hz and set the function switch to pulse. Insure that the function switch is in the square wave position.

(4) Adjust the slotted line handcrank until a peak (antinode) indication is noted on the SWR indicator. Calibrate the SWR indicator to read on the 1-SWR meter range.

(5) Adjust the slotted line handcrank until a null (node) is observed on the SWR meter. Record the measured VSWR as indicated on the SWR meter on the appropriate data sheet.

(6) Repeat paragraphs 55-4c (4) and (5) as applicable for bandwidth at the test frequency steps listed below.

BANDWIDTH (MHz)	STEPS (MHz)
500	50.0
125	12.5
50	5.0
40	5.0

(7) Plot a return loss or VSWR versus frequency curve on figure 8-7; USACC Form 396-R (Test) and summarize the test results on figure 6-4; USACC Form 351-R (Test). Once the VSWR of a device has been determined, the return loss in db can be calculated by:

$$RL = 20 \log \frac{1 + VSWR}{1 - VSWR}$$

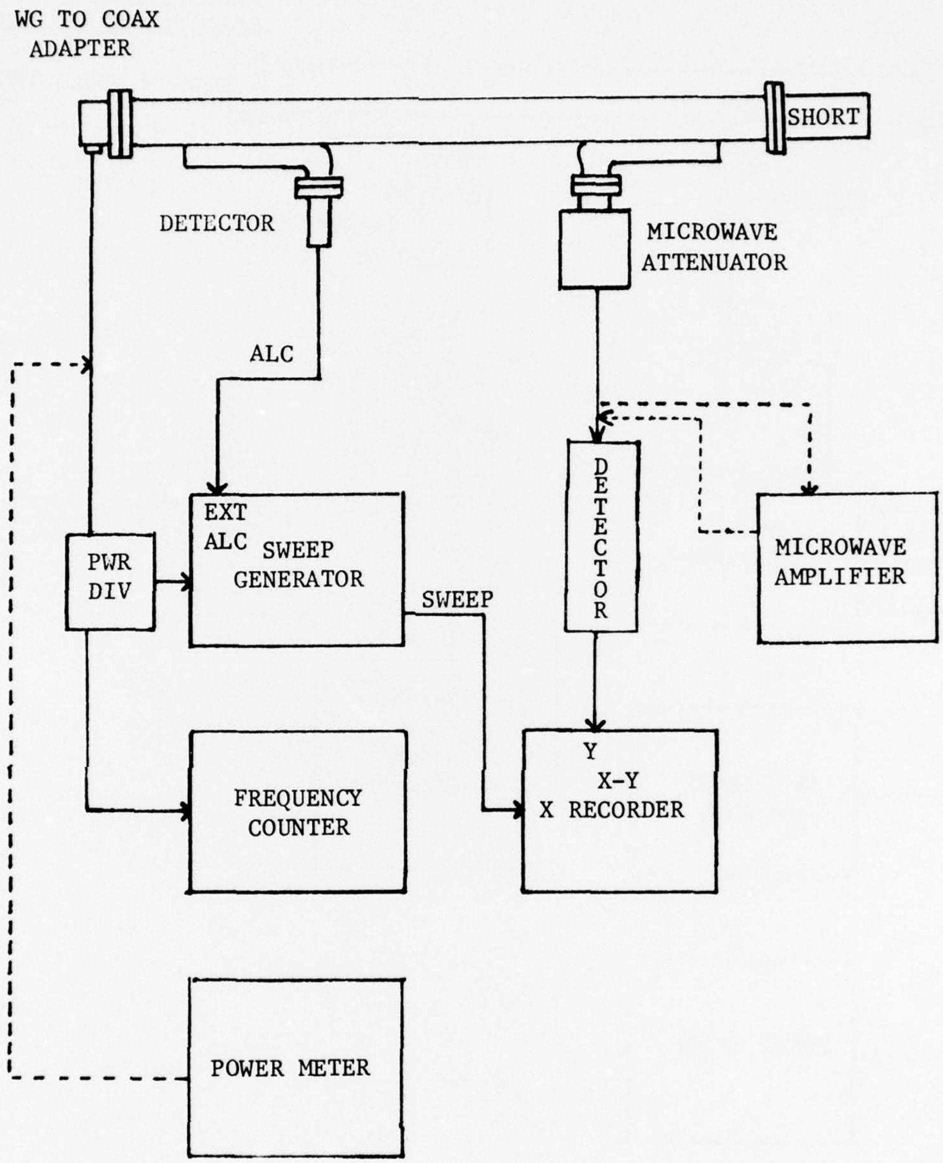


Figure 55-1. Automatic return loss equipment calibration.

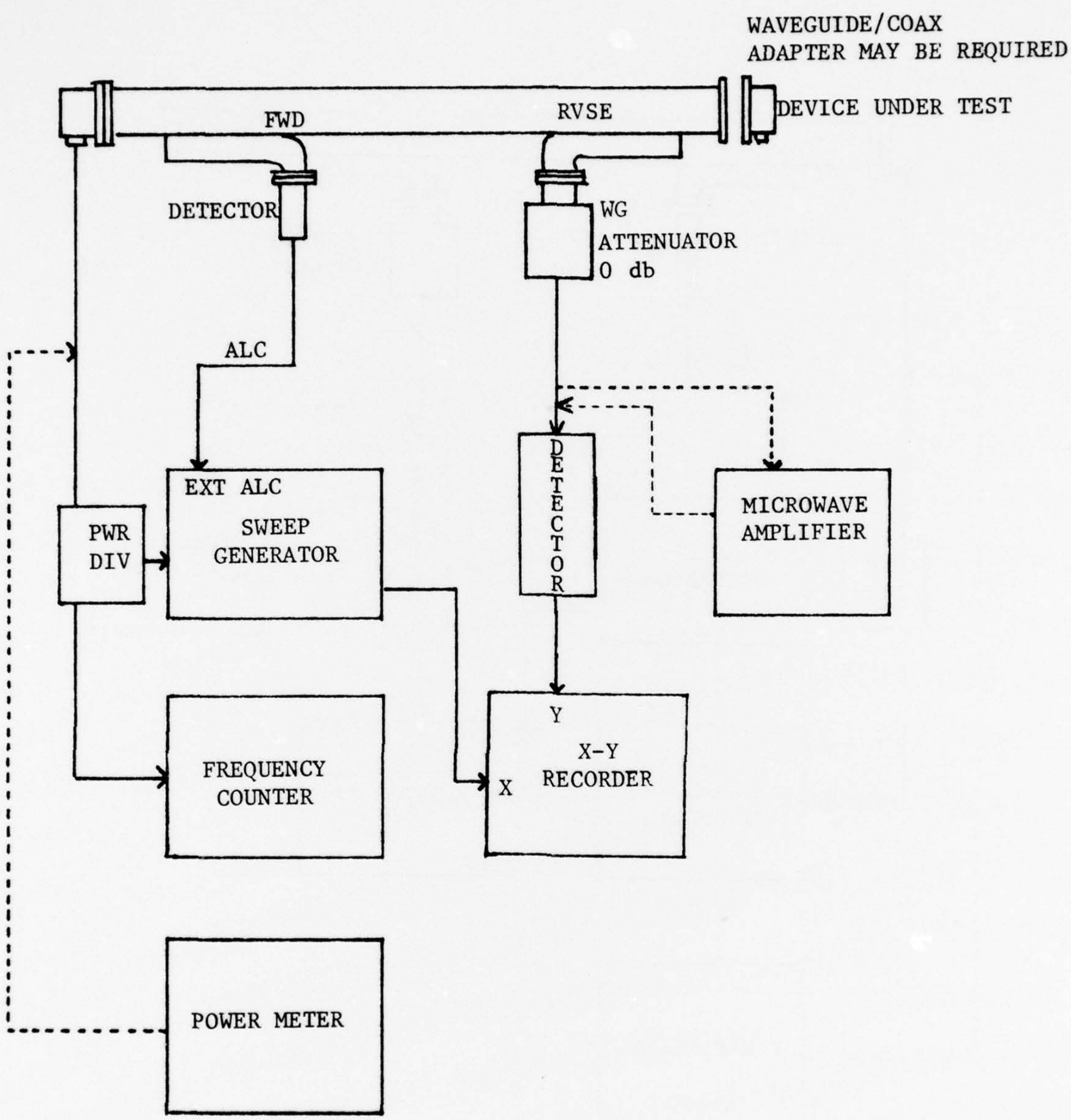
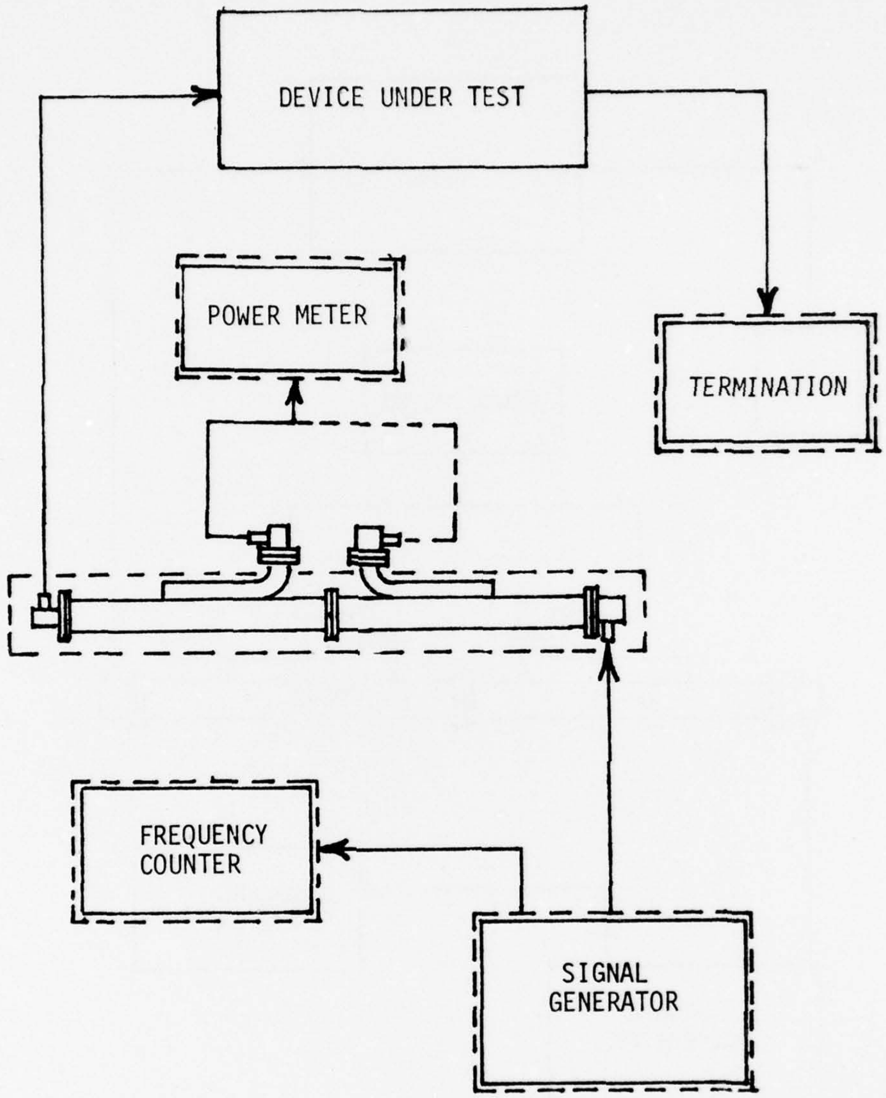
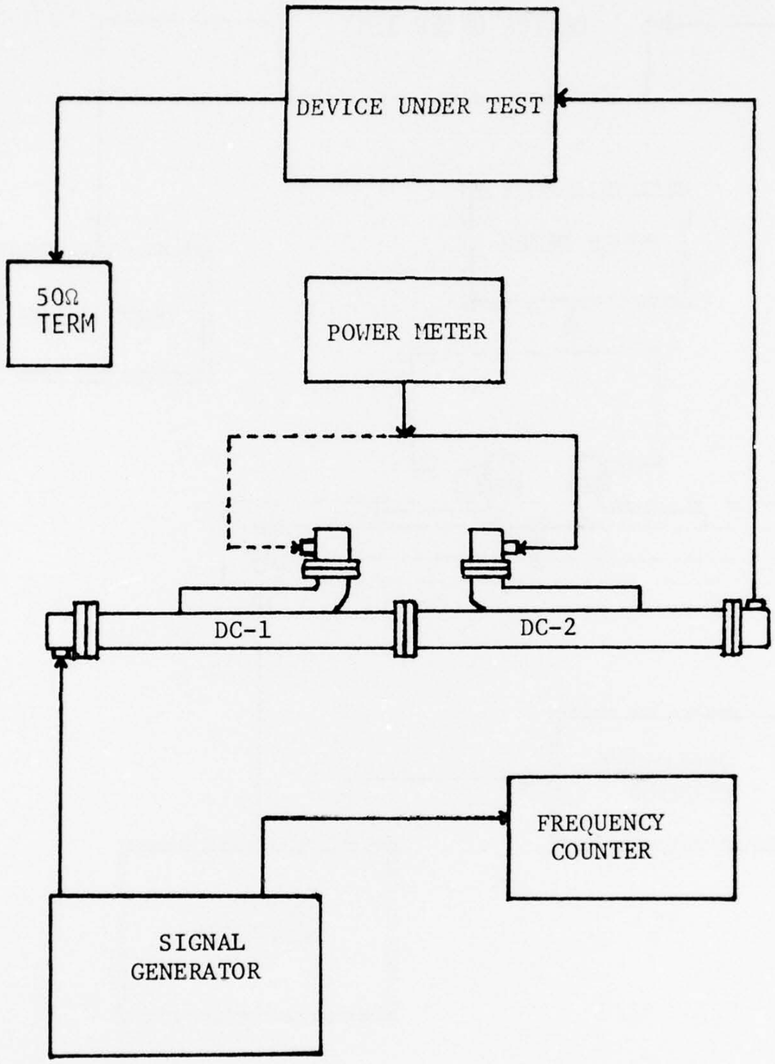


Figure 55-2. Automatic return loss test configuration.



a. INPUT

Figure 55-3. Return loss (input/output) test configuration.



b. OUTPUT

Figure 55-3. Return loss (input/output) test configuration. (continued)

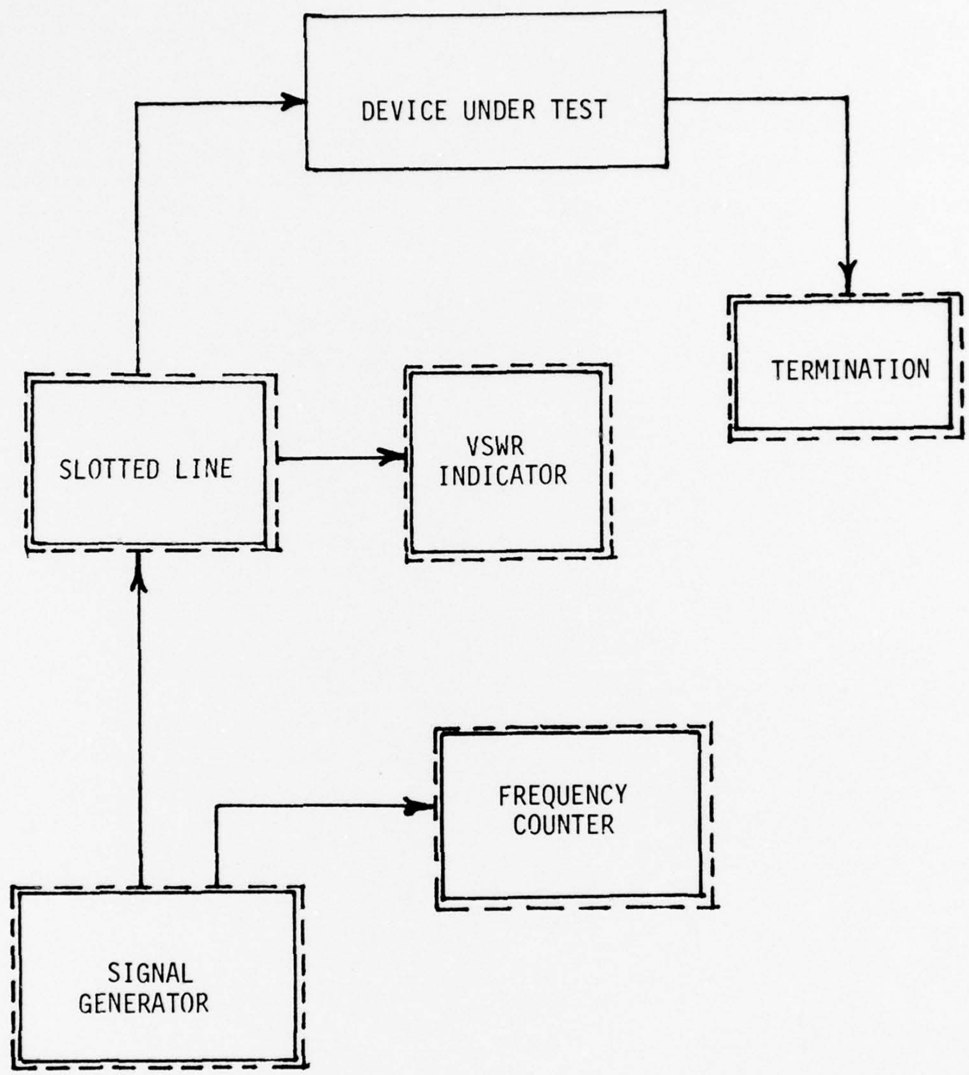


Figure 55-4. VSWR test configuration.

Preceding Page BLANK - NOT FILMED

CHAPTER 56

RECEIVE C/kT RATIO

56-1. GENERAL.

a. The purpose of this test is to provide a technique for measuring C/kT ratio. The accuracy of this technique is ±1.0 db.

b. This procedure is applicable to ST-27 and ST-34. All modulation must be removed to obtain accurate results. The wideband digital phase shift keying and spread spectrum modems should be transmitting a space and be configure for narrowband operation.

c. In order to measure a communications signal C/kT ratio, an AO is required since modulation must be removed.

56-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits delineated in appendix B.

56-3. TEST EQUIPMENT REQUIRED.

a. VHF signal generator.

b. FSVM.

c. Frequency counter.

d. Power meter.

e. UHF mixer.

56-4 TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 56-1. Insure that the down converter is tuned to the frequency of the selected carrier to be measured.

b. Energize the test equipment and allow for a 30-minute warmup and stabilization period.

c. Calibrate the VHF generator for an output power level of zero dbm at 70 MHz.

d. Tune the FSVM or wave analyzer (WA) to 1 MHz and set to the appropriate bandwidth (FSVM: 3.1 kHz, wave analyzer: 3.0 kHz). Set the input impedance to 600-ohms termination.

e. Fine tune the frequency control of the FSVM or WA to obtain a peak indication at 1 MHz. Record the indication on the appropriate data sheet.

f. Tune the FSVM to 1.5 MHz and record the meter indication. The difference between the readings in paragraphs 56-4 e and f in db plus 36.77 db (wave analyzer) or 36.91 db (FSVM) is equal to the receive C/kT ratio defined in db/Hz.

g. The information shown below concerns the deviation of the 36.77 db correction factor.

Bandwidth of the WA 3000 Hz
($10 \log BW_{Hz} = 10 \log 3000 = 34.77$ db)

where:

average to rms conversion factor is -1.0 db

mixer fold-over conversion factor is 3.0 db

total = 36.77 db

NOTE: 3.1 kHz BW should be used for calculations when employing the FSVM.

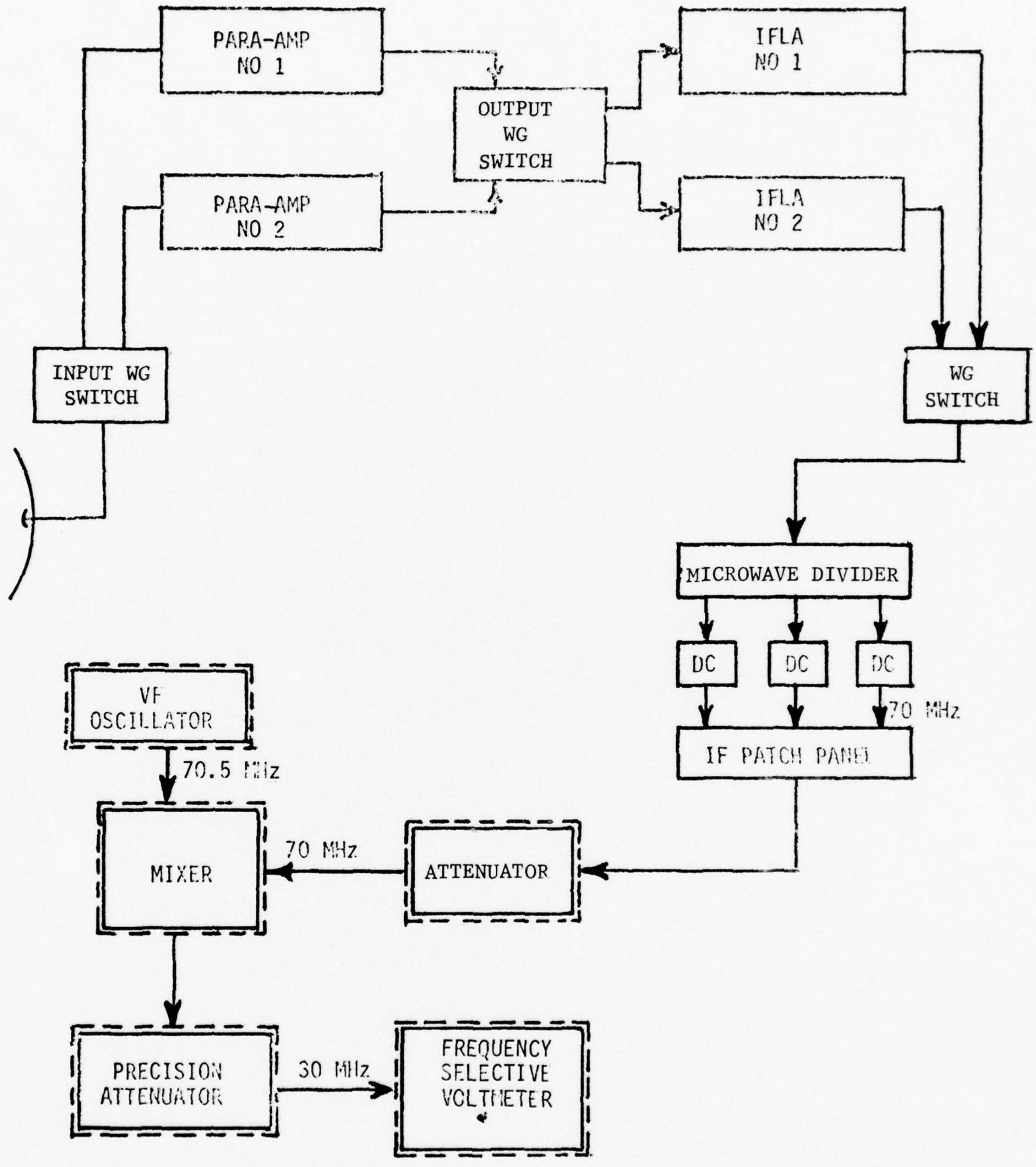


Figure 56-1. Receive C/kT ratio test configuration.

Preceding Page Blank - NOT FILMED

CHAPTER 57

INSERVICE CUSTOMER LEVELS (T-3)

57-1. GENERAL. The purpose of this test is to measure and evaluate the voice channel traffic signal levels of customer-provided voice, voice frequency carrier terminal (VFCT), data, and other types of message signals. This test must be performed using bridging (monitoring) measuring techniques to preclude affecting customer service.

57-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

57-3. TEST EQUIPMENT REQUIRED.

a. AC voltmeter.

b. Balanced/unbalanced transformer.

c. FSVM.

d. Spectrum display unit.

e. Transmission measuring set.

57-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 57-1.

b. Record the applicable data at the top of figure 57-2; USACC Form 462-R (Test). Record the design impedance at each test point, balanced or unbalanced condition, and the equipment design referenced test tone power level. Also, list the correct signal level, relative to the reference test tone power level, and the absolute power at each test point.

c. In sequence, connect the voltmeter through the transformer (if required) to the monitor jacks on --

(1) Primary patch bay: TP-1 (xmit), TP-12 (rec).

(2) Circuit equal level patch bay: TP-2 (xmit), TP-11 (rec).

(3) Baseband high frequency distribution frame: TP-6 (xmit), TP-7 (rec).

Measure the circuit signal level and record it on figure 57-2; USACC Form 462-R (Test). Compute the deviation between the correct circuit level and the measured circuit level. Record the results on figure 57-2; USACC Form 462-R (Test).

d. Connect the FSVM, (in bridging mode) to TP-6 and TP-7 as shown in figure 57-1. Set the impedance switch at the same value as the test point impedance. Set the FSVM in the wide (3-kHz bandwidth) position, insuring the entire 3-kHz channel is included. Record the measured circuit levels on figure 57-2; USACC Form 462-R (Test).

e. Using the spectrum display unit, monitor the frequency spectrum both across the baseband signal spectrum and adjacent to the signal at TP-6 and TP-7. Note any excessively high signal levels and notify site personnel to take immediate corrective action. Record any remaining high signal levels on figure 57-2; USACC Form 462-R (Test) and mount photographs on figure 12-5; USACC Form 397-R (Test).

f. Report all measured level deviations of 2 db or more in excess of the specified correct signal level to site personnel. Summarize test results on figure 6-4; USACC Form 351-R (Test).

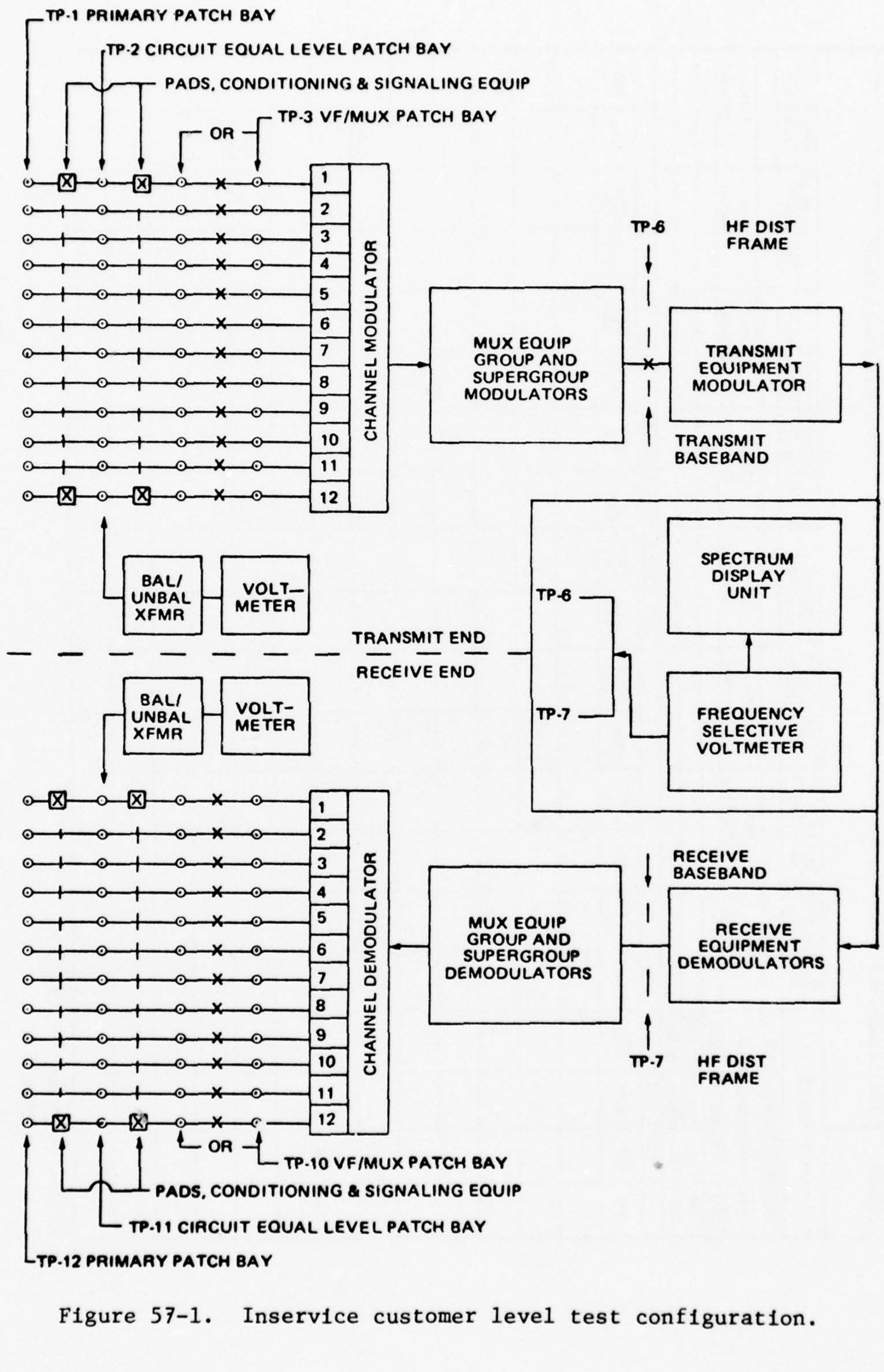


Figure 57-1. Inservice customer level test configuration.

DATA SHEET		INSERVICE CUSTOMER LEVELS (CCR 702-1-3)														PAGE OF PAGES DATE (DAY, MONTH, YEAR)			
LINK NO.		STATION UNDER TEST														TEST ENGR SIGNATURE			
TEST POINTS				PRIMARY PATCH BAY				EQ LVL CIR PATCH BAY				VF/MUX PATCH BAY				BB HF DIST FRAME			
				TP-1 (XMIT)		TP-12 (REC)		TP-2 (XMIT)		TP-11 (REC)		TP-3 (XMIT)		TP-10 (REC)		TP-6 (XMIT)		TP-7 (REC)	
DESIGN IMPEDANCE, OHMS																			
BALANCED/UNBALANCED				☐ BAL ☐ UNBAL		☐ BAL ☐ UNBAL		☐ BAL ☐ UNBAL		☐ BAL ☐ UNBAL		☐ BAL ☐ UNBAL		☐ BAL ☐ UNBAL		☐ BAL ☐ UNBAL		☐ BAL ☐ UNBAL	
TLP (REF T T PWR LVL) dbm																			
CORRECT SIG LEVEL	REL TO TLP, db																		
	ABSOLUTE, dbm																		
CIRCUIT DATA				MEASURED SIGNAL LEVELS															
SG	GP	V.CH	SIG. TYPE	dbm	DEV db	dbm	DEV db	dbm	DEV db	dbm	DEV db	dbm	DEV dB	dbm	DEV db	dbm	DEV db	dbm	DEV db

USACC FORM 462-R (TEST)
1 MAY 77

Figure 57-2. Inservice customer levels data sheet.

CHAPTER 58

1-kHz TEST TONE SIGNAL LEVELS (T-4)

58-1. GENERAL.

a. The purpose of this test is to measure, evaluate, and adjust the VF channel test tone signal power level at selected points throughout the station. This includes the primary patch bay, the circuit equal level patch bay, the VF/multiplex patch bay, the GP and SG test points, and the baseband test point, to the extent that these points are available.

b. On a per radio link basis and with test personnel at each end of the radio link, this test can be performed in both directions simultaneously. Furthermore, where a sufficient number of voice channels are available, this test can be conducted under operating conditions; however, because of impedance variations at some of the multiplex test points, the test tone power measurements may be inaccurate. To obtain more accurate measurements of test tone power levels, it may be necessary to remove the multiplex from service. At each of the test points, the circuit must then be disconnected and properly terminated with a resistance load before making the measurements and adjusting the test tone power levels. This technique is outlined in some multiplex manuals. For links which do not have voice channel breakouts at one or both ends, the tests can be modified accordingly by inserting the test tone signal from the transmission measuring set at the available multiplex input points of the transmit end of the radio link. However, this technique requires the removal of at least one multiplex group at a time from service.

c. If this test is being performed as part of a complete audio series, the voice channel test tone signal power levels must be within ±1 db of the relative test signal power of -10 dbm0 before proceeding with subsequent tests.

d. It is recommended that a minimum of three voice channels per group be measured, preferably channels 2, 6, and 11, if available.

58-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

58-3. TEST EQUIPMENT REQUIRED.

a. AC voltmeter.

b. Balanced/unbalanced transformer (2 ea).

c. Audio oscillator.

d. FSVM.

e. Spectrum display unit.

f. Transmission measuring set.

58-4. TEST PROCEDURES.

a. Configure test equipment as illustrated in figure 58-1.

b. On figure 58-2, USACC Form 463-R (Test), record the equipment design reference test tone signal power levels, the correct signal levels relative to the reference test tone signal power level, and the absolute power levels of the tone signal for each test point indicated on figure 58-1 (except those test points which are not available or not applicable to the particular situation). Record the SG, GP, and voice channel (V CH) as applicable to properly identify the channels tested.

c. To measure the audio levels at the patch panels, use the transmission measuring set, alternately connect a high impedance AC voltmeter to a balanced/unbalanced transformer and use the two together as the level meter. For the multiplex test points, use the FSVM and the spectrum display unit as appropriate for the equipment under test. Connect the bridging mode and set the impedance load switch according to the impedance of the line at that point.

d. Assuming the voice channel impedance is 600 ohms, establish a standard -10 dbm0 reference level either from the transmission measuring set output or from an oscillator tuned to 1000 Hz. Measure the -10 dbm0 level at the precision load. Do not readjust the transmission measuring set output, or the oscillator frequency or amplitude, in the subsequent procedures.

e. Remove the 600-ohm precision load and connect the transmission measuring set output or the transformer output to the desired channel at TP-1. Referring to figure 58-1, measure the level at TP-1 and record this as the input level. The input level may differ from -10 dbm0 due to the fact that the channel impedance is not exactly 600 ohms. (Tests T-5 and T-6 are designed to investigate impedance variation in further detail.)

f. Measure the test tone signal levels at all remaining test points applicable, referring to figure 58-1 for guidance. Record the dbm readings and the deviation from the correct value (computed) on figure 58-2; USACC Form 463-R (Test). Observe the tone frequency spectrum. Add comments as needed on figure 6-4; USACC Form 351-R (Test). Note that the test tone signal power levels made at all test points, except TP-12, are made using a bridging (high impedance) connection; while the measurements made at TP-12 are made using the terminate or 600-ohm loading connection.

g. All level deviations in excess of ±1 db should be reported to site personnel. Corrective action should be taken with the assistance of the operating personnel. No adjustments should be made until the source of the level problem has been identified.

h. Summarize test data on figure 6-4; USACC Form 351-R (Test).

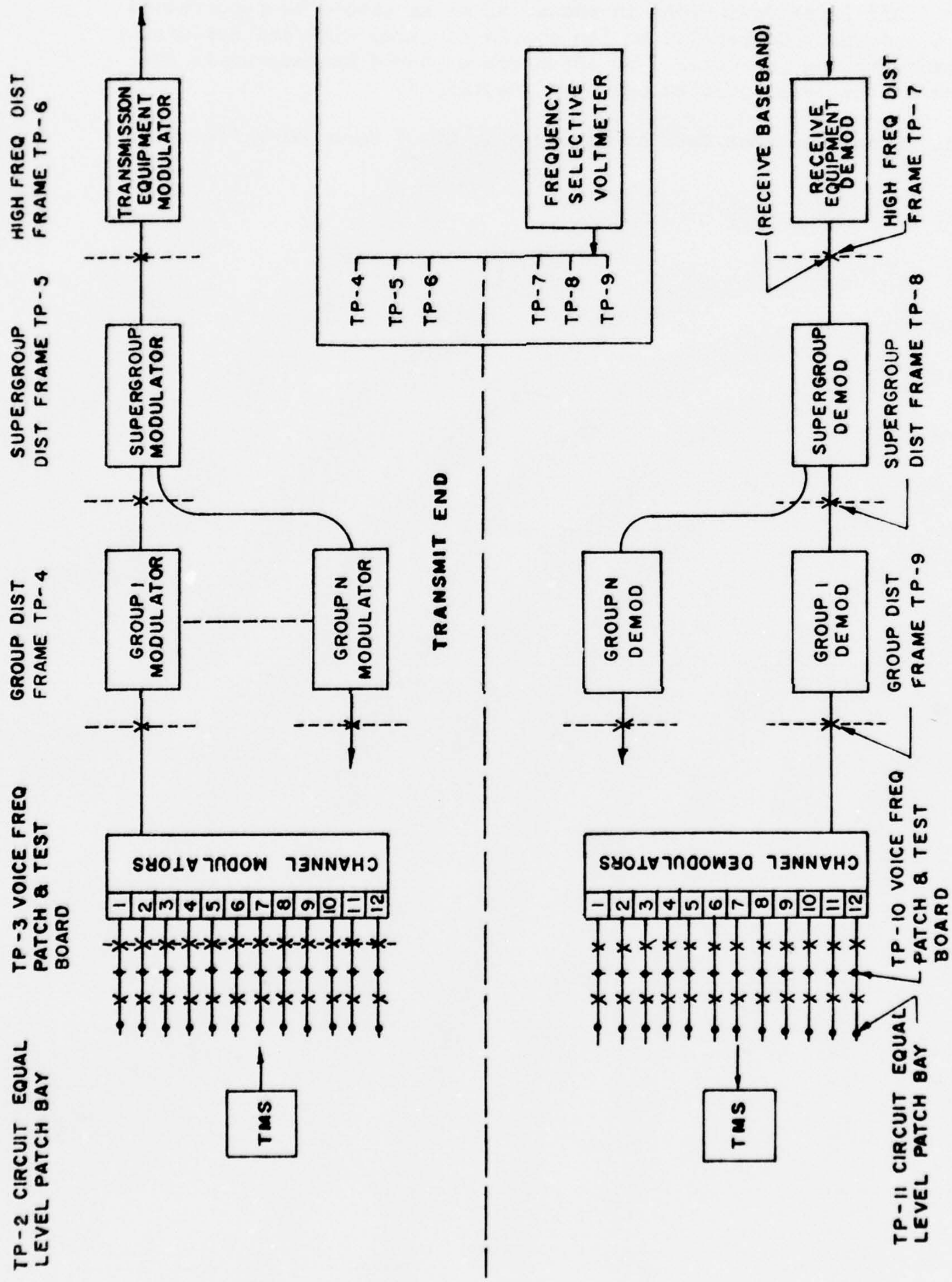


Figure 58-1. 1-kHz test tone levels test configuration.

DATA SHEET

1-kHz TEST TONE LEVELS
(CCR 702-1-3)

PAGE OF PAGES	DATE (DAY, MONTH, YEAR)	TEST ENGR SIGNATURE
LINK NO.	STATION UNDER TEST	DISTANT STATION

TEST POINT			DISTANT STATION TRANSMIT								STATION UNDER TEST RECEIVE							
			EQ LEVEL PT		GP DIST POINT		SG DIST POINT		HF FRAME		HF FRAME		SG DIST POINT		GP DIST POINT		EQ LEVEL PT	
TEST POINT NUMBER			TP-2		TP-4		TP-5		TP-6		TP-7		TP-8		TP-9		TP-11	
BALANCED																		
UNBALANCED																		
TLP dbm0																		
TLP dbm																		
CIRCUIT LOCATION																		
SG	GP	V CH	-dbm	dev	-dbm	dev	-dbm	dev	-dbm	dev	-dbm	dev	-dbm	dev	-dbm	dev	-dbm	dev

USACC FORM 463-R (TEST)
1 MAY 77

Figure 58-2. 1-kHz test tone levels data sheet.

Preceding Page BLANK - NOT FILMED

CHAPTER 59

VOICE CHANNEL IMPEDANCE (AUTOMATIC SWEEP) (T-5)

59-1. GENERAL. The purpose of this test is to determine by means of automatic sweep measurements the input and output impedance of VF channels or other audio equipment with a design impedance of approximately 600 ohms. The test recognizes that when a load of other than 600 ohms is connected to a 600-ohm source, the voltage across the load changes in proportion to the change of the load impedance from 600 ohms. This voltage change can be conveniently read on a db scale calibrated for 600 ohms and correlated to an impedance value. The voice channel impedance measurements, and also the 600-ohm terminations, are made at the patch bays, both at the transmit and receive ends of the voice channel.

59-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

59-3. TEST EQUIPMENT REQUIRED.

a. AC voltmeter.

b. Balanced/unbalanced transformer.

c. Delay measuring set.

d. Log/lin preamplifier.

e. X-Y recorder.

f. 600-ohm, 1-percent termination.

59-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 59-1. Use an external 600-ohm, 1-percent termination (not the internal 600-ohm termination on the bridging transformer). Set the output of the delay measuring set to 1000 Hz, -10 dbm0. For example, if the test is to be conducted at the circuit equal level patch bay and the reference test tone level is zero dbm, then the output of the delay measuring set (into the 600-ohm load) would be set at 10 db below zero dbm, that is, -10 dbm. If the test is to be conducted at the VF patch bay and the reference test tone level at this point is -16 dbm, then the output of the delay measuring set would be set 10 db below -16 dbm, that is, -26 dbm. Load the X-Y recorder with the appropriate graph paper (fig. 8-7; USACC Form 396-R (Test)) and calibrate the horizontal (X) axis by varying the output frequency of the delay measuring set between 100 Hz and 4000 Hz. Adjust the recorder as needed. Return the delay measuring set to a 1000-Hz output. Calibrate the vertical (Y) axis of the recorder by varying the output level of the delay measuring set between 1.5 db and

-2.5 db from the -10 dbm0 reference level. Refer to the manufacturer's manual on the X-Y recorder if difficulty is encountered in calibration. Return the output level to -10 dbm0. Set the delay measuring set frequency to the low end of the range and perform a sweep with the 600-ohm, 1-percent termnination connected. The recorder level should not vary more than 0.15 db throughout the sweep, or at least between 50 Hz and 3600 Hz. A variation greater than ±0.15 db indicates an equipment malfunction and the manual sweep mode (test T-8) will have to be used.

b. This test should be conducted preferably at the circuit equal level patch bay TP-2 or TP-11 to include the maximum number of circuit components. However, if conditioning or signaling equipment is present between the circuit equal level patch bay and the VF patch bay, the test should also be run from the VF patch bay, TP-3 or TP-10. This test may also be conducted at other 600-ohm voice channel points for trouble-shooting purposes; with the output of the delay measuring set appropriately adjusted as described in paragraph 59-4a, above.

c. Disconnect the external 600-ohm termination and connect the output of the delay measuring set to TP-2 at the input (transmit end) of the voice channel being tested; the receive end of the voice channel should be terminated in a 600-ohm load at TP-11. Do not readjust the delay measuring set to the -10 dbm0 level, in the subsequent procedures.

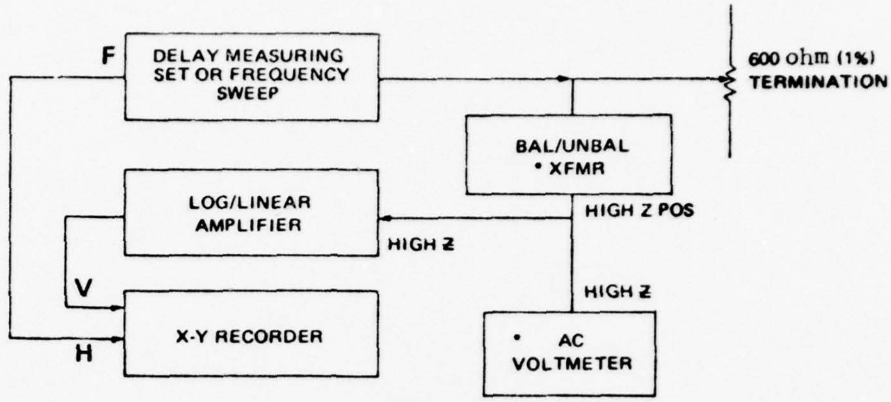
d. Sweep the delay measuring set across the frequency band and record the input level on the X-Y recorder. The sweep rate will have to be slow enough so that any abrupt changes in level will be plotted accurately by the X-Y recorder.

e. Repeat paragraphs 59-4 c and d for the inputs of the other voice channels to be tested.

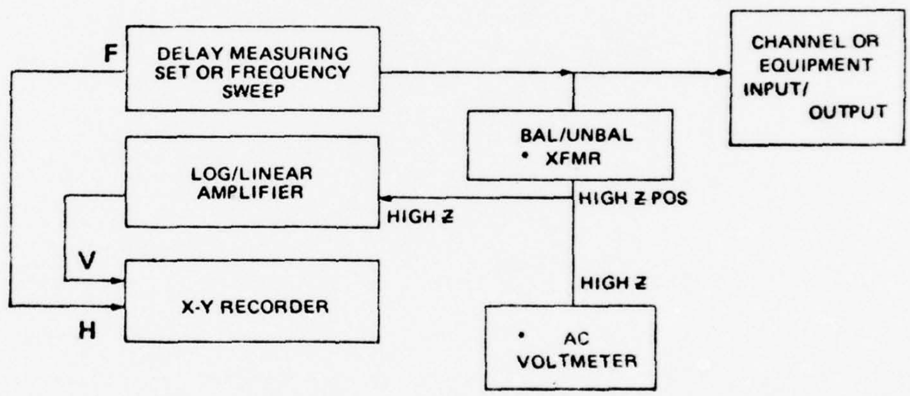
f. Repeat the entire test procedure for the outputs (receive end) of each voice channel tested above. In this case, the tone will be inserted backward; that is, into the output of the channel with the distant end terminated. This reversal should have very little effect on the results of the test. As a precautionary measure, the idle channel output should be checked to insure that no other signals, including crosstalk, are present in the channel which might interfere with readings being taken during this test. If the test is conducted at other than the circuit equal level patch bay, be sure to appropriately readjust the tone level output of the delay measuring set as described in paragraph 59-4a.

g. It is recommended that a minimum of three voice channels per group be measured, preferably channels 2, 6, and 11, if available.

h. Summarize test data on figure 6-4; USACC Form 351-R (Test).



a. CALIBRATION



*MAY BE PART OF A TRANSMISSION MEASURING SET (TMS)

b. MEASUREMENT

Figure 59-1. Voice channel impedance (automatic sweep) test configuration.

Preceding Page Blank - NOT FILMED

CHAPTER 60

VOICE CHANNEL IMPEDANCE (MANUAL SWEEP) (T-6)

60-1. GENERAL. The purpose of this test is to determine by means of manual sweep measurements the input and output impedance of VF channels or other audio equipment with a design impedance of approximately 600 ohms. The test recognizes that when a load of other than 600 ohms is connected to a 600-ohm source, the voltage across the load changes in proportion to the change of the load impedance from 600 ohms. This voltage change can be conveniently read on a db scale calibrated for 600 ohms and correlated to an impedance value. The voice channel impedance measurements and also the 600-ohm terminations are made at the patch bays, both at the transmit and receive ends of the voice channels.

60-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

60-3. TEST EQUIPMENT REQUIRED.

a. AC voltmeter.

b. Audio oscillator.

c. Balanced/unbalanced transformer.

d. 600-ohm, 1-percent termination.

60-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 60-1, with the oscillator feeding into an external 600-ohm, 1-percent termination. Do not use the 600-ohm switch position of the line matching transformer since this may yield inaccurate test results. Calibrate the input signal to the 600-ohm load by adjusting to 1000 Hz at -10 dbm0. For example, if the test is to be conducted at the circuit equal level patch bay, and the reference test tone level is zero dbm, then the output power of the oscillator, would be set 10 db below zero dbm, that is, -10 dbm. If the test is to be conducted at the VF patch bay, and the reference test tone level at this point is -16 dbm, then the output of the oscillator into the 600-ohm load would be set 10 db below -16 dbm, that is -26 dbm.

b. This test should be conducted preferably at the circuit equal level patch bay, TP-2 or TP-11. However, if conditioning or signaling equipment is present between the circuit equal level patch bay and the VF patch bay, TP-3 or TP-10, the test should also be run from the VF patch bay. This test may also be conducted at 600-ohm voice channel points for troubleshooting purposes, with the output of the oscillator adjusted as described in paragraph 60-4a.

c. Disconnect the external 600-ohm termination and connect the output of the balanced/unbalanced transformer to the test point input of the voice channel being tested (fig. 60-1). The receive end of the voice channel should be terminated in a 600-ohm load at TP-11. Do not readjust the oscillator to the -10 dbm0 level, in the subsequent procedures.

d. Vary the oscillator frequency in steps as listed on figure 60-2; USACC Form 464-R (Test) and record the test signal power level from the AC voltmeter, on the data sheet. Calculate the test tone variance from the 600-ohm loaded value. Sufficient frequencies must be used in order to obtain points for a smooth curve on figure 8-7; USACC Form 396-R (Test). Extreme accuracy is important. Take all readings to 0.1 db accuracy or better. (Except for exactly 600-ohm channels, these readings will not be true power, but for purposes of this test we will refer to them as dbm.)

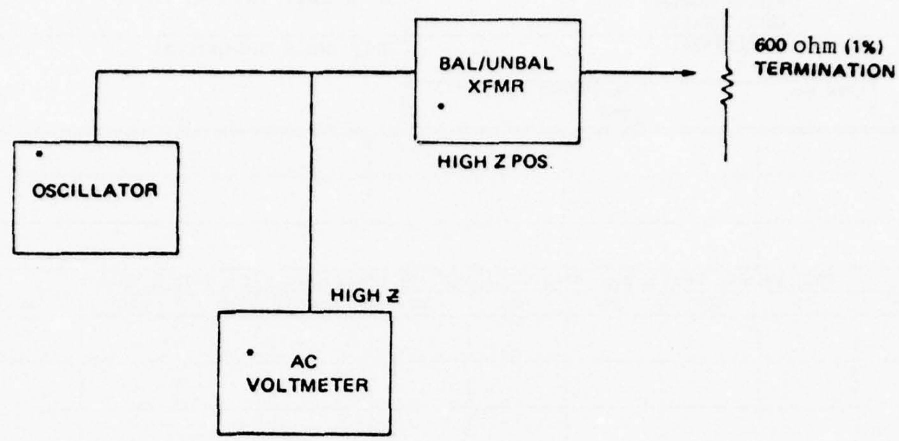
e. Plot the tone variance in db versus frequency on figure 8-7; USACC Form 396-R (Test). Connect the points with a smooth curve. Be careful not to obliterate the data points.

f. Repeat the entire test procedure for the inputs of the other voice channels to be tested.

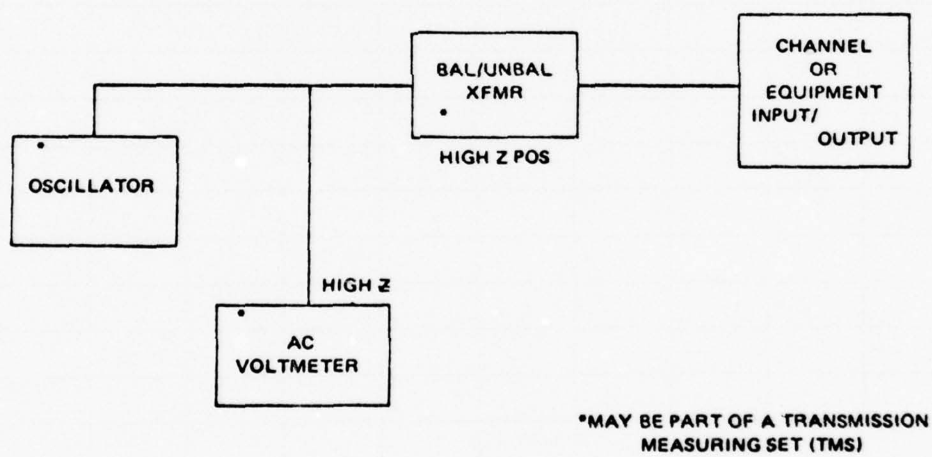
g. Repeat the entire test procedure for the outputs (receive end) of each voice channel tested above. In this case, the tone will be inserted backward; that is, into the output of the channel with the distant end terminated. This reversal should have very little effect on the results of the test. As a precautionary measure, the idle channel output should be checked to insure that no other signals, including crosstalk, are present in the channel which might interfere with readings being taken during this test. If the test is conducted at other than the circuit equal level patch bay, be sure to appropriately readjust the tone level output of the oscillator as described in paragraph 60-4a.

h. It is recommended that a minimum of three voice channels per group be measured, preferably channels 2, 6, and 11, if available.

i. Summarize test results on figure 6-4; USACC Form 351-R (Test).



a. CALIBRATION



b. MEASUREMENT

Figure 60-1. Voice channel impedance (manual sweep) test configuration.

DATA SHEET	CHANNEL IMPEDANCE (Manual Sweep) (CCR 702-1-3)		PAGE OF PAGES
			DATE (DAY, MONTH, YEAR)
☐ TRANSMIT	STATION UNDER TEST		TEST ENGR SIGNATURE
☐ RECEIVE	LINK NO.	TEST POINT TP–	

SG										
GP										
CH										
FREQ (Hz)	TEST SIGNAL LEVEL, dbm; AND VARIANCE, db, FROM 600-ohm LOADED VALUE									
	dbm	db	dbm	db	dbm	db	dbm	db	dbm	db
50										
100										
200										
300										
400										
500										
600										
800										
1000										
1200										
1400										
1600										
1800										
2000										
2200										
2400										
2600										
2800										
3000										
3200										
3400										
3600										

USACC FORM 464-R (TEST)
1 MAY 77

Figure 60-2. Channel impedance (manual sweep) data sheet.

CHAPTER 61

VOICE CHANNEL LONGITUDINAL BALANCE (T-7)

61-1. GENERAL. The purpose of this test is to determine the amount of inbalance existing on the VF channels or other VF equipment using balanced circuits. Normally, speech or carrier signals are carried on a balanced transmission line consisting of two conductors at the same electrical potential above ground. Normal signal current flows in opposite directions in the two conductors, but unequal leakage impedances from the lines to ground and electromagnetic or capacitive voltages induced in the line produce longitudinal currents which create a voltage between the electrical center of the line and ground. This unbalanced voltage causes interference with the desired signals in the line and adds to the ICN. Different methods used for measuring longitudinal balance will produce different values and, therefore, no attempt should be made to compare results unless the same procedures were used to obtain them.

61-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

61-3. TEST EQUIPMENT REQUIRED.

a. Audio oscillator.

b. AC voltmeter.

c. 600-ohm transformer.

d. FSVM.

e. Balanced/unbalanced transformer.

f. 600-ohm, 1-percent termination.

g. 300-ohm, 0.25-percent resistor (2 ea).

h. 150-ohm, 0.5-percent resistor.

i. Transmission measuring set.

j. Headphones.

61-4. TEST PROCEDURES.

a. To measure the input (transmitting) longitudinal balance, configure the test equipment as illustrated in figure 61-1, with the channel properly terminated at the selected patch bay station B, receiving. Adjust the signal generator frequency to 600 Hz at -10 dbm0 with the signal generator connected through transformer D, across the center-tapped resistors R_1 and R_2, and into the input (transmit end) of the voice channel or equipment under test, that is, at the selected patch bay.

b. Connect the FSVM (bridging) to measure the voltage across the $R_L/4$ (150 ohm) resistor R_3, and tune the FSVM to the 600-Hz signal, using the narrow bandwidth position. The use of an FSVM is necessary because the wide bandwidth of the AC voltmeter may pick up signals other than the low level 600-Hz imbalance signal. As a precautionary measure, disconnect the signal generator (A); then measure the voltage across R_3 to determine if other signals, including crosstalk, are present in the channel. Also, headphones should be used to identify extraneous signals.

c. Reconnect the signal generator (A) and measure the voltage (V_2) across the resistor R_3. Record this measured value on figure 61-2; USACC Form 465-R (Test). Note and record the voltage V_1 measured across the line on the data sheet. Voltmeter (C) is connected across the line through the MON jack at the selected patch bay.

d. Calculate the longitudinal balance of the input circuit from:

$$\text{Longitudinal balance} = 20 \log_{10} \frac{(V_1)}{(V_2)} = \text{db}$$

e. Since the voltage V_1 is measured across the line, with a normal impedance (R_L) of 600 ohms, while the voltage V_2 is measured across R_3, having an impedance of ($R_L/4$) 150 ohms, the above definition and measurement of the longitudinal balance is in relative terms, and should not be considered as an absolute power ratio measurement.

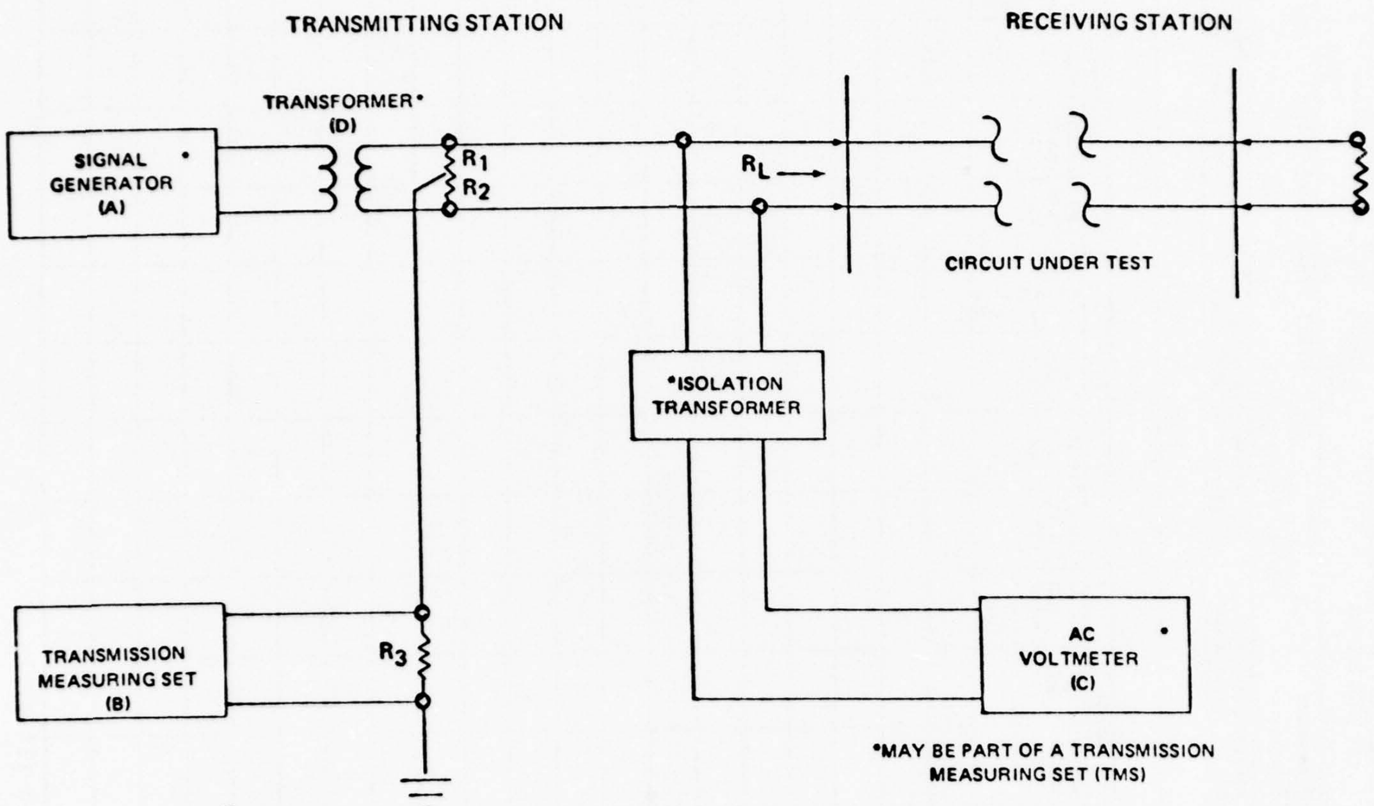
f. Repeat paragraphs 61-4 a through d for 1000 Hz and 2400 Hz.

g. Repeat paragraphs 61-4 a through d for the inputs of other channels or equipment to be tested. It is recommended that a minimum of three voice channels in each group be measured, preferably channels 2, 6, and 11, if available.

h. To measure the output (receiving) longitudinal balance, configure the test equipment as shown in figure 61-3, with the output channel terminated by (accurate, ±0.25-percent) resistors R_1 and R_2 connected in series as shown. Adjust the signal generator (A) frequency at the transmitting end to 600 Hz and set the output level at -10 dbm0.

i. Repeat paragraphs 61-4 b through f and g, inclusive, for the output (receiving) longitudinal balance measurements (as outlined above for the input longitudinal balance measurements). Record the data on figure 61-2; USACC Form 465-R (Test).

j. Summarize test results on figure 6-4; USACC Form 351-R (Test).



$R_1 = R_2 = \frac{R_L}{2}$ (TOLERANCE ±0.25%)

$R_3 = \frac{R_L}{4}$ (TOLERANCE ±0.25%)

R_L - NOMINAL INPUT IMPEDANCE OF SYSTEM (NORMALLY 600 or 900 OHMS FOR VOICE CHANNEL OR 135 OHMS FOR WB OR GROUP CHANNEL)

Figure 61-1. Voice channel longitudinal balance (input) test configuration.

VOICE CHANNEL LONGITUDINAL BALANCE (CCR 702-1-3) DATA SHEET			PAGE OF PAGES
			DATE (DAY, MONTH, YEAR)
LINK NO.	☐ TRANSMIT ☐ RECEIVE	TEST POINT TP–	TEST ENGR SIGNATURE

	REFERENCE TEST TONE SIG POWER dbm	TEST SIG POWER REL. TO REF TEST TONE, dbm0	ABSOLUTE POWER OF TEST SIGNAL, dbm
TRANSMIT			
RECEIVE			

FREQUENCY			600 Hz				1000 Hz				2400 Hz			
SG	GP	CH	LINE VOLTS V1	UNBAL VOLTS V2	$\frac{V1}{V2}$	LONG BAL $20 \log \left(\frac{V1}{V2}\right)$ db	LINE VOLTS V1	UNBAL VOLTS V2	$\frac{V1}{V2}$	LONG BAL $20 \log \left(\frac{V1}{V2}\right)$ db	LINE VOLTS V1	UNBAL VOLTS V2	$\frac{V1}{V2}$	LONG BAL $20 \log \left(\frac{V1}{V2}\right)$ db

USACC FORM 465-R (TEST)
1 MAY 77

Figure 61-2. Voice channel longitudinal balance data sheet.

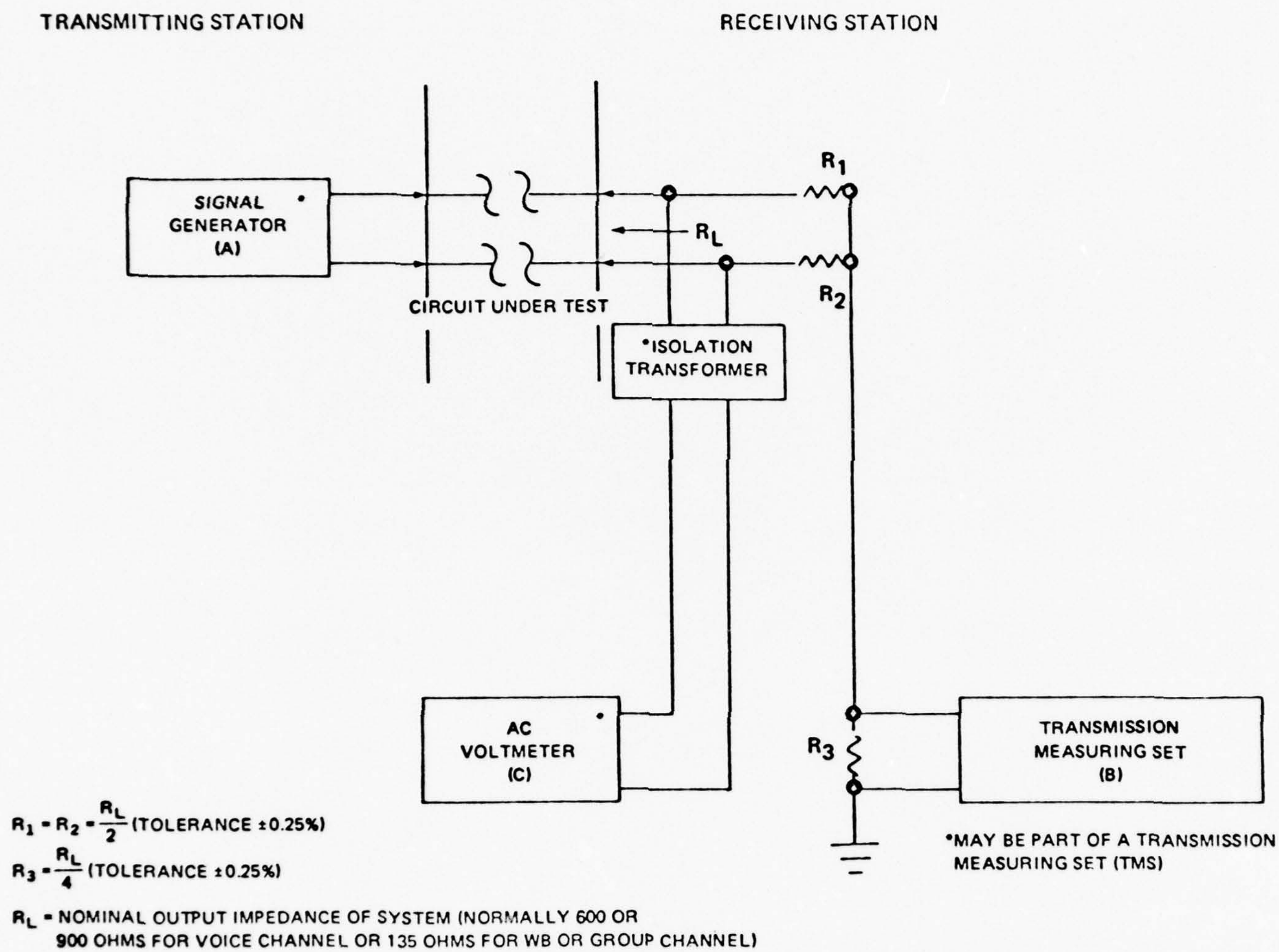


Figure 61-3. Voice channel longitudinal balance (output) test configuration.

Preceding Page Blank - NOT FILMED

CHAPTER 62

IDLE CHANNEL NOISE (T-8)

62-1. GENERAL.

a. The purpose of this test is to measure and evaluate the ICN. The ICN should be measured both with C-message and 3-kHz flat weighting with a 3-db response at 3 kHz. Both types of weighting should be used since the C-message weighting attenuates the 60-Hz noise components which may mask the noise measurement if power line hum is a problem on the channel.

b. In this test procedure, noise measurements are obtained from an indicating meter reading. Since in general the noise level fluctuates with time, the meter reading represents at best only a spot measurement over a comparatively short period of time; furthermore, the actual meter is subject to the inaccuracy of visually estimating the average value of the oscillating meter pointer. As a result, this channel noise measurement is not accurate nor does it indicate the important time varying characteristics of the channel noise.

c. The measurement of the median received RF signal (RSL) should be obtained from a strip chart recording of the RSL, over the period of time required to make each voice channel noise measurement.

d. It is preferred that the channel noise measurements be made between the transmit circuit equal level patch bay TP-2 and the receive circuit equal level patch bay TP-11; however, if there are indications of noise being generated in other parts of the system, additional measurements should be made at other test points in order to isolate the source of this noise.

e. It is recommended that the ICN be measured in at least three voice channels of each group, preferably channels 2, 6, and 11, if available.

f. Due to the low level of signals involved, the accurate measurement of noise entails care and attention to detail. Particular care should be given to providing good grounds, effective shielding, correct terminations, and avoiding ground loops.

62-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

62-3. TEST EQUIPMENT REQUIRED.

a. Audio oscillator or test measuring set.

b. AC voltmeter.

c. Balanced/unbalanced transformer (2 ea).

d. 600-ohm termination plug.

e. Noise measurement set (idle channel).

62-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 62-1.

b. On figure 62-2; USACC Form 466-R (Test) record the equipment reference test tone power level and the SG, GP, and VCH numbers. Also record the distant station termination point and the receive end measure point.

c. For each VF channel to be evaluated, transmit a standard -10 dbm0, 1-kHz test tone to the receiving station, prior to the noise measurement. At the channel receiving end, record the measured tone level (S_m) to insure the validity of the subsequent noise level measurements. Do not adjust the tone level unless it deviates more than 3 db from standard.

d. At the transmit end, terminate the VF channel under test with a 600-ohm termination at the circuit equal level patch bay, TP-2.

e. Adjust the set according to the operating manual supplied and connect the instrument to the receive end of the channel under test at TP-11. Connect the instrument in the 600-ohm termination mode.

f. Set the ICN meter for 3-kHz flat weighting, and measure the ICN on the dbm and the dbrn meter scales. Record the data in the 3-kHz flat columns on figure 62-2; USACC Form 466-R (Test).

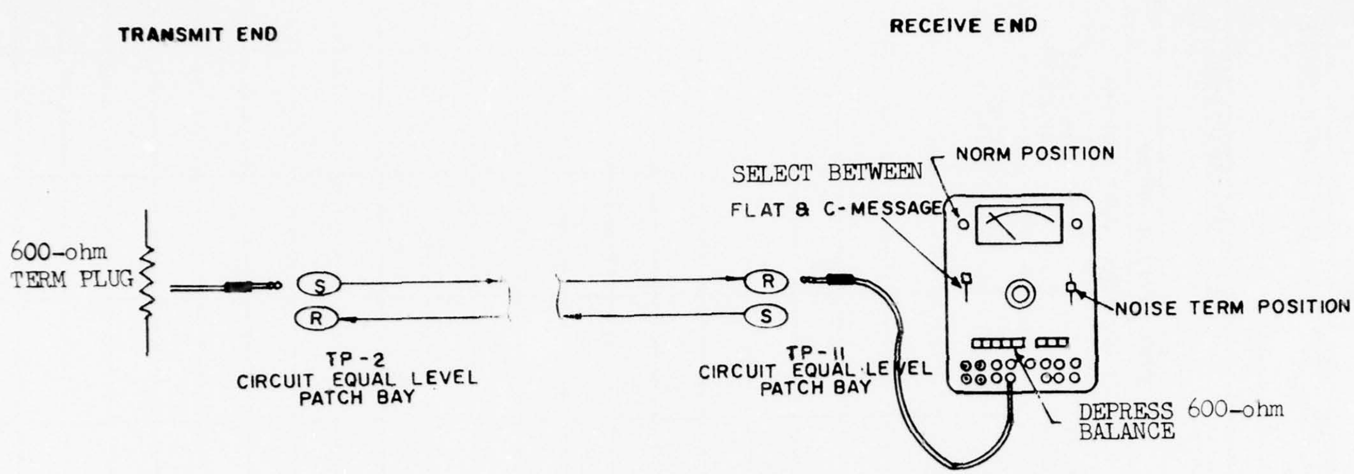
g. Change the weighting network of the instrument to C-message and repeat the above. Record the data in the C-message columns of figure 62-2; USACC Form 466-R (Test).

h. Calculate values for dbrn0, dbrnC0, and the reference test tone signal power to the channel noise power ratio, S_t/N, and record the results on figure 62-2; USACC Form 466-R (Test).

i. If the difference between 3-kHz flat and C-message weighted noise is significantly greater than 1.5 db, listen to the noise spectrum with an earphone and attempt to identify any abnormalities such as tones, powerline hum, undistributed noise, and crosstalk. Investigate the noise spectrum by using an FSVM. Look for carrier leaks, extraneous tones, powerline hum, and out-of-band orderwire signal feedover. Make appropriate comments on figure 6-4; USACC Form 351-R (Test).

j. If excessive noise (10 db or more above theoretical or standard noise) is noted, repeat the test at VF voice channel multiplex patch bay TP-10 in an attempt to isolate, and if possible, eliminate the excessive noise. Also, have the distant station move the 600-ohm termination point to VF voice channel multiplex patch bay TP-3.

k. Summarize test results on figure 6-4; USACC Form 351-R (Test).



NOTE: READINGS SHOULD BE TAKEN IN dbrn AND dbrnC.

Figure 62-1. ICN test configuration.

DATA SHEET **IDLE CHANNEL NOISE** (CCR 702-1-3)				PAGE OF PAGES
LINK NO	TERMINAL RADIO EQUIPMENT	TEST TIME PERIOD START Z	STOP Z	DATE (DAY,MONTH,YEAR)
TEST POINTS				
DISTANCE STATION (XMIT)	LOCAL (REC)			TEST ENGR SIGNATURE

SG NO.	GP NO.	V CH NO.	S_m MEAS TEST SIGNAL POWER	IDLE VOICE CHANNEL NOISE					
				VISUALLY-AVERAGED NOISE PWR (N)					
				3-kHz FLAT WEIGHTING			C-MESSAGE WEIGHTING		
			dbm	dbm	dbrn	dbrn0	dbm	dbrnC	dbrnC0

USACC FORM 466-R (TEST)
1 MAY 77

Figure 62-2. Idle channel noise data sheet.

Preceding Page Blank - NOT FILMED

CHAPTER 63

IDLE CHANNEL IMPULSE NOISE (T-9)

63-1. GENERAL. The purpose of this test is to measure and evaluate the number and levels of VF channel impulse noise bursts. The impulse noise measurement will be in terms of the number of hits per unit time above particular preset noise power levels. In general, the channel impulse noise measurements will be made between the transmit circuit equal level patch bay TP-2 and the receive circuit equal level patch bay TP-11. However, if there are indications of noise being generated in other parts of the system, additional measurements should be made at other test points in order to isolate the source of this noise. The idle channel impulse noise should be measured in at least three voice channels of each group preferably channels 2, 6, and 11, if available.

63-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100, or DCAC 300-175-9.

63-3. TEST EQUIPMENT REQUIRED.

a. Audio oscillator or test measuring set.

b. AC voltmeter.

c. Balanced/unbalanced transformer (2 ea).

d. 600-ohm termination plug.

e. Impulse noise measuring set.

63-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated on figure 63-1.

b. For each test point indicated on figure 63-2; USACC Form 467-R (Test), record the equipment reference level and the SG, GP, and VCH numbers to be measured as applicable. Also record the distant station termination point and the receive end measurement point. For each VF channel to be evaluated, transmit a standard -10 dbm0, 1-kHz test tone to the receiving station. At the channel receiving end, record the tone level in dbm and compute and record the error in db. This is to insure the validity of the subsequent noise level measurements. Due to the low level of signals involved, the accurate measurement of noise entails care and attention to detail. Particular care should be given to providing good grounds, effective shielding, correct terminations, and avoiding ground loops.

c. At the transmit end, terminate the VF channel under test with a 600-ohm termination at the circuit equal level patch bay TP-2. Adjust the impulse noise counter IAW the operating manual and connect the instrument to the receive end at the circuit equal level patch bay TP-11. Connect the instrument in the 600-ohm termination mode, 3-kHz flat weighting. If 3-kHz flat weighting is not available, indicate the type weighting used on the data sheet.

d. Initially, set the noise counters as close as possible to 52, 62, and 72 dbrnCO. Adjust the counters to correspond to the equipment reference level at which the measurement is being made. Record the dbrn counter settings on figure 63-2; USACC Form 467-R (Test). If the highest level counter (72 dbrnO) runs continuously, adjust all counter levels in steps until the highest level counter runs only occasionally (one counter per minute or less), and a separation of 10 db occurs between the other two lower levels. If new level settings are required for different channels, separate data sheets may have to be used for different level settings.

e. Record the impulse noise for a minimum of 15 minutes per channel. Record the low, mid, and high impulse noise counts. After completing the initial 15-minute impulse noise counts per channel, establish a long-term impulse noise measurement on three channels selected from those previously tested. These three channels should represent the worst, best, and average noise burst performance channels. The long-term counts should be 8 hours or more, and should be conducted during periods of heavy, or at least normal, traffic so that the effects of traffic on the link can be seen. Once each hour, record the number of total counts on the strip chart recordings (if these are being done). Do not reset the counters to zero each hour, but be sure that no counter passes its maximum count and recycles without being detected.

f. Since the low level (52 dbrnO) counter has the most sensitivity, it should normally register more counts than the other two counters. If this is not the case, investigate thoroughly and explain in the comments section of figure 6-4; USACC Form 351-R (Test).

g. Summarize test results on figure 6-4; USACC Form 351-R (Test).

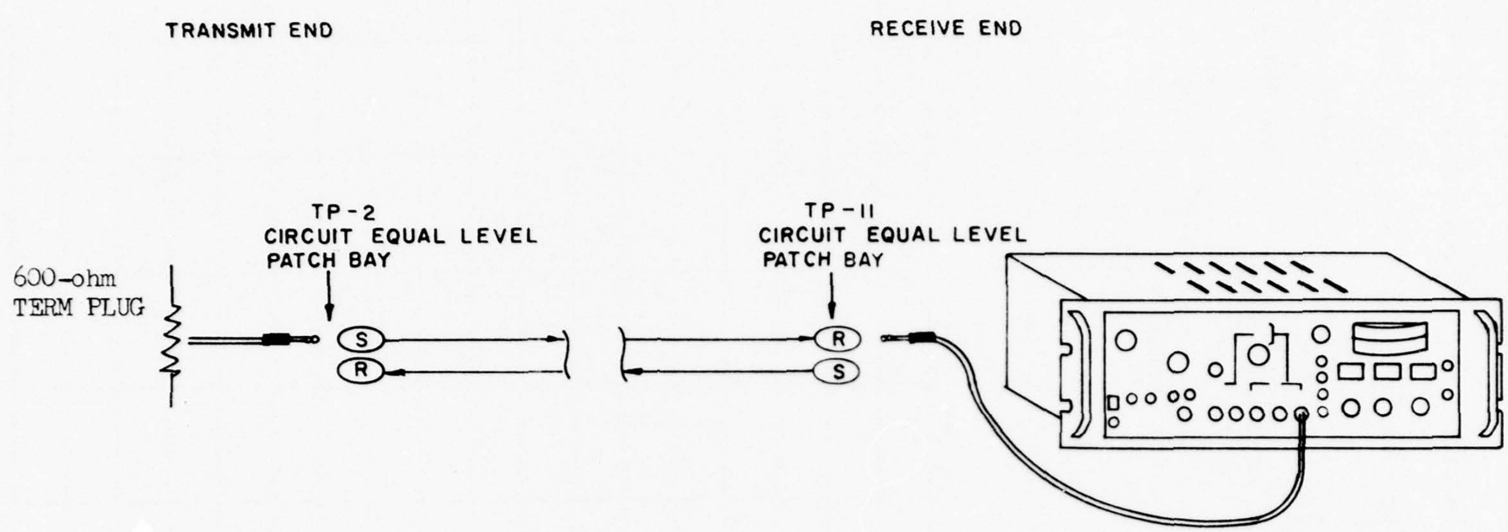


Figure 63-1. Idle channel impulse noise test configuration.

IDLE CHANNEL IMPULSE NOISE DATA SHEET (CCR 702-1-3)			PAGE OF PAGES TEST ENGR SIGNATURE
LINK NO.	TERMINAL RADIO EQUIPMENT	TEST TIME PERIOD START Z / STOP Z	DATE (DAY, MONTH, YEAR)

SG NO.	GP NO.	V CH NO.	S_m MEASURED TEST SIGNAL POWER		NOISE WEIGHTING FLAT ☐ C-MSG ☐ NOISE METER SETTING			TEST PERIODS		
					LOW	MED	HI			
			dbm	ERROR db	dbrn IMPULSE NOISE COUNTS			START (Z)	STOP (Z)	DUR MIN

USACC FORM 467-R (TEST)
1 MAY 77

Figure 63-2. Idle channel impulse noise data sheet.

CHAPTER 64

VOICE CHANNEL FREQUENCY RESPONSE (MANUAL SWEEP) (T-10)

64-1. GENERAL. The purpose of this test is to determine, by point-by-point measurements, the amplitude versus frequency response characteristics of individual 4-kHz VF channel or other VF equipment. In general, the voice channel amplitude, frequency response measurements will be made between the transmit circuit equal level patch bay TP-2, and the receive circuit equal level patch bay TP-11. However, if there are indications that the measured response between these two test points does not meet the applicable standards, additional measurements should be made between other combinations of test points in order to isolate the source of the problem.

64-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

64-3. TEST EQUIPMENT REQUIRED.

a. Audio oscillator.

b. AC voltmeter.

c. Balanced/unbalanced transformer (2 ea).

d. 600-ohm precision load.

e. Frequency counter.

f. Transmission measuring set.

64-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 64-1.

b. At the transmit end, calibrate the audio oscillator for -10 dbm0 at 1000 Hz using an external precision 600-ohm termination. For example, if the test tone signal is to be inserted at the circuit equal level patch bay, where the reference test tone signal level is zero dbm, then the audio oscillator output would be set at -10 dbm, as measured by the AC voltmeter. Manually sweep the oscillator from 50 Hz to 3400 Hz and observe the meter for variations in output level.

c. If the output level is constant throughout the spectrum of interest (tolerance ±0.15 db), then set the balanced/unbalanced transformer to the HIGH IMPEDANCE position and connect the transformer output to the channel to be tested at TP-2.

d. If the oscillator output level is not constant with changes in frequency, it will be necessary to reset the amplitude to -10 dbm0 (with a 600-ohm precision load) for each frequency setting during the test before connecting it to the channel under test.

e. At the receive end, connect the AC voltmeter and the frequency counter to TP-11. Measure the received signal output level and the frequency of the received test signal in the channel under test, and record the readings on figure 64-2; USACC Form 468-R (Test). With a -10 dbm0 signal at 1000 Hz, the receive end should be within ± 1 db of -10 dbm0 or the channel levels are incorrect.

f. Record sufficient frequencies and received test signal levels to obtain a smooth curve on figure 8-7; USACC Form 396-R (Test). The upper and lower frequency limits used should be at least to the -5 db response points relative to the amplitude of the tone at 1000 Hz.

g. Record an amplitude response scale in dbm, corresponding to the range of RSL values on the data sheet, then plot a curve on figure 8-7; USACC Form 396-R (Test).

h. Measure and record at least three channels per group, preferably channels 2, 6, and 11, if available.

i. Summarize test results on figure 6-4; USACC Form 351-R (Test).

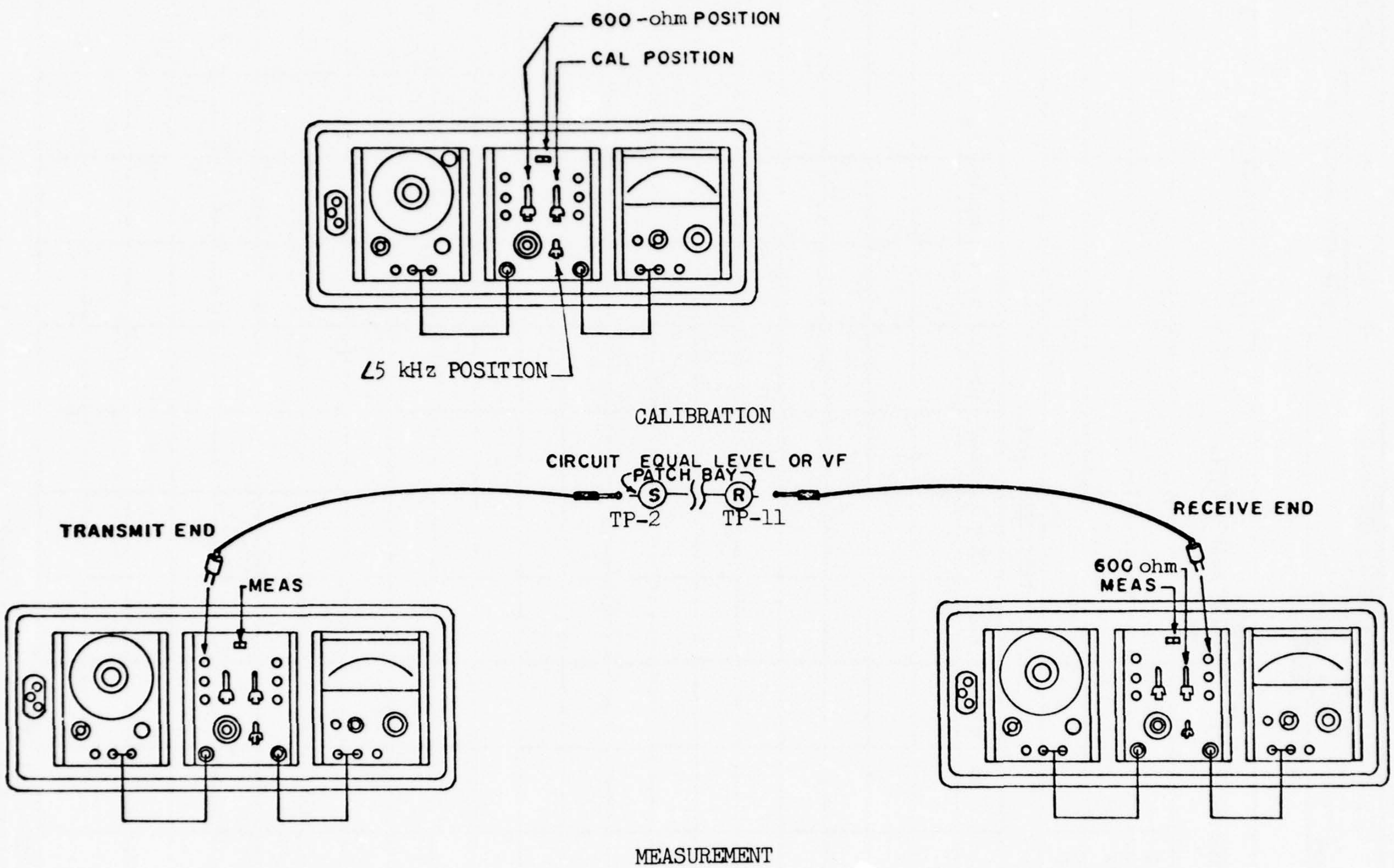


Figure 64-1. Voice channel frequency response (manual sweep) test configuration.

VOICE CHANNEL FREQUENCY RESPONSE (MANUAL SWEEP) (CCR 702-1-3) DATA SHEET	PAGE OF PAGES
	DATE (DAY, MONTH, YEAR)
LINK NO. STATION UNDER TEST	
TEST POINTS	TEST ENGR SIGNATURE
DISTANT STATION (XMIT) TP - LOCAL STATION (REC) TP -	

CHANNEL						
	SG					
	GP					
	CH					

TEST TONE LEVEL

FREQ	dbm	dbm0	dbm	dbm0	dbm	dbm0	dbm	dbm0	dbm	dbm0
100										
200										
300										
400										
500										
600										
800										
1000										
1200										
1400										
1600										
1800										
2000										
2200										
2400										
2600										
2800										
3000										
3200										
3400										
3600										

USACC FORM 468-R (TEST)
1 MAY 77

Figure 64-2. Voice channel frequency response (manual sweep) data sheet.

CHAPTER 65

VOICE CHANNEL FREQUENCY RESPONSE (AUTOMATIC SWEEP) (T-11)

65-1. GENERAL. The purpose of this test is to determine, by means of an automatic sweep, the amplitude versus frequency response characteristics of individual VF channels or other VF equipment. This test procedure utilizes an automatic sweep derived from a delay measuring set to measure the frequency response across a 4-kHz VF channel. In general, the voice channel amplitude, frequency response measurements will be made between the transmit circuit equal level patch bay TP-2 and the receive equal level patch bay TP-11. However, if there are indications that the measured response between these two test points does not meet the applicable standards, additional measurements should be made between other combinations of test points in order to isolate the source of the problem.

65-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

65-3. TEST EQUIPMENT REQUIRED.

a. Delay measuring set.

b. X-Y recorder.

c. Audio oscillator.

d. Attenuator.

e. Log/lin preamplifier.

f. Balanced/unbalanced transformer (3 ea).

g. 600-ohm precision load.

h. AC voltmeter.

i. Transmission measuring set.

65-4. TEST PROCEDURES.

a. At the transmit end, calibrate the delay measuring set by connecting the 600-ohm output to a 600-ohm precision load and an AC voltmeter, as shown in figure 65-1. Adjust the 600-ohm output of the delay measuring set to -10 dbm0 at 1000 Hz. Set the sweep to a range of from 100 Hz to 4 kHz and a sweep rate of approximately 4 per minute. Observe the AC voltmeter as the delay measuring set sweeps across the band. If the test equipment is operating correctly, the meter reading should not vary more than ±0.15 db throughout the sweep. Return the delay measuring set to the 1000-Hz point and connect the delay measuring set output to the input of the voice channel equipment as shown in figure 65-1.

b. At the receive end, calibrate the delay measuring set and the X-Y recorder as follows:

(1) Connect the oscillator output through the step attenuator to the balanced/unbalanced transformer, and terminate the secondary into the delay measuring set, set at 600 ohms. Adjust the level to -10 dbm0, as read on the AC voltmeter.

(2) Connect the remainder of the equipment as illustrated in figure 65-1, receive end calibration.

(3) Using the delay measuring set frequency counter, calibrate the X-axis of the recorder between 50 Hz and 3400 Hz by varying the delay measuring set carrier frequency and adjusting the recorder controls.

(4) Switch the delay measuring set to the RECEIVE position and calibrate the Y-axis of the recorder between -15 and -7 dbm0 by varying the step attenuator and adjusting the controls of the log/lin preamplifier and recorder accordingly.

(5) Always turn off the X-Y recorder servos whenever the pen reaches the end of its travel. Never allow the servos to grind against the stops.

c. Configure the receive equipment as illustrated in figure 65-2 with the input of the delay measuring set connected to the channel to be tested at TP-11.

d. At the transmit end (fig. 65-1), the AC voltmeter should read -10 dbm0, unless the equipment input impedance is incorrect. Do not readjust the delay measuring set to a -10 dbm0 reading on the meter.

e. At the receive end (fig. 65-2) the AC voltmeter should indicate a -10 dbm0 level. Any deviation greater than ±3 db from -10 dbm0 should be investigated and corrected before proceeding.

f. At the transmit end, reduce the frequency of the delay measuring set until the receive end recorder goes off scale, or at least to the -5 db point, relative to the signal level at 1000 Hz.

g. At the receive end, lower the recorder pen onto figure 8-7; USACC Form 396-R (Test).

h. At the transmit end, turn on the delay measuring set sweep. For stable transmission paths, a fast sweep (approximately 4 sweeps per minute) will normally be used. However, if the channel contains abrupt discontinuities or if the transmission path is subject to rapid frequency fades, a slow sweep should be used in order to allow the pen to follow rapid changes, or for the effect of fades to be minimized. Allow the sweep to continue until the pen goes off scale or at least to the -5 db response point. Turn off the delay measuring set sweep and return the delay measuring set output to 1000 Hz.

i. At the receive end, raise the pen and turn off the X-Y recorder servos.

j. At least three channels within each group should be tested, preferably channels 2, 6, and 11, if available.

k. Summarize test results on figure 6-4; USACC Form 351-R (Test).

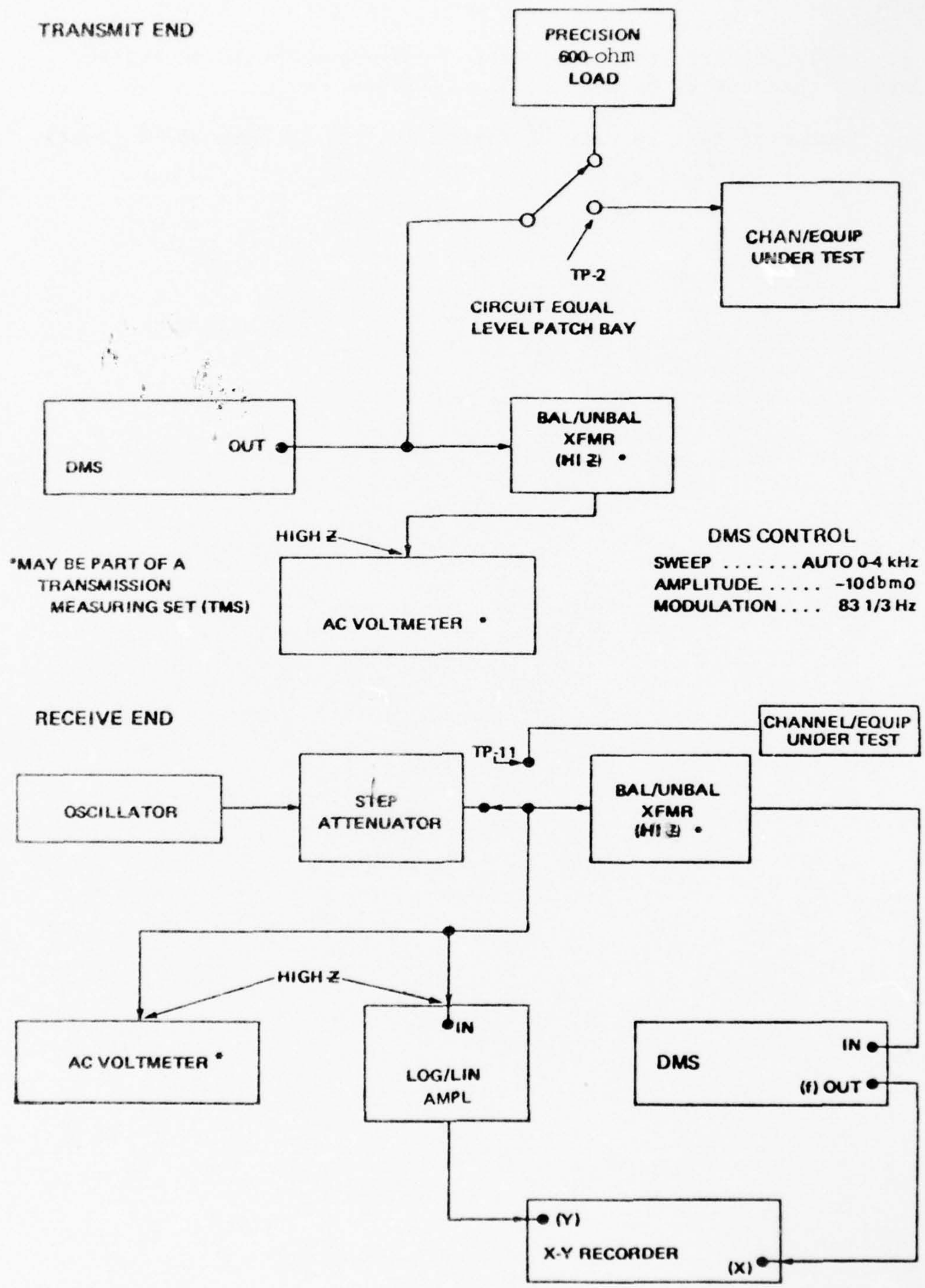


Figure 65-1. Voice channel frequency response (automatic sweep) calibration test configuration.

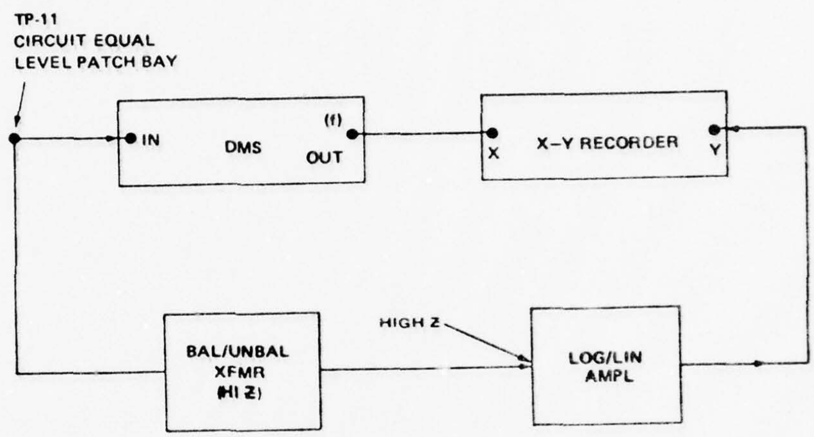


Figure 65-2. Voice channel frequency response (automatic sweep) test configuration.

Preceding Page Blank - NOT FILMed

CHAPTER 66

VOICE CHANNEL ENVELOPE DELAY DISTORTION (MANUAL SWEEP) (T-12)

66-1. GENERAL.

a. The purpose of this test is to evaluate the envelope delay distortion characteristics of individual VF channels by using the delay measuring set for manual sweep across the 4-kHz channel. Four sweep modes are possible: end-to-end without reference, end-to-end with return reference, end-to-end with forward reference, and instation equipment tests. Each method has its own advantages under various operating conditions. The primary difference between the manual sweep technique, outlined in this test procedure, and the automatic sweep technique, outlined in test procedure T-13, is that in the automatic sweep method an X-Y recorder is used; while in the manual sweep method the frequencies are manually set and the data is recorded manually.

b. End-to-end without reference measurements require the line under test to be measured in one direction only. In some situations, it may be the only mode possible. However, the need to establish synchronization between the modulating signal oscillators at both ends, plus time-consuming adjustments requiring voice coordination, make it a less desirable mode when other options exist.

c. End-to-end with return reference eliminates the necessity of synchronizing the modulating signal oscillators. Modulation is detected from the received amplitude modulated swept carrier at the receiving station and applied to an unswept fixed frequency carrier for return to the originating transmitting station. At which point its phase is measured relative to the phase of the modulating signal. This mode measures envelope delay in the transmit direction and is particularly useful where measurements are made and recorded primarily at the transmitting station. However, a separate reference return voice channel is required.

d. End-to-end with forward reference also eliminates the necessity of synchronizing the modulating signal oscillators, but is not an option available on all delay measuring sets. In forward reference, a modulating signal from the receiving station modulating signal generator is transmitted over a fixed frequency carrier to the transmit end where it modulates the transmitter. The receiving station operates in the same manner as for return reference, except that the measurements are made and recorded at the receiving station instead of the transmitting station. However, a separate forward reference voice channel is required.

e. Envelope delay distortion measurements using one delay measuring set can be performed on instation equipment such as line conditioners. These measurements serve as a troubleshooting tool and a quality control check when they can be compared against a known standard. They should never be used for circuit tests.

f. In general, the voice channel envelope delay distortion measurements will be made between the transmit circuit equal level patch bay TP-2 and the receive circuit equal level patch bay TP-11. If there are indications that the measured delay distortion between these two test points does not meet the applicable standards, additional measurements should be made between other combinations of test points in order to isolate the source of the problem.

g. It is recommended that the envelope delay distortion be measured in at least three voice channels per group, preferably channels 2, 6, and 11, if available.

66-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

66-3. TEST EQUIPMENT REQUIRED. Delay measuring set.

66-4. TEST PROCEDURES.

a. General Delay Measuring Set.

(1) Allow the equipment to warm up before calibration and testing. Adjust the delay measuring set input and output impedance switches to 600 ohms. For balanced operation, remove all shorting straps which may be placed between one side of the delay measuring set input line and ground. Switch the delay measuring set to 83-1/3 Hz modulation.

(2) Configure the test equipment as illustrated in figure 66-1. At the transmit end, set the delay measuring set to transmit and connect the output of the delay measuring set to the input of the line to be tested at TP-2. Adjust the delay measuring set to - 10 dbm0 at 2000 Hz.

(3) At the receive end, connect the output of the line under test at TP-11 to the receiver input of the delay measuring set. Adjust the delay measuring set to read the receive level.

(4) Summarize the test data on figure 6-4; USACC Form 351-R (Test).

b. End-to-End without Reference.

(1) Adjust the delay measuring controls as instructed in the operating manual for the end-to-end mode.

(2) At the receive end, make vernier synchronization adjustments to the modulation oscillator to stop any drift in the delay reading.

(3) Set the delay measuring set delay at a reference of 1000 microseconds at 2000 Hz. On some models of the delay measuring set, this reference must be adjusted at the transmit end.

(4) Adjust the delay measuring set at the transmit end to 200 Hz. Record the delay at the receive end on figure 66-2; USACC Form 469-R (Test).

(5) Increase the frequency at the transmit end shown on figure 66-2; USACC Form 469-R (Test) while recording the delay readings in the appropriate column.

(6) Plot a curve of envelope delay versus frequency on figure 8-7; USACC Form 396-R (Test).

(7) Summarize the test data on figure 6-4; USACC Form 351-R (Test).

c. End-to-End with Return Reference.

(1) Configure the test equipment as illustrated in figure 66-3.

(2) Specific instructions for use of this mode are included in operating manuals for various delay measuring set equipment. Controls should be set as per instructions for transmit and receive ends.

(3) Set the transmit and receive delay measuring set to 2000 Hz and adjust the delay reference for a reading of 1000 microseconds at the transmitting delay measuring set. In this mode, the modulating signal is generated at the transmitting station and used to amplitude modulate a carrier whose frequency is controlled and swept at the transmitter.

(4) Adjust the transmitting delay measuring set to 200 Hz and record the delay at the receive delay measuring set on figure 66-2; USACC Form 469-R (Test).

(5) Increase the frequency at the transmitting delay measuring set in the increments shown on the data sheet at the transmitting station, while recording the delay readings in the appropriate column.

(6) Plot a curve of envelope delay versus frequency on figure 8-7; USACC Form 396-R (Test).

(7) Summarize the test data on figure 6-4; USACC Form 357-R (Test).

d. End-to-End with Forward Reference.

(1) Configure the test equipment as illustrated in figure 66-4.

(2) Specific instructions may not be included in operating manuals for this mode. However, delay measuring sets having return reference modes can be configured for forward reference by simply holding the sweep generator to a single frequency at the receiving station and manually setting the desired frequency at the transmitting station. In this mode, the modulating signal is generated at the receiving station where its phase is compared with the phase of the demodulated received signal, and also transmitted to the transmit end over the return modulating signal channel where it is used to modulate the delay measuring set transmitter.

(3) Set the transmit and receive ends to 2000 Hz and adjust the reference delay at the receive end to read 1000 microseconds.

(4) Adjust the transmitting delay measuring set to 200 Hz and record the delay at the receive delay measuring set on figure 66-2; USACC Form 469-R (Test).

(5) Increase the frequency at the transmitting delay measuring set in the increments shown on the data sheet at the transmitting station, while recording the delay readings in the appropriate column.

(6) Plot a curve of envelope delay versus frequency on figure 8-7; USACC Form 396-R (Test).

(7) Summarize the test data on figure 6-4; USACC Form 351-R (Test).

e. Instation Equipment.

(1) Measurements are made in the same manner as end-to-end measurements with one delay measuring set acting as both the transmitter and receiver.

(2) Connect the transmit and receive ends of the delay measuring set to the test points between which the envelope delay distortion is being investigated.

(3) Adjust the delay measuring set to 2000 Hz and 1000 microseconds delay.

(4) Change the frequency to 200 Hz and record the delay on figure 66-2; USACC Form 469-R (Test).

(5) Increase the frequency in the increments shown on the data sheet while recording delay readings in the appropriate column.

(6) Plot a curve of envelope delay versus frequency on figure 8-7; USACC Form 396-R (Test).

(7) Summarize the test data on figure 6-4; USACC Form 351-R (Test).

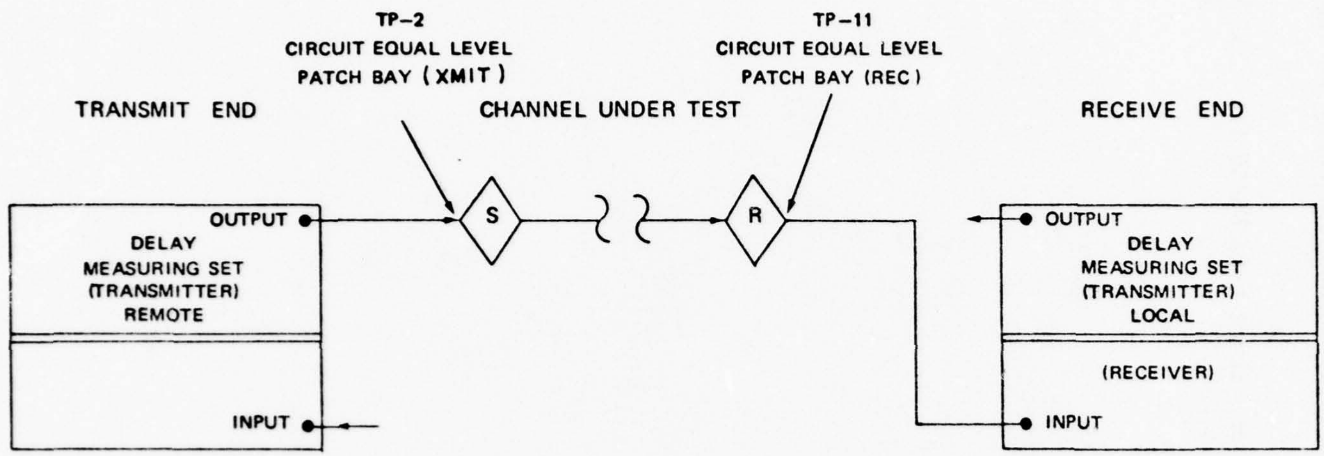


Figure 66-1. Voice channel envelope delay distortion (manual sweep -- end-to-end without reference) test configuration.

VOICE CHANNEL ENVELOPE DELAY DISTORTION (MANUAL SWEEP) DATA SHEET (CCR 702-1-3)		PAGE OF PAGES
		DATE (DAY, MONTH, YEAR)
LINK NO.	TEST METHOD	TEST ENGR SIGNATURE
TEST POINTS		
DISTANT STATION (XMIT)	LOCAL STATION (REC)	

CHANNEL	SG									
	GP									
	CH									
FREQ		MEASURED RELATIVE DELAY *(Microseconds)*								
100										
200										
300										
400										
500										
600										
800										
1000										
1200										
1400										
1600										
1800										
2000										
2200										
2400										
2600										
2800										
3000										
3200										
3400										
3600										

USACC FORM 469-R (TEST)
1 MAY 77

Figure 66-2. Voice channel envelope delay distortion (manual sweep) data sheet.

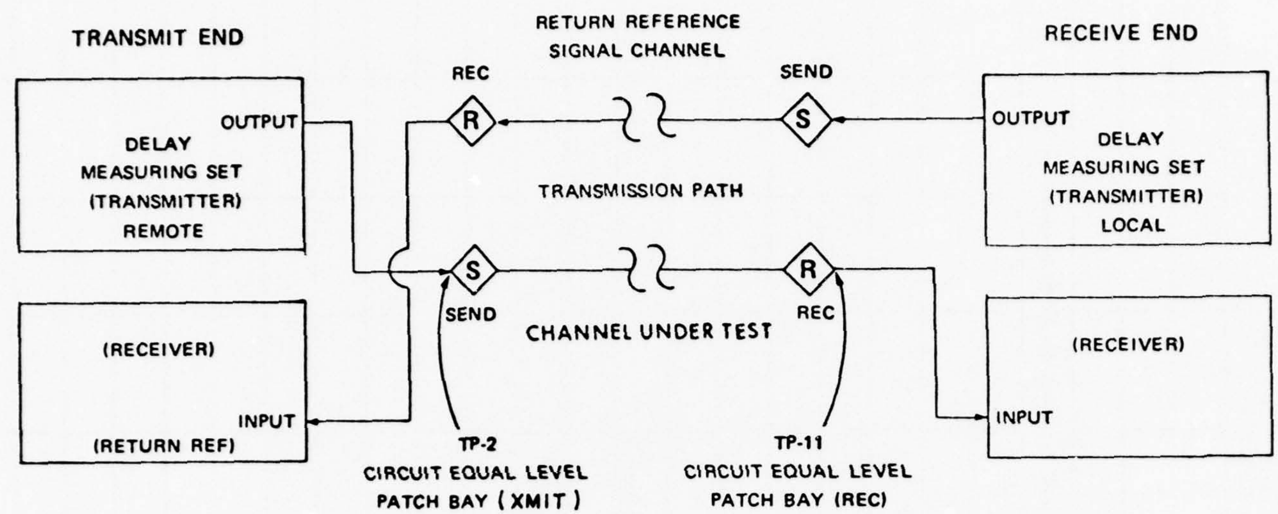


Figure 66-3. Voice channel envelope delay distortion (manual sweep -- return reference) test configuration.

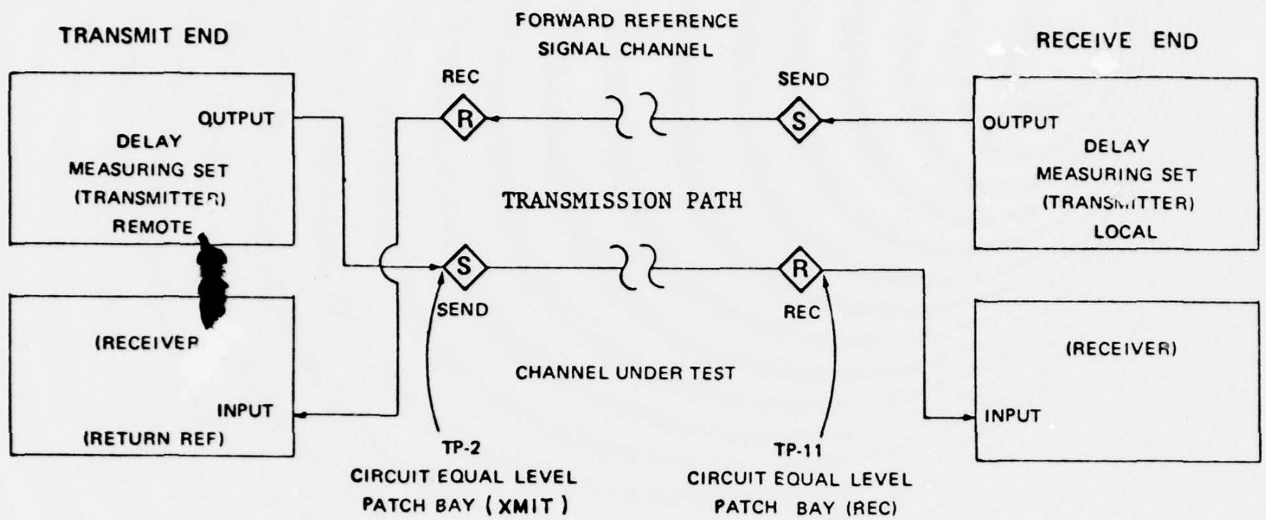


Figure 66-4. Voice channel envelope delay distortion (manual sweep -- forward reference) test configuration.

Preceding Page Blank - NOT FILMED

CHAPTER 67

VOICE CHANNEL ENVELOPE DELAY DISTORTION (AUTOMATIC SWEEP) (T-13)

67-1. GENERAL.

a. The purpose of this test is to evaluate the envelope delay distortion characteristics of individual VF channels by using the delay measuring set for automatic sweep across the 4-kHz channel. Four automatic sweep modes are possible: end-to-end without reference, end-to-end with return reference, end-to-end with forward reference, and instation equipment tests. Each method has its own advantages under various operating conditions. The primary difference between the automatic sweep technique, outlined in this test procedure, and the manual sweep technique, outlined in test procedure T-12 is that in the manual sweep method the frequencies are set manually while in the automatic sweep method the X-Y recorder is used.

b. End-to-end without reference measurements require the line under test to be measured in one direction only. In some situations, it may be the only mode possible. However, the need to establish synchronization between the modulating signal oscillators at both ends, plus time-consuming adjustments requiring voice coordination, make it a less desirable mode when other options exist.

c. End-to-end with return reference eliminates the necessity of synchronizing the modulating signal oscillators. Modulation is detected from the received amplitude modulated swept carrier at the receiving station and applied to an unswept fixed frequency carrier for return to the originating transmitting station, where its phase is measured relative to the phase of the modulating signal. This mode measures envelope delay in the transmit direction and is particularly useful where measurements are made and recorded primarily at the transmitting station. However, a separate reference return voice channel is required.

d. End-to-end with forward reference also eliminates the necessity of synchronizing the modulating signal oscillators, but is not an option available on all delay measuring sets. In forward reference, a modulating signal from the receiving station modulating signal generator is transmitted over a fixed frequency carrier to the transmit end where it modulates the transmitter. The receiving station operates in the same manner as for return reference, except that the measurements are made and recorded at the receiving station instead of the transmitting station. However, a separate forward reference voice channel is required.

e. Envelope delay distortion measurements using one delay measuring set can be performed on instation equipment such as line conditioners. These measurements serve as a troubleshooting tool and a quality control check when they can be compared against a known standard. They should never be used for circuit tests.

f. In general, the voice channel envelope delay distortion measurements will be made between the transmit circuit equal level patch bay TP-2 and the receive circuit equal level patch bay TP-11. If there are indications that the measured delay distortion between these two test points does not meet the applicable standards, additional measurements should be made between other combinations of test points in order to isolate the source of the problem.

g. It is recommended that the envelope delay distortion be measured in at least three voice channels per group, preferably channels 2, 6, and 11, if available.

67-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

67-3. TEST EQUIPMENT REQUIRED.

a. Delay measuring set.

b. X-Y recorder.

67-4. TEST PROCEDURES.

a. General Delay Measuring Set.

(1) Allow the equipment to warm up before calibration and testing. Adjust the delay measuring set input and output impedance switches to 600 ohms. For balanced operation, remove all shorting straps which may be placed between one side of the delay measuring set input line and ground. Switch the delay measuring set to 83-1/3 Hz modulation.

(2) Configure the test equipment as illustrated in figure 67-1. Calibrate the delay measuring set and X-Y recorder at the receiving station by looping back the output of the delay measuring set to the X input. Connect analog delay (O) output of the DMS to the Y input of the X-Y recorder. Connect analog frequency (F) output of the DMS to the X-Y recorder. Set the delay measuring set for end-to-end loop and calibrate the X-axis of the recorder between zero and 4 kHz by varying the delay measuring set frequency and adjusting the controls of the recorder accordingly. Then calibrate the Y-axis of the recorder between 800 and 2400 microseconds by varying the delay measuring set controls and adjusting the recorder accordingly. It may be necessary to insert advice with delay in the loop such as a filter in order to get delay readings from 800 to 2400 microseconds for calibration. Always turn off the X-Y recorder servos whenever the pen reaches the end of its travel. Never allow the servos to grind against the stops.

(3) At the transmitting station, set the delay measuring set to transmit and connect the output of the delay measuring set to the input of the line to be tested at TP-2. Adjust the delay measuring set to -10 dbm0 at 2000 Hz.

(4) At the receiving station, connect the output of the line under test at TP-11 to the receiver input of the delay measuring set and adjust the delay measuring set to read the receive level.

(5) Summarize the test data on figure 6-4; USACC Form 351-R (Test).

b. End-to-End without Reference.

(1) Adjust the delay measuring set control as instructed in the operating manual for end-to-end mode.

(2) At the receive end make vernier synchronization adjustments to the modulation oscillator to stop any drift in the delay reading.

(3) Set the delay measuring set at a reference of 1000 microseconds at 2000 Hz. On some models of the delay measuring set this reference must be adjusted at the transmit end.

(4) At the transmit end, set the upper and lower frequency limits on the delay measuring set to 200 Hz and 4000 Hz IAW operating manual instructions and select the sweep rate desired.

(5) Plot a curve on figure 8-7; USACC Form 396-R (Test) as outlined in paragraph 67-4f.

(6) Summarize the test data on figure 6-4; USACC Form 351-R (Test).

c. End-to-End with Return Reference.

(1) Configure the test equipment as illustrated in figure 67-2.

(2) Specific instructions for use of this mode are included in operating manuals for various delay measuring set equipment. Controls should be set as per instructions for transmit and receive ends.

(3) Set the transmitting and receiving delay measuring set to 2000 Hz and adjust the delay reference for a reading of 1000 microseconds at the transmitting delay measuring set. In this mode, the modulating signal is generated at the transmitting station and used to amplitude modulate a carrier whose frequency is controlled and swept at the transmitter.

(4) At the transmitting station, set the upper and lower limits on the sweep generator to 200 Hz and 4000 Hz using the operating manual instructions and select the sweep rate desired.

(5) Plot a curve on figure 8-7; USACC Form 396-R (Test) as outlined in paragraph 67-4f.

(6) Summarize the test data on figure 6-4; USACC Form 351-R (Test).

d. End-to-End with Forward Reference.

(1) Configure the test equipment as illustrated in figure 67-3.

(2) Specific instructions may not be included in operating manuals for this mode. However, delay measuring sets having return reference modes can be configured for forward reference by simply holding the sweep generator to a single frequency at the receiving station and selecting any desired sweep rate at the transmitting station. In this mode, the modulating signal is generated at the receiving station where its phase is compared with the phase of the demodulated received signal, and also transmitted to the transmit end over the return modulating signal channel where it is used to modulate the delay measuring set transmitter.

(3) Set the transmit and receive ends to 200 Hz and adjust the reference delay at the receive end to read 1000 microseconds.

(4) At the transmit end, set the upper and lower limits on the sweep generator to 200 Hz and 4000 Hz IAW operating manual instructions and select the sweep rate desired.

(5) Plot a curve on figure 8-7; USACC Form 396-R (Test) as outlined in paragraph 67-4f.

(6) Summarize the test data on figure 6-4; USACC Form 351-R (Test).

e. Instation Equipment.

(1) Measurements are made in the same manner as end-to-end measurements with one delay measuring set acting as both the transmitter and receiver.

(2) Connect the transmit and receive ends of the delay measuring set to the test points between which the envelope delay distortion is being investigated.

(3) Plot a curve on figure 8-7; USACC Form 396-R (Test) as outlined in paragraph 67-4f.

(4) Summarize the test data on figure 6-4; USACC Form 351-R (Test).

f. Recorder.

(1) For stable transmission paths, a fast sweep will normally be used. However, if the channel contains abrupt discontinuities or if the transmission path is subject to frequent rapid fades, a slow sweep should be used in order to allow the pen to follow rapid changes or for the effect of fades to be minimized.

(2) Turn on the X-Y recorder servos and insure that the pen reads 1000 microseconds at 2000 Hz. Reduce the frequency of the delay measuring set until the recorder goes off scale or at least to the 2000 microsecond point. Then turn on the sweep. The delay will be recorded on the local station X-Y recorder.

(3) Allow the sweep to continue until the pen goes off scale or at least to the 2000 microsecond point. Raise the recorder pen, turn off the recorder servos, turn off the delay measuring set sweep, and return the delay measuring set frequency to 2000 Hz. Check the delay distortion curve at 2000 Hz. If the curve did not cross 1000 microseconds at that point, the equipment has drifted and the test must be repeated.

(4) Summarize the test data on figure 6-4; USACC Form 351-R (Test).

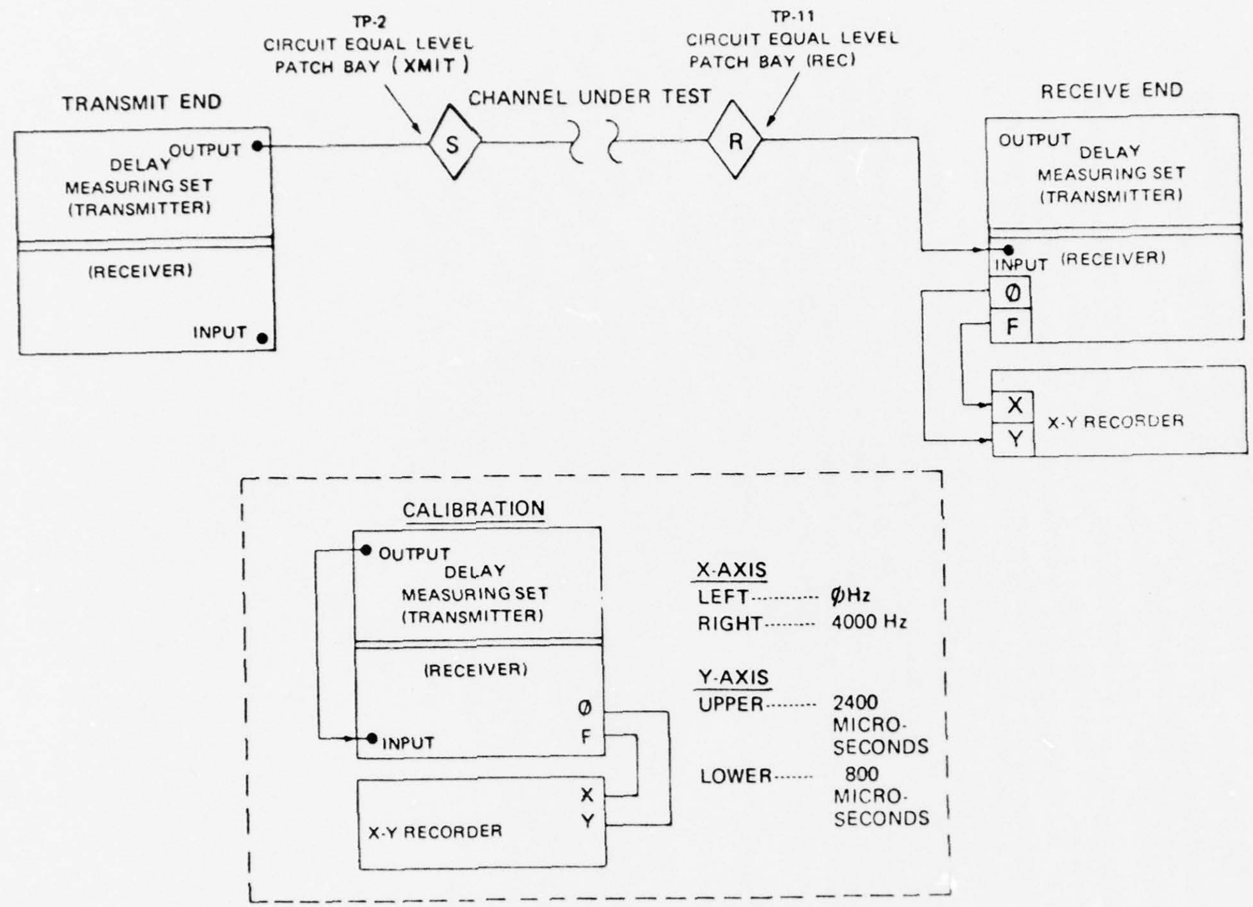


Figure 67-1. Voice channel envelope delay distortion (automatic sweep -- end-to-end without reference) test configuration.

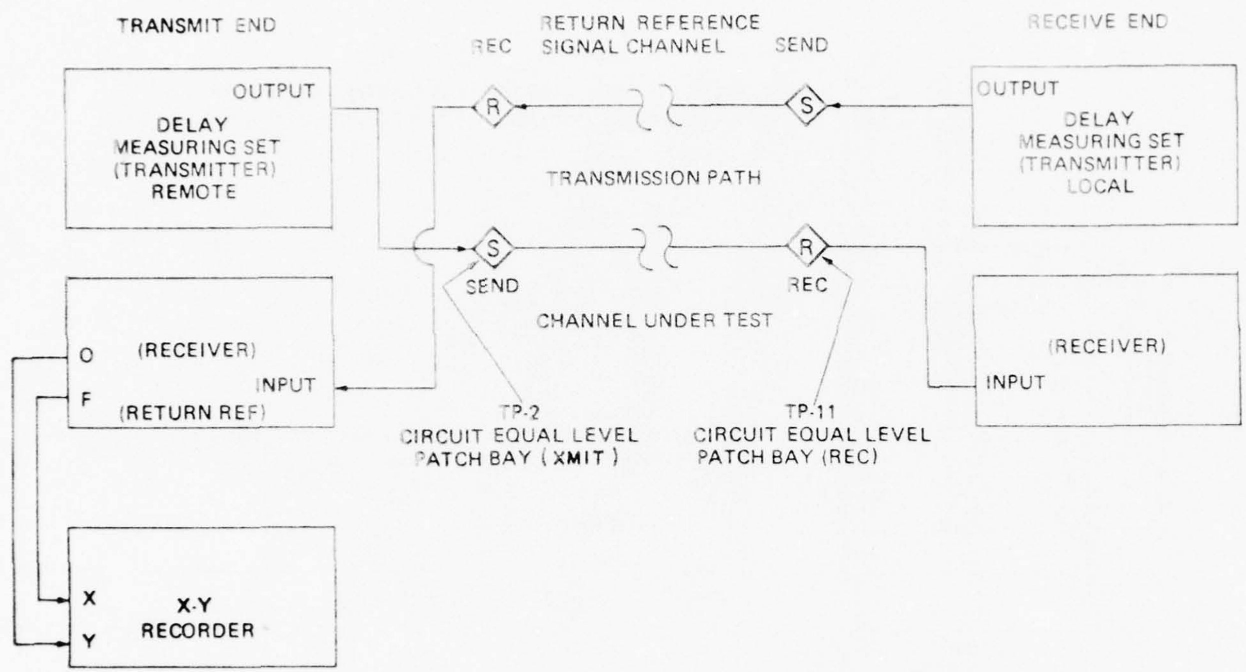


Figure 67-2. Voice channel envelope delay distortion (automatic sweep -- return reference) test configuration.

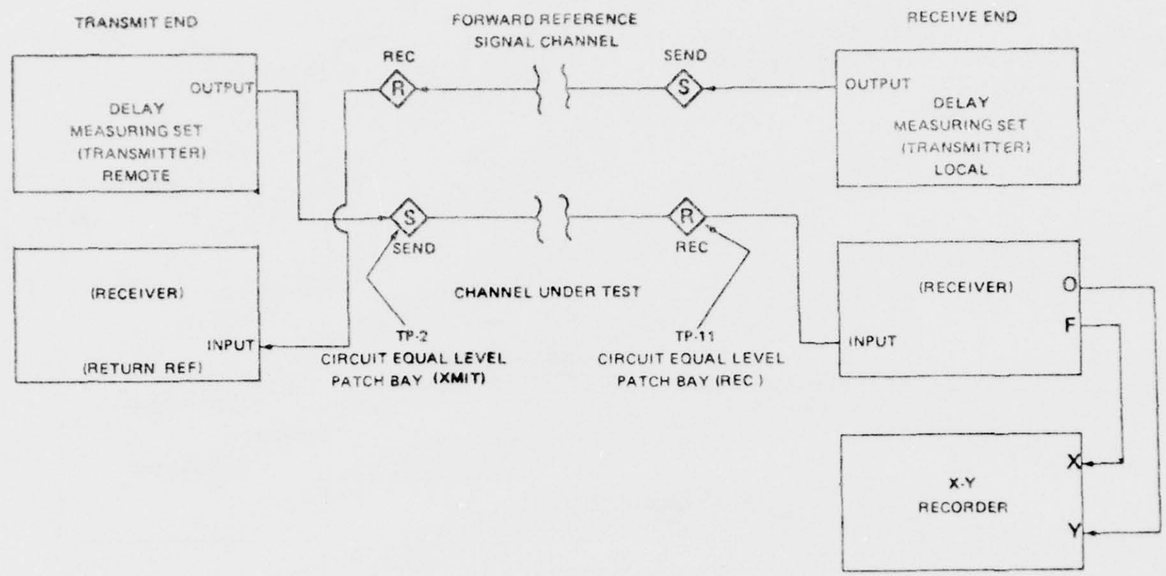


Figure 67-3. Voice channel envelope delay distortion (automatic sweep -- forward reference) test configuration.

CHAPTER 68

VOICE CHANNEL HARMONIC DISTORTION (T-14)

68-1. GENERAL. The purpose of this test is to measure and evaluate the amount of harmonic distortion on VF channel or other equipment by measuring the level of harmonically related frequencies produced when a single-frequency signal is transmitted through the channel. If excessive distortion (either harmonic or nonharmonic) is detected, the specific distortion component frequencies are measured using either or both an FSVM and a distortion analyzer. In general, the measurement is made between the transmit circuit equal level patch bay TP-2 and the receive circuit equal level patch bay TP-11. However, if there are indications that the distortions between these points are excessive, additional measurements between other combinations of test points should be made in order to isolate the source of the problem. Since this test requires higher than standard (-10 dbm0) test tone power levels, it should be conducted only on an out-of-service basis or during nonbusy hours to minimize possible service degradations to system users.

68-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

68-3. TEST EQUIPMENT REQUIRED.

a. Distortion analyzer/voltmeter.

b. FSVM.

c. Balanced/unbalanced transformer (2 ea).

d. 600-ohm termination plug.

e. Audio oscillator or transmission measuring set.

f. AC voltmeter.

68-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 68-1.

b. At the transmit end proceed as follows:

(1) Connect the audio oscillator and AC voltmeter to a 600-ohm terminated balanced/unbalanced transformer.

(2) Connect the distortion analyzer/voltmeter input to the other side of the balanced/unbalanced transformer.

(3) Adjust the oscillator to 700 Hz and set at zero dbm0 output level. If the TLP is at the circuit equal level patch bay TP-2, the oscillator output would be zero dbm as measured on the AC voltmeter. At the VF patch bay TP-3, these power levels would be -16 dbm.

(4) Measure the distortion of the oscillator by setting a reference level on the distortion analyzer/voltmeter, notching out the 700-Hz tone, and reading the total harmonic distortion in db. To successfully conduct this test, the oscillator distortion must be at least 50 db (and preferably 60 db) below the reference level. If the oscillator fails this check, get another oscillator. If another oscillator is not available, try a narrow bandpass filter on the output of the oscillator. Adjust the oscillator to the center frequency of the bandpass filter, but do not conduct this test with a center frequency of over 1000 Hz.

c. At the transmit end connect the output of the oscillator through the balanced/unbalanced transformer (high impedance position) to the channel input circuit equal level patch bay TP-2, and monitor the level set at zero dbm0 with the AC voltmeter connected to TP-2 as illustrated in figure 68-1.

d. At the receive end proceed as follows:

(1) Connect the output of the channel (TP-11) to the balanced side of the 600-ohm terminated balanced/unbalanced transformer.

(2) Connect the unbalanced side of the transformer to the bridged inputs of the distortion analyzer/voltmeter and the FSVM.

(3) The received 700-Hz tone should be within ±1 db of zero dbm0 (para 68-4b(3)).

(4) Measure the channel distortion by setting a db reference level on the distortion analyzer/voltmeter, notching out the 700-Hz tone and reading the total harmonic distortion in db. Record the data on figure 68-2; USACC Form 470-R (Test).

(5) Compute and record the corresponding percent distortion using figure 68-2; USACC Form 470-R (Test).

(6) If the measured distortion is greater than -40 db (1 percent), have the transmit end disconnect the input and insert a 600-ohm termination plug. Without resetting the reference level, check for residual noise on the channel which should be 10 db below the distortion level.

CCP 702-2

(7) If the measured distortion is significantly greater than -40 db, explore the distortion components in more detail with the FSVM. Also, look for and record other spurious frequencies (greater than -50 dbm0) such as leakage from ringing signals and powerline hum.

e. It is recommended that a minimum of three voice channels per group be measured, preferably channels 2, 6, and 11, if available.

f. Plot a curve of distortion conversion versus percentage on figure 8-7; USACC Form 396-R (Test).

g. Summarize test results on figure 6-4; USACC Form 351-R (Test).

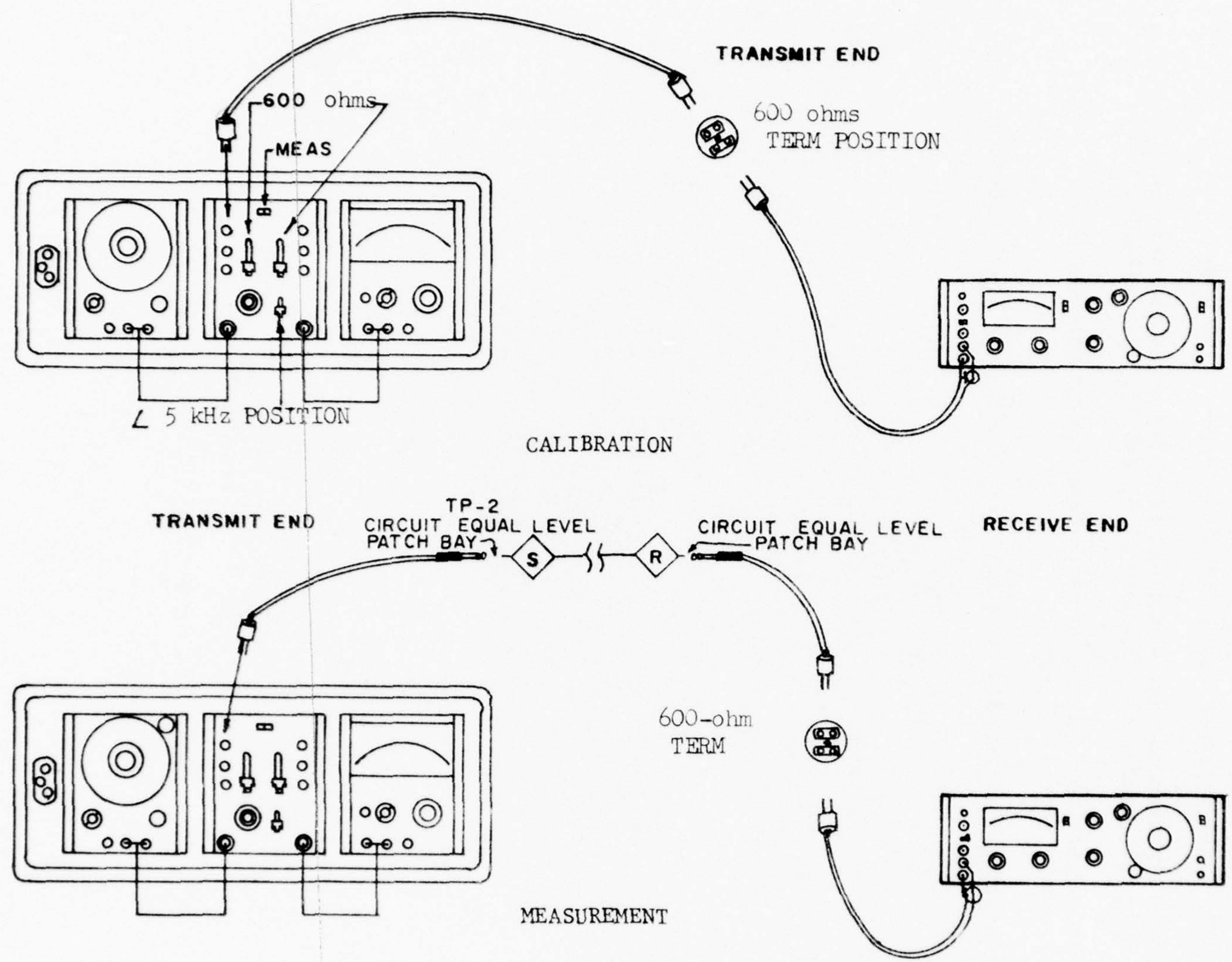


Figure 68-1. Voice channel harmonic distortion test configuration.

VOICE CHANNEL HARMONIC DISTORTION
(CCR 702-1-3)

DATA SHEET

LINK NO.

PAGE OF PAGES

DATE (DAY, MONTH, YEAR)

DISTANT STATION

LOCAL STATION

TEST TIME PERIOD — START Z — STOP Z

TEST ENGR SIGNATURE

TEST POINTS AND TLP LEVELS ▶ XMIT: TP– ____ ; ____ dbm / REC: TP– ____ ; ____ dbm

TEST SIG = 0 dbm0

CHANNEL			DISTORTION ANALYZER					DISTORTION ANALYSIS (FSVM)									
			RECEIVE TEST SIG LEVEL		MEASURED DISTORTION		RESID-UAL NOISE	FREQUENCY, Hz			FREQ Hz	LEVEL dbm	FREQ Hz	LEVEL dbm	FREQ Hz	LEVEL dbm	PERCENT DIS-TORTION
								1400	2100	2800							
								LEVEL									
SG NO.	GP NO.	V CH NO.	dbm	ERROR db	db	%	db	dbm	dbm	dbm							

USACC FORM 470-R (TEST)
1 MAY 77

Figure 68-2. Voice channel harmonic distortion data sheet.

Preceding Page Blank - NOT FILMed

CHAPTER 69

VOICE CHANNEL FREQUENCY TRANSLATION (T-15)

69-1. GENERAL. The purpose of this test is to measure the frequency translation of a 1-kHz test tone as transmitted through a VF channel. Frequency translation is defined as a change in receive frequency as compared to the transmit frequency. This change in frequency results from the multiplex equipment inaccuracies in translating the input frequency to the correct output frequency. This measurement is made between the transmit circuit equal level patch bay TP-2 and the receive circuit equal level patch bay TP-11.

69-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

69-3. TEST EQUIPMENT REQUIRED.

a. Audio oscillator.

b. AC voltmeter (2 ea).

c. Balanced/unbalanced transformer (2 ea).

d. Audio frequency counter.

69-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 69-1. Turn on the oscillator and counter at least 1 hour before test is scheduled, to provide sufficient warmup time for this equipment.

b. At the transmit end connect the audio oscillator, voltmeter, and audio frequency counter to the balanced/unbalanced transformer. Connect the output of the balanced/unbalanced transformer to the selected voice channel at the circuit equal level patch bay TP-2. Set the oscillator at 1000 Hz and -10 dbm0.

c. Check to see if the audio frequency counter has the proper triggering signal by raising the trigger level until the counter will not function. Then set the trigger level about 6 db lower to insure proper operation of the frequency counter; the counter should read approximately 1000 Hz. Check the audio frequency counter reading frequently to see if the oscillator has drifted. If drift is a problem, it will be necessary to check the frequency at both transmit and receive ends simultaneously during the test. This can be done manually using the orderwire for coordination.

d. At the receive end connect the output of the 600-ohm terminated transformer to an AC voltmeter and the audio frequency counter. Connect the input of the balanced/unbalanced transformer to the selected voice channel at the circuit equal level patch bay TP-11. Be sure that the level reads close to -10 dbm0. If not, investigate and correct before proceeding.

e. Check to see if the audio frequency counter has the proper triggering level as described in paragraph 69-4c.

f. Record the transmit frequency (as reported over the orderwire) and then count and record the receive frequency (simultaneously if necessary) to ±0.1 Hz accuracy on figure 69-2; USACC Form 471-R (Test). Calculate and record the translation by subtracting the receive frequency from the transmit frequency.

g. It is recommended that a minimum of three voice channels per group be measured, preferably channels 2, 6, and 11, if available.

h. Summarize test results on figure 6-4; USACC Form 351-R (Test).

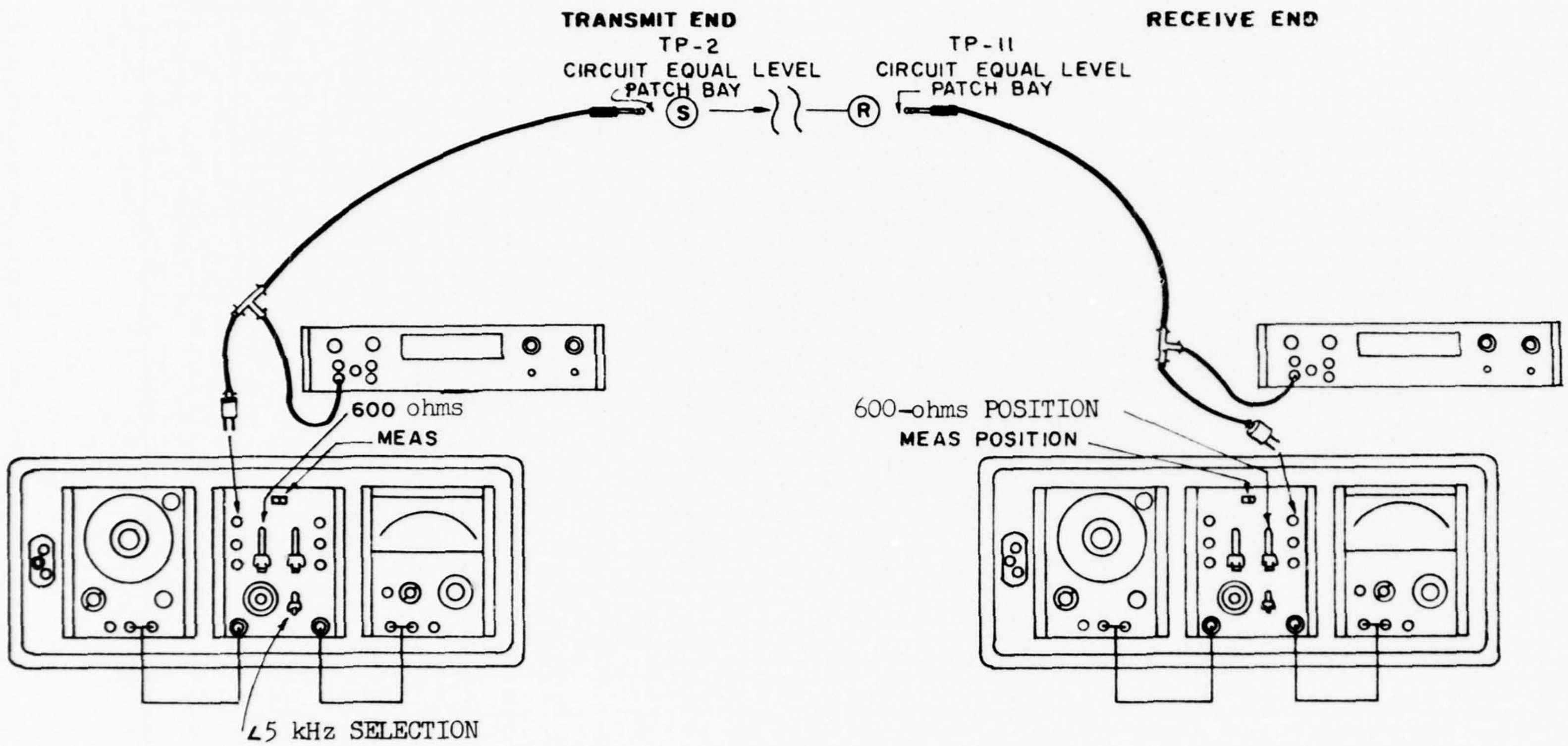


Figure 69-1. Voice channel frequency translation test configuration.

VOICE CHANNEL FREQUENCY TRANSLATION DATA SHEET (CCR 702-1-3)		PAGE OF PAGES DATE (DAY, MONTH, YEAR)
LINK NO.	TEST TIME PERIOD START Z STOP Z	TEST ENGR SIGNATURE
TEST POINTS DISTANT STATION (XMIT)	LOCAL STATION (REC)	

CHANNEL			FREQUENCY		TRANSLATION (F_{xmit} MINUS F_{rec}) (Hz)
SG	GP	CH	TRANSMIT (Hz)	RECEIVE (Hz)	

USACC FORM 471-R (TEST)
1 MAY 77

Figure 69-2. Voice channel frequency translation data sheet.

CHAPTER 70

VOICE CHANNEL SPURIOUS PHASE JITTER AND HITS (METER METHOD) (T-16)

70-1. GENERAL.

a. The purpose of this test is to measure the spurious phase variations of a single-frequency (tone) signal transmitted through a VF channel. These spurious phase variations of the tone signal are generated as the signal is processed through a communications system. Specifically, the phase measurements in this test procedure are restricted to the phase jitter and phase hit components of the spurious phase variations, as measured by phase jitter and phase hit meters. Phase jitter is defined as cyclic variations of the spurious phase, usually associated with power supply hum; and phase hits are defined as very large values of spurious phase having very short duration.

b. In general, the spurious phase measurements are made between the transmit circuit equal level patch bay TP-2 and the receive circuit equal level patch bay TP-11. However, if there are indications that the measured spurious phase between these two test points does not meet the applicable standards, additional measurements should be made between other combinations of test points, including baseband and multiplex, in order to isolate the source of the problem.

c. This test is conducted in an idle channel with the radio link inservice.

70-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

70-3. TEST EQUIPMENT REQUIRED.

a. FSVM.

b. AF-RF oscillator.

c. Phase jitter meter.

d. Phase hit meter.

e. AC voltmeter.

f. Balanced/unbalanced transformer.

g. Frequency counter.

70-4. TEST PROCEDURES.

a. Voice Channel Phase Jitter and Phase Hit.

(1) Configure the test equipment as illustrated in figure 70-1.

(2) Establish a stable 1000-Hz tone (-10 dbm0) at the transmit end. If a phase jitter meter with a 1000-Hz output is available it should be used to produce the test tone. When an audio oscillator is used to produce the test tone, the jitter of the oscillator should be checked. Connect the test tone to the channel under test at the circuit equal level patch bay TP-2.

(3) At the receive end, connect the input of the phase jitter and phase hit meters to the output of the selected channel at the circuit equal level patch bay TP-11.

(4) Check the input signal level to the phase jitter and phase hit meters; this signal level should be within ±1 db of -10 dbm0. Then adjust the controls of the phase meters IAW instructions provided in the manufacturer's operating manual.

(5) Record the phase jitter and phase hit meter readings on figure 70-2; USACC Form 472-R (Test). The type of measurement taken depends on the type of phase jitter meter used. Also, sufficient time must be allowed for each measurement so as to obtain a stable meter reading; a practical time interval should be approximately 5 minutes. The phase hit measurements should be made for periods of at least 15 minutes. These two different time periods allow for three phase jitter measurements for each of the phase hit measurements all of which should be recorded on the data sheet.

(6) It is recommended that a minimum of three voice channels per group be measured, preferably channels 2, 6, and 11, if available.

(7) Summarize test results on figure 6-4; USACC Form 351-R (Test).

b. Voice Channel Phase Jitter and Phase Hit in Baseband and Multiplex Channels.

(1) These phase measurements are made by converting a selected nominal 3.1-kHz voice channel section of the baseband signal spectrum to a voice channel signal. An FSVM is used to make this conversion as shown in figure 70-1. The input circuit undistorted dynamic range and the noise level of the audio section of the FSVM must be such as not to interfere with or restrict the accuracy of the phase measurements.

(2) Repeat paragraphs 70-4a (1) through (7) with the following changes:

(a) The test tone may be inserted at any one of the desired test points, TP-1 through TP-6; and only in an idle channel.

(b) The frequency of the inserted test tone, at the transmit end, must be such that a 1000-Hz tone is recovered at the output of the FSVM (receive end).

(c) Phase jitter and phase hit measurements are made, using the FSVM, at TP-7, TP-8, and TP-9.

c. Instation Voice Channel Phase Jitter and Phase Hit. These measurements can be made by repeating paragraphs 70-4a (1) through (7) and 70-4b(2) but with the following changes:

(1) At the transmit end, insert the test tone signal at TP-1 and measure the phase jitter and phase hits at TP-2 through TP-6. Other combinations of test points may be used, if required.

(2) At the receive end, insert the test tone signal at TP-7 and measure the phase jitter and phase hits at TP-8 through TP-12. Other combinations of test points may be used, if required.

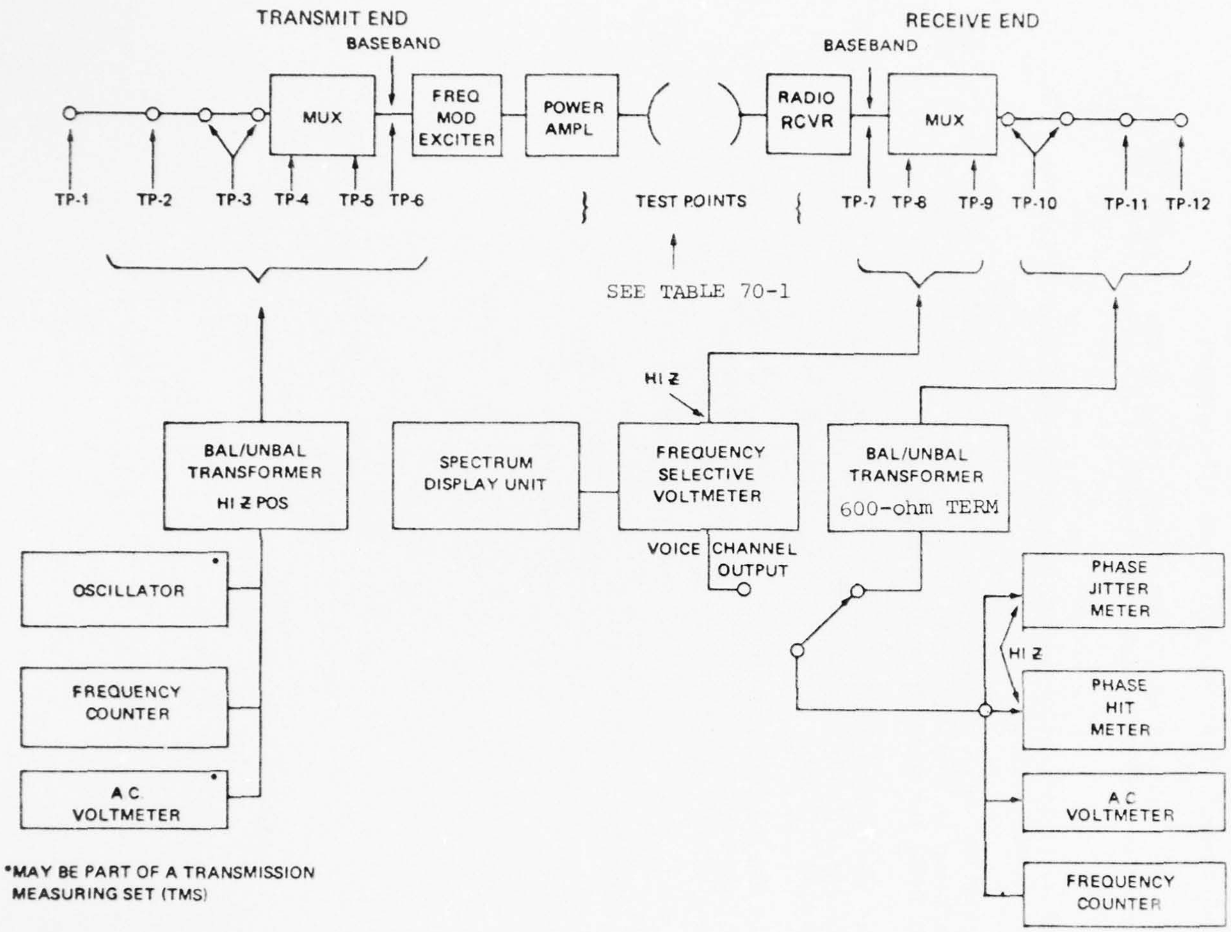


Figure 70-1. Voice channel spurious phase jitter and phase hits (meter method) test configuration.

Table 70-1. Test Points

TEST POINT NO.	DEFINITION
Transmit End	
TP-1	Primary/Cable Patch Bay (PPB)
TP-2	Circuit Equal Level Patch Bay (CPB)
TP-3	VF Patch Bay - Mux Patch Bay (VFPB/MPB)
TP-4	Group Mod Input Test Level Point
TP-5	Supergroup Mod Input Test Level Point
TP-6	Baseband (HF) Dist Frame
Receive End	
TP-7	Baseband (HF) Dist Frame
TP-8	Supergroup Demodulator Output Level Point
TP-9	Group Demodulator Output Level Point
TP-10	Mux Patch Bay-VF Patch Bay (MPB/VFPB)
TP-11	Circuit Equal Level Patch Bay (CPB)
TP-12	Primary/Cable Patch Bay (PPB)

VOICE CHANNEL SPURIOUS PHASE JITTER AND PHASE HITS (METER METHOD) DATA SHEET (CCR 702-1-3)					PAGE OF PAGES DATE (DAY, MONTH, YEAR)	
LINK NO.	STATION UNDER TEST	DISTANT STATION			TEST ENGR SIGNATURE	
INPUT TEST POINT NO.	OUTPUT TEST POINT NO.	CHANNEL			PEAK-TO-PEAK PHASE JITTER (deg)	NUMBER OF PHASE HITS IN 15 MIN
		SG NO.	GP NO.	V CH NO.		

USACC FORM 472-R (TEST)
1 MAY 77

Figure 70-2. Voice channel spurious phase jitter and phase hits (meter method) data sheet.

CHAPTER 71

VOICE CHANNEL PHASE JITTER (OSCILLOSCOPE METHOD) (T-17)

71-1. GENERAL.

a. The purpose of this test is to measure the spurious phase variations of a single-frequency (tone) signal transmitted through a VF channel. These spurious phase variations of the tone signal are generated as the signal is processed through a communications system. Specifically, the phase measurements in this test procedure are restricted to the phase jitter of the spurious phase variations, as measured by the oscilloscope. Phase jitter is defined as cyclic variations of the spurious phase usually associated with power supply hum.

b. In general, the spurious phase measurements are made between the transmit circuit equal level patch bay TP-2, and the receive circuit equal level patch bay TP-11. However, if there are indications that the measured spurious phase between these two test points does not meet the applicable standards, additional measurements should be made between other combinations of test points, including baseband and multiplex, in order to isolate the source of the problem.

c. This test is conducted in an idle channel with the radio link inservice.

d. The oscilloscope method of measuring phase jitter is more time-consuming than using a phase jitter meter; however, it is not frequency limited as are some phase jitter meters. Precautions given in this test procedure must be scrupulously observed, otherwise incorrect data may be recorded. Therefore, this procedure should be employed only if the phase jitter meter method T-16 cannot be used because of lack of instrumentation.

71-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limited specified in MIL-STD-188/100.

71-3. TEST EQUIPMENT REQUIRED.

a. FSVM.

b. Oscilloscope.

c. AF-RF oscillator.

d. Balanced/unbalanced transformer.

e. AC voltmeter.

f. Frequency counter.

71-4. TEST PROCEDURES.

a. Voice Channel Phase Jitter.

(1) Configure the test equipment as illustrated in figure 71-1.

(2) Preset the oscillators (A) and (B) at each station to a 600-ohm output at a frequency of 1000 Hz and a level of -10 dbm0 at the input to the selected test point.

(3) At the transmit end, connect the output of the balanced/unbalanced transformer to the circuit equal level patch bay TP-2.

(4) At the receive end, connect the input of the balanced/unbalanced transformer to the circuit equal level patch bay TP-11.

(5) Connect the vertical input of the oscilloscope to the output of the balanced/unbalanced transformer, carefully adjust the frequency of the oscillator at the receive end, and the sync controls on the oscilloscope for a 1-cycle display which begins at the 0-degree point. Set the vertical position and amplitude controls so that the 0-, 180-, and 360-degree points are exactly on the center graticule. The phase jitter will appear on the oscilloscope as a smear of the zero crossing of the curve; the amount of the smear, in units of degrees on the graticule, is a measure of the peak-to-peak phase jitter. The accuracy and validity of this test will depend upon how critical the crossover point of the sinusoidal wave is maintained on the center graticule of the oscilloscope. If this point is allowed to move above or below the centerline, amplitude variations will appear as phase changes.

(6) Switch the X10 horizontal multiplier to the ON position. Peak-to-peak phase jitter can now be read on the center horizontal line as 3.6 degrees per large division. In the event a X10 horizontal multipier is not available on the oscilloscope, adjust the sweep speed of the oscilloscope to a 10 microseconds per division. This will provide the same display as when using the X10 multiplier.

(7) To provide easier and more accurate reading of the peak-to-peak jitter, the vertical oscilloscope sensitivity may be increased. At extremely sensitive settings, the vertical position of the display may move. Correction for this change must be made before the amount of jitter can be accurately determined. Vertical position accuracy may be checked by grounding the vertical input of the channel and adjusting the trace to centerline. The ground can then be removed and the vertical position of the trace adjusted to the point of minimum jitter. This position then corresponds to the 0-, 180-, and 360-degree position of the waveform.

(8) Record the amount of peak-to-peak phase jitter on figure 71-2; USACC Form 473-R (Test).

(9) It is recommended that a minimum of three voice channels per group be measured, preferably channels 2, 6, and 11, if available.

(10) Summarize the test data on figure 6-4; USACC Form 351-R (Test).

b. Voice Channel Phase Jitter Measurements in Baseband and Multiplex Channels.

(1) These phase measurements are made by converting a selected nominal 3.1-kHz voice channel section of the baseband signal spectrum to a voice channel signal. An FSVM is used to make this conversion as shown in figure 71-1. The input circuit undistorted dynamic range and the noise level of the audio section of the FSVM must be such as not to interfere with or restrict the accuracy of the phase measurements.

(2) Repeat paragraphs 71-4a (1) through (10), but the the following changes:

(a) The test tone may be inserted at any one of the desired test points, TP-1 through TP-6; and only in an idle channel.

(b) The frequency of the inserted test tone, at the transmit end, must be such that a 1000-Hz tone is recovered at the output of the FSVM (receive end).

(c) Phase jitter measurements are made, using the FSVM, at TP-7, TP-8, and TP-9.

c. Instation Phase Jitter. Instation voice channel phase jitter measurements can be made by repeating paragraphs 71-4a (1) through (10) and 71-4b(2), except that the inserted test tone is received instation at TP-2 through TP-6.

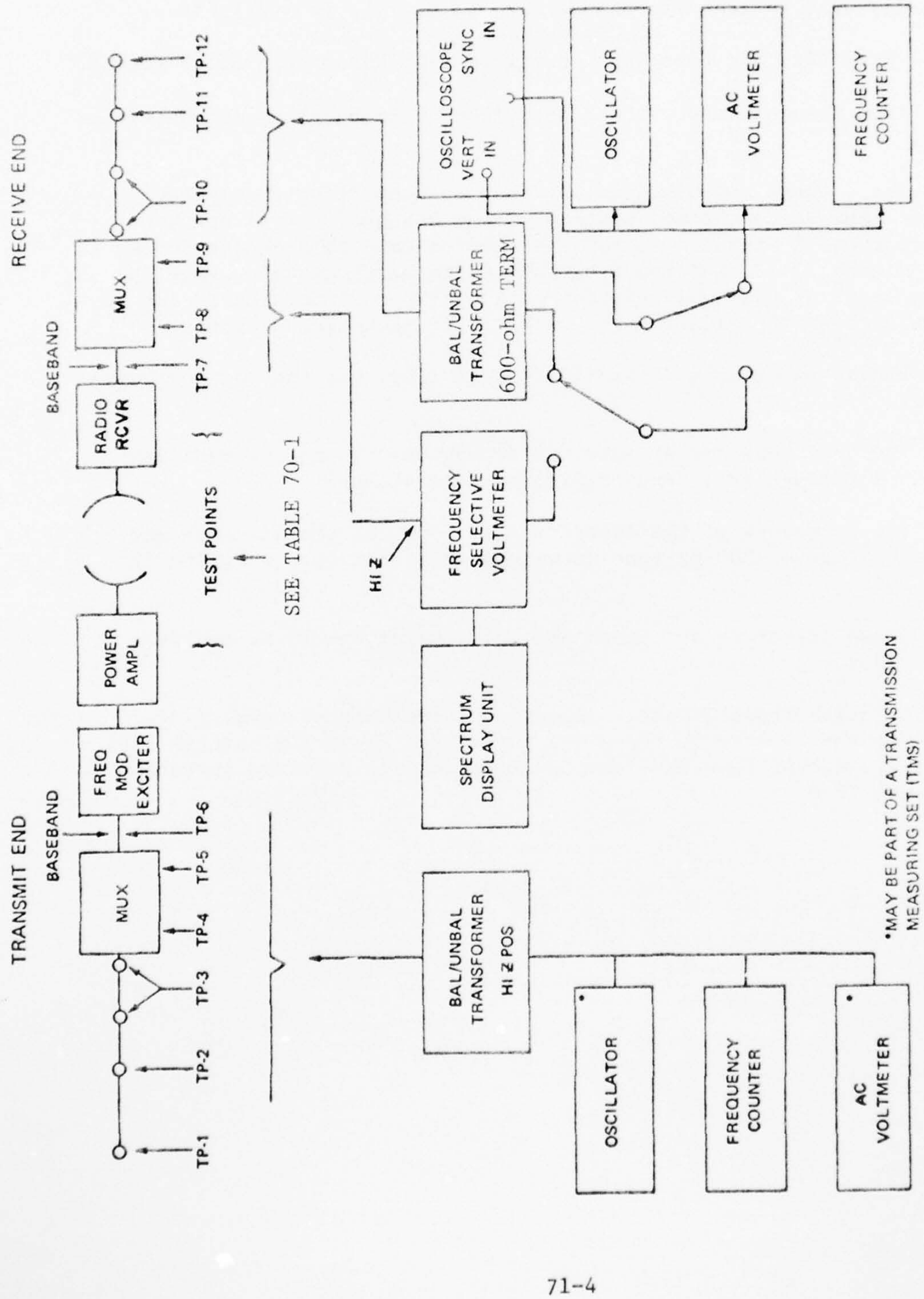


Figure 71-1. Voice channel phase jitter (oscilloscope method) test configuration.

VOICE CHANNEL PHASE JITTER (Oscilloscope Method) DATA SHEET (CCR 702-1-3)			PAGE OF PAGES DATE (DAY, MONTH, YEAR)
LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR. SIGNATURE

INPUT TEST POINT NO.	OUTPUT TEST POINT NO.	CHANNEL			PEAK-TO-PEAK PHASE JITTER (deg)
		SG NO.	GP NO.	V CH NO.	

USACC FORM 473-R (TEST)
1 MAY 77

Figure 71-2. Voice channel phase jitter (oscilloscope method) data sheet.

Preceding Page Blank - NOT FILMED

CHAPTER 72

VOICE CHANNEL CROSSTALK (T-18)

72-1. GENERAL.

a. The purpose of this test is to measure the total amount of crosstalk within a VF channel from all causes. Crosstalk may be caused by an impedance irregularity in the circuit, or capacitive and inductive coupling between the disturbing and disturbed channels. These conditions can occur at any point in a communications system, particularly in the distribution frame wiring and cabling and in the multiplex. Reliable measurements will be obtained only if none of the individual (operating) voice channels are overloaded and since this test requires higher than standard (-10 dbm0) test tone power levels, it should be conducted only on an out-of-service basis or during nonbusy hours to minimize possible service degradations to system users. Due to the low level of signals involved in the measurement of crosstalk, particular care should be given to providing good grounds, effective shieldings, and correct terminations. Ground loops must also be eliminated.

b. In general, the voice channel crosstalk measurements will be made between the transmit circuit equal level patch bay TP-2 and the receive circuit equal level patch bay TP-11. However, if there are indications that the measured crosstalk between these test points does not meet the applicable standards, additional measurements should be made between other combinations of test points in order to isolate the source of the excessive crosstalk.

c. Because of the time required to measure the crosstalk in the very large number of possible combinations of disturbing and disturbed channels, these measurements should be limited to those channels which have reported crosstalk conditions plus three pairs of adjoining channels in each group such as:

Channel 2,	Transmit and Channel 2,	Receive	Near-end
Channel 6,	Transmit and Channel 6,	Receive	Crosstalk
Channel 11,	Transmit and Channel 11,	Receive	Measurements
Channel 2,	Receive and Channel 3,	Receive	Far-end
Channel 6,	Receive and Channel 7,	Receive	Crosstalk
Channel 11,	Receive and Channel 10,	Receive	Measurements

72-2. SPECIFICATIONS.

The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

72-3. TEST EQUIPMENT REQUIRED.

a. Audio oscillator or test measuring set.

b. Balanced/unbalanced transformer (2 ea).

c. FSVM.

d. Noise measuring set.

e. 600-ohm termination plug (2 ea).

f. Earphones.

g. Wave analyzer.

72-4. TEST PROCEDURES.

a. Near-End Crosstalk.

(1) Configure the test equipment as illustrated in figure 72-1. At the transmit end, insert a 1-kHz, zero-dbm0 tone into the voice channel which is to act as the disturbing channel. Insert this test tone at the circuit equal level patch bay TP-2.

(2) At the receive end terminate the selected disturbing channel in 600 ohms at the circuit equal level patch bay TP-11. Measure the level of this tone with the noise measuring set and insure that the level is within specified tolerance (±1 db).

(3) At the receive end, terminate the transmit end input of the channel to be tested (disturbed channel) with a 600-ohm termination plug at the circuit equal level patch bay TP-11.

(4) At the receive end, terminate the receive end of the channel to be tested (disturbed channel) with the noise measuring set at the circuit equal level patch bay TP-2. Adjust the set to 3-kHz flat weighting and measure the noise in the channel. Switch to another voice weighting (preferably C-message) to insure that 60-Hz components are not masking ICN. If more than 3 db difference exists, proceed using C-message weighting.

(5) The receive end will alternately disconnect and reconnect the tone on the disturbing channel. Record the noise levels with the tone on/tone off on figure 72-2; USACC Form 474-R (Test). Calculate the difference between the tone on/tone off levels and record the results on the data sheet.

(6) If the difference is 2 db or greater, connect the FSVM (narrow bandpass) in place of the noise measuring set, and measure the frequencies and levels of the crosstalk signals. Record the frequencies and levels on figure 72-2; USACC Form 474-R (Test).

(7) Maintaining the same disturbing channel, repeat paragraphs 72-4a (2) through (5) for other channels in the same group.

(8) Repeat paragraphs 72-4a (1) through (7) for other disturbing channels as required.

(9) Summarize test results on figure 6-4; USACC Form 351-R (Test).

b. Far-End Crosstalk.

(1) Configure the test equipment as illustrated in figure 72-3. At the transmit end, have a 1-kHz, zero-dbm0 tone inserted into the voice channel which is to act as the disturbing channel (preferably the same channel used in the near-end crosstalk test). Insert this test tone at the circuit equal level patch bay TP-2.

(2) At the receive end, terminate the selected disturbing channel in 600 ohms at the circuit equal level patch bay TP-11. Measure and record on figure 72-2; USACC Form 474-R (Test) the level of this tone with the noise measuring set or AC voltmeter and insure that the level is within ±1 db of the proper level. Calculate and record the tone level error on the data sheet.

(3) At the transmit end, terminate the input of the channel to be tested (disturbed channel), preferably one of the same channels used in paragraph 72-4a, with a 600-ohm termination plug. Terminate this channel at the circuit equal level patch bay TP-2.

(4) At the receive end, terminate the receive end of the channel to be tested (disturbed channel) with the noise measuring set at the circuit equal level patch bay TP-11. Adjust the set to 3-kHz flat weighting and measure noise in the channel with the audio oscillator at the transmit end disconnected. Switch to another voice weighting (preferably C-message) to insure that the 60-Hz components are not masking ICN. If more than 3 db difference exists, proceed using C-message weighting.

(5) At the transmit end, alternately disconnect and reconnect the tone on the disturbing channel.

(6) At the receive end, measure and record the noise levels with the tone on/tone off. Calculate the difference between the tone on/tone off noise levels and record on figure 72-2; USACC Form 474-R (Test).

(7) If the difference is 2 db or greater, connect the FSVM (narrow bandpass) in place of the noise measuring set, and measure the frequencies and the levels of the crosstalk signals. Record the levels on the data sheet.

(8) Maintaining the same disturbing channel, repeat paragraphs 72-4b (3) through (7) for the remaining channel(s) tested.

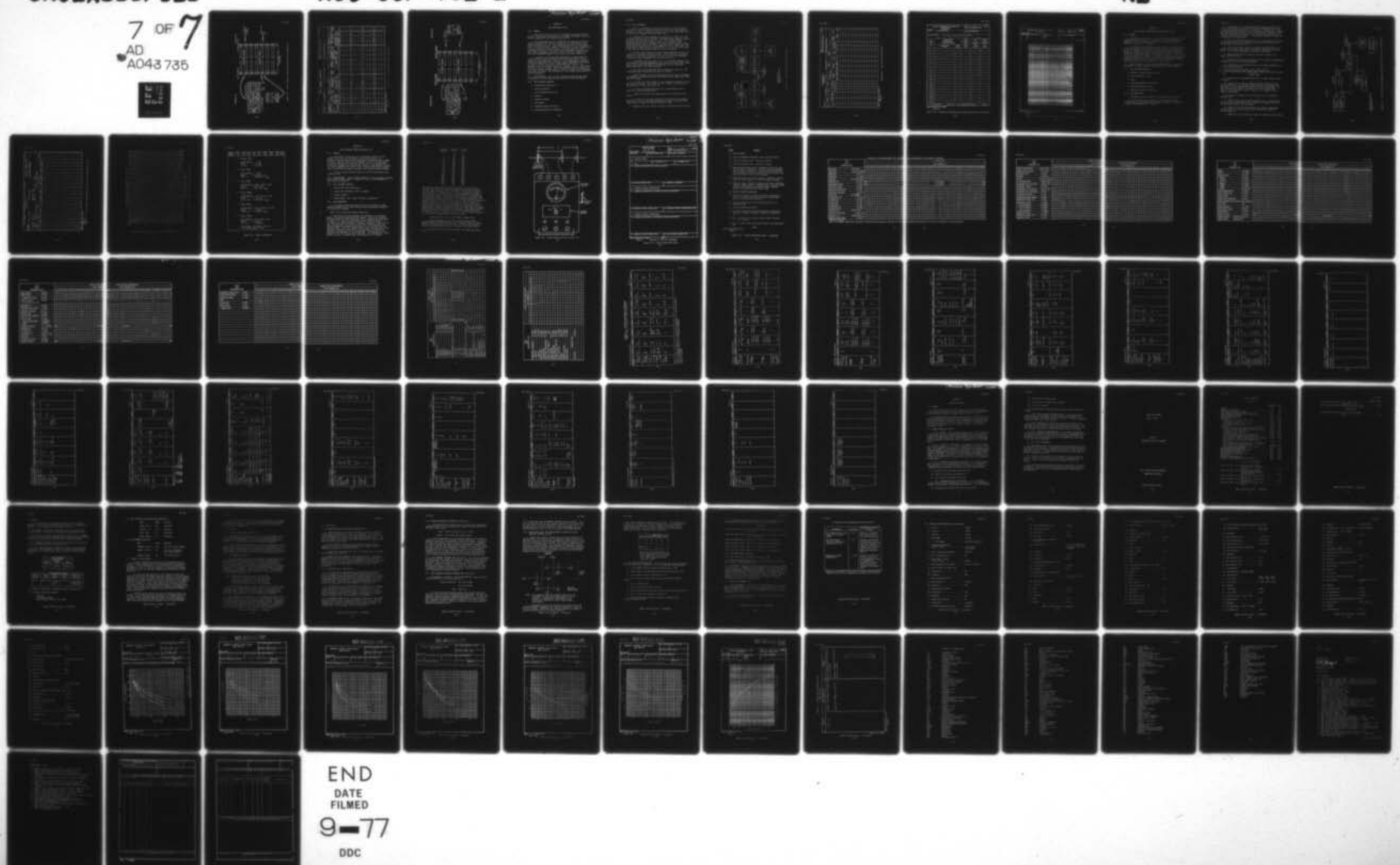
(9) Repeat paragraph 72-4b(3) for other disturbing channels as required.

c. Combined Near-End and Far-End Crosstalk. Using the procedures described in paragraphs 72-4 a and b, this test can be conducted simultaneously. However, this procedure requires a high degree of coordination between the test teams. Note that the disturbing channel must not be energized in both directions at the same time.

AD-A043 735 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA ARIZ F/G 17/2
PRODUCT ASSURANCE, OPERATIONAL QUALITY ASSURANCE, SATELLITE SYS--ETC(U)
MAY 77

UNCLASSIFIED ACC-CCP-702-2 NL

7 OF 7
AD
A043 735

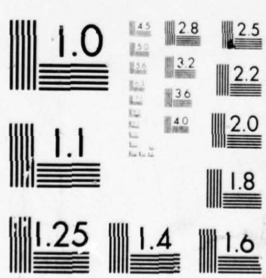


END
DATE
FILMED
9-77
DDC

SIFIED

7 OF 7

AD A043735



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

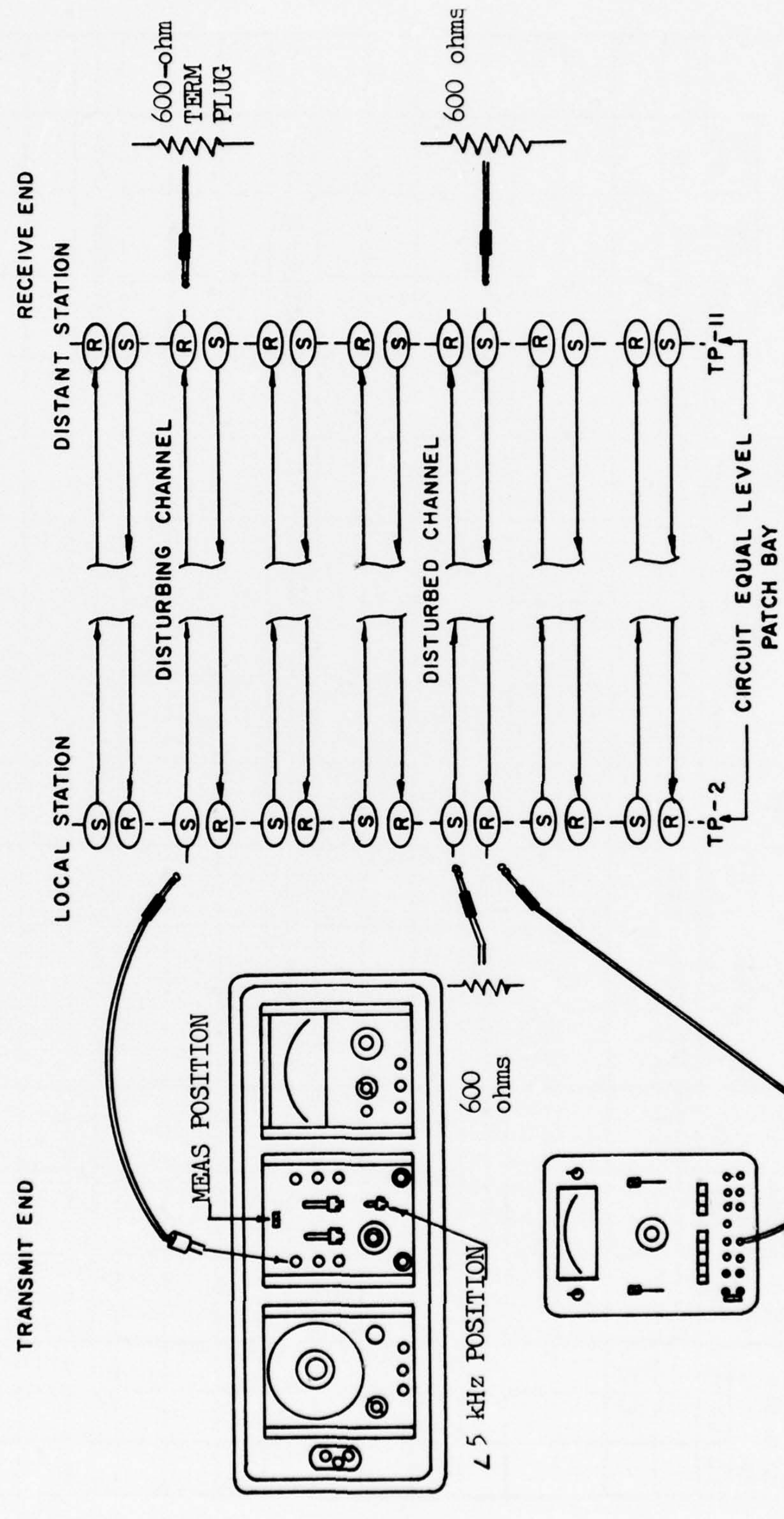


Figure 72-1. Voice channel crosstalk (near-end) test configuration.

VOICE CHANNEL CROSSTALK
(CCR 702-1-3)

DATA SHEET

PAGE OF PAGES			
DATE (DAY, MONTH, YEAR)			
LINK NO	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE

TEST POINT			NEAR END CROSSTALK							FAR END CROSSTALK								
DISTANT STA TP / LOCAL STA TP			NOISE LEVEL FROM NOISE MEAS SET, dbm		NOISE LEVEL DIFF	CROSSTALK SIG LEVEL FROM FREQUENCY SEL VM, dbm			NOISE WEIGHTING	RECEIVE TONE LEVEL		NOISE LEVEL FROM NOISE MEAS SET, dbm		NOISE LEVEL DIFF	CROSSTALK SIG LEVEL FROM FREQUENCY SEL VM, dbm			NOISE WEIGHTING
SG	GP	VCH	TONE ON	TONE OFF	db	PWR AT 1 kHz	FREQ kHz	PWR dbm		dbm	ERROR db	TONE ON	TONE OFF	db	PWR AT 1 kHz	FREQ kHz	PWR dbm	
						DISTURBING CHAN									DISTURBING CHAN			
						DISTURBING CHAN									DISTURBING CHAN			
						DISTURBING CHAN									DISTURBING CHAN			
						DISTURBING CHAN									DISTURBING CHAN			

USACC FORM 474-R (TEST)
1 MAY 77

Figure 72-2. Voice channel crosstalk data sheet.

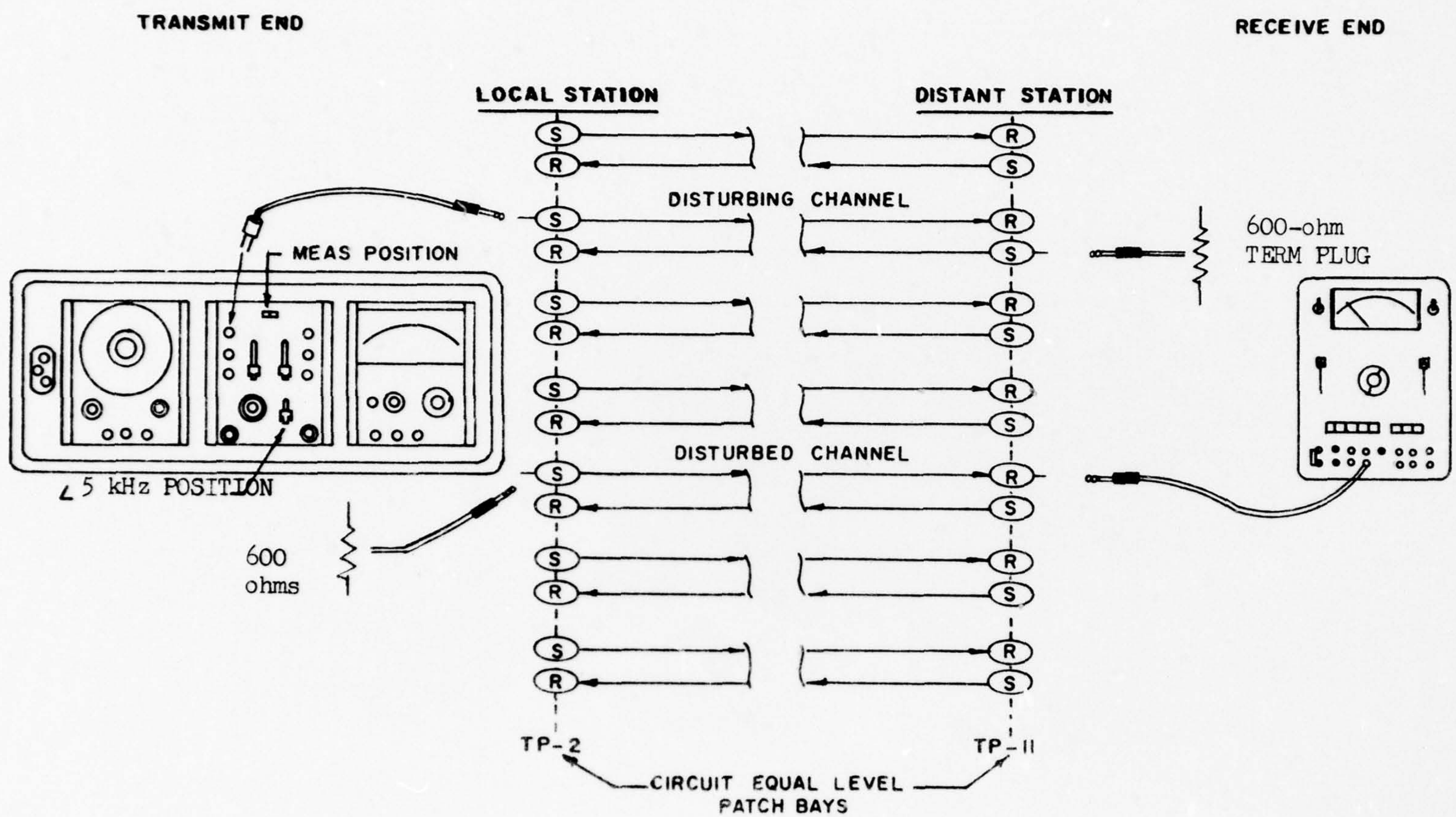


Figure 72-3. Voice channel crosstalk (far-end) test configuration.

Precedeing Page Blank - Filmed

CHAPTER 73

DATA ERROR RATE (T-19)

73-1. GENERAL.

a. The purpose of this test is to determine the high speed (2400 bits/sec) data transfer capabilities of a nominal VF channel. This test will be conducted in time correlation with ST-39.

b. The average BER per run is defined as the number of bit errors measured during the run interval, divided by the total number of bits transmitted during the run. The average BER is related to the median C/kT. In order to obtain a range of average BER's to C/kT, the parameters should be recorded on the strip chart. To enable analysis of BER distributions, bursts of bit errors should be manually recorded on the strip chart recordings at the time of their occurrence, together with the total accumulated number of bit errors at the end of each run.

c. In general, the average BER measurements are made between the transmit circuit equal level patch bay TP-2 and the receive circuit equal level patch bay TP-11. However, if the average BER is excessive, additional measurements should be made between intermediate test points in order to isolate the source of the excessive bit errors. As a minimum, three voice channels should be evaluated, one at a time, during the final 3 days of testing. These three channels should represent the best, worst, and an average channel in terms of channel noise performance previously determined. The performance of each channel tested should be plotted separately.

73-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

73-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Pattern generator.

c. Data transmission test set.

d. Counter.

e. Digital recorder.

f. Data modem.

g. Frequency stable oscillator.

h. Balanced/unbalanced transformer.

73-4. TEST PROCEDURES.

a. Prior to initiating the data error rate test, check and adjust the levels in the voice channel, using a reference test tone signal at a level of -10 dbm0. Insert this signal at the circuit equal level patch bay TP-2 at the transmit end of the radio link.

b. Configure the test equipment as illustrated in figure 73-1 with the modem transmit level at -13 dbm0. The modem output signal is connected at the circuit equal level patch bay TP-2. The frequency stable oscillators should have a frequency stability of one part in 10^7. If these oscillators are not available, the tested channel should be looped at the receive end and the bit errors measured at the transmit end. The voice channel signal should be looped (TP-11 to TP-2 at the receive end). Do not loop the data stream through the receive end modem.

c. Set the pattern generator and the data transmission test set to operate at 2,400 baud or bits per second. Insure that both the pattern generator and the data transmission test set are set at the beginning of the test pattern sequence prior to starting the test.

d. If possible, set the counter for a 2- to 5-second counting cycle with automatic recycling immediately after printout of each cycle. Alternately, the printer may print the accumulated errors at the end of each consecutive 2- to 5-second interval.

e. This test must be performed for the duration of each run. The run duration must be precisely the same as for ST-39.

f. Record transmit and receive data signal levels (actual voltmeter dbm reading), and compute and record the dbm0 level on figure 73-2; USACC Form 475-R (Test).

g. For each run, record number of bits transmitted, number of errors, and calculate the BER. Also record the total number of bit errors on the strip chart at the end of each run.

h. Plot the run average BER versus the (corresponding) obn on figure 8-7; USACC Form 396-R (Test).

i. Complete the stroke chart using figure 73-3; USACC Form 476-R (Test).

j. To obtain the long-term cumulative distribution of the average BER, plot the data in the right-hand column of figure 73-3; USACC Form 476-R (Test) on figure 73-4; USACC Form 449-R (Test).

k. Summarize the test results on figure 6-4; USACC Form 351-R (Test).

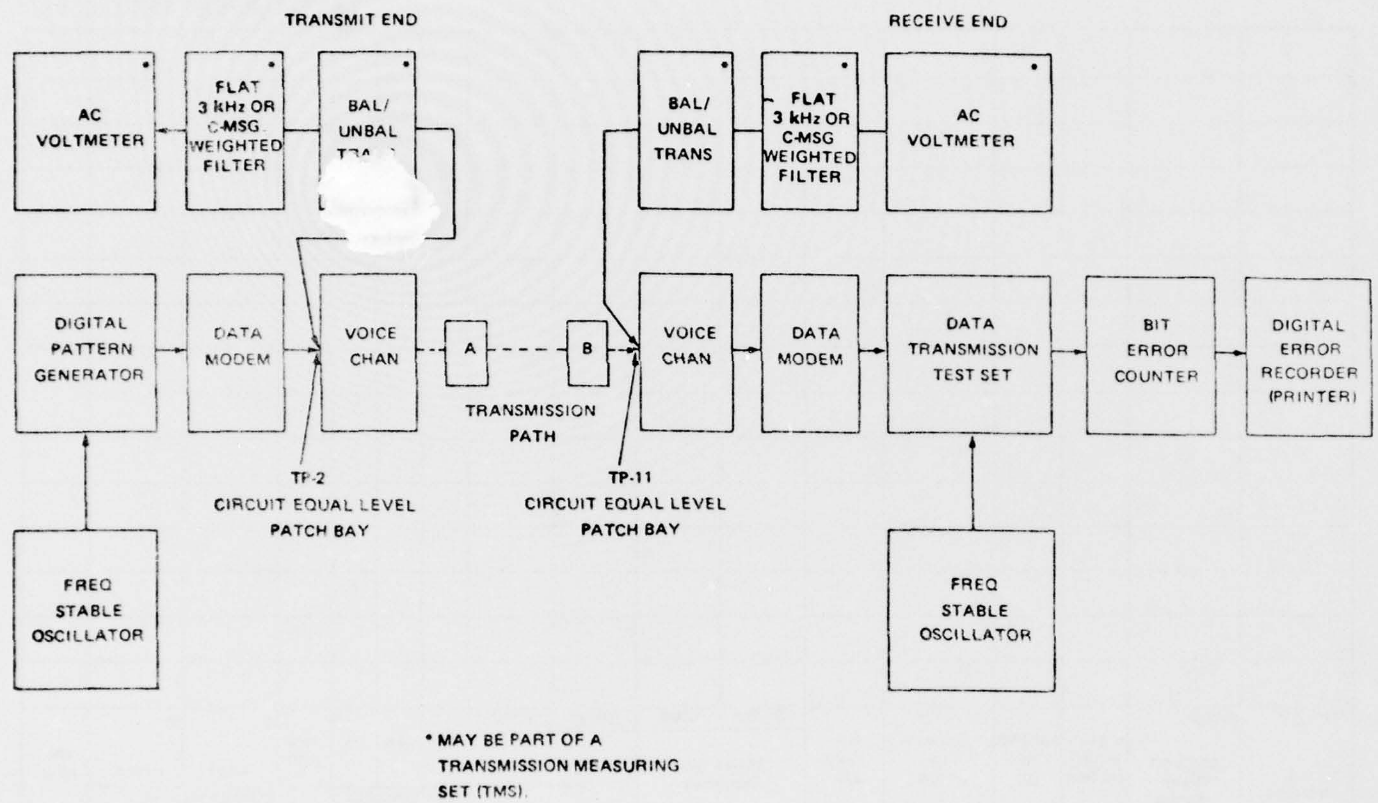


Figure 73-1. Data error rate test configuration.

DATA SHEET

DATA ERROR RATE
(CCR 702-1-3)

PAGE ______ OF ______ PAGES

DATE (DAY, MONTH, YEAR)

TEST POINTS		MSG SIG LDG LVL		TEST ENGR SIGNATURE
TRANS	REC			
TP–	TP–	dbm	dbm0	

DATA ERROR RATE

RUN NO.	RUN TIME PERIOD START	RUN TIME PERIOD STOP	DUR MIN	CHANNEL POS SG	CHANNEL POS GP	CHANNEL POS V CH	TRANSMIT SIG LEVEL		RECEIVED SIG LEVEL		BIT RATE B/S	NO. OF BITS TRANS	NO. OF ERRORS	AVG BIT ERROR RATE %	MEDIAN BB SIG LOADING	MEDIAN RSL
	Z	Z					dbm	dbm0	dbm	dbm0					dbm0	dbm

USACC FORM 475-R (TEST)
1 MAY 77

Figure 73-2. Data error rate data sheet.

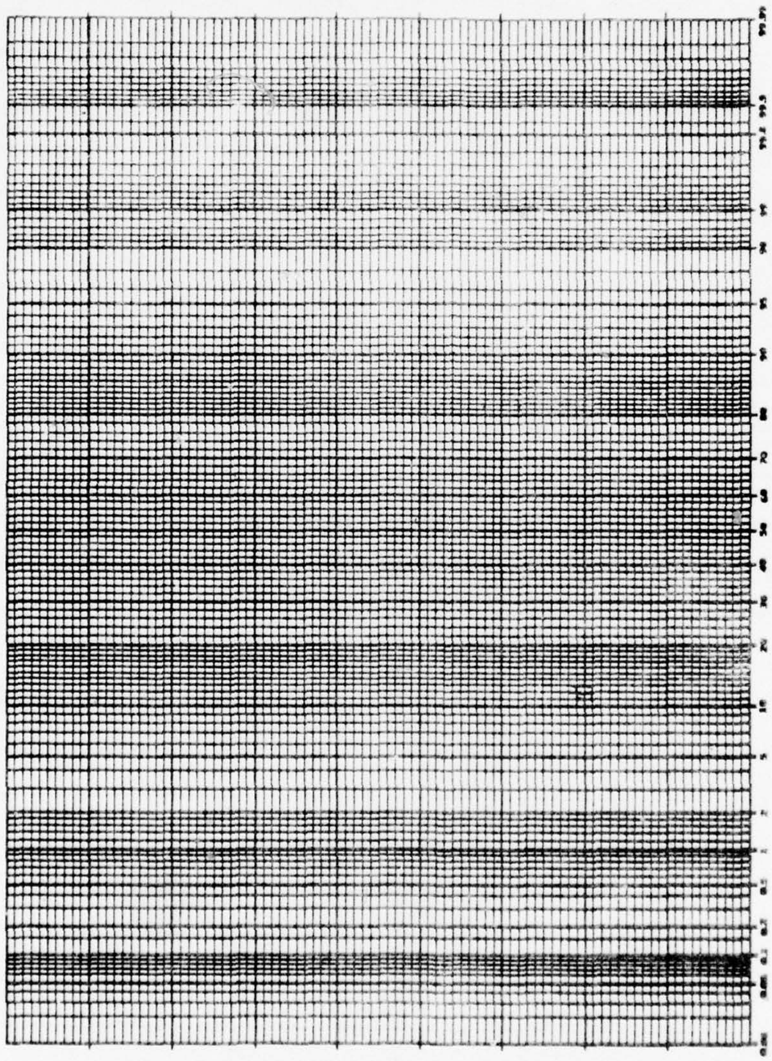
CUMULATIVE PROBABILITY DISTRIBUTION STROKE CHART (CCR 702-1-3) DATA SHEET					PAGE OF PAGES	
					DATE (DAY, MONTH, YEAR)	
LINK NO	STATION UNDER TEST				TEST ENGR SIGNATURE	
DURATION OF RUNS MIN	SG	GP	VCH		RUN NUMBERS FROM: THRU:	

RUN AVERAGE BIT ERROR RATE %	NUMBER OF RUNS EACH HAVING THE INDICATED AVERAGE BIT ERROR RATE (AVG BER)		TOTAL TIME RUN AVG BER's WERE AT THE INDICATED VALUE (MIN)	PERCENT OF TIME RUN AVG BER's WERE AT THE INDICATED VALUE	CUMULATIVE PERCENT OF TIME RUN AVG BER's WERE AT THE INDICATED VALUE
	INDIVIDUAL RUN STROKES	TOTAL NO. OF STROKES			
10.0					
7.0					
3.0					
1.0					
0.7					
0.3					
0.1					
0.07					
0.03					
0.01					
0.007					
0.003					
0.001					
0.0007					
0.0003					
0.0001					
0.00007					
0.00003					
0.00001					
< 0.00001					
TOTAL NUMBER OF RUNS:	TOTAL TIME: MIN		LONG-TERM MEDIAN OF AVG BER		PERCENT

USACC FORM 476-R (TEST)
1 MAY 77

Figure 73-3. Cumulative probability distribution stroke chart data sheet.

DISTRIBUTION PROBABILITY GRAPH (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MONTH, YEAR)
LINK NO.	STATION UNDER TEST	RUN NUMBERS FROM THRU	TEST ENGR SIGNATURE



USACC FORM 449-R (TEST)
1 MAY 77

Figure 73-4. Distribution probability graph data sheet.

CHAPTER 74

VOICE CHANNEL INTERMODULATION DISTORTION (T-21)

74-1. GENERAL.

a. The purpose of this test is to measure and evaluate the two-tone intermodulation distortion in VF channels. It is recommended that a minimum of three voice channels per group be measured, preferably channels 2, 6, and 11, if available.

b. In general, the measurement is made between the transmit circuit equal level patch bay TP-2, and the receive circuit equal level patch bay TP-11. However, if there are indications that the intermodulation distortion between these test points is excessive (above 2 percent) additional measurements between intermediate test points should be made in order to isolate the source of the problem. Since this test requires higher than standard (-10 dbm0) test signal power levels, it should be conducted only on and out-of-service basis or during nonbusy hours to minimize possible service degradations to system users.

74-2. SPECIFICATIONS. The test data obtained during this test shall be compared to the performance limits specified in MIL-STD-188/100.

74-3. TEST EQUIPMENT REQUIRED.

a. 200-ohm, 1-percent resistor (3 ea).

b. Audio oscillator (2 ea).

c. FSVM.

d. Balanced/unbalanced transformer.

e. 600-ohm attenuator (2 ea).

f. 600-ohm, 1-percent termination.

74-4. TEST PROCEDURES.

a. Configure the test equipment as illustrated in figure 74-1.

b. At the transmit end, connect the two oscillators, pads, resistor network, and transformer as shown, and adjust oscillator #1 to 1000 Hz and oscillator #2 to 1400 Hz.

c. Connect point C to a 600-ohm precision termination and set the level of the 1000-Hz and 1400-Hz tones using the bridged FSVM (through a balanced/unbalanced transformer if necessary) to -6 dbm0 each. Measure the intermodulation products at each of the following frequencies: 400, 600, 800, 1800, 2400, and 3400 Hz. Each harmonic must be down at least -50 dbm0 and preferably -60 dbm0. If any harmonic exceeds -50 dbm0, use a different set of oscillators.

d. After the -50 dbm0 specification is met, disconnect the FSVM and the 600-ohm termination, and insert the tones into the channel at the circuit equal level patch bay TP-2.

e. At the receive end, connect the 600-ohm terminated FSVM to the output of the channel under test at the circuit equal level patch bay TP-11. Use a balanced/unbalanced transformer if necessary.

f. Measure and record the levels of each tone on figure 74-2; USACC Form 477-R (Test).

g. Calculate and record on the data sheet the channel intermodulation distortion by one of the following methods:

(1) Using each of the harmonic and test tone signal readings in mv in the following formula:

$$ID = \sqrt{\frac{E^2_{400}+E^2_{600}+E^2_{800}+E^2_{1800}+E^2_{2400}+E^2_{1000}+E^2_{1400}+E^2_{3400}}{E^2_{1000}+E^2_{1400}}} \times 100 = \text{percent}$$

(2) Using each of the harmonic and test tone signal levels in dbm as follows:

(a) Figure 74-3 is used for adding two powers expressed in dbm. The db difference in the two power values is noted on the abscissa of the figure, and the corresponding delta is found from the graph. The delta value is then added to the larger of the two original power levels to obtain the sum. A list of powers can be summed, two at a time, by this method.

(b) As shown in figure 74-4, add the powers in the 1000-Hz and 1400-Hz tones.

(c) Add the powers in the 400-Hz and 600-Hz tones. Then add this sum to the power in the 800-Hz tone. Repeat this procedure until all the distortion products have been added.

(d) Compute the db difference between the results of paragraphs 74-4g (b) and (c), then use figure 74-2 to convert this value to percent distortion.

h. Summarize all test results on figure 6-4; USACC Form 351-R (Test).

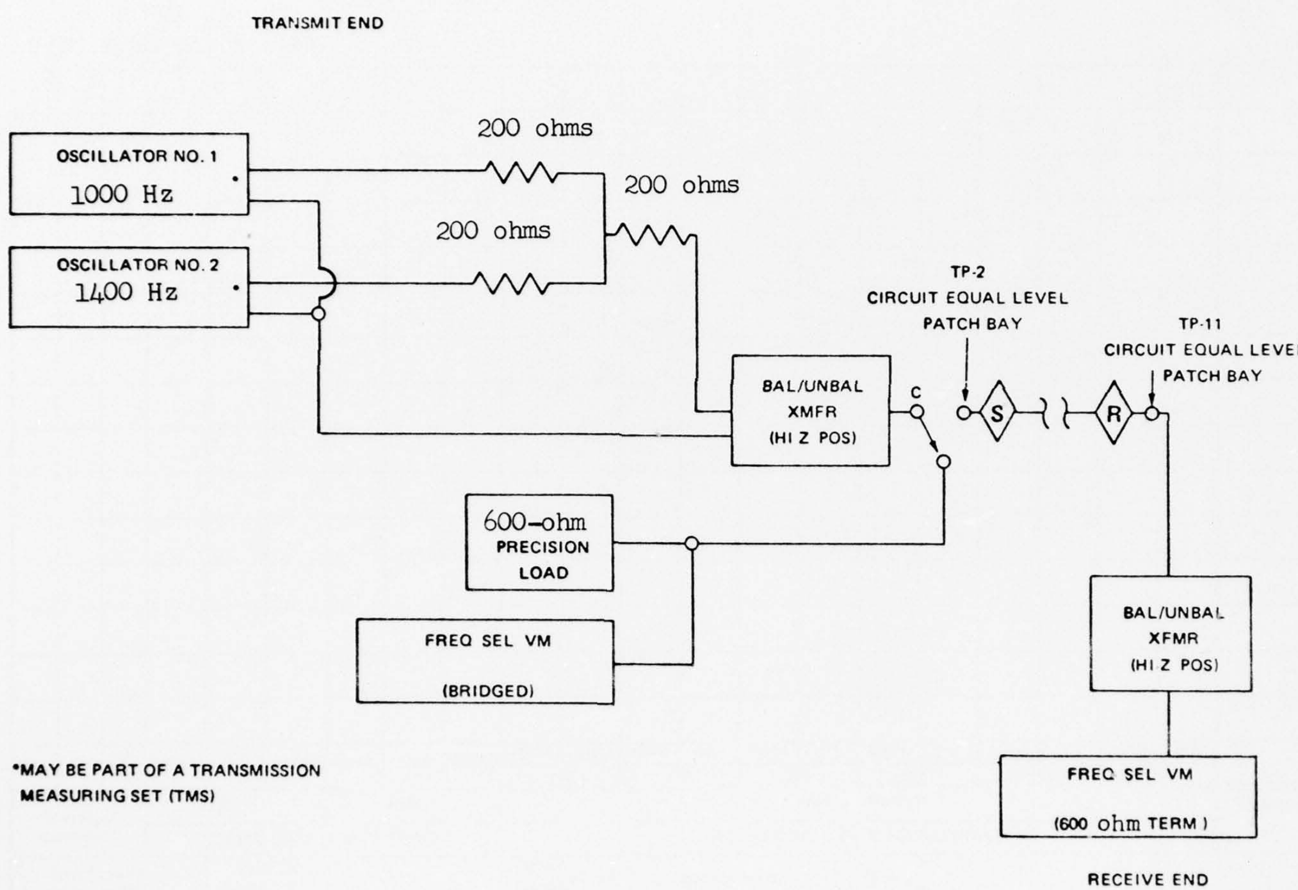


Figure 74-1. Voice channel intermodulation distortion (two-tone) test configuration.

VOICE CHANNEL INTERMODULATION DISTORTION (TWO-TONE)
(CCR 702-1-3)

DATA SHEET

PAGE . OF PAGES

DATE (DAY, MONTH, YEAR)

LINK NO.

DISTANT STATION (XMIT)

LOCAL STATION (REC)

TEST ENGR SIGNATURE

TEST POINTS AND LEVELS ▶ TRANS: TP– : dbm
REC: TP– : dbm

TEST SIG. LEVELS
#1 SIG.: dbm0, #2 SIG dbm0

CHANNEL NUMBERS			RECEIVE TEST SIGNAL LEVELS						INTERMODULATION COMPONENTS												PERCENT DISTORTION
			1000 Hz			1400 Hz			FREQUENCIES, Hz												
									400		600		800		1800		2400		3400		
SG	GP	V CH	dbm	mv	dbm0	dbm	mv	dbm0	dbm	mv	dbm	mv	dbm	mv	dbm	mv	dbm	mv	dbm	mv	

USACC FORM 477-R (TEST)
1 MAY 77

Figure 74-2. Voice channel intermodulation distortion (two-tone) data sheet.

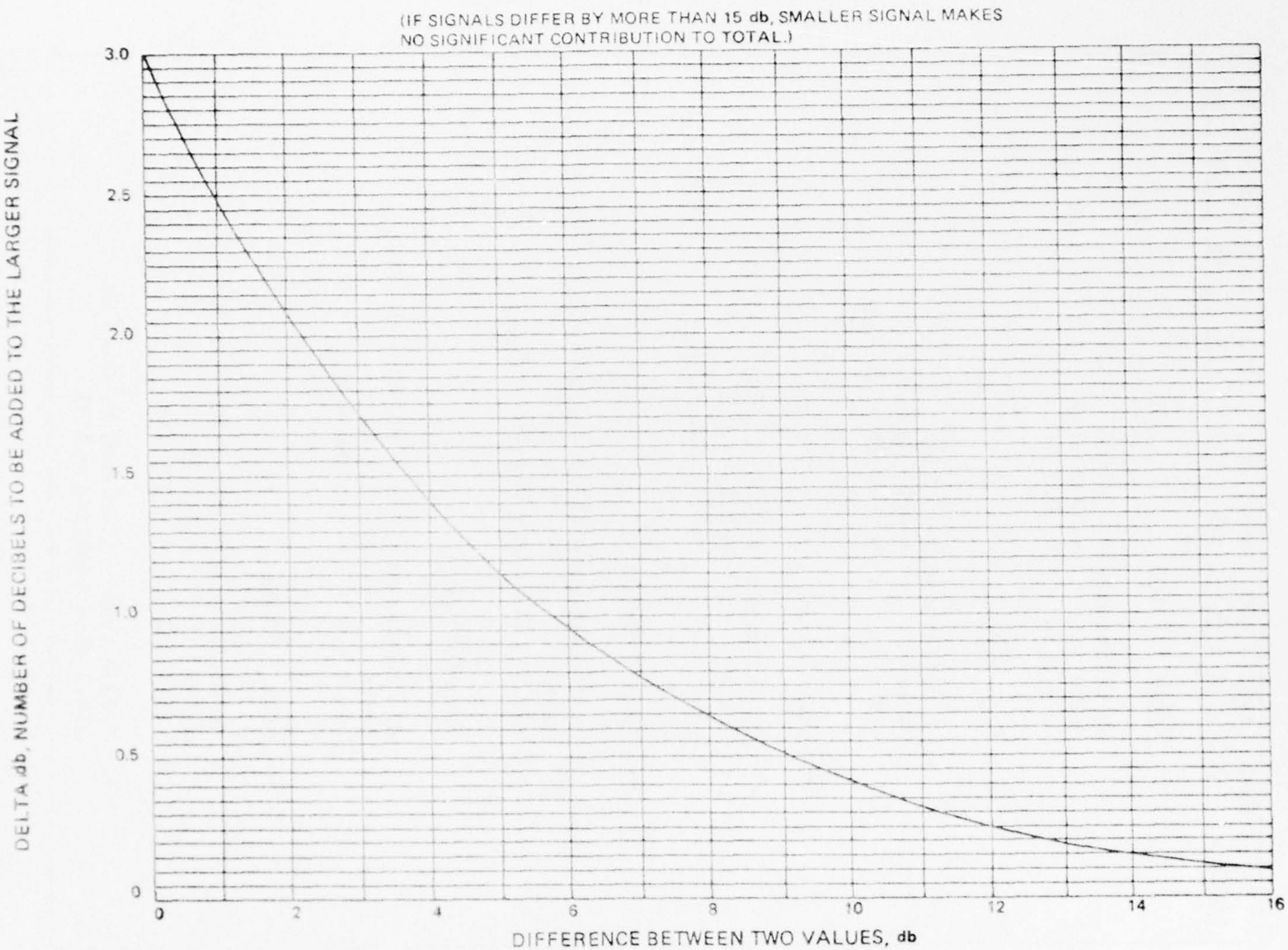


Figure 74-3. Graph for adding signals expressed in db.

FREQ	1000	1400	400	600	800	1800	2400	3400	Hz
LEVEL	-3	-2	-45	-39	-50	-39	-48	-40	dbm

1. $P_{1000} + P_{1400}$

   db difference = 1 db
   delta = 2.5 db
   -2 + 2.5 = 0.5 dbm

2. $P_{400} + P_{600}$

   db difference = 6 db
   delta = 0.95 db = 1 db
   -39 + 1 = -38 dbm = 1 P_{sum}

3. $P_{sum} + P_{800}$

   db difference = 0.38 - (-50) = 12 db
   delta = 0.25 = 0.3
   -38 + 0.3 = 37.7 dbm = P_{sum}

4. $P_{sum} + P_{1800}$

   db difference = -37.7 -(-39) = 13 db
   delta = 2.4 db
   -37.7 + 2.4 = -35.3 dbm = P_{sum}

5. $P_{sum} + P_{2400}$

   db difference = -35.3 -(-48) = 12.7 db
   delta = 0.3 db
   -35.3 + 0.3 = -35 dbm = P_{sum}

6. $P_{sum} + P_{3200}$

   db difference = -35 -(-40) = 5 db
   delta = 1.2 db
   -35 + 1.2 = -33.8 dbm

7. (-33.8 dbm) - (0.5 dbm) = -34.3 db
   -34.3 db distortion = 1.9%

Figure 74-4. Sample calculation.

CHAPTER 75

EARTH TERMINAL GROUND RESISTANCE (G-1)

75-1. GENERAL.

a. The purpose of this test is to determine by means of a null balance earth tester the resistance of the station ground. An adequate station ground and ground distribution system provides a common electrical reference point for all equipment in an area and eliminates, or reduces, differences in potential between pieces of equipment and between the equipment and earth ground. Faulty or high impedance grounds can cause intermodulation effects, noise voltage buildups with resultant service interruptions, signal distortion, and possible equipment damage.

b. The test method described herein is the fall-of-potential earth resistance test.

75-2. SPECIFICATION. The acceptable standard for the satellite terminals has not been defined; however, a ground of 5 ohms or less impedance to earth should be adequate.

75-3. TEST EQUIPMENT REQUIRED.

a. Earth tester with accessory kit.

b. Ground rods (nominally 6 feet in length).

c. Clamp-on ammeter.

d. Sledge hammer, wire, clips, and steel tape measure.

75-4. TEST PROCEDURES.

a. The station ground resistance test will be performed at each satellite terminal and at those locations where grounding is suspected of causing noise problems.

NOTE: Do not remove any ground connections.

b. With the aid of site drawings, the connection of the station ground to the earth electrode will be located. After this electrode has been located, the test instrument will be configured as illustrated in figure 75-1. The null balance earth tester will be located as close to the earth electrode as possible. Terminals P1 and C1 on the test instrument will be connected to the earth electrode under test. (This configuration removes the resistance of the test lead from the measured value.) The first reference rod C2 will be placed as far from the earth electrode as practicable, this distance will probably be limited by the geography of the surroundings. The distance will be a minimum of 100 feet from the earth electrode. The following is a useful guide to P2 and C2 placement when a grid ground is to be tested.

DIAGONAL DIMENSION	DISTANCE E-P2	DISTANCE E-C2
4	62	100
6	78	125
8	87	140
10	99	100
12	105	170
14	118	120
16	124	200
18	130	210
20	136	220
40	198	320
60	242	390
80	279	450
100	310	500
120	341	550
140	366	590
160	397	640
180	422	680
200	440	710

The potential reference rod P2 will be driven in at a point on a straight line between the earth electrode and C2, and at a distance from the earth electrode that is 62 percent of the distance from the earth electrode to reference rod C2. On the instrument, the range switch will be set to x0.01 and the digital readout of the balancing resistor dials to 999. The generator crank will be turned slowly and the galvanometer deflection noted. If the deflection is positive (+), the range factor will be increased to x0.1 or higher until the deflection becomes negative (-). When the deflection is (-), the value of the balancing resistor will be decreased, digit-by-digit, starting with the left knob, then the center, and finally the right knob, until the galvanometer is nulled. The generator will be cranked while all adjustments on the balancing resistors are being made. The cranking speed of the generator will be a minimum of 160 rpm for maximum sensitivity. To avoid the effects of stray currents in the soil, it may be necessary to increase the cranking speed to 200 rpm or more.

Resistance under test = dial reading x range factor

c. Note any readings of more than 5 ohms resistance and if possible identify the problem area. When feasible, corrective action should be taken while the team is onsite. If this is not possible, appropriate recommendations should be included in the final report.

d. Summarize the test results on figure 75-2; USACC Form 300-R (Test).

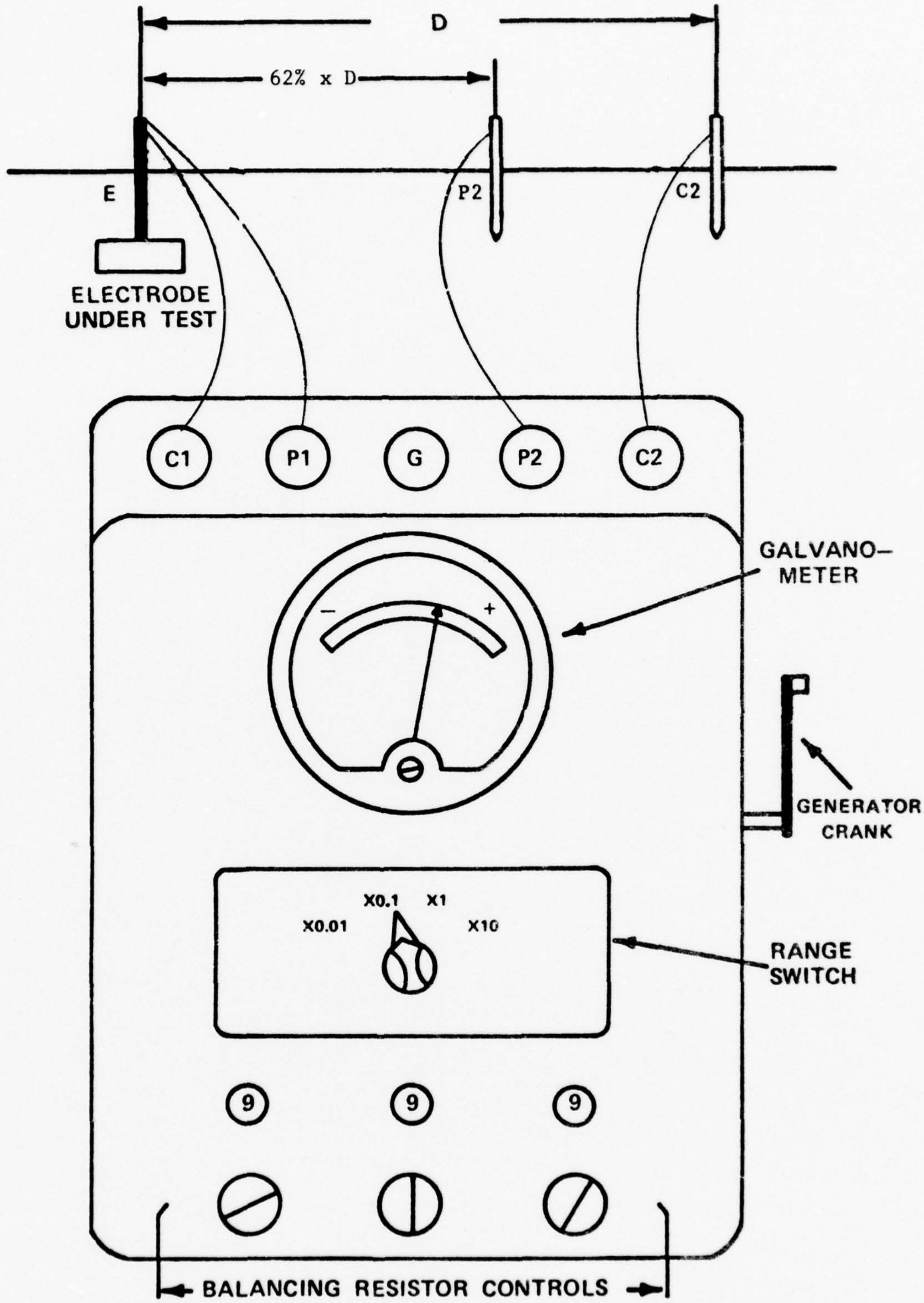


Figure 75-1. Ground resistance test configuration.

Preceding Page BLANK - NOT FILMED

STATION GROUND (CCR 702-1-3) DATA SHEET (Instr on back)		PAGE OF PAGES / DATE (DAY,MONTH,YEAR)
FACILITY	STATION UNDER TEST	TEST ENGR SIGNATURE

1.0 STATION GROUND		
1.1 RE = Ω	1.2 DISTANCE E-C2	1.3 DISTANCE E-P2
1.4 GENERAL DESCRIPTION OF STATION GROUND		
1.5 STATION GROUND COND	1.6 CHEMICAL TREATMENT	
2.0 EXTERIOR GROUND DISTRIBUTION		
2.1 GENERAL DESCRIPTION OF EXTERIOR GROUND DISTRIBUTION		
2.2 EXTERIOR GROUND FEEDER COND	2.3 EXTERIOR GROUND DISTRIBUTION COND	
3.0 INTERIOR GROUND DISTRIBUTION		
3.1 GENERAL DESCRIPTION OF INTERIOR GROUND DISTRIBUTION		
3.2 INTERIOR GROUND FEEDER COND	3.3 RACK GROUND FEEDER COND	

USACC FORM 300-R (TEST) PAGE 1
1 MAY 77 EDITION OF 1 JUL 76 IS OBSOLETE.

Figure 75-2. Station ground data sheet.

BLOCK	ENTRIES
1.0	STATION GROUND
1.1	Enter the measured resistance of the earth electrode.
1.2	Enter the distance E-C2: indicate in meters.
1.3	Enter the distance E-P2: indicate in meters.
1.4	Describe the station ground, commenting on the soil type, soil condition, condition of the earth electrode assembly, marking, type of connections, station ground distribution box, provision for watering, and/or any other factors that may have an affect on the station ground.
1.5	Enter the size of the ground conductor (1000 MCM, 4/0 AWG, 2 AWG, 3" x 1/4" plate, 2" x 10 GA Cu strap, or braid).
1.6	Enter the type of chemical treatment used (none, magnesium sulphate, copper sulphate, sodium nitrate, chloride, sodium chloride, iron sulphate, potassium nitrate, ammonium nitrate, activated charcoal, and/or coke).
2.0	EXTERIOR GROUND DISTRIBUTION
2.1	Describe the exterior ground distribution commenting on condition, marking, method of connection and bonding, and list of major items connected.
2.2	Enter the size of the exterior ground feeder in the appropriate AWG.
3.0	INTERIOR GROUND DISTRIBUTION
3.1	Describe the interior ground distribution commenting on condition, marking, insulation, connectors, branching, etc.
3.2	Enter the size of the interior ground feeder (750 MCM, 4/0 AWG, or 2 AWG).
3.3	Enter the size of the rack ground feeder in the appropriate AWG.

PAGE 2

USACC FORM 300-R (TEST)
1 MAY 77

Figure 75-2. Station ground data sheet. (continued)

TITLE AND NOMENCLATURE		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
AMPLIFIER	C-CDR 4333C																				
AMPLIFIER	LOG/LIN HP 8808A																				
AMPLIFIER	HP 461A																				
AMPLIFIER	AIL 13630				1				1												
ADAPTER	AIL GR 900–QNP				1				1												
ADAPTER WG	HP J281A																				
ADJUSTABLE SHORT	HP J920A																				
ANALYZER AUDIO	HP 3580																				
ANALYZER DISTORTION	HP 334A																				
ANALYZER SPECTRUM	TEK 491A																1				1
ANALYZER	HP 141T/8552B HP 141T/8553B																				
ATTENUATOR SET	HP 11581A												1	1			1	1		1	1
ATTENUATOR	HP 354A			1													1		1		1
ATTENUATOR	HP 355C			1	1												1		1		
ATTENUATOR	HP 355D			1	1												1				
ATTENUATOR WG	HP J382A							1			1		1	1	1			1			
COUPLER 20 db	SM–D–748724											1									
COUPLER DIRECTIONAL	NARDA 3035																				
COUPLER 3 db	NARDA 3004–03	1																			
COUPLER DIRECTIONAL	HP J281A																				

*QUANTITY REQUIRED.

NOTE: THE NORMAL CONNECTORS, RESISTORS, ATTENUATORS, AND HARDWARE (INCLUDED IN THE AN

ST, MEASUREMENT, AND DIAGNOSTIC EQUIPMENT

RADIO TESTS

TEST NUMBER (ST)

8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
																										1*		1											
																											1												
																			1							1		1		1	1	1	1						
1																																							
1																																							
AS REQUIRED →																																							
AS REQUIRED →																																							
																															1								
																															1								
								1				1				1	1			1	1		1											1	1				
																																					1		
				1	1			1	1		1	1	1		1	1	1			1	1					1	1	1					1	1	1	1			
								1		1		1				1																		1					
								1		1															1	1	1	1		1	1	1	1						
								1											1				1		1	1		1		1	1					1			
		1		1	1	1			1					1	1	1		1																					
			1																																				
																1																							
																	1																						

ARDWARE (INCLUDED IN THE AN/TSM–125 PACKAGE) ARE ALSO REQUIRED.

TITLE AND NOMENCLATURE		RADIO TESTS (CON																								
		TEST NUMBER																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	2
COUPLER DIRECTIONAL	NARDA 3004-10						1	1			1			1	1	1		2					1	1		1	
CAMERA OSCILLOSCOPE	TEK C30-AP							1									1			1	1						
DETECTOR XTAL	HP 423A							1										1		1					1		
DOUBLER	HP 10515A																										
FILTER	TELONIC 70-10-50																										
FILTER SMOOTHING	(FABRICATED)			1																							
FREQUENCY SEL VOLTMETER	SIERRA 129A		1																								
FREQUENCY METER	TRG B551											1															
FREQUENCY SEL VOLTMETER	SIERRA 128A	1																									
FREQUENCY SEL VOLTMETER	HP 3591		1																								
FREQUENCY COUNTER	HP 5340	1	1		1	1	1	1	1	1	1		1	1	1	1	1	1		1		1	1	1	1		1
GENERATOR SIGNAL AM/FM	HP 8640																										
GENERATOR SIGNAL VHF	HP 608C	1	1	1	1																						1
GENERATOR SWEEP	HP 8690B						1	1			1			1	1	1		1		1			1	1			
PLUG-IN MODULE	HP 8693A						1	1			1			1	1	1		1									
PLUG-IN MODULE	HP 8694A						1																1	1			
PLUG-IN MODULE	HP 8698A																			1							
GENERATOR NOISE	AIL 07009				1				1																		
GENERATOR SIGNAL SHF	HP 620B					1			1	1			1				1					1			2		
INDICATOR VSWR	HP 415E										1				1	1							1				

RADIO TESTS (CONTINUED)																																	
TEST NUMBER (ST)																																	
14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
1	1		2					1	1		1																						
		1			1	1									1													1					
			1		1					1								1															
																										1	1						
																								1	1								
																									1								
													1							1		1			1							1	
																					1												
1	1	1	1		1		1	1	1	1		1	1	1	1	1	1	1	1						1	1	1			1			1
																															1		
												1	1	1	1				1	1		1			1								
1	1		1		1			1	1									1												1			1
1	1		1																														1
								1	1																								
					1													1												1			1
		1					1			2																							
1	1							1																									

TITLE AND NOMENCLATURE		RADIO TESTS (																							
		TEST NU																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
MIXER	HP 10514A	1	1	1																					
MIXER	AIL 13506				1				1				1												
MEASURING SET	HP 34750																								
MODULE	HP 34702A																								
MODULE	HP 34703A																								
MODULE	HP 34720A																								
PROBE	HP 11096A																								
CABLE	HP 56A–16C																								
NOISE MEASURING SET	HP 3555B																								
NOISE LOADING SET	TM–7816A																								
NOISE SOURCE	HP J347A												1						1						
NOISE METER INDICATOR	HP 342A												1						1						
NOISE LOADING TEST SET W/FILTERS	AN/GSM-161																								
SNT METER	BITE			1																					
NOISE RECEIVER	AIL 13610			1	1				1																
OSCILLATOR AUDIO	HP 654A																								
OSCILLOSCOPE	TEK 475A							1																	
POWER SPLITTER	HP 11667	← AS REQ																							
POWER DIVIDER	MERRIMAC PD 20–50																	2		1					1
POWER METER	BOONTON 42B		1			1																1			

								1	1	1							
								1	1	1							
								1	1	1							
								1	1	1							
								1	1	1							
								1	1	1							
									1	1	1						
											1			1			
									1		1						
						1			1		1	1		1			

TITLE AND NOMENCLATURE		RADIO TESTS (C																								
		TEST NUMBE																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
POWER SUPPLY	HP 6206	1	1															1								
POWER METER	HP 432A						2	1		1	1	1	1	1	1	1	1	1		1			1	1	1	1
THERMISTOR MOUNT	HP 478A						1	1		1	1	1	1	1	1	1	1	1		1			1	1	1	1
PRINTER DIGITAL (OPT 001, 032, 051, 055)	HP 5050																									
RECORDER X–Y	HP 7035																	1								
RECORDER STRIP CHART	HP 7418A																									
SLOTTED LINE PROBE	HP 444A										1				1	1							1			
SLOTTED LINE	HP J810B										1				1	1							1			
SLOTTED LINE CARRIAGE	HP 809C										1				1	1							1			
TEST SET BER	HP 1645A																									
COVER FRONT PANEL	HP 5060-8787																									
CABLE	HP 10233A																									
TERMINATION 50-ohm	TEK 011-0049-01	← AS REQUIRED																								
TERMINATION	TRG 580										1	1														
VOLTMETER rms	HP 3400A																									
VOLTMETER RF	BOONTON 916A												1						1							
INDICATOR	IP-1018																									
VOLTMETER VECTOR	HP 8405A																									
ADAPTER CAMERA	HP 10363	← AS REQUIRED																								

RADIO TESTS (CONTINUED)																																	
TEST NUMBER (ST)																																	
14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
			1																														
1	1	1	1		1			1	1	1	1	1	1	1	1	1		1					1				1			1			1
1	1	1	1		1			1	1	1	1	1	1	1	1	1		1					1				1			1			1
																1							1	1	1								
			1																											1			
												1									1												
1	1							1																									
1	1							1																									
1	1							1																									
																								1	1								
																								1	1								
																								1	1								
AS REQUIRED →																																	
																	1			2	2	2										1	
				1																				1	1	1	1						
																1							1	1	1								
																														1			
AS REQUIRED →																																	

TITLE AND NOMENCLATURE		RADIO TESTS																							
		TEST NUM																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	2
FREQUENCY COUNTER SET	HP 5300			1																1					
COUPLER DIRECTIONAL	HP J752C				3																				
GENERATOR SWEEP	HP 8620C							1																	
ETMS				1																					
CALCULATOR	HP 9825			1																					
POWER METER	HP 436A			1																					
POWER HEAD	HP 8484A																								

2

RADIO TESTS (CONTINUED)

TEST NUMBER (ST)

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
								1								1				1			1		1			1							1	

Preceding Page Blank - FILMED

TITLE AND NOMENCLATURE		AUDIO TESTS																		
		TEST NUMBER (T)																		
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	21		
MEASURING SET	HP 34750	2	1	1	1	1	1	1	1	1			1	1	1	1					
MODULE	HP 34702A	2	1	1	1	1	1	1	1	1			1	1	1	1					
MODULE	HP 34703B	2	1	1	1	1	1	1	1	1			1	1	1	1					
MODULE	HP 34720A	2	1	1	1	1	1	1	1	1			1	1	1	1					
PROBE	HP 11096A	2	1	1	1	1	1	1	1	1			1	1	1	1					
CABLE	HP 56A–16C	2	1	1	1	1	1	1	1	1			1	1	1	1					
TRANSFORMER IMPEDANCE MATCHING		← AS REQUIRED →																			
50 ohms		← AS REQUIRED →																			
75 ohms		← AS REQUIRED →																			
150 ohms		← AS REQUIRED →																			
300 ohms		← AS REQUIRED →																			
FREQUENCY SEL VOLTMETER	SIERRA 128A	1				1							1		1	1	1		1		
TEST SET	HP 3550B	1	1		1	1	1	1	1	1				1			1	1	2		
INDICATOR	IP–1018	1	1			1	1	1	1	1				1			1				
DELAY MEASURING SET	ACTON 490B			1						1	1	1									
RECORDER X–Y	HP 7035			1						1		1									
LOG/LIN AMPLIFIER	HP 8808			2						1											
NOISE MEASURING SET	HP 3555B						1										1				
IMPULSE NOISE SET	SCT TTS–58						1														

TITLE AND NOMENCLATURE		AUDIO TESTS (CONTINUED) TEST NUMBER (T) 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	21		
FREQUENCY COUNTER	HP 5300								1					1	1	1					
MODULE	HP 5302A								1					1	1	1					
MODULE	HP 5310A								1					1	1	1					
OSCILLATOR	HP 654A									1			1		1	1					
ATTENUATOR	HP 355C									1											
ANALYZER DISTORTION	HP 334A												1								
PHASE JITTER METER	48A1														1						
OSCILLOSCOPE	TEK 475															1					
WAVE ANALYZER	HP 3580												1				1				
TRANSLATION TEST SET	HP 880A													1							
DATA TEST SET	HP 1645A																	1			
MODEM	MD-823/U																	1			
PRINTER DIGITAL	HP 5055A																	1			
OSCILLATOR	HP 3330A																	1			
GROUND TEST																					
TEST SET	TS-3221/U																				

APPENDIX B. SUBSYSTEM PERFORMANCE PARAMETERS.
(Draft suppl 6 to annex A, DCAC 310-70-57.)

SUBSYSTEM: TERMINAL DESCRIPTION

Sheet 1 of 3

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Antenna									
Type(1)	P. C.	P. C.	P. C.	P. C.	4 P. C.	P. S. P. C.	P. C.	P. C.	P. C. (2)
Aperture (ft)	60	60	40	38	18 (eff)	8 20 (nom)	33"	6	8 4
Tracking(2)	S. C. M. P.	S. C. M. P.	S. C. M. P.	S. C. M. P	S. C. M. P.	S. T. S. T.	S. T. /C. T.	S. C. M. P.	S. C. M. P.
Receiver									
Pre-Amp(3)	C. P.	C. P.	C. P.	C. P.	U. C. P.	U. C. P.	U. C. P.	U. C. P.	U. C. P.
Bandwidth	500	500	500	500	500	500	500	500	500
Freq. Range(4)	X. D	X. D	X. D	X. D	X. D	X. D	X. D	X. D	X. D
Transmitter									
P. A. type	Klystron	2 TWT	HPA-Klystron LPA-TWT	HPA-TWT(2)	Klystron	2 Klystron	Klystron	Klystron	2 Klystron
Power out (kW)	HPA-12. 5 PA - 0. 4	5 (X2)	HPA-10 LPA - 2	HPA - 5 X2)	HPA - 8 LPA - 1. 3	1	11	11	3 (2)
Inst. Bandwidth (MHz)	HPA - 130 LPA - 500	500	HPA - 125 LPA - 500	HPA -500	HPA -50 LPA - 50	50	125	125	50
Freq. Range(5)	X. U	X. U	X. U	X. U	X. U	X. U	X. U	X. U	X. U
Overall									
G/T (dB/°K)	36. 5	39	34	34	26	18 26	7. 5	14	18 12
ERP (dBm)	126	127	127	HPA - 122	HPA - 112 LPA - 103	103 109	104	110	107 98

Notes:

(1) P. C. = Paraboloid with Cassegrain feed; 4 P. C. = 4 Dish paraboloid with Cassegrain; P. S. = Paraboloid with splash plate

(2) S. C. M. P. Single channel monopulse; S. T. = Steptrack; C. T. = Computer track

(3) C. P. = Cooled parametric amplifier; U. C. P. = Uncooled parametric amplifier

(4) X. D = 7. 25 - 7. 75 GHz

(5) X. U. = 7. 9 - 8. 4 GHz

SUBSYSTEM: TERMINAL DESCRIPTION

Sheet 2 of 3

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Receive:									
IF Freq. (MHz)	70	70 & 700	70	70 & 700	70	70	70 & 700	70 & 700	70 & 700
No. of Carriers	9	Up to 15 (Plus BCN)	Up to 15 (Incl. BCN)	Up to 15 (Plus BCN)	3 (Incl. BCN)	Up to 4 (Incl. BCN)	3 (Incl. BCN)	3 (Incl. BCN)	3 (Incl. BCN for 8') 2 (Incl. BCN for 4')
Bandwidth (MHz)	40	40 @ 70 125 @ 700	40	40 @ 70 125 @ 700	40	40	40 @ 70 100 @ 700	40 @ 70 100 @ 700	10 @ 70 60 @700
Phase Resp. (mR/MHz)		± 100@70 ± 5 ± 250@70 ±20 ± 150@700 ±30 ± 400@700 ±62.5	± 100@70 ± 5 ± 250@70 ± 20	± 100@ 70 ±5 ± 250@70 ±20 ± 150@700 ±30 ±400@700±62.5	±100@ 70 ± 5 ±250@70 ±20	± 100@70 ± 5 ± 250@70 ±20	± 500@ 700±50	± 100@ 700±5 ± 500@ 700±40	± 100@ 700 ± 20 ± 250@ 700 ± 30 ± 400 @700 ± 40
Ampl. Resp. (dB/MHz)		± 1 @70 ± 5 ± 2 @70 ± 20 ± 1@700 ± 30 ± 2@700 ± 62.5	±1@ 70 ± 5 ±2 @70 ± 20	±1@70 ± 5 ± 2@ 70 ± 20 ± 1@700 ± 30 ± 2@700 ±62.5	±1@70 ± 5 ±2@70 ± 20	±0.5 @70 ± 5	± 1.5@700 ± 40	± 1 @70 ± 5 ± 1 @700 ± 40	± 1 @700 ± 30
Output Imp (Ohm)	50	50	50	50	50	50	50	50	50
Output Level (dBm)	0	0	0	0	0	0	0	0	0
Gain - Paramp to D/C out		80 ± 5dB		80 ± 5dB					

SUBSYSTEM: TERMINAL DESCRIPTION

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Transmit:									
IF Freq. (MHz)	70	70 & 700	70	70 & 700	70	70	70 & 700	70 & 700	700
No. of Carriers	6	Up to 9	Up to 6	Up to 9	3	Up to 4	2	2	2 (for 8') 1 (for 4')
Bandwidth (MHz)		40 @ 70	40	40@ 70	40	40	40 @ 70	40 @ 70	
		125 @ 700		125 @700			100 @ 700	100 @ 700	50 @700
Phase Resp. (mR/MHz)		±100 @ 70 ± 5	± 100@ 70 ± 5	± 100 @70 ± 5	± 100@ 70± 5	± 100 @70± 5			
		± 250@ 70 ± 20	± 250 @70 ± 20	± 250 @70 ± 20	± 250@ 70± 20	± 250@ 70± 20			
		± 150@700 ± 30		± 150 @ 70 ± 30			± 500 @700 ± 40	± 100 @700 ± 5	± 100@ 700 ± 10
		± 400@700 ± 62.5		± 400@ 700 ± 62.5				± 500 @700 ±40	± 250 @700 ± 20
									± 400 700 ± 25
Ampl. Resp (dB/MHz)		± 1@70 ± 5	± 1@ 70 ± 5	± 1 @70 ± 5	± 1@ 70 ± 5	± 0.5@ 70± 5		± 1 @70± 20	
		± 2 @70 ± 20	± 2 @70 ± 20	± 2 @70 ± 20	± 2 @70 ± 20				
		± 1@700 ± 30		± 1 @700 ± 30			± 2 @700 ± 50	± 1 @ 700 ± 50	± 1 @700 ± 20
		± 2@700 ± 62.5		± 2 @700 ± 62.5					± 1.2@700 ± 25
Input Imp. (Ohm)	50	50	50	50	50	50	50	50	50
Input Level (dBm)	0	0 ± 10	0 ± 10	0 ± 10	0 ± 10	-10	0 ± 1	0	0 ± 3

SUBSYSTEM: ANTENNA

Sheet 1 of 1

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2	
						8'			8'	4'
Gain										
Receive (dB)	59.4	60.4	55.5	56.6	49.5	42.5	33.2	40.5	42.7	36.7
Transmit (dB)	58.4	61.8	57	58	50.5	43.5	34.3	41.5	43.4	37.4
Sidelobes (-dB)		1st > 15		1st>15		1st >20	-14		1.5° - 2.4°>12	3° - 4.8°>12
		2nd - 4th >20		2nd & 3rd>20		2nd >26			2.4° - 5° >20	4.8° - 10° > 20
		4th - 1.5°>28		3rd to 2^{O}>26		3rd >30			5° - 30° > 30	10° - 30° > 27
		1.5° + >40		2^{O} - 4^{O}>32		4th + > 33			30° - 120° >35	30° - 60°>31
				4^{O} - 6^{O}> 36		back >42			120° - 160° >41	60° - 120° > 35
				Beyond 6^{O}>40					160° - 180° >50	120° - 180°>41
Beam width (°)	0.17	0.15	0.22 ± 0.02	0.25	0.48	1.1(R)/0.95(T)	3	1.35		
Track Error (°)		<0.03 (max)		0.06 (max)	0.75		±1.5 (comp.)	±0.5(3σ)	0.1° (3σ)	
						20'				
						47.6				
						48.6				
						sidelobes?				
						0.38(R)/0.33(T)				

SUBSYSTEM: PARAMP

Sheet 1 of 1

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Bandwidth (MHz)	500	500	500	500	500	500	500	500	500
Ampl. Resp (dB/MHz)		± 0.02/1;±0.5/500 ± 0.4/40	0.25/40	0.02/1;±0.5/500	±0.5/40	±.15/10 ±.25/40 ±1/125		± 0.3/100	± 1/60
Phase Resp. (m Rad/MHz)		± 50/40;100/125		± 50/40;100/125	±50/40	±2.5°/30 ±5°/40 ±12.5°/125		±150/100	±100/40 ±250/60 ±400/80
Input Level (dBm)	-113 to -173	-145 to -60		-145 to -60	-140 to -70		-140 to -70	-140 to -70	-140 to -70
.5 dB Gain Compr (dBm)		-50	-40	-50	-45	-60	-40	-40	-40
Gain (dB)	30	30 - 32	30 ± .5	30 - 32	30 ± .5	32 - 34	30	30	30
Noise Temp. (°K)	35 (cooled) 135 (uncooled)	30	50	135	135	165	135	135	135
VSWR In		< 1.3:1	< 1.5:1	<1.3:1	<1.5:1		< 1.25:1	< 1.25:1	< 1.3:1
VSWR Out		< 1.3:1	< 1.5:1	<1.3:1	<1.5:1			< 1.4:1	< 1.3:1
Pump Freq. (GHz)		35		35	42				35
Pump Power (dBm)									

SUBSYSTEM: IFLA (Receive)

Sheet 1 of 1

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Power Out (dBm)	-53 to -113	12		12	20	N/A		-70 to 0	-10 to -80
Gain (dB)	30	> 24.5	30	> 24.5	30			29 ± 1	30
Power In (dBm)	-83 to -143	-30 to - 115	500	-30 to -115	-30 to -90			-100 to -30	-40 to -110
Bandwidth (MHz)	500	500		500	500				500
VSWR In.		1.25:1		1.25:1	1.3:1			< 1.2:1	< 1.3:1
VSWR Out		1.35:1		1.35:1	1.3:1			< 1.2:1	< 1.3:1
Ampl. Resp. (dB/ MHz)		± 0.35/125		± 0.35/125	±.5/40			± 0.1/100	± 0.5/500
		± 0.2/60		± 0.2/60	±1/500				± 0.3/80
									± 0.2/60
Phase Resp. (mR /MHz)		± 80/125		± 80/125					± 35/80
		± 30/60		± 30/60	±52/40				± 26/60
Dyn. Range (dB)		85		85					
Noise Figure (dB)		<9		<9	<10			7.5	8.0
.5 dB Gain Comp (dBm)		+10		+10	+10			-15(In)	

SUBSYSTEM: DOWN-CONVERTER

Sheet 1 of 2

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Power Out (dBm)	0 to -60	0	0 ± 0.5	0	0 ± .5		-60 to +10 (70) -123 to -53 (70/700)	-19 ± 4 (70) +10 ± 4 (70) -30 ± 2 (700)	+1
Gain (dB)	43	43 ± 0.5 (70) ± 1 (700)	43 ± 0.5	43 ± 0.5 (70) ± 1 (700)	43 ± 0.5	52	95/35	See P_o	41
Power In (dBm)	-43 to -103	-43 to -103	-43 to -103	-43 to -103	-43 to -103		-116 to -46	-41 ref. (-101 to -41)	-7
.5 dB Gain Comp (dBm)	+ 10 (out)	+ 10 (out)	+ 10 (out)	+ 10 (out	+ 10 (out)	-35 (in) (+17 out)			+12
Bandw. In (MHz)	500	500	500	500	500	500	500	500	500
Bandw. Out (70) (MHz) (700) (MHz)	40	40	40	40	40	40	40 100	40 100	50
VSWR In	<1.2:1	<1.2:1	<1.2:1	<1.2:1	<1.2:1	<1.5:1			<1.3:1
VSWR Out	<1.2:1	<1.2:1	<1.2:1	<1.2:1	<1.2:1	<1.15:1			<1.3:1
Ampl. Resp (dB/MHz)	±0.5/10 ±1/40	±1/40(70) ±1/125(700)	±0.5/10 ±1/40	±1/40(70)	±1/40 ±1/40	±0.2/10			±0.25/60
Phase Resp. (mR/MHz)	±200/40	±200/40 ±200/125	±200/40	±200/40 ±200/125	±200/40	±44/30 (center) ±78/40			36/40 94/60 192/80
Noise Fig. (dB)	16	16	16	16	16	10		21	14.5
Spurious (dB)	<-60 (2 at -51 dBm)	<-60 (2 at -51 dBm)	<-60 (2 at -51 dBm)	<-60 (2 at -51 dBm)	<-60 (2 at -51 dBm)	-66 (at -55 in)			-80(CX)

SUBSYSTEM: DOWN-CONVERTER

Sheet 2 of 2

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Tuning Incr. (kHz)	1	1	1	1	1	1		0.01	.01
L.O. Inp. (dBW)	0 to + 10	0 to + 10	0 to + 10	0 to + 10	0 to + 10				+13

SUBSYSTEM: TRACK RECEIVER

Sheet 1 of 1

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86 (Incl. DWNCNTR)	AN/ASC-18	AN/SSC-6	AN/WSC-2
Input Freq. (MHz)	70 ± 0.15	70 ± 0.2	46.9 ± 0.1	70 ± 0.2	70	X. D.	70	70	
Input Bandw. (kHz)	2000	1400		1400			120		
Input Level (dBm)	-3 to -63	-12 to -52	-25 to -86	-25 to -5[illegible]	-43	-115 to -78	-123 to -53	-57 to -21	
AGC (dB/dB)		± 1/40	± 1/61	± 1/40					
Sensitivity (dB-Hz)		53	27	53		39	35		
VSWR In		< 1.3:1		< 1.3:1			<1.25:1	<1.3:1	
Tuning Range (kHz)	± 150	± 200	± 100	± 200		500 MHz			
Auto. Acq. (kHz)		± 15/0.1 sec	± 100	± 15/0.1 sec		± 39 ± 20%/ 1.4 sec	± 10		
Noise Figure (dB)						10			

SUBSYSTEM: FREQUENCY GENERATION

Sheet 1 of 1

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Ext. Freq. Stand	Cesium	Cesium	Cesium	Cesium	Cesium				Cesium
Int. Freq. Stand. Stab.	$\pm 3 \times 10^{-12}$	$\pm 3 \times 10^{-12}$	$\pm 3 \times 10^{-12}$	$\pm 3 \times 10^{-12}$	$\pm 3 \times 10^{-12}$	1×10^{-10}/0.1sec		2×10^{-11}/mon	$\pm 1 \times 10^{-11}$
Accuracy	$\pm 7 \times 10^{-12}$	$\pm 7 \times 10^{-12}$	$\pm 7 \times 10^{-12}$	$\pm 7 \times 10^{-12}$	$\pm 7 \times 10^{-12}$	$\pm 1 \times 10^{-9}$/day		7×10^{-12}/sec	$\pm 3 \times 10^{-11}$
Synth. Inp. Freq (MHz)	5	5	5	5	5	5		5	5
Synth. Outp. Fr (MHz)		10 131-141 144-154	10 131-141 144-154	10 131-141 144-154	10 131-141 144-154				
Incident FM							≤ ± 0.1 Rad at 2.4 kHz		≤ 0.1R(rms)/5-100 Hz ≤ 30 mR(rms)/250 Hz (.1-1kHz)
		★	★	★	★				≤ 10 mR(rms)/250 Hz (1-250 kHz) ≤ 200 mR (rms)/100 Hz-250 kHz)
Spurious (dB)		≤ -80	≤ -80	≤ -80	≤ -80			-40 hours -80 non hours	≤ -40 harm ≤ -80 non harm
						-25/10 Hz-300 kHz -25/.3-20MHz			

★Spectral Purity

0.6Hz	-	75Hz	-	25dB		
10Hz	-	5MHz	-	32dB		
5MHz	-	20MHz	-	32dB		
5MHz	-	40MHz	-	32dB	(700 MHz IF only)	
12kHz	-	20kHz	-	54dB	}	any 3kHz bandwidth FM Mode
20kHz	-	60kHz	-	60dB		
60kHz	-	300kHz	-	68dB		

SUBSYSTEM: UP-CONVERTER

Sheet 1 of 1

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Power Out (dBw)	-1.5 to -31.5	-1.5 to -31.5	-1.5 to -31.5	-1.5 to -31.5	-1.5 to -31.5	+20.7	+14	+14	-10
Gain (dB)	-30	-30	-30	-30	-30	30.7	-10	-10	9-19
Power In (dBw)	0 ± 10	0 ± 10	0 ± 10	0 ± 10	0 ± 10	-10 ± 2	0	0	-20 to 70
Bandw. In									
(70 (MHz)	40	40	40	40	40	40	40	40	
(700) (MHz)		125	125	125	125		100	100	50
Bandw. Out (MHz)	500	500	500	500	500	500	500	500	500
VSWR In	<1.25:1	<1.25:1	<1.25:1	<1.25:1	<1.25:1	<1.15:1			<1.3:1
VSWR Out	<1.25:1	<1.25:1	<1.25:1	<1.25:1	<1.25:1	<1.3:1			<1.3:1
Ampl. Resp. (dB/MHz)	±0.5/10(70), /60 (700)	±0.5/10(70), /60 (700)	±0.5/10(70), /60 (700)	±0.5/10(70), /60 (700)	±0.5/10(70)/60 ±1/40 (700)	±0.3/10			±0.25/50
	±1/40(70), /125 (700)	±1/40(70), /125 (700)	±1/40(70), /125 (700)	±1/40(70), /125 (700)	±1/40(70), /125 (700)	±1/62.5			
Phase Resp. (mR/MHz)	±50/10(70), /60 (700)	±50/10(70), /60 (700)	±50/10(70), /60 (700)	±50/10(70), /60 (700)	±50/10(70), /60 (700)	±44/30 ±78/40			±22/20 ±36/40 ±72/50
	±200/40(70), /125(700)	±200/40(70)/125 (700)	±200/40(70), /125 (700)	±200/40(70), /125 (700)	±200/40(70), /125 (700)	±210/125			
Spurious (dB)	<-80(CX)	<-80(CX)	<-80(CX)	<-80(CX)	<-80(CX)	-80 (-75 dBm in XD)	70(CX)	-70(CX)	-80
Harmonic (dB)	<-66(CX)	-66(CX)	<-66(CX)	<-66(CX)	<-66(CX)				
Tuning Incr (kHz)	1	1	1	1	1	1	.01	.01	.01
L.O. Inp. (dBm) 0.5 dB Compres	0 to +10	0 to +10	0 to +10	0 to +10	0 to +10				13 -7

SUBSYSTEM: IFLA (Transmit)

Sheet 1 of 1

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Power Out (dBm)	None	0	N/A	0	N/A	N/A			-21
Gain (dB)		30		30					22
Power In (dBm)		-30 to -70		-30 to -70					-43
Bandwidth (MHz)		500		500					500
VSWR In		< 1.25:1		< 1.25:1					< 1.2:1
VSWR Out		< 1.25:1		< 1.25:1					< 1.25:1
Ampl. Resp. (dB/MHz)		± 0.18/125		± 0.18/125					± 0.5/500
		± 0.12/40		± 0.12/40					± 0.3/80
									± 0.2/60
Phase Resp. (mR/MHz)		± 80/125		± 80/125					± 35/80
		± 30/40		± 30/10					± 26/60
Dyn. Range (dB)		40		40					
Noise Figure (dB)		< 9		< 9					8.0
.5 dB Gain Compr. (dBm)		+10		+10					
IM		★		★					-86 (two at -43")

★For 2 each - 30dBm input, 3rd order is 30dB down

SUBSYSTEM: IPA

Sheet 1 of 1

PARAMETER	AN/FSC-9 (HPA)	AN/FSC-9 (LPA)	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
			Included with power amplifier		Included with power amplifier					
Power Out (dBm)	40			36		30		39	30	22.7
Gain (dB)	57			50		50		50	30	47
Power In (dBm)	-17			0 to -15		-20		-14	0	-10
Bandwidth (MHz)	500			500		500				500
VSWR In				< 1.3:1					< 1.15:1	< 1.2:1
VSWR Out									< 2:1	< 1.2:1
Ampl. Resp. (dB/MHz)				.6/125		.3/10			± 0.2/100	± 0.25/40 ± 0.30/50 ± 0.5/500
Phase Resp (mR/MHz)				50/125		34/10				± 17/20 ± 35/40 ± 44/50
Noise Figure (dB)						35			7.5	40
Hum Mod. (dB)						-65				
.5 dB Gain Compress (dBm)									-15 (in)	

SUBSYSTEM: POWER AMPLIFIER

Sheet 1 of 2

PARAMETER	AN/FSC-9		AN/FSC-78	AN/MSC-46		AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
	HPA	LPA		HPA	LPA	HPA		Note (1)			
Power Out (dBm)	71	56	65.7 (1)	70	63.5	.7	69	60.6	70.4	70.4	64.8 (2)
Gain (dB)	40		71.7	40	70	71.7	40	41			43
Power In (dBm)			- 6	32.5	- 6	- 6	30	+19.2			21.8
Inst. Bandw. (MHz)	125	500	500	125	500	500	55	50	>100	>100	
Pre-set bands #	6		1	6	1	1	11	5 not pre-set	6	6	6
VSWR In	1.5:1	1.2:1	< 1.2:1	1.5:1	1.2:1	<1.2:1	<1.25:1	<1.25:1		< 1.2:1	
VSWR Out	1.3:1	1.3:1	< 1.4.1	1.3:1	1.3:1	<1.4:1	<1.4:1	<1.25:1	< 1.5:1	< 1.5:1	< 1.3:1
Ampl. Resp. (dB/MHz)			±0.35/40			± 0.35/40	±.4/10	± 0.3/10			± 0.25/50
			± 0.5/125			± 0.5/125		± 0.5/40			
Phase Resp. (mR/MHz)			± 90/40			± 90/40		± 72/30	100/10;300/80		+40/20 ∓50/40
			±140/125			±140/125	±35/10	±155/40			±225/50
IM, 2CX(dB/dBm)			-9.5/65.7			-9.5/65.7		-20/57.6			
			-16/62.7			-16/62.7		-28/54.6			
			-19/59.7			-19/59.7		-37/50.6			
Spurious (dB)			-80(CX)	-50(P_{max})		-80 (CX)		-80		?	
in Receive(dB)			-180	-180(P_{max})		-180					

Note 1: at antenna

SUBSYSTEM: POWER AMPLIFIER

Sheet 2 of 2

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Harmon. (dB)		-60(CX)	-40(P_{max})	-60(CX)	-30	-60	-30	-30(2^{nd} 3^{rd}) -50(high)	-60(OOB)
Hum (dB)		-60(CX)	-50(P_{max})	-60(P_{max})	-86				
Res. AM (dB)		-65(CX)		-65(P_{max})	-68	-62 at 360 Hz -66 at 10 kHz+ -36 at 360 Hz	-50	-50	
Res. FM (dB)		★		★		-40 at 10 kHz+		< 1 Rad/2400 Hz	

★Spectral Purity is 3dB better than Freq. Gen. S.S.

SUBSYSTEM: WAVEGUIDE

Sheet 1 of 1

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Transmit Loss (dB)	9	2		2 8	0.57	Incl. with power amp.			
Receive Loss (dB)	9.5	8 (tot)							
VSRW Tx		1.5:1		1.5:1					
VSWR Rx		1.25:1		1.25:1					
Slope Tx dB/MHz									
Slope Rx dB/MHz		0.08/40		.08/40					

SUBSYSTEM: TERMINAL SYSTEM

Sheet 1 of 1

PARAMETER	AN/FSC-9	AN/FSC-78	AN/MSC-46	AN/MSC-61	AN/TSC-54	AN/TSC-86	AN/ASC-18	AN/SSC-6	AN/WSC-2
Tx/Rx Isol. (dB)		Below 7.756Hz >185dB	Below 7.756Hz >185dB	Below 7.756Hz >185dB					
Crossover IM (dB)		Above 7.756Hz >100dB	Above 7.756Hz >100dB	Above 7.756Hz >100dB					
System Phaselin (mR/MHz)									
System Phase Noise									

Preceding Page Blank - Filmed

APPENDIX C

SAMPLE TEST REPORT

C-1. GENERAL.

a. This appendix prescribes the organization, format, and content of the technical evaluation reports submitted on satellite evaluations. It also provides guidance for preparation of the final report.

b. The report will be divided into two volumes. Volume I will contain the performance characteristics and tabulations of pertinent data collected during the evaluation. Only representative portions of this volume are included in the sample report. Volume II will contain the raw test data collected by the test team and used in preparing the narrative of volume I.

C-2. REPORT FORMAT AND CONTENT.

a. (1.0) GENERAL. This paragraph will contain a short description of the report content, including such information as the test period, operation and maintenance (O&M) command operating and maintaining the terminal test team composition, key personnel contacted, and selected link and equipment parameters as shown in paragraph 1.0b of the sample report.

b. (2.0) SUMMARY OF TEST RESULTS. A summary of the test results will include information on the tests conducted and the results of each test. Any anomalies, discrepancies, or deviations from expected results (design standards or manufacturer's specifications) should be discussed. Separate subparagraphs will be used for each of the performance characteristics discussed. The number of subparagraphs will depend on the number of tests performed and test results. Within specifications test results will require only a listing of the test title with a statement to that effect.

c. (3.0) EQUIPMENT PERFORMANCE INDICATORS. The equipment performance indicators will be graphical presentations of the performance characteristics of the major equipment on each satellite terminal. As a minimum, the following will be included for each terminal tested.

(1) Receiver noise quieting characteristics.

(2) TTNR versus quieting characteristics.

(3) Out-of-band noise (OBN) versus C/kT.

d. (4.0) TRANSMISSION QUALITY INDICATORS. The transmission quality indicators will be graphical presentations of the transmission quality of the satellite link subsystems under test. This will include:

(1) Distribution of median idle channel noise (ICN).

(2) Distribution of median OBN.

(3) Distribution of loading when recorded.

(4) Test tone stability.

(5) Other graphical representations that may portray system performance.

e. (5.0) OMITTED AND/OR INCOMPLETE TESTS. All required tests that are omitted, incomplete, or that yield invalid results will be listed in tabular form (USACC Form 383-R (Test)). A concise explanation will be provided for each test listed.

f. (6.0) CONCLUSIONS. Conclusions reached as a result of the evaluation of the reduced data and test results will be provided. All important satellite terminal link or system performance results, equipment anomalous performance, and O&M deficiencies will be included.

g. (7.0) TECHNICAL RECOMMENDATIONS. All technical recommedations for necessary corrective actions will be provided. Recommended corrective actions will be those that could not be accomplished within the timeframe or for which resources were not available to the test teams or site maintenance personnel.

h. (8.0) DATA TABULATION.

(1) Tabulation of data for the technical evaluation data base will be included in each report. All elements will be listed and not applicable (NA) will be entered for elements not applicable. Where data is not available, enter DNA. A separate subsection will be used for each subsystem or equipment under test.

(2) Station facility data will be included in this paragraph and should consists of such items as the performance worksheets, site layout plan, power distribution scheme, and equipment configuration diagram.

(3) The raw test data collected by the test teams will be included in volume II. This data has not been included in the sample report in an effort to reduce the size of the pamphlet without detracting from its usefulness.

FINAL TEST REPORT

(RCS: CC-OPS-)

VOLUME I

OPERATIONAL QUALITY ASSURANCE

SITE Y SATELLITE EARTH TERMINAL

TECHNICAL EVALUATION

Sample satellite report.

TABLE OF CONTENTS

VOLUME I

LIST OF ILLUSTRATIONS

Sample satellite report. (continued)

LIST OF TABLES

Sample satellite report. (continued)

1.0 GENERAL.

a. The performance of the AN/TSC-54 satellite earth terminal, located at Site Y, was evaluated IAW DCAC 310-70-57 as supplemented by CCP 702-2. The objectives of the evaluation were to:

(1) Optimize, characterize, and insure that the earth terminal was performing at the optimal or predicted noise performance levels.

(2) Provide a technical data base which could be used as a management tool to assist the O&M commander and site personnel in establishing an effective satellite earth terminal quality assurance program.

(3) Provide a listing of the remaining deficiencies and the appropriate recommended corrective actions for each.

b. The link and equipment parameters are shown in the following tabulations. The evaluation is based on test data collected between 6 September and 15 October 1976 except as noted on USACC Form 383-R (Test).

LINK PARAMETERS		
STATION TESTED	TRANSMITTER FREQUENCY (MHz)	TYPE TERMINAL
Site Y	7553.506	AN/TSC-54

LINK EQUIPMENT TESTED				
STATION TESTED	RADIO TYPE	OUTPUT POWER	MULTIPLEX TYPE	ANTENNA TYPE AND SIZE
Site Y	AN/TSC-54	3.0 kw on low taps	AN/UCC-4	Four 10-ft parabolics in a cloverleaf

1.1 PERIOD OF EVALUATION. 6 September through 15 October 1976.

1.2 O&M AGENCY AND MAILING ADDRESS.

Commander
27th Signal Command
Worms, Germany, APO New York 09999

Sample satellite report. (continued)

1.3 USACC TECHNICAL EVALUATION TEAM COMPOSITION.

NAME	GRADE	POSITION
JOHNS, Mary E.	CW3	Team Chief
PETERS, J. W.	GS-12	Engineer
BOYD, Frank	E7	Team NCOIC
GROSS, Edward	E6	Technician

1.4 KEY PERSONNEL CONTACTED.

NAME	GRADE	POSITION
ROBERTS, Joseph C.	COL	CDR, 27th Signal Command
HOWARD, William	LTC	Chief, DSC Operations, 27th Signal Command
RANDALL, Robert	E8	Site Station Chief

2.0 SUMMARY OF TEST RESULTS.

a. The earth terminal located at Site Y was evaluated using a 6 tactical channel configuration of the FM modems (emphasis improvement included). A brief description of the test results is contained in paragraphs 2.1 and 2.2. The data elements are tabulated and compared with manufacturer's and military standards where appropriate in paragraph 8.0.

b. The final test data gathered on this terminal indicates the system is operating at its design capability; however, a few deficiencies were found as a result of testing. The most significant was the degraded bandwidth of the power amplifier (PA) and the low gain of both parametric amplifiers (para-amp). Due to the frequency allocation of the transmit carriers, retuning of a preset power band of the replacement klystron was required in order to meet mission requirements. A detailed description of the frequency interrelationships is contained in paragraph 2.2.5 below. Both para-amps were aligned to meet specifications following modular replacement.

c. Another potential problem area was the tracking system of the antenna. It was discovered that the receive C/kT dropped rapidly (up to 6 db) when the tracking system was placed in the manual mode of operation. This problem was identified and corrected by performing a servo cabinet and azimuth synchro alignment per TM 11-5855-389-34/5.

Sample satellite report. (continued)

d. A brief narrative for each of the significant tests is contained in paragraphs 2.1 and 2.2. Tests which met specifications and provided no significant information on system evaluation are not elaborated on but are listed in paragraph 2.3.

2.1 AUDIO TESTS.

2.1.1 1-kHz TEST TONE SIGNAL LEVELS (T-4).

a. Preliminary testing showed that five of the six channels evaluated at the HF patch panel failed to meet the ±1.0 db requirement as contained in MIL-STD-188/100. Those failing channels were subsequently adjusted by test team personnel to meet the above requirements.

b. It was also noted during this test that the 420-kHz group carrier did not appear at the output of the group carrier supply drawer. Further checks by site personnel isolated the problem to a defective 420-kHz filter module. The inoperative group carrier had no affect on the present communications since it was not being used for normal system operation.

2.1.2 IDLE CHANNEL NOISE (T-8).

a. The requirement to which the measurements are compared is based on the performance characteristics for a 6 tactical channel system. The noise level in the worst channel, as shown on the manufacturer's characterization sheet, is -29.7 dbm0 at the operating C/kT level of 67.3 db. Indications are that this was the worst possible case (emphasis improvement not considered). Since this system uses emphasis the noise performance of the channels should be somewhat better. The ICN median of the six channels tested at the VF patch board with the system looped at the antenna STT was -36.6 dbm0.

NOTE: The above ICN value is shown at a C/kT level of about 64 db instead of the allocated level of 67.3 db. However, even at this lower C/kT level, the noise level of the channels was still better than the established requirement.

b. Hourly ICN measurements were also taken over the satellite link on channel 3. The median value as derived from the 72-hour period was -40.68 dbm0 which is considerably better than the established noise performance level. Based on these measurements, it is apparent that the receive C/kT was higher than the allocated level of 67.3 db.

2.1.3 IDLE CHANNEL IMPULSE NOISE (T-9). The impulse noise specification as contained in table II of DCAC 300-175-9 states that the noise counts should not exceed 15 counts per 15 minutes above 72 dbrn0. Testing over the satellite link indicated that this requirement was met. Subsequent noise measurements were taken with the system looped at the antenna STT. In this loopback configuration, it was found that the impulse noise counts met specifications at all C/kT levels exceeding 62.5 db.

Sample satellite report. (continued)

2.2 RADIO TESTS.

2.2.1 ANTENNA TRACKING AND POINTING ACCURACY (ST-1).

a. Several attempts were made to determine the tracking capability of the antenna system; however, none were successful. Whenever the tracking system was switched to the manual mode, the receive C/kT level rapidly decreased by as much as 6 db, indicating antenna movement. However, no changes in the antenna look angles (azimuth and elevation) were observed on the control panel.

b. This problem was identified and corrected by performing an alignment of the servo cabinet and azimuth synchro resolver IAW the procedures described in TM 11-5855-389-34/5.

c. Subsequent testing indicated that the tracking system is capable of autotracking the satellite.

2.2.2 ANTENNA FOCUSING, BEAMWIDTH, AND SIDE LOBE (ST-2). The antenna beamwidth was within the tolerances (0.4 degree) that are shown in figures 4-5, 4-12, and 4-13 of TM 11-5895-389-50/4. The first side lobes were -9.6 db in the clockwise direction and -8.6 in the UP direction which did not meet the requirements of -10 db by 0.4 and 1.4 db respectively.

2.2.3 WG RETURN LOSS OR VSWR (ST-5).

a. The slotted line technique was used to measure the VSWR's on both the transmit and receive WG's located between the operations control van (OCV) and antenna pedestal. With the transmit WG terminated in the intermediate power amplifier (IPA) (normal configuration), VSWR measurements did not exceed 1.17:1 over the frequency band of interest (7.9 to 8.4 GHz). These results are considered acceptable based on previous data gathered on the other AN/TSC-54 earth terminals.

b. Testing on the receive WG indicated that VSWR's were as high as 1.40:1 in the normal system configuration (microwave divider). Further testing indicated the probable cause to be the flexible WG used to connect the input to the microwave divider. However, the divergencies over the frequency band are not of sufficient magnitude to adversely affect the noise or bit error performance of the terminal.

2.2.4 WG INSERTION LOSS (ST-6). The insertion loss on both the transmit and receive WG runs, as measured between the OCV and the antenna pedestal, are considered acceptable for normal system operation. The average power losses on the WG over the entire frequency range of interest were 1.4 db (transmit) and 1.2 db (receive).

Sample satellite report. (continued)

2.2.5 PARA-AMP FREQUENCY RESPONSE AND GAIN (ST-7).

a. The specifications to which the test results were compared were extracted from the test and demonstration report (contract No. DAAB 07-73-C-0077) which states:

Gain: 29.5±1.0 db from 7.25 to 7.75 GHz

Ripple: <0.5 db over any 40 MHz portion

b. Initial measurements on the para-amps showed that the gain was degraded by 8 and 10 db on para-amps 1 and 2 respectively. The gain of para-amp 1 was brought to within specifications by modular replacement of a defective Gunn oscillator in stage 2 and subsequent realignment. Para-amp 2 required only adjustments of the pump power and bias voltage in order to meet the gain requirements; however, the ripple response of this amplifier was out of tolerance in a portion of the required RF bandpass (7.25 to 7.75 GHz). This deficiency is of little consequence to the present system performance since the response characteristics over the operating frequency spectrum are well within specifications.

2.2.6 IFLA FREQUENCY RESPONSE AND GAIN (ST-13). This test was performed by injecting the test signals at directional coupler DC-3 and measuring the output level at CP-8 on the WG switch. The manufacturer's specifications for tube type WJ-3106 state the gain as 30 to 32 db and the frequency response as 500 MHz at ±1.0 db points. Both amplifiers met the frequency response requirement; however, the measured gain of IFLA 2 exceeded the maximum requirement by 1.0 db. This excessive gain is of no consequence to system performance.

2.2.7 DOWN CONVERTER FREQUENCY RESPONSE AND GAIN (ST-17).

a. Paragraphs 4 through 8 of DTM 11-5895-833-34/7 state the following specifications for the down converter:

Frequency Response: ±0.5 db @ 10 MHz

±1.0 db @ 40 MHz

Gain: 43±0.5 db

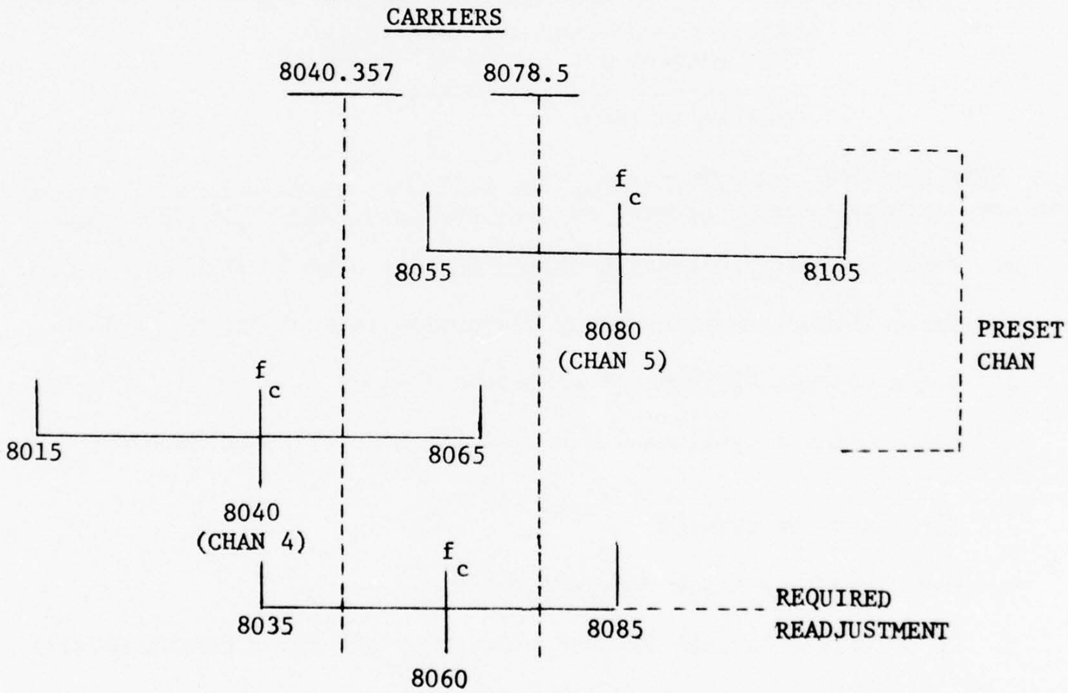
b. Of the three down converters tested, only one down converter (1A4) was found to be below the minimum gain requirement. The gain was improved to specification by readjusting attenuator AT-5. The only unit failing to meet the frequency response requirement was down converter 1A2. Diagnositc testing isolated the problem to the 70 MHz IF amplifier (AR-2) which was replaced. However, retesting of this converter still indicated substandard results.

Sample satellite report. (continued)

2.2.8 UPLINK IFLA AND IPA FREQUENCY RESPONSE AND GAIN (ST-21). This test was performed with the test signals injected at CP-12 and the output power level of the IPA measured at directional coupler DC-2. The measured gain of the IPA met the 50±3 db gain requirement over the required bandpass (7.9 to 8.4 GHz) as stated in TM 11-5895-389-34/3.

2.2.9 POWER OUTPUT, VSWR, AND REFLECTOMETER CALIBRATION; AND PA FREQUENCY RESPONSE (ST-23).

a. Initial test results indicated that the PA was operating in a degraded state. The measured -1.0 db bandwidth response was only 12.5 MHz wide as opposed to the 50 MHz requirement as shown on page 5 of the Varian Test Performance Sheet VA-925S. The filament voltage was also below the 7.0 volts minimum. This condition may have been a result of altering the klystron's preset power bandpass for operational purposes. Shown below are the transmit frequencies in relation to the applicable preset channel frequencies of the klystron and its associated 50 MHz-bandwidth as stated by manufacturer.



NOTE: It is apparent that both transmit carriers are not applicable to either preset mode (chan 4 or 5) of operation. Consequently, readjustment of the klystron was indicated in order to meet mission requirements.

b. A replacement klystron was installed and retuned so that the operating bandpass encompassed both transmit frequencies as shown in the above diagram. Indications are that this klystron is capable of operating satisfactorily in a retuned condition.

Sample satellite report. (continued)

2.2.10 TRACK RECEIVER AGC VOLTAGE VS C/kT (ST-27). The threshold level at which the receivers lost lock and regained lock on the simulated beacon signal was measured in order to evaluate the track receiver's overall performance. The test results below were obtained when the phase lock indicator registered these conditions:

	C/kT (db)	
RECEIVER	LOST LOCK	REGAIN LOCK
1	45	46
2	43	44
Beacon	*	*

*Could not be determined since the beacon demodulator was inoperative. This problem was traced to a missing 1.4-MHz voltage controlled oscillator (VCO).

2.3 TEST THAT MET SPECIFICATIONS. The following tests were performed and the test results were considered to meet the applicable specifications.

a. Voice Channel Frequency Response (Manual Sweep) (T-10).

b. Voice Channel Envelope Delay Distortion (Manual Sweep) (T-12).

c. Voice Channel Frequency Translation (T-15).

d. Voice Channel Spurious Phase Jitter and Hits (Meter Method) (T-16).

e. Para-amp VSWR (ST-10).

f. Down Converter Noise Figure (ST-18).

g. Up Converter/Exciter Frequency Response and Power Output (ST-19).

h. Track Receiver AGC Voltage vs C/kT (ST-27).

i. FM Modem Deviation, Deviation Linearity, Dispersion, and Frequency Response (ST-31).

Sample satellite report. (continued)

3.0 RF EQUIPMENT PERFORMANCE INDICATORS. From the measured data, the performance of the major equipment is presented as follows:

	DESCRIPTION
USACC Form 396-R (Test)	Receiver noise quieting characteristics (looped at OCV STT).
USACC Form 396-R (Test)	Receiver noise quieting characteristics (looped at the antenna STT).
USACC Form 396-R (Test)	TTNR vs C/kT (looped at the OCV STT).
USACC Form 396-R (Test)	TTNR vs C/kT (looped at the antenna STT).
USACC Form 396-R (Test)	OBN vs C/kT (looped at the OCV STT).
USACC Form 396-R (Test)	OBN vs C/kT (looped at the antenna STT).

4.0. LINK PERFORMANCE INDICATORS.

USACC Form 449-R (Test) Distribution median of OBN.

5.0 OMITTED AND/OR INCOMPLETE TESTS. For omitted and/or incomplete tests, refer to USACC Form 383-R (Test).

6.0 CONCLUSIONS. Based on the final test results, this earth terminal is operating at its standard noise performance level and is meeting the mission requirements for which it was designed. It should be noted that initial measurements found the earth terminal to be operating in a degraded state (transmit, receive, and autotrack functions). Therefore, it is essential that periodic maintenance checks be scheduled and performed on both the standby and operational equipment to preclude performance slipping to a degraded state.

7.0 TECHNICAL RECOMMENDATIONS.

a. The recommended corrective actions tabulated below will improve the overall performance of the earth terminal; however, the deficiencies that are marked with an asterisk are not degrading the system to the point of customer dissatisfaction and remedial action is not considered cost-effective at this time.

b. The O&M agency should monitor these uncorrected deficiencies to preclude customer dissatisfaction.

Sample satellite report. (continued)

Deficiencies and Recommended Corrective Action

DEFICIENCY	PARA REF	RECOMMENDED CORRECTIVE ACTION
*No 420-kHz output at the group carrier supply drawer	2.1.1	Replace the defective unit upon receipt of the requisitioned part
Out-of-tolerance frequency response on down converter 1A2	2.2.7	Install a good 70-MHz IF amplifier (AR-2) in this down converter and repeat the frequency response test to insure that the unit meets applicable specifications
*Inoperative beacon demodulation	2.2.10	Install a 1.4-MHz VCO in the receiver and make appropriate checks or alignments as required to bring the receiver within an acceptable performance level

*System is not degraded to the point of customer dissatisfaction; remedial action is not considered cost-effective at this time.

Sample satellite report. (continued)

8.0 SATELLITE EARTH TERMINAL DATA TABULATION.

a. Link No. S-0000

b. Trunk No. 444443

c. Trunk No. 444444

d. O&M MILDEP . . . . US Army

e. Type of Terminal . . . . AN/TSC-54 (phase II)

f. Systems Configurations
(Sites Y and X). . . . . 3 Tac (xmit)
6 Tac (rec)

g. Type of Multiplex Equipment. AN/UCC-4

h. No. of Through Groups. . . . . NA

i. Path Length -- Site Y
to Site X (km) 48,324

j. Path Attenuation (db @ MHz). . . . . . 202.67 @ 7304.599

k. Earth Terminal G/T Ratio (db)

(1) Theoretical 26

(2) Measured. . . . . DNA

l. Earth Terminal SNT (^{O}K)

(1) Specification . . . . 170 max

(2) Measured. . . . . DNA

m. Antenna Gain (Rec)(db)

(1) Theoretical 51.2

(2) Measured. . . . . DNA

n. Antenna Size (meters). 60

o. Antenna Type . . . . Cassegrain

p. Low Noise Preamplifier Type. . . . . . Parametric

Sample satellite report. (continued)

(1) Gain Specification (db) . . . . 29.5±1

(2) Measured Gain (db)

(a) Para-amp 1. . . . . 29.0

(b) Para-amp 2. . . . . 28.8

q. Para-amp Frequency Response (±db @ MHz)

(1) Specification . . . . <0.5 db of any 40 MHz portion of specified bandwidth

(2) Measured

(a) Para-amp 1. . . . . 581.63

(b) Para-amp 2. . . . . DNA

r. Para-amp Noise Temperature (^{O}K)

(1) Specification . . . . 135 max

(2) Measured. . . . . DNA

s. Para-amp Input and Output VSWR

(1) Specification . . . . <1.5:1 from 7.25 to 7.75 GHz

(2) Measured (at 7500 GHz)

(a) Para-amp 1

1. Input. 1.04:1

2. Output 1.17:1

(b) Para-amp 2

1. Input. 1.04:1

2. Output 1.06:1

Sample satellite report. (continued)

t. WG RF Insertion Loss per 3048 cm (Rec) (db @ GHz)

(1) Specification . . . . 1 db at 8 GHz
2.4 db at 7.2 GHz

(2) Measured. 1.2

u. WG Return Loss (Rec) (db)

(1) Specification . . . . >17.69

(2) Measured. 15.9

v. IFLA

(1) IFLA Gain (db)

(a) Specification . . . . 30 to 32

(b) Measured

1. IFLA 1 30

2. IFLA 2 33

(2) IFLA Frequency Response (±db @ MHz)

(a) Specification . . . . ±1 @ 500

(b) Measured

1. IFLA 1 . . . . <500

2. IFLA 2 . . . . <500

w. Down Converter

(1) Down Converter Gain (db)

(a) Specification . . . . 43±0.5

(b) Measured

1. Down Converter 1A2 . . . . 42.7

2. Down Converter 1A3 . . . . 42.5

3. Down Converter 1A4 . . . . 42.6

Sample satellite report. (continued)

(2) Down Converter Frequency Response (±db @ MHz)

(a) Specification . . . . ±0.5 @ 10
±1.0 @ 40

(b) Measured

1. Down Converter 1A2 . . . . 27.0 @ 39.7

2. Down Converter 1A3 . . . . 43.0 @ 45.4

3. Down Converter 1A4 . . . . 43.5 @ 46.0

(3) Down Converter Noise Figure (db)

(a) Specification . . . . 16.5 max

(b) Measured

1. Down Converter 1A2 . . . . 11.4

2. Down Converter 1A3 . . . . 13.0

3. Down Converter 1A4 . . . . 14.1

x. FM Demodulator

(1) FM Demodulator IF Bandpass (MHz)

(a) Specification

	MIN	NOM	MAX
1. 6 Tac Chan.	0.280	0.320	0.352
2. 3 Tac Chan.	0.387	0.432	0.473

(b) Measured

1. 6 Tac Chan. 0.462

2. 3 Tac Chan. 0.321

y. C/kT Ratio (Rec) -- Site X (db)

(1) Specification 67.3

(2) Measured. . . . . DNA

z. ICN (High Chan) -- Site X (6 Chan)

(1) Specification . . . . -29.7

Sample satellite report. (continued)

(2) Measured. . . . . -40.68 (chan 3)

aa. NPR (High Slot -- 6 Tac Chan)(db) . . 23.0 (calculated)

ab. Loading Level -- Site Y (dbm0)

(1) Specification 2.1126

(2) Measured

(a) Transmit. 0.91

(b) Receive 2.11

ac. FM Modulator (SN083) -- Site Y

(1) FM Modulator Power Output (dbm)

(a) Specification . . . . -10 to 10

(b) Measured. 19.5

(2) FM Modulator Frequency Output (MHz)

(a) Specification . . . . 70±700

(b) Measured. 70

ad. Up Converter

(1) Up Converter Power Output (dbm)

(a) Specification . . . . Adjustable from -1.5 to -31.5

(b) Measured

1. Up Converter 8A2 . . . . 9.5 max

2. Up Converter 8A3 . . . . 9.5 max

3. Up Converter 8A4 . . . . 11.0 max

(2) Up Converter Frequency Response (±db @ MHz)

(a) Specification . . . . ±1.0 @ ±20 of F_c

(b) Measured

1. Up Converter 2A2 . . . . 46.67

Sample satellite report. (continued)

2. Up Converter 2A3 . . . . 46.23

3. Up Converter 2A4 . . . . 45.98

ae. IPA

(1) IPA Frequency Response (±db @ MHz)

(a) Specification . . . . ±3 from 7.9 to 8.4 GHz

(b) Measured (IPA 1). . . . . >500

(2) IPA Gain (db)

(a) Specification . . . . 50±3

(b) Measured (IPA 1). 48.6

af. Final PA

(1) Final PA Power Output (HPA) (W)

(a) Specification . . . . 3 kw on low laps

(b) Measured. 3162

(2) Final PA Frequency Response (HPA) (MHz - db)

(a) Specification . . . . 50 @ -1

(b) Measured. . . . . 54 @ -1

(3) Final PA Output VSWR (HPA)

(a) Specification 1.5:1

(b) Measured. 1.134:1

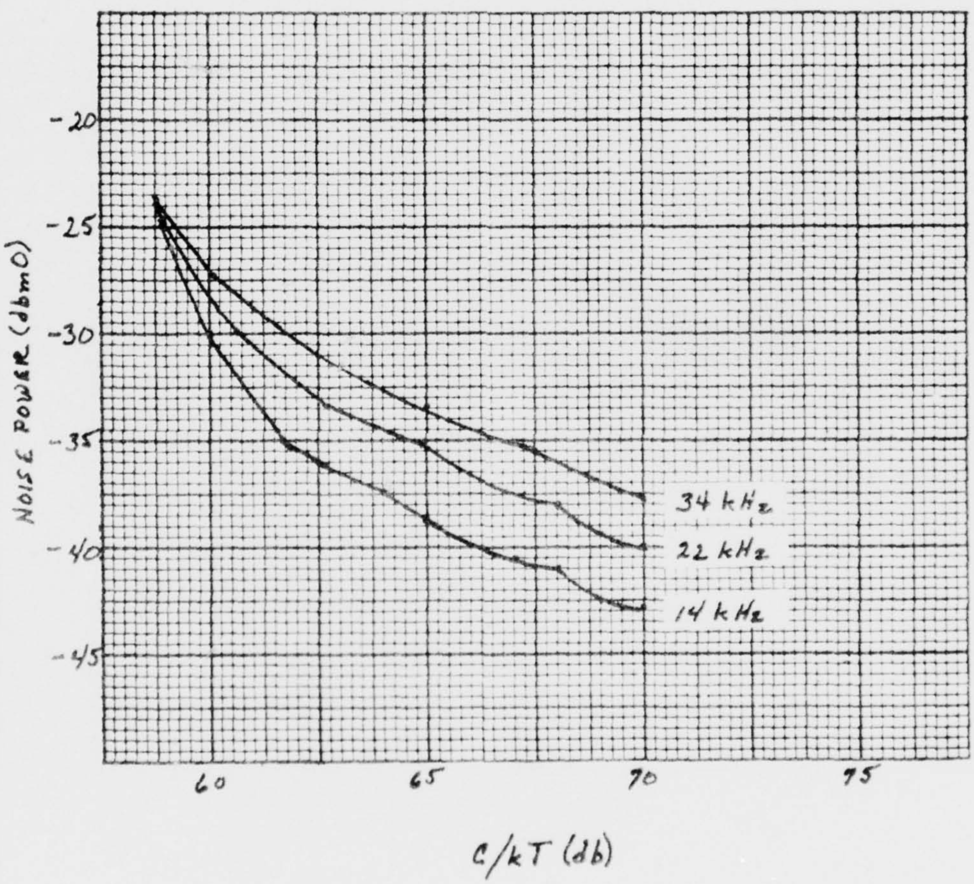
ag. WG RF Insertion Loss per 3048 cm (Xmit) (db @ GHz)

(1) Specification . . . . 1 db at 8 GHz
2.4 db at 7.2 GHz

(2) Measured. 1.4

Sample satellite report. (continued)

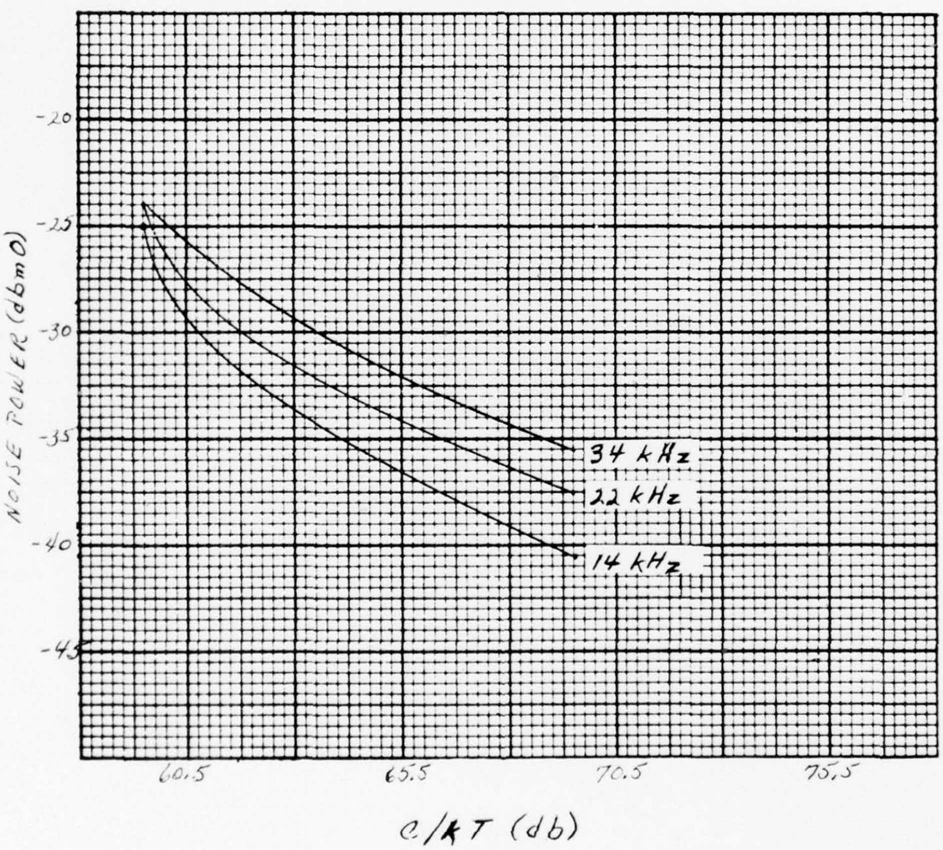
GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3)			PAGE NUMBER: 1	NUMBER OF PAGES: 1
DATA SHEET			DATE (DAY, MONTH, YEAR): 19 Sep 76	
LINK NO.: 5-0000	STATION UNDER TEST: Site Y	DISTANT STATION: Site X	TEST ENGR SIGNATURE: Mary E. Johns, CW3	
TITLE OF PERFORMANCE PLOTTED: RECEIVER NOISE QUIETING CHARACTERISTICS (LOOPED AT OCV STT)				TEST NO.: ST-3



USACC Form 396-R (Test)
1 April 1977

Sample satellite report. (continued)

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3)		PAGE NUMBER	NUMBER OF PAGES
		1	1
DATA SHEET		DATE (DAY, MONTH, YEAR) 19 Sep 76	
LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE
S-0000	Site Y	Site X	Mary E. Johns, CW3
TITLE OF PERFORMANCE PLOTTED			TEST NO.
RECEIVER NOISE QUIETING CHARACTERISTICS (ACCEPED AT ANTENNA STD)			ST-3

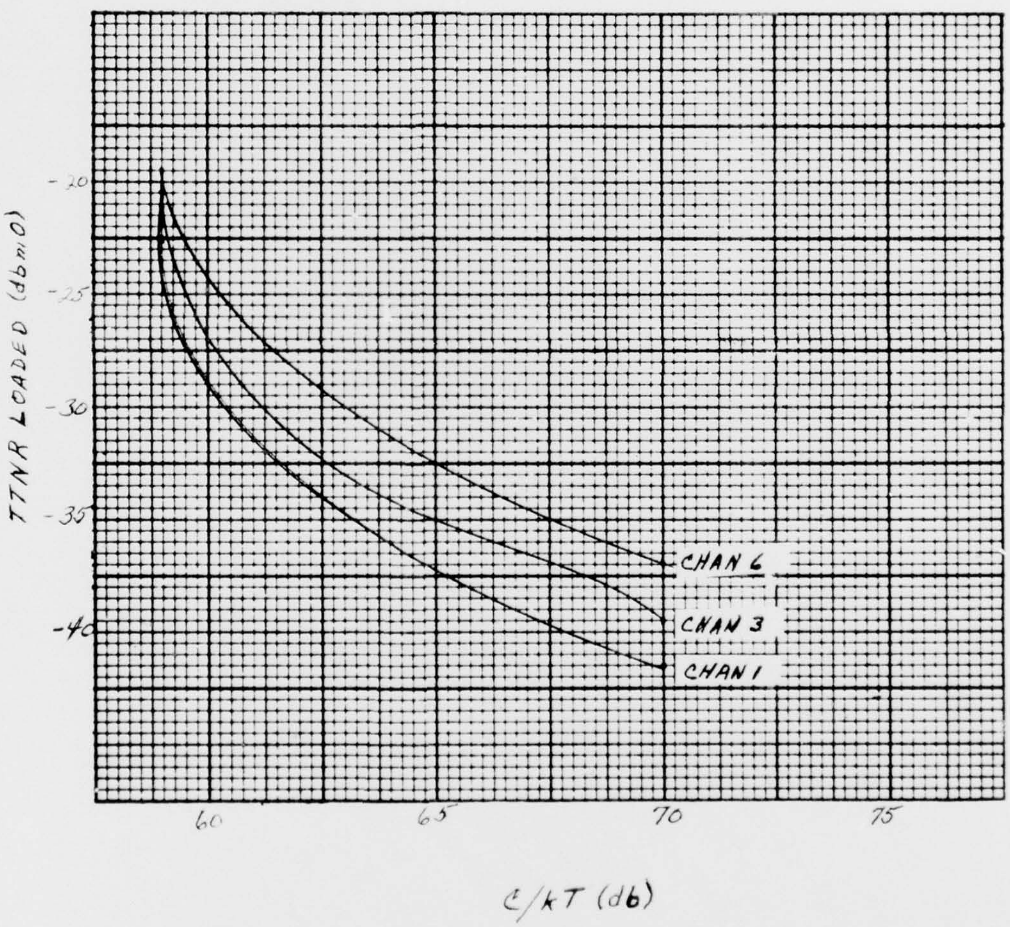


USACC Form 396-R (Test)
1 April 1977

Sample satellite report. (continued)

TO: (Forward direct to addressee listed in publication)	FROM: (Activity and location) (Include ZIP Code)	DATE

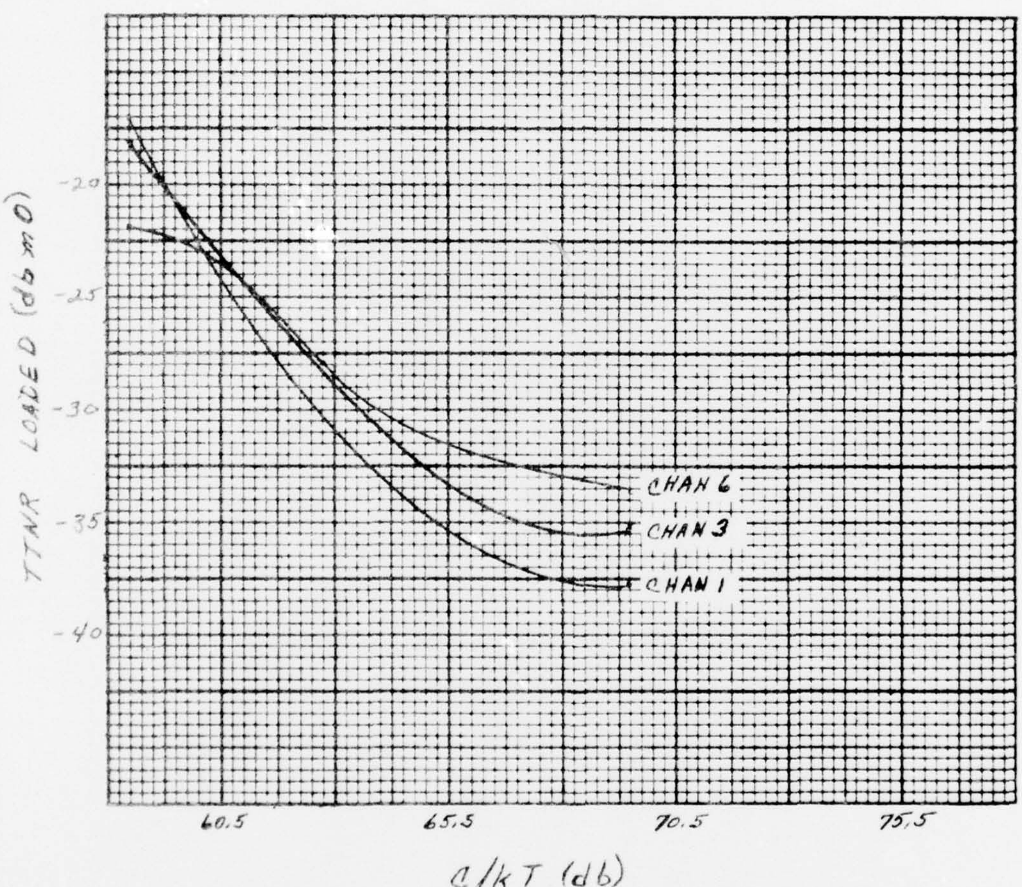
GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3)			PAGE NUMBER	NUMBER OF PAGES
DATA SHEET			1	1
			DATE (DAY, MONTH, YEAR) 19 Sep 76	
LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE	
5-0000	Site Y	Site X	Mary E. Johns, CW3	
TITLE OF PERFORMANCE PLOTTED				TEST NO.
LOADED TTNR VS C/kT (LOOPED AT OCV STT)				ST-34



USACC Form 396-R (Test)
1 April 1977

Sample satellite report. (continued)

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3) DATA SHEET			PAGE NUMBER 1	NUMBER OF PAGES 1
			DATE (DAY, MONTH, YEAR) 19 Sep 76	
LINK NO. 5-0000	STATION UNDER TEST Site Y	DISTANT STATION Site X	TEST ENGR SIGNATURE Mary E. Johns, CW3	
TITLE OF PERFORMANCE PLOTTED TTNR LOADED VS C/KT (LOOPED AT ANTENNA STT)				TEST NO. ST-34



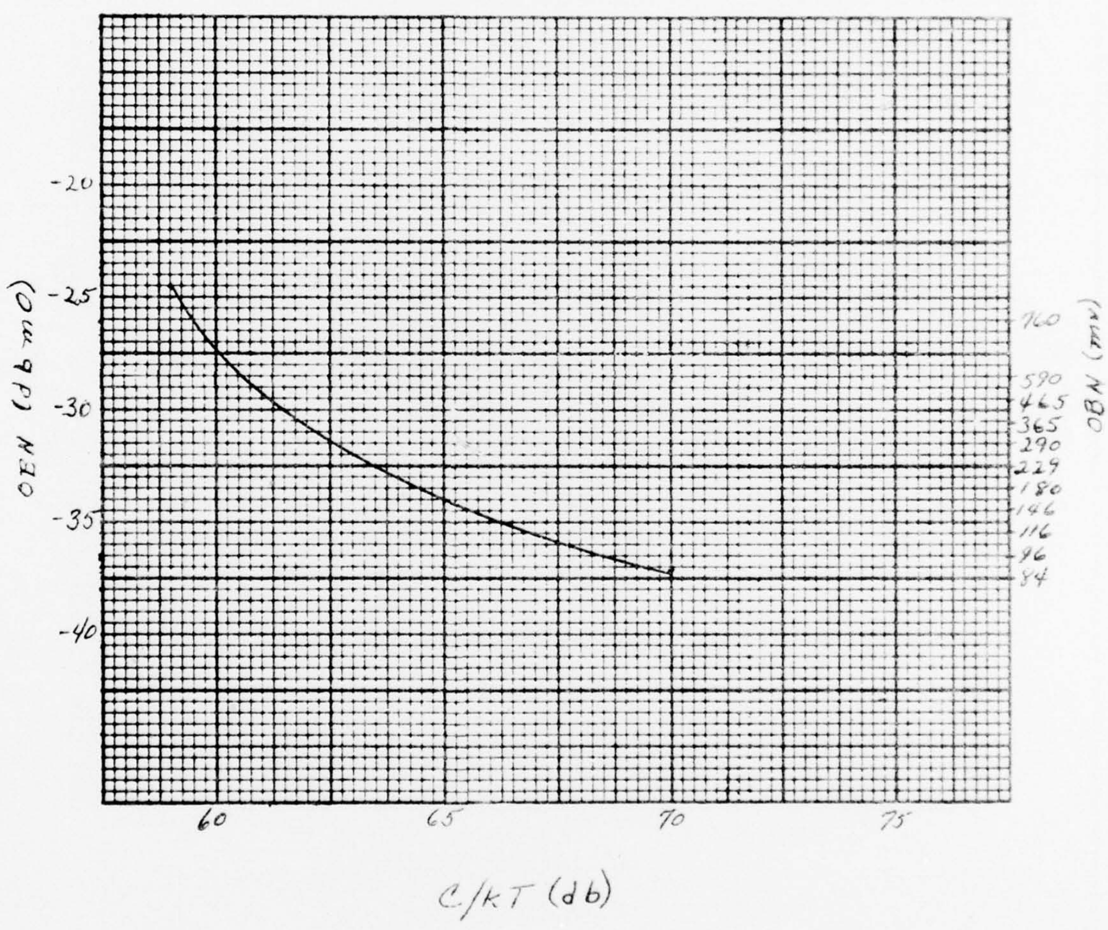
USACC Form 396-R (Test)
1 April 1977

Sample satellite report. (continued)

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3)	PAGE NUMBER	NUMBER OF PAGES
	1	1
DATA SHEET	DATE (DAY, MONTH, YEAR)	
	19 Sep 76	

LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE
S-cccc	Site Y	Site X	Mary E. Johns, CW3

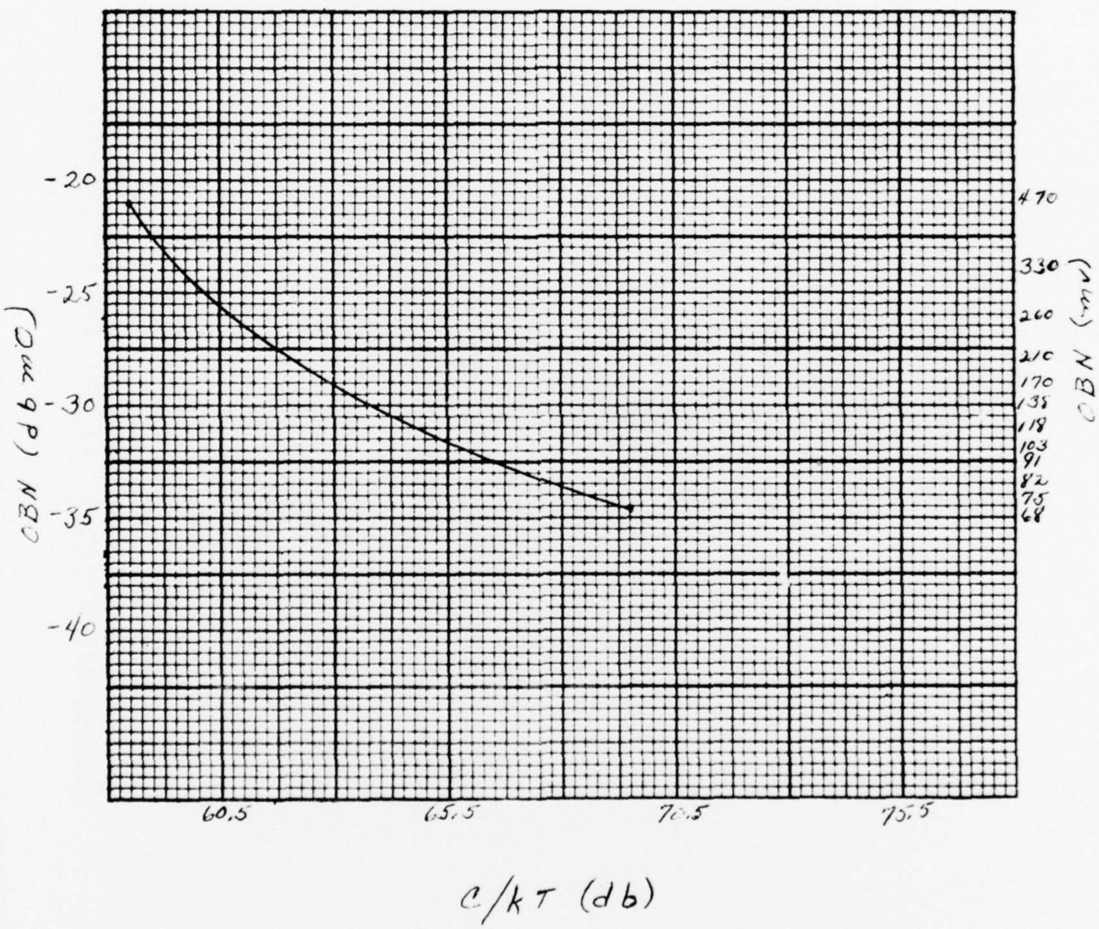
TITLE OF PERFORMANCE PLOTTED	TEST NO.
CBN VS C/kT (OCV STT LOOP)	ST-34



USACC Form 396-R (Test)
1 April 1977

Sample satellite report. (continued)

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3) DATA SHEET			PAGE NUMBER 1	NUMBER OF PAGES 1
			DATE (DAY, MONTH, YEAR) 19 Sep 76	
LINK NO. 5-0000	STATION UNDER TEST Site Y	DISTANT STATION Site X	TEST ENGR SIGNATURE Mary E. Johns, CW3	
TITLE OF PERFORMANCE PLOTTED OBN VS C/kT (LOOPED AT ANTENNA STT)			TEST NO. ST-34	

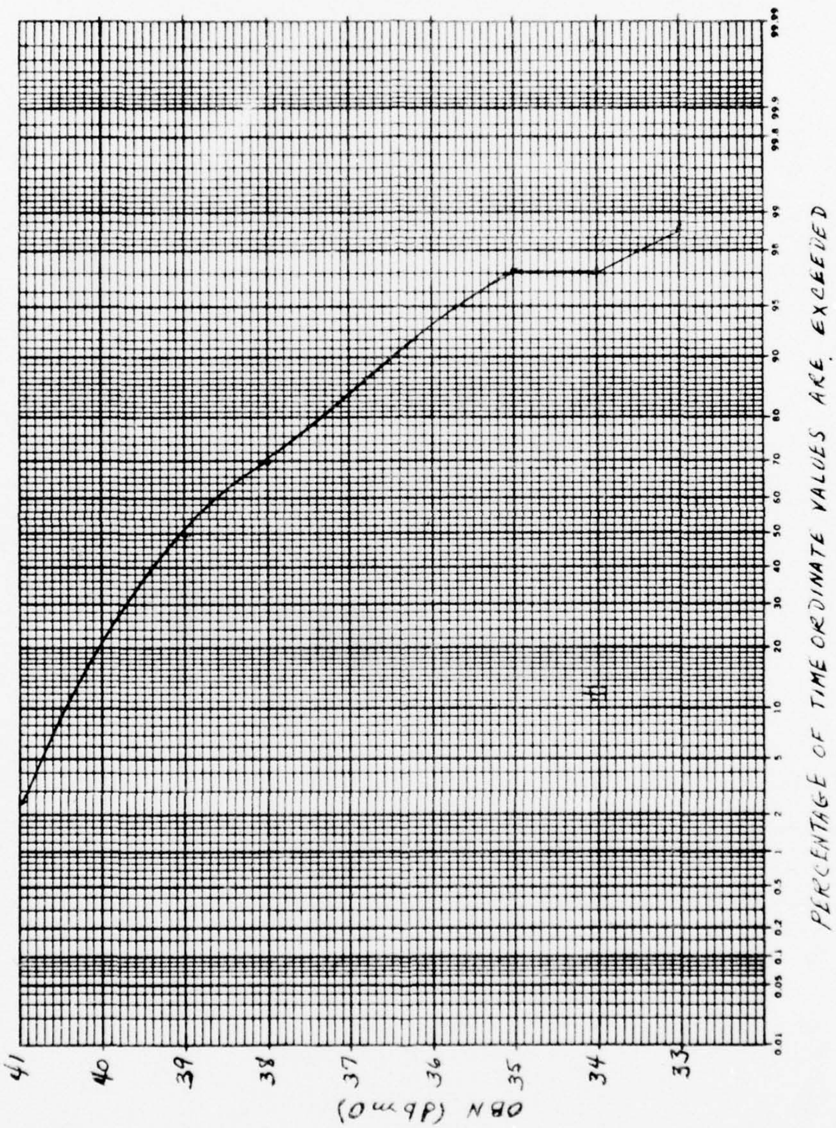


USACC Form 396-R (Test)
1 April 1977

Sample satellite report. (continued)

DISTRIBUTION PROBABILITY GRAPH (CCR 702-1-3) DATA SHEET			PAGE 1 OF 1 PAGES / DATE (DAY, MONTH, YEAR) 16 Sep 76
LINK NO. 5-0000	STATION UNDER TEST Site Y	RUN NUMBERS 76 FROM THRU	TEST ENGR SIGNATURE [illegible]

DISTRIBUTION MEDIAN OF CBN



USACC FORM 449-R (TEST)
1 MAY 77

Sample satellite report. (continued)

Table 1-1. Omitted and/or Incomplete Tests.
(CCR 702-1-3)

STATION	TEST DESCRIPTION	REMARKS
Site 1/	NPR vs Baseband Loading (ST-36)	Noise loading test set TMDE not available
	Satellite Phase Linearity	Vector voltmeter HP 8405A not available

USACC FORM 383-R (TEST)
1 Mar 77

Page 1 of 1 Page

Sample satellite report. (continued)

APPENDIX D. ABBREVIATIONS

AC	alternating current
adj	adjustable
AF	audio frequency
AGC	automatic gain control
ALC	automatic load control
ampl	amplifier
AMSF	area maintenance supply facility
AO	authorized outage
asgd	assigned
atten	attenuator
avg	average
AWG	American Wire Gage
AZ	azimuth
bal	balanced
BB	baseband
BER	bit error rate
BINR	basic intrinsic noise ratio
BITE	built-in test equipment
BN	bandwidth noise
BNR	basic noise ratio
brdg	bridged
B/S	bits per second
BW	bandwidth
BWR	bandwidth ratio
cal	calibrate
cap	capacity
CCIR	International Radio Consultive Committee
CCW	counterclockwise
C-E	communications-electronics
ch	channel
cir	circuit
C/N	carrier-to-noise
coax	coaxial
comm	communications
conv	converter
corr	corrected
CW	continuous wave
CPB	circuit equal level patch bay
DA	Department of the Army
DC	direct current
DCA	Defense Communications Agency
DCS	defense communications system
demod	demodulator
demux	demultiplexer
dev	deviation
diff	difference
dir	directional
dist	distribution
div	divider
DMS	delay measuring set

DNA	data not available
DS	direct support
DSCS	defense satellite communications system
dur	duration
EHF	extra high frequency
E_{irp}	effective isotropic radiated power
EL	elevation
engr	engineer
eq	equal, equation
equip	equipment
ERP	effective radiated power
ext	external
FDM	frequency division multiplex
FDMA	frequency division multiple access
FM	frequency modulated
freq	frequency
FSVM	frequency selective voltmeter
fwd	forward
GA	gage
gen	generator
gp	group
GS	general support
G/T	gain-to-noise
HF	high frequency
HI	high
HPA	high power amplifier
IAW	in accordance with
ICN	idle channel noise
ID	identification
IF	intermediate frequency
IFLA	interfacility link amplifier
IFLO	intermediate frequency local oscillator
IM	intermodulation
int	internal
IPA	intermediate power amplifier
ldg	loading
LF	low frequency
LNA	low noise amplifier
LO	local oscillator
LPA	low power amplifier
lvl	level
max	maximum
med	medium
MILDEP	military department
min	minimum, minutes
mod	modulator
MPB	multiplex patch bay
msg	message
mtr	meter
mux	multiplexer
NA	not applicable

NF	noise figure
NLR	noise loading ratio
norm	normal
NPR	noise power ratio
O&M	operations and maintenance
OBN	out-of-band noise
OCV	operations control van
op	operate, operated, operating, operational
osc	oscillator
PA	power amplifier
para-amp	parametric amplifier
PEP	Performance Evaluation Program
p/o	part of
pos	position
PPB	primary/cable patch bay
PSK	phase shift keying
pt	point
pwr	power
rcvr	receiver
rec	receive
ref	reference
rel	relative
ret	return
RF	radio frequency
RFLO	radio frequency local oscillator
rms	root mean square
rpmn	repairman
RSL	received signal level
rvse	reverse
SATCOM	satellite communications
SATEP	Satellite Technical Evaluation Program
SCCT	single-channel carrier tone
SCTT	single-channel test tone
S/E	signal-to-echo noise
sel	selective
SG	supergroup
SHF	super high frequency
sig	signal
S/N	signal-to-noise
SN	serial number
SNT	system noise temperature
SSN	station serial number
sta	station
STT	self-test translator
SW	switch
SWR	standing wave ratio
TDY	temporary duty
TED	technical evaluation detachment
TEP	Technical Evaluation Program
term	terminal
TLP	test level point

TMDE	test, measurement, and diagnostic equipment
TMS	transmission measuring set
TP	test point
TT	test tone
TTNR	test tone-to-noise
TWT	traveling wave tube
TWTA	traveling wave tube amplifier
UHF	ultra high frequency
unbal	unbalanced
uncorr	uncorrected
USACC	US Army Communications Command
VAC	volts alternating current
var	variable
V CH	voice channel
VCO	voltage controlled oscillator
VDC	volts direct current
vert	vertical
VF	voice frequency
VFCT	voice frequency carrier terminal
VFPB	voice frequency patch bay
VHF	very high frequency
VM	voltmeter
VSWR	voltage standing wave ratio
VTVM	vacuum tube voltmeter
WB	wideband
WG	waveguide
wo	without
WVDC	working voltage direct current
xfmr	transformer
xmit	transmit

(CC-OPS)

FOR THE COMMANDER:

OFFICIAL

A.A. Remling, II

A.A. REMLING, II
Major, AGC
Adjutant General

SAMUEL G. CONLEY, JR.
Colonel, GS
Acting Chief of Staff

DISTRIBUTION:

20 - CC-OPS-OX
5 - CC-PA-AMP
37 - CDR, 5th Signal Command, ATTN: CCE-OP-Q, APO New York 09056
36 - CDR, 6th Signal Command, ATTN: CCP-OP-O, APO San Francisco 96558
15 - CDR, 7th Signal Command, ATTN: CCN-PO-QA, Ft Ritchie, MD 21719
30 - CDR, US Army Communications-Electronics Engineering Installation Agency, ATTN: CCC-AD-RMO
5 - JCS (J-6), Washington, DC 20310
2 - CINCEUR, APO New York 09128
2 - CINCUSAREUR, APO New York 09403
2 - CINCPAC, FPO San Francisco 96610
2 - CINCLANT, Norfolk, VA 23501
2 - CINCSAC, Offutt AFB, NB 68113
2 - CINCRED, MacDill AFB, FL 33608
2 - COMNAVTELCOM, 4401 Massachusetts Ave NW, Washington, DC 20390
6 - Director, Defense Communications Agency, Washington, DC 20305
12 - Director, Defense Documentation Center, ATTN: R-210, Mr D.S. Selland, Cameron Station, Alexandria, VA 22314
4 - Director, Defense Communications Engineering Center, 1860 Wiehle Avenue, Reston, VA 22090
2 - DCA-PAC, APO San Francisco 96515
2 - DCA-EUR, APO New York 09128
5 - HQDA (DAMO-ZA), WASH DC 20310
2 - HQDA (DALO-ZA), WASH DC 20310
5 - CDR, US Army Forces Command, Ft McPherson, GA 30330
5 - CDR, US Army Training and Doctrine Command, Ft Monroe, VA 23651
5 - CDR, US Army Materiel Development and Readiness Command, 5001 Eisenhower Ave, Alexandria, VA 22304
3 - CDR, US Army Intelligence and Security Command, Arlington, VA 22212
2 - CDR, US Army Electronics Command, Ft Monmouth, NJ 07703
3 - CDR, US Army Satellite Communications Agency, Ft Monmouth, NJ 07703
2 - CDR, US Army Military District of Washington, Ft Lesley J. McNair, Washington, DC 20319
2 - CDR, US Army Support Command, APO San Francisco 96557
1 - CDR, USACC Agency White Sands, ATTN: SGT Hutchins, White Sands Missile Range, NM 88002

(Continued on next page)

DISTRIBUTION: (cont)

5 - COMDT, US Army Air Defense School, Ft Bliss, TX 79916
5 - COMDT, US Army Armor School, Ft Knox, KY 40121
5 - COMDT, US Army Aviation School, Ft Rucker, AL 36360
5 - COMDT, US Army Command and General Staff College, Ft Leavenworth, IS 66027
5 - COMDT, US Army Communications-Electronics School, Ft Monmouth, NJ 07703
5 - COMDT, US Army Field Artillery School, Ft Sill, OK 73503
5 - COMDT, US Army Infantry School, Ft Benning, GA 31905
5 - COMDT, US Army Missile and Munitions School, Redstone Arsenal, AL 35809
5 - COMDT, US Army Ordnance School Aberdeen Proving Ground, MD 21005
5 - COMDT, US Army Quartermaster School, Ft Lee, VA 23801
5 - COMDT, US Army Transportation School, Ft Eustis, VA 23604
2 - COMDT, US Military Academy, West Point, NJ 10996
28 - COMDT, US Army Signal School, ATTN: ATSN-DT-M, Ft Gordon, GA 30905
2 - CNO, Navy Department, Washington, DC 20350
2 - Superintendent, Naval Academy, Annapolis, MD 21402
2 - Third Mobile Communications Group, Tinker AFB, OK 73145
2 - HQ US Air Force, Washington, DC 20330
2 - CDR, USAF School of Applied Aerospace Sciences, ATTN: COL Cyr, Keesler AFB, MS 39534
2 - CDR, AFCS, Richards Gebaur AFB, MO 64030
2 - COMDT, USAF Academy, CO 80840

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS

For use of this form, see AR 310-1; the proponent agency is the US Army Adjutant General Center.

Use Part II *(reverse)* for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).

DATE

TO: *(Forward to proponent of publication or form) (Include ZIP Code)*

FROM: *(Activity and location) (Include ZIP Code)*

PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE

ITEM NO.	PAGE NO.	PARA-GRAPH	LINE NO.*	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON *(Exact wording of recommended change must be given)*

**Reference to line numbers within the paragraph or subparagraph.*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE

DA FORM 1 FEB 74 2028 REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED.

TO: *(Forward direct to addressee listed in publication)*	FROM: *(Activity and location) (Include ZIP Code)*	DATE

PART II - REPAIR PARTS AND SPECIAL TOOL LISTS AND SUPPLY CATALOGS/SUPPLY MANUALS

PUBLICATION NUMBER	DATE	TITLE

PAGE NO.	COLM NO.	LINE NO.	NATIONAL STOCK NUMBER	REFERENCE NO.	FIGURE NO.	ITEM NO.	TOTAL NO. OF MAJOR ITEMS SUPPORTED	RECOMMENDED ACTION

PART III - REMARKS *(Any general remarks or recommendations, or suggestions for improvement of publications and blank forms. Additional blank sheets may be used if more space is needed.)*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE

☆U. S. GPO:1976-0-665-697/154