AD-A048 963 WEATHER WING (3RD) OFFUTT AFB NEBR F/G 20/14

SHORT WAVE FADEOUT (SWF) EQUIPMENT AND OPERATIONAL PROCEDURES.(U)

JAN 77 K E EIS

UNCLASSIFIED 3WW-TN-78-1 NL

1 OF 1

ADA048963

END

DATE FILMED

2-78

DDC

3WW TN 78-1

Short Wave Fadeout (SWF) Equipment and Operational Procedures

Kenneth E. Eis, Captain, USAF

Det 2, 12th Weather Squadron
Sagamore Hill Solar Radio Observatory
Box 394, South Hamilton, Massachusetts 01982

3d Weather Wing
Offutt AFB, Nebraska 68113

15 January 1977

This report approved for public release. There is no objection to unlimited distribution of this report to the public at large, or by DDC to the National Technical Information Service (NTIS).

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

Kenneth E. German

KENNETH E. GERMAN, Colonel, USAF
Chief, Aerospace Sciences Division

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER (14) 3WW-TN-78-1	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) SHORT WAVE FADEOUT (SWF) EQUIPMENT AND OPERATIONAL PROCEDURES		5. TYPE OF REPORT & PERIOD COVERED (9) Technical note
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) Kenneth E/ Eis		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Det 2, 12th Weather Squadron Sagamore Hill Solar Radio Observatory Box 394, South Hamilton, Massachusetts 01982		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS 3rd Weather Wing, Aerospace Sciences Division Offutt AFB, Nebraska 68113		12. REPORT DATE (11) 15 Jan 77
		13. NUMBER OF PAGES (12) 20p.
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (Same as item 9)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

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

N/A

18. SUPPLEMENTARY NOTES

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

Ionosphere
Short Wave Receiver
Short Wave Fade
Short Wave Fadeout
Integrator
Antenna
Receiver Sensitivity
Scintillation

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

This Technical Note explains the new AWS short wave fadeout (SWF) instrumentation, its installation, calibration and use. Details of SWF observation are discussed. This paper can be used by local equipment technicians as a Technical Order (T.O.) on the SWF equipment until a formal T.O. exists.

372550 B

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

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

PREFACE

This Technical Note was prepared and distributed at the request of Hq AWS/DOS. The enclosed instructions for installing, calibrating and using AWS short wave fadeout equipment should be used until an appropriate AWS directive is published. Suggestions for improvements of this guidance should be forwarded through channels.

Two points that could cause confusion are:

1. There are three conventions used for the spelling of microamp meter, microammeter, and microam meter. For this Technical Note "microamp meter" will be used.

2. The symbol Kc (kilocycles) was used in lieu of the new convention, KHz (kiloHertz), because the equipment panel markings use the Kc convention.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SHORT WAVE FADEOUT (SWF) EQUIPMENT

AND OPERATIONAL PROCEDURES

CHAPTER 1 - INTRODUCTION

This Technical Note is intended as an introduction to the new instrumentation designed by Det 2, 12WS to monitor short wave fadeouts (SWF). SWFs occur in the earth's ionosphere as a result of increases in ionizing radiation from the Sun during solar active periods. AWSR 105-33 mandates the requirements for SWF observation but it is beyond the scope of that regulation to define calibration procedures, operational details or equipment configuration. The author suggests that operators read chapters 2 and 6 as well as section B of chapter 5. Maintenance technicians should use chapters 3, 4, and 5 as a Tech Order (T.O.) until a T.O. exists for this equipment. The procedural and equipment changes which prompted this technical note represent a considerable improvement in SWF observational technique.

CHAPTER 2 - SWF OBSERVATIONAL REQUIREMENTS

1. The observational requirements for the SWF system are:

a. A short wave broadcasting station in a sunward direction (East in the morning, equatorward at noon and West in the afternoon).

b. A transmitter to receiver distance of at least 1000 km, but not exceeding 2000 km.

c. A monitor frequency between 5 and 25 MHz.

d. A received signal of sufficient strength to be well above the threshold sensitivity of the R-390 radio receiver.

2. Although these requirements are straightforward, they are difficult to meet. Certain monitoring locations can't find broadcasting stations at the proper frequency and/or location to meet these requirements. For instance, during the morning hours, Sagamore Hill Observatory, being on the east coast of the U.S., must monitor stations in Europe that are farther away than would be recommended. There are virtually no stations broadcasting in the Atlantic Ocean at the right frequencies and time of day. The biggest problem associated with SWF monitoring is insufficient signal strength. Because of the distance and frequencies involved, many monitoring stations are forced to use signals only slightly stronger than the R-390 sensitivity threshold. This problem will be partially alleviated by the new equipment and procedures outlined below.

3. AFGWCP 105-1, Vol IV, para 2-14(1) further states that SWFs in excess of 20 dB must be detectable. This means that the monitored signal's pre-fadeout level must always be 20 dB greater than the R-390's sensitivity threshold. If the SWF detector is unable to monitor a 20 dB dynamic range in SWF values, it will miss the most significant events. The equipment and procedures outlined in this technical note will assure that this 20 dB dynamic range requirement is met.

CHAPTER 3 - EQUIPMENT

The equipment used to monitor SWFs are: antenna, attenuator pads, R-390 receiver, integrator, and recorder (See Figure 1).

A. Antenna. Several types of antenna are now being used by the AWS for SWF operations.

1. The horizontal dipole is the most widely used antenna. This type of antenna is also the poorest for SWF monitoring. The horizontal dipole acts as a highly tuned circuit, and as such, is constructed for only one optimum frequency. Therefore, this type of antenna may be very good at 15.4 MHz but very poor at 15.6 or 15.2 MHz. Additionally, horizontal dipoles are directional. A station monitoring in three directions during the day would need at least two, and probably three antennas for good reception. This type of antenna also requires a considerable area to set up since each antenna is 15 to 30 meters long. Only stations that monitor one frequency and one direction should use this type of antenna system.

2. The vertical whip antenna with ground plane offers a substantial improvement over the horizontal dipole. This type of antenna was original equipment with the R-390 receiver. It is also the type of antenna CB'ers are most familiar with, since the vertical whip is used in ground mobile applications. This antenna is omnidirectional and is less frequency sensitive.

3. The eight element vertical conic antenna is currently the best available antenna design for the SWF system. This antenna is omnidirectional, offers wide band performance and a better standing wave ratio than either of the other antennas described. AWS can furnish detailed construction notes on this antenna system.

B. Attenuator Pads. Precision stepped attenuators, in-line between the antenna and R-390, are an absolute requirement for a properly calibrated SWF system. Previous SWF monitoring procedures called for adjusting the Radio Frequency (RF) gain knob to compensate for large signal intensity fluctuations. However, changing the RF gain, changes the characteristics of the receiver from the calibrated setting; thus decalibrating the SWF system. The RF gain knob on the R-390 should be at maximum and never touched again.

C. Receivers. The R-390 receiver is the one unchanged item in the SWF system. However, the mode in which it is operated should be modified if your station is having a hard time acquiring a signal of sufficient strength. Two alternative R-390 hookups are presented.

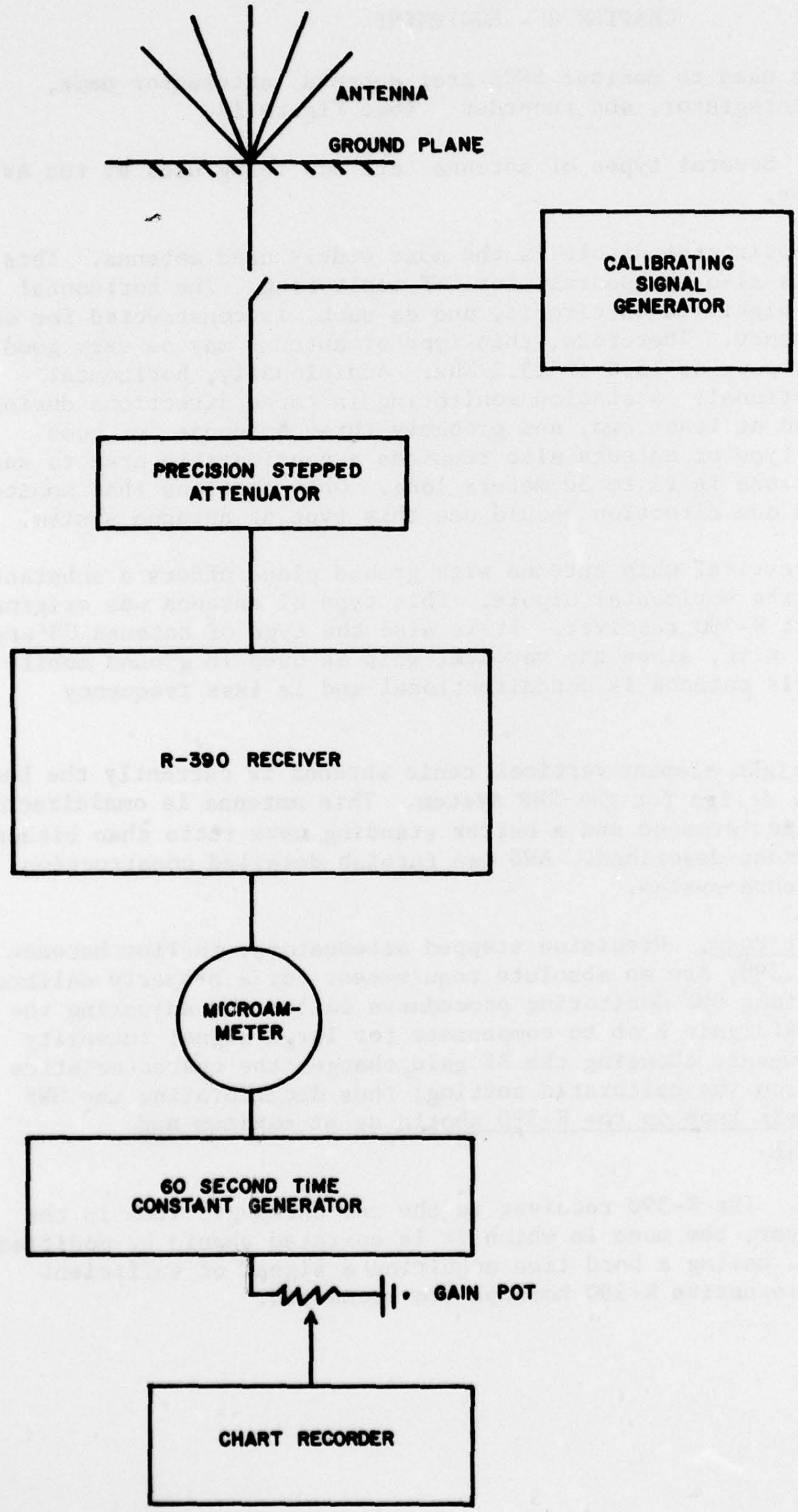


FIG. 1 Schematic, Block Diagram of SWF System

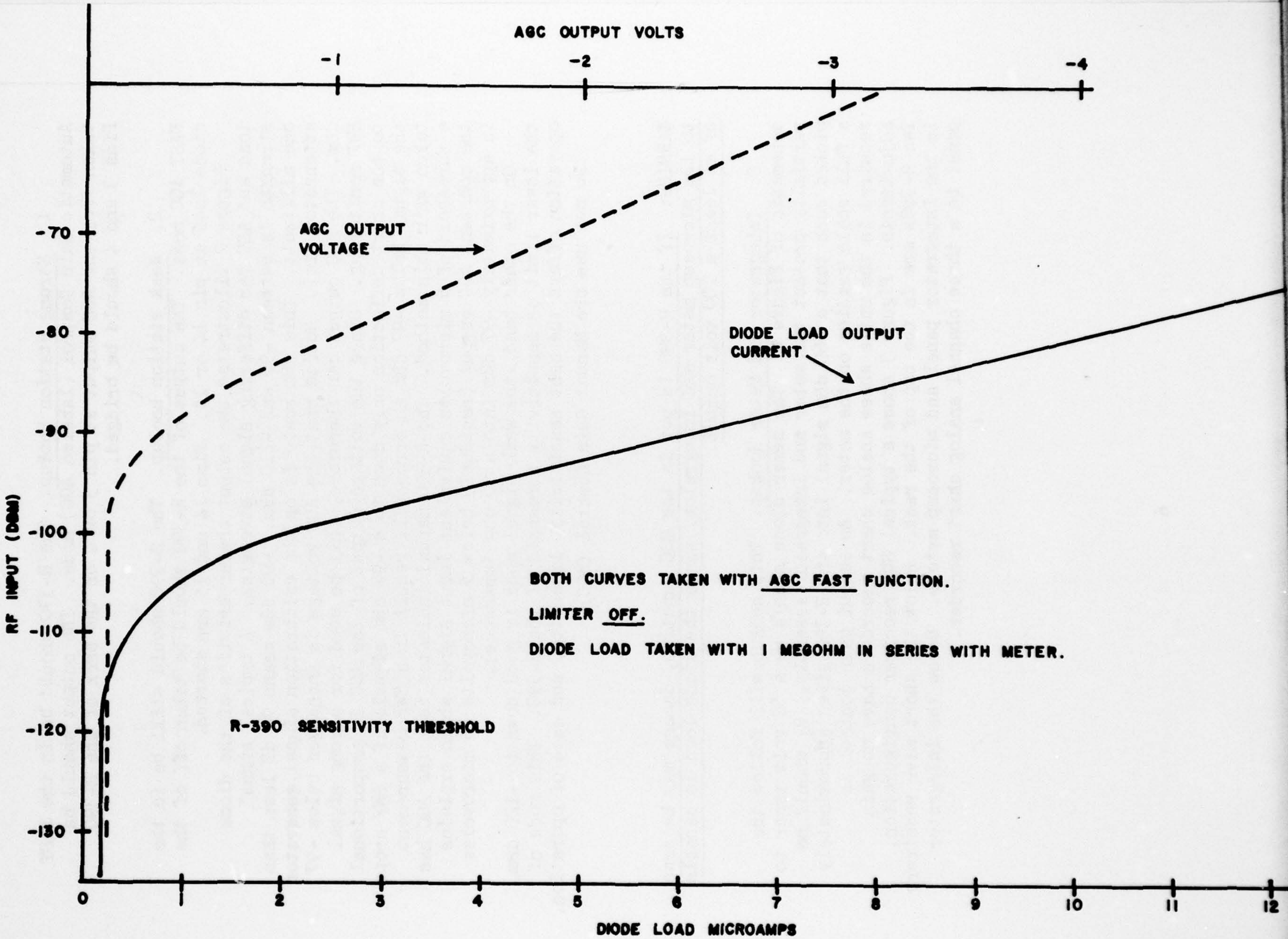


FIG. 2 R-390 Receiver Sensitivity Characteristic

1. Strong station hookup. The R-390 should be in the FAST Automatic Gain Control (labeled AGC) mode. The output should be taken from the AGC output at pin 3 or 4 on the back of the R-390. Pins 3 and 4 should be bridged.

2. Weak station hookup. The R-390 should still be in the FAST AGC mode. The output of the R-390 should be taken off of the diode load at pin 14 or 15. Pins 14 and 15 are shorted.

Figure 2 illustrates the output characteristics of the diode load and AGC for differing signal strengths. A typical signal strength is between -90 and -110 dBm. -90 dBm means 90 dB less than one milliwatt. This dBm scale is on the calibration signal generator attenuator dial. Notice that the AGC voltage is unchanged below -97 dBm. The AGC output can therefore, only be used for strong signal SWF monitoring. Since the voltage output of the AGC is proportional to the chart deflection only down to a -97 dBm signal; if a SWF drops the signal below -97 dBm an error will result in a SWF measurement taken with this method. The R-390 manual indicates that the AGC has a threshold of 5 microvolts equivalent input signal which explains the constant AGC output (residual) below 5 microvolts (5 microvolts is approximately -97 dBm into a 50 ohm impedance).

On the other hand, the weak signal mode is good down to -120 dBm, the lower limit or sensitivity threshold of the R-390. This mode of operation offers the best sensitivity, linearity, and ease of operation.

Do not use the Manual Gain Control (MGC).

WARNING: If the R-390 is put in the MGC function, damage may be done to the microamp meter and integrator, since the diode load is capable of at least a 100 volt output.

D. Integrator and Meter Hookup. This hookup will follow the schematic of Figure 4. The zener diode should be a 50 volt zener to partially protect the meter and integrator assembly. R_1 should be picked such that a -60 dBm signal into the R-390 gives approximately a full scale reading on the meter. An output gain control is required in the units whose analog chart recorders have no gain adjustments. Figure 3 shows a typical SWF receiver configuration. Two R-390s are in the top of the rack. Below the short wave receivers is the integrator panel and microamp meters. Below the integrator panel is a three channel analog chart recorder.

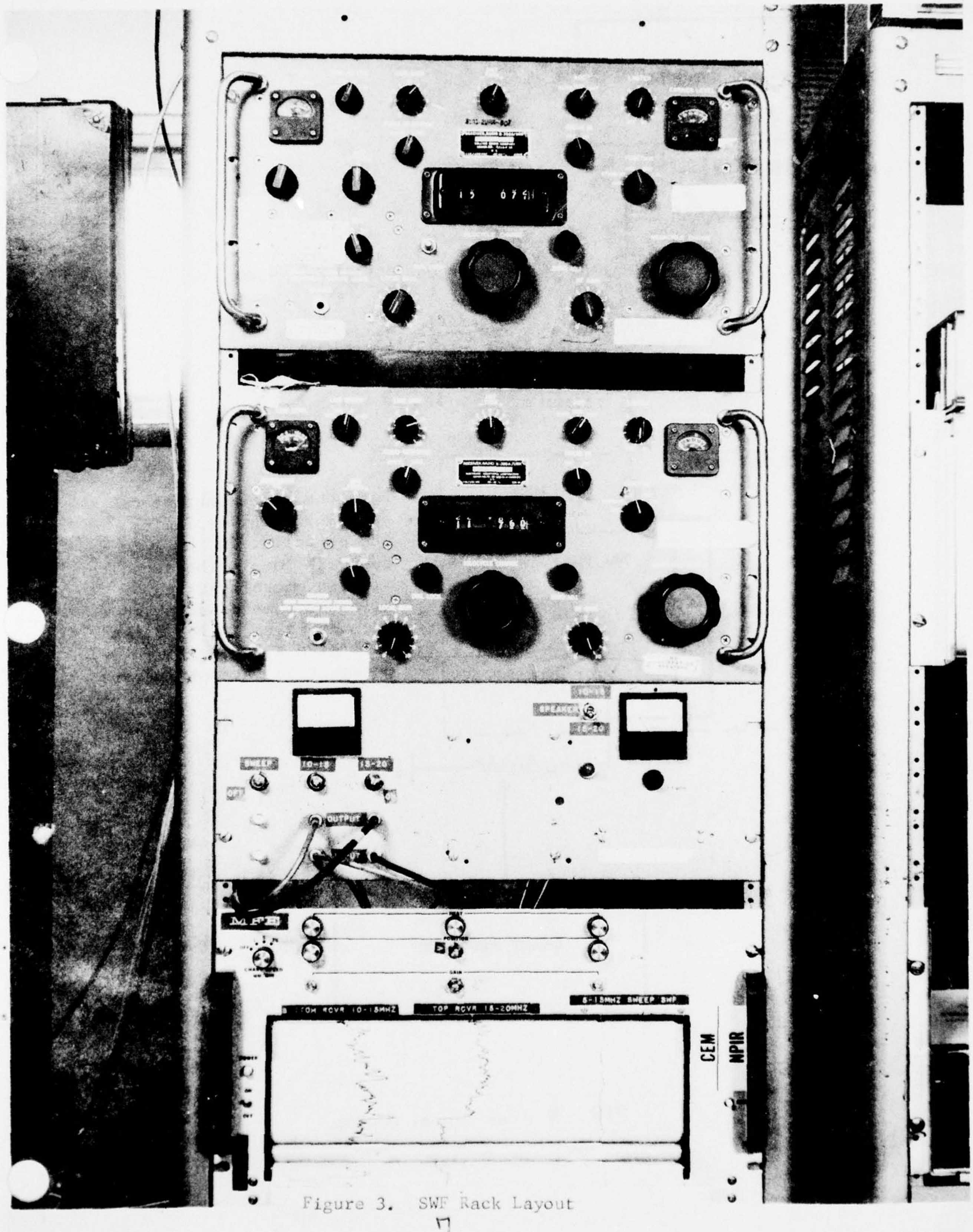
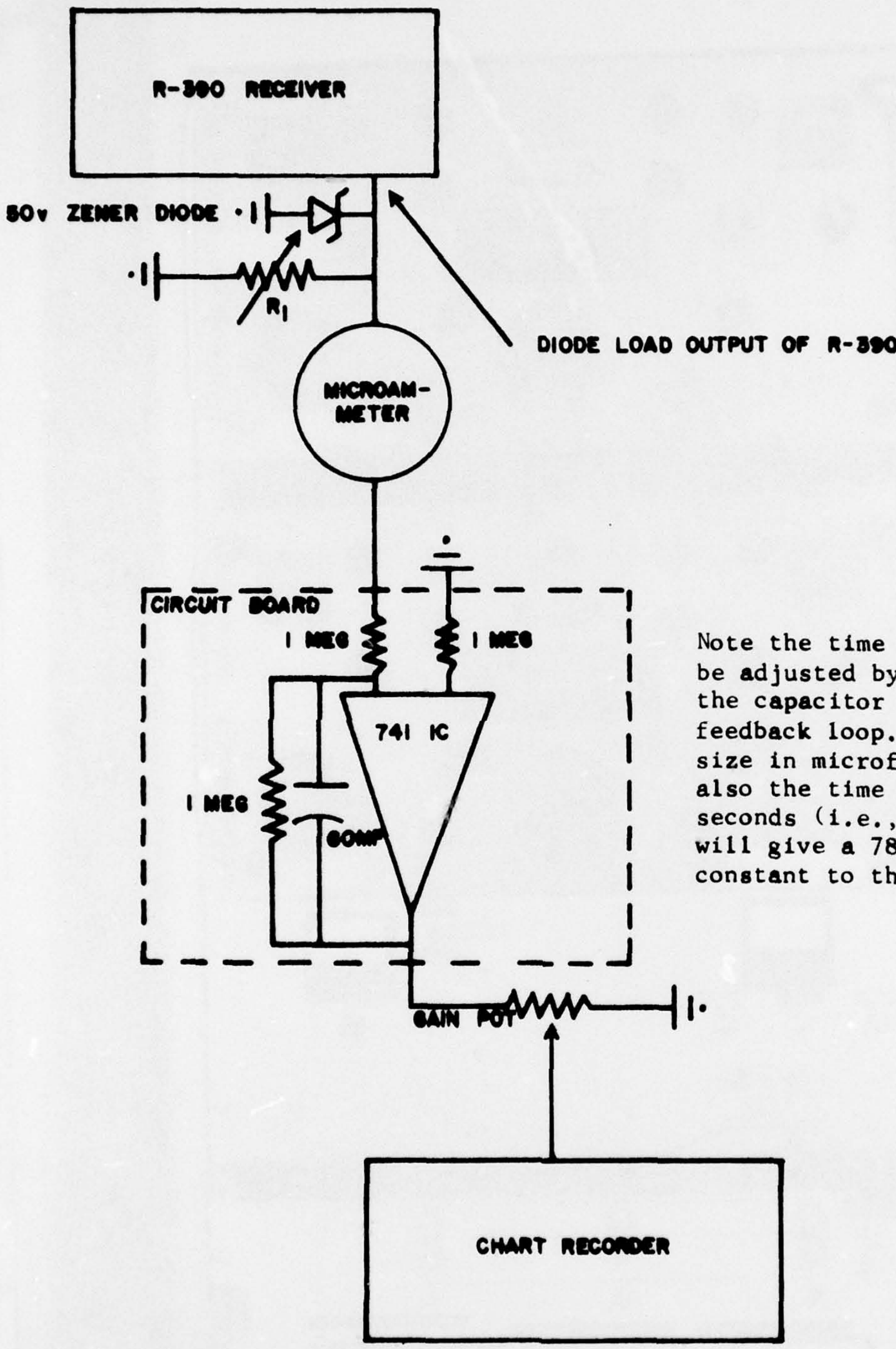


Figure 3. SWF Rack Layout



Note the time constant can be adjusted by replacing the capacitor in the IC's feedback loop. The capacitor size in microfarads is also the time constant in seconds (i.e., a 78 mf cap will give a 78 sec time constant to the integrator).

FIG. 4 Weak Signal Hookup

CHAPTER 4 - INITIAL SETUP

Maintenance should check that the wiring follows the schematic of Figures 1 and 4. The R-390's AGC voltage is negative and the integrator is an inverting amplifier, so the chart recorder will be responding to a positive voltage signal. Prior to the initial adjustments, the equipment (including the signal generator) should be allowed to warm up at least two hours.

A. Verify that the R-390 settings are:

1. Function switch to AGC.

2. AGC switch to FAST.

3. Limiter in off position.

B. Inject a -60 dBm signal from the signal generator (SG) and trim R_1 for a full scale deflection on the microamp meter.

C. Construct a curve similar to the example in Figure 2. This will familiarize maintenance and operations technicians with the characteristics of the R-390 receiver being tested.

1. Connect a voltmeter to the AGC output.

2. Inject a -130 dBm signal with the SG and read the voltmeter and microamp meter indications.

3. Increase the SG signal in 2 or 3 dB steps annotating the diode load current, from the microamp meter, and the AGC voltage from the voltmeter, on the chart.

4. Plot these values on linear graph paper. If the R-390 doesn't give some deflection on the microamp meter between the -130 dBm and -120 dBm input levels, the R-390 doesn't have sufficient sensitivity to be used in the SWF monitoring system. (The offending R-390 should be replaced or repaired.)

D. The chart recorder gain and position should be set so that full scale deflection occurs at -70 dBm and zero deflection occurs at -130 dBm.

E. Input a -100 dBm signal and allow the chart to record the output for twenty to thirty minutes. A straight line trace will verify the stability of the R-390. If the output varies more than 2% of the graph over this period, check the R-390 and the signal generator output for stability. If these are stable and the frequency hasn't drifted, the R-390 is unstable and should again be checked by maintenance.

CHAPTER 5 - CALIBRATION

Calibration or a calibration verification should be performed monthly or whenever a R-390, integrator or chart recorder is repaired or adjusted.

A. Calibration Procedure.

1. Let the signal generator (SG) warm up for at least two hours. (The R-390 should never be turned off other than for maintenance).

2. Set the SG for 30% modulation at 400 Hz.

3. Set frequency of the SG to the frequency most used by the R-390. Example - At Sagamore Hill, one R-390 is used in the 15 - 20 MHz band; WWV Boulder Colorado at 15.0 MHz, Greenville, N.C. at 15.43 MHz, and BBC London at 15.07 MHz, are the most frequently monitored stations in the band. Therefore, 15.2 MHz would be a good calibration frequency.

4. Set the power output level on the SG to the "set level" as indicated by the output meter on the SG.

5. Set the SG for -90 dBm output with the SG's attenuator.

6. Assure no attenuation is switched in with the precision stepped attenuator (PSA).

7. Set the R-390 to .1 KHz bandwidth.

8. Tune the R-390 for maximum deflection on the microamp meter.

9. Set R-390 bandwidth to 2 KHz. Calibration is performed at 2 KHz bandwidth to insure that relative frequency drift between the SG and the R-390 doesn't detune the system during calibration. Proper tuning should be verified several times during calibration. If the R-390 is found to be detuned, the procedure must be started over.

10. Dial in -70 dBm on SG and -130 dBm using precision stepped attenuator (PSA) alternately (perform step 11 simultaneously).

11. Set the gain pot and zero adjust on the recorder so -130 dBm gives zero deflection (not pegged) and -70 dBm gives full scale deflection (not pegged).

12. Set SG to -70 dBm and allow trace to stabilize. Record microamp meter value. Since the integrator has a 60 second time constant, 5 minutes will be needed for complete stabilization each time the RF input level is changed.

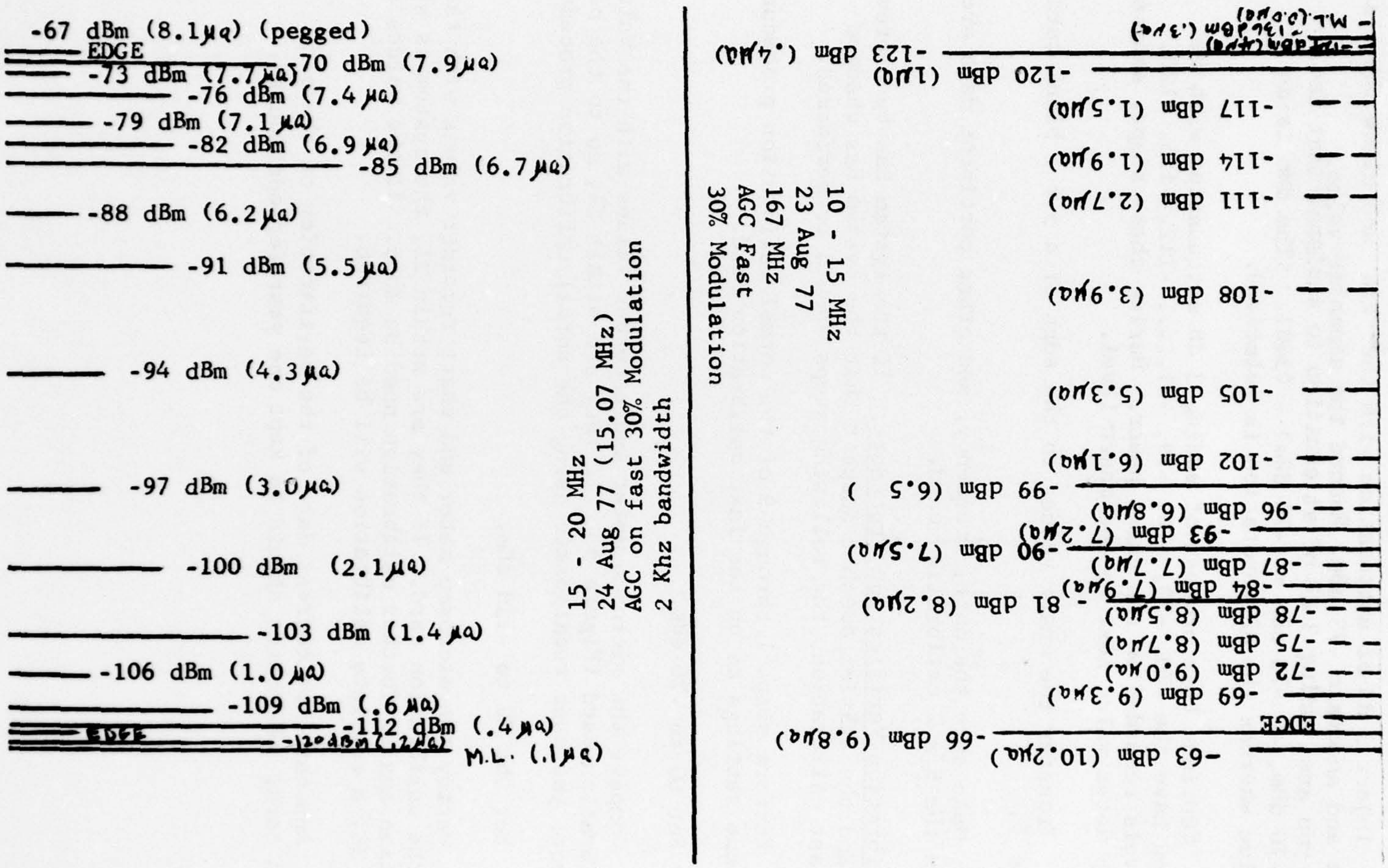


Figure 5. Calibration Card

13. Inject 3 dB of attenuation with the PSA and allow the trace to stabilize and annotate -73 dBm. Record the ampmeter value. Notice that you are adding 3 dB of attenuation to a signal that is already at -70 dBm, so -73 dBm = (-70 dBm) - (3dB). (The dBm is an absolute value whereas the dB annotation is relative).

14. Continue this process of adding 3 dB attenuation with the PSA until you have the -70, -73, -76, -79, -81...., -112, -115, -120, -130 dBm levels recorded on the chart paper. During these steps, annotate the microamp meter value next to the chart level.

15. Transfer the chart values to the edge of a 5 x 7 blank card as in Figure 5.

16. Make sure the date, frequency, and other pertinent data are annotated on the 5 x 7 calibration card.

B. Calibration Verification Procedure. If the system has been previously calibrated and the station doesn't suspect that the system has changed since the last calibration, the following steps should be performed.

1. Perform steps 1 through 9 of the normal calibration procedure using the same settings as on the last calibration card.

2. Set SG to -70 dBm.

3. Compare the microamp meter and recorder values with the values on the calibration card (Figure 5). If they are within 2%, go to the next step. If not, you must recalibrate using the normal calibration procedure.

4. Set the SG to -130 dBm.

5. Verify the microamp meter and chart recorder values with the values on the calibration card. If they are within 2%, the system is still in calibration and no further calibration need be done. If the values are not within 2%, a complete calibration will be required.

6. Annotate the current date of the verification on the old calibration card. Old cards should be kept one year for continuity.

CHAPTER 6 - OPERATION

A system calibrated according to this technical note will require very little adjustment and will be able to detect SWFs of 1-3 dB depending on the stability of the ionosphere before the SWF occurred. No better sensitivity is possible without a more sensitive receiver. Increasing the gain of the system can be accomplished by using -80dBm or even -90dBm for full scale deflection on the chart instead of -70dBm, but this doesn't render the system more sensitive to SWF detection because of normal ionospheric scintillation which is typically 6 dB at 18 MHz and 3 dB at 11 MHz. This means a 6 dB SWF at 18 MHz is often obscured in 6 dB of noise, making accurate readings very difficult. Furthermore, increasing the chart gain forces the observer to repeatedly adjust the signal by adding or subtracting attenuation with the PSA to stop the signal from either pegging the chart or operating at too low a level on the chart to be able to accommodate a 20 dB fadeout.

A. The R-390 settings should be as follows:

1. Bandwidth 1 KC (2 KC if only very weak signals are available).

2. Antenna Trim - tuned to maximum signal for each frequency selected.

3. AGC to FAST.

4. Limiter Off.

5. Function AGC.

6. RF Gain to maximum.

All other R-390 settings are optional.

B. Tuning. *Tuning in a station should never be accomplished by tuning for the loudest or clearest audio signal.* The microamp meter which indicates the diode load current is the best indicator of proper tuning. The carrier level meter and the Beat Frequency Oscillator (BFO) audio null are less attractive tuning alternatives. The BFO is good only when it is calibrated and since the BFO oscillator can drift, calibration is only temporary. Furthermore, the most accurate tuning is achieved with the narrowest bandwidth permitted by the signal being tuned.

C. Strong Signal Procedures. When a strong signal is available, the bandwidth should be at the 1 KC position and the PSA adjusted until the microamp meter registers an average value at or below the -70 dB full chart scale value on the calibrated card. Frequent changes of attenuation with the PSA should be minimized because if a SWF occurs during the 5 minute recovery period imposed by the 60 second time constant of the integrator after the PSA has been switched, the SWF value will be inaccurately measured.

D. SWF Reduction Procedures. When a SWF occurs, the calibration card for the right frequency is placed on top of the chart record and aligned with the edge of the chart. The pre-SWF level is read off of the card as well as the SWF value in dBs. The difference in dBs between the two values is the SWF intensity. If the SWF occurs on multiple channels with correlation on 8800 MHz, satellite X-rays or a flare, the SWF is definite. On the other hand, if the SWF occurs only on a single recorder with no other correlated activity, the fadeout could be caused by the monitored station or R-390 detuning. If the signal falls rapidly to the -130 dBm level, the reason is usually the station going off the air. This is common and broadcast hours can be found in the World Radio TV Handbook. Each SWF monitoring station must have a copy of this publication to aid in station selection. These may be obtained from USAFETAC/CBT through your parent organization.

The chart record should be annotated with the frequency monitored, station identifier and the WMO number of the station. The WMO number should be verified with AFGWC whenever a new station is monitored, even if the WMO number is listed unambiguously. Otherwise, that WMO number may not be loaded in the AFGWC computer.

CHAPTER 7 - CONCLUDING REMARKS

The new equipment configuration and procedures developed by AWS should greatly improve SWF observations. This new procedure offers the best tradeoff between system sensitivity and dynamic range under the existing AWS requirements. In the future, sensitivity improvement will be possible with the replacement of the R-390 with a state-of-the-art HF receiver. Dynamic range improvements will only be possible with dual antenna systems which are too complex and physically large to be feasible.

CHAPTER 8 - REFERENCES

(1) Army Technical Manual 11-5820-358-10, "Radio Receiver R-390A/UAR", 16 Jan 61, Hq Department of the Army, Washington 25, D.C.

(2) Army Technical Manual 11-5820-358-35, "Radio Receiver R-390A/UAR", 8 Dec 61, Hq Department of the Army, Washington 25, D.C.