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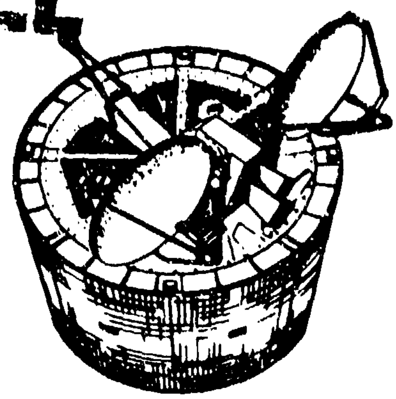

DSCS II

SATELLITE 9444

TELEMETRY TRANSMITTER ANOMALY REPORT

AUGUST 1980

Prepared for

DEPARTMENT OF THE AIR FORCE HEADQUARTERS
SPACE DIVISION (AFSC)

CDRL Sequence Number 009A2
Contract F04701-80-C-0022
Report No. 36060-AR-022-01

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TRW
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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER SD-TR-80-69	2. GOVT ACCESSION NO. AD-A093024	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Satellite 9444 Telemetry Transmitter Anomaly Report		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER 36060-AR-022-01
7. AUTHOR(s) G. E. Neuner		8. CONTRACT OR GRANT NUMBER(s) F04701-80-C-0022
9. PERFORMING ORGANIZATION NAME AND ADDRESS TRW Defense and Space Systems Group One Space Park Redondo Beach, California		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Department of the Air Force Headquarters Space Division (AFSC). Post Office Box 92960 Worldway Postal Center, Los Angeles, CA 90009		12. REPORT DATE August 1980
		13. NUMBER OF PAGES 97
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)

Approved for public release; distribution unlimited.

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

DTIC ELECTE DEC 17 1980 S D F

18. SUPPLEMENTARY NOTES

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

Spacecraft , Satellite
Transmitter
Anomaly Investigation

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

On January 21, 1980, telemetry transmitter #1 on DSCS II Satellite 9444 abruptly failed after two months in orbit. The redundant transmitter was commanded on and normal operation continued. An orbital anomaly investigation team evaluated possible causes, reviewed component manufacturing and test histories and compared the failure with similar previous failures. After an exhaustive analysis and investigation, no definitive cause of failure could be identified.

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DSCS II

SATELLITE 9444

TELEMETRY TRANSMITTER

ANOMALY REPORT

TRW-Report No. 36060-AR-022-01

August 1980

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1. SUMMARY AND CONCLUSIONS

On January 21, 1980, at 10:00 p.m. local time during a routine pass, the downlink telemetry carrier for Flight 14 (Satellite 9444) could not be located. The downlink was commanded off and on with no response. Command to coherent operation also produced no response. It was assumed that transmitter No. 1 (or its power converter), which was operating normally 20.5 hours earlier, had failed. At 11:00 p.m. local time, January 21, (the next pass), the redundant transmitter was commanded on and is now operating normally.

The satellite was launched November 21, 1979, and was in transit toward 5°W longitude (East Atlantic Ocean). No unusual telemetry, tracking and command subsystem conditions or other satellite anomalies were noted during the two months of orbital operation.

An orbital anomaly investigation team was formed to:

- Determine possible failure causes
- Investigate unit and part test histories
- Examine telemetry and test correlations which might give clues to the cause of failure
- Compare with similar failures on Flight 4 and the Defense Space Program (DSP).

After an exhaustive analysis and investigation, no definitive cause of failure could be found. Transmitter ground test history and orbital performance were normal prior to the failure. Possibly a random electronic part failure, such as an open or short in a diode or transistor, caused the failure; however, there is no evidence for suspecting any particular part. Other possibilities include an open circuit in a connector, wiring or printed circuit board trace, but it is unlikely these would have escaped detection during ground testing. No valid reason to suspect any specific failure mode is evident from the information available.

2. BACKGROUND

2.1 TELEMETRY, TRACKING AND COMMAND SUBSYSTEM

The telemetry, tracking and command (TT&C) subsystem performs the primary functions of radiating an RF carrier required for angle tracking and range and range rate determination of the satellite telemetry of measurements required for mission operations, and command of the various satellite subsystem modes of operation. Other functions include telemetry of measurements of subsystem parameters for engineering evaluation of satellite performance, telemetry of data which is useful in diagnosis of failure and/or data which simplifies satellite control facility (SCF) record keeping. A block diagram of the TT&C subsystem is shown in Figure 2-1.

2.2 TELEMETRY SUBSYSTEM

The downlink transmission path through the TT&C subsystem begins with the individual sensing element which is connected to the pulse code modulation (PCM) encoder and/or multiplexer. The encoder accepts all telemetry data (analog, bi-level and digital) from the spinning section, whereas the multiplexer (located on the despun platform) receives all data from the despun platform. The serial data stream from the multiplexer is routed through the slip ring assembly to the PCM encoder. The encoder and multiplexer operate in synchronism to encode and format all inputs into one PCM bit stream. Normally, the resulting digital data output at 250 bits per second is routed to the encrypter for encryption. An encrypter bypass is provided, upon command, which will route the data directly from the encoder to the baseband assembly. The PCM data stream fed to the baseband assembly, either from the encrypter or encoder, is phase modulated on a 1.024 MHz subcarrier and combined with a ranging code into a composite output signal. This composite telemetry signal is then routed to the transmitter where it modulates the phase of the RF carrier. A spacecraft component layout, showing the location of the telemetry transmitter is shown in Figure 2-2.

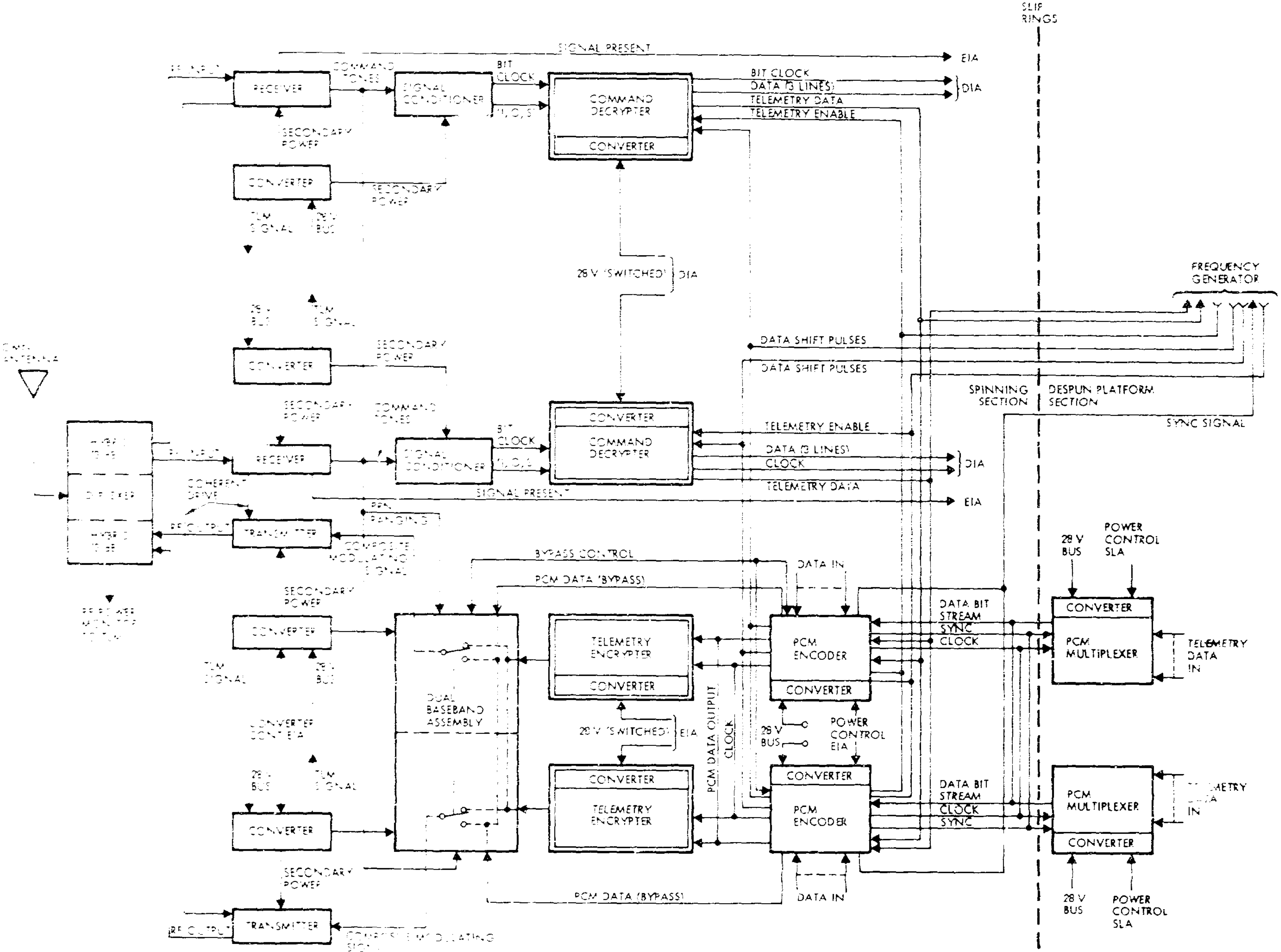


Figure 2-1. TT&C Subsystem Block Diagram

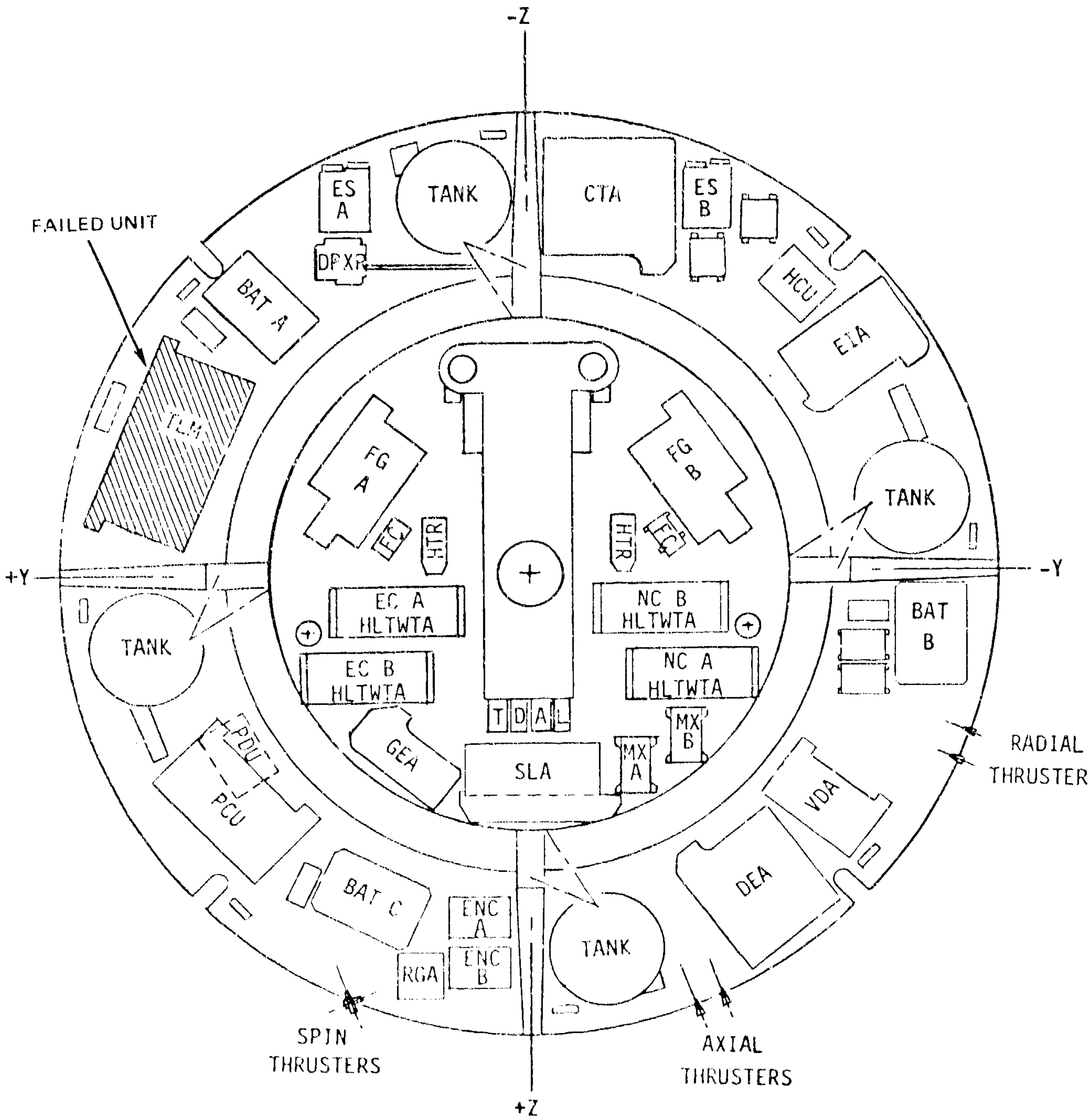


Figure 2-2. Spacecraft Component Layout

2.3 TRANSMITTER INTEGRATION AND TEST (I&T) HISTORY

At the time of failure, the satellite was operating with telemetry transmitter No. 1 (the A side of the redundant transmitter assembly); part number 256164-3, serial number 3-25. This unit was originally integrated onto satellite F-11 and was on board through the entire environmental test series including the post thermal-vac integrated systems test (IST). At this point, it was noted that the output power and mod index had degraded, both in the thermal-vac chamber during Phase 1 testing and during the subsequent IST, at which time the transmitter was removed and returned to manufacturing. other TT&C related units were changed at this time and no further out-of-spec conditions were experienced on the F-11 satellite.

The unit was reworked by manufacturing to incorporate stability modifications (ECP 106) and retuned. It was then integrated into satellite F-14 after being subjected to the following reacceptance testing:

a) Vibration - 3 axes, one minute per axis, to acceptance limits per EV-2-23C

b) Post vibration functional test per DR 12A-01

c) Thermal vacuum test per DR-12A-01, plus two complete thermal cycles with soak time at the high acceptance temperature and at the low acceptance temperature for 24 hours per exposure during each cycle (4 day T-V test)

d) Final functional test per DR-12A-01.

No anomalies were observed during reacceptance testing, subsequent integration testing or prelaunch checkout at Cape Kennedy. The results of integration testing on both F-11 and F-14 are shown in Table 2-1. Transmitter output power versus calendar time are shown plotted in Figure 2-3 together with least squares trend lines. Note the significant improvement in output power after retuning. The effect of temperature on output power is shown in Figure 2-4. There was very little correlation on Flight 11; somewhat more on Flight 14, but not enough to b cons lered significant.

Table 2-1. I&T History of Transmitter 3-25

A) On F-11

Test	Date	TT&C Bus I	Conv + 15 V	Transmitter Power	Temp	Mod Index
IST 1	4-22-78	1.26	15.01	1.000	81	1.57
IST 2	5-23-78	1.25	15.01	.983	87	1.52
IST 3	6-09-78	1.28	15.01	.964	88	1.46
TV Ø II EQ	6-11-78	1.30	15.01	1.130	85	-
TV Ø II WS	6-12-78	1.29	14.97	1.040	95	-
TV Ø I EQ	7-7-78	-	15.01	.933	79	1.48
TV Ø I WS	7-9-78	-	15.01	.909	91	1.48
IST 4	7-19-78	1.30	15.01	.739*	91	1.46

*Spec limit .800 W minimum. Unit removed for modification and retuning.

B) On F-14

Test	Date	TT&C Bus I	Conv + 15 V	Transmitter Power	Temp	Mod Index
IST 1	2-19-79	1.30	15.02	1.56	85	1.60
IST 2	3-17-79	1.31	15.02	1.43	90	1.60
IST 3	3-24-79	1.31	15.02	1.41	93	1.60
TV Ø 1	3-28-79	-	15.02	1.72	82	1.57
IST 4	4-01-79	1.30	15.02	1.46	94	1.57
TV Ø 2	4-04-79	1.29	15.02	1.67	85	-
HAT 1	7-17-79	1.28	15.02	1.42	92	1.58
HAT 1R	8-23-79	1.28	15.02	1.44	94	1.60
HAT ETR	10-02-79	1.28	15.02	1.38	91	1.56
OSF	11-02-79	1.28	15.03	1.53 *	79	-
AOSF	11-18-79	1.28	15.02	1.58 *	82	-

*Measured via omni antenna. Previous measurements made via AGE hardline interface.

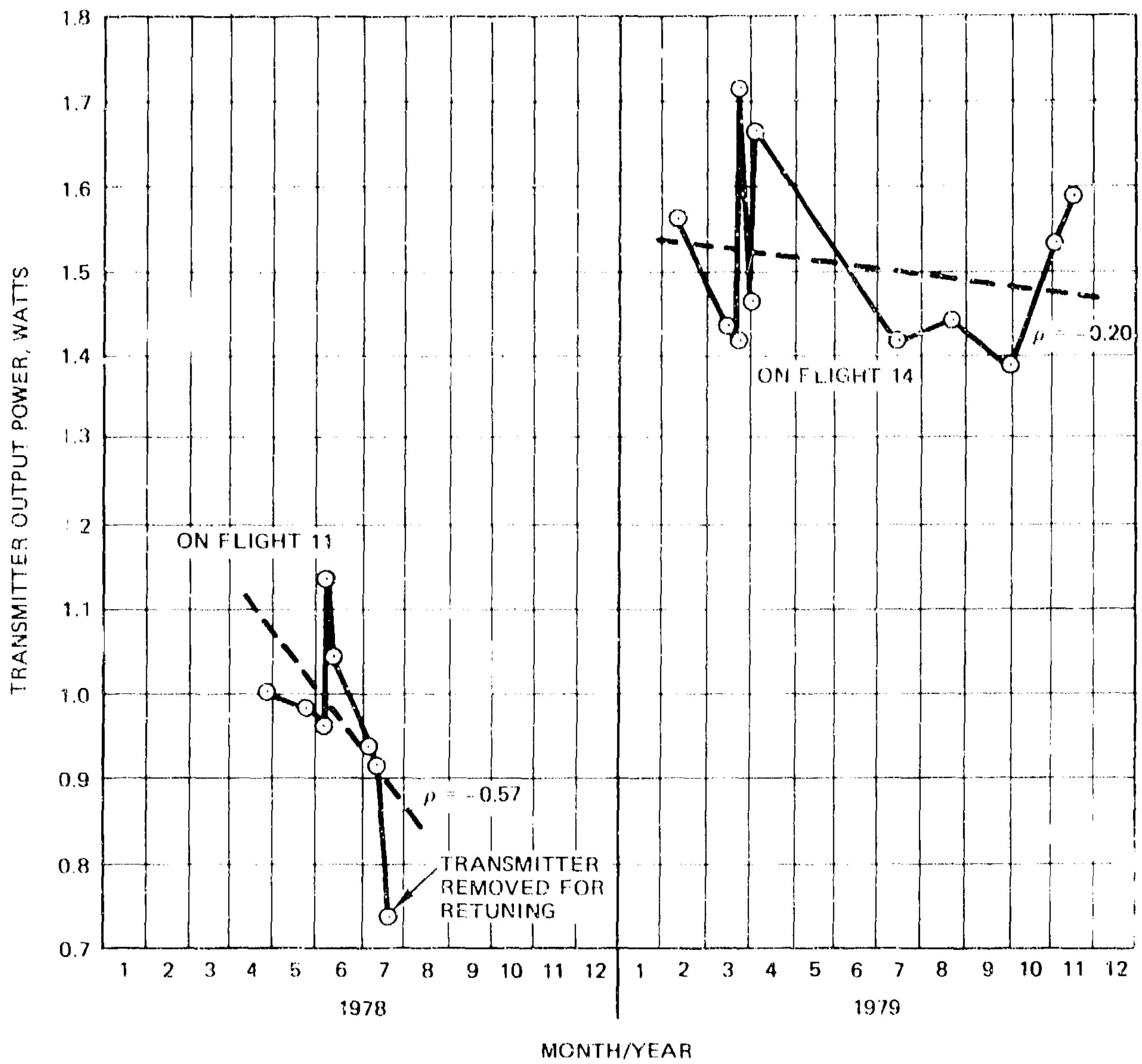


Figure 2-3. Transmitter S/N 3-25 Output Power During Integration and Test

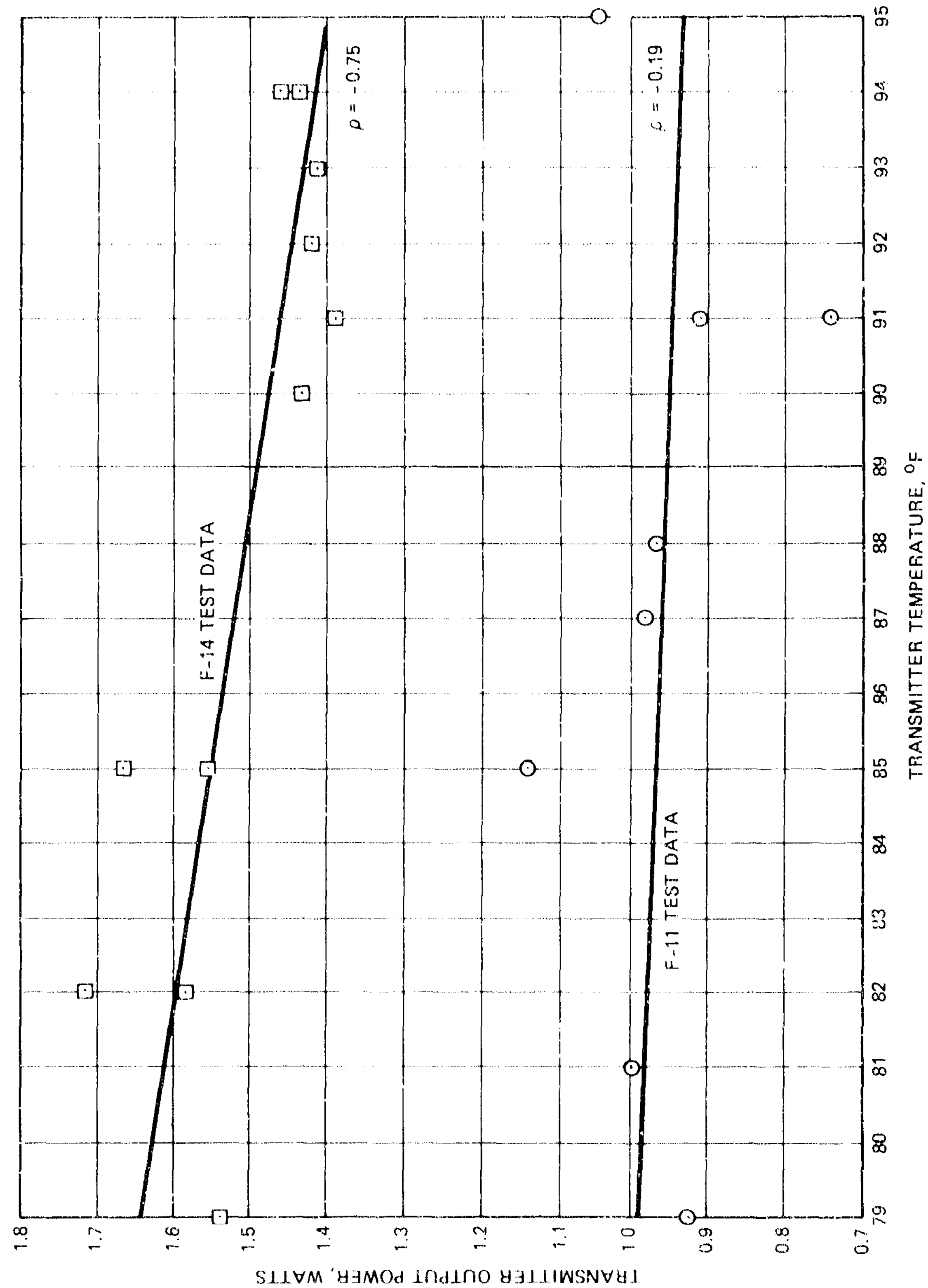


Figure 2-4. Transmitter S/N 3-25 Power vs Temperature

2.4 TRANSMITTER ORBITAL PERFORMANCE

During its two months of orbital operation, transmitter 3-25 performed normally. A graph of serveral operating parameters is shown in Figure 2-5. Converter output voltage was steady at 15.06 V. Transmitter output power increased slightly during the first few days of operation and became steady at 1.05 W, a nominal value. Transmitter internal temperature increased initially when the transmitter was turned-on, then stabilized at a normal value, varying by only 2 to 3 degrees. TT&C bus current also was steady and normal. Thus, there was no evidence of degradation or anomalous behavior of the transmitter prior to the failure.

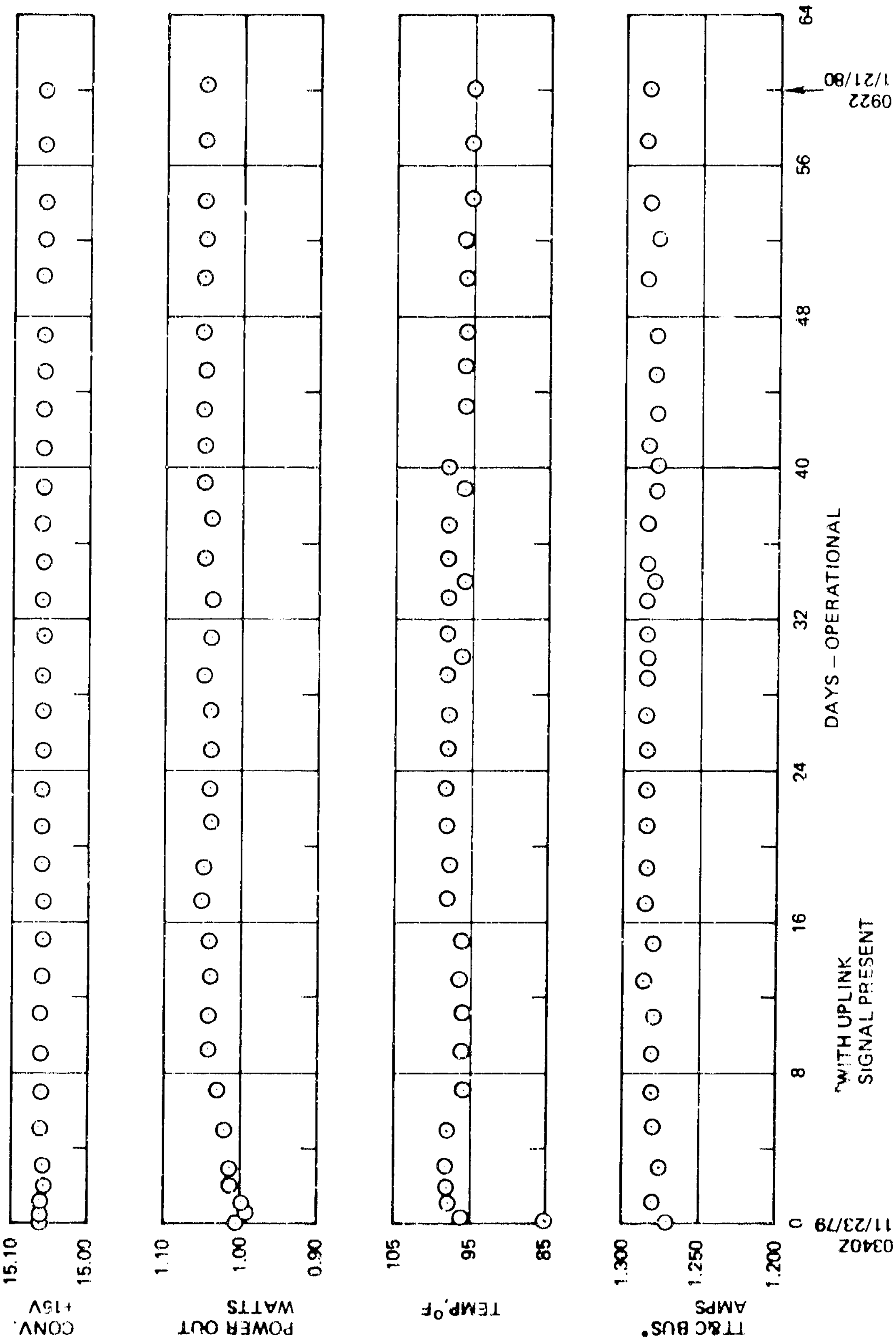


Figure 2-5. 9444 XMTR 1 Orbital Parameters

3. FAILURE ANALYSIS

3.1 POSSIBLE FAILURE CAUSES

Two general categories of possible failure causes exist: external and internal. These are diagrammed in Figure 3-1. Although there is no evidence to suggest any particular external failure cause, they were considered by the anomaly investigation team and are shown here for completeness. Radiation and particle impact were ruled out early as failure causes because they are remote and shielding is provided by the satellite structure and unit housings. The possibility of ground station failure was eliminated because the loss signal from the satellite was verified by a second ground station.

Based on past experience with electronic assemblies, it is more likely that the failure cause is internal. Of these, the transmitter itself, or its power converter, have the highest likelihood. Hence, efforts of the investigation team were concentrated in this area. Drift failure was ruled out quickly because, as seen in Figure 2-5, there was no indication of drift in any of the transmitter parameters. Drift from 1.05 W output power to less than 0.1 W would have had to occur in the 20.5 hours between telemetry samples.

An interconnection failure, such as a broken wire, open printed circuit board trace or improperly mating connector, would fit the observed sudden loss of signal; however, it is highly unlikely that these would not have been detected during ground testing if they existed prior to launch, and are unlikely to occur while the spacecraft is operating normally under relatively benign orbital conditions. Fuse failure is unlikely as there was no indication of any unusual power consumption in the TT&C subsystem. The possibility of corona, as was observed during F-15 thermal-vac testing, was discussed but considered unlikely since the transmitter would have vented completely long before two months in orbit. A diplexer failure is considered unlikely as this would be reflected on the redundant downlink.

Failure analysis efforts were considerably hampered by the loss of A-side telemetry measurements when the A transmitter stopped transmitting. The number of telemetered parameters is small and the frequency of telemetry samples from the SCF precludes observing any fast occurring events.

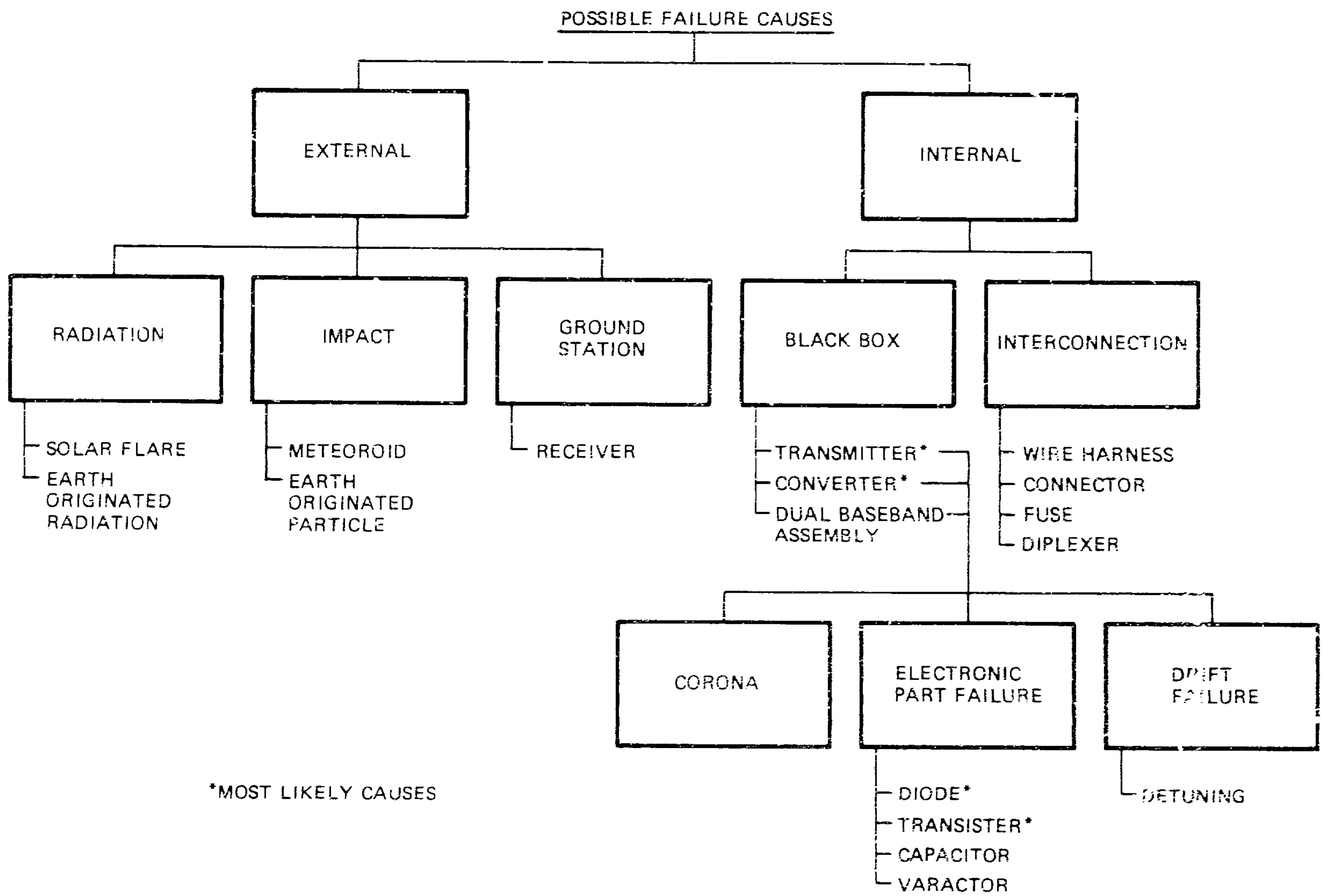


Figure 3-1. Diagram of Possible Failure Causes

Further orbital diagnostic information might be obtained by monitoring current usage and battery depth of discharge at onset of the next eclipse. Another diagnostic approach discussed by the investigation team is to command the failed transmitter on for a period of time (say, 12 hours) and observe any change in transmitter temperature to determine if power is being dissipated. However, no such recommendation was made as it has been the policy not to jeopardize the operation of the satellite in any way simply to obtain failure diagnostic information.

3.2 CONVERTER FOLD-BACK

A possible failure mode investigated by the team is damage to the transmitter or dual baseband unit due to converter fold-back.

The overload characteristics of the converter were tested, using Qual Unit S/N 3-25. Care was used not to overstress the converter beyond its normal load capability.

The test data (Table 3-1) shows that the converter does not exhibit any fold-back characteristics. Instead, the output maintains regulation as the load is increased until the series pass transitor runs out of drive, then voltage starts to drop as the current increases. This happened to the -15 V output during test No. 2. Output oscilloscope traces are shown in Figure 3-2.

It was concluded that as the output load is increased, the input current increases until the input bus fuse blows, thus precluding damage to the transmitter or dual baseband unit.

3.3 F-14 UNIT FABRICATION TEST HISTORIES

Fabrication test histories of the failed transmitter and its power converter were reviewed to identify any possible anomalies which might provide clues for identifying the cause of orbital failure.

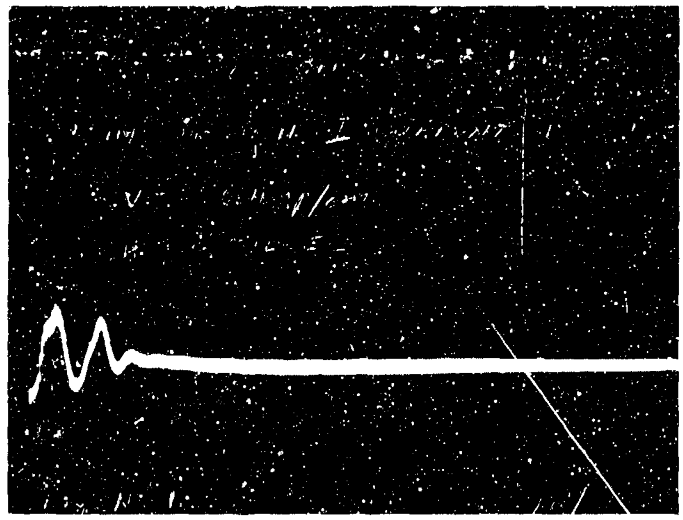
3.3.1 Transmitter

A review of the fabrication test history of transmitter S/N 3-25 revealed the following:

a) Assembly of the unit was completed in August 1977

Table 3-1. Transmitter Converter Overload Test Results - PN 266295-1 SN 3-25

Pix	Input				Output										
					28.0 V			15.0 V			-15 V				
No.	E_{in}, Vdc	I_{in}, mA	AC R_{io}, mA	P_{in}, W	E_o, Vdc	I_o, mA	R_{ip}, mV	E_o, Vdc	I_o, mA	R_{ip}, mA	E_o, Vdc	I_o, mA	R_{ip}, mV	Output Power, W	η, Percent
1	28.00	480	90	13.44	27.978	318	22	14.988	130	5	15.039	8	3	10.966	81.6
2	28.00	630	95	17.69	27.952	402	28	14.969	151	8	13.585	50	5	14.175	80.36
3	28.00	595	90	16.66	27.947	402	28	14.982	151	8	15.035	12	4	13.677	82.09
4	28.00	700	95	19.60	27.927	500	35	14.983	151	8	15.034	12	5	16.40	83.70
5	28.00	630	95	17.64	27.943	402	28	14.973	200	8	15.036	12	5	14.40	81.67



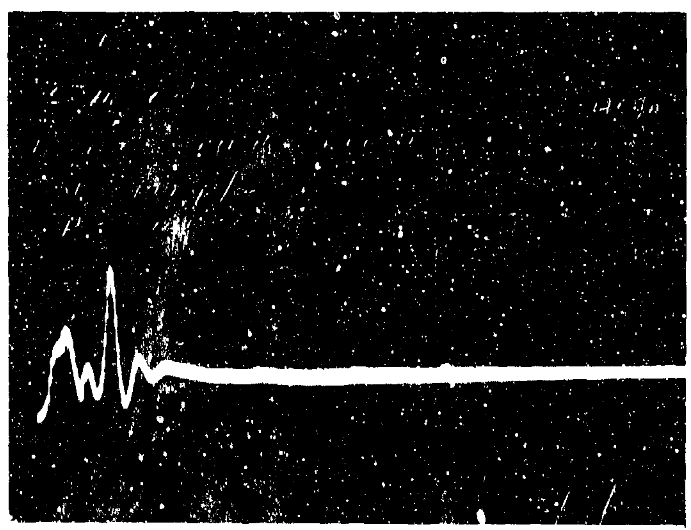


Figure 3-2. Output Oscilloscope Traces From Converter Overload Tests

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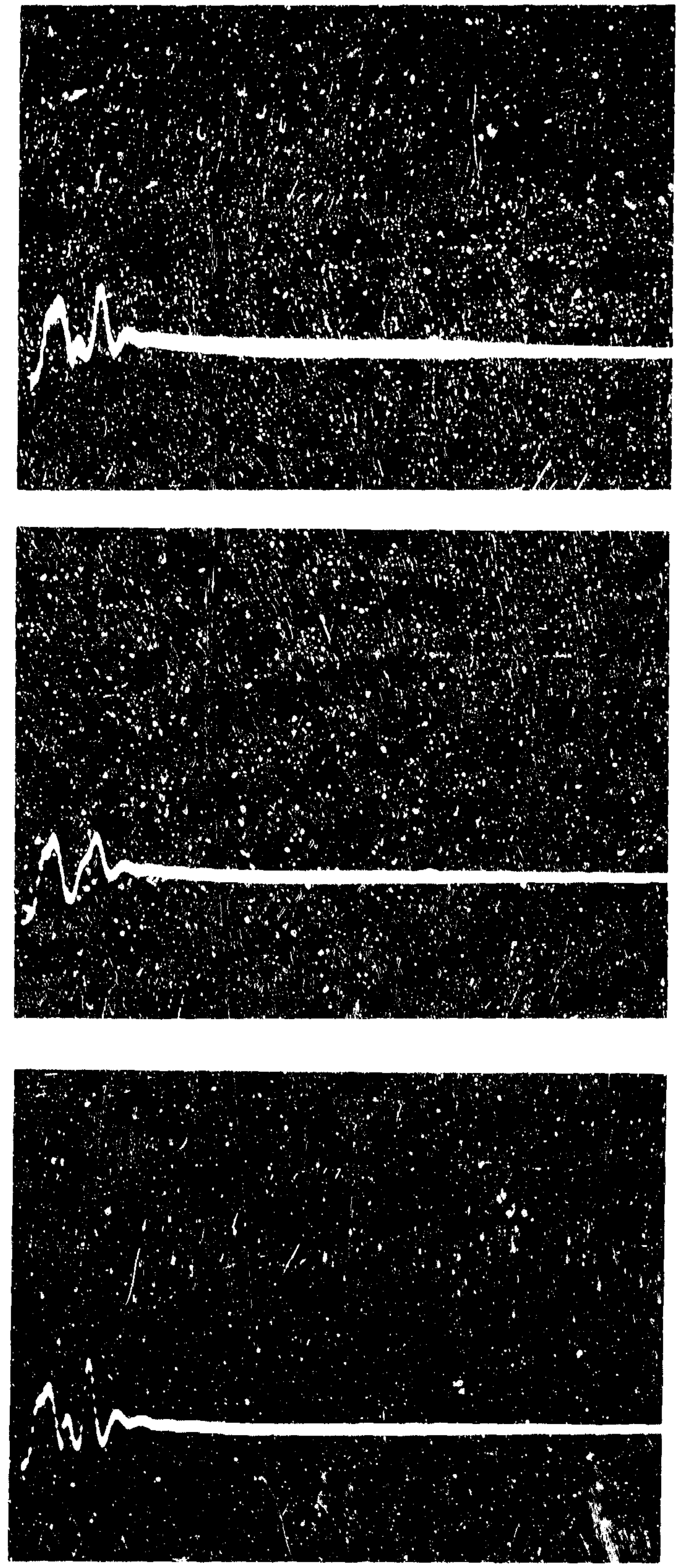

Figure 3-2. Output Oscilloscope Traces From Converter Overload Tests (Continued)

b) Test Discrepancy Report (TDR) T31691 indicates low output power during fabrication test. This type of TDR is typical for the transmitter and is usually caused by alignment problems and/or air-variable capacitor wear-out.

c) TDR T25594 indicates low output power during temperature/altitude test. The unit was opened and the output filter housing was found to be sensitive to pressure and shock. The output filter cavity was opened and repacked with pith balls. Power output was then normal. Several temperature cycles were performed with no power output anomalies. Although no hard evidence of a discrepancy was found, a possible cause of the anomaly was concluded to be due to pith ball contamination. The transmitter completed a full acceptance test sequence with no further anomalies.

d) TDR TA5921 indicates an out-of-spec condition on the modulation index during IST No. 4 Satellite 9441. In addition, the transmitter output power had degraded about 200 mW, although this parameter remained in specification. The unit was returned to Manufacturing. No damage or defects were found. Minor realignment significantly increased power output and brought the mod index within specification. Extensive temperature testing did not reveal any sensitivity to temperature transitions. The unit passed all acceptance tests with no anomalies in October 1978.

The above described anomalies are typical for the DSCS II telemetry transmitter, as indicated by a review of other transmitter data packages. Nothing was discovered in the data review that would indicate a problem with the transmitter. A summary of the fabrication test data is shown in Table 3-2. Copies of the functional test data sheets for transmitter S/N 3-25 are shown in Appendix A.

3.3.2 Converter

The transmitter converter (PN 25629-3) S/N 3-61 unit test data package No. 856-1 was reviewed and is summarized in Table 3-3. A review of the data showed no degradation in output voltage levels during testing.

3.4 UNIT FAILURE HISTORIES FROM PAST FLIGHTS

Test discrepancy follow-up (TDF) reports written against the transmitter, converter, and dual-baseband units used on DSCS II and DSP were reviewed and categorized. In addition, five transmitter failures from the Particles and Fields project were also reviewed. The TT&C transmitter for these three programs has essentially the same design.

Table 3-2. Summary of Fabrication Test Results for Transmitter S/N 3-25

	POWER OUT		DC		MOD INDEX (2.4 RADIAN) Min. 5.136 Volt Max. 7.704 Volt			SIDEBAND SYMMETRY (2.4 RADIAN) Max. 10%
	Coh. Min. 800 mW	Non-Coh. Min. 800 mW	+28 Max. 340 mA	+15 Max. 120 mA	100 KHz	500 KHz	1100 KHz	
1st Acc. Test								
Post T/C	1304	1272	200	85	6.495	6.430	5.870	3.9
Post Vib	1415	1399	210	86	6.152	6.153	5.807	2.9
Temp Alt	NA	1281	220	86	NA	NA	NA	NA
Th Vac Hi	1187	1187	260	86	6.732	6.410	5.933	4
Th Vac Lo	1344	1281	250	86	5.463	5.478	5.934	3.9
Post Env	1302	1323	270	86	6.015	6.010	5.769	1.9
2nd Acc. Test (After I.T. Return)								
Final Fab	1330	1360	250	102	6.550	6.615	6.850	<1
TC Hi	925	955	205	101	6.927	6.833	7.168	1
TC Lo	1440	1465	280	102	5.727	6.0	5.961	3
Post T/C	1545	1360	250	101	6.562	6.672	6.960	1
Post Vib	1300	1340	245	101	6.512	6.657	7.025	1
Temp Alt	NA	1296	240	101	NA	NA	NA	NA
Th Vac Hi	972	1008	210	110	7.002	7.048	7.318	0
Th Vac Lo	1530	1611	285	102	6.236	6.260	6.068	2
Post Env	1424	1484	240	102	7.043	7.068	7.023	1

Table 3-3. Converter S/N 3-61 Test History

Parameter		Test					
Output	Limit	Final Fab	Pre En V	Post Vib	TV Low	TV High	Post En V
+28 Vdc	+27.44 +28.56	28.18	28.17	28.06	28.12	28.09	28.08
+15 Vdc	+14.70 +15.30	15.02	14.96	15.02	15.01	15.03	15.02
-15 Vdc	14.70 -15.30	-14.80	-14.89	-15.13	-15.13	-15.14	-15.12

3.4.1 DSCS II Transmitter Failures

Failure reports written against DSCS II telemetry transmitter, P/N 256164, all dash numbers, S/N 2-1 through 3-34 were divided into six categories: (1) No power; (2) Low power; (3) Fluctuating power; (4) Modulation problems; (5) Bandpass, frequency, or spurious response problems; (6) Other. The first three categoies deal with the output power parameter, while the last three relate to other aspects of the output spectrum as well as miscellaneous problems. The details are tabulated in Appendix B, Attachment 1. The first three categories are then each subdivided by failure cause. These are shown in Attachment 2 of Appendix B.

A total of 96 TDFs were written against the telemetry transmitter. Of these, 32 TDFs were related to the output power parameter, and 64 were related to some other parameter. Of the 32 output power TDFs, only one dealt with a no-power situation (S/N 2-1; due to a procedural problem in thermal-vacuum test, a longer soak time was added).

3.4.2 DSP Transmitter Failures

A similar review was performed on the DSP 0.8 W transmitter, P/Ns 235855, 246027-5, 246027-6, S/N 2-1 through 029. The same six categories mentioned above were used. Details of this can be found in Appendix B, Attachment 3. The subdivision of the first three categories by failure cause is found in Attachment 2. Of the 107 TDFs written against the transmitters, 63 TDFs were related to the output power parameter and 44 dealt with other parameters. Of the 63 TDFs relating to output power, 20 TDFs discuss the no-power situation. Of the 20 no-power TDFs, seven were out-of-tune transmitters, two were caused by employee error, five were caused by corona, two were caused by outgassing/moisture, one was caused by a faulty transistor, one was caused by a loose screw on transformer T2, one was caused by a converter failure, and one failure cause was unknown. See Appendix B, Attachment 2 for the breakdown of failure causes.

3.4.3 Particles and Fields Satellite Transmitter Failures

Also reviewed were five TDRs written against the Particles and Fields (P&F) satellite transmitter. Two concerned a no-power output condition. The failure cause was an open junction of a part on the low-power board. The part, TRW Semiconductor C255185-011, 2N4428, was retro-fitted on DSCS II hardware after this P&F failure.

3.4.4 Converter and Dual Baseband Assembly Failures

DSCS II and DSP converter failure history was reviewed. DSCS II converter P/N 256295 and DSP converter P/N 237974 had 18 and 44 TDFs, respectively. Of the 18 DSCS II TDFs, three concerned a complete loss of output: (1) -15 V to 0.0 caused by a too-long screw, corrected by E.O; (2) +28 V to 0.0 caused by a shorted diode which was considered a one-time occurrence; (3) all outputs to 0.0 caused by a shorted transformer, also considered a one-time occurence. Of the 44 DSP TDFs, six concerned a complete loss of output: (1) no outputs due to a broken wire (considered workmanship); (2) a short in the converter power board during integration testing; (3) -15 V to 0.0 due to a too-long screw corrected by E.O; (4) no output, caused by operator error; (5) no output to the receiver due to a damaged J2 connector on the converter; (6) same as 5.

Finally, the dual-baseband unit failures were reviewed. Of the five DSCS II TDFs written, all were related to the RF output spectrum (such as intermittent output, or out-of-tolerance power versus frequency) rather than an input parameter (such as input current). Earlier failure analysis determined that RF output problems could not result in the orbital anomaly of F14. Of the DSP TDFs written, all were also related to the RF output spectrum rather than an input paramter.

3.4.5 Conclusions From Unit Failure Histories Review

A review of the falure history of transmitters, converters, and dual-baseband units on DSCS II, DSP and Particles and Fields projects revealed relatively few failure modes which could result in the complete loss of transmitter output. In the past, transmitters lost power by detuning, corona, part-failure, outgassing or moisture, and the loose screw. DSCS II transmitters had no hardware failures resulting in a complete loss of power.

Several DSP converters failed in a fashion that would result in a complete loss of transmitter signal. Some of the failure causes mentioned earlier (a broken wire, a short in the converter power board, and a damaged connector) figure as possible F-14 anomaly causes. The two DSCS II converter failures caused by a shorted diode and shorted transformer are also possible F-14 anomaly causes. It is very unlikely these faults could have escaped detection during unit test and integration and test of the satellite.

The history of the dual-baseband units reveals no possible failures such that a condition of no transmitter output power would exist.

3.5 CRITICAL PART FAILURE HISTORY

In an attempt to identify one or more piece-parts which could be suspected of having caused the orbital failure, transmitter and converter schematics were reviewed to identify critical parts whose failure would produce the observed conditions. Since a very large number of parts could have caused the failure, the critical parts listed were limited to the higher failure rate parts. Many lower failure rate parts, such as standard resistors and capacitors, could also have been the failure cause, though much less likely. Government alerts and TRW historical parts failure data were reviewed to determine if any of these critical parts had been problem parts in the past.

3.5.1 Transmitter Critical Parts

After reviewing the transmitter schematics (297452, 297451), the following piece parts were identified along with the type of failure and its effect on the transmitter performance.

A. Low Power Board (Schematic 297452)

1. Voltage Regulator

Ref.	Part No.	Part Type	Failure	Result
Q1	C255270-011	Transistor	Short/Open	Loss of carrier
Q2	C255172-011	Transistor	Short/Open	Loss of carrier

2. Switching Circuit

CR1-CR4	CR255212-011	Diode	Short/Open	Loss of carrier

3. Buffer Amplifier

Q4	C255169-021	Transitor	Short/Open	Loss of carrier
VR4	C25507-071	Diode	Short/Open	Loss of carrier

4. Doubler Amplifier

Q5	C255169-021	Transistor	Short/Open	Loss of carrier
CR5	C255116-011	Diode	Short/Open	Loss of carrier

5. Modulation Amplifier

Q6	C255169-021	Transistor	Short/Open	Loss of carrier
VR5	C255097-031	Diode	Short/Open	Loss of carrier
VR6	C255122-021	Diode	Short/Open	Loss of carrier
CR6, CR7	C255104-131	Diode	Short/Open	Loss of carrier

6. Buffer Amplifier

Q7	C255169-021	Transitor	Short/Open	Loss of carrier

7. Final Amplifier

Q8	C255185-011	Transitor	Short/Open	Loss of carrier

B. High Power Board (Schematic 297451)

1. Low-Level Quadrupler

CR1, CR2	C255104-031	Varactor	Short/Open	Loss of carrier

2. Low-Level Amplifier

Q2	C255164-011	Transistor	Short/Open	Loss of carrier

3. High-Level Amplifier

Q3	C255163-021	Transistor	Short/Open	Loss of carrier

4. Quadrupler

CR3, CR4	C255115-011	Varactor	Short/Open	Loss of carrier

3.5.2 Converter Critical Parts

After reviewing the transmitter converter schematic (256513) the following piece parts were identified along with the type of failure and its effect on the converter performance. In general, any part failure resulting in a loss of the command relay contact closure would result in a turn-off of the converter.

Part No	Part Type	Failure	Result
Oscillator Drive A1 Board			
C255489-2661	Capacitor	Short	Open Input Fuse
C255160-011	Transistor	Short/Open	Low Voltage Output
C255162-011	Transistor	Short/Open	Low Voltage Output
C255172-011	Transistor	Short/Open	Los Voltage Output
C255102-021	Zener Diode	Short/Open	Low Voltage Output
Power Output Board (A2)			
C255196-011	Transistor	Short CE	Open Input Fuse
C255196-011	Transistor	Open Ce	No Output Voltage
C255174-021 (Q5)	Transistor	Open	No +15 V Output
C255174-021 (Q5)	Transistor	Short	+15 V Output Increase to approx +17 V
C255489-2546	Capacitor	Short	$\pm$15 V goes to zero may blow input fuse
C255489-2661	Capacitor	Short	+28 V goes to zero, $\pm$15 V goes low may blow input fuse

3.5.3 Parts History Review

GIDEP Alerts, reliability action requests (RAR) and destructive physical analysis (DPA) history of the critical components used in DSCS II that could have caused the failure were reviewed. The following critical parts, taken from the lists in Sections 3.5.1 and 3.5.2, were researched:

	Part Type	Part No.	Generic Part No.
1.	Diode, Voltage Regulator (Zener)	C255097-031 -071	1N748A 1N752A
2.	Diode, Varactor	C255104-031	PC100
3.	Diode, Varactor	C255115-021	VAB802EC
4.	Diode, Switching	C255116-011	1N3600
5.	Diode, Temp Compensated Ref.	C255122-021	1N4295A
6.	Diode, Step Recovery	C255212-011	PPA-023
7.	Transistor, NPN UHF Amp	C255163-021	2N4430
8.	Transistor, NPN Med. Power UHF Amp	C255164-011	2N4429
9.	Transistor, NPN High Speed Switch	C255169-021	2N2369
10.	Transistor, NPN	C255172-021	2N2222A
11.	Transistor, NPN Low Power UHF	C255185-011	2N4428
12.	Transistor NPN Darlington Amp	C255270-011	2N999

The review of the critical parts revealed several GIDEP Alerts, RARs and unsatisfactory DPAs. A total of four GIDEP Alerts have been written on zener diodes of the same type and voltage as the C255097-031 and -071 but none of the suppliers was used by TRW on the DSCS II Project. Other GIDEP Alerts were written on parts in the same series as the C255097 family from suppliers that DSCS II used, but these were old lot date codes and technical steps have since been taken by the suppliers and TRW specification modifications have been made to minimize the possibility of problem repetition in later parts.

GIDEP Alerts of 2N2222A transistors or the military version of this part (which is the same basic type as the C255172-021) were located, but only one alert was from a supplier used by DSCS II. This particular alert was on parts manufactured in 1968 and could not have been used on this satellite. Again, manufacturing changes by the supplier have eliminated the problem in later lots.

Only one RAR (No. 37) was found on any of critical parts used. This was written on a JANTXV2N2222A for parts made in 1972 by a supplier not used on DSCS II for the C255172-021 part.

Two unsatisfactory DPAs were found on critical part types. The first was on one transistor type C255169-021 (similar to 2N2369) which was manufactured by an approved source, Motorola. The cause of the DPA being unsatisfactory was metallization bridging between the base bonding pad and one of the emitter fingers. There was a very slight separation between the pad and finger so that the unit was probably not electrically shorted. This part was very old (lot date code 6813) and the lot was not used. It was scrapped.

The other unsatisfactory DPA was for a step recovery diode C255212-011 which was manufactured by Hewlett-Packard. Two of the diodes in the DPA sample contained a particle of sufficient size to cause shorting between the anode ribbon and the cathode side of the die or mounting pedestal. The lot of parts was 100 percent screened visually internally and all parts with particles removed. However, none of the parts from this lot (lot date code 7511) were used on DSCS II. In the meantime Hewlett-Packard was apprised of the problem and made significant improvements in the cleanliness of the assembly operation and also in their preseal inspection procedures and equipment.

There were additional unsatisfactory DPAs on parts used by other projects at TRW which are similar to the critical parts such as diode type JANTXV1N3600 or transistor type JANTXV2N2222A. In all such cases however the parts were manufactured by suppliers not used by DSCS II, or were of older lot date codes than the parts used.

Based on this review of TRW and industry part failure information, it was concluded that there is no historical evidence to indicate a specific component part as the cause of the TT&C failure.

3.6 INVESTIGATION OF TEMPERATURE DATA

In an attempt to obtain additional clues regarding the cause of failure, the investigation team took a close look at telemetered temperatures in the vicinity of the failed transmitter and compared them with predicted values using the DSCS II analytical thermal model.

Table 3-4 shows the receiver internal temperature for several days before and after the failure. The receiver temperature sensor is in the same assembly housing as the transmitters, and its telemetry was not affected by switchover to the redundant transmitter. Note that the temperature dropped 5 degrees after the failure, then rose to a stable level at 82-83°F. This reflects shutdown of transmitter No. 1 and warm-up of transmitter No. 2. The stabilization temperature after the failure is lower because transmitter No. 2 is located farther away from the temperature sensor within the receiver than is transmitter No. 1.

Table 3-4. TTC Receiver Temperature Before and After Failure

Date	Time (Z)	Temp °F	
1-15	0426	86°	
1-15	1014	86°	
1-15	2300	86°	
1-16	1024	86°	Transmitter No. 1 ON
1-17	0419	86°	
1-18	1100	86°	
1-19	0609	86°	
1-20	1722	86°	
1-21	0932	85°	
Transmitter #1 Failed During This Period			
1-22	0702	80°	
1-23	0655	83°	
1-24	0224	83°	
1-25	1253	83°	
1-26	0058	83°	Transmitter No. 2 ON
1-27	2204	82°	
1-28	0352	83°	
1-29	0741	83°	
1-30	1017	82°	
1-31	0559	82°	

Telemetered temperature measurements for transmitters No. 1 and 2, the receiver and battery No. 1 are shown plotted in Figure 3-3 for several minutes before and after the failure. This figure clearly shows the warm-up of transmitter No. 2.

A thermal analysis was performed using the DSCS II F13-16 spun platform analytical thermal model to predict the effect of transmitter operation on adjacent flight sensor temperatures. The condition analyzed was Winter Soltice, beginning of life in orbit. Table 3-5 tabulates the predicted flight sensor temperatures. In the analytical thermal model, both transmitter No. 1 and transmitter No. 2 are lumped into one isothermal node, therefore, only one temperature is predicted and applied to both transmitters. These temperature predictions are shown plotted as horizontal lines in Figure 3-3.

Table 3-5. Predicted Temperatures with Transmitter ON and OFF

Flight Sensor	Predicted Temperature, °F	
	XMIT ON	XMIT OFF
2-78, TMX1T	99	71
2-80, TMX2T	99	71
2-82, RCVRT	85	76
2-24, BAIT	70	68

Before the failure, transmitter No. 1 was operating at 95°F, 4°F below the predicted 99°F. This was not considered significant since it is within the accuracy of the measurements and analytical predictions. The receiver and battery were operating very close to the predicted values.

After the failure, transmitter No. 2 temperature was very close (within 1°F) to its predicted value in the off condition. This indicated that neither the transmitter nor its converter was dissipating power. However, this does not necessarily infer that the converter failed causing loss of power to the transmitter, because failure of the transmitter could also reduce power output of the converter causing it to cool down. The receiver temperature dropped to within 4°F of predicted. Battery number one temperature changed only 1-2°F as predicted. Thus, nothing unusual could be inferred from this temperature data.

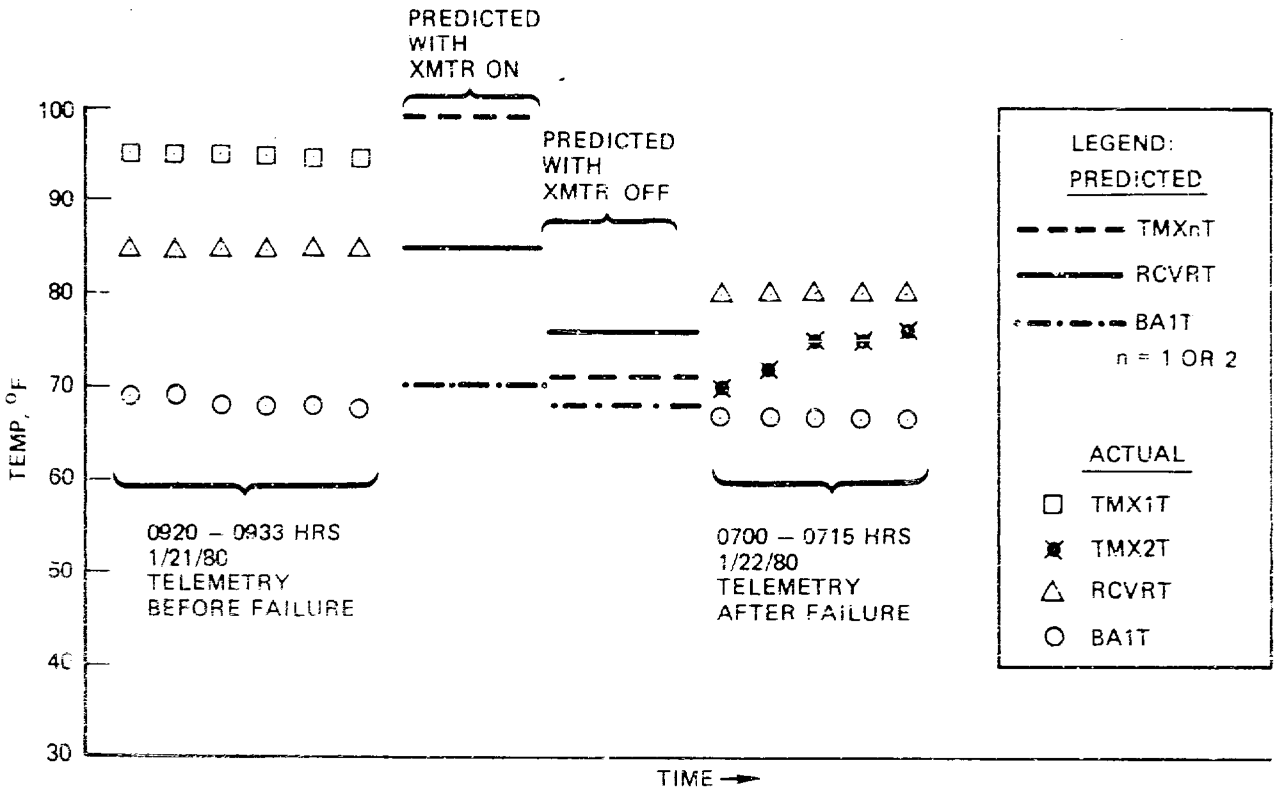

Figure 3-3. 9444 XMTR 1 Failure - Related Temperature Data

3.7 TRANSMITTER POWER OUTPUT COMPARISONS

The most indicative paramter for measuring transmitter performance is output power, measured in watts. The transmitter is designed to nominally produce 1 watt. However, the sensitivity of the transmitter to tuning has resulted in considerable fluctuation in output power from unit to unit.

Records from Integration and Test for each DSCS II spacecraft through Flight 15 were researched and transmitter test measurement values were tabulated. This data is shown in Appendix C. For Flights 7 through 12, it was necessary to apply a correction factor to the power output measurements to convert power measured at the diplexer to output power for the transmitter. This correction factor curve is shown in Figure C-1. (Appendix C)

Figure 3-4 provides an overall picture of transmitter output power for 30 transmitters. Shown for each transmitter are the range of power values measured, the mean value and the last value measured during I&T. Note that output power has varied from less than 0.8 W to over 1.8 W, a range variation of 100 percent from the nominal design power. For comparison purposes, Figure 3-4 also shows an overall mean (i.e. mean of the mean values) for all transmitters and one, two and three sigma deviations from the mean. The mean value is 1.26 W, one sigma is 0.185 W.

In general, Flights 1 through 5 tended to have transmitter powers above the mean, Flights 7 through 12 were generally below the mean and Flights 13 through 15 were above the mean. Flight 13 is a notable exception; the A-side transmitter (S/N 3-34) was one of the lowest power transmitters tested while the B-side transmitter (S/N 3-30) was the highest.

Of particular interest is that the mean output power of the failed transmitter on Flight 14 (S/N 3-25) during I&T was one of the highest ever measured. Only transmitter 3-30 on Flight 13 and the two transmitters on Flight 1 (which had problems in orbit) had higher average output. Transmitter 3-9 on Flight 4 (which failed in orbit) also had some relatively high power measurements, although the last measurement in I&T was near the overall mean. This raised the question of whether high transmitter output power was correlated with failure.

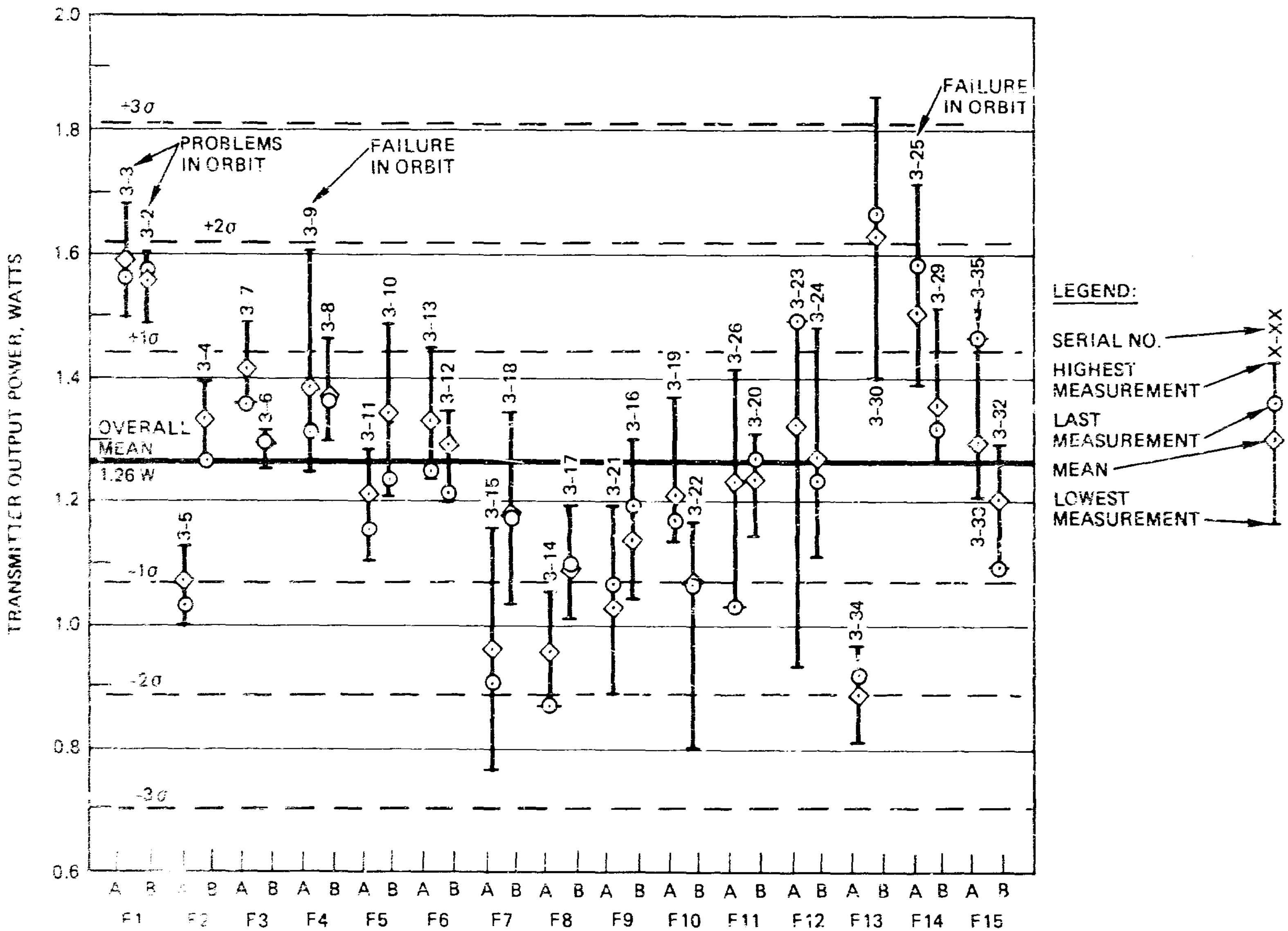

Figure 3-4. TTC Transmitter Output Power History During I&T

The problems experienced with Flight 1 transmitters were of a completely different nature from the failures on Flight 4 and 14. Both Flight 1 transmitters turned off intermittently during eclipses. Difficulties were also encountered getting them turned on again. These problems were traced to an open circuit caused by thermal expansion and contraction in the plated-through holes of a non-redundant part of the transmitter turn-on circuit. Subsequently, the design was changed to incorporate redundancy in this circuit and the plated-through hole manufacturing process was improved. The transmitter failure symptoms on Flight 4 and 14, however, appear to be nearly identical (see Section 4).

To assure that the transmitter power variations shown in Figure 3-4 are not just due to normal random variations, statistical significance tests were performed on the data in Appendix C. First an analysis of variance was conducted on the output power measurements made during I&T on the 30 transmitters. This analysis is summarized in Appendix D. As might be expected, the results show that the observed variation in output power is significant and it is highly unlikely that all transmitters come from the same statistical population. Although all transmitters are of the same design, their performance is highly dependent on their tuning.

A second statistical test was performed to determine if the two transmitters which failed abruptly in orbit (S/N 3-9 and S/N 3-25) had significantly higher output power than the average of non-failed transmitters (excluding Flight 1). This analysis is shown in Appendix E. The results indicate that the observed higher output power of the two failed transmitters is statistically significant and there is less than a 5 percent chance that this observation is due just to random fluctuation. The mechanism of failure and how it is related to output power has not been determined.

4. REVIEW OF OTHER ORBITAL TRANSMITTER FAILURES

Two other transmitter failures, similar in nature to the failure on Flight 14, have occurred in orbit. They are transmitter No. 1 (S/N 3-9) in DSCS II Flight 4 and transmitter No. 2 on DSP Flight 4.* These are essentially the same design as the DSCS II transmitters. As discussed in Section 3.7, the transmitter problem experienced on DSCS II Flight 1 had very different symptoms. They were traced to a likely cause, were reproduced by ground test and, thus, were not considered similar to the other failures.

4.1 DSCS II FLIGHT 4 TRANSMITTER FAILURE

At 1240Z August 25, 1976, transmitter one on Satellite 9434 failed (no downlink carrier output with uplink carrier "signal presence").

Due to satellite power limitations, transmitter No. 1 was being turned off at the end of each pass and was normally turned on by a "signal presence" command at the beginning of each pass.

Accordingly the Satellite Control Facility:

1) Sent the downlink "on" command at 1315Z without success (this bypasses signal presence circuits)

2) Selected transmitter No. 2 at 1435Z. This command was successful and transmitter No. 2 has been left on ever since.

Prior to the failure, there was no indication of a pending problem. Transmitter No. 1 had been cycled on and off approximately 250 times prior to failure. The failure could have been in the transmitter itself or its power converter. It was not possible to isolate it to either unit.

A review was made of the history of selected critical parts used in the transmitter and its converter; however, no significant evidence was found to link the orbital failure with a specific part.

*At this point a numerologist would argue that the cause of the failure is obvious: all flight numbers containing the digit "4" are subject to transmitter failure!

It did not appear that there were significant changes in either the transmitter or its converter other than those necessary to accommodate unavailability of original parts. There were several transmitter and two converter ECPs incorporated since Satellite 9434. They are listed below together with comments as to possible effect.

ECP No. and Effectivity	ECP Title
21 (9437)	Varactor Diode Replacement (Due to parts availability) Replaced the pair of varactors used in the X4 multiplier (output stage) with the same part used in the DSP 1.6 W transmitter. Some circuit changes were also necessary.
34 (9437)	Change of TT&C Transmitter Crystal Change of value of an inductor shunting the crystal to accommodate the crystal manufacturer's product being procured for DSCS II.
68 (9439)	Communications Converter Transformer Inspectability Improvement Added shims under transformers and inductors to improve inspectability for "solder balls."
76 (9439)	TT&C RCVR/XMITR Interface Spec Change Reduced manufacturing problems associated with receiver tuning (did not impact transmitter).
88/123 (9443)	S-Band Diplexer Supplier and Design Change Replaced Wavecom with Teledyne unit. ECP 123 added a 20K resistor to spacecraft harness to control source impedance of power monitoring circuit of Teledyne Diplexer (did not impact transmitter).
98 (9443)	Single Configuration Transponder Converter Made both Tx and Rx converters alike with minor increase in power dissipation (converter manufacturability improvement).

ECP No. and Effectivity	ECP Title
106 (9441)	TLM Transmitter Producibility An attempt to reduce the effort required to tune the transmitter (design effect considered negligible).
120/124 (9441/9443)	Battery Charge Control Mode The only impact was to change the main bus voltage from 32.4 V to 31.8 and 33.8 V respectively. This did not have an effect on the converter.

4.2 DSP FLIGHT 4 TRANSMITTER FAILURE

On 13 July 73, Flight 4 transmitter 2B (S/N 007) failed abruptly, going from full data with no discrepancies in one data frame to fully off with no transmission in the next. After 31 days of operation, the carrier stopped instantaneously and without warning within the sampling interval of the telemetry. After multiple attempts to command it on, Link 2A was commanded on and has been operating since.

Orbital tests checked for temperature influence, RF switch intermittancy, and coherent oscillator switching. Ground test history showed S/N 007 typical of Phase I transmitters, with their relatively large number of misalignments, Johansen capacitor failures, corona and operator errors.

Early in Phase II the DSP instituted the following relevant changes:

a) RF cable impedance matching to transmitters

b) Improved Johansen capacitors

c) 3-point (frequency) tuning

d) Revised Acceptance Test Program.

A concerted effort was made to evaluate the possible failure modes but no evidence was found which could provide a unique failure signature and identify a specific failure cause. It was concluded it was not possible to isolate the problem with the orbital data available or with unit and part ground test history.

5. ANOMALY INVESTIGATION TEAM

The following TRW personnel constituted the orbital anomaly investigation team for the Flight 14 transmitter failure:

G. E. Neuner	Chairman
R. Alborn	Orbital Operations
G. Van der Capellen	Transmitter Unit Engineer
R. Montague	Converter Unit Engineer
D. Hutchinson	Integration and Test
J. Wrobleski	System Effectiveness
J. Streisand	Engineering
R. Doyle	Parts, Materials and Processes

Other significant contributors to the investigation were:

R. Glynn	Orbital Operations
R. J. Henrich	Reliability
J. Sharp	System Engineering
A. H. Sharp	DSP
B. Burdiak	Reliability
H. Pan	Thermal Analysis

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IOC DSCS-G7-024, from D. W. Hutchinson, Subject: I&T History of TT&C Transmitter S/N 3-25, 12 February 80.

IOC 80.8724.2-001, from R. L. Montague, Subject: Review of Fabrication Test History of Transmitter Converter S/N 3-61, 18 February 80.

IOC 80.8724.2-002, from R. L. Montague, Subject: Transmitter Converter Fold-Back, 19 February 80.

IOC 80.8724.2-003, from R. L. Montague, Subject: Identification of Critical Piece Parts That Could Cause Converter Failure, 19 February 80.

IOC DSCS-C4-226, from A. G. Van der Capellen, Subject: Review of Fabrication Test History of 777 Telemetry Transmitter S/N 3-25, 21 February 80.

IOC 80-8715.1.3-04, from H. M. Pan, Subject: 777, 9444 Predicted Orbital Temperatures for Flight Sensors in the Vicinity of the S-Band Transmitter with the Transmitter Operating and Not Operating, 25 February 80.

IOC DSCS-C4C-268, from G. A. Van der Capellen, Subject: Identification of Critical Piece Parts that Would Cause Transmitter Failure, 6 March 80.

IOC DSCS-C4C-267, from G. A. Van der Capellen, Subject: Review of Fabrication Test History of 777 Telemetry Transmitter S/N 3-25, 6 March 80.

IOC 80.8724.2-005, from R. L. Montague, Subject: Fabrication Test History of Transmitter Converter S/N 3-61, 7 March 80.

IOC DSCS-D2-2249, from B. Burdiak, Subject: DSCS and M-35 Transmitter, Converter and DBU Failure History, 10 March 80.

IOC 5512-108/80 DSCS-D3-2215, from R. Doyle, Subject: Review of History of Critical Component Parts Used in DSCS II that Would Cause Telemetry Transmitter Failure, 30 April 80.

6.2 DSCS II FLIGHT 4 TRANSMITTER FAILURE

IOC DSCS-D2-772, from R. J. Henrich, Subject: Action Item Response for A.I. No. 5 Launch Readiness Review Team, 3 Dec 76.

IOC DSCS-Dx-276, from J. A. Nisenbaum, Subject: Failure of 9434 Telemetry Transmitter, 22 November 76.

6.3 DSP FLIGHT 4 TRANSMITTER FAILURE

IOC 35.83-340 dated 5 December 73, Flight 4 Link 2B Anomaly Close Out.

IOC 35.83-339 dated 24 August 73, Flight 4 Link 2B Anomaly.

IOC 35.52-341411 dated 25 July 73, 0.8 W Transmitter S/N 7 Anomaly on Launch 4.

IOC 35.57-18211 dated 20 July 73, Review of Link 2 Transmitter and Converter, Model 35, Phase I.

IOC 35-83-288 dated 18 July 73, Preliminary Operations Anomaly Report, Flight 4 Link 2B Transmitter.

APPENDIX A

Functional Test Data Sheets

For

Transmitter S/N 3-25

S/N 3-25 1st ACCEPTANCE TEST

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1	Limits	FINAL FAB	CYCLE 1 HI TEMP	CYCLE 1 LO TEMP	CYCLE 8 HI TEMP	CYCLE 8 LO TEMP	POST T/C / PRE ENV.
3.2.2 (a)	Bandpass Characteristics							
Step 5	Bandwidth (for reference only) -1 dB Bandpass (No Bandpass Limits)							13.24
	-3 dB Bandpass (No Bandpass Limits)							24.24
Step 6	Coherent Output Power	Limits						
	~~-2~~ -5 dBm Input * SEE REC'D 3	800 mw min.						1304
	+4 dBm Input	800 mw min.						1304
Step 7	+15 Volt Input Current	50 ma max						48
3.2.2 (b)	Non-Coherent Characteristics	Limits						
Step 2	Non-coherent Output Power	800 mw min.						1272
Step 3	Input Currents							
	Input Voltage (DC)	Limit (ma)						
	+28	310 max.						200
	-15 (Bias)	3 max.						0.05
	+15	120 max.						85
								4/25/7

QA ACCEPTANCE

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1		TEST PHASE: POST VIB	TEMP ALT	HI-TEMP VAC	LO-TEMP VAC	POST ENV
3.2.2 (a)	Bandpass Characteristics						
Step 5	Bandwidth (for reference only)	-1 dB Bandpass (No	13.33	N/A	13.00	13.5	12.43
		-3 dB Bandpass Limits)	23.76	N/A	23.26	23.0	24.14
Step 6	Coherent Output Power	Limits					
	~~-3~~ -5 dBm Input + see PCO D3	800 mw min.	~~1415~~ 1415	N/A	1187	1344	1302
	+4 dBm Input	800 mw min.	1415	N/A	1187	1344	1365
Step 7	+15 Volt Input Current	50 ma max	N/A	N/A	N/A	N/A	N/A
3.2.2 (b)	Non-Coherent Characteristics	Limits					
Step 2	Non-coherent Output Power	800 mw min.	1399	1281	1187	~~1344~~ 1281	1323
Step 3	Input Currents						
	Input Voltage (DC)	Limit (ma)					
	+28	340 max.	210	220	260	~~260~~ 250	270
	-15 (Bias)	3 max.	0.05	0.05	0.05	0.05	0.05
	+15	120 max.	86	86	86	~~58~~ 86	86
	ADD. SEE PCO D3						
		QA ACCEPTANCE	9/23/7[illegible]	9/29/7[illegible]	9-29-77	[illegible]	9-30-7[illegible]

				TEMP	TEMP	TEMP	TEMP	F...
3.2.2 (b) (cont)								
* Step 4	Collector Current - Engineering information							
	Item	Engineering Limits						
	Q8	0.09 - 0.23 V on Test Set DVM			N/A			-0.176
	Q2	0.23 - 0.46 V " " " "						-0.445
	Q3	0.10 - 1.70 V " " " "						-1.164
3.2.2 (c)	Temperature Monitor							
	Temperature	TLM Output Limits						
	Ambient	1.5 to 3.5 VDC		N/A	N/A	N/A	N/A	1.927
	Low	2.0 to 5.0 VDC	N/A	N/A		N/A		N/A
	High	0.5 to 2.5 VDC	N/A		N/A		N/A	N/A
	Unit Temperature	°F	←			N/A	→	76°F
3.2.2 (d)	Oscillator Frequency							
Step 3	Actual Frequency (F15) ±66khz (F15) = 2.2725 ghz for -1 unit. ✓ [V]	2.272-	←			N/A	→	2272 501
	(F15) = 2.2775 ghz for -2 unit. ✓ [N/A]	2.277-	N/A				→	N/A

(3)

* NOTE 1) DVM INDICTION WILL BE NEGATIVE.
2) COLLECTOR CURRENTS ARE FOR ENGINEERING INFORMATION ONLY. TOLERANCE LIMITS NOT APPLICABLE DURING HIGH/LOW TEMPERATURE TEST.

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1		POST VIB	TEMP ALT	TEMP VAC	TEMP VAC	POST ENV	(A)
3.2.2 (b) (cont)								
* Step 4	Collector Current - Engineering Information							
	Item / Engineering Limits							
	Q8 0.09 - 0.23 V on Test Set DVM		-0.126	N/A	-.153	-0.132	-0.120	
	Q2 0.23 - 0.46 V " " " "	NOTE(2)	-0.457	N/A	-.494	-0.492	-0.460	
	Q3 (-0.10 - 1.70 V ") " " "	see (CODE)	-1.22	N/A	-1.266	-1.291	-1.26	
3.2.2 (c)	Temperature Monitor							
	Temperature / TLM Output Limits							
	Ambient 1.5 to 3.5 VDC		2.066	1.864	N/A	N/A	1.97	
	Low 2.0 to 5.0 VDC		N/A	N/A	N/A	3.908	N/A	
	High 0.5 to 2.5 VDC		N/A	N/A	1.20	N/A	N/A	
	Unit Temperature	°F	N/A	79°F	111	16°F	75°F	(B)
3.2.2 (d)	Oscillator Frequency							
Step 3	Actual Frequency (F15) ±66khz							
	(F15)=2.2725 ghz for -1 unit. ✓ [✓]	2.272-	2.272 504	2.272 503	2.272 491	2.272 517	2.272 505	
	(F15)=2.2775 ghz for -2 unit. ✓ [N/A]	2.277-	N/A	→	→	→	N/A	

* NOTE 1) DVM INDICATION WILL BE NEGATIVE

2) COLLECTOR CURRENTS ARE FOR ENGINEERING INFORMATION ONLY. TOLERANCE LIMITS NOT APPLICABLE DURING HIGH/LOW TEMP VACUUM TEST.

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1			FINAL FAB	CYCLE 1 HI-TEMP	CYCLE 1 LO-TEMP	CYCLE 8 HI-TEMP	CYCLE 8 LO-TEMP	T/C / PRE ENV
3.2.2 (e)	**Modulation Characteristics**								
	Freq KHz	Mod. Ind. Radians	All Conditions						
	100	1.45	3.088 - 4.632						3.872
	100	2.0	4.264 - 6.396						5.210
	100	2.4	5.136 - 7.704						6.495
	500	1.45	3.088 - 4.632						3.820
	500	2.0	4.264 - 6.396			N/A			5.161
	500	2.4	5.136 - 7.704						6.430
	1100	1.45	3.088 - 4.632						3.685
	1100	2.0	4.264 - 3.396						4.780
	1100	2.4	5.136 - 7.704						5.870
Step 7	**Sideband Symmetry**								
	Mod. Index	Limits							
	1.45	≤10%					N/A		2%
	2.0	≤10%							2%
	2.4	≤10%							3%

QA ACCEPTANCE

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1			POST VIB	TEMP ALT	HI-TEMP VAC	LO-TEMP VAC	POST ENV
3.2.2 (e)	Modulation Characteristics							
	Freq KHz	Mod. Ind. Radians	All Conditions					
	100	1.45	3.088 - 4.632	3.769	N/A	4.062	3.331	3.640
	100	2.0	4.264 - 6.396	4.990	N/A	5.450	4.538	4.971
	100	2.4	5.136 - 7.704	6.152	N/A	6.732	5.463	6.015
	500	1.45	3.088 - 4.632	3.675	N/A	3.914	3.385	3.605
	500	2.0	4.264 - 6.396	4.878	N/A	5.304	4.583	4.986
	500	2.4	5.136 - 7.704	6.153	N/A	6.410	5.478	6.016
	1100	1.45	3.088 - 4.632	3.527	N/A	3.696	3.663	3.484
	1100	2.0	4.264 - 6.396	4.610	N/A	4.984	4.493	4.826
	1100	2.4	5.136 - 7.704	5.807	N/A	5.933	5.934	5.769
Step 7	Sideband Symmetry							
	Mod. Index	Limits						
	1.45	≤10%		2.0%	N/A	4%	3%	2%
	2.0	≤10%		1.0%	N/A	4%	1%	1%
	2.4	≤10%		2%	N/A	4%	3%	1%

QA ACCEPTANCE

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1	FINAL FAB	CYCLE 1 HI-TEMP	CYCLE 1 LO-TEMP	CYCLE 8 HI-TEMP	CYCLE 8 LO-TEMP	POST T/C / PRE ENV
3.2.2 (f)	Spurious Response (Modulation Off)						
Step 1	Limit: ≥45 dB below carrier	←	—	N/A	—	→	>76
3.2.2 (g)	Mismatched Load Test (Modulation Off)						
	Limit						>60
Step 4	Spurious Response ≥45 dB below carrier	←	—	—	N/A	→	>45
3.2.2 (h)	Mode Switching Levels						
Step 1	Non-Coherent Limit: More positive than -5.0 mv	←	—	—	N/A	→	0.0
Step 2	Coherent Limit: ~~+5.0~~ 6.5 mv max. (see pg D-5)	←	—	—	N/A	→	4.29
3.2.4	Bonding Resistance						
	J1 0.010 Ω Max	N/A	N/A	N/A	N/A	N/A	N/A
	J2 0.010 Ω Max	N/A	N/A	N/A	N/A	N/A	N/A
	J3 0.010 Ω Max	N/A	N/A	N/A	N/A	N/A	N/A
	J4 0.010 Ω Max	N/A	N/A	N/A	N/A	N/A	N/A

QA ACCEPTANCE 5/25/7

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1		POST VIB	TEMP ALT	HI-TEMP VAC	LO-TEMP VAC	POST ENV
3.2.2 (f)	Spurious Response (Modulation Off)						
Step 1	Limit: ≥45 dB below carrier		760	760	760	760	760
3.2.2 (g)	Mismatched Load Test (Modulation Off)						
	Limit						
Step 4	Spurious Response ≥45 dB below carrier		760	N/A	760	760	760
3.2.2 (h)	Mode Switching Levels						
Step 1	Non-Coherent Limit: More positive than -5.0 mv		0.0	N/A	0.00	0.00	0.0
Step 2	Coherent Limit: +6.5 ~~+5.0~~ mv max. *-see pcn D5		3.91	N/A	4.02	3.77	4.00
3.2.4	Bonding Resistance						
	J1 0.010 Ω Max		N/A	N/A	N/A	N/A	0.006
	J2 0.010 Ω Max		N/A	N/A	N/A	N/A	0.008
	J3 0.010 Ω Max		N/A	N/A	N/A	N/A	0.008
	J4 0.010 Ω Max		N/A	N/A	N/A	N/A	0.006
	QA ACCEPTANCE						

C/N 3-25 2nd ACCEPTANCE TEST
(INT. RETURN)
([illegible] 10-23-78)

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1		FINAL FAB	CYCLE 1 HI TEMP	CYCLE 1 LO TEMP	CYCLE 8 HI TEMP	CYCLE 8 LO TEMP	POST T/C / PRE ENV.
3.2.2 (a)	Bandpass Characteristics							
Step 5	Bandwidth (for reference only) -1 dB Bandpass	(No	19.03	18.32	18.72	18.3	18.7	19.0
	-3 dB Bandpass	Limits)	32.41	31.20	31.90	31.2	31.9	32.9
Step 6	Coherent Output Power	Limits						
	-5 dBm Input	800 mw min.	1330	925	1440	940	1460	1345
	+4 dBm Input	800 mw min.	1370	955	1500	955	1470	1375
Step 7	+15 Volt Input Current	50 ma max	41	N/A	N/A	N/A	N/A	N/A
3.2.2 (b)	Non-Coherent Characteristics	Limits						
Step 2	Non-coherent Output Power	800 mw min.	1360	955	1465	965	1465	1360
Step 3	Input Currents							
	Input Voltage (DC)	Limit (ma)						
	+28	340 max.	250	205	280	210	280	250
	-15 (Bias)	3 max.	0.0	0.0	0.0	0.0	0.0	0.05
	+15	120 max.	102	101	102	101	102	101
		QA ACCEPTANCE	613 OCT 16 1978	613 OCT 1978	613 OCT 1978	613 OCT 1978	219 10/17/8	613 OCT 17 1978

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1		TEST PHASE: POST VIB	TEMP ALT	HI-TEMP VAC	LO-TEMP VAC	POST ENV (Unit)
3.2.2 (a)	Bandpass Characteristics						
Step 5	Bandwidth (for reference only)	-1 dB Bandpass (No Limits)	19.0	N/A	N/A PER I.O.C.	N/A PER I.O.C.	18.9
		-3 dB Bandpass (No Limits)	31.9	N/A	N/A PER I.O.C.	N/A PER I.O.C.	33.9
Step 6	Coherent Output Power	Limits					
	-5 dBm Input	800 mw min.	1300	N/A	N/A PER I.O.C.	N/A PER I.O.C.	1424
	+4 dBm Input	800 mw min.	1390	N/A	N/A PER I.O.C.	N/A PER I.O.C.	1446
Step 7	+15 Volt Input Current	50 ma max	N/A	N/A	N/A	N/A	N/A
3.2.2 (b)	Non-Coherent Characteristics	Limits					
Step 2	Non-coherent Output Power	800 mw min.	1340	1296	N/A PER I.O.C.	N/A PER I.O.C.	1484
Step 3	Input Currents						
	Input Voltage (DC)	Limit (ma)					
	+28	340 max.	245	240	N/A PER I.O.C.	N/A PER I.O.C.	240
	-15 (Bias)	3 max.	0.05	0.05	N/A PER I.O.C.	N/A PER I.O.C.	0
	+15	120 max.	101	101	N/A PER I.O.C.	N/A PER I.O.C.	102
	QA ACCEPTANCE		613 OCT 17	613 OCT 18 1973	613 OCT 17 1973	613 OCT 17 1973	10-23-73

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PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1			TEST PHASE: CYCLE 1 HI TEMP	CYCLE 1 LO TEMP	CYCLE 2 HI TEMP	CYCLE 2 LO TEMP	POST T/C / PRE ENV.
3.2.2 (a)	Bandpass Characteristics							
Step 5	Bandwidth (for reference only) -1 dB Bandpass	(No Limits)		21.4	22.04	22.07	22.1	
	-3 dB Bandpass	(No Limits)		35.6	34.05	35.34	35.0	
Step 6	Coherent Output Power	Limits						
	-5 dBm Input	800 mw min.		972	1530	1008	1620	
	+4 dBm Input	800 mw min.		1010	1638	1026	1710	
Step 7	+15 Volt Input Current	50 ma max		N/A	N/A	N/A	N/A	N/A
3.2.2 (b)	Non-Coherent Characteristics	Limits						
Step 2	Non-coherent Output Power	800 mw min.		1008	1611	1008	1656	N/A PER I.O.C.
Step 3	Input Currents							
	Input Voltage (DC)	Limit (ma)						
	+28	340 max.		210	285	215	285	
	-15 (Bias)	3 max.		0	0	0.05	0.05	
	+15	120 max.		110	102	102	103	
QA ACCEPTANCE				10-19-78	10-20-78	10-21-78	613 OCT 22 1978	613 OCT 17 1978

THERMAL VACUUM TEST PER I.O.C. DSCS-EQ-107

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1			TEST PHASE: FINAL FAB	CYCLE 1 HI-TEMP	CYCLE 1 LO-TEMP	CYCLE 8 HI-TEMP	CYCLE 8 LO-TEMP	POST T/C / PRE ENV
3.2.2 (e)	Modulation Characteristics								
	Freq KHz	Mod. Ind. Radians	All Conditions						
	100	1.45	3.088 - 4.632	3.947	4.143	3.469	4.158	3.485	3.990
	100	2.0	4.264 - 6.396	5.380	5.645	4.720	5.685	4.742	5.409
	100	2.4	5.136 - 7.704	6.550	6.927	5.727	6.926	5.798	6.562
	500	1.45	3.088 - 4.632	4.000	4.090	3.698	4.098	3.685	4.022
	500	2.0	4.264 - 6.396	5.468	5.575	5.000	5.618	4.993	5.508
	500	2.4	5.136 - 7.704	6.615	6.833	6.000	6.848	6.000	6.672
	1100	1.45	3.088 - 4.632	4.101	4.308	3.600	4.335	3.594	4.173
	1100	2.0	4.264 - 6.396	5.607	5.869	4.910	5.895	4.888	5.728
	1100	2.4	5.136 - 7.704	6.850	7.158	5.961	7.207	5.984	6.960
Step 7	Sideband Symmetry								
	Mod. Index	Limits							
	1.45	≤10%		1%	1%	2%	<1%	3%	1%
	2.0	≤10%		1%	1%	3%	<1%	3%	1%
	2.4	≤10%		<1%	<1%	<1%	<1%	3%	1%

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PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1			TEST PHASE: POST VIB	TEMP ALT	HI-TEMP VAC	LO-TEMP VAC	POST ENV
3.2.2 (e)	Modulation Characteristics							
	Freq KHz	Mod. Ind. Radians	All Conditions					
	100	1.45	3.088 - 4.632	3.921	N/A	N/A PER I.O.C.	N/A PER I.O.C.	3.704
	100	2.0	4.264 - 6.396	5.362	N/A			5.3
	100	2.4	5.136 - 7.704	6.512	N/A			7.043
	500	1.45	3.088 - 4.632	4.004	N/A			4.036
	500	2.0	4.264 - 6.396	5.475	N/A			5.466
	500	2.4	5.136 - 7.704	6.657	N/A			7.060
	1100	1.45	3.088 - 4.632	4.245	N/A			4.245
	1100	2.0	4.264 - 6.395	5.784	N/A			5.734
	1100	2.4	5.136 - 7.704	7.025	N/A			7.023
Step 7	Sideband Symmetry					SEE NEXT PAGE	SEE NEXT PAGE	
	Mod. Index	Limits						
	1.45	≤10%		1%	N/A			1%
	2.0	≤10%		1%	N/A			1%
	2.4	≤10%		1%	N/A	613	613	1%

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PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1			TEST PHASE: FINAL FAB	CYCLE 1 HI-TEMP	CYCLE 1 LO-TEMP	CYCLE 2 HI-TEMP	CYCLE 2 LO-TEMP	POST T/C / PRE ENV
3.2.2 (e)	Modulation Characteristics								
	Freq KHz	Mod. Ind. Radians	All Conditions						
	100	1.45	3.088 - 4.632	N/A PER I.O. TCR	4.231	3.994	4.292	3.8[illegible]	N/A PER I.O. TCR
	100	2.0	4.264 - 6.396		5.8014	5.115	5.854	5.227	
	100	2.4	5.136 - 7.704		7.0[illegible]	6.[illegible]	7.112	6.313	
	500	1.45	3.088 - 4.632		4.235	3.926	4.251	3.7[illegible]	
	500	2.0	4.264 - 6.396		5.979	5.049	5.807	5.118	
	500	2.4	5.136 - 7.704		7.0[illegible]	6.[illegible]50	7.073	6.105	
	1100	1.45	3.088 - 4.632		4.434	3.626	4.385	3.643	
	1100	2.0	4.264 - 6.396		6.021	4.944	6.029	4.995	
	1100	2.4	5.136 - 7.704		7.318	6.[illegible]	7.334	6.068	
Step 7	Sideband Symmetry								
	Mod. Index	Limits							
	1.45	≤10%			0 %	1 %	<1%	2%	
	2.0	≤10%			0 %	1.5%	<1%	2%	
	2.4	≤10%			0 %	2 %	<1%	2%	
			QA ACCEPTANCE	(613) OCT 17 1978	10-19-75	10-[illegible]	10-21-75	OCT 2[illegible] 1978	(613) OCT 17 1978

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1	TEST PHASE: FINAL FAB	CYCLE 1 HI-TEMP	CYCLE 1 LO-TEMP	CYCLE 8 HI-TEMP	CYCLE 8 LO-TEMP	POST T/C / PRE ENV	
3.2.2 (b) (cont)								(A)
* Step 4	Collector Current - Engineering information							
	Item — Engineering Limits							
	Q8 — 0.09 - 0.23 V on Test Set DVM	-0.166	-0.162	-0.165	-0.162	-0.166	-0.169	
	Q2 — 0.23 - 0.46 V " " " "	-0.444	-0.393	-0.460	-0.398	-0.460	-0.456	
	Q3 — 0.10 - 1.70 V. " " " "	-1.106	-0.898	-1.276	-0.918	-1.279	-1.121	
3.2.2 (c)	Temperature Monitor							
	Temperature — TLM Output Limits							
	Ambient — 1.5 to 3.5 VDC	2.122	N/A	N/A	N/A	N/A	2.126	
	Low — 2.0 to 5.0 VDC	N/A	N/A	4.031	N/A	4.10	N/A	
	High — 0.5 to 2.5 VDC	N/A	1.32	N/A	1.309	N/A	N/A	
	Unit Temperature °F	72°	110°	14°	112°	13°	72°	(B)
3.2.2 (d)	Oscillator Frequency							
Step 3	Actual Frequency (F15) ± 66 KHz (F15) = 2.2725 ghz for -1 & -3 unit. 2.272-	2.272 500.1	2.272 454	2.272 512	2.272 443	2.272 512	2.272 501	
	(F15) = 2.2775 ghz for -2 & -4 unit. 2.277-	N/A	→	→	→	→	N/A	

NOTE: 1) DVM INDICATION WILL BE NEGATIVE
2) COLLECTOR CURRENTS ARE FOR ENGINEERING INFORMATION ONLY, TOLERANCE LIMITS NOT APPLICABLE DURING HIGH/LOW TEMPERATURE TEST.

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1		TEST PHASE: POST VIB	TEMP ALT	HI-TEMP VAC	LO-TEMP VAC	POST ENV	
3.2.2 (b) (cont)								(A)
* Step 4	Collector Current - Engineering information							
	Item	Engineering Limits						
	Q8	0.09 - 0.23 V on Test Set DVM	-0.168	N/A	N/A PER I.O.C.	N/A PER I.O.C.	-0.171	
	Q2	0.23 - 0.46 V " " " "	-0.453	N/A			-0.450	
	Q3	0.10 - 1.70 V " " " "	-1.105	N/A			-1.114	
3.2.2 (c)	Temperature Monitor							
	Temperature	TLM Output Limits						
	Ambient	1.5 to 3.5 VDC	2.003	1.92	N/A	N/A	2.18	
	Low	2.0 to 5.0 VDC	N/A	N/A	N/A	(	N/A	
	High	0.5 to 2.5 VDC	N/A	N/A	(	N/A	N/A	
	Unit Temperature	°F	N/A	78°			75°	(B)
3.2.2 (d)	Oscillator Frequency							
Step 3	Actual Frequency (F15) ± 66 KHz (F15) = 2.2725 ghz for -1&-3 unit.	2.272-	2.272 500	2.272 500			2.272 503	
	(F15) = 2.2775 ghz for -2&-4 unit	2.277-	N/A				N/A	

*NOTE 1) DVM INDICATION WILL BE NEGATIVE

2) COLLECTOR CURRENTS ARE FOR ENGINEERING INFORMATION ONLY, TOLERANCE LIMITS NOT APPLICABLE ~~DURING HIGH/LOW-TEMP VACUUM TEST.~~

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1	FINAL FAB	CYCLE 1 HI-TEMP	CYCLE 1 LO-TEMP	CYCLE 2 HI-TEMP	CYCLE 2 LO-TEMP	POST T/C / PRE ENV.
3.2.2 (b) (cont)							
* Step 4	Collector Current - Engineering information						
	Item — Engineering Limits						
	Q8 — 0.09 - 0.23 V on Test Set DVM		-0.1879	-0.182	-0.171	-0.183	
	Q2 — 0.23 - 0.46 V " " " "		-0.3983	[illegible]	-0.460	-0.556	
	Q3 — 0.10 - 1.70 V " " " "		-0.6757	[illegible]	-1.001	-1.383	
3.2.2 (c)	Temperature Monitor						
	Temperature — TLM Output Limits						
	Ambient — 1.5 to 3.5 VDC		N/A	N/A	N/A	N/A	
	Low — 2.0 to 5.0 VDC	N/A	N/A	3.82	N/A	3.84	
	High — 0.5 to 2.5 VDC	N/A	1.22	N/A	1.24	N/A	
	Unit Temperature °F		111°	10°	110°	15°	
3.2.2 (d)	Oscillator Frequency						
Step 3	Actual Frequency (F15) ± 66 KHz (F15) = 2.2725 ghz for -1 & -3 unit. 2.272-		-10KHz	-10KHz	2.272 [illegible]	2.272 [illegible]	
	(F15) = 2.2775 ghz for -2 & -4 unit. 2.277-		N/A	N/A	—	N/A	

(A)

(B)

N/A PER I.O.C. TCP

NOTE: 1) DVM INDICATION WILL BE NEGATIVE
2) COLLECTOR CURRENTS ARE FOR ENGINEERING INFORMATION ONLY. TOLERANCE LIMITS NOT APPLICABLE. DURING HIGH/LOW TEMPERATURE TEST.

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PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1	TEST PHASE: FINAL FAB	CYCLE 1 HI-TEMP	CYCLE 1 LO-TEMP	CYCLE 2 HI-TEMP	CYCLE 2 LO-TEMP	POST T/C / PRE ENV
3.2.2 (f)	Spurious Response (Modulation Off)						
Step 1	Limit: ≥45 dB below carrier	>60	>60	>60	>60	>60	>60
3.2.2 (g)	Mismatched Load Test (Modulation Off)						
	Limit						
Step 4	Spurious Response ≥45 dB below carrier	>60	>60	>50	>60	>50	>60
3.2.2 (h)	Mode Switching Levels						
Step 1	Non-Coherent Limit: More positive than -5.0 mv	0.00	0.00	0.00	0.00	0.00	0.08
Step 2	Coherent Limit: +6.5 mv max.	4.24	4.28	4.18	4.24	4.18	3.96
3.2.2 (i)	J4 Input Return LOSS						
Step 2	≥5.5db	10.0	N/A	N/A	N/A	N/A	N/A
	QA ACCEPTANCE						

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1	TEST PHASE: FINAL FAB	CYCLE 1 HI-TEMP	CYCLE 1 LO-TEMP	CYCLE 2 HI-TEMP	CYCLE 2 LO-TEMP	POST T/C / PRE ENV
3.2.2 (f)	Spurious Response (Modulation Off)						
Step 1	Limit: ≥45 dB below carrier	TCRP	>60	>60	>60	>60	TCRP
3.2.2 (g)	Mismatched Load Test (Modulation Off)						
	Limit						
Step 4	Spurious Response ≥45 dB below carrier		>60	>60	>60	>60	
3.2.2 (h)	Mode Switching Levels	N/A PER I.C.					N/A PER I.C.
Step 1	Non-Coherent Limit: More positive than -5.0 mv		0.00	0.00	0.00	0.00	
Step 2	Coherent Limit. +6.5 mv max.		[illegible]	[illegible]	4.04	3.94	
3.2.2 (i)	J4 Input Return LOSS						
Step 2	≥5.5db		N/A	N/A	N/A	N/A	N/A
	QA ACCEPTANCE						

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3-25 INT. RETURN

PARA NO.	3.2 FUNCTIONAL TEST DATA SHEET #1	Limit	POST VIB	TEMP ALT	HI-TEMP VAC	LO-TEMP VAC	POST ENV
3.2.2 (f)	Spurious Response (Modulation Off)						
Step 1	Limit: ≥45 dB below carrier		>60	>60	N/A PER I.O.C.	N/A PER I.O.C.	>60
3.2.2 (g)	Mismatched Load Test (Modulation Off)						
Step 4	Spurious Response	≥45 dB below carrier	>60	N/A			>60
3.2.2 (h)	Mode Switching Levels						
Step 1	Non-Coherent Limit:	More positive than -5.0 mv	0.00	N/A			0.00
Step 2	Coherent Limit:	+6.5 mv max.	2.96	N/A			4.32
3.2.	J4 Input Return LOSS						
Step 2		≥5.5db	N/A	N/A	N/A	N/A	11 db

QA ACCEPTANCE

APPENDIX B

Tabulation of Unit Failure
Histories for DSCS II, DSP
Particles and Fields Satellite
TT&C Transmitters, Converters
Dual Baseband Assemblies

	No Power	Low Power	Fluctuating Power	Modulation	Bandpass on Spurs	Other
2-1	No non-coho power added longer temp soak T/V		Discontinuities corrected by tuning QUAL T/V		Non-symmetrical bandpass corrected by tuning T/V Spurs corrected by tuning T/V	
3-2			Intermittent caused by a faulty connector INT			
3-5					Bandpass incorrect, corrected by tuning AMB Spurs corrected by tuning T/V	
3-6					Discontinuities in bandpass caused by procedure VIB	
3-7			Discontinuities corrected by tuning VIB			Crystal intermittent corrected by tuning INT
3-8					Frequency OCT: wrong crystal VIB Discontinuities variable caps T/V Spurs corrected by alignment T/V	
3-9					Bandpass break-up caused by poor workmanship VIB	

	No Power	Low Power	Fluctuating Power	Modulation	Bandpass on Spurs	Other
3-10					Spurs use-as-is INT Spurs use-as-is INT	
3-11					Bandpass break-up caused by test equipment VIB Bandpass break-up corrected by tuning T/V	
3-12					Discontinuties corrected by tuning T/V Spurs use-as-is INT - T/V Spurs corrected by tuning VIB Spurs caused by worn variable caps T/V	
3-13			High power variable caps AMB		Improper band-pass corrected by tuning T/V Improper band-pass corrected by tuning T/V Discontinuties corrected by tuning T/V Spurs corrected by tuning T/V Spurs corrected by tuning T/V	
3-14		Slight drop due to T1 tap broken INT				No current (inpu duc to broken cap VIB

	No Power	Low Power	Fluctuating Power	Modulation	Bandpass on Spurs	Other
3-15		Slight drop due to TI tap broken INT		Modulation OOT TI tap cold worked T/V Modulation OOT corrected by tuning T/V		Bonding resistance caused by workmanship AMB
3-16		Low power; procedure change INT		Modulation OOT corrected by tuning INT Modulation OOT due to a workmanship problem T/V	Spurs corrected by tuning T/V	
3-18						Heat sink temp low due to test equipment T/V
3-19		Low power due to procedure problems INT	Degraded power during vibration due to variable caps VIB	Modulation OOT corrected by tuning T/V Modulation OOT due to handling AMB	Spurs corrected by tuning AMB Bandpass break-up corrected by tuning T/V Bandpass break-up corrected by tuning T/V	
3-20			Inconsistent sylgard on caps data review Power fluctuation corrected by ECP 106 INT		Bandpass break-break-8- due to sylgard on caps T/V	High current due to test equipment T/V High current; non repeatable T/A C/N OOT: use INT NOISE Pedestal OOT use INT C/N OOT; use INT
3-21					Spurs use-as-is INT occurred 6 times	

	No Power	Low Power	Fluctuating Power	Modulation	Bandpass on Spurs	Other
3-22			Intermittent worn variable caps AMB Intermittent; worn variable caps AMB			
3-23		Low power due to corona T/V	Marginal power, drifting down corrected by ECP 106			
3-24						Low gain in PWR A[illegible] corrected by design changes AMB Instability in neutralized buffer corrected by design changes AMB
3-25		Low power due to variable cap wearout AMB Low power due to possible pith ball contamination AMB Power degraded; unknown INT - T/V				
3-26		Power degraded; unknown INT			Incorrect bandpass; incorrect capacitor AMB	
3-27		.02 watts worn variable caps AMB		Modulation Ou[illegible], design TEMP		High current due to miswire AMB
3-28		Low power corrected by tuning AMB				

	No Power	Low Power	Fluctuating Power	Modulation	Bandpass or Spurs	Other
3-29			Intermittent; variable caps and crystal AMB			
3-30		Low power corrected by tuning TEMP			Spurs corrected by tuning TEMP Spurs corrected by tuning TEMP	High +15 current; variable caps wearout AMB
3-31		Low power corrected by tuning AMB Low power corrected by tuning INT			Non-symmetrical bandpass due to variable caps AMB	Oscillator failed to start - design AMB
3-32		Low power corrected by tuning AMB				Pressure guage malfunction test equipment T/V
3-33		Low power corrected by tuning AMB Low power due to possible corona INT - T/V		Modulation OOT; FEI crystal AMB		
3-34		Low power corrected by tuning AMB Low power caused by test procedure INT		Modulation OOT; variable caps TEMP Modulation COT due to FEI crystal TEMP Modulation not stable due to variable caps TEMP		Oscillator failed to start design AMB

Attachment 2

	DSCS II			DSP		
	No Power	Low Power	Fluctuating Power	No Power	Low Power	Fluctuating Power
Tuning		7	2	7	12	3
Variable Capacitors		2	6		3	5
Operator/ Procedure/ Workmanship	1	3		2	4	
Design Problems			3			
Corona		2		5	6	
Parts (Other than Capacitors)			1	1	1	5
Outgassing Moisture				2	1	
T1 XFormer TAP Broken		2				
Loose Locking Screw on T2				1		
Induced Failure				1		1
Pith Ball Contamination		1				
Unknown/ Unverified		2		1	2	
TOTAL	1	19	12	20	29	14

	No Power	Low Power	Fluctuating Power	Modulation	Bandpass on Spurs	Other
-1		Low power due to noisy variable caps QUAL Low power, procedure QUAL Low power; mishandling ACC	Intermittent; variable caps ACC	Modulation OOT parts BENCH Modulation OOT corrected by tuning ACC	Frequency OOT procedure QUAL	
?-2	No output; tuning EE				Spurs; variable caps QUAL Bandwith OOT unconfirmed ACC Bandwith OOT unconfirmed ACC Bandpass in-correct; tuning ACC Bandpass erra-tic tuning QUAL	Various problems wrong test cables ACC
003	No output E-B open PT4-7204-02 XSISTOR BENCH No output; operator BENCH	Low power; tuning ACC Very low power; tuning ACC	Intermittent; tuning BENCH Intermittent tuning BENCH			
		Low power corrected by tuning BURN-IN		Modulation OOT corrected by tuning ACC	Bandpass in-correct; corrected by tuning ACC Spurs correc d by tuning ACC	
005	No output, corona ACC No output; converter-induced failure EE No ouput corrected by tuning ACC	Low power variable cap BENCH Low power corrected by tuning BENCH Low power corrected by tuning BENCH Low power corona ACC			Bandpass break-up corrected by tuning ACC	

DSP

Attachment 3

	No Power	Low Power	Fluctuating Power	Modulation	Bandpass on Spurs	Other
006		Low output corona ACC	Intermittent variable caps ACC	Modulation OOT corrected by tuning ACC Modulation OOT not verified ACC	Bandpass incorrect, test equipment ACC Spurs corrected by tuning ACC Bandpass incorrect, corrected by tuning ACC	Voltage OOT test equipment ACC
007	No output corrected by tuning BENCH No output corrected by tuning BENCH	Low power corona ACC Low power corona ACC Low power corrected by tuning ACC	Intermittent corrected by tuning BENCH	Modulation OOT cold solder joint ACC		High current damaged wire ACC
008		Low power corrected by tuning ACC Low power corona ACC	Intermittent loose diode ACC			Current OOT spec change ACC
009		Low power corrected by tuning BENCH				Current OOT spec change ACC
010					Spurs corrected by tuning ACC	
011	No power test set-up T/A No power corona T/A				Bandpass break-up corrected by tuning T/V Bandpass shift corrected by tuning AMB	
012	No output; loose ll locking screw VIB No power outgassing T/V	Low power corrected by tuning INT Low power corrected by tuning VIB	Intermittent; faulty XSISTOR AMB Intermittent; variable caps VIB Intermittent variable caps AMB Fluctuations-ANT S. JNT INT			

	No Power	Low Power	Fluctuating Power	Modulation	Bandpass on Spurs	Other
013	No output corona T/V	Low power corrected by tuning VIB				Possible damage in stores INT
014	No output moisture T/V No power unknown INT - T/V	Low power corrected by tuning VIB	Power increase broken feed- thru VIB	Modulation OOT variable caps AMB		
015		Low power not verified T/V		Modulation OOT shorted wire AMB		
016	No power corrected by tuning TEMP No power corona T/A	Low power outgassing T/A Low power bad XSISTOR T/A Low power variable caps AMB	Fluctuations faulty diode INT	Modulation OOT variable caps AMB Modulation OOT tuning or corona T/V	Bandpass break- up corrected by tuning TEMP	
017		Low power corona T/V		Modulation OOT corrected by tuning INT	Bandpass break- up corona T/V	
018	No power multipaction T/V	Low power due to poor workmanship INT	Fluctuations; faulty XSISTOR INT Intermittent variable caps AMB	Modulation OOT corrected by tuning	Spurs corona TEMP	Test equipment AMB
020	No output corrected by tuning T/V	Low output procedure T/V			Bandpass break- up corrected by tuning TEMP	
022	No output corrected by tuning T/V					

	No Power	Low Power	Fluctating Power	Modulation	Bandpass on Spurs	Other
024		Low power in work INT				
025				Modulation OOT aging varactor in work INT		Noise during VIB loose screw VIB; +28V not drawing current missing wire AMB
027					Bandpass break-up; variable cap VIB	
028					Unsymmetrical bandpass; design AMB	
029					Unsymmetrical bandpass design AMB; Spurs corrected by tuning INT	

APPENDIX C

DSCS II TT&C Transmitter

Integration and Test History

TT&C TRANSMITTER HISTORY FLT-1

Cum Hr	TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
0	IST 1	6-8-71	0.713	15.00	1.62	NO DATA	1.57	A	3-3	1
.6	IST 2	6-26-71	0.740	15.00	1.68	|	1.62			
.8	IST 3	7-2-71	0.723	15.00	1.50		1.62			
[illegible]	IST 4	7-18-71	0.735	15.00	1.55		1.58			
1.0	IST 5	7-25-71	0.750	15.00	1.59		1.60			
19	IST 6	9-3-71	0.735	15.00	1.57		1.60			
					$\bar{x} = 1.59$					
					$\sigma = .06$					
	IST 1			15.00	1.60		1.52	B	3-2	1
	IST 2			15.00	1.57		1.58			
	IST 3			15.00	1.49		1.51			
	IST 4			15.00	1.50		1.57			
	IST 5			15.00	1.59		1.52			
	IST 6			15.00	1.58		1.57			
					$\bar{x} = 1.56$					
					$\sigma = .05$					

TT&C TRANSMITTER HISTORY FLT-2

TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
1ST-1	7-9-71	0.69	15.02	1.13	NO DATA	1.60	A	3-5	2
1ST-2	7-23-71	0.74	15.03	1.06		1.57			
1ST-3	8-3-71	0.68	15.03	1.00		1.55			
1ST-4	8-9-71	0.693	15.03	1.13		1.54			
1ST-5	9-16-71	0.673	15.03	1.04		1.57			
				$\bar{x}$ = 1.07					
				σ = .06					
1ST 1			15.02	1.39		1.52	B	3-4	2
1ST 2			15.03	1.35		1.50			
1ST-3			15.03	1.30		1.50			
1ST-4			15.03	1.33		1.50			
1ST-5			15.03	1.27		1.50			
				$\bar{x}$ = 1.33					
				σ = .05					

TT&C TRANSMITTER HISTORY FLT-3

TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
1ST 1B	8-29-73	0.70	15.02	1.41	NO DATA	1.59	A	3-7	3
1ST 1C	5-22-73	1.27	15.02	1.38		1.58			
1ST 2C	6-19-73	1.27	15.02	1.34		1.54			
1ST 3C	7-13-73	1.26	15.01	1.40		1.52			
1ST 3C-2	7-30-73	1.26	15.01	1.43		1.54			
TV W	8-1-73	1.31	15.01	1.49		1.55			
TV E	8-1-73	1.30	15.01	1.47		1.58			
1ST 4C	8-4-73	1.26	15.02	1.42		1.54			
HAT 1ST	9-7-73	1.26	15.01	1.36		1.52			
				$\bar{x} = 1.41$	$\sigma = .05$				
1ST 1B			15.01	1.26		1.62	B	3-6	3
1ST 1C			15.01	1.32		1.58			
1ST 2C			15.02	1.29		1.57			
1ST 3C			15.02	1.31		1.52			
1ST 3C 2			15.01	1.32		1.54			
TV W			15.01	1.32		1.52			
TV E			15.01	1.31		1.60			
1ST 4C			15.02	1.31		1.54			
HAT 1ST			15.02	1.30		1.55			
				$\bar{x} = 1.30$					
				$\sigma = .02$					

TT&C TRANSMITTER HISTORY FLT 4

TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
1ST 1B	8-10-72	0.72	15.03	1.25	NO DATA	1.57	A	3-9	4
1ST 2B	9-5-72	0.718	15.03	1.27		1.58			
1ST 3B	10-12-72	0.695	15.02	1.30		1.53			
1ST 1C	5-9-73	1.24	15.02	1.36		1.58			
1ST 2C	6-7-73	1.31	15.03	1.39		1.57			
1ST 3C	6-30-73	1.30	15.02	1.39		1.48			
TV-W	6-23-73	1.30	15.03	1.42		1.52			
TV-F	6-25-73	1.32	15.03	1.62		1.58			
1ST 4C	7-5-73	1.31	15.03	1.49		1.52			
HAT 1	8-18-73	1.30	15.03	1.32		1.55			
				$\bar{x} = 1.38$	$\sigma = .11$				
1ST 1B			15.00	1.40		1.61	B	3-8	4
1ST 2B			15.00	1.30		1.60			
1ST 3B			15.00	1.30		1.57			
1ST 1C			15.00	1.37		1.57			
1ST 2C			15.00	1.33		1.59			
1ST 3C			15.00	1.36		1.47			
TV-W			15.00	1.38		1.56			
TV-F			15.00	1.47		1.60			
1ST 4C			15.00	1.44		1.52			
HAT 1			15.00	1.36		1.59			
				$\bar{x} = 1.37$	$\sigma = .06$				

TT&C TRANSMITTER HISTORY FLT 5

TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
IST 1	1-24-74	1.25	14.93	1.23	NO DATA	1.52	A	3-11	5
IST 2A	3-26-74	1.31	14.93	1.23		1.54			
IST 2B	6-14-74	1.25	15.00	1.23		1.50			
IST 3	7-23-74	1.25	15.00	1.23		1.50			
TV (W)	7-17-74	1.25	15.06	1.27		1.55			
TV E	7-19-74	1.27	15.06	1.29		1.50			
IST 3B	8-25-74	1.25	14.93	1.13		1.50			
TV (W)	8-27-74	—	15.06	1.18		1.50			
TV E	8-28-74	—	15.06	1.19		1.50			
IST 4	8-29-74	1.25	14.93	1.21		1.52			
HAT 1A	10-3-74	1.25	14.93	1.106		1.52			
HAT 1B	11-14-74	1.25	15.02	1.16	$\bar{X}=1.21$ $\sigma=.06$	1.56			
IST 1			15.06	1.45		1.55	B	3-10	5
IST 2A			15.06	1.36		1.60			
IST 2B			15.06	1.35		1.58			
IST 3			15.06	1.36		1.60			
TV (W)			15.06	1.43		1.76			
TV E			15.06	1.48		1.65			
IST 3B			15.06	1.29		1.57			
TV (W)			15.06	1.34		1.67			
TV E			15.06	1.27		1.64			
IST 4			15.10	1.27		1.60			
HAT 1A			15.06	1.21		1.52			
HAT 1B			14.93	1.23		1.52			

$\bar{X}=1.34$

$\sigma=.09$

TT&C TRANSMITTER HISTORY FLT-6

	TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
	1ST 1	3-23-74	1.29	15.10	1.27	NO-DATA	1.57	A	3-13	6
	1ST 2	4-1-74	1.29	15.00	1.24		1.58			
	1ST 2B	6-29-74	1.25	15.00	1.33		1.57			
ØI	1ST 3	8-1-74	1.24	15.00	1.29		1.54			
	TV-W	8-8-74	1.23	15.00	1.33		1.58			
	TV-E	8-10-74	1.27	15.00	1.36		1.58			
	1ST 4	8-12-74	1.26	15.00	1.40		1.54			
ØII	TV-W	8-14-74	1.26	15.13	1.38		—			
	TV-E	8-14-74	1.27	15.13	1.45		—			
	HAT 1	9-27-74	1.25	15.00	1.25		1.56			
					$\bar{x}$ = 1.33	σ = .07				
	1ST 1			15.00	1.33		1.57	B	3-12	6
	1ST 2			15.00	1.29		1.57			
	1ST 2B			15.00	1.27		1.57			
ØI	1ST-3			15.00	1.20		1.58			
	TV W			15.00	1.29		1.60			
	TV-E			15.00	1.35		1.60			
ØII	1ST-4			15.00	1.27		1.59			
	TV W			15.10	1.29		—			
	TV-E			15.00	1.35		—			
	HAT			15.00	1.22		1.60			

$\bar{x}$ 1.2[illegible]
σ .05

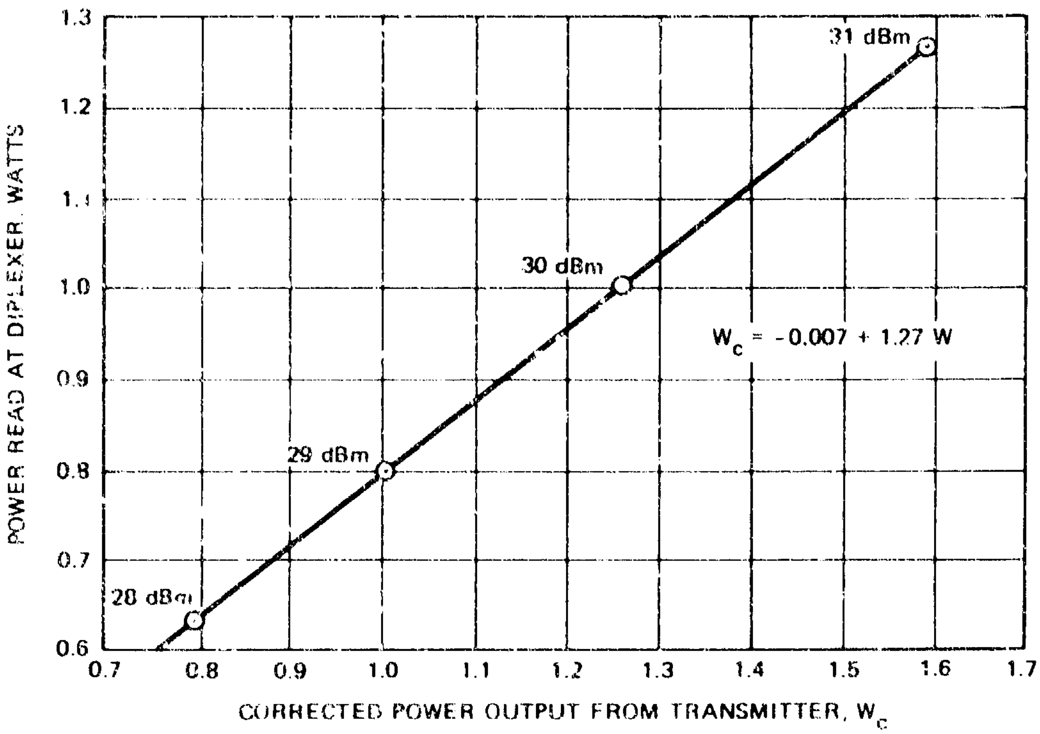

Figure C-1. Transmitter Output Power Correction for Flights 7 through 12

TT&C TRANSMITTER HISTORY FLT 7

TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
1ST 1	10-1-76	1.24	15.00	.77/.61	79°	1.55	A	S-1R	FLT 7
1ST 2	12-8-76	1.25	15.00	.88/.76	87°	1.54			
1ST 3	12-12-76	1.25	15.00	.94/.79	82°	1.55			
TV-E	12-21-76	1.24	15.0	1.16/.92	82°	1.50			
TV-W	12-23-76	1.25	15.13	1.02/.81	88°	1.47			
1ST 4	12-18-76	1.23	15.00	.91/.72	83°	1.56			
				$\bar{x}$ = .96					
				σ = .13					
1ST 1			15.00	1.10/.97	91°	1.18	B	3-18	FLT 7
1ST 2			15.00	1.03/.92	92°	1.57			
1ST 3			15.00	1.11/.98	72°	1.57			
TV-E			15.00	1.32/1.05	75°	1.58			
TV-W			15.13	1.34/1.06	92°	1.60			
1ST 4			15.00	1.17/.93	91°	1.59			
				$\bar{x}$ = 1.18					
				σ = .13					

TT&C TRANSMITTER HISTORY FLT 8

TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
IST 1	10-28-76	1.24	15.00	1.06/.84	77.4°	1.5[illegible]	A	3-14	8
IST 2	12-23-76	1.24	15.00	.98/.777	80.6°	1.60			
IST 3	1-6-77	1.20	15.00	.96/.763	77.4°	1.56			
TV-E	1-8-77	1.228	15.00	1.01/.80	74.4°	1.60			
TV-W	1-11-77	1.205	15.00	.96/.76	80.6°	1.60			
IST 4	1-13-77	1.216	15.00	.89/.70	81.4°	1.60			
ØII TV-E	1-16-77	1.20	15.00	.93/.74	76°	–			
TV-W	1-18-77	1.23	15.00	.87/.697	84°	–			
IST 2B	3-15-77	1.30	15.00	1.48/1.17	84°	1.59			
HIST 1	3-23-77	1.30	15.00	1.47/1.16	84°	1.50			
HIST 2	4-13-77	1.29	15.0[illegible]	1.49/1.14	80.6°	1.47			
		$\bar{x}_1 = .96$	$\sigma_1 = .06$	$\bar{x}_2 = 1.10$	$\sigma = .24$				
IST 1			14.93	1.06/.837	[illegible]°	1.48	B	3-17	[illegible]
IST 2			14.92	1.01/.804	[illegible]°	1.56			
IST 3			14.92	1.03/.82	86°	1.57			
TV-E			14.87	1.19/.95	77.4°	1.60			
TV-W			14.87	1.13/.70	[illegible]°	1.58			
IST 4			15.06	1.03/.92	[illegible]°	1.59			
ØII TV-E			15.06	1.19/.95	74°	–			
TV-W			15.06	1.10/.87	81°	–			
IST 2B			14.93	1.77/1.40	91°	1.58			
HIST 1			14.93	1.77/1.40	91°	1.57			
HIST 2			14.93	1.66/1.3[illegible]	87°	1.66			

$\bar{x}_1$ 1.09 $\bar{x}_2$ 1.27

σ_1 .07 σ_2 .[illegible]

TT&C TRANSMITTER HISTORY FLT-9

TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
1ST 1	6-3-77	1.27	14.94	1.10/.872	33°	1.60	A	3-21	7
1ST 1A	10-5-77	1.26	14.94	.93/.736	83°	1.60			
1ST 2	11-3-77	1.26	14.95	.93/.737	84°	1.60			
1ST 3	11-10 77	1.26	14.94	.89/.705	84°	1.55			
TV-E	11-13 77	1.28	14.95	1.19/.947	53.4°	1.60			
TV-W	11-15 77	1.27	14.95	1.13/.900	74.3°	1.58			
1ST 4	11-17-77	1.27	14.94	1.06/.845	36°	1.55			
				$\bar{x}$ = 1.03					
				σ = .12					
1ST 1		/	14.92	1.04/.833	36°	1.52	B	3-16	7
1ST 1A			14.92	1.06/.844	85°	1.54			
1ST 2			14.92	1.06/.845	85°	1.53			
1ST 3			14.92	1.06/.844	86°	1.49			
TV E			14.92	1.30/1.03	79.8°	1.50			
TV-W			14.95	1.22/.967	74.3°	1.54			
1ST 4			14.92	1.19/.947	86°	1.50			
				$\bar{x}$ = 1.13					
				σ = .10					

TT&C TRANSMITTER HISTORY FLT 10

XMTR	TEST	DATE	TT&C BUS I	CONV +15 V	[illegible]	TEMP	[illegible]	S/C	[illegible]
A	1ST 1	7-1-77	1.32	14.93	1.22/.97	93	1.60	F10	3-19
	1ST 1A	11-14-77	1.32	14.93	1.13/.90	87°	1.60		
	1ST 2	11-19-77	1.30	14.93	1.13/.90	87°	1.60		
	1ST 3	11-30-77	1.30	14.93	1.20/.95	87°	1.58		
	TV-EQ	12-03-77	-	14.93	1.37/1.09	88°	1.57		
	TV-WS	12-05-77	-	15.0[illegible]	1.28/1.02	90°	1.61		
	1ST-4	12-16-77	1.32	14.93	1.17/.93	85°	1.55		
					$\bar{x} = 1.21$				
					$\sigma = .09$				
B	1ST 1	7-1-77	1.32	14.94	1.17/.93	81°	1.645	F10	[illegible]
	1ST 1A	11-14-77	1.32	14.94	1.14/.87	84°	1.66		
	1ST 2	11-19-77	1.30	14.94	1.09/.87	84°	1.66		
	1ST 3	11-30-77	1.30	14.94	1.13/.90	86°	1.65		
	TV-EQ	12-03-77	-	15.07	1.13/.9[illegible]	91°	1.66		
	TV-WS	120577		15.07	.80/.64	82°	1.65		
	1ST-4	12-16-77	1.32	14.93	1.06/[illegible]	84°	1.53		
					$\bar{x} = 1.07$				
					$\sigma = .12$				

TT&C TRANSMITTER HISTORY FLT 11

	TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
	IST 1	4-2?-78	1.26	15.01	1.26/1.0	81°	1.54	A	~~3-2?~~	FLT-11
	IST 2	5-23-78	1.25	15.01	1.24/.933	87°	1.51		3-26	
	IST 3	6-?-78	1.28	15.01	1.21/.964	58°	1.47			
ΦI	TV-E	6-09-78	1.30	15.01	1.42/1.13	35°	–			
	TV-W	6-11-78	1.29	14.97	1.31/1.04	95°	–			
ΦII	TV E	7-7-78	–	15.01	1.24/.983	73.79°	1.47			
	TV W	7-9-78	–	15.01	1.14/.909	91°	1.47			
	IST 4	7-19-78	1.30	15.01	1.03/.815	86°	1.42 *			
					x̄ = 1.23	σ = .11				
	IST 1			14.97	1.19/.944	32°	1.62	B	3-20	FLT-1[illegible]
	IST 2			14.97	1.14/.906	33°	1.64			
	IST 3			14.9[illegible]	1.16/.9	[illegible]°	1.60			
ΦI	TV E			14.97	1.27/1.006	51°	–			
	TV W			14.97	1.23/.98	94°	–			
ΦII	TV E			14.97	1.31/1.04	77.39°	1.60			
	TV W			14.97	1.2[illegible]/1.0	59°	1.60			
	IS 4			14.96	1.27/1.0[illegible]	[illegible]	1.57			
					x̄ = 1.23	σ = .06				

* OUT OF TOLERANCE

TT&C TRANSMITTER HISTORY FLT-12

TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
1ST 1	5-11-78	1.208	14.97	.93/.739	79°	[illegible]	A	3-23	FLT-12
1ST 2	7-19-78	1.23	14.[illegible]7	1.37/1.09	87°	1.52			
1ST 3	7-25-78	1.[illegible]9	14.97	1.35/1.07	92°	1.50			
TV E		1.30	15.10	1.37/1.09	83°	1.50			
TV-W		1.29	15.10	1.40/1.11	92°	1.56			
1ST 4	7-31-78	1.30	14.97	1.49/1.18	85°	1.58			
				$\bar{x}$ = 1.32					
				σ = .20					
1ST 1			15.01	1.48/1.172	84°		E	3-24	FLT-12
1ST 2			15.14	1.11/[illegible]	7[illegible]°				
1ST 3			15.14	1.11/.886	78.[illegible]°				
TV-E			15.14	1.39/1.10	77.4°				
TV-W			15.14	1.23/.98	70.0				
1ST 4			15.01	1.23/.18	89°				
				$\bar{x}$ = 1.26					
				σ = .15					

TT&C TRANSMITTER HISTORY FLT-13

TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
1ST-1	3-31-79	1.23	15.02	.633/.394	79.2°	1.62	A	5-34	27
1ST-2	4-20-79	1.23	15.02	.622/.879	81.4°	1.60			
1ST-3	5-05-79	1.21	15.02	.567/.801	77.4°	1.60			
TV-W	5-06-79	1.25	15.02	.590/.832	94.8°	1.60			
TV-E	5-12-79	1.23	15.01	.688/.973	79.8°	1.60			
1ST-4	5-11-79	1.23	15.02	.654/.923	73.2°	1.62			
			$\bar{x}$ = .63 σ = .04	$\bar{x}$ = .88 σ = .06					
			Δ$\bar{x}$ =	.258					
			Δσ =	.018					
1ST-1	/	/	15.01	1.29/1.862	80.6	1.7	F	5-[illegible]	[illegible]
1ST-2			15.01	1.08/1.56	—	1.7			
1ST-3			15.01	1.125/1.625	75	1.62			
TV-W			15.01	.968/1.40	78.2	1.66			
TV-E			15.02	1.18/1.706	80.6	1.56			
1ST-4			15.01	1.11/1.604	77.8	1.61			
			$\bar{x}$ = 1.13 σ = .11	$\bar{x}$ = 1.63 σ = .15					
			Δ$\bar{x}$ =	.501					
			Δσ =	.04[illegible]					

F-14, XMTTR B.

TEST	DATE	TT&C BUS I	CONV +15V	XMTTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
IST 1	2-20-79	1.30	15.10	1.30/.915	78	1.60	B	3-29	F-14
IST 2	3-16-79	1.31	15.10	1.32/.929	87	1.60			
IST 3	3-24-79	1.31	15.10	1.26/.886	83	1.59			
TV Ø I	3-30-79	N/A	15.10	1.52/1.09	72	1.60			
IST 4	4-01-79	1.30	15.10	1.33/.929	82	1.61			
TV Ø II	4-04-79	1.29	15.10	1.50/1.05	74	N/A			
HIST I	7-17-79	1.28	15.10	1.26/.887	84	1.60			
HIST I R	8-23-79	1.28	15.10	1.32/.929	83	1.60			
				$\Delta\bar{x}$ = .399375					
				$\Delta\sigma$ = .027229					
		$\bar{x}$ 1.35		$\bar{x}$ = .952					
		σ .10		σ = .076					

TT&C TRANSMITTER HISTORY FLT 15

TEST	DATE	TT&C BUS I	CONV +15V	XMTR POWER	TEMP	MOD INDEX	XMTR	S/N	S/C
1ST-1	9-21-79	1.21	14.93	.866/1.209	80.6°	1.61	A	3-33	15
1ST-2	11-29-79	1.20	14.93	.876/1.22	79°	1.58		[illegible]	
TV 2	12-11-79	1.21	14.80	.903/1.26	79.8°	—			
1ST-3	12-14-79	1.21	15.06	.912/1.275	79.8°	1.59			
TV 1	12-18-79	—	15.06	.93/1.29	82°	1.60			
1ST 4	12-20-79	1.23	14.93	.93/1.27	77°	1.62			
HAT-1	2-07-80	1.27	14.93	1.46*	86°*	1.64*			
			$\bar{x}$ = .90 σ = .03	$\bar{x}$ = 1.29 σ = .09					
1ST-1			14.95	.806/1.15	14.4°	1.74	B	3-32	15
1ST-2			14.95	.787/1.12	79°	1.74			
TV-2			14.95	[illegible]/1.27	79.8°	—			
1ST 3			14.[illegible]	.856/1.23	86°	1.72			
TV 1			14.95	.891/1.27	82°	1.75			
1ST 4			14.95	.865/1.23	80.6°	1.74			
HAT 1			14.95	1.27	86°	1.70			
			$\bar{x}$ = .85 σ = .05	$\bar{x}$ = 1.20 σ = .08					

* UNIT CHANGE

APPENDIX D

Analysis of Variance of DSCS II

Transmitter Output Power Measurements

During Integration and Test

ONE-WAY ANALYSIS OF VARIANCE ON TRANSMITTER OUTPUT POWER

Objective: To determine if observed variation in transmitters is statistically significant.

Data: 30 normal populations, with equal variances
30 unequal sample sizes, one from each population

$$n_i \ (i = 1, 2, \ldots, 30)$$

$$N = n_1 + n_2 + \ldots + n_{30}$$

Null Hypothesis: $\mu_1 = \mu_2 = \ldots = \mu_{30}$

Alternative Hypothesis: At least two of the means are unequal

Results from TI-59 Program ST-15:

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Between Samples	$\nu_1 = 30-1 = 29$	SSB = 13.01	$MSB = \frac{13.01}{29} = 0.449$
Error	$\nu_2 = 230-30 = 200$	SSE = 2.26	$MSE = \frac{2.26}{200} = 0.0113$
Total	229	SST = 15.27	

Test Statistic:

$$F = \frac{MSB}{MSE} = \frac{0.449}{0.0113} = 39.7$$

$$\nu_1 = 29, \ \nu_2 = 200$$

From F Table: $F_{0.01, 29, 200} = 1.7$

Since 39.7 >> 1.7, the null hypothesis must definitely be rejected. It may be concluded that the observed variation in transmitter output power from unit to unit is statistically significant and at least two of the transmitters do not come from the same population.

APPENDIX E

Statistical Significance Test

on

Output Power of Failed Transmitters

TEST FOR FAILED TRANSMITTERS HAVING SIGNIFICANTLY HIGHER POWER OUTPUT DURING I&T

(Normal Distribution, Unequal Variances)

Ref: Nartvella P 3-36

1) Let α = 0.10, 0.05, 0.01

2) $\bar{x}_A = 1.22,\ s_A^2 = 0.16^2 = 0.0256,\ n_A = 26$

   $\bar{x}_B = 1.45,\ s_B^2 = 0.09^2 = 0.0081,\ n_B = 2$

3) $$V_A = \frac{s_A^2}{n_A} = \frac{0.0256}{26} = 0.000985$$

   $$V_B = \frac{s_B^2}{n_B} = \frac{0.0081}{2} = 0.00405$$

4) d.o.f. $$f = \frac{(V_A + V_B)^2}{\frac{V_A^2}{n_A+1} + \frac{V_B^2}{n_B+1}} - 2 = 2.61$$

5) $f' = 3,\ t'_{0.90} = 1.638,\ t'_{0.95} = 2.353,\ t'_{0.99} = 4.541$

6) $$u = t'_{1-\alpha}\sqrt{V_A + V_B} = 0.116 \quad \alpha = 0.10$$
   $$= 0.167 \quad \alpha = 0.05$$
   $$= 0.322 \quad \alpha = 0.01$$

7) $\bar{x}_B - \bar{x}_A$ 1.45 - 1.22 = 0.23, which is greater than u for α > 0.10 and 0.05. Group B mean is significantly higher at α 0.05 level of significance.

DATA: Mean transmitter output power during I&T

GROUP A: Transmitters operating normally in orbit.

Flight/Side	S/N	Watts
2A	3-5	1.07
2B	3-4	1.33
3A	3-7	1.41
3B	3-6	1.30
4B	3-8	1.37
5A	3-11	1.21
5B	3-10	1.34
6A	3-13	1.33
6B	3-12	1.29
7A	3-15	0.96
7B	3-18	1.18
8A	3-14	0.96
8B	3-17	1.09
9A	3-21	1.03
9B	3-16	1.13
10A	3-19	1.21
10B	3-22	1.07
11A	3-26	1.23
11B	3-20	1.23
12A	3-23	1.32
12B	3-24	1.26
13A	3-34	0.88
13B	3-30	1.63
14B	3-29	1.35
15A	3-33-39	1.29
15B	3-32	1.20

$n = 26$

$\bar{x} = 1.22$

$\sigma = 0.16$

R5-214-80

Flight/Side	S/N	Watts	Rank
4A	3-9	1.38	25
14A	3-25	1.51	27

$n = 2,\ \overline{x} = 1.45,\ \sigma = 0.09$

GROUP C: Transmitters which failed or had problems in orbit

Flight/Side	S/N	Watts	Rank
4A	3-9	1.38	25
14A	3-25	1.51	27
1A	3-3	1.59	29
1B	3-2	1.56	28

$n = 4,\ \overline{x} = 1.51,\ \sigma = 0.09$

Statistics for all transmitters:

Means $\overline{x} = 1.26$

Means $s = 0.185$

Means $n = 30$

95% conf. limits on $\overline{x}$:

Upper: $\overline{x} + Z_{\alpha/2} \frac{s}{\sqrt{n}} = 1.26 + 1.96 \frac{0.185}{\sqrt{30}} = 1.326$

Lower: $\overline{x} - Z_{\alpha/2} \frac{s}{\sqrt{n}} = 1.194$

$\overline{x} + 1s = 1.442,\ + 2s = 1.627,\ + 3s = 1.811$

$\overline{x} - 1s = 1.072,\ - 2s = 0.887,\ - 3s = 0.703$