COMPUTER CONTROLLED TESTING OF TELEMETRY GROUND STATIONS

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ABSTRACT

The testing of telemetry ground stations by manual methods can be very time consuming. The test time can be reduced by using an automated test system. A minicomputer controlled test system is described and is shown to provide accurate, repeatable results and to reduce the test time to about one-fifth of the manual test time.

INTRODUCTION

This paper describes a minicomputer controlled system for testing telemetry ground stations. This system is called the Self-Check Automated Telemetry System (SCATS). SCATS is also a prototype telemetry receiving and recording station. SCATS uses the standard Inter-Range Instrumentation Group (IRIG) document number 118 tests. The tests implemented are:

1. Antenna Figure of Merit
2. Intermediate Frequency (i-f) Signal-to-Noise Ratio (SNR)
3. Bit Error Probability (BEP)
4. Noise Power Ratio (NPR)
5. Tape Recorder Frequency Response

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SCATS performs the first two tests using the SCATS computer controlled receiver but can perform the last three tests on any manually controlled receiver and/or recorder/ reproducer.

SCATS can also be patched to test one of the Pacific Missile Test Center's operational telemetry ground stations. This operational telemetry ground station has four dual polarization, 32 foot dish, tracking antennas; 24 dual-channel telemetry receivers with built-in combiners; and eight analog magnetic tape recorders. RF signals can be inserted into the pre-amplifier inputs of the antennas. The antenna outputs can be patched to either the SCATS receiver or the ground station receivers. The receiver outputs can be patched to either the tape recorders or the SCATS data inputs. The tape recorder outputs can be patched to the SCATS data inputs. SCATS accepts video or 450-KHz and 900-KHz frequency modulated pre-detection carrier signals as inputs.

The use of a computer controlled system to test telemetry ground stations has the following advantages:

1. Test results are more repeatable because the operator is not in the set-up, adjustment, and meter reading loop and the computer does the same things each time.

2. Tests take much less time to perform which is very important in a "busy" ground station.

3. A quick, impartial test can be run immediately before a mission which will increase the probability of receiving and recording good data during the mission.

4. The tests are easy-to-do, this makes it more likely that they will be done.

The disadvantage of a computer controlled test system is the higher initial cost. This should be more then offset by the overall improved data quality, problem detection capability, and decreased down-time for testing.

SYSTEM DESCRIPTION

A simplified block diagram of SCATS is presented in Figure 1. SCATS contains the following equipment: (Asterisks indicate equipment designed and built by Pacific Missile Test Center (PACMISTESTCEN), all other equipment is commercially available)

1. Minicomputer with 32K of core memory

2. 2.5 Megabyte disk + 2 dual floppy disk drives (250 Kilobytes each drive)

3. Typewriter terminal + CRT terminal

* 4. Interface between minicomputer and test equipment

5. Radio Frequency (RF) Signal Generator, L- and S-band, 1dB step attenuator, Frequency and Phase Modulation (FM and PM)

6. Frequency Synthesizer

7. RF Power Meter

8. RF Counter

* 9. RF Distribution Unit

10. Dual Channel Telemetry Receiver with synthesized tuner

11. Diversity Combiner

* 12. 450-KHz and 900-KHz pre-detection discriminators

* 13. Programmable Gain Amplifier

14. Pulse Code Modulation (PCM) test set

15. Noise Generator and Receiver (for NPR test)

16. RMS Meter

17. Function Generator

18. Counter

19. Ten discrete relays and two 10 x 10 matrices

* 20. Controller for amplifier, relays, and matrices

21. Telemetry Analog Tape Recorder

22. PCM Bit Synchronizer

23. S-band to P-band downconverter

24. Oscilloscope, not under computer control

25. RF spectrum analyzer not under computer control

The RF distribution unit, the discrete relays, and the matrices are used to interconnect the SCATS equipment and also to connect the SCATS equipment with the operational telemetry ground station.

TEST PARAMETER ENTRY

The test operator can create a data file which contains the following data:

1. RF center frequency

2. i-f bandwidth

3. Video bandwidth

4. Pre-detection carrier frequency

5. Counter time base exponent (BEP test measurement interval in bits)

6. PCM bit rate

7. Peak RF frequency deviation (for BEP test)

8. rms RF frequency deviation (for NPR test)

This data file can then be called anytime the operator wants to run a test with these parameter values.

ANTENNA FIGURE OF MERIT TEST

This test determines the antenna Figure of Merit which is ten times the logarithm of the ratio of the antenna gain to the system noise temperature (G/T). The G/T is measured at ten frequencies at S-band and three frequencies at both upper and lower L-band and for both antenna polarizations. The SCATS equipment used in this test are: Telemetry receiver, rms meter, RF distribution unit, and discrete relays. The antenna outputs are manually patched into the SCATS receiver and the solar flux, flux measurement frequency, Julian date, and Greenwich Mean Time are entered into the computer terminal. The sun position is then calculated and printed out. The antenna is then manually pointed at the sun and put into autotrack mode.

The program first determines if the largest signal is received at the low or high end of the passband with the antenna tracking the sun. The gain is set (for each receiver channel independently) at the frequency with the largest signal. The rms value of the receiver linear 10 MHz is then measured at each frequency for both receiver channels. A check is made to verify that the receiver gain (or something else) hasn't changed by remeasuring the signal at the lowest frequenc and comparing it to the value measured earlier. The antenna is then pointed at the cold sky (30° in elevation from the sun) and the rms values are again measured. The Figure of Merit is calculated from the following equation:

$$10 \log G/T = 10 \log \frac{8\pi K L \left(\frac{P_2}{P_1} - 1\right)}{F_o \left(\frac{f}{f_o}\right)^{\frac{1}{2}} \lambda^2} \tag{1}$$

Where L = antenna beamwidth correction factor = $1 + .38 \left(\frac{0.5^{o}}{\text{Ant. Beamwidth}}\right)^2$

P_2 =Sun power

P_1 =Cold sky power

F_o =Solar flux (watts/m^2 ·Hz)

f_o =Solar flux measurement frequency

f =Test frequency

λ =Test frequency wavelength (meters)

K =Boltzmann's constant = $1.38 \cdot 10^{-23}$ watts/°K·Hz

A typical Figure of Merit test output is presented in Figure 2. The measured G/T values as well as the prior cumulative averages, maximums, minimums, percentages of time exceeding specification, and standard deviations are displayed. The test operator has the option of storing the results of the test and updating the statistical data or not storing the results if there were interfering frequencies present or equipment malfunctions. The standard deviation of the first 21 tests was about 0.3dB for the eight highest frequencies and slightly higher for the two lowest frequencies. The average spread between the maximum and minimum values of G/T for the first 21 tests was 1.3dB and the largest spread was 1.8dB at 2200.5 MHz for the left hand circular data. This gives a better than ±1.0dB worst case repeatability for the test.

The main sources of error are: The latest solar flux value may have been measured several hours ago and the solar flux may have changed since then, the extrapolation from the flux measurement frequency to the antenna measurement frequency is not exact, the rms meter has a specified accuracy of ±0.2dB, the antenna system and receiver introduce errors because of gain changes during the test and amplitude non-linearities, and there may have been unnoticed interfering signals present. However, the SCATS system gives G/T results which are quite repeatable (within ±0.3dB at S-band for tests which are run within a few minutes of each other) and agree very well with measurements made manually using the calibrated attenuator method. The overall accuracy is estimated to be better than ±1.0dB at S-band.

The results at L-band give a standard deviation of about twice the S-band results. This is probably caused by the fact that the solar flux is usually extrapolated from 2800 MHz which would tend to give a larger error because of the greater extrapolation and also there appears to be more interference at L-band.

Since the G/T values are stored on a floppy diskette, various analyses can be performed on the data by writing the necessary software. One existing program prints out the results of any specific test along with the cumulative statistical package. Figure 3 presents the results of a test performed on Julian day 179. A comparison of the data in Figures 2 and 3 shows that all measured G/T values on Julian day 179 are within 0.1dB of the values measured on Julian day 177. The usual agreement of tests conducted two days apart is not quite this good, but this does demonstrate the data repeatability. The results of this test are being used in the TRIDENT antenna reliability tests at PACMISTESTCEN. SCATS performs the S-band antenna Figure of Merit test in about seven minutes (this includes the time it takes to enter data and manually point the antenna). It would take about 30 minutes to manually measure the sun and cold sky powers and calculate the 20 G/T values. Any statistical data analysis would be extremely time consuming unless the data was stored on a computer.

INTERMEDIATE FREQUENCY SNR TEST

This test determines the RF powers which give SNRs in the receiver second i-f of 0dB and 10dB (with minor software modifications these values could be changed to any desired value). This data is then used to calculate the effective system noise temperature from the equation:

$$N = KTB \text{ or } T = \frac{N}{KB} \tag{2}$$

where

N = noise power = signal power at 0dB i-f SNR

K = Boltzmann's constant

T = Effective system noise temperature (°K)

B = i-f bandwidth in hertz

The system noise figure is then calculated from

$$F = 1 + \frac{T}{290^{0}} \qquad (3)$$

and ten times the logarithm of F is displayed in the output. This test uses the RF signal generator, RF power meter, counter, telemetry receiver, rms meter, RF distribution unit, and the discrete relays.

The test procedure is to insert a known RF power into the antenna preamplifier, measure the i-f SNR, and then extrapolate to the 0dB and 10dB i-f SNR power levels. The RF generator is then set to the expected power levels and the i-f SNR is measured. If it is within ±1.0dB of the desired i-f SNR, the RF power for the desired SNR is determined by subtracting the SNR error from the RF power to give the actual RF power for the desired SNR.

If the measured value is not within ±1.0dB of the desired value a new estimate of RF power for the desired SNR is made, the RF generator output power is changed, and the measurement repeated. The measurement procedure is:

1. Point antenna at cold sky (away from sun and other signal sources)

2. Set RF generator to desired power

3. Measure power with RF power meter

4. "Freeze" gain of receiver

5. Measure rms voltage in receiver linear 10 MHz output of both receiver channels (S + N)

6. Set RF generator output to minimum power

7. Measure rms voltage in receiver linear 10 MHz output of both receiver channels (N)

8. Calculate i-f SNR from i-f SNR = $\dfrac{(S + N)^2 - N^2}{N^2}$

9. Display 10·log(i-f SNR).

The sources of error are the same as for the antenna Figure of Merit test except that the errors due to solar flux inaccuracies are replaced by errors due to inaccuracies in cable loss, connector loss, power meter errors, etc. The test repeatability is about ±0.3dB. SCATS performs this test in about 3 minutes.

A comparison of the results of the i-f SNR test with the results of the antenna Figure of Merit is of interest. The antenna gain is approximately 42.5 dBi and the system noise temperatures calculated from the i-f SNR test results are 302°K and 288°K which yield G/T's of 17.7dB and 17.9dB for channels 1 and 2 respectively. The average value of G/T for antenna 4 is 17.9dB for each polarization. Therefore, the results of these tests agree very well.

PULSE CODE MODULATION BIT ERROR PROBABILITY TEST

This test determines the bit error probability (BEP) versus RF power performance of the equipment under test. The BEP test can currently be performed only for non-return-to-zero-level (NRZ-L) FM formats but will be expanded to include at least Manchester and PM formats. The BEP test can be performed by inserting an RF signal into either an antenna pre-amplifier or directly into a telemetry receiver. The antenna system output (if an antenna is used) is patched to the receivers) to be tested and the antenna is pointed at the cold sky. The receiver output is either connected to one of the SCATS data inputs or to a tape recorder (or both). If a tape recorder is used, its output is patched to one of the SCATS data inputs. SCATS accepts either video or 450KHz or 900KHz FM pre-detection signals at its data inputs. The pre-detection signals are first demodulated using a pulse-averaging discriminator and then applied to the PCM bit synchronizer. The video signals are applied directly to the bit synchronizer. The reconstructed data and clock from the bit synchronizer are connected to the PCM test set for error detection. The counter displays the ratio of bit errors to bits received (bit error probability).

The test sequence is:

1. First the RF generator and the telemetry receivers are set to the desired frequency and the necessary manual patching is done.

2. The RF generator frequency deviation is set to the proper value as follows:

   The PCM data stream is connected to the programmable gain amplifier and the amplifier output is applied to the modulation input of the RF generator. This amplifier includes an asynchronous set-reset flip-flop through which the PCM data passes. The amplifier gain is first set to unity (the gain of the amplifier can be set to any gain between 0.006 and 1.0 by the following formula, gain = 0.995^x; $0 \leq x \leq 1023$). The flip-flop is first set and the RF frequency is counted. The flip-flop is then reset and the RF frequency again counted. The gain of the amplifier is then set to the ratio of the desired peak-to-peak frequency deviation to the difference between the above counter readings. The deviation is checked by setting and resetting the flip-flop and determining the actual frequency deviation. If it is within a pre-determined tolerance the test con7 tinues, if not a new gain is calculated and the deviation is again checked, etc.

3. The necessary interconnections to measure the BEP are made and the RF generator is set to a power level that should produce no errors. The error probability is measured and the test continues if the BEP is less than 10^{-5}. If there are too many errors an error message to that effect appears and the test is stopped until the problem is corrected.

4. If the system passes the initial BEP test, the RF power is set to give about a 13dB i-f SNR for a specified system noise temperature and the i-f bandwidth being used. The RF power is varied in integral steps (step size determined by operator). The BEP is measured for each channel under test and for each RF power level and displayed along with the theoretical BEP. The theoretical BEP is calculated from[1]:

$$\text{Theoretical BEP} = 0.5\, e^{-\rho} \qquad (4)$$

where ρ = i-f SNR (expressed as power ratio)

This equation is only an approximation but is quite accurate for NRZ-L FM formats with optimum frequency deviation ($\Delta f \approx 0.35$ times the bit rate) and an i-f bandwidth of at least 1.5 times the bit rate. A noise figure of 3dB is assumed for the antenna systems. This gives an i-f SNR of 0dB at -114.0dBm when using a 1.0MHz i-f bandwidth.

A typical BEP test output is shown in Figure 5. Examination shows that the theoretical BEP (at high BEP) falls between the two experimental BEP values. For low BEP, the theoretical value is slightly lower than the experimental values (channel 1 is 0.4dB worse then theoretical at -104dBm). A comparison of the BEP data with the i-f SNR data is also of interest. The i-f SNR data indicates that channel 1 should give BEP results which are between 0.2dB and 0.4dB worse than theoretical and channel 2 should give BEP results that are equal to or 0.1dB better than theoretical. The results from the BEP test show that channel 1 is 0.1dB to 0.4 dB worse than theoretical and channel 2 varies between 0.1dB worse and 0.1 dB better than theoretical. The data in Table I are calculated from the theoretical BEP expression (rewritten to give i-f SNR as a function of BEP) and from the expression

$$\text{i-f SNR} = \text{measured RF power} - \text{RF power for 0dB i-f SNR}$$

with the 0dB i-f SNR values taken from Figure 4. This comparison shows agreement within ±0.2dB between the results of the BEP test and the i-f SNR test. It should be mentioned that this data was not selected to give good agreement but was instead selected at random from tests run during the last week in June. Other test data also agree within ±0.2dB. The test agreement is this good because several of the sources of error are common to both tests, e.g., cable losses, power meter errors, etc. The absolute accuracy of both tests is about ±0.5dB but the repeatability is better than this. The PCM test set output can also be connected directly to the PCM bit synchronizer to test the PCM subsystem alone.

	Channel 1		Channel 2	
RF Power(dBm)	BEP		i-f SNR	BEPi-f SNR
-104.1	9.5	9.7	9.8	9.9
-105.1	8.7	8.7	8.9	8.9
-106.1	7.8	7.7	8.0	7.9
-107.2	6.6	6.6	6.8	6.8
-108.2	5.7	5.6	5.9	5.8
-109.2	4.7	4.6	4.9	4.8

Table 1: Comparison of i-f SNR Values Calculated From i-f SNR Test Data and BEP Test Data (all i-f SNRs are in dB)

NOISE POWER RATIO TEST

This test measures the noise power ratio of the telemetry system under test. Noise power ratio power is determined by the video SNR and intermodulation distortion at a particular frequency. The data quality of an FM/FM multiplex can be estimated from the NPR[2]. The noise power ratio test is very sensitive to certain types of non-linearities and also to noise. The telemetry system is tested using a noise generator and a noise receiver. The noise generator modulates the RF generator and the video data is applied to the noise receiver. The noise generator has several notch (band-reject) filters and the noise receiver has narrow band-pass filters at the same center frequencies. A band-pass filter is selected and the power in the passband is measured. The matching notch filter is then inserted in the noise generator and the power in the passband is again measured. The ratio of these powers (expressed in dB) is the NPR. Next, the noise generator is turned off and the power in the passband is again measured. The ratio of the first power measurement to this power is called the noise power ratio floor (NPRF). This test displays the NPR and NPRF at pre-determined frequencies in the video spectrum.

The NPR test uses all of the SCATS equipment except the PCM test set. The rms RF frequency deviation is set by a procedure which is an extension of the RF deviation routine of the BEP test. The rms deviation is used because the rms voltage of a gaussian signal is easy to measure. The RF deviation routine sets the peak-to-peak frequency deviation of the RF generator equal to twice the desired rms deviation. The fact that the rms and peak of a two-valued waveform (where each value is equally probable) are equal is then used. The PCM data rate is set to 100 Kilobits per second and the rms value of the RF generator modulation input is measured. The noise generator is then applied to the RF generator modulation input (the PCM is removed from the modulation input) and the rms value of the noise is set equal to the rms of the PCM data. This sets the rms deviation with the noise equal to the peak deviation with the PCM as was desired. The RF generator is then set to maximum output power and the NPR and NPRF of the system under test are measured. The tests can then be repeated at other RF powers if desired. This test can also be performed with or without the antenna and with or without a tape recorder. One of the important features of this test is that it can show how much noise and distortion a tape recorder is adding to the system. This is illustrated in Figures 6 and 7. Figure 6 shows the NPR at the input and output of the tape recorder. Figure 7 shows the NPR at the input to the tape recorder with the i-f SNR varied. Figure 6 shows that the tape recorder degraded the NPR by 6dB to 13dB. The reason for this is that the SNR of the tape recorder is about 24dB. A comparison with Figure 7 shows that the output of the tape recorder with a high SNR at the input is about the same as the NPR at the input with a 23dB i-f SNR as expected based on the tape recorder SNR. The test data shown in Figure 6 took 3 minutes to generate and the test data shown in Figure 7 took 12 minutes to generate. This is about one-fifth the time it would take to perform the test manually. The NPR is displayed in

0.5dB increments and the accuracy is about ±1.0dB. Also, the noise generator can be connected directly to the noise receiver to test the NPR subsystem.

INSTRUMENT TESTS

SCATS also has the capability of writing data to or reading data from each piece of test equipment. This is used for equipment troubleshooting. The instrument interface cards can also be written to and read by this routine. The interface has had one integrated circuit failure in about 2,000 hours of operation. This problem was quickly traced down and the bad integrated circuit was found and replaced. There have been several failures of the commercial test equipment. There were two failures between 1 April and 10 July 1978. A relay in the attenuator driver of the RF generator failed and was replaced and the rms meter failed and was replaced by a back-up unit. Therefore, the system has been quite reliable.

SUMMARY

The SCATS system can test a telemetry system in about one-fifth the time it takes to manually test the system. The test results are printed out and can be stored on the computer for trend analysis and other statistical analyses. The system accuracy is ±1.0dB or better for all tests. The antenna Figure of Merit and i-f SNR tests have been shown to give results that agree very well. The results of the i-f SNR and BEP tests have been shown to agree within ±0.2dB. Overall, the SCATS system performs a good, fast, accurate test on a telemetry ground station. It is expected that similar systems will become more widely used because computer controllable telemetry test equipment is becoming more available; test operations (missile flights, etc.) are becoming fewer but more expensive, therefore getting “good” data is becoming ever more important; and personnel ceilings are being decreased which is forcing more automation.

REFERENCES

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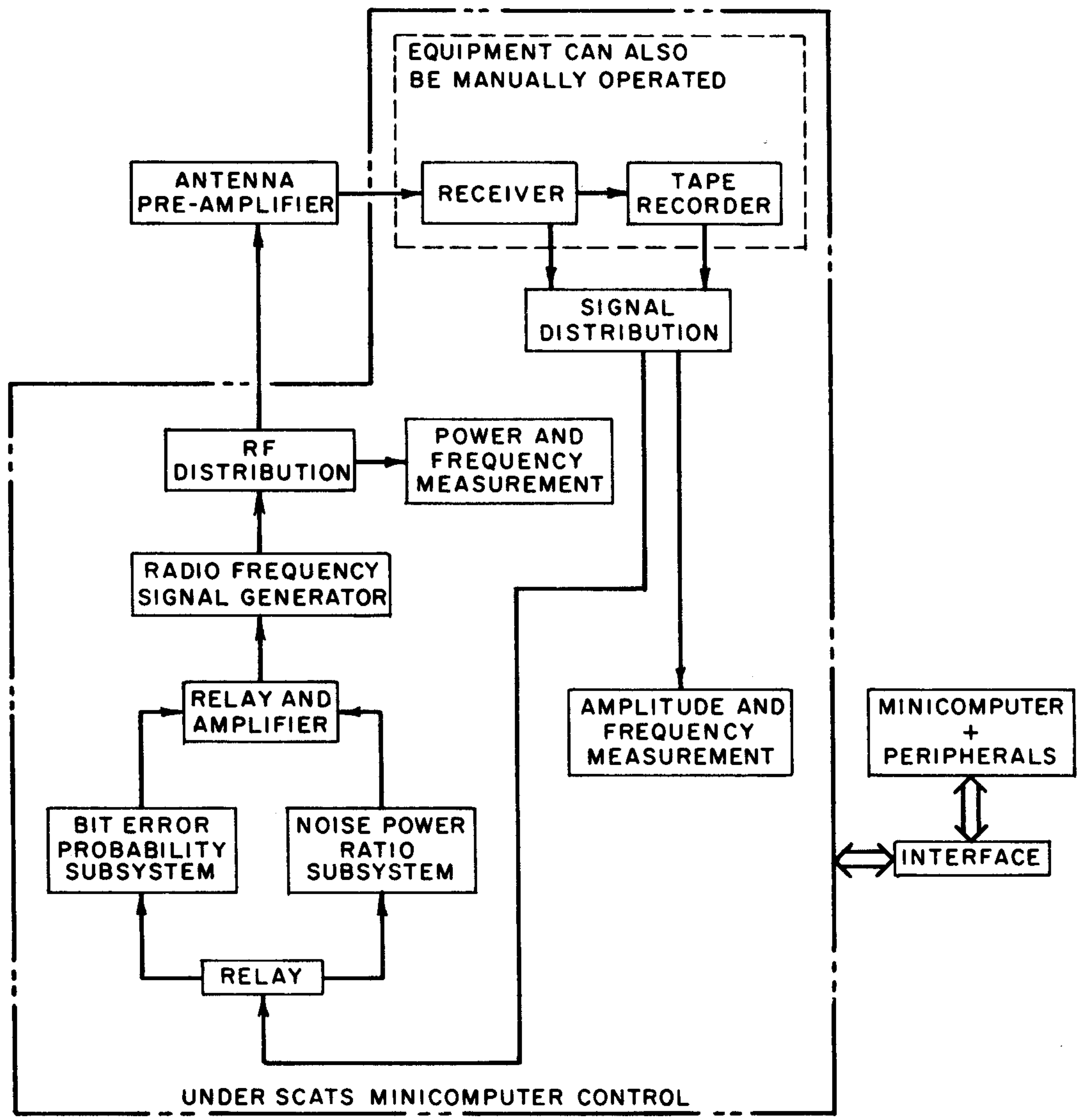

FIGURE 1. SCATS BLOCK DIAGRAM

ANTENNA SOLAR CALIBRATION NUMBER OF TESTS 21
JULIAN DAY=177 GMT HOUR=22 MINUTE= 0 SOLAR FLUX= 174.0 AT 2800.0 MHZ
ANTENNA#= 4 RHC

FREQ	RMS METER (DB)		THIS	G/T (DB)			% AGE	
(MHZ)	SUN	COLD SKY	TEST	AVE	MAX	MIN	15 DB	S.D.
2200.5	-16.9	-33.2	17.5	17.6	18.2	17.0	100.00	0.36
2210.5	-18.9	-35.4	17.7	17.9	18.5	17.2	100.00	0.35
2220.5	-18.4	-35.0	17.9	18.0	18.5	17.4	100.00	0.30
2230.5	-17.5	-34.0	17.8	17.8	18.3	17.2	100.00	0.31
2240.5	-18.7	-35.3	17.9	17.9	18.4	17.0	100.00	0.31
2250.5	-21.0	-37.2	17.6	17.9	18.3	17.4	100.00	0.26
2260.5	-21.6	-37.6	17.5	17.8	18.3	17.2	100.00	0.29
2270.5	-21.5	-37.4	17.3	17.6	18.1	16.8	100.00	0.28
2280.5	-19.5	-35.5	17.4	17.6	18.2	16.9	100.00	0.28
2290.5	-19.6	-35.4	17.2	17.6	18.2	17.1	100.00	0.29

ANTENNA#= 4 LHC

FREQ	RMS METER (DB)		THIS	G/T (DB)			% AGE	
(MHZ)	SUN	COLD SKY	TEST	AVE	MAX	MIN	15 DB	S.D.
2200.5	-14.9	-31.3	17.6	17.4	18.4	16.6	100.00	0.51
2210.5	-16.6	-33.3	18.0	17.8	18.6	17.0	100.00	0.35
2220.5	-18.0	-34.8	18.0	17.9	18.6	17.2	100.00	0.30
2230.5	-17.9	-34.4	17.8	17.8	18.3	17.1	100.00	0.27
2240.5	-18.9	-35.4	17.8	17.9	18.4	17.1	100.00	0.30
2250.5	-20.2	-36.6	17.7	17.9	18.4	17.0	100.00	0.29
2260.5	-20.5	-36.7	17.6	17.8	18.4	16.9	100.00	0.30
2270.5	-21.6	-37.4	17.3	17.6	18.2	16.8	100.00	0.28
2280.5	-20.9	-36.8	17.3	17.6	18.2	17.0	100.00	0.30
2290.5	-23.6	-39.3	17.2	17.6	18.1	16.7	100.00	0.31

FIGURE 2. ANTENNA FIGURE OF MERIT TEST RESULTS FOR JULIAN DAY 177

ANTENNA SOLAR CALIBRATION NUMBER OF TESTS 25
JULIAN DAY=179 GMT HOUR=22 MINUTE= 9 SOLAR FLUX= 168.0 AT 2800.0 MHZ
ANTENNA#= 4 RHC

FREQ	THIS	G/T (DB)			% AGE	
(MHZ)	TEST	AVE	MAX	MIN	15 DB	S.D.
2200.5	17.5	17.5	18.2	16.8	100.00	0.38
2210.5	17.7	17.9	18.5	17.0	100.00	0.39
2220.5	17.9	17.9	18.5	17.1	100.00	0.34
2230.5	17.8	17.8	18.3	17.1	100.00	0.33
2240.5	17.9	17.8	18.4	17.0	100.00	0.33
2250.5	17.7	17.8	18.3	17.0	100.00	0.33
2260.5	17.6	17.7	18.3	16.9	100.00	0.35
2270.5	17.4	17.5	18.1	16.8	100.00	0.32
2280.5	17.5	17.6	18.2	16.9	100.00	0.31
2290.5	17.3	17.5	18.2	16.7	100.00	0.34

ANTENNA#= 4 LHC

FREQ	THIS	G/T (DB)			% AGE	
(MHZ)	TEST	AVE	MAX	MIN	15 DB	S.D.
2200.5	17.7	17.4	18.4	16.6	100.00	0.48
2210.5	18.0	17.8	18.6	17.0	100.00	0.35
2220.5	18.0	17.9	18.6	17.2	100.00	0.31
2230.5	17.8	17.8	18.3	17.1	100.00	0.30
2240.5	17.8	17.8	18.4	17.1	100.00	0.33
2250.5	17.7	17.9	18.4	17.0	100.00	0.34
2260.5	17.6	17.7	18.4	16.8	100.00	0.36
2270.5	17.3	17.5	18.2	16.7	100.00	0.33
2280.5	17.4	17.6	18.2	16.8	100.00	0.33
2290.5	17.3	17.5	18.1	16.3	100.00	0.38

FIGURE 3. ANTENNA FIGURE OF MERIT TEST RESULTS FOR JULIAN DAY 179

SCATS IFSNR TEST 29 JUN 78

FREQ(MHZ)=2252.5 IFBW(KHZ)=1000 VIDEO BW(KHZ)=1000

ANTENNA NUMBER 4

CHANNEL 1

IFSNR(DB)	RF GEN(DB)	RF POWER(DBM)	NOISE FIGURE(DB)
0	-37.0	-113.8	3.1
10	-27.0	-103.6	

CHANNEL 2

IFSNR(DB)	RF GEN(DB)	RF POWER(DBM)	NOISE FIGURE(DB)
0	-37.0	-114.0	3.0
10	-27.0	-104.1	

FIGURE 4. INTERMEDIATE FREQUENCY SIGNAL-TO-NOISE RATIO TEST RESULTS

BIT ERROR PROBABILITY TEST 6 30 78

RECEIVER VIDEO, CHANNELS 1 AND 2

BIT RATE: 614.0 KBS/SEC PEAK DEV: 230.0 KHZ CENTER FREQ:2252.5 MHZ

I.F. BANDWIDTH: 1000 KHZ

ANTENNA NUMBER 4

POWER(DBM.)	CHAN 1	CHAN 2	THEOR.(3 DB NOISE FIGURE)
-109.2	2.57E-02	2.26E-02	2.46E-02
-108.2	1.21E-02	1.02E-02	1.15E-02
-107.2	4.93E-03	4.25E-03	4.22E-03
-106.1	1.23E-03	9.73E-04	9.92E-04
-105.1	3.03E-04	2.15E-04	2.05E-04
-104.1	6.30E-05	3.70E-05	2.72E-05
-103.1	9.00E-06	1.00E-06	2.27E-06
-102.1	1.00E-06	0.00E-01	8.13E-08
-101.1	0.00E-01	1.00E-06	1.95E-09
-100.2	0.00E-01	0.00E-01	1.45E-11

FIGURE 5. BIT ERROR PROBABILITY TEST RESULTS

NOISE POWER RATIO TEST 7 JULY 1978

CENTER FREQ= 2252.5 MHZ IF BANDWIDTH= 1000 KHZ RF RMS DEV= 100.0 KHZ

PRE-D FREQ= 900 KHZ

		NPR/NPRF(DB.)		
	IF SNR(DB.)	40 KHZ.	98 KHZ.	185 KHZ.
PRE-DETECTION TO T.R.:	38	44.0/52.5	41.0/45.5	38.5/41.0
TAPE RECORDER OUTPUT:	38	38.0/39.5	30.5/32.0	25.5/26.5

FIGURE 6. NOISE POWER RATIO TEST RESULTS AT INPUT AND OUTPUT OF TAPE RECORDER

NOISE POWER RATIO TEST JULY 7 1978

CENTER FREQ= 2252.5 MHZ IF BANDWIDTH= 1000 KHZ RF RMS DEV= 100.0 KHZ
PRE-D FREQ= 900 KHZ TAPE RECORDER= NO

PRE-DETECTION, CHANNEL 1
NPR/NPRF(DB.)

IF SNR	16 KHZ	40 KHZ	70 KHZ	98 KHZ	140 KHZ	185 KHZ
38 DB	46.0/58.5	44.5/52.0	43.0/47.0	41.0/44.5	39.0/41.5	37.5/40.0
33 DB	45.5/57.0	44.0/49.0	41.0/44.0	38.5/41.0	36.5/36.0	35.0/36.0
28 DB	45.0/53.5	42.0/45.0	38.5/40.5	35.5/37.0	33.0/33.5	31.0/31.0
23 DB	44.5/49.5	39.0/41.0	35.5/36.0	31.5/32.5	28.5/29.0	26.5/27.0
18 DB	42.0/44.0	35.5/36.0	30.5/31.0	27.0/27.0	24.5/25.0	22.0/21.5
13 DB	39.0/39.5	30.5/31.0	25.0/25.0	22.5/22.5	19.5/19.0	17.0/17.0

FIGURE 7. NOISE POWER RATIO TEST RESULTS AT INPUT OF TAPE RECORDER