DSS 13 Frequency Stability Tests Performed During May 1985 Through March 1986

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This article presents results of station frequency stability testing performed at DSS 13 during May 1985 through March 1986. The testing was done on X-band uplink and X- and S-band downlink subsystems as well as on end-to-end systems. The subsystem test data are useful for assessing the frequency stability of various prototype X-band uplink or downlink subsystems for purposes of making design improvements. Information derived from extensive testing at DSS 13 will be useful in the preparation of an X-band Uplink Demonstration Experiment to be conducted at DSS 13, and will also be valuable in the preparations of gravity wave experiments to be conducted at other DSN stations in the future.

I. Introduction

An excellent introduction to the "Gravitational Wave Experiment" was given by Berman (Ref. 1) in 1978. As stated in Ref. 1, "One of the most exciting challenges facing gravitational theoreticians and experimenters in the remaining decades of the 20th century will be the attempted detection and measurement of 'gravitational waves' as predicted by Einstein's General Theory of Relativity." One of the steps recommended by Berman for gravitational wave detection was the development of X-band uplink capability.

The DSN undertook a development program in 1979 to add an X-band uplink capability to DSN Deep Space Stations. Early X-band uplink development work is described in Ref. 2. Descriptions of the overall X-band uplink and X- and S-band downlink systems at DSS 13 and the planned demonstration at DSS 13 with the Galileo spacecraft were given by Meeker and Timpe in Ref. 3. A theoretical phase stability analysis of this new DSS 13 system was performed by Koerner (Ref. 4).

Frequency stability tests performed at JPL on some prototype subsystems (for the X-band uplink project) were reported by Sosa (Refs. 5 and 6) in 1981. The first actual station stability testing on X-band uplink equipment at DSS 13 was done by Otoshi during March 1984 through March 1985, and the results of those tests were reported in internal JPL documents (Table 4, items 1 through 5). More recently, from May 1985 through March 1986, Otoshi and Franco have performed extensive frequency stability tests at DSS 13 (Table 4, item 6).

The purpose of this current article is to present the results of the recent frequency stability tests performed at DSS 13. It is also the purpose to impart some of the knowledge gained from this work that will be useful to designers of X-band uplink systems and to users of radio science data. The following sections of this article are organized as follows: (1) description of the current system status at DSS 13 and discussions of problem areas to correct or avoid for future X-band uplink systems, (2) brief descriptions of the test setups and measurement techniques used to obtain the test data, (3) a summary of test results for nine test periods, and (4) concluding remarks, including a list of important knowledge gained as a result of extensive testing at DSS 13.

II. Present System Status

Many problems were encountered during the 11-month period from May 1985 through March 1986. Failures occurred on two different Dana synthesizers, the DSN prototype cable stabilizer, the X-band klystron magnet power supply, the klystron vacuum seal, two S-band translator modules, an X-band translator module, the X-band maser, the S-band maser, and the Block III receiver modules. Some of the problems and failures occurred during testing, while other failures occurred between test periods. Very often, the test plans had to be modified after arriving at the site so that improvised tests could be performed on whatever subsystems were working at the time.

At the present time, most of the hardware is now working and problems are identified. The R&D X-band uplink-downlink hardware at DSS 13 is not up to DSN quality standards, and cannot be expected to perform as reliably as the implementation versions that will be going into 34-m antenna DSN stations in the near future.

Leakage signals corrupted data taken at the Block III receiver doppler extractor ports. The leakage problem was circumvented in subsequent end-to-end tests by putting terminations on the output ports of the doppler reference signal paths at the control room bulkhead, and then operating the Block III receivers in modified open-loop configurations.

The current open- and closed-loop receiver systems at DSS 13 are very difficult to check for leakage or to perform AGC calibrations on because all controls for the step attenuators have to be manually operated by personnel inside the cone on the antenna.

Another important problem area discovered was that the Hydrogen Maser Frequency Distribution system outputs are not adequately isolated. When personnel for other projects run simultaneous tests at DSS 13 (on a noninterference basis) and begin connecting and disconnecting cables from 1 MHz and 5 MHz output ports on the Hydrogen Maser Frequency distribution boxes, the frequency stability of the end-to-end system is affected and degraded.

III. Test Setups

Figure 1 shows the output test ports used for DSS 13 X-band uplink and X-band downlink subsystem and end-to-end system tests. Figure 2 shows the output test ports for the X-band uplink and S-band downlink system. Figure 3 shows the special test equipment used for performing station frequency stability tests, and Fig. 4 is a block diagram of the Data Acquisition System (DAS) used to acquire and collect the test data.

At test output ports 4, 5, and 6, shown in Fig. 1, measurements were made by comparing the output phase of the test signal (coming out the microwave subsystem under test) to the phase of a reference signal. For X-band uplink and X-band translator output tests, respectively, the reference signals were generated by use of oven-stabilized ×72 and ×84 multipliers that were driven by the cable-stabilized 100 MHz reference frequency in the cone. For translator S-band output port 12, shown in Fig. 2, the reference signal was generated by an oven-stabilized ×23 multiplier driven by the cable-stabilized 100 MHz in the cone. The reference signal was fed into one of the ports of a test equipment X- or S-band microwave mixer, while the test signal from the output of the microwave subsystem under test was fed into the other port of the mixer.

The transmitter synthesizer in the control room was set so that the frequency of the test signal would be offset from the frequency of the reference signal by 1 Hz. Then the 1 Hz output from the test equipment X- or S-band mixer was fed into a 1 Hz amplifier-filter (with a passband of DC to 10 Hz) which was followed by the Zero Crossing Detector (ZCD) and the Data Acquisition System (see Fig. 4). The 1 Hz amplifier-filter was not used in all of the tests, but tests showed that negligible degradation of the test data resulted from use of this amplifier-filter.

Connections to mixer(s), subsystem test ports, reference multiplier, and 100 MHz cable stabilizer output port were made with special phase stable test cables. Fixed attenuator pads having the appropriate values were used to obtain desired power levels. For translator output tests, it was necessary to insert an external low-noise amplifier between the translator output port and the mixer input port.

For purposes of testing the microwave subsystems at frequencies that were not integer multiples of 100 MHz, the two-mixer method test configuration shown in Fig. 5 was used. The two-mixer method permits testing at any of the microwave frequencies in the DSN band. This technique is a new development in the specialized field of frequency stability measurements.

For tests at Multi-Mission Receiver (MMR) output ports (see port 7 in Fig. 1 and port 13 in Fig. 2), an HP 8662A synthesizer, driven by a 10 MHz reference frequency, was used as part of the external test equipment. The 10 MHz reference frequency for the synthesizer was derived from the output of a divide-by-10 assembly that was driven by the station's 100 MHz reference frequency from the hydrogen maser. The output frequency of the HP 8662A synthesizer was set to the MMR IF output plus 1 Hz and fed into one port of a test equipment IF mixer. The IF test signal from the MMR was fed into an IF amplifier whose output was fed to the other port of the mixer. The 1 Hz output from the mixer was then fed into the 1 Hz amplifier-filter, followed by the Zero Crossing Detector and Data Acquisition System.

For closed-loop receiver output tests at the X-band doppler mixer output ports (see ports 8 and 9 in Fig. 1) and S-band doppler mixer output ports (see ports 14 and 15 in Fig. 2), an HP 8662A synthesizer was set at 1 MHz + 1 Hz or 5 MHz + 1 Hz and fed into a test equipment IF mixer. The test signal output from the doppler mixer was fed into the other port of the test equipment IF mixer. The 1 Hz output was then fed into the 1 Hz amplifier-filter, followed by the Zero Crossing Detector and Data Acquisition System.

For modified open-loop receiver output tests at ports 11 and 17, it was only necessary to set the transmitter and receiver synthesizers to the appropriate values to obtain a 1 Hz output which was then fed directly into the Zero Crossing Detector, which was followed by the Data Acquisition System. No test equipment mixer or amplifier-filter were necessary in this test configuration and only a single test cable (carrying the 1 Hz signal) was required.

IV. Test Results

The results for the tests performed at DSS 13 during May 1985 through March 1986 are summarized and tabulated in Tables 1 through 3. Tables 1, 2, and 3, respectively, show the results for X-band uplink only tests, X-band uplink and X-band downlink only tests, and X-band uplink and S-band downlink only tests. The test output ports are described in the tables and refer to the test ports shown in Figs. 1 and 2. In order to keep this report concise, only frequency stability results for tau = 1000s will be given.

The following symbols used in the tables are defined as follows:

FFS = Fractional Frequency Stability (Allan Sigma)

#SDP = Number of second difference points used to determine FFS

The heading "Xmtr Syn" used in column 2 of the tables refers to the particular synthesizer used for the transmitter (or uplink) synthesizer. The symbol

T refers to the Dana synthesizer, J270(F)-84502, normally used at DSS 13 as the transmitter synthesizer.

R refers to the Dana synthesizer, J270(F)-79284, normally used at DSS 13 as the receiver synthesizer.

S refers to the Dana synthesizer, J270(F)-59853, normally used as a DSN spare synthesizer.

It is important to record which synthesizer is used for the tests because the stability of the particular synthesizer used for the transmitter or uplink synthesizer is crucial for obtaining good station stability.

In the tables, the heading "Air Temp." is used to refer to the outside air temperature as monitored by a thermometer placed on the cable tray just outside the control room interface bulkhead. It is important to monitor the outside air temperature because test results seem to improve considerably during periods when the air temperature was 12°C or colder, and also from about 10 p.m. to 3 a.m., when the outside temperature variations are minimal. Good test results were sometimes difficult to obtain during some times of the day and whenever the outside air temperature rose above 25°C.

In the Comments column in the tables, the term "edited data" is used to indicate that the original data set had bad data points in it. For the FFS results corresponding to edited data, only selected good portions of the original data were used. Although the "edited data" results tend to indicate that stabilities are better than what was actually achieved, it was necessary in some cases to edit and salvage the data. In some cases, the causes of bad data points could be isolated and attributed to a non-typical event occurring at the station during the test.

Although much more information is contained in the tables, the discussion of results will be limited to the following general points of interest and comments

(1) For exciter closed-loop tests, the FFS (for tau = 1000s) ranged from 2.27E-16 to 1.58E-15 and was typically better than 1.2E-15.

(2) For transmitter closed-loop tests, the FFS ranged from 3.46E-16 to 2.68E-15. In previous tests (Table 4, items 1 through 5) the FFS for the same configuration was typically better than 1.4E-15, but most of the time, the FFS results were only slightly worse than the exciter closed-loop results.

(3) For transmitter open-loop tests, the FFS ranged from 4.94E-16 to 1.42E-15. It should be noted that the

tests were intentionally done during a period when the air temperature change was small to minimize the klystron heat exchanger cycling on and off during the tests. Previous tests (Table 4, items 1 through 5) showed that the FFS for this configuration varied between 1.2 and 2.0E-15, depending on the air temperature variations occurring during the test.

(4) The X-band translator output tests showed that FFS ranged from 4.99E-16 to 1.56E-15. This is consistent with previously reported data (Table 4, item 5).

(5) The end-to-end tests for X-band uplink and X-band downlink with the receiver in closed loop will not be discussed because the data may be invalid due to leakage signals which were detected after the tests were completed. The effect of the leakage signals is not presently known. The data is shown for reference only.

(6) The end-to-end tests for X-band uplink and X-band downlink with the receiver in modified open loop showed that the stabilities were far better than expected. For the system with the transmitter bypassed, the FFS ranged from 6.72E-16 to 3.05E-15. Most of the time the FFS was better than 1.25E-15. For the system with the transmitter included, the FFS values ranged from 9.51E-16 to 2.09E-15.

(7) The S-band translator output tests showed that FFS ranged from 4.71E-16 to 7.07E-15. The FFS was typically about 3.0E-15 or better, which agrees with some earlier test results that were not reported.

(8) The S-band MMR output tests showed that the FFS ranged from 1.15E-15 to 5.04E-15. Some problems were encountered in these measurements due to noisy 295 MHz IF signals coming down to the control room. The IF signal had to be amplified with an external amplifier and mixed with a 295 MHz plus 1 Hz signal from an HP 8662A synthesizer.

(9) The end-to-end tests for X-band uplink and S-band downlink with the receiver in closed loop may not be valid because leakage signals might have existed at the time of these particular S-band downlink tests. The results, therefore, should be considered preliminary and are shown for reference purposes only. This data will be compared to data taken at some future time when equipment leakage problems are eliminated.

(10) The end-to-end test for X-band uplink and S-band downlink with the receiver in modified open-loop configuration showed that the stability was not good. However, only one test was made and the results may not be indicative of true system performance.

Based upon the test results obtained at various subsystem output ports, the total end-to-end system stabilities were better than expected. It should be pointed out that subsystem test results were degraded by the use of external test setup equipment such as reference path multipliers, mixers, an auxiliary synthesizer, amplifiers, and test cables. In the final end-to-end system tests for the modified open-loop configurations, the test setup did not include any of this external equipment, except for a test cable that was used to carry the 1 Hz output signal from the system to the Zero Crossing Detector.

It should be pointed out that none of the FFS test results presented in this report included the instability of the hydrogen maser. The reason for this is that, for the various test configurations and test methods employed to make the measurements, the instability of the hydrogen maser (or station frequency standard) cancels out to a first order.

V. Summary and Conclusions

In conclusion, it is appropriate to pass on knowledge gained from extensive DSS 13 frequency stability testing. Not all of this information can be determined from the test results given in this report, but most of the information can be derived from internal documents (Table 4).

(1) The stability of the Cable Stabilizer is extremely critical to obtaining good system stability results (Table 4, item 5).

(2) The best synthesizer should be used as the transmitter synthesizer. The receiver synthesizer should also have good stability, but its stability did not seem to be as critical as that of the transmitter synthesizer.

(3) The outside air temperature change is definitely a factor in station stability degradation. There is currently 1200 ft of uncompensated cable from the Dana synthesizer in the control room to the exciter subassembly in the cone. Phase changes of this uncompensated cable can be considerable during some time periods of the day when the outside air temperature is high.

(4) Poor isolation of 1 MHz and 5 MHz output ports on the frequency distribution system at DSS 13 caused degradation of test results on some of the end-to-end system tests. It is important that while stability tests are being performed at the station, other experimenters using the station on a noninterference basis do not connect and disconnect any of the cables carrying station reference frequencies into their equipment (Table 4, item 6).

(5) The test results show that the two-mixer method is a valid technique for measuring the stability of a microwave subsystem whose output frequency is not an exact integer multiple of 100 MHz. The innovative development of this two-mixer method is an important technological breakthrough for station stability measurement work.

(6) It was discovered that the 1 Hz signal at the output of the test equipment mixer can be amplified and piped down 1200 ft of cable to the control room without degrading the test data. This allows most of the test equipment (Zero Crossing Detector, oscilloscope, computer, disk drives, keyboard, and monitor) to be located in the control room and to be operated from inside the control room rather than inside the cone on the antenna (Table 4, item 6).

(7) No significant differences in results were observed when special tests were made using the DSS 13 hydrogen maser and then the cesium frequency standard as the reference frequency standard (Table 4, item 6). These experimental results gave verification to theoretical predictions that, for the particular measurement techniques employed, most of the instability of the reference frequency source cancels out.

(8) For performing station stability tests, it is important to have a data collection software program that enables the quality of every data point to be examined. If a current data point is bad, the experimenters should be immediately alerted by an audio beep note and also by a visual message on the computer monitor. Oftentimes, someone in the station inadvertently disconnects cables, or slams doors on the racks of critical equipment, or moves critical test cables inside the cone. Also, power glitches occur. With the data collection software currently being used at DSS 13, any degradation of data due to these causes could be seen immediately.

(9) For station stability testing, it is important to have a data collection software program that enables all data points to be stored and saved for postprocessing. Oftentimes, a glitch occurs in the data. If the cause of the glitch is known, and is a unique isolated phenomenon, it is valid to edit out the data point and thereby save most of the test data. It is also important to save this data to be used later to plot stability versus time for diagnostic purposes.

This article has presented results of tests performed on subsystem and end-to-end test systems at DSS 13 during May 1985 through March 1986. The test result of particular interest to participants of the Galileo Gravity Wave Experiment and members of the X-band Uplink Demonstration Team are the FFS values (for tau = 1000s) of between 9.51E-16 to 2.09E-15 obtained for an end-to-end system consisting of the exciter, transmitter in closed loop, X-band translator, X-band maser, MMR, and a modified Block III open-loop receiver. It is important to reemphasize that the FFS values do not include the stability of the hydrogen maser station frequency standard because in the measurement technique used, the instability of the frequency source tends to cancel out.

Due to the fact that only a few valid tests could be performed thus far on complete end-to-end system configurations, the end-to-end system test results are limited and not conclusive. It is recommended that more testing be done on the end-to-end systems at DSS 13. It is also recommended that a complete analysis be made of the measurement technique. Furthermore, cross-comparisons need to be made between the field-use test equipment (that was used to obtain the results of this article) and the test equipment being used by the JPL Frequency and Timing Group to make stability measurements on hydrogen masers. It is further recommended that the DSS 13 system be reanalyzed to see if account can be taken of common frequency source stabilities. Perhaps the method of taking the square root of the sum of individual subsystem Allan Variances is too conservative an approach. It is possible that some common-mode cancellations might be taking place in the system, thereby making the actual system stability better than was predicted.

Acknowledgments

The cooperation and assistance of DSS 13 personnel, including the transmitter group, are gratefully acknowledged. We are especially grateful for the cooperation of DSS 13 Station Supervisor G. Wischmeyer and Station Manager A. Price, and the very capable technical assistance of J. Garnica. On several occations, G. Wischmeyer and J. Garnica worked weekends to get the equipment ready and working for upcoming tests. The competent and always cooperative help of D. Choate of the Transmitter Group is acknowledged and appreciated.

C. Johns of the Radio Frequency and Microwave Subsystems Section made valuable contributions and made emergency repairs on translator and receiver modules whenever requested. R. Sydnor and A. Kirk of the Communications System Research Section gave helpful advice and assistance on both the theoretical and practical aspects of stability testing. C. Greenhall of the Communications System Research Section provided a writeup on the Beat Period Measurement Method and the equations for Allan Variance data reductions that were helpful in the development of a computer program to reduce test data in the field.

The original Data Acquisition System (DAS) for collecting data was designed by M. Tam (formerly of the Radio Frequency and Microwave Subsystems Section). T. Ly of the Radio Frequency and Microwave Subsystems Section was a key person who wired the counter board, assembled the DAS hardware, and performed the tasks necessary to ensure that the DAS worked reliably in the field. Kam Chu (a contractor) wrote assembly language software for an updated version of the Data Collection Program at a time when the modifications were urgently needed.

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Table 1. DSS 13 X-band uplink only test results during May 1985 — March 1986

Date of test	Xmtr syn[a]	Uplink frequency, MHz	Downlink frequency, MHz	FFS for tau = 1000s	#SDP	Air temp., °C	Comments
Part A. Exciter output tests with the exciter operating closed loop. The output test port is EXC in Fig. 1.							
MAY 85	R	7200.00	NA[b]	1.58E-15	18	21.0–15.0	5-hour test
JUN 85	S	7200.00	NA	3.27E-16	13	37.0–36.5	
JUL 85	S	7200.00	NA	3.86E-16	11	31.9–30.0	
JUL 85	S	7200.00	NA	4.98E-16	9	29.0–26.0	
JUL 85	S	7195.00	NA	3.08E-16	15	24.0	Two-mixer method
JUL 85	S	7162.30	NA	1.09E-15	13	23–26.5–22	Two-mixer method
JUL 85	S	7200.00	NA	2.27E-16	3	26.0–28.0	Short test
SEP 85	S	7200.00	NA	8.77E-16	10	21.3–21.0	
SEP 85	T	7200.00	NA	9.49E-16	6	17.5–13.0	
SEP 85	T	7200.00	NA	9.46E-16	13	20.5–19.5	
NOV 85	S	7200.00	NA	4.77E-16	13	10–12–9.6	
DEC 85	T	7200.00	NA	8.84E-16	3	12.0	Short test
JAN 86	T	7200.00	NA	1.15E-15	6	21.0–20.0	
JAN 86	S	7200.00	NA	2.80E-16	6	19.8–18.5	
FEB 86	S	7180.00	NA	1.32E-15	10	15.5–14.5	Two-mixer method
FEB 86	S	7180.00	NA	9.06E-16	10	14.0–14.5	Two-mixer method
FEB 86	S	7166.94	NA	2.51E-16	3	17.0–15.0	Two-mixer method
FEB 86	S	7200.00	NA	7.65E-16	10	15.0–16.0	
Part B. Transmitter output tests with the transmitter operating closed loop. The output test port is XMT in Fig. 1.							
MAY 85	R	7200.00	NA	2.68E-15	6	29.0–28.0	Edited data
MAY 85	R	7200.00	NA	1.76E-15	5	29.0–28.0	Edited data
MAY 85	R	7200.00	NA	3.46E-16	8	26.5–21.0	
DEC 85	T	7200.00	NA	5.13E-16	8	11.5–10.3	
Part C. Transmitter output tests with the transmitter operating open loop. The output test port is XMT in Fig. 1.							
MAY 85	R	7200.00	NA	1.42E-15	13	20.0–18.5	
DEC 85	T	7200.00	NA	4.94E-16	13	10.0–10.5	

[a]The symbols T, R, S in column 2, respectively, refer to the DSS 13 Transmitter, DSS 13 Receiver, and DSN Spare Dana synthesizers used as the transmitter (or uplink) synthesizer.
[b]NA = not applicable.

Table 2. DSS 13 X-band uplink and X-band downlink only test results during May 1985 — March 1986

Date of test	Xmtr syn[a]	Uplink frequency, MHz	Downlink frequency, MHz	FFS for tau = 1000s	#SDP	Air temp., °C	Comments
		Part A. Translator X-band output tests with transmitter bypassed. The output test port is XLTRX in Fig. 1.					
DEC 85	T	7162.30	8415.00	1.56E-15	13	13.5–8.5	Two-mixer method
DEC 85	T	7162.30	8415.00	6.08E-16	13	9–10–9	Two-mixer method
DEC 85	T	7162.30	8415.00	4.99E-16	13	8.5–9.0	Two-mixer method
		Part B. End-to-end system test with transmitter bypassed and with the Block III receiver in closed loop. The output port is EECLX (Port 8) in Fig. 1. The results for Part B were corrupted by leakage signals and are shown for reference purposes only.					
JAN 86	S	7177.92	8433.33	6.00E-16	9	17.0–9.5	
JAN 86	S	7177.92	8333.33	9.65E-16	2	5.5–6.0	Antenna moving
JAN 86	S	7177.92	8433.33	9.60E-16	11	5.5–10.8	
JAN 86	S	7177.92	8433.33	2.96E-15	6	9.5–8.5	Edited data
		Part C. End-to-end system test with closed-loop transmitter included and with the Block III receiver in closed loop. The output port is EECLX (Port 8) in Fig. 1. The results for Part C were corrupted by leakage signals and are shown for reference purposes only.					
JAN 86	S	7177.92	8433.33	5.93E-16	13	8.0–7.0	
JAN 86	S	7177.92	8433.33	1.62E-15	2	7.0–5.5	Antenna moving
JAN 86	S	7177.92	8433.33	4.03E-15	4	10.0–9.5	Edited data
		Part D. End-to-end system test with transmitter bypassed and with the Block III receiver in modified open loop. The output port is EEOLX (Port 11) in Fig. 1.					
JAN 86	S	7177.92	8433.33	7.95E-16	7	10.8–14.2	
FEB 86	S	7180.00	8435.78	9.04E-16	9	24.5–16.0	Note air temp.
FEB 86	S	7166.94	8420.43	6.72E-16	10	14.5–15.0	
MAR 86	S	7166.94	8420.43	3.05E-15	13	21.5–14.0	Edited data
MAR 86	S	7166.94	8420.43	1.19E-15	20	12.0–17.0	6-hour test
MAR 86	S	7166.94	8420.43	6.94E-16	16	24.8–12.5	Note air temp.
		Part E. End-to-end system test with closed-loop transmitter included and with the Block III receiver in modified open loop. The output port is EEOLX (Port 11) in Fig. 1.					
FEB 86	S	7180.00	8435.78	1.25E-15	6	25.5–24.8	
FEB 86	S	7180.00	8435.78	2.09E-15	17	25.2–28.5	
MAR 86	S	7166.94	8420.43	9.51E-16	11	25.0–25.5	

[a]See footnote a, Table 1.

Table 3. DSS 13 X-band uplink and S-band downlink only test results during May 1985 — March 1986

Date of test	Xmtr syn[a]	Uplink frequency, MHz	Downlink frequency, MHz	FFS for tau = 1000s	#SDP	Air temp., °C	Comments
Part A. Translator S-band output tests with transmitter bypassed. The output test port is XLTRS in Fig. 2.							
MAY 85	R	7177.92	2300.00	3.36E-15	13	15.0–16.0	Reasonable
MAY 85	R	7177.92	2300.00	7.07E-15	5	17.0–25.0	Edited data
JUL 85	S	7162.30	2295.00	2.05E-15	13	26.0–21.0	Two-mixer method
NOV 85	S	7162.30	2295.00	1.17E-15	6	3.5–1.0	Edited data
NOV 85	S	7162.30	2295.00	4.71E-16	4	3.5–1.0	Edited data
Part B. Multi-mission receiver S-band output tests with transmitter bypassed. The output test port is MMRS in Fig. 2.							
JUL 85	S	7162.30	2295.00	2.76E-15	4	20.5–19.5	Edited data
JUL 85	S	7162.30	2295.00	1.15E-15	7	20.5–19.5	Edited data
SEP 85	T	7162.30	2295.00	5.04E-15	8	22.0–24.2	Edited data
Part C. End-to-end system test with transmitter bypassed and with the Block III receiver in closed loop. The output port is EECLS (Port 14) in Fig. 2. The results for Part C might have been corrupted by leakage signals and are shown for reference purposes only.							
NOV 85	S	7162.30	2295.00	6.45E-15	13	0.8–<0.0	
NOV 85	S	7180.00	2300.70	4.40E-15	2	2.0–1.5	
NOV 85	S	7180.00	2300.70	4.60E-15	14	<0	
JAN 86	S	7177.92	2300.00	1.23E-15	9	14.0–11.5	
Part D. End-to-end system test with closed loop transmitter included and with the Block III receiver in closed loop. The output port is EECLS (Port 14) in Fig. 2. The results for Part D might have been corrupted by leakage signals and are shown for reference purposes only.							
NOV 85	S	7180.00	2300.70	6.94E-15	3	5.0–4.0	Xmtr output 6 kW
NOV 85	S	7180.00	2300.70	4.26E-15	3	0.0–1.0	Edited data
Part E. End-to-end system test with transmitter bypassed and with the Block III receiver in modified open loop. The output port is EEOLS (Port 17) in Fig. 2.							
NOV 85	S	7162.30	2295.00	1.52E-14	8	7.0–8.0	Bad result

[a]See footnote a, Table 1.

Table 4. JPL internal documents

1. Otoshi, T. Y., "Report on First Station Stability X-Band Measurements at DSS 13,", *IOM 3331-XX-XXX* (not numbered), Jet Propulsion Laboratory, Pasadena, Ca., April 4, 1984.
2. Otoshi, T. Y., "Final Report on Second Station Stability X-Band Measurements at DSS 13 During April 1984," *IOM 3331-84-027*, Jet Propulsion Laboratory, Pasadena, Ca., May 5, 1984.
3. Otoshi, T. Y., "Report on Third Station Stability X-Band Measurements at DSS 13," *IOM 3331-84-034*, Jet Propulsion Laboratory, Pasadena, Ca., June 18, 1984.
4. Otoshi, T. Y., "Current Status Report and Distribution of Preliminary Reports for Dec 1984 and Feb 1985 Stability Tests at DSS 13," *IOM 3331-085-012*, Jet Propulsion Laboratory, Pasadena, Ca., March 6, 1985.
5. Otoshi, T. Y., "Report on DSS 13 Station Stability Tests Performed during March 7–13, 1985," *IOM 3331-85-027*, Jet Propulsion Laboratory, Pasadena, Ca., May 8, 1985.
6. Otoshi, T. Y., and Franco, M. M., "Interim Progress Report on DSS 13 Station Stability Tests Performed During May 1985–March 1986," *IOM 3331-086-026*, Jet Propulsion Laboratory, Pasadena, Ca., May 20, 1986.

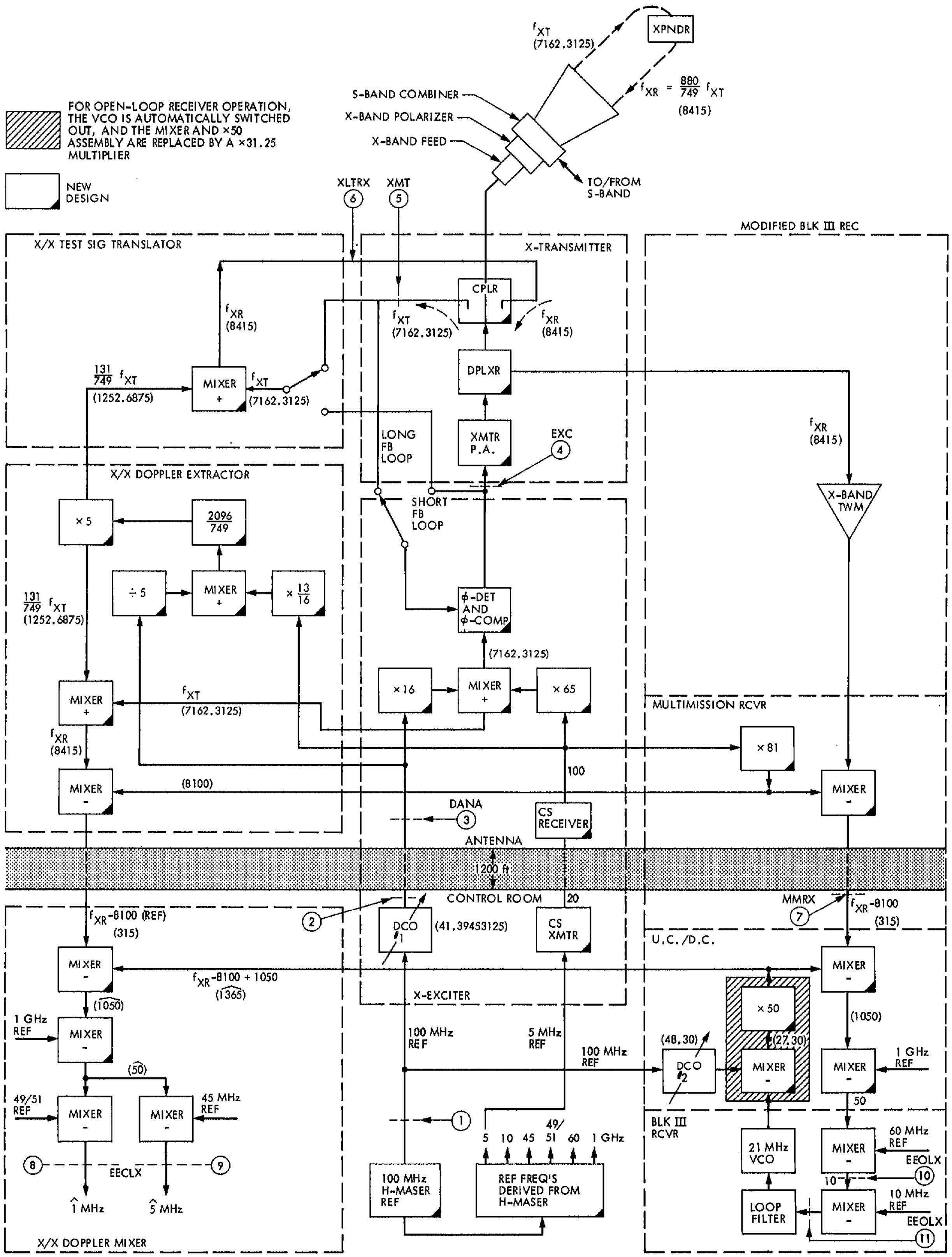


Fig. 1. Output test ports for frequency stability testing on X-band uplink and X-band downlink subsystems at DSS 13 (modified figure from Ref. 3). Example frequencies are for channel 14.

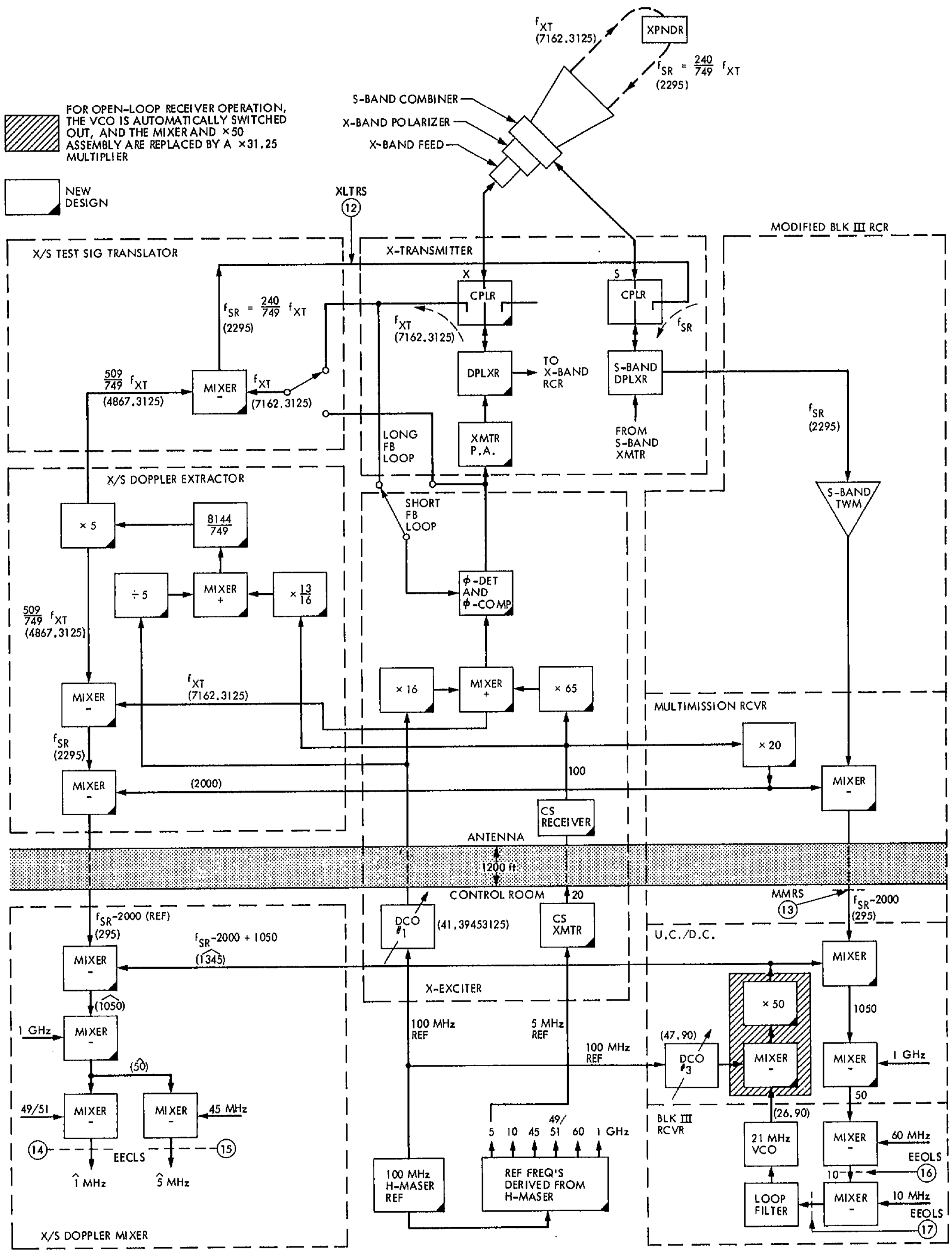


Fig. 2. Output test ports for frequency stability testing on X-band uplink and S-band downlink subsystems at DSS 13 (modified figure from Ref. 3). Example frequencies are for channel 14.

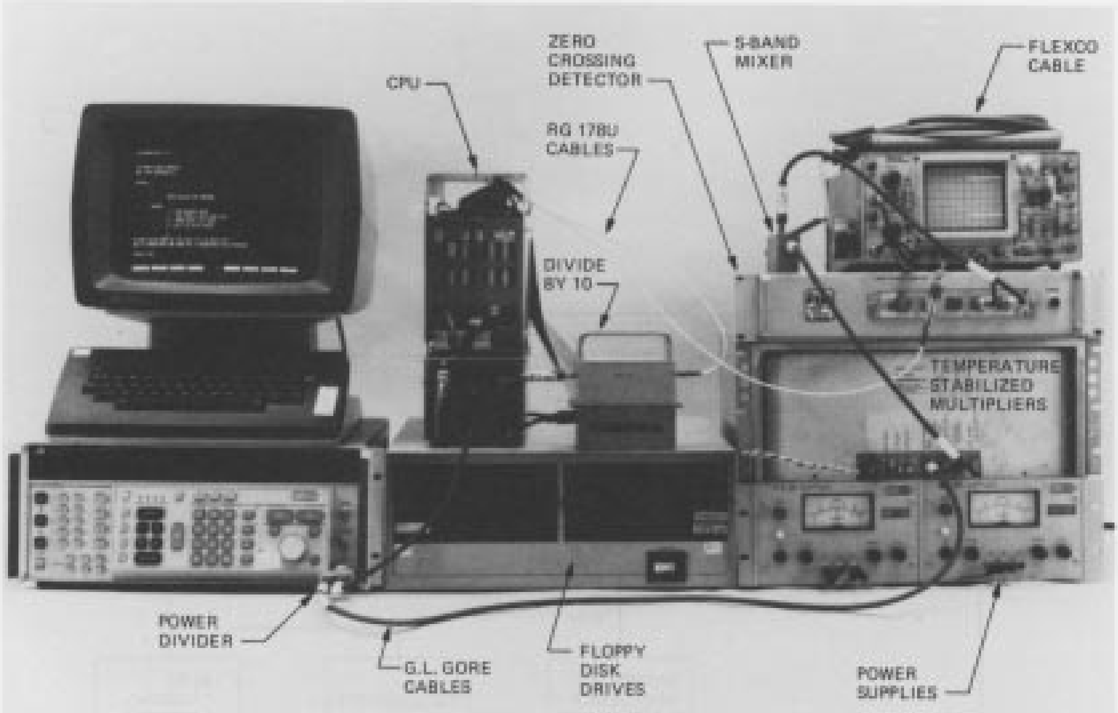


Fig. 3. Instrumentation used for station stability testing

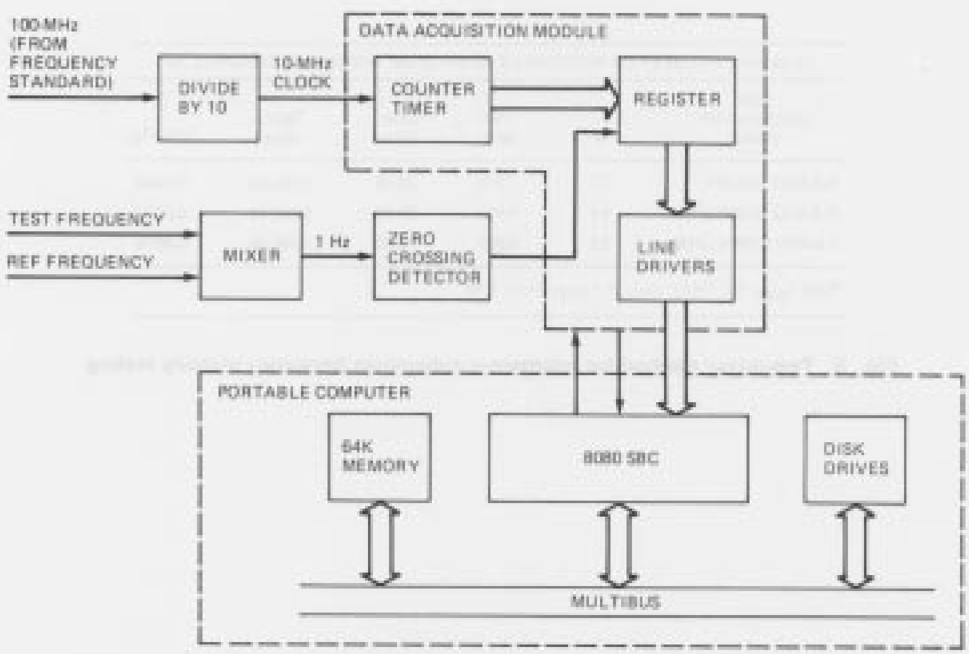
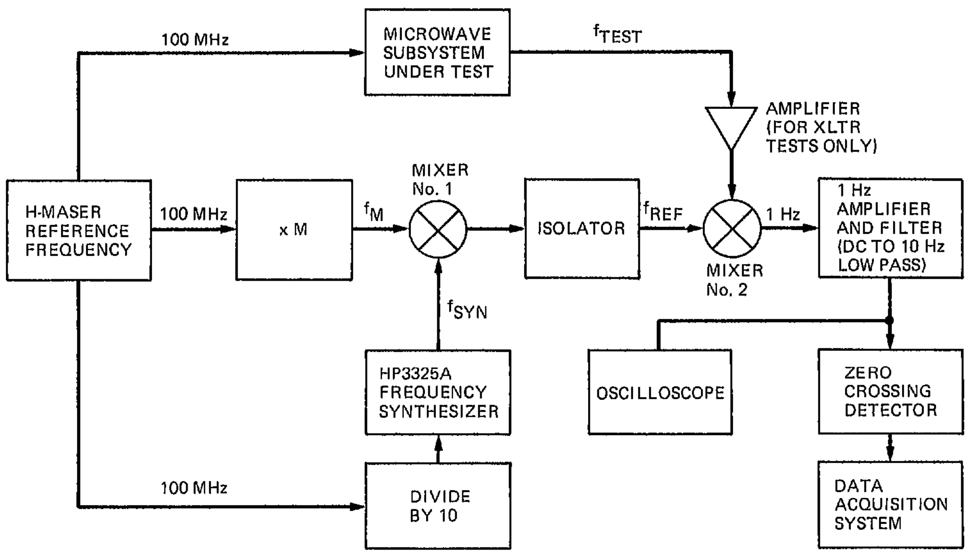


Fig. 4. Block diagram of Data Acquisition System (inside the dashed lines)



NOMINAL VALUES FOR MICROWAVE SUBSYSTEM TESTING AT CHANNEL 18

DSN MICROWAVE BAND	M	f_M, MHz	f_{SYN},[a] MHz	f_{REF}, MHz	f_{SYN}/f_M
X-BAND UPLINK	72	7200	33.06	7166.94	0.0046
X-BAND DOWNLINK	84	8400	20.43	8420.43	0.0024
S-BAND DOWNLINK	23	2300	3.52	2296.48	0.0015

[a]SET f_{SYN} SO THAT $f_{REF} = f_{TEST}$ (+/-) 1 Hz

Fig. 5. Two-mixer method for microwave subsystem frequency stability testing