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ANTENNA FEEDS AND RECEIVERS

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INTERIM REPORT

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Martin Marietta Corporation
Orlando, Florida

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SUMMARY

This report describes the results of 7 months of study, tradeoffs, test design, and fabrication in connection with the NASA Contract NAS5-21615 to modify three ground stations in support of the ATS-F program.

As a result of tests on the existing feed system of the Rosman No. 2 85-foot antenna and on the Transportable Ground Station (TGS) 40-foot antenna, it was determined that modifications of the existing phase-compensating rotary joints at Rosman are feasible. It was also confirmed that other components, such as the orthomode transducer, must be completely replaced, as indicated by NASA test data. In the TGS 40-foot antenna feed system, it was found to be feasible to broadband the existing monopulse comparator by adding simple irises and posts; both spare and active comparators have been modified. Likewise, it was demonstrated that the TGS polarizers can be broadbanded by adjusting existing pins and adding two new pins. These modifications are also directly applicable to the Mojave 40-foot antenna.

A subcontract was let for the design and construction of a new orthomode transducer for Rosman. Preliminary tests on the new design indicate that it will meet all requirements of the modified system, although weight of the new unit is high.

A tradeoff of cost factors indicated the desirability of subcontracting the receiver down-converters associated with the new communications and tracking receiving systems, and these units are now under construction and will be ready for integration into a system for preliminary acceptance tests at Orlando. Such tests are expected to be completed for the Rosman system in time for shipment to Rosman, North Carolina on or about April 1, 1972.

This report gives detailed electrical and mechanical characteristics of the new equipment as well as installation plans to enable NASA and its other contractors to determine the adequacy of the designs and to confirm that planned locations are both available and compatible with planned operational concepts.

A summary of remaining activities is given, showing the expected completion of procurement and fabrication in January of 1972. Subsequently, in-house preliminary system acceptance tests will be performed, followed by on-site installation and final acceptance tests. The schedule shows detailed steps remaining to achieve on-time performance of all contract milestones.

1. INTRODUCTION

This report describes progress to date in the design and implementation of modifications to feeds and receivers under Contract NAS5-21615. The contract requires modifications to three ground receiving stations to increase frequency coverage from the present 3.9 to 4.2 GHz to a new capability of 3.7 to 4.2 GHz. The modifications will also increase operational flexibility by providing a double conversion receiving system in which preselection filters need not be switched and in which frequency selection is performed by digitally controlled frequency synthesizers providing better than 1 kHz resolution over the 500 MHz range. The contract also provides for a new wideband cooled amplifier having a noise temperature of less than 18 degrees K. The contract provides for miscellaneous additions to, or improvements in, test or calibration features and provides for limited refurbishment of feed cone mechanical condition at Mojave and TGS.

This document reports the measurements made on the existing Rosman 85-foot No. 2, Mojave 40-foot, and Transportable Ground Station (TGS) 40-foot antennas and receiving systems. It presents the conclusions reached regarding necessary changes and describes implementation planned to achieve increased bandwidth capability and other features required by NASA GSFC Specification S-571-P-35. This document also describes designs which will implement Contract Amendments 1 through 6.

This report supplements the Design Review Report, OR 11,239, dated August 1971 with particular emphasis on test results and actual hardware design information including electrical specifications, planned locations, and dimensional data which will be useful to NASA and its support contractors in verifying that space is available, that the equipment will perform the function intended, that the operational layout will be functionally feasible, and that the new equipment will interface with other planned equipment being provided by or relocated by other contractors.

Finally, the report delineates the expected schedule of events through completion of the contract in December 1972.

2. MAKE OR BUY

From Table 1, which summarizes the make/buy decisions that have been made and implemented for the contract, it can be seen that the preponderance of equipment is purchased by Martin Marietta. These decisions were made on the basis of the most advantageous arrangement to the Government.

As expected, it has proved more economical to procure from other vendors and contractors those items that dovetail with their existing product line or closely relate to their most predominant product line. Thus, such waveguide components as orthomode transducer, diplexers, and bandpass and reject filters have been subcontracted to WaveCom; cooled amplifiers to Comtech; and down-converters to Aertech. Off-the-shelf frequency synthesizers have been procured from the John Fluke Manufacturing Company.

Martin Marietta has chosen to build those assemblies which are peculiar to this contract: collimation tower stable sources, receiver control panel, junction box, power supply assembly, etc. or which, by their similarity to equipment built on other contracts, made it obvious that significant engineering labor would be saved by adapting existing designs. Thus, the frequency generator panel, which is nearly identical to those built for the ATS-F transmitters (Contract NAS5-21198), is being fabricated in-house.

With the exception of the down-converters, all of these decisions have followed the proposed contract execution plan. In the case of the down-converters, rigorous competition, from both within and outside the Martin Marietta Corporation, made a clear-cut case for the subcontract. It is believed that the prevailing business climate throughout the industry at the time of the subcontract resulted in a unique opportunity for Martin Marietta to provide the Government with the required equipment at very reasonable cost.

TABLE 1

Make or Buy List

MAKE

	Ref. MM Drawing No.	Supplier
Frequency generator	614-01560	
Control and monitor panel	614-01575	
Stable sources unit	614-01574	
Junction box	614-01690-2	
Power supply assembly	614-01610	
Coaxial cables	--	
Ten-conductor cables	--	
55-conductor cables	--	
Rework TGS antenna assembly	--	
Rework Mojave feed assembly	--	

BUY

Cooled amplifier system	614-01513	Comtech
Communications down-converter	614-01525	Aertech
Tracking down-converter assembly	614-01526	Aertech
Multiplier assembly	614-01518-A	Aertech
Performance monitor/frequency translator	614-01543	Aertech
Orthomode transducer	614-01508	WaveComm
Diplexer	614-01510	WaveComm
Transmit reject filter	614-01511	WaveComm
Transmit reject filter	614-01512	WaveComm
Tunnel diode amplifier	614-01516	Aertech
Solid state source	614-01535	AIL
Synthesizers	614-01500	Fluke
Synthesizers	614-01540	Fluke
Transmit waveguide switch	Logus L05-228	
Coax transfer switch	Logus L07-232	
Coaxial direction coupler (30 dB)	614-01547	Narda
Directional coupler coax (20 dB)	614-01547	Narda
Directional coupler coax (10 dB)	614-01547	Narda
TWT amplifier	614-01520	Varian
Stable sources multiplier	614-01519	Greenray
Stable sources	614-01521	Greenray

3. HARDWARE DEVELOPMENT

3.1 Antenna Feeds and Microwave Components

At the Bidders' Conference of December 1969, a data package presented to each prospective contractor showed the measured performance from 3.7 to 4.2 GHZ for selected assemblies and components of the Rosman and Mojave systems to assist the contractor in deciding the extent of modification and/or replacement necessary to render the system useful over the extended frequency band. It became obvious that all microwave components (such as filters, diplexers, and orthomode transducers (OMT's) were initially designed for maximum performance in the 4.0 to 4.2 GHz band and that rapid rolloff in out-of-band performance made it necessary to replace these components to employ a broader portion of the band.

This section reports on on-site and in-house measurements made on the feed system since contract award. This data was taken from specific components and subassemblies to confirm the need for replacement or modification and to serve as a baseline, or pre-mod reference. Those modifications already made to some feed components are discussed here, as well as the performance of new components and plans for completing the feed modification.

Modifications to the Mojave, TGS, and Rosman feeds will have very little impact on the gain and noise temperature performance of those systems, other than the normal degradation that could be expected from extending the receiving frequency band down to 3.7 GHz. (The inherent primary beam broadening, experienced as frequency is lowered, causes subreflector spill-over, which leads to lower illumination efficiency, higher sidelobes, and a slight increase in noise temperature.) Each of these characteristics is a direct function of the feed apertures, which will not be altered in this program. All items to be replaced or modified (such as the OMT, diplexers, filters) will have insertion loss and VSWR characteristics equal to or better than those of the existing equipment; therefore, they will not contribute to an increase in noise temperature or a decrease in gain.

3.1.1 Rosman 85-Foot Antenna

A block diagram of the Rosman microwave configuration to be contained in the feedcone is shown in Figure 1. Essential features of the system are:

1 Use of a single horn for transmit, receive, monopulse sum channel, and polarization sensing

2 Use of a circularly polarized ring array for the monopulse error channels

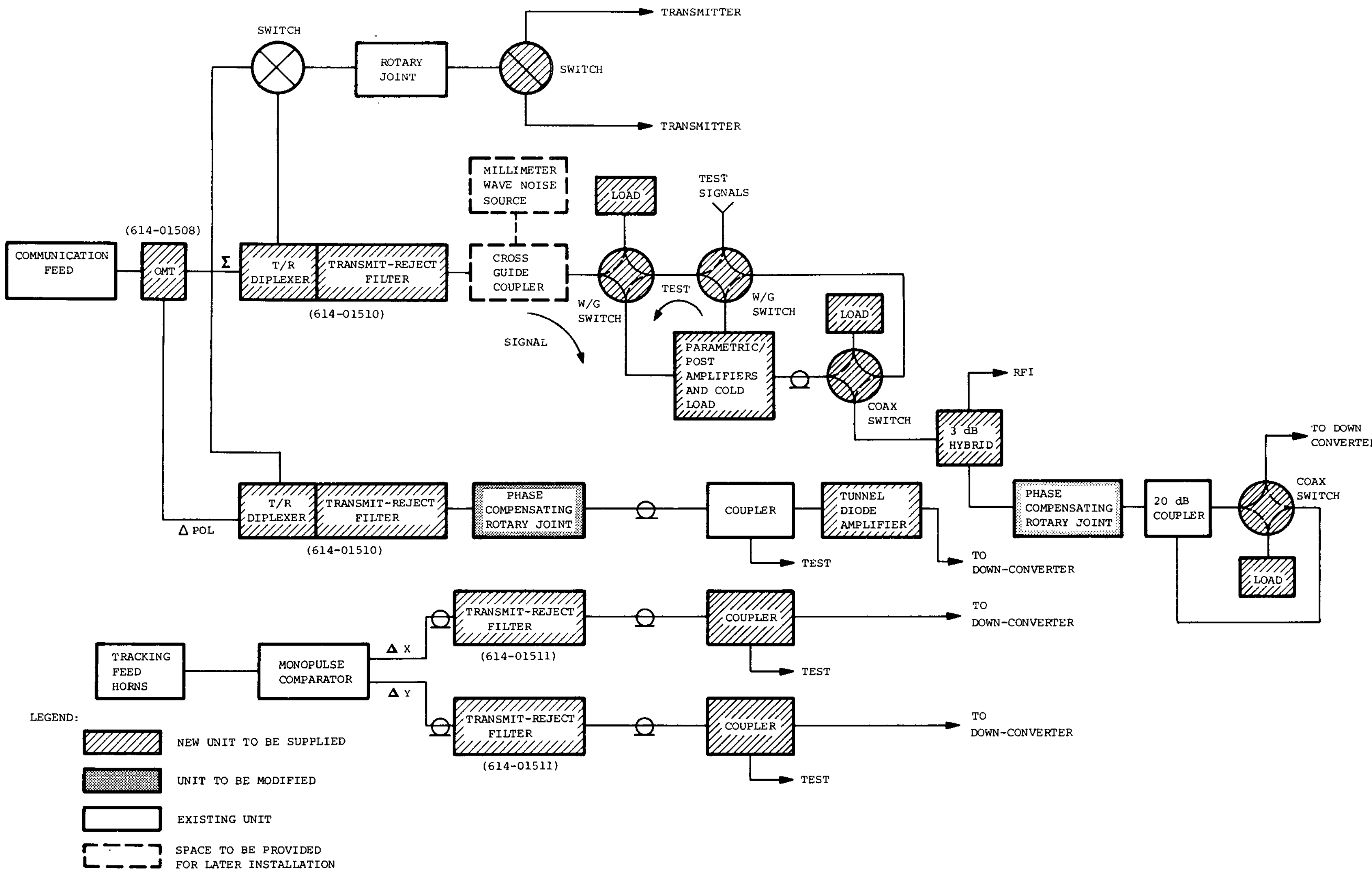

Figure 1. New Rosman Feed System

3 Polarization sensing on the null in the orthogonally polarized receive input

4 Automatic polarization sensing and alignment over a 270-degree sector

5 Extraction of the beacon signal for the monopulse sum channel after amplification, and use of a phase-compensating rotary joint to maintain relative phase with the circularly polarized error channel array

6 Capability to transmit parallel or perpendicular to the polarization of the receive signal

7 Low-noise cooled amplifier

8 Filters to isolate the transmitter from the receivers

9 Ability to inject test signals (CW or noise)

10 Capability to extract an RF signal (prior to down-conversion) and send it directly to the Instrumentation Building via a low-loss elliptical waveguide for RFI experiments.

Comparison of the existing microwave system at Rosman with the new system shows that operation and capabilities are essentially the same, the prime difference being performance of the individual components. The major exception to this is replacement of the paramp amplifier TWT combination with a parametric amplifier/transistor amplifier combination and alteration of the test signal injection circuits.

3.1.1.1 Communication Feedhorn and Tracking Array

A series of measurements was performed on the communications feedhorn and tracking array, including the comparator network, to determine their utility over the new operating frequency band. VSWR measurements on the center (communications) feedhorn, using a WR187 slotted line and a tapered transition from WR187 to the 1.8 inch square horn input (Table 2) show that the horn will operate down to 3.7 GHz. No VSWR measurements were made in the transmit band from 5.925 to 6.425 GHz because the required transition from WR137 to 1.8 inch square was not available. Since the horn was initially designed to operate from 5.9 to 6.4 GHz, however, no difficulty is anticipated. VSWR measurements of the tracking array (Table 2), using a coaxial slotted line directly at the ΔX and ΔY outputs terminals of the comparator networks, show that the tracking array is well matched over the receive band, except in the immediate vicinity of 3.7 GHz where the VSWR is a maximum of 1.6:1. This performance is considered acceptable since it will not noticeably degrade the tracking performance of the Rosman antenna.

TABLE 2

VSWR of Rosman Feeds

Frequency (GHz)	Communication Horn	ΔX Output	ΔY Output
3.60	1.18	1.48	1.20
3.65		1.21	1.60
3.70	1.13	1.05	1.06
3.75		1.53	1.45
3.80	1.06	1.32	1.33
3.85		1.35	1.26
3.90	1.06	1.32	1.12
3.95		1.23	1.14
4.00	1.02	1.05	1.15
4.10	1.15	1.15	1.15
4.20	1.10	1.20	1.27

Isolation measurements were made between the communications horn and the error channels by inserting the transmitter frequency signals into a WR187 wavegide-to-coax transition connected to the communications horn through the tapered transition; VSWR of this setup was 1:04 to 1 at 6.1 GHz. The measured isolation (Table 3) was in excess of 50 dB over the entire transmit band, although in most cases it was in excess of 70 dB, the measurement limit of the instrumentation.

Several attempts were made to measure the secondary axial ratio of the tracking array; the best data presently available, however, indicates that the axial ratio may be less than 3 dB over the receive band from 4.0 to 4.2 GHz. In the band from 3.7 to 4.0 GHz, it appears that the axial ratio degrades to a maximum of 6 to 8 dB. The high axial ratio in the tracking horns has a definite effect on the angle-tracking performance of the antenna by adding pre- and post-comparator phase errors.

On 19 and 20 May 1971, an attempt to measure secondary axial ratio was hampered by equipment problems. Resulting data led to the supposition that the dichroic subreflector may be partly responsible for the high secondary axial ratios. Details of these data, measurement techniques, and problem details were reported in the Design Review Report, OR 11,239, August 1971, pages 25 to 29.

TABLE 3

Isolation From Communication Horn to
Tracking Error Ports (Rosman)

Transmitted Frequency (GHz)	Isolation (dB)	
	ΔX	ΔY
5.9	>70	>70
6.0	>70	>70
6.1	63	63
6.2	54	56
6.21	50	51
6.22	55	56
6.25	>70	>70
6.3	>70	>70
6.4	>70	>70

On 10 and 11 August 1971, a renewed attempt to measure the axial ratio of the tracking array also met with limited success. It was decided to measure first the primary axial ratio of the array, using the polarization calibration horn mounted in the subreflector. (The dichroic subreflector was replaced by the original all-metal unit to measure effects, if any, on the axial ratio.) The equipment setup for these primary measurements is shown in Figure 2. Due to the on-axis null generated by the comparator network, as seen at the ΔX or ΔY channel output, it was not possible to measure the axial ratio of the complete array. Instead, the axial ratio of one quadrant and two separate horns within that quadrant were measured (Table 4). Also shown in the table is the axial ratio of a spare tracking horn measured at Martin Marietta's anechoic chamber.

The spare horn data shows that the axial ratio is good in the original design band from 4.0 to 4.2 GHz, but exhibits significant degradation in the neighborhood of 3.7 GHz. The on-site measurements of individual horns were not so conclusive, although quadrant measurements show a definite trend toward a degradation of axial ratio toward 3.7 GHz. Unlike earlier attempts to measure the axial ratio, this data was consistent and repeatable.

Another attempt was then made to measure the secondary axial ratio from Bald Knob Tower. Due to the very low grazing angle, ground reflections were considered a possible cause for measurement anomalies; however, equipment problems overshadowed those considerations at the time. The setup for the secondary measurements (Figure 3) was essentially the same as for primary measurement except the calibration horn was replaced with

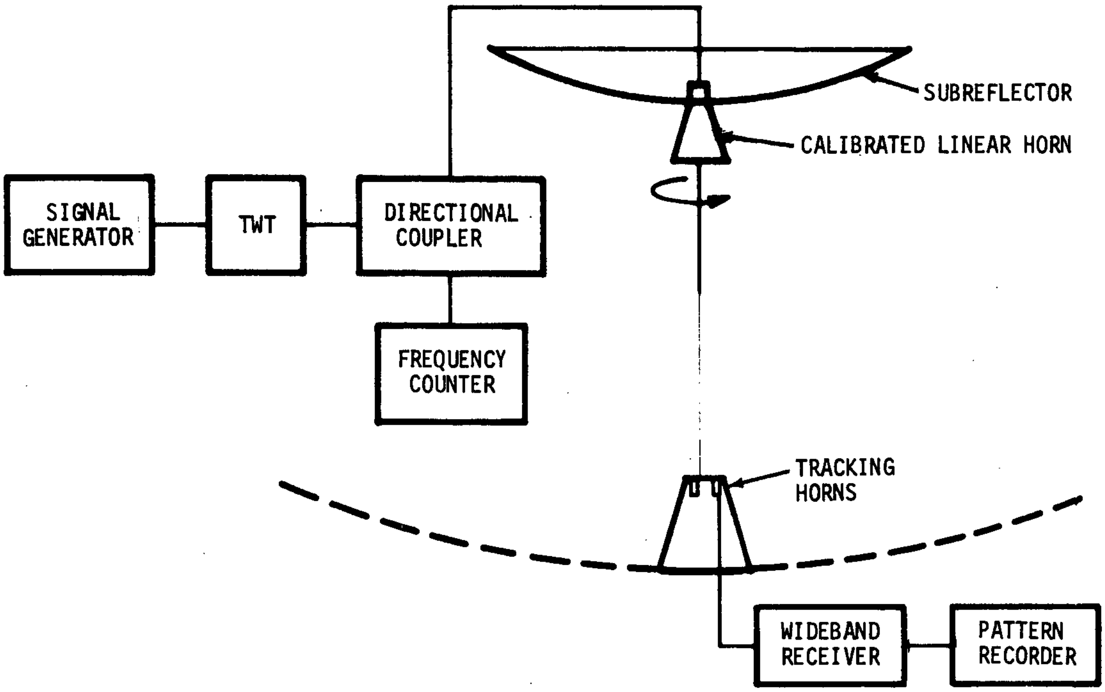

Figure 2. Equipment Set-Up for Primary Axial Ratio Measurements

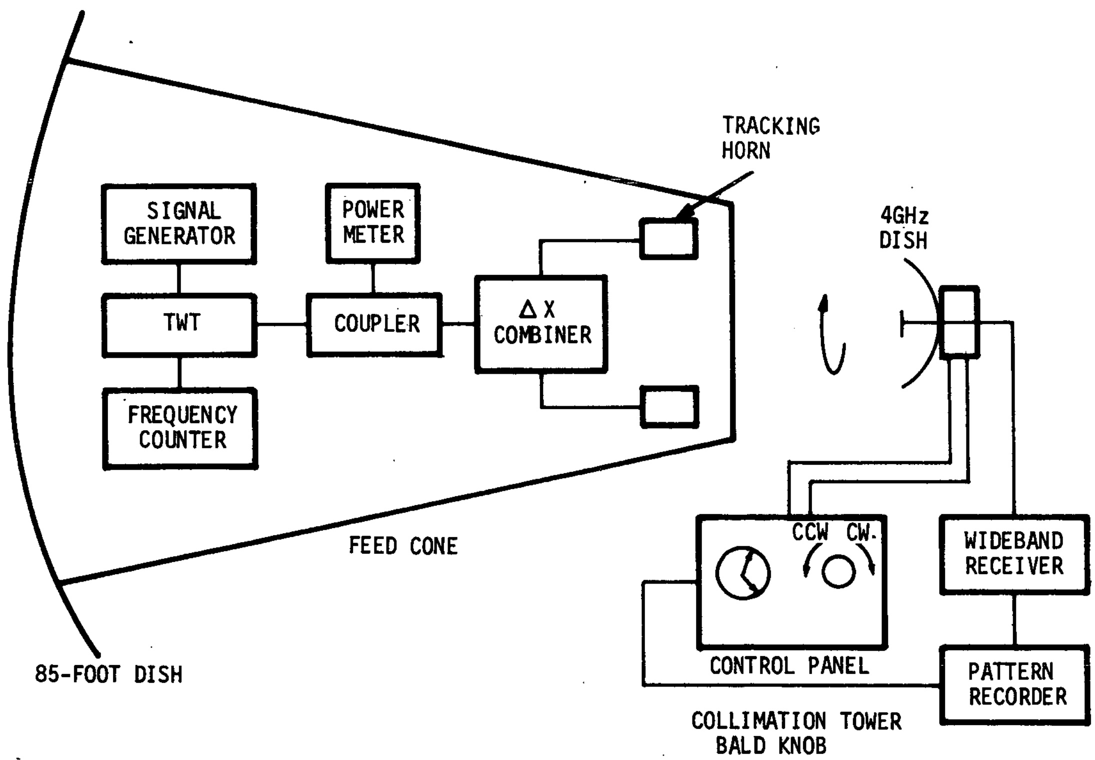

Figure 3. Equipment Set-Up Secondary Axial Ratio Measurements

TABLE 4

Primary Axial Ratio of Rosman

Tracking Feed Horns

Frequency (GHz)	4 Horns North Quad. (dB)	North Horn West Quad. (dB)	South Horn West Quad. (dB)	Spare Horn at Martin (dB)
4.2	1.8	3.0	1.3	1.5
4.1	2.5	5.4	4.5	1.5
4.0	2.3	2.3	3.7	0.0
3.9	3.4	1.9	6.2	4.0
3.8	4.6	2.7	4.3	6.0
3.7	4.6	5.8	8.5	8.0

a 6-foot reflector. Due to the capability to remotely rotate the polarization of the 6-foot antenna with synchro position data available at the base of the tower, it was possible to record the axial ratio on chart paper. As a result, it was possible to detect other anomalies in the measured data, which earlier could not be seen.

Initial measurements again displayed a very high axial ratio in the design band from 4.0 to 4.2 GHz. Close examination of the data (Figure 4) shows a definite lack of pattern symmetry, e.g., the change from a maximum to a minimum response should be smooth and periodic every 90 degrees. Instead, the signal was erratic and not periodic.

In an attempt to determine the cause of this data irregularity, the axial ratio of the Polang channel was measured using the identical setup. The Polang horn was linearly polarized and should have shown nulls more than 35 dB below the peak. Examination of the measured pattern (Figure 5) shows not only deep nulls but also irregular peaks which could be caused only by ground reflections and/or a misaligned rotating boresight antenna.

To investigate the effect of the latter possibility, the test signal was rerouted through the 6 GHz (4-foot) reflector located just below the 4 GHz reflector on the collimation tower. This data (Figure 5) was excellent since it displayed the deep nulls and periodic function characteristics of a linearly polarized antenna. At this point, the axial ratio of the tracking horns was measured again using the 6 GHz reflector. The limited data measured (Figure 6) was also excellent since measured axial ratios were about 3 dB; even more importantly, the data for the first time displayed the periodic function characteristics of the polarization pattern. It was not possible to make measurements below 4.1 GHz due to cutoff characteristics of the 6 GHz horn.

These measurements show that there is in the 4 GHz antenna a problem which is probably a combination of aligning the feed in the dish and aligning the dish with the Rosman II antenna. When a NASA program, implemented to refurbish and realign the collimation tower antennas, is completed, another attempt will be made to measure the axial ratio of the tracking array.

3.1.1.2 High Power Switch and Rotary Joint

The high power switch, currently employed in the feed system to switch the transmit signals between the two diplexers, will be retained in its present form and will continue to perform the same function. The waveguide rotary joint, which is contained at the base of the rotating table within the feedcone and which transfers the high power transmit signal from the stationary transmitter to the rotating feed, will also be retained as is. Both of these units have been designed to cover the transmit band from 5.925 to 6.425 GHz and, although no specific measurements were made to confirm their performance, the current and continuous use of these components in the system is evidence that their performance is satisfactory.

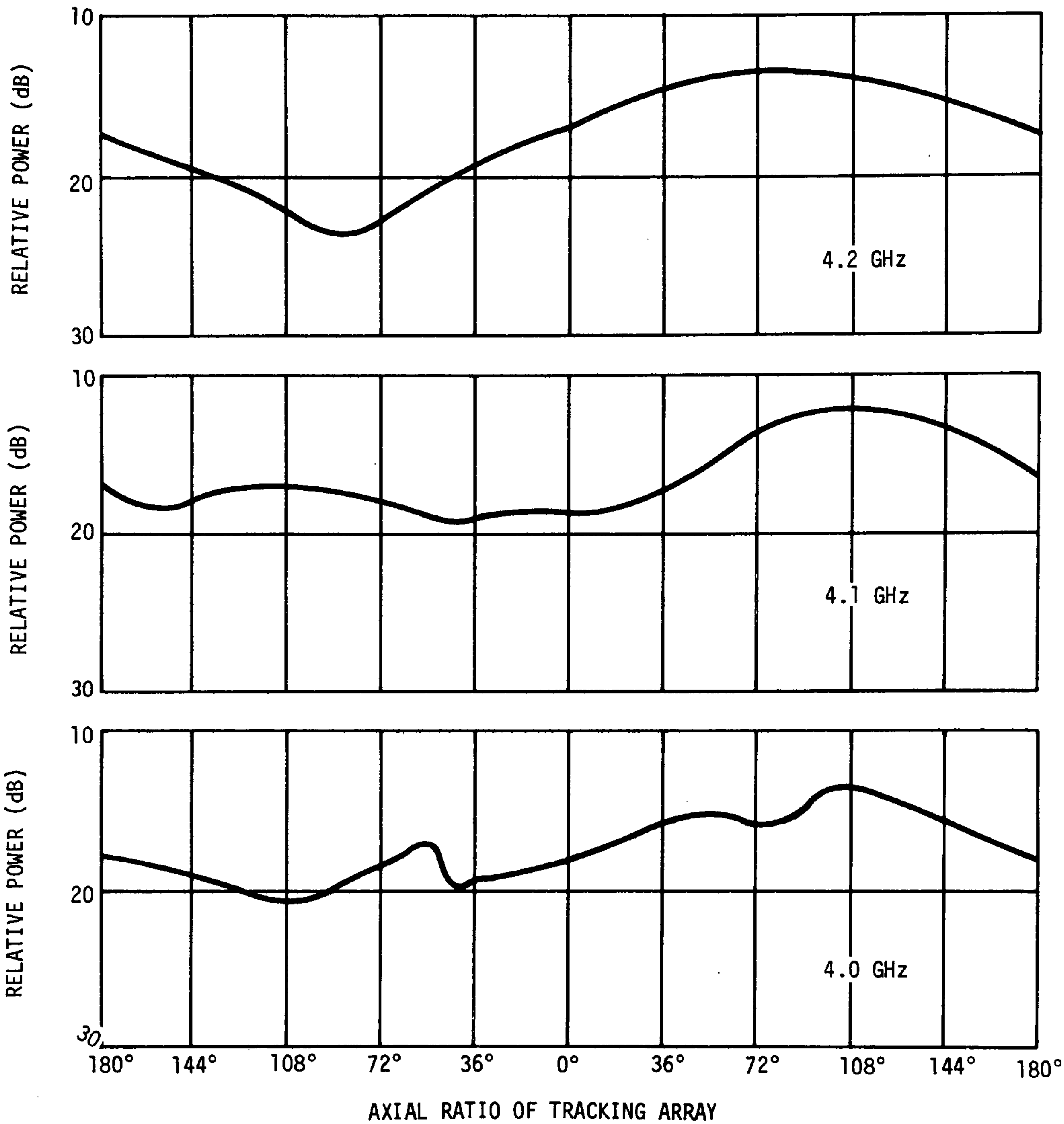

Figure 4. Secondary Axial Radio of Tracking Array Showing Lack of 180-Degree Symmetry

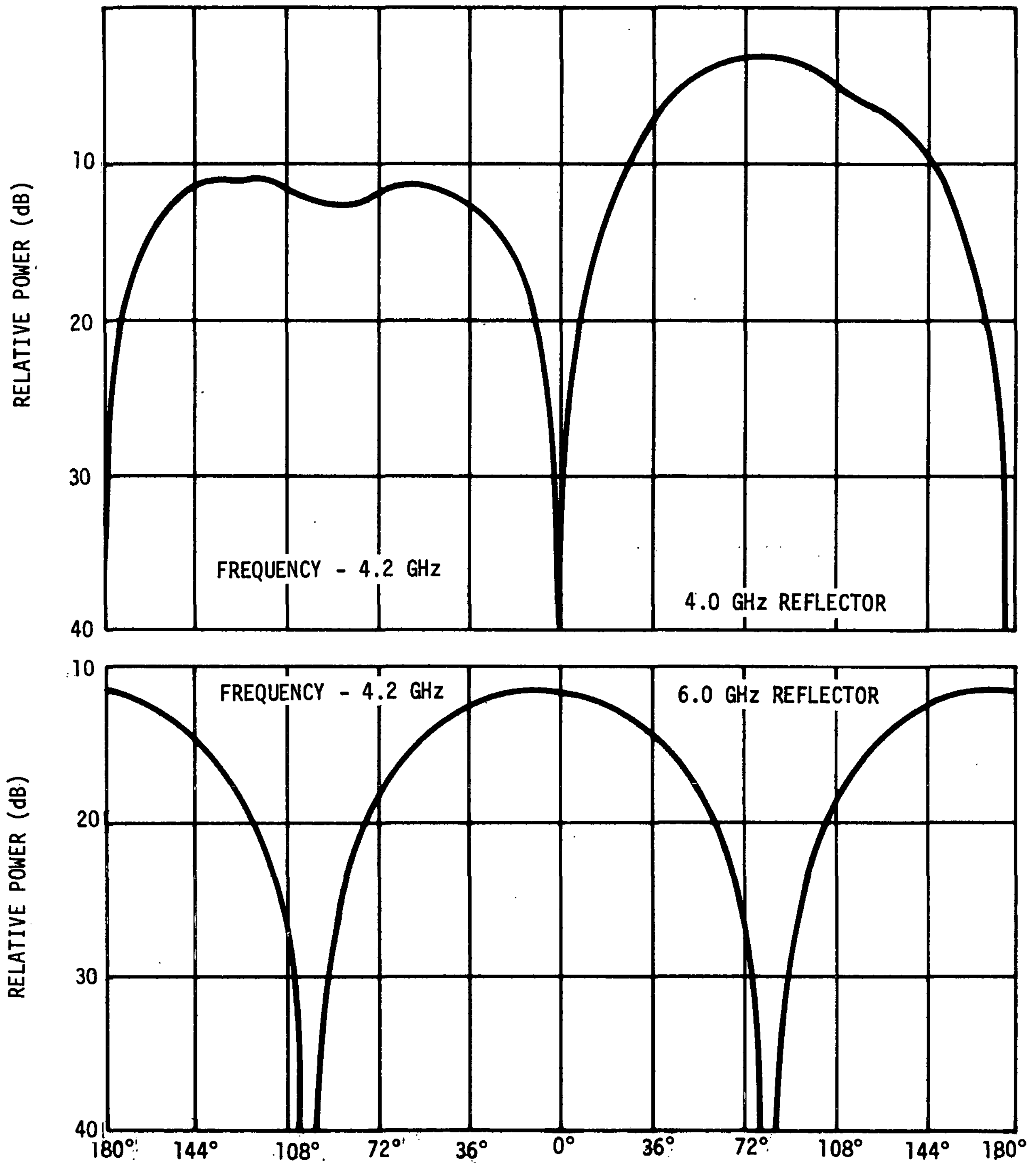

Figure 5. Axial Ratio of Polang Antenna

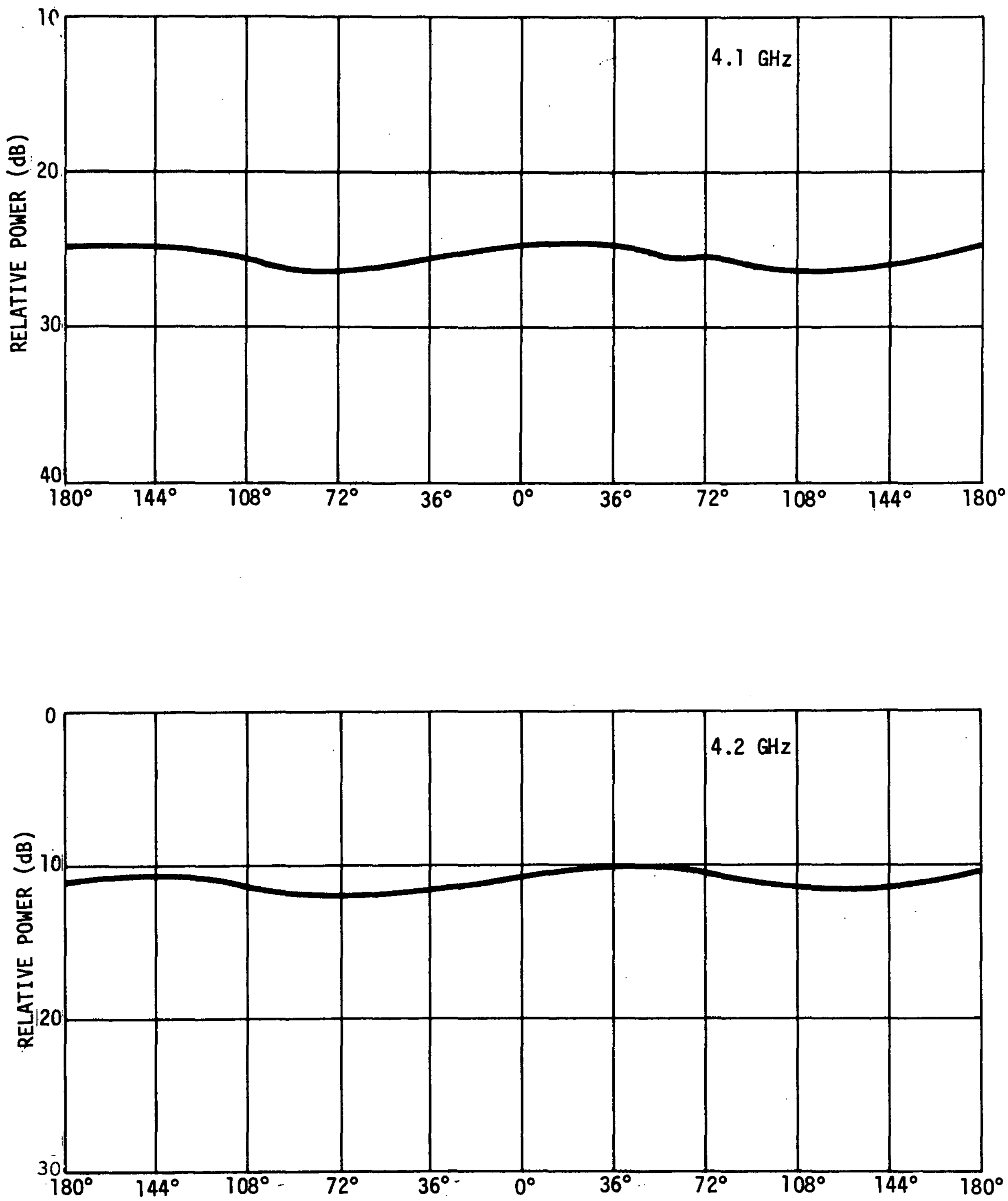

Figure 6. Axial Ratio of Tracking Array Using 6 GHz Collimation Tower Antenna

Prior to reinstallation of these units into the modified feed, they will be cleaned and tested for performance over the band.

3.1.1.3 Components to be Replaced or Modified

In the communications and Polang channels, the present OMT, transmit-receive diplexer, and transmit-reject filter will be replaced by units designed to operate over the new frequency band. The present image-reject filters are not required because Martin Marietta is employing the double-conversion approach, which places the image far below the passband of transmit-reject filters and of bandpass filters in the down-converters. In the tracking error channels, the present transmit-reject filters will be replaced by units designed for the new frequency range.

A short section of flexible waveguide will be employed in all long waveguide runs to relieve any stresses and strains and avoid cracking of waveguide components. In the transmit waveguide run, the only change will be addition of another high power waveguide switch to connect either of the two transmitters. Previously, both transmitters could be used simultaneously, if desired, by employing a diplexer. This switch will be located in the immediate vicinity of the transmitters, leaving only one waveguide run into the feed cone.

The phase-compensating rotating joints, presently optimized for the 4.0 to 4.2 GHz receive band will be redesigned for operation over the new frequency range. Coaxial directional couplers will be provided and calibrated over the new frequency range. Three waveguide and two coaxial switches will be added to check performance and to aid in troubleshooting.

The parametric amplifier, tunnel diode amplifier, and test circuits will be covered in other sections of this report.

3.1.1.3.1 Orthomode Transducer (OMT)

The OMT is a device comprising an antenna port, through port, and side port. The antenna port mates with the communications horn input, while the other two ports mate with the antenna port of the transmit-receive diplexers. All ports of the OMT are used for transmitting and receiving RF energy.

A new OMT is being designed, developed, and fabricated by Wavecom, Inc., Northridge, California, under subcontract to Martin Marietta. Specifications being used to govern OMT design and ultimate performance of the OMT are summarized below:

Transmit frequency band	5.925 to 6.425 GHz
Receive frequency band	3.70 to 4.20 GHz
Transmit power	16 kW, CW
Isolation (through port to side port)	40 dB minimum

Isolation (side port to through port)	40 dB minimum
Insertion loss (through port to antenna port and antenna port to through port)	0.05 dB maximum
Insertion loss (side port to antenna port and antenna port to side port)	0.05 dB maximum
VSWR (transmit and receive)	1.15:1 maximum

Wavecom's initial OMT design (Figure 7) employed a ridge-loaded waveguide into which a wave is inserted in a plane having its E field normal to the surface of the ridges. The wave is then guided into a similar orthogonal section of waveguide. The use of a ridge waveguide creates a broadband device having very low loss and capable of handling the high power. As the design became more detailed, the ridges were made more symmetrical and an orthogonal set of ridges was added. The initial design concept intended that the ridge section would generate only the desired TE_{10} mode, even though the TE_{11} mode could be supported (if excited) in the band from 5.9 to 6.4 GHz. This thinking was partially correct. Measurements on the breadboard model showed a significant amount of energy converted to the TE_{11} mode at the junction where the orthogonal ridged waveguide enters the main body of the OMT. Although exact measurements were not made to determine the frequency response characteristics and magnitude of the TE_{11} mode, the evidence was conclusive that it existed and was causing high insertion loss, high VSWR, and significant cross coupling.

The OMT design has been changed to a symmetrical orthogonal feed network (Figure 8). This configuration comprises a main body with four ports: antenna port, through port connecting to the diplexer, and two symmetrical orthogonal ports combined and coupled to the second diplexer. The combining network is composed of E-plane and H-plane bends machined to hold 1.8 by 0.740 inch I.D., and a power combiner that resembles a Majestic tee. This combiner will be capable of matched performance over the entire receive and transmit band. Logic behind this design is that the symmetrical orthogonal feed will provide a self-cancelling mechanism for elimination of the TE_{11} mode.

A breadboard "half section" of this new design has been built and successfully tested for matching on the orthogonal port. A full section unit has also been built and matched in the thru port. The combining network, when completed, will be attached to the main OMT body, matched, and tested as a complete unit.

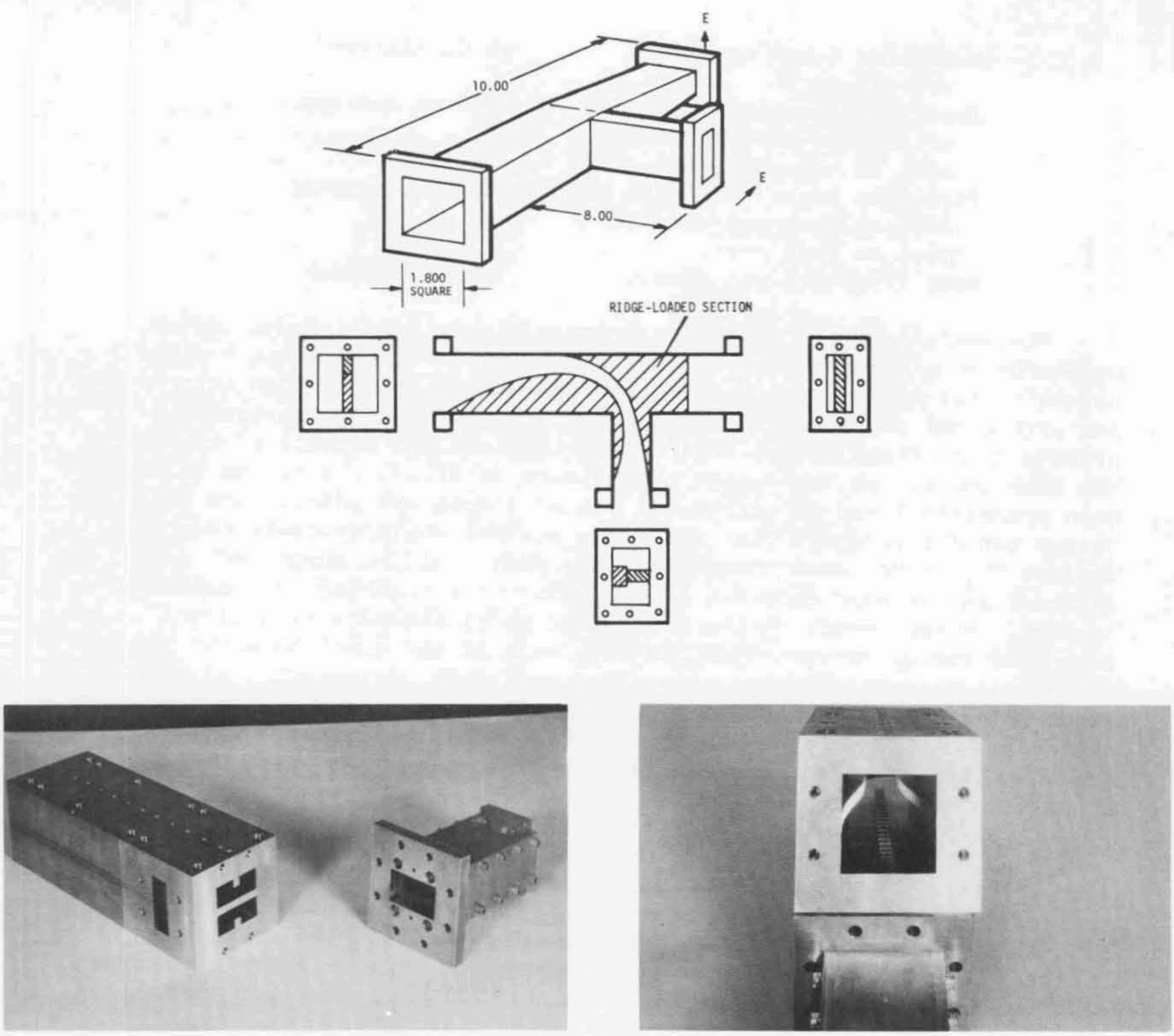

Figure 7. Initial Ridged OMT Configuration

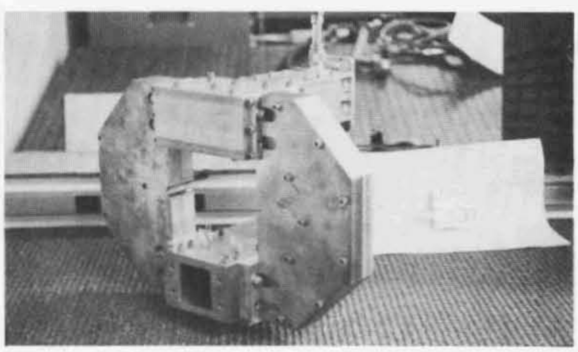

Figure 8. Symmetrical Feed OMT

3.1.1.3.2 Transmit-Receive Diplexer

The transmit-receive diplexer is a three-port device which serves to couple the transmit and receive signals to the antenna through the OMT while maintaining isolation between the transmit and receive ports. The diplexer consists of a T-junction with a high-pass filter in the transmit arm and a separate transmit-reject filter in the receive arm.

The present unit is designed to operate from 3.992 to 4.200 GHz. in the receive band and from 6.000 to 6.425 GHz in the transmit band. Transmit-to-receive isolation is 100 dB minimum and receive-to-transmit isolation is 40 dB minimum. Maximum VSWR is 1.15:1 in the appropriate frequency bands for the input ports. Insertion loss is 0.075 dB in the transmit arm and 0.10 dB in the receive arm. The present unit will not operate over the new frequency band with the high isolation and low VSWR requirements.

A new diplexer has been designed and developed and is currently being fabricated by Wavecom in accordance with Martin Marietta Specification 614-01510 summarized below:

Transmit frequency band	5.925 to 6.425 GHz
Receive frequency band	3.70 to 4.20 GHz
Isolation (transmit to receive)	100 dB minimum
Isolation (receive to transmit)	40 dB minimum
Insertion loss (transmitter port to antenna port)	0.1 dB maximum
Insertion loss (antenna port to receive port)	0.1 dB maximum
Transmit power	16 kW, CW
VSWR (any port)	1.15:1 maximum
Delay distortion (unequalized):	
Linear component	0.3 nanosecond/ 40 MHz maximum
Parabolic component	0.025 nanosecond/ MHz^2 maximum
Residual ripple	0.3 nanosecond peak-to-peak maximum

Wavecom's design is based on a high-pass filter in the transmit arm and a band-reject filter in the receive arm. The high-pass filter is composed of a special cross section of waveguide designed to have a cut-off frequency of 4.8 GHz. The length of this section is selected to give the required attenuation to signals in the receive band, while maintaining the lowest possible insertion loss to signals in the transmit band. The band-reject filter comprises a section of ridge-loaded waveguide to which an appropriate number of resonators are included to provide the required rejection to the transmit frequencies while maintaining the lowest possible insertion loss at the receive frequencies. The total configuration of the diplexer (Figure 9) includes the necessary waveguide transitions to mate with WR159 waveguide at the transmitter port, WR229 at the receive port, and 1.800 x .740-inch waveguide at the OMT port.

In the design process, each filter was developed separately and then combined to complete the diplexer. The complete prototype diplexer was tested to give the following performance:

VSWR	=	1.05 maximum (5.925 to 6.425 GHz)
	=	1.07 maximum (3.7 to 4.2 GHz)
Insertion Loss	=	0.025 dB - OMT to transmitter
	=	0.11 dB* - OMT to receiver
Rejection	>50 dB - 3.7 to 4.2 GHz in transmit port	
	>100 dB - 5.925 to 6.425 GHz in receive port	

3.1.1.3.3 Band-Reject Filters (Error Channels)

A band-reject filter is provided in each of the two tracking-error channels to prevent the transmit signal from interfering with the ΔX and ΔY channels. Transmit-receive isolation in these channels is the sum of that provided by these filters, plus the decoupling of the transmit and receive signals through use of separate tracking antennas. The present system employs filters that provide 160 dB minimum isolation to the transmit frequency. The specification requires that 100 dB isolation be maintained in both channels. Measurements on the feed system recently performed at Rosman indicate that the isolation between transmit feed and tracking feed is at least 50 dB. In addition, past experience has shown that both Mojave and TGS operate satisfactorily with only 100 dB isolation. Based on these considerations, a new filter specification has been written which

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* The model is made of copper and brass materials soldered together. The final unit is expected to have a maximum insertion loss of 0.07 dB in the receive band.

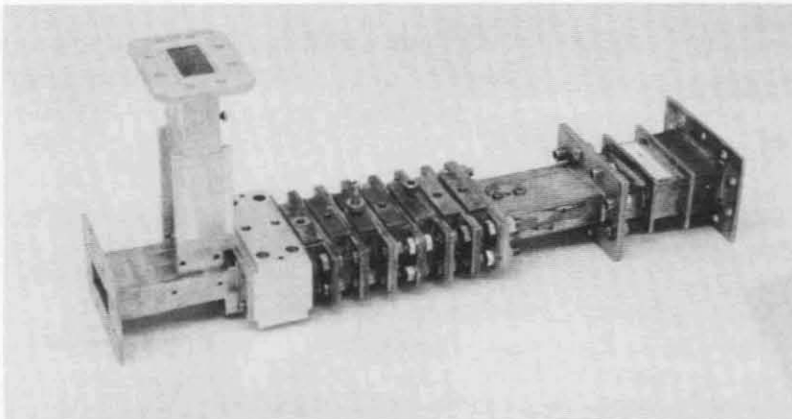

Figure 9. Prototype Diplexer

requires 90 dB isolation be achieved from the filters alone. Thus a minimum of 140 dB of isolation will be realized.

A new filter has been successfully designed, developed, and fabricated by Wavecom in accordance with Martin Marietta Specification 614-01511, summarized as follows:

Transmit (reject band)	5.925 to 6.425 GHz
Receive (pass band)	3.70 to 4.20 GHz
Insertion loss (reject band)	90 dB
Insertion loss (pass band)	0.35 dB maximum
VSWR (pass band)	1.15:1 maximum

Initial specifications for this filter required less than 0.15 dB of insertion loss, which limited the design to a waveguide configuration. A brief study on the need for such a low insertion loss, and a trade of system performance, size, weight, cost, reliability, and installation problems, resulted in ultimate selection of a coaxial version of the filter. The first copy of this TEM interdigital filter (Figure 10 has been delivered to Martin Marietta. The following summarizes its performance:

VSWR	1.16 maximum (3.7 to 4.2 GHz)
Insertion loss	0.35 dB maximum (3.7 to 4.2 GHz)
Rejection	90.2 dB minimum (5.925 to 6.4 GHz)

Figure 10. Band-Reject Filter (Coax)

3.1.1.3.4 Phase-Compensating Rotary Joints

The Rosman feed system contains two phase-compensating rotary joints, one in the sum channel after the parametric amplifier and the second in the Polang line. The need for these rotary joints is to provide a phase rotation identical to that experienced in the circularly polarized tracking horns for an incoming linearly polarized signal. The phase-compensating rotary joint in the sum channel is needed to establish a (relatively) fixed sum phase reference to which the tracking error signal is compared for direction. As the sum channel needs to be phase compensated to be compatible with the tracking horns, the Polang error signal must also be phase-compensated because it is also compared to the phase of the sum channel for direction.

Each rotary joint is made up of three sections: an input transition from rectangular waveguide or coax to circular waveguide, a quarter wave phasing section to provide circular polarization within the rotary joint, and an output transition from circular waveguide back to coax. The two transition sections are designed to maximize the coupling from the transmission line to the rotary joint and to provide isolation between the LCP and RCP output ports on the sum channel rotary joint. Performance of these transitions is not considered to be extremely critical to intended performance of the joint. The quarter wave differential phase shifter is the most critical section of the rotary joint. It is essential that the axial ratio of the elliptically polarized wave, produced by the quarter wave section, remain better than 2 dB over the entire band from 3.7 to 4.2 GHz. If the axial ratio becomes too great, both the antenna tracking system and the Polang system will experience a loss in signal and tracking non-linearities.

The Rosman Polang channel data measured by NASA and distributed at the Bidders' Conference on 16 December 1969 illustrates the effects of a poor axial ratio in the rotary joint. This data included the entire Polang channel through the rotary joint. On 20 May 1971, the rotary joints, sum and Polang, were removed from the feed, and bench tests for VSWR, axial ratio, and wow showed a trend toward increasing axial ratio outside the original 4.0 to 4.2 GHz design band. This data substantiates the data NASA provided to the bidders; high wow and VSWR below 4.0 GHz is believed to be related to the high axial ratio.

On 10 August 1971, additional tests were made at Rosman to further evaluate the need for modifying the rotary joints. The setup employed for making measurements is shown in Figure 11. The first set of data was derived from using the entire Polang microwave line, including the OMT, diplexer, and rotary joint. This data (Figure 12) was identical to that given out at the bidders' briefing with one exception: the null position did not shift as a function of frequency. A review of factors contributing to the measured data showed that a null shift is not possible; hence, the apparent shift must have been caused by alignment errors or backlash in the various drive mechanisms involved in the measurement.

In the Design Plan (OR 11,239, pages 18 through 20), the cause of axial ratio asymmetries measured at 3.7 GHz was hypothesized to be the arbitrary alignment of axial ratio minima of the OMT and rotary joint. This hypothesis has proved to be correct and is illustrated by the sequence of measured data given in Figure 13. This figure shows the axial ratio of the Polang channel prior to entry at the rotary joint and the axial ratio of the rotary joint alone. (Note that the angular reference on all data is fixed and absolute). Finally, this figure illustrates the result of combining these effects as in normal operation of the Polang system. Further measurements at 3.7 GHz showed that an alignment of the minima (Figure 14) will produce a symmetrical axial ratio without inflections. This alignment was shown to provide symmetry and linearity throughout the frequency band from 3.7 to 4.2 GHz (compare data in Figures 12 and 15).

Even though the "minima alignment experiment" was successful in eliminating asymmetries, it was decided to modify the rotary joints,

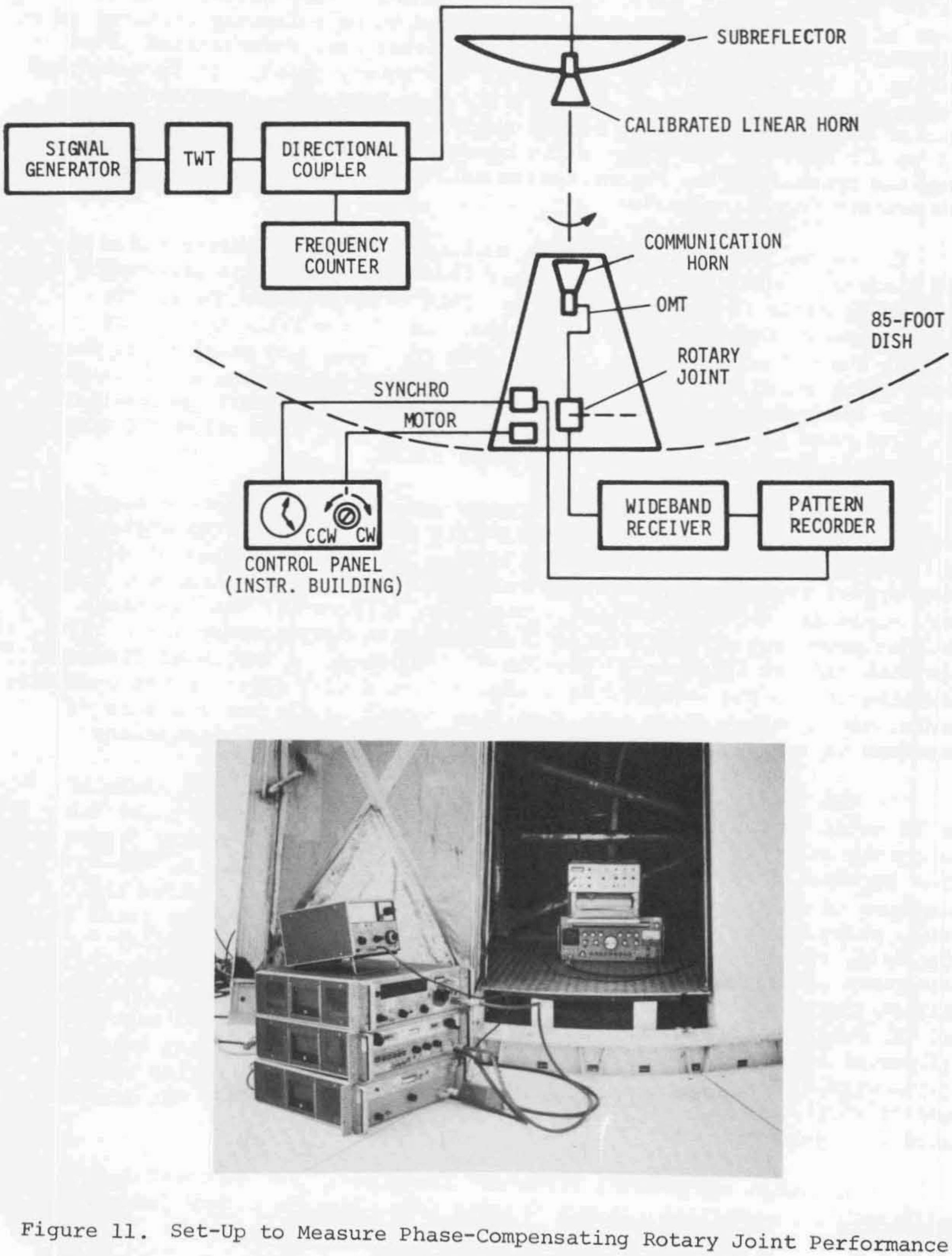

Figure 11. Set-Up to Measure Phase-Compensating Rotary Joint Performance at Rosman

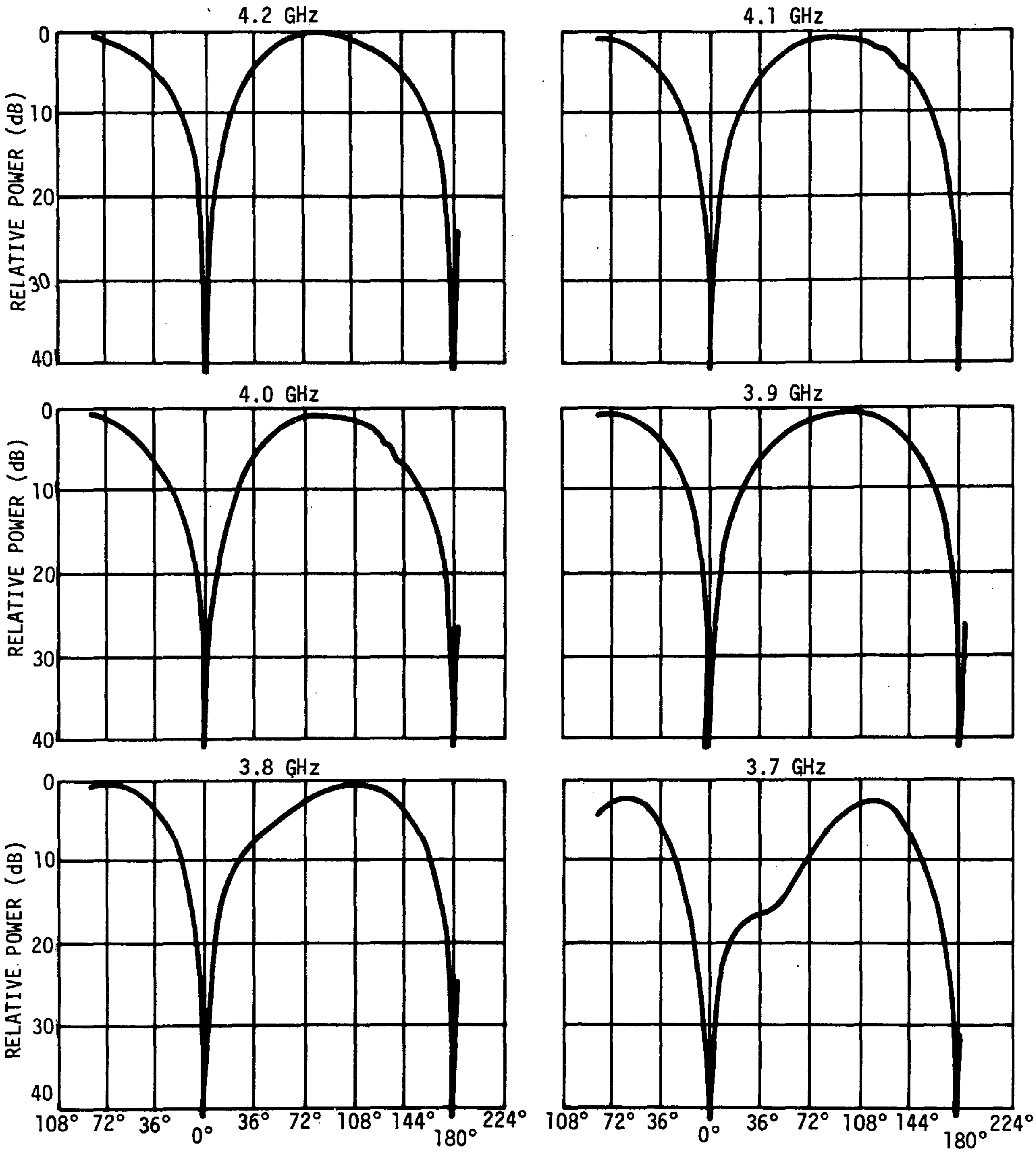

Figure 12. Polang Channel Axial Ratio Including Rotary Joint Effects

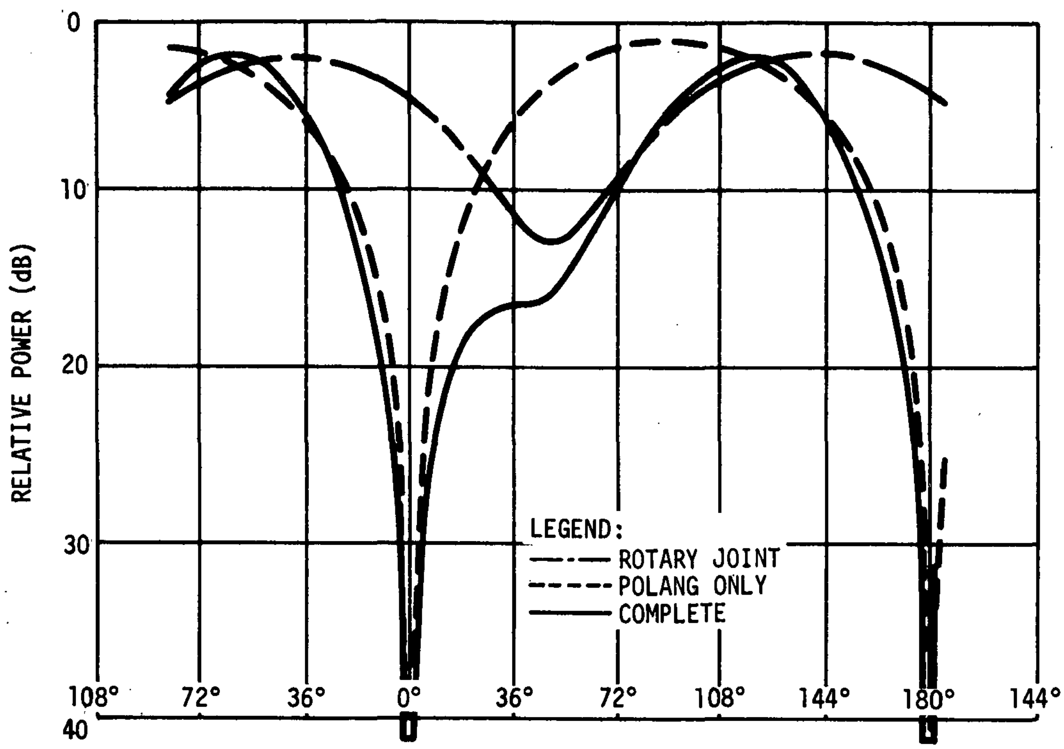

Figure 13. Measured Effect of Existing Axial Ratio Alignment

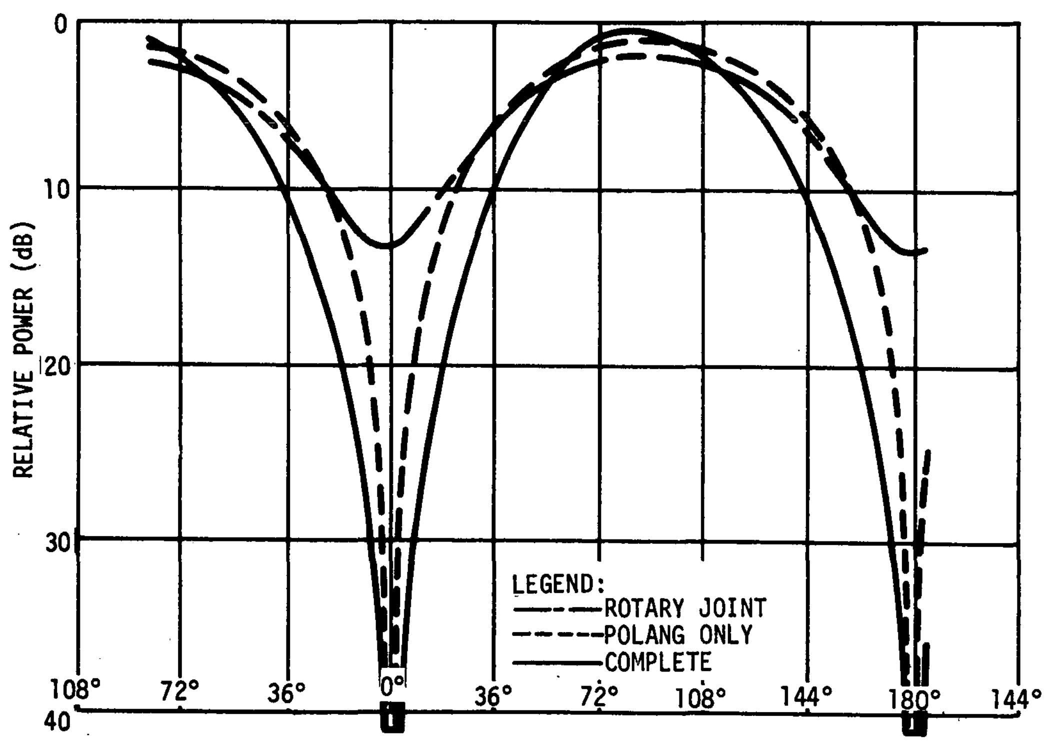

Figure 14. Measured Effect of Aligning Axial Ratio of Polang and Rotary Joint

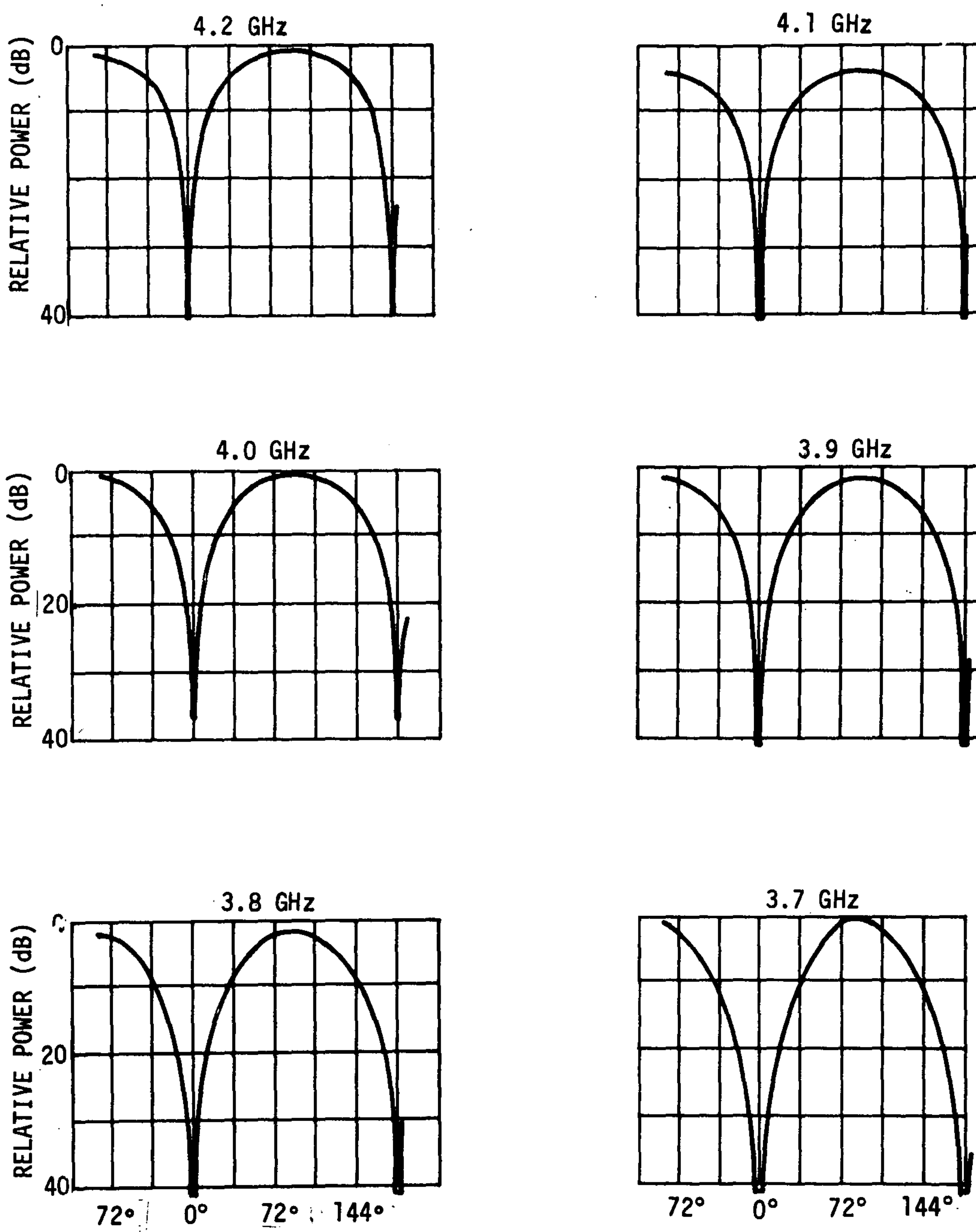

Figure 15. Measured Effects of Axial Ratio Alignment Over the Complete Receive Band

based on the unavoidable loss of signal in the tracking sum and Polang channel when the incoming signal is aligned with that polarization which produces a minimum response in the rotary joint. This post-amplifier signal loss could amount to the axial ratio's maximum value, which is 10 dB at 3.7 GHz. The effect of this signal loss is to upset the signal balance between sum and error channels in the antenna angle tracking and Polang receivers. In addition, the VSWR of the rotary joints below 4.0 GHz are much too high and would require at least a modification to those components that would improve the match.

Plans for implementing these modifications are limited to redesign of the input and output ports for a broader band impedance match and redesign of the 90-degree phase-shifting section to enable response over the entire receive band from 3.7 to 4.2 GHz. No change will be made to the rotating components and outside configuration.

More specifically, when the Rosman antenna is shut down for modification, the rotary joints will be returned to Orlando for modification and testing. The current 90-degree phase-shifting section, consisting of six irises, will be removed and replaced with an array of four to five pairs of pins. The coaxial-to-waveguide transition probe will be replaced with a broadband probe. The unit will then be matched, tested, and returned to Rosman for installation. No changes will be made to the bearings, bearing housings, or any external dimensions; therefore, the rotary joint can be easily replaced in the system without any consideration for mechanical and electrical interface.

In preparing for these modifications, an RF model of the phase-compensating rotary joint has been built and tested. Measured data on this model (Figure 16) shows that an axial ratio of less than 1.5 dB can be realized over the entire receive band from 3.7 to 4.2 GHz. Further effort will be directed toward improving the axial ratio to less than 1.0 dB and providing an impedance match better than 1.5:1 over the band.

Once performance of the RF model is found to be acceptable, a set of modification drawings will be prepared and detailed parts will be fabricated. These drawings and parts will then be set aside until the Rosman rotary joints are returned to Orlando for modification.

3.1.1.3.5 Mechanical Configuration

The feed cone design locates the "antenna-mounted unit" portion of the parametric amplifier in the approximate position of the present Paramp. The new OMT, diplexer, and transmit-reject filters are also located in approximately the same position as the existing units. Space has also been allocated for future installation of a 6-inch-long cross-guide coupler for the millimeter wave noise source between the diplexer, transmit-reject filter, and the antenna-mounted portion of the parametric amplifier. Provisions have also been made for installing two flexible

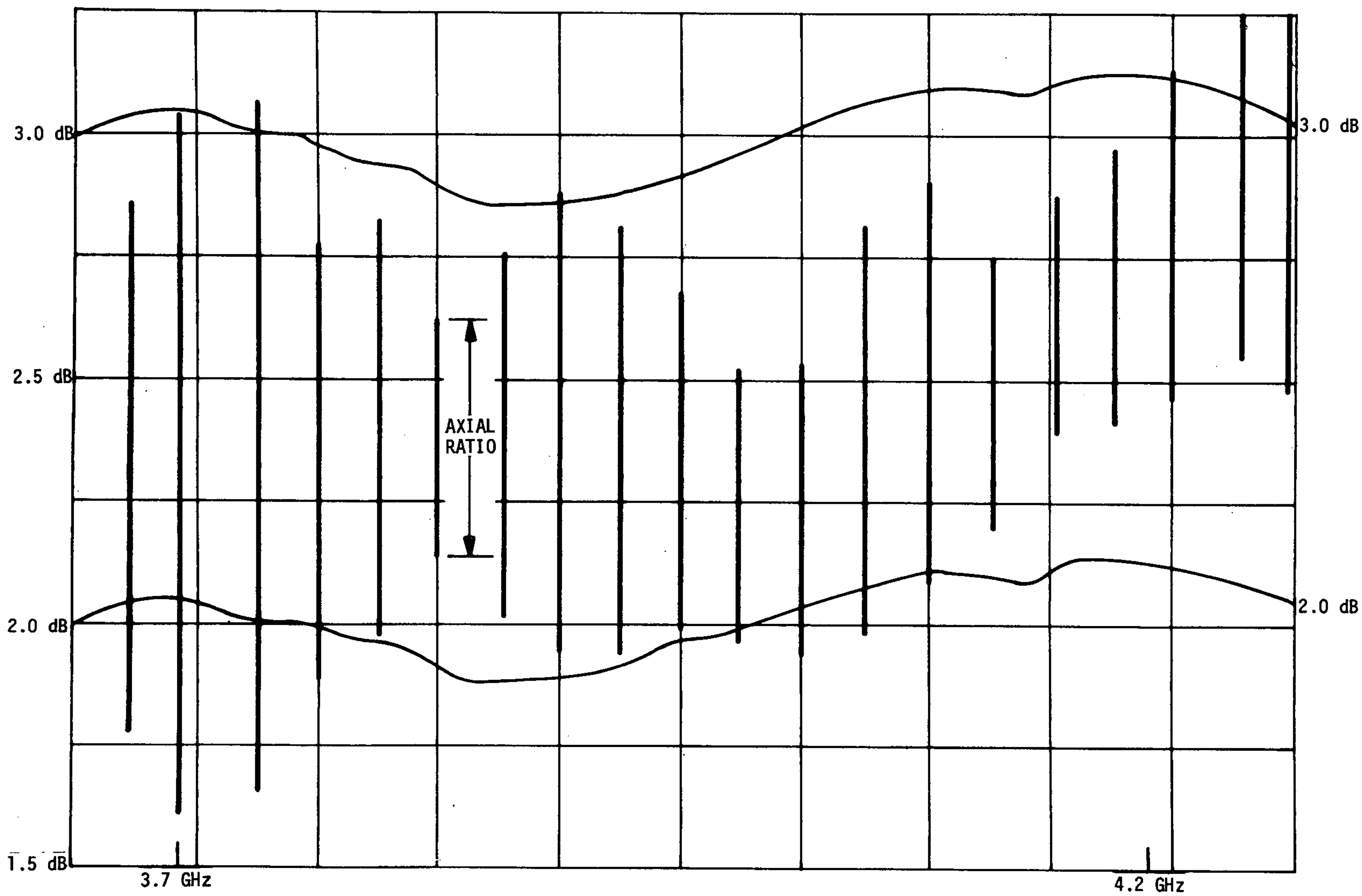

Figure 16. Axial Ratio of Phase-Compensating Rotary Joint Model

waveguides 4 inches long (for strain relief) in each waveguide run adjacent to the transmit-reject filters. The two band-pass filters (614-01511) will be mounted near the existing monopulse comparator in the top of the feed cone. The tracking down-converter (614-01526) will be located in the position presently occupied by the monopulse converter. Since final dimensions of the OMT are not now available, a detailed layout of the Rosman feed cone assembly is not included in this report.

3.1.2 Mojave/TGS 40-Foot Antenna

A block diagram of the equipment configuration to be employed in the Mojave and Transportable Ground Station (TGS) feed cones is shown in Figure 17. Essential features include:

1 A feed system comprised of polyrod antenna elements

2 A center polyrod used expressly for transmitting up to 16 kW CW

3 A four-element array of polyrods for monopulse tracking, receiving communication signals, and polarization sensing

4 Capability to transmit parallel or perpendicular to the received signal

5 Low-noise, cooled amplifier

6 Filters to isolate the transmitter from the receiver

7 Automatic polarization alignment.

Operation of the modified feed and microwave network for the Mojave installation is essentially the same as the present system, except for the increased frequency range covered by the new system. The configuration of the feed network will remain unchanged. Transmit reject filters will be provided to cover the new frequency band. The existing directional coupler in the communication channel will be retained and calibrated over the new frequency band. New coaxial couplers will be provided in the Polang and tracking error channels. The test switching circuits used to inject noise and CW signals into the low-noise amplifier will be the same as the test signal circuits at Rosman.

The existing Transportable Ground Station (TGS) system employs a pseudo-monopulse tracking system wherein the communications signals, the sum, ΔEL and ΔAz tracking signals, and the Δ Polang signals are routed down a common line through a common low noise amplifier. Angle tracking and Polang tracking functions are performed by time sharing a single tracking receiver. The key element to this system was the time division multiplexer (lobing switch) which sequentially samples the ΔEL, ΔAz, and Δ Polang signals.

The TGS system is being modified to make the tracking system identical to Mojave, i.e., a three-channel monopulse system. NASA will provide two additional tracking receivers to implement this change. In layout, the

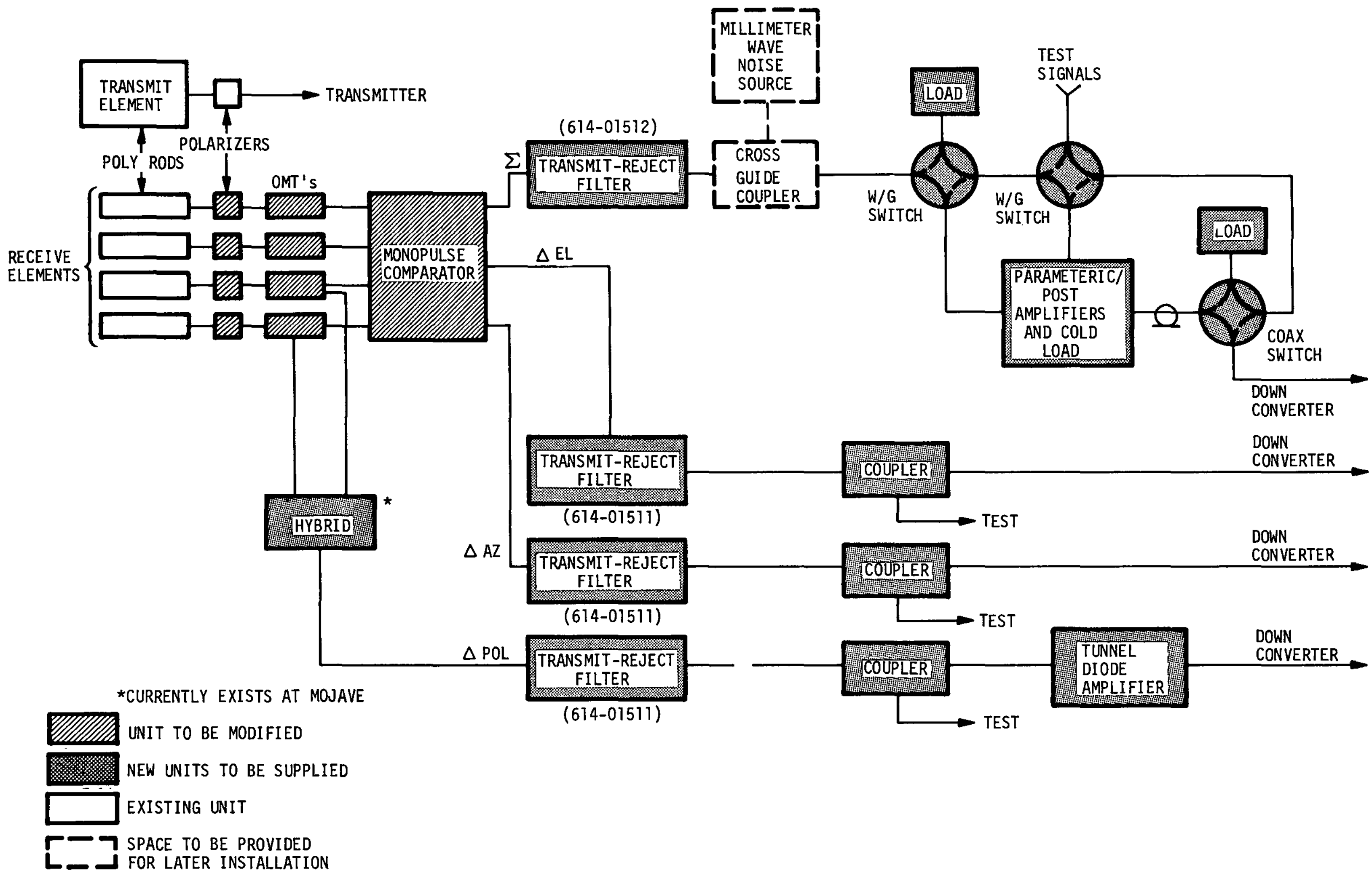

Figure 17. New Mojave and TGS Feed System

TGS system is exactly like Mojave. The feed/comparator assemblies are identical and will require similar modification to render it usable down to 3.7 GHz. The Δ Polang hybrid and the three couplers are new units since they do not currently exist on the TGS system. Other than these items, the new units to be supplied and the units to be modified are identical to Mojave.

3.1.2.1 Feed/Comparator Assembly

The feed/comparator assembly is composed of polyrods, polarizers, orthomode transducers, adapter/phasing plate, and comparator network. The complete assembly was initially designed to receive at 4.05 to 4.2 GHz and transmit at 5.9 to 6.4 GHz. Measured data distributed at the Bidders' Conference of 1969 showed that the feed/comparator assembly, as installed in the 40-foot reflector, degrades in receive band performance below 4.0 GHz. The TGS feed/comparator assembly was removed by Martin Marietta and brought to Orlando for inspection and measurement. Assembly measurements confirmed the NASA data, indicating a noticeable change in performance below the design band. The feed was then disassembled into the smaller subassemblies for more complete and thorough measurement, which demonstrated that every subassembly falls short of the desired performance below 4.0 GHz.

With the exception of the polyrods, each subassembly has been redesigned to extend its measured performance from 4.0 to 4.2 GHz over the entire frequency band from 3.7 to 4.2 GHz. Some modifications are now complete, while some have recently been released to drafting for detailed drawings. There is no indication that performance will be compromised in extending the operating frequency band of existing hardware. The next critical milestone, then, is testing the complete modified feed/comparator assembly.

The object of the feed modification program is to make the "full band" performance of each subassembly equal to, or better than, the in-band (4.0 to 4.2 GHz) performance of that subassembly prior to modification. In this way, satisfactory performance of the complete feed/comparator network can be ensured (with only minor adjustments) when the subassemblies are recombined. To follow this plan, it was necessary to measure and record the complete performance of each original subassembly to provide a baseline for evaluating the modification progress and performance. Data from the Sylvania Final Report* was used as a guide for evaluating the validity of Martin Marietta data. In most cases, data from Sylvania compared closely with that from Martin Marietta; in a few cases, however, deviations were considered to be significant. A considerable effort was directed toward resolving these differences through changes in equipment, setups, and even personnel. In a few cases (in particular, measurements of insertion loss), it was necessary to proceed with modifications in spite of the difference. The Martin Marietta measurements will serve as baseline data, then, for future evaluation of the subassembly modification program.

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* Sylvania Final Report F178-1, Contract NAS5-9533, "ATS Transportable Communications Ground Station," Sylvania Electronics Systems, November 1964-1966.

Current modifications involve only the TGS assembly; drawings and plans, however, are directly applicable to the Mojave assembly. Furthermore, double quantities of all new parts and components have already been fabricated and are awaiting return of the Mojave feed to Orlando for modification. The Mojave feed/comparator subassembly will be removed and returned to Orlando as soon as the Antenna Pre-Mod Test Program is completed.

3.1.2.2.1 Antenna Elements (Polyrod)

Such transmitting antenna elements and associated system components as the polarizer, chokes, and transitions perform well down to 5.9 GHz, according to Sylvania, and will be retained in their present form. Care will be taken not to change their characteristics as a result of any other modifications. (Martin Marietta measurements showed a maximum VSWR of 1.5:1 at 6.0 GHz whereas Sylvania reported a maximum of 1.3:1 at the same frequency. This difference is most likely occasioned by a partially burned pressure window found in the feed when it was removed from TGS at Mojave.)

The receiver elements are 17-inch-long, tapered teflon rods external to the 2-inch I.D. circular waveguide. Element parameters were initially designed by Sylvania to cover the 3.8 to 4.4 GHz band. An inter-element spacing of 4.5 inches (1.6λ at 4.2 GHz) was determined to be optimum for this initial band. Extending the band downward to 3.7 GHz with an upper band edge of 4.2 GHz represents a decrease in required bandwidth over the initial design. Retaining the present 4.5-inch element spacing permits the polarizer gearbox casting, drive motors, synchros, etc. to be reused. This represents a significant advantage. With regard to array performance, the fact that the frequency extension is in the lower direction is an advantage. The initial 4.5-inch spacing was the closest that could be attained and still allow room for the transmitting element and associated drive gears. Lowering the frequency is equivalent to moving the elements closer together. The characteristics of that portion of the difference pattern incident on the subreflector are so slightly changed that no measurable difference in tracking performance is anticipated. Martin Marietta-measured VSWR data (Figure 18) indicates very good performance over the band from 3.7 to 4.2 GHz. No modifications to the polyrod elements will be required.

3.1.2.2.2 Half-Wave Polarizer

The nonlinearity evident at frequencies below 3.9 GHz in Polang system data made available at the Bidders' Conference is due to phase dispersion between orthogonal components in the half-wave polarizers. If these polarizers were modified to have a differential phase shift of 180 degrees with close tolerance and equal characteristics down to 3.7 GHz, tracking linearity would be satisfactory.

Prior to embarking on modification of the polarizers, a series of baseline tests was conducted in the anechoic chamber to evaluate performance of the polarizers without the influence of the 40-foot reflector. To make these measurements in the controlled environment of the anechoic

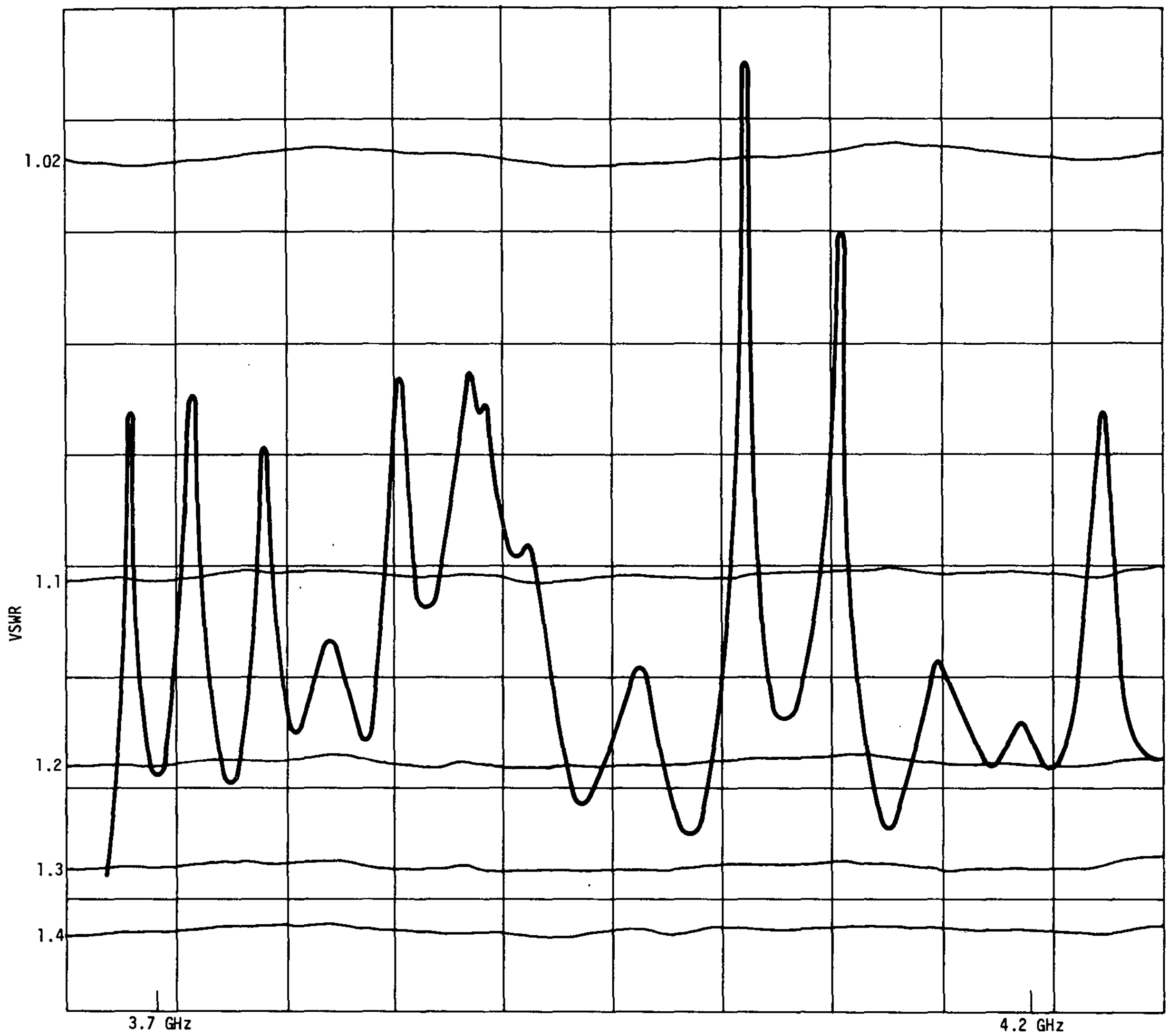


Figure 18. VSWR of Receiver Polyrods

chamber, the feed wiring was so altered that the polarizer drive motor accepted commands from the pattern recorder console and the polarizer synchro drove the chart paper as well as the position indicator of the recorder. This instrumentation made it possible to measure and record the axial ratio of each polarizer through the polyrod antennas.

The most significant measurements were a series of null position and null depth recordings as a function of frequency. A coax-to-waveguide adapter with detector was placed on the Polang port of one OMT, the transmit polarization was selected to be aligned with the Polang port polarization, and the feed polarizer section was slowly rotated. Under these conditions, it is the action of the 180-degree polarizer section that produces a null when the pins are aligned at 45 degrees to the incoming polarization. The effectiveness of the polarizer pins can be determined by the null depth. By re-running the null position measurements for each frequency in the band from 3.7 to 4.2 GHz, the frequency dependence and effectiveness of the polarizer can be determined.

Measured data is presented in the superimposed pattern of Figure 19. From this, it can be seen that there is a considerable null error at 3.7 GHz which must be corrected to meet the Polang tracking linearity specification of 2.0 degrees.

A breadboard model of a polarizer section (Figure 20) was fabricated to electrically reproduce the actual units in the feed, e.g., same I.D., length, and pin spacing. Pin depth and the number of pins were designed to be variable. A special fixture (Figure 20) was designed and fabricated to assist in the design and testing of the polarizer. This fixture is composed of a transition from WR229 to 2-inch circular waveguide on each end of the breadboard polarizer, which is inserted between two pillow blocks of the fixture. This fixture permits the selection of input and output polarization while allowing the polarizer section to be rotated continuously with respect to both transitions. This fixture closely approximates the polarized mechanisms in the feed.

The depth and number of pins were empirically determined with the aid of the swept-frequency insertion-loss display on the Hewlett-Packard microwave network analyzer. It was found that the addition of a seventh pair of pins made a significant improvement in the broadband performance of the polarizer. Performance of the final breadboard polarizer, compared to the unmodified TGS polarizer, is summarized below.

Null Depth and Position

The breadboard test fixture was designed to accept a single TGS polarizer as well as the breadboard model in order to test both units on an equal basis. Again, with the input and output polarization aligned, each polarizer was rotated for minimum signal, which should occur at 45 degrees pin orientation. The data contained in Table 5 shows that the existing TGS polarizer has a maximum null shift of 10 degrees, while the breadboard polarizer has only 1.8 degrees (maximum) shift over the entire

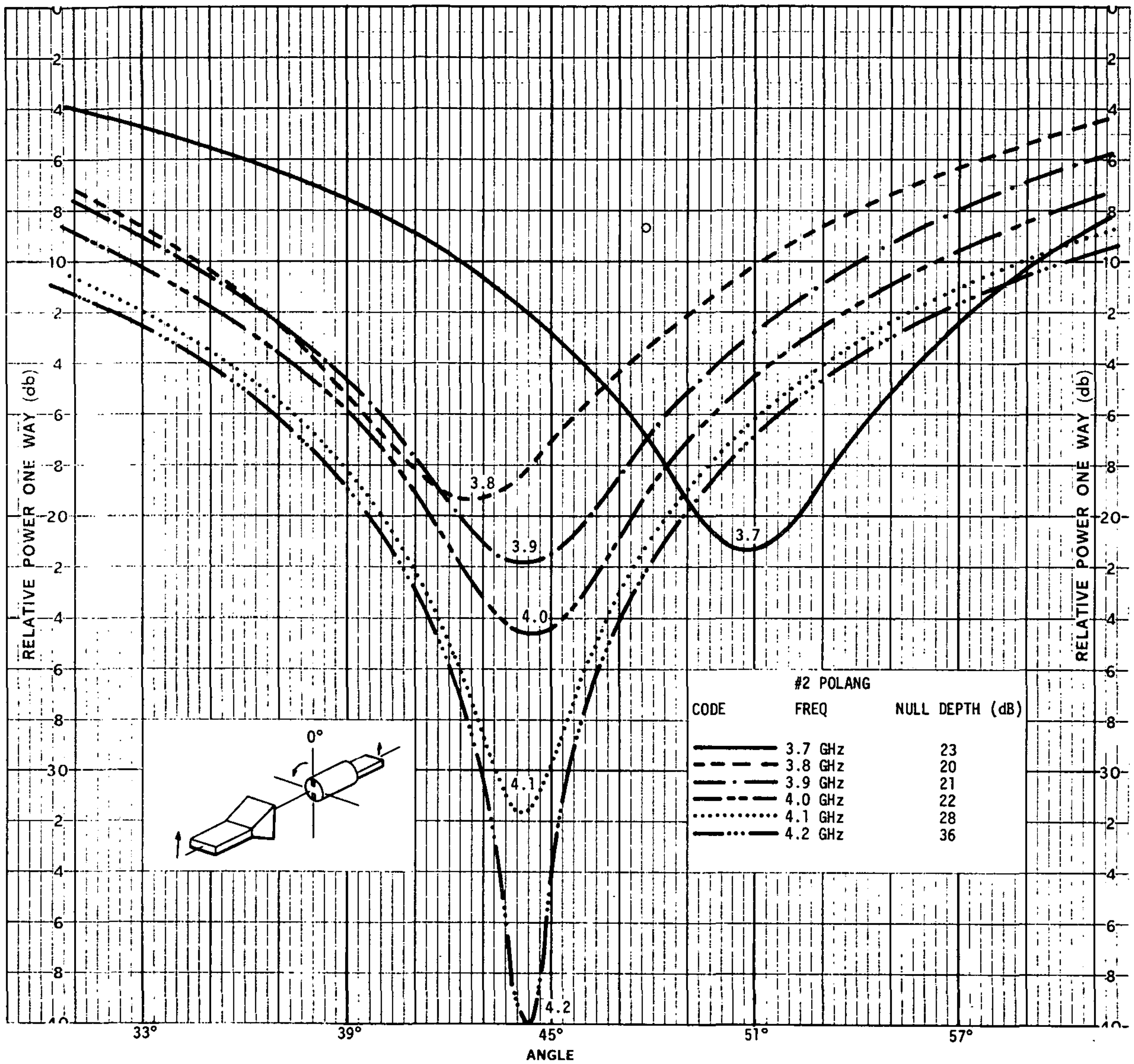


Figure 19. Measurements of Axial Ratio Null Depth and Position Versus Frequency (TGS Feed)

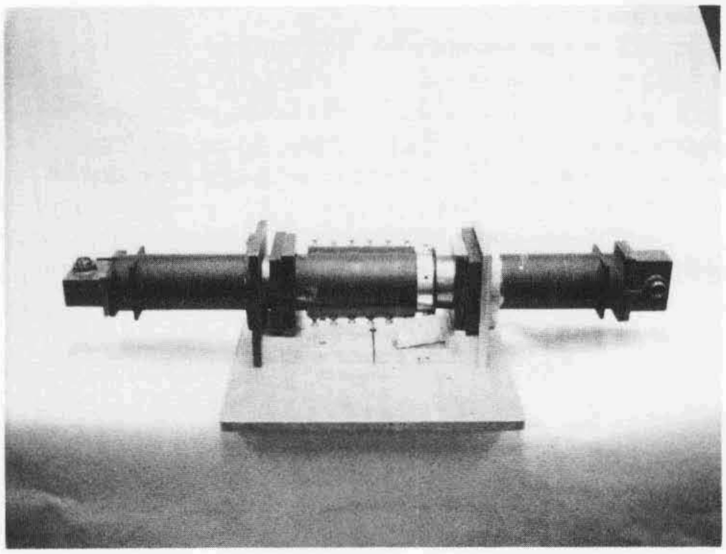


Figure 20. Breadboard Polarizer in Test Fixture

TABLE 5

Polarizer Null Position Stability

Frequency (GHz)	TGS Polarizer 6 Pins - Unmodified (degrees)	Breadboard Polarizer 7 Pins (degrees)
3.7	-8.1	-0.4
3.8	+3.0	+0.3
3.9	+0.9	+0.9
4.0	0.0	+0.9
4.1	0.0	0.0
4.2	0.0	0.0

band from 3.7 to 4.2 GHz.

Insertion Loss

In comparing insertion loss data from the breadboard and the existing polarizer (Figure 21) there is on the average very little difference. except in the vicinity of 3.7 GHz where the breadboard model shows a considerable improvement, from >5.0 dB to only 0.25 dB. (This data includes losses of the rectangular-to-circular waveguide transitions which are part of the measurement fixture.) The sharp resonances recorded on the existing unit have been verified. Although the cause is not fully understood, similar resonances which were evident in the breadboard model were tuned out by adjusting pin depth.

The breadboard polarizer design is currently being detailed and a step-by-step plan for implementing this design in the existing unit is being developed. The TGS feed is completely disassembled and the polarizers will be modified as soon as the drawings are released. Each polarizer will be individually optimized and matched using the special breadboard fixture. When all tests are complete, the new units will be installed in the feed and the assembly will be rebuilt.

3.1.2.2.3 Orthogonal Mode Transducer (OMT)

The OMT used here consists of an in-line circular waveguide with an orthogonal rectangular waveguide (WR 229). One end of the circular guide mates with the choke joint and half-wave polarizer. The other end is coupled to rectangular waveguide through two $\lambda g/4$ transformer sections. Various matching devices are used at the three ports.

VSWR, insertion loss, and isolation performance of the OMT's reported by Sylvania are excellent over the 3.98 to 4.225 GHz band, with VSWR's typically being lower than 1.06 and isolation of 38 dB or greater. The initial swept-frequency measurements made at Martin Marietta and reported in the Design Review Report, OR 11,239, indicated that OMT performance was acceptable. Since then, additional measurements showed a sharp resonance in VSWR and insertion loss in the vicinity of 3.7 GHz (Figure 22). It was also found that the thin septum, which is added to decrease cutoff (waveguide width), is the cause of this resonance. Measurements made on a breadboard model of the OMT displayed an almost identical resonance. Preliminary experimentation indicates this resonance can be eliminated by changing the length of the septum contained in the through port. This design will continue until the resonance is completely eliminated.

3.1.2.2.4 Adapter/Phasing Block

The adapter block mates the input ports of the comparator to the inline ports of the orthomode transducer. Broached holes in the block are at a diagonal angle in the H-plane and were cut $\lambda g/2$ (4.0 to 4.2 GHz) in length to minimize mismatch. Each waveguide section in this block contains a pair of screws spaced $\lambda g/4$ apart for phase trimming.

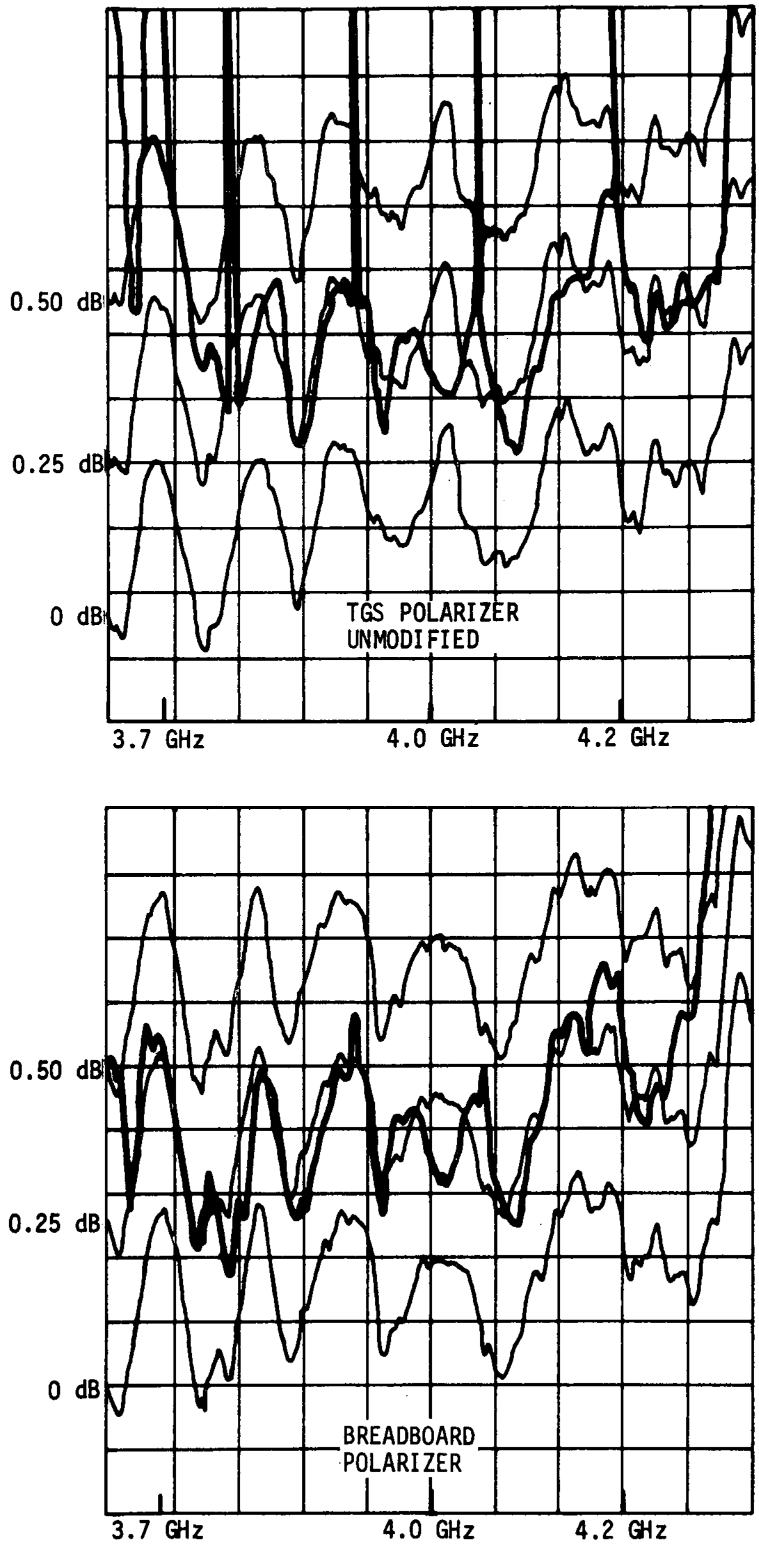


Figure 21. Insertion Loss Comparison of Unmodified TGS Polarizer and Breadboard Polarizer

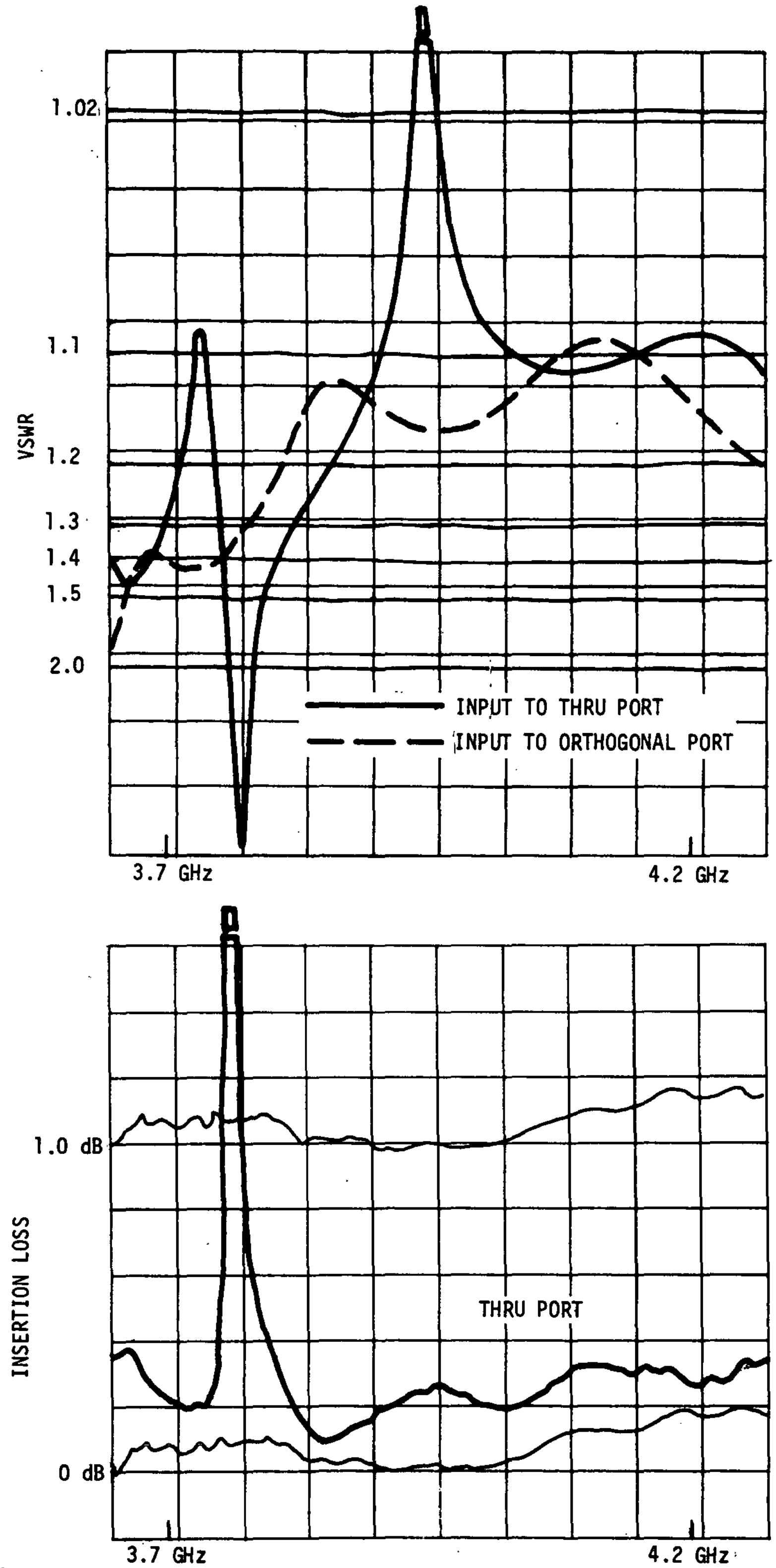


Figure 22. Measurements of VSWR and Insertion Loss on the TGS OMT (Unmodified)

The only modifications contemplated for this component are retuning of the phase-compensating screws to balance the feed/comparator assembly.

3.1.2.2.5 Monopulse Comparator

The monopulse comparator was fabricated from two basic hybrid types: the folded H-plane tee and a standard magic tee. Two MDL Model 229 TH12 folded H-plane hybrids were used in fabricating the comparator assembly. According to MDL, these devices were designed and tested to operate over the 3.7 to 4.2 GHz band.

The complete comparator package was made as compact as possible to minimize line lengths and, consequently, losses. Figure 23 shows this assembly. To accomplish such a compact design, the E-plane matching structure of the MDL unit was completely removed and rematched as a combined junction with the center magic tee. Eccentric posts were employed at several junctions to obtain final matching and to optimize the balance between ports. It was found that inductive irises inserted near the antenna input ports were needed for adequate balance. These matching structures were far from the reflection source, resulting in reduced bandwidth. Narrow-band performance in the assembly, however, was superior to the individual MDL hybrids as they were received from the vendor.

Swept-frequency measurements made at Martin Marietta verified superior in-band performance (4.0 to 4.2 GHz) and showed that performance in the band from 3.7 to 4.0 GHz is unusable as the VSWR and insertion loss are not consistent with requirements. Insertion loss (4.0 to 4.2 GHz) was nominally 0.25 dB as measured between the sum output port and one of the four antenna ports (Figure 24). According to data published in Sylvania's final report, the insertion loss should be less than 0.007 dB. Therefore, several measurement techniques and equipment variations were employed to resolve the difference in data, only to find excellent correlation of all Martin Marietta data. It is obvious from the swept insertion-loss data (Figure 24) that, at certain frequencies, insertion loss is very low. Discrete frequency tests of these low-loss points, using the AIL Attenuation Calibration Model 137, show good correlation with Sylvania data. A continuing effort is being made toward resolving the differences in measured data; however, the comparators have been redesigned and are currently being tested against Martin Marietta baseline data.

NASA made a spare comparator available to Martin Marietta for additional measurements and for use as a breadboard for designing and implementing trial fixes for test and evaluation. Tests were also run on the spare unit prior to its modification. Results of the modification can best be described by comparing before and after data as follows:

<u>VSWR</u>

The pre-mod data (Figure 25) shows a serious increase in the sum and elevation error VSWR below 4.0 GHz. Post-mod data shows the success achieved in rematching the comparator network. The matching procedure

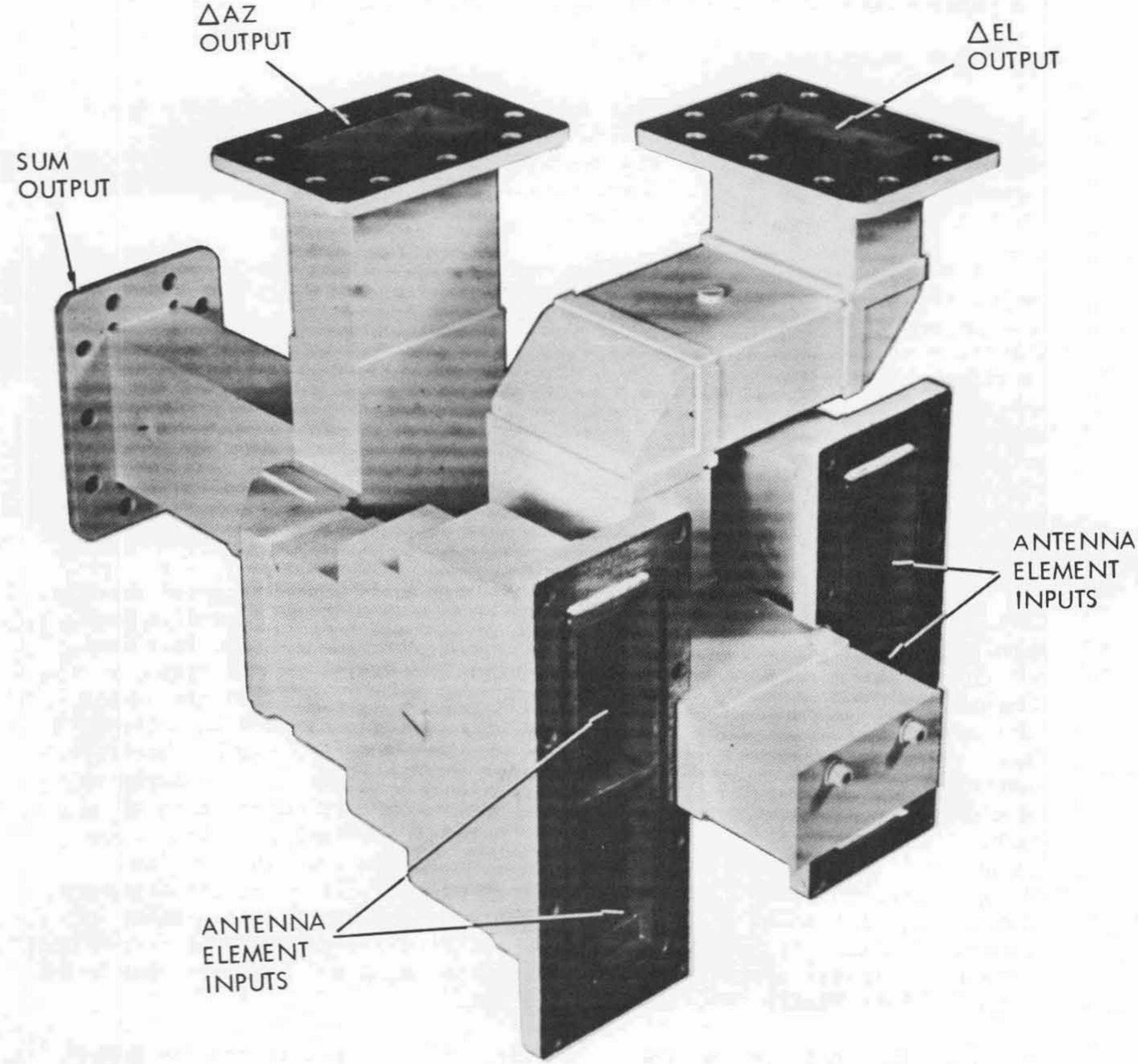


Figure 23. Monopulse Comparator

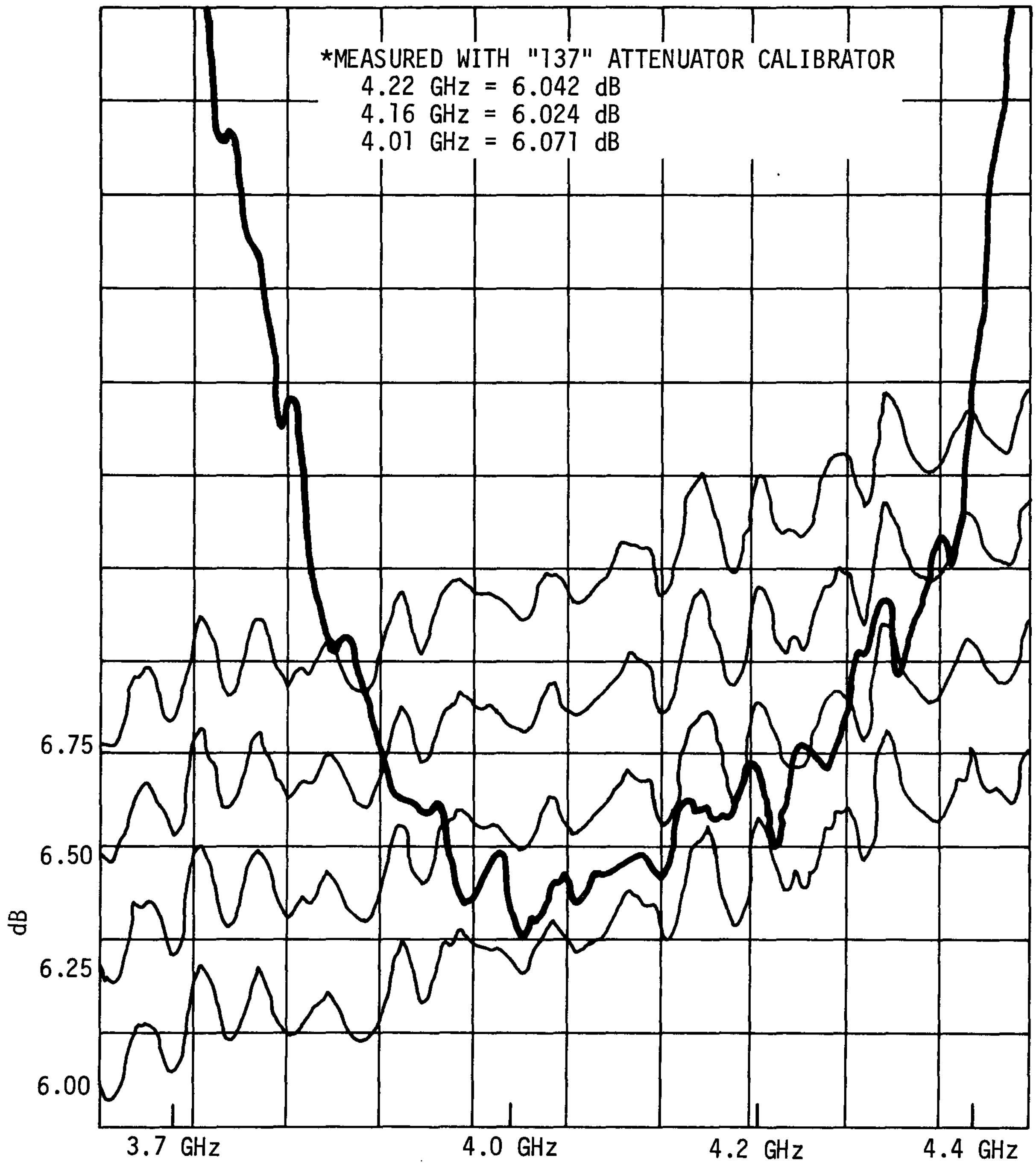


Figure 24. Insertion Loss Measurements of TGS Comparator (Unmodified) - Sum Port to Antenna Port

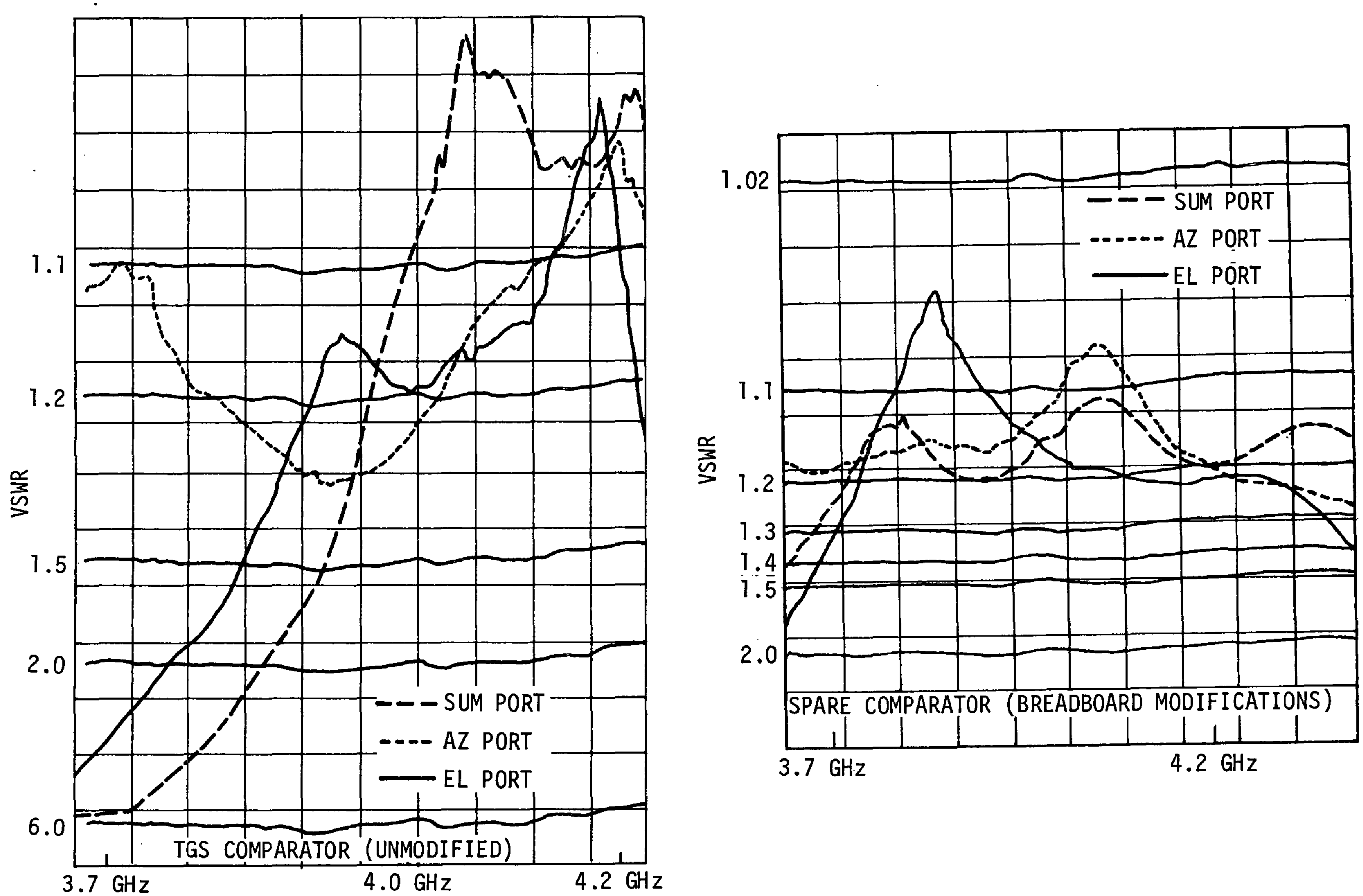


Figure 25. Comparator VSWR Measurements (Pre- and Post-Modification)

was entirely empirical while using a swept frequency scope display of the VSWR. Figure 26 illustrates minor changes made to the comparator to improve VSWR. The most significant change was addition of a shaped wedge at each magic-tee junction. The remaining alterations involved removing, repositioning, and/or readjusting irises and pins.

The improved comparator was then completely tested to ensure that no other parameters were adversely affected. For example, the VSWR of the comparator looking into each of the feed ports (Figure 27) shows that the pre-mod performance was also improved over the extended band.

Insertion Loss

A comparison of post-mod insertion loss data (Figure 28) with pre-mod data (Figure 25) shows definite improvement in the vicinity of 3.7 GHz with no noticeable change in the 4.0 to 4.2 GHz band. The difference in flatness of the swept calibration points between pre- and post-mod data is due to the use of different equipment and in no way reflects a change in performance.

Isolation

The most important isolation measurements (Figure 29) between the sum and two error ports shows a minimum isolation of 35 dB over the band, which is more than adequate.

Phase Balance

The phase balance, measured with the Hewlett-Packard Microwave Network Analyzer, reflects the relative phase response at each of the four antenna ports to a signal entering the comparator in the sum and two error ports. Ideally, the sum port insertion should produce an in-phase response at each of the antenna ports, while an insertion at either of the two error ports would produce a 180-degree phase shift in two of the antenna ports relative to the other two. Table 6 tabulates the measured data and includes the phase-shifting mechanism of the adapter blocks, which was adjusted only for the unmodified comparator. Although it is not possible to make a direct data comparison, it is obvious that the modified unit is equal to, or better than, the original.

3.1.2.3 Band-Reject Filters

A band-reject filter is required in the communications receive channel at Mojave to meet the specification requirement of 100 dB minimum isolation between transmit and receive signals. A minimum of 40 dB is realized by use of separate transmit and receive elements; thus, the filter must supply 60 dB minimum in the new system.

Existing units do not provide sufficient transmit band rejection in the extended band and cannot be used in the modified system. A specification has been written to cover the requirements of a filter to operate

NOTE:

1. REMOVE PAINT WITH "ZIP-STRIP" STAR BRONZE CO, ALLIANCE, OHIO
2. REMOVE IRIS (6 PLACES) & SCREWS (2 PLACES)
3. CLEAN PER EPS 50070 & BRIGHT DIP PER PARA. 3.1.1
4. INSTALL F/N 5, 7, 8 & 9
5. INSTALL & TUNE F/N 2, 3, 4 & 6 & PARTS REMOVED PER NOTE 2
6. SOLDER IN PLACE F/N 4, 5, 6 & 7 & PARTS REMOVED PER NOTE 2 USE SN63WARP2 SOLDER PER QQ-S-571
7. CLEAN ASSY PER PARA. 4.4 OF MIL-STD-171
8. SEAL JOINTS & SCREWS (SCREWS FLAGGED) WITH ECCOBOND E EMERSON & CUMING, INC., CANTON, MASS.
9. FINISH OUTSIDE, EXCEPT FLANGE FACES, PER PARA. 22.2 OF MIL-STD-171 WITH COLOR WHITE NO. 17875 PER MIL-STD-595

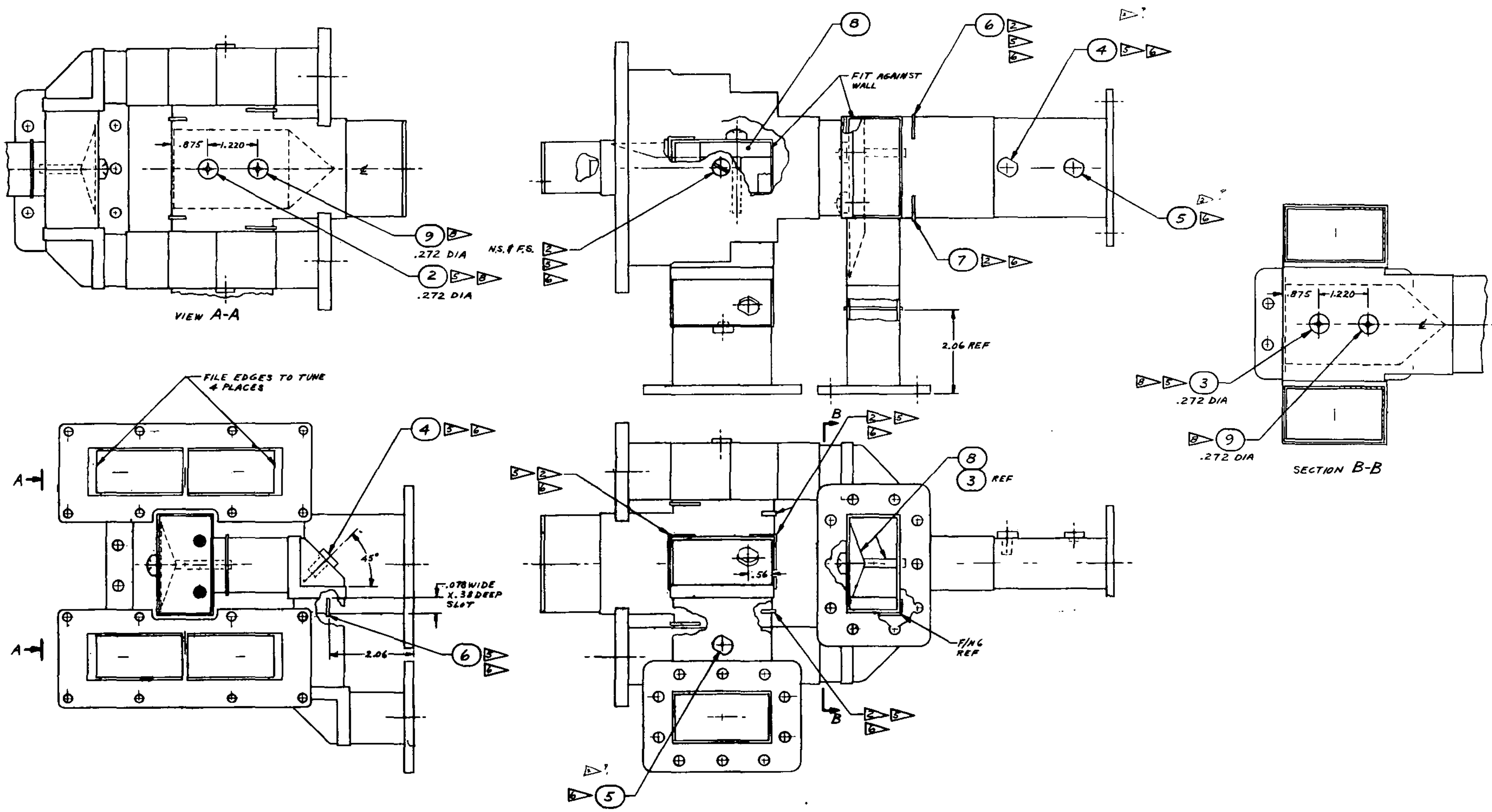


Figure 26. Comparator, Illustrating Modification Areas

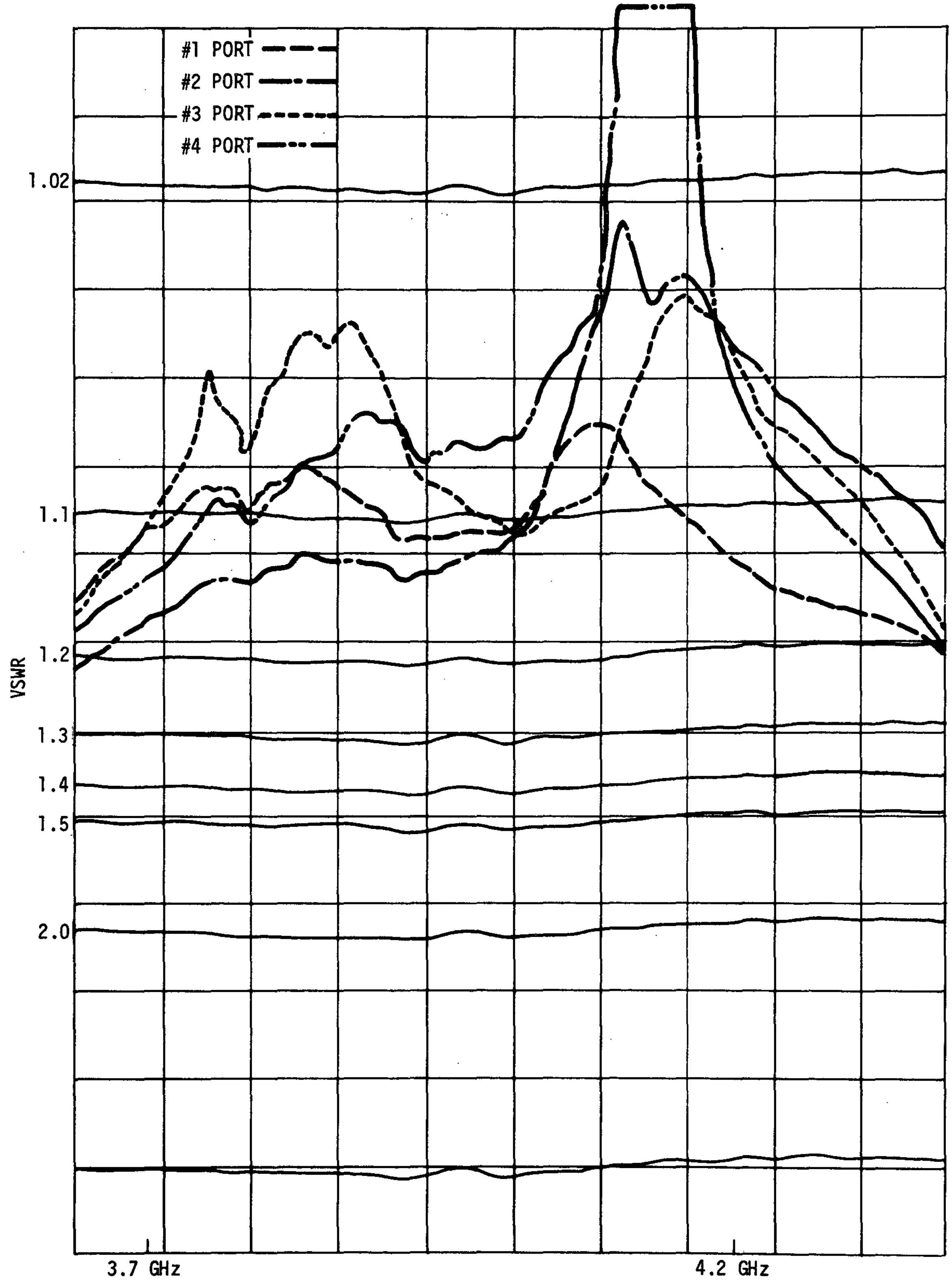


Figure 27. Post-Modification VSWR Measurements Looking Into Antenna Posts of Spare Comparator

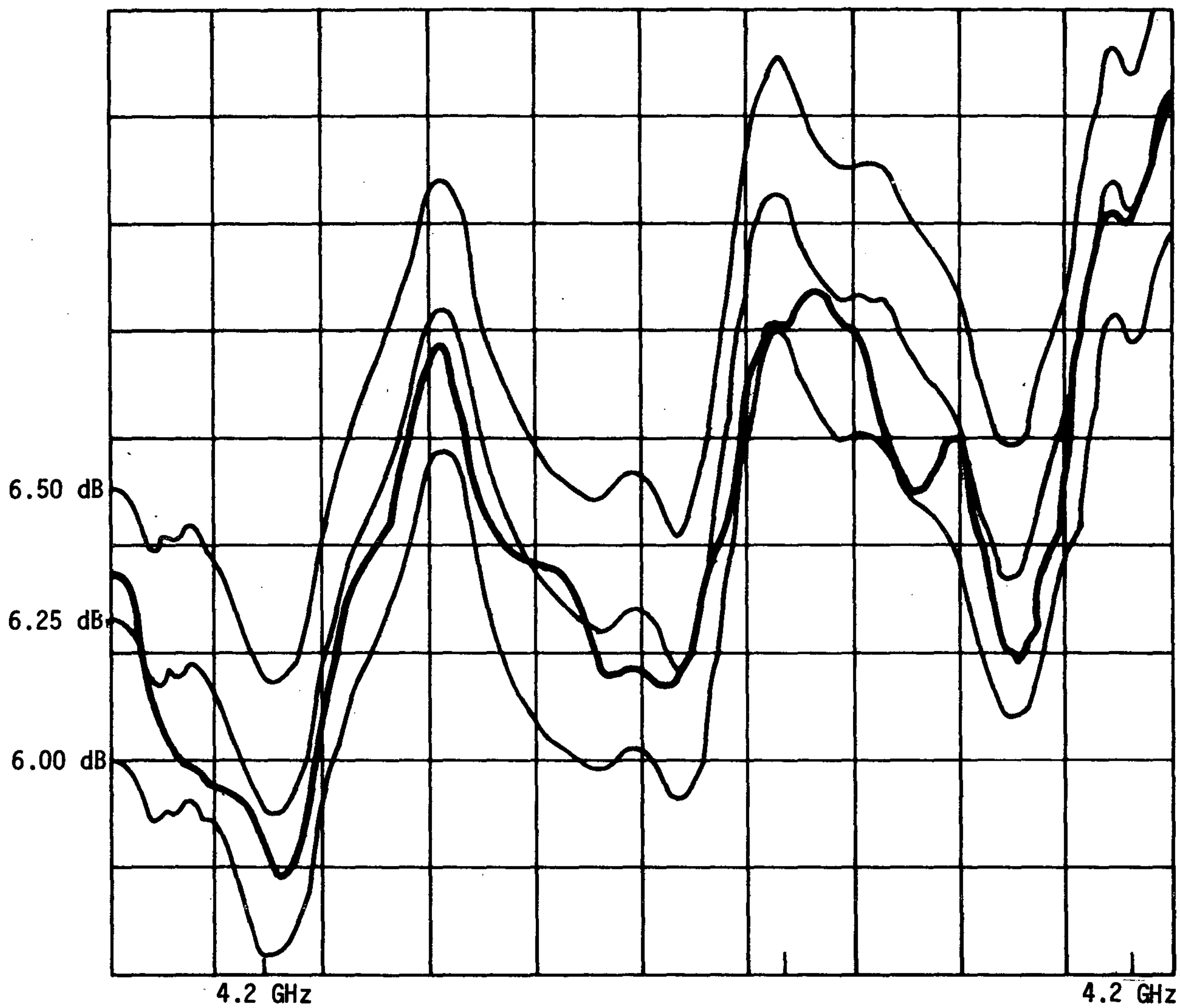


Figure 28. Post-Modification Insertion Loss Measurements of Spare Comparator - Sum Port to Antenna Port

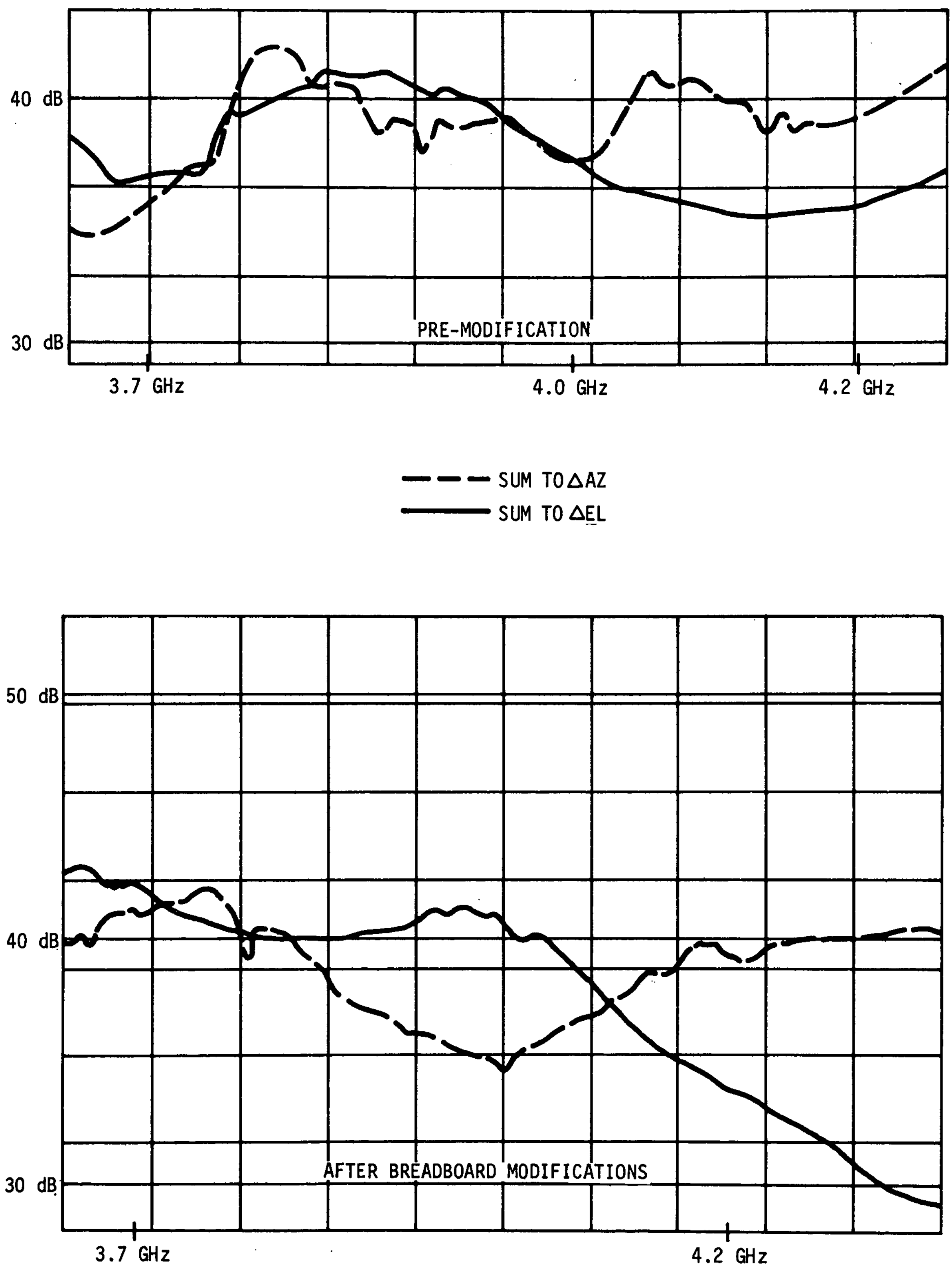


Figure 29. Comparator Isolation Measurements (Pre- and Post-Modification)

TABLE 6

COMPARATOR PHASE MEASUREMENTS

A. TGS Comparator with Phasing Block

(Prior to Modifications)

Frequency (GHz)	Σ Port (degrees) Antenna Ports				Δ El Port (degrees) Antenna Ports				Δ Az Port (degrees) Antenna Ports			
	1	2	3	4	1	2	3	4	1	2	3	4
3.70	-2.4	Ref.	-0.3	-6.0	-162.01	-175.1	+18.2	Ref.	-177.1	+6.6	-175.8	Ref.
3.80	+0.6	+1.0	Ref.	-1.2	-164.1	-175.1	+14.4	Ref.	-179.1	+5.1	-177.8	Ref.
3.90	Ref.	+1.6	+0.1	-1.4	-167.4	-175.6	+17.8	Ref.	-177.3	+5.9	-176.9	Ref.
4.00	Ref.	+1.6	+1.6	-0.2	-175.7	-173.1	+16.4	Ref.	-173.01	+6.3	-176.6	Ref.
4.10	+0.4	+0.8	Ref.	-0.8	-161.8	-176.8	+15.2	Ref.	-176.8	+4.2	-179.6	Ref.
4.20	+2.1	+2.3	+3.0	Ref.	-162.7	-176.6	+18.5	Ref.	-175.9	+3.8	-175.1	Ref.

B. Spare Comparator with TGS Phasing Block

(After Breadboard Modifications)

Frequency (GHz)	Σ Ports (degrees) Antenna Ports				Δ El Port (degrees) Antenna Ports				Δ Az Port (degrees) Antenna Ports			
	1	2	3	4	1	2	3	4	1	2	3	4
3.70	+6.3	+4.1	+6.1	Ref.	-176.1	-176.6	+4.9	Ref.	-174.4	+5.16	-173.8	Ref.
3.80	+3.6	+4.3	+7.2	Ref.	-178.1	-175.1	+3.9	Ref.	-178.1	+4.0	-172.7	Ref.
3.90	+13.4	+3.8	+8.7	Ref.	-179.4	-176.6	+5.3	Ref.	-163.9	+4.7	-168.2	Ref.
4.00	+12.8	+3.9	+6.8	Ref.	-174.3	-177.4	+5.3	Ref.	-168.0	+4.9	-172.7	Ref.
4.10	+9.9	+3.5	+6.2	Ref.	-174.3	-177.8	+4.7	Ref.	-170.5	+3.1	-173.5	Ref.
4.20	+9.0	+3.6	+8.3	Ref.	-174.2	-177.1	+8.8	Ref.	-171.8	+2.9	-172.6	Ref.

over the new frequency band. Electrical requirements for the communications filter are:

Transmit reject band	5.925 to 6.425 GHz
Receive pass band	3.70 to 4.20 GHz
Insertion loss, reject band	100 dB minimum
Insertion loss, pass band	0.1 dB maximum
VSWR, pass band	1.15:1 maximum

Delay Distortion (unequalized):

a) Linear component	0.3 nanosecond/40 MHz maximum
b) Parabolic component	0.025 nanosecond/MHz^2 maximum
c) Residual ripple	0.3 nanosecond peak-to-peak maximum

Consideration was given in the present system to possible interaction between the band-reject and the filtering in the input circuit of the low noise amplifier. This problem was previously solved by having the receiver port VSWR somewhat less than a short circuit. An optional requirement was included in the specification for similar performance in the new filters. It was decided, however, that the additional 40 dB (60 to 100 dB) in reject characteristics would circumvent any spikes in the reject band due to interaction.

This band-reject filter, being designed and fabricated by Wavecom, Inc., of Northridge, California, is identical to the band-reject portion of the diplexer discussed in Paragraph 3.1.1.3.2 of this report; the only difference is that a transition from WR229 waveguide is provided on both ends of this unit, while only one transition is required on the diplexer.

The transmit-reject filter to be employed in the Polang and tracking error channels will be identical to the Rosman error tracking filters described in Paragraph 3.1.1.3.3.

3.1.2.4 Mechanical Configuration

The general layout of both sites is similar, except for orientation of the antenna-mounted unit portion of the parametric amplifier. Orientations shown in Figures 30 and 31 were selected for maximum accessibility for maintenance and test. The transmit-reject filter connects to the modified monopulse comparator. Space has been allocated for future installation of a 6-inch-long crossguide coupler for the millimeter wave noise source. A flexible 4-inch-long waveguide has been provided in the waveguide connection to the antenna-mounted unit portion of the parametric amplifier. The coaxial components, including the band-pass filters, variable attenuators, directional couplers, coaxial switch, and tunnel diode amplifier, are all mounted on a common plate within the feed cone. The tracking down-converter is located in the area immediately behind the feed cone.

FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

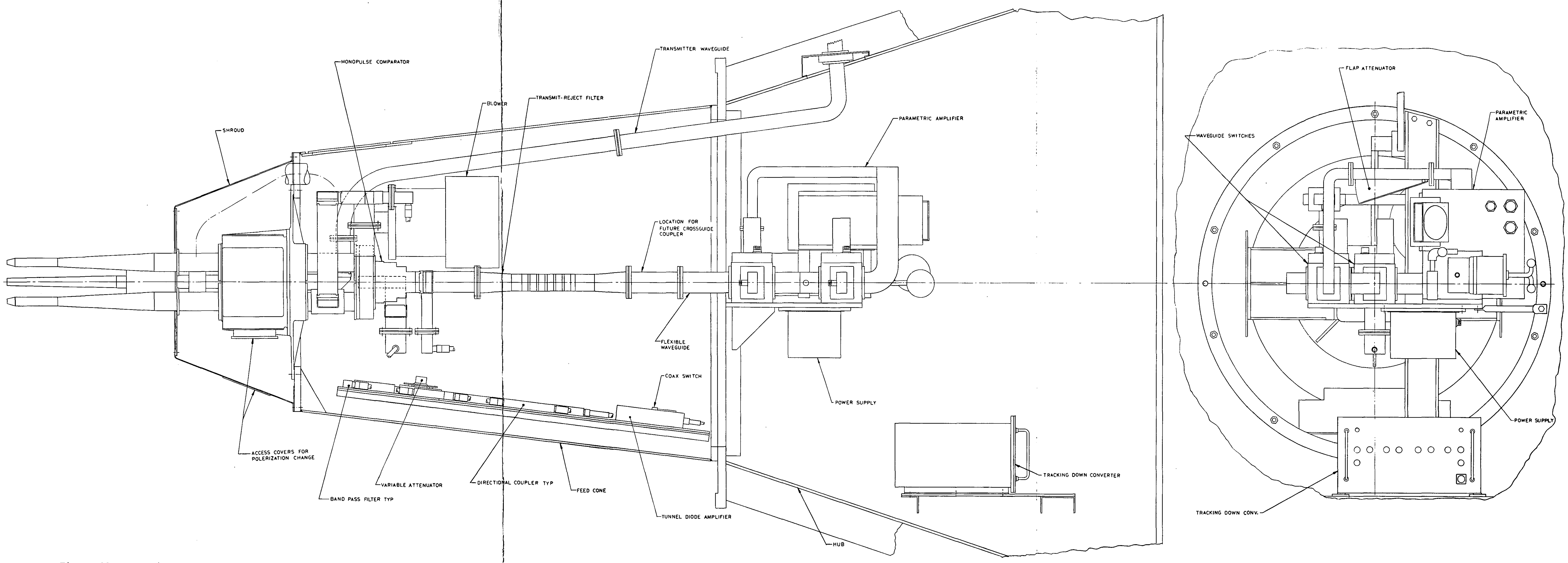


Figure 30. Mounting of Parametric Amplifier in TGS 40-Foot Antenna Feed Cone

FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

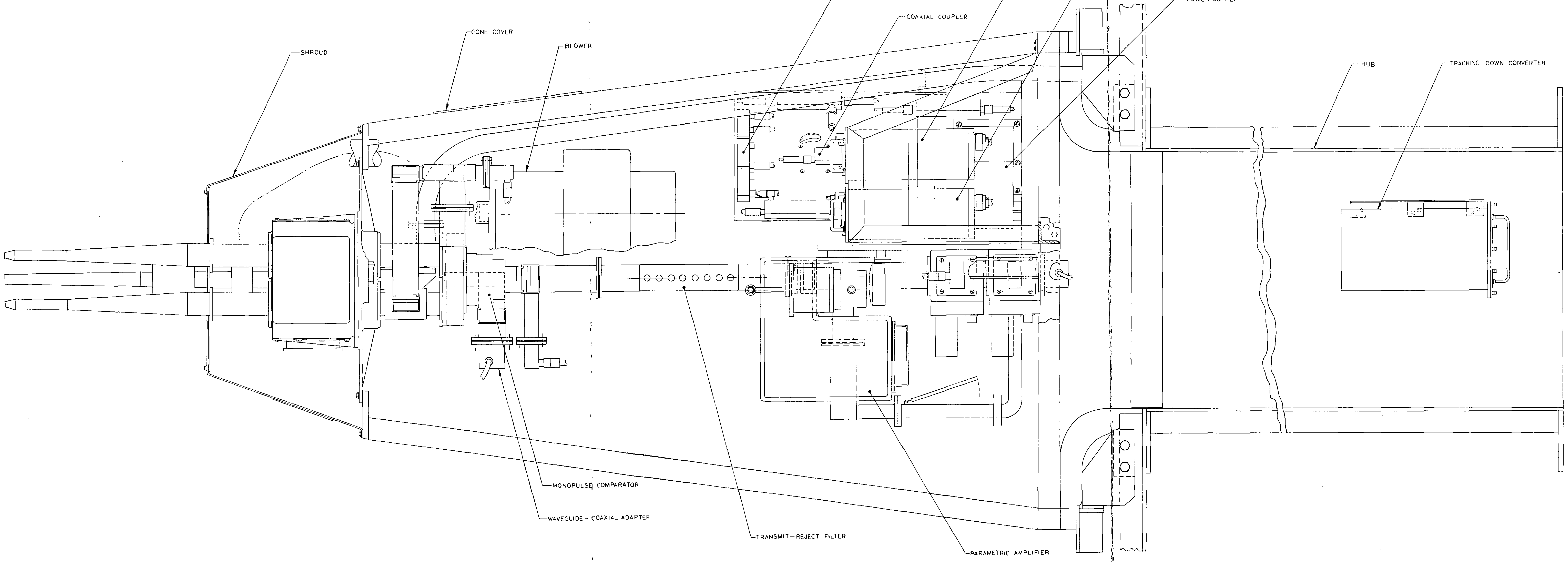


Figure 31. Mounting of Parametric Amplifier in Mojave 40-Foot Feed Cone

3.2 Receiver System

3.2.1 Overview

The receiver system block diagrams for the three sites are shown in Figures 32, 33, and 34. Due to Contract Amendment No. 2 dated 20 July 1971 converting the TGS station to a conventional monopulse tracking system, there will be only slight differences in the block diagrams for TGS and Mojave. The primary difference between block diagrams for these stations and Rosman lies in the Rosman feeds, including the orthogonal transmit polarization feature and RFI experiment hardware.

Block diagrams and performance numbers have changed little since publication by Martin Marietta of the Design Review Report in August 1971. However, slight changes in expected levels are recorded here as a result of more realistic appraisal of cable and component losses.

3.2.1.1 Communication Channels

The Design Review Report stated the contractual requirements for providing a minimum 60 dB gain for Rosman and 65 dB gain for the 40-foot sites from RF feed input to IF output. Models used for those gain calculations were incomplete only because they ignored cable losses and the minor losses associated with such passive components as relays, directional couplers, and power dividing hybrids. Although 2 dB excess gain was provided in the communications down-converters to compensate for such losses, it has turned out that they were not insignificant; therefore, a slight deficit in overall gain may be experienced. The more complete model is shown in Figure 35.

Updated information on signal levels, losses, noise temperature, and noise figures for the three sites is presented in Table 7, which may be compared with Table IX, page 52, of the Design Review Report.

3.2.1.2 Polarization Error-Tracking Channels

The polarization error-tracking channel has not changed significantly from that described in the Design Review Report. The simplified block diagram of Figure 36 may be compared with Figure 3.4-3 of the Design Review Report, page 57.

Table 8, corresponding to Table XII of the Design Review Report, shows the new gains, noise temperature, and noise figures; differences between the new figures and those used in the Design Review Report are due primarily to the additional cable losses.

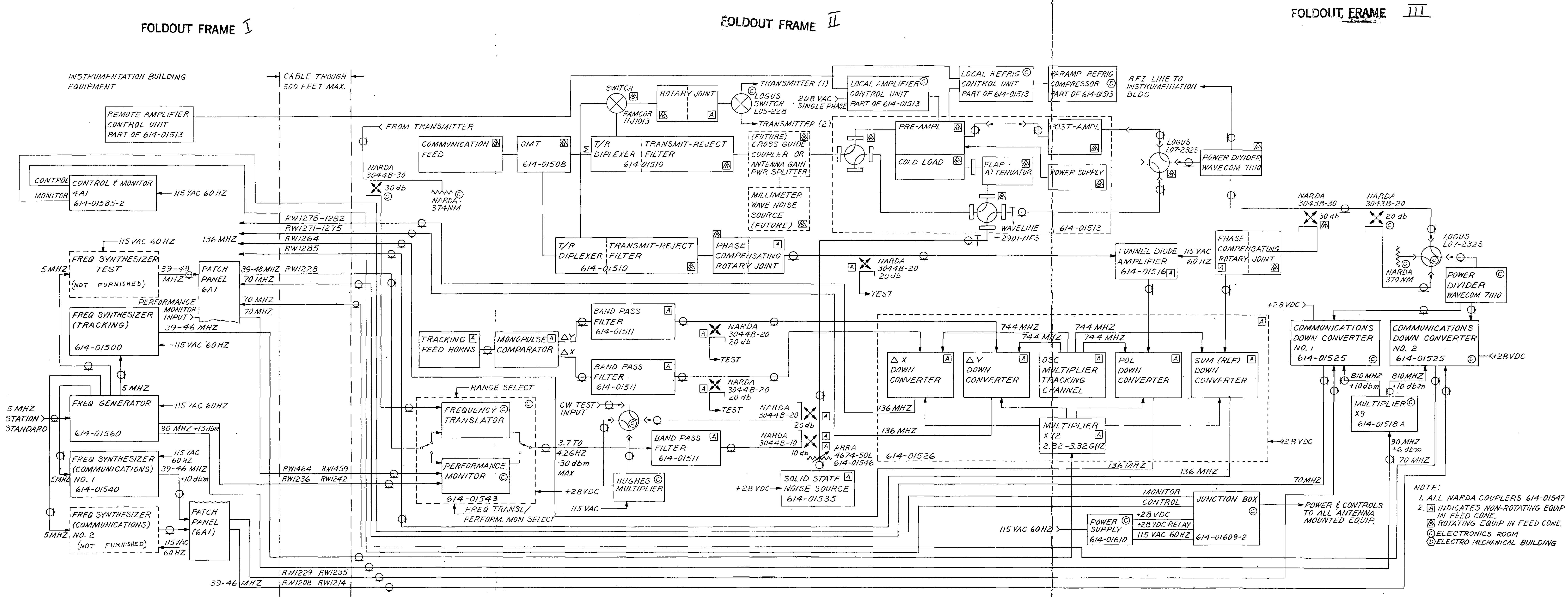


Figure 32. Receiver System - Rosman

FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

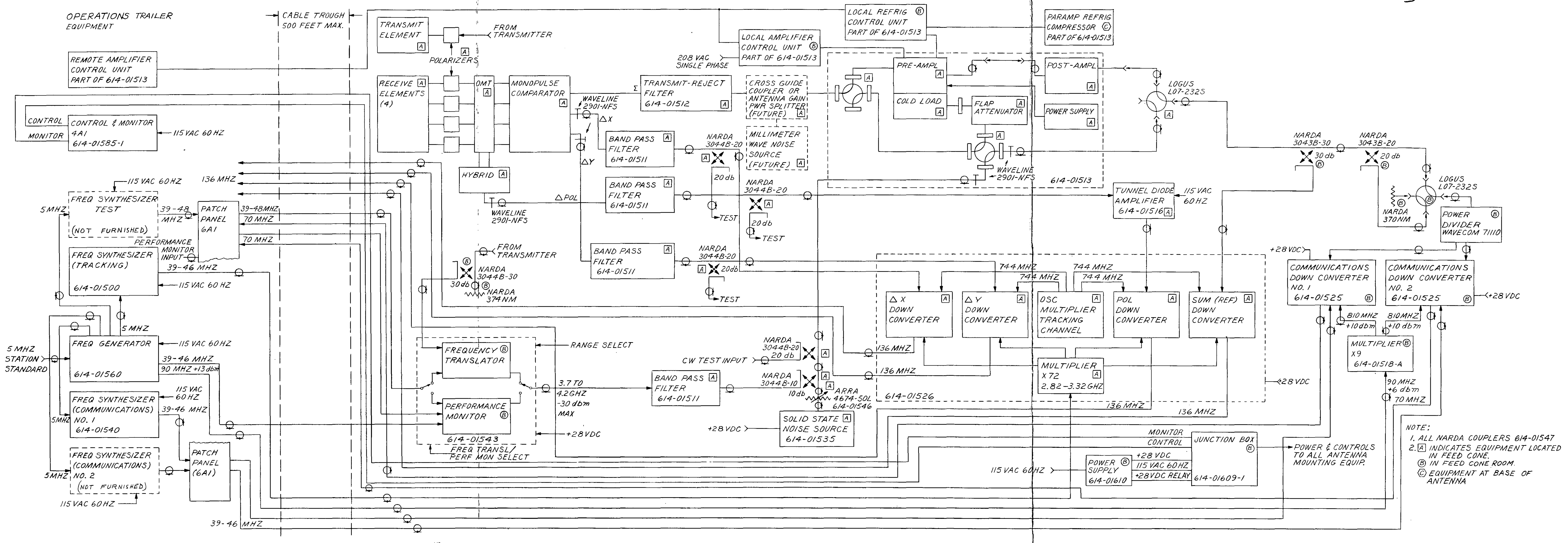


Figure 33. Receiver System - TGS

FOLDOUT FRAME I

FOLDOUT FRAME II

FOLDOUT FRAME III

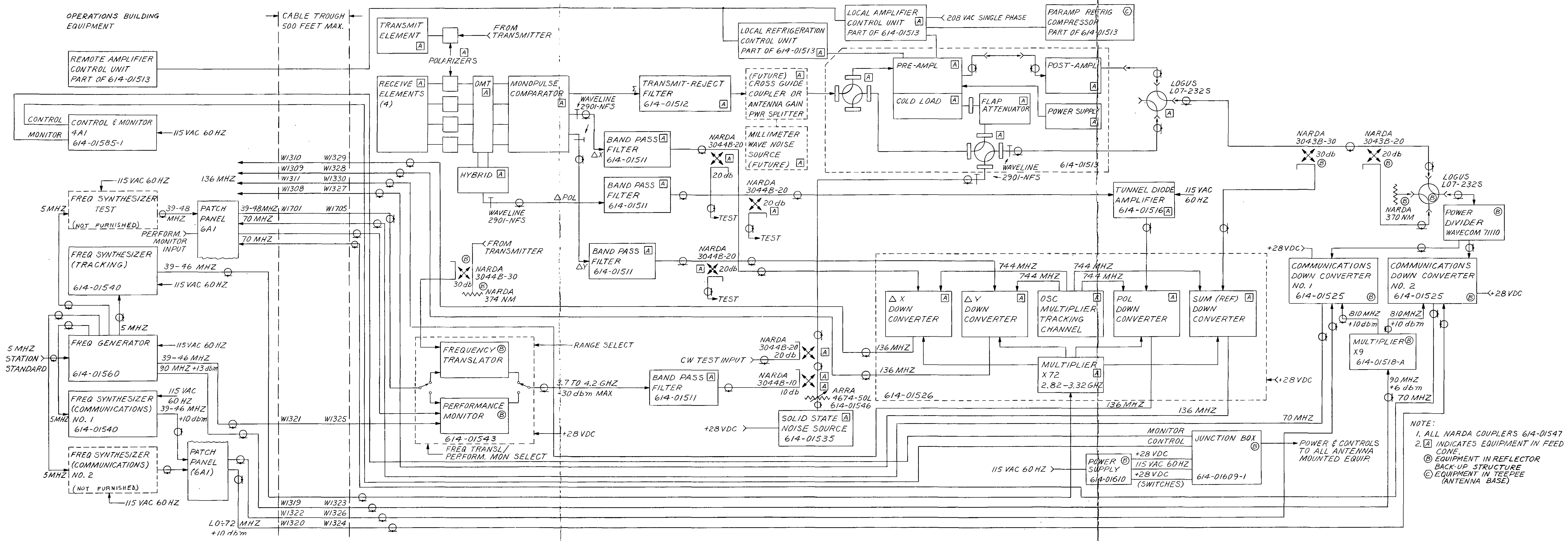


Figure 34. Receiver System - Mojave

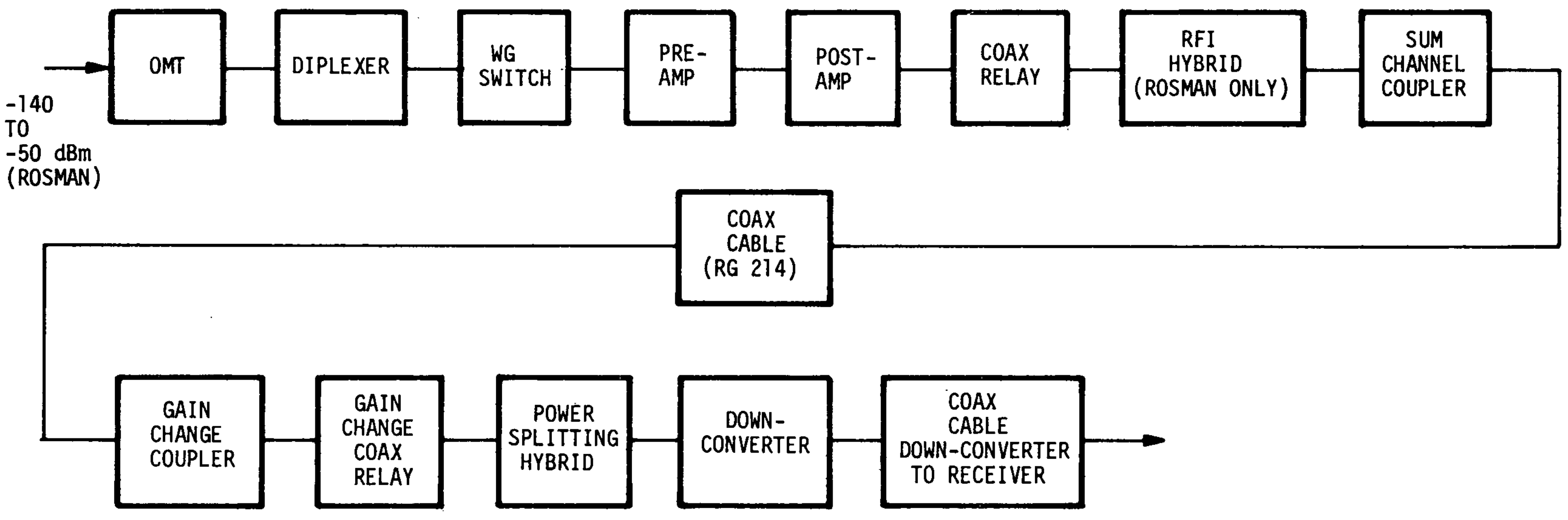


Figure 35. Rosman-Mojave-TGS Communications Channels

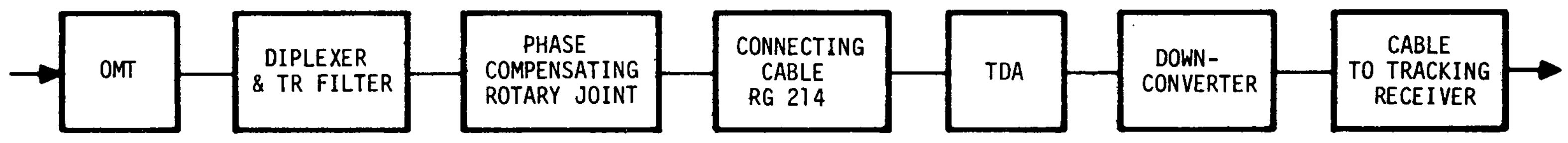


Figure 36. Polarization Error-Tracking Channel

TABLE 7

Updated Communications Channel Data

	Rosman		Mojave		TGS	
Component	Gain (dB)	Noise Temp Contribu-tion (°K)	Gain (dB)	Noise Temp Contribu-tion (°K)	Gain (dB)	Noise Temp Contribu-tion (°K)
OMT or Mono Compare	-0.05	3.5	-0.10	7.0	-0.10	7.0
Diplexer or Xmit Reject Filter	-0.10	7.0	-0.10	7.0	-0.10	7.0
Wage Guide	-0.01	1.5	-0.01	1.5	-0.01	1.5
Waveguide Switch	-0.01	1.5	-0.01	1.5	-0.01	1.5
Preamp/Post-amp	+60.0	16.0	+60.0	16.0	+60.0	16.0
Coax Switch	-0.2	0.000015	-0.2	0.00015	-0.2	0.000015
RFI Hybrid	-3.2	0.00029				
Σ Channel Coupler	-0.5	0.00009	-0.5	0.000036	-0.5	0.000036
Cable	-4.0	0.00110	-2.0	0.0002	-2.0	0.0002
Gain Change Coupler	-0.5	0.00020	-0.5	0.00007	-0.5	0.00007
Gain Change Coax Switch	-0.2	0.00015	-0.2	0.00003	-0.2	0.00003
Hybrid (Down-Converter)	-3.2	0.0029	-3.2	0.0007	-3.2	0.0007
Down-Converter	+15.0	0.700	+15.0	0.250	+15.0	0.250
Coax Cable	-4.0	0.00022	-3.0	0.00015	-3.0	0.00015
TOTAL (Ref. to Paramp Input)	59.2	32.204965	65.4	33.251336	65.4	33.251336

TABLE 8

New Polang-Error Channel Data

Component	Rosman		Mojave		TGS	
	Gain (dB)	Noise Temp Contribution (°K)	Gain (dB)	Noise Temp Contribution (°K)	Gain (dB)	Noise Temp Contribution (°K)
Diplexer Xmit Reject Filter	-0.3	20				
Cable			-0.32	22	-0.32	22
Phase-Compensated Rotary Joint	-3.0	145				
Bandpass Filter			-0.3	20	-0.3	20
Cable	-0.4	25	-0.4	25	-0.4	25
TDA	+20.0	530	+20.0	530	+20.0	530
Down-Converter	+13.0	360	+13.0	360	+13.0	360
Cable	-3.0	0.145	7.0	0.6	-4.0	0.220
TOTAL (Ref. to TDA Input)	+30.0	1080.145 (NF=6.8 dB)	+26.0	957.6 (NF=6.4 dB)	+29.0	957.2 (NF=6.4 dB)

3.2.1.3 Angle Tracking Channels

Figure 37 is the updated, simplified block diagram for the angle tracking channels. Again, the model takes into account updated gain or loss figures for the filters and adds the cable loss previously omitted. Table 9, which presents the net results for each site, corresponds to Table XVI, page 65, of the Design Review Report.

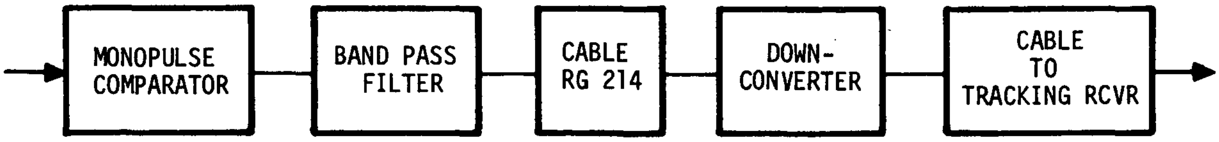


Figure 37. ΔX and ΔY Error Channels

TABLE 9

Angle Tracking-Error Channels

Component	Rosman		Mojave		TGS	
	Gain (dB)	Noise Temp. Contribution (°K)	Gain (dB)	Noise Temp. Contribution (°K)	Gain (dB)	Noise Temp. Contribution (°K)
Cable	-0.16	10.5	-0.40	25.0	-0.24	15.5
Bandpass Filter	-0.35	23.0	-0.35	23.0	-0.35	23.0
Test Coupler	-0.3	19.0	-0.3	19.0	-0.3	19.0
Cable	-1.12	66.0	-0.8	49.0	-.64	40.0
Down-Converter	+28.2	5500.0	+28.2	5500.0	+28.2	5500.0
Cable	-15.0	22.0	-7.0	3.0	-4.0	1.1
TOTAL	+13.2	5640.5	+21.2	5619.0	+24.2	5598.6
(Ref. to Down-Converter Input)		(NF=13.1dB)		(NF=13.0dB)		(NF=13.0dB)

3.2.2 Cooled Parametric Amplifier

The antenna-mounted unit portion of the parametric amplifier is shown in Figure 38. At each site, this unit, along with the universal power supply, is mounted within the feed cone area. At the Mojave site the local amplifier control unit and local refrigerator control unit are non-pressurized, rack-mounted, and are located in the feed cone area for weather protection (Figure 31). The remote amplifier control units are also rack-mounted units and will be located in the instrumentation and operations buildings at Rosman and Mojave respectively and in the operations trailer (V-10) at the TGS site. The compressor units are self-contained units floor mounted at the base of the antenna at each site.

The cooled parametric amplifier is composed of three varactor stages mounted in a vacuum dewar on a helium refrigerator cold station at 20 degrees K. A controlled, solid state Gunn diode oscillator (≈30 GHz) is employed as the pump source for the three stages of parametric amplification. Following the last varactor diode stage is a transistor amplifier mounted outside the dewar on the electronic chassis along with the Gunn diode pump source and its amplitude control circuits. Significant technical characteristics of the amplifier are:

Gain:	60 dB minimum
Noise temperature:	17.5°K maximum at input WG switch flange
Bandwidth:	500 MHz at the 1 dB points
Ripple:	±0.75 dB maximum
Gain Slope:	0.4 dB/MHz in any 20 MHz
VSWR:	1.35:1 (input); 1.3:1 (output)
1 dB compression point:	In-band -50 dBm; transmit band +30 dBm
Delay distortion:	Linear, 0.3 nsec/40 MHz; parabolic, 0.025 nsec/MHz^2; ripple, 0.3 nsec peak to peak
Intermodulation:	Less than -45 dBm at the output with two in-band signals at a level of -60 dBm and another signal in the transmit band at a level of -30 dBm.

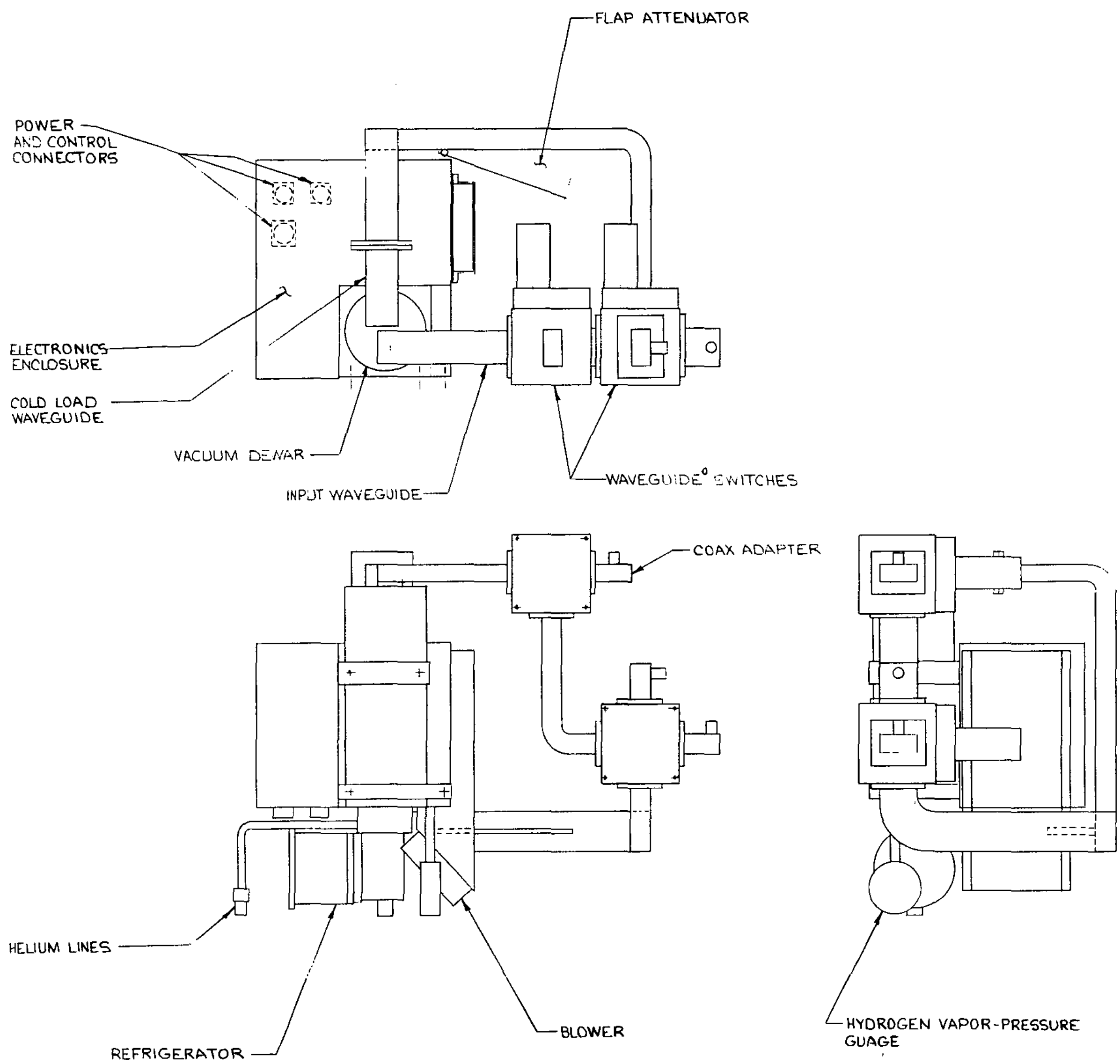


Figure 38. Antenna-Mounted Unit Portion of Parametric Amplifier

The cooled parametric amplifier also contains a built-in cold load, attenuator card (flap attenuator), and waveguide switches. The built-in cold load is physically attached to the 20 degree K cold station and can be applied to the input of the cooled paramp by remote control of the waveguide switches. The flap attenuator can be operated only locally, at the paramp, for the Y factor measurement. There is, however, a solid state noise source (AIL Model 76) whose output is calibrated and can be applied to the paramp input by remote control; thus, the Y factor can be measured by the operator in the instrumentation room.

In addition to the hot and cold loads, a linear receiver with precise gain control must be employed to measure the Y factor. This linear receiver is made up of one of the communication down-converters which follows the cooled paramp whose 70 MHz output is located at the patch panel in the instrumentation room. The output is then applied to the input of a test receiver such as the AIL Type 136 receiver, which has an IF attenuator whose accuracy is better than ± 0.05 dB. The receiver-detected output is then displayed on a mirrored panel meter.

The operator switches-in the built-in cold load and adjusts the IF attenuator for half scale reading on the panel meter. The IF attenuator setting is recorded; the output of the calibrated solid state noise (hot load) is then switched-in, and the IF attenuator is adjusted to obtain the same half scale reading on the panel meter. The IF attenuator setting is then recorded; the difference between the two attenuator recordings is the Y factor in decibels. The cooled paramp noise temperature can now be determined by the formula:

$$T \text{ paramp} = \frac{T_{\text{hot load}} - YT_{\text{cold load}}}{Y-1}$$

where Y is expressed as a power ratio, and the temperatures are in degrees Kelvin.

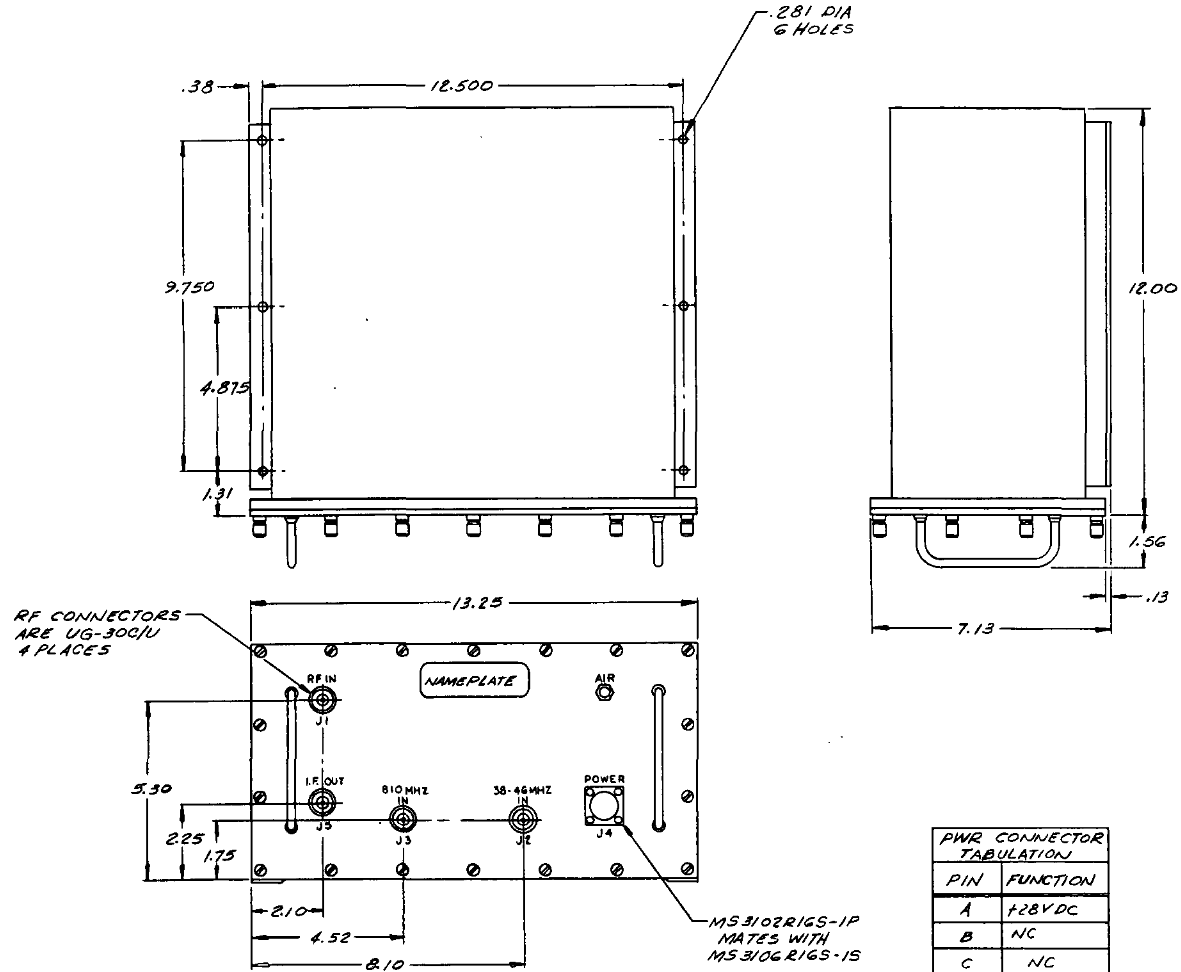
To make the measurement with a ± 1 degree K accuracy, the hot/cold load temperature must be known to within ± 3 percent, assuming a hot load temperature of 300 degrees K and a cold load temperature of 30 degrees K.

3.2.3 Communication Down-Converter

Basic dimensions of the overall communications down-converter package are 13.25 inches wide, 7.13 inches high, and 12.00 inches deep (Figure 39). At each site, the unit is mounted in standard 19-inch racks; additional bracketry required for mounting is currently being designed. The unit will be sealed and will have provisions for pressurization.

Two identical units at each site will employ double conversion with low side local oscillator injection. The first IF is 880 MHz and the second IF is 70 MHz. Any input frequency within the range of 3.7 to 4.2 GHz can be remotely selected by means of a John Fluke (645A or 6160A) synthesizer located in the instrumentation room. Major technical characteristics are:

Input frequency	3.7 to 4.2 GHz
Input impedance:	50 ohms with a VSWR of 1.2:1 maximum
Input level range:	-13 to -103 dBm
Noise figure:	22 dB maximum
Overall gain:	15 dB maximum with 10 dB adjustment
Amplitude flatness:	$\pm$0.2 dB/40 MHz bandwidth
Group delay:	Linear - 0.1 nsec/MHz 2.0 nsec/40 MHz Parabolic - 0.025 nsec/MHz^2 Ripple - 1.0 nsec peak to peak
Intermodulation products:	50 dB below either output signal level when their input levels are -15 dBm maximum
Output center frequency:	70 MHz
Output Bandwidth:	50 MHz at the 1 dB bandwidth
Output impedance:	75 ohms with a VSWR of 1.1:1 maximum
Output spurious:	63 dB below the desired output signal
Output signal to single sideband phase noise: (measured in a 1 Hz band-bandwidth) (Refer to 614-01525, page 11A)	57 dB at 10 Hz from the carrier, falling off at the rate of 10 dB per decade to 10 kHz away from the carrier. At 1 MHz from carrier, it will be at least 100 dB.



PWR CONNECTOR TABULATION	
PIN	FUNCTION
A	+28VDC
B	NC
C	NC
D	GND(CHASSIS)
E	NC
F	28V RET
G	NC

NOTE:
1. FINISH: ONE COAT ZINC-CHROMATE PRIMER PER MIL-P-8585A
2. THIS INFORMATION FROM AERTECH DWG OF MODEL C5105
3. REFERENCE: "LOCAL OSCILLATOR SPECIFICATION" 614-01525

Figure 39. Communications Down-Converter Configuration

The above specifications will apply when the first local oscillator is derived from a Fluke 6160A synthesizer and the second local oscillator is derived from a Martin Marietta 90 MHz signal phaselocked to the station standard.

The communications down-converter (Figure 40) employs a circulator at the input to ensure a 1.2:1-VSWR, 50-ohm input. This circulator also helps terminate one end of the bandpass filter, which keeps the amplitude and delay ripples to a minimum. The bandpass filter passes the desired signal while attenuating the image, first local oscillator, and transmitter frequencies. The first mixer converts the input signal to 880 MHz and is then applied to the bandpass filter. The filter attenuates the undesired products of the first mixer, as well as image frequencies associated with the second mixer. A circulator terminates the bandpass filter and presents a good driving impedance for the second mixer, thus minimizing the amplitude and delay ripple. The second mixer converts the 880 MHz signal to 70 MHz and is followed by a low-noise, variable-gain preamplifier with a 75-ohm output impedance.

The "x72" frequency multiplier utilizes a configuration of x2x3x3x4. This will provide a sufficient percentage frequency separation between undesired sidebands at the output of each multiplier stage to permit effective filtering.

All components for each communication down-converter are mounted in a pressurized container and are interconnected with solid 50-ohm coax and SMA connectors. The panel connector for the RF input is a precision "N" and the output connector is a 75-ohm TNC. All other RF panel connectors are Type "N". The down-converter operates from the +28 VDC of power supply assembly 614-01610. This input power is filtered and regulated down to +20 VDC for the "x72 multiplier and the 70 MHz preamplifier.

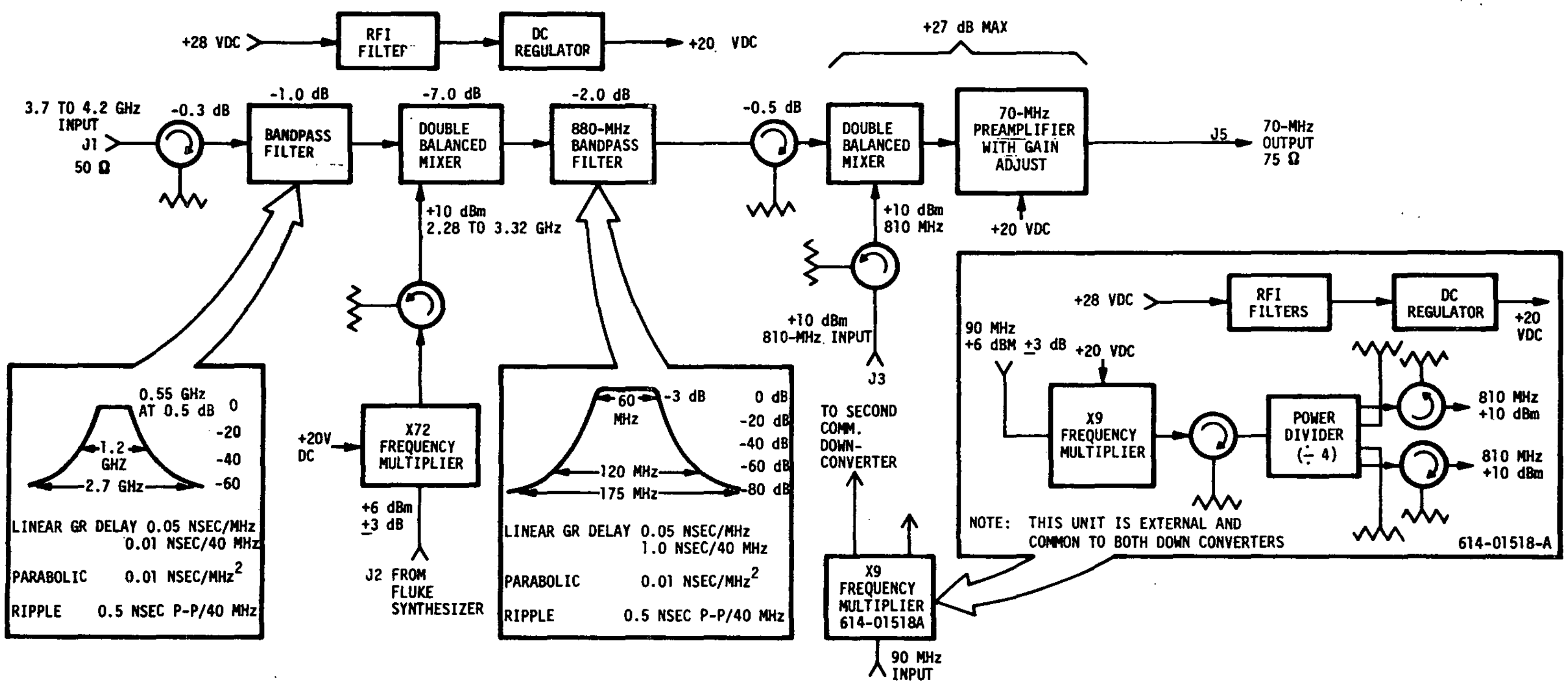


Figure 40. Communications Down-Converter

3.2.4 "X9" Multiplier

Basic dimensions of the overall "x9" multiplier package are 13.25 inches wide, 7.13 inches high, and 12.00 inches deep (Figure 41). At each site, the unit is mounted in standard 19-inch racks; additional bracketry required for mounting is currently being designed. The unit will be sealed and will have provisions for pressurization.

The "x9" frequency multiplier (MM Specification No. 614-01518-A) is shown in block diagram form in Figure 41. A single unit furnishes second LO power to both communications down-converters at each site. Its electrical characteristics are:

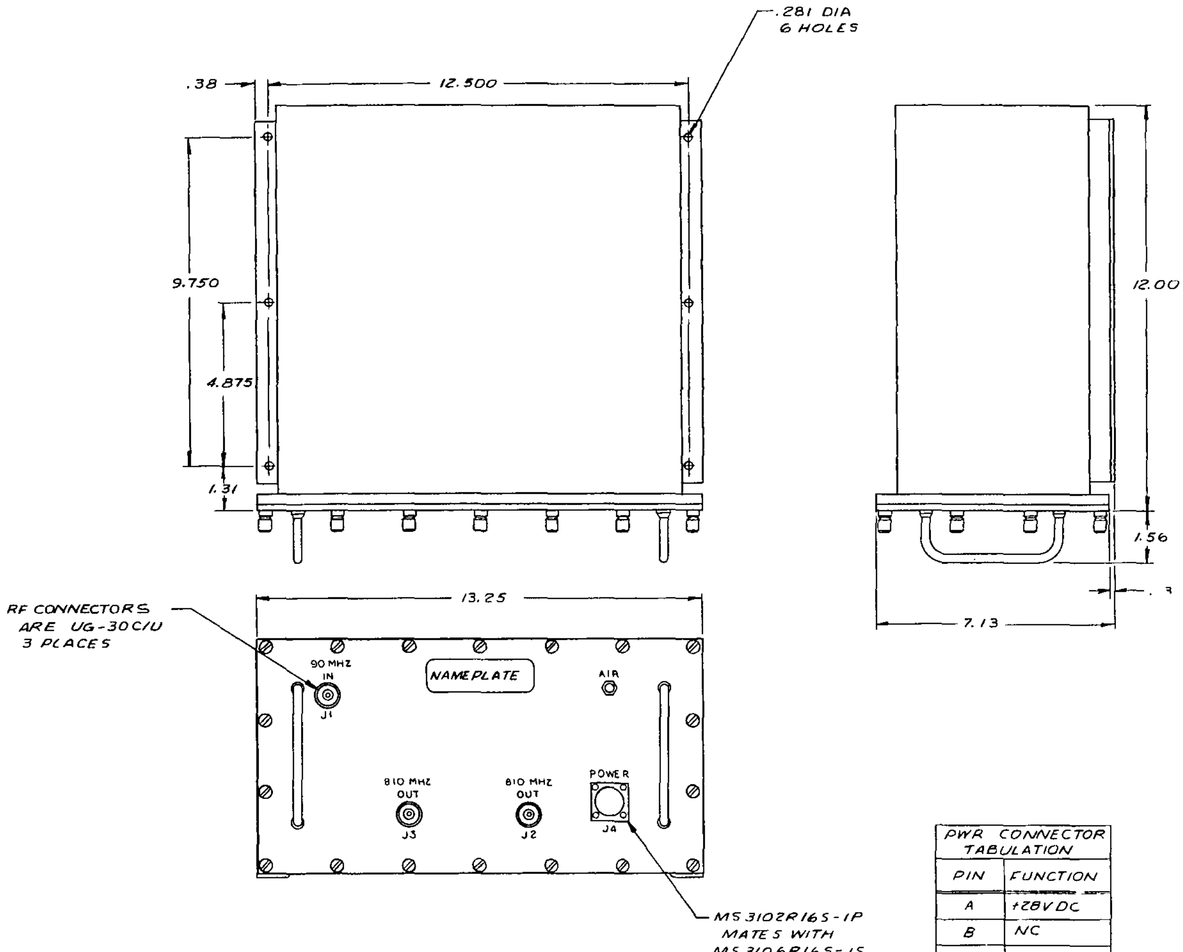
Output frequency:	810 MHz
Output power (each output):	+10 dBm ±1 dB
Output VSWR:	1.5:1 maximum
Spurious output:	80 dB minimum below the output
Output port-to-port isolation:	60 dB minimum over the range of 50 MHz to 1 GHz
Input frequency:	90 MHz
Input power:	+6 dBm ±3 dB
Input VSWR:	2:1 maximum

The "x9" frequency multiplier components are mounted inside a separate pressurized container that has Type "N" panel connectors for the RF signals. Interconnecting cables within the container are solid 50-ohm coax with SMA connectors.

3.2.5 Tracking Down-Converter

Basic dimensions of the overall tracking down-converter package are 17.00 inches wide, 9.00 inches high, and 14.20 inches deep (Figure 42). At each site the unit is mounted in standard 19-inch racks; additional bracketry required for mounting is currently being designed. The unit will be sealed and will have provisions for pressurization.

The tracking down-converter has four channels (Δ_1, Δ_2, Δ_{POL}, Σ), each employing double conversion with low side local oscillator injection. The first IF is 880 MHz and the output frequency is 136 MHz. Any input frequency within the range of 3.7 to 4.2 GHz can be remotely selected for all four channels simultaneously by a Fluke synthesizer located in the instrumentation room. The necessary multiplier for the first local oscillator is contained within the down-converter assembly as is a crystal oscillator and multiplier for the second local oscillator.

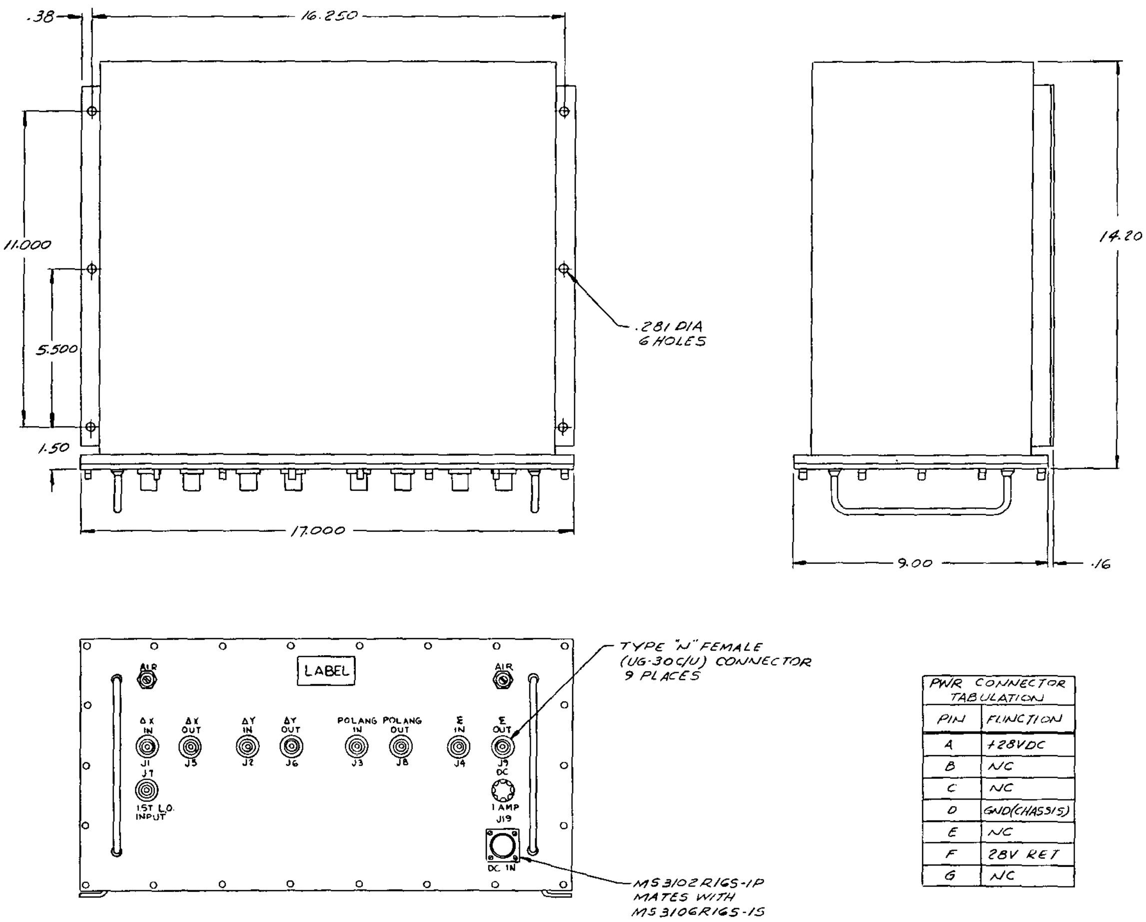


PWR CONNECTOR TABULATION	
PIN	FUNCTION
A	+28VDC
B	NC
C	NC
D	GND(CHASSIS)
E	NC
F	28V RET
G	NC

NOTE:

1. FINISH: ONE COAT ZINC-CHROMATE PRIMER PER MIL-P-8585A
2. THIS INFORMATION FROM AERTECH DRAWING OF MODEL SX 1001.
3. REFERENCE: "LOCAL OSCILLATOR SPECIFICATION" 614-01518A

Figure 41. "X9" Multiplier Configuration



PWR CONNECTOR TABULATION	
PIN	FUNCTION
A	+28VDC
B	NC
C	NC
D	GND(CHASSIS)
E	NC
F	28V RET
G	NC

NOTE:
1. FINISH: ONE COAT ZINC-CHROMATE PRIMER PER MIL-P-8585 A.
2. THIS INFORMATION FROM AERTECH DRAWING OF MODEL C5255
3. REFERENCE: "LOCAL OSCILLATOR SPECIFICATION" 614-01526

Figure 42. Tracking Down-Converter Configuration

MAJOR TECHNICAL CHARACTERISTICS

Input frequency range:	3.7 to 4.2 GHz
Input impedance:	50 ohms with 1.5:1 VSWR
Input level range:	Δ_1, Δ_2 -51 to -141 dBm Δ_{POL} -31 to -121 dBm Σ -21 to -111 dBm
Noise figure:	Δ_1, Δ_2 13 dBm maximum Δ_{POL} 21 dB maximum Σ 21 dB maximum
Channel-to-channel isolation:	60 dB minimum
Overall gain: Δ_1, Δ_2	28.2 dB/+2, -8 dB gain control
Δ_{POL}	13.2 dB/+2, -8 dB gain control
Σ	13.2 dB/+2, -8 dB gain control
Amplitude flatness:	$\pm$1.0 dB peak to peak
Intermodulation products:	60 dB below either output signal level when their input levels are -20 dBm
Output center frequency:	136 MHz
Output bandwidth:	3.0 MHz at the 3 dB points
Output impedance:	50 ohms
Output spurious:	Due to transmitter leakage and first local oscillator products (fifth order), 33 dB minimum below the desired signal. Due to first and second local oscillator products (fifth order), 34 dB minimum below the desired signal. All other spurious, 60 dB minimum below the desired signal.
Local oscillator stability:	Long term, $\pm$5 parts in 10^9/day; short term, 1 x 10^{-10} rms/1 second average. The above specifications apply when the first local oscillator is derived from a Fluke synthesizer and the second local oscillator is derived from an ultra stable 9.1851852 MHz crystal oscillator.

The tracking down converters (Figure 43) employ identical input bandpass filters (3.7 to 4.2 GHz) as the communications down-converter. This bandpass filter passes the desired signal while attenuating the image, first local oscillator, and the transmitter frequencies. The circulator following the filter terminates the filter and the mixer for a broad band of frequencies other than the passband. The first mixer converts the input frequency to 880 MHz, and, in the Δ_1 and Δ_2 channels, its output is applied to an 880-MHz amplifier. The Δ_{POL} channel has a tunnel diode amplifier while the Σ channel has the cooled parametric amplifier ahead of their tracking down-converters. Thus, any additional gain provided by an 880-MHz amplifier is not required.

The 880-MHz bandpass filter attenuates the undesired first mixer products and image frequencies associated with the second mixer. The circulator following the bandpass filter presents a stable broadband impedance for the second mixer. The second mixer converts the 880-MHz signal to 136 MHz and is followed by a variable-gain preamplifier with a 50-ohm output impedance.

The local oscillator chain, associated with the first mixer, accepts the output of the Fluke synthesizer (located in the instrumentation room) and multiplies its output frequency by 72 (the order of multiplication is x2x3x3x4). After the second "x3," there is a high-level (approximately +30 dBm) 800-MHz signal generated which is the input to the "x4" diode multiplier (last stage) and four-way power divider. Power and signal lines must be well shielded to keep this high level signal from leaking into the first IF (880 MHz) amplifier. The 16 percent bandwidth of the multiplier chain allows complete tuning of the entire tracking down-converter to be accomplished by changing only the output frequency of the Fluke synthesizer.

The second local oscillator is derived from a fixed-frequency crystal oscillator. This oscillator is followed by a crystal filter which attenuates the noise sidebands by 60 dB. This filter prevents the higher level noise sidebands from mixing, in the multiplication process, and falling near or on top of the main signal which degrades frequency stability. Output of the crystal filter is applied to a "x81" frequency multiplier, and the order of multiplication is x9x9.

All components for all four channels are mounted in a pressurized box and are interconnected with solid 50-ohm coax and SMA connectors. Panel connectors for all RF signals are Type "N." Tracking down-converter power is +28 VDC which is supplied by the power supply assembly (614-01610). The 28-VDC input is filtered and regulated down to +20 VDC.

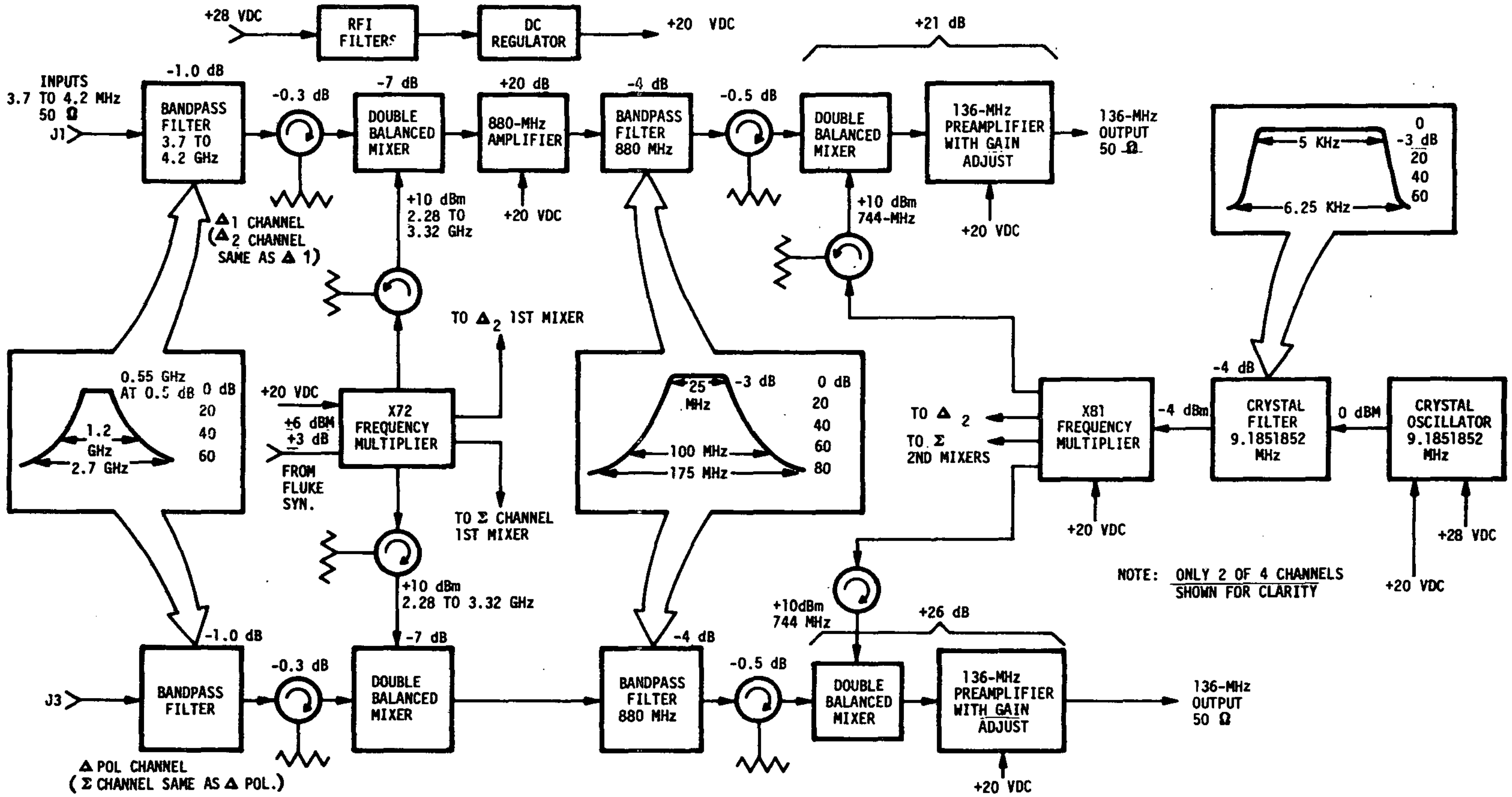


Figure 43. Tracking Down-Converter

3.2.6 Performance Monitor/Frequency Translator

Basic dimensions of the overall Performance Monitor/Frequency Translator (PM/FT) package are 17 inches wide, 9 inches high, and 14.20 inches deep (Figure 44). At each site the unit is mounted in standard 19-inch racks; therefore, additional bracketry required for mounting is currently being designed. The unit will be sealed and have provisions for pressurization.

The PM/FT unit includes two independent test tools, only one of which can operate at one time. A block diagram is shown in Figure 45.

The frequency translator accepts a sample of the C-band transmitter output (modulated or unmodulated) and translates it downward to the input frequency range of the C-band receiver. The desired receive frequency is also set by employing the frequency synthesizer* mentioned above. In the case of the Frequency Translator (FT), however, only certain combinations of transmit and receive frequencies may be used. These combinations include nearly all of the expected ATS-F uplink and downlink frequencies (Table 10). For those combinations which have spurious responses in excess of desired levels, a non-ATS-F receive frequency can always be found which will avoid the problem.

The Performance Monitor (PM) accepts a 70-MHz signal (which may have any modulation up to a 40-MHz bandwidth) and translates it upward to any desired frequency within the receive band of 3.7 to 4.2 GHz. The exact frequency is determined by use of a Fluke synthesizer located in the instrumentation room. Output of the PM may be applied to the input of the receiver cooled amplifier. Thus the entire receiver subsystem may be evaluated with a modulated signal.

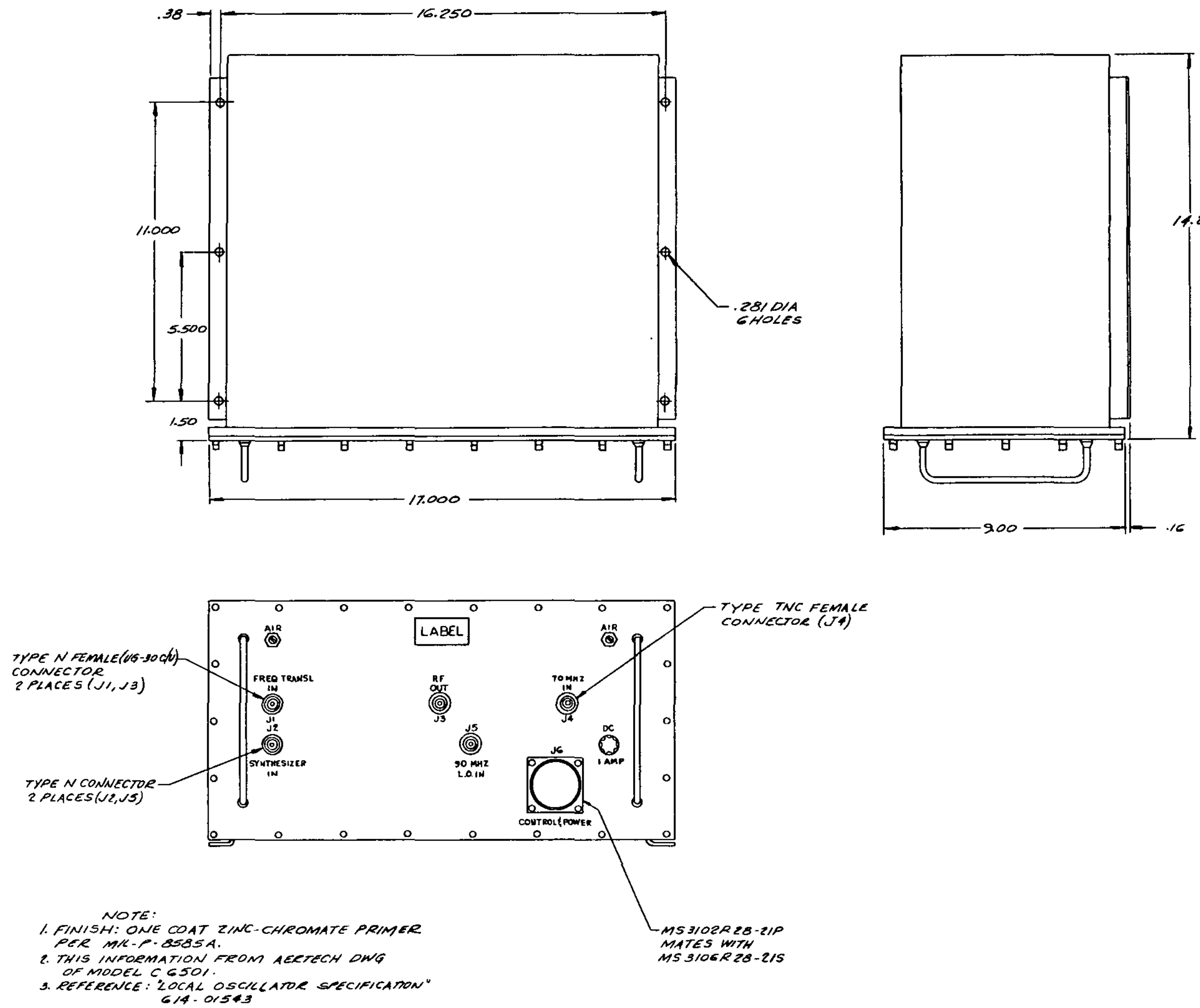
Detailed descriptions of the two functions follow.

3.2.6.1 Frequency Translator

Figure 46 shows the frequency translator in block diagram form. The signal path consists of a simple mixer which translates the transmitter signal to the receive frequencies. Local oscillator (LO) for the translator is derived from a self-contained multiplier subsystem which generates (LO) frequencies in the range of 1.7 to 2.7 GHz, under control of a synthesizer in the instrumentation room.

The multiplier subsystem consists of a common x2x2x2 section which drives any one of four additional multipliers. This arrangement is necessary due to the wide percentage bandwidth represented by the 1.7 to 2.7 GHz output, which would make it difficult if not impossible to achieve such bandwidth in a single unit.

*In accordance with Contract Amendment 1 and NASA Synthesizer Plan dated 11 August 1971, use of the Frequency Translator/Performance Monitor is considered an "off-line" function and a dedicated synthesizer is not provided for its use. Synthesizers may be diverted from other receiver (or other system) functions for this purpose.



CONTACT CONNECTION TABULATION

PIN	FUNCTION
A	INPUT CONTROL RELAY-FREQ TRANSLATOR
B	INPUT CONTROL RELAY-COMMON
C	INPUT CONTROL RELAY-PERF MONITOR
D	OUTPUT SELECT RELAY-FREQ TRANSLATOR
E	OUTPUT SELECT RELAY-COMMON
F	OUTPUT SELECT RELAY-PERF MONITOR
G	INPUT RELAY VERIFY-FREQ TRANSLATOR
H	INPUT RELAY VERIFY-COMMON
J	INPUT RELAY VERIFY-PERF MONITOR
K	OUTPUT RELAY VERIFY-FREQ TRANSLATOR
L	OUTPUT RELAY VERIFY-COMMON
M	OUTPUT RELAY VERIFY-PERF MONITOR
N	MULTIPLIER SELECT RELAY CONTROL-MULT #1
P	MULTIPLIER SELECT RELAY CONTROL-MULT #2
R	MULTIPLIER SELECT RELAY CONTROL-MULT #3
S	MULTIPLIER SELECT RELAY CONTROL-MULT #4
T	SPARE
U	MULTIPLIER SELECT RELAY CONTROL-COMMON
V	MULTIPLIER SELECT VERIFY-MULT NO.1
W	MULTIPLIER SELECT VERIFY-MULT NO.2
X	MULTIPLIER SELECT VERIFY-MULT NO 3
Z	SPARE
a	MULTIPLIER SELECT VERIFY-COMMON
b	+28V DC
c	+28V DC RETURN
d	MULTIPLIER SELECT VERIFY-MULT NO 4
e	SPARE
f	SPARE
g	SPARE
h	SPARE
j	SPARE
k	SPARE
m	SPARE
n	SPARE
p	SPARE
r	SPARE
s	SPARE

Figure 44. Performance Monitor/Frequency Translator Configuration

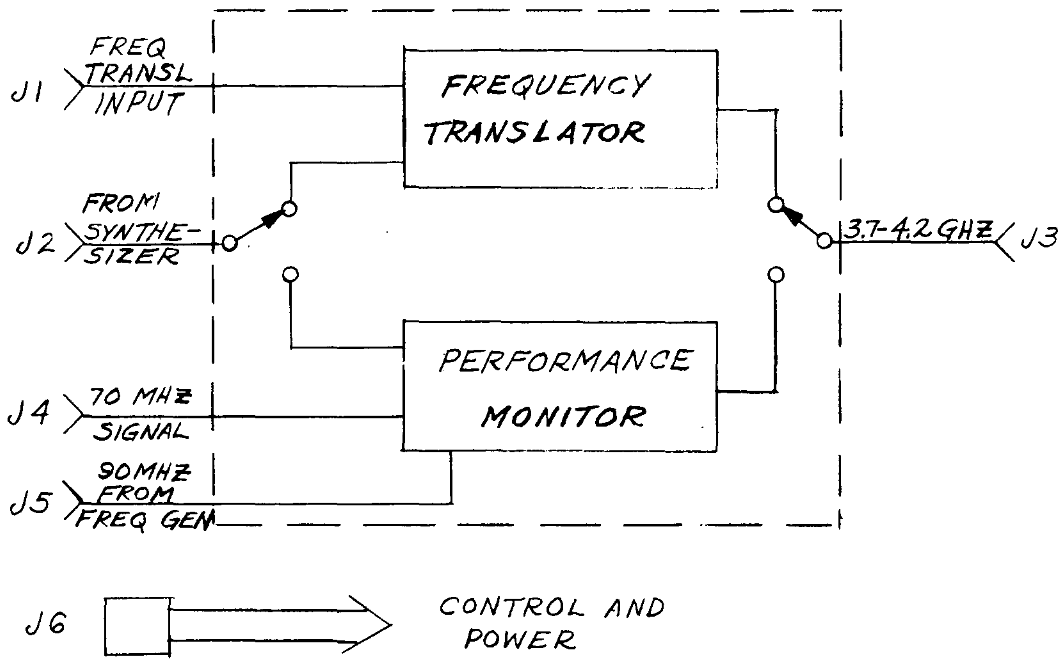


Figure 45. Performance Monitor/Frequency Translator

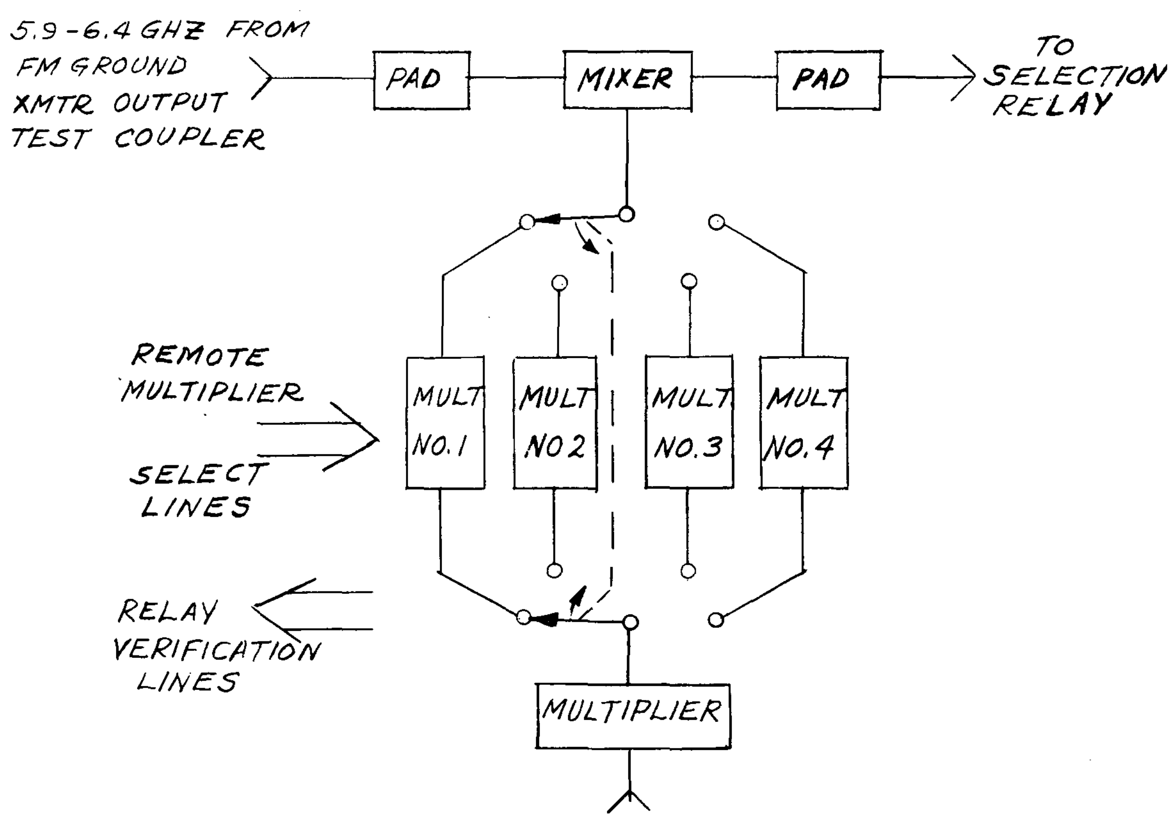


Figure 46. Frequency Translator

TABLE 10

Frequency Translator LO Frequencies and Second Harmonics, and Separation of Such Harmonics from Desired "Receive" Frequencies

Transmitter Frequency (MHz)	Rec.Freq. (MHz)	LO Freq. (MHz)	2 x LO Freq. (MHz)	Separation of Center Frequencies (MHz)
	4119.599	2092.495	4184.990	65.391
	4178.591	2033.503	4067.006	102.585
6212.094	3750.000	2462.094	4924.188	1174.188
	3950.000	2262.094	4524.188	574.188
	4150.000	2062.094	4124.188	25.812 *
	4119.599	2181.451	4362.902	243.303
	4178.591	2122.459	4244.918	66.327
6301.050	3750.000	2551.050	5102.100	1352.100
	3950.000	2351.050	4702.100	752.100
	4150.000	2151.050	4302.100	152.100
	4119.599	1830.401	3660.802	458.797
	4178.591	1771.409	3542.818	635.773
5950.000	3750.000	2200.000	4400.000	650.000
	3950.000	2000.000	4000.000	50.000 *
	4150.000	1800.000	3600.000	550.000
	4119.599	2030.401	4060.802	58.797
	4178.591	1971.409	3942.818	235.773
6150.000	3750.000	2400.000	4800.000	1050.000
	3950.000	2200.000	4400.000	450.000
	4150.000	2000.000	4000.000	150.000
	4119.599	2230.401	4460.802	341.203
	4178.591	2171.409	4342.818	164.227
6350.000	3750.000	2600.000	5200.000	1450.000
	3950.000	2400.000	4800.000	850.000
	4150.000	2200.000	4400.000	250.000

*These combinations (and difference frequencies between Second Harmonic and desired frequency) will provide marginal signal-to-spurious performance.

Selection of the multiplier, and of the synthesizer setting to be employed to achieve the desired translation, must be determined by the operator by calculation and by operation of selection switches at the control and monitor panel.

It is readily seen that the second harmonics of LO frequencies from 1.85 to 2.1 GHz fall in the receive band of 3.7 to 4.2 GHz. Furthermore, although this spurious response represents an even-order product that will be suppressed favorably by the doubly balanced mixer, a 40 dB rejection is about the best that can be achieved. Achieving an LO level of +10 dBm (a desirable level for other reasons), the output of the mixer would contain undesired signals at approximately -30 dBm. Optimizing input signal levels will result in desired signals at the output of the mixer of about -17 dBm at the highest expected input level. Thus signal-to-spurious ratios of no better than 23 dB could result. With lower level inputs, this ratio could be degraded linearly. Adjustment of input pads and LO levels may improve this somewhat, but cannot be expected to produce the desired signal-to-spurious ratios for all frequency translation combinations.

An alternative to this method of operation was proposed by Aertech, the subcontractor producing this subsystem. The alternative could involve using the transmitter sample signal as the LO source, with the multiplier outputs being adjusted to a much lower level (in the area of -20 to -40 dBm). At these levels the production of an undesired second harmonic would be greatly reduced, achieving a desirable spurious response in the order of 60 dB below the desired signal. To implement this, the transmitter sample signal would have to be in the order of +30 dBm with an ALC loop normalizing it to approximately +10 dBm at the input to the mixer.

NASA-GSFC has directed that this approach shall not be used, consequently it was not pursued. Instead, NASA has stated that the LO second harmonics would be tolerated as long as they do not fall within ± 50 MHz of the receive frequency when using specified ATS-F up-link and down-link frequencies. Accordingly, a computer tabulation was made showing all possible combinations of such frequencies with separation of LO second harmonics from the desired receive frequency (Table 10). The two asterisks at the extreme right show the only two combinations which could give any problem. As previously stated, even for this condition a slight adjustment of the selected receive frequency would eliminate any possible problem.

Undesirable combinations are also shown graphically (Figure 47).

3.2.6.2 Performance Monitor (PM)

The Performance Monitor (PM) is a double-conversion up-converter which converts a 70-MHz signal to any selected region of the 3.7 to 4.2 GHz receive region. A block diagram is shown in Figure 48.

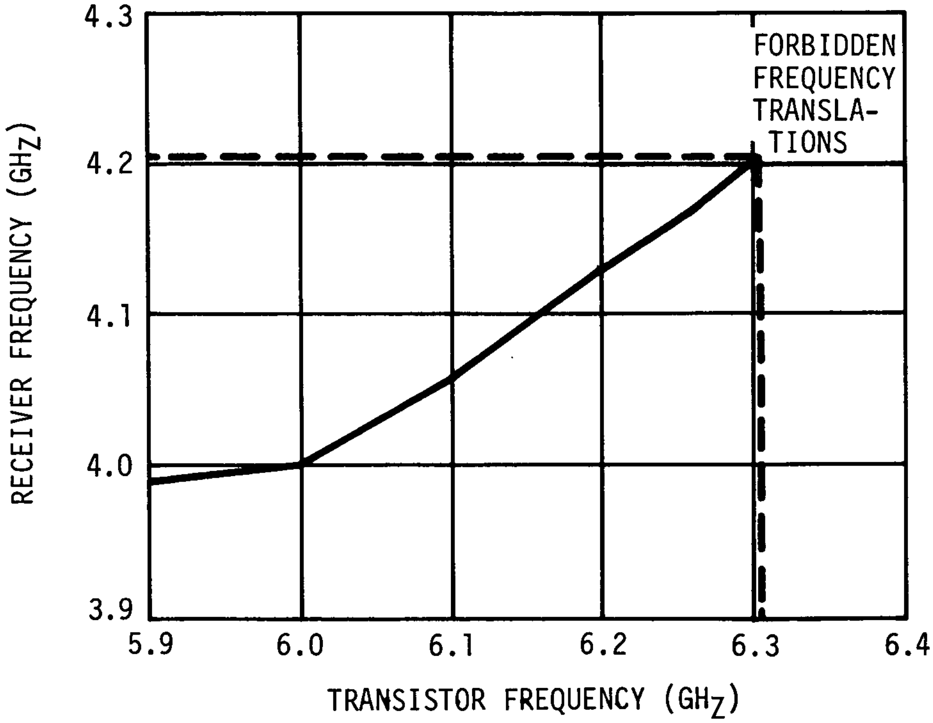


Figure 47. Translator Transmit-Receive Frequency Combinations That Provide Undesired Spurious Responses Due to Local Oscillator

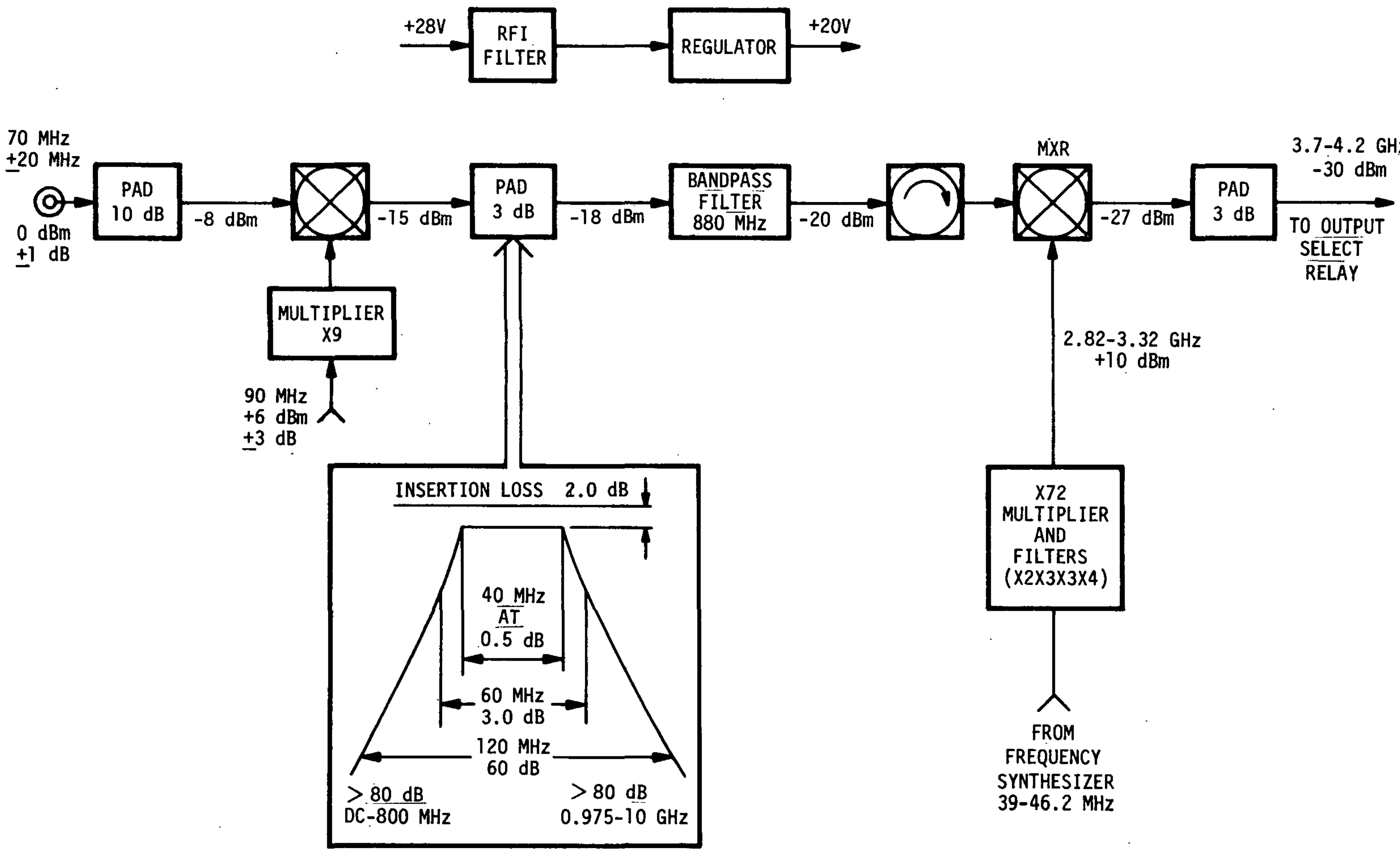


Figure 48. Performance Monitor

Significant electrical characteristics are:

Signal input:

Frequency	70 ±20 MHz
Level	0 dBm ±1 dB
Input impedance	75 ohms
VSWR	Less than 1.5:1

Signal output:

Frequency	Any selectable frequency within range of 3.7 to 4.2 GHz. Frequency setability determined by resolution of synthesizer 10 Hz x 72 - 720 Hz
Level	-30 dBm ±1 dB
Impedance	50 ohms
VSWR	1.2:1 maximum

Passband characteristics:

Flatness	±0.2 dB over any 40 MHz
Group Delay:	
Combined linear and parabolic ripple	1 nanosecond over 40 MHz 0.5 nanoseconds peak-to-peak
Amplitude linearity	For two tones at input of 0 dBm 3rd order intermod's at output will be at least 17 dB below desired output.
Spurious	All spurious signals within ±100 MHz of desired output frequency will be at least 60 dB below desired output signal.

Local oscillator inputs:

LO # 1	
Frequency	90 MHz
Level	+6 dBm ±3 dB
LO # 2	
Frequency	39 to 46.2 MHz
Level	+6 dBm +3 dB
	Both LO signals will have phase noise characteristics such that output single sideband phase noise in a 1-Hz bandwidth, 1 MHz from carrier, will be at least 100 dB below desired signal.

3.2.7 Miscellaneous Receiver Test Aids

A number of miscellaneous test aids, loops, sources, etc. may be necessary in trouble shooting or as part of planned experiments. A general block diagram, extracted from the Rosman overall system block diagram, is shown in Figure 49. Signal paths for these various sources are self explanatory but details of the sources are discussed in the following paragraphs.

3.2.7.1 Noise Sources (614-01535)

A solid state noise source is provided to facilitate noise temperature measurements by an operator in the instrumentation room (Figure 49). The noise source (Figure 50) is an AIL Type 76 (Part Number 07616), which operates on a +28 VDC command. Once the noise source has been installed with all interconnecting cable (RG 214), its power output may be calibrated at the paramp input switch with a variable attenuator (ARRA 4674-50L) and flap attenuator. The flap attenuator is part of the cooled preamp assembly and acts as an accurate room-temperature noise source. Once the calibration is complete, the operator can remotely select the noise source for the Y-factor measurement. Noise source characteristics are:

Frequency range:	1.0 to 12.5 GHz
Excess noise ratio (ENR):	15.5 $\pm$0.5 dB
Load decoupling:	20 dB
Power required (fired):	+28 VDC/30 ma
Output connector:	Type "N"
Input connector (power):	BNC
Size (including connectors):	1 x 1 x 6 inches

3.2.7.2 Tracking Signal Source Splitters (Rosman Only)

At Rosman (only), there presently are two Merrimac magic tees that accept a tracking test signal and split it into ΔX, ΔY, and Σ channel signals (Figure 49). This signal can then be applied to the respective tracking channels through Martin Marietta-supplied directional couplers (MM supplies new tracking channel couplers for all three sites).

The Merrimac magic tees are located near the monopulse (tracking) down-converter near the base of the feedcone. This test equipment will be left as is when new tracking down-converters are installed.

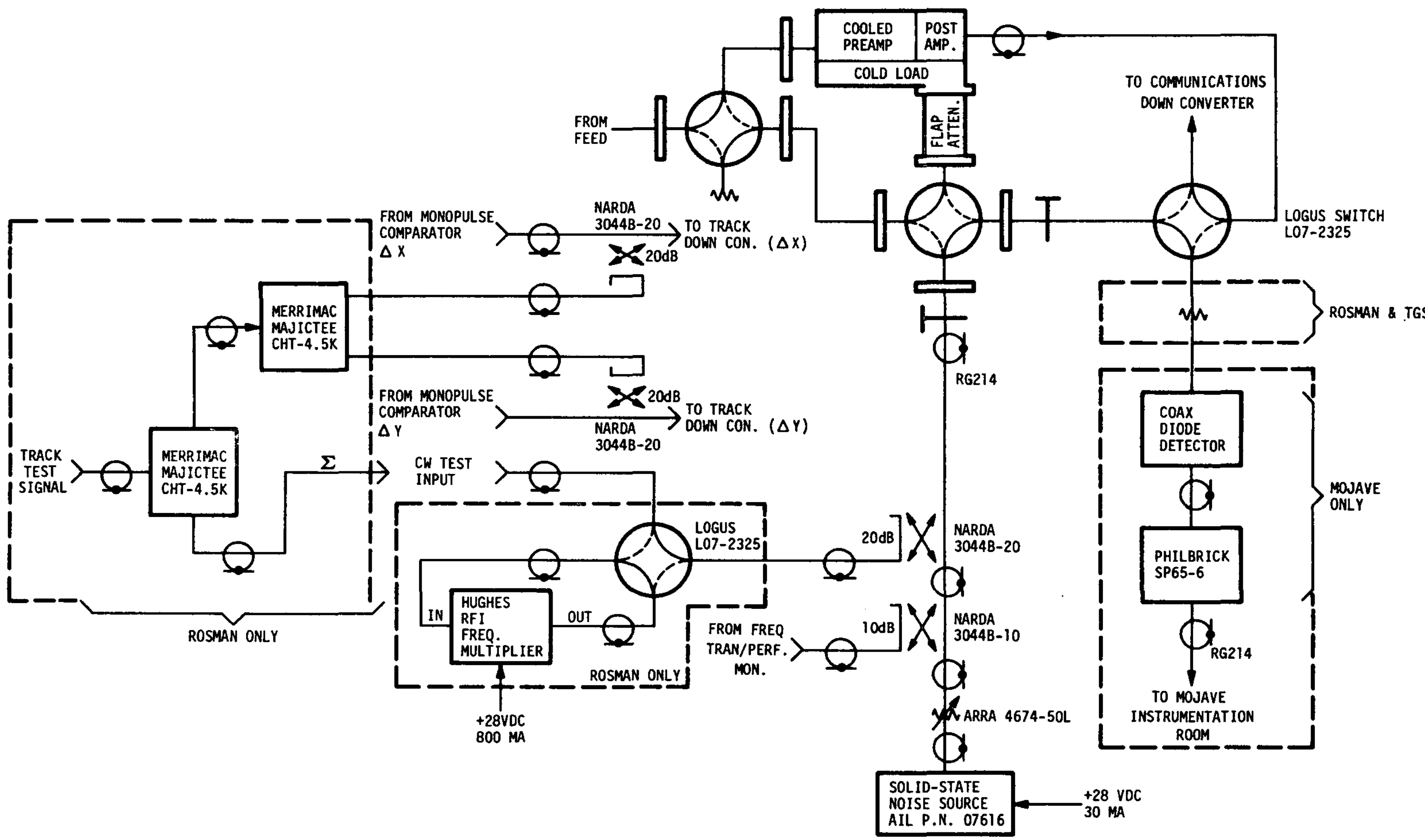


Figure 49. Miscellaneous Receive Test Aids - Rosman

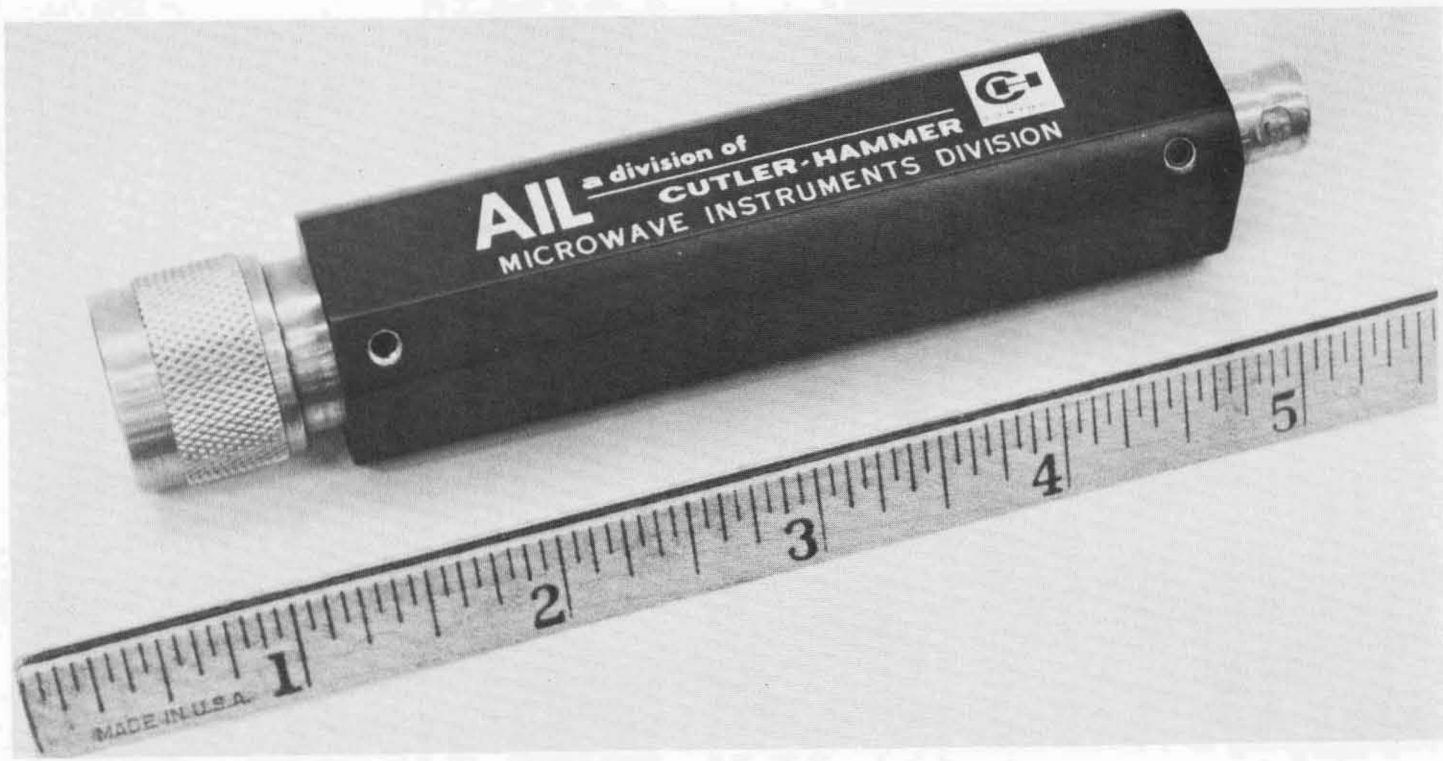


Figure 50. AIL Type 76 Noise Source

3.2.7.3 Detector/DC Amplifiers for Cooled Amplifier (Mojave Only)

At Mojave (only), a coaxial diode detector mount, followed by a Philbrick DC amplifier, is mounted on a support member of the feedcone (Figure 49). This test equipment is used to remotely monitor gain-band width of the cooled preamplifier when a swept signal is applied to the preamplifier input. This capability will be retained as-is, when Martin Marietta modifies the feedcone for extended frequency range (3.7 to 4.2 GHz) operation. The swept display can be accomplished when the function switch on the control panel (4A1) is in one of the following "low noise amplifier input" positions: (1) frequency translator, (2) performance monitor, or (3) noise source, and the output switch of the low noise amplifier is in the override position. This switching arrangement allows the CW test input, to which the frequency sweeper is applied, to be connected through a 20 dB coupler to the cooled preamp input, while the post-amp output is connected to the diode detector mount.

3.2.7.4 CW Test Input Switch (Rosman Only)

Martin Marietta is providing a switch in the CW test input line that permits a test signal, or the Hughes RFI multiplier, to be switched in through the 20 dB coupler to the input of the cooled preamplifier. Control for this transfer switch is located on the monitor and control panel (4A1) and is labeled "test input multiplier in-out." This feature is being provided at Rosman only.

3.2.7.5 Attenuator Calibrator

Martin Marietta is providing one AIL Type 137 RF attenuator calibrator (Figure 51). This item is presently employed in the antenna lab to make accurate, low insertion loss, feed line component measurements (OMT, diplexer, transmit reject filters, bandpass filters). In addition to insertion loss measurements, the Type 137 receiver can be used for the Y factor measurement (noise temperature) at 70 MHz, the output frequency of the communications down-converter. Mechanics of the Y-factor measurement were described in Paragraph 3.2.2 of this report; other features may be found further in this section.

No plans have been made for installing this equipment at any of the sites. Present plans are to ship this item to NASA-GSFC.

3.2.8 Local Oscillator System

Figure 52 shows local oscillator generation at all sites. Generally, communication channel local oscillator frequencies are referenced back to the 5 MHz station standard, and tracking local oscillator signals are generated from independent sources. Therefore, all communication local oscillator signals will exhibit the same long term frequency stability as the 5 MHz station standard, e.g., 5 parts in 10^{10} for 24 hours and 1 part in 10^8 per year. Tracking channel local oscillator signals will have no more than ± 5 parts in 10^9 per day. The VCXO and multiplier combinations

Type 137 RF Attenuation Calibrator

Simple Operation — Only 4 Controls • Single-step Range — 0.01 to 100 dB • Broad-band Frequency — Coverage 10 MHz to 40 GHz

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DEER PARK, LONG ISLAND, NEW YORK 11729

Figure 51. AIL Type 137 Calibrator

Having Calibration Problems?
Here's a foolproof, simple Attenuation Calibrator that anyone can use

IF substitution systems are classified as either series or parallel depending on whether the attenuation standard is in series with the main signal path or in a parallel reference path.

The series method provides the user with such simplicity of operation as to make this approach highly desirable; however, varying system noise levels have restricted the useful measurement range of series systems compared with that usable with parallel systems.

AIL has now developed a completely new IF series-substitution system that overcomes past restrictions and greatly increases the single-step measurement range, while retaining the inherent simplicity for the user. This new improved series-substitution system, which includes several new exclusive user features, offers the following advantages:

WIDE RF RANGE
Limited only by availability of suitable mixers.

HIGH ACCURACY
From 0.007 dB for small attenuation measurements to a maximum of 0.4 dB for a 100-dB range. For increased accuracy the reference attenuator is easily removable for calibration at NBS.

EXCEPTIONAL RESOLUTION
Expanded scale operation provides sensitivity of 0.008 dB per division.

SIMPLE OPERATION
Fewer controls and adjustments greatly reduce personnel training and technical qualifications.

INTERNAL MODULATION
Requirement to modulate external signal source is eliminated, thereby reducing equipment complexity and personnel hazard.

INTERNAL AFC
Completely integrated AFC eliminates requirement to control the frequency of external signal sources.

EXCLUSIVE "PROHIBIT FUNCTION"
Prevents the operator from making false measurements if system falls out of AFC.

ALL SOLID STATE
Provides highest stability and lowest maintenance costs.

For Accurate Measurements of

- RF ATTENUATION
- IF ATTENUATION
- NOISE FIGURE
- FREQUENCY DEVIATION
- AMPLITUDE MODULATION
- SENSITIVE NULL INDICATION

Specifications

RF Range — 10 MHz to 40 GHz (determined by mixer used)

Attenuation Measurement Range
Single-step measurement — 100 dB (maximum)

Range versus Accuracy

Attenuation Step (dB)	Overall Accuracy (dB)
10	±0.04
20	±0.05
40	±0.07
80	±0.20
90	±0.30
100	±0.40

Attenuator
Range — 0 to 100 dB
Accuracy — ±0.005 dB/10-dB increment + 0.03 dB attenuator accuracy included in overall accuracy
Resolution — 0.01 dB/division

Meter Functions — Crystal current; Detector level; Reference level

Meter Resolutions
Normal — 0.2 dB/division
Expand — 0.008 dB/division

Automatic Frequency Control
Frequency error reduction — 1000 to 1 (min.)
RF signal frequency drift — 10 MHz
Minimum input signal — —115 dBm into mixer
Maximum input signal — —15 dBm into mixer

Dimensions (inches) — 19-13/16 wide by 9-7/8 high by 13 deep

Power Required — 115/230 VAC ±10%, 50 to 400 Hz, 40 watts

Price — $3,500 F.O.B. Deer Park, New York

Figure 51 (continued)

Exclusive Features

INTERNAL AUTOMATIC FREQUENCY CONTROL

The Type 137 consists of a dual-conversion system where AFC is maintained in the second local oscillator. This provides the user with a completely integrated system and eliminates loop gain adjustments, response time adjustments, and frequency control of external oscillators.

A front-panel indicator provides the user with a positive indication of proper AFC operation.

SOLID-STATE CONSTRUCTION

The Type 137 is the only completely transistorized instrument of its type. It provides a degree of stability, reliability, and low maintenance previously not available.

PLUG-IN MIXERS FOR BROAD RF COVERAGE

The external preamplifier is designed to accept an entire series of mixers by a simple mechanical plug-in arrangement.

AIL makes available a series of Type 135 mixers covering the frequency range from 10 MHz to 40 GHz. The user need only provide a signal source and local oscillator.

METER TIME CONSTANT

Through a unique circuit design, the detector time constant is automatically increased as the signal-to-noise ratio decreases. This ensures that the user always has the optimum time constant for his measurement and eliminates the need for a manual control.

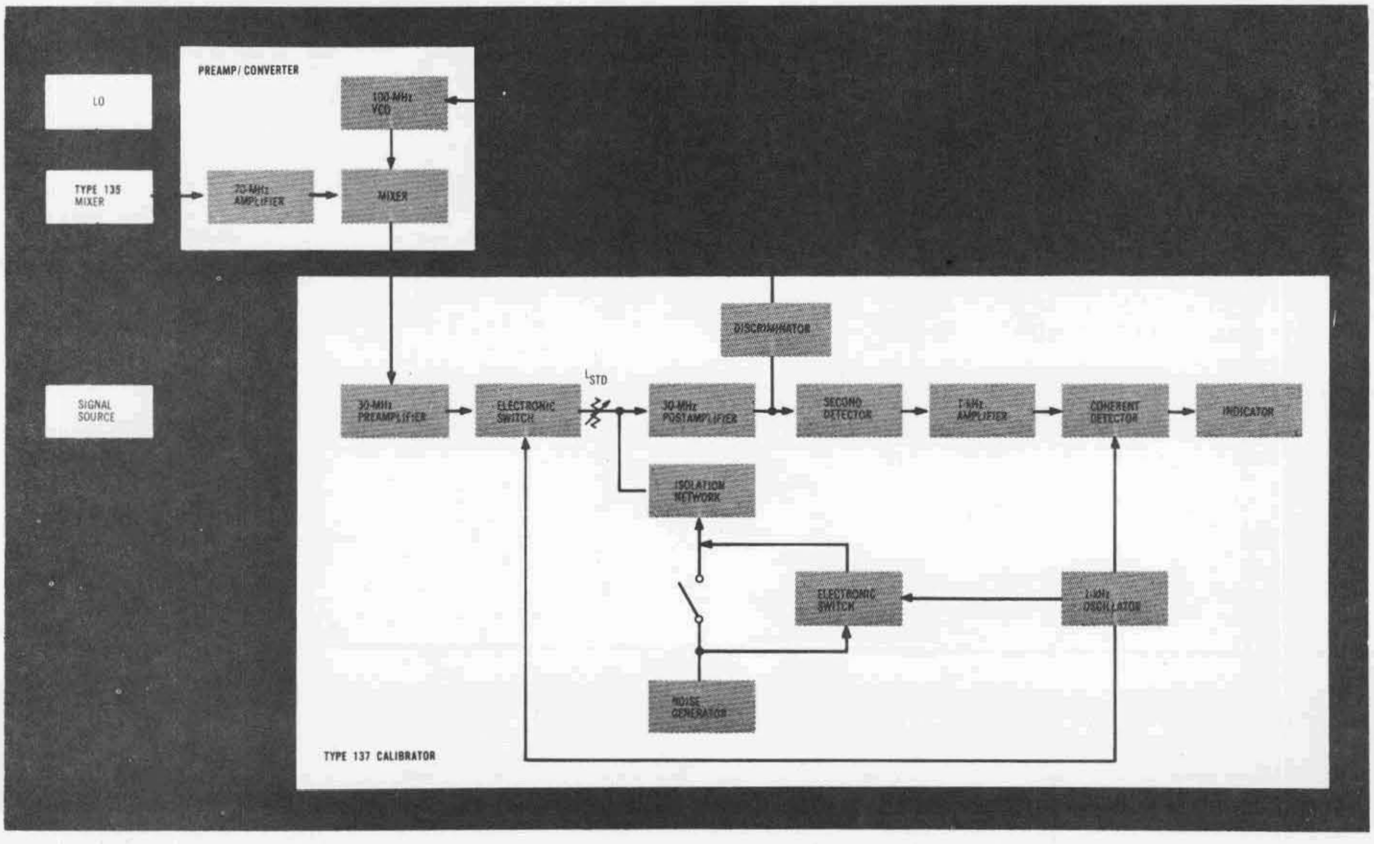
PROHIBIT FUNCTION

In addition to the front-panel AFC indicator, the Type 137 includes an exclusive function that causes the meter indication to go to zero if the unit drops out of AFC. This feature makes the instrument fail-safe since it is virtually impossible to make a measurement under improper conditions.

NOISE STABILIZATION

A unique internal noise-stabilization circuit eliminates apparent nonlinearities in the detector thereby increasing measurement range and permitting recovery of signals well below noise.

A convenient null system is provided to enable the operator to set the level of the background noise.



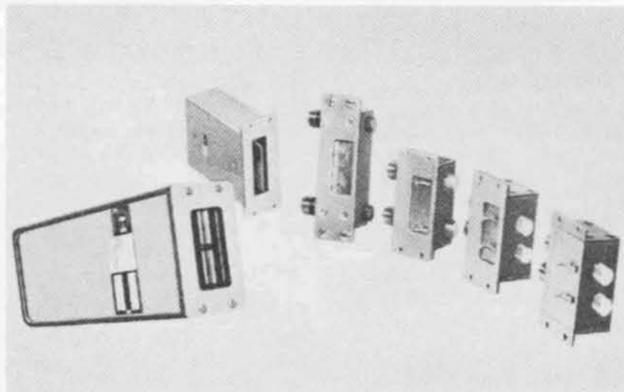
SIMPLIFIED SYSTEM BLOCK DIAGRAM

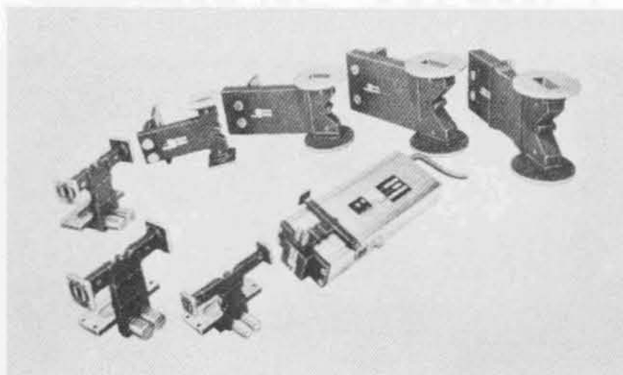
Figure 51 (continued)

TABLE OF TYPE 135 MIXERS

AVAILABLE FOR DIRECT PLUG-IN OPERATION WITH THE TYPE 137

P/N	Frequency Range (GHz)	Price
TYPE 135 COAXIAL MIXERS		
13508	0.01 to 1.0	$495.00
13504	1.0 to 2.0	290.00
13505	2.0 to 4.0	290.00
13506	4.0 to 8.0	290.00
13507	7.0 to 11.0	495.00
13509	3.6 to 4.2	290.00
TYPE 135 WAVEGUIDE MIXERS		
13522	3.7 to 4.2	750.00
13523	4.4 to 5.0	750.00
13524	5.4 to 5.9	605.00
13525	5.9 to 6.5	605.00
13526	6.5 to 7.5	605.00
13527	7.5 to 8.5	525.00
13528	8.5 to 9.6	450.00
13529	8.8 to 10.25	525.00
13531	10.0 to 12.4	800.00
13532	12.4 to 14.0	580.00
13533	13.5 to 15.6	580.00
13534	15.0 to 17.0	580.00
13538	23.0 to 25.0	825.00
13539	34.0 to 36.0	950.00
13541	17.0 to 19.7	650.00
13542	25.0 to 29.0	1,200.00
13543	29.0 to 34.0	1,200.00
13544	36.0 to 40.0	1,250.00
13545	19.7 to 23.0	950.00
13546	8.2 to 12.4	750.00
13547	12.4 to 18.0	675.00





Prices and specifications subject to change without notice.

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Phone: (516) 595-3216/3217

Figure 51 (continued)

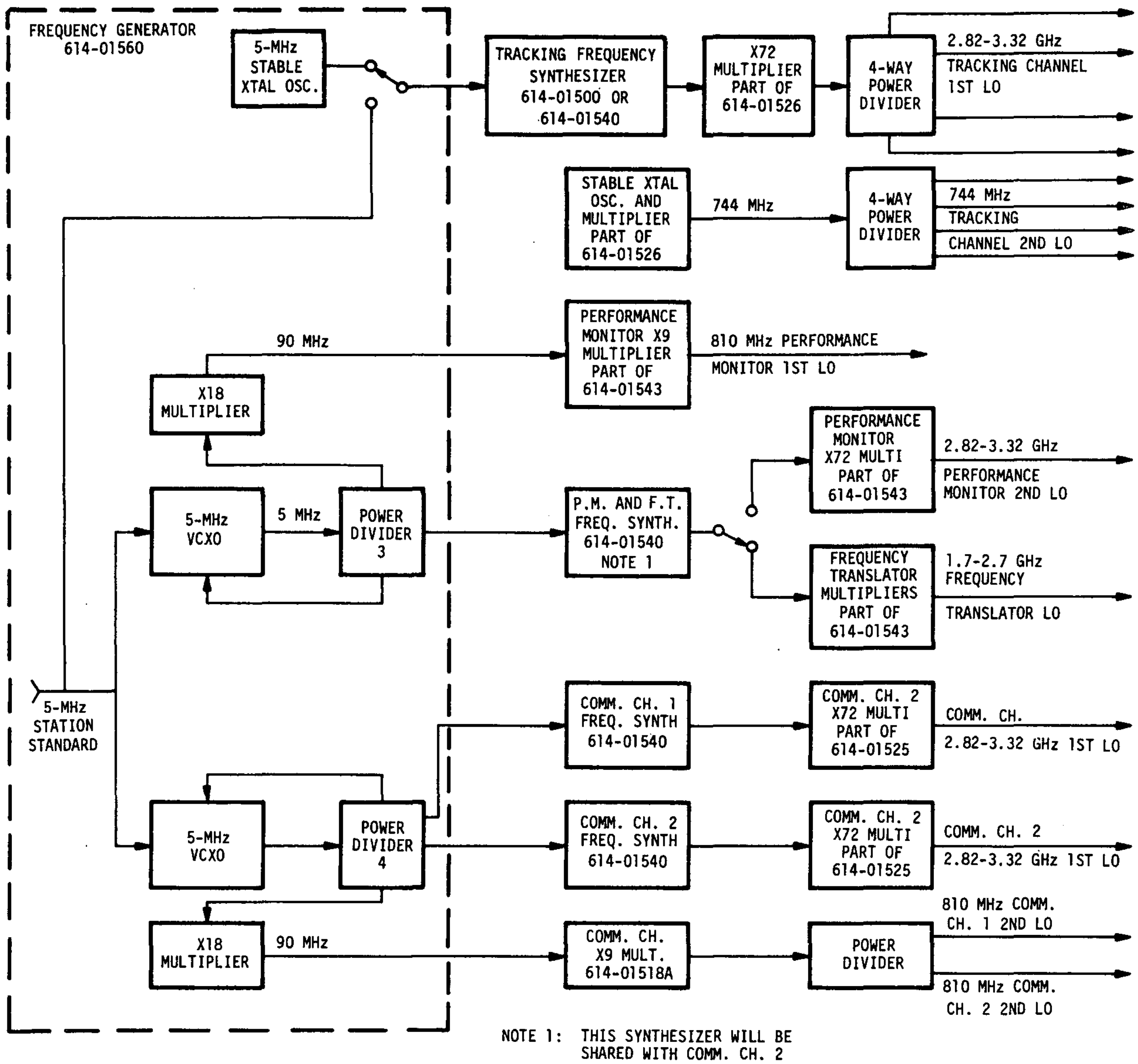


Figure 52. Local Oscillator Generation System - All Sites

employed will meet the following required short term stability and phase noise requirements:

Tracking channels:

1 8 parts in 10^{11} for 1 second averaging

2 Phase noise will be at least 50 dB below 1 radian from 20 Hz to 1 kHz when measured with a 3-Hz analyzer bandwidth.

3 Phase fluctuation noise will be at least 70 dB below 1 radian from 1 kHz to 1 MHz.

Communications channels (including performance monitor and frequency translator):

1 The signal-to-phase noise in any 1 Hz bandwidth at a separation from the carrier of 10-1000 Hz (excluding powerline frequencies) will be at least 48 dB and, at a separation of 1000 Hz, the ratio will be at least 80 dB (Figure 53).

2 The signal-to-phase noise ratio measured in any 3 kHz bandwidth between 1 kHz and 1 MHz away from carrier will be at least 55 dB (Figure 53).

3 When using the Fluke 6160A synthesizer, the signal-to-phase noise ratio in any 1 Hz bandwidth at a separation of 1 MHz or more from the carrier is expected to be at least 100 dB (Figure 53).

3.2.8.1 Synthesizers

A major advantage of the new receiver system is the ability to set receive frequencies in the operations room by the simple manipulation of front panel rotary switches, each of which selects a decimal digit of the basic local oscillator source. Multiplication of this basic source provides the ultimate local oscillator frequency.

To accomplish this, two different frequency synthesizers are being provided under the contract as follows:

1 Two Fluke Model 645A/CF synthesizers (Figure 54) with 10 Hz resolution (Martin Marietta Specification 614-01500)

2 Four Fluke Model 6160A synthesizers (Figure 55) with 1 Hz resolution (Martin Marietta Specification 614-01540).

This represents a change in both quantity and types of synthesizers from the original contract which was based on supplying nine Fluke 645A

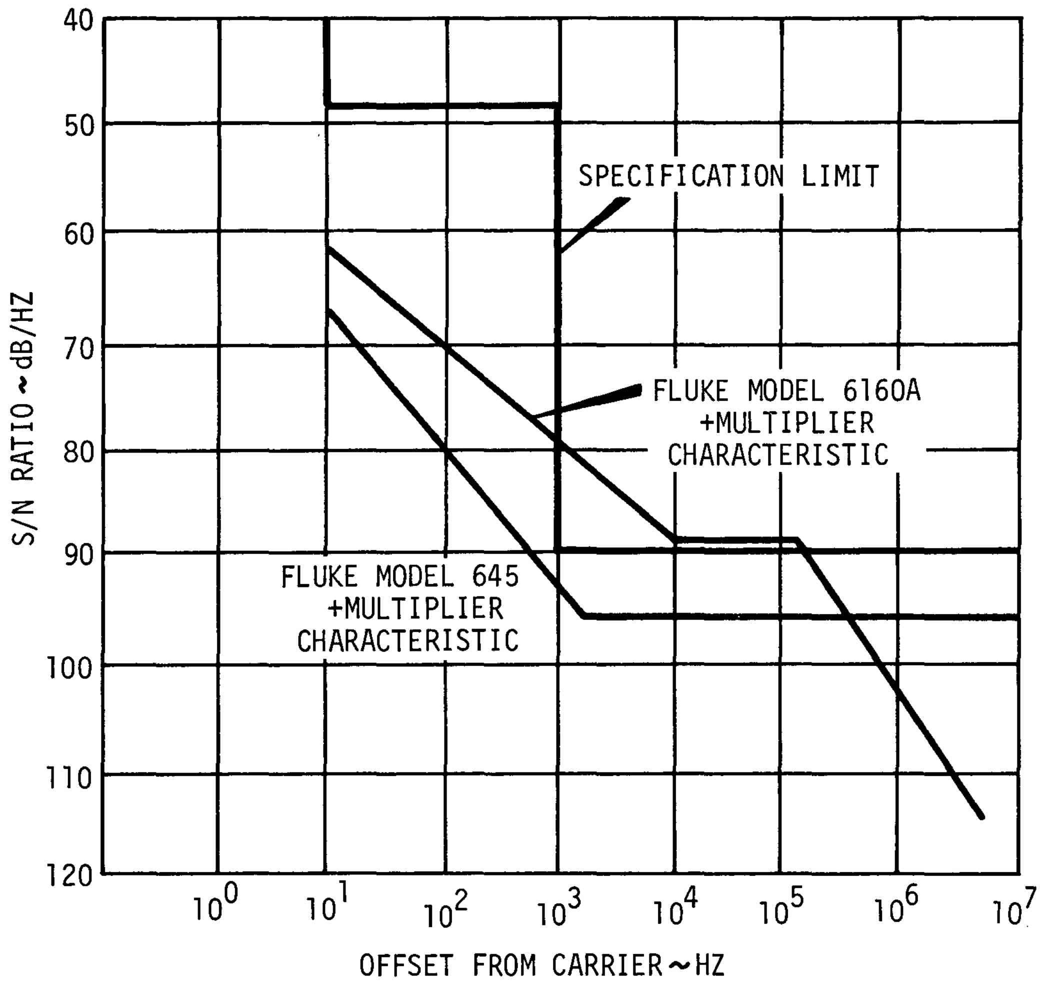


Figure 53. Worst Case Receiver Local Oscillator to Single Sideband Phase Noise

Figure 54. Fluke 645A Synthesizer (Front View)

Figure 55. Fluke 6160A Synthesizer (Front View)

units (three per site). The change was brought about by Contract Amendment Number 1 which provided for a maximum of six synthesizers. Purposes for the change included:

1 Reduce the total number of synthesizers being furnished by several contractors because of plans to time-share units, and

2 Provide at each site at least one communications channel synthesizer that would have superior phase noise characteristics at 1 MHz or more away from center frequency.

From Figure 56 which shows the phase noise characteristics of both units versus frequency, it can be seen that the 645A provides slightly better performance out to approximately 200 kHz from the carrier, but then reaches a floor beyond which no further improvement occurs. The 6160A, on the other hand, provides significantly better performance at 1 MHz or more away from the carrier.

Since the multiplication factor for the communications down-converter local oscillator is 72, the multiplication process can be expected to degrade the single sideband phase noise by at least:

$$\text{degradation (dB)} = 20 \log 72 = 37 \text{ dB.}$$

This would result from a perfect multiplier. To account for additional noise, which may be contributed by the multiplier itself, another 3 dB of degradation is assigned to the multiplier itself with the result that the actual local oscillator signal is expected to have a single sideband phase noise approximately 40 dB poorer than represented by the curves of Figure 56.

The multiplication factor of 72 also implies that receive frequencies can be set to a resolution of 720 Hz for the 645 model, or 72 Hz for the 6160A,both of which greatly exceed the requirement for 10 kHz resolution.

Both units have essentially identical performance in other respects and are completely interchangeable, physically and electrically. Either synthesizer may be used in any application in the receiver system; however, only the Fluke 6160A synthesizer outputs will be routed through the patch panels. Essential characteristics of both units are:

	645	6160A
Output frequency range	0 to 50 MHz	1 to 10 MHz 10 to 159.999999 MHz
Resolution	10 Hz	1 Hz in upper range
Output level	+13 dBm maximum	+13 dBm maximum

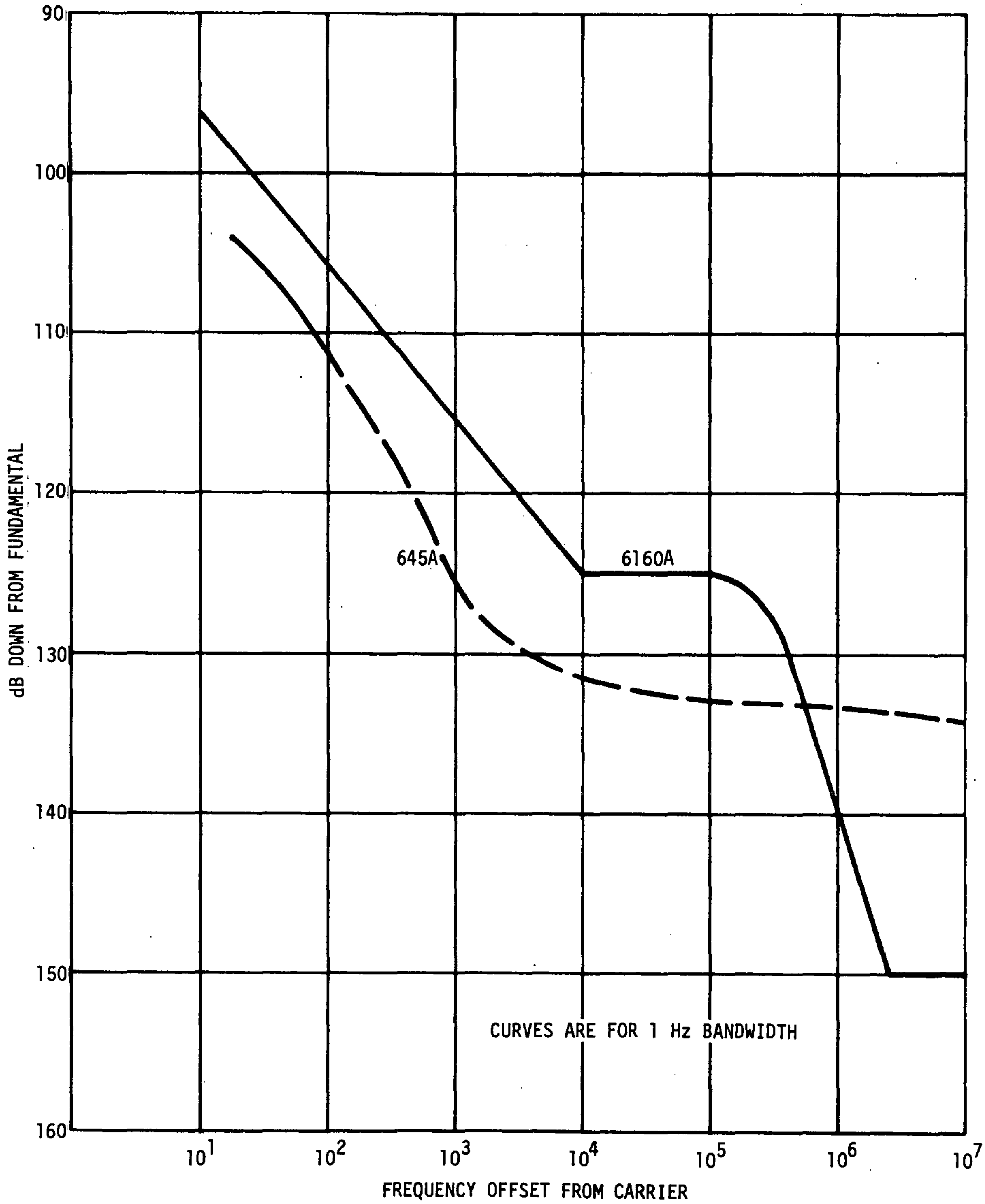


Figure 56. Single Sideband Phase Noise Characteristics of Fluke 645A and 6160A Synthesizers

	645	6160A
Output impedance	50 ohms	50 ohms
Spurious outputs		
Nonharmonic	100 dB below fundamental	60 dB below fundamental
Harmonic	30 dB below fundamental	25 dB below fundamental
Signal-to-phase noise ratio	(see Figure 56)	(see Figure 56)

Both units have provision for locking their basic 5 MHz standard input to the station standard, thus providing the long term accuracy identical to the station standard.

Since the Fluke 6160A was a model not yet in production, it was necessary to make its final selection contingent upon RFI tests to be performed on the Fluke demonstration model by Martin Marietta. These tests made at Orlando, Florida on August 2, 1971, were in accordance with MIL-STD 461A and 462. The following tests were made:

RS03	Radiated Susceptibility	14 kHz - 1 GHz
CS01	Conducted Susceptibility	30 Hz - 50 kHz
CS02	Conducted Susceptibility	50 kHz - 400 MHz
CS06	Conducted Susceptibility	Spike
CE01	Conducted Emissions	20 Hz - 20 kHz
CE03	Conducted Emissions	20 kHz - 50 MHz
RE02	Radiated Emissions	14 kHz - 1 GHz

Of these tests, the following exceeded MIL Spec limits:

Test	Spec Limit	Test Measurement	Excess
CE01 Broadband	90 dB/μv/20 kHz	125 dB/μv/20 kHz	35 dB
CE03 Broadband (725 kHz)	78 dB/μamp/MHz	90 dB/μamp/MHz	12 dB
RE02 Broadband (150 MHz)	56 dB/μv/1 MHz	66 dB/μv/1 MHz	10 dB

Although it was the opinion of Martin Marietta engineering that such "out of spec" conditions would have no adverse effect on any of the systems now installed or expected to be installed, NASA directed that the deficiencies revealed in the RE02 and CE03 tests be corrected and that the CE01 problem be corrected or improved.

Fluke Company subsequently quoted the correction for the RE02 and CE03 problem and have been directed to implement such corrections. Fluke Company gave the opinion that little could be done about the CE01 problem, but offered to perform a 4-week investigation, if funded, and then prepare a fixed-price quote.

In lieu of the latter, Martin Marietta has elected to provide line filters (Filtron Part Number FSR-304D) which probably will not completely cure the problem but will provide low frequency attenuation as follows:

2 kHz	3 dB
10 kHz	40 dB
14 kHz	50 dB
20 kHz	60 dB

Thus, for all but the lowest frequencies around 2 kHz and below, the filter will provide adequate suppression. It is believed that no trouble will be encountered from any residual conducted interference at 2 kHz and below.

The filter is approximately 8 1/4 by 4 1/2 by 2 1/2 inches and will mount in the rack immediately behind the synthesizer.

3.2.8.2 Frequency Generator

With the normal exception of the tracking channel local oscillator generators, the local oscillator frequencies are phase-locked to the 5 MHz station standard. These frequencies are generated by direct multiplication of the 5 MHz sources, or the output of the sources are used to drive frequency synthesizers, with the output from the synthesizers being multiplied to the correct local oscillator frequencies. Due to NASA requirements, the tracking channel local oscillator generators are not normally phase-locked to the 5 MHz station standard, although a switch will be provided to permit selection of the station standard if desired.

Figure 57 presents a block diagram of the local oscillator basic generator system. The frequency generator subsystem contains two VCXO's which are phase-locked to the 5 MHz station standard. One of the two 5 MHz VCXO's is provided to furnish the 5 MHz input for each of the communications channel frequency synthesizers. The output of the communications channel VCXO is also fed to the "x 18" multiplier which furnishes 90 MHz to the communications channel second oscillator generator. To prevent the possibility of phase noise cancellations when the performance monitor is being used, a separate 5 MHz VCXO, phase-locked to the frequency standard, provides a 5 MHz source to the "x 18" multiplier that furnishes 90 MHz to the performance monitor second local oscillator generator. Any phase noise generated in the receiving local oscillator system and performance monitor local oscillator system is uncorrelated, since the same source is not used to generate the local oscillator signal for both performance monitor and communications down-converter. The modules employed in the frequency generator were previously designed under the NASA L- and S-band transmitter contract.

The Performance Monitor second local oscillator generator and Frequency Translator local oscillator generator operate from the same frequency synthesizer. A common synthesizer may be employed, since the performance

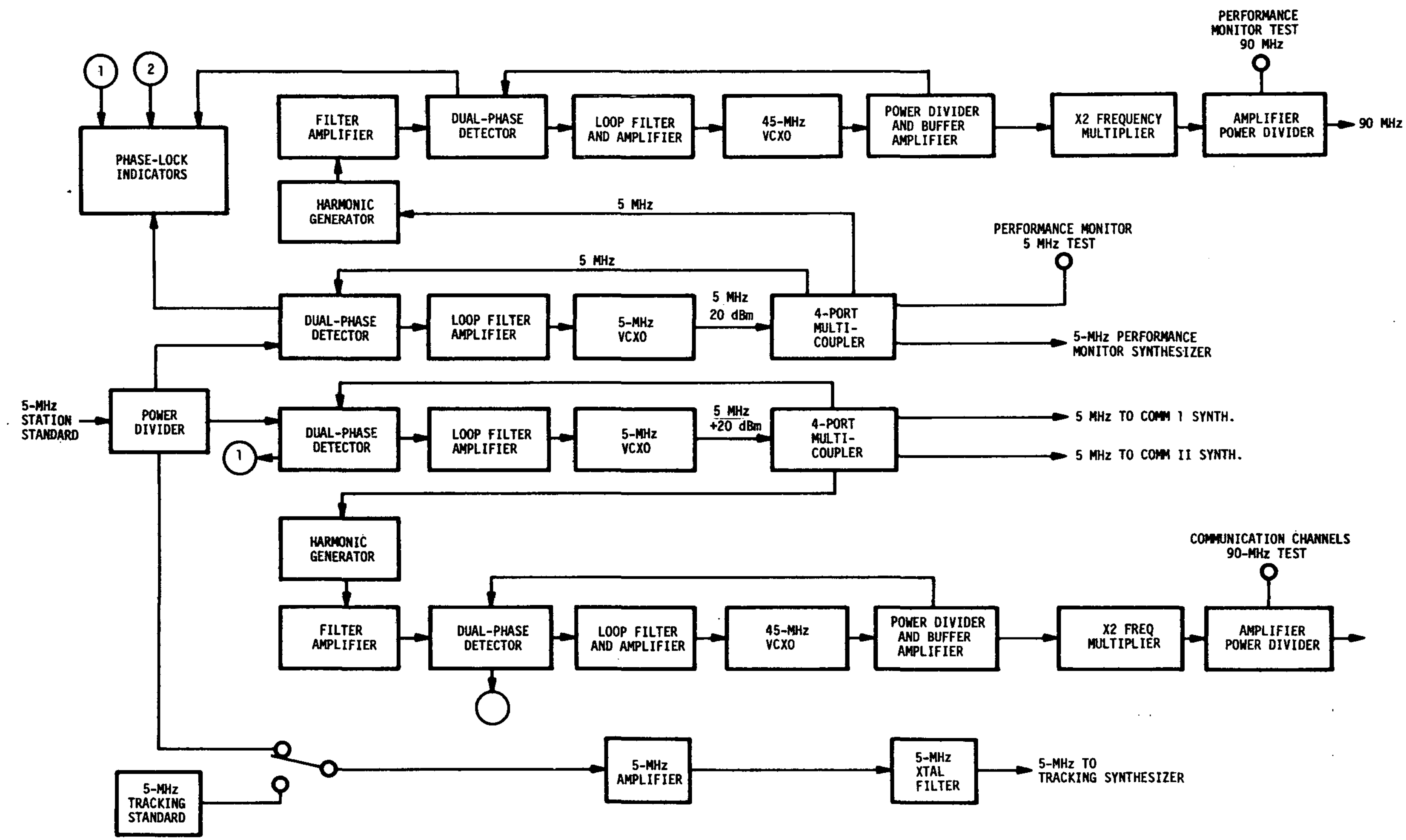


Figure 57. Frequency Generator

monitor and frequency translator are not used simultaneously. Furthermore, it is the understanding of Martin Marietta that it is NASA's intent to share the synthesizer of the Performance Monitor/Frequency Translator with the synthesizer requirement for Communications Channel No. 2.

The front panel view of the frequency generator is shown in Figure 58.

3.2.8.3 Local Oscillator Multipliers

The relationship of the local oscillator multipliers to the frequency synthesizers and frequency generators is depicted in Figure 52. It was originally intended that these multiplier assemblies would be separate entities; however, it has since been decided to include such multipliers inside respective down-converters as well as the Performance Monitor/Frequency Translator. The only exception is that the "x 9" multiplier used to generate the 810 MHz second LO for the communications down-converters (614-01518-A), will be a separate assembly. However, since all down-converters, the Performance Monitor/Frequency Translator, and the "x 9" multiplier have been subcontracted to Aertech, description of the multiplier packages is discussed elsewhere with the major assembly they are a part of or with which they are used.

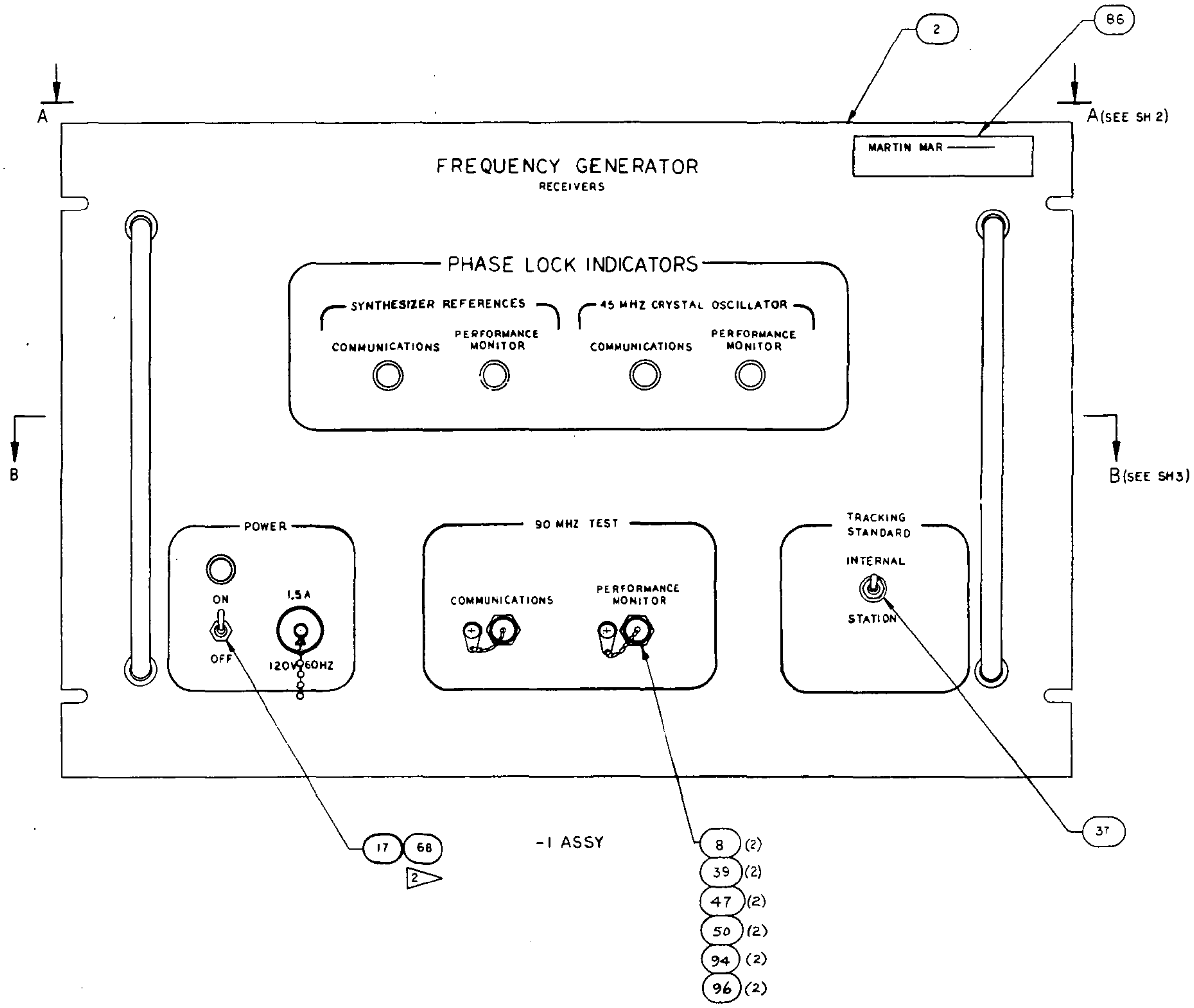


Figure 58. Front Panel of Frequency Generator

3.2.9 Interconnection and Cabling

3.2.9.1 Intersite RF Cables

Where possible, existing cables will be employed for RF cabling at the various sites. Additional cables required will be supplied. All available drawings and reports were reviewed to identify existing available cables, and a cable plan for each site is presented in this section. All required interconnecting RF cables are shown, existing cables are identified and assigned, and any new cables required are itemized. In addition, the cable lengths and attenuations are presented for each signal path.

Figure 59 shows all intersite RF cables for the Rosman station, with their cable numbers and characteristics. Table 11 presents the cable lengths and cable attenuations for each signal path.

Figure 60 shows intersite RF cables for the Mojave station and Table 12 presents cable lengths and attenuations.

Figure 61 shows intersite RF cables for the TGS station and Table 13 presents cable lengths and attenuations.

These figures and tables represent an updating of the RF cable plan contained in Section 4.6 of the Design Review Report, OR 11,239, dated August 1971.

3.2.9.2 Control/Monitor Cables (Inter- and Intra-Site)

Various multiconductor shielded cables will be used to provide the various control, monitor, and power circuits required by the receiving system. These cables interconnect the control and monitor unit in the instrumentation room with the junction box in the antenna and the various remote switches and units located at the antenna site. Figure 62 shows the control and monitor cables that will be installed at each of the sites. There will be two 50-conductor cable assemblies (W10 and W11) connecting the control and monitor unit with the junction box. Cable W10 will provide all monitor circuits and W11 will contain the control circuits. In addition, Cable 23 between the junction box and the Performance Monitor/Frequency Translator unit is a 50-conductor cable assembly. These cable assemblies will use ITT (P/N 8864) 50-conductor, 20 AWG cable which has an overall bonded shield and outer neoprene jacket.

All other junction box interconnecting cable assemblies shown in Figure 62 will use ITT (P/N 8863), 10-conductor, 20 AWG cable. This cable also has an overall bonded shield and outer neoprene jacket.

3.2.9.3 Junction Box

The junction box serves as an interconnecting and distribution center for all control/monitor circuits and +28 VDC power control and distribution to all units (except paramp) located at the antenna site. It is located in

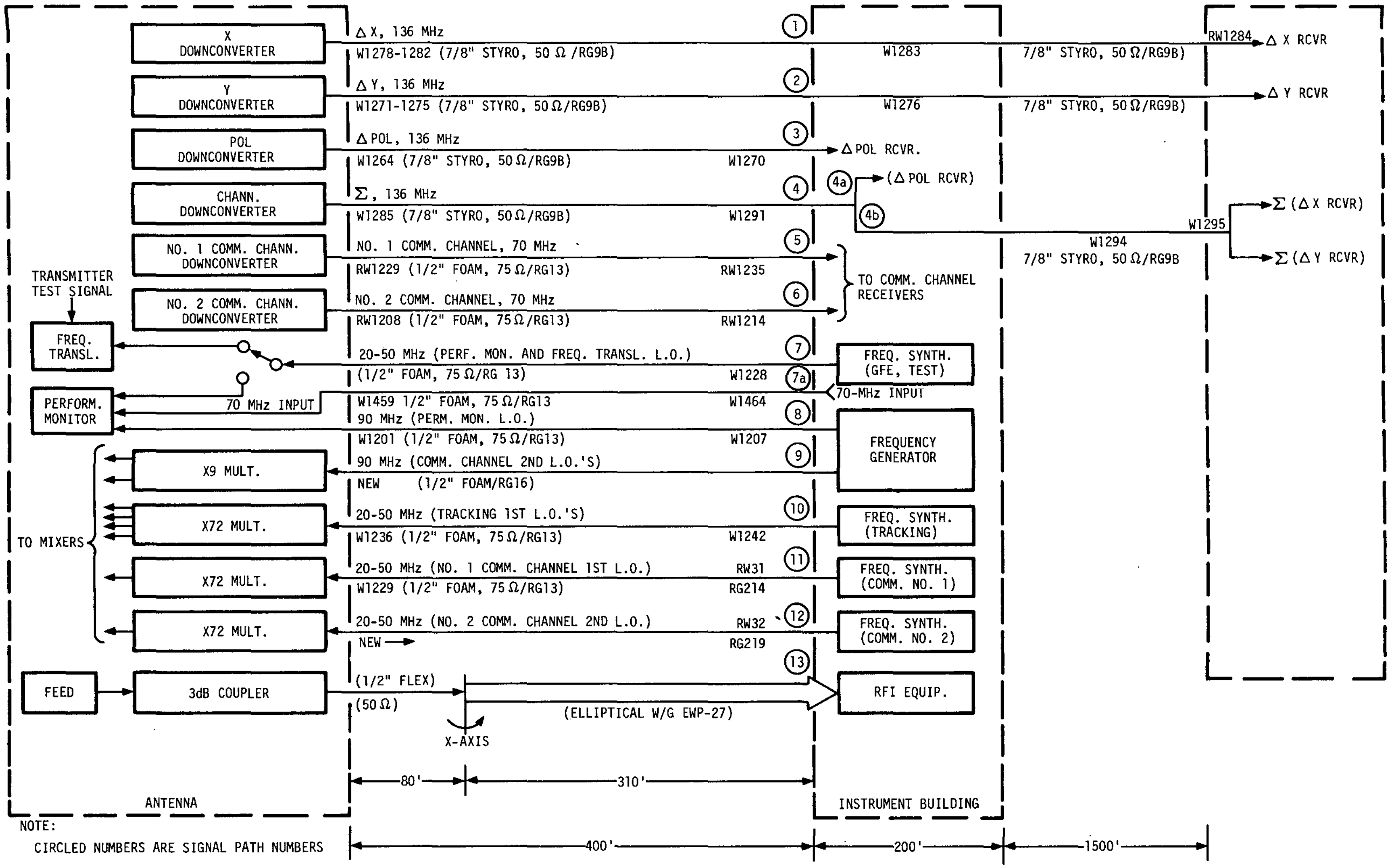


Figure 59. Intersite RF Cables - Rosman

TABLE 11

Rosman RF Intersite Cable Attenuation

Path 1:	Signal Freq: 136 MHz		
	1. Total Path Length		2200 feet
	(a) 7/8" Styro, (50 Ω)	2000 feet	
	(b) RG9B	200 feet	
	2. Total Attenuation		15 dB
	(a) 7/8" Styro, (50 Ω)	10 dB	
	(b) RG9B	5 dB	
Path 2:	Signal Freq: 136 MHz		
	1. Total Path Length		2200 feet
	(a) 7/8" Styro (50 Ω)	2000 feet	
	(b) RG9B	200 feet	
	2. Total Attenuation		15 dB
	(a) 7/8" Styro, (50 Ω)	10 dB	
	(b) RG9B	5 dB	
Path 3:	Signal Freq: 136 MHz		
	1. Total Path Length		500 feet
	(a) 7/8" Styro (50 Ω)	400 feet	
	(b) RG9B	20 feet	
	2. Total Attenuation		2.9 dB
	(a) 7/8" Styro (50 Ω)	2.4 dB	
	(b) RG9B	0.5 dB	
Path 4a:	Signal Freq: 136 MHz		
	1. Total Path Length		500 feet
	(a) 7/8" Styro (50 Ω)	480 feet	
	(b) RG9B	20 feet	
	2. Total Attenuation		2.9 dB
	(a) 7/8" Styro (50 Ω)	2.4 dB	
	(b) RG9B	0.5 dB	

TABLE 11 (Continued)

Path 4b:	Signal Freq: 136 MHz		
	1. Total Path Length		2200 feet
	(a) 7/8" Styro, (50 Ω)	2000 feet	
	(b) RG9B	200 feet	
	2. Total Attenuation		15 dB
	(a) 7/8" Styro, (50 Ω)	10 dB	
	(b) RG9B	5 dB	
Path 5:	Signal Freq: 70 MHz		
	1. Total Path Length		500 feet
	(a) 1/2" Foam, (75 Ω)	480 feet	
	(b) RG13	20 feet	
	2. Total Attenuation		4.0 dB
	(a) 1/2" Foam, (75 Ω)	3.6 dB	
	(b) RG13	0.4 dB	
Path 6:	Same as 5		
Path 7:	Signal Freq: 50 MHz		
	1. Total Path Length		500 feet
	(a) 1/2" Foam (75 Ω)	480 feet	
	(b) RG13	20 feet	
	2. Total Attenuation		3.2 dB
	(a) 1/2" Foam (75 Ω)	2.9 dB	
	(b) RG13	0.3 dB	
Path 7a:	Same as 5		
Path 8:	Signal Freq: 90 MHz		
	1. Total Path Length		500 feet
	(a) 1/2" Foam (75 Ω)	480 feet	
	(b) RG13	20 feet	
	2. Total Attenuation		4.3 dB
	(a) 1/2" Foam (75 Ω)	3.9 dB	
	(b) RG13	0.4 dB	

TABLE 11 (Continued)

Path 9: Signal Freq: 90 MHz

1. Total Path Length — 400 feet

   (a) 1/2" Foam (75 Ω) — 300 feet
   (b) RG216 — 100 feet

2. Total Attenuation — 3.2 dB

   (a) 1/2" Foam (75 Ω) — 1.8 dB
   (b) RG216 (75 Ω) — 1.4 dB

Path 10: Same as 7

Path 11: Signal Freq: 500 MHz

1. Total Path Length — 400 feet

2. Total Attenuation — 5.6 dB

Path 12: Same as 7

Path 13: Signal Freq: 3.7 to 4.2 GHz

1. Total Path Length — 390 feet

   (a) Elliptical Waveguide — 310 feet
   (b) 1/2" Superflex Coax — 80 feet

2. Total Attenuation

   (a) Elliptical Waveguide — 2.4 dB
   (b) 1/ 2" Super Flex Coax — 9.6 dB
   (c) Misc. Connectors — 1.0 dB

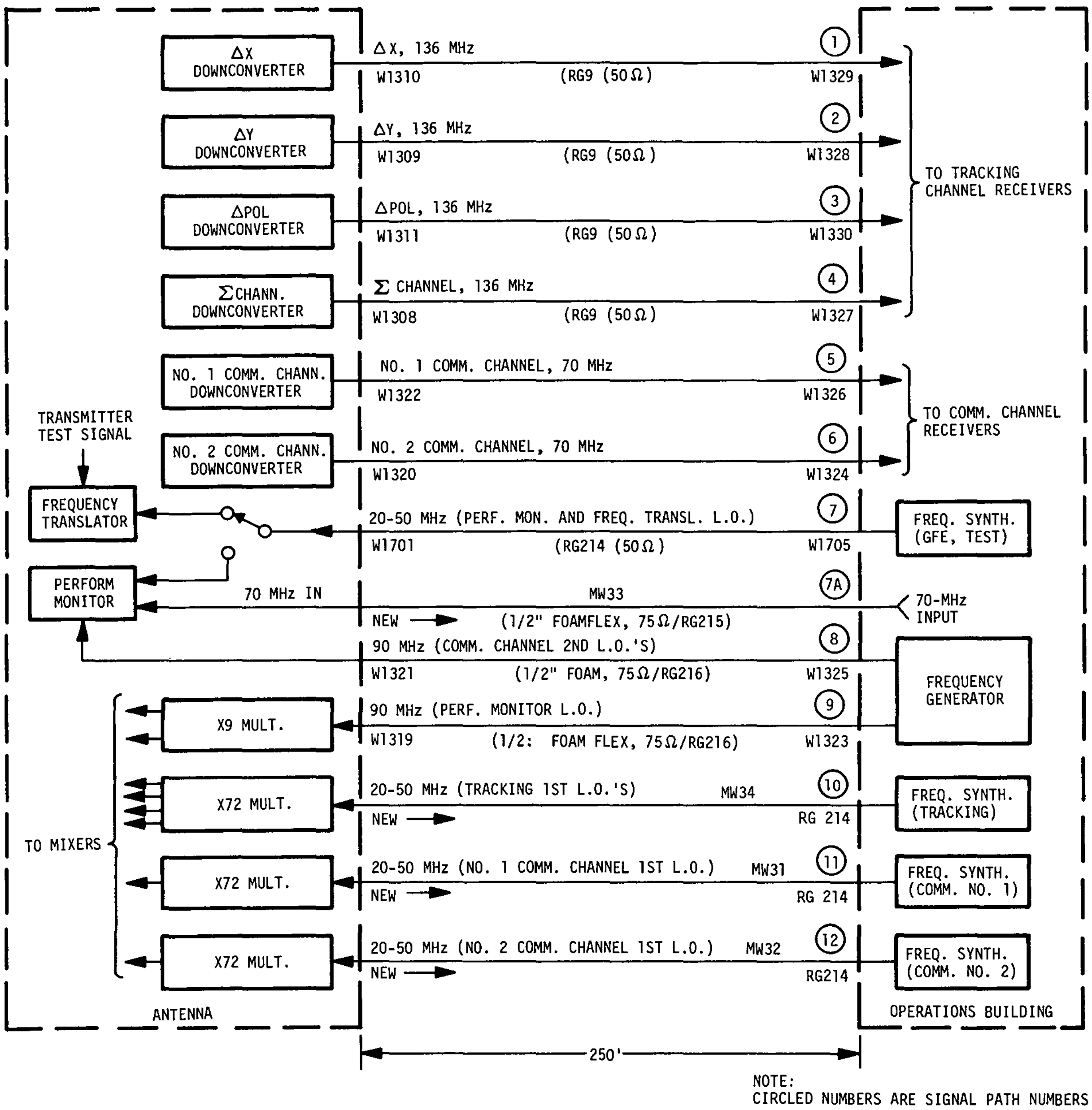
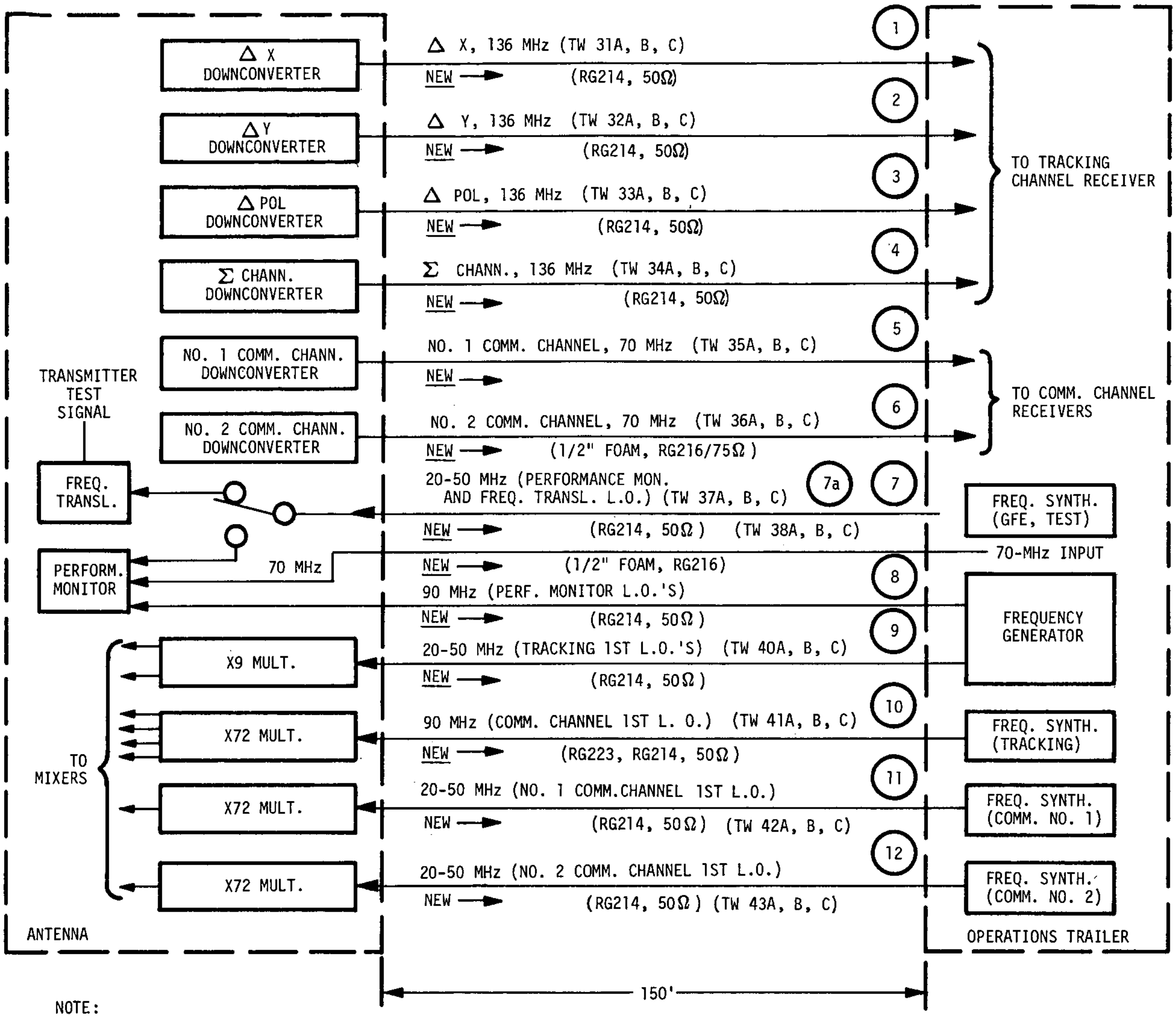


Figure 60. Intersite RF Cables - Mojave

TABLE 12

Mojave RF Cable Attenuation

Path 1:	Signal Freq: 136 MHz		
	1. Total Path Length		250 feet
	(a) RG9	250 feet	
	2. Total Attenuation		6.3 dB
	(a) RG9	6.3 dB	
Path 2:	Same as 1		
Path 3:	Same as 1		
Path 4:	Same as 1		
Path 5:	Signal Freq: 70 MHz		
	1. Total Path Length		250 feet
	(a) 1/2" Foam Flex (75 Ω)	230 feet	
	(b) RG216 (75 Ω)	20 feet	
	2. Total Attenuation		2.0 dB
	(a) 1/2 Foam Flex (75 Ω)	1.6 dB	
	(b) RG216 (75 Ω)	0.4 dB	
Path 6:	Same as 5		
Path 7:	Signal Freq: 50 MHz		
	1. Total Path Length		250 feet
	(a) RG214 (50 Ω)	250 feet	
	2. Total Attenuation		3.5 dB
	(a) RG214 (50 Ω)	3.5 dB	
Path 7a:	Same as 5		
Path 8:	Signal Freq: 90 MHz		
	1. Total Path Length		250 feet
	(a) 1/2" Foam Flex (75 Ω)	230 feet	
	(b) RG216	20 feet	
	2. Total Attenuation		2.3 dB
	(a) 1/2" Foam Flex (75 Ω)	1.9 dB	
	(b) RG216	0.4 dB	
Path 9:	Same as 8		
Path 10:	Signal Freq: 50 MHz		
	1. Total Path Length (RG214)		315 feet
	2. Total Attenuation		4.4 dB
Path 11:	Same as 10		
Path 12:	Same as 11		



NOTE:
CIRCLED NUMBERS ARE PATH NUMBERS.

Figure 61. Intersite RF Cables - TGS

TABLE 13

TGS RF Cable Attenuation

Path 1:	(2.3 dB/100 feet) (175 feet) = 4.0 dB		
Path 2:	Same as 1		
Path 3:	Same as 1		
Path 4:	Same as 1		
Path 5:	Signal Freq: 70 MHz		
	1. Total Path Length		195 feet
	(a) 1/2" Foam	145 feet	
	(b) RG216	50 feet	
	2. Total Attenuation		1.93 dB
	(a) 1/2" Foam	1.03 dB	
	(b) RG216	0.9 dB	
Path 6:	Same as 5		
Path 7:	(1.4 dB/100 feet) (195 feet) = 2.73 dB		
Path 7a:	Same as Path 5		
Path 8:	(2.0 dB/100 feet) (190 feet) = 3.8 dB)		
Path 9:	(1.4 dB/100 feet) (190 feet) = 2.66 dB		
Path 10:	Signal Freq: 90 MHz		
	1. Total Path Length		190 feet
	(a) RG223 (50 Ω)	35 feet	
	(b) RG 214 (50 Ω)	155 feet	
	2. Total Attenuation		4.57 dB
	(a) RG223	1.47 dB	
	(b) RG214	3.10 dB	
Path 11:	Same as 10		
Path 12:	Same as 10		

FOLDOUT FRAME I

FOLDOUT FRAME II

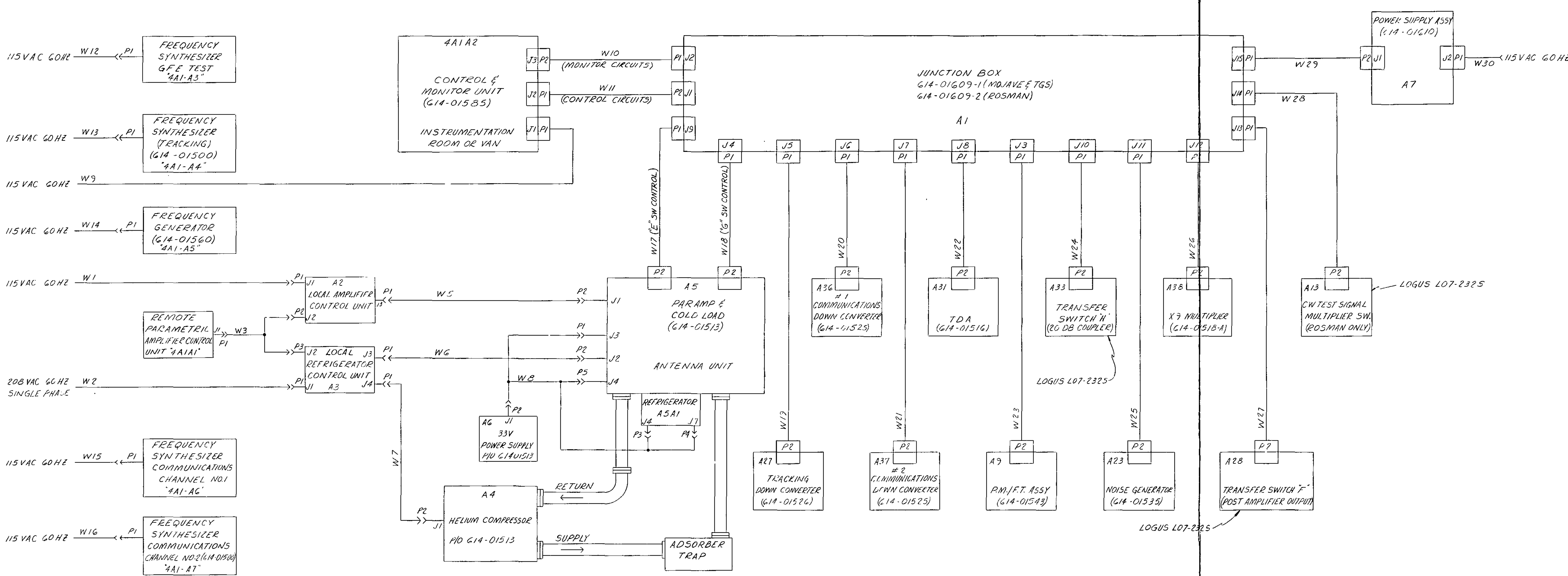


Figure 62. Interconnecting Cable Assemblies (Non-RF) - All Sites

the electronics room at the Rosman site, in the antenna structure behind the dish at Mojave, and in the antenna pedestal at TGS. Control signals from the control and monitor unit arrive at the junction box via Cable W11 (Figure 62) and +28 Vdc and 115 Vac 60 Hz power is received from the power supply box via Cable W29. Power and/or control signals are then distributed to all antenna-mounted switches and units as required. All controlled switches and power switching relays have Form C contents which provide verification that each switching command has been accomplished. Monitor signals from all remote switches and power relays are sent back to the junction box which, in turn, directs them back to the control and monitor unit where the state of each switch (or combination of switches) is indicated.

An assembly drawing of the junction box is shown in Figure 63. Each connector pin is tied to a terminal of a barrier terminal strip for ease in trouble shooting and testing. These terminals, along with the terminals of all relays, are readily accessible when the cover of the junction box is opened or removed. All connectors have integral RFI filters thus ensuring that no undesired signals are coupled into or out of the junction box. The nine relays employed are remotely controlled from the control and monitor unit, and apply +28 VDC to the proper coils in the various remote coaxial and waveguide switches, or control the +28 VDC circuit power to various antenna-mounted units. Figure 64 is a schematic diagram of the junction box.

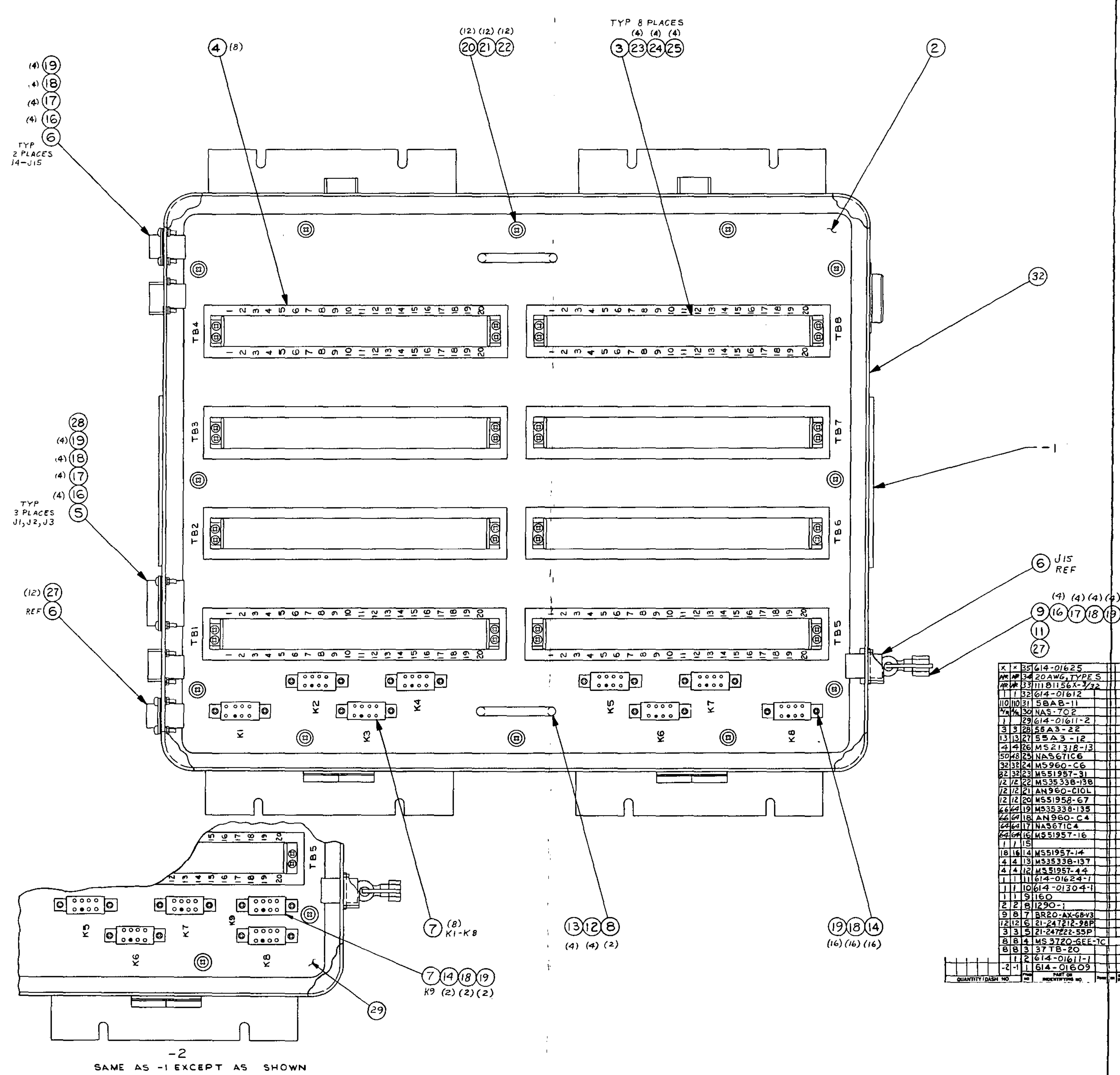
3.2.9.4 Power Supply Box

The power supply box contains two +28 VDC power supplies which supply power to the junction box via Cable W29 (Figure 62). One of these power supplies is a Sorensen Model QSA28-8.8, which supplies power to all electronic circuits in such antenna-mounted units as the down-converters, multipliers, and Frequency Translator/Performance Monitor. This supply has an output power capability of 26-30 volts at 0 - 8.8 amps with voltage regulation of $\pm 0.05\%$. It also meets MIL-1-26600, MIL-1-6181D, and MIL-1-16910C RFI specifications. The other supply is a Wanlass Model Brute 1, which supplies +28 VDC to all of the remote switches and has a current output capability of 10.5 amps.

In addition to the two power supplies, the power supply box contains a relay which is controlled from the control and monitor unit via the junction box. This relay controlls the 115 VAC 60 Hz power used to energize the tunnel diode amplifier. All connectors have integral RFI filters. Figures 65 and 66 show the assembly-drawing and schematic, respectively, for this unit.

FOLDOUT FRAME I

NOTES:
1. INTERPRET DRAWING PER MIL-STD-100.



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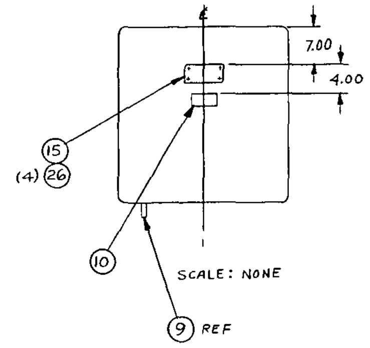

QUANTITY/DASH NO. -2	QUANTITY/DASH NO. -1	FIND NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	MATERIAL SPECIFICATION
X	X	35	614-01625	SCHEMATIC DIAGRAM			
AR	AR	34	20 AWG, TYPE S	WIRE, ELEC			QQ-W-343
AR	AR	33	1118156X-3/32	CLR TUBING, H.S.			
1	1	32	614-01612	CASE ASSY			
110	110	31	5BAB-11	TERMINAL, LUG			
A/R	A/R	30	NAS-702	WIRE 20UA9			
1		29	614-01611-2	PANEL			
3	3	28	55A3-22	GASKET			
13	13	27	55A3-12	GASKET			
4	4	26	MS21318-13	DRIVE SCREW			
50	48	25	NAS671C6	NUT, HEX, PLAIN			
32	32	24	MS960-C6	WASHER, FLAT			
32	32	23	MS51957-31	SCREW, MACHINE			
12	12	22	MS35338-138	WASHER, LOCK			
12	12	21	AN960-C10L	WASHER, FLAT			
12	12	20	MS51958-67	SCREW, MACHINE			
66	64	19	MS35338-135	WASHER, LOCK			
66	64	18	AN960-C4	WASHER, FLAT			
64	64	17	NAS671C4	NUT, HEX			
64	64	16	MS51957-16	SCREW, MACHINE			
1	1	15		NAME PLATE			
18	16	14	MS51957-14	SCREW, MACHINE			
4	4	13	MS35338-137	WASHER, LOCK			
4	4	12	MS51957-44	SCREW, MACHINE			
1	1	11	614-01624-1	PLATE, THREADED			
1	1	10	614-01304-1	NAME PLATE			
1	1	9	160	SHUT OFF COCK		ESSEX BRASS	
2	2	8	1290-1	HANDLE		CAMBION CORP.	
9	8	7	BR20-AX-G8-V3	RELAY	K1 THRU K9	BABCOCK CO.	
12	12	6	21-247212-98P	RECEPTACLE	J4 THRU J15	BENDIX ELECT CO	
3	3	5	21-247222-55P	RECEPTACLE	J1, J2, J3,	BENDIX ELECT CO	
8	8	4	MS3720-GEE-7C	MARKER STRIP		KULKA CO.	
8	8	3	37TB-20	TERMINAL BOARD		KULKA CO. (NO. 20020)	MIL-T-55164/1
	1	2	614-01611-1	PANEL			
-2	-1	1	614-01609	JUNCTION BOX ASSY			

Figure 63. Junction Box Assembly

FOLDOUT FRAME I

FOLDOUT FRAME II

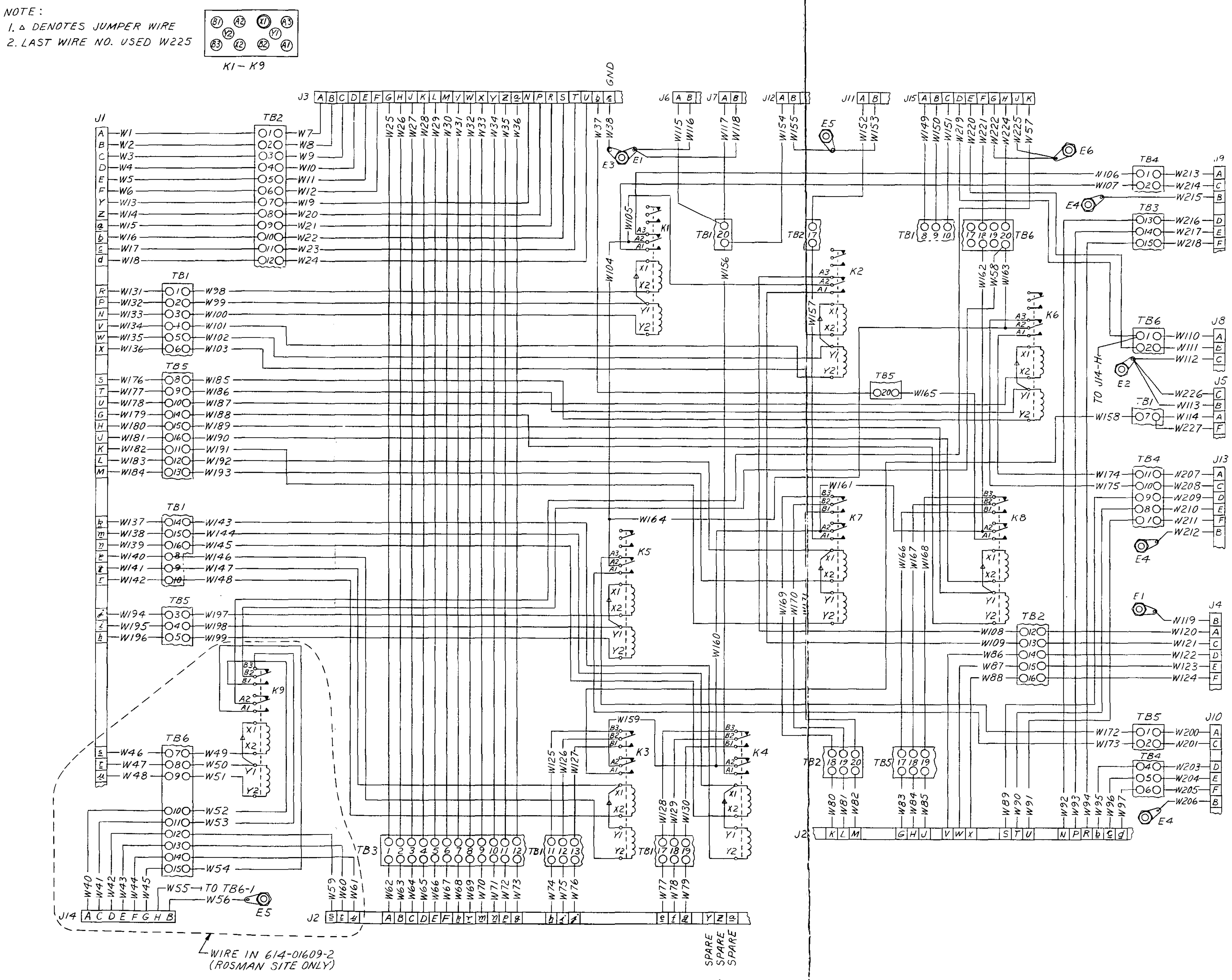

Figure 64. Junction Box Schematic

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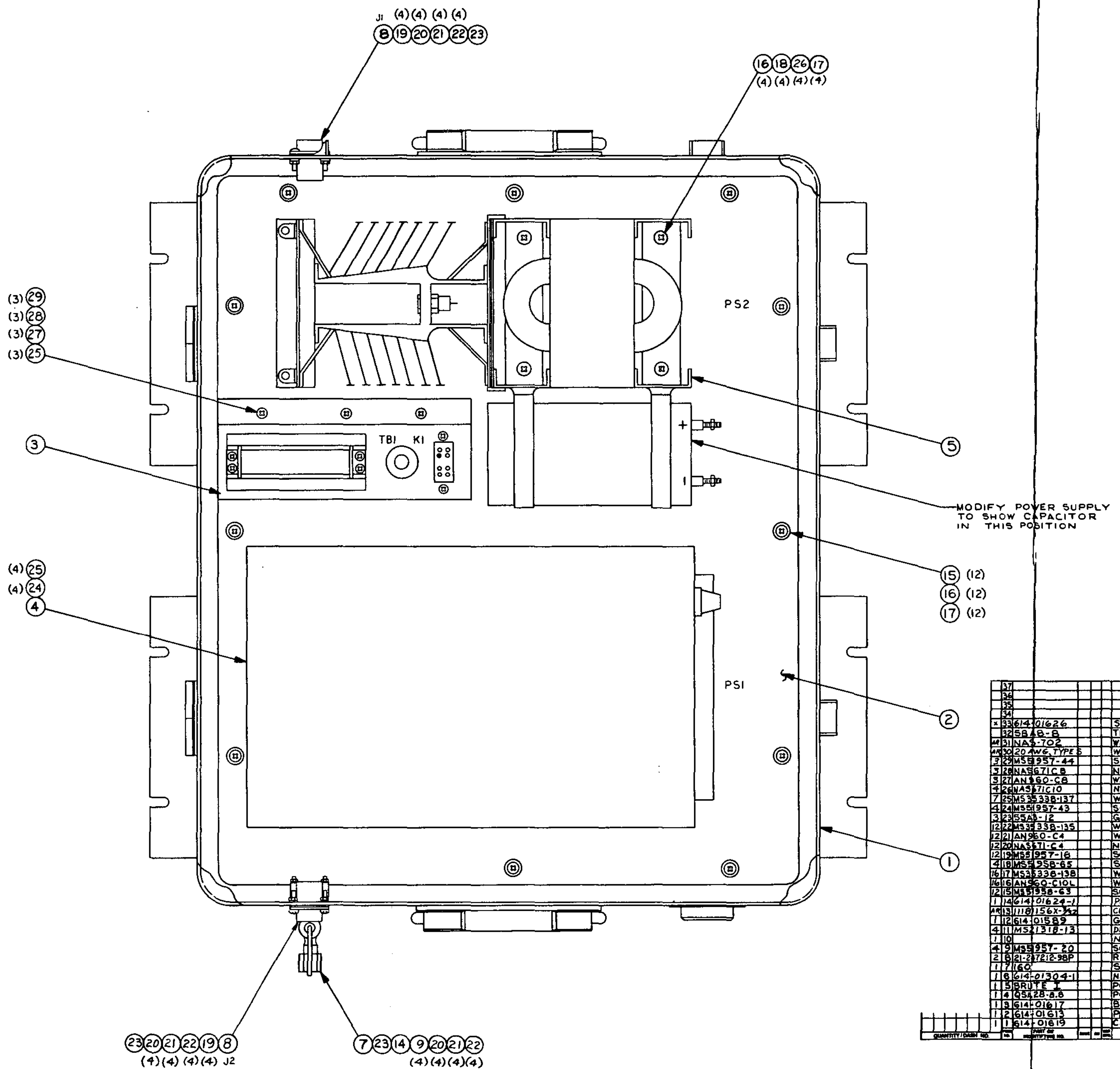

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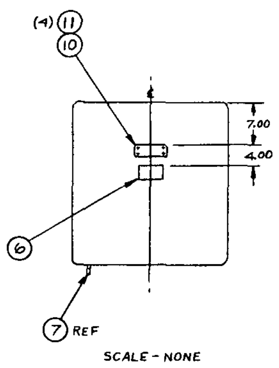


Quantity/Dash No.	Item No.	Part or Identifying No.	Nomenclature or Description	Stock Size	Material or Vendor	Material Specification
	37					
	36					
	35					
	34					
x	33	614-01626	SCHEMATIC DIAGRAM			
	32	58AB-8	TERMINAL, LUG		MARTIN STD	
AR	31	NAS-702	WIRE 20 UA9			
AR	30	20 AWG, TYPE S	WIRE, ELEC			QQ-W-343
3	29	MS51957-44	SCREW, MACHINE			
3	28	NAS671C8	NUT, PLAIN HEX			
3	27	AN960-C8	WASHER, FLAT			
4	26	NAS671C10	NUT			
7	25	MS35338-137	WASHER, LOCK			
4	24	MS51957-43	SCREW, MACHINE			
3	23	55AB-12	GASKET, RUBBER		MARTIN STD	
12	22	MS35338-135	WASHER, LOCK			
12	21	AN960-C4	WASHER, FLAT			
12	20	NAS671-C4	NUT, HEX			
12	19	MS51957-16	SCREW, MACHINE			
4	18	MS51958-65	SCREW, MACHINE			
16	17	MS35338-138	WASHER, LOCK			
16	16	AN960-C10L	WASHER, FLAT			
12	15	MS51958-63	SCREW, MACHINE			
1	14	614-01624-1	PLATE, THREADED			
AR	13	1118 156X-3/32	CLR TUBING, H.S.			
1	12	614-01589	GASKET, RUBBER			
4	11	MS21318-13	DRIVE SCREW			
1	10		NAME PLATE			
4	9	MS51957-20	SCREW, MACHINE			
2	8	21-217212-98P	RECEPTACLE	J1, J2	BENDIX	
1	7	160	SHUT OFF COCK		ESSEX BRASS	
1	6	614-01304-1	NAME PLATE			
1	5	BRUTE I	POWER SUPPLY	PS2	WANLASS	
1	4	QSA28-8.8	POWER SUPPLY	PS1	SORENSEN	
1	3	614-01617	BRACKET ASSY			
1	2	614-01613	PANEL			
1	1	614-01619	CASE ASSEMBLY			

Figure 65. Power Supply Assembly

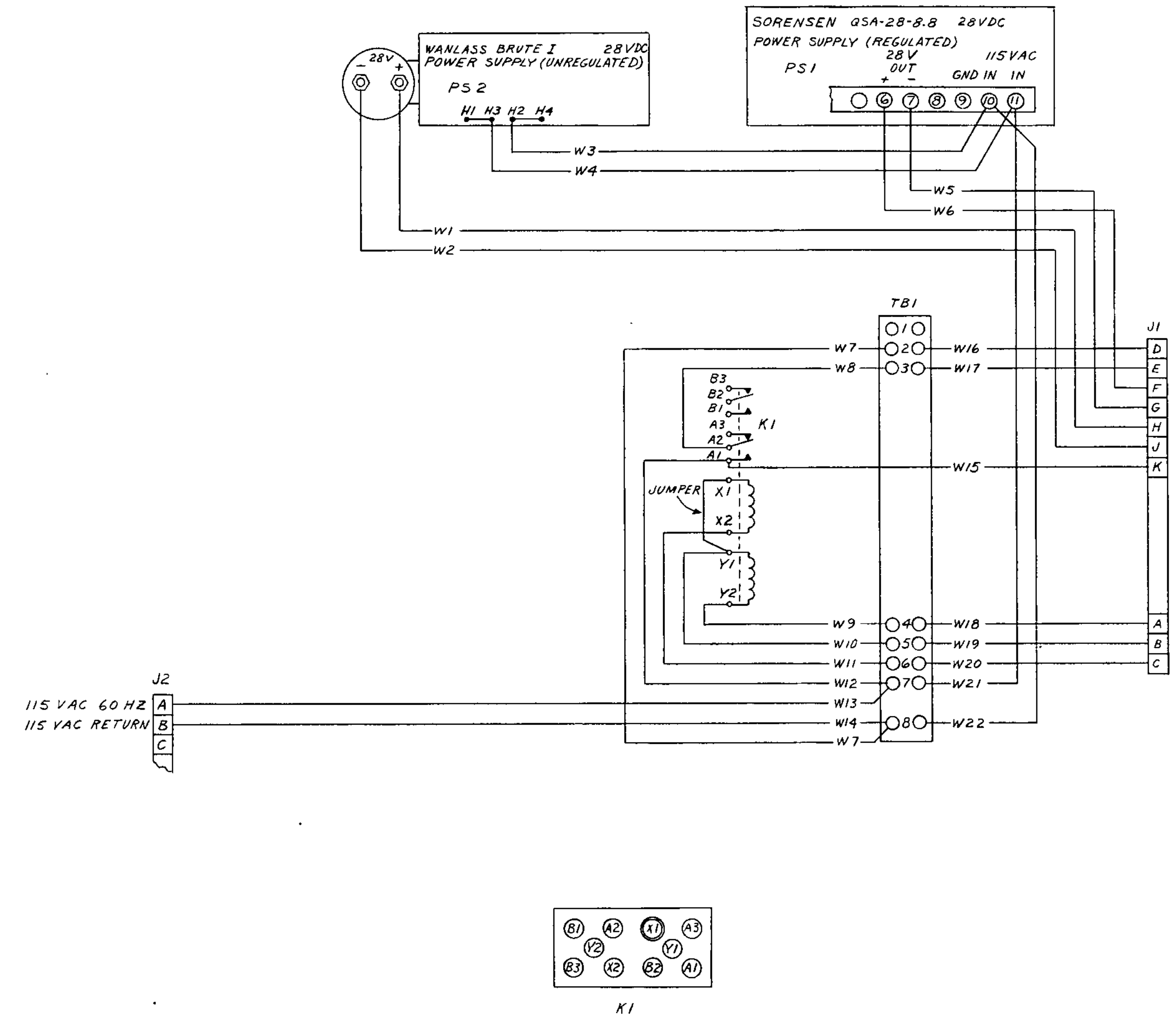


Figure 66. Power Supply Schematic

3.2.9.5 RFI Precautions

A number of precautionary measures have been taken to reduce the susceptibility of control and monitor circuits to outside RFI. It is also desirable to reduce RFI from such sources as power supplies and switch and relay contacts. Another important requirement is the minimization of RF coupling between units of the receive system due to common power supply impedances and stray capacity and inductive coupling.

All of the control and monitor cables supplied by Martin Marietta have an overall braided shield that is grounded through the shell of the connectors to the unit cases. In addition, all connectors used on the junction box and power supply box have integral EMI filters that exhibit the attenuation versus frequency characteristics shown in Figure 67. These filter connectors, along with the RFI filtering built into the various units, provide adequate decoupling within the receiver system.

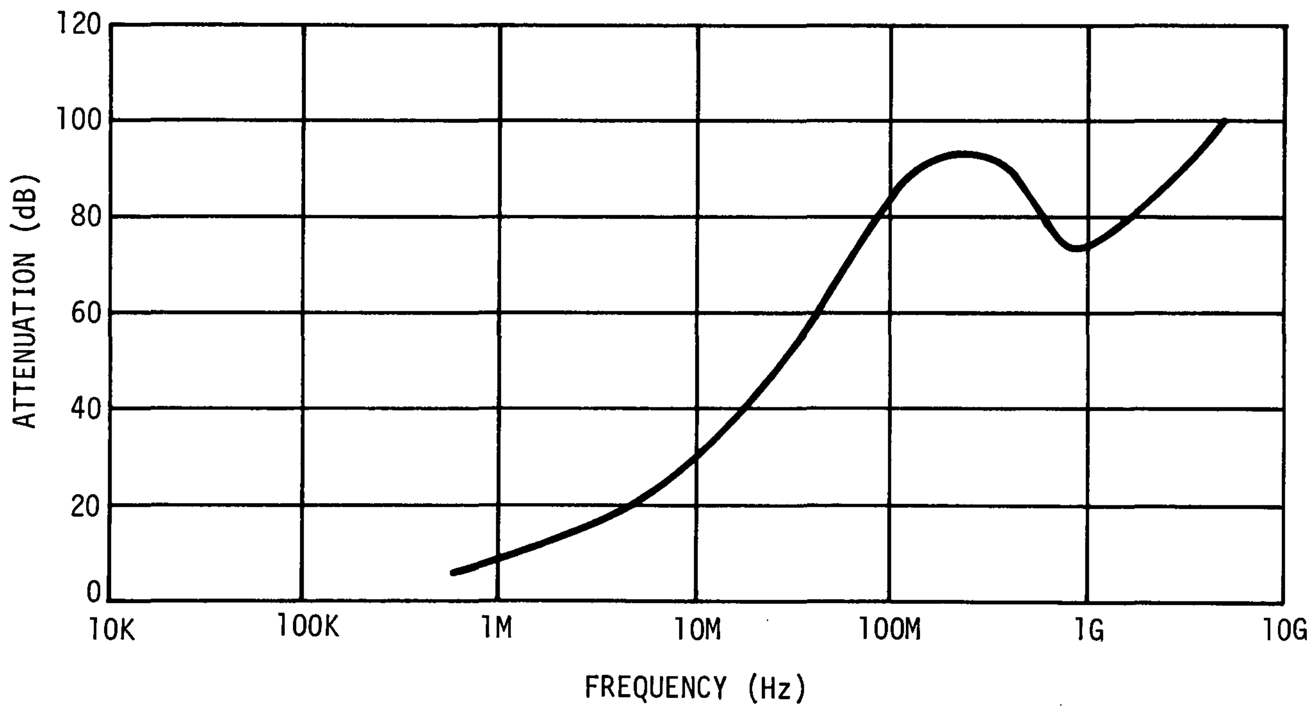


Figure 67. Attenuation vs Frequency Characteristics of EMI Filters

3.2.10 Receiver Monitoring and Control

3.2.10.1 Control and Monitor (C&M) Unit

Control and monitor functions for the receiving system are centralized in the receiver control and monitor unit. This is a rack-mounted unit, located in the Instrumentation Bldg. at Rosman and Mojave, and in the control center van at the TGS site. Primary purpose of the C&M unit is to control and monitor all remotely controlled switches and relays in the receive system.

A rotary mode selection switch on the front panel (Figure 68) selects either the desired test mode or the normal "operate" condition. Each position of this switch activates a unique combination of switching states of the controlled relays. Each relay has verification contacts which indicate its mechanical state. These verification signals are applied to a logic gate which lights an indicator lamp (located at the corresponding mode selection switch position) when the desired combination of switch states is achieved. In addition to the test mode switch, there are a number of pushbutton switches with integral lamp indicators along the bottom of the front panel. These switches perform the various functions indicated in Figure 68.

An individual override capability is provided for each remote switch controlled by the Test Mode Selector Switch. Realization of the capability consists of seven 3-position toggle switches, each of which overrides the Test Mode Selector Switch, selecting either of the two switch states for any remote switch (Figure 69). These switches are located at the rear of the C&M Unit chassis. When all toggle switches are in the center position, the rotary Test Mode Selector Switch takes over control. A locking bar (Figure 70) can be switched down over the toggles when in this mid-position, thus assuring normal test mode control from the front panel.

To further explain the operation of the monitor and control panel, an examination of Figure 71 will show that, for various system configurations, the relays must operate in various combinations. This implies a "logic" system which, for a given configuration "command" issues the appropriate subcommands to the individual relays. This is indeed accomplished by the Test Mode Selector Switch.

Thus, for the "operate" mode, the Test Mode Selector Switch issues commands to the "G" and "F" relays ordering them to be in the "true" state, as shown in Figure 71. The "H" relay receives a "true" state command from the associated front panel pushbutton switch. With ordering of these three relays, the normal operating path is established as shown in the figure. The condition of all other relays is irrelevant and, for this operating mode, the condition of all other relays is normally referred to as the "Don't Care" condition.

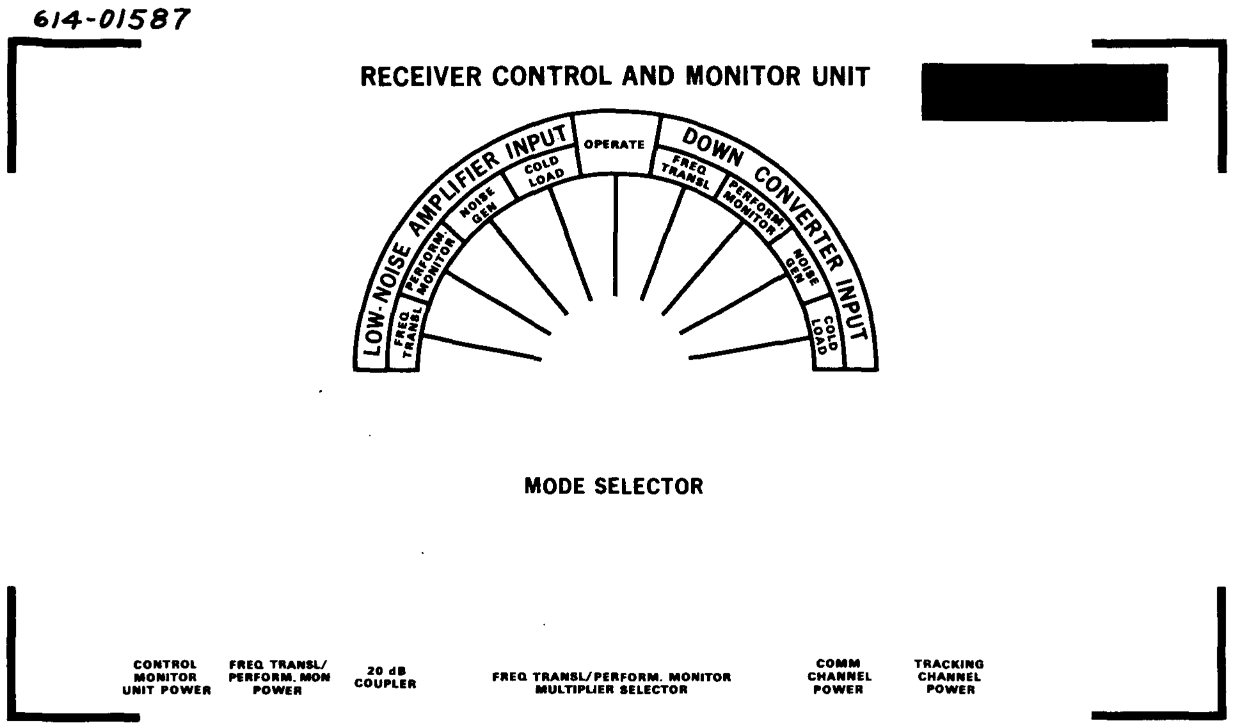
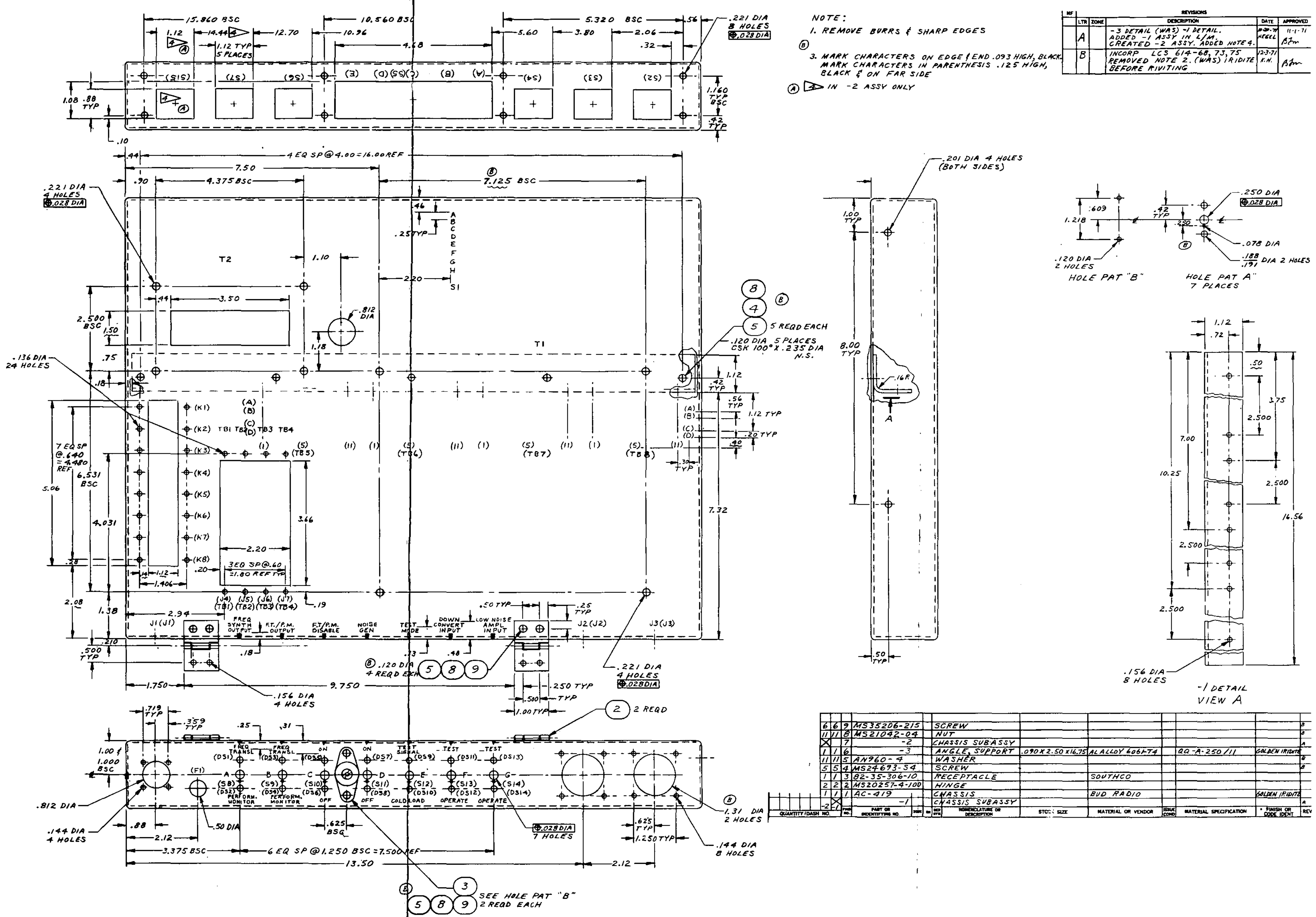


Figure 68. Rotary Mode Selection Switch

FOLDOUT FRAME 1

FOLDOUT FRAME 11



NOTE:

1. REMOVE BURRS & SHARP EDGES

(B)

3. MARK CHARACTERS ON EDGE & END .093 HIGH, BLACK. MARK CHARACTERS IN PARENTHESIS .125 HIGH, BLACK & ON FAR SIDE

(A) 4 IN -2 ASSY ONLY

REVISIONS					
MF	LTR	ZONE	DESCRIPTION	DATE	APPROVED
	A		-3 DETAIL (WAS) -1 DETAIL. ADDED -1 ASSY IN L/M. CREATED -2 ASSY. ADDED NOTE 4.	10-30-71 HEELL	11-1-71 BJm
	B		INCORP LCS 614-68, 73, 75 REMOVED NOTE 2. (WAS) IRIDITE BEFORE RIVITING	12-3-71 K.H.	BJm

QUANTITY/DASH NO. -2	QUANTITY/DASH NO. -1	FIND NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	ISSUE COND	MATERIAL SPECIFICATION	FINISH OR CODE IDENT	REV
6	6	9	MS35206-215	SCREW						B
11	11	8	MS21042-04	NUT						B
X		7	-2	CHASSIS SUBASSY						A
1	1	6	-3	ANGLE, SUPPORT	.090 X 2.50 X 16.75	AL ALLOY 6061-T4		QQ-A-250/11	GOLDEN IRIDITE	
11	11	5	AN960-4	WASHER						B
5	5	4	MS24693-S4	SCREW						B
1	1	3	82-35-306-10	RECEPTACLE		SOUTHCO				
2	2	2	MS20257-4-100	HINGE						
1	1	1	AC-419	CHASSIS		BUD RADIO			GOLDEN IRIDITE	
-2	X		-1	CHASSIS SUBASSY						A

Figure 69. Control and Monitor Chassis Subassembly

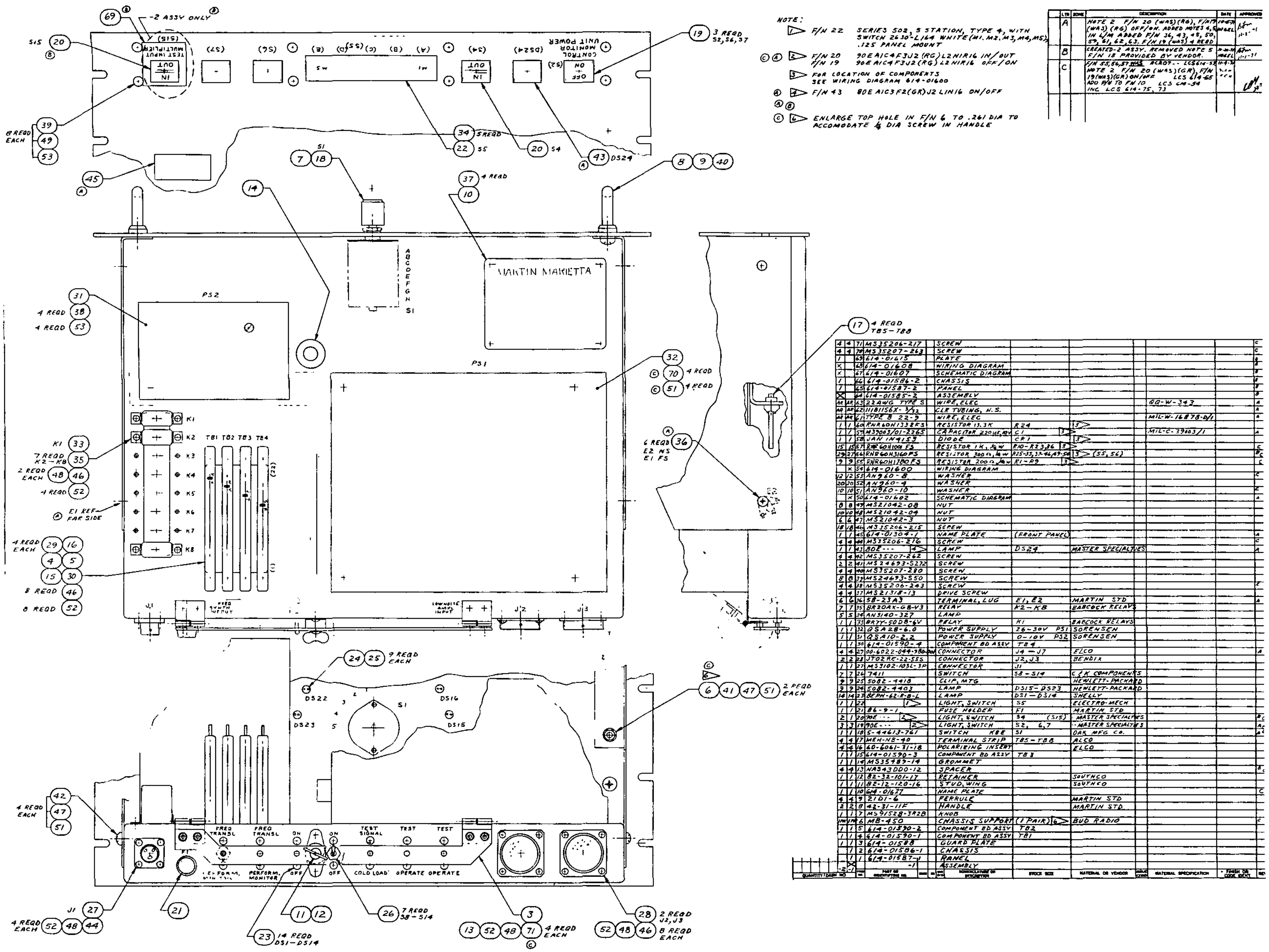


Figure 70. Control and Monitor Assembly

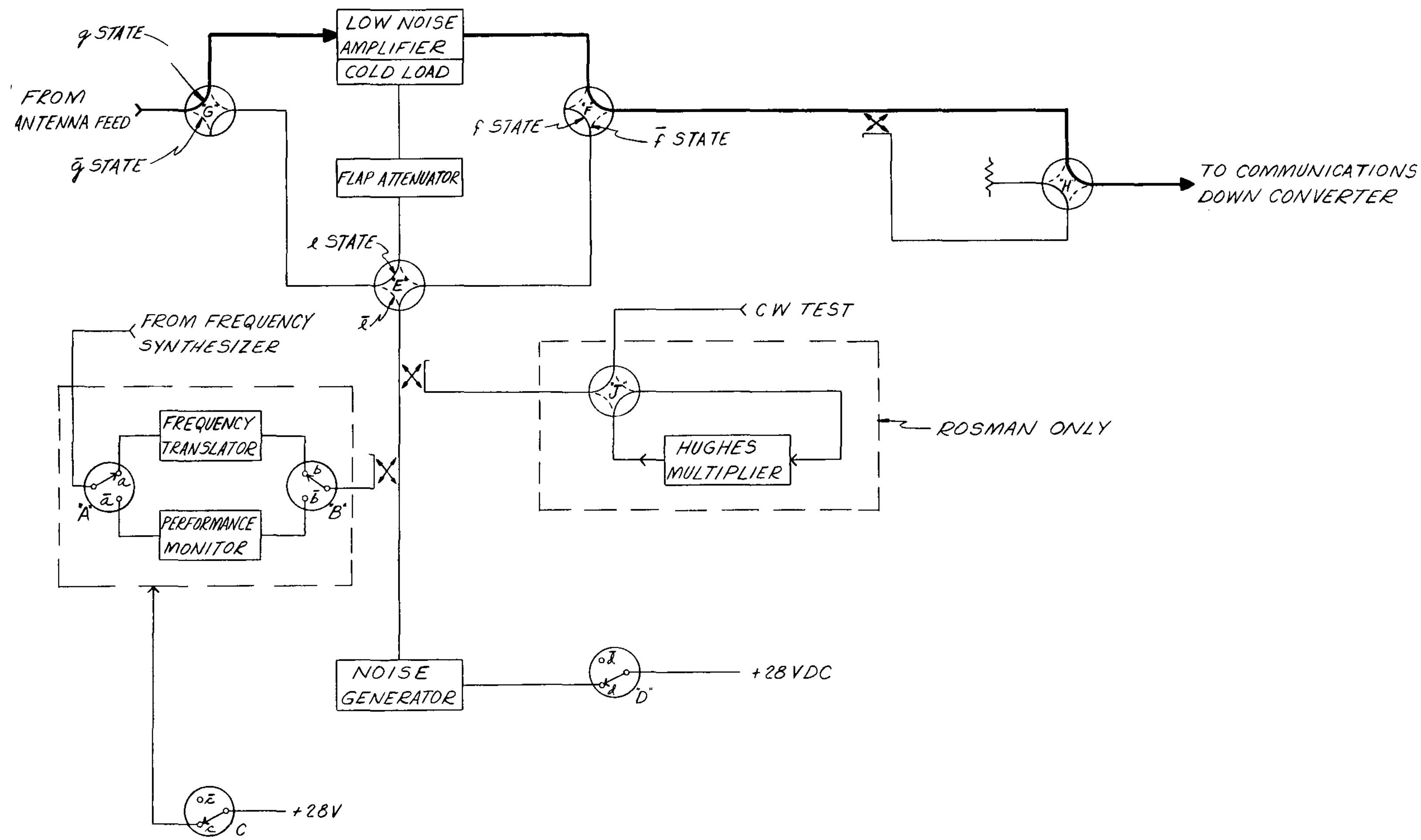


Figure 71. Signal and Test Relays Controlled by Mode Selector Switch

To extend this further, a truth table was generated (Table 14) which shows the unique combination of switch states for each mode selected. With the Test Mode Selector Switch in each of the positions shown, the corresponding relay states are set up, thus providing the desired signal and signal path. The Form C verification contacts on each switch feed back information to the C&M Unit indicating the mechanical state of that switch, and this information is converted to either zero volts or +5 VDC corresponding with the switch state; e.g., zero volts correspond with $\bar{a}$, and +5 VDC with a). Logic N and gates are used to decode each unique combination of switch states. The decoder output drives an indicator lamp on the front panel located in proximity to the corresponding mode selector position.

Consider a typical control/monitor loop used for controlling and monitoring Transfer Switch "G", located in the Paramp (Figure 72). Assume that the override switch (S14) is in its midposition, and the Test Mode Selector Switch is in the "operate" position. Since the truth table calls for Stage "G", +28 VDC from the +28 V power supply in the C&M Unit is applied to the appropriate coil of Relay K2 in the junction box. This relay in turn applies +28 VDC to the desired coil of Transfer Relay "G." After mechanical switching occurs, the Form C contact (located in Relay "G") applies +28 VDC to Relay K2 in the C&M Unit, which grounds (zero volts) the appropriate gate input. The +28 VDC energizing K2 in the C&M unit also lights the proper indicator lamp for Relay G, State "g" on the rear of the C&M Unit chassis. The override switch (S14) in the C&M Unit can be used to position Relay "G" in either the "g" or "$\bar{g}$" state, regardless what state the Test Mode Selector Switch calls for. In a like manner, other decks of the Test Mode Selector Switch control other remote switches and verification logic is applied to the Nand gates. When the correct combination of supply in switching states occurs, the panel lamp associated with the "operate" switch position lights, thus verifying that the desired signal path has been set up.

One deck of the Test Mode Selector Switch is used to activate a delay/one-shot multivibrator circuit which activates a relay that inhibits all outgoing +28 VDC control signals while the Test Mode Selector Switch is being rotated. Approximately 1 second after switch rotation has stopped, normal operation is resumed. This prevents unnecessary activation of the remote relays during mode selection.

There are two power supplies in the C&M Unit: A Sorensen Model QSA10-2-2 supplies the +5 VDC for the logic circuits and a QSA28-6.0 supplies +28 VDC to the remote switches and junction box relays. Both supplies meet MIL-I-26600, MIL-I-16910C, and MIL-I-6181D RFI specifications.

TABLE 14

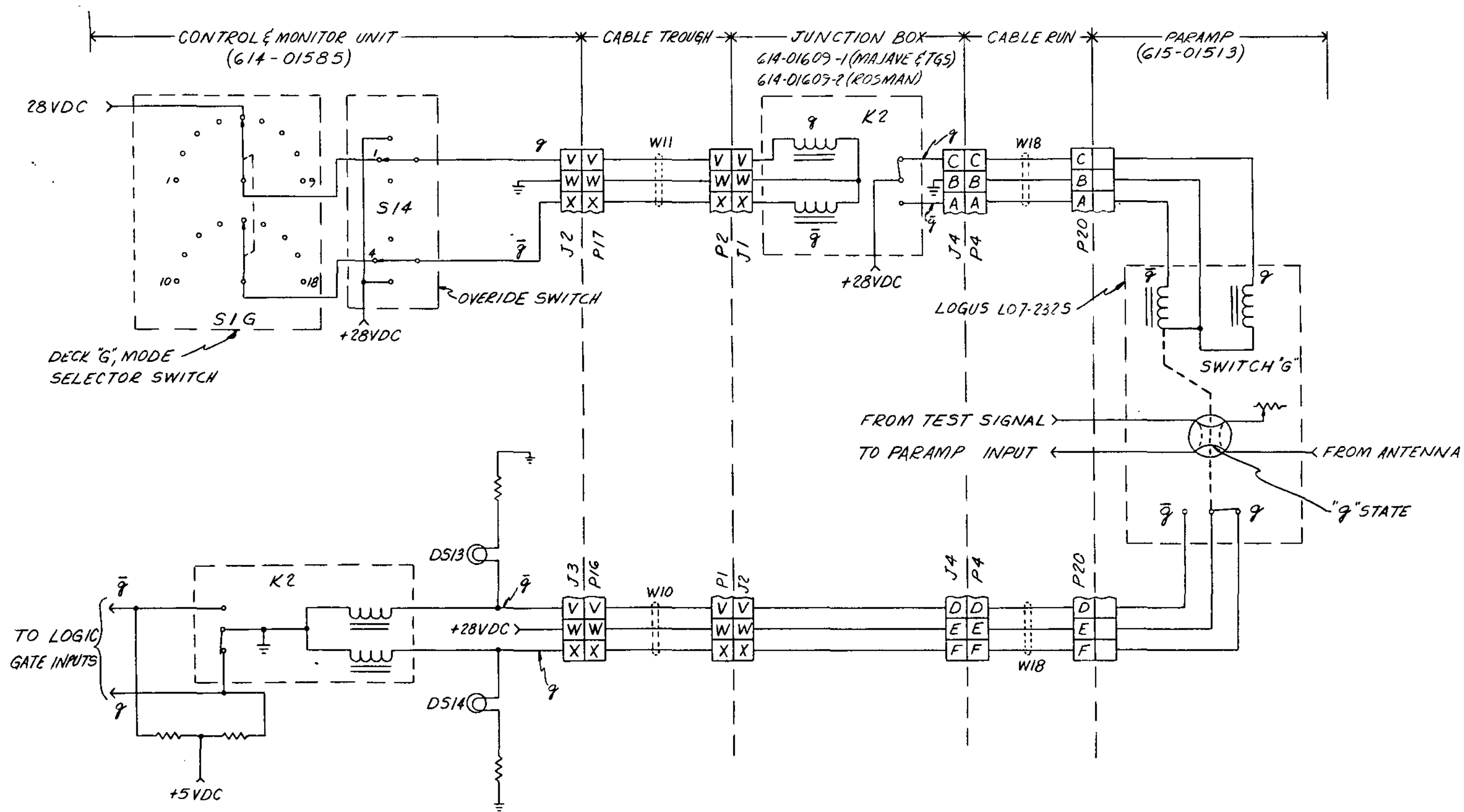
Test/Operate Mode Truth Table

Test/Operate Mode \ Switch Monitored		A	B	C	D	E	F	G
Low-Noise Amplifier Input	(1) Frequency translator	a	b	c	$\bar{d}$	e	f	$\bar{g}$
	(2) Performance monitor	$\bar{a}$	$\bar{b}$	c	$\bar{d}$	e	f	$\bar{g}$
	(3) Noise generator	X	X	$\bar{c}$	d	e	f	$\bar{g}$
	(4) Cold load	X	X	$\bar{c}$	$\bar{d}$	$\bar{e}$	f	$\bar{g}$
Communications Down-Converter	(5) Operate	X	X	$\bar{c}$	$\bar{d}$	X	f	g
Communications Down-Converter Input	(6) Frequency translator	a	b	c	$\bar{d}$	$\bar{e}$	$\bar{f}$	X
	(7) Performance monitor	$\bar{a}$	$\bar{b}$	c	$\bar{d}$	$\bar{e}$	$\bar{f}$	X
	(8) Noise generator	X	X	$\bar{c}$	d	$\bar{e}$	$\bar{f}$	X
	(9) Cold load	X	X	$\bar{c}$	$\bar{d}$	e	$\bar{f}$	X

Note: X Indicates that switch can be in either state or the "Don't Care" condition.

3.2.10.2 "CW Test Signal" Multiplier Switching

Provision has been made for switching a multiplier "in" and "out" at the "CW Test Signal" directional coupler input. This feature, implemented at Rosman only, provides a pushbutton switch/indicator on the C&M Unit panel, along with a coax transfer latching switch near the multiplier and CW Test directional coupler input. Figure 73 is a schematic of the multiplier switching. The 115 VAC power for the multiplier is supplied from the power supply box via a "multiplier in/out" control relay in the junction box. The Form C contacts on the Logus L07-2325 transfer switch are used to provide a monitor of the switch states on the panel of the C&M Unit.



NOTE: ALL SWITCH STATES SHOWN CORRESPOND WITH APPLICATION OF +28VDC TO J2-V ("g" STATE)

Figure 72. Typical Control and Monitor Loop for Control of Transfer Switch "G" in Paramp

3.2.10.3 Layout of Instrumentation Room

Rosman Site

Existing equipment racks 4A1 and 6A1 will be used for installation of the equipment located in the Instrumentation Building. Figure 74 shows the location of the equipment in the racks. The remote parametric amplifier control, receiver control and monitor, two frequency synthesizers (John Fluke Models 6160 and 645A), and the frequency generator are located in the upper portion of Rack 4A1 for ease of operator control and monitoring. The GFE patch panels will be located in Rack 6A1 in approximately the same position they now occupy. An additional 5.5-inch-high panel (ATS F/G transmitter output control) will be located in the 28A1 rack along with the junction box and the existing polarization switch control currently located in 24A1. The AIL Receiver Type 132, currently located in Rack 28A1, will be relocated to the 4A1 rack.

The RFI transmission line (EWP 37 - Elliptical Waveguide) will enter the Instrumentation Building via the existing cable trough near the ceiling of the lower level. Unlike the other cables and lines that go up through the ceiling and into the false flooring, the RFI line will continue straight down the corridor along the ceiling. About one-third of the way down the corridor the line will gradually bend into the storeroom through a small hole in the wire mesh barrier. The line will be terminated in a waveguide-to-coax transition just beneath the RFI racks located near the west wall of the building. The input to the RFI equipment will be connected to the RFI line via low-loss coaxial line dropped through a hole in the reinforced concrete floor. The hole will be located and drilled by site personnel. The elliptical waveguide will be held onto the ceiling with hangers spaced 3 feet apart.

Mojave Site

The equipment layout at the Mojave site, the same as at Rosman, is also shown in Figure 74. The receiver control and monitor assembly at this site is the same as the unit located at Rosman except that the switch for the test input multiplier has been deleted. The Mojave site has two John Fluke Model 6160 frequency synthesizers. The noise receiver (Ewan Knight Model EKLF-7000 Pr) will be moved from Rack 28A1 to Rack 4A1.

TGS Site

Existing equipment Racks V104A2 and V103A2 will be used for installation of the equipment in operations trailer. The remote parametric amplifier control, receiver control and monitor, two frequency synthesizers (John Fluke Models 6160 and 645A), and the frequency generator are located in the upper portion of rack V104A2 for ease of operator control and monitoring (Figure 75). The patch panels and the AIL Noise Receiver will be located in Rack V103A2. The Teledyne Model 105A tracking receivers will be located in Rack V110A2.

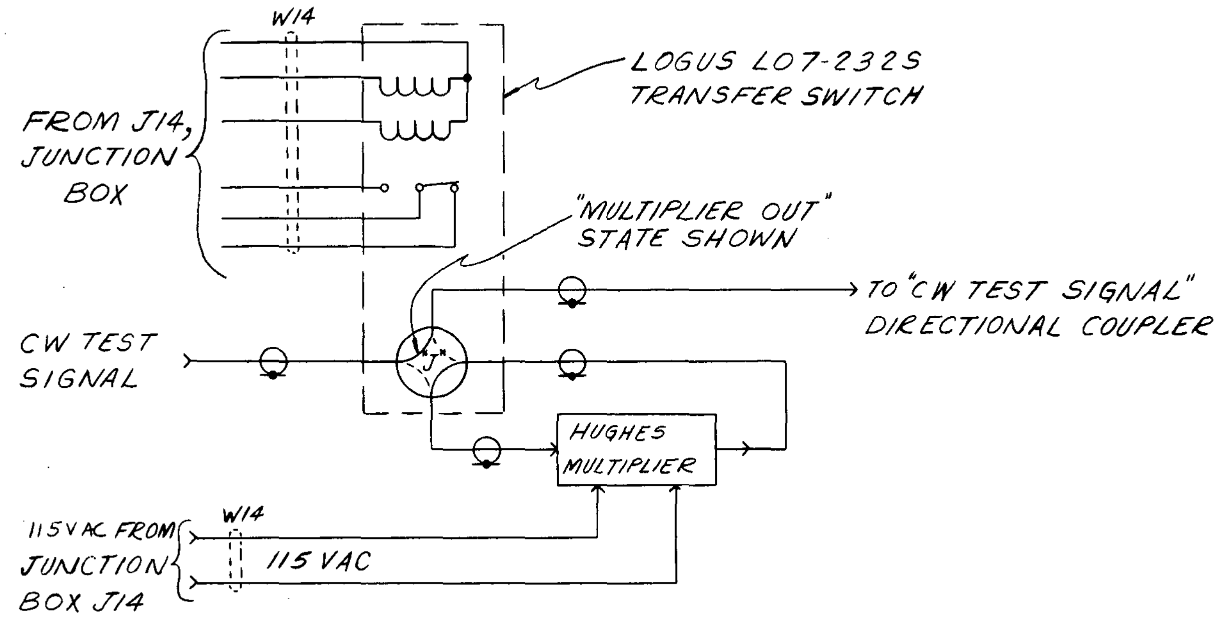
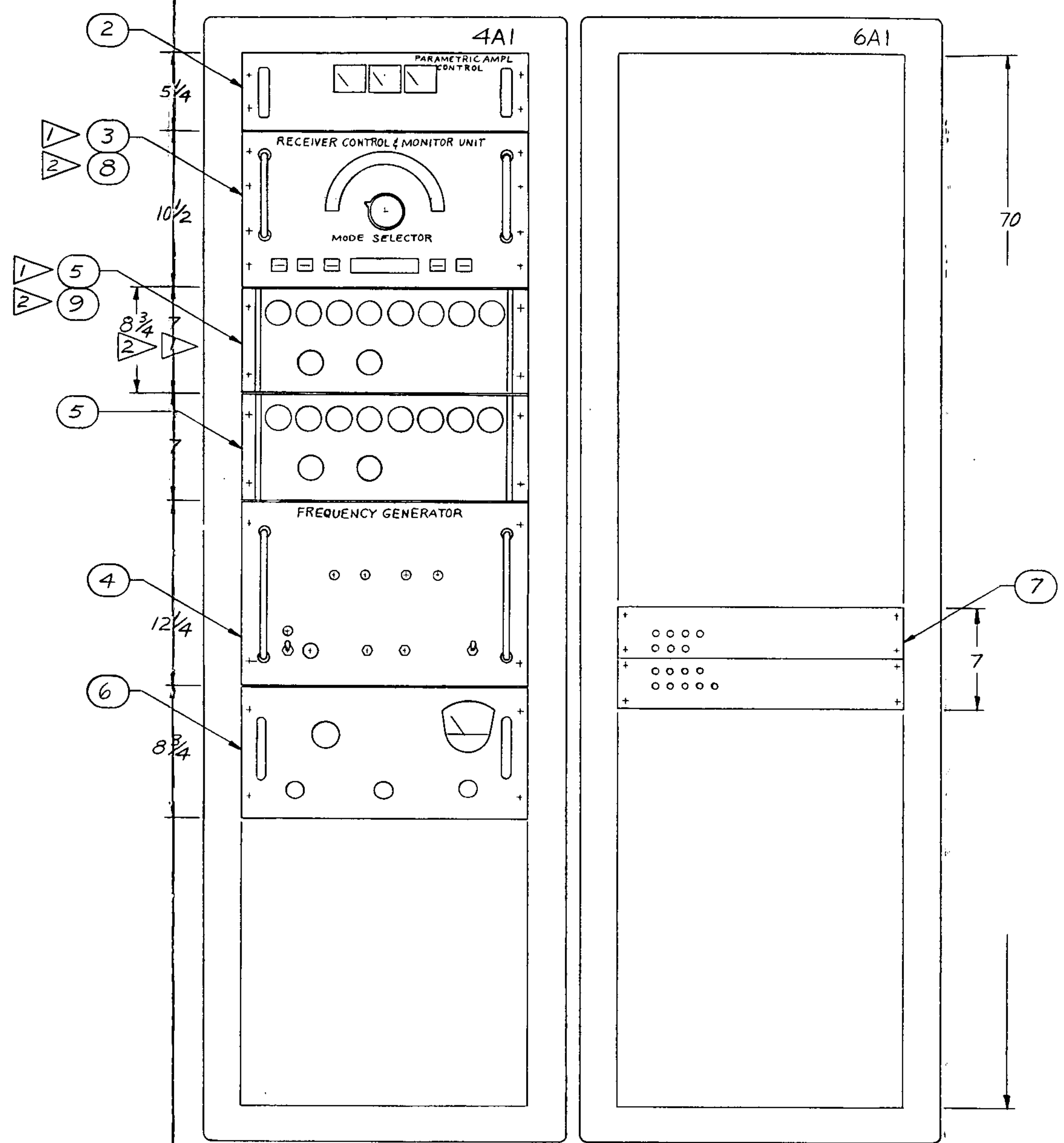


Figure 73. CW Test Signal Multiplier Switching

FOLDOUT FRAME 1



QUANTITY / DASH NO.	FIND NO.	PART OR IDENTIFYING NO.	SM	NOMENCLATURE OR DESCRIPTION	MATERIAL OR VENDOR	ISSUE COND	MATERIAL SPECIFICATION	FINISH OR CODE IDENT
	14							
	13							
	12							
	11							
	10							
1	9	614-01500		FREQUENCY SYNTHESIZER	(645A JOHN FLUKE MFG.) 2			
1	8	614-01585-2		RCVR CONTROL & MONITOR UNIT			2	
PR	7			PATCH PANEL			REF GFE	
1	6	EKLF-7000PR		NOISE RECEIVER	EWAN KNIGHT		REF GFE	
2	5	614-01540		FREQUENCY SYNTHESIZER	(6160A JOHN FLUKE MFG.)			
1	4	614-01560		FREQUENCY GENERATOR				
1	3	614-01585-1		RCVR CONTROL & MONITOR UNIT				
1	2	614-01513		REMOTE PARAMETRIC AMPL CONT	(COMTECH LAB. NO. 367-14000000)			
	1							

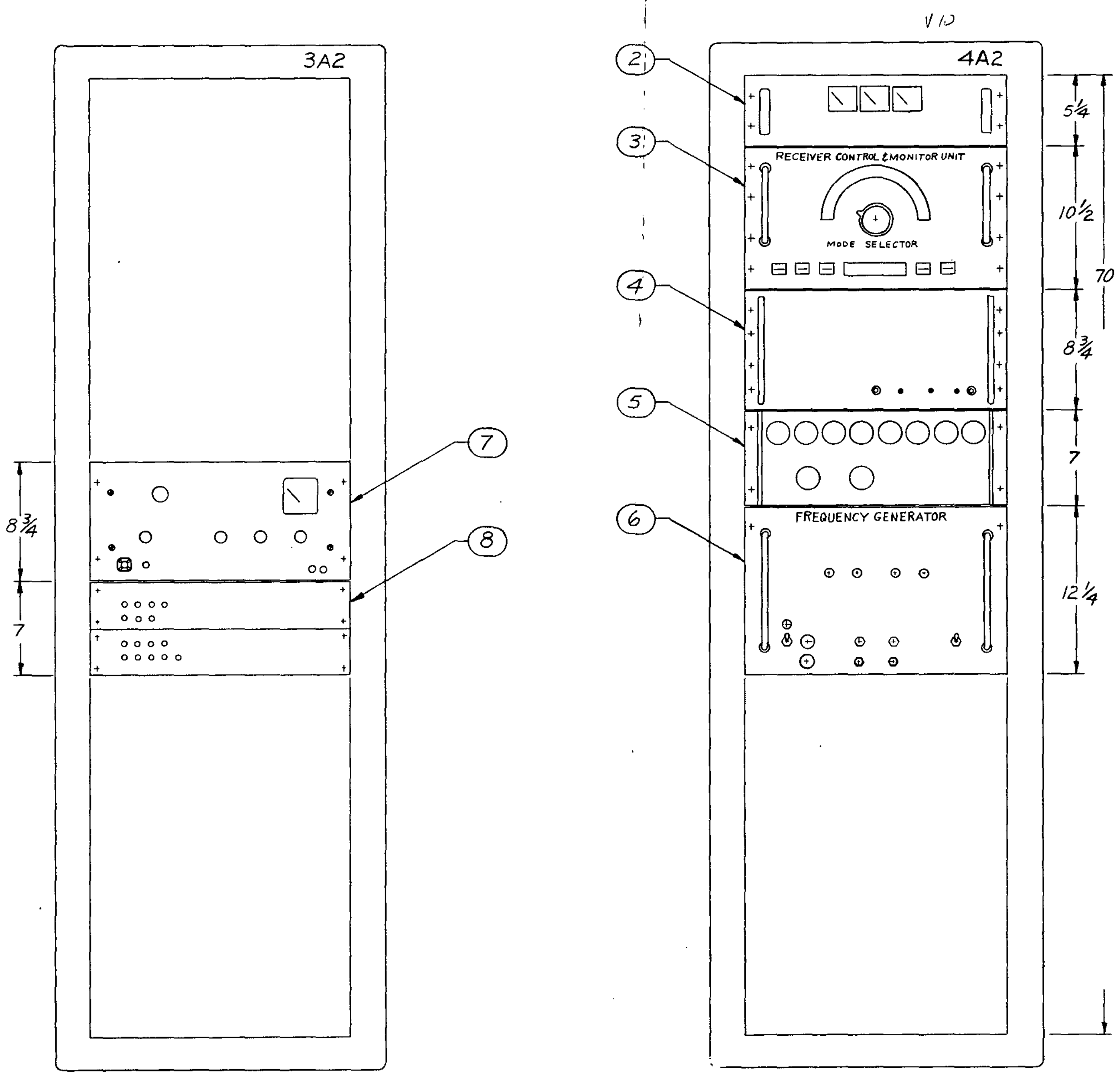
NOTE:
1 MOJAVE
2 ROSMAN

FOLDOUT FRAME 11

Figure 74. Location of Equipment in Racks - Instrumentation Building - Rosman

FOLDOUT FRAME I

FOLDOUT FRAME II



QUANTITY/DASH NO.	FIND NO.	PART OR IDENTIFYING NO.		NOMENCLATURE OR DESCRIPTION	MATERIAL OR VENDOR	ISSUE COND	MATERIAL SPECIFICATION	FINISH OR CODE IDENT	REV
PR	8			PATCH PANEL			REF GFE		
1	7	TYPE 132		NOISE RECEIVER	A.I.L. DIV		REF GFE		
1	6	614-01560		FREQUENCY GENERATOR					
1	5	614-01540		FREQUENCY SYNTHESIZER	(JOHN FLUKE MFG. NO. 6160A)				
1	4	614-01500		FREQUENCY SYNTHESIZER	(JOHN FLUKE MFG. NO. 645A)				
1	3	614-01585-1		RCVR CONTROL & MONITOR UNIT					
1	2	614-01513		REMOTE PARAMETRIC AMPL CONT.	(COMTECH		LAB. NO. 367-14000000)		
	1								

Figure 75. Location of Rack-Mounted Equipment Operations Trailer - TGS

3.2.10.4 Installation of Cooled Amplifier Cryogenics System

Rosman Site

The helium compressor, compressor bypass manifold, adsorber trap, and adsorber bypass manifold will be installed in the room at the base of the antenna in the same position as the existing helium compressor. Existing helium lines will be used between the compressor and the refrigerator unit located in the feed cone. The local amplifier control unit and refrigerator control unit will be installed in existing equipment racks located in the equipment room behind the antenna dish (Figure 76). The antenna-mounted unit consists of two major subassemblies: (1) The refrigerator/vacuum dewar assembly, containing the three-stage cooled parametric amplifier and the referenced cold load, and (2) the electronic assembly containing the pump system, solid-state source, and the pump power regulating loop.

Both subsystems will be mounted in the feed cone on the rotating table near the existing cooled paramp. The universal power supply is also located on the rotating table near the antenna-mounted unit. The remote amplifier control unit will be located in the instrumentation room in Rack 4A1 (Figure 74). Access for maintenance and testing has been considered in positioning each portion of the system.

Mojave Site

Installation at the Mojave site is basically the same as at Rosman except the local amplifier control unit and the refrigerator control unit are located in the feed cone for weather protection close to the antenna-mounted unit (Figure 31).

TGS Site

The helium compressor, compressor bypass manifold adsorber trap, and adsorber bypass manifold will be mounted on the concrete pad near the base of the antenna pedestal. The compressor is designed to meet the following environmental conditions:

Ambient temperature operating range	-25 to +125°F (-32° to +52°C)
Humidity	0 to 100 percent
Rain	Rate of 4 inches per hour and an accumulation of 12 inches per 24 hours
Solar radiation	350 BTU/ft^2/hr
Altitude	0 to 10,000 ft
Snow	6-inch snow load.

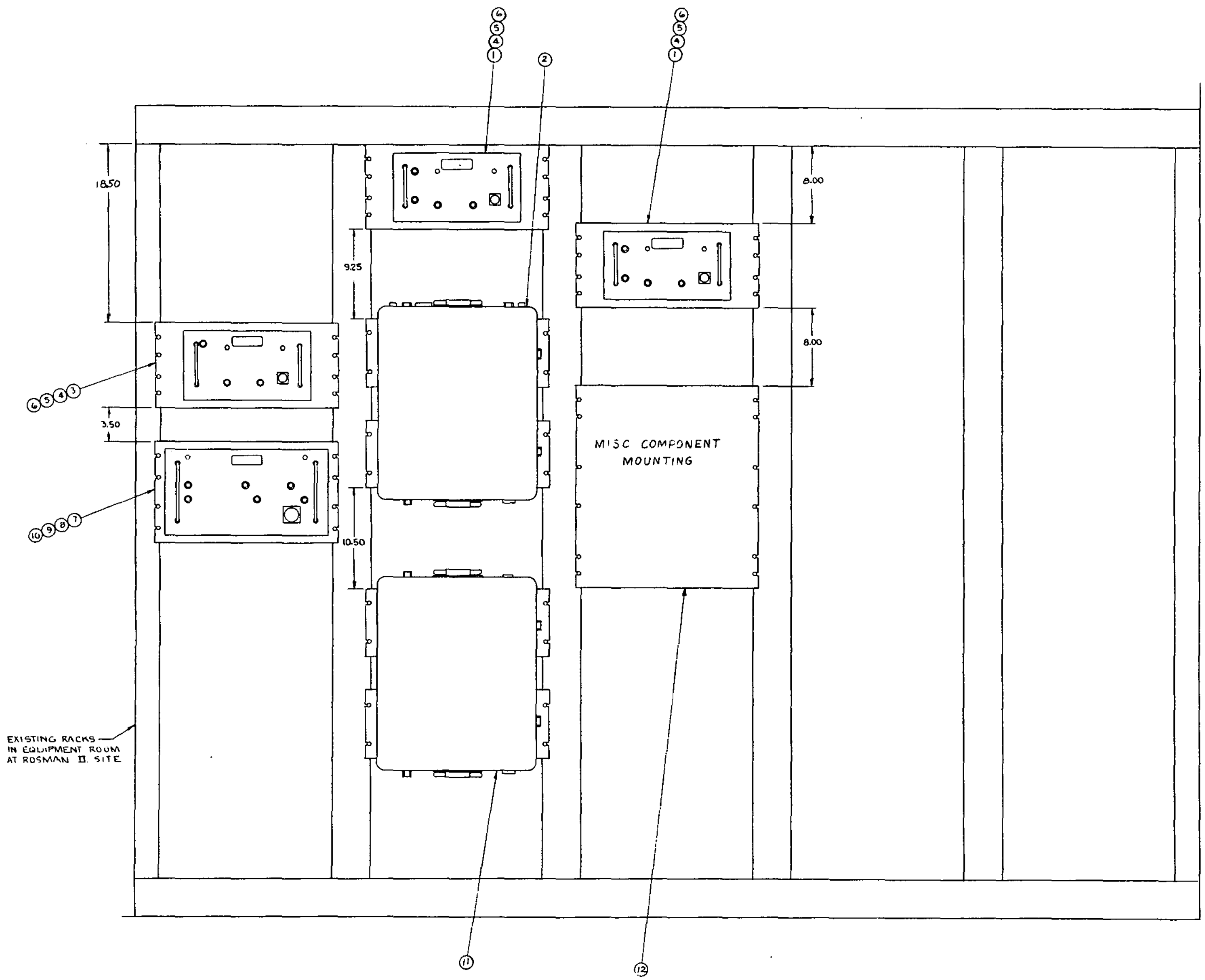


Figure 76. Electronics Equipment Location - Electronics Room - Rosman

New helium lines will be installed between the compressor and refrigerator units mounted in the feed cone. The antenna-mounted unit will be installed at the base of the feed cone (Figure 30). The local amplifier control unit and refrigerator control unit will be mounted on the equipment racks located in the area behind the feed cone (Figure 77).

3.3 Collimation Tower Equipment

3.3.1 Collimation Tower Electronics

Collimation tower electronics include a stable source assembly (Figure 78) and external attenuator panel assembly (Figure 79). Block diagram of the usual electronics configuration is shown in Figure 80.

The stable source assembly is in a pressurized container which may be mounted in the collimation tower equipment houses or installed in a standard relay rack in an aircraft for special dynamic tracking tests.

Five such assemblies will be furnished, one for each of the collimation towers and two for the tracking aircraft. Only three external attenuator panels will be furnished; these are intended for use only in the collimation tower equipment houses.

The stable source assembly furnishes only one of 10 available frequencies at any one time in the frequency range of 3.7 to 4.2 GHz. Frequencies available will be:

3.750000 GHz
3.780000 GHz
3.950000 GHz
3.980000 GHz
4.119599 GHz
4.135956 GHz
4.150000 GHz
4.178591 GHz
4.180000 GHz
4.195172 GHz

Frequency stability of any one oscillator will be better than 1 part in 10^8 over any 3 millisecond period. Long and short term stability will be enhanced by operating the basic crystal oscillators (Greenray Model T316A in the 46 to 52 MHz range) continuously from highly regulated and low noise power supplies and from shock mounts that isolate the oscillators from shock and vibration.

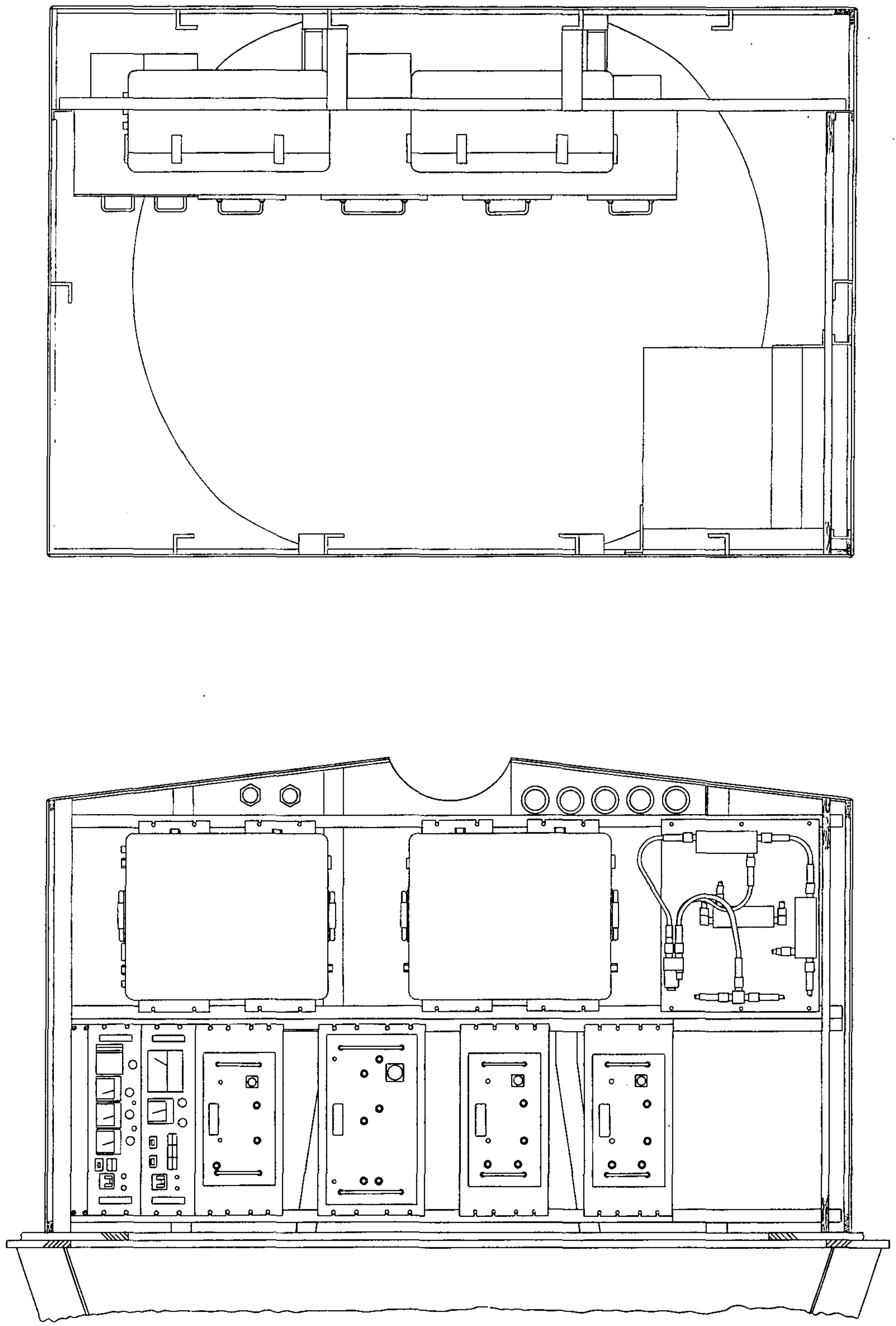


Figure 77. Installation of Local Amplifier Control Unit and Refrigeration Control Unit - TGS Feed Cone Room

NOTES:
1. INTERPRET DRAWING PER MIL-STD-100.
2. THIS DIMENSION TO BE MAINTAINED AT ASSEMBLY.

FOLDOUT FRAME 1

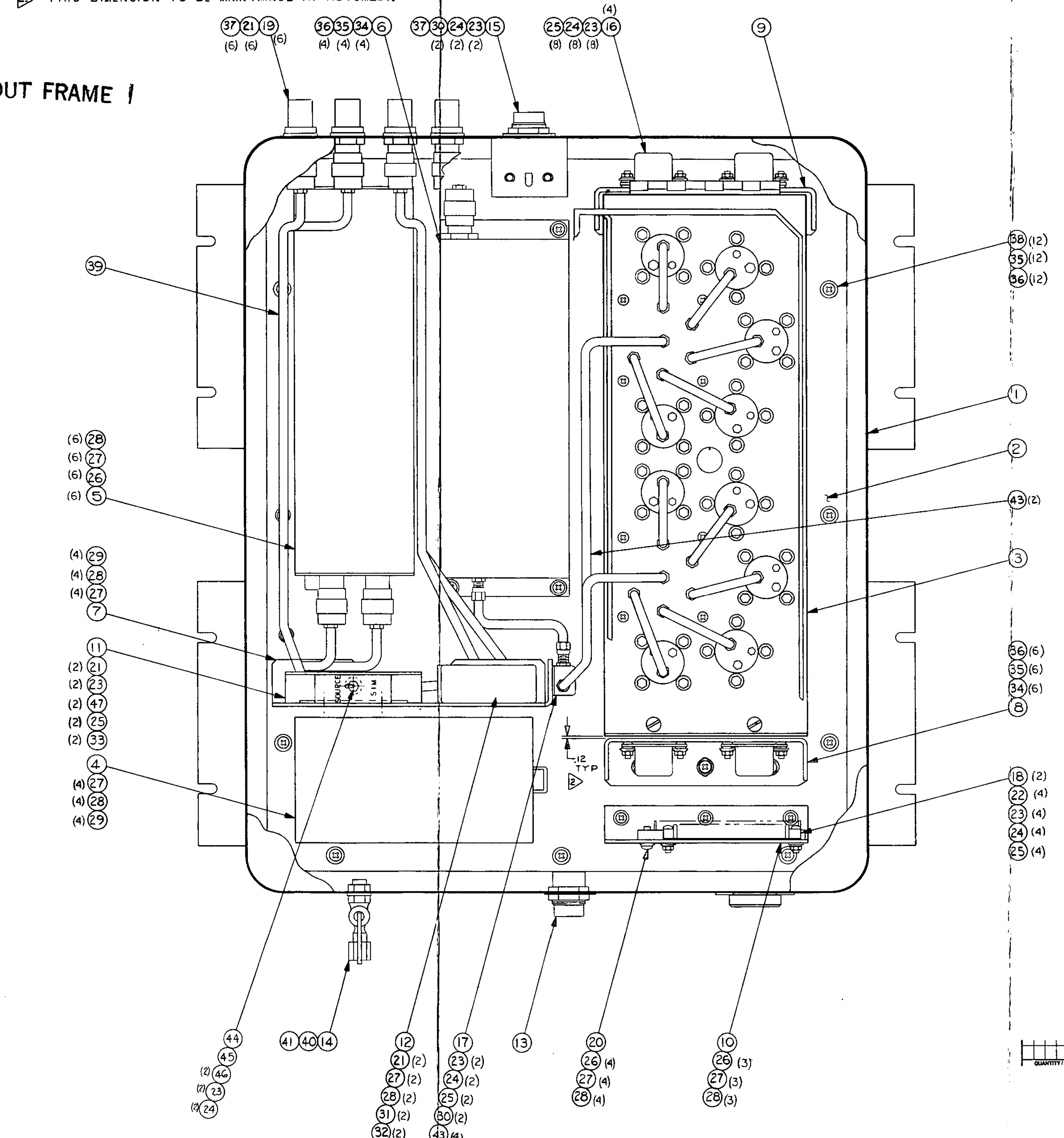
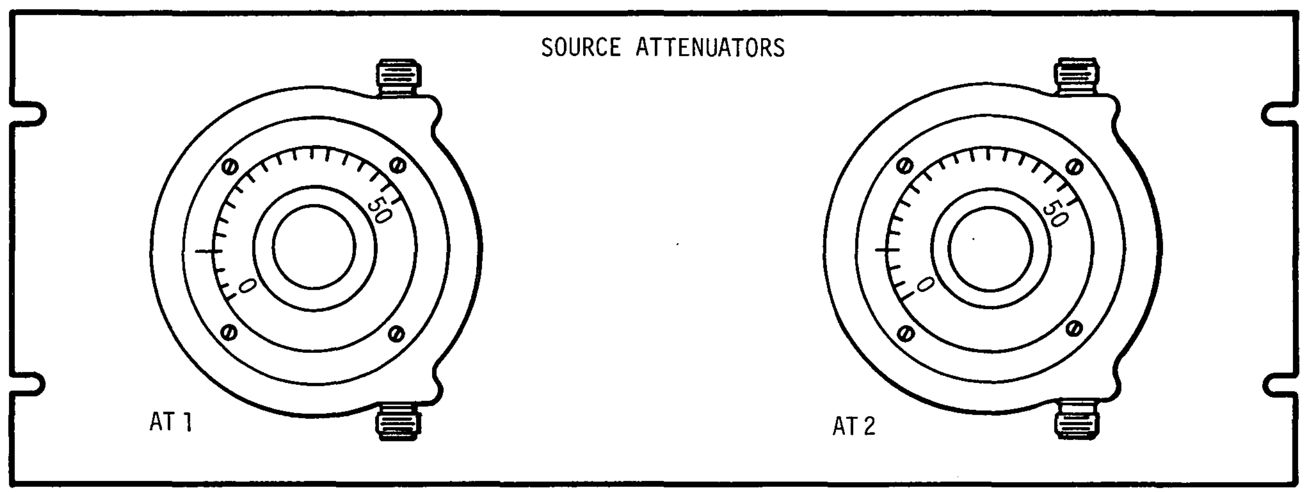


Figure 78. Stable Source Assembly

FOLDOUT FRAME 11

QUANTITY/DASH NO	ITEM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	STOCK SIZE	MATERIAL OR VENDOR	ISSUE COND	MATERIAL SPECIFICATION	FINISH OR CODE IDENT
2	47	MS35338-136	WASHER, LOCK					
2	46	MS51957-28	SCREW, MACH	#6-32 x 3/8 LG				
1	45	614-01642	BRACKET, SWITCH					
1	44	TR2106	SWITCH, SPDT	52			CONTROLS CO.	
6	43	OSM501-1	CONNECTOR				OMNI SPECTRA	
1	42	614-01589	GASKET RUBBER					
1	41	961-F	NUT .25 O.D. TUBE				IMPERIAL/EASTMAN	
1	40	50-14-3	WASHER RUBBER	.25 I.D. x .75 O.D.				
A/R	39	RG-223/U	COAX CABLE					
12	38	MS51958-67	SCREW MACH					
6	37	50-14-3	WASHER RUBBER	.62 I.D. x 1.00 I.D.				
22	36	AN960-C10L	WASHER FLAT					
22	35	MS35333-73	WASHER TOOTH					
10	34	MS51958-61	SCREW, MACH					
2	33	MS51957-35	SCREW, MACH					
2	32	NAS671C8	NUT HEX, PLAIN					
2	31	MS51957-51	SCREW, MACH					
2	30	MS51957-27	SCREW, MACH					
8	29	MS51957-43	SCREW, MACH					
23	28	MS35338-137	WASHER, LOCK					
23	27	AN960-C8L	WASHER, FLAT					
12	26	MS51957-44	SCREW, MACH					
16	25	NAS671C6	NUT, HEX					
18	24	MS35333-71	WASHER TOOTH					
18	23	AN960C6L	WASHER FLAT					
4	22	MS51957-30	SCREW P.H.C.R					
14	21	3001-714-10	CONNECTOR				AMERICON	
1	20	59001-1-6	BUS BAR				SEASTROM CO	
6	19	82-849	CONNECTOR				AMPHENOL	
2	18	53-32-5A8	TERMINAL BOARD					
1	17	PDM-20-55	POWER DIVIDER				MERRIMAC	
4	16	J-8138-5	SHOCK MTG				LORD MFG CO.	
1	15	SM-B524011	CONNECTOR				U.S ARMY ELECT	
1	14	160	SHUT OFF COCK				ESSEX BRASS	
1	13	21-203-716-26P	CONNECTOR					
1	12	SR 2N-D	RELAY COAX				RCL ELECT INC	
1	11	614-01512	BAND REJECT FILTER					
1	10	614-01581	BRACKET T.S.M					
1	9	614-01580	BRACKET ASSY					
1	8	614-01579	BRACKET ASSY					
1	7	614-01591	PANEL COMPONENT					
1	6	EZ122	MULTIPLIER x 80				GREEN WAY	
1	5	032072	TWT AMPLIFER				VARIAN	
1	4	QSA 28 MOD II	POWER SUPPLY				SORENSEN	
1	3	614-01594	PANEL BOX ASSY					
1	2	614-01576	PANEL ASSEMBLY					
1	1	614-01601	CASE ASSEMBLY					



NOTE:

A 1. ATTENUATORS TO BE CALIBRATED AT 3950 MHZ

Figure 79. External Attenator Panel Assembly

FOLDOUT FRAME 1

FOLDOUT FRAME II

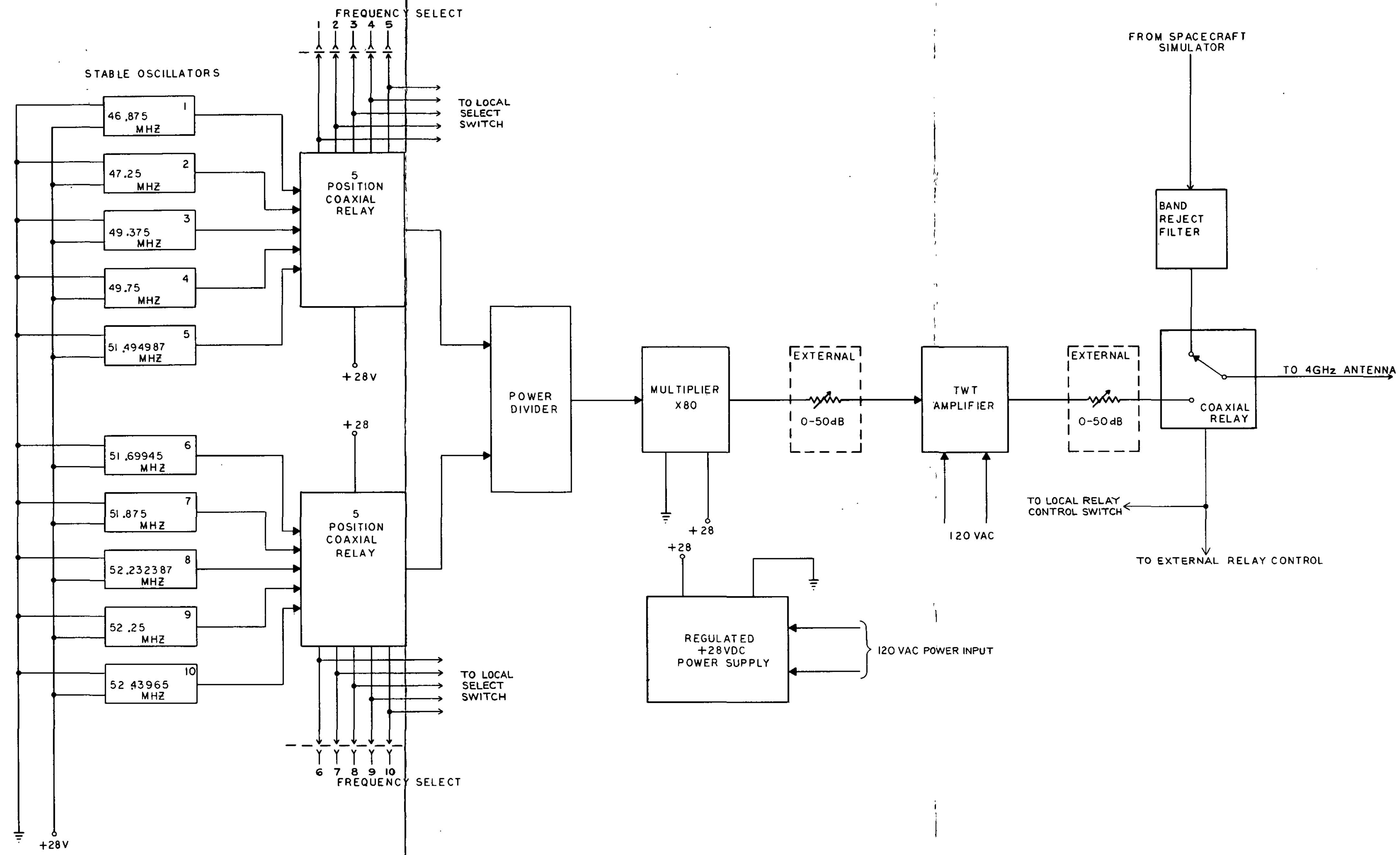


Figure 80. Collimation Tower Electronics

The basic frequency of the oscillator in the 50 MHz region will be raised to the desired output frequency by applying it at approximately 0 dBm to the input of a "x80" multiplier. The multiplier provides filtering sufficient to remove all spurious outputs to a level at least 60 dB below the output signal.

The output of the multiplier (nominal 0 dBm) is raised to the desired +20 dBm level by a Varian Model VTG 4420 TWT amplifier, which is capable of operating over the frequency range of 3.7 to 6.4 GHz. The external attenuator panel may be used to adjust input and output levels to and from the TWT. The attenuators are both ARRA Model 4674-50L units having a range of 0 to 50 dB (calibrated in 1 dB increments) and an accuracy of $\pm$0.2 dB or 1 percent of dial reading, whichever is greater, at 3.950 GHz. Thus, the attenuators when manually operated can provide an accurate change of level for calibrating receive equipment and for measuring linearity.

The oscillator (and thus, the output frequency selection) relays are RLC Model SR-5-R-D which have greater than 90 dB isolation at 50 MHz. Since the multiplier efficiency is a sensitive function of input level, the amount of leakage at the multiplier will be nil (less than -140 dBm). Accounting for a TWT gain of 25 dB and isolation in the output relay of at least 60 dB at 4 GHz, the undesired output from the stable sources, when the output relay is in the "simulator" position, will be in the order of -175 dBm, a negligible amount.

Although five stable source assemblies will be furnished, only four TWT's will be provided. Thus, one of the units must operate at the 0 dBm output level. Since two assemblies are provided for infrequent tracking-aircraft use, it is presumed that one of these units will not be equipped with TWT and may even serve as an emergency back-up unit for the other four.

Selection of "stable source" or "simulator," and selection of a particular frequency from the stable source, will be accomplished by applying a ground to the appropriate pin of J. This will normally be accomplished via the remote control links at Mojave and Rosman. For TGS and for local manual control at any of the sites or in the aircraft, a switch panel inside the assembly will permit local control. No damage can result from simultaneous multiple operation of switches.

3.3.2 TGS Antennas and Controls

The collimation tower antennas and controls were supplied by Scientific-Atlanta, Inc. in conformance with Martin Marietta Specification 614-01534. The following items will be delivered to TGS:

1 Antenna (3.7 to 4.2 GHz) consisting of:

- a Model 22-4 48-inch Parabolic Reflector
- b Model 23-3.9/4 Antenna Feed
- c Model 11A-3.9/M Coax-to-Waveguide Adapter

2 Antenna (5.9 to 6.4 GHz) consisting of:

- a Model 22-3/M 32-inch Parabolic Reflector
- b Model 23-5.9/3/M Antenna Feed
- c Model 11A-5.8 Coax-to-Waveguide Adapter

3 Model 5616-1-5136-R Polarization Positioner (Figure 81) (2) including:

- a Coaxial rotary joint (DC to 12.4 GHz)
- b DC motor for variable speed and direction control
- c Dual 1:1 and 36:1 synchro transmitters
- d All-weather operation

4 Model 4112 Positioner Control Unit (Figure 82):

- a Compatible with the Polarization Positioner
- b Capable of driving both positioners, one at a time
- c Front panel switch selection of either positioner
- d Single knob speed and direction control
- e Two 2-speed-position indicators, one for each positioner
- f Main line fuse and individual armature fuses located on front panel

This equipment is nearly identical to that currently in use at Rosman and Mojave. All components and interconnecting control cables have been received and tested at Martin Marietta and are awaiting shipment to the TGS site.

Table 15 summarizes RF performance measured on each antenna. All characteristics meet or exceed specifications.

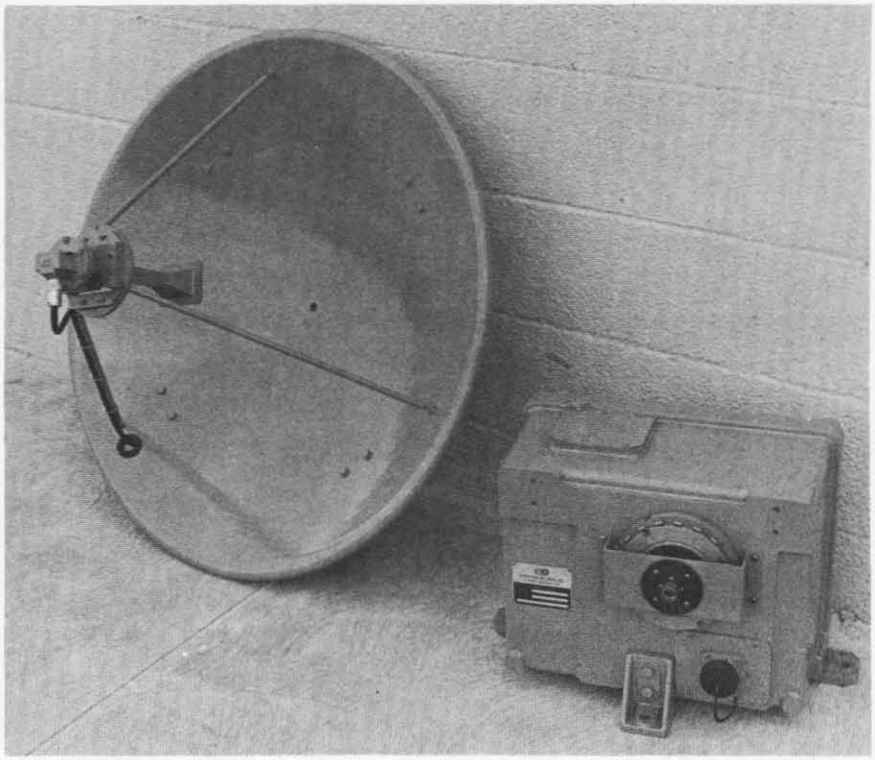


Figure 81. Model 5616-1-5136-R Polarization Positioner

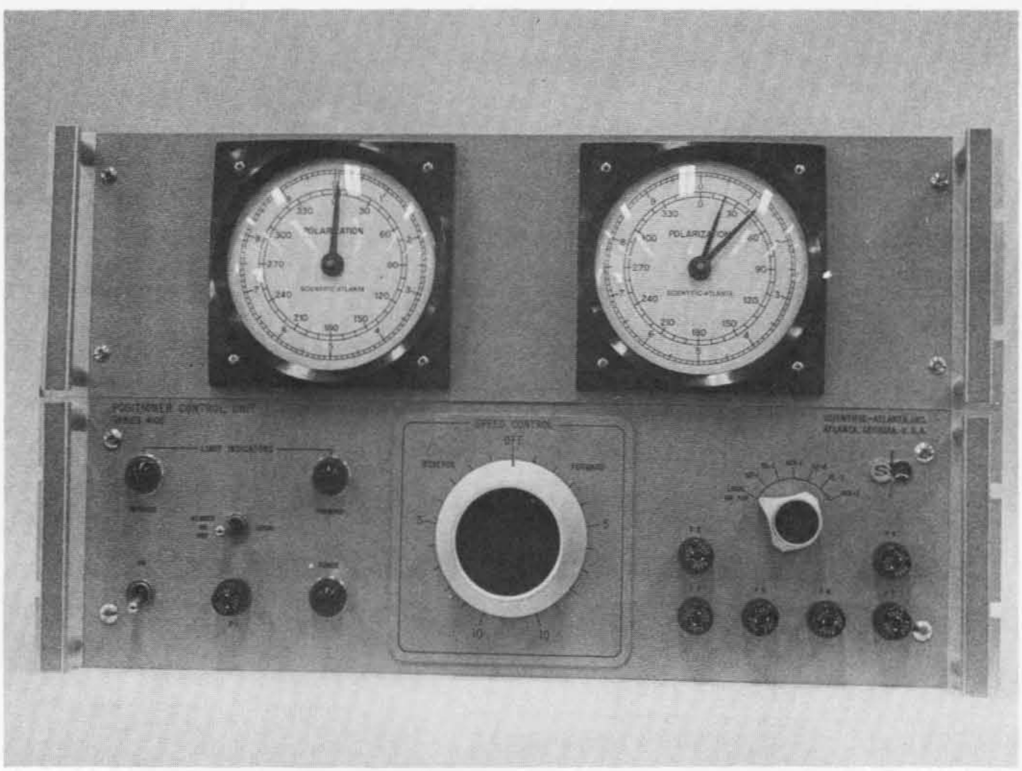


Figure 82. Model 4112 Positioner Control Unit

TABLE 15

Collimation Tower Antenna Performance

4 GHz Antenna

Frequency	VSWR	Beamwidth (°)	Sidelobe (db)	Gain (dB)	Axial Ratio (dB)
3.70 GHz	1.06	E - 4.8	E - 18.0	30.5[1]	
		H - 4.0	H - 15.5		
3.95	1.30	E - 4.3	E - 20.0	31.0	40
		H - 4.5	H - 17.0		
4.20	1.45	E - 4.0	E - 20.0	31.6[1]	
		H - 4.1	H - 18.5		

6 GHz Antenna

Frequency	VSWR	Beamwidth (°)	Sidelobe (db)	Gain (dB)	Axial Ratio (dB)
5.90 GHz	1.22	E - 4.0	E - 21.0	31.7[2]	
		H - 4.3	H - 21.0		
6.15	1.46	E - 4.1	E - 22.0	32.0	37
		H - 4.1	H - 19.0		
6.40	1.38	E - 3.6	E - 20.0	32.4[2]	
		H - 4.0	H - 23.0		

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1 Calculation based on measurement at 3.95 GHz

2 Calculation based on measurement at 6.15 GHz

4. SCHEDULE OF REMAINING ACTIVITIES

The schedule for timely completion of the contract is presented in Figure 83. Critical milestones include start of modifications at Rosman on 10 April and at TGS on 22 May. The latter date is a month in advance of contractual dates and represents a contingency in the event unforeseen troubles develop with the TGS system.

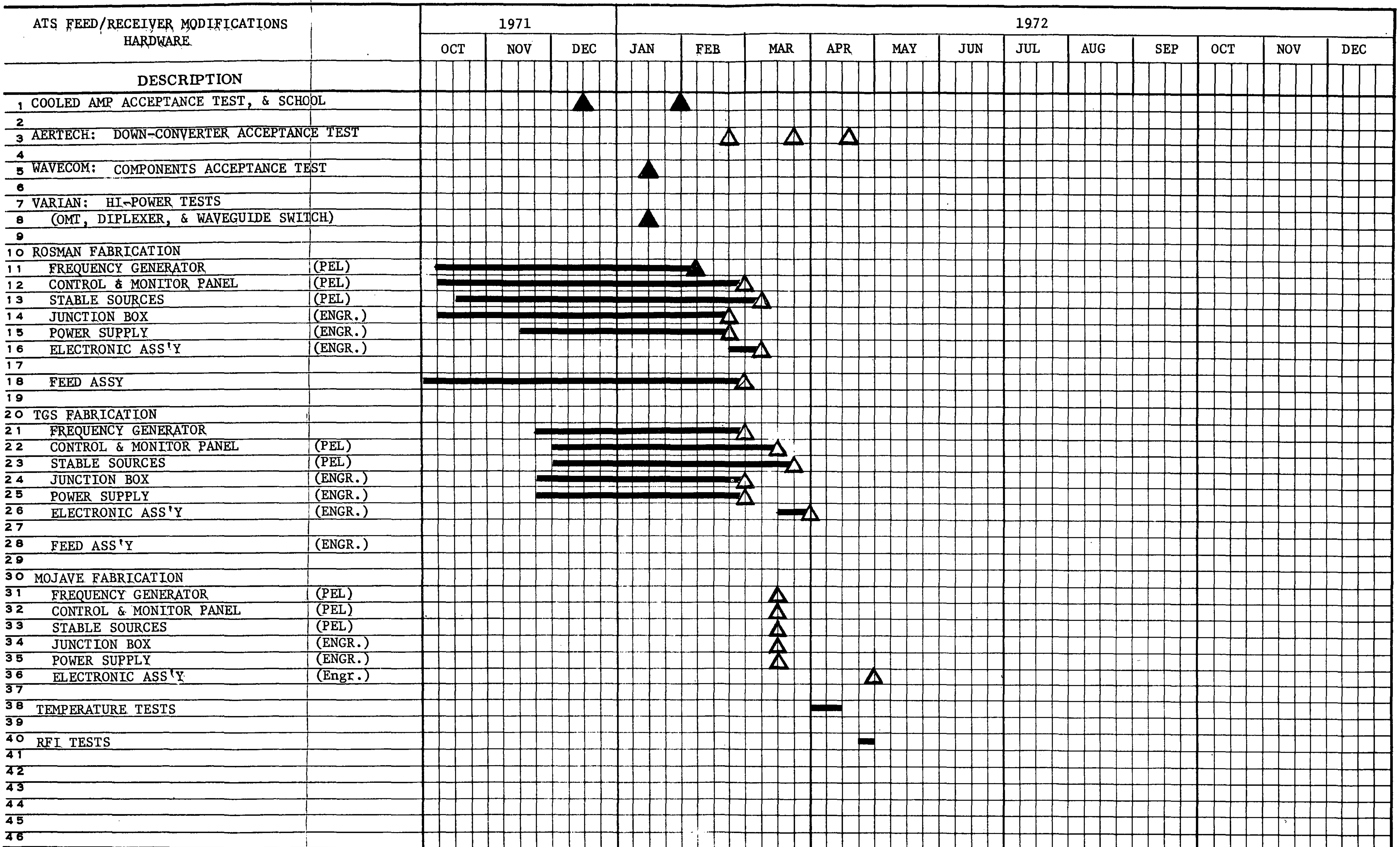
The major procurement that could impact the first installation date is delivery of down-converters from Aertech. This delivery date has slipped from 3 December 1971 to approximately 15 January 1972. A concentrated effort has been made to analyze Aertech's problems, make helpful recommendations, and urge them to fabricate and perform preliminary testing prior to receipt of multipliers from Applied Research, Inc.

Other procurements, including waveguide components from WaveCom, cooled amplifier from Comtech, and synthesizers from Fluke, appear to be well within need dates.

FOLDOUT FRAME I

FOLDOUT FRAME II

MASTER PLAN



PEL = Prototype Engineering Laboratory

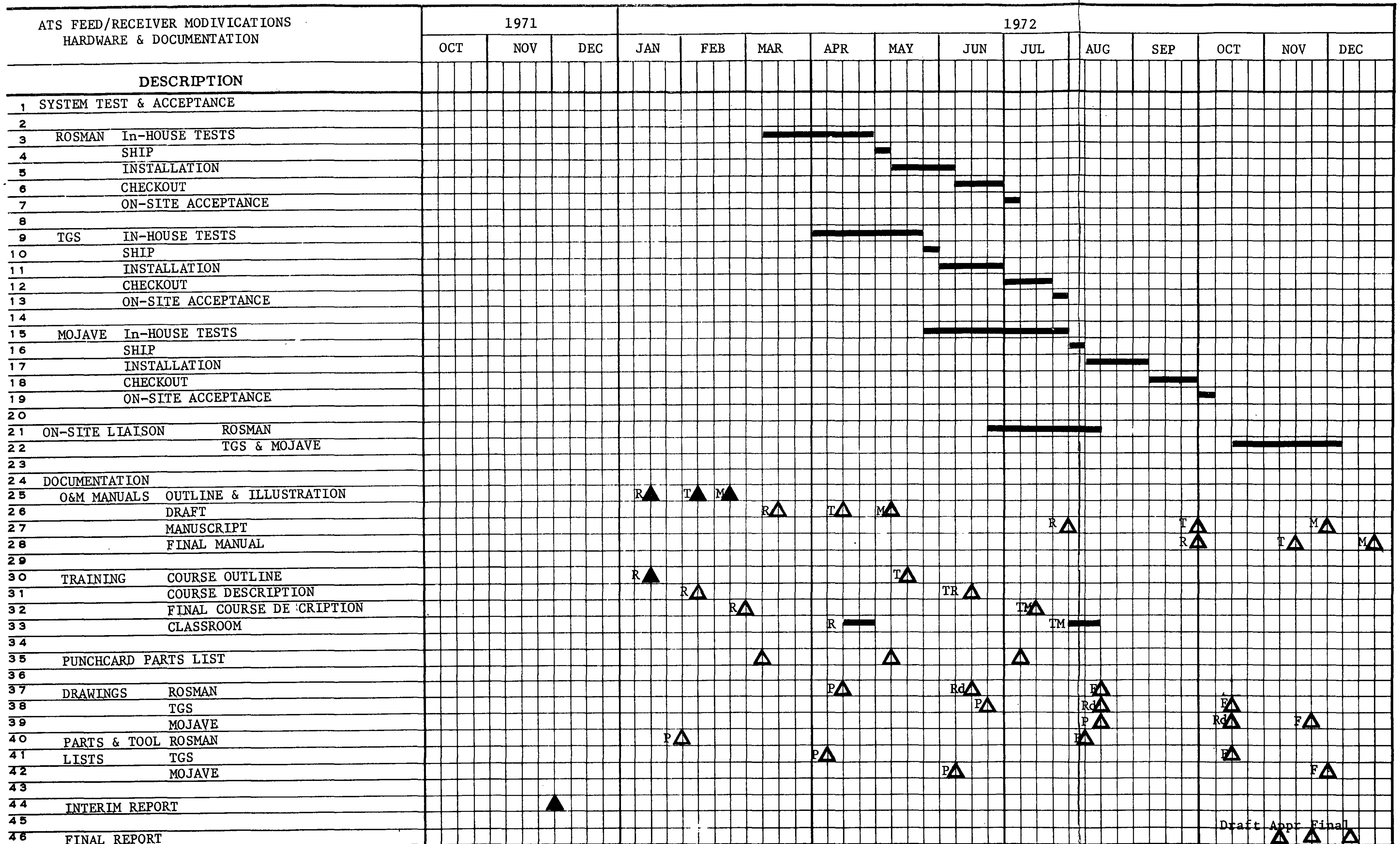
ENGR = Design Engineering

Figure 83. Master Plan

FOLDOUT FRAME I

MASTER PLAN

FOLDOUT FRAME II



LEGEND: R = Rosman P = Preliminary M = Mojave
T = TGS Rd = Redlined F = Final

Figure 83. Master Plan (Cont)