Exciter Switch

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A new exciter switch assembly has been installed at the three DSN 64-m deep space stations. This assembly provides for switching Block III and Block IV exciters to either the high-power or 20-kW transmitters in either dual-carrier or single-carrier mode. In the dual-carrier mode, it provides for balancing the two drive signals from a single control panel located in the transmitter local control and remote control consoles. In addition to the improved switching capabilities, extensive monitoring of both the exciter switch assembly and Transmitter Subsystem is provided by the exciter switch monitor and display assemblies.

I. Summary

A prototype exciter switch was installed and tested at Goldstone (DSS 14) in November 1972. Subsequently, three new exciter switches were procured to replace the prototype and for installation in Australia at DSS 43 and in Madrid at DSS 63. The new assembly provides an excellent example of combining RF hybrid stripline techniques with digital control and monitoring circuits.

The exciter switch consists of four separate assemblies. The first, (Fig. 1) contains the RF package and control logic. The second (Fig. 2) contains multichannel data collection, conditioning, and serial transmission logic. The last two are the dual-carrier and diagnostic display and control panels. One (Fig. 3) displays RF switching configuration and RF level monitoring. In dual-carrier mode, klystron output levels are controlled from this panel. The other (Fig. 4) displays compute transmitter operating parameters. Both displays provide thumbwheel switches for selecting any of the 416 status channels sampled by the exciter switch monitor.

The four assemblies thus provide necessary RF switching between the two exciters and the 20-kW and high-power transmitters in single-carrier and dual-carrier mode. This RF switching within the exciter switch is controlled from the Antenna Microwave Subsystem. In the dual-carrier mode, dual receivers are used to provide a simple and accurate method for monitoring and adjusting the relative carrier outputs of the klystron. Through the digital scanning of the exciter switch and transmitter operating parameters, the assemblies provide extensive operation and diagnostic information.

II. Exciter Switch Assembly

A. New Design

The exciter switch assembly provides the interface of the Block III and Block IV exciters with the 20-kW and high-power transmitters (Fig. 5). A new exciter switch assembly has been installed at the three DSN 64-m sites. This assembly replaced a similar prototype exciter switch design installed at DSS 14 for testing purposes (Ref. 1).

The new assembly provides for switching of Block III and Block IV exciters into the 20-kW or high-power transmitter in either the single- or dual-carrier mode, and remote balancing of the exciter drive levels. Some functions not found in the prototype were added to the new assembly:

(1) Dual receivers were added to the exciter switch assembly to extract the relative output carrier levels being transmitted and to display these levels on the control panel. The control panels also contain the controls for balancing the two output carriers in the dual-carrier mode. This eliminates the need for a monitoring spectrum analyzer with operator interpretation to perform the needed calibration.

(2) The multi-channel data collection and serial transmission portion of the original prototype (Ref. 2) is now packaged in a separate J-box (Fig. 2), and additional capabilities have been added, such as

   (a) Expanded channels: Using monolithic analog multiplexers, 208 (0 to 5 V) analog channels are multiplexed into a (12-bit) analog-to-digital converter, and 208 corresponding digital channels are multiplexed into one bit for serial transmission to the control areas.

   (b) Ten 61-pin connectors: These connectors are available for interfacing the monitoring assembly to other assemblies within the Transmitter Subsystem. Six 61-pin connectors are available for future monitoring requirements.

   (c) A programmable calculator: This calculator performs digital scaling and computation on the analog inputs. Such parameters as calorimeter power measurements can be calculated from the water flow and temperature changes within the klystron. All collected as well as calculated information is available at the display panels in the control areas.

B. RF Drive Signal Flow (Fig. 6)

Block III and Block IV drive signals, channel A and channel B, respectively, are received from the exciter assembly through semi-rigid cable at their respective S-band frequencies (2114 ±4 MHz). The two drive signals are first sampled with an RF power head, and then the drive signals are amplified to 10 W through a solid-state buffer amplifier (Ref. 3). The drive signals then pass into a dual-channel RF hybrid combiner. Each channel of the hybrid consists of couplers for RF-level monitoring, a diode switch, and a diode attenuator. The couplers provide RF-level indications prior to entering the diode switch and after passing through the diode attenuator.

The dual-carrier display panels (Fig. 3) provide direct readout of the RF levels after leaving the attenuator. Other power readings may be accessed using the thumbwheel switch on the lower portion of the panels. On the dual-carrier display panels, other controls adjust bias levels on the diode attenuators for carrier balancing in dual-carrier mode. The diode switches (Fig. 6) are used to select dual-carrier or single-carrier mode. In single-carrier mode, the outputs from the diode switches go directly to a pair of coaxial switches (Fig. 3), where the drive is either terminated or switched into the selected transmitter. In dual-carrier mode (Fig. 6), the two channels are combined and fed through the coaxial switches to the selected transmitter. The microwave switch panel in the control room provides controls for the pin diode and coaxial switches.

C. Dual-Carrier Transmission

The dual-carrier mode provided by the exciter switch allows two separate RF signals to be transmitted through a single transmitter. However, difficulties arise in trying to adjust the two carriers to provide specified carrier levels. Power meter measurements are unusable due to the close spacing of the two S-band carriers (nominally 300 kHz) and the resulting intermodulation due to the klystron nonlinearity (Fig. 7). The close spacing of the carrier prohibits the use of S-band filters.

Previous methods of balancing the output carriers required sampling of the transmitter output with a spectrum analyzer. The spectrum analyzer was used to monitor carrier levels while adjusting drive levels from controls in the control room (Ref. 1). Although straightforward, it required reconfiguration and interpretation of test equipment which, at best, provided only a coarse indication of the carrier level with poor repeatability and resetability. A new technique for recovering the relative RF output levels was then developed (Fig. 8) that allows accurate monitoring of the output carrier levels and accurate adjusting of these levels from a single display panel. Two similar receiver circuits are used to detect each carrier. Channel A receiver's local oscillator (LO) frequency is derived from multiplying the Block III exciter LO (66-MHz) frequency to 66 MHz above Block III carrier frequency. The receiver LO frequency is then mixed with a sample of the transmitter output. The resulting complex signal is passed through a narrow bandpass filter. The resulting signal represents the relative Block III carrier level. Channel B uses a similar receiver with local oscillator frequency 44 MHz above Block IV carrier frequency and a 44-MHz filter to provide Block IV carrier level indications.

The output of each filter is connected to a power meter, which is converted to a three-digit BCD number in the exciter switch monitor. It is then transmitted (as described in Section IV) for display at the two dual-carrier display panels (Fig. 3) as channel A and channel B. The same display contains "raise" and "lower" controls for the two carriers, greatly simplifying calibration. Also, each channel can be checked against the transmitter waterload calorimeter reading displayed on the same panel.

III. Exciter Switch Monitor Assembly (Fig. 2)

The control and monitoring capabilities of the exciter switch are contained in the exciter switch monitor J-box, which is mounted in close proximity to the exciter switch, and two display panels located in the control areas. Serial interface between the exciter switch monitor and the display panel is used to minimize cabling, and optical isolators are used as line receivers to reduce ground loop problems and provide a 27-kHz bit rate over 610 m (2000 ft) of cable.

The interface between the exciter switch (Fig. 5) and exciter switch monitor is provided through a 61-pin connector carrying parallel and digital signals. The parallel analog signals represent power meter readings and power supply voltages. The parallel digital signals represent exciter switch switching configuration.

In addition to monitoring functions in the exciter switch, the monitor samples status and level indications from the high-power transmitter and provides both operational and diagnostic information, which is available on the dual-carrier and diagnostic display panels located in the control areas.

IV. Exciter Switch Monitor Circuit Description

The exciter switch monitor accepts 208 (0 to 5 V) analog signals and 208 (0 V = logic "0," +5 volts = logic "1") digital signals, and multiplexes these parallel lines into 208 channels, 24 bits wide. Each 24-bit channel contains 11 bits of address information, 12 bits (3 BCD digits) corresponding to the analog input signal, and 1 bit representing the logic state of the digital input line. The 24-bit word is latched into a shift register and shifted into the accumulator register of a programmable calculator, where it can be used for input to the calculator or replaced with the calculator output. It is then serially shifted out of the exciter switch monitor and into the display panels in the control areas. The synchronous transmission technique requires that a clock and latching pulse accompany the data over a three-pair cable.

The data are shifted serially through the display panels, with each display panel acting as a driver for the next. Within the display panel, decoding logic is enabled during occurrence of the latch pulse, allowing data to be stored by the addressed display and ignored by all other displays.

References

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2. Smith, R. H., "Data Collection System for the Dual-Carrier Exciter," in *The Deep Space Network Progress Report,* Technical Report 32-1526, Vol. XV, pp. 63–65, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1973.
3. Smith, R. H., "10-W S-Band Amplifier," in *The Deep Space Network Progress Report,* Technical Report 32-1526, Vol. IX, pp. 196–200, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1972.

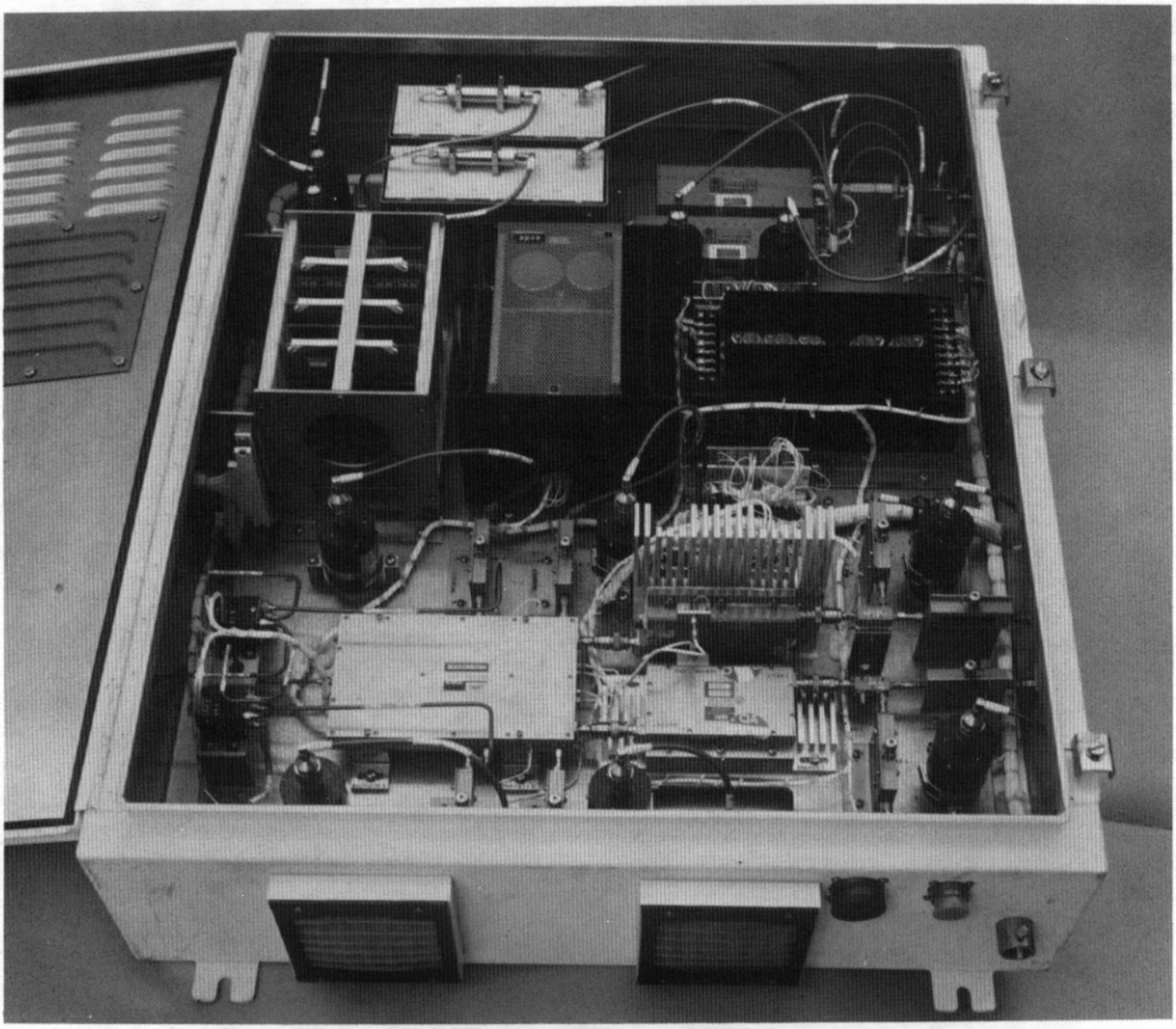

Fig. 1. Exciter switch assembly

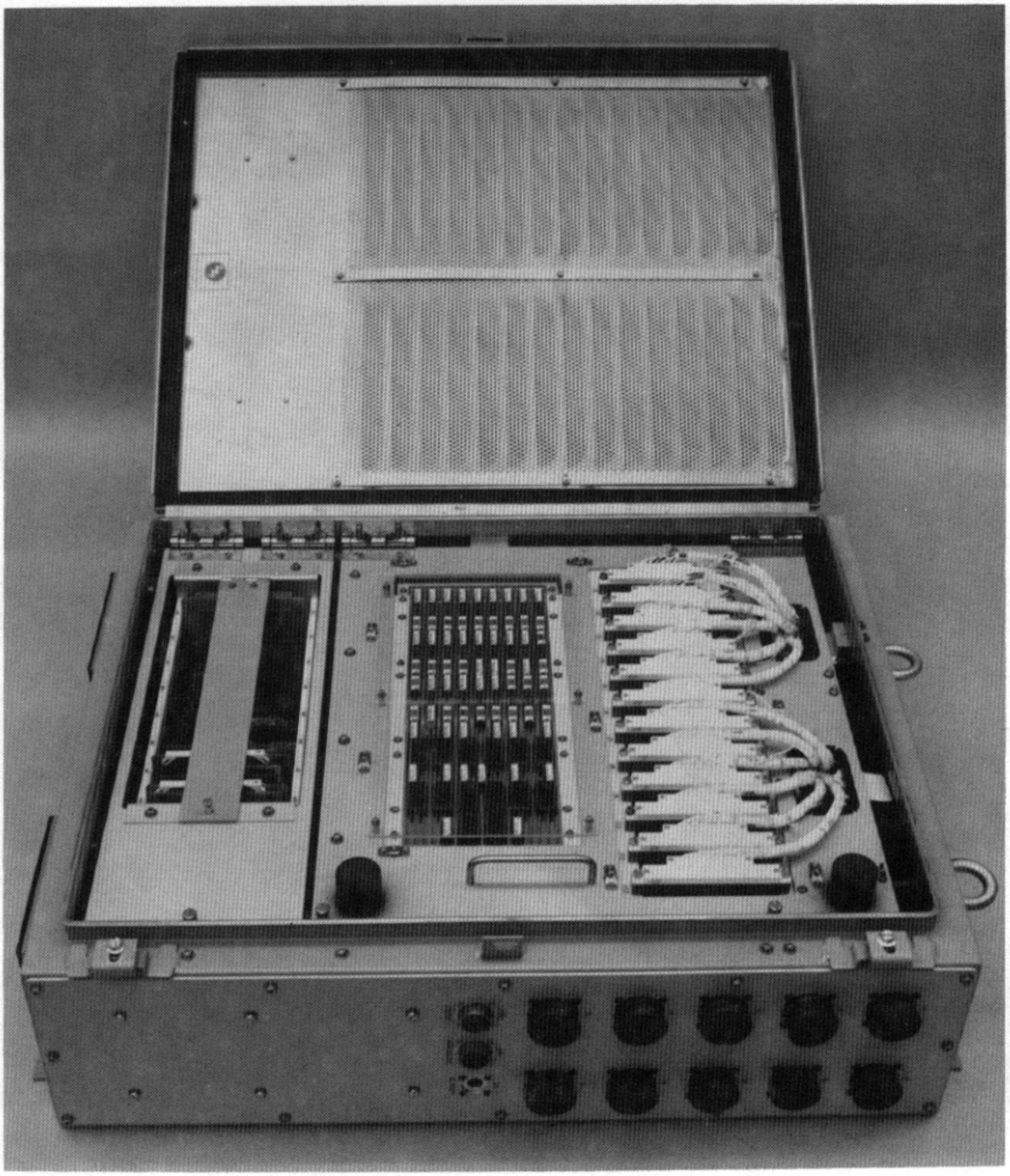

Fig. 2. Exciter switch monitor assembly

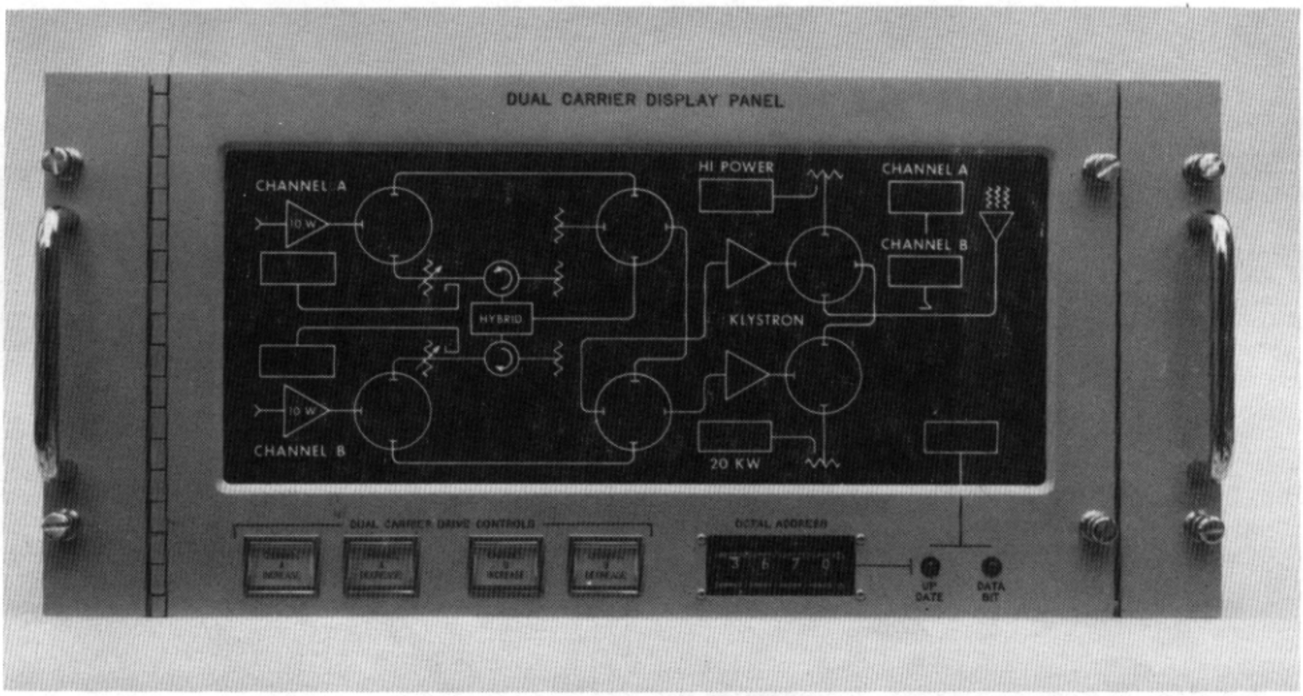

Fig. 3. Dual-carrier display assembly

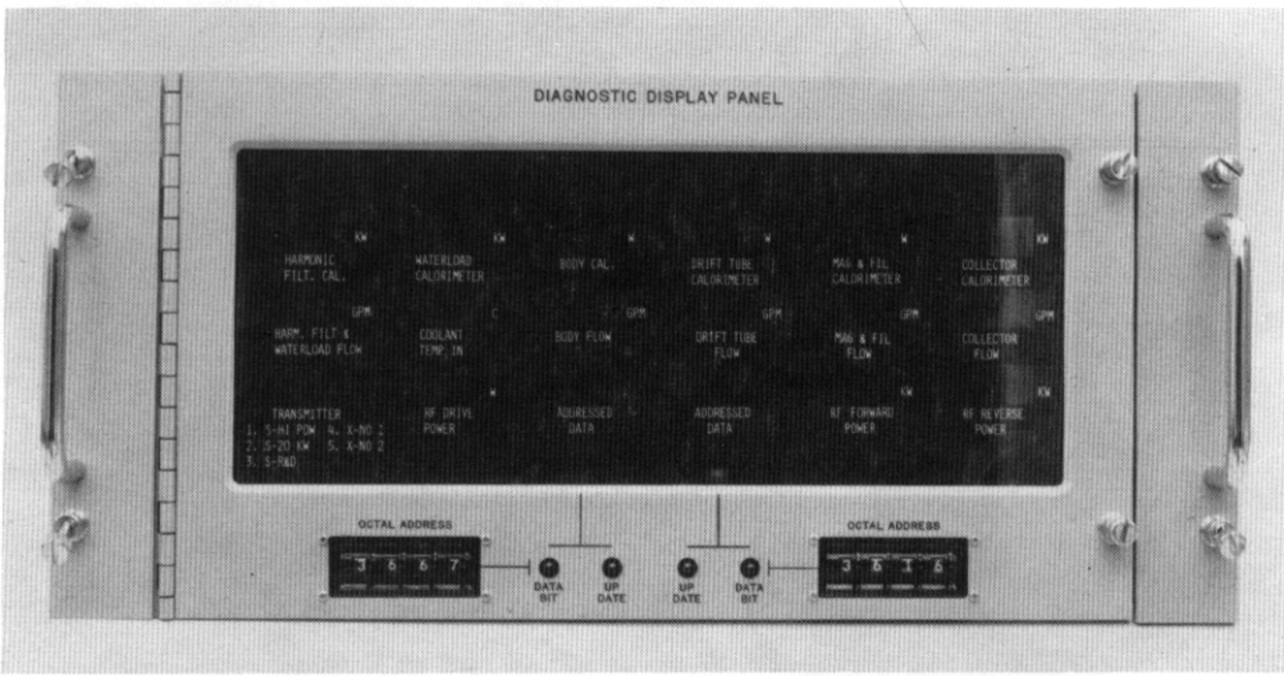

Fig. 4. Diagnostic display panel

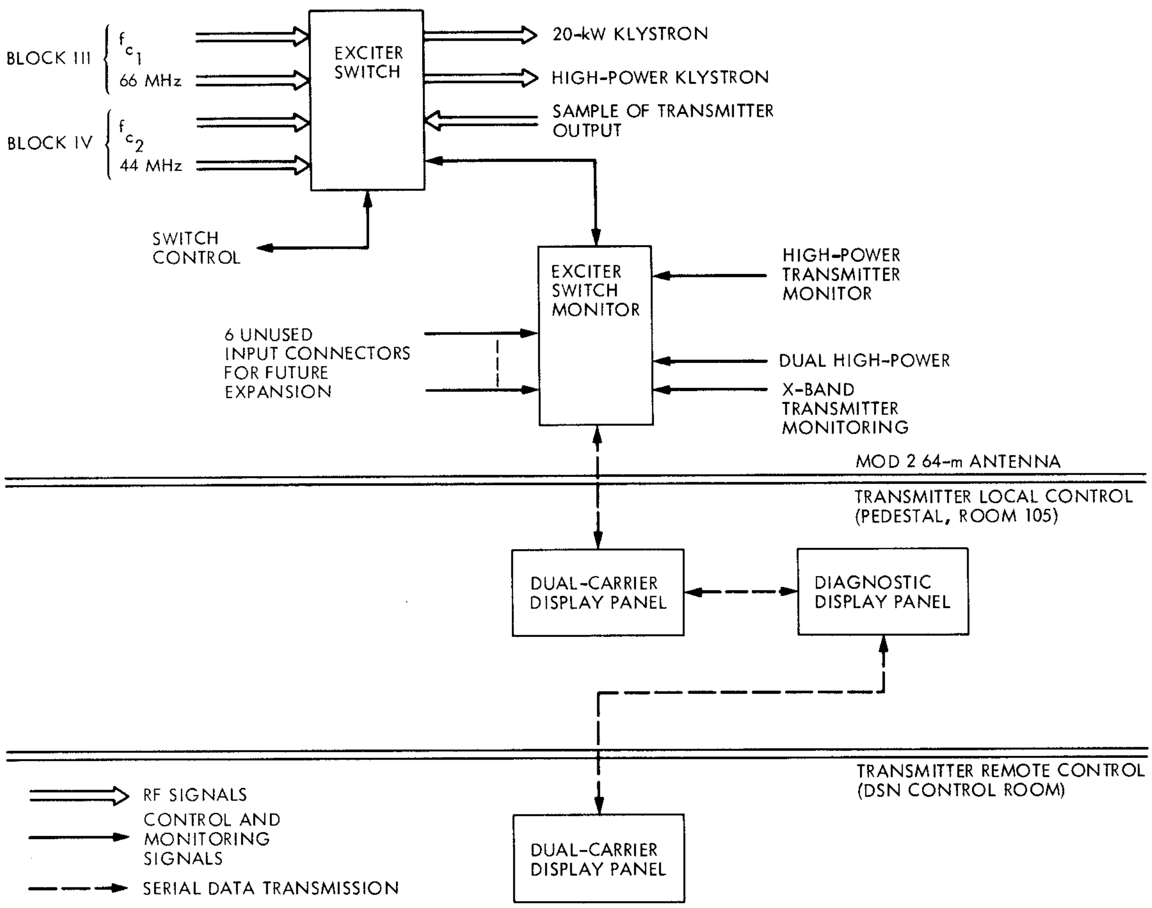

Fig. 5. Exciter switch interconnect

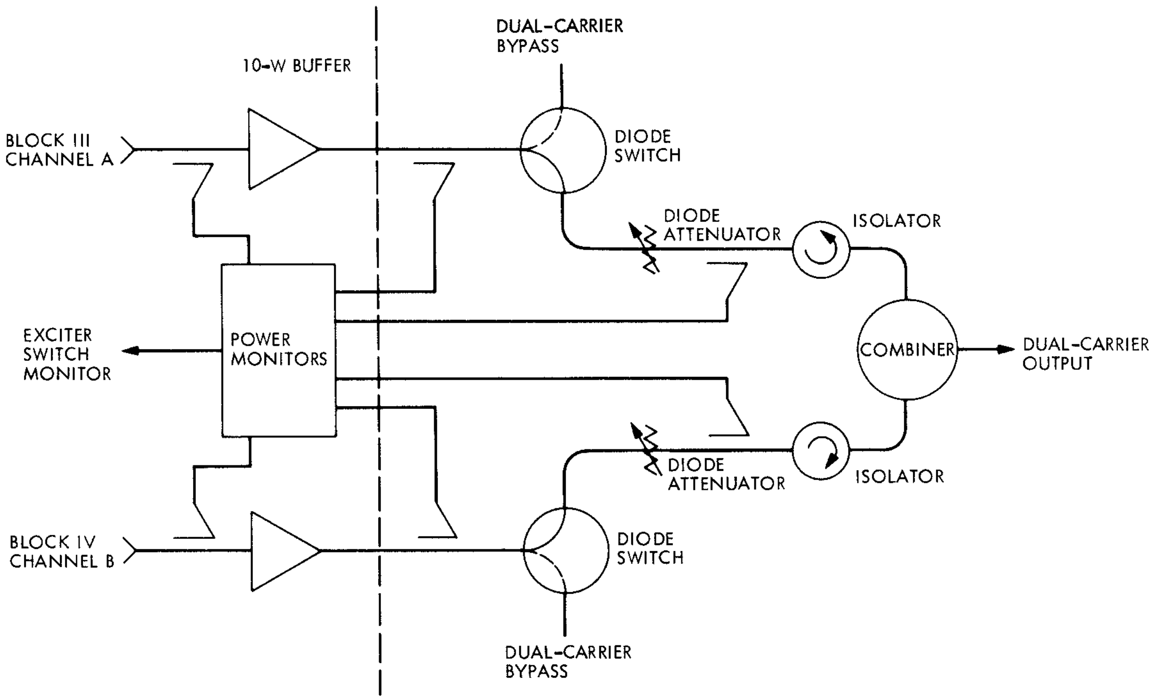

Fig. 6. Hybrid combiner

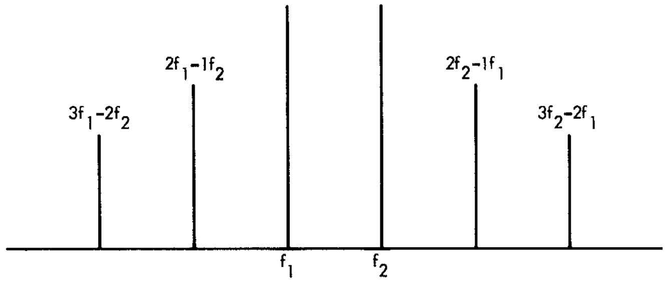

Fig. 7. Transmitter output spectrum

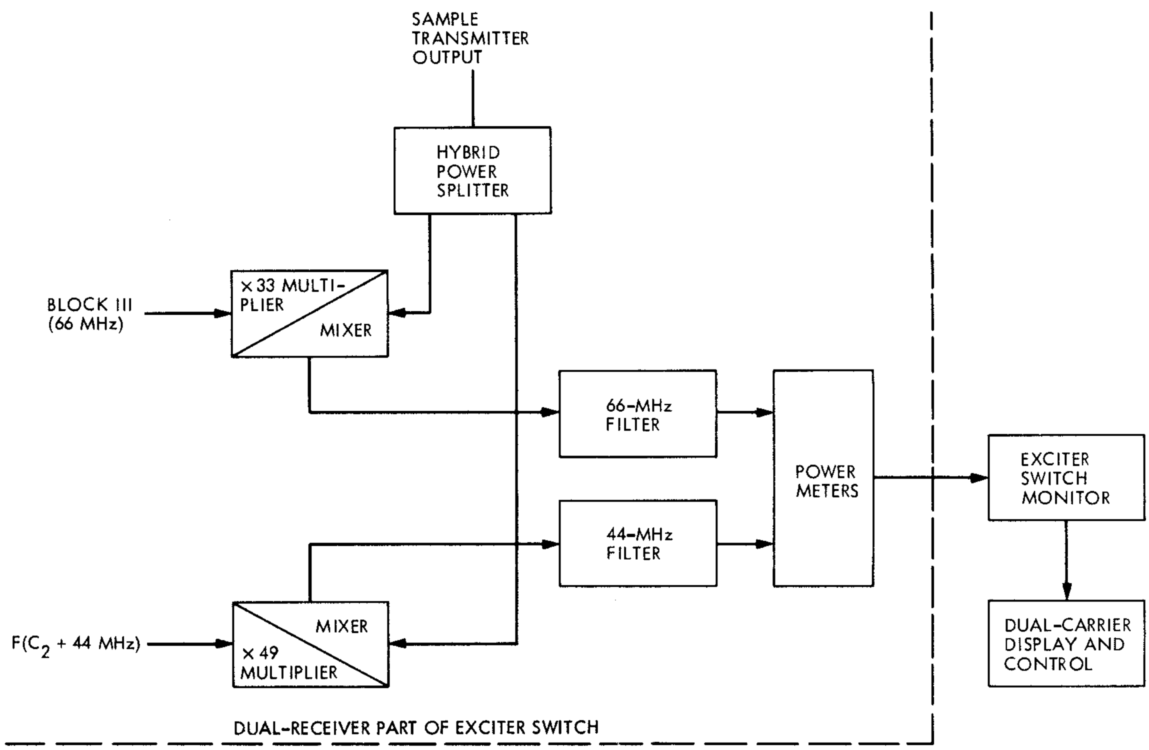

Fig. 8. Dual-carrier calibration receivers