J68386J, K, L, M, N, AND P TRANSMITTER-RECEIVER BAYS

DESCRIPTION

TD-3D MICROWAVE RADIO

CONTENTS PAGE

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CONTENTS PAGE

CONTENTS PAGE

1. INTRODUCTION

1.01 This section describes the TD-3D type J68386J, K, L, M, N, and P repeater and main station transmitter-receiver (T-R) bays of the TD-3 Microwave Radio System. An overall functional and physical description of the T-R bays is given in Part 2. Part 3 describes the hot standby (HS), hot standby/space diversity (HS/SD), and space diversity applications. Parts 4 through 25 describe each of the major units of the bays. The functional descriptions are limited in scope to block diagram type descriptions. For more detailed information, refer to the applicable schematic drawings (SD) listed in Part 26 of this section.

1.02 This section is reissued to include descriptive information on the 45-megabits per second (Mb/s) digital channel to the TD-3D microwave radio. Revision arrows are used to emphasize significant changes.

2. GENERAL

A. Brief Description of TD-3 Microwave Radio System

2.01 The TD-3 Microwave Radio System is intended primarily for high-capacity, long-haul routes carrying multichannel telephone, television, carrier telegraph, high-speed data, or other broadband signals. The system operates in the common-carrier frequency band between 3700 and 4200 MHz. Radio stations are spaced typically 20 to 30 miles apart, and are placed at locations and elevations suitable for line-of-sight transmission. At a loading of 1200 to 1800 message circuits per radio channel, the system meets the current Bell System noise objective of 41-dBrnc0 worst circuit noise for a 4000-mile system during nonfading conditions.

2.02 On a fully equipped route, 12 broadband radio channels are provided in each direction of transmission. These channels are normally used as eleven working and one standby protection channel. Half of these channels are vertically polarized and the other half horizontally polarized in an interstitial arrangement described by the TD-( ) frequency plan. The current maximum capacity of each channel is 1800 message circuits or one monochrome or National Television System Committee (NTSC) color television signal with diplexed audio subcarriers. Thus, a fully equipped route handling only telephone traffic can carry 19,800 message circuits. Provision is made for dropping or adding baseband signals through FM terminal equipment at main stations.

2.03 ➧When equipped for TD-45A digital operation, the TD-45A system operates in conjunction with an all solid-state TD-3D microwave radio route. The system is designed to operate at any assigned frequency within the 4-GHz band, allowing the channel to coexist with analog FM channels on the same radio route. The TD-45A radio bays use a 660( )-type amplifier with the IF input power to the up-converter reduced to give linear operation at about +25 dBm (approximately 0.32W) of output power. In the receiver, the IF power levels are reduced to achieve linear operation of the IF preamplifier and the IF main amplifier. To ensure the linearity, an adaptive IF amplitude slope equalizer (ADP1) is used. Additional filters are added in order to meet channel interference requirements. This 45-Mb/s digital channel will be used for data transmission.➧

2.04 The TD-3D transmitter-receiver bay is electrically and mechanically compatible with the TD-2, TD-3, and TD-3A transmitter-receiver bays, which are no longer being manufactured. The TD-3D equipment will interface properly into bay lineups of the earlier equipment that are not complete.

2.05 Provision is made for an application of the transmitter-receiver bay in either a hot standby (HS) only or hot standby/space diversity arrangement. These arrangements provide protection in systems having only one or two regular radio channels and no frequency diversity protection channel.

2.06 Test access points, called monitor-shutter assemblies, are provided in the receiver and transmitter for connecting both a portable microwave repeater and the transmitter-receiver bay test set without opening the waveguide.

B. Overall Description of Transmitter-Receiver (T-R) Bays

General

2.07 The microwave transmitter, microwave receiver, microwave generator, and power unit(s) constitute the basic building blocks for both the main station and repeater station type T-R bays. The transmitter and receiver are of the heterodyne type, operating between the microwave frequencies of the radio channel and the 70-MHz IF frequency. The transmitted and received microwave frequencies differ by 40 MHz on the same channel.

2.08 In a repeater station bay (Fig. 1), the microwave receiver and transmitter serve one direction of transmission only. The IF output of the receiver is connected directly to the IF input of the associated transmitter. A single microwave generator and a single low-voltage (−19 volts) power unit serve both the receiver and transmitter. The microwave generator provides the local oscillator frequency required for the transmitter. A 40-MHz oscillator—shift modulator circuit is used in the receiver to shift by 40 MHz a portion of the generator output to obtain the local oscillator frequency required for the receiver.

2.09 In a main station bay (Fig. 2), the microwave receiver and transmitter serve opposite directions of transmission. The IF output from the receiver and the IF input to the transmitter are connected to IF switching, patching, and distribution circuits in the station. The bay uses one microwave generator and one low-voltage power unit for the receiver and a second generator and power unit for the transmitter to provide independent operation for the two directions of transmission. This arrangement improves overall system reliability and facilitates main station bay maintenance. Since separate generators are used, the 40-MHz difference required between the receiver and transmitter local oscillator frequencies is obtained by using generators which differ in output frequency by 40 MHz. This eliminates the need for a 40-MHz oscillator—shift modulator in a main station receiver. In almost all other respects, the main station bay is identical to the repeater station bay.

2.10 The T-R bay uses semiconductor devices in all its active circuits when the bay is equipped with a 660( ) integrated circuit (IC) transmitter amplifier. Electron tubes (416-type) are used in the T-R bay if equipped with the J68330K transmitter amplifier. Unless otherwise indicated, all waveguide portions of the T-R bays use WR-229 size waveguide. All IF circuits are 75-ohm input and output impedance and are interconnected with type 731A coaxial cable.

Functional Description

2.11 The following descriptions of the microwave receiver, microwave transmitter, and microwave generator output power distribution circuit are concerned primarily with the functional operation of the equipment. In the illustrations associated with the descriptions, the functional block diagram is placed alongside an equipment layout diagram with corresponding elements of both diagrams oriented the same way. This is done to pictorially correlate the signal flow with the equipment arrangement of the various components in the bay. An overall block diagram of the T-R bay is shown in Fig. 57. ♦Figure 58 shows a block diagram of the T-R bay equipped for 45-Mb/s digital operation.♦

2.12 Because of the similarity of the signal paths in the repeater station and main station bays, only the repeater station bay is described in the paragraphs that follow. However, some of the differences between the two types of bays that were noted in paragraph 2.09 are mentioned again where appropriate.

Microwave Receiver

2.13 The microwave receiver selects an input signal from one of the 24 radio channels in the 3700- through 4200-MHz frequency range. At each station, the receiving antenna for each direction of transmission receives up to six horizontally polarized and six vertically polarized channels. The channels are separated in the antenna system by polarization and are applied through rectangular waveguide to separate T-R bay lineups, one for each polarization. Thus, each bay lineup may contain up to six T-R bays, one for each received channel of the particular polarization. The 2A circulator and bandpass filter combination (Fig. 3) in each T-R bay selects a specific channel for application to the associated receiver and passes on to the succeeding T-R bays any remaining received channels outside the selected band. The received signal is passed through the bandpass filter which provides the RF discrimination (selectivity) against out-of-band signals that is required at the receiver input.

2.14 A 652A integrated circuit RF preamplifier (not shown in Fig. 3) may be used in the common receiving waveguide run ahead of the 2A circulator and bandpass filter combination. The 652A RF preamplifier, which is common to all the receiving channels in a 6-bay lineup, has a typical insertion gain of 10 dB when powered and a maximum of 10-dB insertion loss when unpowered. Because of its low noise figure (typically 1.8 dB), the 652A RF preamplifier offers a means of improving the system noise

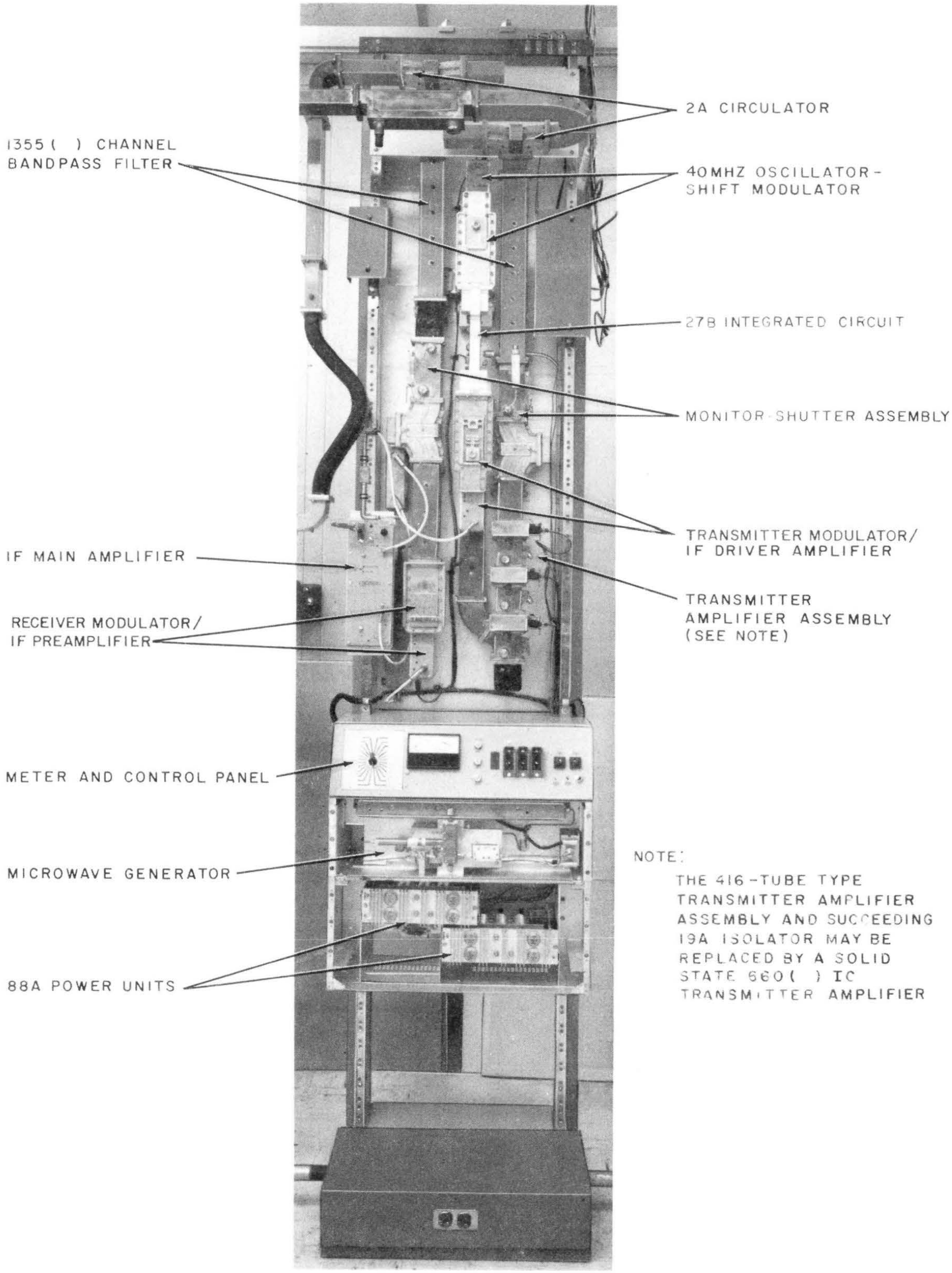


Fig. 1—J68386J Repeater Station Bay

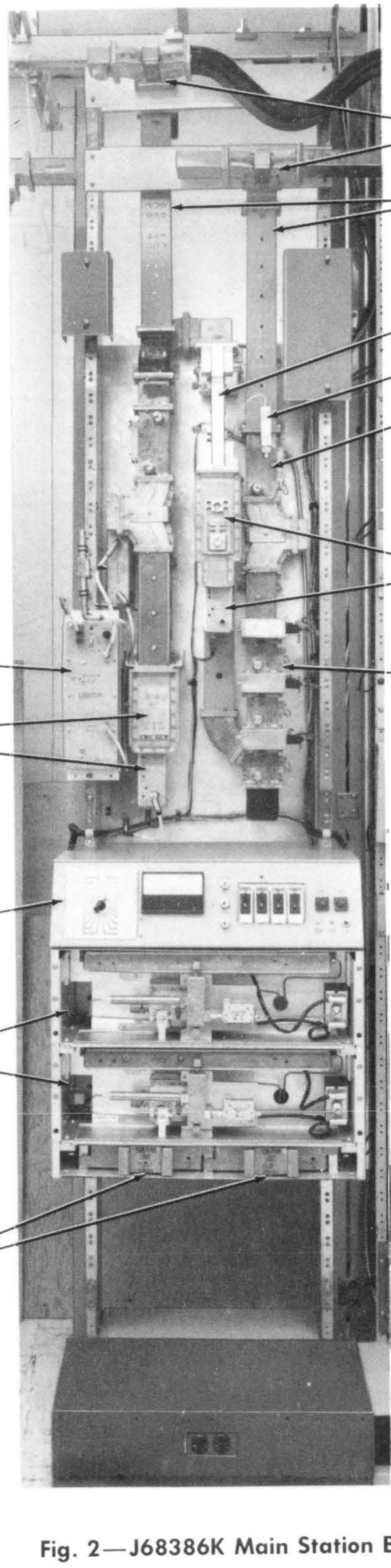


Fig. 2—J68386K Main Station Bay

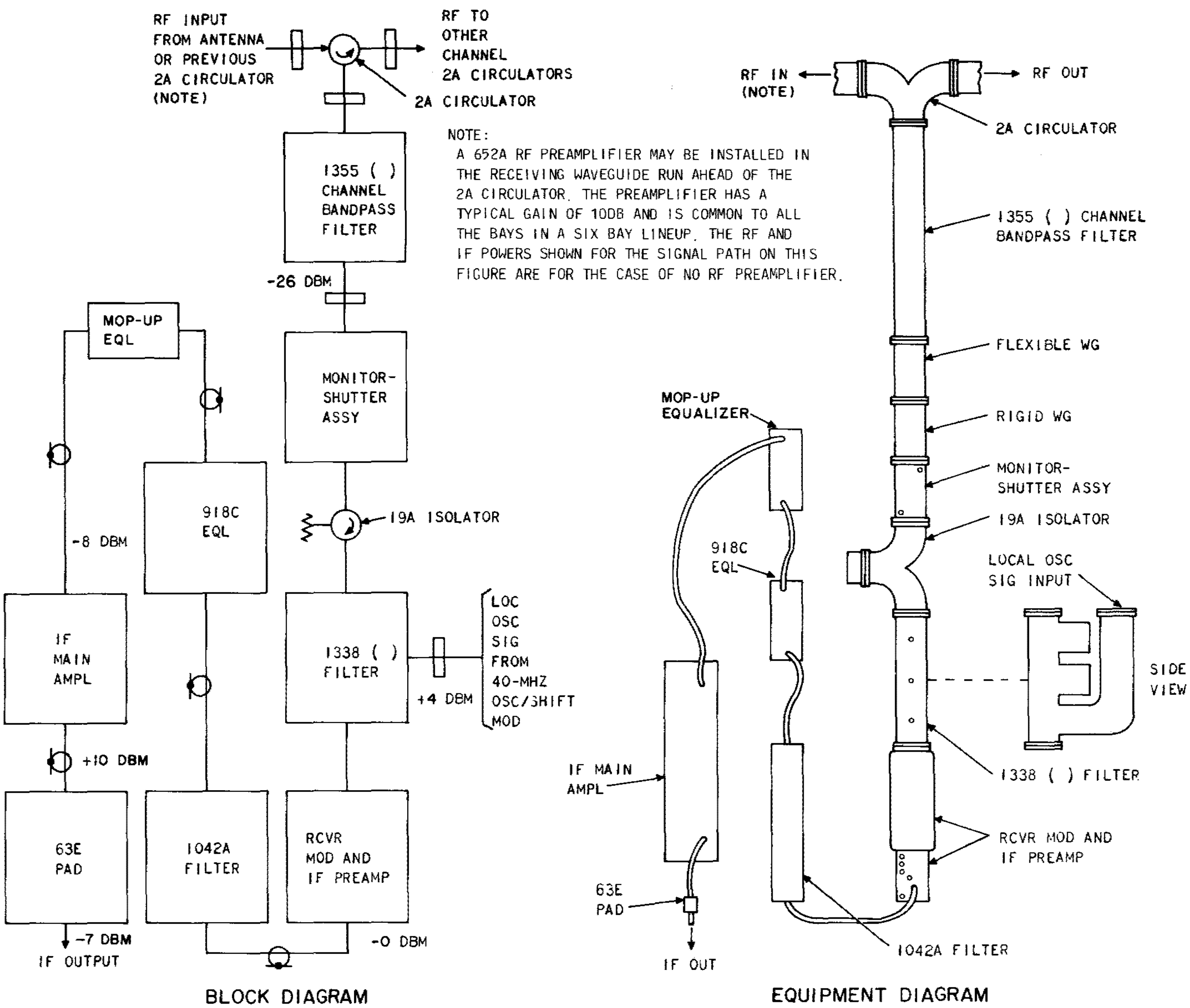


Fig. 3—Microwave Receiver—Functional and Equipment Diagrams—Repeater Station

performance and fade margin; improvements that can be taken advantage of when increasing the message circuit loading. One example is that with the use of the 652A RF preamplifier, existing radio bays with 1200 message circuit capability may be converted to 1800 message circuit capability without increasing the transmitter output power to 5 watts. Conversely, transmitters operating at 5-watt output power may be reduced to 2-watt output power without degrading the noise performance when the preamplifier is utilized. See Part 25.

2.15 The output of the channel bandpass filter, shown in Fig. 3 and 4 at a typical level of −26 dBm, is passed through a monitor-shutter assembly and an isolator to the band-rejection segment of a directional filter. One function of the isolator is to provide a good return loss over a wide bandwidth at the output of the channel bandpass filter to prevent undesirable impedance interactions between the bandpass filter and the directional filter. The local oscillator signal from the 40-MHz oscillator—shift modulator is applied to the bandpass segment of the directional filter. (The local oscillator signal in a main station receiver comes directly from a microwave generator instead of from the 40-MHz oscillator—shift modulator.) The received and local oscillator signals differ in frequency by 70 MHz. Both the band-rejection filter and the bandpass filter segments of the directional filter are tuned to the local oscillator signal frequency. The band-rejection filter directs virtually all of the local oscillator signal toward the receiver modulator; the filter loss, together with the reverse loss of the isolator, provides high attenuation to that component of the local oscillator signal directed toward the antenna to prevent it from causing interference in other channels. The bandpass filter portion of the directional filter serves to direct virtually all of the received signal toward the receiver modulator and prevents all but a negligible portion of the signal from entering the local oscillator path.

2.16 ♦If the 45-Mb/s channel is adjacent to an analog FM channel, both the 45-Mb/s channel

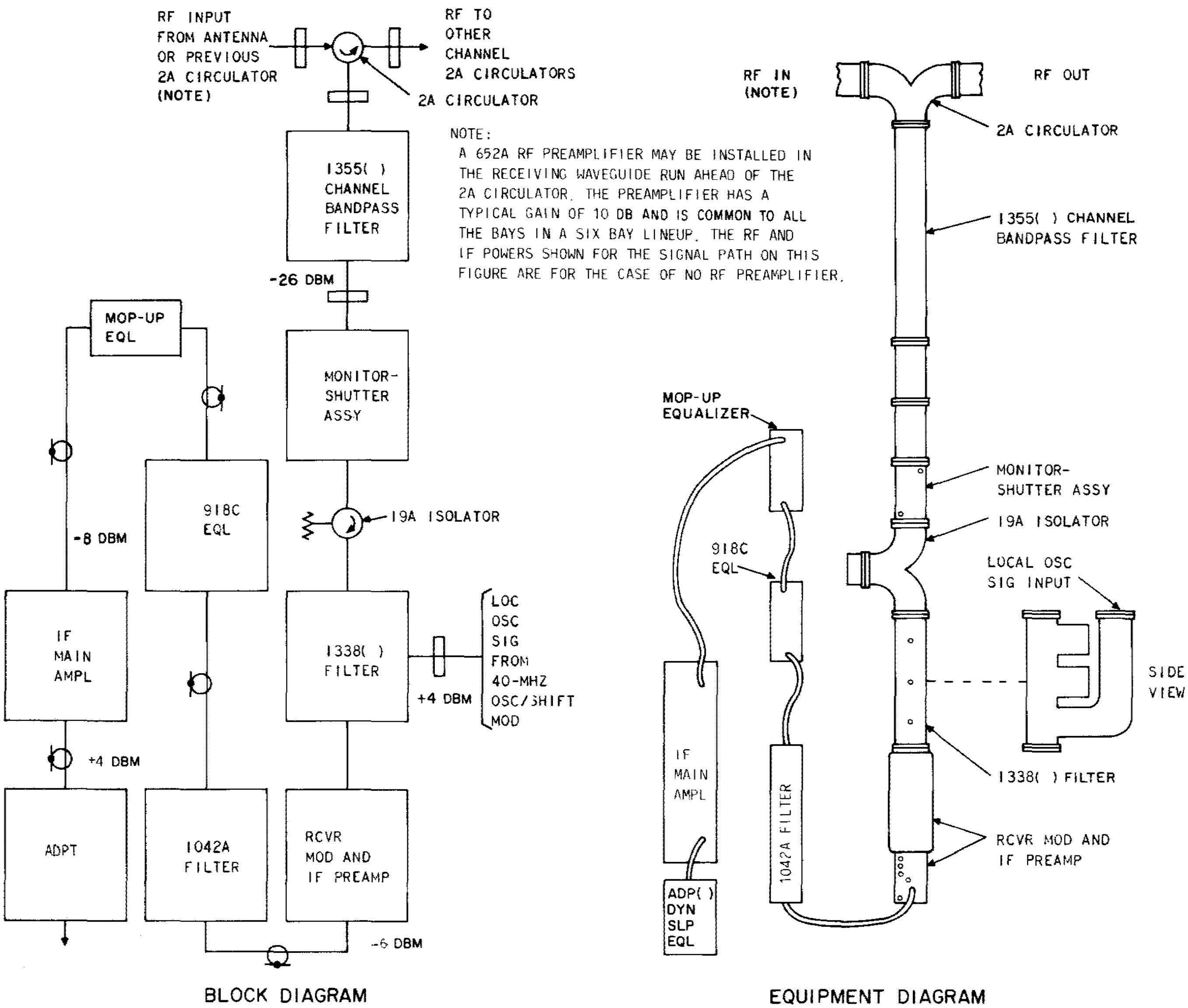


Fig. 4—♦Microwave Receiver—Functional and Equipment Diagrams—Repeater Station—Equipped for 45-Mb/s Digital Operation♦

(i.e., ±20 MHz away) and the adjacent analog FM channel must use the TD-2 IF filters (types 574 and 1080A) to meet the adjacent channel interference requirements. Any TD radio channel that is carrying FM message circuits shall have a 1525-type waveguide bandpass filter added to the receiver if the following exist:

(a) Without space diversity and located 80 MHz lower in frequency than a 45-Mb/s digital channel in the same lineup or,

(b) With space diversity and located either 80 MHz higher or lower in frequency than a 45-Mb/s digital channel in the same lineup.◀

2.17 The combined local oscillator and received signal output from the directional filter is applied to the input of the receiver modulator. The receiver modulator is an unbalanced-type downconverter which uses a single Schottky-barrier diode as the mixing element. The two RF input signals are mixed (or modulated) together in the diode, and the 70-MHz difference frequency product which is generated forms the desired IF output signal. This IF output signal is applied directly to the IF preamplifier. The preamplifier gain normally is adjusted to provide an IF output power, under nonfading conditions, of 0 dBm if there is no RF preamplifier in the common receiving waveguide run, or +3 dBm if an RF preamplifier is used.

2.18 The output from the preamplifier is applied to the IF main amplifier through an IF bandpass filter, a 918C equalizer (in most bays), and, if required, a delay slope mop-up equalizer. The IF bandpass filter passes the IF band of frequencies between about 60 and 80 MHz with very little transmission distortion but provides high attenuation to the region of 50 and 90 MHz. These out-of-band loss peaks further increase the overall selectivity of the receiver to protect it and the succeeding transmitter from the effects of adjacent channel carriers. The filter also attenuates the second- and third-order harmonics of the IF signal generated in the IF preamplifier. If not suppressed, these harmonics would generate excessive cross-modulation noise in the IF main amplifier.

2.19 The 918C equalizer was intended to equalize the nominal parabolic-type delay distortion of the radio hop. For this reason, the 918C equalizer has been referred to on drawings and other documents as the basic equalizer required for each hop. However, experience has shown that the 918C tends to overequalize the hop, with the result that only two equalizers are required for approximately every three hops. Hence, the 918C now is being treated as a mop-up rather than a basic equalizer.

2.20 The provision for, and administration of, the delay slope mop-up equalization for the radio channel follows the current practices for TD-2 and TD-3. In all cases, the type and magnitude of the mop-up equalization required is determined from measurements of the overall radio channel in each IF protection switching section. For TD-3D bays used on existing TD-3 routes or on new routes, provision has been made in each receiver for adding one delay slope mop-up equalizer ahead of the IF main amplifier. This permits the mop-up equalization to be distributed among the receivers within the switching section as is the practice in TD-3. In many cases, particularly in switching sections of only a few hops, only a single mop-up equalizer may be required; this normally will be mounted in the last receiver at the receiving main station. For TD-3D bays used on existing TD-2 routes, the mop-up equalization normally will be installed in the IF amplifier and equalizer bay or other type of bay used for this purpose in the TD-2 main stations.

2.21 Because of the filter and equalizer losses, the level of the signal applied to the IF main amplifier under nonfading conditions is about 8 dB lower than the output of the IF preamplifier. The IF main amplifier has an automatic gain control (AGC) circuit to maintain an output of approximately +10 dBm for inputs as low as −48 dBm. Thus, when the input signal is −8 dBm, corresponding to the case of 0 dBm output from the IF preamplifier, the normal (nonfaded) gain of the IF main amplifier is 18 dB, and the output is maintained at approximately +10 dBm for fades up to 40 dB. Any further reduction of the input signal level (below −48 dBm) results in a corresponding reduction of the IF main amplifier output signal level. ▶For 45-Mb/s digital operation, the operating point of the receiver is reduced for more linear operation. All of the power levels (dBm) given in this paragraph must be reduced by 6 dB for 45-Mb/s operation. The dB values remain the same.◀

2.22 An IF carrier resupply is provided in the IF main amplifier of each receiver. The resupply automatically inserts a pilot-modulated carrier in the event the normal carrier is lost, either because of an equipment failure or a very deep fade. The reinserted carrier eliminates the problem of noise spillover into the adjacent channels which otherwise would occur if the succeeding repeaters were to go to full gain with only their own noise as an input signal. The pilot modulation on the reinserted carrier permits the IF protection switching system to distinguish the reinserted carrier from a normal signal. The carrier resupply is not used in hot standby/space diversity systems. It is disabled by means of a front panel adjustment for these applications.

2.23 Provision has been made for mounting a lowpass filter at the output of the IF main amplifier in a main station receiver. The purpose of this filter is to attenuate the second and third harmonics of the IF signal generated in the IF main amplifier. If not attenuated, these harmonics can cause envelope delay distortion ripple and associated crossmodulation noise by recombining with the 70-MHz signal in the FM terminal receiver or other active circuits that follow the radio receiver in a main station. The filter is not required in a repeater station receiver, in which the IF output normally is connected directly to the transmitter input via a short cable and an appropriate value IF pad.

2.24 Some radio channels carrying TV or message service for long distances may go through several individual switching sections. In some cases, especially when the channel is carrying 300 message circuits in mastergroup 3 (1500 message circuit loading), the overall baseband response and noise requirement may not be met even though each individual switching section meets its requirement. This is due to the cumulative effects of the variation in each switching section. Provisions have been made for adding an IF amplitude equalizer amplifier at the output of the IF preamplifier in the last main station receiver in long switching sections to compensate for baseband roll-off or roll-up. The J68330Y IF amplitude equalizer amplifier consists of an amplifier and an adjustable, parabolic-shaped, amplitude equalizer. The amplifier compensates exactly for the loss of the equalizer at 70 MHz, thereby giving a net loss of 0 dB for the overall unit at the IF center frequency. The loss of the equalizer at 60 and 80 MHz can be adjusted approximately ±3 dB relative to the loss at 70 MHz, thereby providing amplitude equalization.

2.25 The output from the microwave receiver, at a power of −7 dBm, (TD-3 stations) or +10 dBm (TD-2 stations), is applied to an FM receiver at a main station (normally via an IF protection switching system and a patch and access bay) or to the IF driver amplifier—transmitter modulator in the transmitter of a repeater station. ➧For 45-Mb/s digital operation, the output from the microwave receiver is at a power of 0 dBm and is applied to a digital receiver at a main station (normally via an IF protection switch system and a patch and access bay) or through an attenuator to the IF driver amplifier-transmitter modulator in the transmitter of a repeater station.➧

Microwave Transmitter

2.26 The input to the transmitter (Fig. 5) is an IF signal originating from the FM terminal equipment or from a previous receiver. ➧For 45-Mb/s digital operation, the input to the transmitter (Fig. 6) is an IF signal originating from the digital terminal or from a previous receiver.➧ The IF signal, at a nominal level of −7 dBm, is applied to the amplifier section of the IF driver amplifier—transmitter modulator. ➧For 45-Mb/s digital operation, the power level is approximately −12 dBm.➧ The purpose of this circuit is to shift (or "up-convert") the IF signal to the transmitter channel frequency. The driver amplifier raises the level of the IF signal and applies it to the transmitter modulator.

2.27 The local oscillator signal for the transmitter modulator, at a frequency either 70 MHz above or below the transmitter channel frequency, is obtained from a microwave generator. The microwave generator provides a signal to the 27B integrated circuit which is split into two directions. One of the signals is fed to the 40-MHz oscillator—shift modulator and is shifted by 40 MHz. The modulator output is then fed to the directional filter on the receiver side of the repeater. The other portion of the microwave generator signal is applied to the transmitter modulator where it is mixed (modulated) with the IF signal. The output products of the modulator include signals centered at the local oscillator frequency plus 70 MHz and the local oscillator frequency minus 70 MHz. These outputs are returned through the 27B to a bandpass filter which passes the desired frequency and rejects all others.

2.28 The output of the bandpass filter is applied to the transmitter amplifier where it is amplified to the power required for transmission. The transmitter amplifier is either a 3-stage, electron tube-type amplifier, or a completely solid-state 660( )

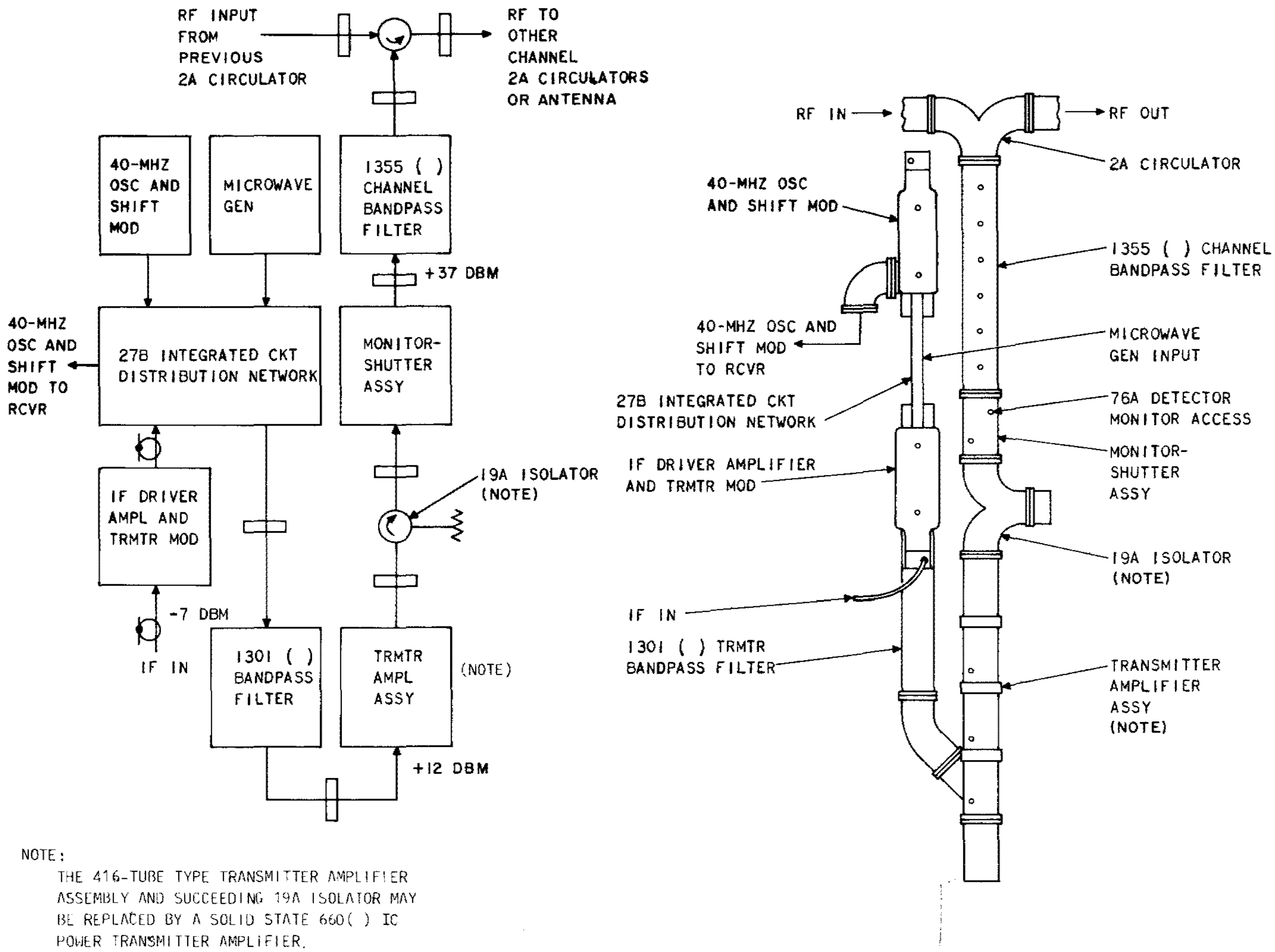


Fig. 5—Microwave Transmitter—Functional and Equipment Diagrams—Repeater Station

IC power amplifier. ♦For digital operation, only solid-state amplifiers are used.♦

2.29 The output signal is delivered through a bandpass filter—circulator combination which combines the signal, along with the signals from other channels, for delivery to the transmitting antenna. The bandpass filter provides additional selectivity required at the transmitter output. The bandpass filter—circulator combination permits connecting up to six radio transmitters, each separated by 80 MHz, in a common bay lineup.

2.30 The TD-3D transmitter can be operated at output powers of 5 watts (+37 dBm), 2 watts (+33 dBm) or 1 watt (+30 dBm), using either the 416 tube-type transmitter amplifier or the solid-state 660( ) IC transmitter amplifiers that were introduced, starting in 1979, as replacements for the tube-type amplifier. ♦For 45-Mb/s digital operation, the transmitter is operated at +25 dBm.♦

Equipment Description

2.31 The various applications of the TD-3D bay, both now and anticipated for the future, have resulted in three basic categories of bays:

(a) Nine-foot bays intended for channel additions on existing TD-2 routes

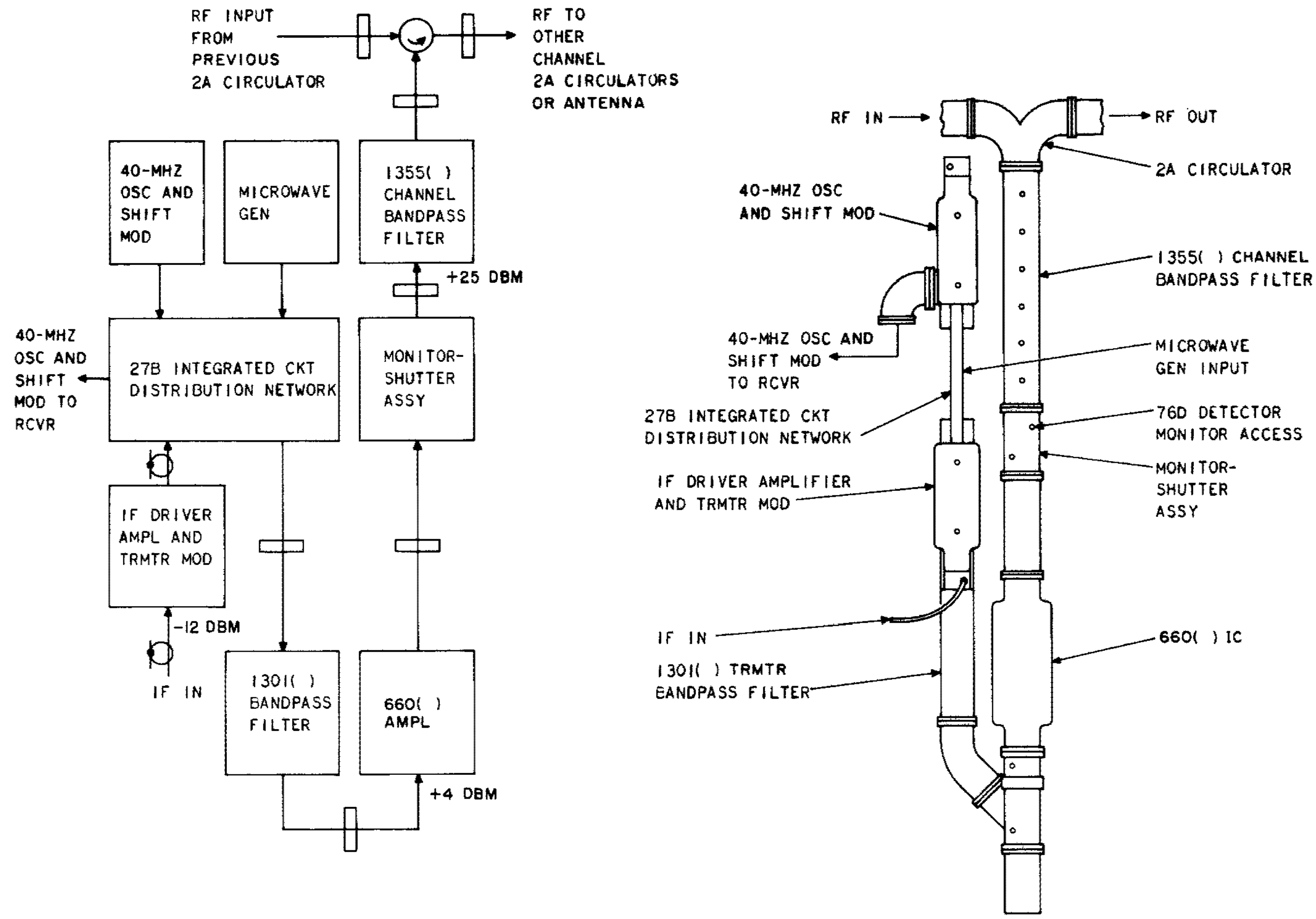


Fig. 6—♦Microwave Transmitter—Functional and Equipment Diagrams—Repeater Station—Equipped for 45-Mb/s Digital Operations♦

(b) Nine-foot bays intended for channel additions on existing TD-3 routes and for new routes where buildings are engineered for this height

(c) Seven-foot bays for new routes where the buildings are engineered for bays of this height.

2.32 The first two categories are necessary because of the equipment and dc powering differences that exist between TD-2 and TD-3. The third category is provided to meet the equipment arrangements possibly needed in the future for installations in low ceiling height buildings or shelters. Within each category, there is a main station bay for use at terminal and/or IF switching station locations and a repeater station bay for use at all intermediate stations between the main stations. The resulting six equipment codes are shown in Table A.

2.33 The TD-2 station bays (J68386J and J68386K) are assembled on a 19-inch, equal-flange, duct-type framework. This is the same framework as that used for the TD-2 (J68331B) bay. The vertical separation of the channel networks in these bays is the same as that of the networks in the TD-2 bay to simplify the waveguide connection to a TD-2 bay.

2.34 The TD-3 station bays (J68386L and J68386M) and the 7-foot bays (J68386N and J68386P) are assembled on the newer 19-inch, unequal-flange, duct-type framework that was used for the TD-3 and TD-3A bays. The vertical separation of the channel

TABLE A

EQUIPMENT CODES OF TRANSMITTER-REPEATER BAYS FOR TD-3D MICROWAVE RADIO

TRANSMITTER-RECEIVER		
REPEATER	MAIN	STATION BAY LOCATION
J68386J	J68386K	9-foot bay for channel additions on existing TD-2 routes
J68386L	J68386M	9-foot bay for channel additions on existing TD-3 routes and new routes
J68386N	J68386P	7-foot bay for new routes

networks in the 9-foot bay is the same as that in the TD-3 and TD-3A bays to simplify interconnection.

2.35 The J-drawings should be referred to for the detailed list information.

2.36 The control, alarm, and meter panel is mounted approximately waist high (in the 9-foot bay) and is slanted for ease of operation and visual observation. The panel forms the front of the housing for the control, alarm, and meter circuits. Access to the control, alarm, and meter circuits for visual inspection and maintenance purposes can be accomplished by removing five screws from the top cover.

2.37 The microwave generator(s) and power supply(ies) are located in a housing at the bottom of the bay below the control, alarm, and meter panel. Access to the microwave generator and power supply can be accomplished by removing four screws from the front panel on the housing.

3. HOT STANDBY, HOT STANDBY/SPACE DIVERSITY, SPACE DIVERSITY

A. General

3.01 The principal application of the TD-3D bay will be on new or existing (partially filled) radio routes having a growth rate or cross section sufficient to permit the use of a frequency diversity protection channel to protect the working channels. In those cases where a frequency diversity protection channel cannot be installed because of FCC regulations governing the minimum number of channels allowed to be protected by frequency diversity, the required system reliability can be achieved by using the TD-3D bay in a hot-standby-only or hot standby/space diversity arrangement.

3.02 In stations where hot-standby-only or HS/SD arrangements are used, the radio facilities for each channel are provided in duplicate at each station. One set of facilities, designated ***regular,*** is the normally used transmission path. The duplicate parallel facility, designated ***standby,*** constitutes a hot standby protection path. By means of automatic switch control, the standby equipment is substituted for the regular path in the station if the regular path fails.

3.03 Additional use of the hot standby radio receiver can be made at any station by connecting it to a separate receiving antenna. In this manner, the station is provided with space diversity protection for the air path in addition to the hot standby protection for the receiving equipment.

B. Radio Transmitter and Receiver Arrangements

Hot-Standby-Only Receiver Arrangement

3.04 In a hot-standby-only arrangement, (Fig. 7) the regular and standby are fed simultaneously from a common antenna. Under normal conditions, only the IF output of the regular receiver is used. The output of the standby receiver is used only if the regular receiver fails or must be removed from service for maintenance. Thus, the standby receiver will be connected into the transmission path very infrequently and probably for only a few hours, at the most, at any one time.

3.05 The infrequent use of the standby receiver has been taken advantage of in the design of the hot-standby-only receiver arrangement. As shown in Fig. 7, an 11.6-dB directional coupler, located in the receiving waveguide run just ahead of the bay lineup, is used to feed the regular and standby receivers. In this arrangement, the regular receiver is favored by being connected to the through or low-loss (0.3 dB) arm of the directional coupler. Thus, nearly the full received carrier power is delivered to the regular receiver. As a result, the thermal noise of the hop is virtually the same as that expected for a normal (nonhot standby) hop when the transmission path is through

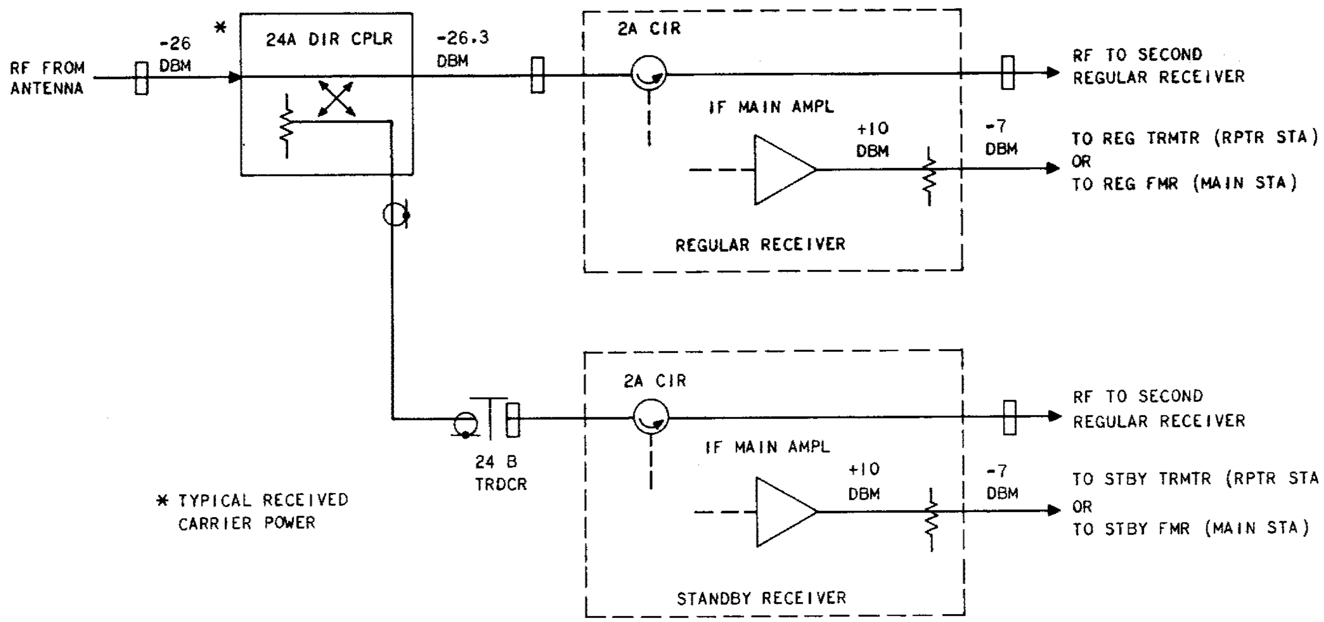


Fig. 7—Receiver Circuit for Hot Standby Only—Block Diagram

the regular receiver. The standby receiver, on the other hand, is connected to the sidearm of the directional coupler and sees effectively an 11.6-dB flat fade on the incoming signal. Therefore, on those occasions when the transmission path is via the standby receiver, the thermal noise contributed by the hop will be approximately 11 dB greater than normal. This somewhat poorer performance is acceptable because of the infrequent use of the standby receiver at any one repeater and because no more than one standby receiver is expected to be connected into the transmission path at any one time in a multihop system.

3.06 An alternate method may be used to obtain the input signals for the regular and standby receivers on short hops when the receive carrier power is −23 dBm or greater. In this method, a splitting hybrid is used in place of the directional coupler in the common waveguide run. When this method is used, the RF signal to both the regular and standby receivers will suffer a 3-dB loss.

3.07 Figure 7 illustrates a conventional arrangement in which the outputs of the regular and standby receivers are fed to the input of either the corresponding transmitter at a repeater station or the corresponding FM terminal receiver at a main station. For either of these cases, a failure of the regular receiver will be sensed by detection circuits in the succeeding equipment. The succeeding circuit, in turn, will switch to its standby path. Since this path is being fed by the standby radio receiver, the standby radio receiver thereby becomes switched into the transmission path. A somewhat different output circuit and switching arrangement (described in paragraphs 3.26 through 3.29) is required for the case where the hot-standby-only receivers are connected directly to an IF patch and access bay.

3.08 The IF carrier resupply is disabled for the HS and HS/SD applications because the probability of losing the transmitted carrier is extremely low (both the regular and standby transmitters would have to fail). To allow the carrier resupply to operate would unnecessarily complicate the switching logic which would have to recognize that a reinserted carrier, rather than a normal carrier, was inserted. For these applications, the carrier resupply is disabled by a simple front panel adjustment on the IF main amplifier and carrier resupply unit.

Hot Standby/Space Diversity Receiver Arrangement

3.09 For a HS/SD application, (Fig. 8) separate receiving antennas are provided for the regular and standby receivers. Typically, the diversity antenna is an 8-foot parabolic dish located about 30 feet below the regular (horn-reflector) receiving antenna. Under normal conditions, only the IF output of the regular receiver is used. In the event of a deep fade on the regular path or a failure of the regular receiver, the standby receiver automatically switches into the transmission path and the output from the regular receiver is muted. The switch occurs only if the standby receiver is sensed to be operating satisfactorily. If the revertive mode of operation of the switch control circuit has been chosen, a switch back to the regular receiver will occur when the regular receiver is sensed to have satisfactory output. If the nonrevertive mode has been selected, the transmission will remain on the standby receiver until the standby fades deeply or fails.

3.10 A pair of hybrids, mounted in the standby bay, provide a means of using the output of either receiver to feed either the regular and standby transmitters at a repeater station or the regular and standby FM receivers at a main station. The arrangement used for feeding an IF patch and access bay is described in paragraphs 3.26 through 3.29.

3.11 At any one time, the output from only one receiver is applied to the hybrids. The output from the other receiver is attenuated by at least 70 dB by a squelch gate in the output of the IF main amplifier of that receiver. The squelch gate operation is controlled by voltages supplied by the switch control circuit, which is located externally to the radio bays. The switch control circuit is supplied with information on the status of the regular and standby receivers by means of a HS/SD control circuit connected to the output of the automatic gain control amplifier within each IF main amplifier. The HS/SD control circuit furnishes the equivalent of a 0 or 1 logic signal to the switch control circuit.

3.12 When the carrier input to the IF main amplifier in the regular receiver drops approxi-

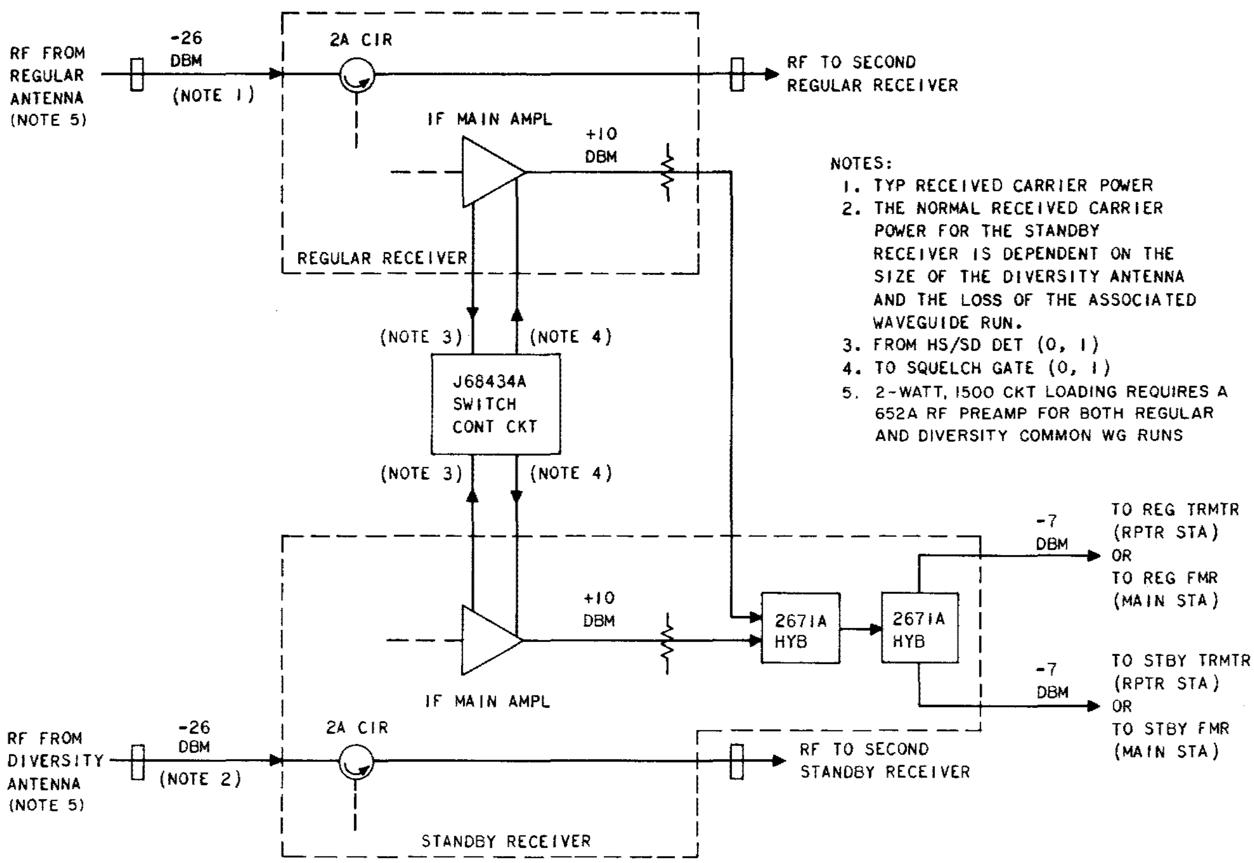


Fig. 8—Receiver Circuit for Hot Standby/Space Diversity Applications—Block Diagram

mately 35 dB or more below normal, either because of fading or equipment failure, the output from the HS/SD control circuit in that amplifier will change state. This change will be recognized immediately by the switch control circuit as a switch request. If, at the same time, the HS/SD control circuit in the IF main amplifier of the standby receiver is indicating satisfactory operation of the standby path, the switch control circuit will supply the necessary control voltages to squelch the IF main amplifier in the regular receiver and unsquelch the IF main amplifier in the standby receiver. By this means, the transmission is transferred to the standby path. The operation of the system will remain on standby (nonrevertive operation), or will return to regular when satisfactory transmission is restored through the regular receiver (revertive operation). The switching time from regular to standby is approximately 140 μs in the case of a sudden equipment failure and less than 4 μs under fading conditions.

Auxiliary Squelch Control for Hot Standby or Hot Standby/Space Diversity With Receiver Switching

3.13 An auxiliary squelch control circuit is provided for hot standby or hot standby/space diversity systems that use receiver switching. The auxiliary squelch control circuit is an applique unit which is inserted between the bay cable socket and the IF main amplifier power plug. One applique unit is required in each regular and standby receiver. The purpose of the circuit is to squelch noise that would otherwise build up in the remainder of the system in the event the RF signal to both the regular and standby receivers were to fail simultaneously. Normally, one receiver of a regular/standby pair is active, while the other is muted. A simultaneous failure of the RF signal to both receivers would result in noise buildup in the unmuted portion of the system. The auxiliary squelch circuit may be provided in hot standby/space diversity systems with and without IF access and hot-standby-only systems with IF access. In hot-standby-only systems, where receiver switching is not used, a feature is provided which will mute the active receiver in the event of loss of signal. This feature is implemented via an option in the IF main amplifier. This option, which is applied to both the regular and standby receivers, permits internal control of the squelch gate in the IF main amplifier. This is the same means used for squelching in frequency diversity systems.

3.14 When a fade of approximately 35 dB occurs to the RF input signal at either the regular or standby receiver, the HS/SD control lead in the IF main amplifier changes state. This causes the switch control circuit to gate off transmission through the affected IF main amplifier by operating the squelch gate and, at the same time, gate on the unaffected IF main amplifier, provided its IF input signal is not faded by more than 35 dB. A through connection is provided in the auxiliary squelch control circuit for the HS/SD control lead. Normally, the regular to standby switching operates whenever either input fades by 35 dB. However, when the fade reaches 40 dB, the output of the IF main amplifier then drops 1 dB for each 1 dB of fade. When the output has dropped 10 dB, to 0 dBm or lower, the logic signal from the carrier resupply control circuit in the affected IF main amplifier will change state. The auxiliary switch control circuit recognizes this change of state and operates the squelch gate in the affected IF main amplifier to gate off transmission. Thus, if the two input signals fail simultaneously and the regular receiver is providing transmission, the auxiliary squelch control circuit will squelch the receiver, while the standby receiver remains squelched under control of the external switch control unit. The point at which the HS/SD circuit changes state is adjustable by the HS/SD TRIP control. The point at which the carrier resupply circuit changes state is adjustable by the CRS TRIP control on the IF main amplifier. Different test arrangements are applied to the IF main amplifier so that the HS/SD TRIP and CRS TRIP points may be adjusted independently.

Hot Standby Transmitter Arrangement

3.15 The IF input to the HS transmitters (Fig. 9) is from either the HS or HS/SD receivers at a repeater station or from the regular and standby FM terminal transmitters at a main station. Under normal conditions, only the output of the regular transmitter is applied to the antenna. The output of the standby transmitter is terminated.

3.16 If the output of the regular transmitter decreases more than 3 dB, the output of the standby transmitter is switched automatically to the antenna connection and the output of the regular transmitter is terminated. The switching occurs only if the operation of the standby transmitter is sensed to be satisfactory.

Hot Standby Using the Electromechanical Switch

3.17 A 4-port, electromechanical, latching coaxial switch, located in the output circuit of the reg-

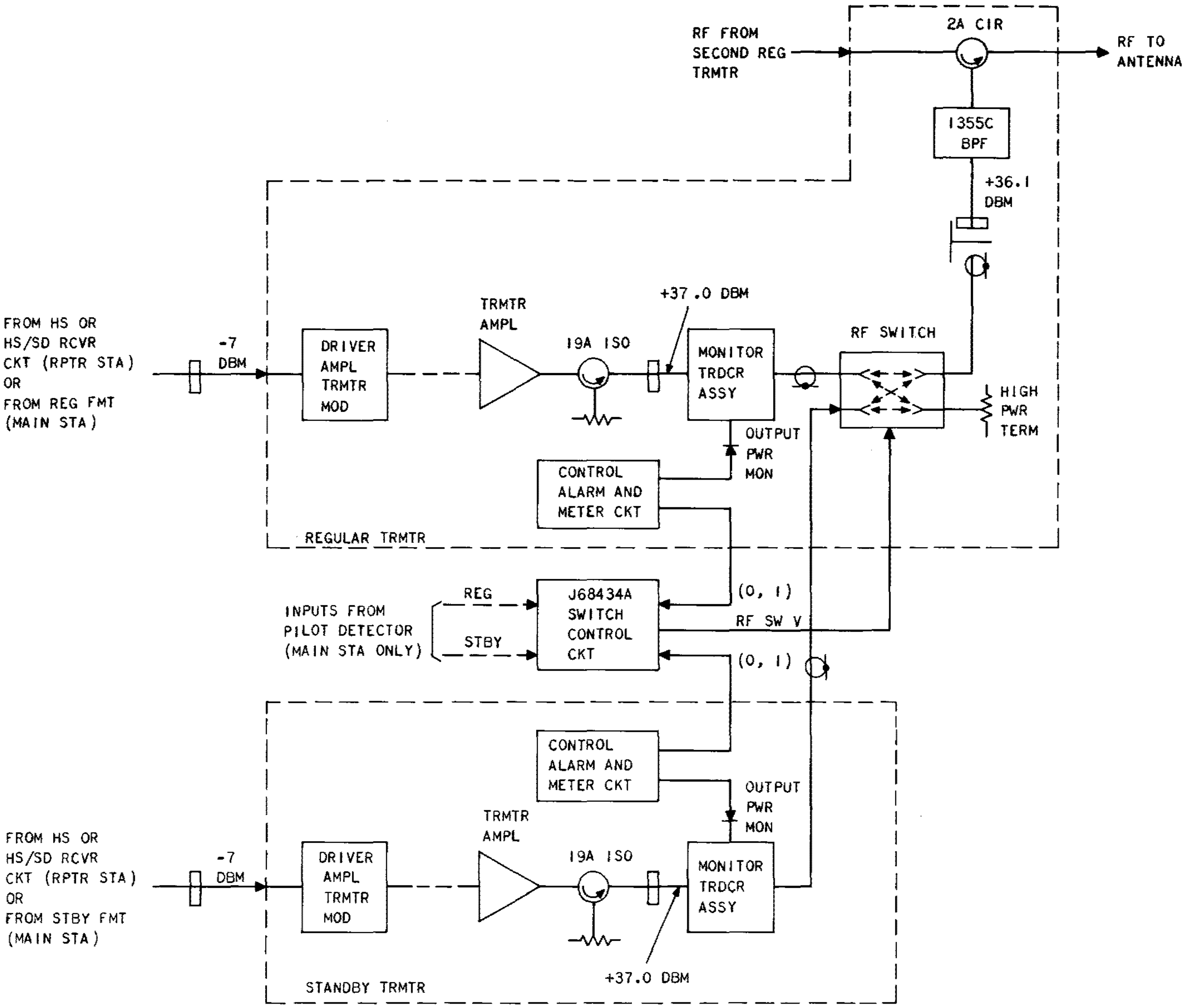


Fig. 9—Transmitter Circuit for Hot Standby or Hot Standby/Space Diversity Applications—Block Diagram

ular transmitter, is used to switch the transmitter outputs. The RF switch is controlled by an externally mounted switch control circuit which is supplied status information, in the form of a voltage logic (0, 1) type signal, on the RF output of each transmitter. If the output of the regular transmitter fails, the logic signal applied to the switch control circuit will change, thereby indicating a switch request. If, at the same time, the output power of the standby transmitter is sensed to be satisfactory, the switch control circuit will supply a voltage pulse to operate the RF switch. The switch will transfer the output of the standby transmitter to the antenna connection, and the output of the regular transmitter will be terminated. The system will remain on standby (nonrevertive operation), or will return to the regular when satisfactory output power from the regular transmitter is sensed by the switch control circuit (revertive operation).

3.18 In the case of a sudden failure, the total time required to switch from regular to standby is approximately 13 milliseconds, of which about 4 milliseconds is the actual switch transfer time. A manual switch, made to perform routine maintenance on the regular transmitter, will cause a 4-millisecond "hit" due to the switch transfer time. Such switches are expected to be infrequent.

3.19 For hot standby applications, the ED-52277-( ) monitor-shutter assembly normally used in the output circuit of the transmitter is replaced by an ED-52278-( ) monitor-transducer assembly. This assembly consists of a waveguide-to-coaxial transducer preceded by a monitoring port which, as in the monitor-shutter assembly, can be converted to a waveguide-to-coaxial transducer for test purposes. Normally, a 76-type detector is connected by means of a short probe to the monitoring port to monitor the output power of the transmitter. For test purposes, the monitoring port is converted to a waveguide-to-coaxial transducer by replacing the detector and short probe assembly with a full-length probe and by inserting a single shorting plate or shutter through a slot in the waveguide wall behind the probe. Unlike the monitor-shutter assembly, no additional shutters are necessary to isolate the transmitter under test from the in-service transmission path. The RF switch provides the additional isolation required. In this manner, test equipment may be connected to the transmitter output without opening any of the waveguide or coaxial connections in the signal transmission path.

3.20 The waveguide-to-coaxial transducer portion of the monitor-transducer assembly provides the transition to coaxial cable that is required to connect to the RF switch. The RF switch is located in the output circuit of the regular transmitter in order to minimize the circuit losses introduced by the switch and its connecting cables in the normally used transmission path.

3.21 The standby transmitter makes use of the circulator and bandpass filter in the output of the regular transmitter for channel combining. For this reason, these components are not furnished in a transmitter ordered for hot standby applications.

Hot Standby Using the 409A Switch

3.22 The 409A diode switch is a replacement for the electromechanical coaxial latching-type switch and auxiliary relay drive circuit used in the original design of the TD-3D hot standby arrangement. The 409A switch has waveguide ports for the regular transmitter output and the antenna system connection and an OSM-type 50-ohm coaxial port for the connection to the standby transmitter. A built-in high-power (10-watt) termination is provided for the switched-out transmitter. These features eliminate two waveguide-to-coaxial transducers, three semi-rigid coaxial cables, and a high-power termination that was required with the electromechanical switch. The switch portion of the circuit comprises a series of 50-ohm microstrip transmission lines shunted by a total of eight PIN diodes. The waveguide ports are connected to the microstrip circuit by means of waveguide probe to microstrip transitions. The switch is operated by forward biasing one set of four diodes and zero biasing the other set of four diodes. When forward biased, the diodes conduct heavily and present a low RF shunt impedance to ground. When zero biased, the diodes present a high RF shunt impedance to ground. By reversing the bias condition on the two sets of diodes, the high- and low-loss paths are reversed. This permits switching of the transmission path to the antenna from the REGULAR IN to the STBY IN or from the STBY IN to the REGULAR IN ports. The dc bias for the diodes is supplied by a 5-transistor driver circuit mounted on one side of the switch housing. The input to the driver circuit is a logic type signal obtained from an externally mounted switch control circuit.

3.23 The 409A switch also has built into it the monitor and test access feature of the ED-52278-( ) monitor-transducer assembly. The monitor-transducer assembly was used in conjunction with the electromechanical coaxial switch and is another component replaced by the 409A switch. A coaxial transducer port is located at the IN port of the 409A switch. Normally a short coaxial probe, which is part of the 76-type detector, is inserted in the transducer port. The dc output of the detector is connected to the transmitter output alarm circuit for bay metering, alarm, and switch control purposes. For test purposes, the detector is removed and replaced by a normal length probe. In addition, a shorting plate is inserted behind the probe through a slot in the narrow wall of the waveguide switch. This converts the IN port of the switch to a waveguide-to-coaxial transducer, thereby permitting coaxial test connections to be made to the output of the regular transmitter without opening the waveguide. The shorting plate plus the isolation of the switch provides sufficient loss to prevent the testing of the regular transmitter from interfering with the in-service signal being carried through the switch from the standby transmitter.

3.24 The RF switch is controlled by an externally mounted switch control circuit which is supplied status information in the form of a voltage logic-type signal on the RF output of the regular and standby transmitters. If the output of the regular transmitter fails, the logic signal applied to the switch control circuit will change. The switch control circuit recognizes this change as a switch request. If, at the same time, the output of the standby transmitter is sensed to be satisfactory, the switch circuit will change the logic-type voltage which it supplies to the switch driver circuit. This will cause the switch to operate, thereby transferring the output of the standby transmitter to the antenna connection and terminate the output of the regular transmitter. If the switch control circuit has been set up for revertive operation, the transmission path will revert automatically to the regular transmitter as soon as its output restores to within about 2 dB of its normal output power. If the nonrevertive option is used, the operation will remain permanently on the standby, regardless of the condition of the regular transmitter. If the standby transmitter should fail, and the output of the regular transmitter is satisfactory, an automatic switch back to the regular transmitter will take place. The selection of the revertive or nonrevertive mode of operation is accomplished by a strapping change in the switch control circuit. Manual switches and lockouts can also be made with the switch control circuit.

3.25 The 409A switch has a break-before-make transfer characteristic. Transfer is completed in 6 to 10 microseconds. A circuit outage of not more than 10 microseconds will occur on a maintenance-type switch. In the event of a sudden or complete loss of output power from the transmitter carrying the message service, the transmitter output power detector circuit and switch control circuit together will require approximately 11 milliseconds to respond and supply a new control signal input to the switch driver circuit. Since the switch and switch driver circuit respond within 10 microseconds, the circuit outage resulting from an equipment failure is about 11 milliseconds.

Transmitter and Receiver Connections to IF Patch and Access Bay

3.26 In some applications, the radio receivers and transmitters for a hot-standby-only or HS/SD system are connected at a main station to an ED-50719-( ) IF patch and access bay rather than directly to the FM terminal facilities. This situation may occur, for example, at a junction station where a channel within a frequency diversity protection switching section on the main route is branched off at IF to a sideleg hot-standby-only or HS/SD route.

3.27 Figure 10 shows the arrangement used for connecting the regular and standby hot-standby-only or HS/SD radio receivers, for one channel, to the IF patch and access bay. Only one IF output, from either the regular or standby receiver, can be used at any one time to feed the patch and access bay. Therefore, the receivers must be interconnected and controlled by means of an IF switch control circuit. As a result, the receiver arrangement is virtually identical to that described in paragraphs 3.09 through 3.12 for the HS/SD receiver applications, and all of the information given in those paragraphs concerning the operation of the switch control circuit is applicable. The only difference in this arrangement is that a single hybrid, rather than two, is provided in the standby receiver to the patch and access bay.

3.28 Figure 11 shows the arrangement used on the transmitter side. A hybrid, mounted in the standby transmitter, is used to split the output signal from the patch and access bay to feed the regular and standby transmitters. From this point on, the transmitter circuit is identical to that described in paragraphs 3.15 through 3.21.

3.29 For these applications, the transmitting and receiving arrangements have been designed to provide standard IF levels at the patch and access bay. This has resulted in nonstandard levels at the receiver output (+6.6 dBm instead of −7 dBm) and transmitter output (−3.6 dBm instead of −7 dBm).

C. Space Diversity Within a Frequency Diversity Switching System

General

3.30 Receiver space diversity switching may be used on an individual radio hop to supplement the protection provided by the frequency diversity protection switching system and thereby increase the radio system reliability. Space diversity reception, which involves a second receiving antenna mounted on the same tower, typically 30 to 50 feet below the first antenna, is effective because multipath fading

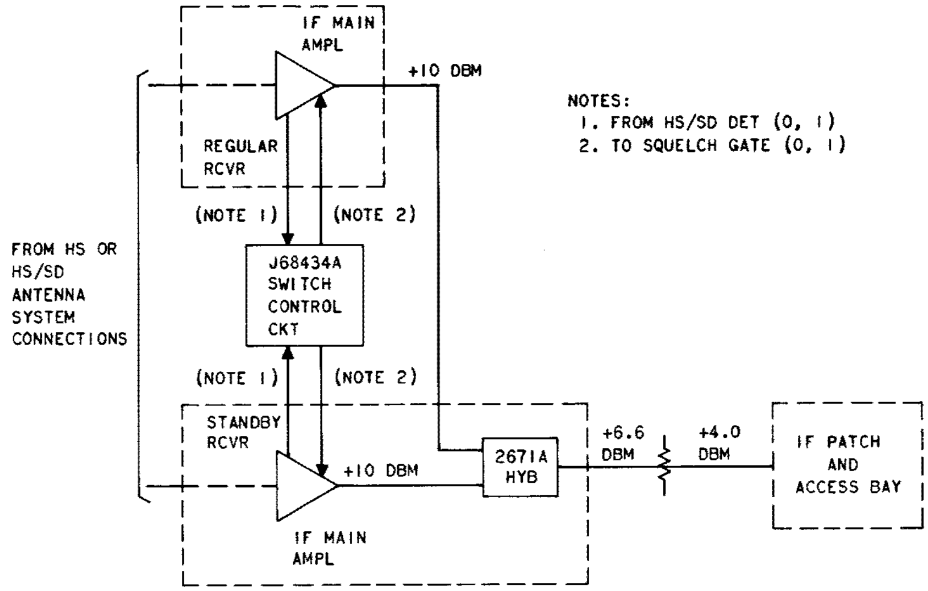


Fig. 10—Connection of Hot Standby or Hot Standby/Space Diversity Receiver Circuit to IF Patch and Access Bay—Block Diagram

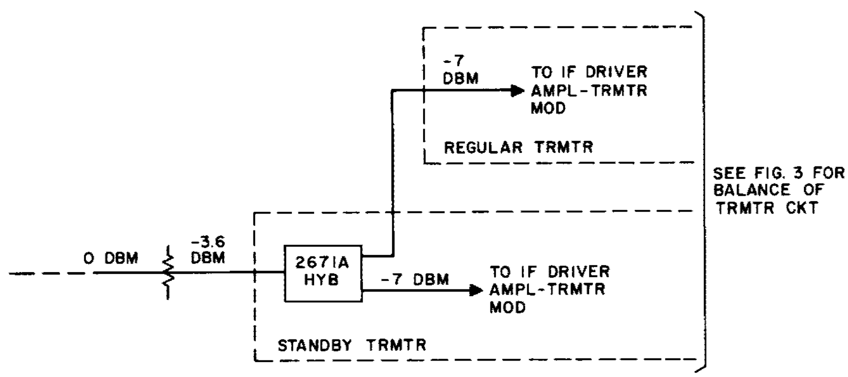


Fig. 11—Connection of Hot Standby Transmitter Circuit to IF Patch and Access Bay—Block Diagram

produces significant variation in the received carrier power as a function of antenna height. Thus, while the signal may be deeply faded on one antenna, a perfectly usable signal may be present on the other antenna. By equipping each receiver of a radio hop with a means of switching from one antenna to the other, each channel on the hop has, from the standpoint of multipath fading, the equivalent of a one-for-one protection channel.

3.31 Receiving space diversity arrangements are provided for TD-3D radio bays. Two different waveguide arrangements are required depending on whether the TD-3D bays are intermixed with TD-2 bays in the same bay lineup or are installed in a TD-3D only bay lineup. In TD-3D only bay lineups (Fig. 12), a second, independent set of channel-separating circulator and bandpass filter assemblies is added to the bay lineup. This additional set is connected to the waveguide system associated with the diversity receiving antenna. The space diversity switch in each receiver is connected between the output of the bandpass filters. The output of the switch, which is the signal received from either the regular or diversity antenna, is passed on to the rest of the receiver. In a TD-2 lineup equipped for space diversity (Fig. 13), the waveguide run from the diversity antenna is connected to the end of the last channel-separating network in the bay lineup. When a TD-3D bay is added to this type bay lineup, the TD-3D receiver must be able to accept a signal from either end of the bay lineup. This is accomplished by connecting in tandem the circulators for two circulator-bandpass filter assemblies. The circulators are oriented for opposite direction of signal flow. In this manner, the TD-3D receiver may receive a signal from either end of the bay lineup while at the same time maintaining 2-way signal flow through the adjoining TD-2 channel networks. The tandem connections of the circulators in each TD-3D bay is necessary regardless of the location of the TD-3D bay in the TD-2 bay lineup. The space diversity switch in each receiver is connected between the outputs of the bandpass filters and passes on to the rest of the receiver the signal from either the regular or diversity antenna.

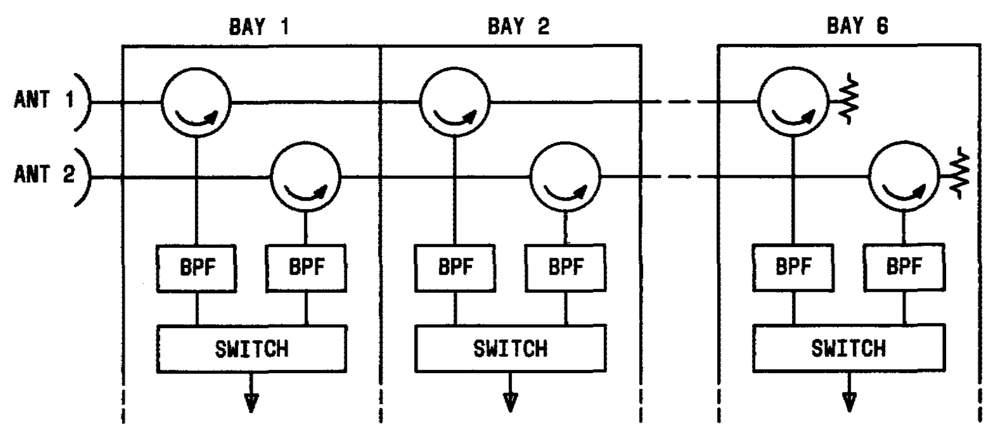


Fig. 12—Space Diversity TD-3D Only Bay Lineup

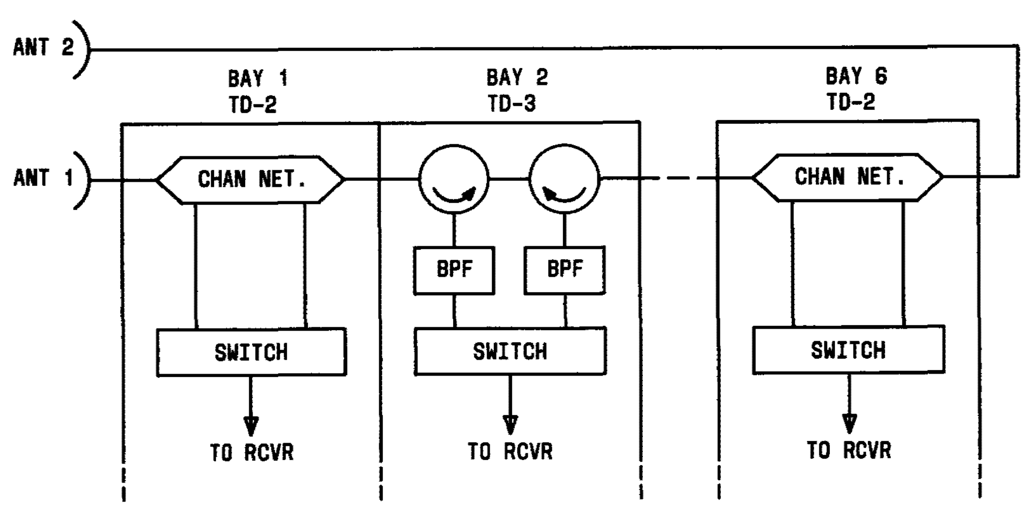


Fig. 13—Space Diversity TD-2/TD-3D Bay Lineup

3.32 The switching or selection of the received signal from the regular or diversity antenna is accomplished by either an Electromagnetic Sciences, Inc. (EMS), waveguide switch using switchable circulators and an associated logic and driver circuit or a solid-state 409B diode-type switch and a separate switch control logic circuit plug-in assembly. The diversity switch is set to operate with a fade of typically 3 dB less than it would take to operate the IF frequency protection switching system. With either switch, the switching between the regular and diversity antennas is "blind". That is, a switch is made without knowing in advance the condition of the signal from the other antenna. This method of operation is successful because of the nature of multipath selective fading; almost all of the time when the signal from one antenna is deeply faded, a better signal will be present from the other. In the event that the signals from both the regular and diversity antenna are faded, then the IF protection switching system operates in the normal manner and transfers service to the protection channel until a good signal returns to either the regular or diversity antenna.

Space Diversity Using the EMS Switch

3.33 The EMS space diversity switch consists of three switchable latching-type circulators assembled in a die-cast 3-port waveguide housing. Attached to the waveguide switch is a box (7-3/4 by 4-3/4 by 2 inches) containing a logic card and the circulator driver card. Three connectors, AGC INPUT, POWER, and TEST are mounted on the circuit housing. The AGC INPUT is used to connect the logic circuit input to the output of the HS/SD control circuit in the IF main amplifier. The POWER connector serves to bring power and ground connections into the unit from the bay control alarm and meter circuit. The TEST connector is used for making connections to an external test fixture. This test fixture is not used for field testing. An externally mounted 3-position toggle switch (S1) provides automatic switching (OPERATE), testing (TEST), and manual switching (TRIGGER). A pair of slide switches, mounted on the logic circuit board, are used to define, for purposes of the logic circuit operation, which of the antenna ports is to be considered the regular antenna connection and which is the diversity. These switches normally are set once, at the time of installation. In all bay arrangements, the ANT 1 port is always associated with the regular antenna. Likewise, the ANT 2 port is always connected to the circulator and bandpass filter added for the second antenna, which normally would be the diversity antenna. By using the slide switches, the role of the two antennas may be reversed without any waveguide changes. Lamps on the logic circuit housing provide a visual indication of which antenna port connection is supplying the receiver the input signal. An amber lamp indicates when the 15-minute timer is operating.

3.34 When the received carrier power from the regular antenna falls below a threshold value, usually 2 or 3 dB above the threshold set to operate the IF protection switching system, the logic of the HS/SD trip control lead in the IF main amplifier changes state. The logic circuit of the EMS switch recognizes this change of state as a switch request and causes the driver circuit to deliver a current pulse to the switch, thereby reversing the circulators and transferring the transmission path to the diversity antenna. If after a switch to the diversity antenna has been made and the input carrier power to the IF main amplifier is above the threshold setting of the HS/SD control circuit, the RF transmission path through the switch will remain connected to the diversity antenna and a 15-minute timing interval will commence. If the signal from the diversity antenna remains above the threshold throughout this interval, the connection to the diversity antenna will be maintained for the entire interval. After 15 minutes, the logic circuit will cause the switch to revert to the regular antenna. If the signal from the regular antenna is now above threshold, the switch will remain on the regular antenna. If, however, the signal is still below threshold, the logic circuit will direct the switch back to the diversity antenna and a second 15-minute timing interval will commence. This cycling will continue until the signal from the regular antenna is found to be above the threshold. If at any time during the 15-minute interval the signal from the diversity decreases below the threshold setting of the HS/SD control circuit, the logic circuit will cause the switch to revert to the regular antenna where it will remain if the signal from the antenna is satisfactory. However, if the signal from the regular antenna is also below threshold, the switch will transfer back to the diversity antenna. If the signal from the diversity antenna is still unsatisfactory, the logic circuit will start the switch cycling between the two antennas at a 0.1-second rate until one or the other antenna provides a signal above the threshold value. If this happens to be the diversity antenna, the normal 15-minute cycle operation on the diversity antenna resumes.

Space Diversity Using the 409B Switch

3.35 The 409B switch is a diode-type switch having waveguide ports for the regular antenna input and the receiver and an OSM-type 50-ohm coaxial connection for the diversity antenna and waveguide system. The switch portion of the circuit comprises a series of 50-ohm microstrip transmission lines shunted by a total of eight PIN diodes. The waveguide ports are connected to the microstrip circuit by means of waveguide probe to microstrip transitions. The switch is operated by forward biasing one set of four diodes and zero biasing the other set of four diodes. When forward biased, the diodes conduct heavily and present a low RF shunt impedance to ground. When zero biased, the diodes present a high RF shunt impedance to ground. By reversing the bias condition on the two sets of diodes, the high- and low-loss paths are reversed. This permits switching of the transmission path to the receiver from the REGULAR IN to the DIV IN or from the DIV IN to the REGULAR IN ports. The dc bias for the diodes is supplied by a 5-transistor driver circuit mounted on one side of the switch housing. The input to the driver circuit is a logic type signal obtained from an external mounted space diversity control circuit. This control circuit receives its logic commands from the AGC developed logic in the IF main amplifier.

3.36 Mounted on the space diversity control unit is a 4-position rotary switch which provides for selecting any one of four modes to operate the 409B switch. Position A programs the logic to the automatic mode which assigns the low-loss transmission path from the waveguide IN port to the waveguide OUT port. The regular antenna will normally be connected to the waveguide IN port of the switch and the switch will revert to this position after time-out on the diversity antenna. Position B reverses the priority of the automatic selection and the regular antenna is received from the DIV IN connector on the switch. The FSA and FSB switch positions provide a means of locking to either the regular or diversity antenna. Lamps are provided to indicate which antenna is in service. A receiver alarm is initiated as well as the lighting of the alarm lamp on the unit in the event that the diversity antenna is providing service for one hour or more. The same alarm is initiated immediately whenever the FSA or FSB positions are selected.

3.37 When the received carrier power from the regular antenna falls below a threshold value, usually 2 or 3 dB above the threshold set to operate the IF protection switching system, the logic of the HS/SD trip control lead in the IF main amplifier changes state. The space diversity control unit recognizes this change of state as a switch request and changes the logic applied to the internal switch drive circuit of the switch. The drive circuit then changes the state of the bias applied to the two sets of four PIN diodes that are mounted in the microstrip circuit of the switch thereby transferring the transmission path to the diversity antenna. The switch will remain in this state for 30 seconds. If, after 30 seconds, the signal from the diversity antenna is above the threshold setting of the HS/SD control circuit, the RF transmission path through the switch will remain connected to the diversity antenna and a 30-minute timing interval will commence. If the signal from the diversity antenna remains above the threshold throughout this interval, the connection to the diversity antenna will be maintained for the entire interval. After 30 minutes, the logic circuit will cause the switch to revert to the regular antenna. If the signal from the regular antenna is now above the threshold, the switch will remain on the regular antenna. If, however, the signal is still below threshold, the logic circuit will direct the switch back to the diversity antenna, and a second 30-minute timing interval will commence. This cycling will continue until the signal from the regular antenna is found to be above the threshold. If at any time during the 30-minute interval, the signal from the diversity antenna decreases below the threshold setting of the HS/SD control circuit, the logic circuit will cause the switch to revert to the regular antenna where it will remain if the signal from the antenna is satisfactory. However, if the signal from the regular antenna is also below threshold, the switch will transfer back to the diversity antenna. If the signal from the diversity antenna is still unsatisfactory, the logic circuit will start the switch cycling between the two antennas at a 30-second rate until one or the other antenna provides a signal above threshold. If this happens to be the diversity antenna, the normal 30-minute cycle operation on the diversity antenna resumes.

4. RECEIVER MODULATOR—IF PREAMPLIFIER

4.01 The receiver modulator—IF preamplifier (Fig. 14) serves two main functions. The modulator portion of the circuit is used to shift (or "down-convert") the received microwave signal to the 70-MHz IF band. The IF preamplifier provides gain to make up for the loss of the modulator and raise the level of the signal sufficiently for delivery to the succeeding circuits of the receiver.

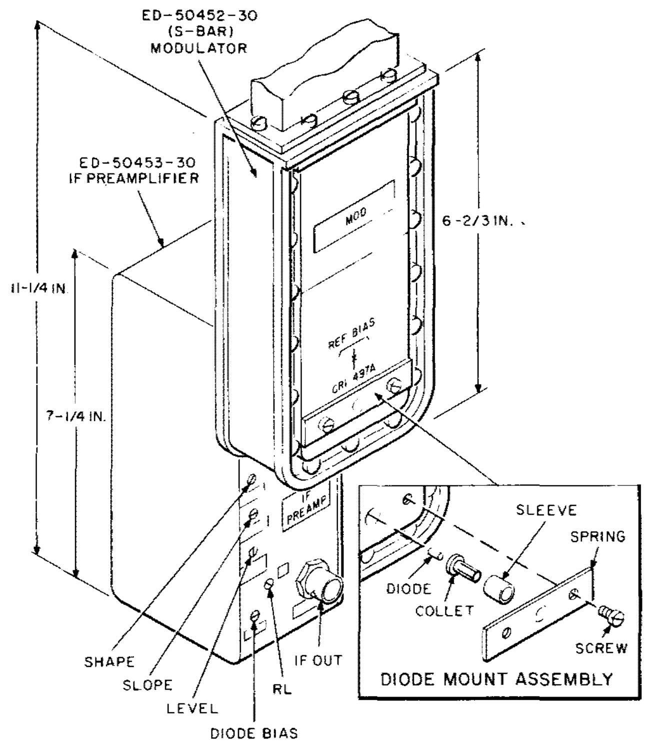


Fig. 14—J68387P Receiver Modulator and IF Preamplifier

J68387P RECEIVER MODULATOR—IF PREAMPLIFIER

4.02 The J68387P receiver modulator—IF preamplifier uses an unbalanced (single-diode) modulator section. The noise figure is typically 7 dB, and the normal (nonfaded) IF output power is set to 0 dBm if there is no RF preamplifier in the common receiving waveguide run, or to +3 dBm if an RF preamplifier is used. The unit was specified originally to work with a normal received carrier power input up to approximately −22 dBm. Later tests, made in conjunction with the use of the common waveguide RF preamplifier, have shown the performance to be satisfactory for inputs up to at least −13 dBm. The local oscillator input power required is +4 dBm.

4.03 Figure 15 is a block diagram of the overall down-converter circuit consisting of a 1338-type waveguide directional filter and the J68387P receiver modulator—IF preamplifier. The received signal and local oscillator signal are combined in the waveguide directional filter. Refer to Part 20 for a description of the filter. The combined signal output of the filter is fed through a step transducer and waffle-iron low-pass filter to the diode modulator where mixing of the two signals takes place. The IF output signal from the diode (i.e., the 70-MHz difference frequency between the received signal and the local oscillator) is fed through a coaxial low-pass filter to the IF preamplifier.

4.04 The semiconductor device used for RF-to-IF down-conversion in the modulator is a gallium arsenide Schottky-barrier diode. This diode has a low noise figure and is an efficient, low conversion-loss, microwave mixer. The conversion loss, and therefore noise figure, of the modulator is dependent on the dc bias applied to the diode. The diode bias is obtained from the −19 volts available in the IF preamplifier through a potentiometer control (DIODE BIAS). The optimum bias for each unit for operation at 4010 MHz (channel 4B) is determined at the factory and stamped on the modulator block. The appropriate maintenance practice gives the correction factors to apply to the stamped bias value when using the modulator on other frequencies.

4.05 Second and third harmonics of the local oscillator signal are generated in the modulator diode. These harmonics, if allowed to reach the receiving common waveguide run, can cause interference in other receivers, particularly those in the same bay lineup. The harmonics are too high in frequency to be effectively attenuated by the isolator or filters in the external circuit preceding the modulator. A waffle-iron type low-pass filter, therefore, is used ahead of the diode to attenuate these harmonics before they leave the modulator input. This filter has a cutoff frequency of about 6 GHz and provides typically more than 50-dB loss to the second and third harmonics. The loss introduced across the 4-GHz band is negligible.

4.06 The coaxial low-pass filter which follows the diode has a cutoff frequency of 2460 MHz. This filter passes the IF signal to the preamplifier with virtually no loss but introduces more than 40-dB attenuation between 3.7 and 8.4 GHz. The filter is necessary to prevent the input signals, as well as the many RF products that are generated in the diode, from causing interference and overloading effects in the IF preamplifier.

4.07 The IF preamplifier is a transistorized, 5-stage amplifier. Because the signal level is

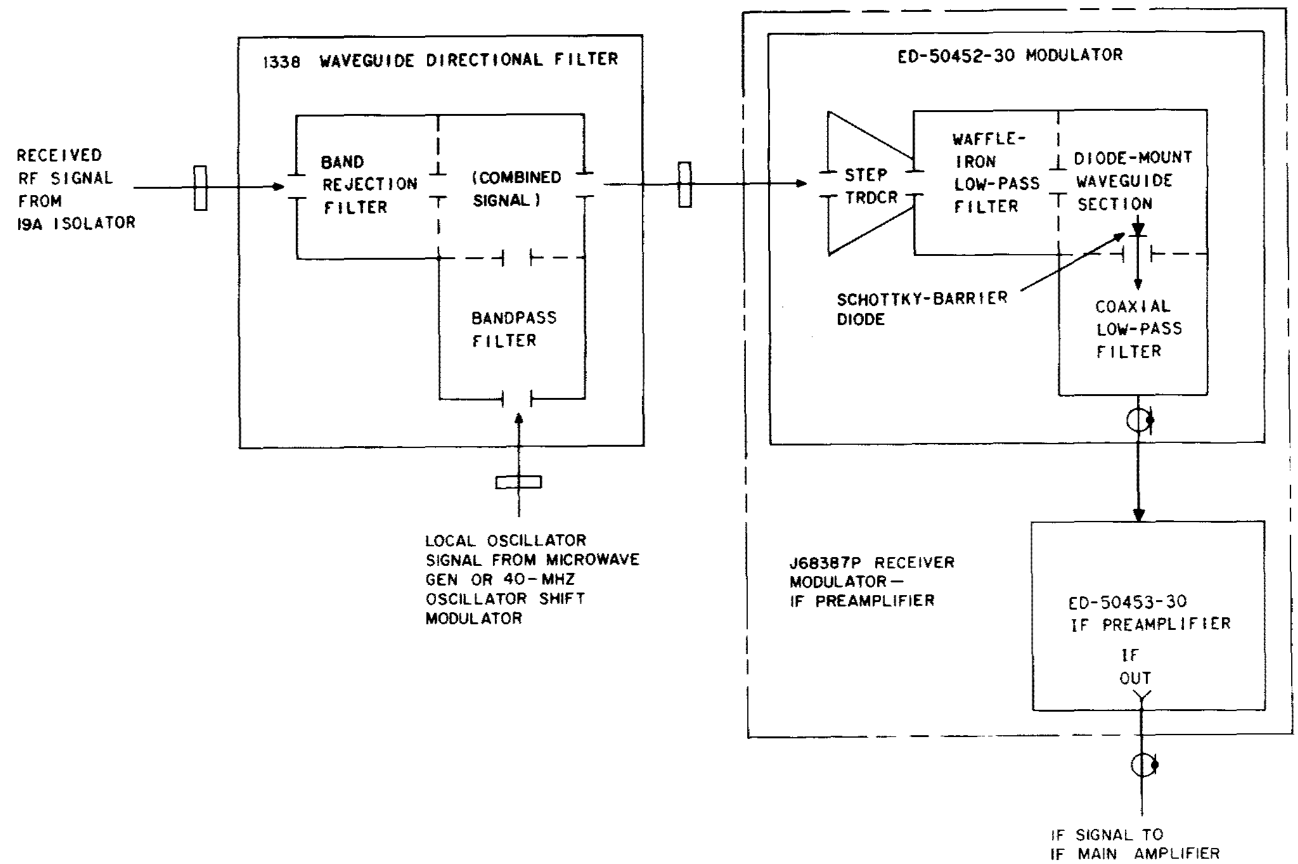


Fig. 15—Receiver Downconverter—Preamplifier—Block Diagram

lowest at the input to the IF preamplifier, the noise figure of the entire receiver is affected significantly by the noise figure of the IF preamplifier. The noise figure of the preamplifier, in turn, is dependent mainly on the first stage. This stage uses a transistor having a noise figure of 2.5 dB or less and provides a gain of approximately 17 dB at 70 MHz to mask the noise contribution of the following stages. The overall noise figure of the preamplifier is typically about 2.5 to 3.0 dB.

4.08 A circuit (option N) in the IF preamplifier is provided for monitoring the dc voltage delivered to the preamplifier input terminals from the receiver modulator diode. This voltage, which is inversely proportional to the local oscillator power applied to the diode, is used for monitoring the receiver local oscillator power on the bay panel meter.

4.09 There are four controls on the preamplifier: DIODE BIAS, SHAPE, SLOPE, and LEVEL. The DIODE BIAS control is used to set the bias on the receiver modulator diode as described in paragraph 4.04. The SHAPE and SLOPE controls are adjusted to obtain a flat amplitude response from the receiver modulator input to the preamplifier output. The LEVEL control is used to set the power output of the preamplifier.

4.10 The receiver downconverter—preamplifier assembly consists of two units: the 1338-type waveguide directional filter and the J68387P receiver modulator—IF preamplifier. A description of the directional filter is given in Part 20.

4.11 The receiver modulator (Fig. 16) contains four main components: a die-cast housing, a collet assembly, the diode, and the coaxial low-pass filter. Figure 17 is a simplified mechanical schematic of how the modulator components fit together.

4.12 The receiver modulator diode section and waffle-iron filter require reduced-height wave-

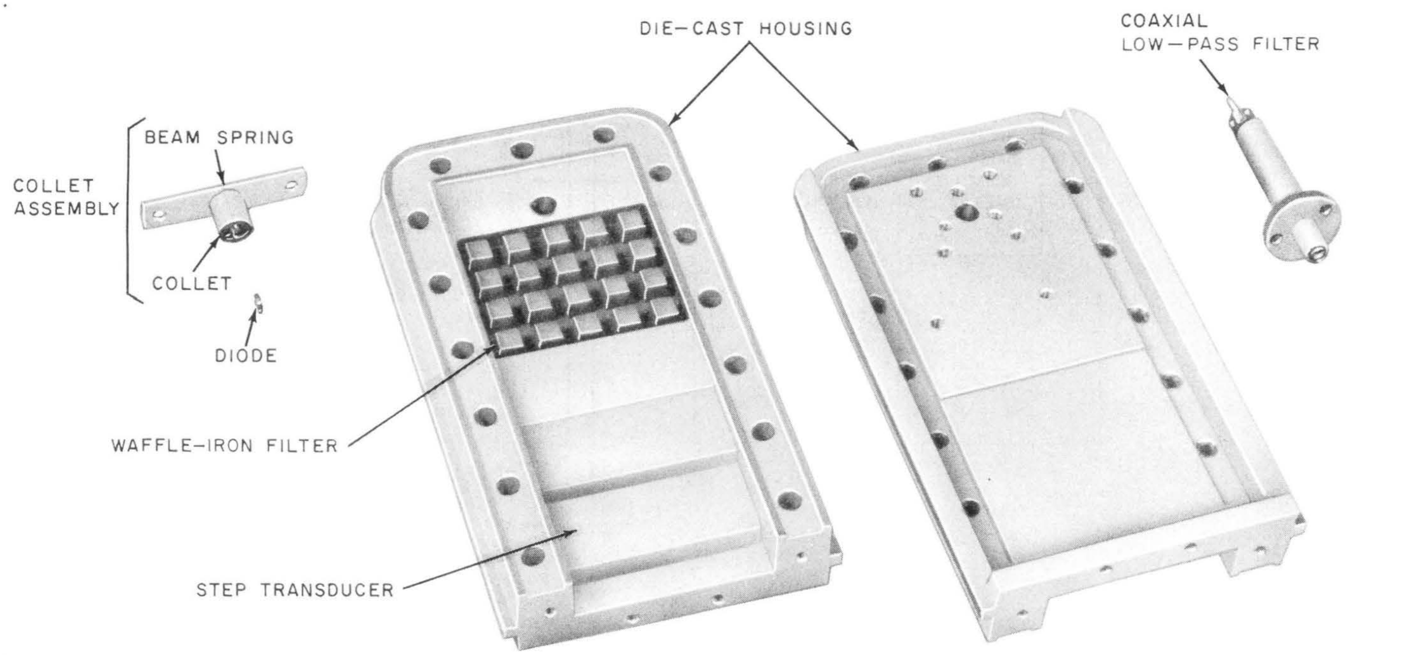


Fig. 16—Receiver Modulator Components

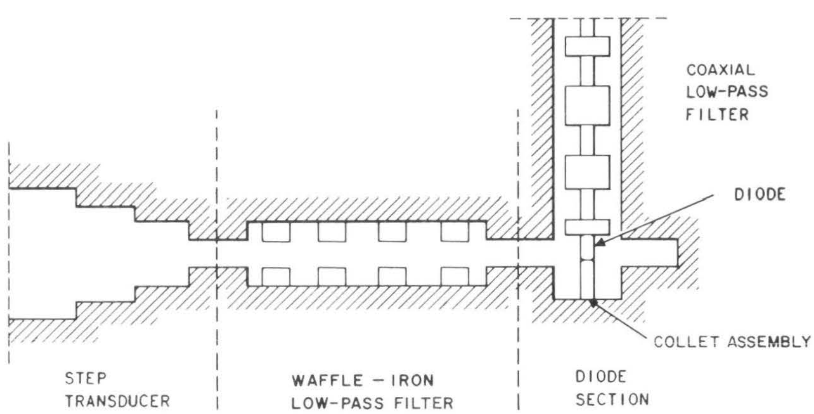


Fig. 17—Cross Section of Receiver Modulator

guide to obtain the desired performance. Thus, a waveguide transducer is needed at the receiver modulator input to transduce from full-height waveguide (1.145 inches) to the reduced height (0.090 inch) used in the filter and diode sections. The transducer, waffle-iron filter, and diode section are formed in a die-cast housing (Fig. 16) consisting of two cast-aluminum halves fastened together with machine screws. Features of the transducer and the waffle-iron low-pass filter are apparent in the photograph. The transducer is a conventional 3-step design.

4.13 The collet assembly consists of a beam spring and collet. The collet tightly holds one end of the diode. The other end of the diode plugs into a holder on the flange end of the coaxial low-pass filter. The collet assembly enables the diode to be replaced easily without any further dismantling of the modulator.

4.14 The coaxial low-pass filter is shown in Fig. 18. One end of the inner conductor serves as a receptacle for one end of the modulator diode. The other end is soldered to the input circuit of the IF preamplifier.

4.15 The IF preamplifier uses conventional printed wiring construction and is assembled in a die-cast aluminum housing. The housing, in turn, is attached to the die-cast modulator housing with machine screws. The modulator and IF preamplifier are not designed to be separated in the field but instead are kept together as a complete assembly. The overall assembly measures approximately 11 by 4 by 5 inches and weighs about 3-1/2 pounds.

J68387AD RECEIVER MODULATOR—IF PREAMPLIFER

4.16 The J68387AD receiver modulator—IF preamplifier is a direct replacement for the J68387P unit used in the original design of TD-3D. Both units perform identical functions using very similar circuits. Each employs a single Schottky-barrier diode in a modulator structure to mix the received signal and the receiver beat oscillator signal to obtain the 70-MHz difference frequency. In both units, the 70-MHz product is fed from the diode to an IF preamplifier attached to the modulator assembly. The physical appearance of both units is similar due to the fact that both use the same basic castings for the modulator and both have similar housings for the IF preamplifier.

4.17 The most significant difference in the J68387AD unit is its lower noise figure compared to that of the J68387P unit. The noise figure of the J68387AD receiver modulator—IF preamplifier is typically 3.7 dB as compared to typically 6.8 dB for the J68387P unit. The lower noise figure for the new unit has been achieved by: (a) adding the image frequency rejection filter to reduce the conversion loss of the modulator, (b) using a lower capacitance Schottky-barrier diode in the modulator to obtain a better impedance match between the diode and the associated circuit, and (c) using lower noise figure

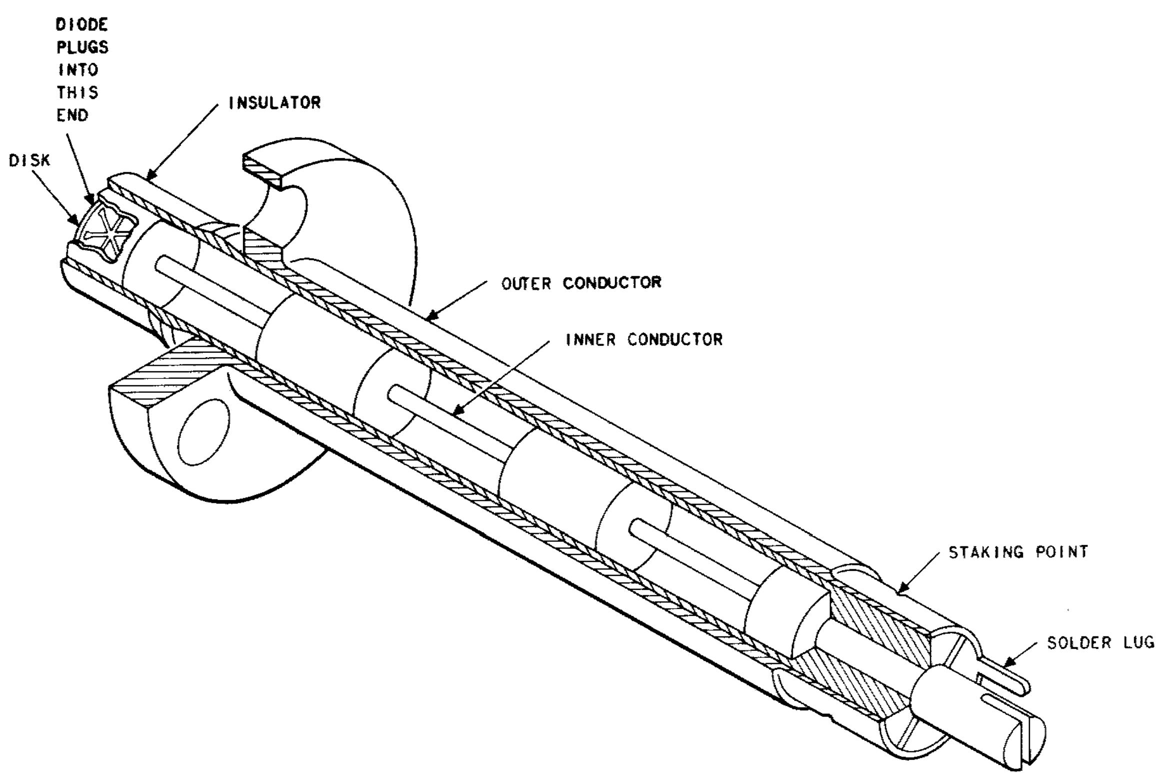


Fig. 18—Coaxial Low-Pass Filter

transistors in the first two stages of the IF preamplifier.

4.18 The image-rejection filter keeps current from flowing in the diode at the image frequency and thereby prevents the image frequency product from being formed. By eliminating this product, signal power that would have gone into the image frequency product is converted, instead, to a useful IF output signal from the diode. Thus, the image-rejection filter has the effect of reducing the conversion loss of the modulator which, in turn, directly improves the noise figure of the modulator by the amount that the conversion loss was reduced. The image-rejection filter is tunable so it can be adjusted for the specific image frequency of the receiver in which the modulator is used. Once tuned, no further check or tuning adjustment of the filter is necessary, even if the modulator diode is replaced, as long as the modulator is used on the channel frequency for which the filter was tuned.

4.19 The J68387AD unit may be used with normal received carrier power inputs up to at least −13 dBm. The local oscillator input power is a +4 dBm.

4.20 The IF preamplifier has four field-adjusted controls. The controls are panel-marked DIODE BIAS, GAIN, SLOPE, and BO LEV MTR ADJ. The DIODE BIAS control, which is used to set a dc bias current applied to the modulator diode, is adjusted to maximize the 70-MHz output of the IF preamplifier (to minimize the modulator conversion loss). The GAIN adjustment is used to set the IF output of the preamplifier. The SLOPE control is used to remove any residual amplitude slope across the 60- through 80-MHz band. The BO LEV MTR ADJ control is used to set the bay control panel meter to a prescribed indication for normal BO power input (+4 dBm) to the modulator. Unlike the J68387P unit, there is no field-adjustable control for the IF return loss. The output return loss is factory-adjusted to greater than 30 dB over the 60- through 80-MHz band.

5. J68387AB IF MAIN AMPLIFIER AND CARRIER RESUPPLY

A. General

5.01 The IF main amplifier—carrier resupply (Fig. 19) provides IF amplification under automatic gain control (AGC) for the radio receiver and provides (by option) for either the insertion of a carrier resupply (CRS) signal or a signal to an external control circuit for hot standby/space diversity system applications.

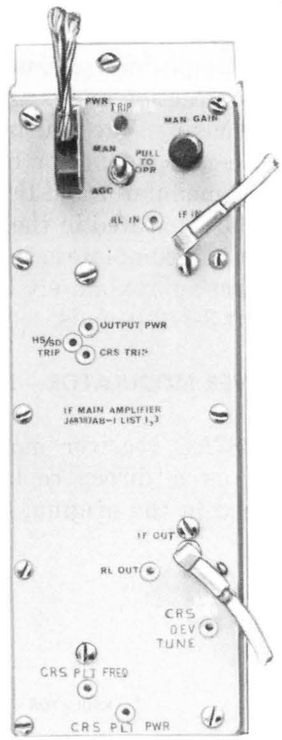


Fig. 19—J68387AB IF Main Amplifier/Carrier Resupply Circuit

5.02 The IF main amplifier—carrier resupply is comprised of ten major sections (see Fig. 20 for a block diagram.) The sections are as follows:

(a) IF amplifier

(b) Detector

(c) AGC amplifier

(d) Meter circuit

(e) CRS control circuit

(f) SW/ALM driver circuit

(g) Squelch circuit

(h) Carrier resupply generator circuit

(i) HS/SD control circuit

(j) Delayed alarm circuit.

5.03 The IF amplifier provides a 70-MHz output of +10 dBm into a 75-ohm load with a normal input power of −8 dBm (no RF preamplifier in the common receiving waveguide run) or −5 dBm (with an RF preamplifier). ♦For digital operation, the IF amplifier provides a 70-MHz output of +4 dBm into a 75-ohm load with a normal input power of −14 dBm.♦

5.04 The detector monitors the 70-MHz output of the IF amplifier and applies a signal to the AGC amplifier and the CRS control. The AGC amplifier, via feedback circuits, maintains the output of the IF amplifier approximately constant for any input power between −48 and −2 dBm, a range of 46 dB. The meter circuit monitors the output of the AGC amplifier and provides an indication of the level of the input signal to the external meter circuit in the bay.

Carrier Resupply Option (Frequency Diversity Systems)

5.05 The CRS control receives its signal from the detector. Since the output power of the IF amplifier is held essentially constant over the AGC range, the CRS switch point, that is, the point at which the carrier resupply is operated, must be set for an output power outside the AGC range. Typically, the control circuit is adjusted to cause the CRS to operate when the output of the IF main amplifier has decreased to 0 dBm. This corresponds to a fade of approximately 50 dB at the IF IN jack of the amplifier. When the switch is made, the SW/ALM driver causes the squelch gate to operate, thus attenuating noise or other unwanted signals that may be present at the output of the IF amplifier.

5.06 The CRS generator is controlled by the squelch gate. When the squelch gate is operated, the 9-MHz pilot oscillator is turned on which, in turn, causes the 70-MHz oscillator to operate (see note). The 70-MHz oscillator is modulated by the 9-MHz oscillator, and its output is applied to the IF

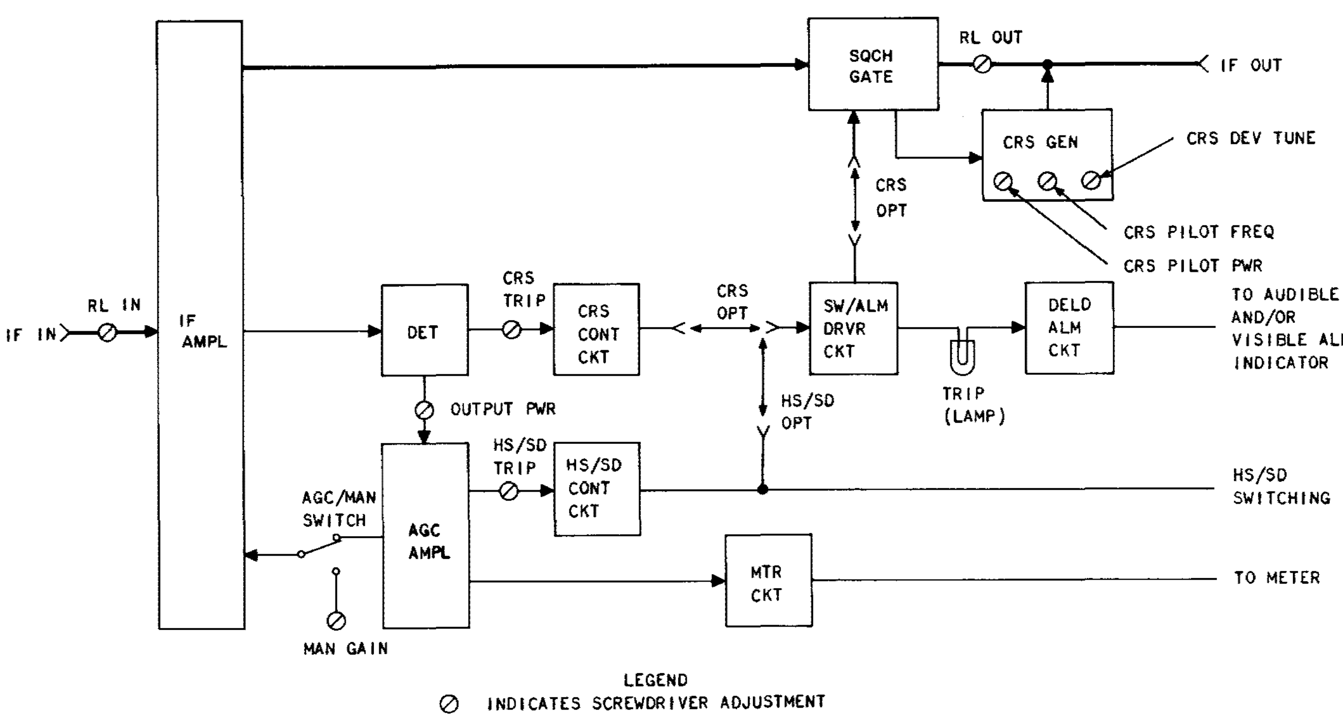


Fig. 20—J68387AB IF Main Amplifier/Carrier Resupply Circuit—Block Diagram

OUT jack of the IF main amplifier to provide a frequency-modulated 70-MHz signal. The function of this signal is to prevent the succeeding repeaters from going to maximum gain in the absence of an IF input signal. The pilot modulation serves as an indication to the protection switching system that the channel has failed.

> ***Note:*** A 9-MHz oscillator (option Y) is used to modulate the 70-MHz oscillator in T-R bays used in conjunction with 100A and 400A switching. An 8.8864-MHz oscillator (option Z) is used to modulate the 70-MHz oscillator for systems utilizing TDAS switching. The circuits for both oscillators are the same except for the crystal. For simplicity, only the 9-MHz oscillator will be discussed in this section.

5.07 The output of the SW/ALM driver also supplies a signal to the delayed alarm circuit and lights the TRIP lamp to indicate that a switch has been made. After a 45-second delay, the delayed alarm circuit provides a signal to external audible and/or visible alarm indicators.

Hot Standby/Space Diversity Option

5.08 The HS/SD control circuit monitors the output of the AGC amplifier and signals an external control circuit that the received IF signal level has fallen below some predetermined point which is determined by the setting of the HS/SD trip control. The output of the HS/SD control circuit is also applied to the SW ALM driver circuit which provides an output as described in paragraph 5.07.

B. Functional Description

IF Amplifier

5.09 The IF amplifier is a solid-state amplifier operating over the range of 60 through 80 MHz. The input and output impedance is 75 ohms. The amplifier is powered by a regulated −19 volt power supply.

5.10 The IF amplifier section contains three gain stages. The first two stages are variable, and the last stage is fixed. Each gain stage is a 2-transistor feedback amplifier utilizing both series and shunt feedback. The stages are dc-coupled to minimize the use of coupling capacitors and bias resistors. The feedback, and therefore the gain, of the variable gain stages is controlled by varying the current through a pair of PIN diodes in the feedback path.

Detector Circuit

5.11 The detector circuit for detecting the 70-MHz signal is a peak detector using a series diode and bias-resistors to provide proper drive voltages for the AGC amplifier and the CRS control circuit. The diode is forward-biased to improve the detection efficiency and to provide the proper source impedance for the AGC amplifier and CRS control circuit.

AGC Amplifier

5.12 The AGC amplifier section is a differential input, high-gain, integrated operational amplifier. Negative feedback is employed to stabilize the gain at the desired value. The output of the amplifier is proportional to the difference between the detector output voltage and a reference voltage. The reference voltage is set by the output power control (OUTPUT PWR) and is adjusted to provide the desired IF output power. The output of the AGC amplifier drives the PIN diodes in the IF amplifier section to vary the IF gain. For testing purposes the mode of operation may be switched to manual, whereby the AGC loop is broken and the IF gain is determined by the setting of the manual gain control (MAN GAIN).

Meter Circuit

5.13 The meter circuit is a passive network which connects the bay meter between the AGC amplifier output and the −19 volt supply. For IF signals less than or equal to −48 dBm, the AGC amplifier is saturated and provides an output voltage close to the supply voltage. In this condition, the voltage difference between the meter circuit output and a −19 volt reference voltage is essentially zero, and the bay meter reading will be zero. As the input signal increases, the AGC amplifier output voltage decreases, causing the voltage at the output of the meter circuit to decrease. Since the −19 volt reference voltage is fixed, the difference between the output of the metering circuit and the −19 volt reference voltage increases, causing the bay meter to deflect upscale.

CRS Control Circuit

5.14 The CRS control circuit is a differential input, high-gain, integrated operational amplifier connected as a highly sensitive Schmitt trigger. Positive feedback is used to obtain fast switching time and the desired amount of hysteresis. The detector signal is applied to the positive input, and a reference voltage is applied to the negative input. When the detector output voltage drops below the reference, which is set by the adjustment of the CRS trip control, the output state of the operational amplifier changes. This, in turn, changes the state of the squelch gate. The squelch gate then turns on the carrier resupply generator, which provides the 70-MHz modulated resupply signal.

SW/ALM Driver Circuit

5.15 The SW/ALM driver circuit is an operational amplifier used as a comparator. Its operation is the same as a Schmitt trigger without hysteresis. Depending upon the option selected, the circuit is driven by either the CRS control circuit or the HS/SD control circuit. When the CRS option is selected, the circuit inverts the phase of the CRS control circuit output to drive the squelch gate. For either CRS or HS/SD operation, when the switch threshold has been reached, the SW/ALM driver circuit turns on the TRIP indicator lamp immediately, initiates the operation of the delayed alarm circuit, and operates the squelch gate.

Squelch Circuit

5.16 The squelch gate is a solid-state switch formed by two series PIN diodes and a shunt transistor which provides the proper phase and noise margin for the switch circuit. Under normal received signal level conditions, the output of the switch driver circuit maintains the gate in a forward-biased condition to provide a low-impedance connection between the IF amplifier and the IF OUT jack. Under this condition, the shunt transistor is off (controlled by the output of the SW/ALM driver circuit) and the two PIN diodes are forward-biased. This configuration forms a through connection between input and output. When the shunt transistor is on, the PIN diodes are reverse-biased and the transmission path is shorted to ground through the transistor. In this condition, the gate is off and the output is isolated from the input.

Carrier Resupply Generator Circuit

5.17 The carrier resupply generator circuit includes two crystal-controlled series-feedback oscillators, one operating at 9 MHz (see note after paragraph 5.06) and the other operating at 70 MHz. The controlling signal for starting the 9-MHz oscillator is derived from the bias level which either enables or inhibits the squelch gate. When a switch to the CRS mode is made, the squelch gate is turned off and the 9-MHz oscillator is turned on. The output of the 9-MHz oscillator is used to start the 70-MHz oscillator via a 9-MHz detector and an operational amplifier. Thus, a failure of the 9-MHz oscillator prevents the 70-MHz oscillator from operating, thereby preventing the insertion of a "quiet" or unmodulated carrier which would be viewed by the protection switching system as an indication of a good channel. The output of the 9-MHz oscillator deviates the capacitance of a varactor which is in the frequency determining circuit of the 70-MHz oscillator, thus modulating the 70-MHz oscillator at a 9-MHz rate. The output of the modulated 70-MHz oscillator is applied through a buffer amplifier to the output circuit of the IF amplifier.

HS/SD Control Circuit

5.18 The HS/SD control circuit is an operational amplifier connected as a Schmitt trigger similar to the CRS control circuit. When the received signal level drops below some point within the AGC range of the IF amplifier as determined by a reference voltage and the setting of the HS/SD trip control, the operational amplifier output changes state. When the external HS/SD wiring options are used, this indication is sent to the external HS/SD control circuit which controls the state of the squelch gates in the regular and standby receivers.

Delayed Alarm Circuit

5.19 The delayed alarm circuit provides an alarm indication, in the form of a ground, for prolonged fades at the input to the IF amplifier greater than approximately 50 dB. The circuit uses a field effect transistor (FET) constant current source driving a capacitor to give a linearly changing output voltage with time. This voltage is compared to a reference voltage in an operational amplifier connected as a comparator. When the capacitor voltage exceeds the reference voltage, the amplifier output changes state. This turns the following transistor on to provide an electronic ground for the bay alarm circuit. The total delay time is approximately 45 seconds. Thus normal fades, of short duration, will not trigger the alarm circuit. When the received signal level increases above the trip point, the alarm circuit resets quickly.

Controls

5.20 The IF main amplifier contains nine controls for adjusting and tuning the circuit, and one indicator lamp to indicate whether or not a switch has been requested for a standby channel. The controls are as follows:

(a) RL IN—Input return-loss adjustment

(b) RL OUT—Output return-loss adjustment

(c) OUTPUT PWR—Output power adjustment

(d) HS/SD TRIP—Hot standby/space diversity operate point control

(e) CRS TRIP—Carrier resupply operate point control

(f) CRS DEV TUNE—70-MHz oscillator tuning adjustment

(g) CRS PILOT CONTROL—Sideband frequency adjustment

(h) CRS PILOT PWR—Sideband power adjustment

(i) MAN GAIN—Manual adjustment of IF amplifier gain

(j) AGC/MAN switch—***AGC position:*** The gain of the IF amplifier is controlled automatically by the output of the AGC amplifier. ***MAN position:*** The gain of the IF amplifier is controlled manually by adjustment of the MAN GAIN control.

(k) TRIP lamp—Visual indication that output of the SW/ALM circuit has requested a switch to another channel.

C. Equipment Description

5.21 The IF main amplifier—carrier resupply is assembled on a cover which in turn is mounted on an aluminum housing. The return-loss and other adjustments are accessible through guides on the cover, on which also are mounted the 567A coaxial IF input and output jacks and a multicontact power, alarm, and meter circuit connector. The dimensions of the unit are approximately 11-5/8 inches long, 4-1/8 inches wide, and 1-3/4 inches deep. The knob for the MAN GAIN control and connectors extends an additional 1 inch from the front. The unit weighs approximately 3 pounds.

6. J68387U IF DRIVER AMPLIFIER—TRANSMITTER MODULATOR

A. General

6.01 The J68387U driver amplifier—transmitter modulator (Fig. 21) converts an input 70-MHz IF signal to a 4-GHz output signal with a 16-dB gain. The driver amplifier accepts a −7 dBm input signal in the 60- through 80-MHz band and delivers a nominal output of +21 dBm to the transmitter modulator. Input return loss, slope, gain, and diode bias controls are provided to optimize transmission level and flatness. The amplifier is coupled to the modulator through a coaxial low-pass filter. In the modulator, the IF signal combines with a local oscillator signal in the 4-GHz band and produces two sidebands at ±70 MHz from the local oscillator frequency. One of the sidebands is desired; the other is removed by a subsequent filter. The transmitter modulator consists of six basic parts: a step waveguide transducer, a waffle-iron low-pass filter, a diode, a diode mount, a coaxial low-pass filter, and a harmonic termination to absorb harmonics of the 4-GHz signals generated in the modulator diode. The modulator has a single waveguide port which serves as both input for the local oscillator signal and output for the modulated sideband signals. The nominal local oscillator input power is +20 dBm. The nominal RF output power is +12 dBm.

B. Functional Description

6.02 A block diagram of the IF driver amplifier is shown in Fig. 22. The first stage is essentially an impedance-matching, unity-gain stage. The RL1 and RL2 controls associated with this stage are used to adjust the input return loss of the driver amplifier.

6.03 The second stage contains the SLOPE control for adjustment of the amplitude response of the overall IF driver amplifier and transmitter modulator. The variation of the SLOPE control is about 2 dB. The gain of the second stage is approximately 8 dB.

6.04 The third stage comprises a 2-transistor feedback amplifier. A GAIN control in the feedback path provides a variable range of 8 dB.

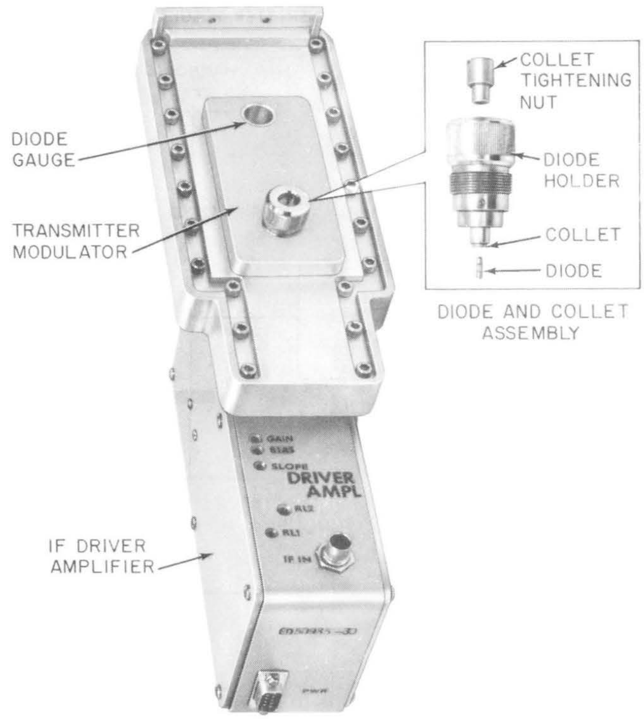


Fig. 21—J68387U IF Driver Amplifier—Transmitter Modulator

6.05 The last stage delivers a nominal output of +21 dBm at a 50-ohm impedance to drive the transmitter modulator. The BIAS control at the output of the last stage sets the self-bias developed by the modulator diode and is adjusted to maximize the power output of the modulator. The BIAS control may also be adjusted to trim the transmission slope.

6.06 The transmitter modulator consists of six basic parts: a stepped waveguide transformer, a waffle-iron low-pass filter, a diode, a diode holder, a coaxial low-pass filter, and a harmonic termination.

6.07 The stepped transformer provides an impedance transformation from the standard-height waveguide input-output port (1.145 inches) to a reduced-height waveguide structure (0.100 inch).

6.08 The waffle-iron low-pass filter passes frequencies from 3700 through 4200 MHz with negligible loss but provides at least 50-dB loss to frequencies of 7 GHz and above. This prevents harmonics of the 4-GHz signals generated in the diode from entering succeeding circuits in the transmitter and causing undesired intermodulation and transmission distortion effects.

6.09 The diode is a Schottky-type device mounted in a diode holder located on the front of the modulator unit. The diode is connected in series with the coaxial low-pass filter and an impedance-matching stub formed by the diode holder and composed of a short length of coaxial line terminated in a short circuit. The low-pass filter offers very high insertion loss to frequencies above 3 GHz and negligible loss at IF frequencies. The filter prevents the 4-GHz signals in the modulator from entering the output stage of the driver amplifier where they could cause undesirable overload and intermodulation effects.

6.10 The harmonic termination is a reduced-height (0.100 inch) and reduced-width (1.245 inches) waveguide structure. The termination absorbs harmonics generated in the diode but reflects the 4-GHz signals. This reflective (at 4 GHz) termination, together with the impedance-matching stub, provides a fixed, broadband match for the diode in the modulator unit. No diode tuning adjustments are necessary.

C. Equipment Description

6.11 The assembly consists of two physically associated, nonfield-separable units. The IF driver amplifier is assembled in a cast aluminum housing which connects to the modulator and is fitted with covers. The amplifier printed wiring board and RF decoupling networks for the dc power connections are mounted inside this frame. Adjustments are accessible through guides in the front of the unit. A 567A coaxial jack in the front provides for the IF input signal. A multicontact connector for dc power is located at the bottom of the frame. The transmitter modulator consists of a 2-piece aluminum housing which forms the step transducer from full- to reduced-height waveguide, the waffle-iron low-pass filter, and the reduced-width waveguide section into which fits the harmonic termination. The construction is similar to that of the receiver modulator (Fig. 16). A diode holder screws into the front of the housing, and the IF coaxial low-pass filter fastens to the rear. A hole gauge is provided at the front to set the position of the diode in its holder. The assembled unit measures approximately 3-1/2 by 6 by 12-1/2 inches and weighs 4-3/4 pounds.

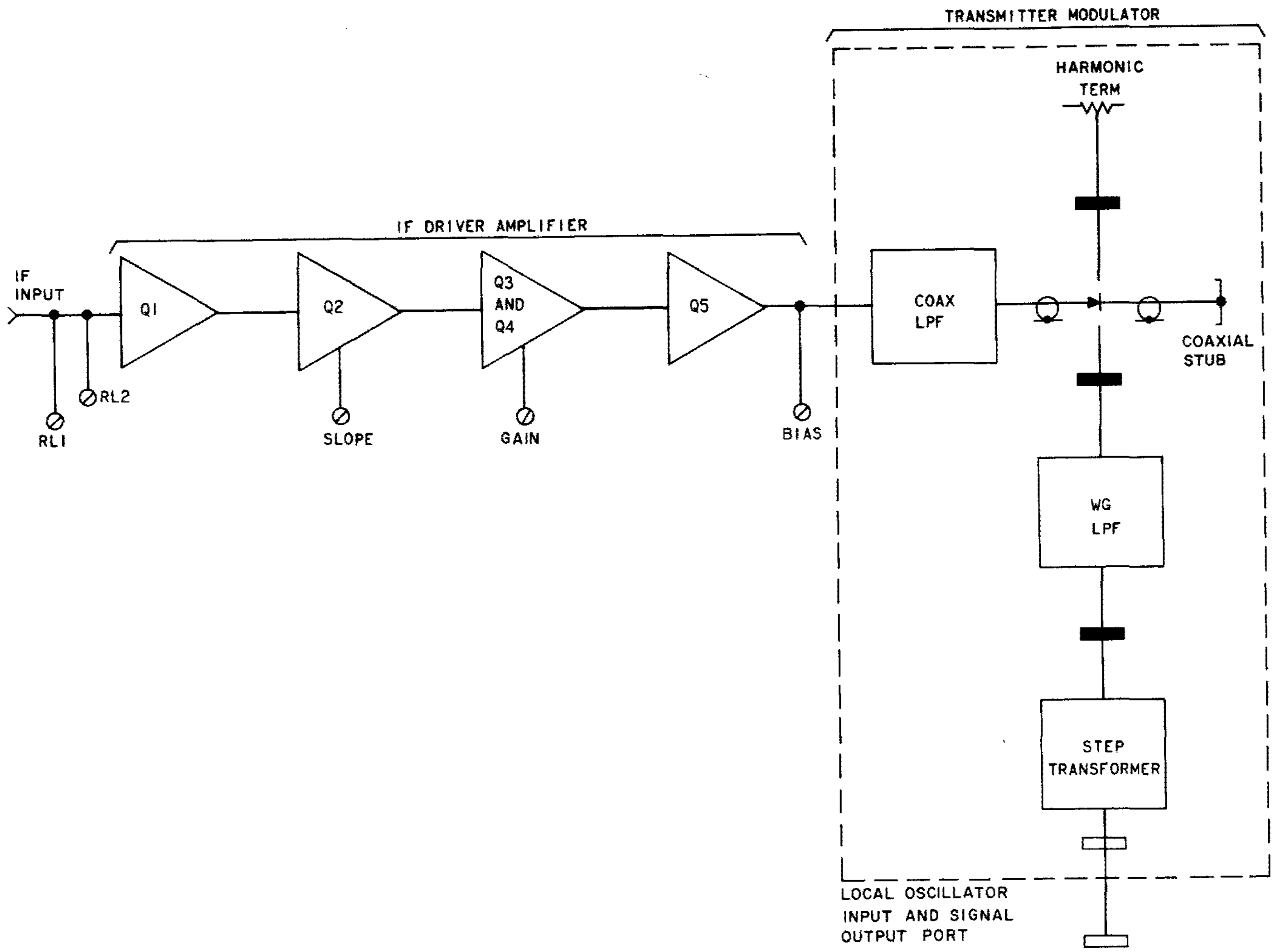


Fig. 22—J68387U IF Driver Amplifier—Transmitter Modulator—Block Diagram

7. J68387R-2 MICROWAVE GENERATOR

A. General

7.01 The microwave generator (Fig. 23 and 24) is a crystal-controlled, low-noise source of microwave power which provides the local oscillator signal for modulators in the transmitter-receiver bay. The microwave generator furnishes an output on one of 17 different frequencies in the 3780- through 4100-MHz frequency range.

7.02 In the generator, the signal originates in a crystal-controlled oscillator operating in the 118.125- through 128.125-MHz frequency range. This frequency is then multiplied to the desired output frequency.

7.03 For application in repeater station bays, option Z is implemented to provide a high-power output (+25 dBm) for both the transmitter and receiver.

7.04 For application in main station bays, option V is implemented to provide a low-power output (+9 dBm) for the receiver.

B. Functional Description

7.05 The high-power output (+25 dBm) J68387R-2 microwave generator (Fig. 25) consists of a crystal-controlled oscillator and buffer amplifier followed by three transistor doublers and a diode quadrupler. The low-power output (+9 dBm) J68387R-2 microwave generator consists of the same

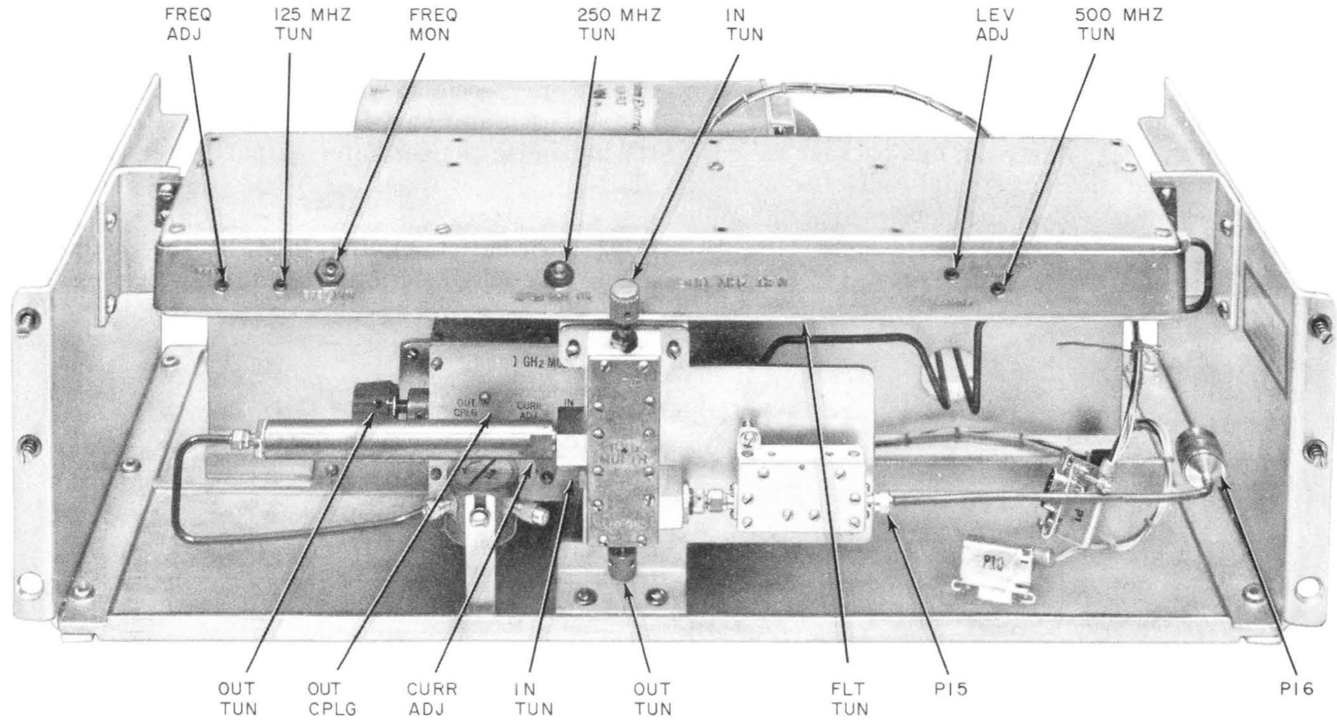


Fig. 23—J68387R-2 Microwave Generator, High-Power Output

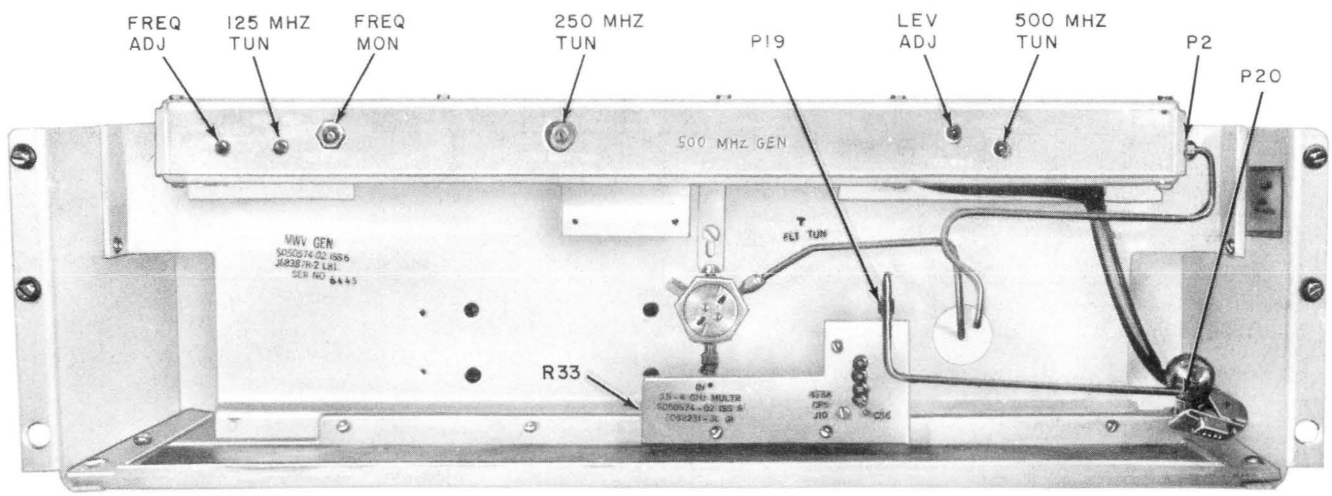


Fig. 24—J68387R-2 Microwave Generator, Low-Power Output

components as the high-power generator except the last doubler and the quadrupler are replaced by an octupler.

7.06 The oscillator, amplifier, and first two doublers are contained in one package called the 500-MHz generator. The crystal-controlled oscillator operates on one of 17 frequencies spaced 1.25 MHz apart in the frequency range from 118.125 through 128.125 MHz. The specific crystal frequency is determined by the output frequency that must be supplied by the microwave generator and is equal to that frequency divided by 32. Two tuning adjustments are associated with the oscillator stage: one to set the oscillator on frequency (FREQ ADJ) and one to maximize the oscillator output power (125 MHz TUN).

7.07 The buffer amplifier following the oscillator is a single fixed-tuned amplifier which provides

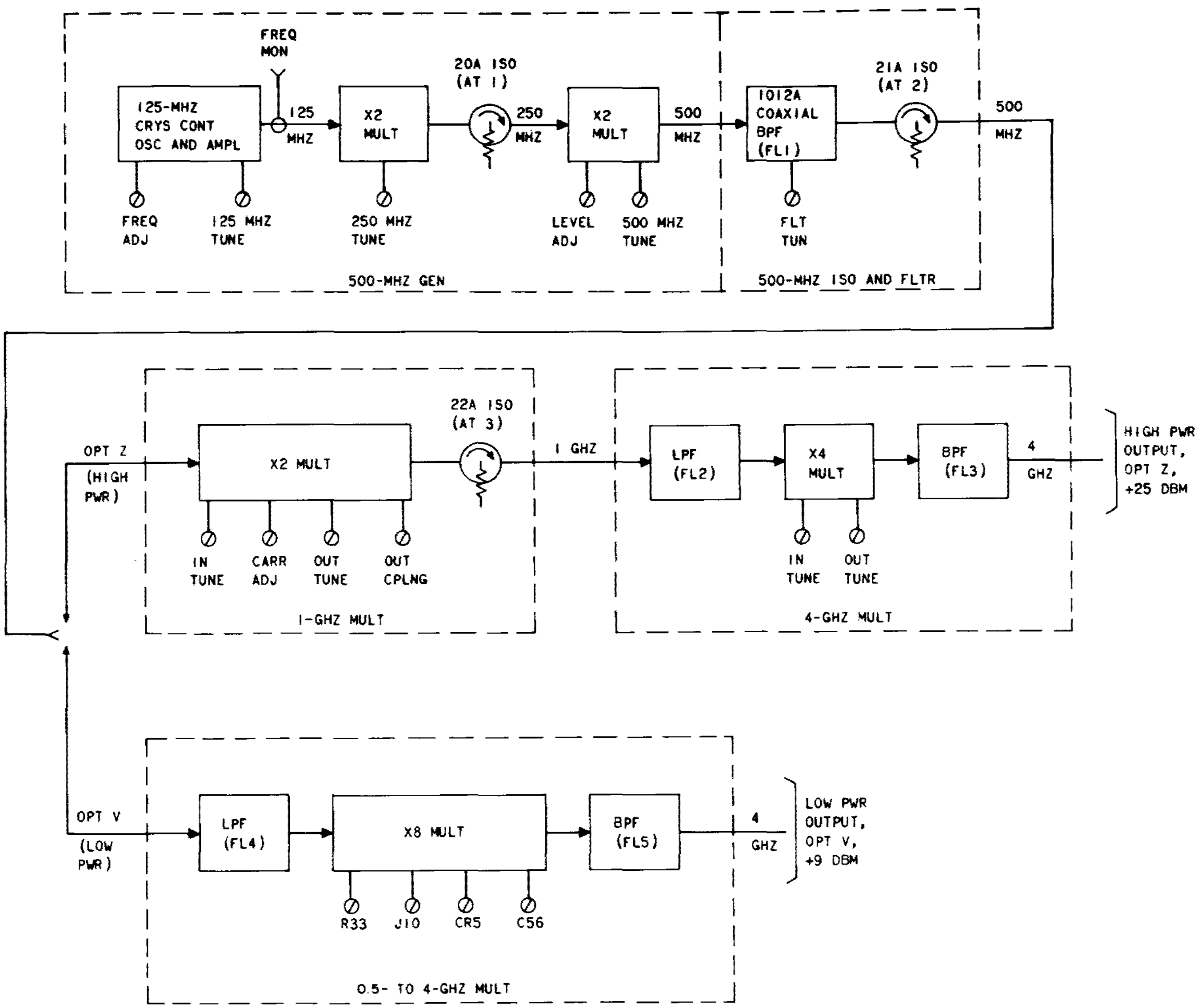


Fig. 25—J68387R-2 Microwave Generator—Block Diagram

approximately 10-dB gain to the oscillator signal. This stage raises the signal level and also serves to isolate the oscillator from the first doubler stage, thereby preventing oscillator instability due to circuit interactions. A monitoring diode is connected to the output of this stage to provide an indication of the oscillator-amplifier output level on the meter circuit of the transmitter-receiver bay.

7.08 In the following paragraphs, 125-, 250-, 500-, 1000-, and 4000-MHz values are used as nominal frequencies to describe the operation of the frequency multiplying circuits. Actually, the frequencies could be values from 118.125 through 128.125 MHz, 236.25 through 256.25 MHz, 472.5 through 512.5 MHz, 945 through 1025 MHz, and 3780 through 4100 MHz, respectively, depending on the crystal frequency.

7.09 The 125- through 250-MHz and the 250- through 500-MHz doubler stages each use an overlay-type transistor to simultaneously obtain frequency doubling and conversion gain. A bandpass filter at the output of each doubler circuit passes the desired harmonic frequency and rejects all others. A 250-MHz isolator having approximately 20-dB reverse loss is used between the two doubler stages to provide isolation and prevent interaction when making tuning adjustments. Three controls are associated with these stages. One is used to maximize the output of the first doubler (250 MHz TUN); another is used to maximize the output of the second doubler (500 MHz TUN). The third control, LEV ADJ, is a common gain control for both doublers and is used to set the 500-MHz output level. A portion of the output of each doubler stage is rectified by a monitoring diode to provide an indication of output level on the meter circuit of the transmitter-receiver bay.

7.10 The output of the 500-MHz generator is applied to a 1012A bandpass filter. This is a tunable, high-Q cavity filter used to improve the signal-to-noise ratio of the microwave generator. The filter has a bandwidth of approximately 300 kHz at the 3-dB points. An isolator having about 20-dB reverse loss is used at the output of the filter to prevent interaction between the filter and the adjoining doubler stages.

Option Z (High-Power Output, +25 dBm)

7.11 The 1-GHz multiplier circuit uses a transistor amplifier—doubler stage to multiply the 500-MHz input signal to 1000 MHz. A filter at the output passes the 1000-MHz signal and rejects the other harmonics generated in the multiplier. Four tuning adjustments are used for setting the 1000-MHz output. A measure of this output is provided by the transistor collector current which can be monitored by the meter circuit in the transmitter-receiver bay. A 22A isolator, having about 20-dB reverse loss, is used at the output of the 1-GHz multiplier to prevent interaction with the 4-GHz multiplier.

7.12 Frequency multiplication in the 4-GHz multiplier is obtained using a varactor diode mounted in a distributed-element circuit. The multiplier stage is preceded by a low-pass filter which passes the 1000-MHz input signal and rejects all harmonics of 1000 MHz generated in the multiplier. The multiplier stage has two tuning adjustments used for maximizing the 4000-MHz output. The bandpass filter at the output of the multiplier passes only the 4000-MHz harmonic, rejecting all other harmonics.

Option V (Lower-Power Output, +9 dBm)

7.13 The 0.5- through 4-GHz multiplier circuit is used to provide ×8 frequency multiplication of any single frequency input signal in the 472.5- through 512.5-MHz range to result in an output signal in the 3.78- through 4.10-GHz range. The normal input power is +27 dBm, and the nominal output power is +9 dBm. The assembly is self-biased and requires no external power sources.

C. Equipment Description

7.14 The J68387R-2 microwave generator measures 21 inches wide by 11 inches deep by 7 inches high and weighs 40-3/4 pounds. The generator is assembled on a die-cast aluminum chassis that mounts into the lower portion of the transmitter-receiver bay framework. The chassis fastens to the sides of the framework with 1/4-turn fasteners. Handles are provided at each side for lifting. All adjustments are accessible from the front of the unit. Two cables with multicontact connectors are used to connect to a pair of bay-mounted connectors, appearing near the front right-hand side of the generator to provide dc power and metering connections. Also located at this same point is a type-N coaxial connector from which the microwave output from the unit is taken.

8. J68387W 40-MHz OSCILLATOR—SHIFT MODULATOR

A. General

8.01 In a standard transmitter-receiver bay, the transmitted and received frequencies differ by 40 MHz. The common microwave generator furnished in a repeater station bay operates at the local oscillator frequency required by the transmitter modulator. The function of the 40-MHz oscillator and shift modulator is to shift a portion of the output of the microwave generator by 40 MHz to provide the local oscillator frequency required by the receiver modulator.

8.02 The modulator combines the input signal from the microwave generator with a 40-MHz signal from the oscillator unit to produce two output signals 40 MHz above and below the microwave generator output frequency. The desired signal is selected and the other removed by a subsequent bandpass filter. The 40-MHz oscillator unit consists of a crystal-controlled transistor oscillator stage followed by two transistor amplifier stages. The unit generates a 40-MHz signal at a level adjustable over the range from +12 through +21 dBm. Frequency adjustment is provided. The signal is coupled through a 50-ohm coaxial low-pass filter to the modulator. The modulator unit includes a stepped waveguide transducer, a waveguide low-pass filter, a diode, a diode holder, and a waveguide termination. The modulator has a single port which serves as both input for the generator signal and output for the shifted-frequency signals. The nominal input from the microwave generator is +18 dBm, and the shifted output is +9 dBm.

B. Functional Description

8.03 The 40-MHz oscillator—shift modulator (Fig. 26) consists of a 40-MHz oscillator and a modulator. An RF signal from the microwave generator is applied to the modulator along with the output from the 40-MHz oscillator. The modulator produces two RF output signals: one 40 MHz higher than the frequency of the microwave generator signal and one 40 MHz lower in frequency. A bandpass filter in the external circuit selects the desired sideband for use as the local oscillator input to the receiver modulator.

8.04 The 40-MHz oscillator consists of a crystal-controlled oscillator stage followed by a buffer amplifier and a power amplifier. The oscillator stage uses a third overtone crystal to produce the 40-MHz signal. Fine adjustment of the oscillator frequency is provided by the FREQ control. The PWR ADJ control is used to set the power output of the last stage, typically to +16 dBm. The output from the power amplifier is fed through the 50-ohm coaxial low-pass filter to the modulator circuit.

8.05 The shift modulator consists of six basic parts: a stepped waveguide transformer, a waffle-iron low-pass filter, a diode, a diode holder, a coaxial low-pass filter, and a harmonic termination.

8.06 The stepped transformer provides an impedance transformation from the standard-height waveguide input port (1.145 inches) to a reduced-height waveguide structure (0.100 inch).

8.07 The waffle-iron low-pass filter passes frequencies from 3700 through 4200 MHz with negligible loss but provides at least 50-dB loss to frequencies of 7 GHz and above. This prevents harmonics of the 4-GHz signals generated in the diode from entering succeeding circuits in the receiver and causing undesired intermodulation and transmission distortion effects.

8.08 The diode is a Schottky-type device mounted in a diode holder located on the front of the modulator unit. The diode is connected in series with the coaxial low-pass filter and an impedance-matching stub formed by the diode holder and composed of a short length of coaxial line terminated in a short circuit. The low-pass filter offers very high insertion loss to frequencies above 3 GHz and a negligible loss at 40 MHz. The filter prevents harmonics of the 4-GHz signals in the modulator from entering the output stage of the oscillator where they could cause undesirable overload effects.

8.09 The harmonic termination is a reduced-height (0.100 inch) and reduced-width (1.245 inches) waveguide structure. The termination absorbs harmonics generated in the diode but reflects the 4-GHz signals. This reflective (at 4 GHz) termination, together with the impedance-matching stub, provides a fixed, broadband match for the diode in the modulator unit. No diode tuning adjustments are necessary.

C. Equipment Description

8.10 The 40-MHz oscillator—shift modulator (Fig. 27) consists of two physically associated

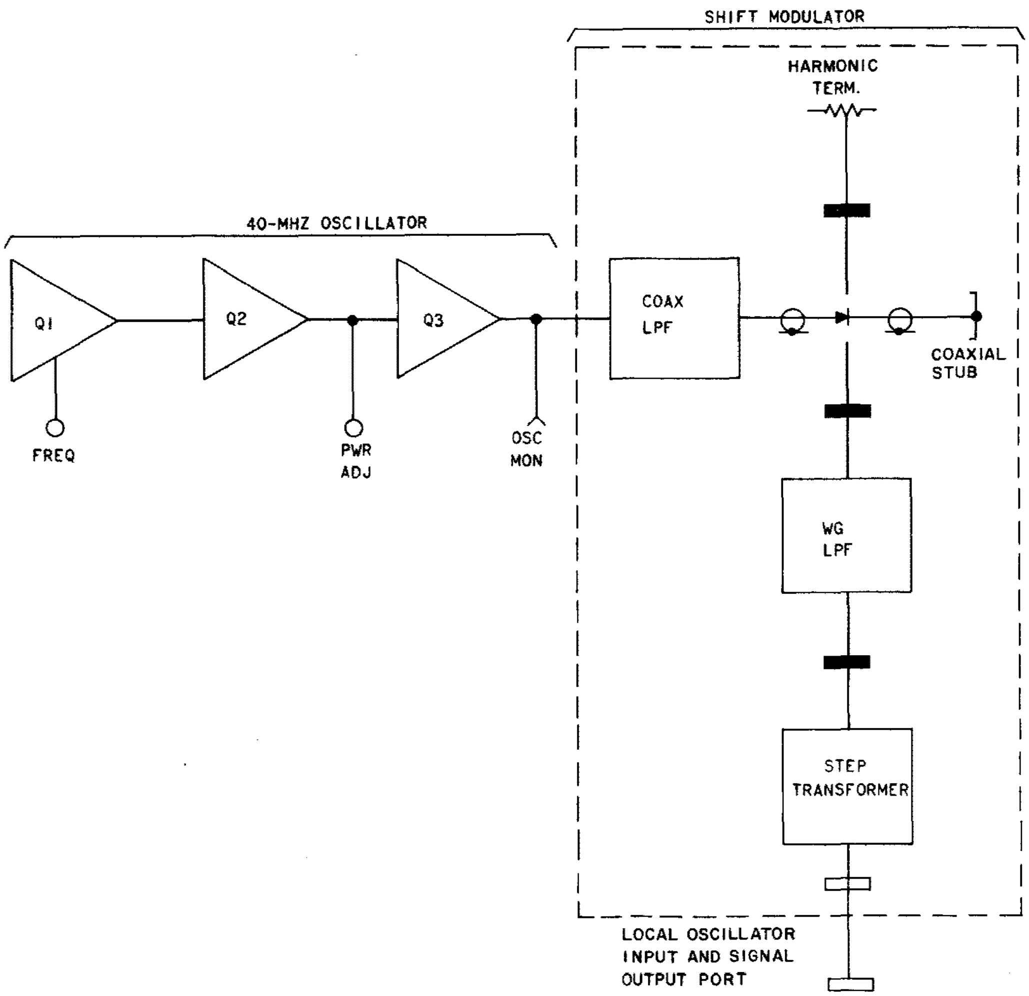


Fig. 26—J68387W 40-MHz Oscillator—Shift Modulator—Block Diagram

nonfield-separable units. The 40-MHz oscillator, assembled on a printed wiring board, and RF decoupling networks for the dc power connections are mounted inside a cast-aluminum frame. The frame is fitted with covers and connects to the modulator. Adjustments are accessible through guides in the front of the unit. A coaxial jack in the front provides for monitoring the frequency of the oscillator. A multicontact connector for dc power is located in the top of the frame. The shift modulator consists of a 2-piece aluminum housing which forms the step transducer from full- to reduced-height waveguide, the waffle-iron low-pass filter, and the reduced-width waveguide section into which fits the harmonic termination. The construction is similar to that of the receiver modulator (Fig. 16). The diode holder screws into the front of the housing, and the coaxial low-pass filter fastens to the rear. A hole gauge is provided at the front to set the position of the diode in its holder. The assembled unit measures approximately 3-1/2 by 6 by 12-1/2 inches and weighs 4-3/4 pounds.

9. DISTRIBUTION NETWORK

A. 27B Integrated Circuit

9.01 The 27B integrated circuit (Fig. 28) is a distribution network for the microwave generator output signal in a repeater station T-R bay. The input signal from the microwave generator is split in two directions by the integrated circuit, one portion going

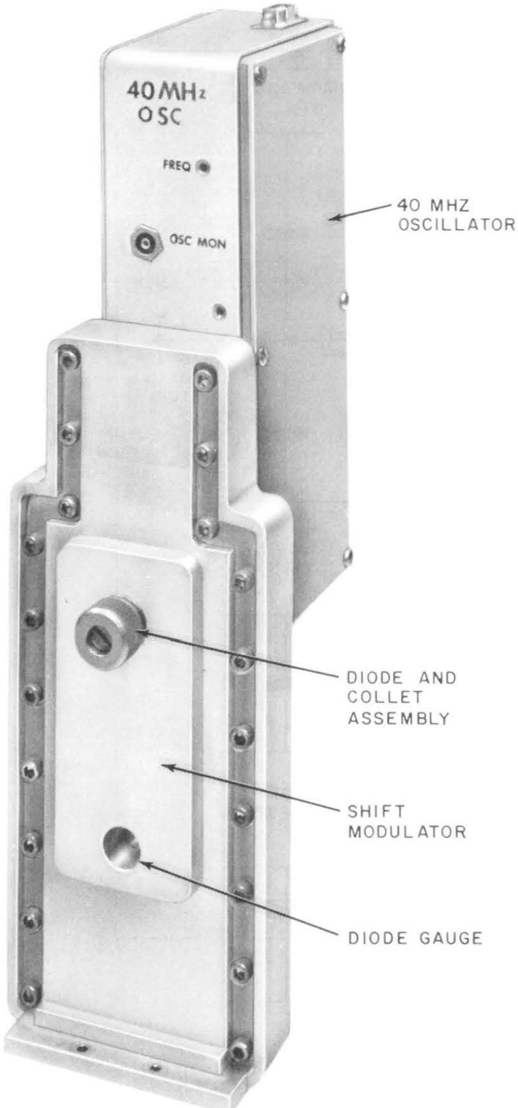


Fig. 27—J68387W 40-MHz Oscillator—Shift Modulator

to the 40-MHz shift modulator and the other to the transmitter modulator. The 27B provides connecting ports for these modulators, a means of passing the desired output signals from the modulators onto the succeeding circuits, and the necessary isolation between the modulators. Also included is a monitoring diode that permits checking the power from the microwave generator on the T-R bay meter circuit.

9.02 A schematic of the 27B integrated circuit is shown in Fig. 29. The output from the microwave generator is connected to the circuit at port 1

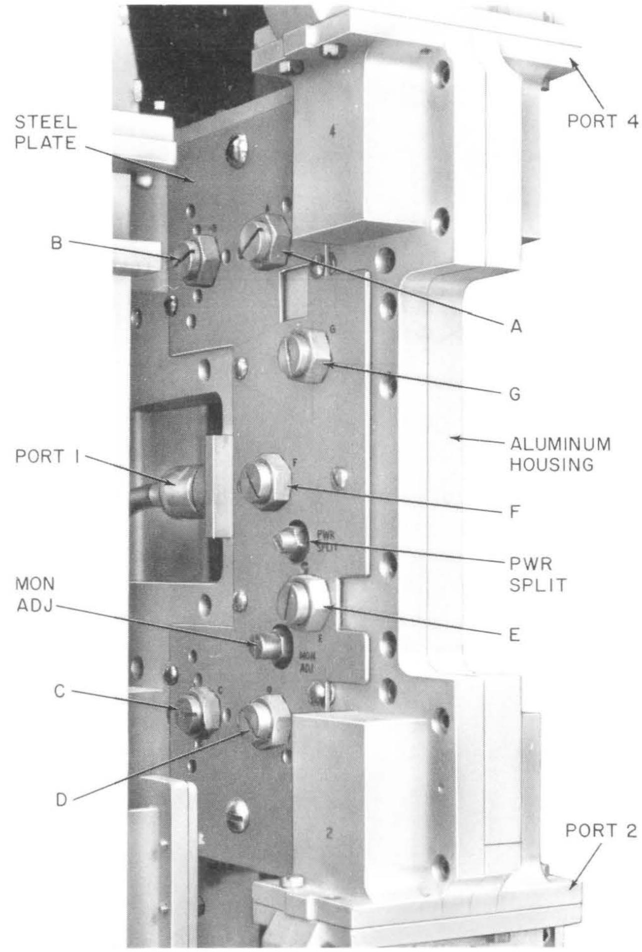


Fig. 28—27B Integrated Circuit

via a coaxial-to-50-ohm stripline transducer. The signal passes through circulator F, in the direction indicated, to a power splitter formed by an adjustable reactive mismatch. This mismatch is factory-adjusted so that approximately 60 percent of the power goes past the power splitter and the remainder is reflected back towards circulator F.

9.03 The portion of the signal passing through the power splitter is delivered to port 2 of the circuit via circulators E and D and a 50-ohm stripline-to-waveguide transducer. Circulator E acts as an isolator. The T-R bay transmitter modulator is connected directly to port 2. The sideband outputs (microwave generator frequency ±70 MHz) from the transmitter modulator are returned to port 2 and, after passing through circulators D and C, are delivered to port 3 by another stripline-to-waveguide

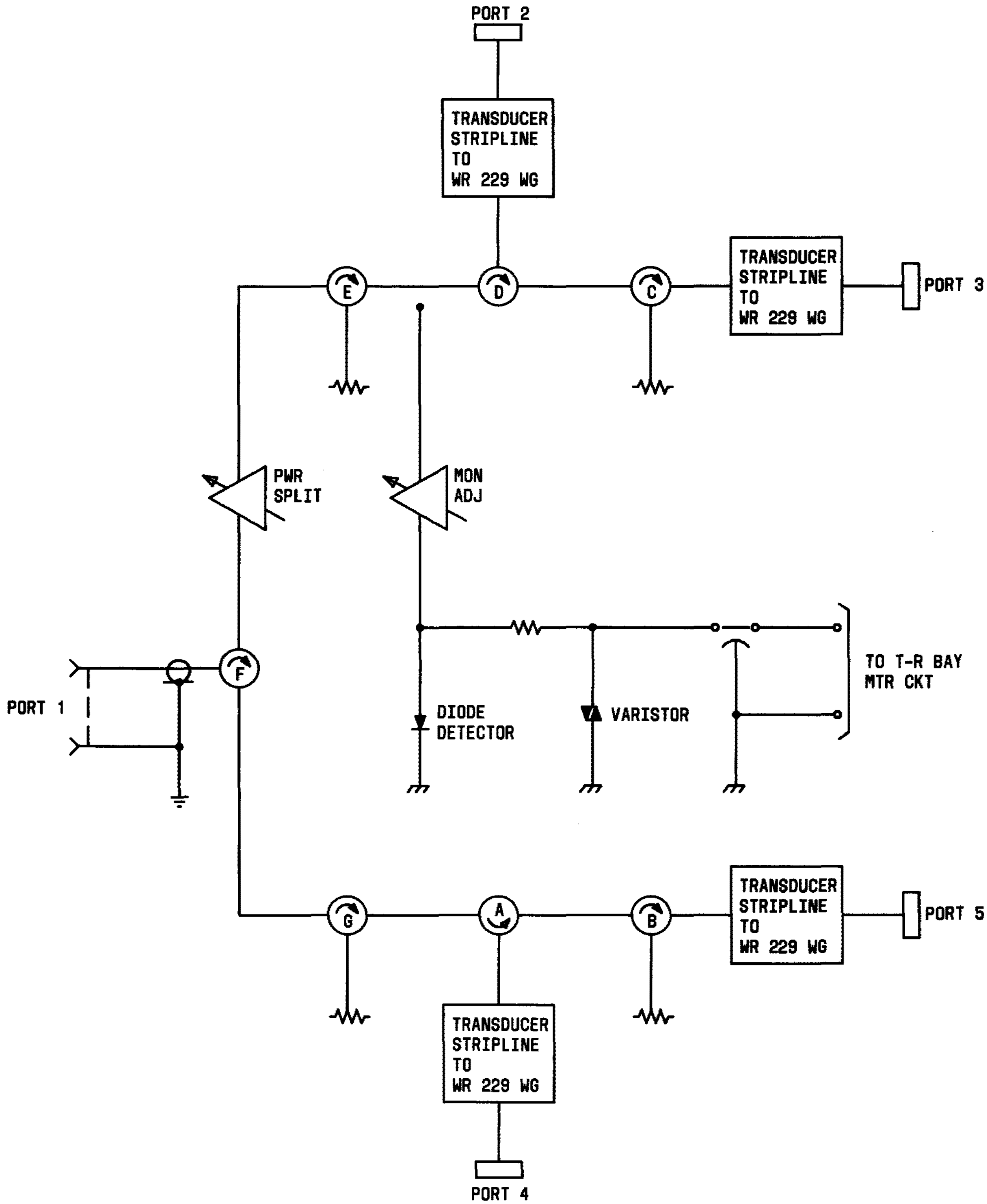


Fig. 29—27B Integrated Circuit—Schematic Diagram

transducer. The desired sideband output is selected by an external filter (1301-type) connected to port 3. Unwanted outputs from the modulator are reflected by the filter and absorbed in the termination on circulator C.

9.04 The portion of the microwave generator signal that is reflected from the power splitter is delivered to port 4 of the circuit via circulators F, G, and A and a 50-ohm stripline-to-waveguide transducer. Circulator G serves as an isolator. The 40-MHz shift modulator in the T-R bay is connected directly to port 4. The sideband outputs (microwave generator frequency ±40 MHz) are returned to port 2 and are delivered to port 5 via circulators A and B and a stripline-to-waveguide transducer. An external filter (1323-type) connected to port 5 selects the desired sideband output. The unwanted outputs from the modulator are reflected back to port 5 by the filter, where they are absorbed in the termination on circulator B.

9.05 A diode detector circuit capacitively coupled to the main transmission line between circulators D and E provides a means of monitoring, on the T-R bay meter circuit, the microwave generator power delivered to the transmitter modulator. The MON ADJ control is used to adjust the meter indication to a specific value for the normal power condition. A varistor across the meter connection protects the diode from damage that could result if transient voltage spikes were to couple onto the meter circuit leads.

9.06 The 27B integrated circuit is assembled in a 2-piece aluminum housing. The transmission paths through the circuit are 50-ohm stripline formed by conductor strips plated onto thin alumina ceramic substrates. The circulators are composed of ferrite disks bonded to opposite sides of the substrate. Each circulator is magnetically biased by a permanent magnet attached to a steel screw (Fig. 28) which is factory-adjusted to obtain the required circulator performance. Return paths for the magnetic field are provided by interconnected steel plates attached to both sides of the aluminum housing and by steel plugs below each circulator.

B. 28B Integrated Circuit

9.07 The 28B integrated circuit (Fig. 30) furnishes the connecting circuits needed between the transmitter microwave generator and the transmitter modulator and between the receiver microwave generator and the receiver modulator in a main station T-R bay. Separate paths are provided for this purpose. Each path provides isolation between the generator and the connecting circuits, and each includes a level-setting attenuator to adjust the generator power delivered to the modulator. The transmitter path also contains a monitoring diode that permits checking the power from the transmitter microwave generator on the T-R bay meter circuit.

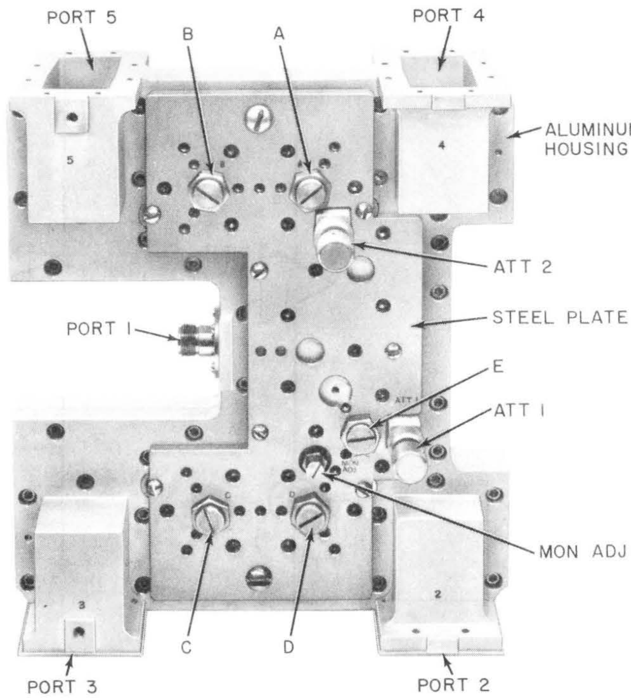


Fig. 30—28B Integrated Circuit

9.08 A schematic of the 28B integrated circuit is shown in Fig. 31. The output of the transmitter microwave generator is connected to the circuit via a coaxial-to-50-ohm stripline transducer at port 1. The signal is passed through circulator E to an adjustable reactive mismatch, ATT 1. This mismatch serves as a variable attenuator, reflecting a portion of the incident power and passing the remainder onto the termination. The power reflected from ATT 1 returns through circulator E and is delivered to port 2 via circulator D and a stripline-to-waveguide transducer. The T-R bay transmitter modulator is connected directly to port 2. The setting of ATT 1 determines the amount of microwave generator power that is delivered to the transmitter modulator. The sideband outputs (microwave generator frequency ±70 MHz) from the transmitter modulator are returned to port 2 and, after passing through circulators D and C, are delivered to port 3 via another stripline-to-waveguide transducer. The desired sideband output is selected by an external filter (1301-type) connected to port 3. Unwanted outputs from the modulator are reflected by the filter and absorbed in the termination on circulator C.

9.09 A diode detector circuit identical to that in the 27B integrated circuit (paragraph 9.05) provides a means of monitoring on the T-R bay meter circuit the transmitter microwave generator power delivered to the transmitter modulator.

9.10 The output of the receiver microwave generator is connected to port 4 of the circuit. The signal is passed through a waveguide-to-stripline transducer and circulator A to an adjustable reactive mismatch, ATT 2. The power reflected from ATT 2 is returned to circulator A and is delivered to port 5 via circulator B and a stripline-to-waveguide transducer. The power that is not reflected is absorbed in the termination beyond ATT 2. Thus, the setting of ATT 2 determines the amount of microwave generator power that is delivered to port 5. The output signal from port 5 is passed through an external filter (1338-type) to the T-R bay receiver modulator. Circulator B serves as an isolator.

9.11 The construction of the 28B integrated circuit is essentially identical to that of the 27B integrated circuit (paragraph 9.06).

10. J68330K TRANSMITTER AMPLIFIER

A. General

10.01 The transmitter amplifier (Fig. 32) is a 3-stage, grounded-grid, electron-tube-type amplifier. Each stage (Fig. 33) consists of a tuner-transducer and a 416-type electron tube mounted in a cavity assembly. The first two stages are alike except for the RF powers at which they operate. The last stage is similar to the first two stages with the addition of a filter section for broadbanding.

10.02 The transmission band of the amplifier is capable of being tuned flat to 0.1 dB over a bandwidth of approximately 20 MHz and is approximately 70 MHz wide at the 3-dB downpoints.

10.03 The input power to the amplifier is typically +12 dBm, and the output may be +37 dBm (5 watts), +33 dBm (2 watts), or +30 dBm (1 watt), depending on the system application. When 2-watt (+33 dBm) output power is required, the 416-tube transmitter amplifier may be replaced by the solid-state 660( ) IC transmitter amplifier. See Part 11.

10.04 The ED-51566-( ) tuner-transducers permit the in-bay alignment of the amplifier to be made without mechanical disassembly. Each unit allows access to the through-signal via a threaded coaxial probe and a waveguide short circuit which slides into place behind the probe to form a waveguide-to-coaxial transducer. The coaxial probe and shorting plate are furnished with the test equipment for the bay.

B. Functional Description

Input Circuit to Each Stage

10.05 The input to each stage is fed to a capacitively loaded iris at the input to the cavity assembly through an impedance tuner [part of the ED-51566-( ) tuner-transducer assembly, Fig. 33] capable of tuning out a standing wave of 8 dB.

10.06 The input of each cavity is loaded by the input conductance and the ceramic loss of the tube. Coupling into the cavity is adjusted by rotating a capacitive screw (the input aperture tuning control, CP1) in the input iris. The input circuit without any impedance-matching controls is a single tuned circuit heavily loaded by the input conductance of the tube. Since no adjustment is available in the input conductance of the tube and since no loading resistance is provided in the input cavity, the external tuner is required to obtain a good impedance match.

10.07 The tuner portion of the tuner-transducer assembly consists of two antiresonant circuits separated by approximately one-eighth wavelength; this combination is separated by approximately one-eighth wavelength from the input iris capacitive screw. The two rods act as inductances, and the two screws act as adjustable capacitances.

10.08 An impedance match having a bandwidth of over 20 MHz can be obtained in the input circuit when both the input and output circuits are matched. The adjustment of these circuits is done using an in-bay alignment procedure in which the

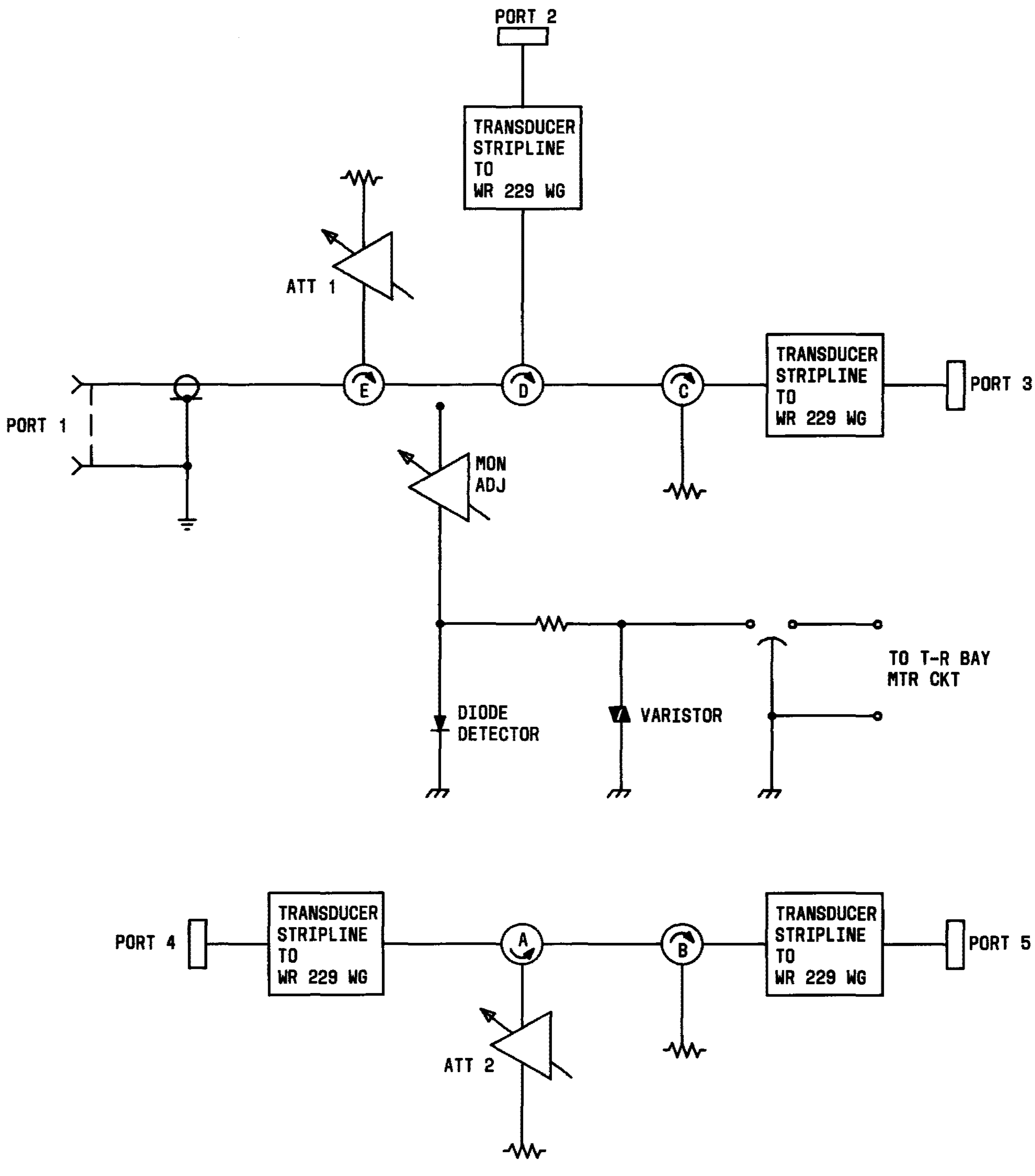


Fig. 31—28B Integrated Circuit—Schematic Diagram

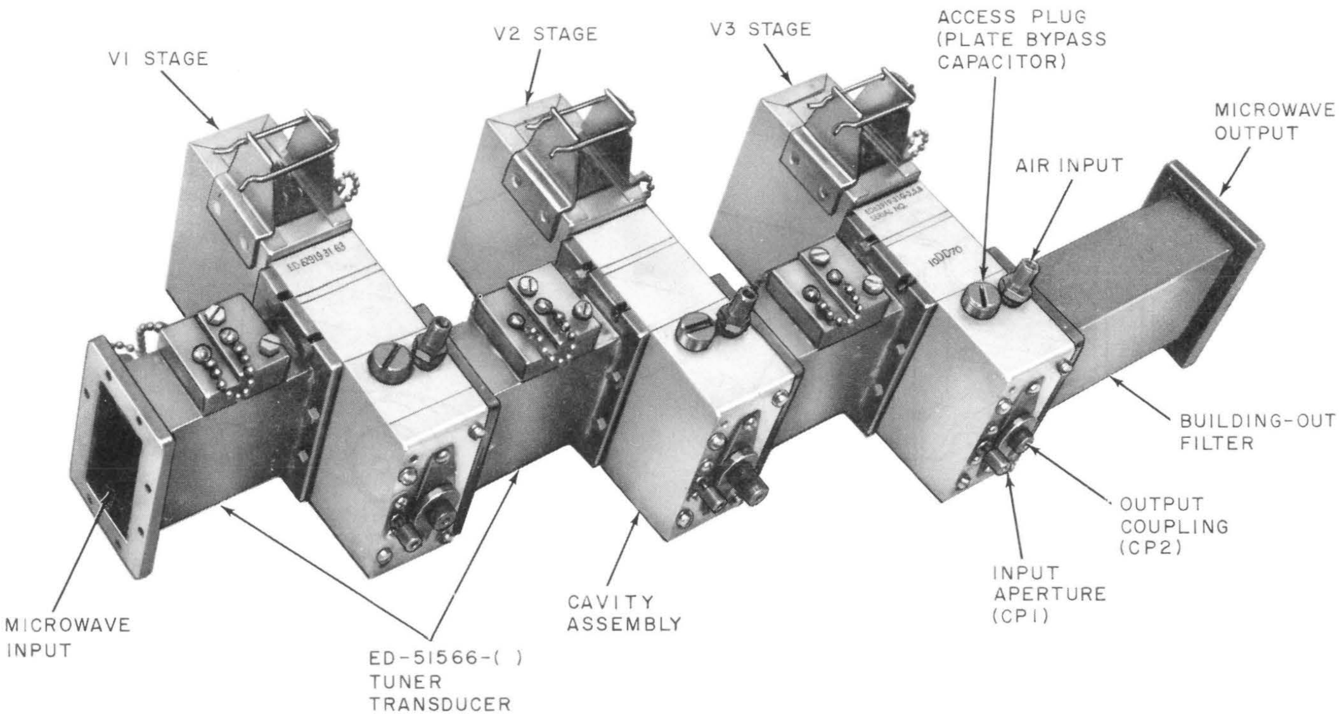


Fig. 32—Assembled 3-Stage Transmitter Amplifier

input and output tuning of the stage is adjusted for maximum power transfer.

Plate Circuit of the Tube

10.09 A small resonant section of coaxial line is connected to the plate of the tube with the high-impedance end of the line located at the plate. A 1/4-wavelength coaxial transformer is located at the low-impedance point of this line which transforms the impedance at this point to match a 47-ohm coaxial line. The 47-ohm coaxial line terminates in a broadband transducer with variable capacitive loading. Variation of the position of the 1/4-wave transformer (by means of the plate tuning control) changes the inductance of the resonant section of line for tuning. Variation of the capacitive loading of the transducer (by means of the output coupling control, CP2) varies the coupling between the plate circuit and the transducer.

Interstage Circuit

10.10 The output circuit of one stage and the input circuit of the next, each of which is antiresonant, are separated by an odd number of one-fourth wavelengths through the tuner-transducer. The overall circuit forms a bandpass filter which is approximately 30 MHz wide at the 1-dB downpoints.

Output Circuit of the Amplifier

10.11 The output circuit consists of the equivalent of a 2-section bandpass filter terminated on one end by the variable loading and plate resistance of the tube and, on the other end, by the characteristic impedance of the waveguide. Effectively, the plate circuit and associated cavity form one antiresonant circuit or cavity, and a single building-out filter section (antiresonant circuit in waveguide) is the other circuit. These circuits are electrically separated by an odd number of one-fourth wavelengths forming a bandpass filter with a bandwidth of approximately 30 MHz at 0.1 dB down and approximately 80 MHz at 3 dB down.

10.12 The building-out filter is spaced approximately one-fourth wavelength from the electrical position of the plate circuit. It consists of a resonant iris, the hole forming an inductance and the

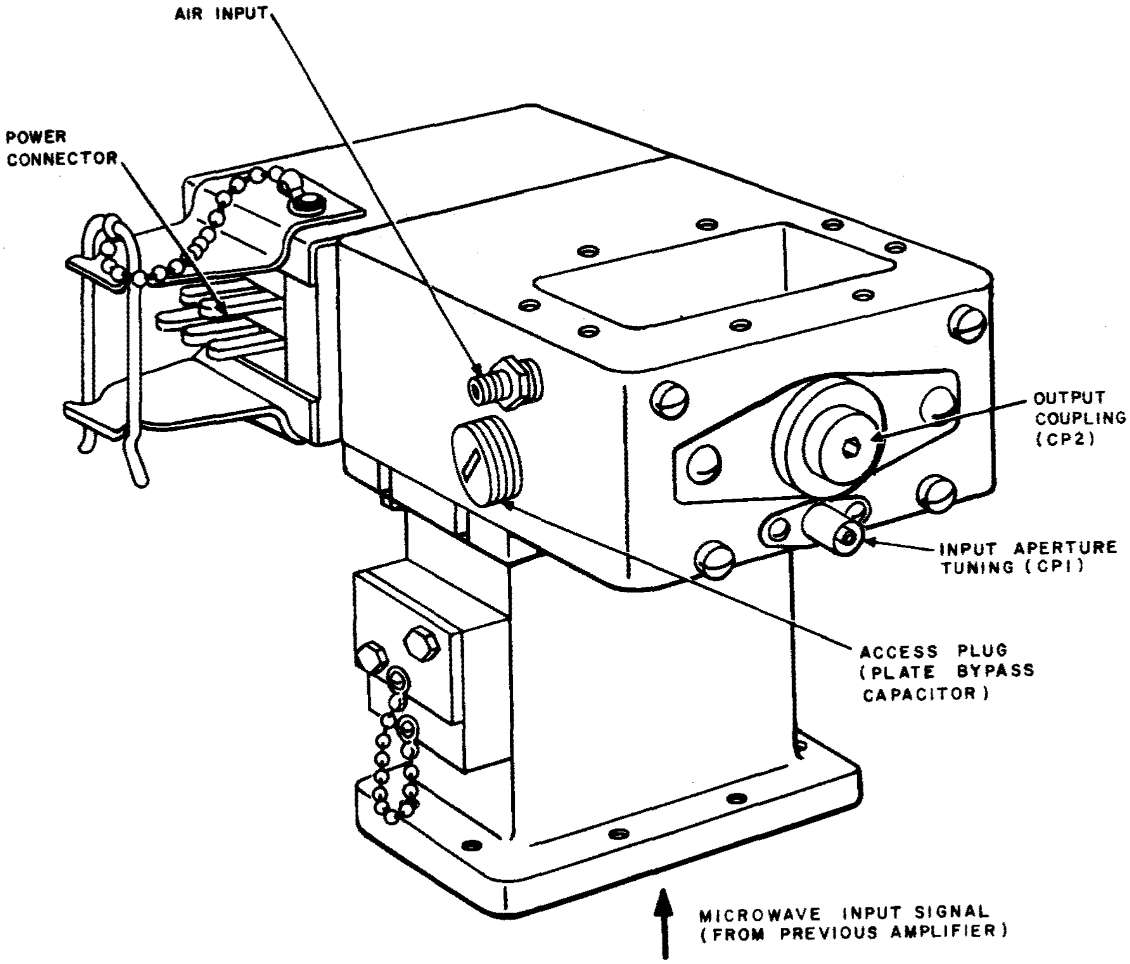


Fig. 33—Single Stage of Transmitter Amplifier

two posts forming a capacitance shunted across the inductance. The filter is tuned by means of a screw which varies the capacitance. The bandwidth at the 3-dB downpoints is approximately 100 MHz.

C. Equipment Description

10.13 The components of the transmitter-amplifier assembly are of the waveguide type, and the whole constitutes one rigid assembly with an overall length of 17 inches. The unit is supported in the bay by means of brackets mounted on the rear panel.

10.14 The amplifier interstage allows the V1 and V2 stages to be aligned without requiring mechanical disassembly. The interstage, referred to as the "tuner-transducer" interstage, allows access to the through-signal via a screw-in coaxial probe. In the test position, a removable waveguide short circuit is placed behind the probe to form a waveguide-to-coaxial transducer. During the normal transmission, the waveguide short and the coaxial probe are removed and replaced by covers to prevent RF leakage. A double-screw tuner is included as part of the transducer assembly for impedance matching purposes. Similar in-bay alignment and testing of the V3 stage is done using the transmitter monitor-shutter assembly mounted above the amplifier in the bay.

10.15 The cavity assembly (Fig. 32 and 33) is made of silver-plated brass with overall dimensions of approximately 3-1/4 by 6 by 1-1/2 inches. A special torque wrench (KS-14408) is required to insert and remove the 416-type electron tube. The input of each stage, obtained in each case through a tuner-transducer, is fed into the cavity through an iris and coupled directly to the tube between the cathode and the grounded grid. The plate connection on the electron tube fits into a 3/16-inch rod which extends up into the output cavity as a probe. The 250V plate supply is connected to the probe end of this rod by means of a 1/4-wavelength wire. The output cavity is connected directly to a tuner-transducer or, in the case of the output stage, to the waveguide output filter. There are three controls on an amplifier cavity. About the intercavity conductor is a cylinder which acts as part of the transformer. Moving the cylinder along the conductor changes the plate tuning. This motion is accomplished by a shaft (plate tuning control) which extends out through the wall of the cavity and can be rotated by means of a rod-like tool. On the inner face of the shaft is an eccentric plug which fits into a slot in the cylinder for translating the rotating motion of the shaft to a sliding motion of the cylinder. The rather large thumbnut (indicated in Fig. 32 and 33 as output coupling CP2) affects the plate-to-waveguide couplings. Rotating the thumbscrew varies the amount the screw protrudes into the cavity. A small thumbscrew (indicated as input aperture tuning control CP1) varies the amount a tuning screw protrudes into the input iris.

D. Transmission Characteristics

10.16 The transmission characteristics are as follows:

(a) For +30 dBm operation

Frequency Range	3700 to 4200 MHz
Gain — As Aligned	18 dB
Amplifier Bandwidth (01-dB Downpoints)	20 MHz
Output	+30 dBm (1-watt)
Input Return Loss	28 dB min over 20-MHz band
Output Return Loss	30 dB or more over 20-MHz band
Compression	9 dB (approx) at +30 dBm output
Plate Currents:	
First Stage	30 mA max
Second Stage	30 mA max
Third Stage	35 mA

(b) For +33 dBm operation

Frequency Range	3700 to 4200 MHz
Gain — As Aligned	21 dB
Amplifier Bandwidth (01-dB Downpoints)	20 MHz
Output	+33 dBm (2-watt)
Input Return Loss	25 dB over 20-MHz band
Output Return Loss	30 dB over 20-MHz band (controlled by 17-type flange isolator)
Compression	5 dB (approx) at +33 dBm output
Plate Currents:	
First Stage	45 mA max
Second Stage	45 mA max
Third Stage	45 mA max

(c) For +37 dBm operation

Frequency Range	3700 to 4200 MHz
Gain — As Aligned	25 dB
Amplifier Bandwidth (01-dB Downpoints)	20 MHz
Output	+37 dBm (5-watt)
Input Return Loss	24 dB over 20-MHz band
Output Return Loss	30 dB over 20-MHz band
Compression	5 dB (approx) at +37 dBm output
Plate Currents:	
First Stage	55 mA max
Second Stage	55 mA max
Third Stage	55 mA max

Note: For +33 or +37 dBm operation, characteristics, and features when the 660( ) transmitter amplifier is used, see Part 11 and Table B.

TABLE B

660 ( ) INTEGRATED CIRCUIT FEATURES AND CHARACTERISTICS

FEATURES	CHARACTERISTICS
Frequency Range	
660A or 660C	3.70 to 3.94 GHz
660B or 660D	3.94 to 4.20 GHz
RF Output Power	
660A or 660B	+33.0 dBm (2 watts)
660C or 660D	+37.0 dBm (5 watts)
RF Input Power	+12.0 dBm (typical)
Gain Flatness	0.2 dB maximum variation over any 20-MHz band
Noise Figure	≤ 8 dB
AM/PM Conversion	2°/dB at +33 dBm (typical) 1°/dB at +37 dBm (typical)
Input/Output Connections	WR229 waveguide
Input/Output Return Loss	25 dB (minimum)
Harmonic Output	50 dB (minimum) below the carrier
Tuning Adjustments	One (to set output power)
Metering	None
DC Power	1.25A at—24V (2 watts) 2.45 ±0.4A at —24V (5 watts)

11. 660( ) IC TRANSMITTER AMPLIFIER

A. General

11.01 The 660( ) IC transmitter amplifier is a completely solid-state broadband power amplifier that replaced the 416 tube-type transmitter amplifier in new production TD-3D bays and which may be retrofitted easily into existing bays that were furnished with the tube-type amplifier.

11.02 With the 660( ) IC amplifier, the TD-3D bay is totally solid-state and thus has the inherent advantages of a completely solid-state bay, that is, greater reliability, more uniform (from bay to bay) transmission characteristics, greater transmission stability with time, and reduced maintenance.

11.03 The 660( ) IC has only one tuning adjustment (PWR ADJ) which is an RF input attenuator used to set the output power. See Fig. 34.

11.04 The 660( ) IC transmitter amplifier is powered directly from a standard −24 volt battery plant at approximately 1.25 amperes for (2 watts) or 2.45 ±0.4 amperes (5 watts) operation. The dc power, control, and metering functions provided for the 416 electron tube-type transmitter amplifier are ***not*** required for the 660( ) IC transmitter amplifier. Therefore, the −11 and +250 volt supplies and associated circuits previously required for the 416 tube-type amplifier may be disconnected and/or removed in existing bays and, of course, are not furnished in new production bays employing the 660( ) IC transmitter amplifier (see Parts 12 and 13).

11.05 At TD-2 stations where the −24 volts required to power the 660( ) IC amplifier is unavailable, a 281A or a 305B power unit must be used. The power unit is a −11V to −24V converter and is described in paragraph 15.07.

11.06 The 19A isolator used at the output of the 416 tube-type transmitter amplifier is not required in bays that employ the 660( ) IC amplifier. All other units in the T-R bay are retained.

11.07 Four apparatus codes are required for the 660( ) IC transmitter amplifiers to cover the 4-GHz band. The 660A and 660C are used from 3.7 to 3.94 GHz (channels 1, 2, 3, 7, 8, and 9). The 660B and 660D IC are used from 3.94 to 4.2 GHz (channels 4, 5, 6, 10, 11, and 12). The use of four codes permits optimizing the performance of the transmitter-amplifier in each half of the 4-GHz band. The 660A and 660B

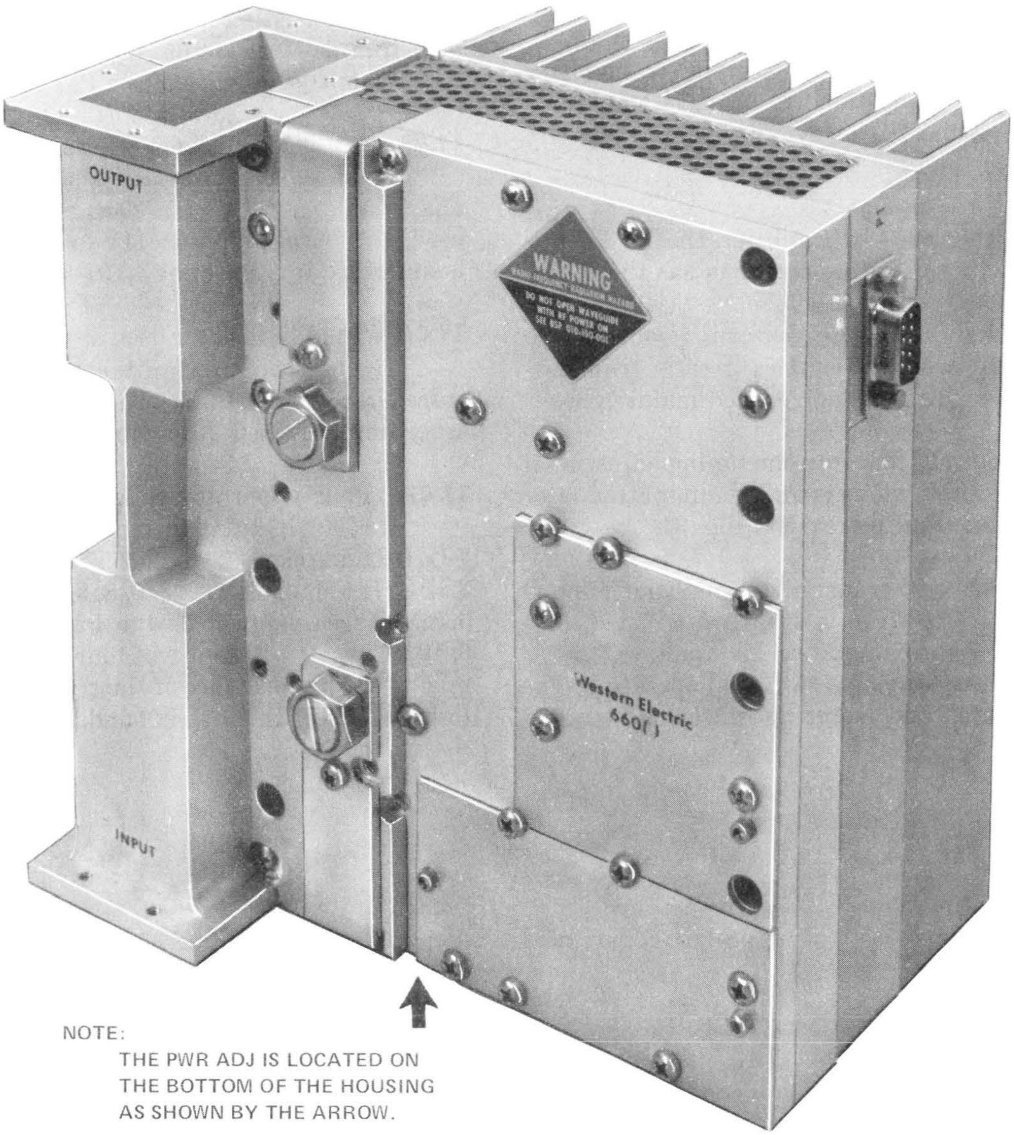


Fig. 34—660( ) Integrated Circuit 2-Watt or 5-Watt Power Transmitter Amplifier

are designed for 2-watt output operation but may be used for 1-watt output. The 660C and 660D are used for 5-watt operation.

B. Functional Description (2-Watt Operation)

11.08 Figure 35 shows a simplified block diagram of the 660( ) 2-watt IC amplifier. The amplifier has three gain stages, each of which employs a single gallium arsenide field effect transistor (GaAs FET). Each GaAs FET is mounted in a microstrip-type circuit that includes the necessary input and output impedance matching networks for the stage. The first two stages form a preamplifier which provides a net gain of about 17 dB to drive the power output stage. A circulator, also constructed in microstrip, isolates the preamplifier from the output stage and permits the second stage to be optimized for power handling capacity and linearity.

11.09 The input and output isolators, which serve to provide a good input and output return loss for the amplifier, are constucted in air-dielectric stripline. The output stripline circuit contains a low-pass filter used to attenuate the second and third harmonics of the signal generated in the amplifying stages. As already mentioned, the input stripline circuit includes an adjustable RF attenuator, which is the only adjustment required in the amplifier. Stripline-to-waveguide transducers complete the circuit to provide standard WR-229 waveguide connections to the input and output of the amplifier.

C. Functional Description (5-Watt Operation)

11.10 Figure 36 shows a simplified block diagram of the 660( ) IC 5-watt amplifier. The amplifier has four gain stages, each of which employs a single gallium arsenide field effect transistor. The first three stages are essentially the same as those used to form the 2-watt amplifier; the fourth stage provides the additional gain and power handling capacity needed to supply 5 watts output. The 2- and 5-watt amplifiers are physically interchangeable in the TD-3D bay. Like the 2-watt amplifier, the 5-watt amplifier may be powered either directly from a −24 volt battery plant or from a −12 volt plant by means of a −12V to −24V converter (i.e., 305B power unit).

D. Equipment Description

11.11 The amplifier circuit is assembled in a 2-piece, die-cast aluminum housing. The amplifier is cooled by free air convection. The nominal operating temperature of the housing is about 12°C (22°F) higher than the room ambient for the 2-watt units and about 26°C (47°F) higher than the ambient temperature for the 5-watt units.

12. J68387AC CONTROL, ALARM, AND METERING PANEL

A. General

12.01 The control, alarm, and metering circuit (Fig. 37) provides means to control the 416 tube-type transmitter output power of the radio transmitter, activates alarms and switches when trouble develops in the transmitter or receiver section of the bay, and meters essential voltages and currents to give an indication of the operating status of the T-R bay.

12.02 For TD-3 station applications, this circuit also provides power units for converting −24

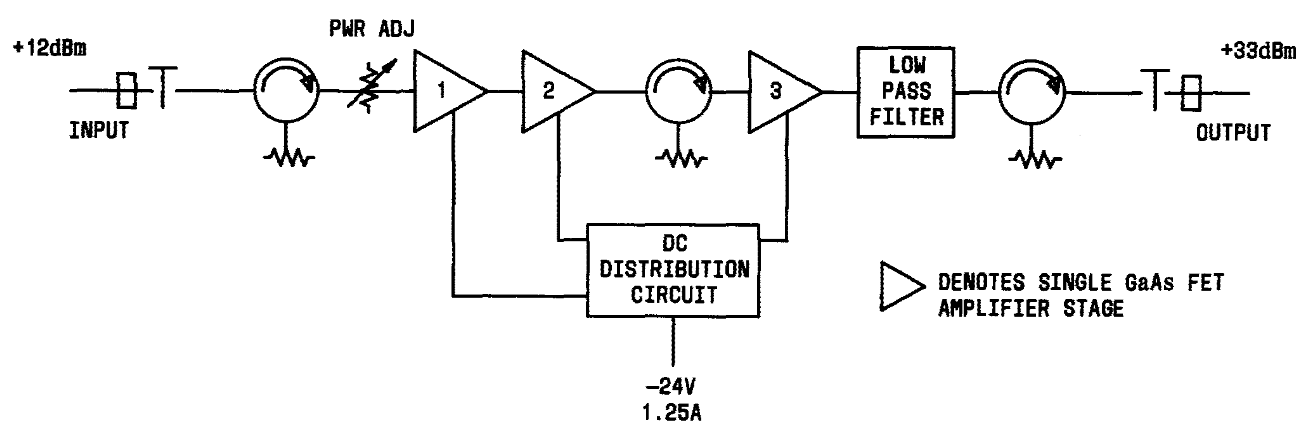


Fig. 35—Integrated Circuit (2-Watt Power Transmitter Amplifier)—Block Diagram

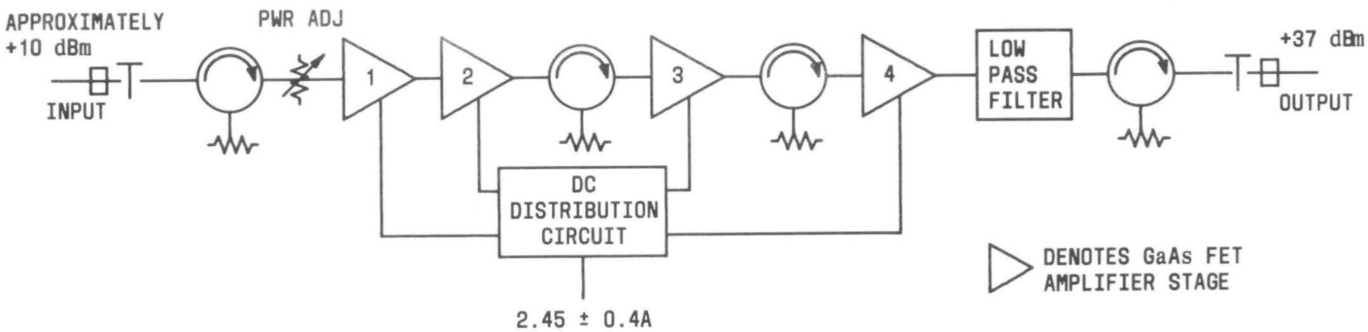


Fig. 36—Solid-State 660C and D Amplifier—Block Diagram

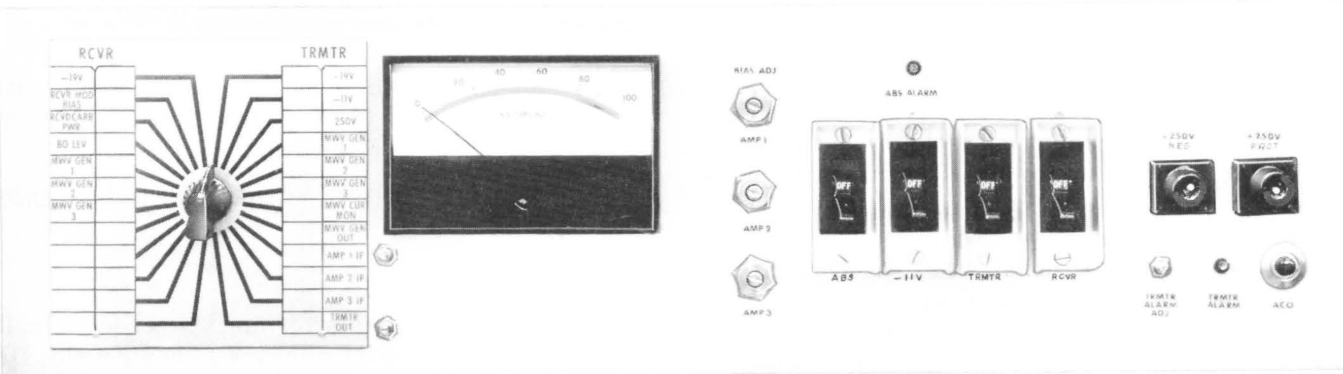


Fig. 37—J68387AC Control, Alarm, and Metering Panel

volts to regulated −11 and +250 volts. The −11 and +250 volts are required by the 416-type electron tubes in the transmitter amplifier and are not available as part of the TD-3 station power plant.

12.03 The control, alarm, and metering functions provided for the 416 tube-type transmitter amplifier are ***not*** required for bays retrofitted with the 660( ) IC amplifier. New production bays equipped with the 660( ) IC amplifier contain a simplified control, alarm, and metering circuit coded J68387AG that eliminates all of the circuits provided in the J68387AC panel for operation of the tube-type amplifier. See Part 13.

B. Functional Description

Control

12.04 The transmitter control circuit automatically provides for filament warm-up time for the 416-type electron tubes prior to applying the +250 volts plate voltage and the −11 volts bias. The ground circuit of the control circuit is looped through the power plugs of the three transmitter amplifier stages. Therefore, if the plug to any one of the three stages is disconnected, the heater timer will not be activated and consequently the plate and bias voltages cannot be applied. The transmitter control circuit also provides overload protection and metering points for the −11 and +250 voltages.

Alarms

12.05 A repeater bay and a main station bay are equipped with only two alarms: one for the receiver and one for the transmitter. In both bays, the two alarms are multipled to give a single bay alarm.

12.06 The receiver alarm is initiated by a predetermined drop in received carrier power due to either a low incoming RF signal or faulty circuitry. The alarm is delayed approximately 45 seconds to avoid alarms for short, deep fades. If an alarm condition exists longer than 45 seconds, the T-R bay common alarms are energized. The same alarm condition is activated whenever the MAN-AGC switch on the main IF amplifier is operated to the manual gain position (MAN), but without the 45-second delay.

12.07 The transmitter alarm is initiated by a predetermined drop (nominally 3 dB) in RF output power. The RF signal power is monitored at the transmitter monitor-shutter assembly by the output power monitor (76A) detector. ▶For 45-Mb/s digital operation a (76D) detector is used.◀ The dc voltage from the detector may be applied to the meter to give a measure of RF output power. The dc voltage is also applied to the alarm circuitry where, after a 45-second delay, the T-R bay common alarms are energized in the event the dc voltage is at or below the alarm threshold level.

12.08 Facilities are provided in the alarm circuitry for audible alarm cutoff (ACO) at the radio bay and for a visual alarm indication on the control panel if the transmitter fails (TRMTR ALARM). (A visual indication of a receiver failure is provided on the IF main amplifier.) Both receiver and transmitter alarms are multipled inside the alarm circuitry. Thus, an alarm for either the receiver or the transmitter will give a visual indication on the bay as well as cause the local and remote visual and/or audible alarms to operate.

12.09 When the HS/SD control circuit within the IF main amplifier calls for a switch (if this option is used), a signal is sent to the alarm circuit which, in turn, activates the T-R bay common alarms.

Metering

12.10 Metering is provided in the control, alarm, and metering circuit for those circuits which require monitoring, adjustment, or alignment for maintenance purposes.

12.11 The meter is a 20-microampere, 5900-ohm movement with a separate −19 volt terminal post. The selector switch is a 23-position rotary type. The switch connects the meter to various bay points for monitoring and metering.

12.12 The bay points that are metered are as follows:

(a) −19V: Voltage output of 88A power units or 92B power unit (depending upon option used)

(b) −11V: Voltage of transmitter amplifier bias and control voltages (tube-type only)

(c) +250V: Voltage of transmitter amplifier plate voltage (tube-type only)

(d) MWV GEN 1: Microwave generator power at the output of the 125-MHz oscillator-amplifier

(e) MWV GEN 2: Microwave generator power at the output of the ×2 multiplier (250-MHz point)

(f) MWV GEN 3: Microwave generator power at the output of the 500-MHz generator

(g) MWV CUR MON: Microwave generator current in the 1-GHz multiplier

(h) MWV GEN OUT: Microwave generator power monitored in the 27B or 28B distribution network

(i) AMP 1 I_P: Plate current in the first (V1) transmitter amplifier stage (tube-type only)

(j) AMP 2 I_P: Plate current in the second (V2) transmitter amplifier stage (tube-type only)

(k) AMP 3 I_P: Plate current in the third (V3) transmitter amplifier stage (tube-type only)

(l) RCVR MOD BIAS: Voltage of the receiver modulator diode bias

(m) RCVD CARR PWR: Level of received carrier power monitored in the IF main amplifier

(n) BO LEV: Voltage of the beat (local) oscillator signal monitored in the receiver modulator

(o) TRMTR OUT: RF carrier power at the output of the transmitter amplifier.

13. J68387AG CONTROL, ALARM, AND METERING PANEL

13.01 The J68387AG control, alarm, and metering panel (Fig. 38) has been designed for use in new production TD-3D T-R bays equipped with the

660( ) IC transmitter amplifier. The major change is the elimination of all the circuits and wiring that were associated with the 416 tube-type amplifier. Otherwise, the functions provided by the new circuit are identical to the remaining function in the original (J68387AC) circuit, that is, the metering of various circuits in the bay, the alarm circuits for the transmitter, receiver and ABS, and the circuit breakers for the −12 volt or −24 volt input to some of the bay circuits.

13.02 The transmitter alarm circuit has been redesigned using newer integrated circuits to reduce the number of components. The new control panel is similar in appearance to the original control panel except for the reduced height of the panel. The original control panel (J68387AC) shown in Fig. 37 is 6 inches in height and the newer control panel shown in Fig. 38 is 4 inches in height.

14. DC POWER REQUIREMENTS

A. General

14.01 The operating voltages required for the individual circuits in the bay are −11 volts and +250 volts for the 416-tube transmitter amplifier, −24 volts for the 660( ) IC transmitter amplifier, and −19 volts for all of the other circuits. The means of obtaining these voltages is dependent on the type of station in which the bay is installed.

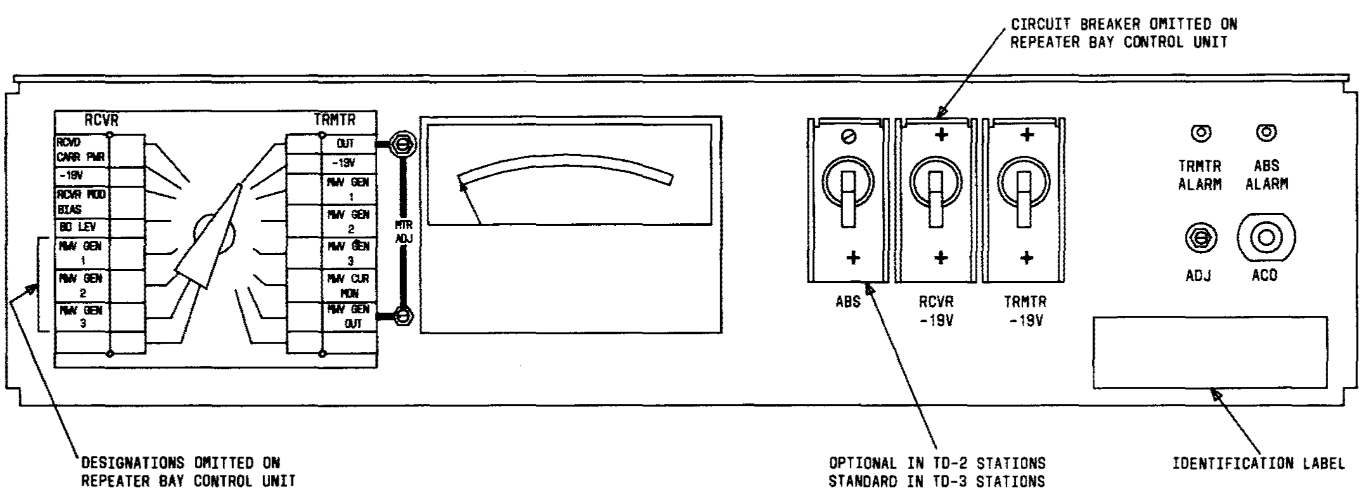
B. Existing TD-3 Stations and All New Construction

14.02 All existing TD-3 stations have a −24 volt battery plant. All new construction is expected to have −24 volts available. For this reason, the J68386L, M, N, and P bays are designed for operation from −24 volts. In each of these bays, the −19 volts is obtained using a −24 to −19 volt regulator. The −11 and +250 volts for the transmitter amplifier are obtained using a −24 to −11/+250 volt converter. The current drains are given in Table C.

14.03 As was the case with the earlier TD-3 type bays, the J68386L, M, N, and P bays contain the alarm relays and thus require a connection to the station −24 volt alarm battery supply (ABS). A connection to a −24 volt ABS (or equivalent) battery supply also is required for the J68386J and K bays when the option furnishing the alarm relays within these bays is provided. The current drain from the −24 volt ABS is 0.1A under an alarm condition and 1.5 mA for the normal (nonalarmed) condition.

C. Existing TD-2 Stations With −12V and +250V Plants

14.04 As of this time, all existing TD-2 repeater stations and main stations have −12 and +250 volt battery plants. For this reason, the J68386J and K bays currently are arranged for powering the 416-tube transmitter amplifier directly from these battery plants. As described in the next part (D), an



J68387AG CONTROL, ALARM AND METERING PANEL

Fig. 38—J68387AG Control, Alarm, and Metering Panel

TABLE C

TD-3D CURRENT DRAIN IN EXITING TD-3 STATIONS AND ALL NEW CONSTRUCTION

STATION BAY	-24V CURRENT DRAIN
Repeater J68386L or N	7.4A
Main J68386M or P Receiver Transmitter	 1.2A 7.4A

TABLE D

TD-3D CURRENT DRAIN IN EXISTING TD-2 STATIONS WITH -12 VOLT AND +250 VOLT PLANTS

STATION BAY	CURRENT DRAIN		
	-24V	-12V	+250V
J68386J Repeater at station with insufficient -24V Plant	—	12.0A	0.21A
J68386J Repeater at station with sufficient -24V Plant	1.7A	3.7A	0.21A
J68386K Main Receiver Transmitter	 1.2A 1.2A	 — 3.7A	 — 0.21A

optional arrangement for powering the entire bay, including the transmitter amplifier, from −24 volts will be provided.

14.05 For the TD-2 repeater station bay, J68386J, the −19 volts required for the other circuits is obtained by either of two means. Some TD-2 repeater stations have a −24 volt plant of sufficient capacity to power the added TD-3D bays. For this case, the J68386J bay can be furnished with a −24 to −19 volt regulator. For those repeater stations having insufficient −24 volt capacity, the bay can be furnished with a −11 to −19 volt converter-regulator option.

14.06 Virtually all TD-2 main stations have a −24 volt plant of adequate capacity to handle the TD-3D bays. Thus, for the TD-2 main station bay, J68386K, the −19 volts is derived from the station −24 volt supply using a −24 to −19 volt regulator. The current drains for the several cases described above are given in Table D.

D. Future TD-2 Stations Having Only a −24V Plant

14.07 In the near future, many of the −12V and +250V battery plants in existing TD-2 main and repeater stations will be replaced by a −24 volt plant. Converters (one per TD-2 radio bay) will be used to supply the operating voltages required for the 416-tube transmitter amplifier in the existing TD-2 bays. One reason for making this change is to obtain building space for a TH-3 radio overbuild on the TD-2 route; another is to simply retire old, worn-out, and high maintenance expense −12V and +250V plants.

14.08 For this future situation, another option has been made available for the J68386J and K bays to permit the entire bay, including the transmitter amplifier, to be powered from −24 volts. This is done by equipping these bays with the −24 to −11/+250 volt converter that is used for powering the transmitter amplifier in the J68386L, M, N, and P bays.

14.09 The current drains for the J and K bays, when equipped with this option, are the same as those listed for the TD-3 station bays in Table C.

15. DC POWER UNITS

A. General

15.01 As described in Part 14, the means of obtaining the voltages required to operate the various circuits in the T-R bay is dependent on the type of station, and therefore the type of battery plant, in which the bay is installed. Three basic power units are available; one or more of these units is used to equip each type of bay for compatibility with the station battery plant.

B. 92B Power Unit

15.02 The 92B power unit (Fig. 39) is used for those cases where the low voltage (−19 volts) required within the bay can be derived directly from an available −24 volt battery plant. One 92B is used in a repeater station bay, and two are used in a main station bay (one for the receiver and one for the transmitter). Currently, the 92B power units are specified for the J68386K, L, M, N, and P bays and for the J68386J bay when installed at a TD-2 repeater station having a sufficient capacity −24 volt battery plant.

15.03 The 92B power unit is a dc-to-dc, solid-state, feedback-controlled series voltage regulator providing a −19 volt ±1 percent output for any input supply voltage between −21 and −29 volts and any load current between 0.2 and 2.0 amperes. The output voltage may be set by a control on the front of the unit.

C. 88A Power Unit

15.04 The 88A power unit (Fig. 40) is a dc-to-dc converter-regulator which is used when the −19 volts must be derived from an available −12 volt battery plant. The 88A is used only in the J68386J repeater station bay when installed in a TD-2 station having an insufficient capacity −24 volt battery plant. Because of the limited current capacity of the 88A, two units are required in the bay: one for the microwave generator and one for the remaining circuits. If, in the future, the −12 volt plant at such a station is replaced by a −24 volt plant, the 88As in any previously installed J-bays at that station can be replaced with a 92B power unit to convert the bays to −24 volt operation.

15.05 The 88A power unit is a dc-to-dc, solid-state converter operated by a multivibrator and regulated by a series-regulating circuit. The unit converts −11 volts to −19 volts by a capacitor voltage multiplier in which power-switching transistors, operating at a nominal switching rate of 1 kHz, charge two capacitors in parallel. The two capacitors are discharged in series with the input. The output is approximately three times the input and is applied to a −19 volt series regulator circuit. The 88A is factory-set to deliver −19.5 ±0.2 volts. It will maintain this output within ±2 percent for any input supply volt-

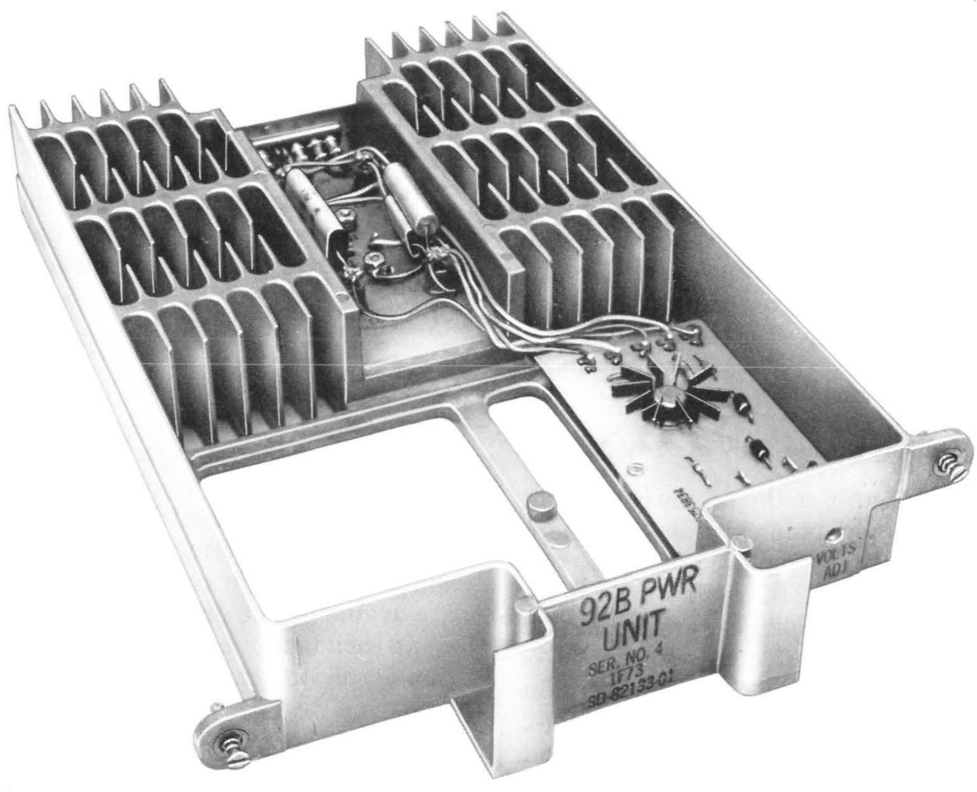


Fig. 39—92B Power Unit

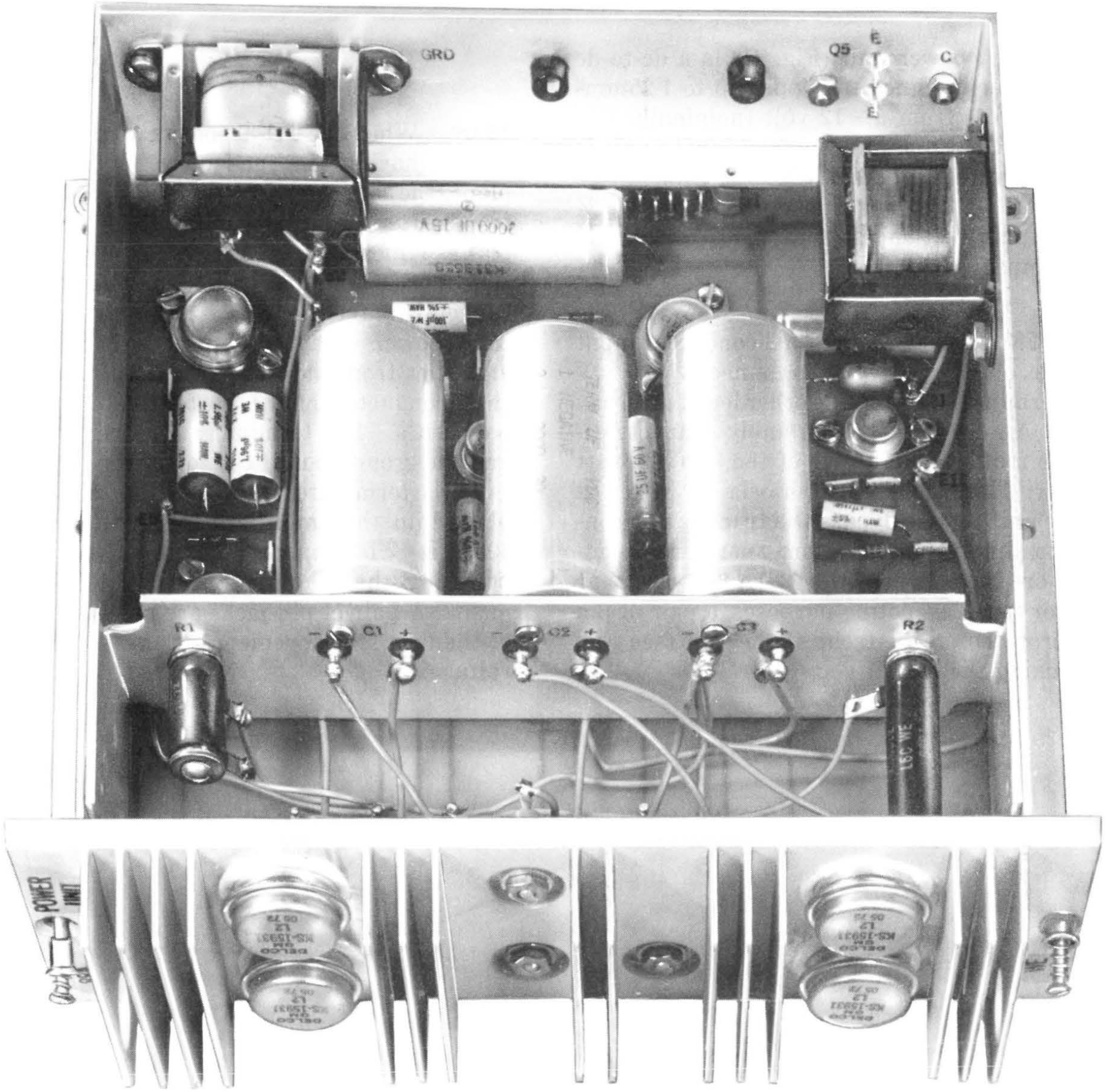


Fig. 40—88A Power Plant

age between −9.9 and −11.5 volts and any load current between 0.06 and 0.9 ampere.

D. 75A/76A Power Unit

15.06 The voltages required for the 416-tube amplifier (−11 volts and +250 volts) are obtained either directly from the available power plants in existing TD-2 stations or by means of a converter operating from −24 volts for all other cases. The converter is composed of two units: an inverter, coded the 75A power unit, and a rectifier-filter, coded the 76A power unit. These units currently are specified for use in the J68386L, M, N, and P bays and are contained within the control, alarm, and meter panel for these bays. The option of using the 75A/76A converter has been provided for the J68386J and K bays to take care of those cases in the future where the existing TD-2 power plants are replaced with a −24 volt plant. Where this occurs, the 75A/76A unit will be retrofitted into any previously installed J or K bay to provide the 416-tube amplifier voltages.

E. 281A Power Unit

15.07 The 281A power unit (Fig. 41) is a dc-to-dc converter designed to supply up to 1.25 amperes at −24 volts from a −12 volt (nominally −11 volts at the T-R bay) input. The 281A power unit is used to power the 660A or 660B IC 2-watt transmitter amplifier in ***TD-2*** stations that do not have a −24 volt battery plant of adequate capacity to directly power the amplifier.

15.08 The 281A power unit has a 2-conductor input cable, one lead of which is connected to −24V at the bay terminal strip and the other lead to the bay ground bus. An output cable assembly connects directly to the multipin connector of the 660( ) 2-watt IC amplifier. The connections associated with the 281A power unit totally bypass the transmitter control panel to simplify installation. There are no adjustments or controls on the 281A power unit. However, for troubleshooting purposes, a pair of pin jacks are provided on the front of the unit (see Fig. 41) for checking the output voltage.

F. 305B Power Unit

15.09 When the TD-3D bay is used in a TD-2 office having an inadequate capacity −24 volt plant, the dc power for the 5-watt 660C or 660D IC transmitter amplifier is obtained from the −12 volt plant by means of a −12V to −24V converter, coded 305B power unit (see Fig. 42). The connecting arrangements for the 305B are similar to those for the 281A power unit that is used to power the 2-watt amplifier from the −12V plant. That is, the leads of the 2-conductor input cable of the 305B are connected between a −12V terminal at the bay terminal strip and the ground bus at the top of the bay. The output cable is terminated in a multipin connector which plugs into the amplifier. The input current to the 305B is 7.1 amperes maximum at −12V when powering the amplifier. The 305B has no adjustments. A pair of pin jacks are provided on the front of the unit for convenience in measuring the output voltage.

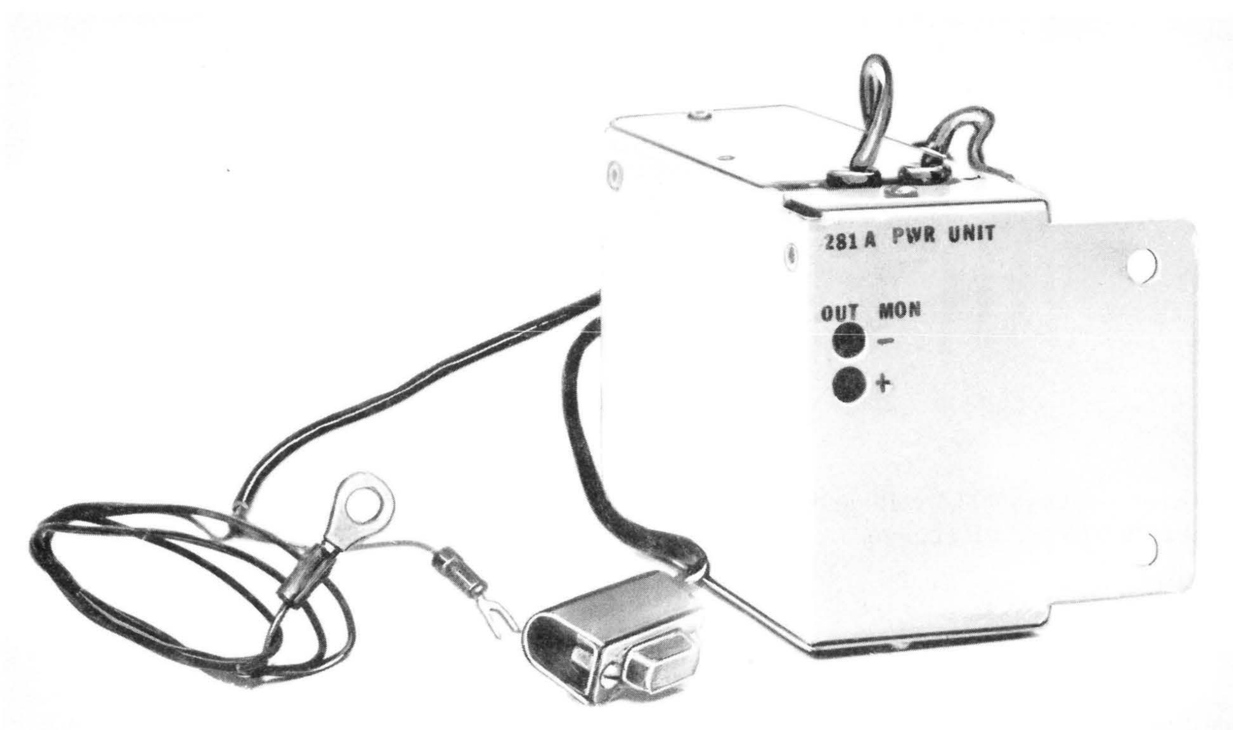


Fig. 41—281A Power Unit

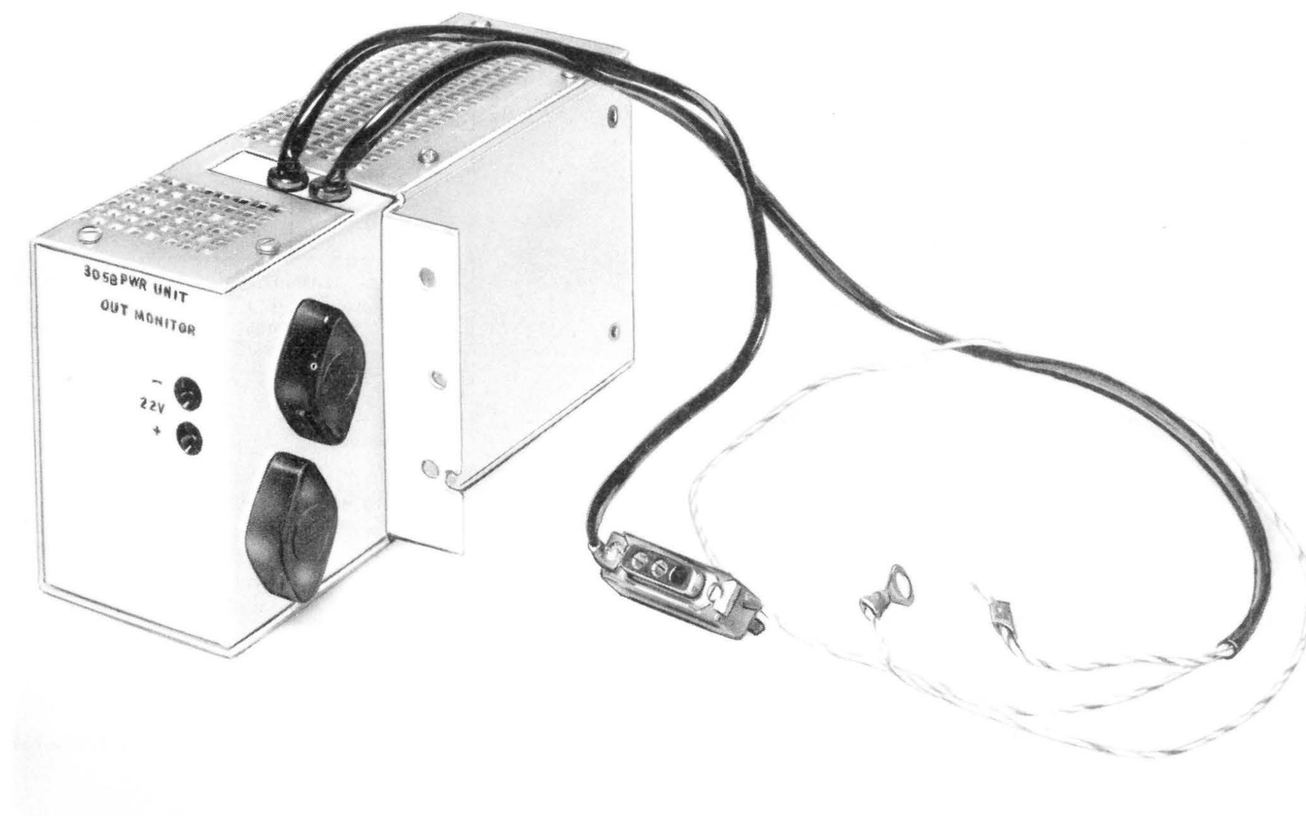


Fig. 42—305B Power Unit

16. LIGHTNING PROTECTION

16.01 Several cases of service outage have occurred in TD-3 as a result of lightning striking the tower and causing damage to the low-voltage circuits in the T-R bays. Investigation has shown that a very massive lightning discharge current may produce a momentary voltage differential between the bay framework and the −24 volt feeder at the bay terminals. This voltage pulse is passed directly into and through the −19 volt regulator, causing damage to components in both the regulator and the connected circuits.

16.02 A low-pass filter may be used at the −24 volt input terminals to the bay to reduce the amplitude of the voltage pulse before it reaches the bay circuits. The addition of such a filter was recommended for the TD-3 and TD-3A bays as a result of the lightning damage investigation. This same filter has been furnished in all codes of the TD-3D bay in which the low-voltage circuits derive their power from the −24 volt plant.

16.03 In addition to protecting the circuits from lightning damage, the filter also serves to suppress switching transients, inverter noise, and other disturbances that may be present on the −24 volt leads and which otherwise might impair the signal transmission through the bay.

16.04 The J68386J bay may be equipped with the 88A converters to derive the −19 volts from the −12 volt battery plant. In this case, the low-pass (lightning protection) filter is not provided at the −12 volt terminals on the bay because each converter has an equivalent filter built into its input circuit for the purpose of suppressing its own inverter noise.

16.05 Experience with TD-2 has indicated that the 416-tube amplifier apparently is unaffected by momentary overvoltages in the heater circuit such as might be caused by lightning. For this reason, no lightning protection low-pass filtering has been provided in the heater circuit. However, a low-pass filter has been used for many years in the +250 volt input to the TD-2 bay, principally to suppress interactions between amplifiers in different bays caused by turnon transients. This filter, which also affords excellent protection against overvoltages due to lightning, has been retained in the TD-3D bay.

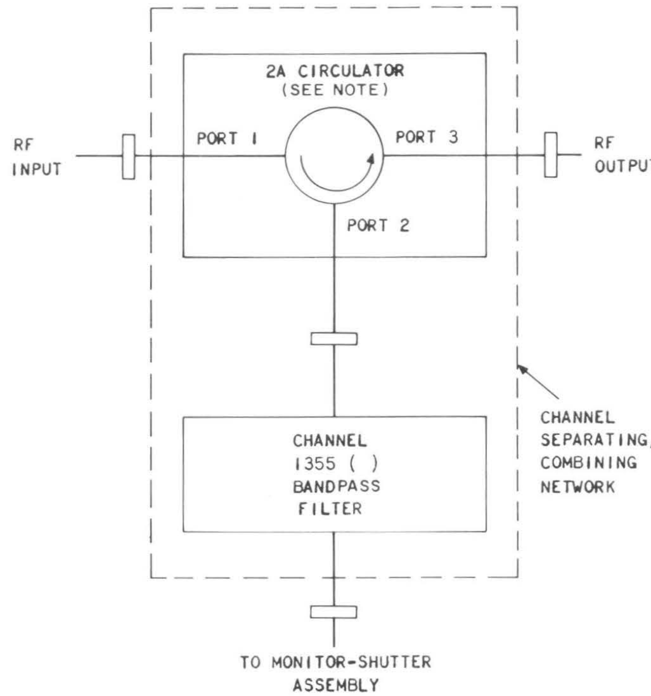
17. CHANNEL SEPARATING/COMBINING NETWORKS

A. Receiving Channel Separating Network

17.01 Figure 43 is a block diagram of the channel separating network which is comprised of a 2A circulator (Fig. 44) and a 1355( ) channel bandpass filter (Fig. 45).

17.02 For illustrative purposes, the receiver is assumed to be the first one in the T-R bay lineup. Up to six channels of the same polarization having a separation between carriers of 80 MHz may be delivered to the T-R bay lineup from the receiving antenna. Unlike the earlier TD-( ) radio bays which used networks composed of hybrids and band-rejection filters for channel separating and combining, the TD-3D bay makes use of circulators and bandpass filters for this function. The received signals appearing at port 1 of the 2A circulator are directed by the circulator to port 2, to which is connected a bandpass filter tuned to the channel frequency of the receiver. The bandpass filter passes the incoming signal at the receiver frequency but reflects all of the other incoming signals back towards the circulator. There the remaining signals are directed to port 3 of the circulator, which is connected to the circulator and bandpass filter in the next receiver in the bay lineup.

17.03 A second incoming received channel is selected similarly by the next receiver. The process continues down the bay lineup until all incoming signals have been separated into their respective receivers.



NOTE:
THE PORT LABELING (1, 2, 3) SHOWN ON THIS FIGURE FOR THE 2A CIRCULATOR IS FOR DESCRIPTIVE PURPOSES ONLY AND MAY NOT BE THE SAME AS THE LABELING THAT IS ACTUALLY STAMPED ON THE CIRCULATOR.

Fig. 43—Channel Separating/Combining Network

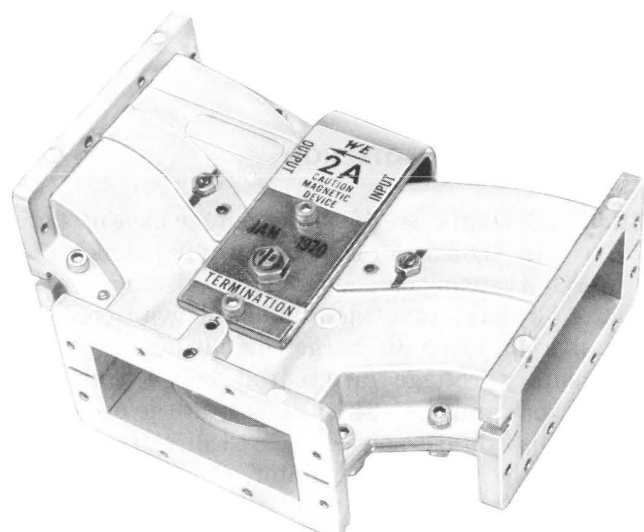


Fig. 44—2A Circulator

Fig. 45—1355( ) Bandpass Filter

B. Transmitting Channel Combining Network

17.04 Channel combining, like channel separating, is accomplished using a 1355( ) bandpass filter and a 2A circulator. The output signal from the transmitter amplifier passes through the filter and exits toward the antenna via ports 2 to 3 of the circulator (Fig. 43). Signals from preceding transmitters in the bay lineup enter port 1 of the circulator where they are directed toward the bandpass filter connected to port 2. Since all of these signals are outside the passband of the filter, they are reflected back toward the circulator, which directs them on to port 3 and the antenna.

C. Transmission Characteristics of Channel Networks

17.05 Each channel network introduces approximately 0.2-dB loss to the nondropped channels. This low insertion loss is the result of two factors: the inherently low forward loss of the 2A circulator (typically 0.11 dB between adjacent ports) and the optimum spacing of the bandpass filter with respect to port 2 of the circulator. By properly spacing the bandpass filter, the nondropped channels, which are reflected by the filter, are combined in-phase with the signals traversing a leakage path internal to the circulator. This reduces the effective loss between ports 1 and 3. The spacing has been optimized for the higher frequency channels.

17.06 The loss of the channel network to the dropped or combined channel (i.e., the loss from the common waveguide run to the output of the bandpass filter) is typically 0.46 dB. The reverse loss of the network (i.e., the loss to a signal traversing the path from port 3 to port 1 of the 2A circulator in Fig. 43) is greater than 33 dB. The return loss, at port 1 or port 3, is greater than 30 dB.

17.07 The 1355( ) bandpass filter provides the RF selectivity required at the receiver input and transmitter output. The filter comprises six resonant cavities tuned to the center frequency of the desired passband and assembled in an 18-inch section of WR229 copper waveguide. Each of the filter codes has a distinct dimensioning of elements to obtain uniformity of performance from channel to channel. The loss of the filter is typically 0.35 dB at the channel center frequency (f_o), 1.8 dB at $f_o \pm 20$ MHz, 23 dB at $f_o \pm 40$ MHz, and 55 dB at $f_o \pm 80$ MHz.

17.08 ➧For 45-Mb/s digital operation, the 1500-type filter is used in conjunction with a 19A isolator, a 1525-type filter, and a shorter waveguide spacer. The 1500-type filter will replace the 1355-type filter and is required on the analog FM TD-3D channel to suppress the interference from the 45-Mb/s channel 80 MHz away.

D. Equipment Features

17.09 The 1500-type filter (Fig. 46) has an overall length of about 7 inches and is mechanically built into an aluminum die-cast housing which is equipped on both ends with the standard indoor-type WR-229 flange with eight waveguide screw holes per flange. Six screw adjustments, which are tuned and sealed in place at the factory, project from one narrow waveguide wall.

E. Circuit Description

17.10 The 1500-type filter is a 6-cavity, flat amplitude design filter housing with WR-229 waveguide input and output ports and a reduced width midsection in which the cavities are located. Each cavity consists of a single barium titanate dielectric resonator and an associated factory-adjusted capacitive tuning screw. The fields are highly concentrated in the dielectric resonators; therefore, the cavities can be closely spaced compared to those in certain other complex filter designs.

17.11 Internally, the waveguide adjacent to the waveguide flanges is the full standard size type. The central portion of the waveguide length is reduced from the standard 2.290-inch dimension to 0.800-inch dimension. Within this latter area, at approximately equal spacings along the longitudinal line-of-center of the waveguide, six barium titanate ceramic discs are mounted in plastic holders. For each of the filter codes, these ceramic discs are provided specifically so they may be tuned to resonate at the bandpass center frequency of the filter. The bandpass center frequencies of the 1500-type filters are spaced 20 MHz apart and cover the 3710- to 4190-MHz range. For each ceramic disc, a lockable tuning screw is provided that projects through the narrow wall of the waveguide. This dielectric resonator design filter has excellent temperature stability. A typical insertion loss characteristic of a 1500-type bandpass filter is shown in Fig. 47.

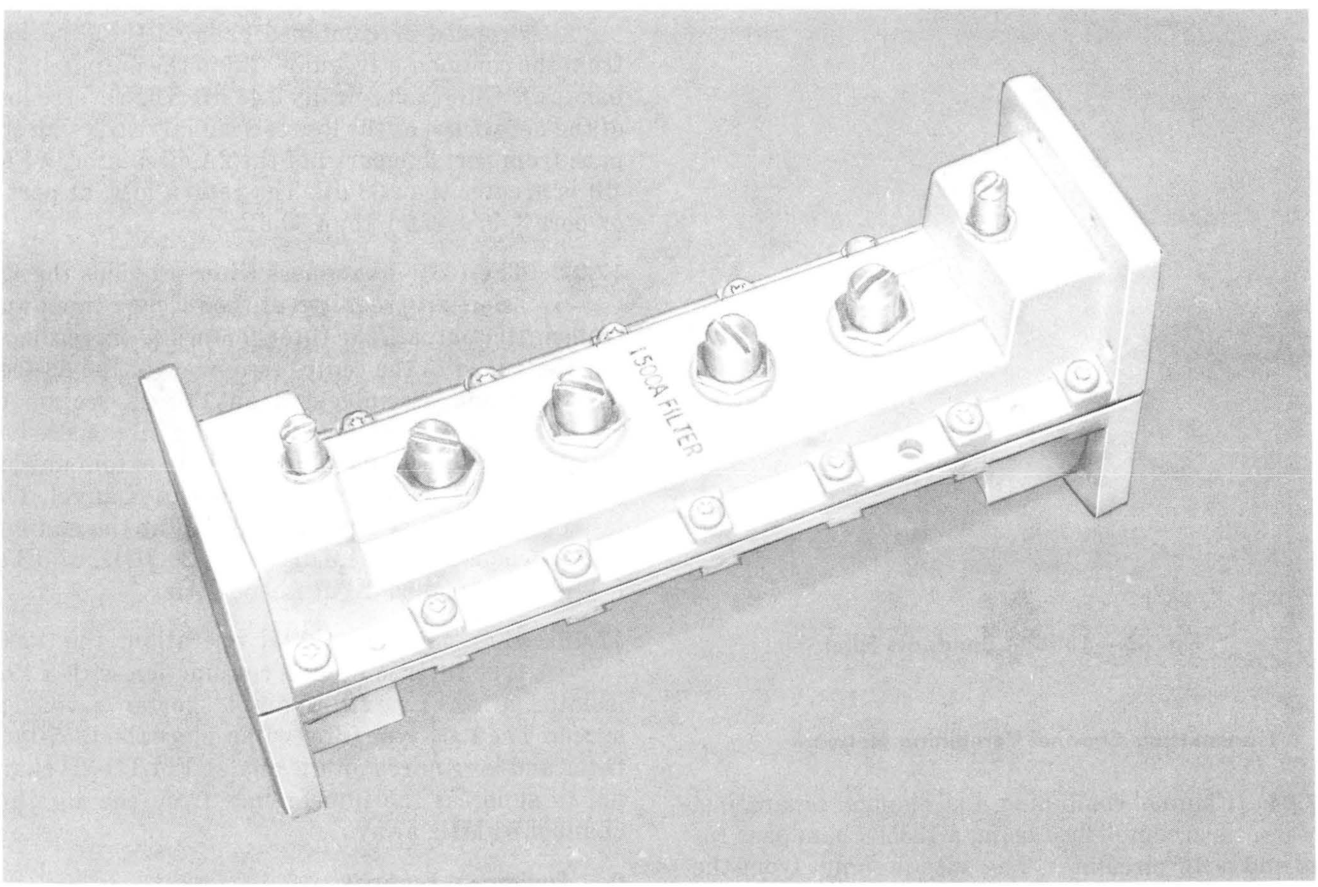


Fig. 46—♦1500-Type Bandpass Filter♦

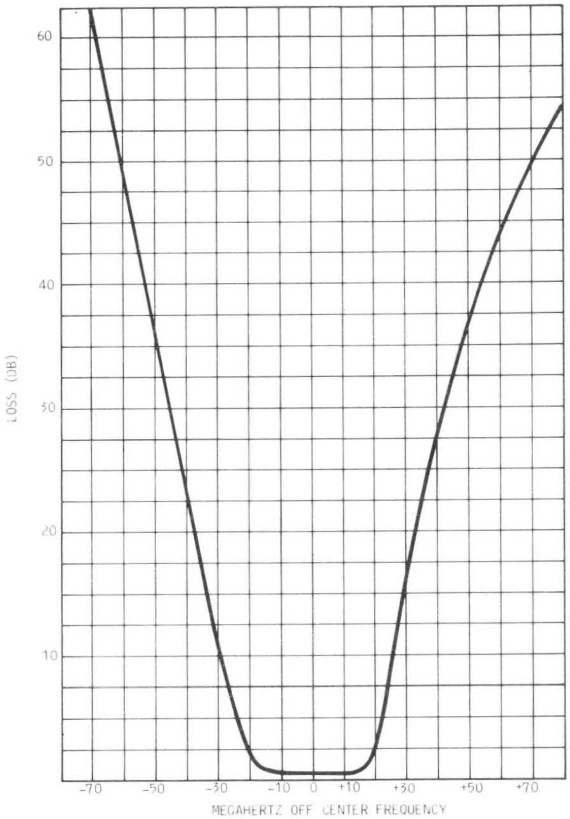


Fig. 47—⧫Typical Insertion Loss Characteristic of 1500-Type Bandpass Filter⧫

17.12 The 1525-type bandpass filter is a 3-cavity 80-MHz waveguide filter, used in the TD-3D radio bay. The filter suppresses 10-MHz tones that may appear in a channel 80 MHz away from a TD-45A channel, as the result of an intermodulation process which takes place in the receiver 80 MHz away. It provides at least 20 dB of attenuation at frequencies 80 MHz or more away from the center frequency, with less than 0.05 dB of slope and less than 1 nanosecond of delay shape inside the 20-MHz bandwidth. The filter is mounted in series with an isolator and a 1500-type filter in the receiver of the channel 80 MHz away from the TD-45A channel.⧫

18. MONITOR-SHUTTER ASSEMBLY

A. Receiver

18.01 Following the 1355( ) bandpass filter is an ED-52277, G2 monitor-shutter assembly. This unit is used both in the input circuit of the receiver and the output circuit of the transmitter (Fig. 48).

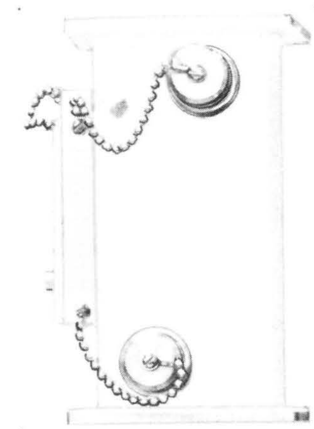


Fig. 48—ED-52277, G2 Monitor-Shutter Assembly

18.02 In its normal (nontest) usage, the monitor-shutter assembly in the receiver functions as a section of waveguide. For out-of-service test purposes, the assembly can be converted into a pair of back-to-back waveguide-to-coaxial transducers to enable tests to be made without the necessity of removing a section of waveguide. This conversion is accomplished by removing a plug and inserting a coaxial probe at each end of the assembly and by inserting three shutters or plates into the waveguide region between the probes. The outer shutters form the back walls for the waveguide-to-coaxial transducers. The third or middle shutter provides additional isolation required between the two transducers.

18.03 The probes and shutters are furnished with the test equipment. Connection of the T-R bay test equipment is made at the lower transducer. The upper transducer, directly below the channel network, may be used to connect a portable microwave repeater (PMR) into the transmission path.

B. Transmitter

18.04 The ED-52277, G1 monitor-shutter assembly in the output circuit of the transmitter is electrically identical to and serves the same purpose as the monitor-shutter assembly provided in the receiver. The only difference in the application of the two units is that in the normal (nontest) usage, the transmitter monitor-shutter assembly has a short coaxial probe and a 76A detector connected to one of the transducer ports. The probe couples a signal into the detector approximately 21 dB below the transmitter output signal. The detector is a modified version of the 61A detector used for RF power monitoring in the TD-3 T-R bay. The dc output of the detector, which is proportional to the transmitter output power, is used for metering and alarm purposes.

19. 19A ISOLATOR

19.01 The 19A isolator (Fig. 49) is a magnetically-biased ferrite device which propagates a microwave signal with very low attenuation in one direction (termed the forward direction) but which provides high attenuation to signals propagating in the reverse direction. Over the 3700- through 4200-MHz frequency range, the isolator has typically 0.25-dB forward loss and at least 30-dB reverse loss. Over the same frequency range, the input and output return losses are greater than 30 dB. One isolator is used between the channel network and directional filter in the receiver to absorb unwanted products generated in the receiver modulator. Another isolator is used at the output of the 416 tube-type transmitter amplifier to provide a good return loss looking back towards the amplifier from the transmitter channel network and monitor-shutter assembly.

> ***Note:*** The 19A isolator used at the output of the 416 tube-type transmitter amplifier is not required for bays equipped with the 660( ) IC transmitter amplifier.

19.02 The isolator is housed in a 2-piece aluminum waveguide casting. The connections are of the WR-229 waveguide type. The isolator is 5.600 inches long by 5.440 inches wide by 2.015 inches deep.

20. 1338( ) DIRECTIONAL FILTER

20.01 The 1338 waveguide directional filter (Fig. 50) is used directly ahead of the J68387P receiver modulator and IF preamplifier to combine the incoming microwave signal with the receiver local oscillator signal. The directional filter consists of a 2-cavity band-rejection filter in the signal input arm and a 2-cavity bandpass filter in the local oscillator input arm. Both of these filters are tuned to the local

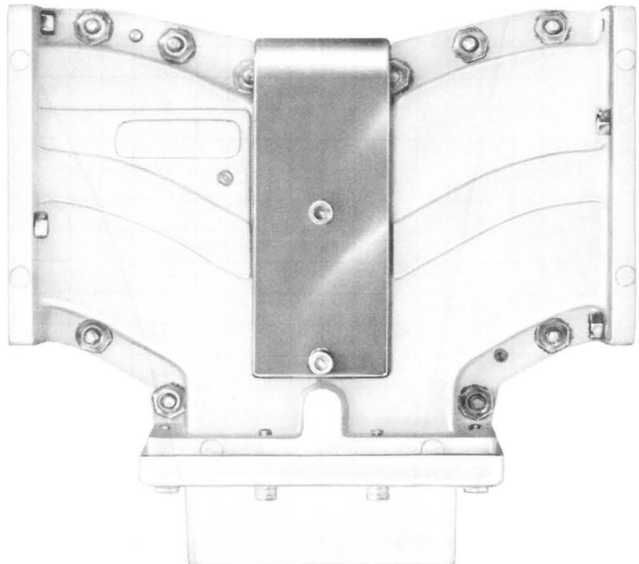


Fig. 49—19A Isolator

oscillator frequency. The band-rejection filter passes the received signal with negligible loss but provides more than 40-dB attenuation to the local oscillator signal. The bandpass filter has about 0.3-dB insertion loss to the local oscillator signal and greater than 35 dB to the received signal. Together, these filters provide the required isolation between the received signal port and the local oscillator signal port, thereby keeping the received signal out of the waveguide toward the local oscillator and the local oscillator signal out of the waveguide toward the antenna.

21. IF FILTERS

A. 1042A IF Bandpass Filter

21.01 The 1042A IF bandpass filter (Fig. 51) is used at the output of the IF preamplifier to provide additional receiver selectivity. The filter has loss peaks greater than 40 dB at 50 and 90 MHz to provide attenuation at the frequencies of the adjacent channel carriers. In addition, the filter has at least 30-dB loss at the second harmonic and 15-dB loss at the third harmonic of the 70-MHz carrier. Loss at the harmonic frequencies is necessary to prevent an echo-type of cross-modulation noise that can result when these harmonics, generated in the receiver modulator and IF preamplifier, recombine with the fundamental in a nonlinear stage of the IF main amplifier. The amplitude and delay distortion of the

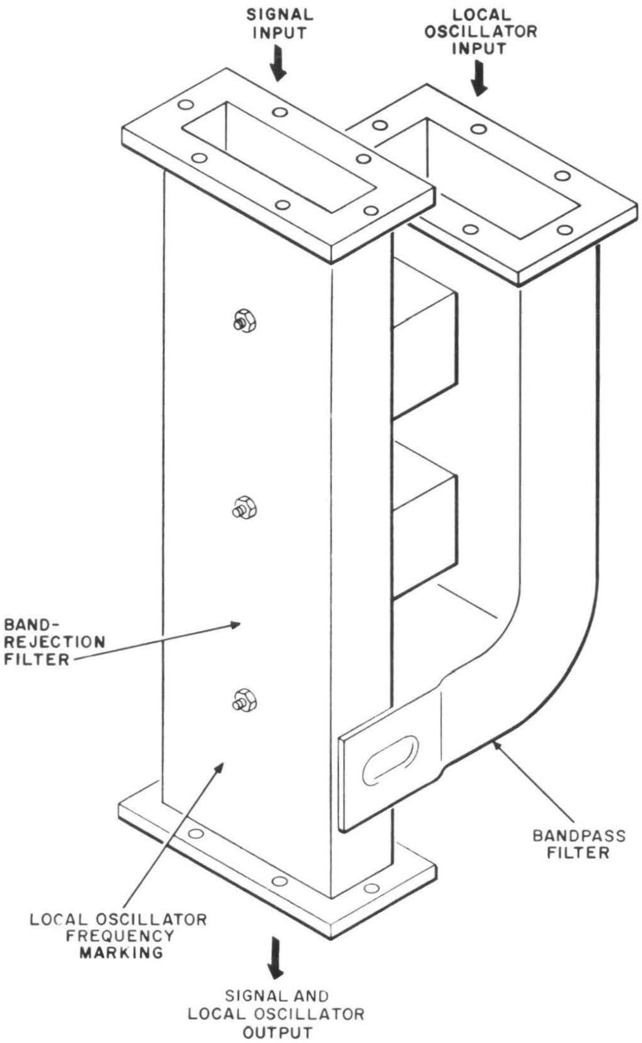


Fig. 50—1338-Type Directional Filter

filter are equalized to within 0.06 dB and 0.6 nanoseconds peak to peak, respectively, over the band from 62 through 78 MHz.

B. 747A IF Low-Pass Filter

21.02 The 747A IF low-pass filter (Fig. 52) is used after the IF main amplifier in main station receivers to attenuate, by at least 20 dB, the second and third harmonics of the IF signal generated in the IF main amplifier. The insertion loss of the filter across the 60- to 80-MHz band is approximately 0.6 dB. Over this IF band, the filter is amplitude equalized to within ±0.05 dB and delay equalized to within ±0.3 ns.

Fig. 51—1042 IF Bandpass Filter

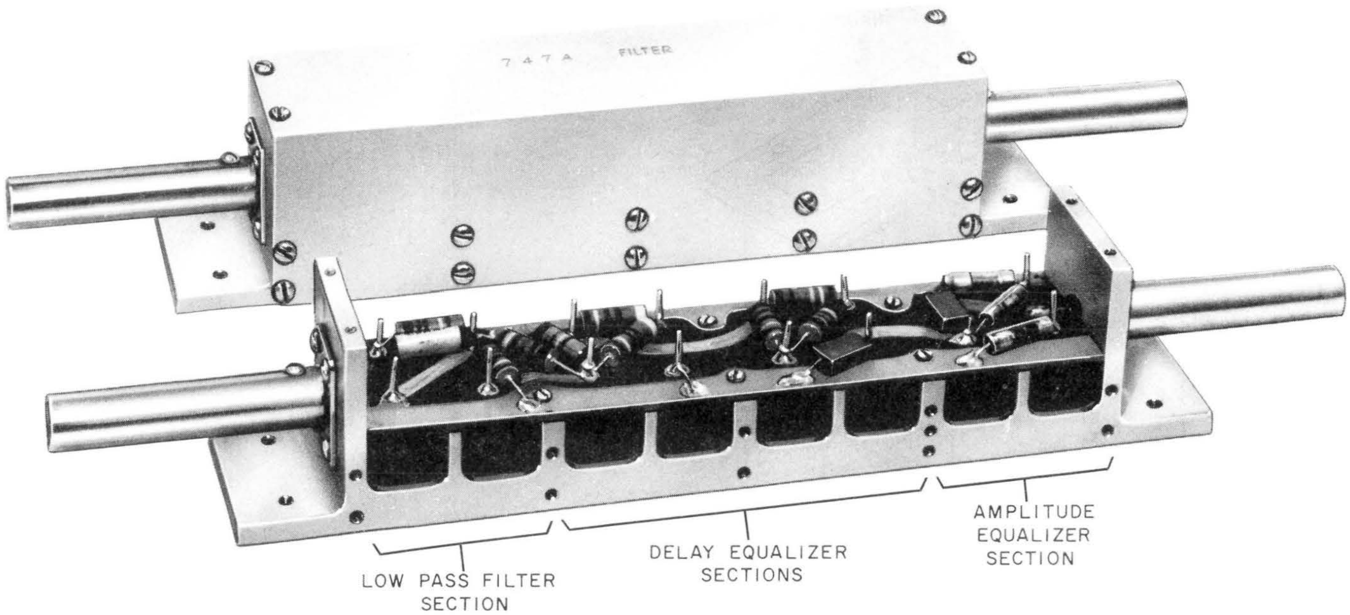


Fig. 52—747A IF Low-Pass Filter

C. ➧574A IF Bandpass Filter

21.03 The 574A IF bandpass filter is used at the output of the IF preamplifier to provide additional receiver selectivity. The filter is amplitude equalized to within ±0.1 dB and delay equalized to within ±1.0 ns over the band from 62 to 78 MHz. The midband insertion loss is typically 2.6 dB. Out of band, the filter has insertion loss peaks, typically of at least 33 dB, in the region of 50 and 90 MHz.

21.04 The circuit components of the filter are mounted on a printed circuit board which is assembled on a sectionalized, cast-aluminum base and cover. Each inductor is enclosed in an individual compartment of the base to minimize coupling between inductors.

D. 1080A IF Bandpass Filter

21.05 The 1080A IF bandpass filter is used in tandem with the 574A IF filter to provide additional receiver selectivity. The filter is amplitude equalized to within ±0.12 dB and delay equalized to within ±0.5 nanoseconds over the 62- to 78-MHz frequency band. The midband insertion loss is typically 4.5 dB. Out of band, the filter has an insertion loss of 10 dB at f_0 ±20 MHz and 20 dB at f_0 ±40 MHz, where f_0 = 70 MHz. In addition, the 1080A functions as a low-pass filter with a loss of 25 dB at 140 MHz (2 f_0) and 20 dB at 210 MHz (3 f_0).

21.06 The circuit components of the 1080A IF bandpass filter are mounted on a printed circuit board assembled in a stamped sheet-aluminum can.➧

22. EQUALIZERS

A. 918C Equalizer

22.01 The 918C equalizer (Fig. 53) that follows the IF filter is intended to equalize the nominal parabolic-type envelope delay distortion of the radio hop; specifically, the distortion introduced by the RF filters in the receiver and preceding radio transmitter as well as by the cavities in the 416-tube transmitter amplifier. As explained in paragraph 2.19, the 918C somewhat overequalizes the hop. As a result, it is used in only approximately two out of every three receivers in an IF switching section. The equalizer has a downward parabolic-type shape; the delay distortion at 64 and 76 MHz is nominally −3.4 nanoseconds relative to the absolute delay at 70 MHz.

B. Delay Slope Mop-up Equalizers

22.02 A provision has been made in the receiver for inserting, at the output of the 918C equalizer,

Fig. 53—Equalizers

one 918A (−0.5 ns/MHz), 918B (−0.25 ns/MHz), 919A (+0.25 ns/MHz), or 920A (+0.5 ns/MHz) mop-up delay slope equalizer. This provision applies principally to TD-3D bays used to build out existing TD-3 routes or for installation on new routes (i.e., the J68386L, M, N, and P bays). For these applications the required delay slope equalization, determined from measurements of the overall switching section, is distributed as uniformly as practical among the individual receivers within the section, using the option. This is the practice currently followed in the TD-3 system. In TD-2, on the other hand, mop-up equalization of delay slope normally is done using 319-type equalizers which are mounted in an IF amplifier and equalizer bay, TDAS bay, or miscellaneous bay at the receiving main station at the end of the switching section. This practice can be continued in exactly the same manner using 319-type equalizers for any channels equipped with TD-3D type bays (i.e., the J68386J or K bays) added to an existing, partially filled TD-2 route. For all cases, an IF cable, furnished with the bay, provides continuity between the 918C equalizer and the input to the IF main amplifier when the mop-up equalizer option is not equipped.

22.03 ➧When equipped for 45-Mb/s operation, the digital radio channel may experience amplitude shape distortion during atmospheric fading conditions. To compensate for this time-varying characteristic, a new dynamic amplitude slope equalizer has been designed. This equalizer, coded ADP1, will provide up to ±10 dB slope compensation with 0-dB insertion loss. The input of this unit includes an IF attenuator circuit to set the IF signal power at the equalizer output to 0 dBm. A local cable assembly for the power and alarm leads will be required to connect the ADP1 unit into the TD bay wiring. Power for this unit will be required from a −24V source in the TD bay. A second ADP1 output at −3.2 dBm is provided for test access from a repeater bay, or for the FM signal path at a main station protection channel bay.➧

23. 1301( ) TRANSMITTER-MODULATOR FILTER

23.01 The 1301( ) filter (Fig. 54) selects the desired sideband output from the transmitter modulator and attenuates the local oscillator signal and the unwanted sidebands appearing at the modulator output. The signals not passed by the filter are reflected back to the 27B (or 28B) distribution network and dissipated in a termination on a circulator within the network.

23.02 The filter is composed of four cavities assembled in a section of WR-229 waveguide 19-13/32 inches long. The loss of the filter is typically 0.2 dB at the channel center frequency (f_0), 22 dB at f_0 ±70 MHz, and 45 dB at f_0 ±140 MHz.

24. 1323( ) RECEIVER LOCAL OSCILLATOR BANDPASS FILTER

24.01 The 1323-type bandpass filter (Fig. 55) is a narrowband filter used at the output of the 40-MHz oscillator and shift modulator. The filter passes the desired local oscillator signal for the receiver modulator and attenuates the microwave generator signal and other unwanted products generated in the shift modulator. The midband insertion loss is about 2 dB, and the losses at 40 and 80 MHz off center frequency are typically 90 and 112 dB, respectively.

24.02 The filter consists of four resonant cavities (Fig. 55), each one-half wavelength long, built into a length of waveguide. Each cavity is bounded on each end by three equal-diameter, uniformly spaced, cylindrical posts. A capacitive tuning screw centrally located between the array of posts is used to tune each cavity to the channel center fre-

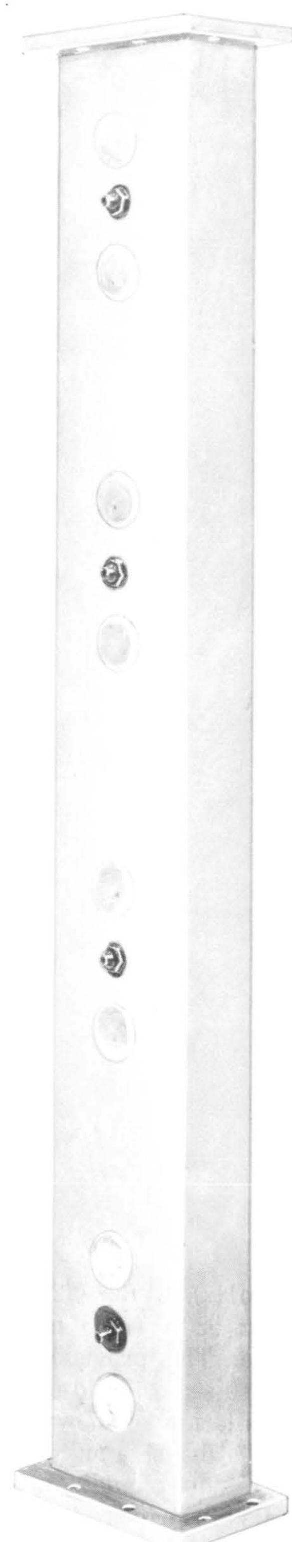


Fig. 54—1301( ) Transmitter-Modulator Filter

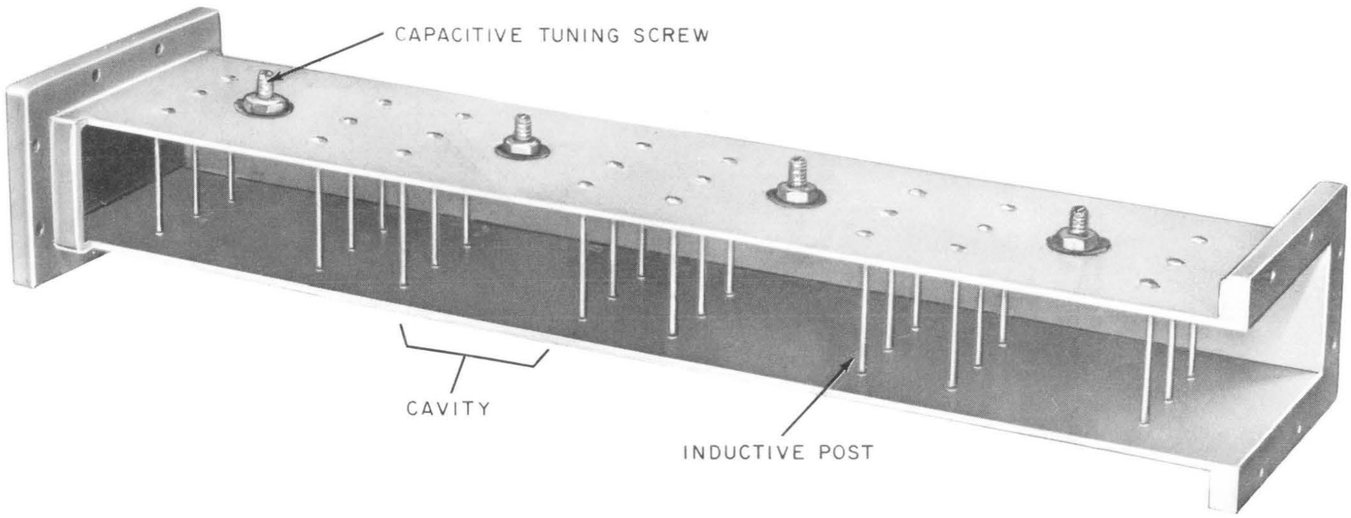


Fig. 55—1323( ) Receiver Beat-Oscillator Bandpass Filter

quency. One-quarter wavelength spacing is used between cavities. This type cavity is referred to as the "triple-post" type. The cavities are assembled in a 15-inch length of standard WR-229 copper waveguide tubing.

25. 652A RF PREAMPLIFIER

25.01 The 652A RF preamplifier is a solid-state, fixed gain, factory aligned, broadband amplifier designed for use in the common receiving waveguide runs of the TD-type microwave radio systems (Fig. 56). The preamplifier is common to all received channels in a 6-bay lineup and has a typical insertion gain of 10 dB when powered, and a maximum insertion loss of 10 dB when unpowered.

25.02 The 652A RF preamplifier may be used for thermal noise and margin improvement on any hop having a normal received carrier power less than −23 dBm, as measured or calculated at the first equipped radio bay facing the regular antenna. Two 652A RF preamplifier units are required per bay lineup in stations where a space diversity antenna is provided. One preamplifier is required for the regular common waveguide run and the other for the diversity common waveguide run.

25.03 The low noise figure (typically 1.8 dB) and moderate gain (typically 10 dB) of the 652A RF preamplifier combine to reduce the overall noise figure of the TD-3D repeater to between 3.1 and 3.6 dB, depending on the received carrier power. This improvement permits, for example, reducing the transmitter output power from 5 watts to 2 watts for 1500-circuit loading, while still meeting 1500-circuit loading thermal noise requirements. For this application, it is only necessary to use the 652A on those hops having less than −27 dBm normal received carrier power (as calculated or measured for 2-watt operation). For 1800-circuit loading, the 652A is used on hops having received carrier powers up to −23 dBm to meet noise and fade margin objectives.

25.04 The preamplifier operates from a −24 Vdc power supply at 45 milliamperes. In case of dc power supply or internal circuit failure a contact to ground is provided which energizes a remote alarm. When the 652A RF preamplifier is unpowered or internal circuit failure occurs, transmission is maintained by means of a passive bypass within the unit that yields a maximum insertion loss of 13 dB (typically 5 to 8 dB).

25.05 The major amplifying component in the preamplifier is a gallium arsenide field effect transistor (GaAs FET). The GaAs FET is mounted in a microstrip circuit along with the dc-blocking capacitors. Factory adjustments for optimum noise figure and gain flatness are the only adjustments on the unit which compensate for transistor parameters as well as manufacturing tolerances of the piece

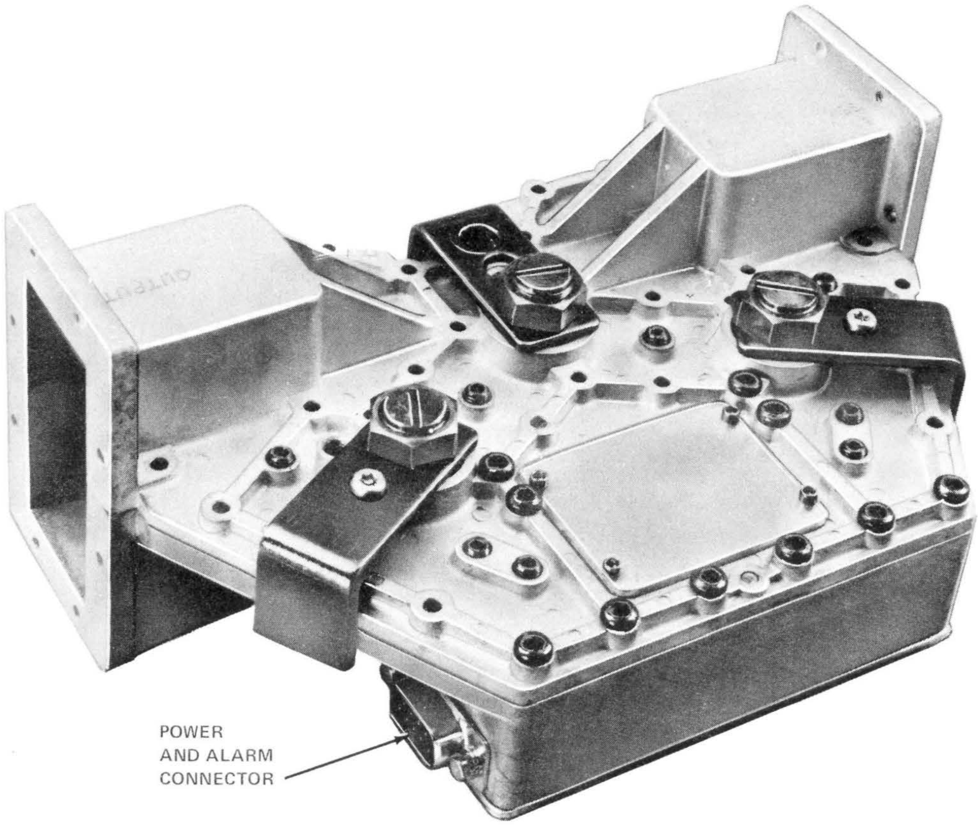


Fig. 56—652A RF Preamplifier

parts. The amplifier contains three circulators assembled in air dielectric stripline. One circulator is used at the input and another at the output to provide a good return loss (greater than 25 dB) over the 4-GHz band. The third circulator is connected between the other two to form the passive bypass path for fail-safe operation.

25.06 The housing and major piece parts are die-cast aluminum. On the bottom side of the lower housing is the power regulator and alarm circuit where the cable plug connector is located, as shown in Fig. 56. Refer to Section 420-802-100 for a further description of the preamplifier.

26. REFERENCE DRAWING LIST

26.01 For additional information relating to this section, refer to the following list:

DRAWING	TITLE
SD-51546-01	Toll Systems—Application Schematic—TD-3D Radio Transmitter-Receiver Bay
SD-50558-01	Receiver Modulator—IF Preamplifier (J68387P)
SD-51612-01	Receiver Modulator—IF Preamplifier (J68387AD)

DRAWING	TITLE
SD-51548-01	IF Main Amplifier—Carrier Resupply
SD-50585-02	IF Driver Amplifier—Transmitter Modulator
SD-50574-02	Microwave Generator
SD-50586-01	40-MHz Oscillator—Shift Modulator
SD-59404-02	Transmitter-Amplifier Cavity
SD-82138-01	88A Power Unit
SD-82133-01	92B Power Unit
SD-51549-01	Control, Alarm, and Meter Circuit
SD-50575-01	TD-3 Radio Indoor Waveguide Distribution Circuit
SD-51463-01	Toll Systems—Application Schematic for 4-GHz Heterodyne Systems Using Hot Standby/Space Diversity Switching
SD-51576-01	Interconnecting Information for Systems Using 401B Protection Switching

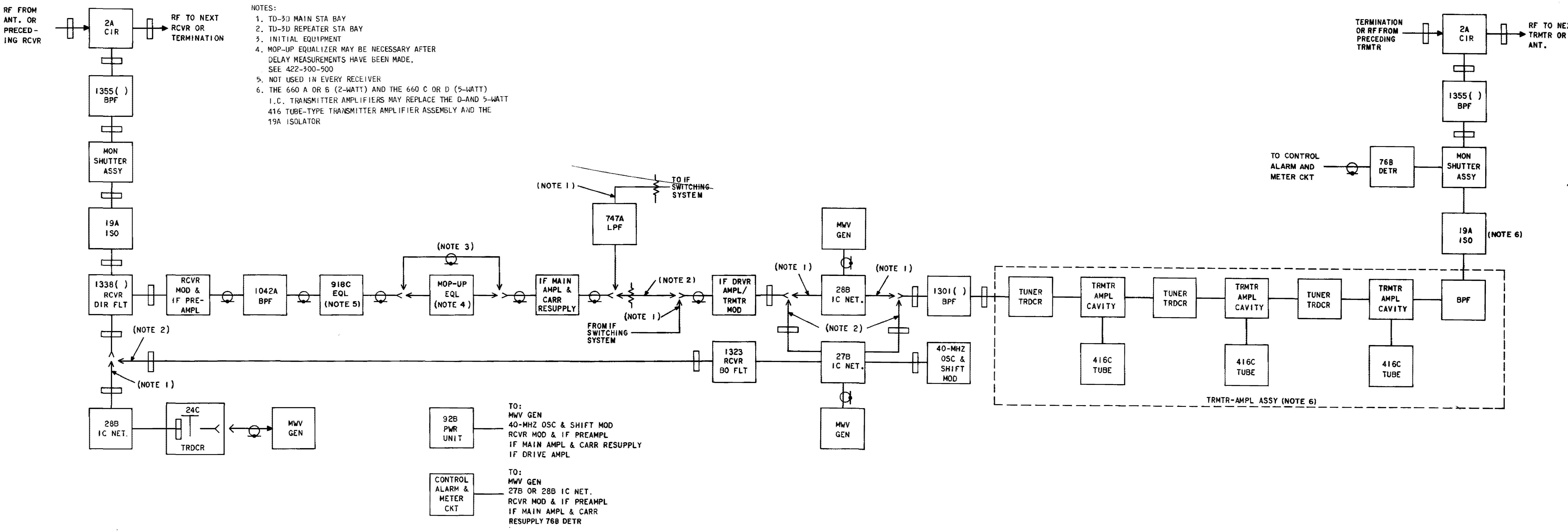


Fig. 57—TD-3D Microwave Radio—Main and Repeater Station—Transmitter and Receiver Bay—Block Diagram

NOTES:
1. TD-3D MAIN STA BAY
2. TD-3D REPEATER STA BAY
3. INITIAL EQUIPMENT
4. MOP-UP EQUALIZER MAY BE NECESSARY AFTER DELAY MEASUREMENTS HAVE BEEN MADE.
5. NOT USED IN EVERY RECEIVER

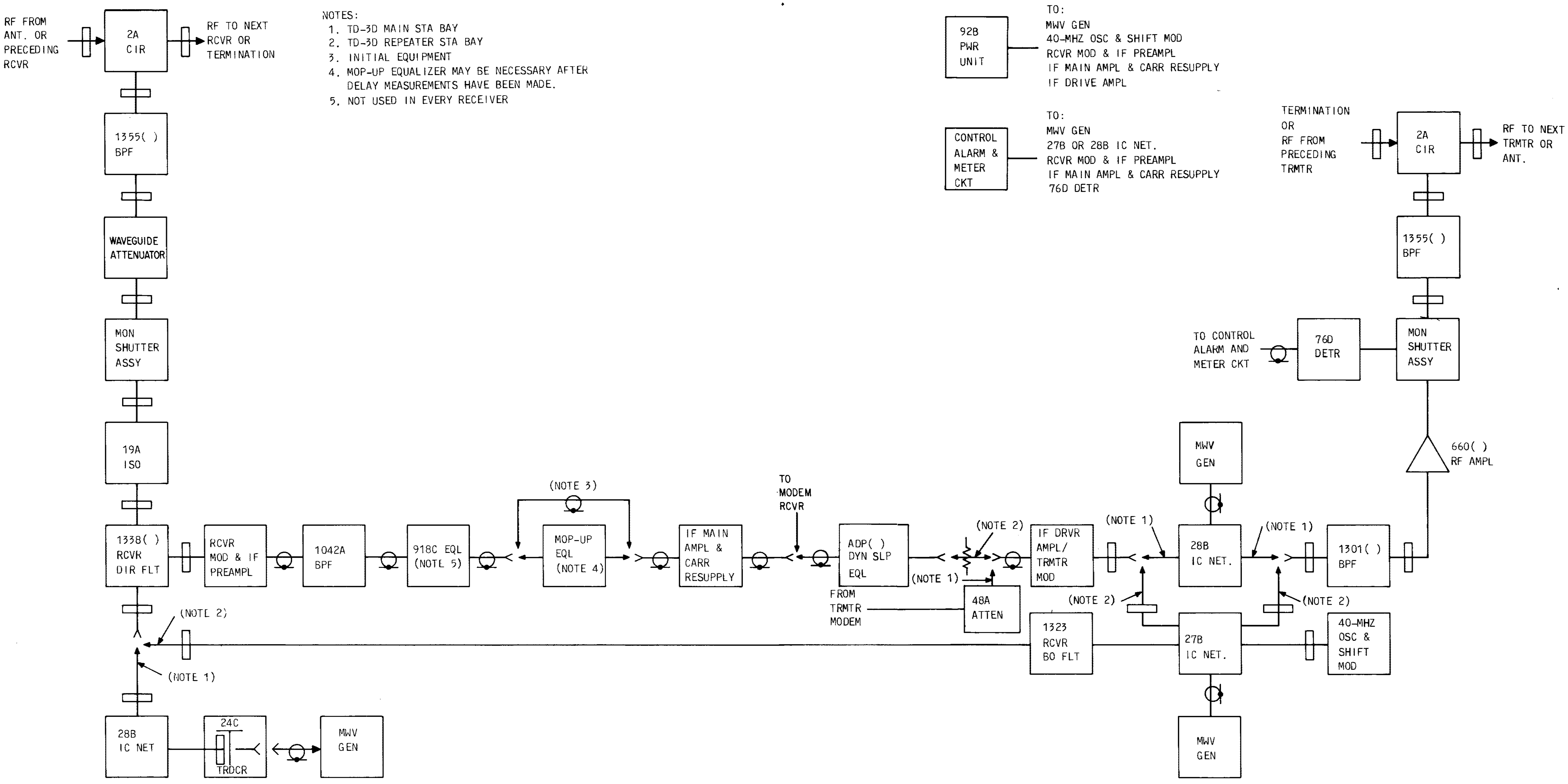


Fig. 58—TD-3D Microwave Radio—Main and Repeater Station—Transmitter and Receiver Bay—Block Diagram—Equipped for 45-Mb/s Digital Operation