N2 CARRIER TELEPHONE SYSTEM
N2WM1 WIDEBAND MODEM
(10 TO 51 KC)
DESCRIPTION

CONTENTS PAGE

1. GENERAL

1.01 This section describes equipment used in conjunction with the N2 carrier telephone terminal for the purpose of utilizing approximately half of the transmission capacity of the N carrier system for the transmission of wideband signals. This equipment is accommodated in the normal N2 terminal bay and utilizes construction and circuit design techniques similar to the rest of N2 equipment design.

1.02 The N2WM1 wideband modem equipment replaces the six voice channel modems and compandors located in channel positions G through M in the top shelf of an N2 terminal as shown in Fig. 1. The wideband signal occupies the frequency spectrum allocated to voice channel numbers 5 through 11. The remaining channels, including 1, 2, 3, 4, 12, and 13, are inserted in the bottom shelf of the terminal, providing the facility for six voice channels in addition to the wideband channel. The voice channel carriers are required for regulation of the N carrier band. Channel 4 is used as a coordinating voice channel for the wideband circuit.

1.03 Multiplexing arrangements for the composite wideband signal plus the voice signal are similar to those for voice-only operation. The connections between the N2 group transmitter and receiver units and the N line remain unaltered. The transmitted wideband signal is combined with the voice carrier signals by summation of the outputs of all channel units at the input of the group transmitter. The process of demultiplexing the received wideband signal from the composite signal is accomplished by a bandpass filter connected to the output of the group receiver and in parallel with the bandpass filters in the voice channel modems.

1.04 The wideband signal and the coordinating voice signal are connected to the subscriber loop or L-type multiplex at the WPB1 wideband patching bay. These connections are made on a 4-wire basis. The transmitting and receiving wideband signal levels at the WPB1 are standardized at −10 dbm, 135 ohms balanced.

2. EQUIPMENT DESCRIPTION

2.01 The N2WM1 wideband modem is designed primarily for the purpose of providing a transmission facility for the digital data set 301B signal. This data set converts a 40.8-kilobit-per-second binary sequence into a 4-phase carrier modulated signal. The 301B carrier is located at 30.6 kc, and the spectrum width required for transmission extends from 10.2 to 51.0 kc. For transmission over the N carrier system, this spectrum is translated upward in frequency into the high-group frequency band of the N system. The choice of frequency allocation for the wideband signal is governed by considerations of minimizing delay distortion and single-tone interference into paral-

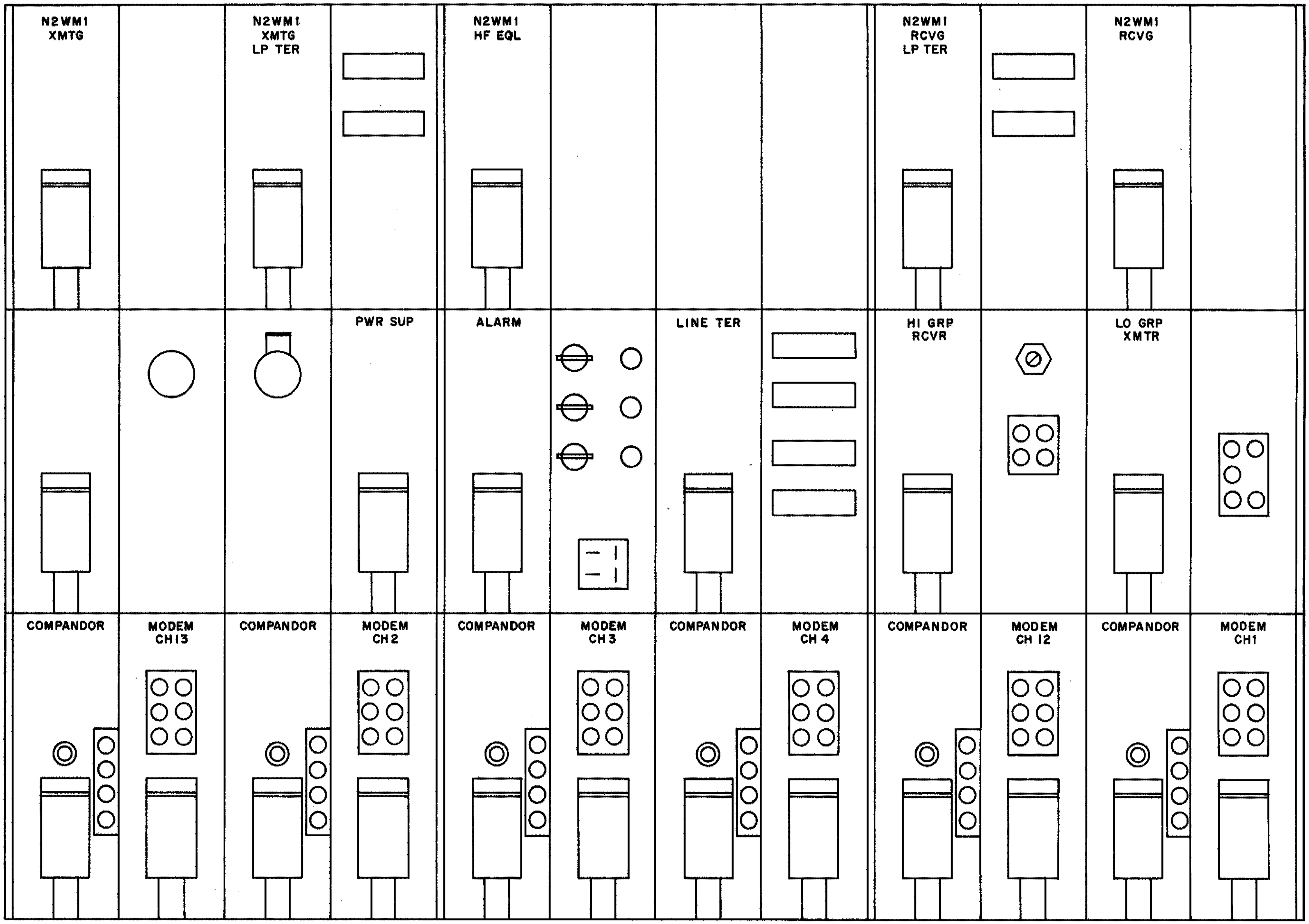

Fig. 1 — N2 Carrier Terminal Equipped with N2WM1 Plug-In Units

leling N systems. Single-tone interference is likely to occur when the wideband signal consists of repeated short binary sequences, since the spectrum in this case is largely concentrated at a few discrete frequencies which can interfere with voice messages in other systems because of far-end crosstalk. In particular, when no message is transmitted, the data set 301B emits an idle circuit signal whose energy is almost entirely concentrated at the carrier frequency. Accordingly, the wideband signal is centered approximately at the carrier frequency allocation of channel 8 in the high-group band. The 301B carrier is offset by 100 cycles to prevent low-frequency beating effects when the idle circuit signal is present. The 301B signal spectrum extends from 203.5 to 244.3 kc in the high-group band and from 59.7 to 100.5 kc in the low-group band.

2.02 The N2WM1 wideband modem equipment consists of five separate units:

(a) Transmitting unit

(b) Receiving unit

(c) Transmitting loop terminating unit

(d) Receiving loop terminating unit

(e) High-frequency equalizing unit.

2.03 The N2WM1 units, except the high-frequency equalizing unit, are of Amplas construction mounted on standard N2 castings. Fig. 2 shows the construction details of the receiving unit. The other units are of similar construction. The filter assemblies for the receiving and transmitting units are bolted to the Amplas circuitry. The plug-in N2WM1 units are mounted in the shop-wired N2 terminal bay. The switching

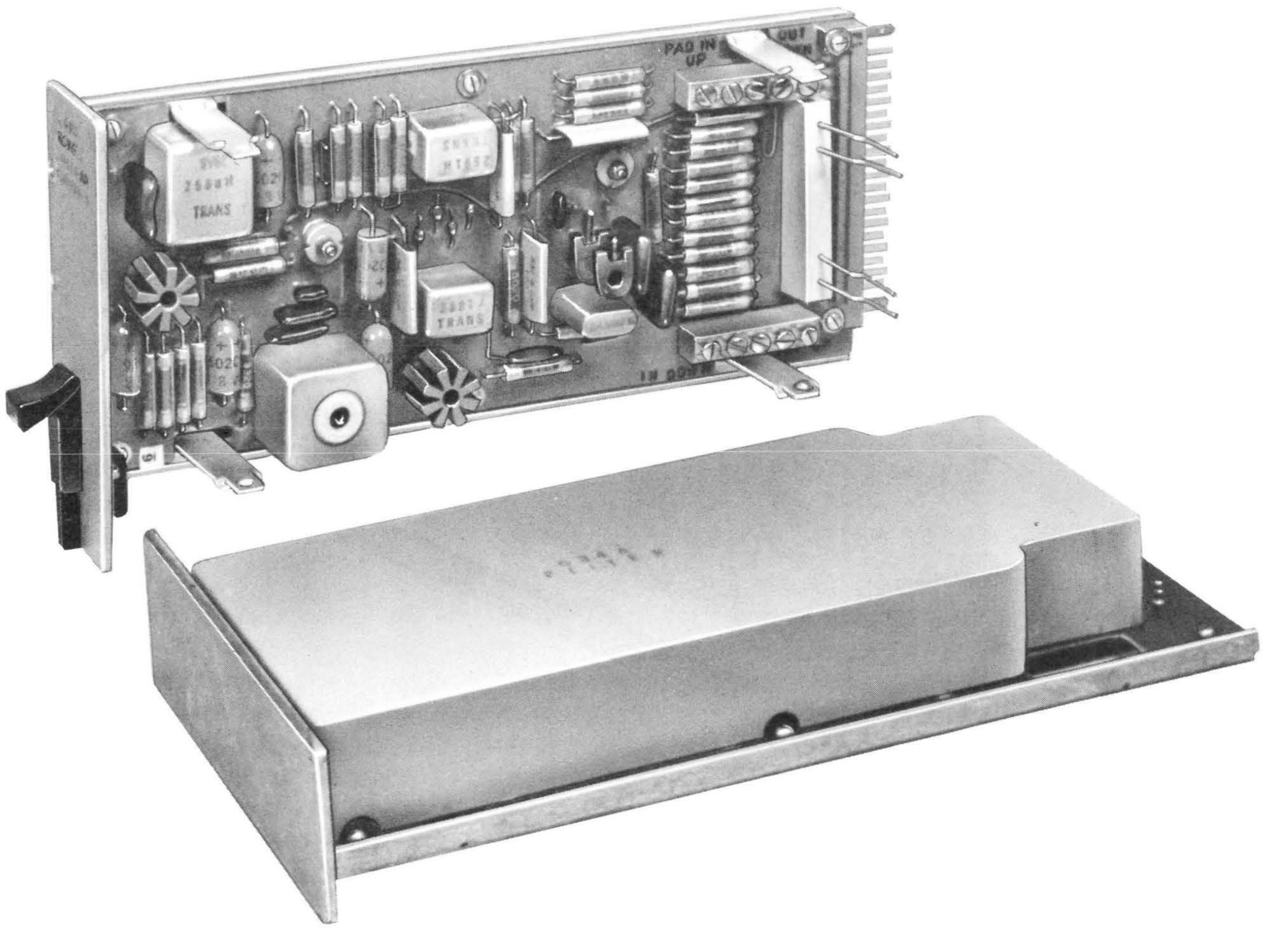

Fig. 2 — N2WM1 Receiving Unit, Construction Details

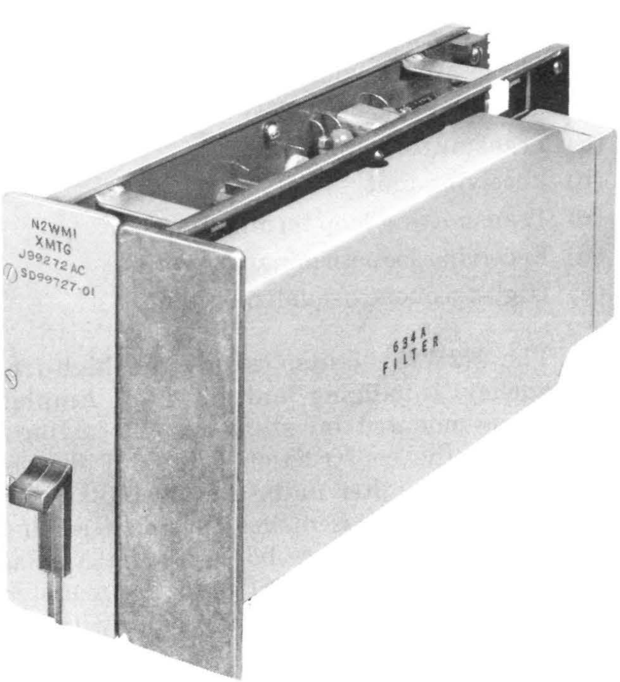

Fig. 3 — N2WM1 Transmitting Unit

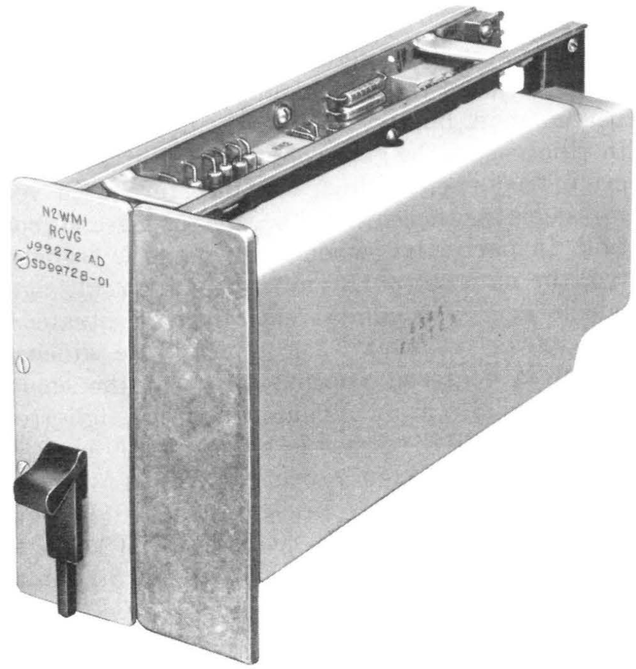

Fig. 4 — N2WM1 Receiving Unit

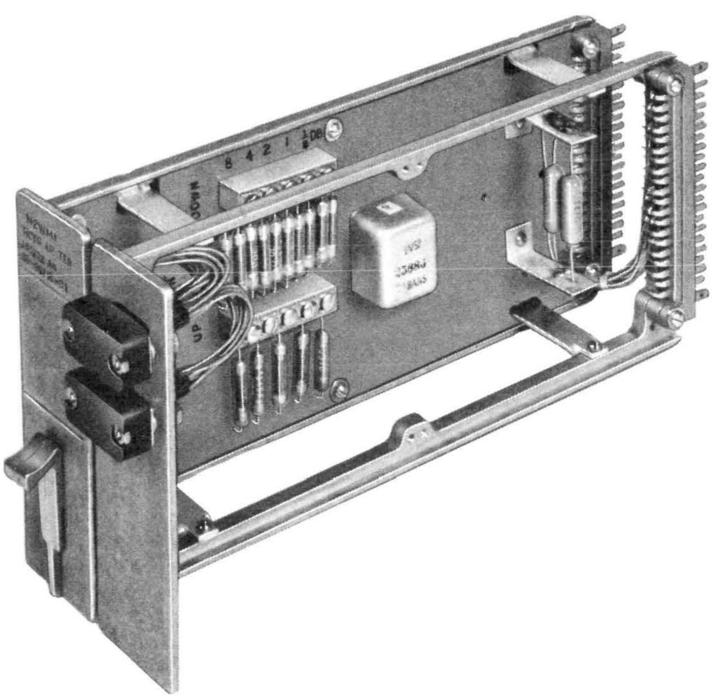

Fig. 5 — N2WM1 Receiving Loop Terminating Unit

jacks, necessary for initial line-up and maintenance, are on the front of the panels of the loop terminating units.

2.04 The N2WM1 transmitting and receiving units, shown in Fig. 3 and 4, perform the wideband signal processing operations of band selection, frequency translation, and amplification.

2.05 The transmitting loop terminating unit and the receiving loop terminating unit, shown in Fig. 5, provide:

(a) Transformers for conversion from balanced operation at the WPB1 to unbalanced operation in the N2WM1 equipment.

(b) Adjustable pads for obtaining the correct relative power levels between the WPB1 and the transmitting and receiving circuits.

(c) Switching jacks for in-service testing and maintenance of the N2WM1 equipment.

2.06 The high-frequency equalizing unit, shown in Fig. 6, provides plug-in equalizers for variable delay equalization of the N carrier system over the wideband channel frequencies (203.5 to 244.3 kc).

3. CIRCUIT DESCRIPTION

A. General

3.01 The N2WM1 equipment in the transmitting and receiving signal paths is shown in block diagram form in Fig. 7 and 8. The components in the two paths, with the exception of the high-frequency equalizing unit, are similar. The primary difference is in the order in which they occur.

3.02 In the transmitting direction, the incoming 10.2- to 51-kc signal from the patching bay passes through an adjustable pad in the transmitting loop terminating unit to the transmitting

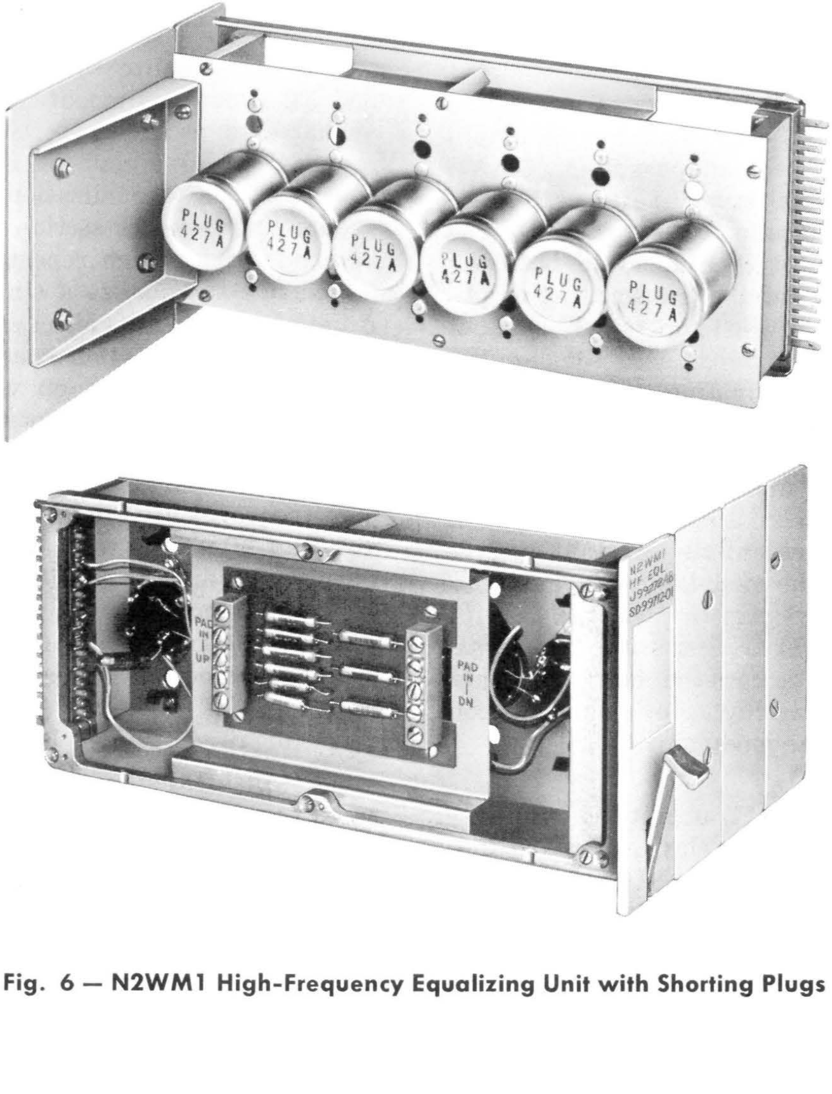

Fig. 6 — N2WM1 High-Frequency Equalizing Unit with Shorting Plugs

unit. The transmitting unit modulates the wideband signal into the N2 band and amplifies it to the proper level. Then the signal is passed through the transmitting loop terminating unit to the high-frequency equalizer where the delay of the N2 line is pre-equalized by a set of plug-in equalizers. The signal is finally combined with the six voice channel signals in the line terminating unit.

3.03 The transmitting loop terminating unit contains a fixed 4-db pad and an adjustable pad which provides 0 to 15.5 db of attenuation (in 0.5-db steps) ; these pads reduce the level of the incoming signals to the −25 dbm level required by the modulator in the transmitting unit. The adjustable pad is a cascade of T pads that may be placed in the circuit by adjusting two screw-down connectors as described in 3.12. The input and output connections to the transmitting unit are wired through switching jacks (J1 and J2) on the front panel of the transmitting loop terminating unit. In normal operation, the signal path is closed by shorting plugs inserted in the jacks.

3.04 The transmitting unit contains a balanced modulator, a 254.5-kc oscillator, an amplifier, and a delay-equalized bandpass filter (634A). The 10.2- to 51-kc signal is modulated with 254.5 kc, and the lower sideband, 203.5 to 244.3 kc, is selected. The modulator is coupled to both the loop terminating unit and the transmitting amplifier circuit through transformers. The input transformer matches the unbalanced 135-ohm impedance of the loop terminating unit to the balanced 3000-ohm impedance of the modulator. The output transformer has an impedance ratio of 3000 to 3000 ohms to match the balanced modulator to the unbalanced amplifier circuit. The oscillator provides an essentially constant current switching source for the modulator. The amplifier provides the necessary gain to raise the level of the modulated signal for transmission. The signal present in the amplifier contains both the upper and lower sidebands and higher order modulation products created by the modulator.

3.05 The output of the transmitting amplifier is passed through a delay-equalized bandpass filter (634A). The purpose of the filter is to attenuate out-of-band components of the data set 301B signal spectrum in order to minimize interference into the adjacent voice channels. The filter is also required to suppress the upper sideband and other spurious modulation products, including carrier leak due to imperfect modulator balance. A high degree of suppression of the carrier leak is obtained by placing one of the attenuation peaks of the 634A filter directly on the carrier frequency (254.5 kc). The filter is designed to have a transmission characteristic, as shown in Fig. 9, when terminated with a 135-ohm resistive load and driven from a low-impedance source (less than 10 ohms). The passband width is approximately 40.8 kc and the minimum out-of-band attenuation is 24 db. A 3-section all-pass network, isolated from the bandpass filter by a 6-db pad, provides delay equalization over the pass band. The resulting phase linearity of the 634A filter is within 1 degree. Flat loss of the filter is approximately 7 db. The output of the filter is connected to the high-frequency equalizing unit through the switching jacks on the loop terminating unit.

3.06 The high-frequency equalizing unit provides six sockets for plug-in delay equalizers to pre-equalize the N2 high-frequency line and N2 group equipment. Plug-in equalizers are available to provide one, two, or four units of equalization. One unit of equalization provides envelope delay equalization for two high-frequency line repeater sections including one high-low and one low-high repeater. No provision has been made to equalize a single repeater section. A plug-in equalizer is also available to compensate for the delay distortion caused by the transmitting and receiving group units in the N2 terminals. When all the sockets are not used for equalization, shorting plugs are inserted in the remaining sockets to provide continuity. The high-frequency equalizing unit contains an adjustable pad to set the total equalizer loss to 3.5 db for any plug-in combination. The pad has a range of attenuation of 0 to 3.5 db, adjustable in 0.5-db steps, as described in 3.12. The equalizer codes and their associated loss are listed in Table A.

3.07 In the receiving direction, the incoming wideband signal from the N2 line is separated from the voice channels by a selective filter at the input to the N2WM1 receiving unit after passing through the loop terminating unit. The receiving unit modulates the signal back to baseband and amplifies it to the proper level. The output level is adjusted by a pad in the receiving

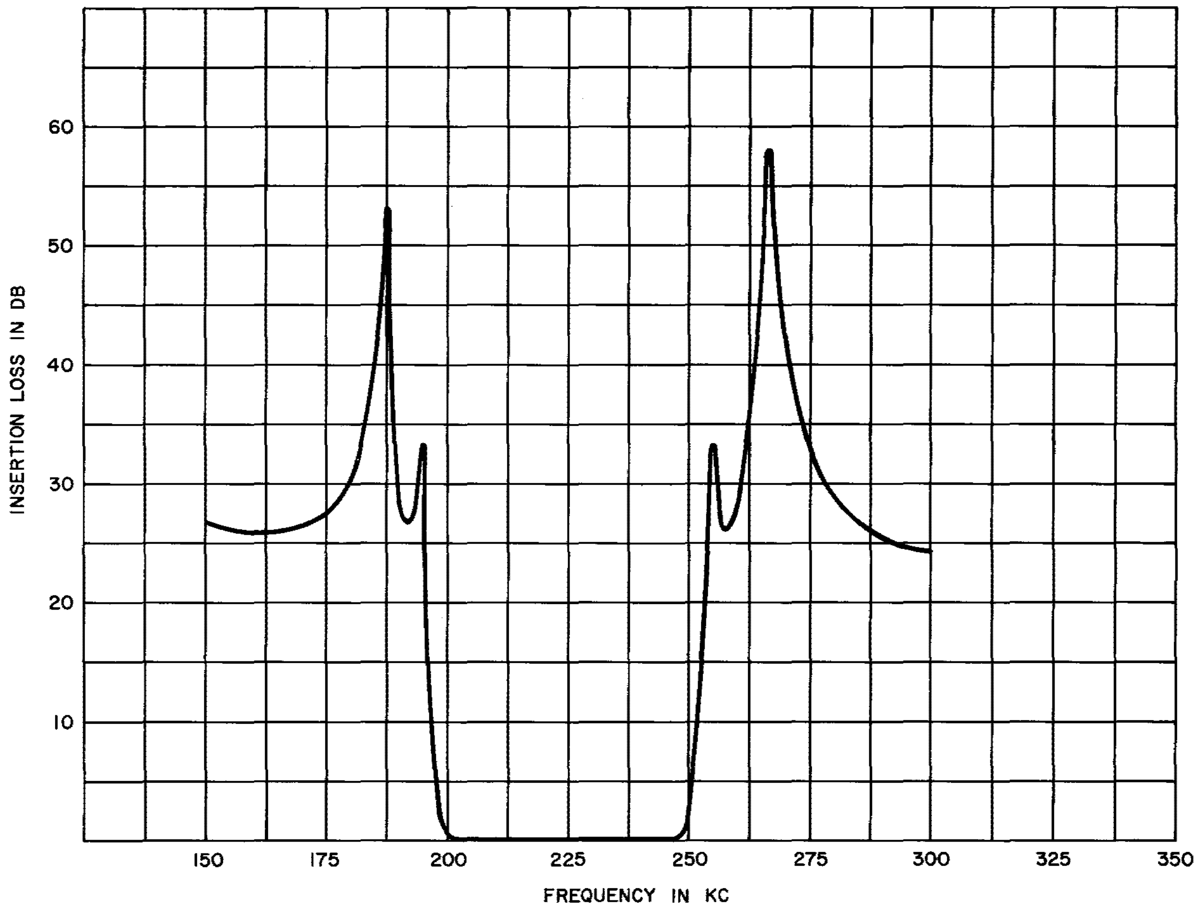

Fig. 9 — The 634A Bandpass Filter Insertion Loss Characteristics

unit to compensate for tolerances in the N2 line. The signal then passes through a pad in the receiving loop terminating unit to the WPB1.

3.08 The selective filter in the N2WM1 receiving unit is a 634A filter identical to that

TABLE A

CODE	UNITS OF EQUALIZATION	LOSS db
372A	1	0.15
372B	2	0.30
372C	4	0.60
372D	Terminal Equalizer	0.15
427A	Shorting Plug	0

used in the transmitting unit. The low output impedance of the N2 group receiver provides the proper driving source for the filter. The filter is terminated in a 135-ohm fixed 4-db pad in cascade with a 0- to 7-db adjustable pad. The adjustable pad provides attenuation settings in 1-db steps as described in 3.12.

3.09 The modulator in the receiving unit is identical in configuration and impedance levels to the modulator in the transmitting unit described in 3.04. The difference in modulators is in the design of input and output transformers to maintain suitable conversion characteristics in the opposite frequency translations. The receiver modulator translates the 203.5- to 244.3-kc spectrum in the N carrier high-group band down to the 10.2- to 51.0-kc operating band. The 254.5-kc local oscillator circuit is identical to that in the transmitting unit and is described in 3.13.

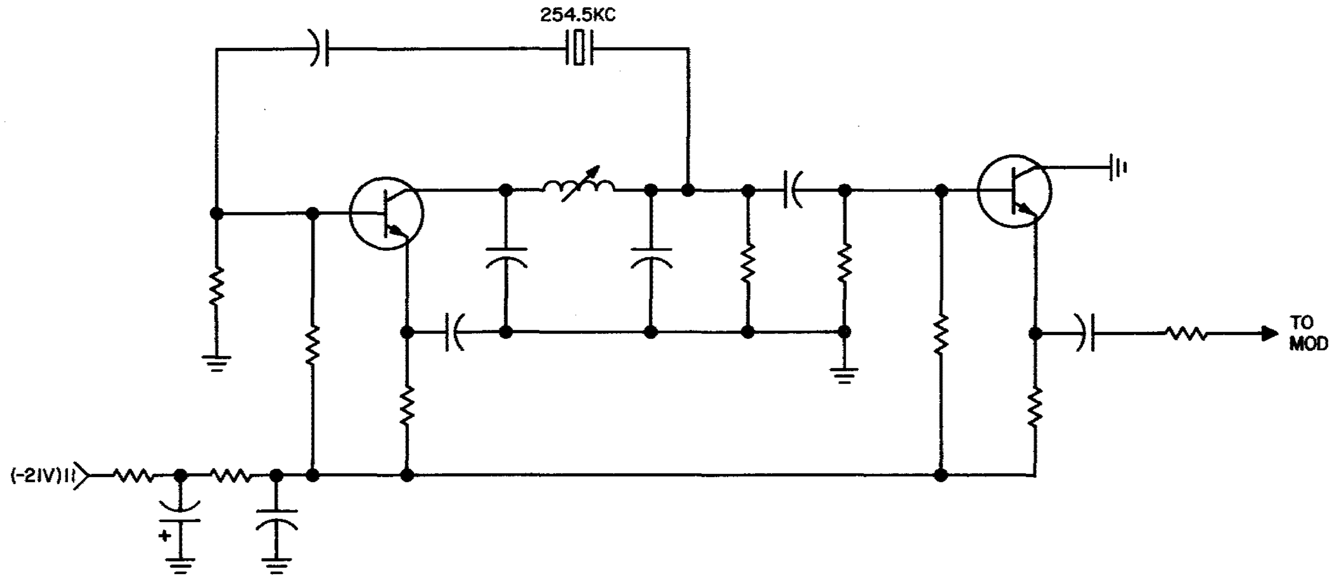

Fig. 10 — N2WM1 Transmitting and Receiving Oscillator Schematic

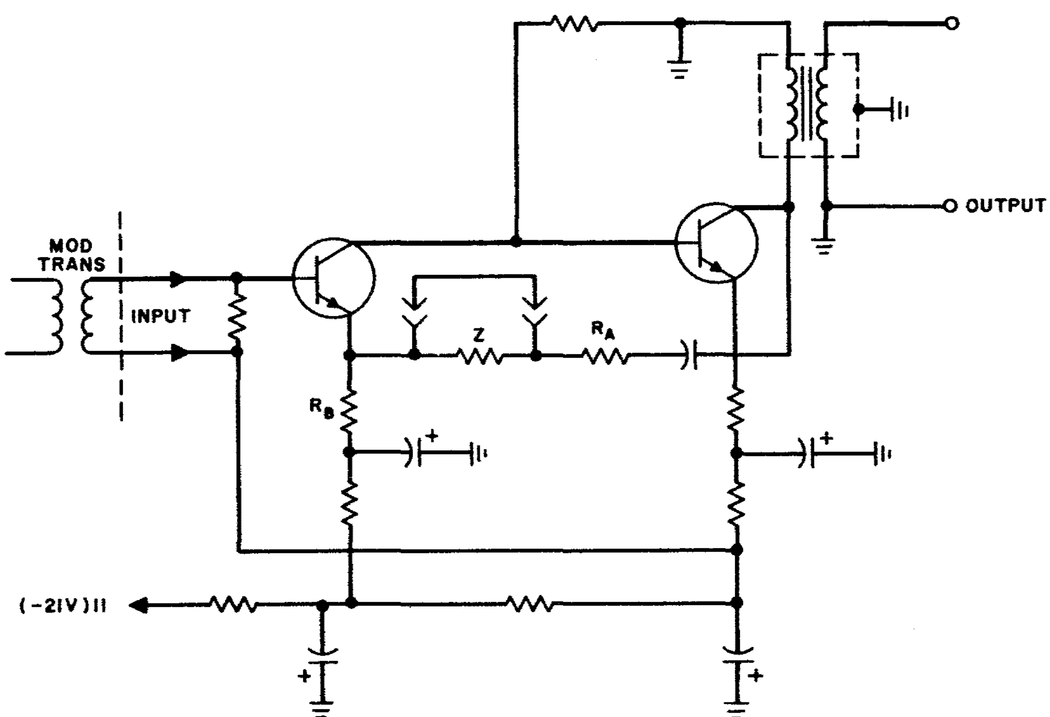

Fig. 11 — N2WM1 Transmitting and Receiving Amplifier Schematic

3.10 The modulator in the receiving unit is followed by a 3000-ohm single pi-section low-pass filter. This filter removes image band and harmonic products generated by the modulation process. In addition, the filter suppresses carrier leak and input signals due to imperfect modulator balance. Carrier suppression is increased by making the attenuation peak of the low-pass filter coincide with the carrier frequency.

3.11 The 10.2- to 51-kc wideband signal is amplified in the receiving amplifier and passed through the receiving loop terminating unit to the patching bay. The receiving loop terminating unit is essentially the same as the transmitting loop terminating unit except that the fixed 4-db pad is omitted. It contains an adjustable 0- to 15.5-db pad (see 3.12) to set the level at the patching bay to −10 dbm. The input and output connections to the receiving unit are wired through switching jacks (J3 and J4) on the front panel of the receiving loop terminating unit. In normal operation the signal path is closed by shorting plugs inserted in the jacks.

B. Adjustable Pads

3.12 There are four adjustable pads in the N2WM1 equipment. Each of these pads is a cascade of T pads that may be placed in the circuit by adjusting ***two*** screw-down connectors. The loop terminating units contain five T pads with losses of 0.5, 1, 2, 4, and 8 db to provide 0 to 15.5 db of attenuation in 0.5-db steps. The high-frequency equalizing unit contains three T pads with losses of 0.5, 1, and 2 db to provide 0 to 3.5 db of attenuation in 0.5-db steps; and the receiving unit contains three T pads with losses of 1, 2, and 4 db to provide 0 to 7 db of attenuation in 1-db steps. For insertion of a pad in the circuit, the screw corresponding to the desired pad marked PAD IN— DN should be tightened until the terminals are shorted, while the screw corresponding to the desired pad marked PAD IN — UP should be loosened until the terminals are no longer shorted. For removal of a pad from the circuit, the above procedure should be reversed. Since a pad is either in the circuit or out of the circuit, one of its screws must be up and one of its screws must be down at all times. For adjustment of a pad, the associated unit must be removed from the terminal mounting.

C. Transmitting and Receiving Oscillator

3.13 The oscillator circuit for both the transmitting and receiving units is a single-stage crystal-controlled oscillator followed by an emitter-follower buffer stage as shown in Fig. 10. A pi-section network at the collector of the oscillator stage provides the necessary phase shift for oscillation. Inductor L1 in this network is factory adjusted to compensate for component variation and to provide the correct oscillator output. The series resistance at the emitter of the buffer stage produces the high-impedance current source for switching the modulator diodes.

D. Transmitting and Receiving Amplifier

3.14 The transmitting amplifier is a 2-stage direct-coupled transistor feedback amplifier. A schematic diagram is shown in Fig. 11. Feedback from the collector of the output stage is applied to the emitter of the input stage. This connection provides an amplifier with high input impedance and low output impedance. Stability of the quiescent operating point of both stages is gained by using large bypassed emitter resistors and by incorporating a dc feedback path from part of the total emitter resistance of the output stage back to the base of the input stage through the secondary winding of the modulator transformer. The amplifier is designed for essentially flat amplitude and linear phase response in the 200- to 250-kc range. Gain is determined by the ratio of RA to RB in the feedback path. Removing wiring option Z increases the series resistance in the feedback path and provides approximately a 3-db increase in gain. This gain increase is required when the unit is used as the alternate unit in the switching test set.

3.15 The receiving amplifier is a 2-stage direct-coupled feedback amplifier similar to the transmitting amplifier except that it is designed to have optimum transmission characteristics in the 10.2- to 51.0-kc range and a somewhat higher gain. The relatively low output impedance is increased to match the 135-ohm impedance level of the loop circuit by means of a series resistor (not shown in Fig. 11). The receiving circuit amplifier gain can also be increased by approximately 3 db by removing wiring option Z when the unit is to be used as an alternate unit in the switching test set. A collector-to-ground capacitor (not shown in Fig. 11) is added to increase the stability margin of the feedback loop.

E. Power

3.16 DC power for the active circuits in the transmitting and receiving units is obtained directly from the −21 volt supply available at the jacks in the N2 terminal bay.

4. TRANSMISSION PERFORMANCE

4.01 The pertinent wideband signal levels are shown in the block diagrams of Fig. 7 and Fig. 8. The levels indicated refer to the 30.6-kc component of the 301B idle signal or to a 30.6-kc test tone. However, the rms power in the 301B data signal is fairly constant for all possible signals, including both the 301B idle signal and completely random data signals. The level at the WPB1 is standardized to −10 dbm. The level at the output of the N2WM1 transmitting unit is set to −18.7 dbm by adjusting the pad in the transmitting loop terminating unit. This level produces, at the input to the group transmitter, a signal 4 db lower (−47 dbm) than the level of a single voice channel carrier at this point.

4.02 The composite multiplexed signal, consisting of the wideband signal plus six voice signals, has a total power 2.7 db less than that of a fully voice-loaded multiplexed signal at the output of the group transmitter. However, because of the power regulating action of the N system line repeaters and group receivers, this lower transmitted total power is increased to normal values in the rest of the system. However, the associated voice carrier levels will be approximately 3 db higher than an equivalent fully voice-loaded system, since the repeaters are essentially regulating on six voice carriers instead of twelve. Assuming the N2 system has perfect regulation and a flat frequency response, the individual voice carrier levels at the output of the group receiver will be −11 dbm into 75 ohms, or 3 db above normal. The wideband signal *voltage* level at this point will be 4 db below that of a single voice carrier. However, since the input impedance to the N2WM1 receiving unit is 135 ohms, the *power* level at this point will be −18 dbm. If the 30.6-kc component of the 301B idle signal and the voice carriers are measured with a high-impedance voltmeter at this point, the idle signal will measure 4 db below the individual voice carrier level (in the ideal case).

4.03 In practice there are tolerances on the total output power and the frequency response at the output of the N2 group receiver. The adjustable pad in the N2WM1 receiving unit is used to compensate for these tolerances so that the output of the receiving unit may be set to −5 dbm into 135 ohms for any N system. The adjustable pad in the receiving loop terminating unit is used to compensate for office wiring losses so that the level at the WPB1 may be set to −10 dbm.

4.04 Amplitude and phase response characteristics of the transmitting and receiving units are essentially identical. Amplitude deviation and phase deviation from linearity are about 0.5 db and 0.5 degree, respectively, for each unit over the 40.8-kc data signal bandwidth.

5. TESTING ARRANGEMENTS AND FACILITIES

5.01 The input and output terminals of the N2WM1 transmitting and receiving units are accessible at the switching jacks on the face of the respective loop terminating units. The two transmitting jacks are labeled J1 and J2, while the two receiving jacks are labeled J3 and J4. Cords are available to connect a selective voltmeter or a wideband voltmeter to the jacks to measure the output of the transmitting or receiving units. The output levels are set at initial lineup by measuring the 30.6-kc component of the 301B idle signal or a 30.6-kc test tone with a selective voltmeter. After the levels are set, they may be roughly monitored on an in-service basis with a wideband voltmeter.

5.02 When the replacement of an N2WM1 transmitting or receiving unit is necessary, it may be accomplished without interruption of service on the system by use of the N2 switching set. A cord built into the test set connects the switching set to the switching jacks on the appropriate loop terminating unit. Power for the switching set is derived from the TEST PWR jack on the face of the alarm unit. The switching set contains the necessary switches and gain adjustments so that an alternate transmitting or receiving unit may be switched into the circuit in place of the regular unit. The regular unit may then be removed, repaired, or replaced. The alternate unit is a regular unit with wiring option Z removed, which increases its gain by 3 db.

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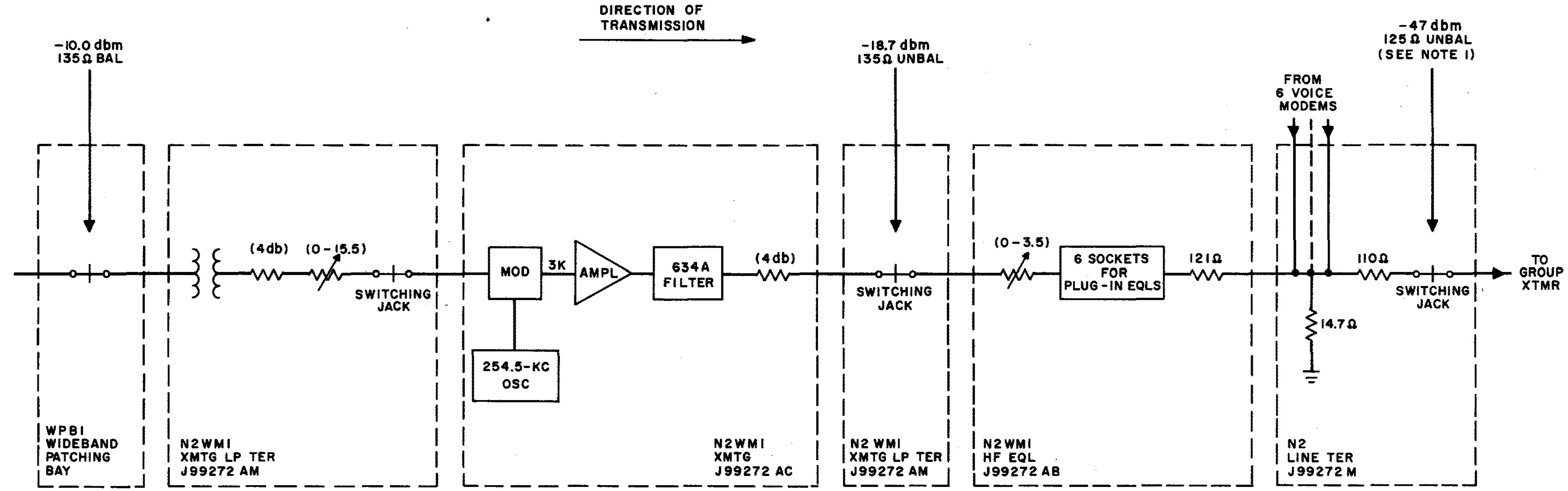
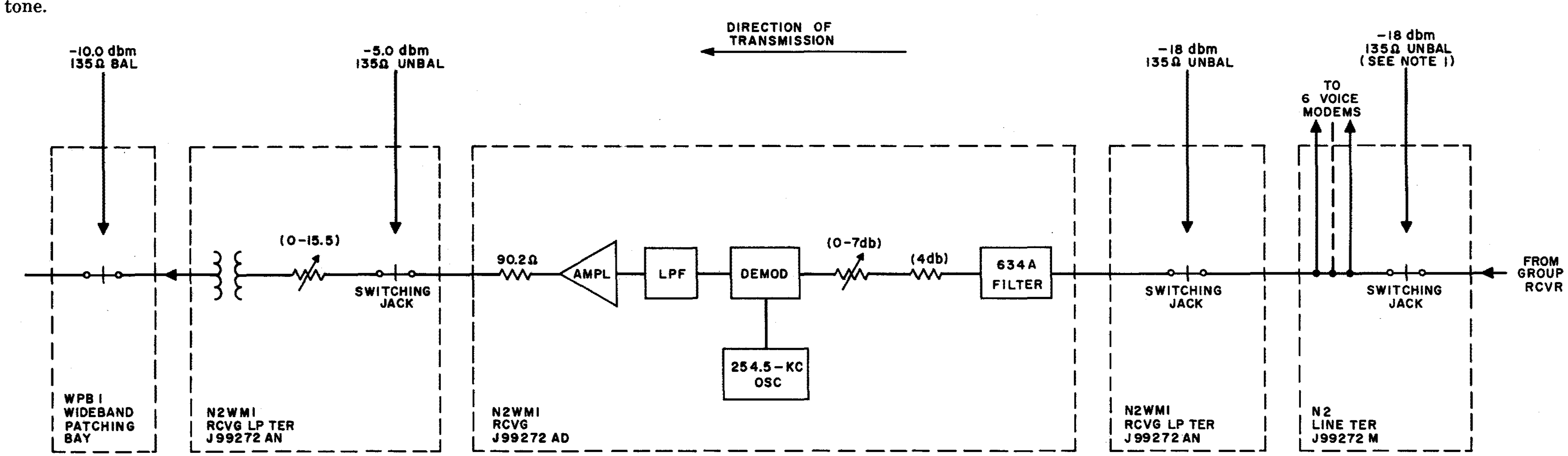


Note 1: Voice channel carrier level at this point equals −43 dbm into 125 ohms.

Note 2: Levels indicated refer to the 30.6-kc component of the 301B idle signal or a 30.6-kc test tone.

Fig. 7 — N2WM1 Transmitting Signal Path, Block Diagram



Note 1: Voice channel carrier level at this point equals −11 dbm into 75 ohms. It will read −14 db on a meter calibrated for 135 ohms.

Note 2: Levels indicated refer to the 30.6-kc component of the 301B idle signal or a 30.6-kc test tone.

Fig. 8 — N2WM1 Receiving Signal Path, Block Diagram

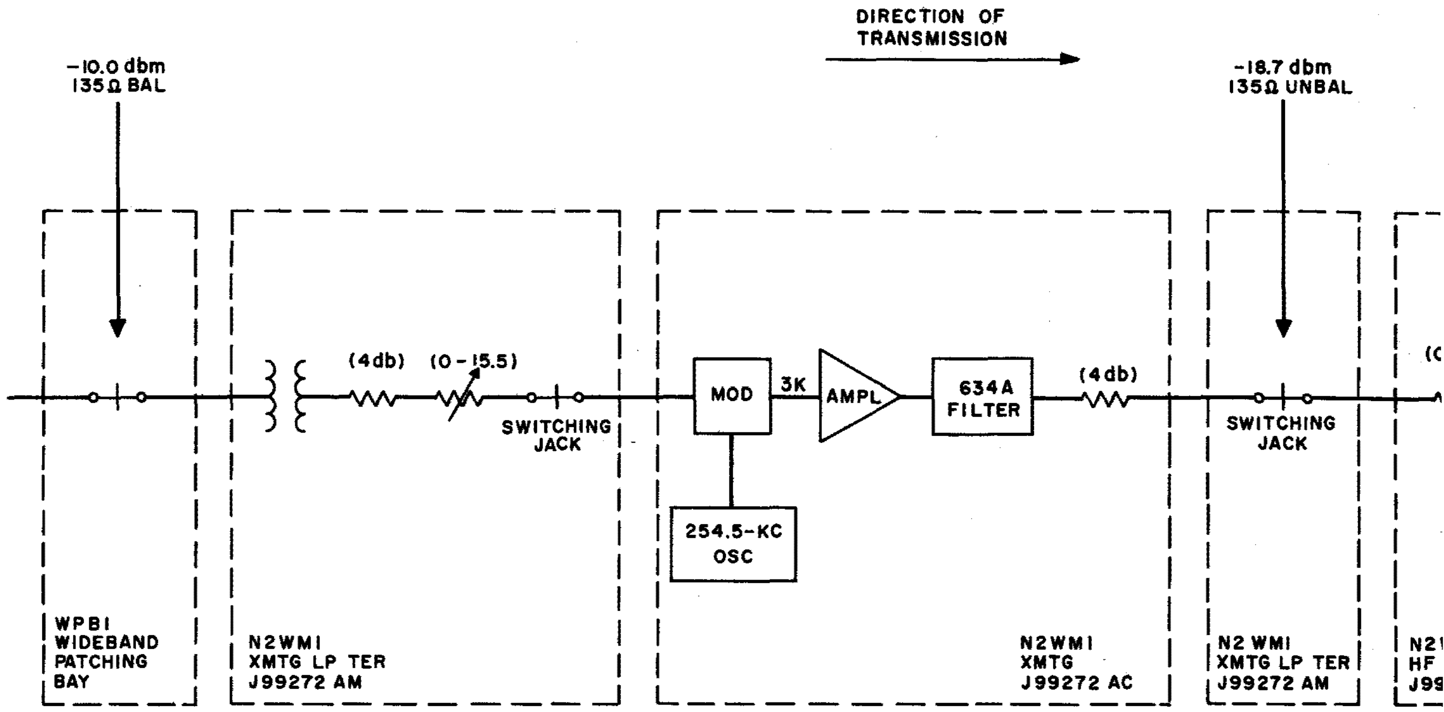
6. **DRAWINGS (Not Attached)**

SD-99712-011—N2WM1 Wideband Modem Application Schematic

SD-99712-012—N2WM1 Wideband Modem Application Schematic

SD-99727-01—N2WM1 Wideband Modem Transmitting Circuit

SD-99728-01—N2WM1 Wideband Modem Receiving Circuit



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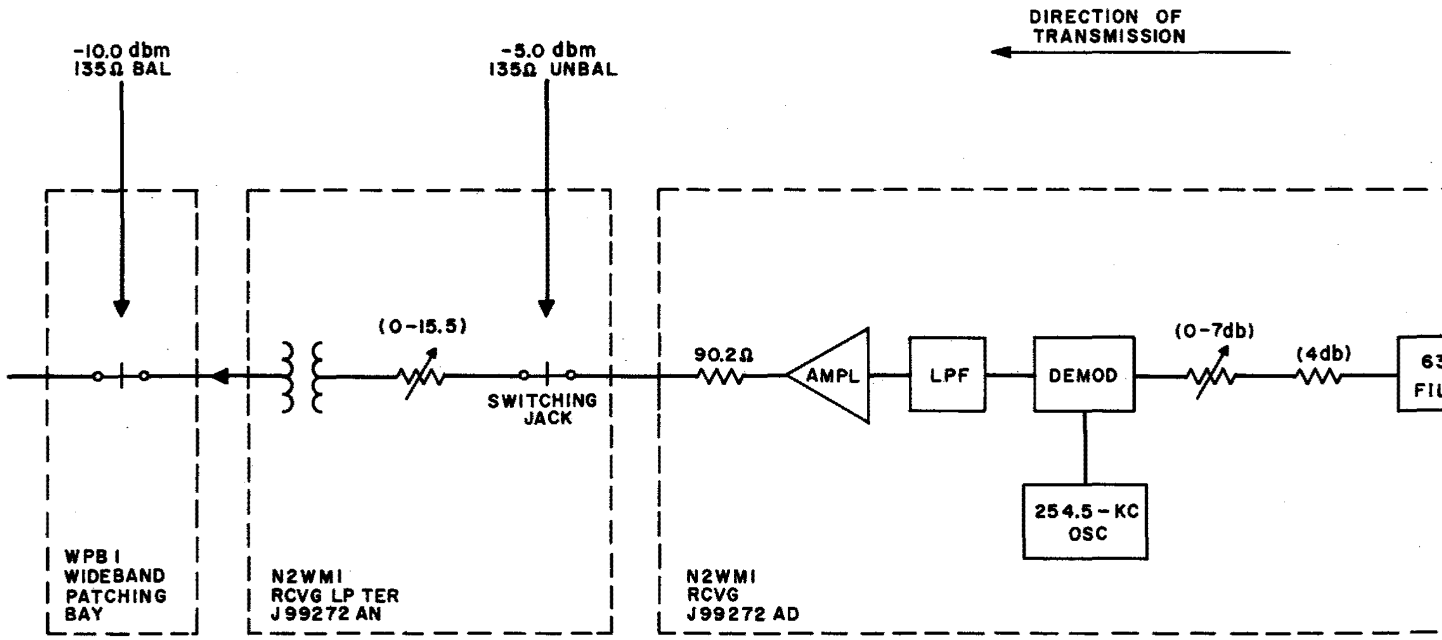

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