TYPE N3 CARRIER TELEPHONE SYSTEM
CHANNEL GROUP MODEM UNIT DESCRIPTION

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1. GENERAL

A. System Function of Channel Group Modem

1.01 This section describes the channel group modem which is a component part of the N3 carrier telephone system.

1.02 A complete 24-channel terminal for the N3 carrier telephone system as shown in Fig. 1 includes two channel group modem units. Each channel group modem is a single plug-in assembly providing two independent circuits, a modulator, and a demodulator.

1.03 In the transmitting terminal, a modulator is used in each channel group modem unit to translate in frequency the combined 12-channel 6-carrier signal from the channel equipment into half of the low-group band of signals. As seen in the modulation plan of Fig. 2, the signals from two sets of channel equipment (148 to 196 kc each) are channel group modulated by 280- and 232-kc carriers, respectively. These are then combined to produce the desired solid lay up of channels falling in the standard N and ON low-group frequency range of 36 to 132 kc.

1.04 In the receiving terminal the modulation steps are the reverse of those in the transmitting terminal. The demodulator circuit in each of the channel group units selects from the received group signal either the 36- to 84- or 84- to 132-kc band of frequencies according to the demodulating carrier used and demodulates it to the band of frequencies (148 to 196 kc) needed by its receiving channel equipment.

B. Description and Features

1.05 The channel group modem for the N3 carrier system is a single plug-in modular unit. For convenience, a modulator and a demodulator have been assembled together and share a 20-pin plug and receptacle. These two circuits function independently, except for a common connection to the power supply. A photograph of a channel group modem unit is shown in Fig. 3.

1.06 All components have been reduced to minimum size and wired directly into their respective circuits in a manner that is consistent with design objectives.

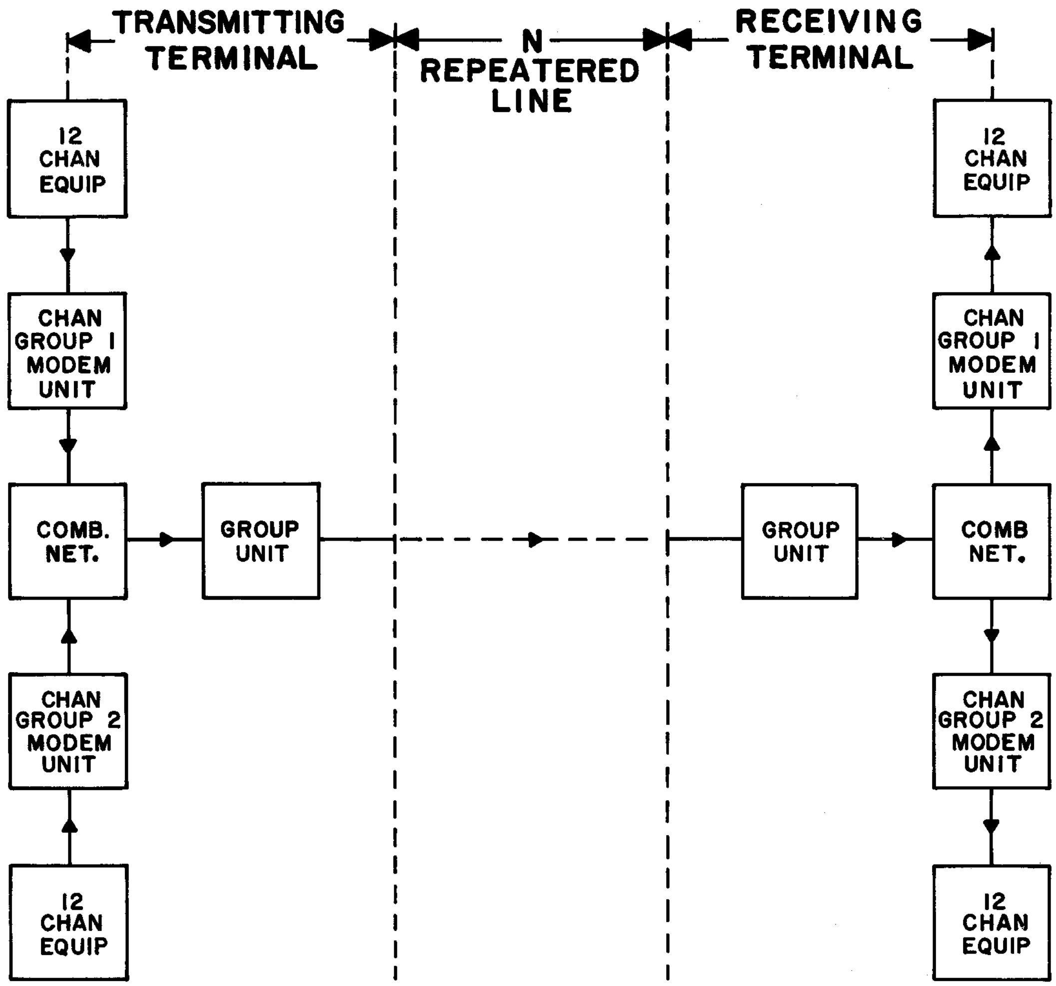

Fig. 1 — N3 Carrier Telephone System

1.07 Circuit components are mounted on a printed circuit board which is contained in a die-cast metal frame. All interconnecting wiring to and from the modem unit enter the rear of the assembly via a 20-pin plug which is part of the printed circuit board. Five pin jacks for testing, and a mechanical latch for locking the unit in position are located on the front panel.

C. General Characteristics of Circuits

1.08 The channel group modem unit for the N3 carrier system is composed of two independent circuits, a modulator and a demodulator circuit. The essential components of each circuit are indicated on the block diagram of Fig. 4.

1.09 The modulator circuit functions in the following manner: channel frequencies from the combining multiple are mixed with a carrier frequency from the carrier amplifier to produce a double sideband signal. The energy content of the input and carrier signals found at the output is negligible due to the high degree of balance in the modulator. The output of the modulator is fed without filtering to either the low- or high-group transmit unit. The carrier amplifier receives its input from a common carrier supply unit.

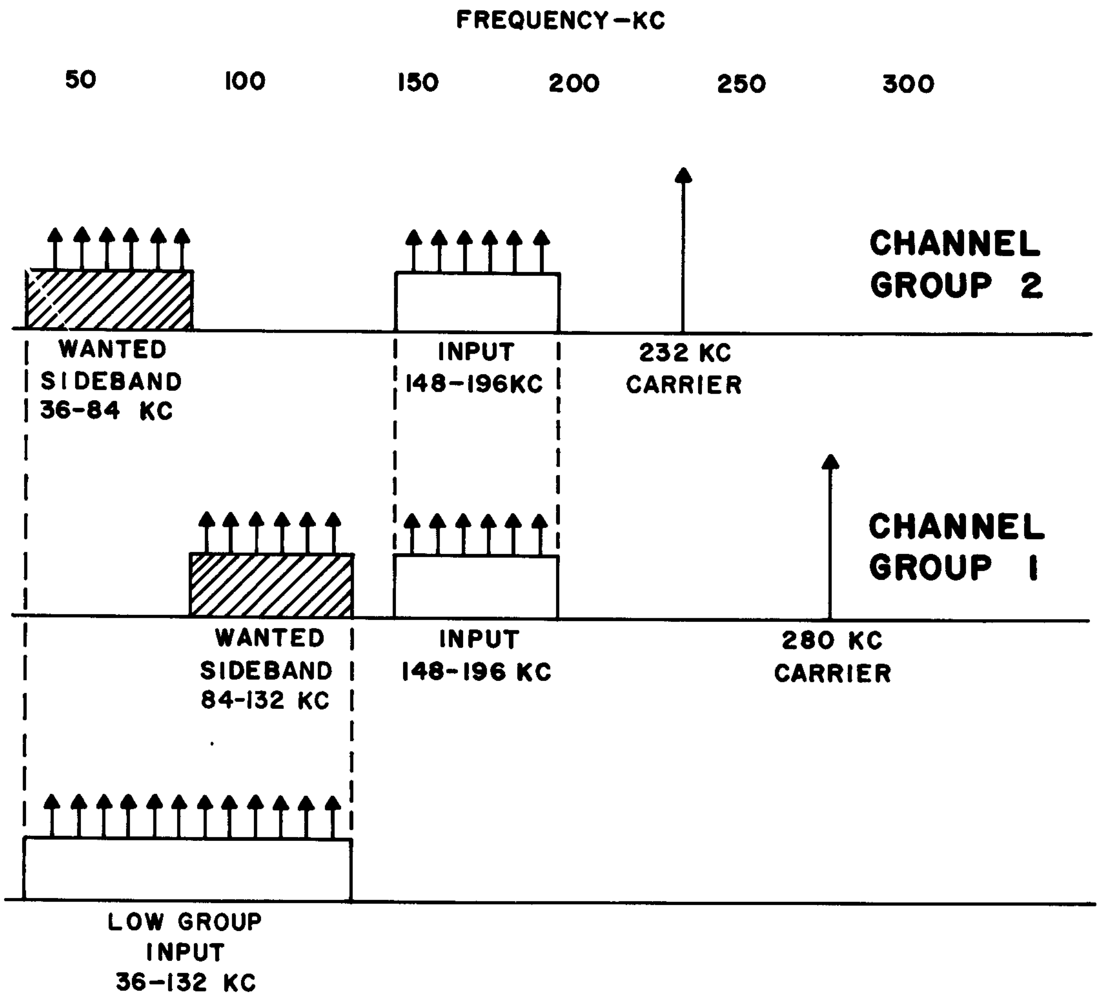

Fig. 2 – Channel Group Modulation Plan

1.10 The input to the demodulator circuit, as shown in Fig. 4, is from either a low- or high-group receive unit. A filter and an equalizer, preceding the demodulator, selects the desired half of the low-group (36 to 132) received signal and provides gain frequency equalization for the complete receiving channel group.

1.11 The channel group demodulator translates the selected low-group frequency signals up to the channel frequency range (148 to 196 kc) with a high degree of balance to both the carrier and input signal band. A band filter, following the demodulator, passes the lower sideband, rejects the upper sideband, and further suppresses the carrier and input signal energy present at the output. The 148- to 196-kc signal is amplified by a 2-stage hybrid-feedback amplifier. The feedback in the amplifier reduces the distortion and stabilizes the gain of the amplifier. A carrier amplifier receives its input from the frequency correction unit and amplifies it to the proper level for the demodutor.

2. MODULATOR CIRCUIT

A. Circuit Description

2.01 The modulator circuit accepts a 12-channel 148- to 196-kc signal from a combining multiple at the output of the channelizing equipment. This signal is amplitude-modulated,

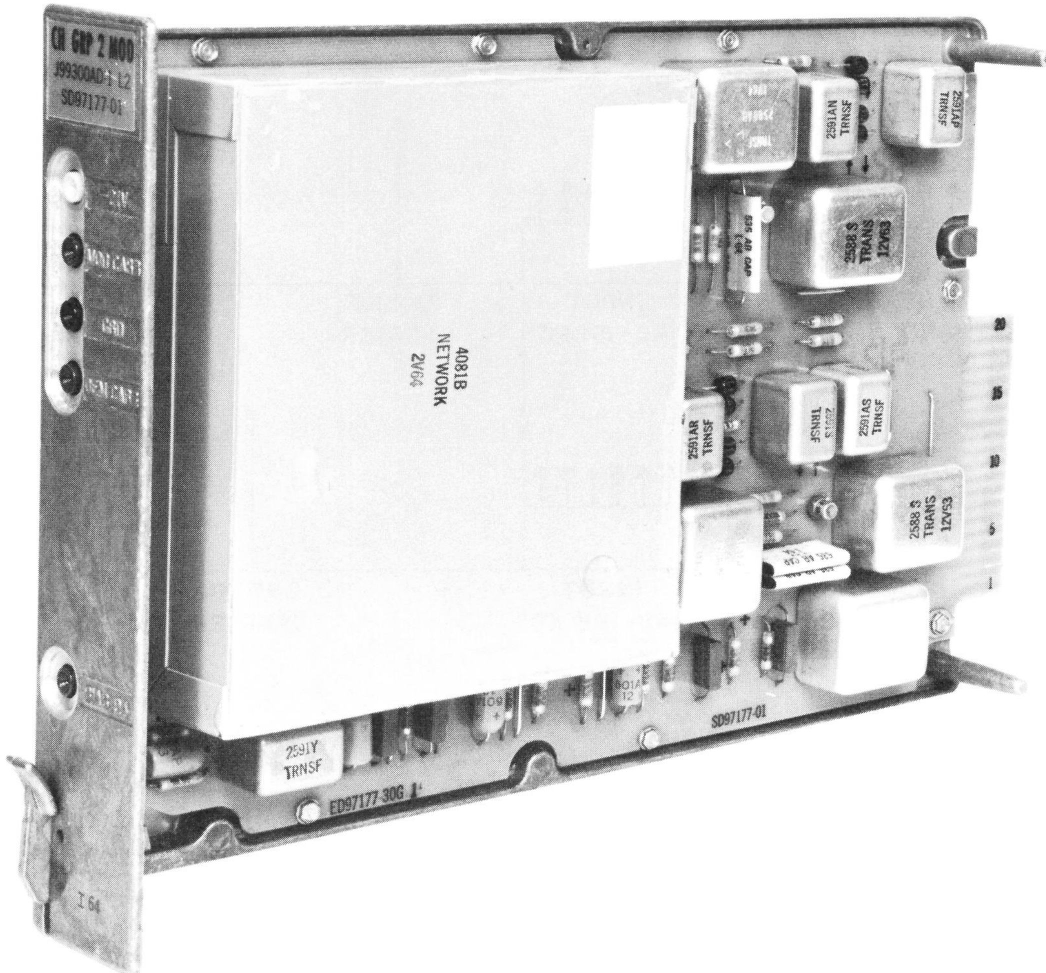

Fig. 3 – Channel Group Modem Unit

using a carrier frequency from a common carrier supply, so that the carrier minus signal (C-S) product at the modulator output falls into one-half of the low-group frequency band. The modulator output signal is then transmitted through a hybrid combining network located on a combining and switching panel to a group transmit circuit. Sufficient discrimination has been provided in subsequent parts of the transmission path against the unwanted modulation products eliminating the need for filtering in the transmitting channel group circuit. The essential components of the modulator circuit are shown in block diagram form in Fig. 4 and in circuit detail in Fig. 5.

B. Modulator

2.02 The modulator used in the N3 channel group modem circuit is a double-balanced switch-type diode modulator. The combined channel frequency signal is applied to the modulator at the primary of transformer T1. The carrier signal which is applied to the center tap of the transformers T1 and T2 controls the switching of the diode quad CR1. The two outside diodes are conducting and the two inside diodes are off for one polarity of the carrier. The diode conditions are reversed for the other polarity of the carrier. The resistor in series with the center taps provides a constant current

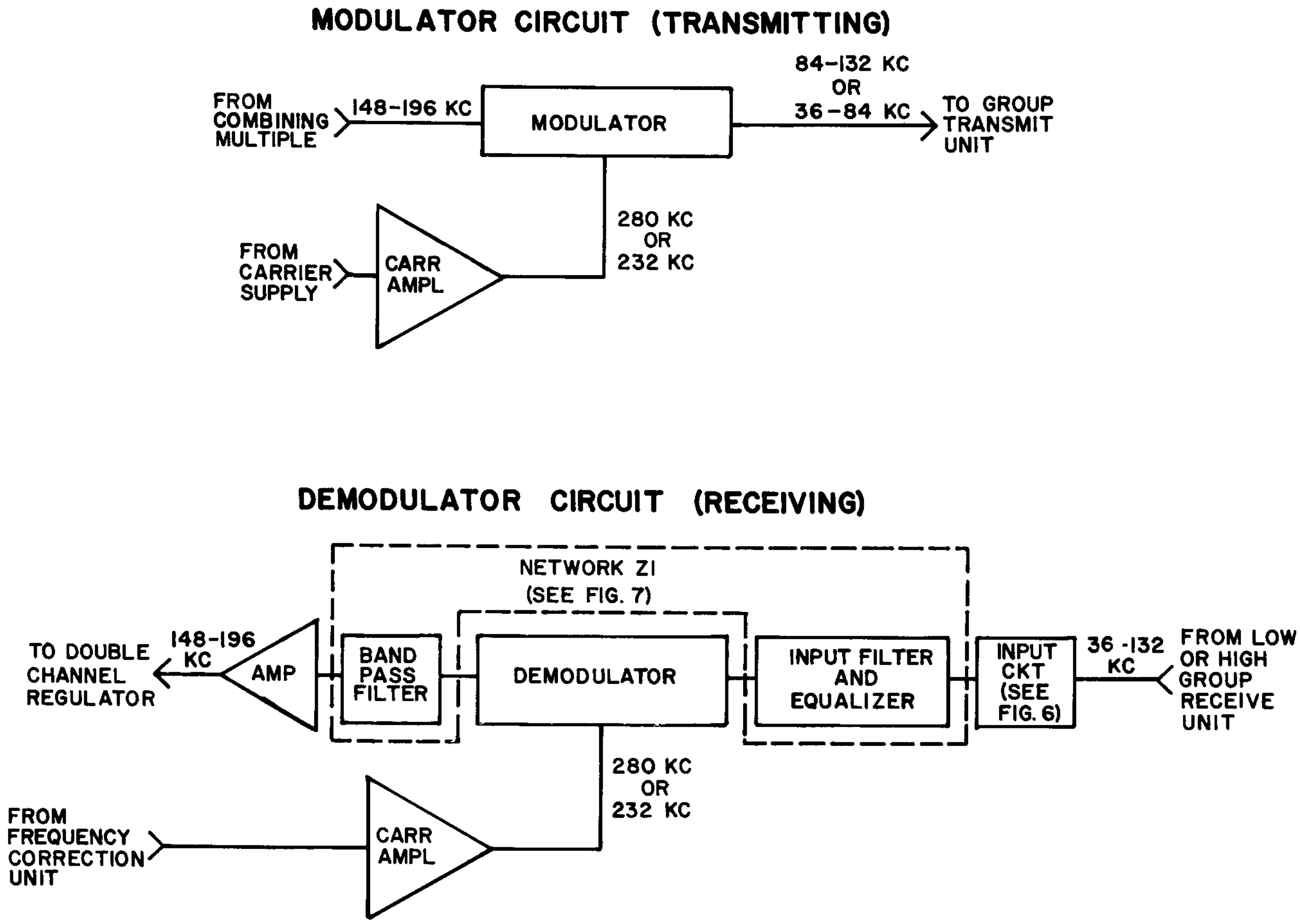

Fig. 4 – Channel Group Modem Unit Block Diagram

source to the modulator and a good impedance load to the carrier amplifier. As the diodes switch with changes in polarity of the carrier, the signal current changes direction through the primary of transformer T2 at twice the carrier frequency. This operation produces sidebands above and below the carrier frequency at the output of the modulator. This output is then fed to the combining network in the combining and switching panel.

C. Carrier-frequency Amplifier

2.03 The carrier signal obtained from the common carrier supply is applied through transformer T3 and a dc blocking capacitor to the base of transistor Q1. This stage is operated with a grounded collector in order to supply the required amount of carrier power to the modulator with a negligible amount of distortion. Transformer T4 ensures good modulation performance by providing the proper output termination. A test point connection to the emitter of transistor Q1 is provided for in-service testing.

3. DEMODULATOR CIRCUIT

A. Circuit Description

3.01 The demodulator circuit is the receiving portion of the N3 channel group modem assembly. As shown in the block diagram of Fig. 4, this circuit includes an input circuit, an equalizer and input filter, a demodulator, an output bandpass filter, an output amplifier, and a carrier amplifier. The input filter, equalizer, and output filter are combined in network Z1.

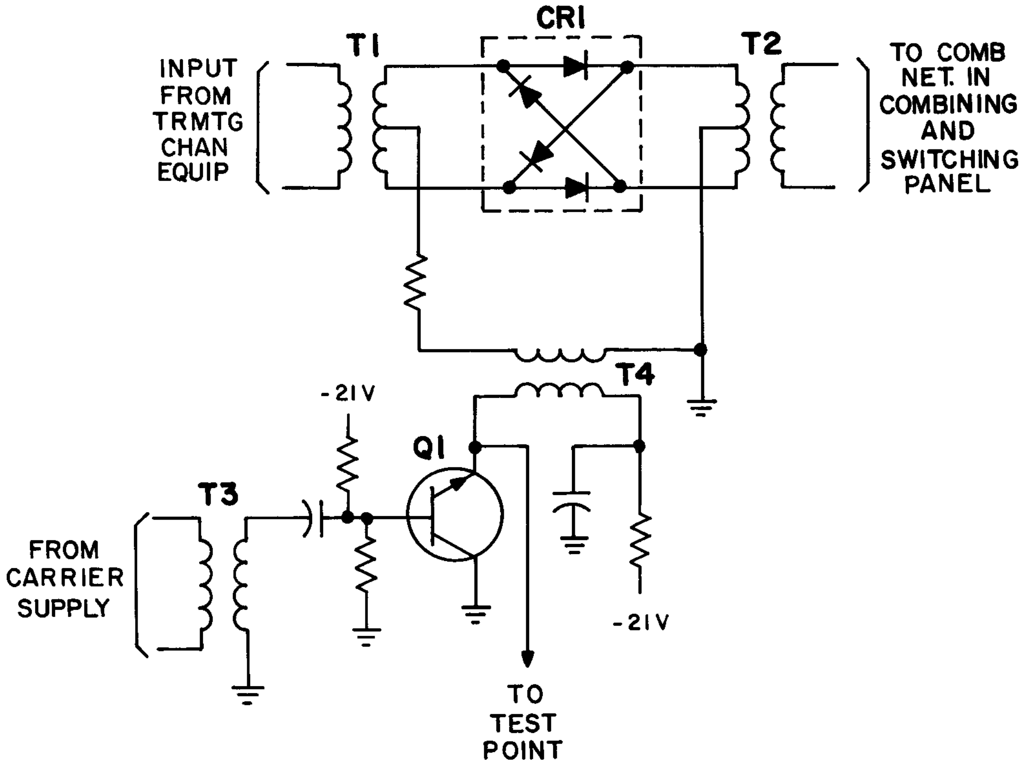

Fig. 5 — Modulator Circuit

The functions of these components have been shown in Fig. 7 and described in general terms in 1.10 and 1.11. The essential relationships can best be described by analyzing the components separately.

B. Input Circuit

3.02 The input circuit consists of a transformer and a resistive pad as shown in Fig. 6. The sole purpose of the transformer is to transform with a minimum amount of power loss the balanced impedance at its input to the unbalanced impedance needed by the input filter and equalizer circuit. Isolation of the input transformer from the input filter and equalizer circuit is accomplished by the resistive pad.

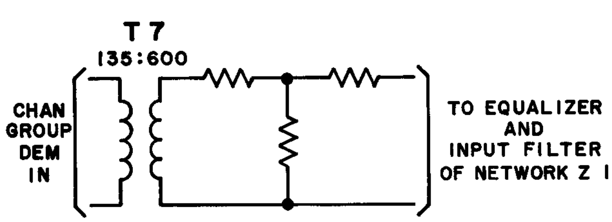

Fig. 6 — Channel Group Demodulator Input Circuit

C. Equalizer and Filters of Network Z1

3.03 Network Z1 is shown in block diagram form in Fig. 7. This network contains a predistortion equalizer, an isolation pad, and an input filter in the input transmission path of the demodulator, and an output bandpass filter in the output transmission path. The characteristics and structure of these components are different in each of the two designs of this network. Network Z1 is a 4081A network when a 280-kc demodulator carrier is used and is a 4081B network when a 232-kc carrier is used.

3.04 The input filter contained in a 4081A network has been designed for a maximum flat passband, with a minimum of inductors by the image design method, whereas, the input filter in network 4081B is a self-equalized low-pass image design filter designed for minimum delay distortion. The predistortion equalizers for both networks are shunt type designed to correct for amplitude distortion that is generated in components of the channel group modem. Frequency characteristics of both input filters with their predistortion equalizers are shown in Fig. 8.

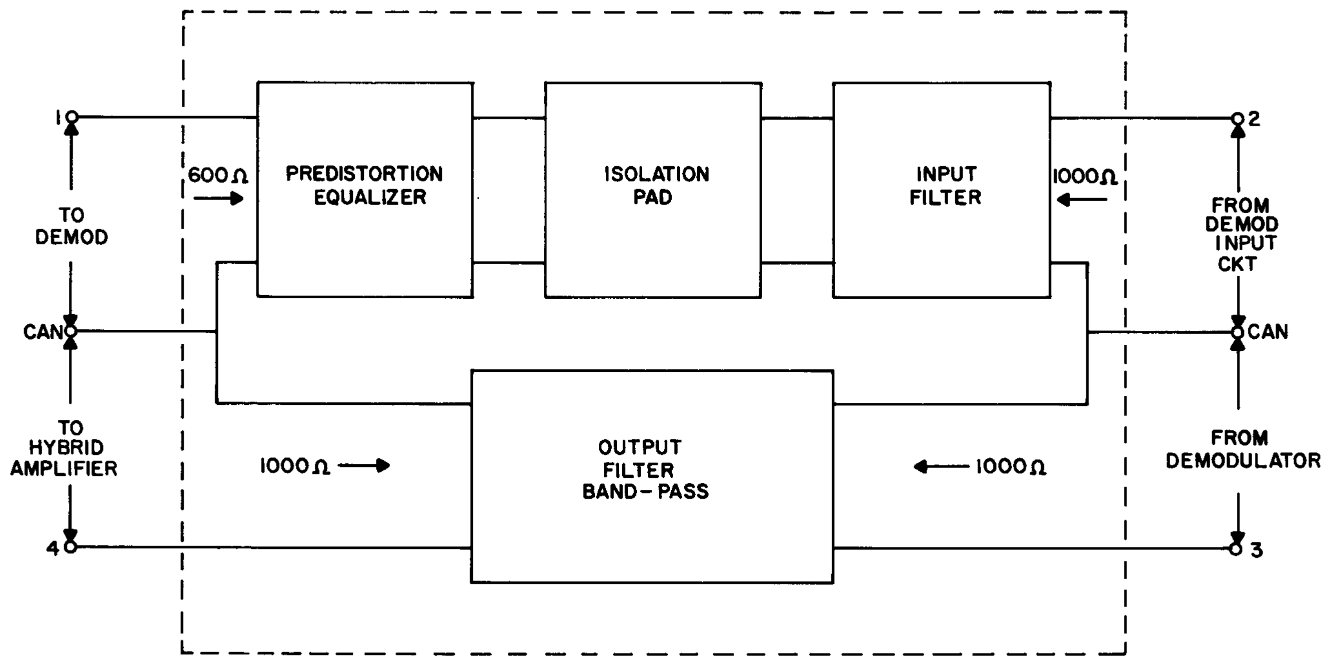

Fig. 7 — Network Z1

3.05 The output filter for network 4081A is a minimum inductance, bandpass filter with all loss peaks in the upper stop band, whereas, in the 4081B network the filter is an image design bandpass filter designed for an optimum return loss and minimum delay distortion. The frequency characteristics of both output filters are shown in Fig. 9.

3.06 Fig. 10 shows the schematic diagrams of both the 4081A and 4081B networks.

D. Demodulator and Carrier Amplifier

3.07 The channel group demodulator shown in Fig. 11 contains a resistive pad at both its input and output to provide for a good impedance match between the demodulator and its associated filters. This effectively isolates the demodulator and increases the return loss of the filters. The demodulator, itself, is a double-balanced switch-type diode structure. The switching of diodes CR2 is controlled by a carrier signal which is applied to the center taps of transformers T8 and T9; the two outside diodes are conducting and the two inside diodes are off for one polarity of the carrier. The diode conditions are reversed for the opposite polarity of the carrier. The resistors in series with the center taps provide a constant current source to the demodulator and a good impedance load to the carrier amplifier. The switching of the diodes causes the signal current to reverse its direction of flow through the primary of transformer T9 at a rate twice that of the carrier frequency. This operation creates the desired sidebands above and below the carrier frequency at the output of the demodulator. This demodulator has a high degree of balance to both the input signal and carrier. This ensures that the signal and carrier energy is suppressed to a negligible amount at the secondary of T9.

3.08 A carrier signal from the frequency correction unit is applied to the carrier amplifier through transformer T5. This signal is fed through a dc blocking capacitor to the base of transistor Q2 stage. This stage is operated in a grounded collector configuration in order to supply the required amount of carrier power to the demodulator with a negligible amount of distortion. Transformer T6 ensures that a good modulation performance is obtained by providing the proper output termination. A connection to the emitter of transistor Q2 is provided for in-service testing.

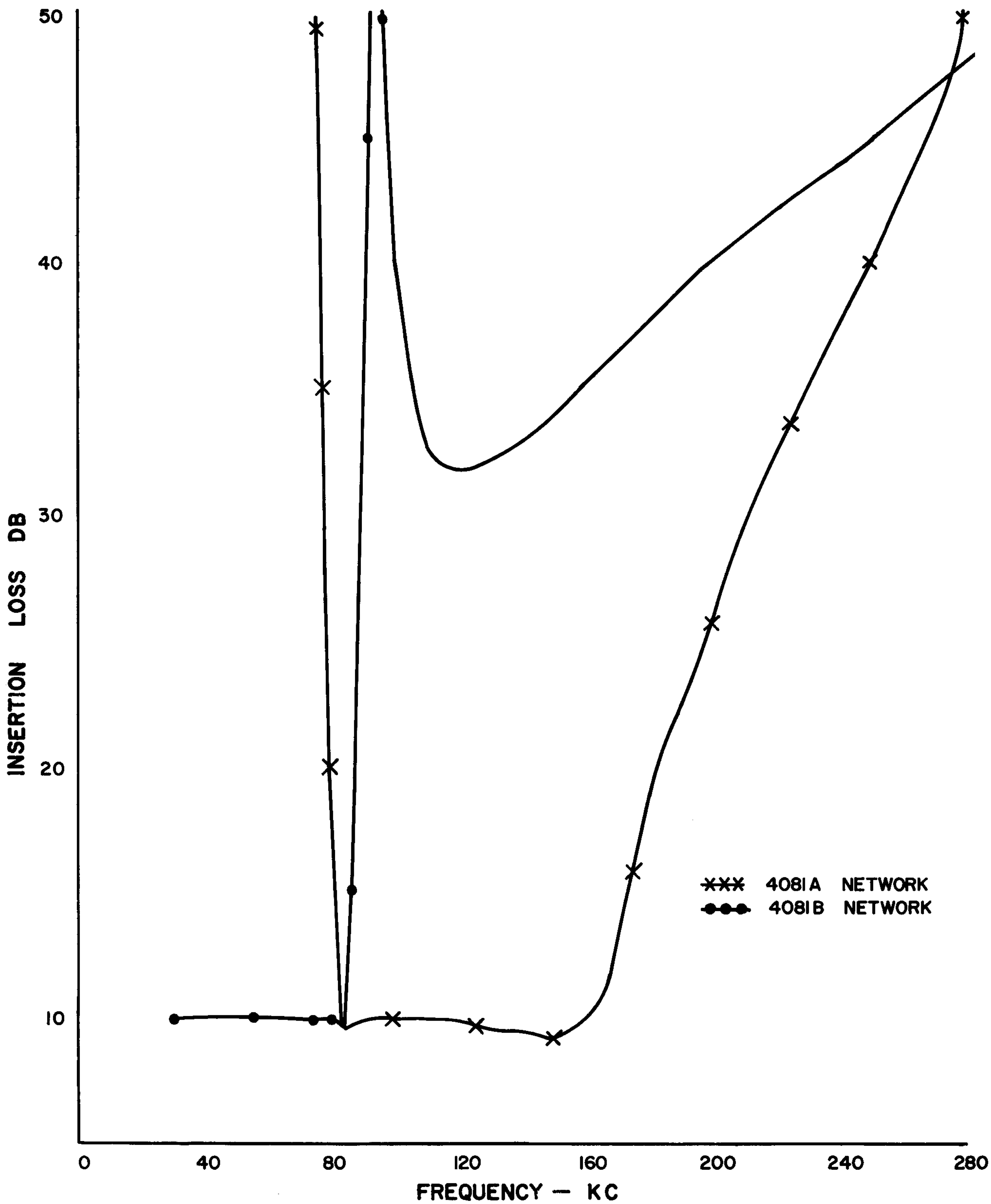

Fig. 8 — Input Filter and Equalizer Frequency Characteristics

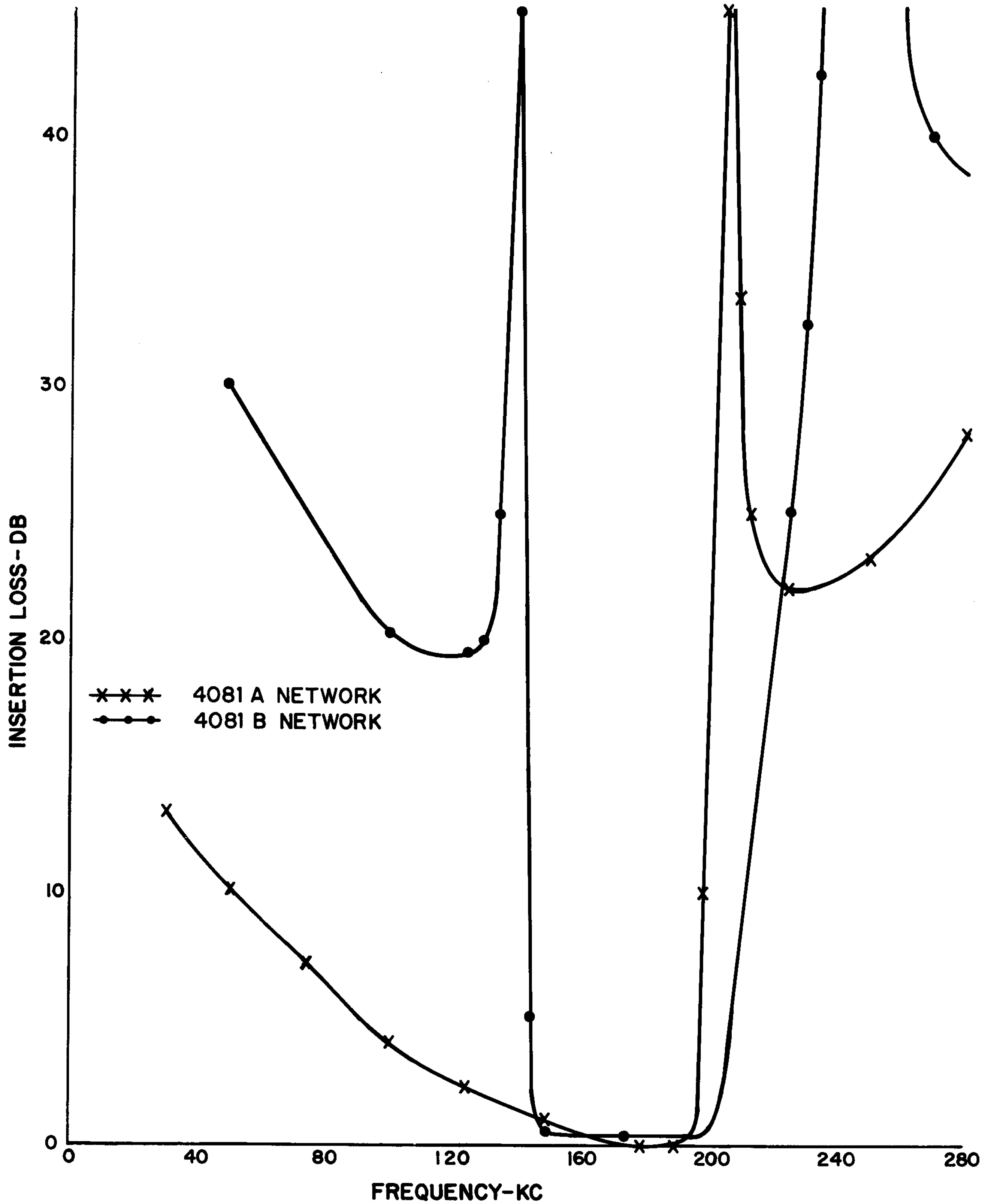

Fig. 9 – Channel Group Demodulator Output Filter Characteristics

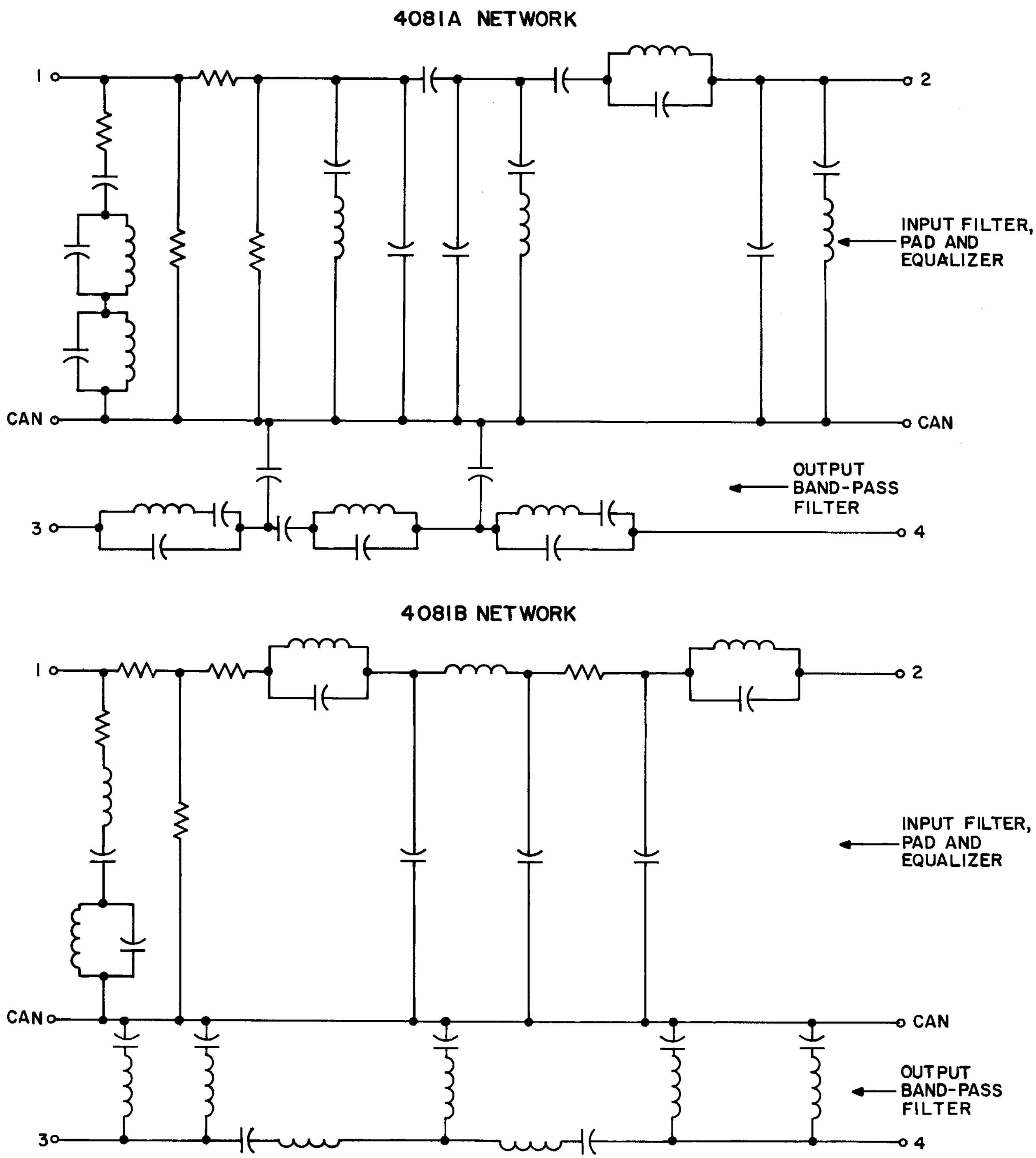

Fig. 10 — Schematic Diagrams of Networks 4081A and B

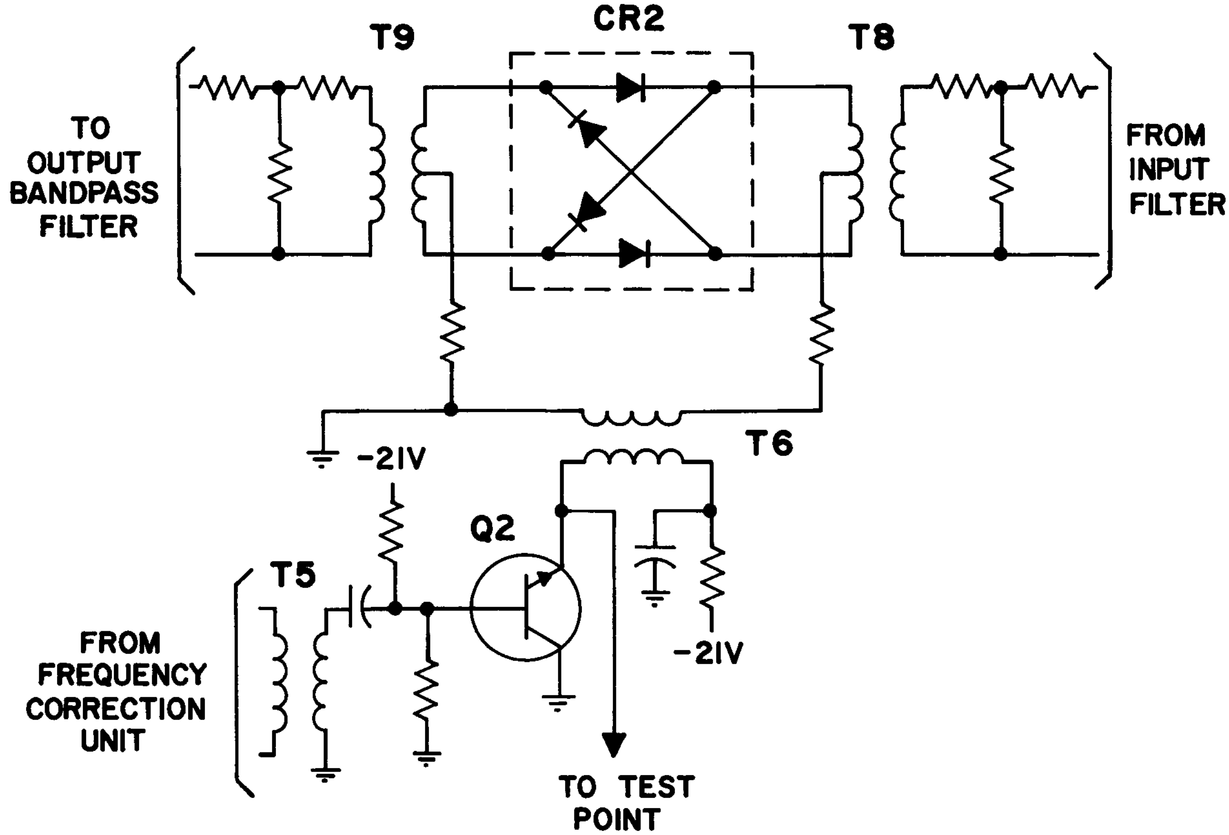

Fig. 11 – Demodulator and Carrier Amplifier

E. Demodulator Amplifer

3.09 The demodulator amplifier shown in Fig. 12 is a two-stage feedback amplifier with hybrid-feedback connections at both the input and output. The two stages employ transistors Q3 and Q4, each being used in a common emitter connection and are direct-coupled to conserve bias current. The input to the amplifier is across the primary of hybrid transformer T10 and is obtained from the bandpass filter which is contained in network Z1. The input impedance of transistor Q3 along with the feedback section of transformer T10 ensures that the 1000 ohms of impedance necessary to properly terminate the filter is obtained. The impedance seen by the first stage looking back into the transformer is about 500 ohms. This value is the optimum generator impedance needed to minimize the noise figure of transistor Q3. The hybrid tap is placed so that the ratio between turns on the secondary is 9:1. This turns ratio ensures that the noise figure of the amplifier will be degraded by less than 0.5 db due to the hybrid connection. It also ensures that variations in impedance seen looking into the feedback network will have little effect on the transmission through the hybrid. Resistor R20 is the input hybrid termination and sets the impedance level seen at the other hybrid terminal. Resistor R24 ensures that the feedback network is well matched to the hybrid.

3.10 The amplifier output is obtained across the secondary of hybrid transformer T11. The hybrid connection of transformer T11 ensures that a good match is obtained between the output impedance of the amplifier and the 22.5-ohm line impedance. The impedance seen by the last transistor Q4 stage is 825 ohms. The hybrid tap ratio is 9:1, which is chosen to minimize the output power dissipated in the feedback circuit. Resistor R30 is the output hybrid termination and sets the impedance level seen at the other hybrid terminal.

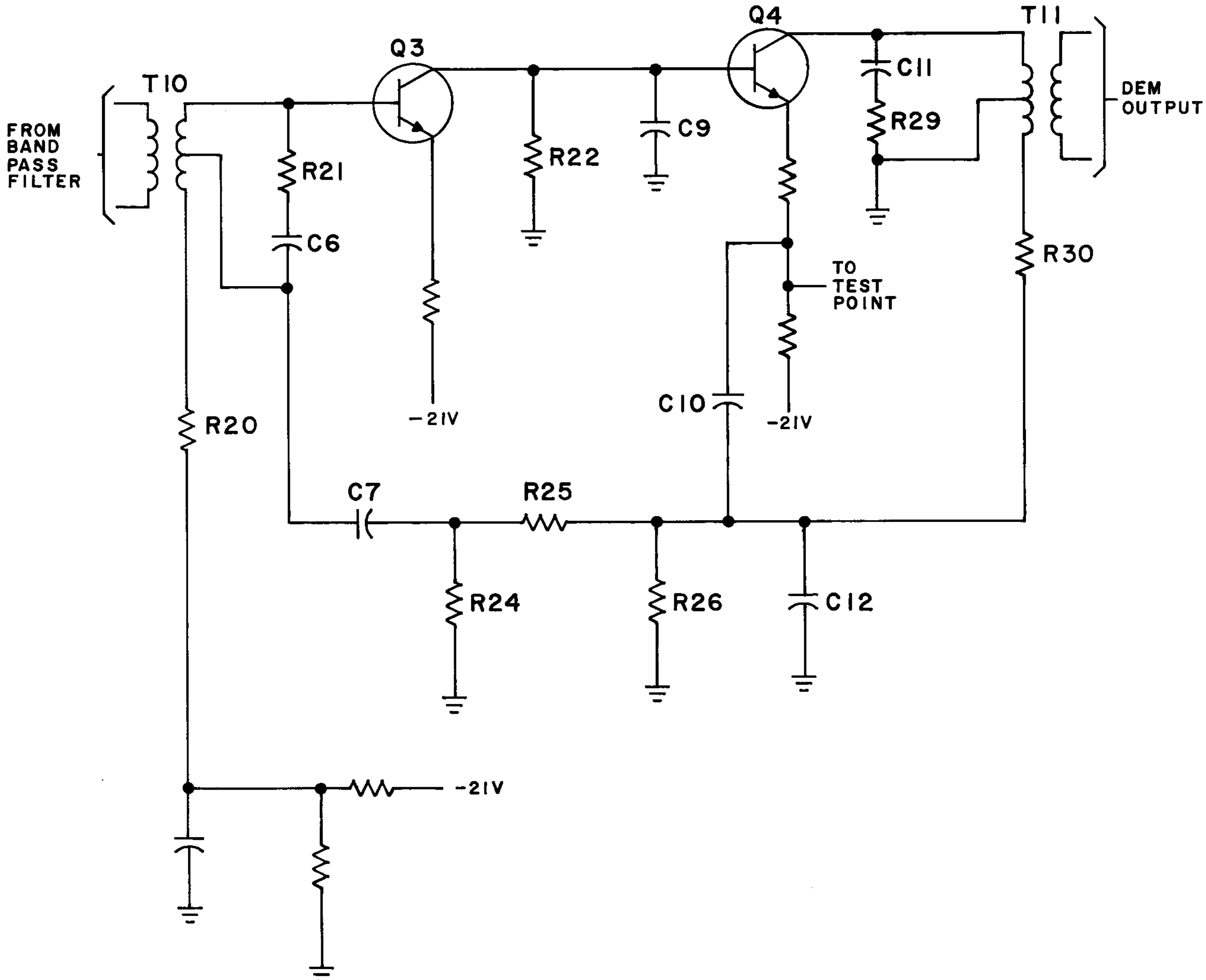

Fig. 12 — Demodulator Amplifier

3.11 Low-frequency stabilization of the feedback loop involves the two emitter bypass capacitors and dc blocking capacitor C7. High-frequency stabilization is accomplished by the input stage network components R21 and C6, interstage capacitor C9, output stage network components R29 and C11, and feedback capacitor C12 which bypasses the output hybrid transformer at high frequencies. Resistors R24, R25, and R26 set the desired amount of in-band feedback, thus controlling the amplifier gain.

4. TESTING AND MAINTENANCE FEATURES

A. Terminal Assignment

4.01 In the N3 carrier channel group modem unit all connecting wiring to and from the terminal is made through a 20-contact plug at the rear of the unit. The plug terminal assignments are as shown in the following table:

PIN	ASSIGNMENT
1	Frame Ground
2	No Connection
3 and 4	Demodulator Output
5	Demodulator Carrier Amplifier Test
6 and 7	Demodulator Carrier Input
8	No Connection
9 and 10	Demodulator Signal Input
11	−21 Volts

PIN	ASSIGNMENT (Cont)
12	Demodulator Carrier Leak Test
13	Circuit Ground
14	No Connection
15 and 16	Modulator Carrier Input
17 and 18	Modulator Output
19 and 20	Modulator Signal Input

B. Test Points

4.02 In order to facilitate the in-service detection of component variations in either the modulator or demodulator circuits, test points are provided. These test points consist of five jacks located on the front panel. The GRD jack J2 is connected to circuit ground, and its companion −21V jack J5 is connected to the −21V supply. The modulator and demodulator +10 dbm carrier levels can be monitored respectively by MOD CARR jack J1 and DEMOD CARR jack J3. The BIAS Q4 jack J4 supplies a test point for measuring the emitter voltage on transistor Q4. This effectively measures the emitter current of this transistor. Any change in emitter current indicates a current gain or biasing component change.

C. Trouble Clearing

4.03 If it is found that a trouble arises in a channel group modem, the trouble will be cleared by removing the unit and replacing it with a spare.

5. TRANSMISSION PERFORMANCE

A. Frequency Characteristics

5.01 Fig. 13 shows typical transmission frequency characteristics of a channel group modulator and demodulator connected in tandem when the demodulator is equipped with either the 4081A or 4081B network.

6. DRAWINGS

6.01 The following schematic and equipment drawings show detailed information.

TITLE	NUMBER
Channel Group Modem Circuit	SD-97177-01
Channel Group Modem Unit	J99300AD

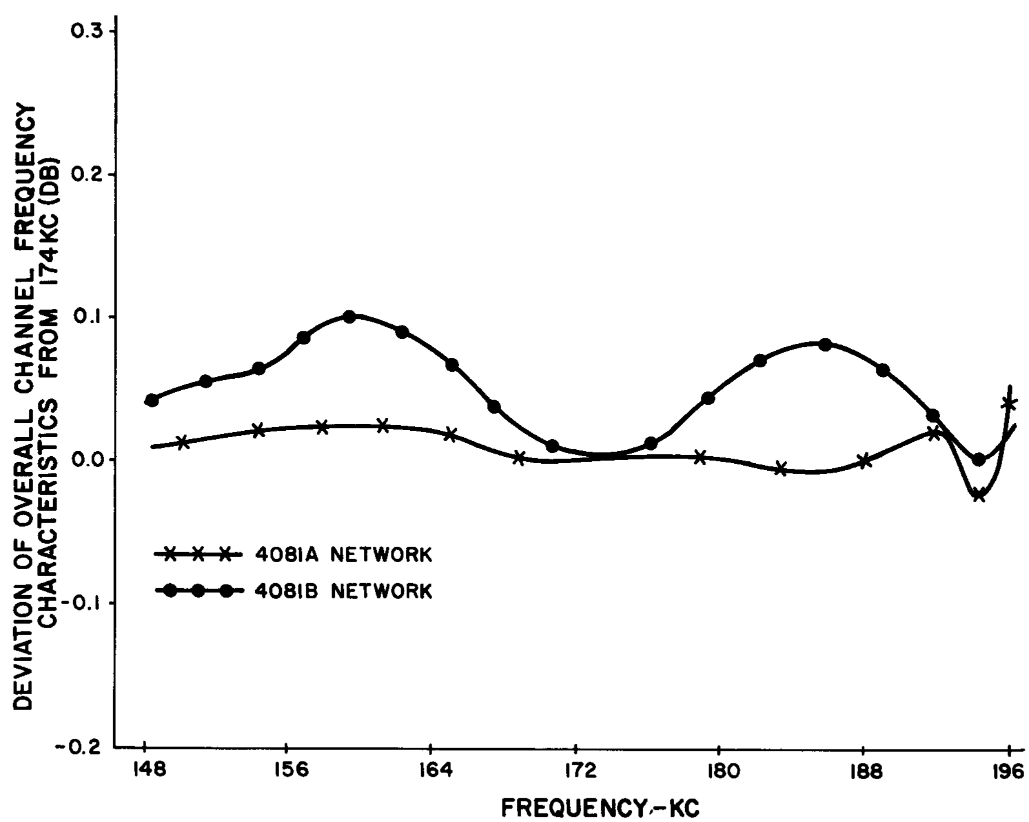

Fig. 13 – Frequency Characteristics of Channel Group Modulator and Demodulator in Tandem