TYPE N3 CARRIER TELEPHONE SYSTEM
GROUP TRANSMITTER AND RECEIVER UNITS
DESCRIPTION

CONTENTS

1. GENERAL

1.01 This section describes the group transmitter and group receiver units used in the N3 carrier telephone system. The group equipment transmits and receives 12 carriers and 24 channels in either the low-group (36 to 132 kc) or the high-group (172 to 268 kc) range. The transmitted carrier frequencies and their designations for the high group and low group are given in Table A. Modulating one group with 304 kc and choosing the lower sideband will produce the other group.

1.02 The N3 channel group equipment transmits low-group frequencies to the group transmitter and receives low-group frequencies from the group receiver. In order to transmit the high group to the cable pair, the group transmitter unit must convert low-group frequencies to high-group frequencies by modulating them with 304 kc and choosing the lower sideband. Similarly, in order to receive the high group from the cable pair, the group receiver unit must convert the high-group frequencies to low-group frequencies by modulating them with 304 kc and choosing the lower sideband.

1.03 The terminal group equipment consists of a group transmitter unit and an associated group receiver unit. These units provide the desired frequency conversion and amplification for a group of 12 carriers and 24 sidebands, between the channel group units and the cable pairs, in both the transmitting and receiving directions.

1.04 There are four types of group units:

(a) The high-group transmitter unit

(b) The low-group transmitter unit

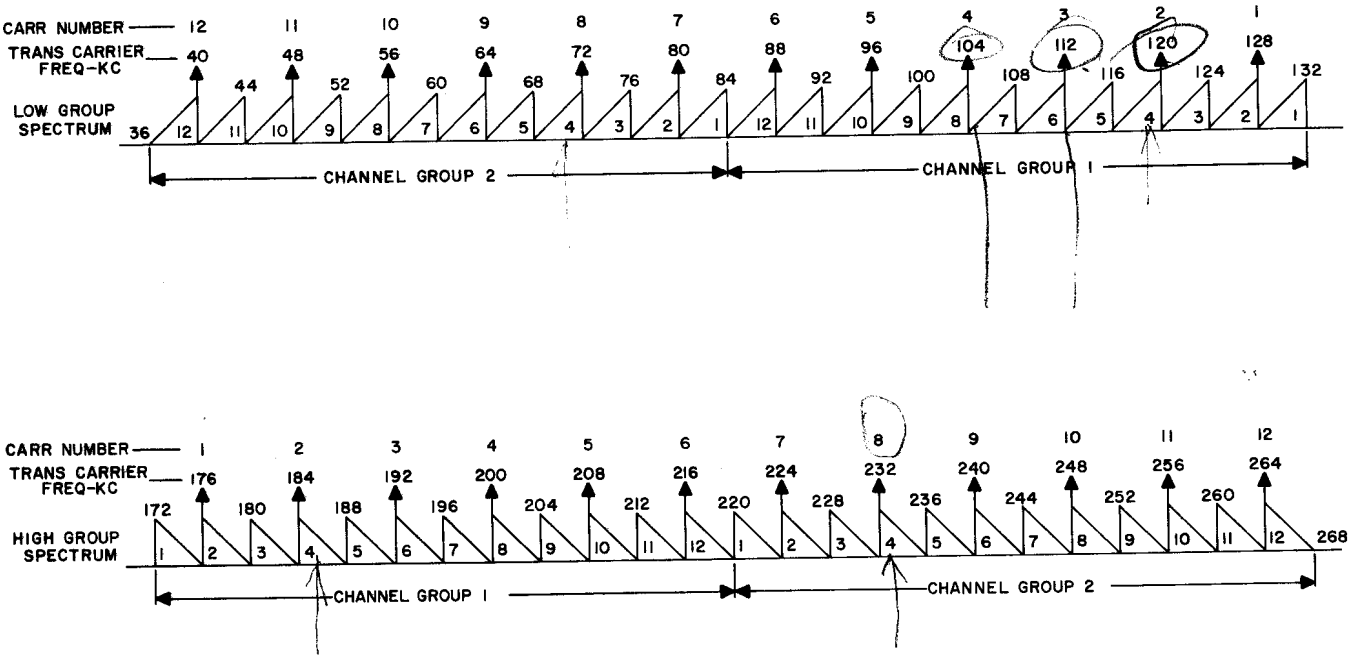
(c) The high-group receiver unit

(d) The low-group receiver unit

1.05 A terminal which transmits the high-group frequencies must receive the low group. Therefore, a terminal which transmits the high group will contain one high-group transmitter unit and one low-group receiver unit. Similarly, a terminal which transmits the low group will contain one low-group transmitter unit and one high-group receiver unit.

1.06 The transmitted signal from an N3 message terminal is composed of 12 carriers and 24 sidebands. The output of each 12-channel

TABLE A



group consists of 6 carriers and 12 sidebands, and the two 12-channel groups are combined in the combining and switching unit to form the signal sent to the group transmitter unit. The 6 carriers in each channel group are generated in the common carrier supply bay. The high-group transmitter unit filters out unwanted frequencies, converts the signal to the high-group frequency range, and amplifies the signal to the proper level for transmission to a cable pair. The low-group transmitter unit filters out unwanted frequencies and amplifies the signal to the proper level for transmission to a cable pair. The signal is transmitted to the cable through the line-terminating unit.

1.07 The group transmitter unit contains a slope equalizer. This equalizer allows the transmitted signal to be pre-equalized to partially compensate for the cable-loss characteristic. The seven equalizers, one of which is used in each group unit, provide a range of group unit output slopes of 0, ±3, ±6, or ±9 db for carrier 12 relative to carrier 1.

1.08 A signal received from the cable enters the terminal through the line-terminating unit. Here the power is adjusted by the receiving span pads. The high-group receiver unit filters out unwanted frequencies, converts the signal to the low-group frequency range, and amplifies and regulates the signal to the proper output power. The low-group receiver unit filters out unwanted frequencies and amplifies and regulates the signal to the proper output power. The signal is then transmitted through a splitting pad to the channel group equipment.

1.09 The group receiver contains one of seven slope equalizers, as described above, and a switch which selects added slope equalization of +1, 0, or −1 db. It is possible to adjust the output slope to zero, within 0.5 db, by the proper choice of the slope equalizer and slope selector switch.

1.10 The group receiver is provided with automatic gain regulation which keeps its total output power nearly constant even though the input power varies due to the effects on cable loss caused by changes in temperature.

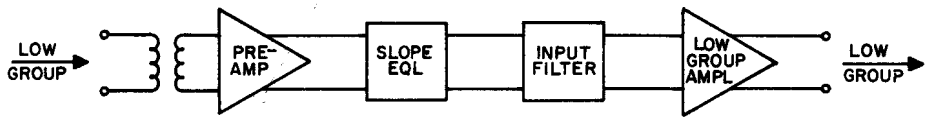
1.11 Transmitter and receiver group units are protected from transverse voltage surges on the line by lightning-protection diodes in the line terminating unit.

1.12 The external connections of the group units are made through a plug which is an extension of the printed wiring board. The plug connects with a mating jack in the terminal mounting.

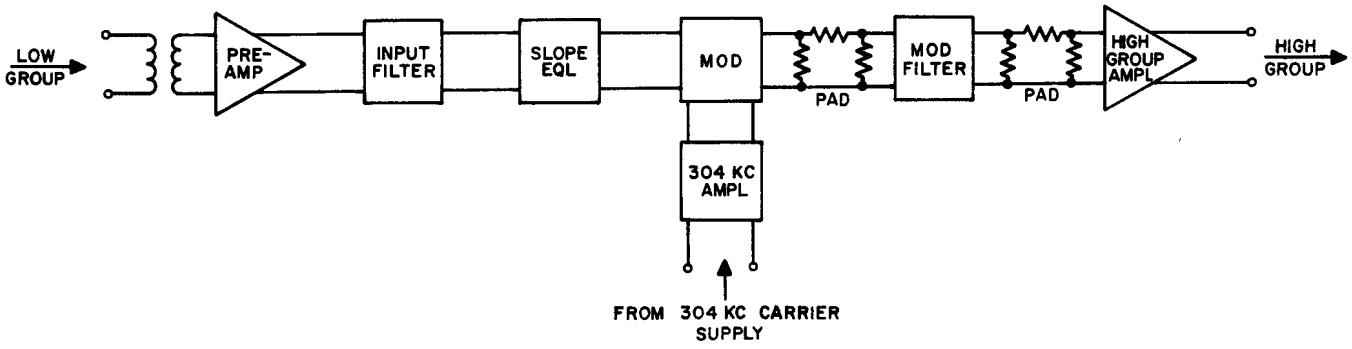
The connections include signal input and output, 304-kc carrier, −21 volt power, circuit ground, and chassis ground.

2. CIRCUITS

2.01 Block diagrams of the four group units are shown in Fig. 1 and 2. In block form, they appear quite similar and actually many of the component blocks are identical. The two transmitting units have amplifiers which are identical in form but differ because they handle different frequency ranges and have different output powers. The output amplifiers in the two receiving units are identical except for the gain strapping resistors. All the group units use the same slope equalizers. The high-group transmitter and receiver have the same modulator and carrier amplifier.

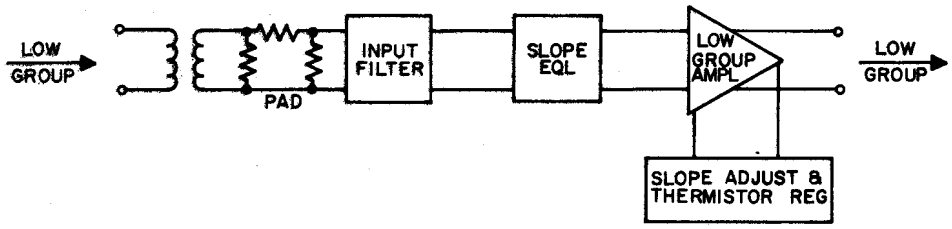


LOW GROUP TRANSMITTER

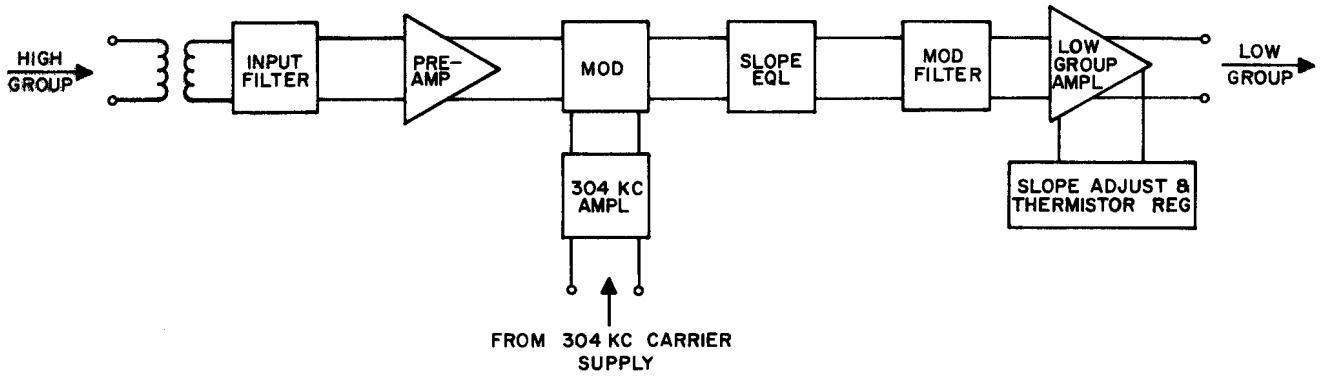


HIGH GROUP TRANSMITTER

Fig. 1 – Block Diagrams of Transmitter Group Units



LOW GROUP RECEIVER



HIGH GROUP RECEIVER

Fig. 2 – Block Diagrams of Receiver Group Units

A. Input Filters

2.02 Low-pass filters are used in both group transmitter units to transmit the low-group frequencies and to attenuate channel group carrier frequencies, input signal leak, and image frequencies from the channel group. In the low-group transmitter unit, the low-pass filter is the only filter. In the high-group transmitter unit, the low-pass filter is at the input to the modulator. The measured responses of these filters are shown in Fig. 3 and 4. The nominal input and output impedance of the filter is 1000 ohms.

2.03 The input filters in the group receiver units select the desired frequency group and reject other group frequencies that are not fully attenuated in the last repeater and that may be present due to cable crosstalk. The band-pass filter in the high-group receiver unit passes the high group and provides at least 33 db of attenuation to low-group frequencies and frequencies above the high group. The low-pass filter in the low-group receiver unit passes the low group and provides at least 25 db of attenuation to the high group and higher frequencies. The

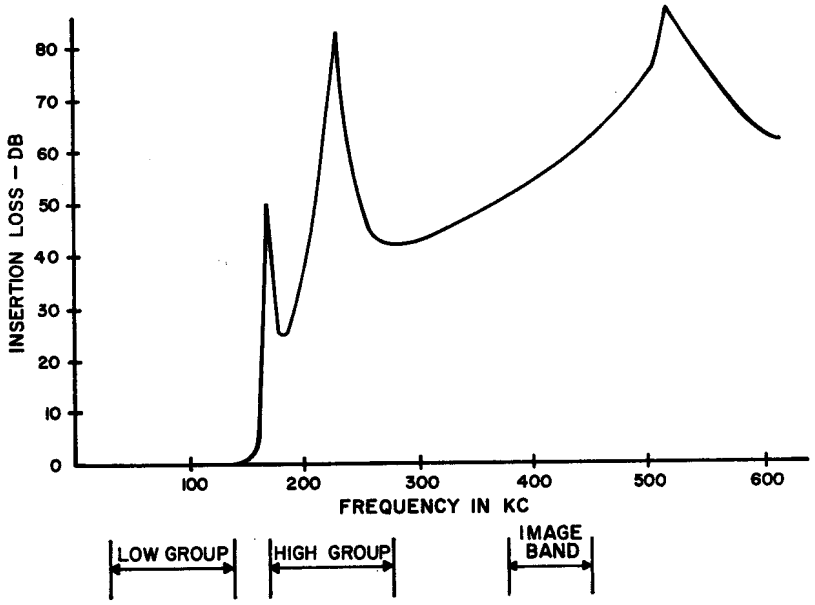


Fig. 3 – Insertion Loss Characteristic High-group Transmitter Input Filter

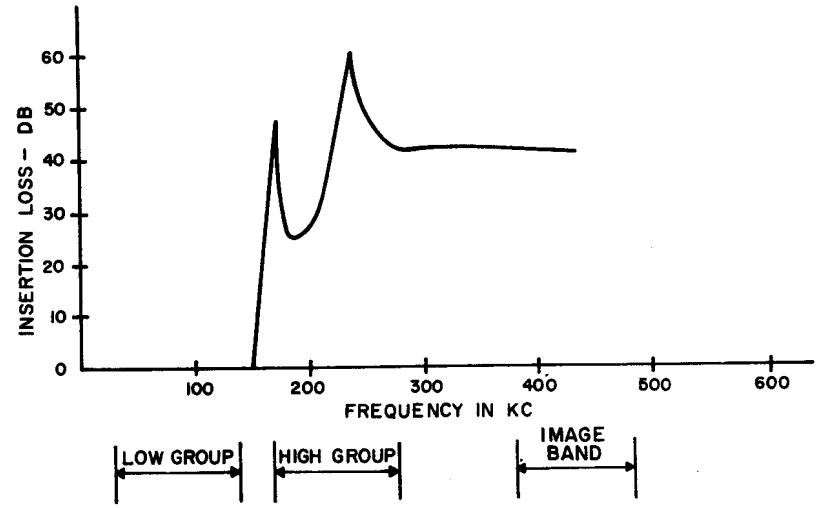


Fig. 4 – Insertion Loss Characteristic of the Low-group Transmitter Input Filter

measured responses of these filters are shown in Fig. 5 and 6, respectively. The nominal input and output impedance of the filters is 1000 ohms.

B. Group Modulator

2.04 The group modulator is used in both the high-group transmitter and high-group receiver units. It converts one frequency group to the other by modulating the group with a 304-kc carrier. The modulator is followed by a filter to select the lower sideband (below 304 kc). The high-group transmitter unit receives signals in the low-group frequency range from the channel group equipment and translates the signals to the high group for transmission on the cable. The high-group receiver unit receives signals in

the high-group frequency range from the cable and converts them to the low group for transmission to the channel group equipment.

2.05 A simplified schematic of the modulator, together with the carrier amplifier, is shown in Fig. 7. The modulator is of the double-balanced type (input signal and carrier are both balanced with respect to the output and do not appear in the output). It consists of four matched diffused silicon diodes connected between two transformers. The modulator action may be considered to be that of a double-pole double-throw switch inserted in the signal path between the input and output transformers, activated by the plus and minus voltages of the carrier. When the carrier voltage is positive on the right and negative on the left side (Fig. 7), carrier current flows through the two outer diodes and their impedance is made low. A signal present at the input will then flow directly through the modulator to the output trans-

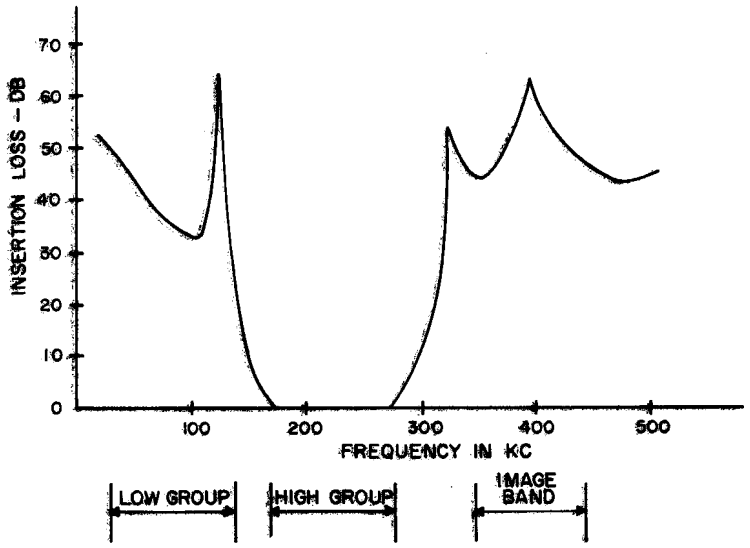


Fig. 5 – Insertion Loss Characteristic High-group Receiver Input Filter

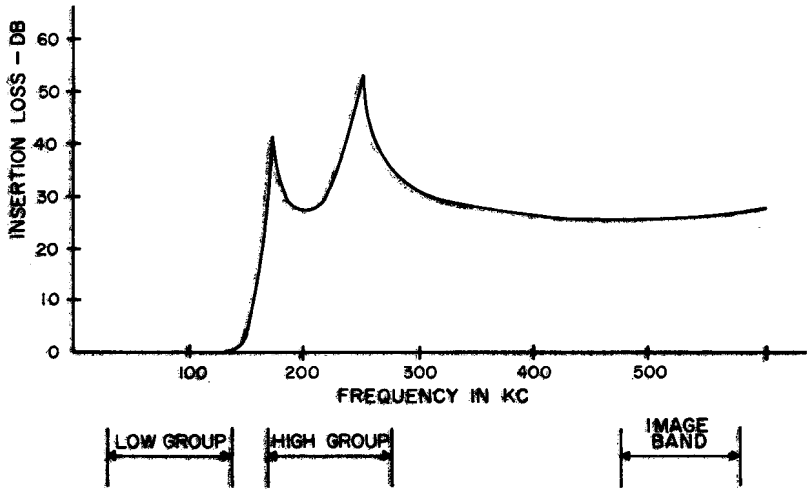


Fig. 6 – Insertion Loss Characteristic Low-group Receiver Input Filter

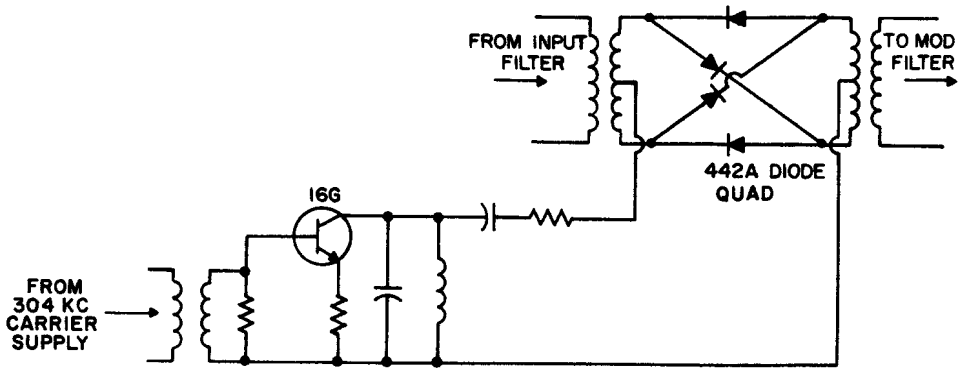


Fig. 7 – Schematic of Modulator and Carrier Amplifier

former. During the next half-cycle of carrier the carrier polarity is reversed and the carrier current flows through the inner diodes, making their impedance low. This action reverses the path for signal voltages from the input to the output transformer at a 304-kc rate.

2.06 The output of the group modulator consists principally of first order modulation products, input signal leakage, and 304-kc carrier leakage. The last two items are due to imperfect balance of the diodes and transformers. The desired signal is the lower sideband. The upper sideband or image band contains as much power as the desired lower sideband and must be rejected by the modulator output filters. The modulator output frequencies for the high-group transmitter and high-group receiver units are shown in Table B.

TABLE B — MODULATOR OUTPUT FREQUENCIES

ITEM	HIGH-GROUP TRANSMITTER	HIGH-GROUP RECEIVER
	kc	kc
Desired Output	High Group 172 to 268	Low Group 36 to 132
Input Leakage	Low Group 36 to 132	High Group 172 to 268
Image Band	340 to 436	476 to 572
Carrier Leakage	304	304

C. Modulator Filters

2.07 The modulator filters must pass the desired lower sideband produced by the modulator and reject all other unwanted modulation products, especially the image band. It must also attenuate the modulator input frequencies and 304-kc carrier leakage. The high-group transmitter unit bandpass filter passes the high group and provides at least 40 db of attenuation to all unwanted frequencies. The high-group receiver unit low-pass filter passes the low group and provides at least 50 db of attenuation to all unwanted frequencies. The measured responses of the filters are shown in Fig. 8 and 9, respectively. The nominal input and output impedance of the filters is 1000 ohms.

D. 304-kc Carrier Amplifier

2.08 A schematic of the 304-kc carrier amplifier is shown in Fig. 7. The amplifier is necessary in order to obtain sufficient carrier power and to shield the carrier supply from the nonlinear modulator load to prevent intersystem crosstalk via the 304-kc supply.

E. Preamplifier

2.09 A single stage preamplifier is used in the low-group transmitter, high-group transmitter, and high-group receiver in order to increase the signal level at the input to the 3-stage output amplifier.

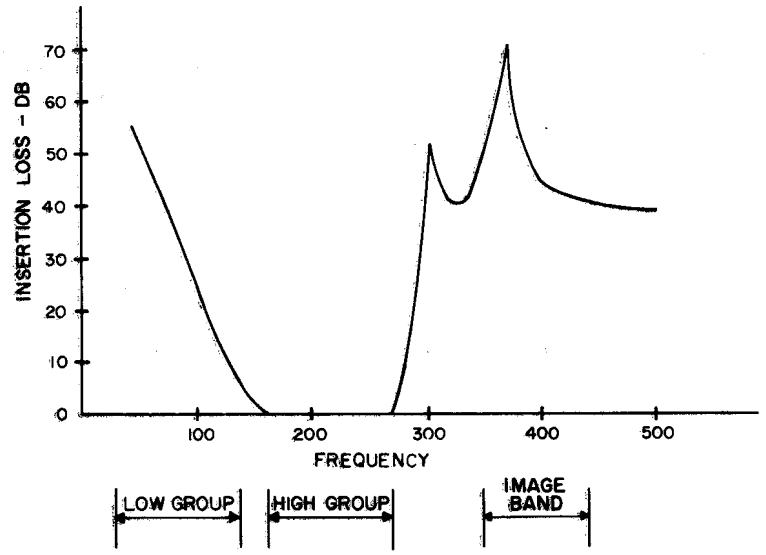


Fig. 8 – Insertion Loss Characteristic of the High-group Transmitter Modulator Output Filter

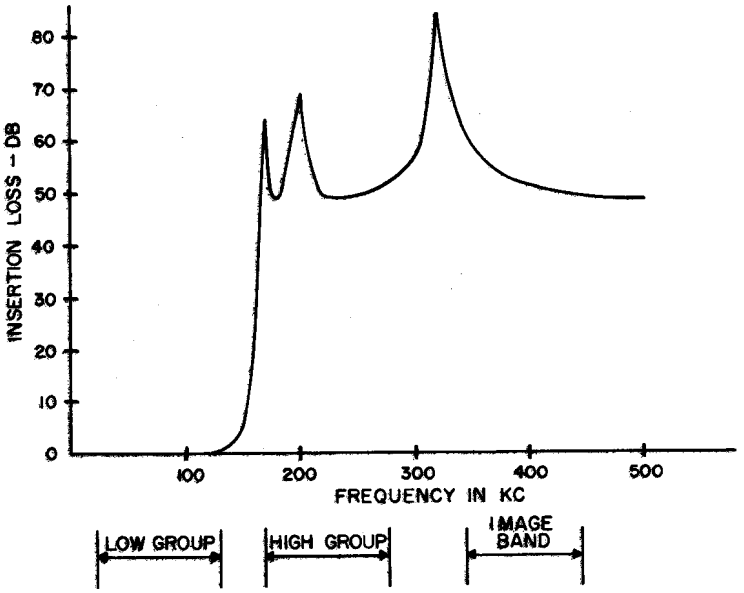


Fig. 9 – Insertion Loss Characteristic of the High-group Receiver Modulator Output Filter

F. Slope Equalizer

2.10 A slope equalizer is used in both the group transmitter and receiver units to partially compensate for slope in the cable loss characteristic. The equalizer, which is held in place by five screws, is accessible when the group unit is removed from the bay. Seven different equalizers are available producing slopes of −9, −6, −3, 0, +3, +6, and +9 db for carrier 12 relative to carrier 1. All seven equalizers operate at a 1000-ohm impedance level in the low-group frequency band and are compatible with all four group units. In the high-group receiver, the equalizer is located just after the group modulator; in the low-group receiver and high-group transmitter units, it is located just after the input filter; and in the low-group transmitter unit, it is located ahead of the input filter.

2.11 In the group transmitter unit, the slope equalizer is used to adjust the output of the group unit and, thus, pre-emphasize the transmitted signal. The ***output slope*** of the transmitter unit is equal to the ***slope*** of the equalizer used. The flat loss of the equalizers has been adjusted so that the rms loss of a 12-carrier signal is 6 db for all equalizers when used in the transmitter unit. Thus, the total power output of the transmitter is the same no matter which slope equalizer or output slope is chosen (i.e., +12.0 dbm for high-group transmitter and +3.0 dbm for low-group transmitter).

2.12 In the group receiver units, by a correct choice of a slope equalizer and adjustment of the screw-type slope adjust switch, the output slope can be adjusted to within ±0.5 db of zero (see 2.21). The same slope equalizers are used in group transmitters and group receiver units. Five layout computations are based on the loss and gain at carrier 2 frequencies. The carrier 2 loss is different for the several equalizers; however, this difference is accounted for in the computation method used to choose the proper span pad. The slope equalizer codes and losses are shown in Table C.

G. Amplifiers — General

2.13 The amplifiers in the four group units are quite similar. The 3-stage transistor amplifiers in the group transmitter units employ hybrid feedback at both the input and output.

TABLE C

SLOPE EQUALIZER CODE	NOMINAL GAIN SLOPE	INSERTION LOSS	
	CARRIER 12 RELATIVE TO CARRIER 1	CARRIER 1	CARRIER 12
	db	db	db
377A	−9	2.0	11.0
377B	−6	3.0	9.0
377C	−3	4.2	7.2
377D	0	6.0	6.0
377E	+3	7.2	4.2
377F	+6	9.0	3.0
377G	+9	11.0	2.0

The 3-stage transistor amplifiers in the group receiver units use hybrid feedback at the input and shunt feedback at the output. The input hybrid is used to improve the noise figure.

H. Transmitting Amplifiers

2.14 The amplifiers in the two transmitter units are identical in form. A simplified schematic is shown in Fig. 10. They differ only in the frequency group amplified and the nominal output power. The low-group transmitter must deliver a nominal output power to the cable of +3 dbm and have a peak power handling capacity of +14 dbm. The high-group transmitter must deliver a nominal output power to the cable of +12 dbm and have a peak power handling capacity of +23 dbm.

2.15 The gains of both transmitting amplifiers can be increased 3 db by removing wiring option Y, which increases the resistance in the feedback network. This is required when the group transmitter is used as an alternate group unit in the group switching set. Wiring Y is initially provided on all group transmitters. Wiring straps A1 and A2 provide two 1-db gain adjustment steps in the high-group unit and two 0.5-db steps in the low-group unit. These straps are cut as required as a factory adjustment to compensate for the accumulated manufacturing tolerance variations of all the circuit components.

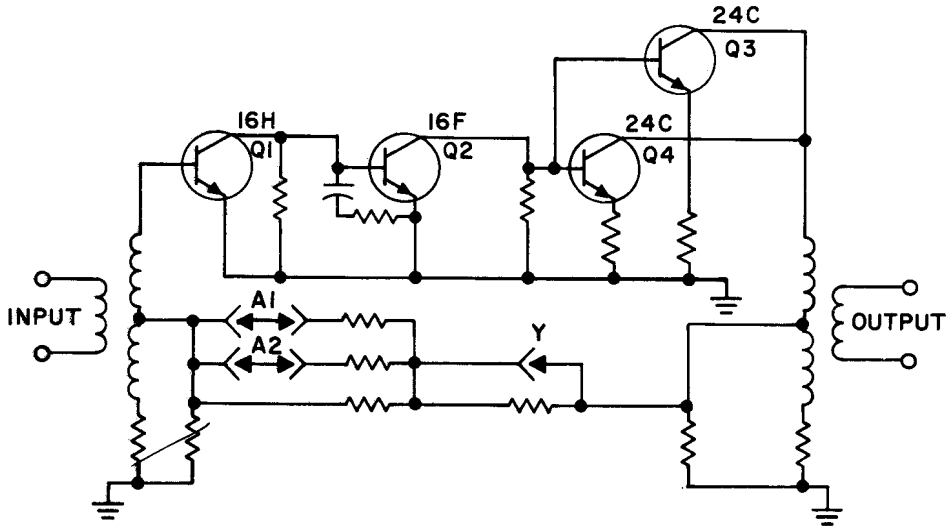


Fig. 10 – Simplified Schematic of Transmitter Amplifier

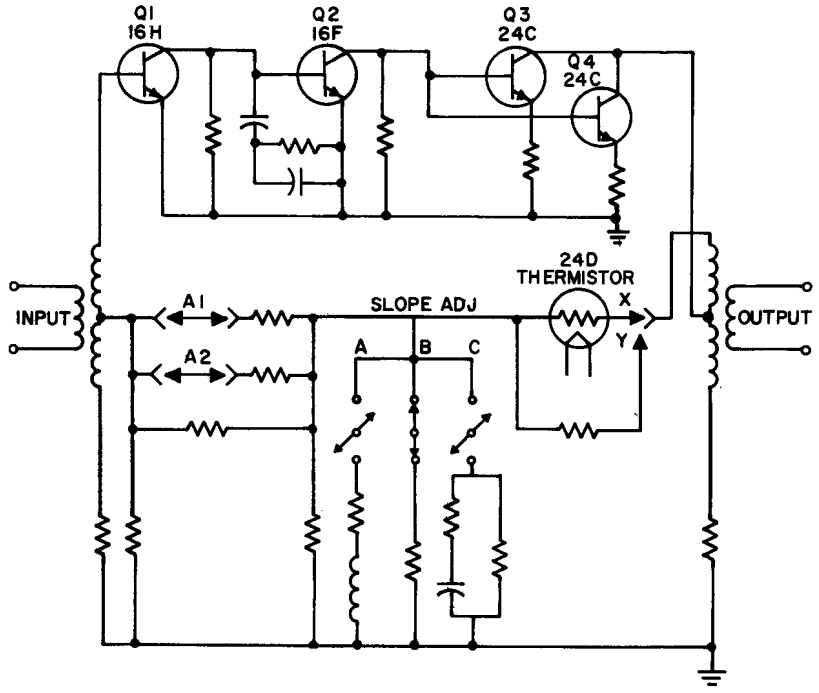


Fig. 11 – Simplified Schematic of Receiver Amplifier

I. Receiving Amplifiers

2.16 The two group receiver units have essentially identical amplifiers. A simplified schematic is shown in Fig. 11. The output of the receiving amplifier is terminated by a splitting network which divides the receiver output for the two channel group demodulators.

2.17 The gain of the amplifier is determined by the loss in the feedback network. The feedback network includes a thermistor regulator which automatically adjusts the amplifier gain to maintain an output power which is almost constant over the operating range of input powers from the line. The output power is

nominally +1.8 dbm and the thermistor holds it to within ±1 db for a change in input level of ±8 db. A typical regulation curve is shown in Fig. 12.

2.18 The thermistor unit consists of a thermistor pellet and an associated ambient temperature control for this pellet. The temperature of the thermistor pellet is determined by the total power at the output of the group unit. The thermistor pellet is a negative temperature coefficient resistance unit. The resistance varies from approximately 3000 ohms to approximately 27,000 ohms. Under abnormal transmission conditions the resistance may vary from a few hundred ohms to upwards of 40,000 ohms. For a receiving unit having nominal gain, the thermistor resistance will be approximately 9000 ohms.

2.19 The thermistor regulator decreases group unit output power 3 to 5 times as fast as it increases it. The relatively slow reaction time of the regulator materially influences field use in that, after any transmission change, a waiting period is required before the circuit will stabilize within the desired measuring accuracy. An increase in input of 2 db requires a wait of approximately 4 minutes for correction to within 0.1 db of the final gain, whereas a decrease in input of 2 db would require a wait of approximately 14 minutes. A cold receiver unit when installed is at high gain and for normal input will have a high output; to obtain stabilization to within 0.25 db of the final output power requires approximately a 20-minute wait. Accuracy within 0.1 db requires a wait of 25 or 30 minutes.

2.20 When a group receiver is used as an alternate group unit in the group switching set or during maintenance tests, a fixed gain without regulation is desired. This condition is obtained by using Y option wiring which inserts a 20,000-ohm resistor in place of the thermistor. With the 20,000-ohm resistor connected in the circuit the gain of the amplifier is increased by approximately 6 db from that provided by the thermistor at its mean operating resistance. This resistor is also used for manufacturing and repair testing. It is normally replaced by the thermistor (X wiring) for field installation. Wiring straps A1 and A2 provide two 0.5-db gain adjustment steps in the low-group receiver unit and two 1-db steps in the high-group receiver unit. These straps are cut as required as a factory adjustment to compensate for the accumulated manufacturing variations of all the circuit components.

2.21 The receiving amplifier contains a screw-type slope switch which provides manual control of its frequency characteristic in order to provide values between the 3-db steps of slope provided by the slope equalizer (see 2.10). The slope adjustment switch SLOPE ADJ has three washer-head screws designated A, B, and C which when turned and tightened (but only one at a time) provide a slope of approximately +1 db, 0 db, or −1 db in gain, respectively. These adjustments are so arranged that for each setting the circuit has the same output power. Thus, a change in slope setting may be made on an operating system without affecting the thermistor regulating action of the group receiver. A small

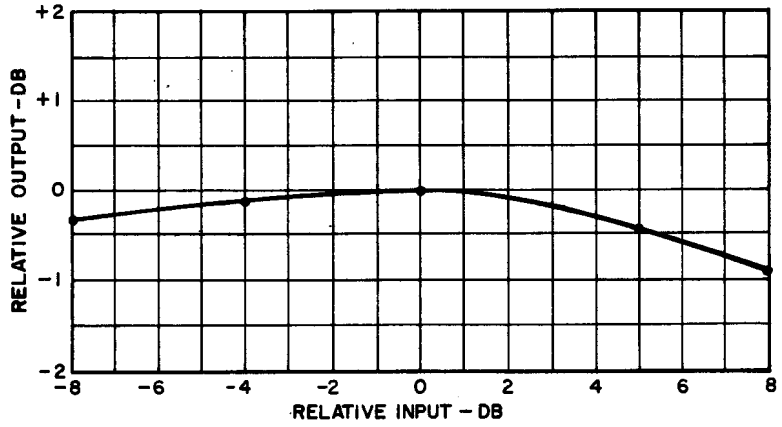


Fig. 12 – Regulation Characteristic of Receiving Amplifier

regulation change transient will be experienced in some channels as a result of double channel regulation action.

3. TRANSMISSION PERFORMANCE

A. Transmitter Units — High Group and Low Group

3.01 The transmitter units receive the combined signals from the combining and switching unit at a level of −53.5 dbm per carrier or −42.7 dbm total carrier power. The measured power gains for the high-group and low-group transmitter units are shown in Fig. 13 and 14, respectively. The total power output of the high-group transmitter unit is +12 dbm. In Fig. 13, the high-group transmitter output is shown with seven slope equalizers inserted in the unit, in turn, yielding output slopes of 0, ±3, ±6, and ±9 db. The total power output of the low-group transmitter unit is +3 dbm. In Fig. 14, the low-group transmitter output is shown with seven slope equalizers inserted in the unit, in turn, yielding output slopes of ±9, ±6, ±3, and 0 db.

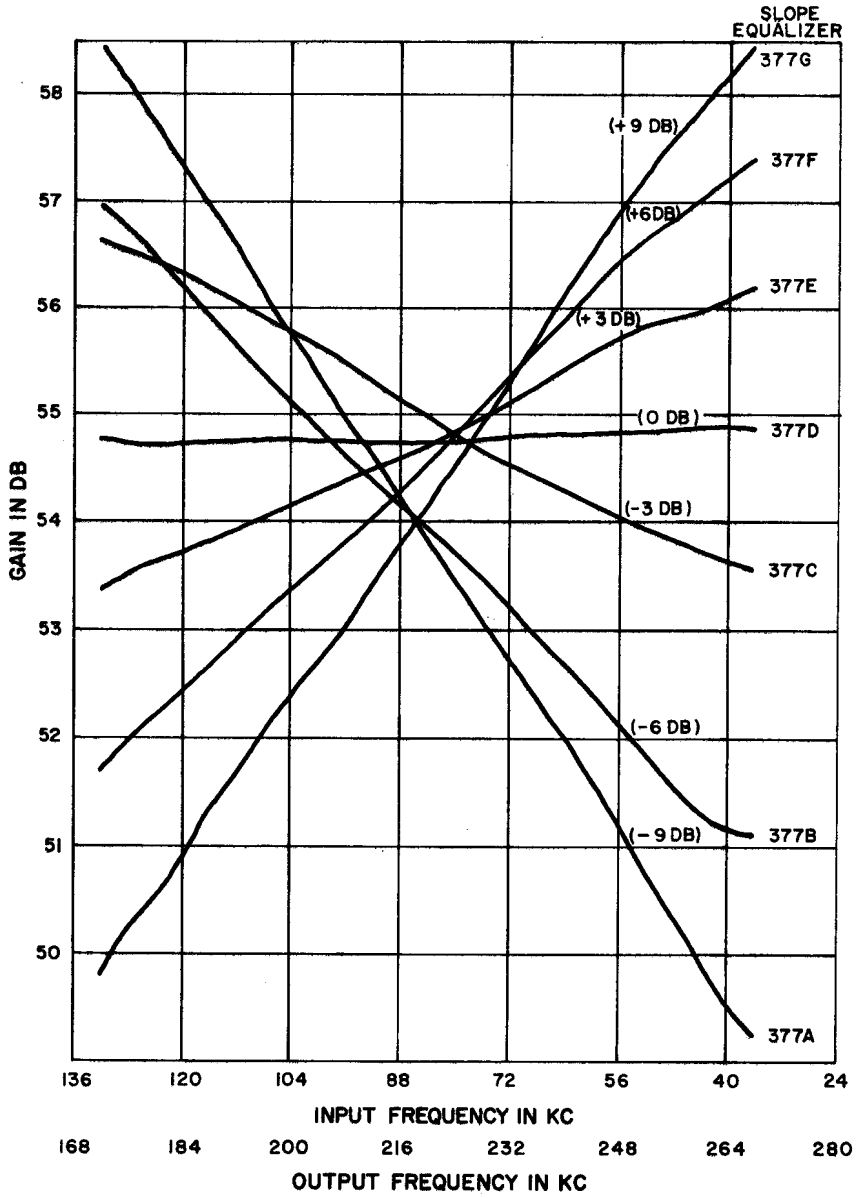


Fig. 13 – Gain of High-group Transmitter with Each Slope Equalizer

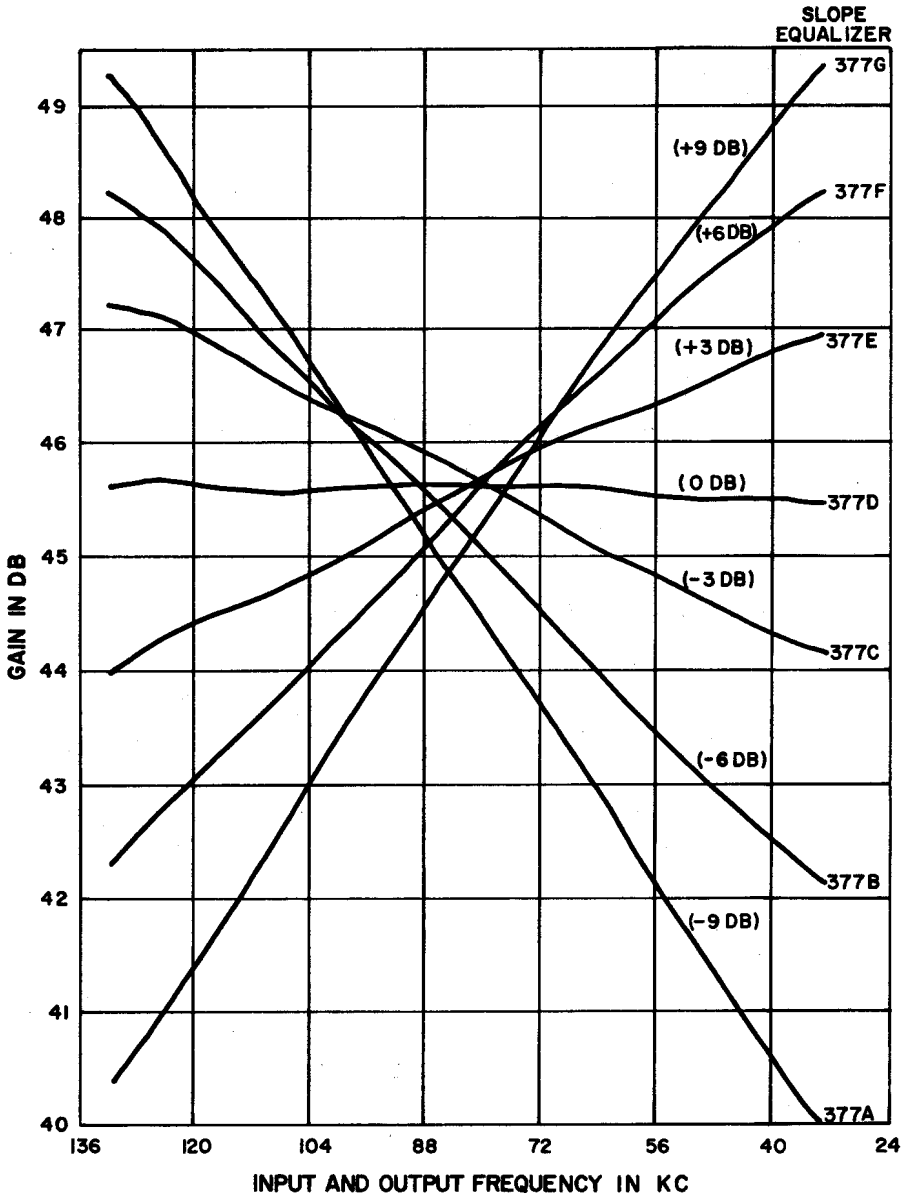


Fig. 14 – Gain of Low-group Transmitter with Each Slope Equalizer

B. Receiver Units — High Group and Low Group

3.02 The receiver units receive the signal from the cable at a slope and level which depends on the line repeater adjustments and lengths of cable sections. The total input power can be adjusted by the selection of the proper receiving span pad in the line terminating unit. The slope of the group receiver output signal may be adjusted to 0 ±0.5 db by the selection of the proper slope equalizer and SLOPE ADJ switch position. The measured power gains of the high-group and low-group receiver units are shown in Fig. 15 and 16, respectively. The gains are shown for the nominal value of thermistor resistance and for B slope settings. The power gain of the high-group receiver unit (for the above condition), not taking into account the slope equalizer loss, is 52.6 db. With the 0-db slope equalizer inserted, the gain is 46.6 db. The power gain of the low-group receiver unit (for the above conditions), not taking into account the slope equalizer loss, is 44.1 db. With the 0-db slope equalizer inserted, the gain is 38.1 db. In

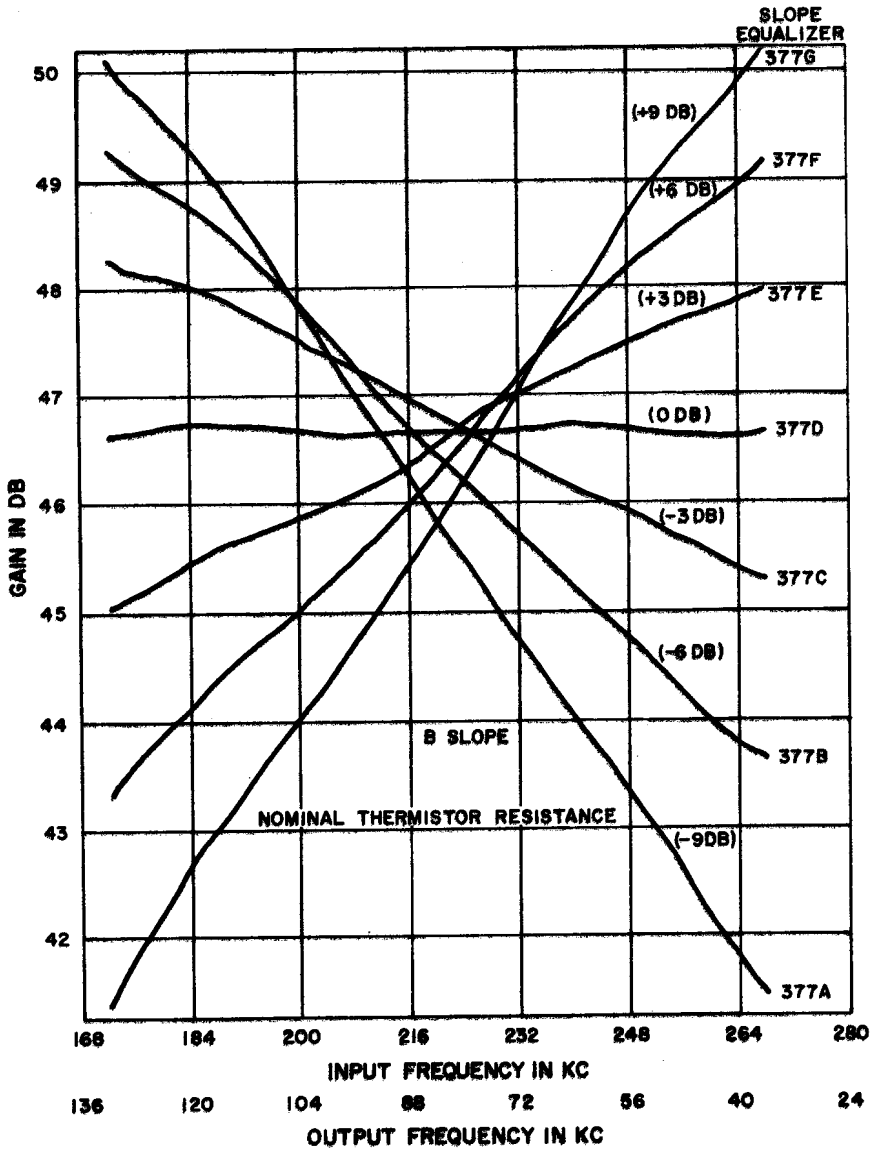


Fig. 15 – Gain of High-group Receiver with Each Slope Equalizer

Fig. 15, the high-group receiver unit gain is shown with seven slope equalizers inserted, yielding gain slopes of 0, ±3, ±6, and ±9 db. In Fig. 16, the low-group receiver unit gain is shown with seven slope equalizers, yielding gain slopes of ±9, ±6, ±3, and 0 db. The relative gain of the receiving amplifier is shown in Fig. 17 for the three slope switch positions. This adjustment provides relative slopes of +1, 0, or −1 db for settings of the slope switch of A, B, and C, respectively to interpolate between the 3-db slope steps of Fig. 15 and 16. Thus, gain slopes are obtainable in 1-db steps from −10 to +10 db for the group receiver units.

4. TESTING ARRANGEMENTS AND FACILITIES

4.01 The testing facilities for the group units are arranged so that all tests may be made on an in-service basis. The tests include:

(a) Transistor emitter current tests.

(b) Measurement of the total carrier power at the output of group transmitter and output and input of the group receiver units.

(c) Measurement of the individual carrier power output of the group transmitter and group receiver units.

(d) Switching a standby group unit into the circuit without service interruption to make the regular group unit available for out-of-service maintenance or replacement.

When accuracy is desired, the measurement of individual carrier powers at the output of a transmitting group unit should be made on a terminated basis, which requires removing the unit from service.

4.02 Transistor emitter current tests may be made with a KS-14510, List 1 volt-ohm-milliammeter. The test points are provided on the faces of the individual group units. The ***voltage*** measured from an emitter test point to the −21 volt test point effectively measures the emitter current of that transistor. Any change in emitter current indicates a change in the current gain of that transistor or a change in biasing circuit component values due to aging or temperature change.

4.03 The output terminals of the group transmitter and group receiver units are accessible at the switching jacks on the face of the

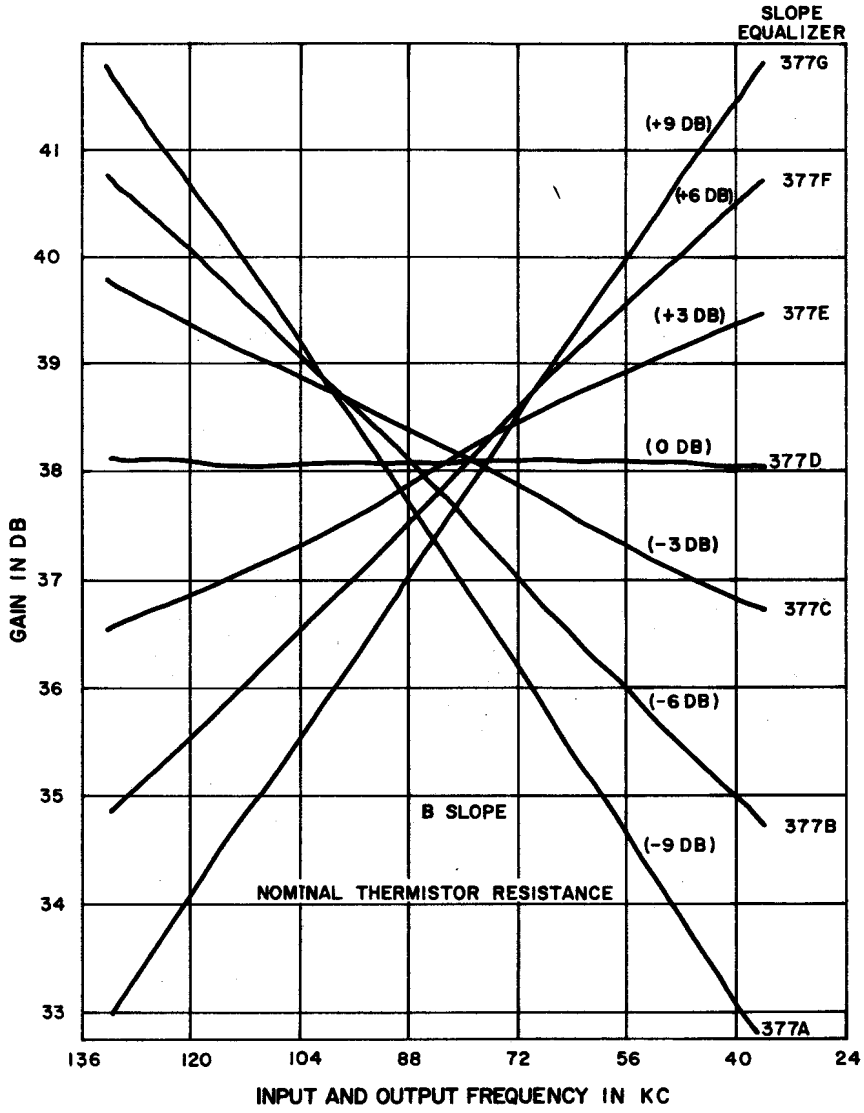


Fig. 16 – Gain of Low-group Receiver with Each Slope Equalizer

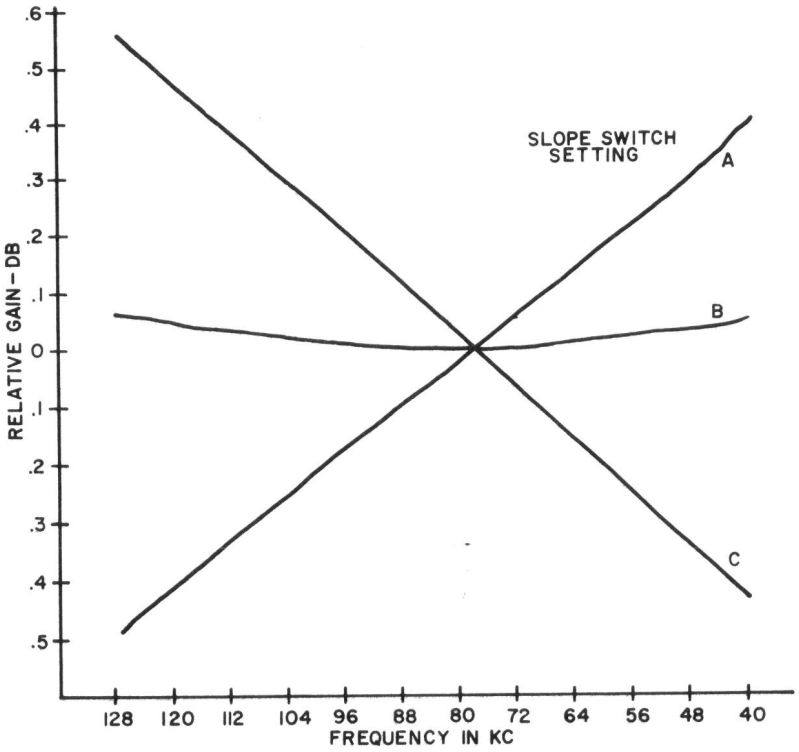


Fig. 17 – Relative Gain Versus Frequency Characteristic Controlled by Slope Switch of Receiver Amplifier

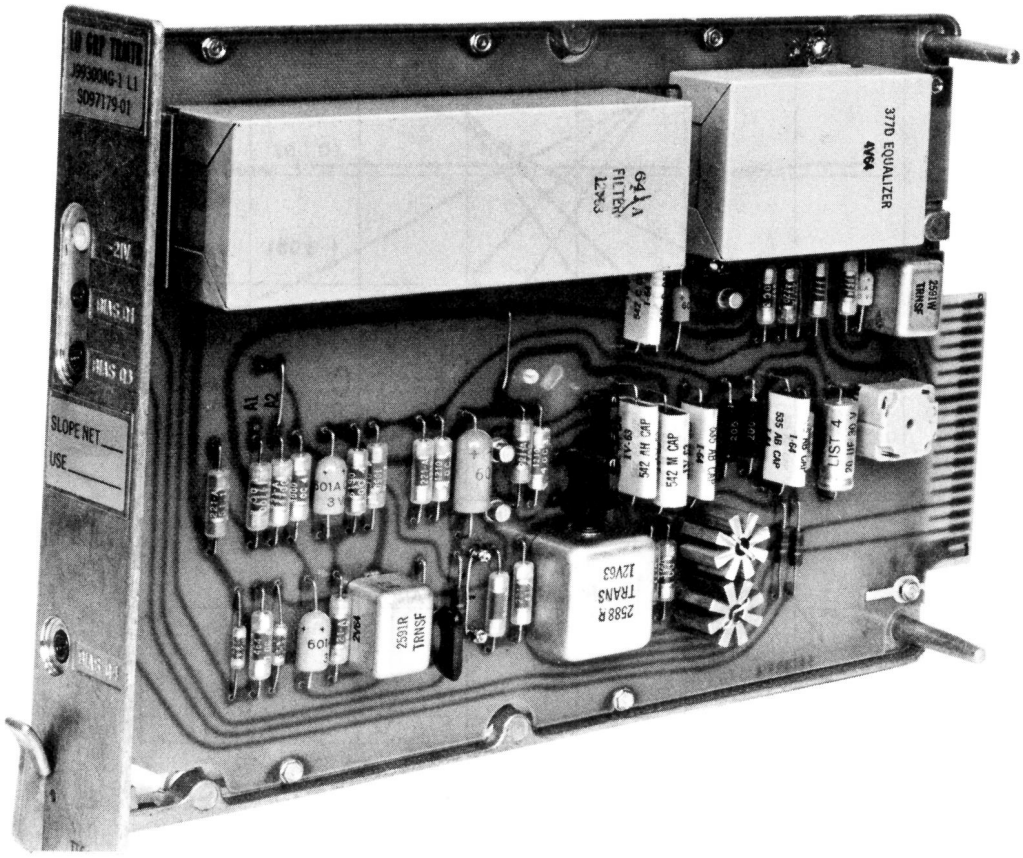


Fig. 18 – Low-group Transmitter

combining and switching unit. The two transmitter jacks are TRMTG (J72 and J73), while the two receiver jacks are RCVR (J74 and J75). The individual and total carrier power outputs may be measured by bridging meters across the output terminals. Special cords are available to connect the proper meters to the switching jacks to make these measurements.

4.04 The total carrier power output of a group transmitter unit may be measured with a 2J repeater test set. This measurement provides an easy check that the group unit is working properly. To check that each individual carrier is being transmitted correctly and that the output slope is correct, the individual carriers are measured with a carrier frequency voltmeter.

4.05 The total carrier power output of a group receiver unit may be measured with a 2J repeater test set. This measurement provides an easy check that carriers are being received from the repeatered line, and that the group receiver unit is regulating properly. If the total carrier power output does not meet requirements, the total input carrier power to the group receiver unit should be measured to see if the trouble is in the group receiver unit or prior to it. To obtain information about line equalization, the individual carriers are measured with a carrier frequency voltmeter.

4.06 When the replacement of a group unit is necessary, it may be accomplished without interruption of service on the system by use of the N3 switching set. A cord built into the test set connects the switching set to the appropriate group unit switching jacks on the line terminating unit. Power for the switching set is derived from the TEST PWR connector on the combining and switching unit. The switching set contains the necessary switches and gain adjustments so that an alternate group unit may be switched into the terminal circuit in place of the regular group unit. The regular unit may then be removed, repaired, or replaced. The alternate group unit is a regular group unit with a special wiring option. In the group transmitter units the Y wiring is removed, as shown in Fig. 10, increas-

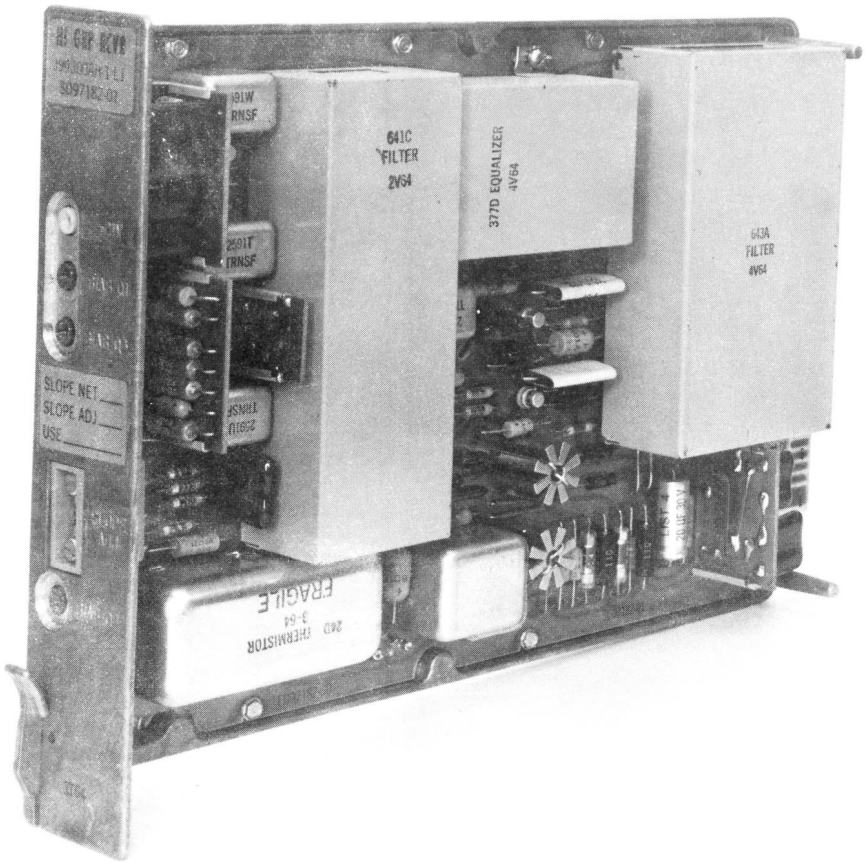


Fig. 19 – High-group Receiver

ing the gain by 3 db. In the group receiver units the thermistor (X wiring) is replaced by a 20,000-ohm resistor (Y wiring) as shown in Fig. 11, which yields a gain 6-db higher than nominal.

5. EQUIPMENT

5.01 The group transmitter and group receiver units are separate plug-in items. A photograph of the low-group transmitter unit is shown in Fig. 18. Fig. 19 is a photograph of the high-group receiver. The slope equalizer unit shown with them must be provided separately.

6. LIST OF DRAWINGS

6.01 The following schematic and equipment drawings (not attached) provide detailed information:

SUBJECT	DESIGNATION
Low-group Transmitter Subassemblies	ED-97179-30
Low-group Receiver Subassemblies	ED-97180-30
High-group Transmitter Subassemblies	ED-97181-30
High-group Receiver Subassemblies	ED-97182-30
Low-group Transmitter Circuit	SD-97179-01
Low-group Receiver Circuit	SD-97180-01
High-group Transmitter Circuit	SD-97181-01
High-group Receiver Circuit	SD-97182-01