

METALLIC FACILITY TERMINAL

4-2 WIRE REPEATERS (J99343RB, RC, RG)

2-4 WIRE INTERMEDIATE REPEATERS (J99343RD, RE, RH)

SD-1C359-01

DESCRIPTION

CONTENTS	PAGE	
1. GENERAL	1	1.02 This section is reissued to add the J99343RG, RH (loaded) repeaters. The J99343RG, RH are compatible with metropolitan area trunk (MAT) cable facilities and replace the J99343RB, RD respectively which are rated MD. Arrows used to indicate changes have been omitted.
2. 4-2 INTERMEDIATE/TERMINAL REPEATER (LOADED), J99343RB (MD)	3	
3. 4-2 INTERMEDIATE/TERMINAL REPEATER (LOADED), J99343RG	11	1.03 This section gives detailed descriptive information for the J99343RB, RC, RG 4-2 intermediate/terminal repeaters and the J99343RD, RE, RH 2-4 intermediate repeaters. Section 332-912-131 gives a detailed description of the J99343RA, RF 2-4 terminal repeaters. Sections 332-910-100 and 332-910-101 give a general description of all MFT equipment, including typical MFT terminals, packaging, powering arrangements, cabling, accessory equipment, etc. Additional application information for these units can be found in Section 332-910-180. Installation, line-up, and testing information is given in Section 332-912-221. Prescription settings are contained in Section 332-912-222.
4. 4-2 INTERMEDIATE/TERMINAL REPEATER (NONLOADED), J99343RC	11	
5. 2-4 INTERMEDIATE REPEATER (LOADED), J99343RD (MD)	13	
6. 2-4 INTERMEDIATE REPEATER (LOADED), J99343RH	14	
7. 2-4 INTERMEDIATE REPEATER (NONLOADED), J99343RE	15	
8. TRANSMISSION CHARACTERISTICS	15	1.04 The 4-2 repeaters (J99343RB, RC, RG) may be used in terminal applications to terminate either loaded or nonloaded 2-wire cable in 4-wire equipment. They can also be used as an intermediate repeater at the junction of 4-wire and 2-wire cable. The 2-4 repeaters (J99343RD, RE) are for intermediate use only.
9. MAINTENANCE	23	

1. GENERAL

1.01 The Metallic Facility Terminal (MFT) is a standard grouping of modular equipment which furnishes transmission and/or signaling functions required with metallic (wire) facilities. The 4-2 and 2-4 repeaters are the part of the MFT family of equipment which perform transmission treatment required for 2-wire extensions from 4-wire facilities.

Note: When the 4-2 or 2-4 repeaters described in this section are used in intermediate applications, the 2-wire facility should be greater than 1 dB in length. A J99343RA or RF 2-4 terminal repeater should be used when the 2-wire facility is 1 dB or less in length.

1.05 The MFT 4-2 and 2-4 repeaters are functionally similar and are successors to the 24V4

NOTICE

Not for use or disclosure outside the
Bell System except under written agreement

SECTION 332-912-121

family of repeaters. The repeaters are complete, compact plug-in units containing 2-wire to 4-wire hybrid conversion circuitry and active devices employing modern integrated circuitry which produce gain, equalization, and precision balancing. Stockpiling and selection of term sets, amplifiers, equalizers, and precision balancing networks are not required.

1.06 309A and 309B operational amplifier integrated circuit modules (referred to as "amplifier units" in this section) furnish voice frequency gain (or loss) of -20 to +24 dB in both directions of transmission. The 309A is a flat-gain amplifier and the 309B contains a flat-gain amplifier plus an equalization amplifier.

1.07 Precision hybrid balancing is accomplished by 4240-type precision balancing networks (PBNs). A 4240A PBN is used in the J99343RB, RD (L) repeaters; a 4240B PBN balances nonloaded facilities in the J99343RC, RE (NL) repeaters. The 4240C PBN is compatible with H88 loaded MAT cable and is used in the J99343RG, RH.

1.08 In certain intermediate applications, the 4-2 intermediate/terminal and 2-4 intermediate repeaters will functionally replace a 24V4A repeater in tandem with an E6 repeater to allow "gain transfer" to the 2-wire facility. The circuit applications which utilize gain transfer are described in Section 332-912-221.

1.09 Typical applications of the 4-2 and 2-4 repeaters include toll connecting trunks (to 4-wire switching machines), foreign exchange (FX) trunks, FX lines, off premise station (OPS) lines, WATS trunks, and the customer premises facility terminal (CPFT) family of equipment.

1.10 There are three main distinguishing features which differentiate between the repeaters described in this section:

- Whether the A-side is 2-wire or 4-wire (and conversely the B-side is 4-wire or 2-wire)
- The type of precision balancing required for the hybrid circuitry (a 4240A network plus line build out capacitance (LBOC) if the 2-wire facility is H88 loaded, 4240B if nonloaded)
- Whether the amplifier unit in each direction of transmission is a 309A flat gain type or 309B equalizing type.

1.11 With only minor exceptions, the 4-2 repeaters are identical to the 2-4 intermediate repeaters with the 4-wire and 2-wire transmission sides reversed. This transmission side reversal becomes important primarily in split frame arrangements where the A-side of the MFT frame is wired to one frame and the B-side is wired to another frame. In this type of split frame situation, the proper choice of either a 2-4 intermediate repeater or a 4-2 repeater used in an intermediate application will eliminate the necessity for tie cables between the frames.

1.12 In non-split frame arrangements at the junction of 4-wire and 2-wire cable, many requirements can be satisfied with a single repeater type (either the 2-4 intermediate or the 4-2 repeater used as an intermediate). The differences in the signaling interfaces are summarized below:

- The 4-2 repeaters contain a midpoint capacitor option which permit use with DX trunk circuits (and possibly some older DX conversion circuits). The 2-4 intermediate repeaters contain fixed midpoint capacitors.
- The 4-2 repeaters have the capability to reverse the A and B leads on the 2-wire side only. This may cause problems when two 4-2 repeaters are used in tandem as intermediate repeaters in a 2-wire/4-wire/2-wire circuit arrangement. In this configuration there is no capability to reverse the 4-wire simplex signaling leads should such a reversal be necessary. The 2-4 intermediate repeaters have SX lead reversing capability on the 4-wire side.

1.13 The circuit design of the 4-2 repeaters is optimized for terminal applications with 4-wire equipment. Although they can be used effectively in many intermediate applications, the use of tandem 4-2 repeaters in intermediate locations should be checked carefully for proper signaling lead continuity.

1.14 The MFT repeaters are plug-in assemblies which are made up of circuit components mounted on a printed wiring board. The board, which includes a connector along one edge, is fastened to an aluminum die-cast frame. Each assembly is approximately 1-11/16" wide by 7-7/8" high by 9" deep.

1.15 The repeaters can be used alone (without a signaling unit) in applications which require only voice frequency gain. When used alone, they can be mounted in either of two arrangements:

- In the transmission unit position (labeled TU) of the J99343A double-module shelf or one of the double-module frames. The adjacent signaling unit position (labeled SU) is left vacant.
- In the single mounting position which is associated with each circuit in a J99343B single-module shelf or one of the single-module frames.

When the repeater is used alone in one of these mounting arrangements, the A-side and B-side signaling leads can be connected together by the operation of two slide switches located on the component board.

1.16 In applications which require both gain and a signaling function, the repeater and an

associated MFT signaling unit are plugged into adjacent slots in one of the double-module mounting arrangements. This is the more versatile method for mounting MFT plug-in equipment.

1.17 The repeaters described in this section have breaks in the A-side T and R (or T1 and R1) paths that make them compatible with the Switched Maintenance Access System (SMAS). In non-SMAS applications, the MFT shelves and frames have the appropriate terminals strapped together in the shelf wiring (terminals 37 to 38, 39 to 40).

1.18 A NOR/DISABLE slide switch on each repeater component board allows the companion MFT signaling unit to disable the repeater during idle loop conditions. When this switch is set in the DISABLE position, the signaling unit disconnects the -24 volt regulator circuit that supplies power to the active devices in the repeater when there is no loop current.

1.19 Ordering information for these repeaters is as follows:

REPEATER	"J" CODE	COMMON LANGUAGE CODE
*4-2 I/T(L)	J99343RB(), L1	MT42100AAA
4-2 I/T(NL)	J99343RC(), L1	MT42200AAA
*2-4 I(L)	J99343RD(), L1	MT24200AAA
2-4 I(NL)	J99343RE(), L1	MT24300AAA
4-2 I/T(L)	J99343RG(), L1	MT42310AAA
2-4 I(L)	J99343RH(), L1	MT24510AAA

* Rated MD

1.20 Additional information may be obtained in the following publications:

SECTION	TITLE
332-910-100	Metallic Facility Terminal—Description
332-910-180	MFT Application Guidelines
332-912-221	Installation, Line-up, and Testing Information for J99343RB, RE, RG, RH Repeaters
332-912-222	Prescription Settings for J99343RB, RE, RG, RH Repeaters

2. 4-2 INTERMEDIATE/TERMINAL REPEATER (LOADED) J99343RB

Note: The J99343RB is rated MD and is replaced by the J99343RG.

2.01 A photograph of the 4-2 intermediate/terminal repeater is shown in Fig. 1. The front panel contains complete identification information including the unit common language code.

2.02 Figure 2 is a side view which shows the component board. All repeater switches and controls are mounted on the component board and are identified in the figure. Also identified in the figure are an equalizing amplifier unit (RU1,

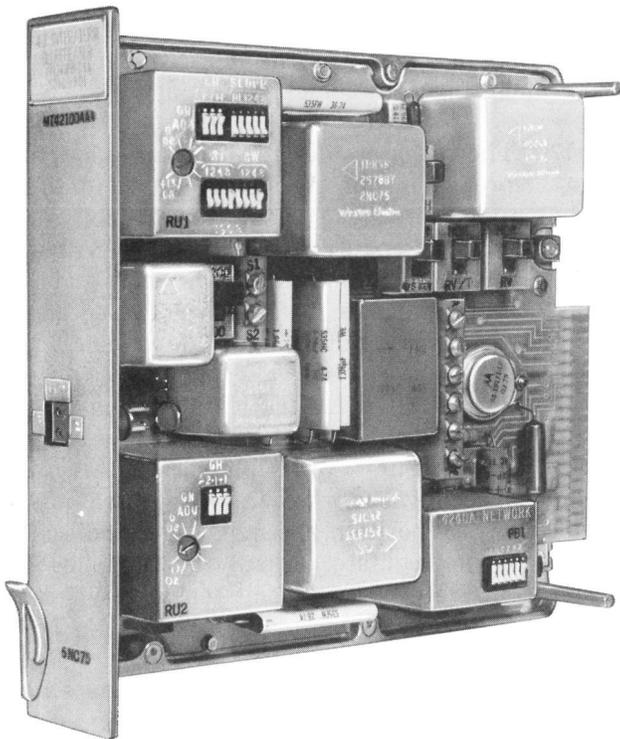


Fig. 1—The 4-2 Intermediate/Terminal Repeater (Loaded), J99343RB (MD)

type 309B), a flat-gain amplifier unit (RU2, type 309A), and a PBN (PB1, type 4240A).

2.03 A block diagram of the 4-2 intermediate/terminal repeater (loaded) is shown in Fig. 3. A two-transformer hybrid converts from 4-wire operation on the A-side to 2-wire operation on the B-side.

2.04 Figure 4 is a simplified diagram which explains the operation of the RV/T and RV switches. This diagram, in conjunction with the repeater block diagram, shows the three switch setting combinations for routing the signaling leads in each equipment arrangement that the repeater can be used.

2.05 A and B signaling leads are derived within the hybrid by a midpoint capacitor in the transformer windings. A slide switch on the component board (marked A/B REV) is used to establish the correct polarity of the B-side (station side) signaling leads.

2.06 Simplex inductors in series with the signaling leads separate voice frequencies from dc and low frequency signaling currents. Certain DX signaling applications require that the inductors be removed from the signaling path and the SX SH/NOR slide switch shorts them when in the SX SH position.

2.07 Figure 5 is a diagram of the 309B amplifier unit with each group of controls identified. The 309A amplifier unit is similar to the 309B except it contains only the three gain range switches (labeled GN) and a gain-adjust potentiometer (labeled GN ADJ). The GN switches are marked -2, -1, and +1 and set the repeater for -20 dB (loss), -10 dB (loss), and +10 dB (gain) respectively. Only one of the GN switches may be operated at the same time (thus operation of the -2 and -1 switches simultaneously will not yield -30 dB). When all GN switches are in the nonoperated position, the repeater is set for 0 dB gain (assuming the GN ADJ potentiometer is fully counterclockwise). A switch is "operated" by pressing the rocker toward the number.

Note: A 309B equalizing amplifier unit can be used as if it were a 309A flat-gain amplifier unit by turning off the equalizing circuits (setting the SLOPE, BW, and HT switches=0).

2.08 The GN ADJ potentiometer permits fine gain adjustment by adding from 0 to +14 dB to the gain set by the GN switches. The gains indicated for the GN and GN ADJ controls are calibrated to represent the gain of the entire repeater and take into account internal losses of the passive components.

2.09 The 309B amplifier unit has equalization controls in addition to the gain characteristics and controls as described in 2.07. Four basic adjustments are required to select the appropriate equalization.

- A switch labeled NL selects either of two sets of equalization characteristics. The switch rocker is normally depressed toward the NL marking for nonloaded cable and in the opposite direction for loaded (L) cable. There may be instances, however, where the switch setting is not related to the type of cable.

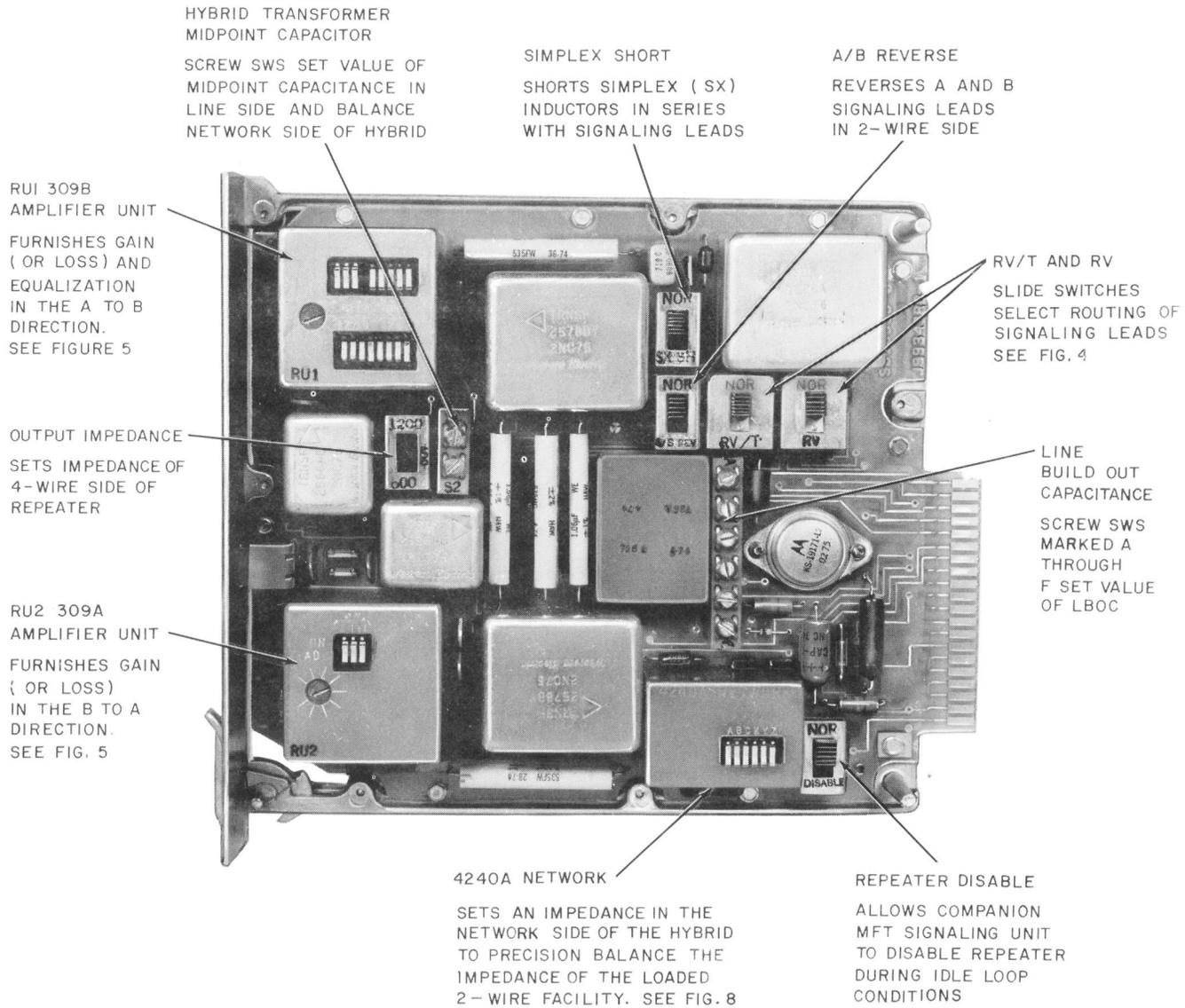


Fig. 2—Switch and Control Functions of the 4-2 Intermediate/Terminal Repeater (Loaded), J99343RB (MD)

- A group of four switches labeled SLOPE generates one of 16 possible low-frequency gain characteristics
- A group of four switches labeled HT (height), and
- A group of four switches labeled BW (bandwidth) combine to form a high frequency “bump” shape to the gain-frequency characteristic centered at 3250 Hz.

Figure 6 shows the general effect of each of these equalizer functions on the gain-frequency characteristic of the 309B.

Note: Later production versions of the 309B amplifier unit have revised markings for the NL switch. These contain only the single letter “N” indicating the switch position for nonloaded facilities. The letter “L” on the opposite side of the switch indicates the switch

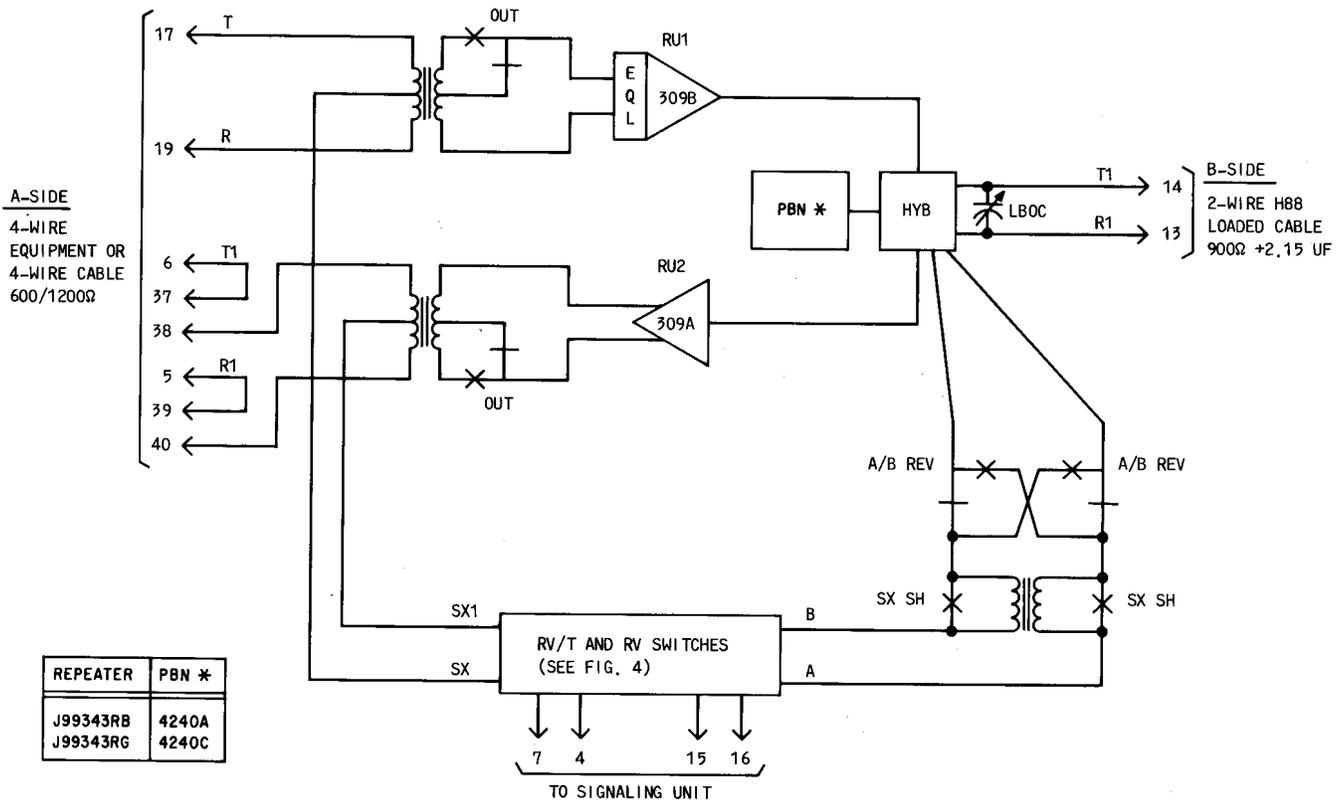


Fig. 3—Block Diagram of the 4-2 Intermediate/Terminal Repeater (Loaded), J99343RB (MD), RG

position for loaded facilities. Electrical characteristics of both versions are identical.

2.10 The SLOPE, HT, and BW functions are each controlled by a group of four miniature rocker switches marked 1, 2, 4, and 8. A switch is operated by depressing the rocker toward the marking, with the number over each switch indicating the relative effect of operating that switch. More than one switch in a group may be operated, with the total effect determined by adding the switch numbers. Thus, sixteen possible combinations can be formed from 0 (all switches off, least effect) through 15 (all switches operated, greatest effect). For example, a SLOPE value of 10 is formed by operating the 8 and 2 switches of the SLOPE group. The 4 and 1 switches remain off. The following might be a typical equalizer setting for nonloaded cable (see Fig. 7):

NL/L = NL (rocker toward NL)

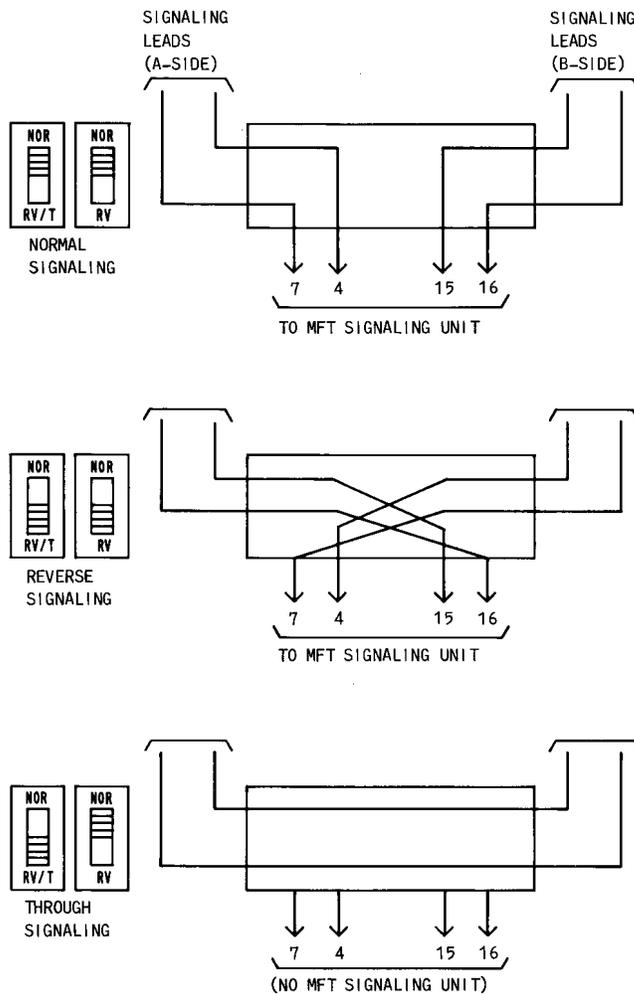
SLOPE = 7 (4, 2, 1 switches operated)

HT = 10 (8, 2 switches operated)

BW = 14 (8, 4, 2 switches operated)

2.11 The 309-type amplifier units operate on -24 Vdc. A one-transistor power regulator circuit on the component board converts -48 Vdc standard office battery to the -24 Vdc which is required for proper operation of these devices. A 24-volt zener diode holds the supply at a constant -24 Vdc.

2.12 The 4-wire input to the repeater is through isolation transformers which are tapped to present either 600- or 1200-ohms impedance to the facility or equipment connected to the 4-wire side. In intermediate applications, the 600-ohm setting is normally used for nonloaded cable and the 1200-ohm setting for loaded cable. A slide switch (OUTPUT) on the component board selects either of these impedances. Simplex signaling leads are brought out from center taps in the primaries of these two transformers.



NOTES:

1. THESE DIAGRAMS SHOW FUNCTIONALLY THE THREE SIGNALING CONNECTIONS. THE EXACT WIRING CONNECTIONS HAVE BEEN OMITTED FOR CLARITY.
2. THE ORIENTATIONS OF THE TWO SWITCHES ARE SHOWN AS THEY APPEAR ON THE J99343RB, RC 4-2 REPEATERS. THE SWITCHES ARE ARRANGED DIFFERENTLY ON THE OTHER REPEATERS.

Fig. 4—RV/T and RV Switch Settings for Routing Signaling Leads

2.13 In order for the hybrid to operate properly (ie, separate the receive and transmit currents in the 2-wire circuit and route them into the appropriate 4-wire circuit), the impedance connected to the line side of the hybrid (the 2-wire cable facility) must be closely matched with an impedance connected to the network side of the hybrid. This is accomplished in the 4-2 and 2-4 MFT repeaters by a 4240-type PBN.

2.14 The J99343RB (MD) 4-2 intermediate/terminal repeater (loaded) contains a 4240A PBN. The 4240A is an active two-terminal device containing integrated circuitry which can be set to present the required matching impedance to the network side of the hybrid. Since it is an active device (like the 309-type amplifier units), it requires a power source and uses the same 24-volt regulator supply as the amplifier units.

2.15 A diagram of the 4240A PBN is shown in Fig. 8. Identified in the figure are two sets of miniature rocker switches (three switches per set) which affect the impedance versus frequency characteristic appearing at the output terminals of the network.

Note: Early production 4240A PBNs were marked as shown in Fig. 8A; later production is marked as shown in Fig. 8B. Decals are available (part no. 842165557) to show the preferred marking as in Fig. 8B and should be applied to all early production versions in use and in inventory. The electrical characteristics of both versions are identical.

2.16 The three switches which control the R and Z functions are prescription set similarly to those on the 309-type amplifier units. As in the amplifier units, the numbers over the switches in Fig. 8B represent the relative effect of operating that switch. Multiple switches in a group can be operated together, with the total effect determined by adding the numbers of the operated switches. Thus, eight setting combinations can be formed from 0 (all switches off, least effect) through 7 (4+2+1; all switches operated, greatest effect). A switch is "operated" by pressing the rocker toward the switch designation and dot. A typical prescription setting for the 4240A might be:

R=5 (switches 4 and 1 operated; 2 not operated)

Z=1 (switch 1 operated; 4 and 2 not operated).

Sections 332-912-221 and 332-912-222 contain complete line-up and prescription setting instructions for the 4240A PBN.

2.17 Figure 9 is a general impedance-frequency characteristic for H88 loaded cable. This

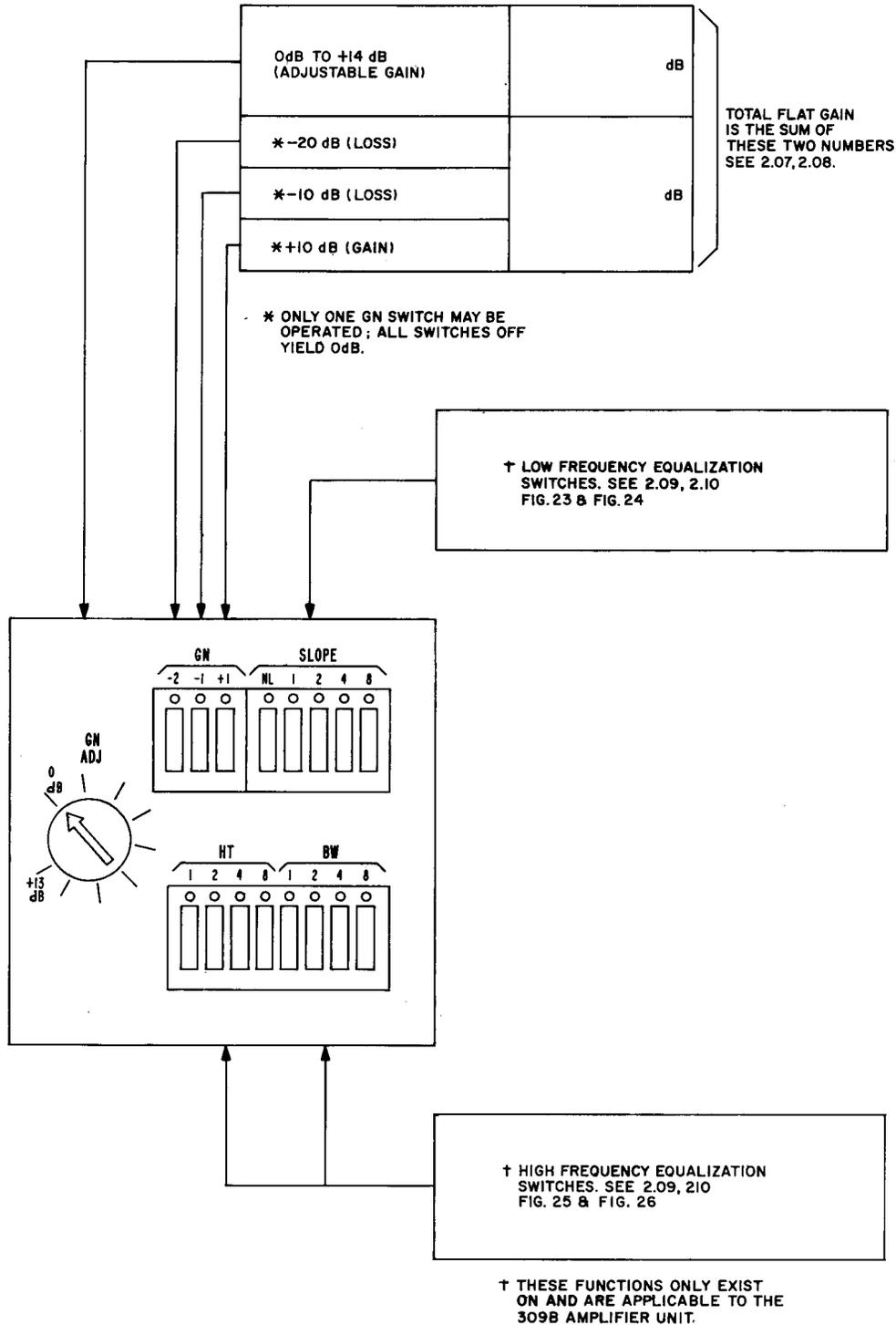


Fig. 5—309B (and 309A) Amplifier Unit Controls

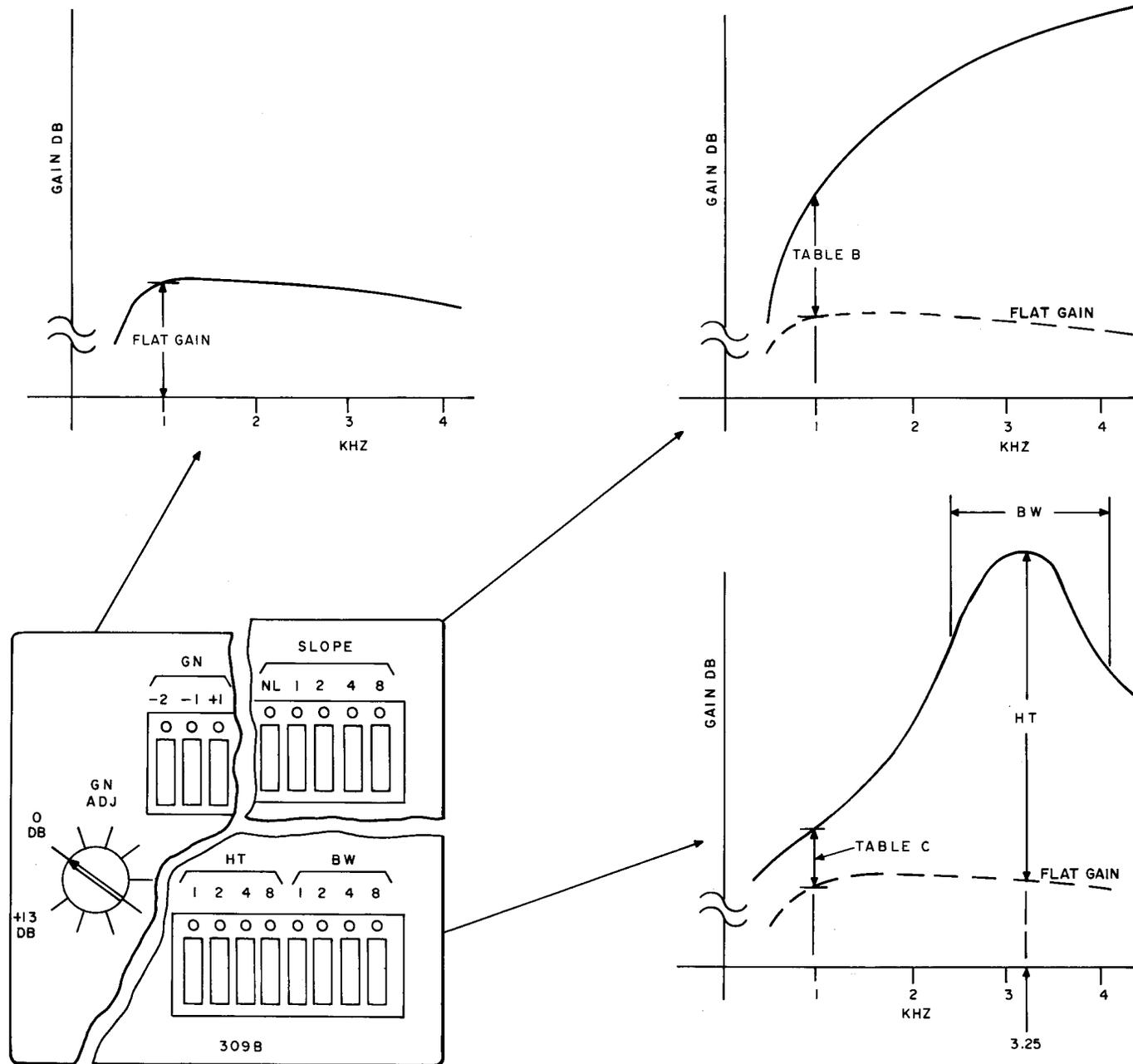


Fig. 6—General Gain and Equalization Characteristics of the 309B Amplifier Unit

characteristic is balanced in the hybrid by setting the 4240A PBN so that the impedance characteristics of both are nearly the same. The "R" function switches on the network shift the frequency (indicated by the dotted line in Fig. 9) where the impedance of the network begins to change rapidly. The

"Z" function switches affect the magnitude of the impedance equally across the voiceband.

2.18 The LBOC is an additional adjustment that is necessary to achieve optimum hybrid balance for H88 loaded cable. The effect of the

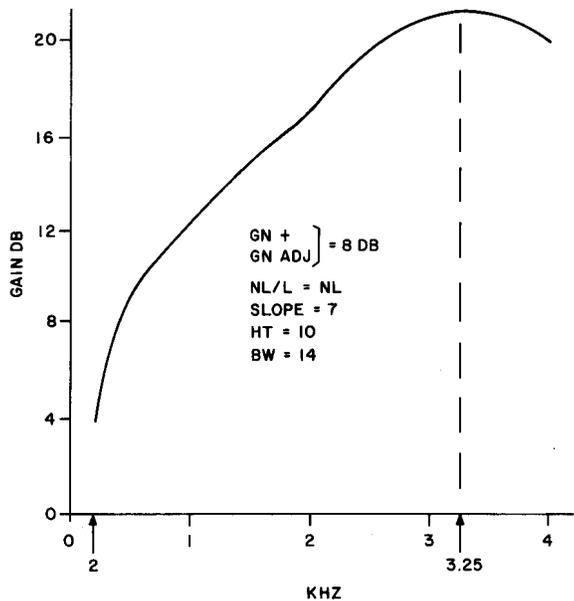


Fig. 7—Gain Characteristic of the 309B Amplifier Unit With Typical Equalizer Settings For Nonloaded Cable

LBOC is to electrically build out the end section of a 2-wire loaded extension to appear like a full section. The LBOC consists of a bank of screw switches marked A through F which connect from 0 to .126 μ F across the 2-wire line input to the hybrid:

SCREW SWITCH	CAPACITANCE
A	.002 μ F
B	.004 μ F
C	.008 μ F
D	.016 μ F
E	.032 μ F
F	.064 μ F

The capacitors are in parallel and their values add together when a switch is closed by tightening

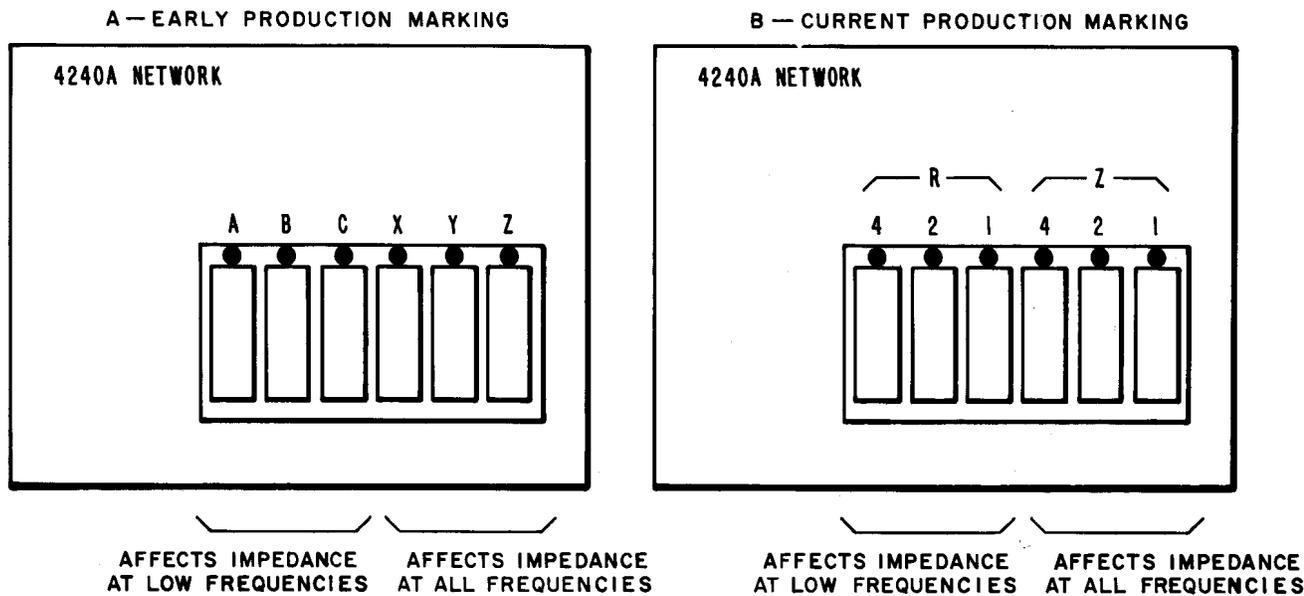


Fig. 8—4240A Precision Balancing Network Switch Functions

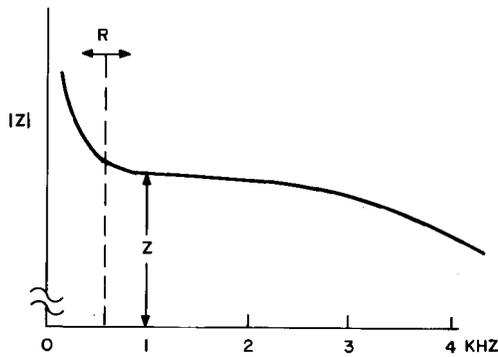


Fig. 9—General Impedance Characteristic of H88 Loaded Cable (Including Buildout Capacitance) Which is Balanced by the 4240A PBN

the screw. The LBOC is adjustable in .002 μF steps.

2.19 Midpoint capacitance on the line side and network side of the hybrid are connected by screw switches marked S1 and S2:

LINE SIDE	BALANCE NETWORK SIDE
*0 μF —S2 out	1.06 μF —S1 out
1.06 μF —S2 in	*4.30 μF —S1 in

*These capacitor settings may be required when the repeater is used on 2-wire circuits employing non-MFT DX signaling. Most other applications use 1.06 μF .

3. 4-2 INTERMEDIATE/TERMINAL REPEATER (LOADED), J99343RG

3.01 The 4-2 intermediate/terminal repeater (loaded), J99343RG is similar to and replaces the J99343RB (MD). The J99343RG contains a 4240C PBN in place of the 4240A PBN in the J99343RB and is compatible with MAT cable facilities. All other repeater characteristics are identical to those discussed for the J99343RB repeater in Part 2.

3.02 Figure 10 is a photograph of the J99343RG component board with all repeater controls and switches identified. A block diagram is shown in Fig. 3.

3.03 A sketch of the 4240C PBN is shown in Fig. 11. Identified in the figure are two

sets of rocker switches (three switches per set) and a single switch designated "L". The settings of these switches affect the impedance-frequency characteristic of the two-terminal active network.

3.04 The three switches which are marked R and Z are prescription set similarly to those on the 4240A PBN (see 2.16).

3.05 The single switch which is designated "L" is for use with MAT facilities. The switch rocker is pressed toward the "L" designation for MAT facilities and in the opposite direction for other loaded facilities.

3.06 Figure 12 is a general impedance-frequency characteristics for H88 loaded cable which is balanced by the 4240C PBN. The R group of switches affects the characteristic in the low frequency region as indicated in the figure; the L switch affects the characteristic at the upper end of the voice band. The Z switches affect the impedance at all frequencies. Specific instructions for prescription setting the 4240C PBN are contained in Sections 332-912-221 and 332-912-222.

4. 4-2 INTERMEDIATE/TERMINAL REPEATER (NONLOADED), J99343RC

4.01 The 4-2 intermediate/terminal repeater (nonloaded) is similar to the 4-2 intermediate/terminal repeater (loaded). The following are the significant differences between the J99343RC (nonloaded) repeater and the J99343RB (loaded) repeater:

- Both amplifier units are the 309B equalizing type.
- There is no LBOC.
- The PBN is a type 4240B.

See Fig. 13 for a side view of the J99343RC with all repeater switches and controls identified. A block diagram is shown in Fig. 14.

4.02 The RU2 receive amplifier unit in the J99343RC is a 309B equalizing-type for furnishing post equalization to the 2-wire nonloaded facility (RU2 in the J99343RB is a 309A flat-gain type.) The gain and equalization characteristics of the 309B are described in Fig. 5 and Fig. 6.

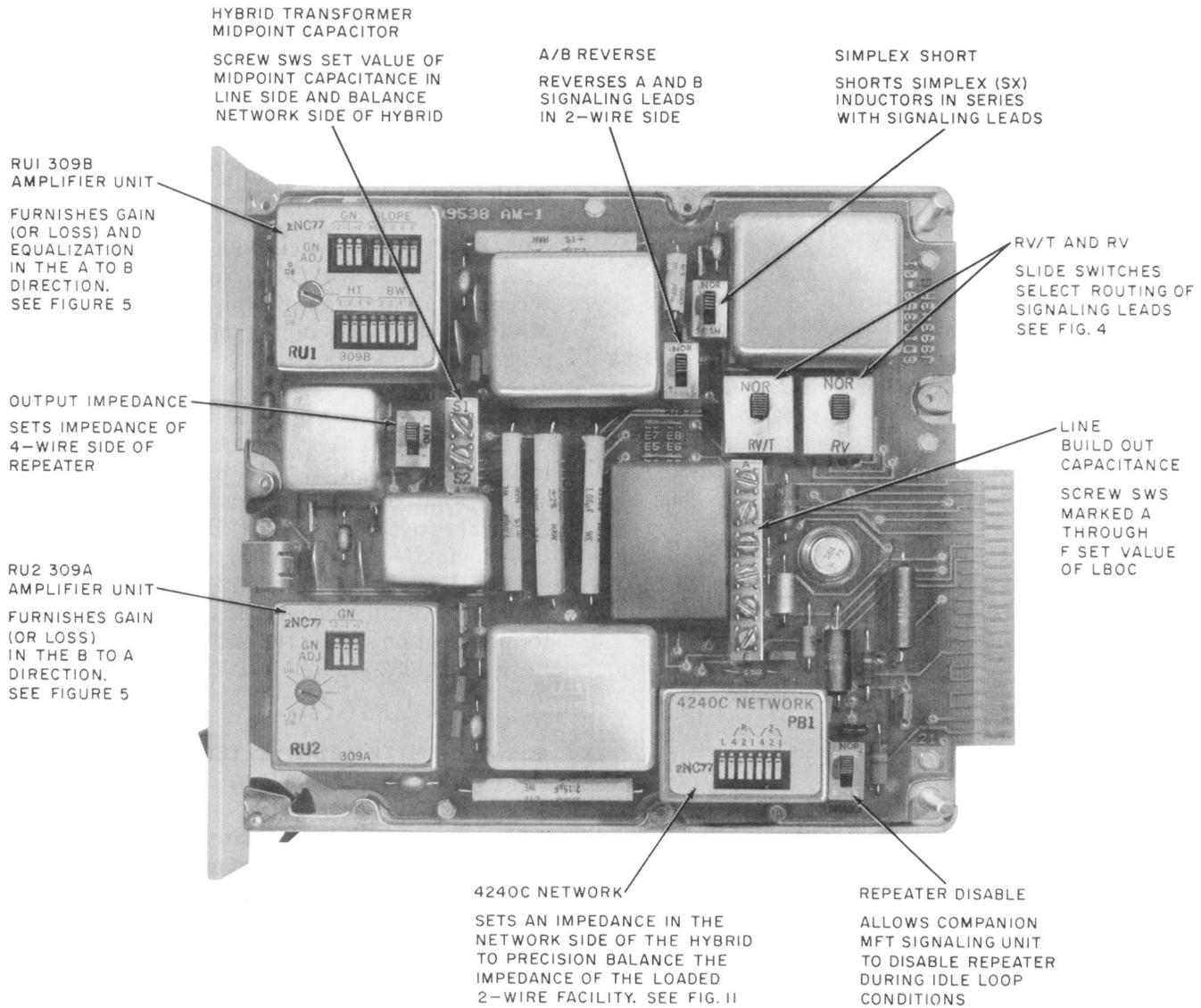


Fig. 10—Switch and Control Functions of the 4-2 Intermediate/Terminal Repeater (Loaded), J99343RG

4.03 The LBOC is not required in the J99343RC repeater because the 2-wire facility is nonloaded. Build-out capacitance is necessary only with loaded facilities.

4.04 The impedance characteristic of 2-wire nonloaded cable (which the PBN must accurately match) has a more complex shape than the typical characteristic of a loaded facility. The 4240B PBN used in the J99343RC repeater (NL) has an additional set of controls which gives it more flexibility than the 4240A and 4240C PBNs used in the J99343RB, RG repeaters (L).

4.05 Figure 15 is a diagram of the 4240B PBN with the three sets of controls identified. There have also been two versions of the 4240B manufactured as discussed in 2.15 for the 4240A. All repeaters containing 4240B PBNs marked as shown in Fig. 15A should be modified by applying the appropriate decal (part no. 842165565) as discussed for the 4240A (see note in 2.15).

4.06 The three sets of switches on the 4240B are prescription set similarly to the method described for setting the 4240A PBN (see 2.16).

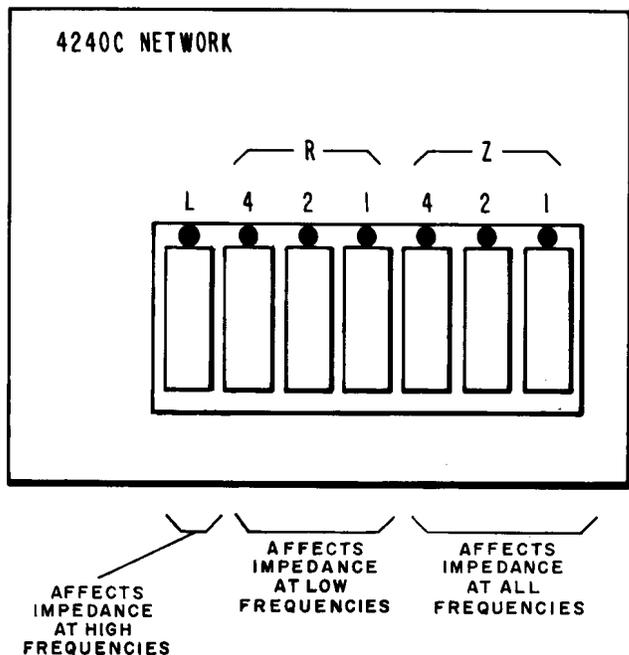


Fig. 11—4240C Precision Balancing Network Switch Functions

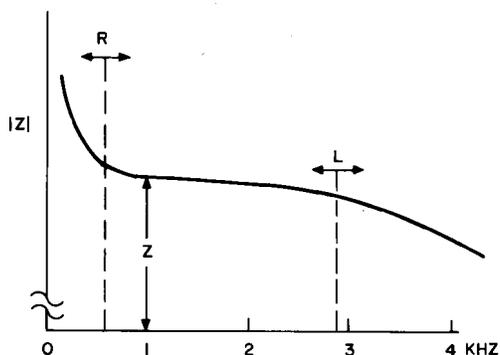


Fig. 12—General Impedance Characteristic of 25H88 Loaded MAT Cable (Including Buildout Capacitance) Which is Balanced by the 4240C PBN

A typical setting for the 4240B contains three parameters, eg:

$R_1 = 4$ (switch 4 operated; 2 and 1 not operated)

$R_2 = 9$ (switches 8 and 1 operated; 4 and 2 not operated)

$Z = 20$ (switches 16 and 4 operated; 8, 2, and 1 not operated).

4.07 Figure 16 is a general impedance-frequency characteristic for nonloaded cable. There are two general segments of the curve where the impedance varies at a significantly different rate on either side. The dotted lines identify these approximate points on the curve in Fig. 16.

4.08 The R_1 switches on the 4240B PBN affect the low frequency portion of the impedance characteristic. The bend in the curve identified by the R_1 dotted line in Fig. 16 is shifted in frequency by variations in the settings of the R_1 switches. Likewise, the portion of the curve identified by the R_2 dotted line is moved by varying the settings of the R_2 switches. The Z group of switches changes the magnitude of the impedance equally across the frequency band. Specific instructions for prescription setting the 4240B PBN are contained in Sections 332-912-221 and 332-912-222.

5. 2-4 INTERMEDIATE REPEATER (LOADED), J99343RD

Note: The J99343RD is rated MD and is replaced by the J99343RH.

5.01 Figure 17 is a photograph of the 2-4 intermediate repeater (loaded) with the switches, amplifier units, and PBN identified. A block diagram is shown in Fig. 18.

5.02 The J99343RD is similar to the J99343RB repeater described in Part 2. Both contain a 309A and 309B amplifier unit, a 4240A PBN for loaded cable, and a LBOC. Both repeaters also contain the same slide switches on the component board.

5.03 The following are the significant differences between the J99343RD and J99343RB:

- The 4-wire side tip and ring pairs (T, R, T1, R1) of each repeater appear at different terminals on the repeater connector; likewise, the 2-wire side T and R of each are brought out to different connector terminals.
- Since the J99343RD cannot be used as a terminal repeater (and consequently will not be used with a DX trunk circuit), the hybrid transformer midpoint capacitors are fixed at 1.06 μ F.

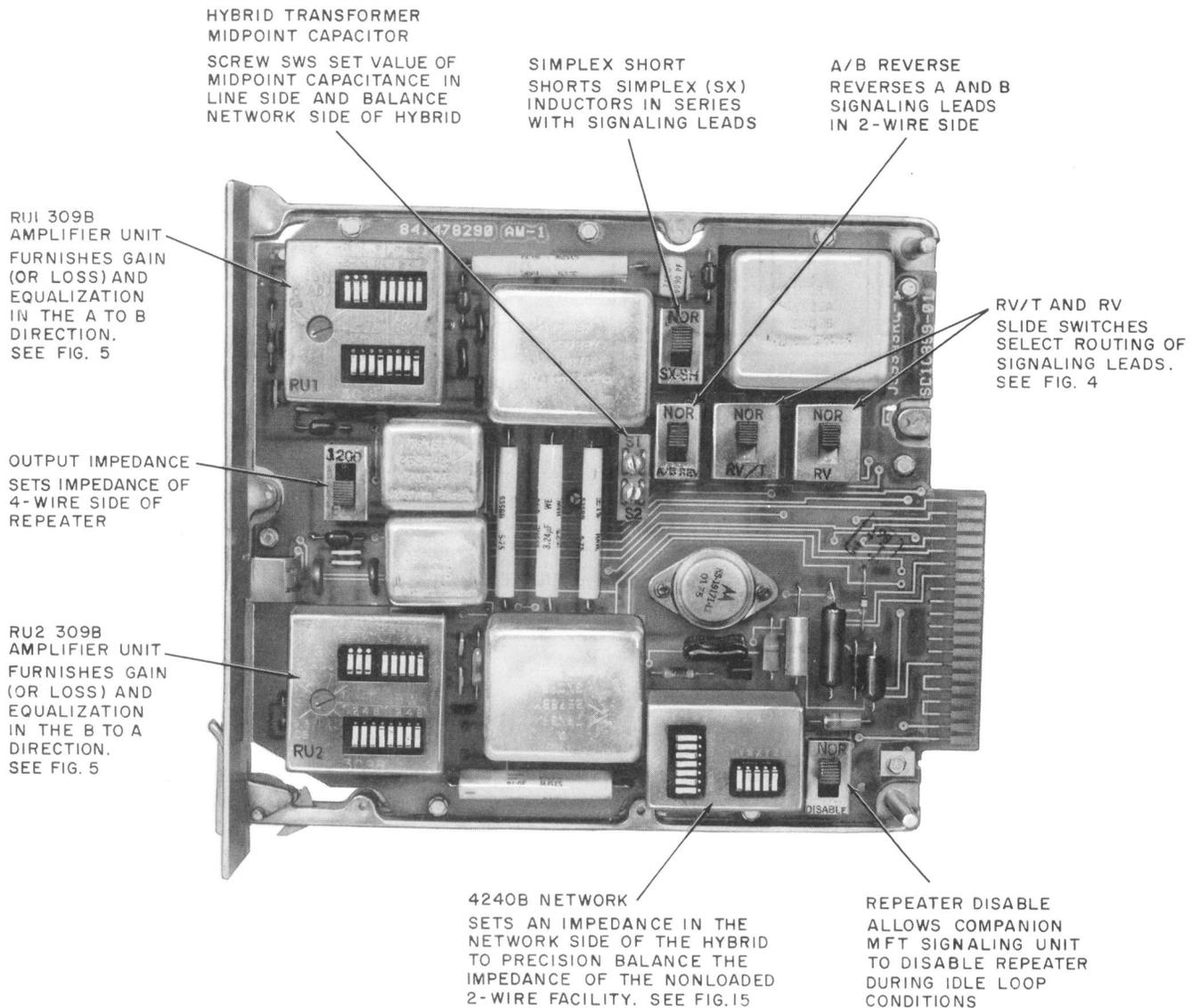


Fig. 13—Switch and Control Functions of the 4-2 Intermediate/Terminal Repeater (Nonloaded), J99343RC

- The signaling lead reversing switch reverses the B-side (station side) signaling leads in all MFT repeaters. This switch is marked A/B REV in the 4-2 repeaters and SX RV in the 2-4 repeaters.

All other repeater functions are as described in Part 2.

6. 2-4 INTERMEDIATE REPEATER (LOADED), J99343RH

6.01 The 2-4 intermediate repeater (loaded), J99343RH is similar to and replaces the

J99343RD (MD). The J99343RH contains a 4240C PBN in place of the 4240A PBN in the J99343RD and is compatible with MAT cable facilities. All other repeater characteristics are identical.

6.02 See Part 3 for a description of the 4240C PBN.

6.03 Figure 19 is a photograph of the J99343RH component board with all repeater controls and switches identified. A block diagram is shown in Fig. 18.

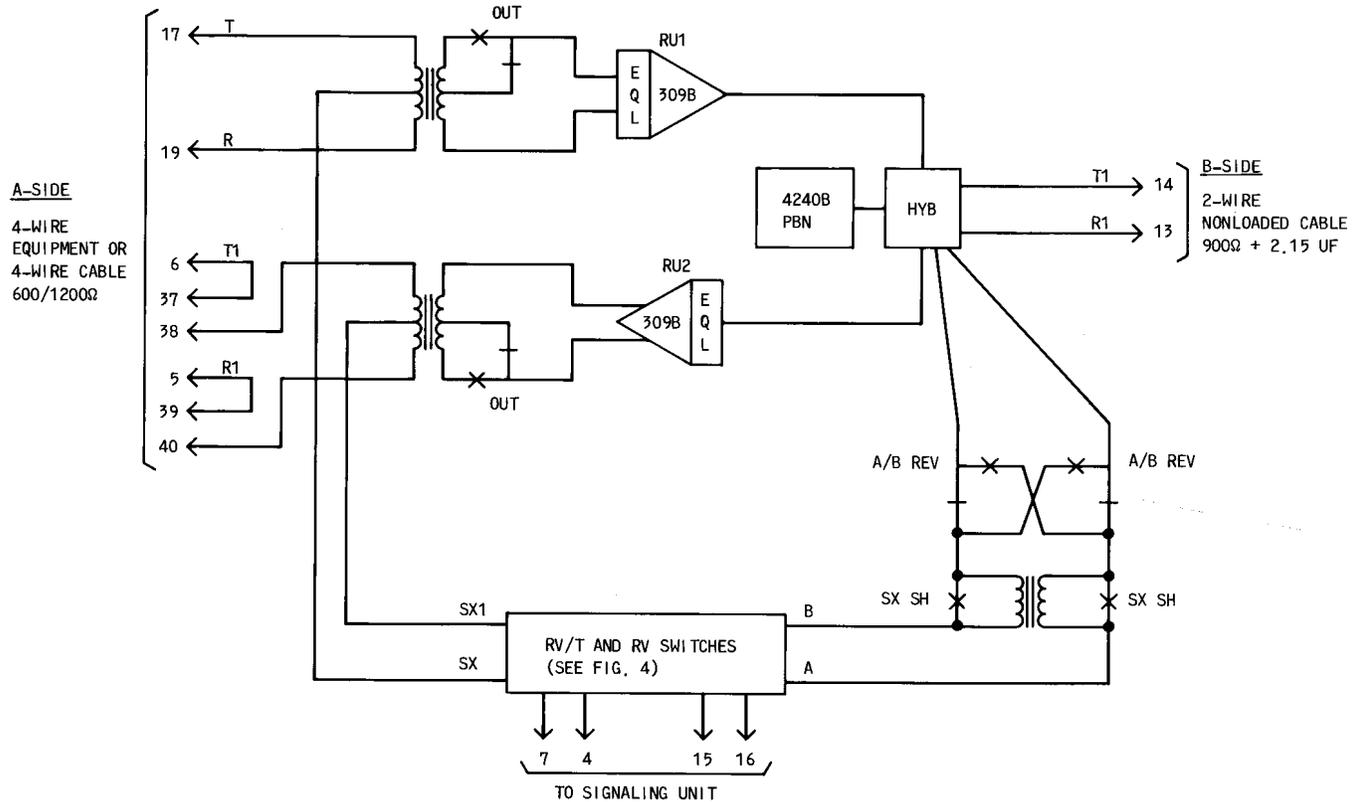


Fig. 14—Block Diagram of the 4-2 Intermediate/Terminal Repeater (Nonloaded), J99343RC

7. 2-4 INTERMEDIATE REPEATER (NONLOADED), J99343RE

7.01 The 2-4 intermediate repeater (nonloaded), J99343RE is similar to the 4-2 intermediate/terminal repeater (nonloaded), J99343RC. Both repeaters contain two 309B equalizing type amplifier units and a 4240B PBN.

7.02 The following are the significant differences between these two repeaters:

- The 4-wire side tip and ring pairs (T, R, T1, R1) appear at different connector terminals on the two repeaters since one operates 4-wire on the A-side and the other operates 4-wire on the B-side. Likewise, the 2-wire T and R appear at different connector terminals.
- The switch that reverses the polarity of the B-side signaling circuit is marked A/B REV on the J99343RC repeater and SX RV on the J99343RE repeater.

- The J99343RE repeater does not contain the S1 and S2 midpoint capacitor switch options.

See Fig. 20 for a side view of the J99343RE with all switches and controls identified. A block diagram is shown in Fig. 21.

8. TRANSMISSION CHARACTERISTICS

8.01 The transmission characteristics given in the following paragraphs apply to all repeaters covered in this section. A summary of electrical characteristics is given in Table A.

Gain Frequency

8.02 Gain and frequency shaping for equalization is accomplished by active 309-type amplifier units. Repeater gains of -20 dB to +24 dB are available by selecting a combination of the GN and GN ADJ controls. The basic voice frequency response of the repeater is shown in Fig. 22. This

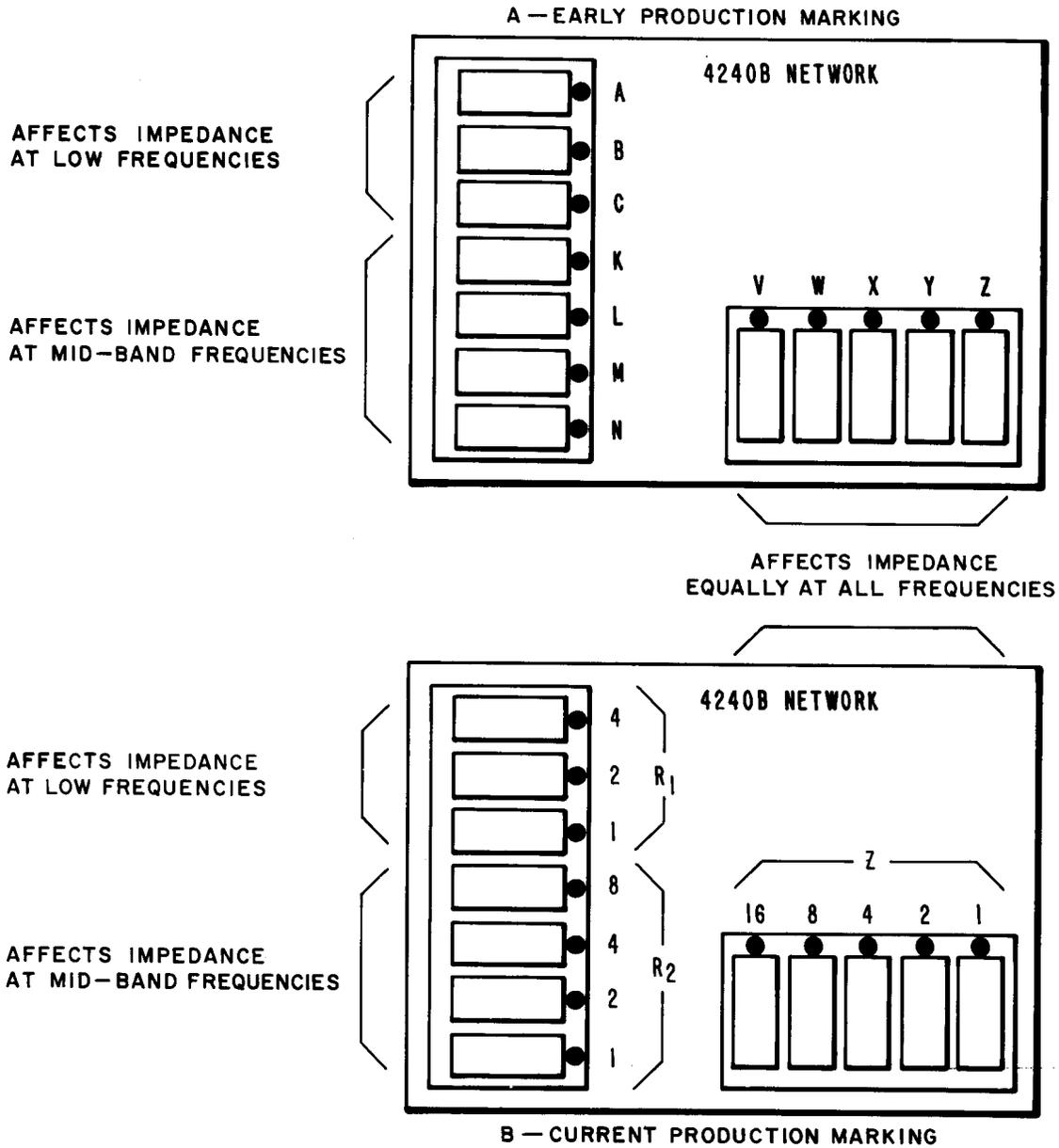


Fig. 15—4240B Precision Balancing Network Switch Functions

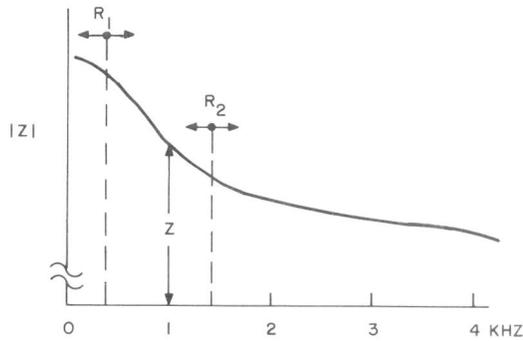


Fig. 16—General Impedance Characteristic of Nonloaded Cable Which is Balanced by the 4240B PBN

response is not significantly affected by gain adjustment.

8.03 Figures 23 through 26 show gain-frequency characteristics of the 309B amplifier unit with representative settings of the equalizer. Each figure is a family of curves which shows the approximate range of adjustment of the equalizer functions. Note that there is greater variation in the SLOPE curves at the higher frequencies when the equalizer is set for nonloaded (NL) cable. Conversely, the lower frequencies are affected more when the NL/L switch is set for loaded cable.

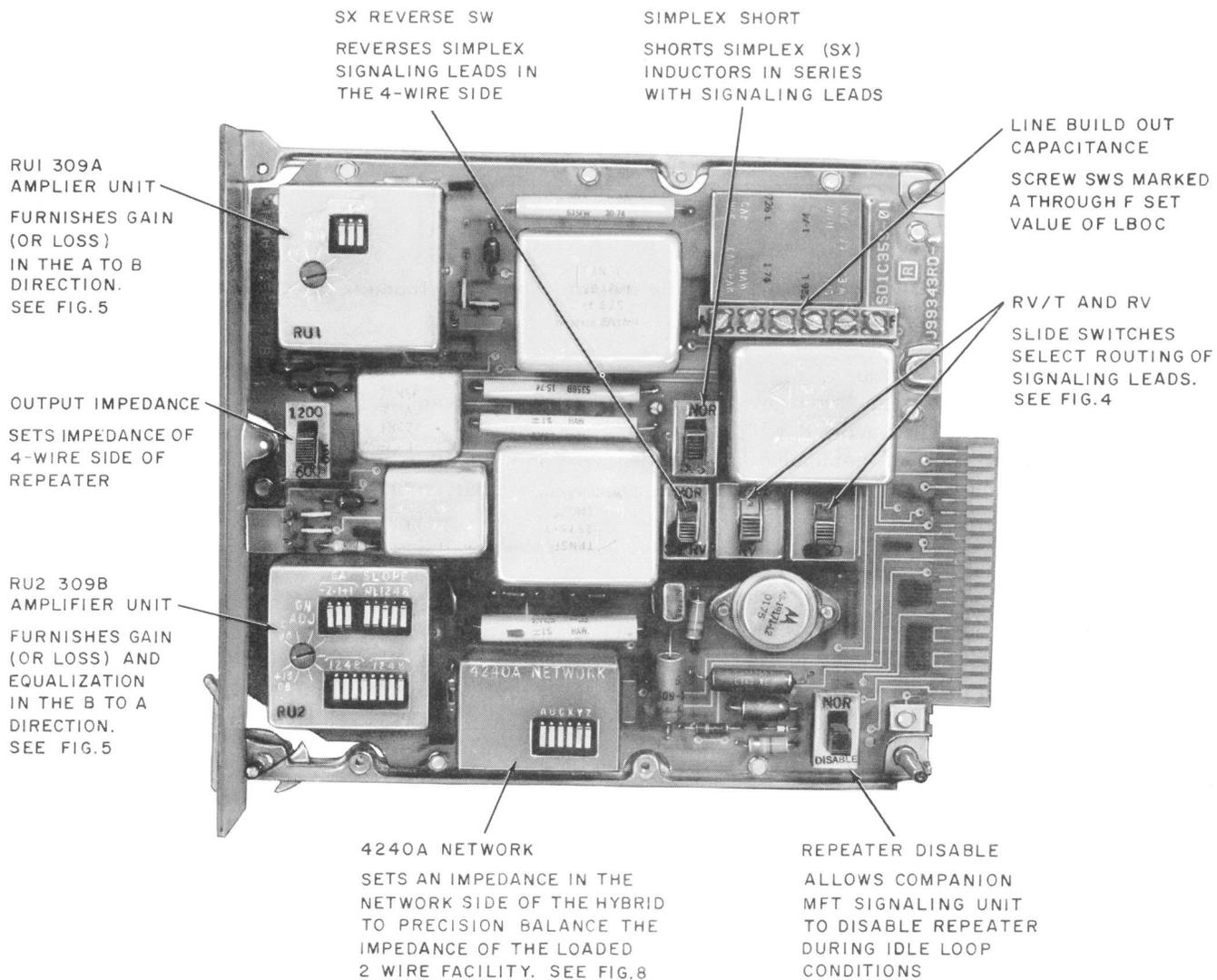


Fig. 17—Switch and Control Functions of the 2-4 Intermediate Repeater (Loaded), J99343RD (MD)

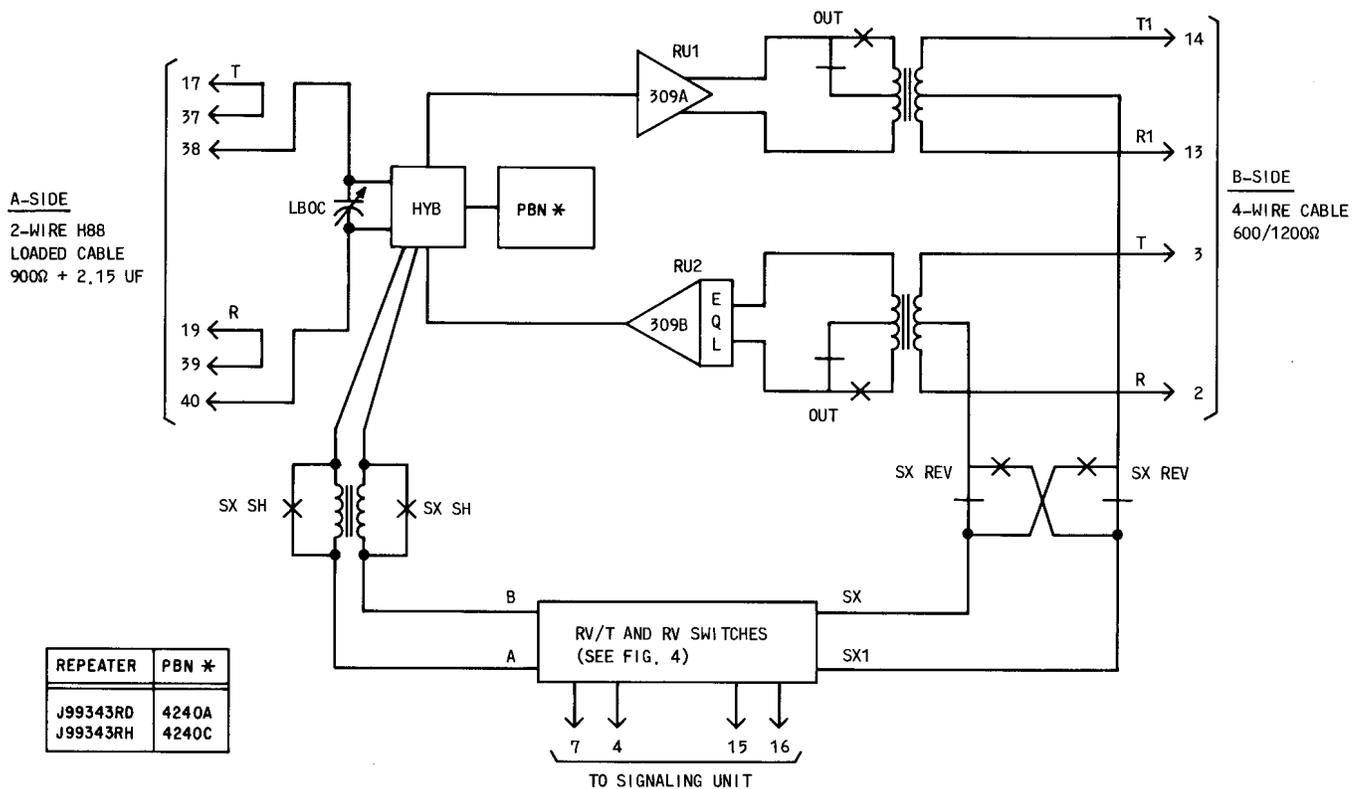


Fig. 18—Block Diagram of the 2-4 Intermediate Repeater (Loaded), J99343RD (MD), RH

8.04 The narrow bump shape of Fig. 25 is typical of settings used for high-frequency equalization of loaded cable. An intermediate width bump is used for a combination of nonloaded and loaded cable, and a wide bump (Fig. 26) is used to equalize nonloaded facilities.

- Gain resulting from the SLOPE function given in Table B
- Gain resulting from the HT and BW functions given in Table C.

8.05 The equalizer section of the 309B amplifier unit is an active equalization-amplification device and introduces additional gain when each equalizer function is activated. This contrasts with V4 repeater equalization techniques in which equalization is accomplished with passive RLC networks (which introduce loss). Table B gives the additional gain at 1 kHz when the SLOPE switches are operated. The HT and BW functions likewise introduce gain and are given in Table C for all combinations of these two groups of switches. Thus the total 1 kHz gain is determined by adding the following three quantities:

- Flat gain indicated by the GN and GN ADJ controls

Envelope Delay Distortion

8.06 Figure 27 shows the envelope delay distortion characteristic of the repeater with no equalization (SLOPE=0, HT=0). The characteristic is not significantly affected by gain adjustment, but is affected by all equalizer functions.

8.07 Figures 28 and 29 show the envelope delay distortion of the repeater with maximum and minimum SLOPE settings when used with nonloaded and loaded cable. The high frequency bump circuits are disabled (HT=0).

8.08 The effect of variations of the HT and BW functions on envelope delay distortion is shown in Fig. 30 and 31. The narrowest width bump has the greatest effect as seen in Fig. 30.

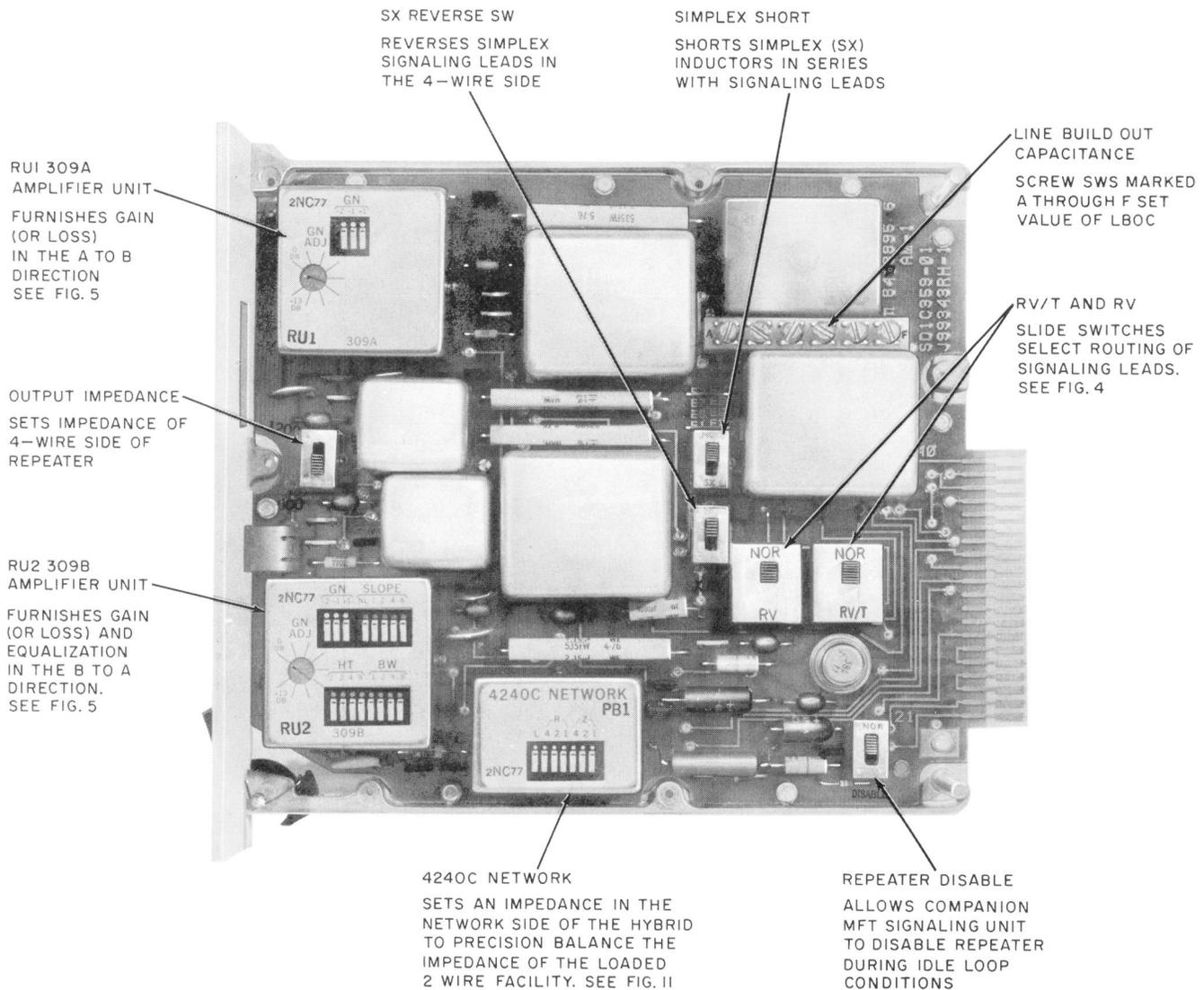


Fig. 19—Switch and Control Functions of the 2-4 Intermediate Repeater (Loaded), J99343RH

Note in Fig. 30 that variation in the HT setting has no effect below about 1 kHz.

Impedance

8.09 The 4-wire side of the 2-4 and 4-2 repeaters have nominal 600- or 1200-ohm inputs and outputs, selectable by a slide switch marked OUTPUT on the component board.

8.10 There is a slight difference in the reactive component of the impedance on the 4-wire side of the repeater, depending on whether the input or the output of RU1 and RU2 is being

measured. This difference is shown in Fig. 32 for an impedance setting of 600 ohms and in Fig. 33 for an impedance setting of 1200 ohms. These impedance values are not significantly affected by changes in gain and equalization settings.

8.11 The 2-wire side impedance is fixed at 900 ohms + 2.15 μ F.

2-Wire Return Loss

8.12 Figure 34 shows typical 2-wire return loss curves for the 2-4 and 4-2 repeaters. The return loss is not significantly affected by gain

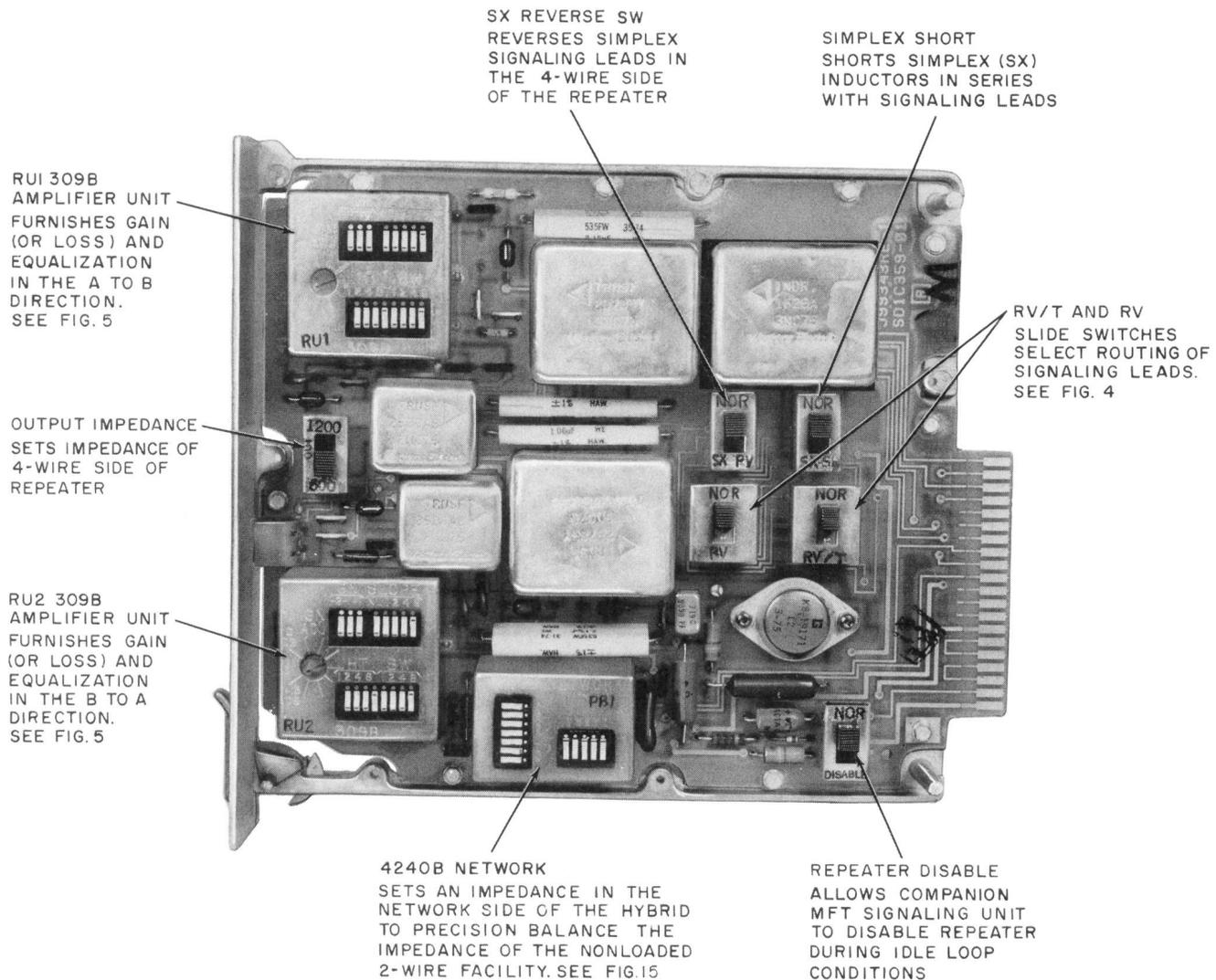


Fig. 20—Switch and Control Functions of the 2-4 Intermediate Repeater (Nonloaded), J99343RE

and equalization adjustments, but may be degraded by equipment connected to the A and B leads if the simplex inductors are shorted.

Transhybrid Loss

8.13 The transhybrid loss (4-wire loss from receive leg to transmit leg) is dependent on the match between the impedance connected to the 2-wire side and the impedance of the PBN. Under ideal test conditions (with matched line and balance impedances), the transhybrid loss of the two-transformer hybrid circuit is greater than 60 dB across the voiceband.

Output Power Capability

8.14 Figure 35 shows the output power capability of the 4-2 and 2-4 repeaters. In 4-wire applications, power limiting occurs in the transmit amplifier unit at about +18 dBm. The output power may be generated by a combination of input power and repeater gain, with the same limiting characteristic as shown by the +6 dB gain line in the figure.

8.15 The maximum power which can be delivered to the 2-wire side of the repeater before limiting occurs is reduced by loss in the hybrid

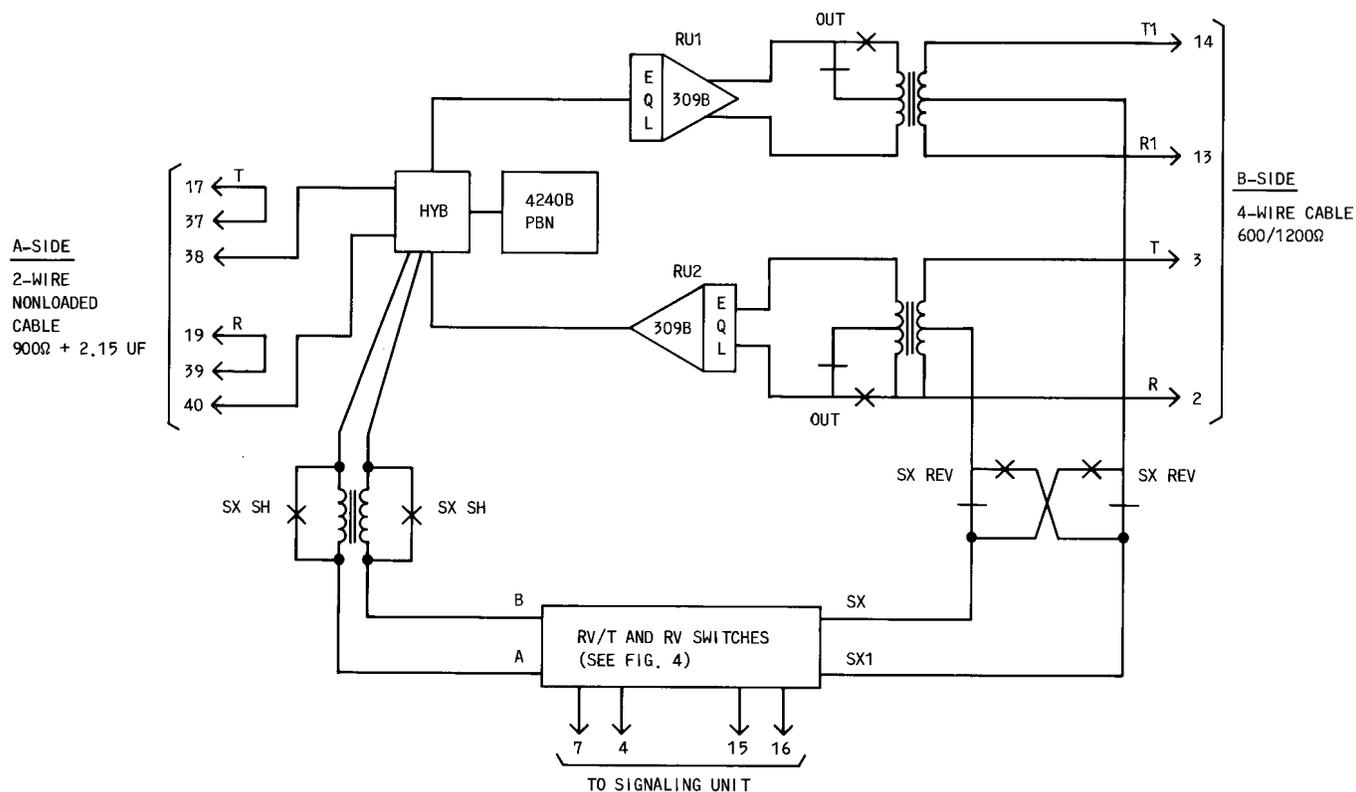


Fig. 21—Block Diagram of the 2-4 Intermediate Repeater (Nonloaded), J99343RE

circuit. Power limiting occurs at about +15 dBm on the 2-wire facility.

Harmonic Distortion

8.16 Although the power transfer characteristic is linear to the values discussed in 8.14 and 8.15, harmonic distortion becomes excessive at a slightly lower output power. Fig. 36 indicates the second and third harmonic content of a 1 kHz sine wave for increasing output power levels. Note that the harmonic distortion becomes excessive at a lower output power in the 2-wire side than in the 4-wire side.

Reverse Transmission Loss

8.17 The reverse transmission loss is greater than 90 dB for frequencies from 20 Hz to 20 kHz.

Longitudinal Balance

8.18 Longitudinal balance on the 4-wire line transformers is greater than 60 dB for

frequencies from 60 Hz to 4000 Hz. Resistive balance allows dc simplex currents of up to 120 ma with no distortion of the voiceband signal. The 120 ma simplex current assumes balanced T and R conductors. Simplex currents of up to 65 made can be applied with a 5 percent unbalance in T and R conductors without significantly affecting the voiceband signal.

8.19 The hybrid transformers have balanced windings to suppress longitudinal currents induced in cable facilities connected to the 2-wire side. The longitudinal balance is greater than 60 dB for frequencies from 60 Hz to 4000 Hz. Transformers in the 2-wire side will accommodate up to 100 ma of dc loop current without significantly affecting the voiceband signal.

Crosstalk

8.20 The equal level crosstalk coupling loss between adjacent repeaters is greater than 90 dB across the voiceband.

TABLE A

REPEATER GAIN	-20 dB to -24 dB
EQUALIZATION	Adjustable
EQUALIZER GAIN	0 dB to +15.3 dB additional gain at 1 KHz depending on setting
IMPEDANCE	2 wire: 900 ohms + 2.15 microfarads 4 wire: 600 or 1200 ohms
HYBRID BALANCE	4240A network and LBOC for H88 loaded HI-CAP cable; 4240B network for nonloaded cable
MAX OUTPUT POWER	+15 dBm - 2 wire +17 dBm - 4 wire
HARMONIC DISTORTION	60 dB (2f and 3f below fundamental)
REVERSE TRANSMISSION LOSS	90 dB
LONGITUDINAL BALANCE (transmission path)	60 dB
CROSSTALK LOSS (to adjacent repeater)	90 dB
DC RESISTANCE	17 ohms - 4 wire 55 ohms - 2 wire, SX shorted 130 ohms - 2 wire, SX in 147 ohms - Through Signaling
CURRENT DRAIN	Disabled: 0 ma No signal: 27 ma Typical: 32-38 ma Maximum: 60 ma

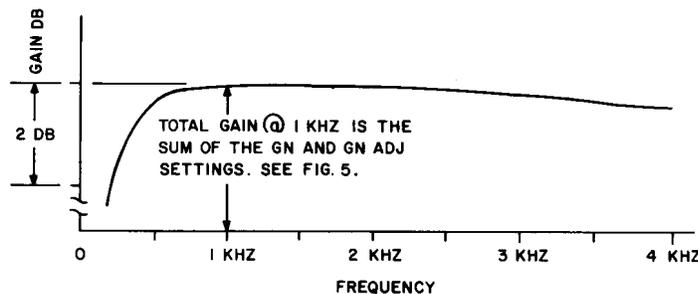


Fig. 22—Gain-Frequency Response of the 309A Amplifier Unit

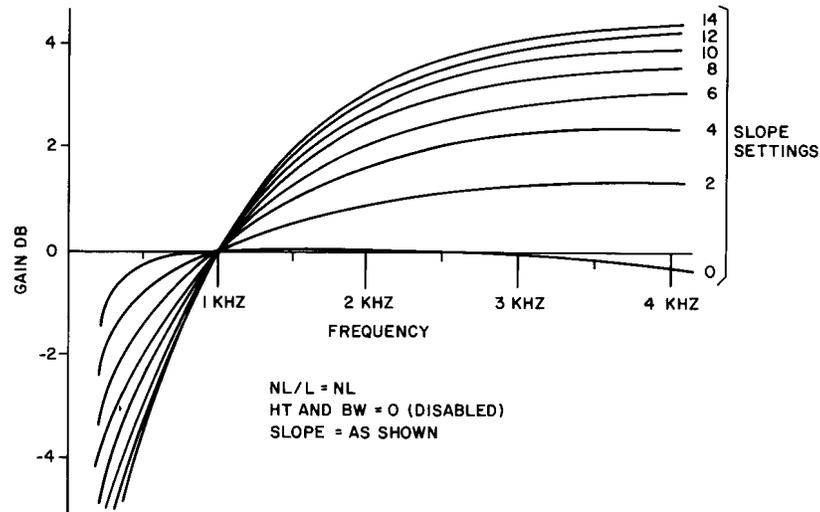


Fig. 23—Relative Gain-Frequency Response of the 309B Amplifier Unit (Equalizer)—NL/L=Nonloaded, Slope Variable

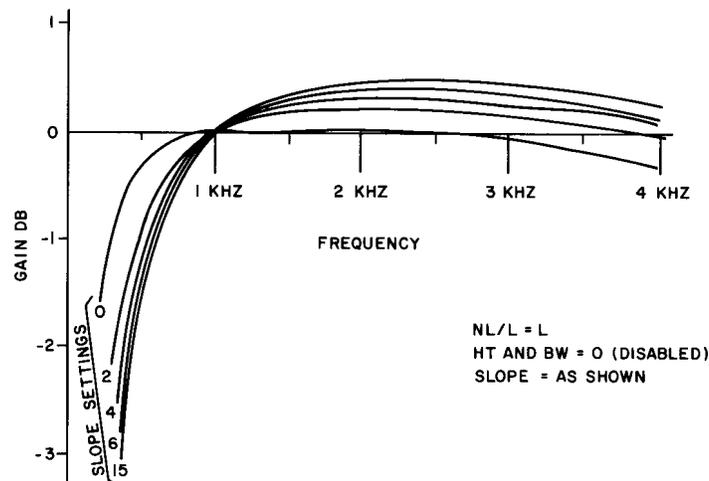


Fig. 24—Relative Gain-Frequency Response of the 309B Amplifier Unit (Equalizer)—NL/L=Loaded, Slope Variable

Noise

8.21 The -24 volt power regulator circuit makes the repeater virtually insensitive to noise on the -48 volt supply. Battery noise from 20 Hz to 20 kHz at a level of +100 dBrn is completely filtered with less than 0 dBrn appearing at the repeater output. High frequency impulse noise generated by nearby relay circuits is minimized by

the metal case and bypass capacitors surrounding the 309-type amplifier units.

9. MAINTENANCE

9.01 There is no routine maintenance required for the MFT repeaters.

9.02 If trouble occurs on a circuit, the problem should first be localized. This procedure is

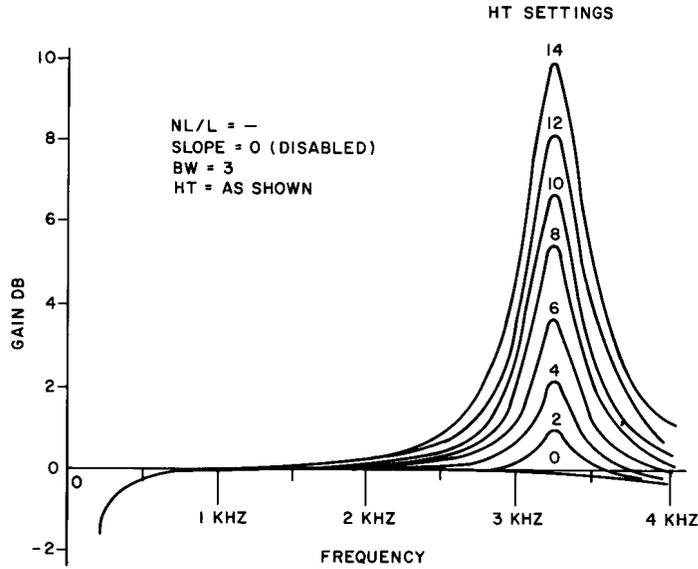


Fig. 25—Relative Gain-Frequency Response of the 309B Amplifier Unit (Equalizer)—BW=Small Setting, HT Variable

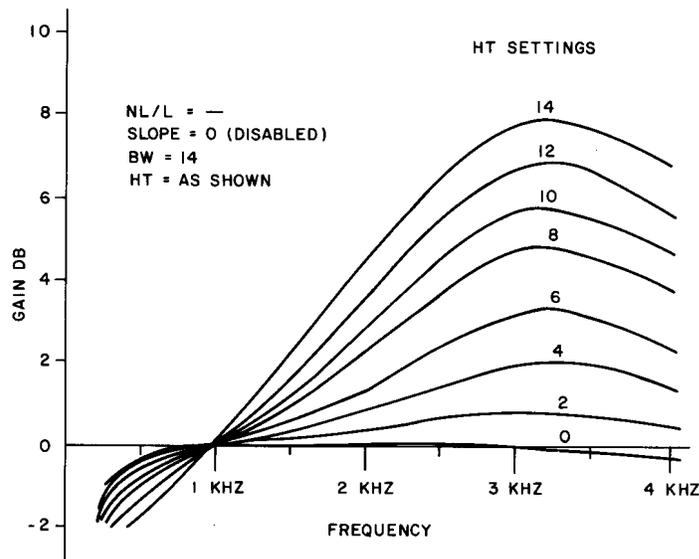


Fig. 26—Relative Gain-Frequency Response of the 309B Amplifier Unit (Equalizer)—BW=Large Setting, HT Variable

simplified in an MFT installation because the repeater and signaling unit (if used) are located adjacent to each other in a bay with supporting equipment.

9.03 If one of the repeaters is determined to be faulty, it is removed from service and replaced by a spare. The defective unit is then sent to the Western Electric Service Center for repair.

TABLE B

**ADDITIONAL 1 KHZ GAIN IN DB
AS A RESULT OF SLOPE SETTINGS**

SLOPE SETTING	NL/L SWITCH	
	NL	L
0*	0	0
1	0.4	1.4
2	0.9	2.6
3	1.4	3.7
4	1.8	4.7
5	2.3	5.5
6	2.8	6.3
7	3.4	7.2
8	3.7	7.8
9	4.2	8.4
10	4.6	9.0
11	5.0	9.5
12	5.4	10.0
13	5.8	10.5
14	6.2	11.0
15	6.6	11.4

* SLOPE setting 0 disables the slope unit.

TABLE C
 ADDITIONAL 1 KHZ GAIN IN DB AS A
 RESULT OF HT AND BW SETTINGS

		HT SETTING																	
		0*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
B W S E T T I N G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0.1	
	6	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.2	
	7	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3
	8	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	
	9	0	0	0	0	0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.5	
	10	0	0	0	0	0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.7	0.7	
	11	0	0	0	0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.6	0.7	0.9	0.9	
	12	0	0	0	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.8	0.9	1.2	1.2	
	13	0	0	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.1	1.3	1.7	1.7	
	14	0	0	0.1	0.1	0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.2	1.4	1.7	2.0	2.5	2.5	
	15	0	0.1	0.2	0.3	0.4	0.5	0.7	0.9	1.2	1.5	1.7	2.0	2.4	2.8	3.3	3.9	3.9	

* HT setting 0 disables the bump unit for all BW settings.

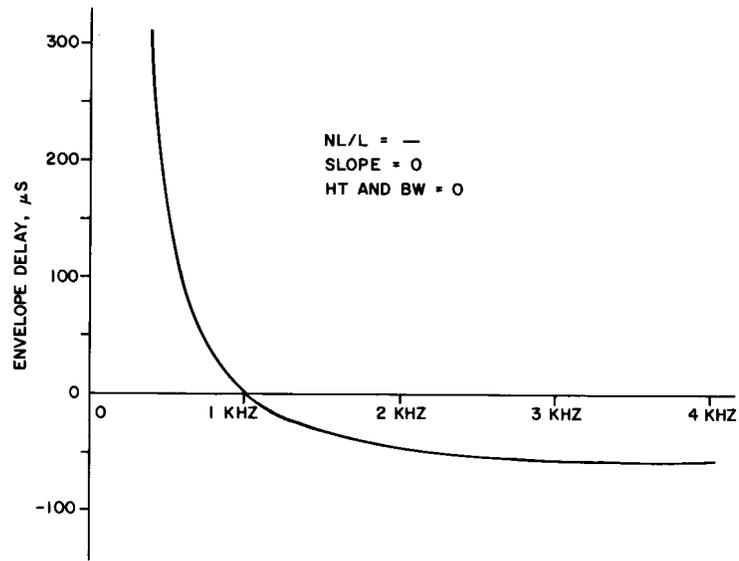


Fig. 27—Relative Envelope Delay Distortion—Equalizer Turned Off

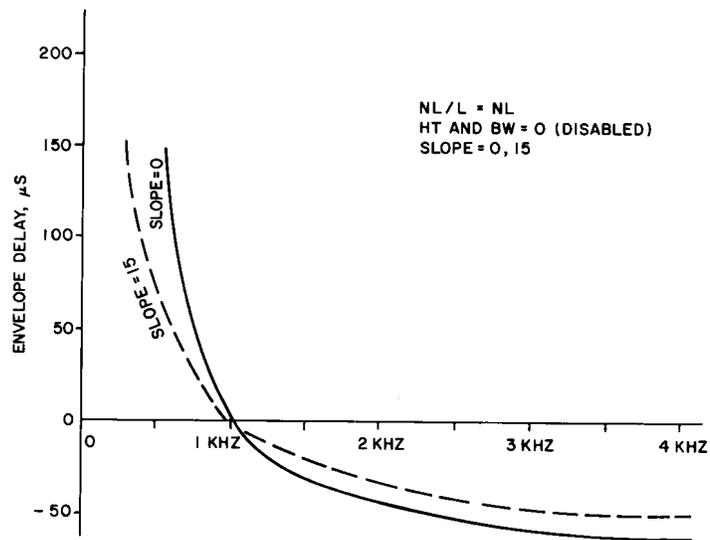


Fig. 28—Relative Envelope Delay Distortion—NL/L=Nonloaded, Slope Variable

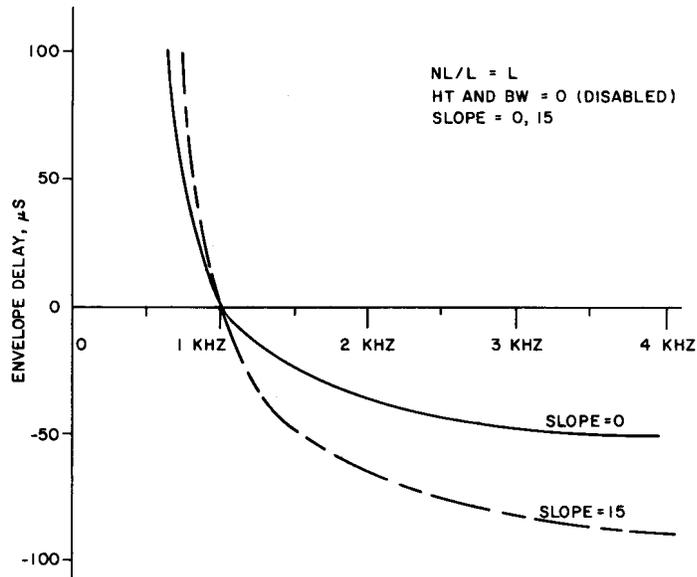


Fig. 29—Relative Envelope Delay Distortion—NL/L=Loaded, Slope Variable

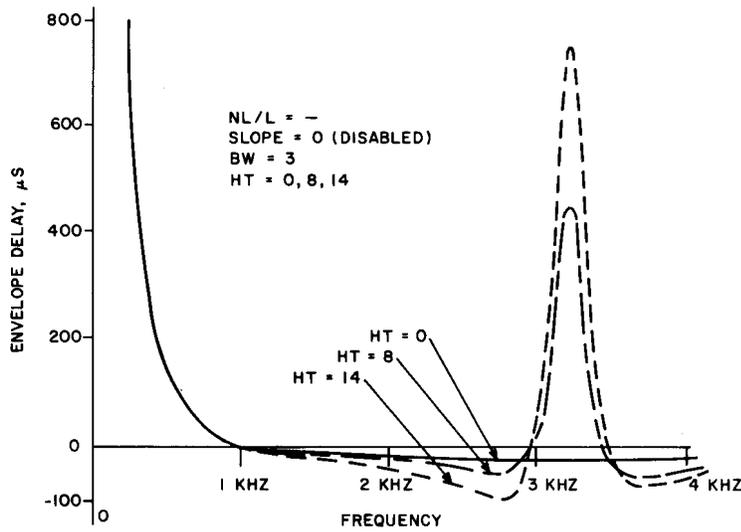


Fig. 30—Relative Envelope Delay Distortion—BW=Small Setting, HT Variable

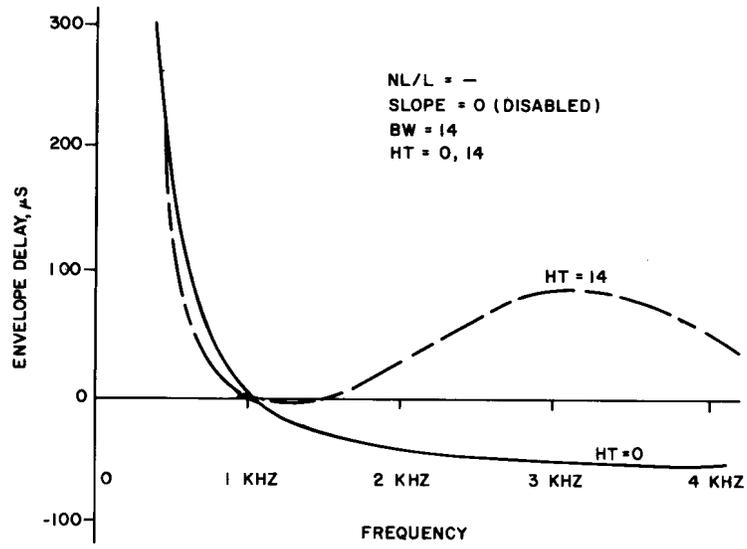


Fig. 31—Relative Envelope Delay Distortion—BW=Large Setting, HT Variable

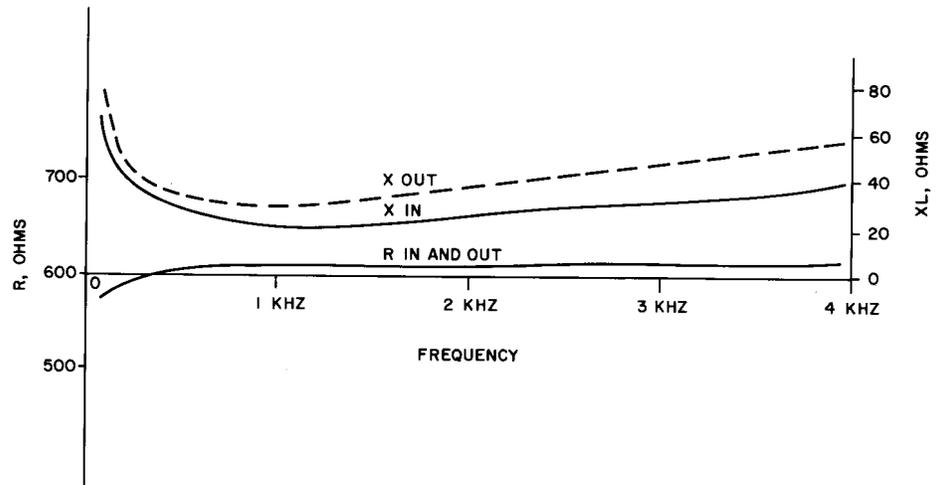
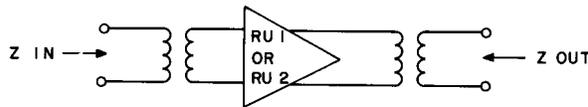


Fig. 32—Input and Output Impedance of 4-Wire Side, 600-Ohm Setting

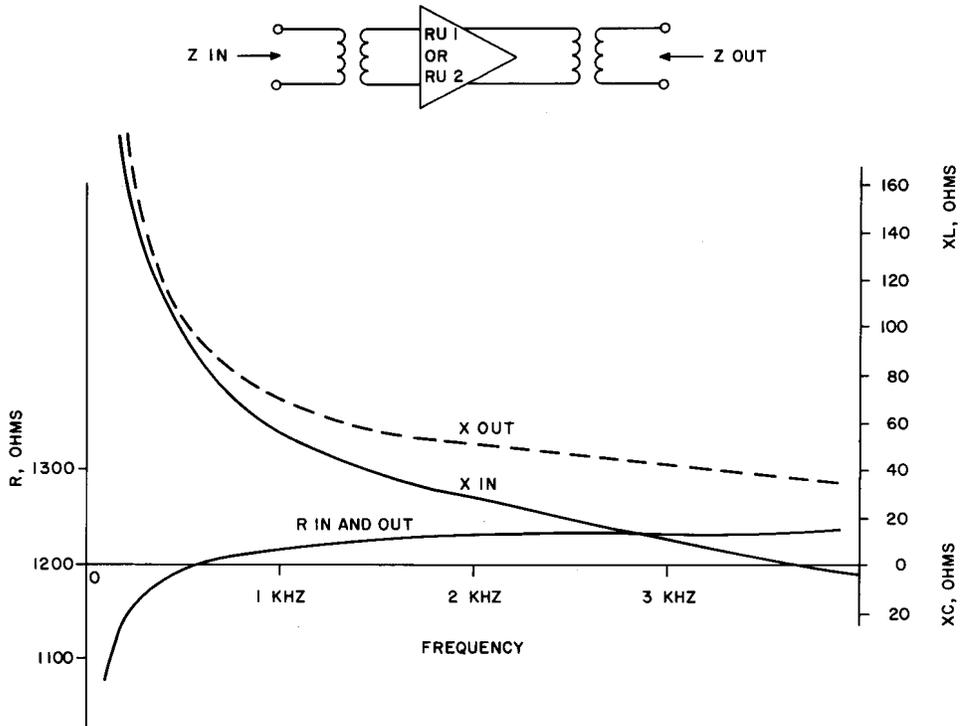


Fig. 33—Input and Output Impedance of 4-Wire Side, 1200-Ohm Setting

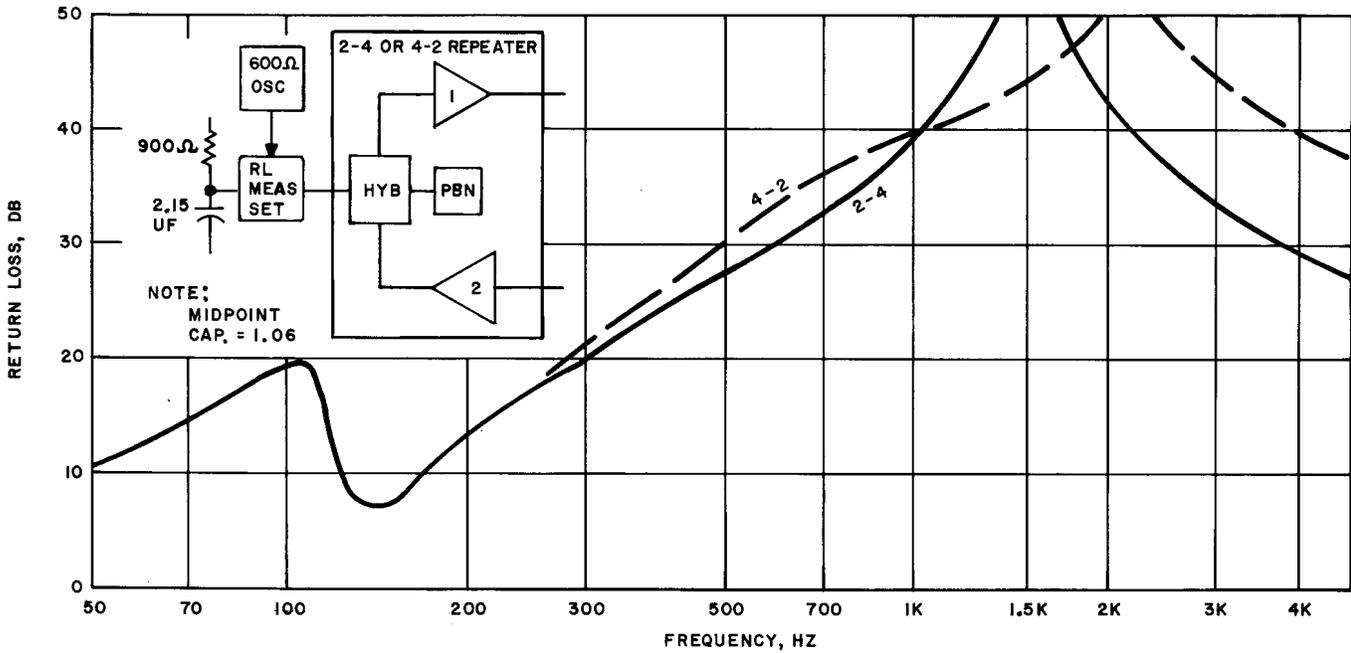


Fig. 34—Typical 2-Wire Return Loss Against $900\Omega + 2.15 \mu F$

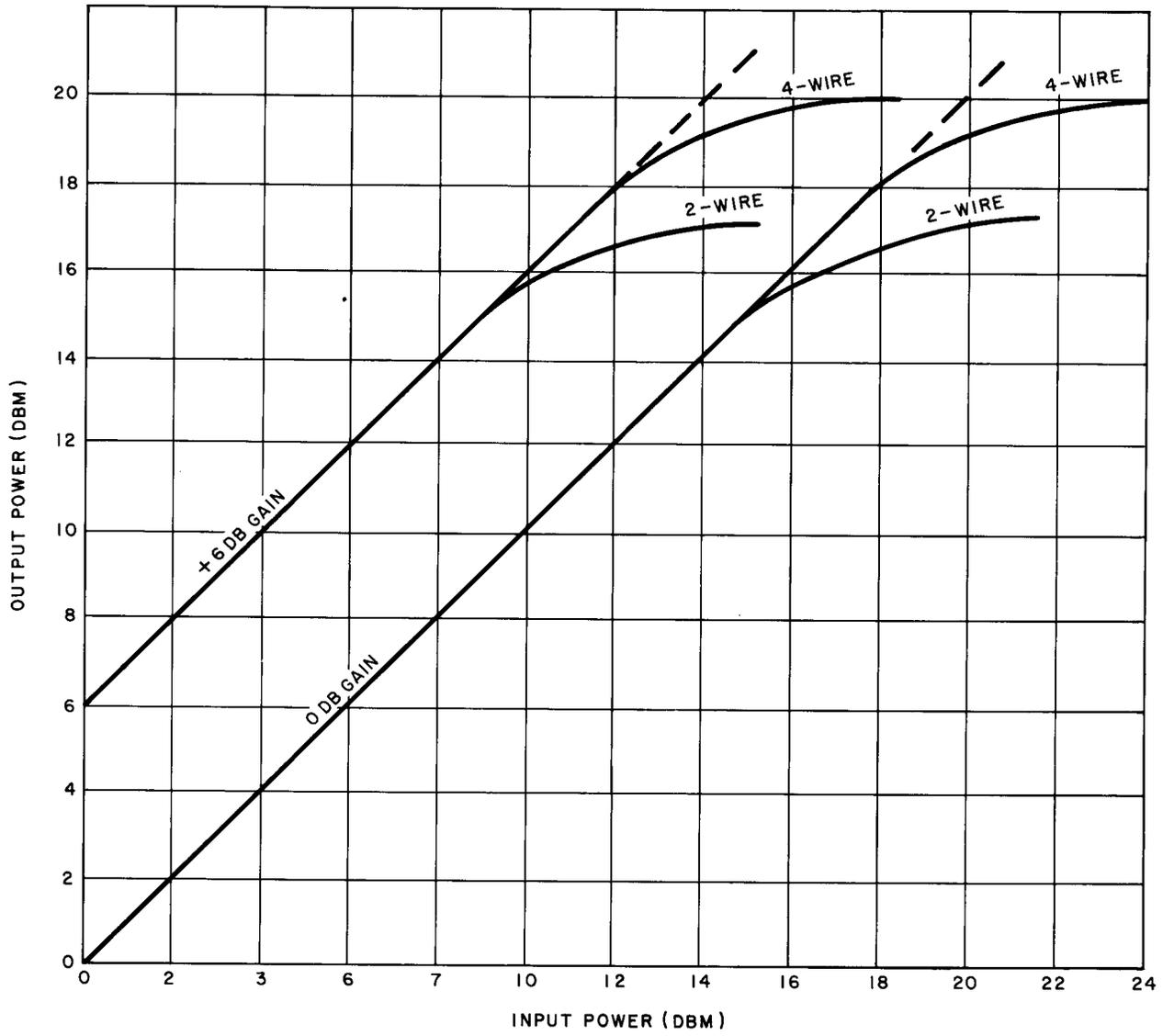


Fig. 35—Output Power Capability of 4-2 and 2-4 Repeaters

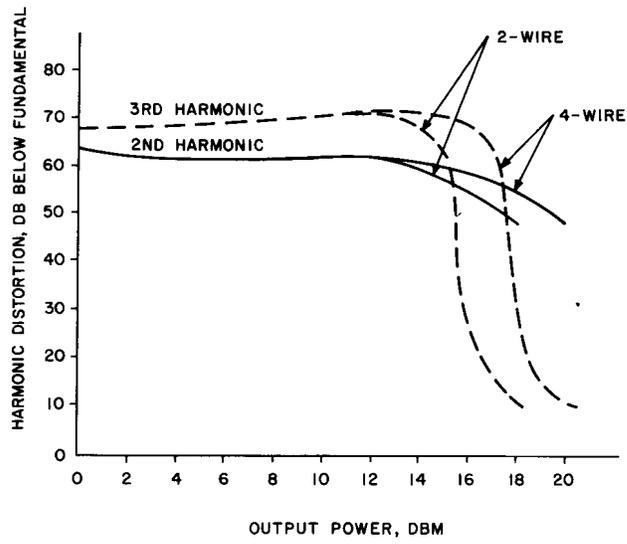


Fig. 36—Harmonic Content of 1 kHz Sine Wave