METALLIC FACILITY TERMINAL

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

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

SD-1C359-01

INSTALLATION AND TESTING

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1. GENERAL

1.01 This section describes the installation and test of the 4-2 and 2-4 repeater units (except as noted below) designed for use in Metallic Facility Terminal (MFT) units or in Customer Premises Facility Terminals (CPFTs). These units supply gain, equalization, and precision balance for 2-wire voice-frequency (VF) circuits either loaded (L) or nonloaded (NL), and loaded or nonloaded 4-wire VF circuits.

> ***Note 1:*** The 2-4 terminal repeater J99343RA and J99343RF are similar to the 4-4 repeaters in their use and operation. Therefore, they are described in Section 332-912-131. Installation and testing of the J99343RA and RF are included in Section 332-912-231, and prescription settings are found in Section 332-912-232.

> ***Note 2:*** The 2-wire cable is often referred to in this section as a "2-wire extension" off of 4-wire equipment or off of a 4-wire cable facility.

1.02 This section is reissued to include information on the J99343RG intermediate/terminal 4-2 wire MFT repeater (used with loaded 2-wire circuits), the J99343RH intermediate 2-4 wire MFT repeater (used with loaded 2-wire circuits), and the J99380TB test extender. The J99343RG and J99343RH repeaters are compatible with metropolitan area trunk (MAT) loaded cable and replace the J99343RB and J99343RD repeaters, respectively, which are rated MD. The J99380TB test extender is used primarily for installation and testing of MFT repeaters at CPFT locations. The J99380TB test extender permits jack access of MFT repeaters for monitoring, transmitting, and receiving test tones. This revision does not affect the Equipment Test List. Since this is a general revision, no arrows have been used to denote significant changes.

1.03 The 4-2 and 2-4 wire repeaters covered in this section are part of the MFT family of standardized, modular equipment which furnishes transmission and/or signaling functions for VF metallic (wire) circuit facilities. A variety of transmission and signaling plug-in equipment may be paired together in an MFT shelf or bay mounting arrangement. A complete list of this equipment with application guidelines are contained in Section 332-910-180.

1.04 Wiring connections between the MFT shelf and the main distributing frame (MDF) route all circuit functions into the MFT repeater when it is plugged into the shelf. A, B, SX, and SX1 signaling leads are derived in the repeater and routed to the companion signaling unit through wiring straps on the shelf connectors.

1.05 The terminal repeater A-side normally faces the office side (sometimes referred to as the terminal equipment or equipment side). The terminal repeater B-side normally faces a cable facility (sometimes referred to as the cable or facility side). Both sides of an intermediate repeater normally face a cable facility.

1.06 The first digit in the repeater description [eg, the 4 in 4-2 intermediate/terminal repeater (L)] indicates the type of operation on the A-side which is 4-wire in this case. The second digit indicates the type of operation on the B-side. The 4-2 repeaters therefore connect to a 4-wire arrangement on the A-side and the 2-4 repeaters connect to a 4-wire arrangement on the B-side. The opposite side of each connects to a 2-wire arrangement.

1.07 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, RH) are for intermediate use only.

> ***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.

1.08 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 if the 2-wire facility is H88 loaded; 4240B if nonloaded; and 4240C if 2-wire facility is H88 loaded MAT
- Whether the amplifier unit in each direction of transmission is a 309A flat-gain type or 309B equalizing type.

1.09 A detailed description including applications for the J99343RB, RC, RG, RD, RE, and RH repeaters is given in Section 332-912-121.

Prescription setting information is given in Section 332-912-222.

2. GAIN AND EQUALIZATION

A. General

2.01 The J99343RB, RC, and RG (terminal/intermediate) and the J99343RD, RE, and RH (terminal) repeaters utilize 309-type amplifier units for gain, or gain and equalization treatment. Block diagrams of the J99343RB/RG, RC, RD/RH, and RE repeaters are shown in Fig. 1, 2, 3, and 4, respectively.

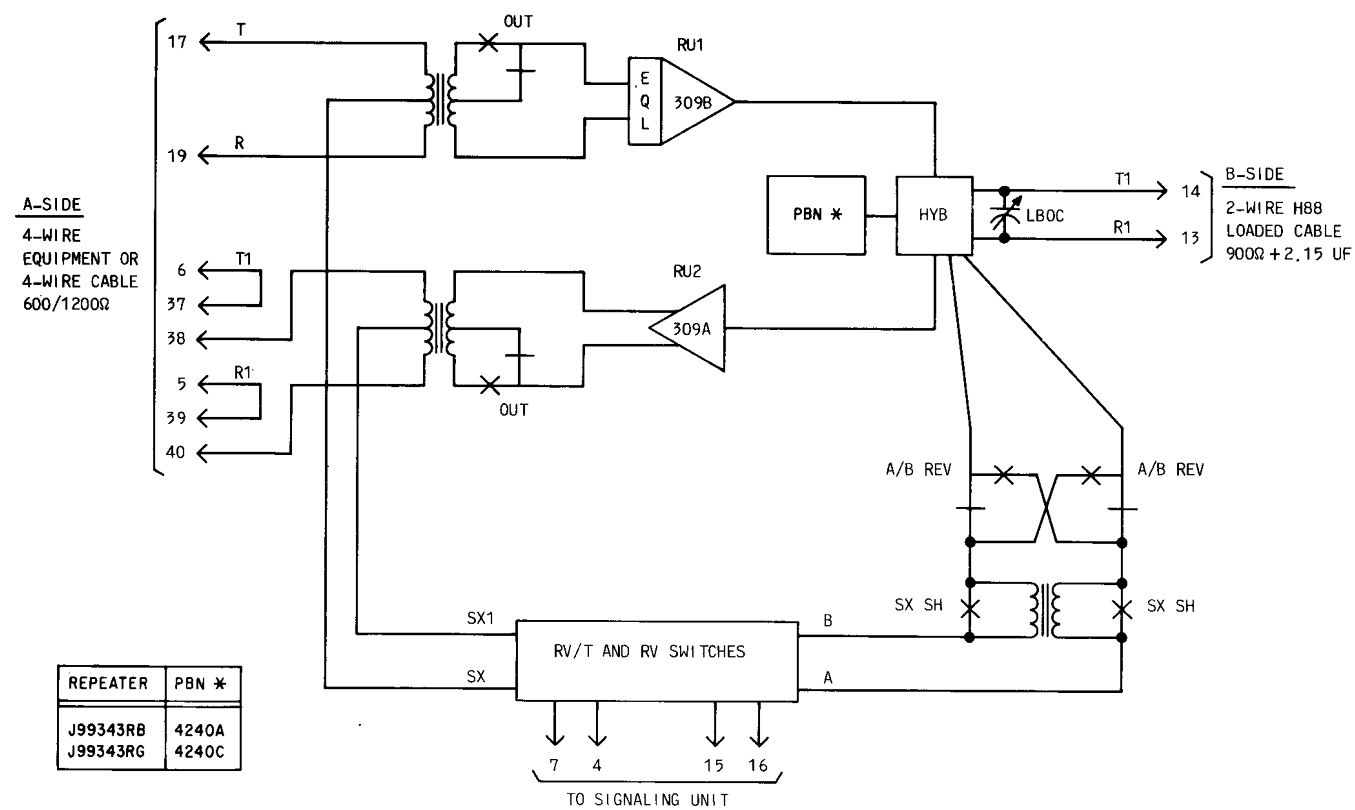
2.02 The 309-type amplifier units are labeled RU1 and RU2. Equalization and/or gain is provided by RU1 for VF transmission from the A-side to the B-side and by RU2 for VF transmission from the B-side to the A-side. The amplifier units can be adjusted for -20 dB (loss) to +24 dB (gain).

B. Amplifier Unit Description

309A Amplifier

2.03 The 309A flat-gain amplifier unit controls are shown in Fig. 5. Three gain range switches labeled GN (-2, -1, +1) and a gain adjust potentiometer labeled GN ADJ control the flat gain of the amplifier. The -2, -1, and +1 values of the gain range switches set the repeater for -20 dB (loss), -10 dB (loss), and +10 dB (gain), respectively. Only one of the gain range switches may be operated at the same time, eg, operation of the -2 and -1 switches simultaneously will not provide -30 dB loss. When all gain range switches are operated away from the -2, -1, and +1 designations (off), in the nonoperated position, the amplifier is set for 0 dB gain (assuming the GN ADJ potentiometer is turned fully counterclockwise). A gain range (GN) switch is operated by depressing the rocker toward the designation (either -2, -1, or +1).

2.04 The GN ADJ potentiometer permits fine gain adjustment by adding from 0 to +14



REPEATER	PBN *
J99343RB	4240A
J99343RG	4240C

Fig. 1—Block Diagram of the 4-2 Intermediate/Terminal Repeater (L), J99343RB(MD), RG

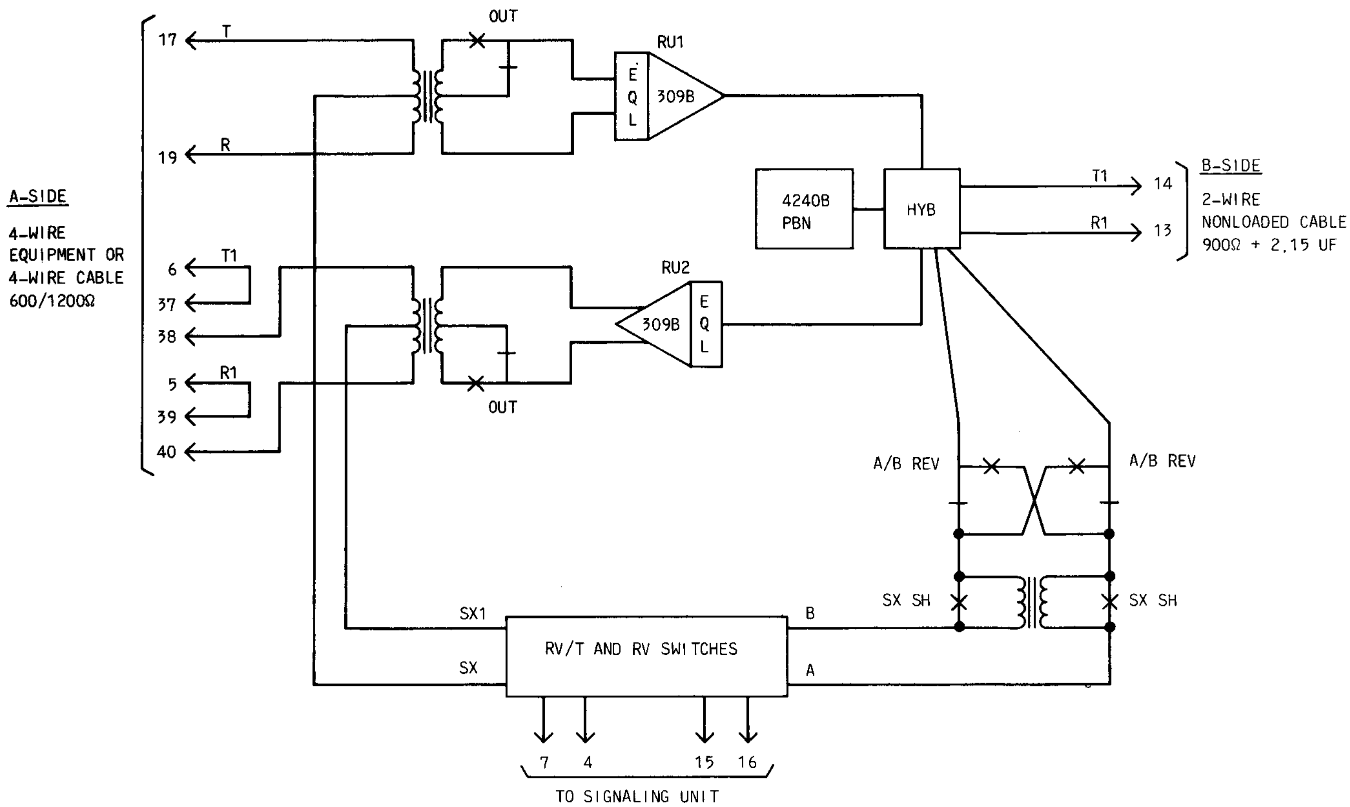


Fig. 2—Block Diagram of the 4-2 Intermediate/Terminal Repeater (NL), J99343RC

dB to the gain set by the GN switches. The gains indicated for both 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.

309B Amplifier

2.05 The 309B equalizing amplifier unit has identical flat-gain characteristics and controls as described for the 309A amplifier. In addition, adjustable equalization is provided which is controlled by the following four adjustments shown in Fig. 6.

(a) A switch labeled NL selects the equalization characteristics for loaded or nonloaded cable (the switch rocker is depressed toward the NL marking for nonloaded cable). Although this switch is marked NL on the 309B amplifier unit, its operation in the opposite direction sets the equalizer for use with loaded (L) facilities. It is therefore referred to as the NL/L switch in the following discussion.

Note: There may be instances where the NL/L switch setting is not necessarily correlated with the type of cable. For example, a section of loaded cable with a very long end section may require the NL setting. The setting of this switch is determined by the procedures and tables in Section 332-912-222.

(b) A group of four switches labeled SLOPE generates one of 16 possible low-frequency gain characteristics.

(c) A group of four switches labeled HT (height).

(d) A group of four switches labeled BW (bandwidth) combines to form a high-frequency "bump" shape to the gain-frequency characteristic centered at 3250 Hz.

Note: Later production versions of the 309B amplifier unit have revised marking for the NL switch. These contain only the single letter "N" indicating the switch position for nonloaded facilities. The letter "L" on the

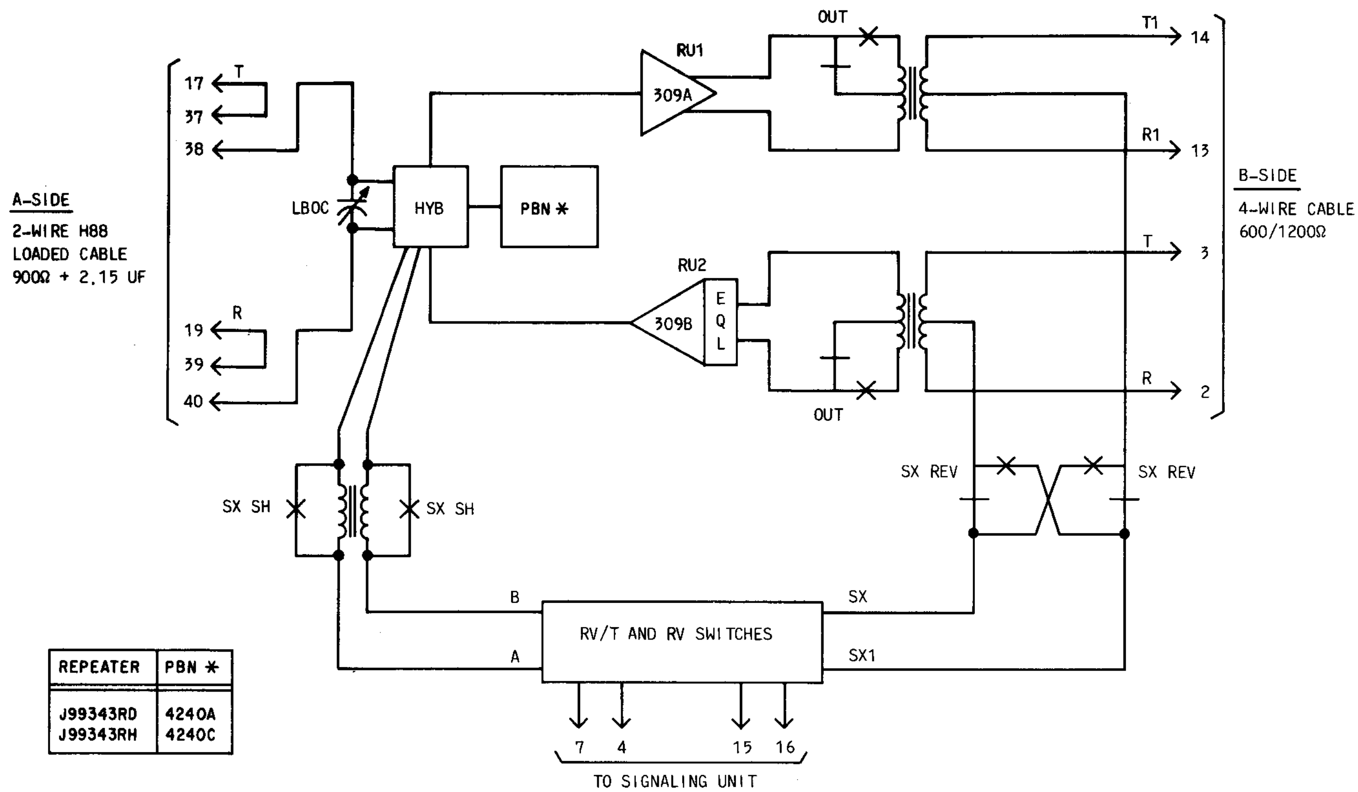


Fig. 3—Block Diagram of the 2-4 Intermediate Repeater (L), J99343RD(MD), RH

opposite side of the switch indicates the switch position for loaded facilities. Electrical characteristics of both versions are identical.

2.06 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).

2.07 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, 16 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:

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)

3. PRECISION BALANCING

A. General

3.01 The 4-2 and 2-4 wire repeaters utilize a 2-transformer hybrid to split the 2-wire transmission path into a 4-wire path through the repeater unit permitting separate equalization and/or gain treatment for each direction of transmission. Precision balance or impedance matching for the hybrid transformer circuits of the 4-2 and 2-4 wire repeaters (which interface H88 loaded or nonloaded 2-wire cable) is accomplished by three types of

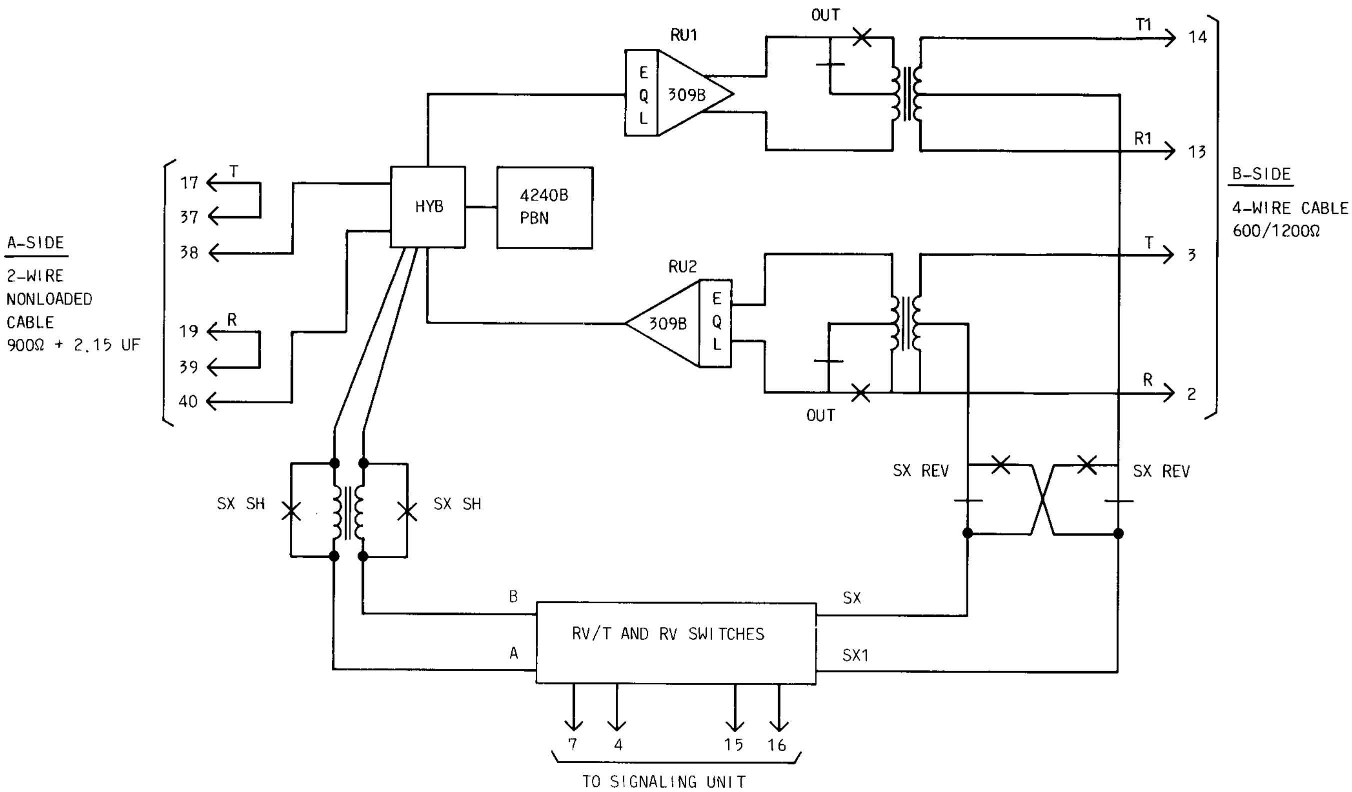


Fig. 4—Block Diagram of the 2-4 Intermediate Repeater (NL), J99343RE

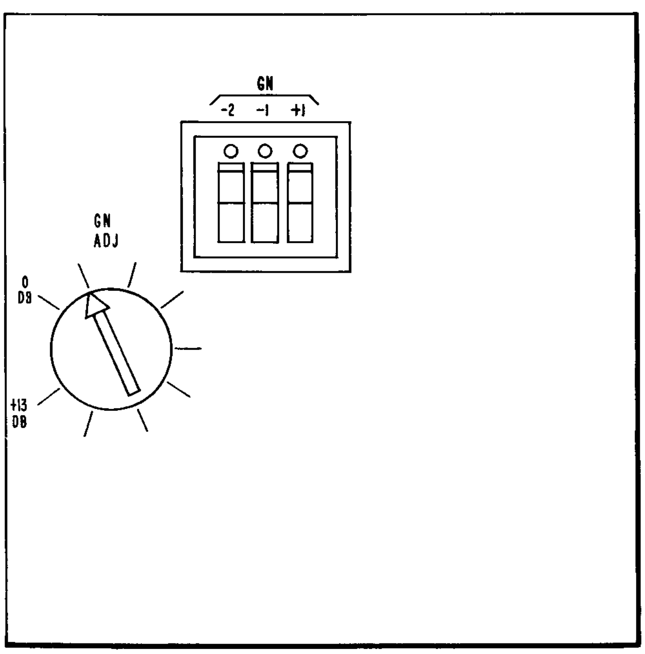


Fig. 5—309A Amplifier Unit Controls

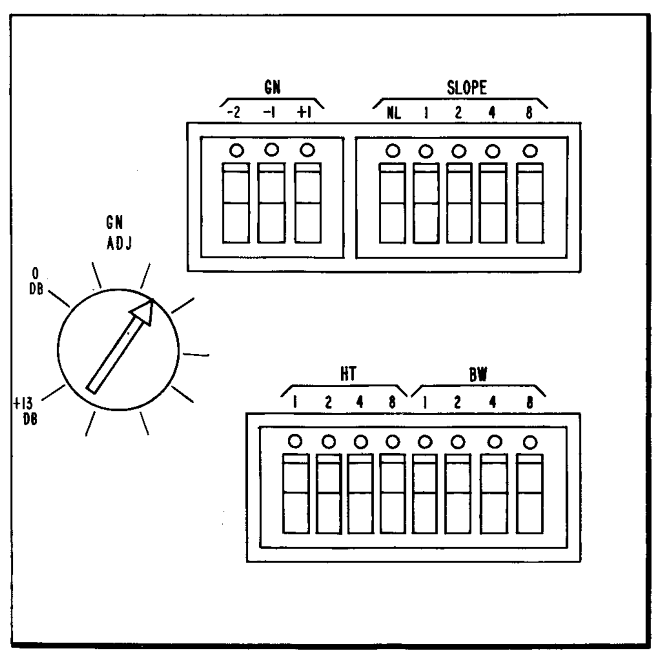


Fig. 6—309B Amplifier Unit Controls

4240-type precision balancing networks (PBNs). The PBNs required for each of the repeaters in this section are shown in Fig. 1 through 4. Prescription settings for the PBNs are given in Section 332-912-222.

3.02 Label designations of early production 4240A and 4240B precision-built networks were changed in later production models as described in paragraphs 3.03 and 3.04. The old label designations can be replaced with the current production labels by application of the appropriate decals to the network housing. The new decals may be ordered from the Western Electric Service Center by the following part numbers:

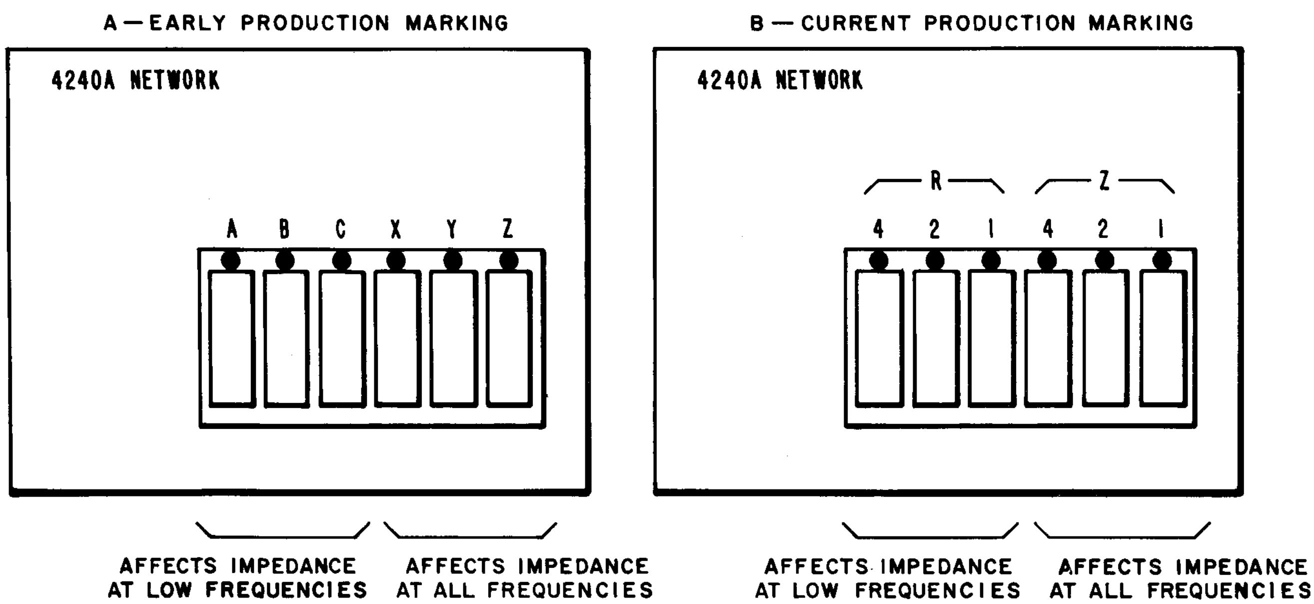
- 4240A Network—Part No. 842165557
- 4240B Network—Part No. 842165565

B. 4240A PBN

3.03 The 4240A PBN, in combination with Line Build-Out Capacitors (LBOCs), is used to balance or impedance match high-capacitance (.083 μF/mile) H88 loaded 2-wire cable. The 4240A, used in the J99343RB and J99343RD, is rated MD. The controls of the 4240A are shown in Fig. 7. Early production models were labeled ABC and XYZ which were changed to R(4,2,1) and Z(4,2,1) for current production models (see paragraph 3.02). The letter or number designation for each switch represents the relative effect of operating that switch. The R or ABC switches establish the frequency at which the impedance of the network increases with a decrease in frequency. The Z or XYZ switches affect the magnitude of impedance at all frequencies, as shown graphically in Fig. 8. Multiple switches in a group can be operated simultaneously. The total effect can be determined by adding the numbers of the operated switches, eg, 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 depressing the rocker toward the switch designation. 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).



NOTE:
FUNCTIONS ARE ENERGIZED WHEN SWITCHES ARE PRESSED TOWARD THE DESIGNATION.

Fig. 7—4240A Precision Balancing Network Switch Functions

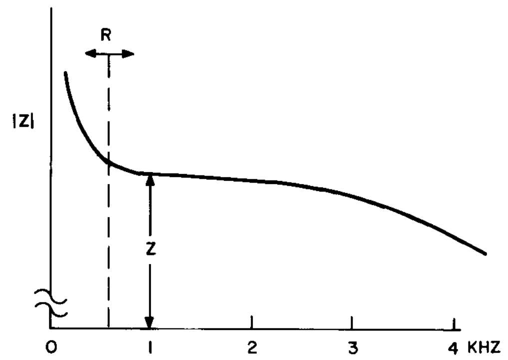


Fig. 8—Effect of 4240A Controls on Impedance

C. 4240B PBN

3.04 Precision balance for transformer hybrids interfacing nonloaded 2-wire cable is accomplished by a 4240B network. The 4240B controls are shown in Fig. 9. Two diagrams are shown due to label changes as described for the 4240A controls. The R1 or ABC controls affect the point at which the network impedance begins decreasing with an increase in frequency. The R2 or KLMN controls determine the frequency at which the impedance curve levels out. The R1 adjustment will affect the frequency at which the impedance curve levels out and should therefore be adjusted before setting R2. The Z or VWXYZ controls determine the value of impedance across the voiceband, as shown graphically in Fig. 10. The three sets of switches on the 4240B are set similar to the method described for setting the 4240A PBN. A typical setting for the 4240B contains three parameters such as the following:

R1 = 4 (switch 4 operated; 2 and 1 not operated)

R2 = 9 (switches 8 and 1 operated; 4 and 2 not operated)

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

D. 4240C PBN

3.05 The 4240C PBN, being an improved version of the 4240A, has the same impedance matching capability as the 4240A PBN for 19-, 22-, 24-, and 26-gauge high-capacitance H88 loaded cable. In addition, the 4240C PBN has impedance matching capability for 25-gauge low-capacitance H88 loaded MAT cable. An additional switch designated L configures the 4240C PBN for matching low-capacitance MAT cable. The settings for high-capacitance cable (L switch in nonoperated position) are identical to those given for the 4240A PBN. The affect of the R and Z controls on the network impedance are also the same as for the 4240A PBN. The 4240C is shown in Fig. 11. The L control affects the degree of roll-off at the higher frequencies as shown graphically in Fig. 12.

4. LINE BUILD-OUT CAPACITANCE

A. General

4.01 Line build-out capacitance (LBOC) is available on the J99343RB, RG, RD, and RH repeaters to "build out" the near end cable (H88 loaded 2-wire) length to an equivalent 6000 feet.

B. Settings

4.02 The LBOC is adjusted by tightening screw switches (located on the repeater component board) labeled A through F for the value of capacitance required. These switches connect capacitors in parallel to permit selection of 0 to .126-μf values. The capacitance value required is determined by cable type (high- or low-capacitance) and the length of the near end section. Two formulas are given for computation of the LBOC required, one for high-capacitance (.083 μf/mile) cable and one for low-capacitance (.064 μf/mile) MATs. The formulas are described as follows:

> ***Note:*** The LBOC must be set prior to adjusting the PBN.

- High-Capacitance Cable

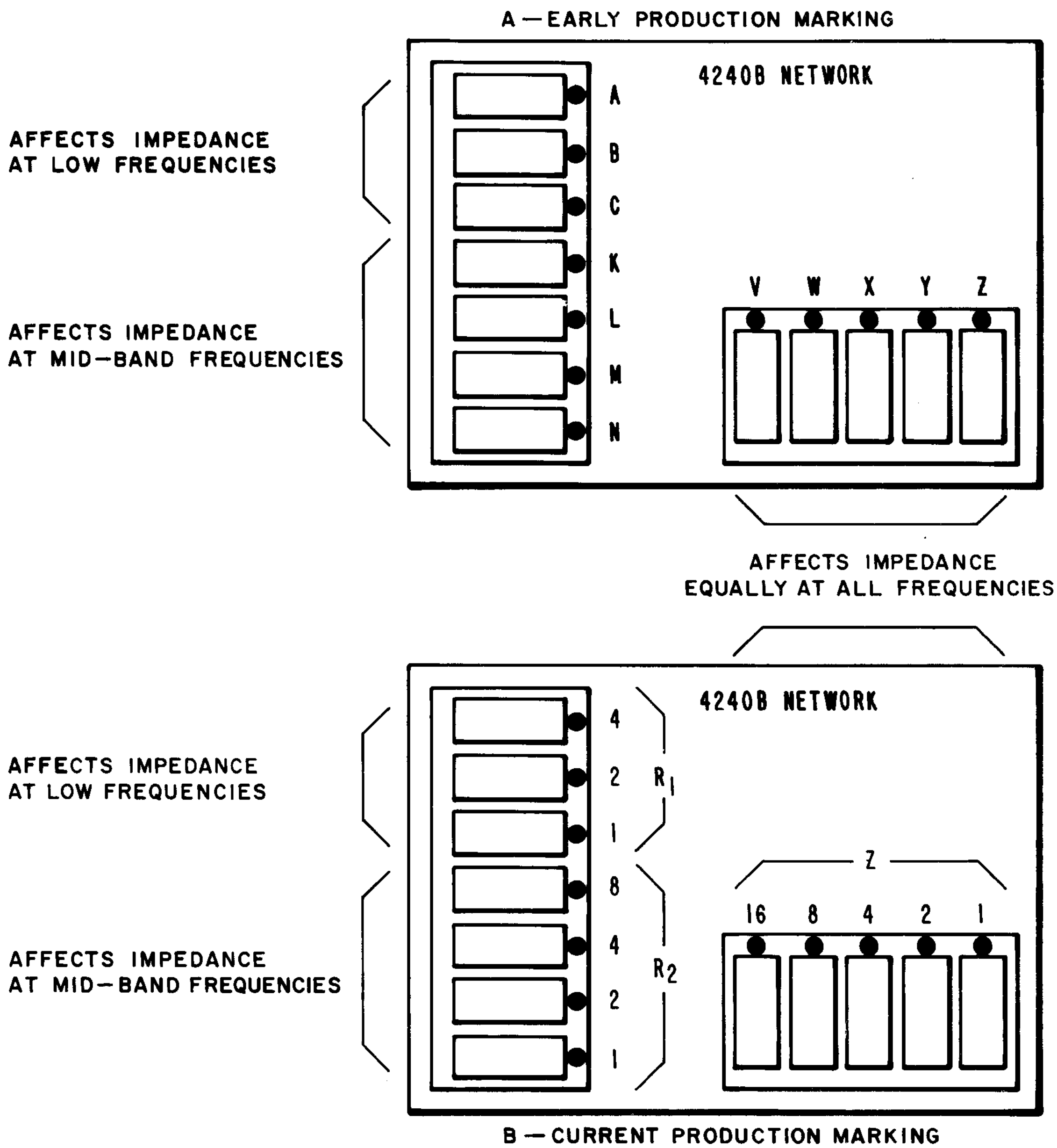
  C = .008 + .016 (6-N)

- Low-Capacitance Cable

  C = .008 + .0122 (6-N).

Value C is the capacitance in μf and N is the length of the near end section in kilofeet.

4.03 For convenience, the value of capacitance and screw-switch settings required for end sections from 1450 to 4549 feet are listed in Table A by cable type.



NOTE:
FUNCTIONS ARE ENERGIZED WHEN SWITCH(S) ARE PRESSED TOWARD THE DESIGNATIONS.

Fig. 9—4240B Precision Balancing Network Switch Functions

5. SIGNALING

A. General

5.01 The A and B signaling leads of the 4-2 and 2-4 repeaters are derived on the 2-wire side of each hybrid and are routed through a pair of simplex (SX) inductors. A shorting switch on the repeater component board (SX SH) allows the inductors to be bypassed in certain signaling arrangements.

5.02 The B-side (station side) signaling leads are routed through a switch which reverses the polarity of the B-side signaling circuit. This switch

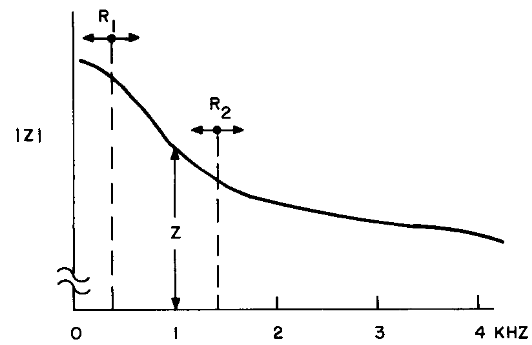


Fig. 10—Effect of 4240B Controls on Impedance

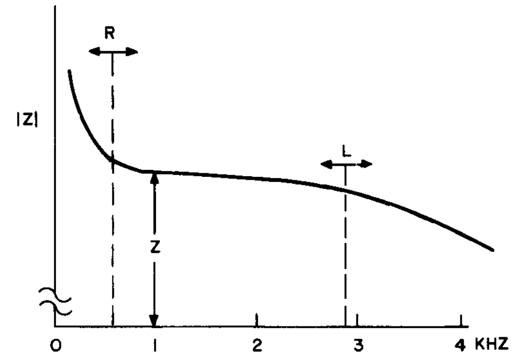


Fig. 12—Effect of 4240C Controls on Impedance

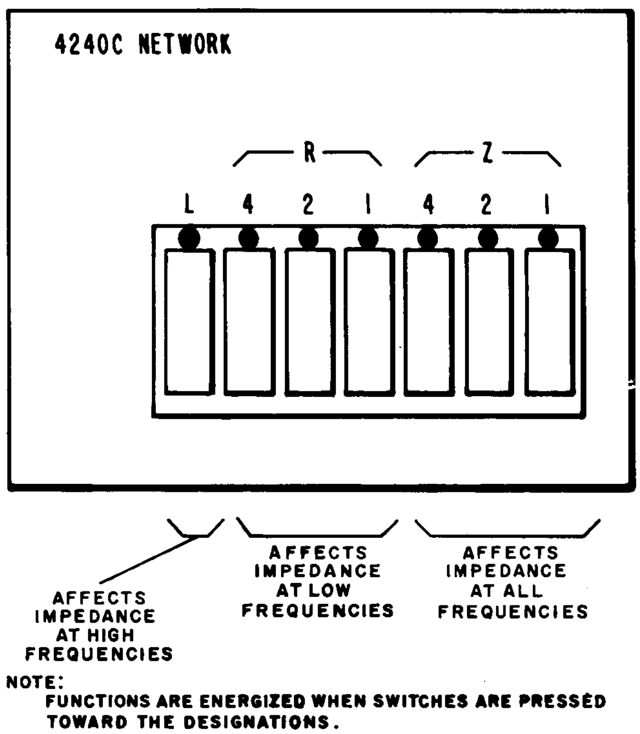


Fig. 11—4240C Precision Balancing Network Switch Functions

is marked NOR, A/B REV in the 4-2 repeaters and NOR, SX RV in the 2-4 repeaters.

5.03 The routing of the signaling leads between the A-side and B-side of the repeater (through the companion signaling unit if one is used) is controlled by a pair of slide switches marked NOR, RV/T and NOR, RV. There are three signaling configurations for which these switches can be set.

(a) Both switches set for NOR—This is the NORMAL signaling mode in which the signaling leads from the A-side of the repeater are routed to the switching side of the signaling unit, and the signaling leads from the B-side of the repeater are routed to the station side of the signaling unit.

(b) Switches set in the RV/T and RV positions—This is the REVERSE signaling mode in which the signaling leads from the A-side of the repeater are routed to the station side of the signaling unit, and the B-side leads from the repeater to the switching side of the signaling unit.

(c) RV/T switch in RV/T position, RV switch in NOR position—This is the THROUGH signaling mode which routes the signaling leads through the repeater when a signaling unit is not used.

5.04 Each repeater has a DISABLE switch on the component board. When this switch is in the NOR position, power to the active devices in the repeater is supplied continuously. When in the DISABLE position, power to the repeater is controlled by a set of relay contacts in the companion signaling unit such that the repeater is energized only when the circuit is in use. This switch must be set in the NOR position when there is no signaling unit present or if the signaling unit does not have a disable feature.

B. Midpoint Capacitor Setting

General

5.05 The repeaters that can be used in terminal applications (J99343RB, RC, and RG) contain

TABLE A

LBOC SETTINGS
(H88 LOADED CABLE)

END-SECTION LENGTH (FEET)	CAPACITANCE VALUE HI-CAP.	SCREWS DOWN	CAPACITANCE VALUE LOW-CAP. (MAT CABLE)	SCREWS DOWN
1450 — 1549	.080	DF	.064	F
1550 — 1649	.078	ABCF	.062	ABCDE
1650 — 1749	.076	BCF	.060	BCDE
1750 — 1849	.076	BCF	.060	BCDE
1850 — 1949	.074	ACF	.058	ACDE
1950 — 2049	.072	CF	.058	ACDE
2050 — 2149	.070	ABF	.056	CDE
2150 — 2249	.068	BF	.054	ABDE
2250 — 2349	.068	BF	.054	ABDE
2350 — 2449	.066	AF	.052	BDE
2450 — 2549	.064	F	.052	BDE
2550 — 2649	.062	ABCDE	.050	ADE
2650 — 2749	.060	BCDE	.048	DE
2750 — 2849	.060	BCDE	.048	DE
2850 — 2949	.058	ACDE	.046	ABCE
2950 — 3049	.056	CDE	.046	ABCE
3050 — 3149	.054	ABDF	.044	BCE
3150 — 3249	.052	BDE	.042	ACE
3250 — 3349	.052	BDE	.042	ACE
3350 — 3449	.050	ADE	.040	CE
3450 — 3549	.048	DE	.040	CE
3550 — 3649	.046	ABCE	.038	ABE
3650 — 3749	.044	BCE	.036	BE
3750 — 3849	.044	BCE	.036	BE
3850 — 3949	.042	ACE	.034	AE
3950 — 4049	.040	CE	.032	E
4050 — 4149	.038	ABE	.032	E
4150 — 4249	.038	ABE	.030	ABCD
4250 — 4349	.036	BE	.030	ABCD
4350 — 4449	.034	AE	.028	BCD
4450 — 4549	.032	E	.026	ACD

an adjustable hybrid transformer midpoint capacitor on the repeater B-side. This capacitor is set for an optimum value, depending upon the type of signaling used on the circuit.

Settings

5.06 The J99343RB and RC intermediate/terminal repeaters contain midpoint capacitor options to maintain hybrid balance in certain DX signaling applications. A pair of screw switches marked S1 and S2 on the component board connects capacitors between windings of the hybrid transformer. The screws should be set as follows:

- With non-MFT DX signaling, the DX trunk circuit places 4.0 μF across the A and B leads with the SX inductors shorted. The S1 screw should be down and the S2 screw should be up to maintain balance.

- With all other signaling (including MFT DX), the S1 screw should be up and the S2 screw should be down.

6. GAIN TRANSFER

6.01 The 4-2 and 2-4 repeaters which are used in intermediate applications should be adjusted so the 4-wire portion of the circuit operates at a net gain. Figure 13 shows an access line which includes a 4-wire portion between central offices and a 2-wire extension to a customer. An MFT 2-4 repeater and 4-2 repeater are located at each end of the 4-wire portion of the circuit and furnish gain for the entire access line.

6.02 As shown in Fig. 13, the overall end-to-end objective is 3.5 dB. Since the 2-wire extension has a 1-kHz loss of 5.5 dB, an output level of +2 dBm is required at the junction between the 4- and 2-wire facilities. The transmission level must therefore be higher leaving the 4-wire portion (+2 dBm at CO B) than entering the 4-wire portion (0 dBm at the switch). Notice also that the receive level at the switch (-3.5 dBm) is higher than the level entering the 4-wire cable from the 2-wire cable (-5.5 dBm). By adjusting the repeaters to the levels shown, the gain in the 4-wire circuit is, in effect, "transferred" to the 2-wire portion of the circuit. If the transmit level at the switch in CO A is defined as the 0 TLP, then the levels discussed above translate directly to TLPs.

6.03 As a result of this gain transfer, the entire 4-wire portion of the circuit behaves in many ways like a 2-2 repeater. It exhibits a net gain, requires precision balancing of the 2-wire cable, and when the balance is set incorrectly can oscillate (sing or howl).

7. APPLICATION GUIDELINES

A. Level Requirements

7.01 The maximum allowable transmission level for 4-wire circuits are limited by crosstalk and stability considerations. As pointed out in Part 6, a 4-wire circuit with a single 2-wire extension behaves much the same as a terminal 2-2 repeater with the same amount of 2-wire cable. Likewise, a 4-wire circuit with two 2-wire extensions behaves very much like a 2-2 intermediate repeater. These similarities result in the level requirements for

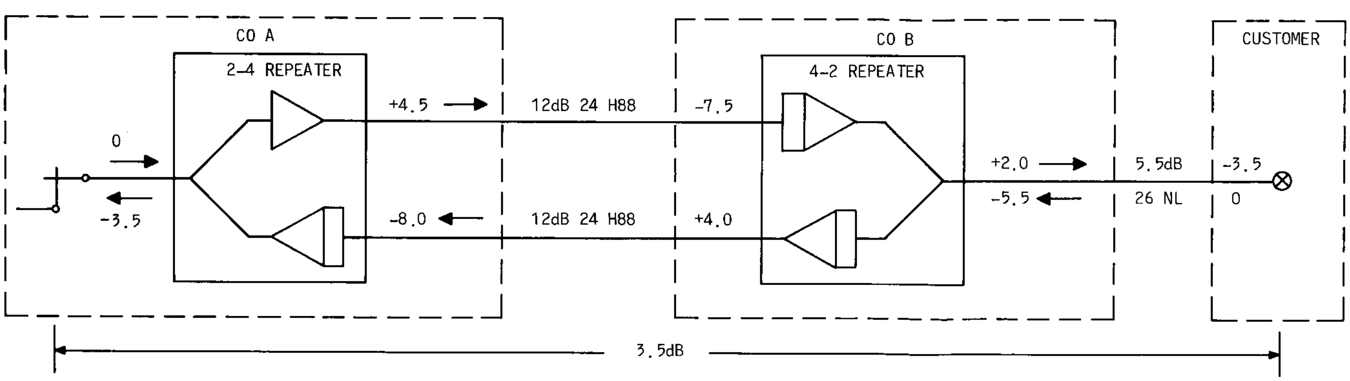


Fig. 13—Circuit With Gain Transfer

this circuit to be the same as for the MFT 2-2 repeatered circuits.

7.02 Figure 14 shows the two types of 4-wire circuits with 2-wire extensions with the maximum allowable gain limits between the end 2-wire points indicated. The 4-wire portion of each circuit is not limited solely to a metallic facility but may also include a carrier link. These maximum gains are limited by stability considerations.

7.03 The general level requirements of the repeaters covered in this section are shown in Table B. The minimum and maximum levels shown have been established as a result of crosstalk considerations.

7.04 When mixed loaded and nonloaded facilities are encountered within a single cable link adjacent to a PBX or customer location, the levels for nonloaded may only be used if there is at least 9 kilofeet of cable plus bridged tap from the customer to the first load coil. Otherwise, the levels for loaded cable must be used.

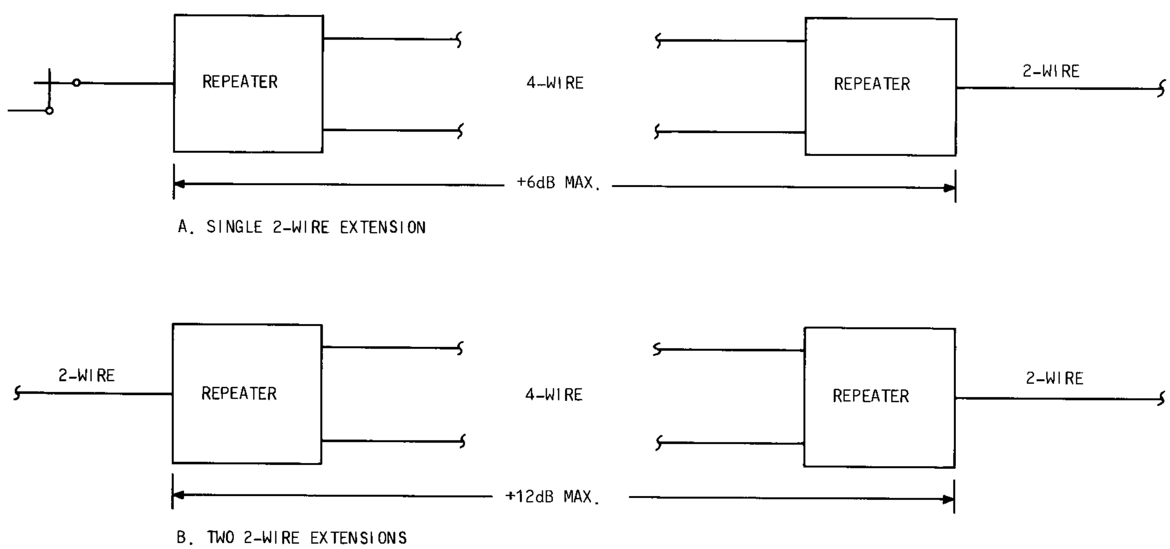


Fig. 14—Maximum Gain Limits on 4-Wire Circuits With 2-Wire Extensions

TABLE B

LIMITS ON TRANSMIT AND RECEIVE 1-KHZ LEVELS WITH RESPECT TO THE 0 TLP

LOCATION	CABLE TYPE	MINIMUM INPUT LEVEL	MAXIMUM OUTPUT LEVEL
At Central Office	Nonloaded	−9 dB	+6 dB
	H88 Loaded	−9 dB	+6 dB
At PBX or other customer location	Nonloaded	−9 dB	+6 dB
	H88 Loaded	−6 dB	+3 dB

7.05 The following 1-kHz maximum loss limits apply between repeaters on 4-wire cable because of the crosstalk limits given in Table B:

	Nonloaded	Loaded
Between PBX (or customer) and CO	15 dB	12 dB
CO to CO	15 dB	15 dB

7.06 Cable loss limits for 2-wire facilities vary with the loss objectives for the individual types of special services and message trunks.

B. 4-Wire Impedance Selection

7.07 All MFT repeaters which connect to 4-wire cable facilities include an impedance option of 600 or 1200 ohms on the 4-wire side of the unit. A slide switch on the component board selects either of these impedance values. The choice of terminating impedance determines the true 1-kHz loss and affects the loss vs frequency characteristics of the cable. The rules given in Table C should be followed in selecting the 4-wire impedance.

7.08 The impedance selection rules for mixed nonloaded and H88 loaded cable assume at least 9 kilofeet of cable plus bridged tap from the repeater to the first load coil on the nonloaded end. If there is less than 9 kilofeet of cable plus bridged tap to the first coil, an impedance of 1200 ohms should be selected.

C. Repeater Gain

7.09 The 1-kHz gains which are indicated by the settings of the 309-type amplifiers and equalizers in the repeater are calibrated to represent the gain through the entire repeater from input terminals to output terminals. Internal losses due to the passive components (eg, the hybrid transformers) have been included in the gain data given in Part 2, and Tables D and E. Therefore, it is not necessary to consider loss through the hybrid as with V4 equipment.

7.10 The gain of a repeater at 1 kHz is dependent on two parameters:

- The flat-gain setting (GN + GN ADJ)
- The 1-kHz gain developed by the active equalizer.

These two quantities are added together to obtain the total repeater gain at 1 kHz.

Note: In cases where a 309A amplifier unit is used, the total gain is the flat gain only.

7.11 The LBOC (on the two repeaters which contain an LBOC) contributes a slight loss at 1 kHz. This loss should be considered as part of the cable losses and is discussed in Part 8D. For greatest accuracy, the gain of the repeater should be measured with the LBOC out of the circuit (all screws backed out).

7.12 Since the equalizer is an active device, there is a 1-kHz gain associated with each equalizer setting. The 1-kHz gain for each SLOPE setting is given in Table D; Table E contains the 1-kHz

TABLE C

4-WIRE IMPEDANCE SELECTION RULES

4-WIRE CABLE TYPE	IMPEDANCE SELECTION
Nonloaded	600 ohms both ends
H88 loaded	1200 ohms both ends
Mixed (nonloaded and loaded; see para. 7.08)	600 ohms on the nonloaded end 1200 ohms on the loaded end

TABLE D

1-KHZ GAIN IN DB FOR 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.**

gain for each of the possible setting combinations of the HT and BW switches.

7.13 The equalizer can contribute from 0 to 15.3 dB additional 1-kHz gain to the flat repeater gain. However, it is not the objective to equalize to a completely flat response in 4-wire systems with a 2-wire extension and it is unlikely that the maximum-gain equalizer settings will be required.

8. TESTS AND ADJUSTMENTS USING THE MFT TEST EXTENDER

A. General

8.01 In making tests and adjustments to the MFT repeaters, it is necessary to obtain jack access to certain circuits and to be able to switch the PBN in and out. The J99343TB and the J99380TB MFT Test Extenders are used to obtain ready access to these circuits when the repeater is in a normal operating configuration. Detailed descriptions of the test extenders are contained in Section 332-910-102 for the J99343TB and Section 332-610-500 for the J99380TB test extender.

8.02 The following four test adjustment procedures are described in this part:

- Obtaining (or improving) the PBN setting by measurement
- Adjusting the repeater for a specified gain
- Adjusting the repeater for a specified output level
- Measurement of loss vs frequency data. This data is then used in setting the equalizer (see Part 9).

8.03 A good general rule is that the PBN should always be set first after initial setup adjustments. This is because the data on predicted gain and loss from such sources as the Universal Cable Circuit Analysis Program (UNICCAP) and the prescription tables assume there is good balance. High gain settings can be used only when the PBN is set properly.

8.04 The balancing network setting procedure is a repetitive method in which an initial setting is improved on and the improved setting becomes a new initial setting which is again improved by a repetition of the procedure. The procedure is repeated until satisfactory performance is obtained. The equalizers are turned off during the PBN setting procedure.

8.05 The procedures which adjust for a specified gain and output level necessitate that the equalizer be previously set, since any changes in the equalizer will affect the 1-kHz gain of the repeater. If the equalizer setting is not known, it must either be found in a table or determined using the procedure in Part 8E of this section.

8.06 The fourth procedure requires that the PBN be properly set and ***that the equalizers, which are to be set, are initially set to zero (HT=0, SLOPE=0).*** Minor changes to

TABLE E

1-KHz GAIN IN dB FOR HT AND BW SETTINGS

	HT SETTING															
BW SETTING	0*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
4	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	0.1	0.1	0.1	0.1
6	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	0.1	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	0.2	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	0.3	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
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
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
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
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
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

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

an existing equalizer setting can be made by using the touchup guidelines given in Part 10.

B. PBN Setting by Measurement

8.07 The following procedure describes an orderly way to determine a PBN setting by the measurement of echo return loss (ERL), singing return loss (SRL), and high singing return loss (SRL HI): A return-loss measuring set [(RLMS) KS-20501, L3 or equivalent] arranged to measure 4-wire return loss is connected to the 4-wire side of the repeater. The three return-loss readings are maximized by making a series of trial settings of the PBN switches. See Fig. 15 for a diagram of the equipment arrangement for making these measurements.

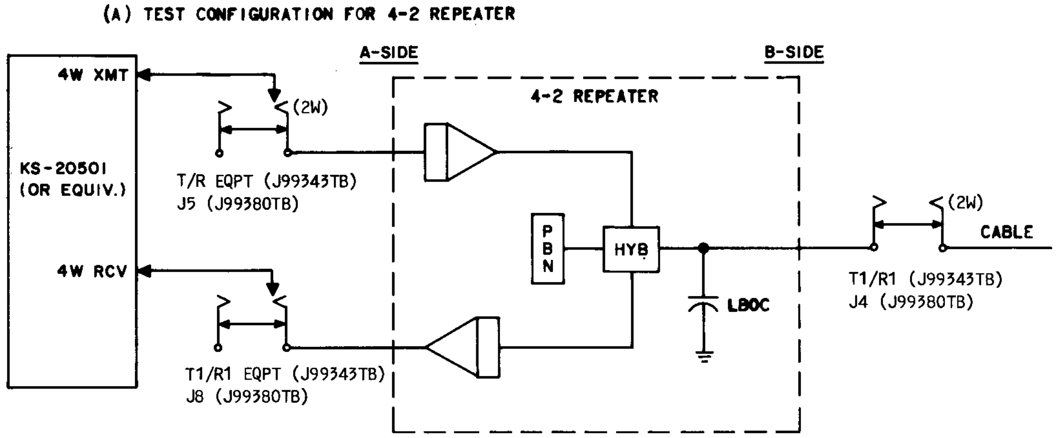
8.08 Since there are different repeaters for nonloaded and loaded cable, it must be known beforehand whether or not the cable is loaded. Otherwise, both a nonloaded repeater and loaded repeater might have to be tried. To avoid this the following rules should be observed:

Rule I If the distance from the repeater to the first load coil (near end section length) plus the length of any bridged taps in the end section exceeds 8000 feet, or the facility does not contain any load coils, it is nonloaded.

Rule II If the near end section length plus the length of any bridged taps in the end section is less than 8000 feet, the facility is loaded.

8.09 The following test equipment is required:

- One MFT Test Extender (J99343TB or J99380TB)



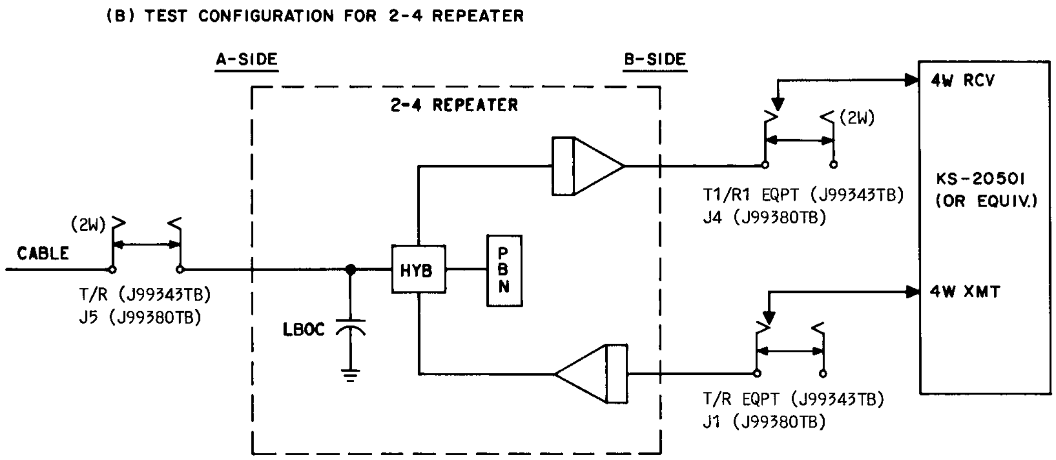


Fig. 15—Test Configuration For Setting the Precision Balancing Network by Measurement

- One KS-20501, L3 RLMS or equivalent
- Nominal termination at the far end.

8.10 In the following procedures of Part 8, either the J99343TB or the J99380TB test extender can be used. Test setup for both is described. Chart 1 describes the initial test setup using the MFT test extender.

CHART 1

INITIAL SETUP PROCEDURE

STEP	PROCEDURE
1	Terminate the far end of the circuit in its nominal impedance. If the far end is a switch or PBX, a compromise network (600 or 900 ohms + 2.15 μF) should be used. If the far end terminates in a telephone set, use the off-hook telephone with loop current or a 4066H network.
2	Insert the repeater into the slot on the side of the J99343TB test extender or into the J928A connector of the J99380TB test extender. Plug the cable extender card of the J99343TB into the shelf or mounting slot. The entire assembly of the J99380TB which contains the repeater is plugged into the shelf or mounting slot.
3	Set the repeater options as follows: (a) Gain—Switches off, potentiometer fully counterclockwise (b) Equalizers—Set to zero (HT=0; SLOPE=0) (c) Signaling options as specified on CLR (RV, RV/T, A/B or SX/RV, SX SH) (d) NOR/DISABLE to NOR (e) LBOC as specified on CLR or from Table A (f) Midpoint capacitor as specified on CLR (g) Output impedance (OUT 600/1200) to 600.
4	Set the J99343TB test extender as follows: (a) For 4-2 Repeaters

A-Side	B-Side
2W/4W to 4W	2W/4W to 2W
600/900 to 600	600/900 to 900
COMP NET IN/OUT to OUT	COMP NET IN/OUT to OUT

CHART 1 (Contd)

STEP	PROCEDURE

(b) For 2-4 Repeaters

A-Side	B-Side
2W/4W to 2W	2W/4W to 4W
600/900 to 900	600/900 to 600
COMP NET IN/OUT to OUT	COMP NET IN/OUT to OUT

Set the J99380TB test extender as follows:

For 4-2 and 2-4 Repeaters set S2 to NORMAL.

5 Connect the RLMS to the J99343TB test extender as follows:

(a) For 4-2 Repeaters

4-Wire transmit to T/R EQUIP (2W) on the A-side of the test extender

4-Wire receive to T1/R1 EQUIP on the A-side of the test extender

(b) For 2-4 Repeaters

4-Wire transmit to T/R EQUIP on the B-side of the test extender

4-Wire receive to T1/R1 EQUIP (2W) on the B-side of the test extender

Connect the RLMS to the J99380TB test extender as follows:

(a) For 4-2 Repeaters

4-Wire transmit to J5 (EQPT) of test extender

4-Wire receive to J3 (EQPT) of test extender

(b) For 2-4 Repeaters

4-Wire transmit to J1 (LINE) of test extender

4-Wire receive to J4 (LINE) of test extender

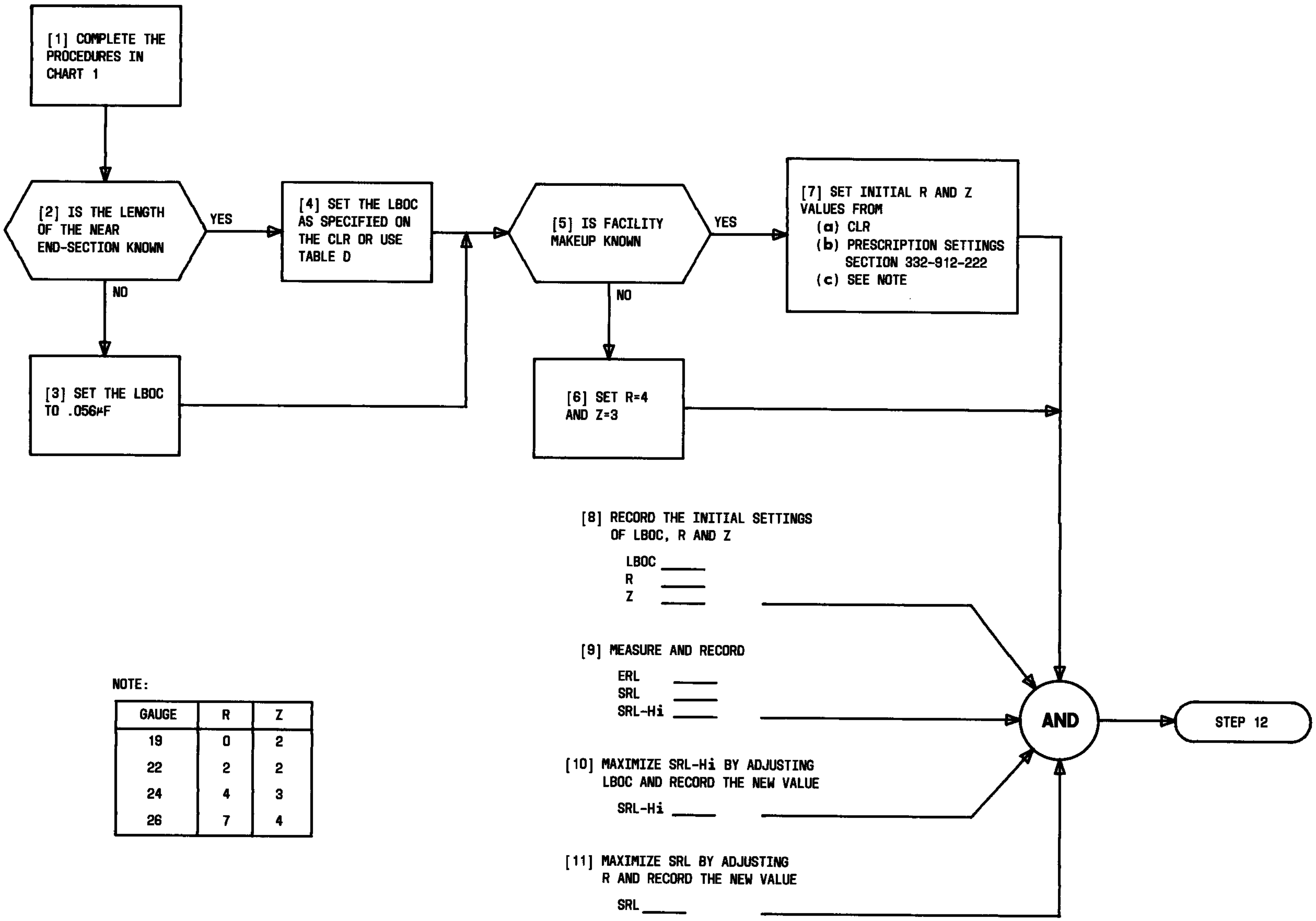
6 See Section 103-106-115 for operation of the KS-20501, L3 RLMS.

7 For setting the 4240A PBN (for loaded cable), go to Chart 2.

For setting the 4240B PBN (for nonloaded cable), go to Chart 3.

For setting the 4240C PBN (for loaded cable including MAT cable), go to Chart 4.

Note: The procedures in Charts 2 through 4 describe PBN settings by measurement. When the makeup of the cable facility is known, the prescription setting tables in Section 332-912-222 may be used.



GAUGE	R	Z
19	0	2
22	2	2
24	4	3
26	7	4

Chart 2—Adjustment of 4240A Precision Balance Networks

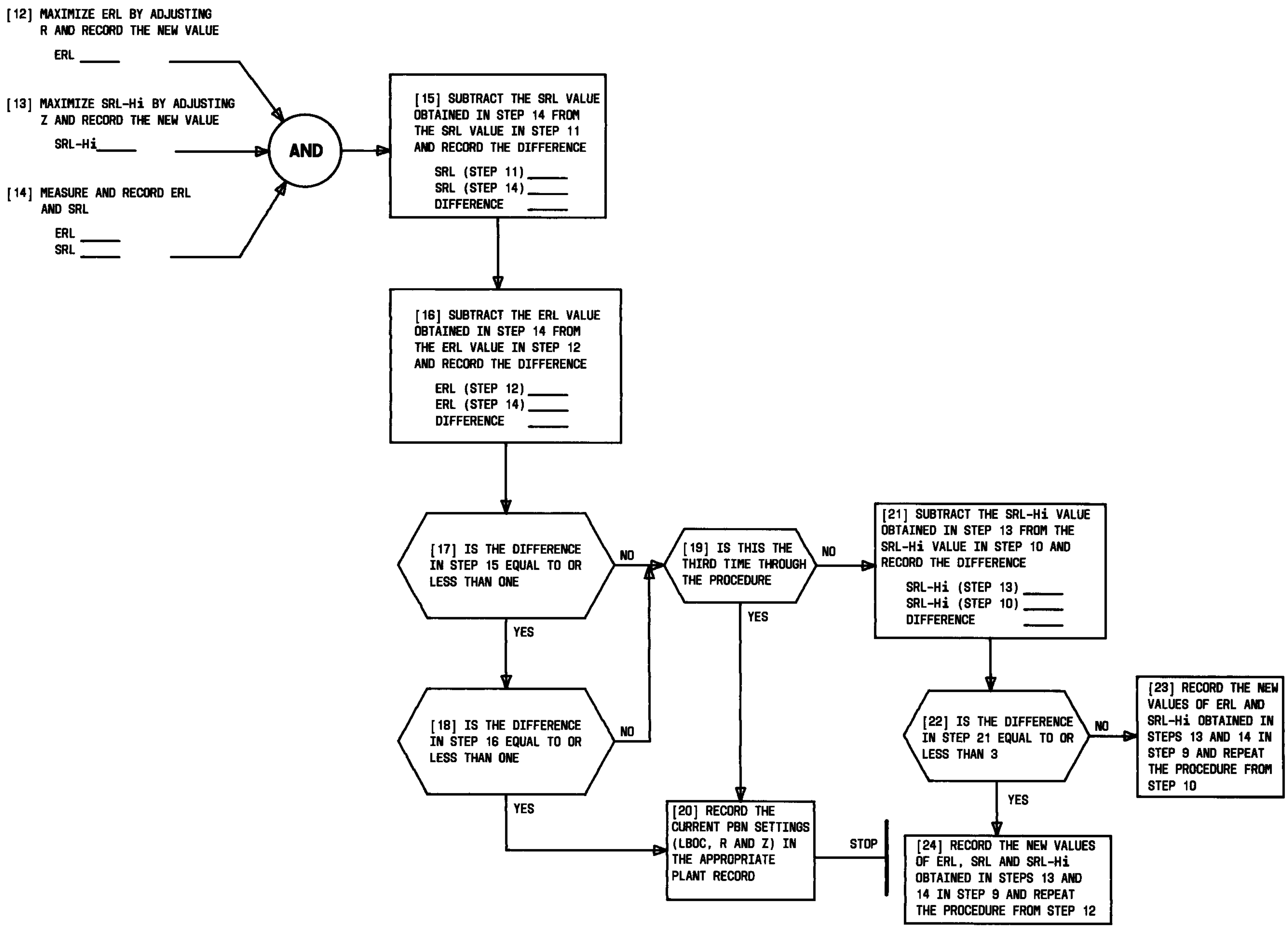


Chart 2—Adjustment of 4240A Precision Balance Networks (Cont)

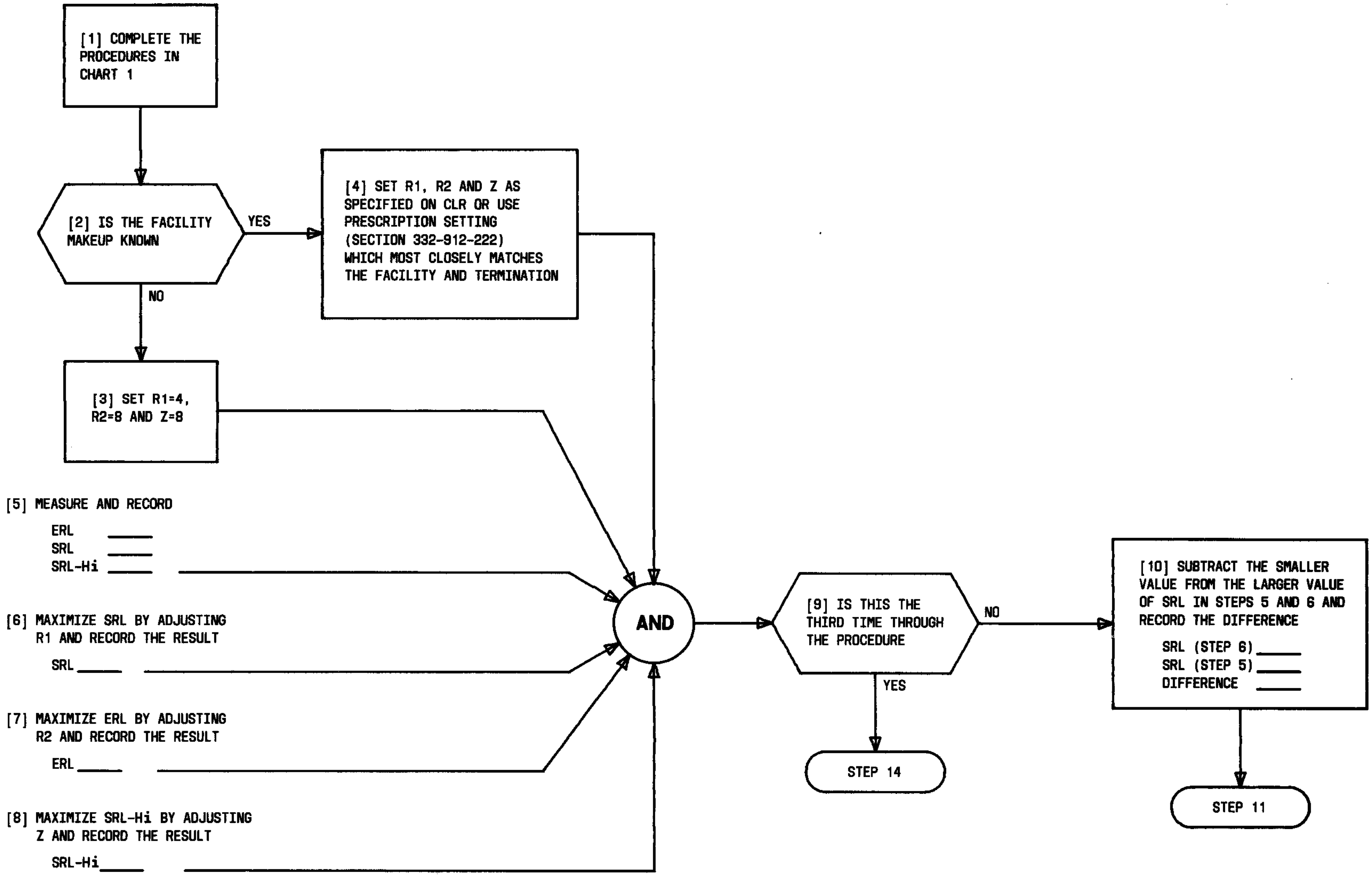


Chart 3—Adjustment of 4240B Precision Balance Networks

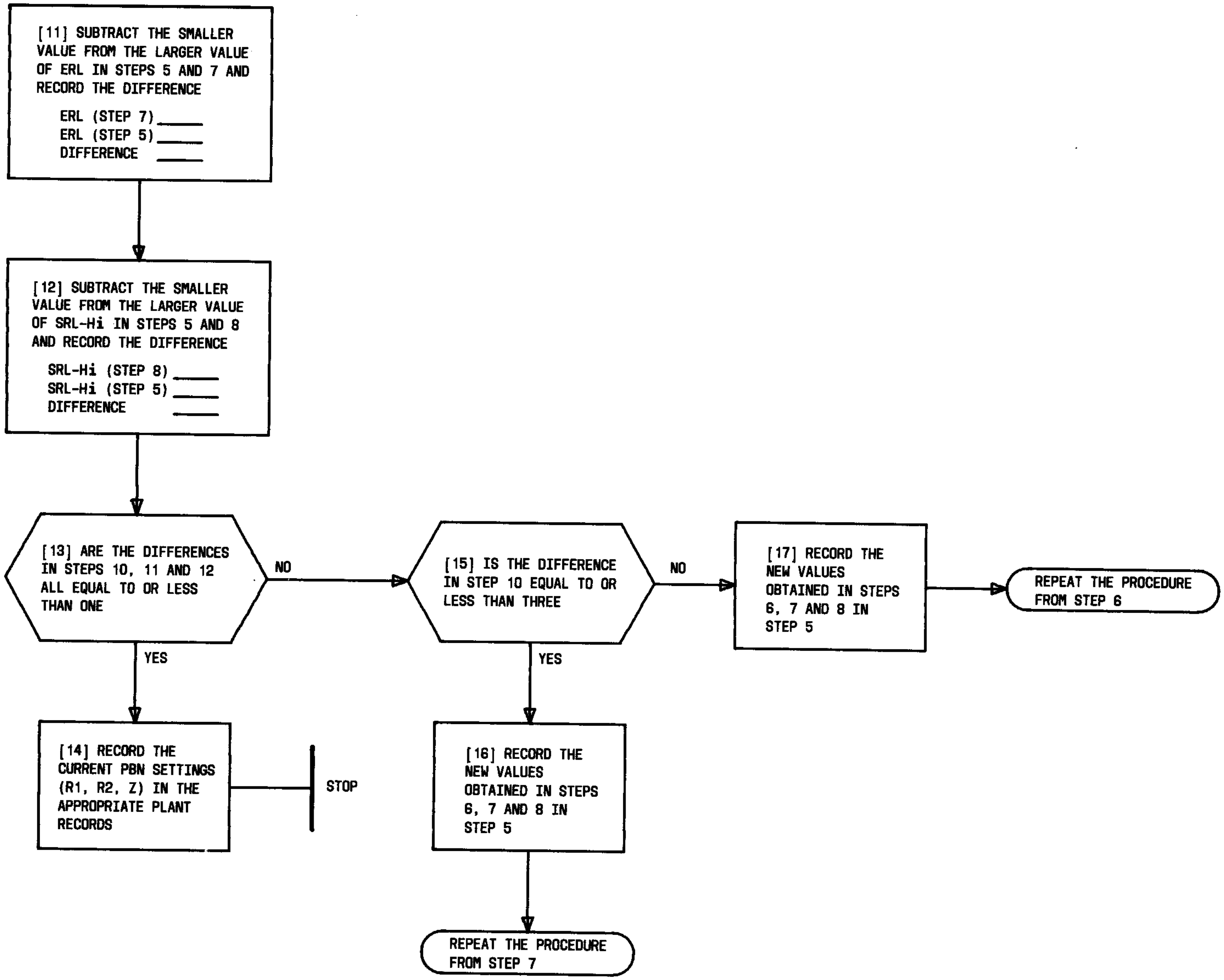


Chart 3—Adjustment of 4240B Precision Balance Networks (Cont)

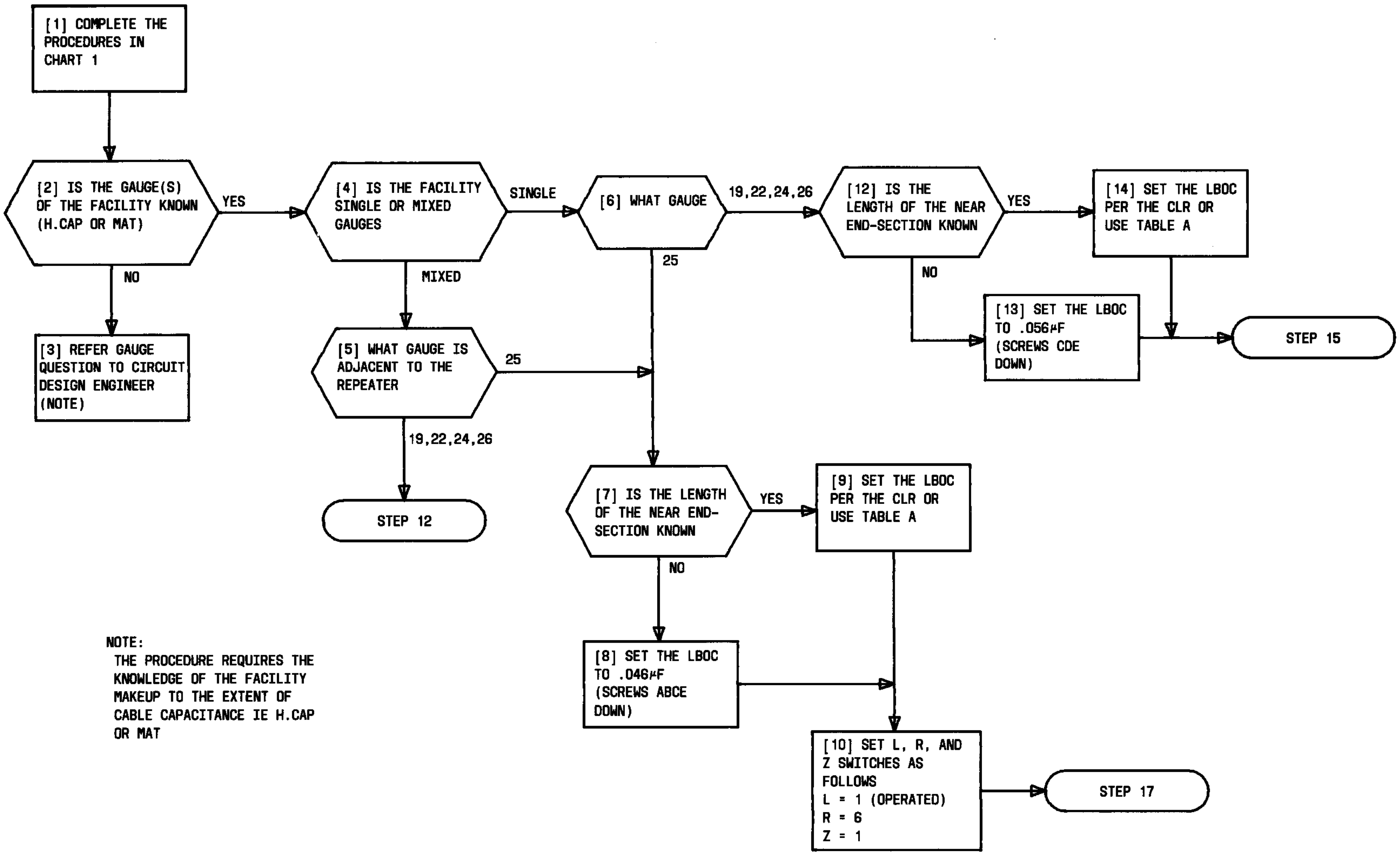
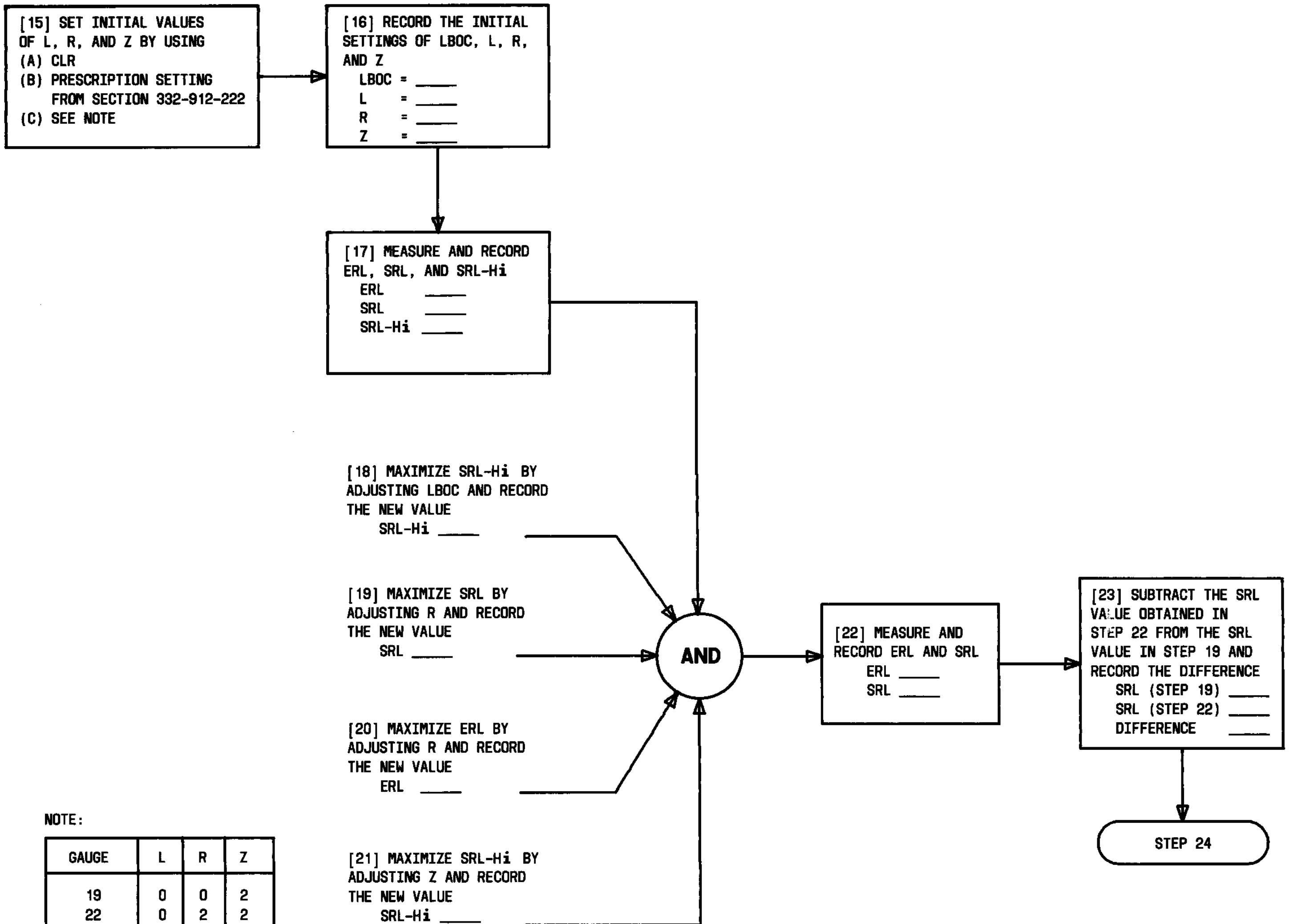


Chart 4—Adjustment of 4240C Precision Balance Networks



NOTE:

GAUGE	L	R	Z
19	0	0	2
22	0	2	2
24	0	4	3
26	0	7	4
UNKNOWN	0	4	3

Chart 4—Adjustment of 4240C Precision Balance Networks (Cont)

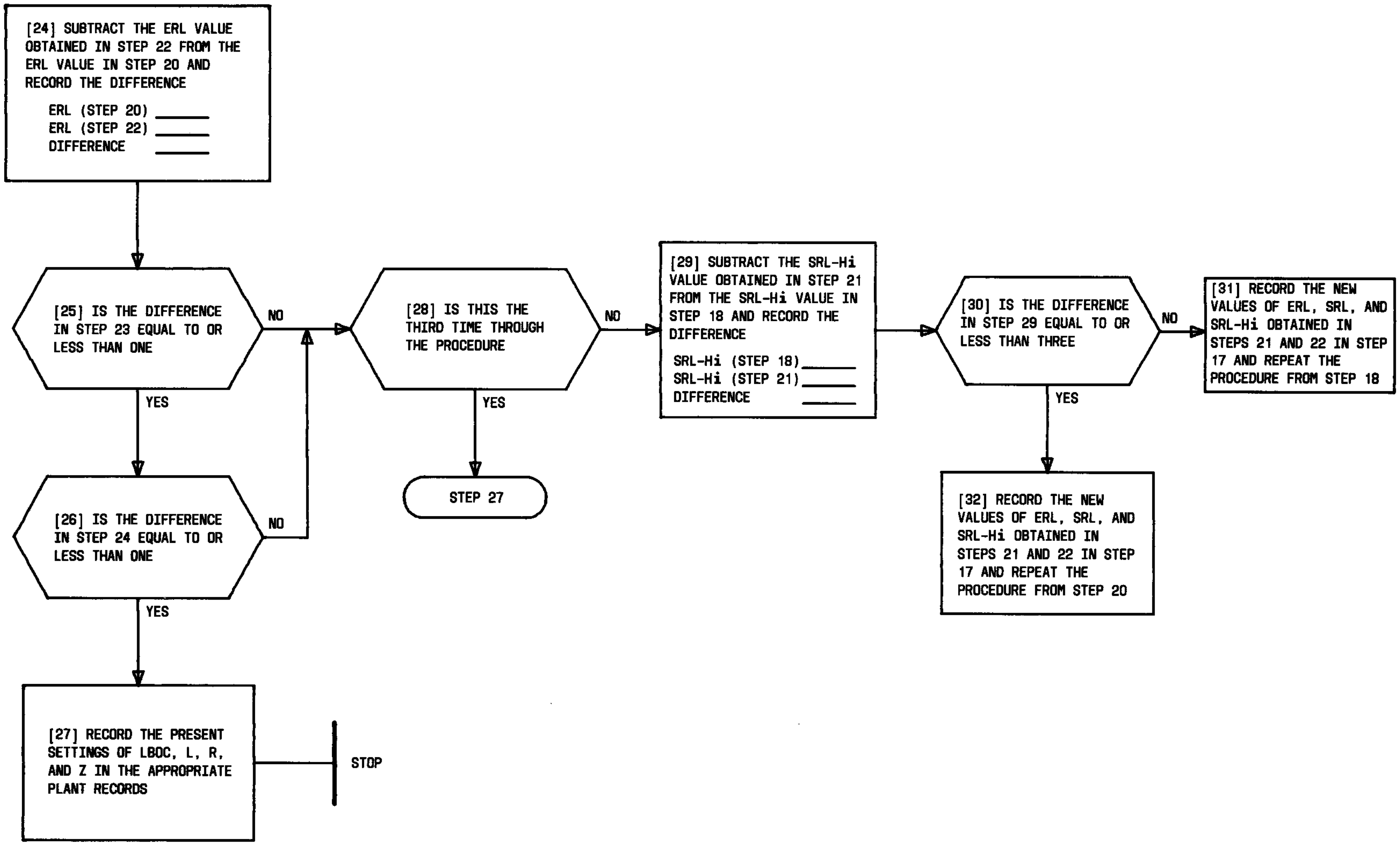


Chart 4—Adjustment of 4240C Precision Balance Networks (Cont)

C. Adjusting For a Specified Gain

8.11 This procedure requires that the equalizer(s) be set to their final setting and that the repeater output impedance (600 or 1200 on the 4-wire side) be selected. The following test equipment is required:

- One MFT Test Extender J99343TB or J99380TB
- One oscillator with adjustable output power, preferably with a 900-ohm impedance capability
- One transmission measuring set, preferably with a 900-ohm impedance capability.

The oscillator and measuring set may be combined in a single test instrument.

8.12 The test configuration for the 4-2 repeaters is shown in Fig. 16 and the configuration for the 2-4 repeaters is shown in Fig. 17.

CHART 5

ADJUSTING THE 4-2 REPEATERS FOR A SPECIFIED GAIN

STEP	PROCEDURE
1	Verify (or set) the proper transmission and signaling options on the repeater: (a) Set the 4-wire impedance (OUT switch). (b) Set the equalizer(s). (See Parts 8E and 9.) (c) Make sure the LBOC screws (A through F) are UP (applicable to J99343RB, RG, RD, and RH). (d) Set the midpoint capacitor switches S1=UP, S2=DOWN. (e) Set the signaling options (RV, RV/T, SX SH, A/B REV). (f) Set gain range switches off; rotate gain potentiometers to full counterclockwise. (g) Set DISABLE switch to NOR position.
2	Set switches on the J99343TB MFT test extender as follows: **A-Side**: 2W/4W to 4W; 600/900 to 900; COMP NET IN/OUT to OUT **B-Side**: 2W/4W to 2W; 600/900 to 900; COMP NET IN/OUT to IN

CHART 5 (Contd)

STEP	PROCEDURE

Set switches on the J99380TB MFT test extender as follows:

S1 to B IN

S2 to TEST

S3 to 900

3 Insert repeater into the test extender and connect test extender into the proper slot of the MFT shelf or bay.

4 Note the specified gain for RU1 and call it G. If the test equipment is not 900 ohms, G may need to be modified by a correction factor C:

4-WIRE SIDE IMPEDANCE SETTING	CORRECTION FACTOR C	
	600 OHM TEST EQUIPMENT	900 OHM TEST EQUIPMENT
600 ohms	None	None
1200 ohms	0.7 dB	None

G = (specified gain)—C

5 Connect oscillator to the detector. Adjust the output of the oscillator to obtain a reading of -G dBm on the detector.

6 Connect oscillator and detector to the test extender (refer to Fig. 16). Adjust repeater gain to measure 0 dBm on the detector. It may be necessary to operate a gain range (GN) switch to add -10 dB or +10 dB to the potentiometer gain in order to obtain the 0 dBm reading on the detector.

7 Repeat Steps 4 through 6 to set the gain of RU2.

8 Set the PBN, LBOC, midpoint capacitor switches, and DISABLE switch to their specified settings (CLR card).

9 Disconnect all test equipment from repeater and re-insert into its proper shelf location.

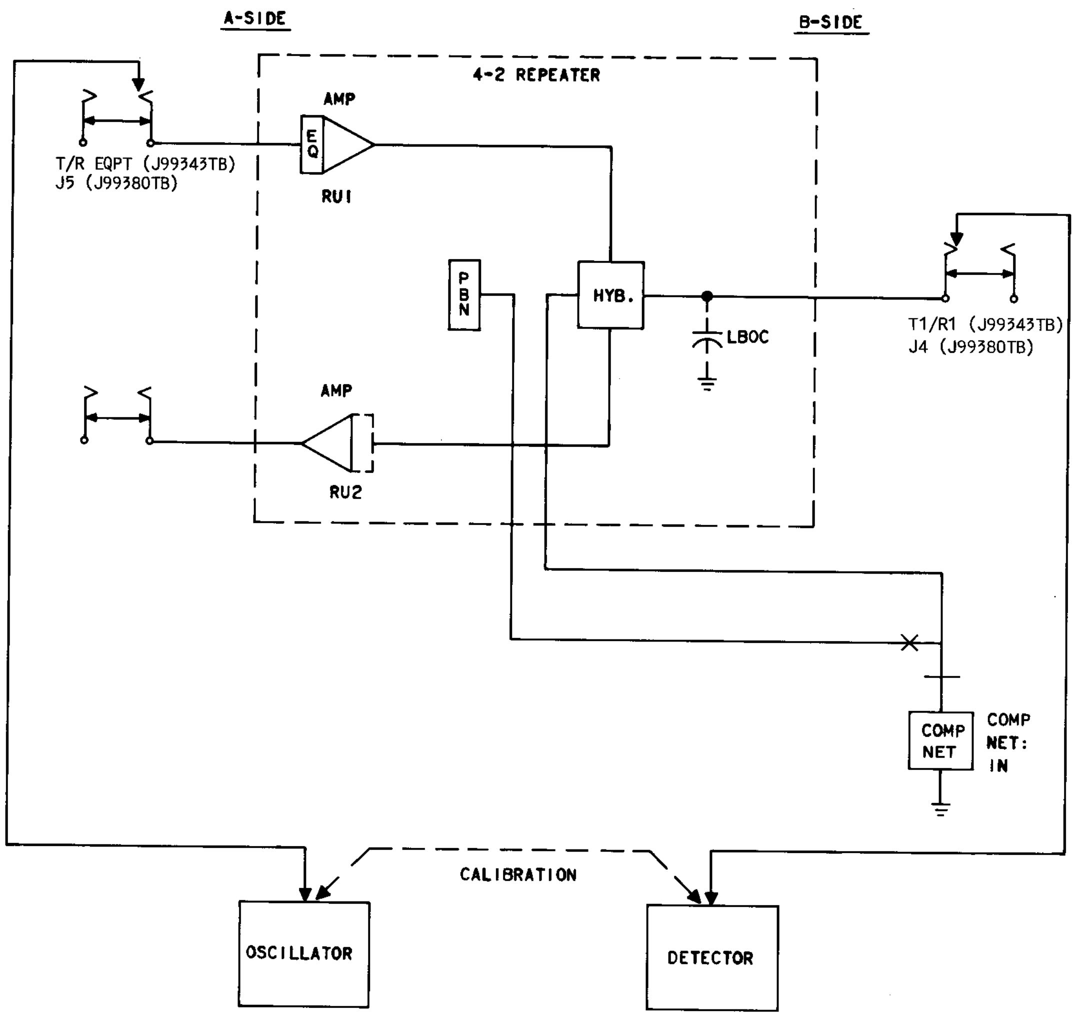


Fig. 16—Test Configuration For Adjusting the 4-2 Repeaters For a Specified Gain

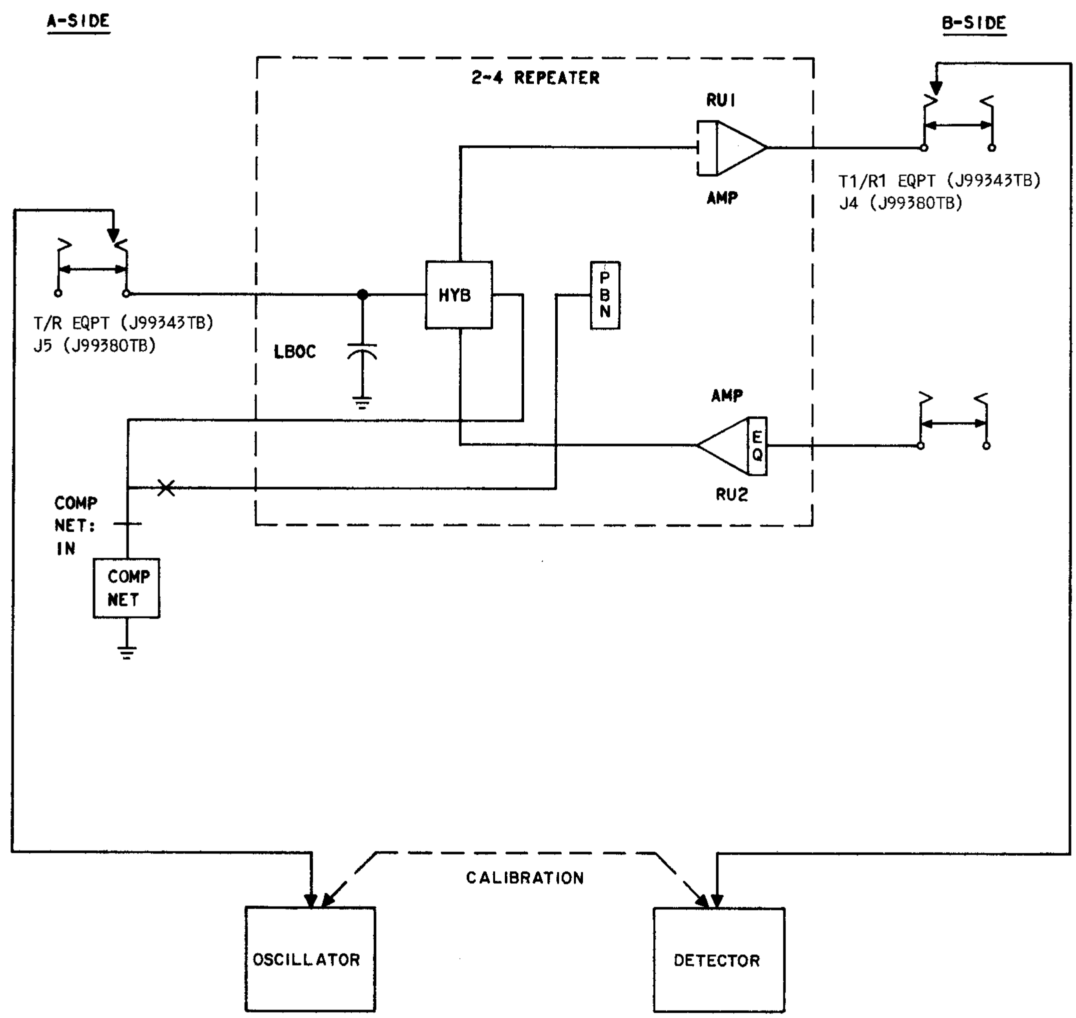


Fig. 17—Test Configuration For Adjusting the 2-4 Repeaters For a Specified Gain

CHART 6

ADJUSTING THE 2-4 REPEATERS FOR A SPECIFIED GAIN

STEP	PROCEDURE
1	Verify (or set) the proper transmission and signaling options on the repeater: (a) Set 4-wire output impedance (OUT switch). (b) Set the equalizer(s). (See Parts 8E and 9.) (c) Make sure LBOC screws (A through F) are UP (applicable to J99343RB, RG, RD, and RH). (d) Set the signaling options (RV, RV/T, SX SH, SX REV). (e) Set gain range switches off; rotate gain potentiometers to full counterclockwise. (f) Set DISABLE switch to NOR position.
2	Set switches on the J99343TB MFT test extender as follows: **A-Side**: 2W/4W to 2W; 600/900 to 900; COMP NET IN/OUT to IN **B-Side**: 2W/4W to 4W; 600/900 to 900; COMP NET IN/OUT to OUT Set switches on the J99380TB MFT test extender as follows: S1 to A IN S2 to TEST S3 to 900
3	Insert repeater into the test extender and connect test extender into the proper slot of the MFT shelf or bay.
4	Note the specified gain for RU1 and call it G. If the test equipment is not 900 ohms, G may need to be modified by a correction factor C. See the correction factor table above in Step 4 of the procedure for adjusting the 4-2 repeaters for a specified gain.
5	Connect oscillator to the detector. Adjust the output of the oscillator to obtain a reading of -G dBm on the detector.

CHART 6 (Contd)

STEP	PROCEDURE
6	Connect oscillator and detector to the test extender (refer to Fig. 17). Adjust repeater gain to measure 0 dBm on the detector. It may be necessary to operate a gain range (GN) switch to add -20 dB, -10 dB, or +10 dB to the potentiometer gain in order to obtain the 0 dBm reading on the detector.
7	Repeat Steps 4 through 6 to set the gain of RU2.
8	Set the PBN, LBOC, and DISABLE switch to their specified settings.
9	Disconnect all test equipment from repeater and re-insert into its proper shelf location.

D. Adjusting For a Specified Output Level

8.15 The following procedure is given for adjusting the repeater output to a specified level. The equalizer settings for the repeater must be known and installed. Changes in the equalizer settings will affect the repeater 1-kHz gain.

8.16 In addition, the LBOC setting (loaded repeater only) must be known but is not installed until after the level on the 2-wire side has been set. The LBOC is then set to its proper value so that the 4-wire output level setting will be correct (LBOC has a slight effect on the 2-wire cable loss at 1 kHz). The PBN should also be set to its proper value.

> ***Note:*** If LBOC and PBN settings are not known, follow the procedures outlined in Part 8B. Determine equalizer settings from Part 9.

8.17 The procedures assume a signal source of 0 dBm at 1 kHz is being applied at the 0 TLP of the circuit. The following test equipment is required:

- One MFT Test Extender (J99343TB or J99380TB)
- One transmission measuring set, preferably with a 900-ohm impedance capability.

8.18 The test configurations for the 4-2 repeaters are shown in Fig. 18 and the configurations for the 2-4 intermediate repeaters are shown in Fig. 19. The figures show the test connection for each direction of transmission.

CHART 7

ADJUSTING THE 4-2 REPEATERS FOR A SPECIFIED OUTPUT LEVEL

STEP	PROCEDURE
1	Verify (or install) the proper transmission and signaling options on the repeater: (a) Set the 4-wire impedance (OUT switch). (b) Set the equalizer(s). (See Parts 8E and 9.) (c) Set the midpoint capacitor switches S1=UP, S2=DOWN. (d) Make sure that the LBOC screws (A through F) are all up (applicable to J99343RB, RG, RD, and RH). (e) Set the DISABLE switch to the NOR position. (f) Set the signaling options (RV, RV/T, SX SH, A/B REV). (g) If an attempt has been made to install the proper gain setting, verify that the gain setting is approximately the desired value. Otherwise, turn all GN switches off and rotate the GN ADJ potentiometer fully counterclockwise.
2	Set the switches on the J99343TB MFT test extender as follows: **A-Side**: 2W/4W to 4W; 600/900 to 900; COMP NET IN/OUT to OUT **B-Side**: 2W/4W to 2W; 600/900 to 900; COMP NET IN/OUT to IN Set the switches on the J99380TB MFT test extender as follows: S1 to B IN S2 to TEST S3 to 900

CHART 7 (Contd)

STEP	PROCEDURE
3	Insert the repeater into the test extender and connect test extender into the proper slot of the MFT shelf or bay.
4	Connect the detector to the test extender as shown in Fig. 18(A).
5	If the measuring instrument is not 900 ohms, a correction factor C may be needed to compensate for the mismatch between the repeater impedance and the measuring set impedance:

REPEATER IMPEDANCE AT DETECTOR	CORRECTION FACTOR C	
	600 OHM TEST EQUIPMENT	900 OHM TEST EQUIPMENT
600 ohms	None	None
900 ohms	None	None
1200 ohms	0.5 dB	None

STEP	PROCEDURE
6	Note the 2-wire output level on the CLR card and call it L. Adjust the gain of RU1 to obtain a reading of L on the detector. If a correction factor C has been called for (table above), RU1 should be adjusted to produce a reading of L-C on the detector.
7	On the B-side of the test extender, set the COMP NET switch OUT on the J99343TB test extender or operate switch S2 to NORMAL on the J99380TB test extender.
8	Install the proper LBOC setting.
9	Connect the detector to the proper A-side jack as shown in Fig. 18(B).
10	Repeat Steps 5 and 6 adjusting RU2.
11	Set the midpoint capacitor switches (S1, S2) and the DISABLE switch to the positions specified on the CLR card.

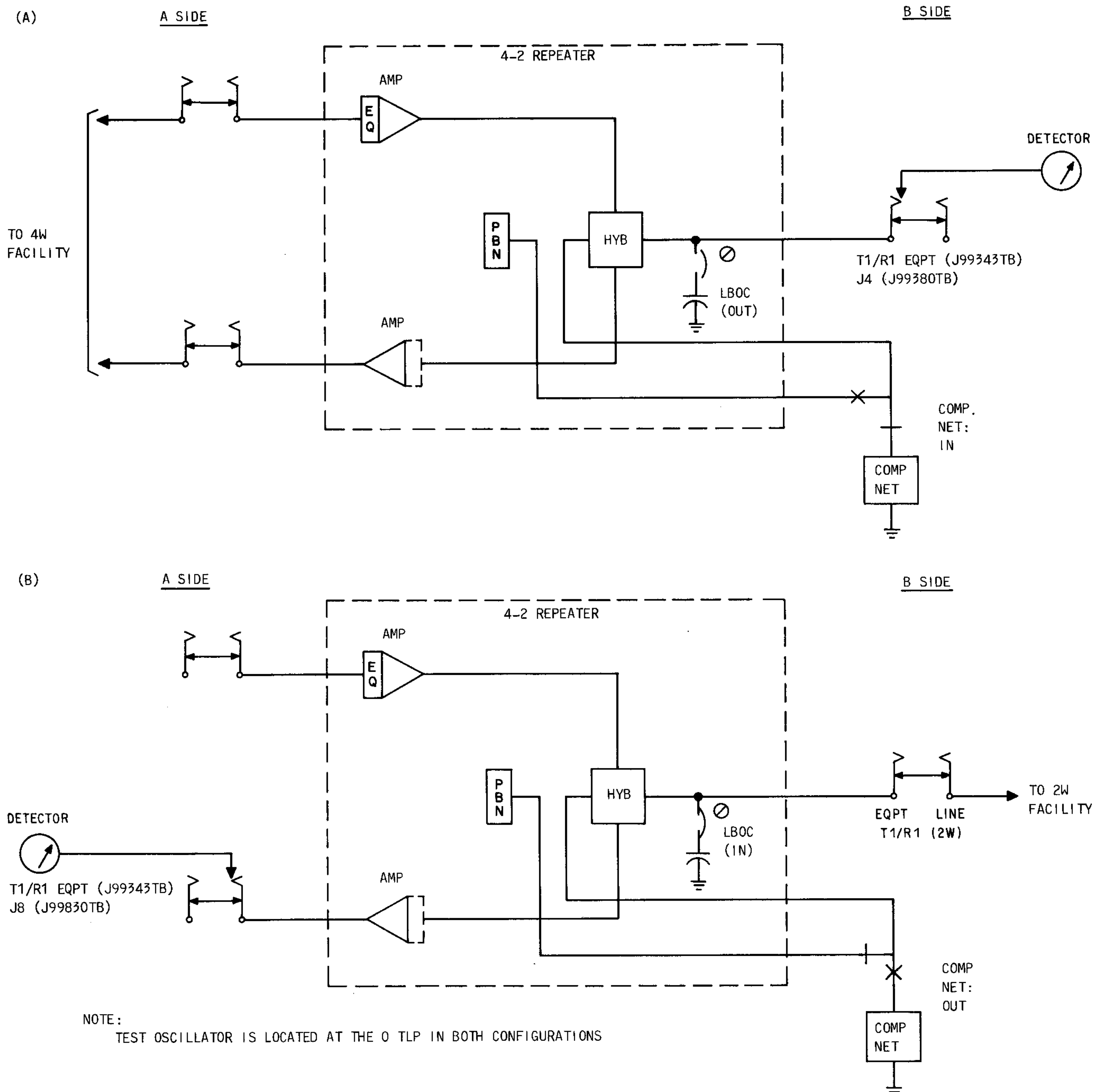


Fig. 18—Test Configuration For Adjusting the 4-2 Repeaters For a Specified Output Level

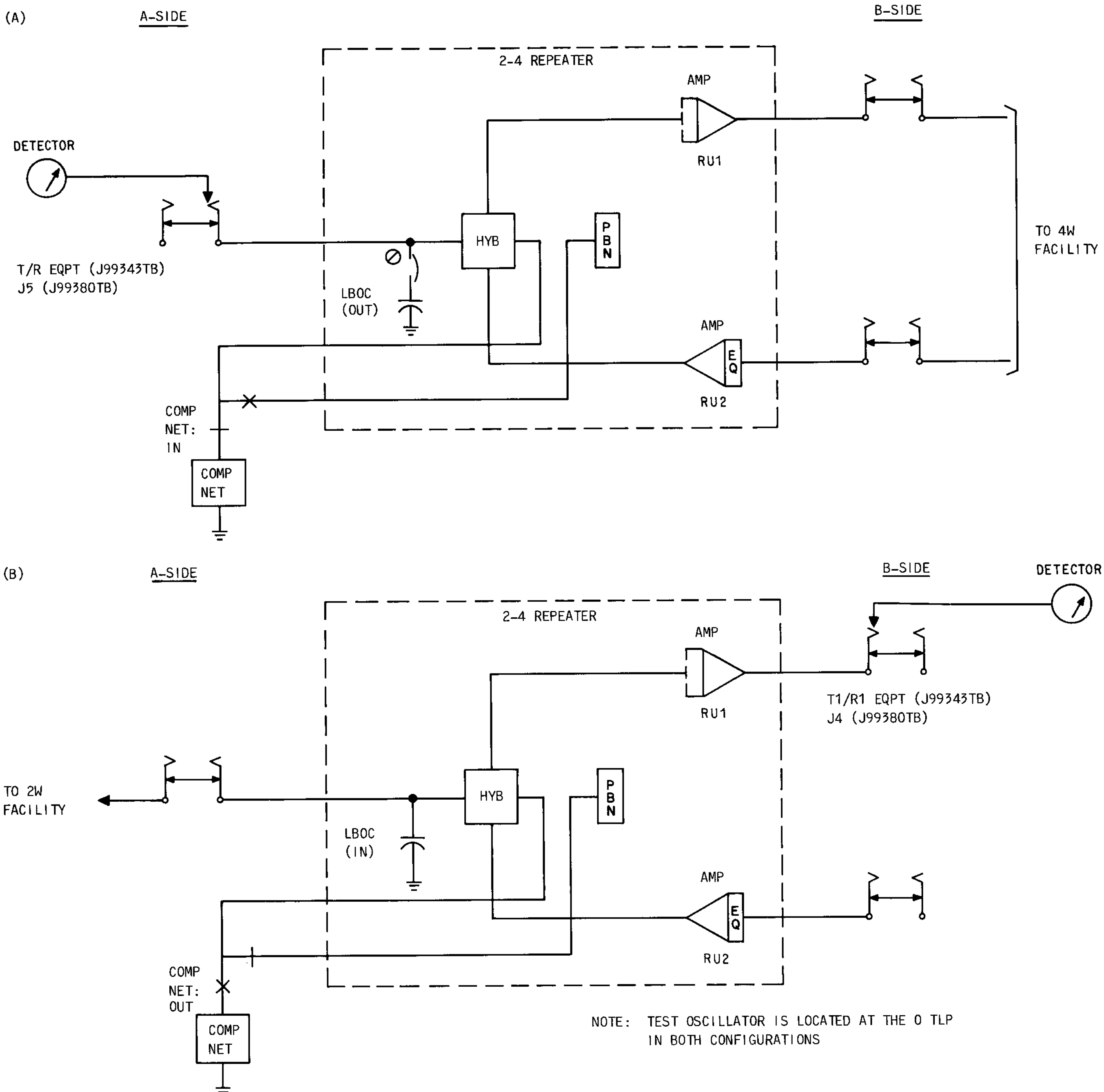


Fig. 19—Test Configuration For Adjusting the 2-4 Repeaters For a Specified Output Level

CHART 8

ADJUSTING THE 2-4 REPEATERS FOR A SPECIFIED OUTPUT LEVEL

STEP	PROCEDURE
1	Verify (or install) the proper transmission and signaling options on the repeater: (a) Set the 4-wire impedance (OUT switch). (b) Set the equalizer(s). (See Parts 8E and 9.) (c) Make sure that the LBOC screws (A through F) are all UP (applicable to J99343RB, RG, RD, and RH). (d) Set the DISABLE switch to the NOR position. (e) Set the signaling options (RV, RV/T, SX SH, SX REV). (f) If an attempt has been made to install the proper gain setting, verify that the gain setting is approximately the desired value. Otherwise, turn all GN switches off and rotate the GN ADJ potentiometer fully counterclockwise.
2	Set the switches on the J99343TB MFT test extender as follows: **A-Side**: 2W/4W to 2W; 600/900 to 900; COMP NET IN/OUT to IN **B-Side**: 2W/4W to 4W; 600/900 to 900; COMP NET IN/OUT to OUT Set switches on the J99380TB MFT test extender as follows: S1 to A IN S2 to TEST S3 to 900
3	Insert the repeater into the test extender and connect test extender into the proper slot of the MFT shelf or bay.
4	Connect the detector to the test extender as shown in Fig. 19(A).
5	If the measuring instrument is not 900 ohms, a correction factor C may be needed to compensate for the mismatch between the repeater impedance and the measuring set impedance. See the correction factor table above in Step 5 of the procedure for adjusting the 4-2 repeaters for a specified output level.

CHART 8 (Contd)

STEP	PROCEDURE
6	Note the 2-wire output level on the CLR card and call it L. Adjust the gain of RU2 to obtain a reading of L on the detector. If a correction factor C has been called for (Step 5), RU2 should be adjusted to produce a reading of L-C on the detector.
7	On the A-side of the test extender, set the COMP NET switch OUT on the J99343TB test extender or operate switch S2 to NORMAL on the J99380TB test extender.
8	Install the proper LBOC setting.
9	Connect the detector to the proper B-side jack (output of RU1) as shown in Fig. 19(B).
10	Repeat Steps 5 and 6 adjusting RU1.
11	Set the midpoint capacitor switches (S1, S2) and the DISABLE switch to the positions specified on the CLR card.

8.19 In cases where the milliwatt supply is not available on both ends of the circuit, a combination of the two procedures can be used as follows:

CHART 9

ADJUSTING FOR A SPECIFIED OUTPUT LEVEL WHERE MILLIWATT SUPPLY IS NOT AVAILABLE AT ONE END OF THE CIRCUIT

STEP	PROCEDURE
1	Use the procedure in 8D to set the level in the direction served by the milliwatt supply.
2	In the same direction, measure the gain of the repeater which was set in Step 1.
3	Note this gain and call it G. No correction factor is necessary.
4	Use the procedure in 8C to set the gain in the other direction to G, omitting any correction factors from the procedure.

E. Loss Versus Frequency Measurements

8.20 The following procedure describes how to obtain the loss versus frequency characteristics of a facility consisting of at least one repeater and at least one cable section. The method will determine the input data for use in Part 9.

8.21 The PBN and the LBOC section if included on the repeater must both be set correctly prior to using this procedure. Use the procedure in 8B if the settings are not specified on the CLR.

> ***Note:*** When the procedures in the following paragraphs are used on circuits requiring terminal balance, the loss measurements must be made through the impedance compensator.

8.22 The measurements outlined below are made with the equalizer set to zero (HT=0, SLOPE=0). After the measurements are made and the equalizer set, the facility can then be remeasured to verify the accuracy of the setting. The setting is then also applied to a corresponding equalizer in the opposite transmission direction.

8.23 Because pre-equalization is utilized in many of the circuits, it is not recommended that a 0-dBm signal be connected directly to the 4-wire input of a 4-2 or 2-4 repeater. This is because the resulting high gain at the higher frequencies (to compensate for the higher cable loss at high frequencies) places an excessive level at the balancing network and the line.

8.24 The equalizer configurations described below are chosen to avoid this condition. However, if a connection of the oscillator to the 4-wire input of a repeater is made, the oscillator should be set to -10 dBm and the readings of the detector at the other end corrected to account for the lower input level. The oscillator and detector should enclose the entire facility addressed by the equalizer.

8.25 Since the equalizers are set in pairs, only one facility need be measured per equalizer pair. Figure 20 illustrates the four types of equalizer configurations for 4-wire repeaters. The cases shown can be combined to form any 4-wire circuit with a 2-wire extension employing the 4-2 and 2-4 repeaters covered in this section.

8.26 The four cases of Fig. 20 are as follows:

> ***Note:*** For Cases 1 and 2 of Fig. 20, the equalizer is at a third location from the oscillator and the TMS. Therefore, arrangements should be made to have the repeater at the third location set up properly and install into the circuit. For Case 3, the equalizer to be set is located at the receiving end.

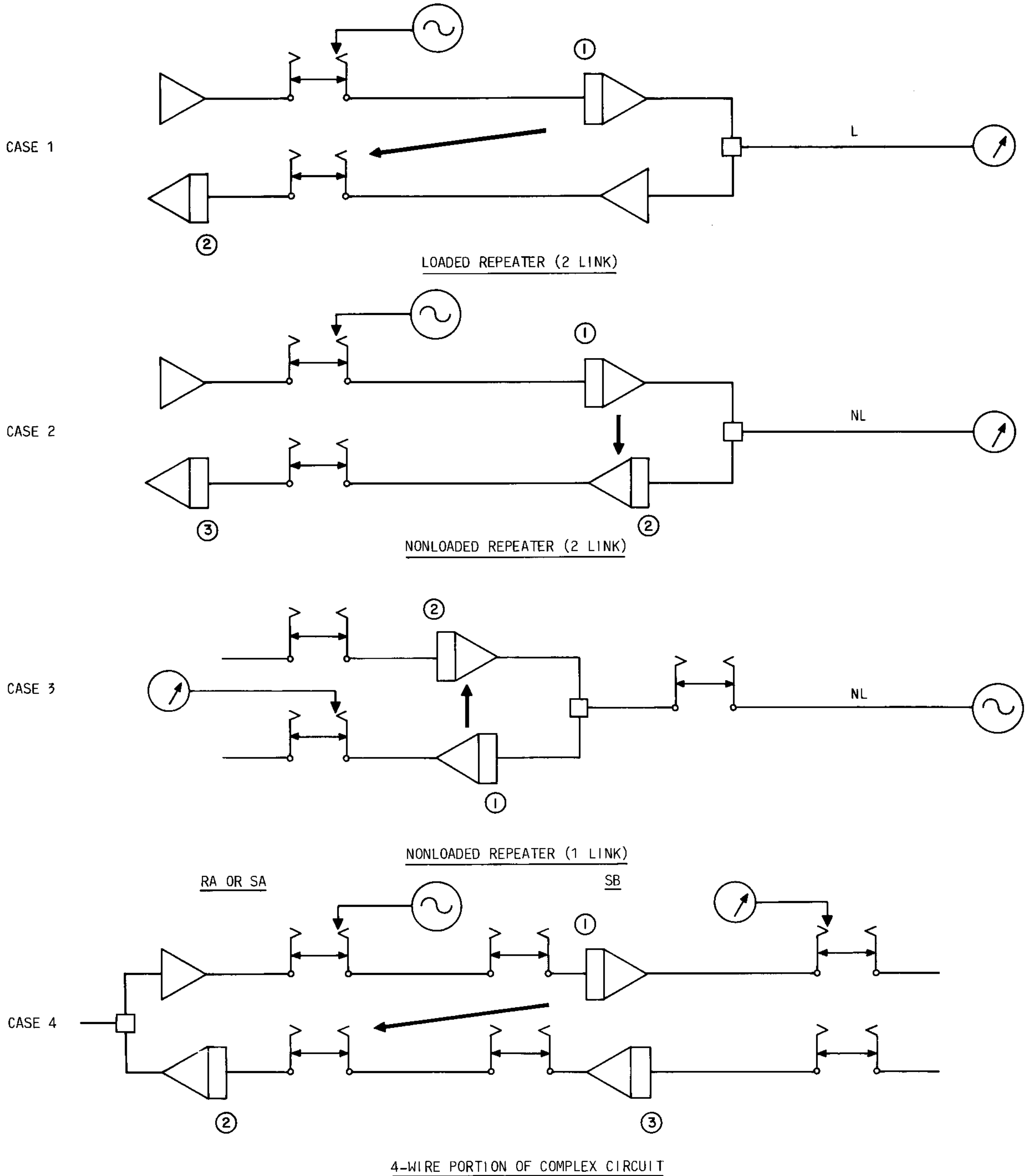
Case 1: Here the measurement is set up to obtain settings for equalizer 1. The oscillator is connected to the proper jack of the test extender at the left of the figure, and the detector is connected to the 2-wire far end. Equalizer 1 has been set to zero before measurements are made. After settings have been obtained for equalizer 1, these settings are also applied to equalizer 2 as indicated by the arrow.

Case 2: Again the oscillator is connected to the far end of the 4-wire link and detector connected at the 2-wire link. With the equalizer set to zero (HT=0, SLOPE=0), the facility is measured and settings for equalizer 1 are derived. These settings are then also applied to equalizer 2 in the figure.

Case 3: In this case the oscillator is connected at the far 2-wire end and detector at the A-side output of the 4-wire port. The 2-wire link plus repeater is then measured and settings for equalizer 1 are derived. These equalizer settings are then applied to equalizer 2.

Case 4: This part of the circuit could also be part of an all 4-wire circuit and is equalized in the same manner. At the terminal repeater end of the circuit, the oscillator is connected at the B-side LINE T1/R1 jack on the J99343TB test extender or to J3 of the J99380TB test extender with terminating plug inserted into J4. The detector is connected at the output of the 4-4 intermediate repeater. Settings are thus obtained with equalizer 1 set to zero, measuring the facility and determining the settings for equalizer 1. These settings are then also applied to equalizer 2 on the 2-4 terminal or 4-4 terminal repeater.

> ***Note:*** The settings arrived at in Case 4 will not be the same as those in the tables in Section 332-912-222 because this method introduces roll-off while the tables do not. If flat settings are desired, refer to the all 4-wire documentation (Sections 332-912-231, 232).



NOTES:

1. EQUALIZERS INDICATED BY ① ARE SET USING THE PROCEDURES IN THIS SECTION WITH THE TEST INSTRUMENTS CONNECTED AS SHOWN. THE ARROW IN EACH DIAGRAM POINTS TO A SECOND EQUALIZER WHICH IS THEN SET EXACTLY AS EQUALIZER ①.
2. ALTHOUGH CASE 4 APPEARS TO BE A 4-WIRE CIRCUIT WHICH SHOULD BE EQUALIZED BY THE TECHNIQUES GIVEN IN 332-912-231, IT IS INCLUDED HERE BECAUSE OF ITS USE IN COMPLEX CIRCUITS WHICH INCLUDE A 2-WIRE EXTENSION.

Fig. 20—Equalizer and Cable Configurations

8.27 The following test equipment is required for these measurements:

Transmitting End

- One MFT test extender J99343TB or J99380TB (required only if the transmitting end has an MFT repeater)
- One oscillator with a 900-ohm output impedance capability

Receiving End

- One MFT test extender (J99343TB or J99380TB)
- One transmission measuring set with a 900-ohm output impedance capability.

8.28 Figure 21 shows the test access for making loss measurements of typical circuits. Figure 21A contains only 2-4 and 4-2 repeaters; Figure 21B also contains a 4-4 intermediate repeater. Note that the A-side and B-side designations chosen for this example are arbitrary and do not dictate how this type of circuit should be wired.

CHART 10

INTERMEDIATE LOCATION (Cases 1 and 2)

STEP	PROCEDURE
1	Install the repeater as follows: (a) Equalizer(s) turned off (HT=0, SLOPE=0). (b) PBN and LBOCs (if included) set properly. *Note:* If settings for PBN and LBOC are not available, perform the procedure in Part 8B before proceeding. (c) Slide switches set per CLR card. (d) DISABLE switch set to NOR.
2	After settings have been determined from measurements at the transmitting and receiving ends, install the resulting settings to the equalizer(s).
3	When all measurements are complete, note the final settings in the appropriate plant records.
4	If specified on the CLR card, return the DISABLE switch to the DISABLE position.

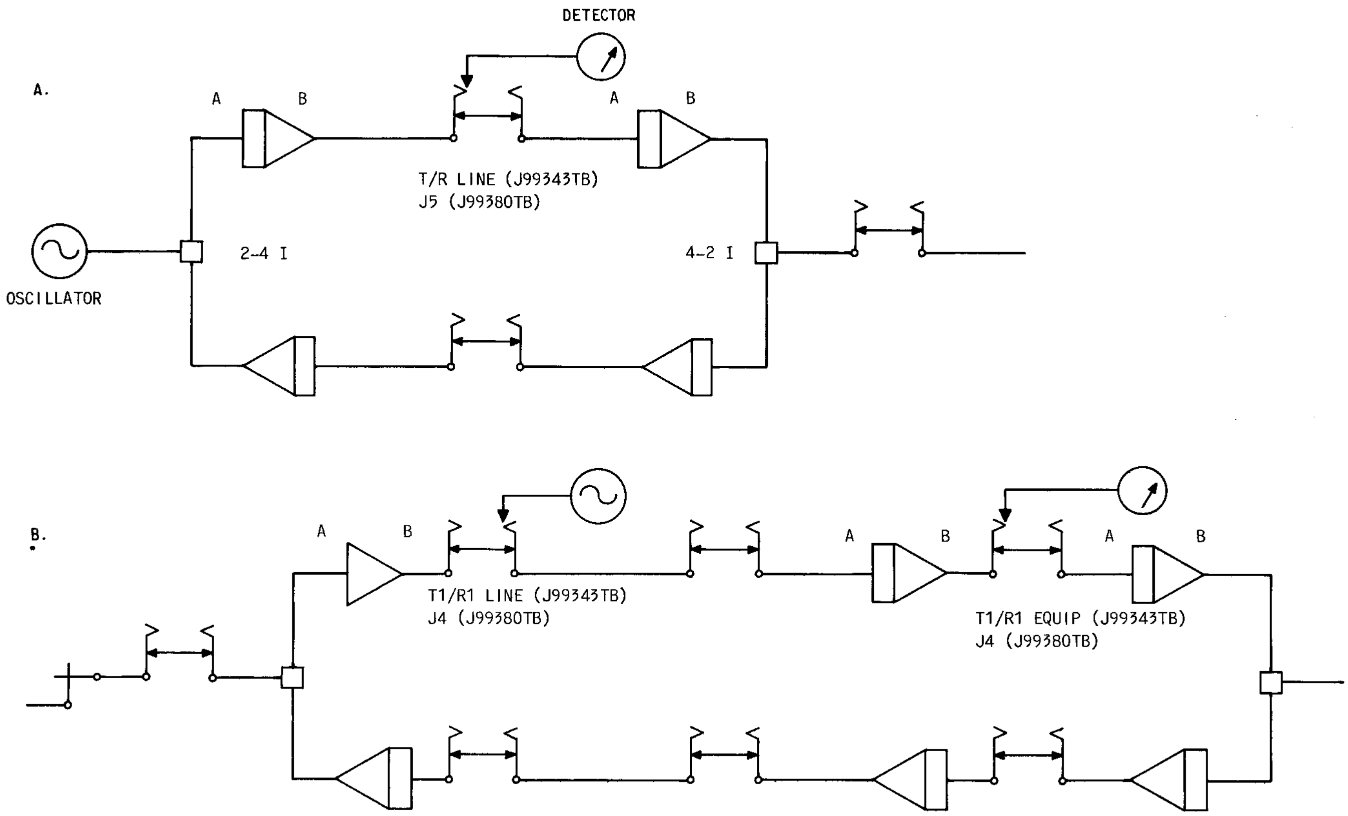


Fig. 21—Oscillator and Detector Connections For Loss Measurements of Typical Circuits

CHART 11

TRANSMITTING LOCATION (Cases 1 and 2)

STEP	PROCEDURE
1	Insert the repeater into the test extender and connect test extender into the proper slot of the MFT shelf or bay.
2	If the facility to be measured is on the A-side, connect a 900-ohm oscillator to the T1/R1 LINE jack of J99343TB or to J8 of the J99380TB test extender. If the facility to be measured is on the B-side, connect a 900-ohm oscillator to the T1/R1 (2W) LINE jack of J99343TB or to J4 of the J99380TB test extender as shown for case 1 and 2 of Fig. 20.
3	Make sure that the repeater at the intermediate location has been installed as described above.
4	Coordinate with the receiving location to measure the facility loss at 400, 1000, and 2800 Hz.

CHART 11 (Contd)

STEP	PROCEDURE
5	From these measurements, settings can now be determined by applying the procedure in Part 9. The settings should be determined and the results given to the intermediate location.
6	If the facility conforms to Case 1, also install the same settings determined in Step 5 on the "receive" equalizer (2 in Fig. 20, Case 1).
7	Measure the facility with the equalizer settings installed to verify their accuracy.
8	When measurements are complete, record the final settings in the appropriate plant records.

CHART 12

RECEIVING LOCATION (Cases 1 and 2)

STEP	PROCEDURE
1	Connect the transmission measuring set (TMS) to the line.
2	Make sure that the intermediate location repeater has been properly set.
3	Coordinate with the transmitting end to measure the facility response at 400, 1000, and 2800 Hz.
4	Using the data from the measurements and the procedure in Part 9, determine the proper equalizer settings.
5	Relate the settings to the intermediate and transmitting locations for installation on the proper repeaters.
6	Remeasure the facility with the settings installed to verify their accuracy.
7	Record the final settings in appropriate plant records.

CHART 13

TRANSMITTING LOCATION (Case 3)

STEP	PROCEDURE
1	Connect a 900-ohm oscillator directly to the line.
2	After the receiving section has set its repeater properly, coordinate the measurement of the facility response to measure the loss at 400, 1000, and 2800 Hz.
3	From these loss measurements, settings for the equalizer can be derived by applying the procedure in Part 9. The settings should be determined and applied to the equalizers at the receive end.
4	Measure the facility loss with the equalizer settings installed to verify their accuracy.
5	Record the final equalizer settings in the appropriate plant records.

CHART 14

RECEIVING LOCATION (Case 3)

STEP	PROCEDURE
1	Insert the repeater into the test extender and connect test extender into the proper slot of the MFT shelf or bay.
2	Set the repeater as follows: (a) Equalizers turned off (HT=0, SLOPE=0). (b) PBN set properly. *Note:* If the setting for the PBN is not available, perform the procedure in Part 8B before proceeding. (c) Slide switches and screw switches set per the CLR card. (d) DISABLE switch set to NOR.
3	If the facility to be measured is on the A-side of the repeater, connect the TMS to the T1/R1 (2W) EQUIP jack of the J99343TB test extender or to J4 of the J99380TB. If the facility to be measured is on the B-side, connect the TMS to the T1/R1 EQUIP jack of the J99343TB or to J8 of the J99380TB test extender as shown for Case 3 in Fig. 20.

CHART 14 (Contd)

STEP	PROCEDURE
4	Coordinate with the transmitting end to measure the facility loss at 400, 1000, and 2800 Hz.
5	Using the data from the measurements and the procedure in Part 9, determine the proper equalizer settings.
6	Install the settings on both of the equalizers.
7	Remeasure the facility with the equalizer set to verify the accuracy of the settings.
8	Record the final settings in the appropriate plant records.
9	If called for on the CLR card, return the DISABLE switch to the DISABLE position.

9. EQUALIZER SETTINGS FROM LOSS DATA

9.01 The procedure described in the following paragraphs can be used to obtain 309B equalizer settings using measured facility loss data. Such a procedure is necessary when a facility is not covered by the tables in Section 332-912-222 or if the facility makeup is not known.

9.02 The procedure assumes that the facility to be equalized has been measured with the equalizer set to zero. To improve upon a setting which has already been determined, use the touchup guidelines in Part 10.

9.03 The inputs to the procedure are the facility losses at 400, 1000, and 2800 Hz measured between 900-ohm impedances. This data may come from any source such as actual measurements of the facility (see Part 8E), artificial cable kit simulation, UNICCAP, or other simulation programs.

9.04 The results of the procedure are the BW, HT, SLOPE, and NL/L switch settings for an equalized facility response which has a controlled amount of roll-off with respect to 1000 Hz (4-wire systems with gain transfer require roll-off at 400 Hz and 2800 Hz for stability purposes).

9.05 To use the procedure, the loss at the three frequencies is entered and a loss difference is calculated. This difference is then looked up in a range chart to determine either the HT or SLOPE setting. If the difference falls on a dividing line, use the setting to the right of the number.

9.06 Table F is used to compute a 400-Hz adjustment using the HT setting. This table is necessary to correct for the low-frequency effect of a particular HT setting. The BW setting is always 15 (all BW switches operated, see paragraph 10.05).

TABLE F

400-HZ ADJUSTMENT FOR HT SETTING

HT SETTING	400 Hz ADJ
0	0.0
1	.1
2	.1
3	.2
4	.3
5	.4
6	.6
7	.8
8	1.0
9	1.2
10	1.4
11	1.6
12	1.9
13	2.2
14	2.6
15	3.1

9.07 The procedure for determining equalizer settings is shown in Chart 15. Following are two examples using Chart 15:

Example 1: (The following data was obtained from cable loss measurements.)

STEP	PROCEDURE	
1	400-Hz loss	8.3 dB
	1000-Hz loss	8.3 dB
	2800-Hz loss	11.4 dB
2	2800-Hz loss	11.4 dB
	1000-Hz loss	8.3 dB
	Difference	3.1 dB is not greater than 5.5 dB
	From Fig. 22(A) HT = 1 when 2800-Hz difference = 3.1 dB.	
	From Table F the 400-Hz adjustment corresponding to HT = 1 is 0.1.	
3	1000-Hz loss	8.3 dB
	400-Hz loss	8.3 dB
	Difference	0 dB
	Add	1.5 dB
	Total	1.5 dB
	400-Hz Adj	0.1 dB
	Difference	1.4 dB
	From Fig. 22(B) SLOPE = 4 when 400-Hz difference = 1.4 dB.	
	NL/L = L	
	Go to Step 6	
6	BW = 15	
	HT = 1	
	SLOPE = 4	
	NL/L = L	

The facility was then remeasured to obtain the following results:

400-Hz loss	5.0 dB
1000-Hz loss	3.5 dB
2800-Hz loss	5.8 dB

Notice that at 400 Hz the equalized response has 1.5 dB more loss than at 1000 Hz while the unequalized response is flat between 400 and 1000 Hz. This roll-off is necessary for stability and the procedure will use the equalizer to achieve this effect.

Example 2: (The following data was obtained from cable loss measurements.)

STEP	PROCEDURE	
1	400-Hz loss	9.0 dB
	1000-Hz loss	11.2 dB
	2800-Hz loss	19.8 dB
2	2800-Hz loss	19.8 dB
	1000-Hz loss	11.2 dB
	Difference	8.6 dB
	This is greater than 5.5 so proceed to Step 4.	
4	From Fig. 22(C) HT = 6, and from Table F the 400-Hz adjustment is 0.6.	
5	1000-Hz loss	11.2 dB
	400-Hz loss	9.0 dB
	Difference	2.2 dB
	Add	1.5 dB
	Total	3.7 dB
	400-Hz Adj	0.6 dB
	Difference	3.1 dB
	From Fig. 22(D) SLOPE = 9 NL/L = NL	
6	BW = 15 HT = 6 SLOPE = 9 NL/L = NL	

The above settings were installed and the facility remeasured. The following results were obtained:

400-Hz loss	7.6 dB
1000-Hz loss	6.3 dB
2800-Hz loss	8.4 dB

9.08 To put the facility in Example 2 into service, some flat gain (set by potentiometer) must be added. Note that again there is a controlled amount of roll-off for stability reasons.

9.09 In long cable circuits where this procedure is used to obtain settings for two different facilities in the same circuit, the combined effect of the two responses may be on the border line of trunk requirements. Complying with trunk requirements may necessitate a variation of the equalizer setting procedure for long cable circuits. Rather than setting the two facilities separately, the first should be set and then the ***entire circuit*** measured with the second equalizer set to zero. This will cause the second set of measurements to produce settings for the second equalizer which are more compatible with the equalization needs of the entire circuit.

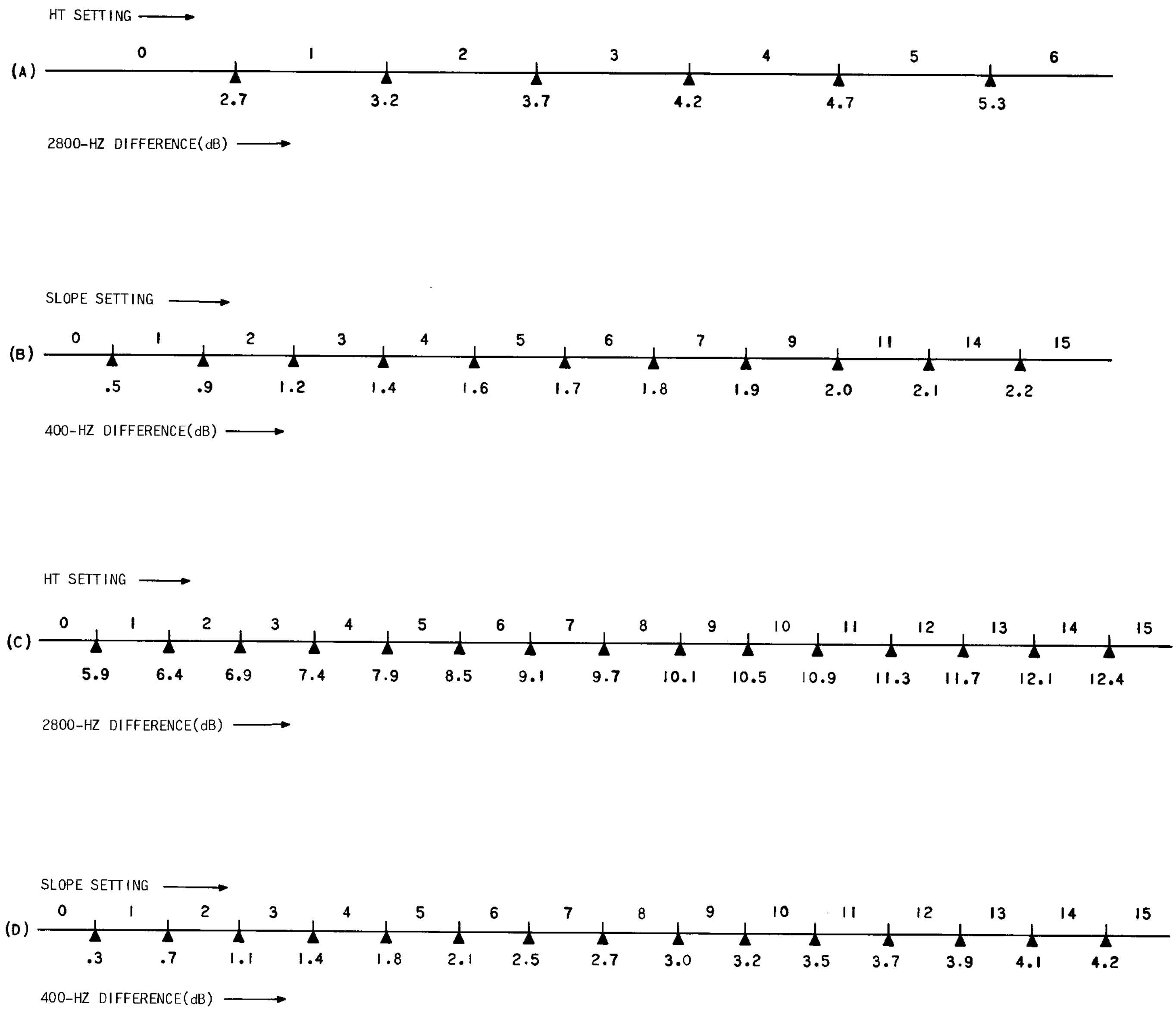


Fig. 22—Loss Range Charts For Obtaining 309B Equalizer Settings

CHART 15

EQUALIZER SETTINGS FROM CABLE LOSS DATA

STEP	PROCEDURE
1	Determine cable loss 400 Hz ________ 1000 Hz________ 2800 Hz ________
2	2800-Hz loss ______ 1000-Hz Loss______ DIFFERENCE___If greater than 5.5, enter this difference in Step 4 and proceed to Step 4. From Fig. 22(A), select HT setting and enter in Step 6. From Table F, find the 400-Hz adjustment corresponding to this HT setting and enter at * in Step 3.
3	1000-Hz Loss ________ 400-Hz Loss ________ DIFFERENCE ________ ADD ______1.5____ TOTAL________ 400-Hz Adj.______*___ DIFFERENCE ________ From Fig. 22(B), select SLOPE setting and enter in Step 6. Enter NL/L = L in Step 6. Proceed to Step 6.
4	DIFFERENCE From Step 2 ________ From Fig. 22(C), select HT setting and enter in Step 6. From Table F, find the 400-Hz adjustment corresponding to this HT setting and enter at † in Step 5.
5	100-Hz Loss ________ 400-Hz Loss________ DIFFERENCE ________ ADD ______1.5____ TOTAL ________ 400-Hz Adj.________ † DIFFERENCE________ From Fig. 22(D), select SLOPE setting and enter in Step 6. Enter NL/L = NL in Step 6.

CHART 15 (Contd)

STEP	PROCEDURE
6	BW = 15 HT = SLOPE = NL/L = END OF SETTING CALCULATION

10. EQUALIZER TOUCHUP GUIDELINES

10.01 The following guidelines explain how to improve an initial equalizer setting by measurements and also describe the effect of the various equalizer controls. This procedure assumes that the initial setting is reasonably close to the correct value. For cases where an initial setting is not available, use the procedure outlined in Part 9.

10.02 Figure 23 shows the desired equalized facility frequency response. Unlike an all 4-wire facility (no 2-wire extension) which strives for a flat response across the band, the response objective here has 1.5 dB roll-off at 400 Hz and 2.25 dB roll-off at 2800 Hz. Of the two objectives, the 400 Hz one is the more critical because, in many cases, the stability of the circuit is directly related to the loss at 400 Hz.

Note: This is an ***objective***—not a requirement. Actual response limits are determined by the requirements of the overall circuit. By adjusting each facility of a circuit to the loss shape of Fig. 23, the overall circuit will be set for optimum stability while still meeting its end-to-end loss objectives.

10.03 Low-frequency equalization is controlled by the SLOPE adjustment in combination with the NL/L switch:

- With NL/L = L

  Increasing SLOPE—more loss at low frequencies relative to 1 kHz

  Decreasing SLOPE—more gain at low frequencies relative to 1 kHz

  There is almost no effect at frequencies above 1 kHz with NL/L = L

- With NL/L = NL

  Increasing SLOPE—more loss at low frequencies and more gain in the midband relative to 1 kHz

  Decreasing SLOPE—more gain at low frequencies and more loss in midband relative to 1 kHz

Note: Changing the slope setting ***always*** affects the 1-kHz gain of the repeater.

10.04 The equalization for frequencies above 1 kHz is controlled by a "bump" function centered at 3250 Hz. The height of the bump is controlled by the HT (height) switches and the width of the bump is controlled by the BW (bandwidth) switches.

10.05 Since none of the facilities discussed in this section have requirements beyond 2800 Hz, small BW settings are not necessary. By setting BW = 15, most cases can be handled without significantly impairing the flexibility of the equalizer.

10.06 When touching up equalization, always adjust the low-frequency roll-off first (SLOPE). Changes in the HT and BW settings can then be made because these will have a minor effect on the low-frequency response. Changing the SLOPE setting can have a major effect on the high-frequency response.

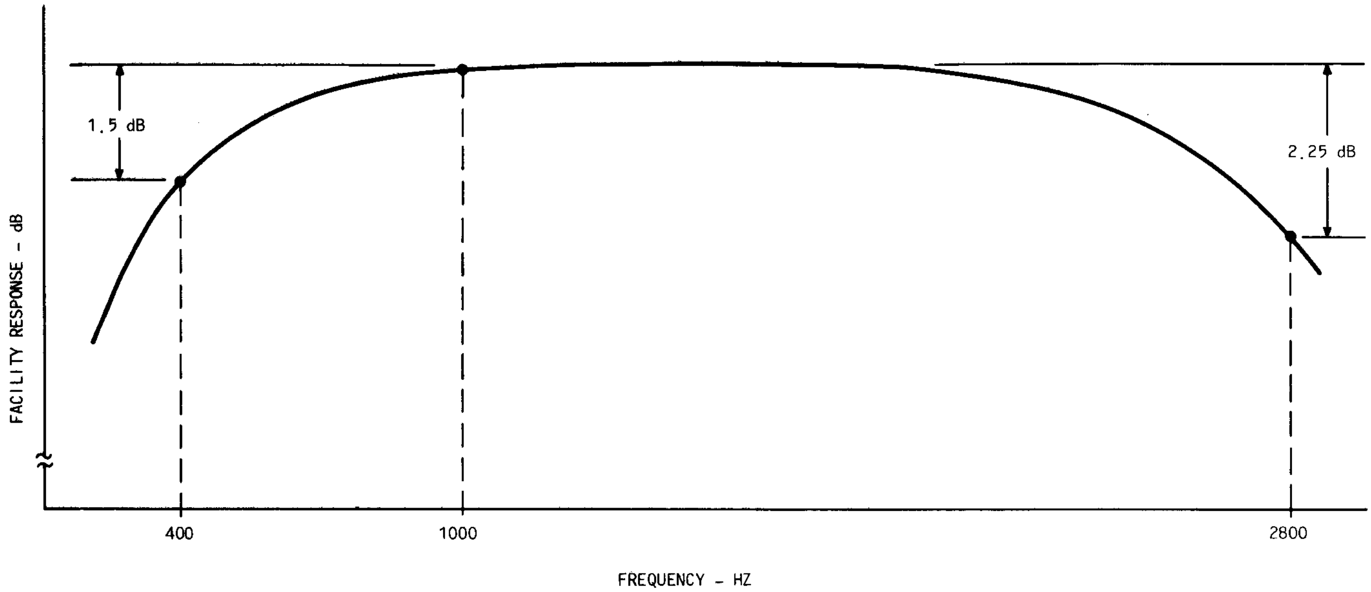


Fig. 23—Objective For Equalized Response on a 4-Wire Circuit With 2-Wire Extension

10.07 The following guidelines should be considered when touching up equalization:

- Check roll-off at 400 Hz (compared to 1 kHz)

  too much loss - decrease SLOPE

  too much gain - increase SLOPE

- Since the NL/L switch affects the gain characteristic significantly, this switch should not be changed during touchup.

- Check roll-off at 2.8 kHz compared to 1 kHz

  too much loss - increase HT

  too much gain - decrease HT

- Most circuits covered in this section can be equalized by leaving the BW (bandwidth) control set to 15. However, if the response is acceptable at 400 Hz and 2800 Hz, but too much gain at 2000 Hz, decrease the BW setting.

- If good results cannot be obtained in two or three adjustments, the initial settings were probably too far from optimum. It is suggested that the equalizer settings be determined by the procedures outlined in Part 9.

10.08 Circuits consisting of more than one equalized link should have the equalization for the overall circuit "touched up" as discussed below and as shown in Fig. 24. Equalization of the overall circuit on an end-to-end basis may be required to meet trunk objectives. Circuits consisting of one or two equalized links will normally meet trunk loss objectives with prescription settings (ie, no touchup adjustments should be required). When touchup is necessary for complex circuit configurations, this should be done in a sequence as indicated in Fig. 24. First, the touchup procedures are applied to a single equalized section as shown in Step 1. After adjusting the two equalizers designated "A", touchup procedures are then applied to the next section (Step 2). The remaining sections of the circuit are touched up in a like manner without any further adjustment to the equalizers of the previously touched up section(s).

11. PROCEDURES FOR CIRCUITS REQUIRING TERMINAL BALANCE

11.01 The MFT 4-2 terminal repeaters in combination with 837- or J99380-type impedance compensators may be used for circuits with terminal balance requirements. The following paragraphs discuss the use of these repeaters on circuits requiring terminal balance (the 2-4 intermediate repeaters are not used with impedance compensators).

11.02 Prescription settings for the repeaters (4240-type PBNs and 309B equalizers) and the impedance compensating networks are contained in Section 332-912-222. It is important to note that the special tables found in Section 332-912-222 must be used for MFT applications which include the above impedance compensators.

11.03 If the cable makeup does not fit the tables (eg, includes bridged taps or more than two gauges of wire), a manual adjustment procedure must be used. Chart 16 gives the manual lineup procedures for MFT/837D or J99380AA network configurations on nonloaded cable.

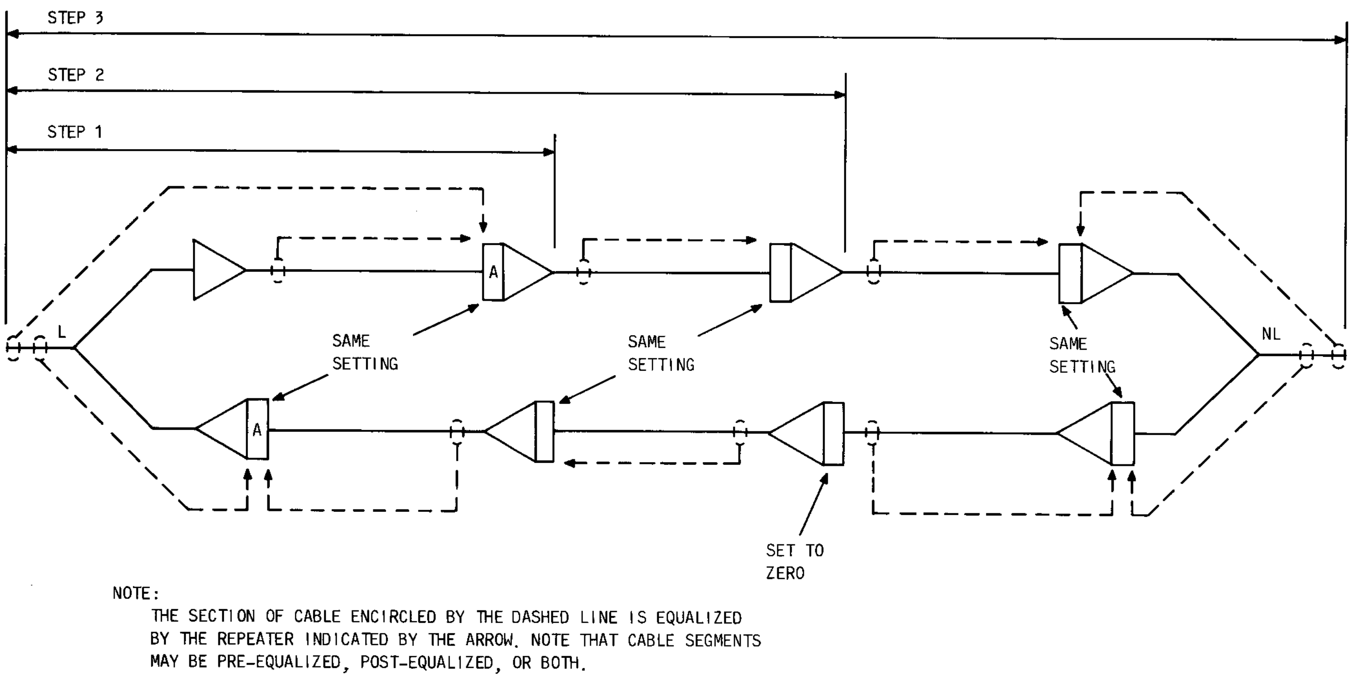


Fig. 24—Equalizer Touchup Procedure For a Complex Circuit

CHART 16

MANUAL ADJUSTMENT OF J99343RC REPEATER AND 873D OR J99380AA NETWORK

STEP	PROCEDURE
1	If the facility does not fit the prescription setting tables contained in Section 332-912-222, a group of initial settings should be chosen using an equivalent gauge and length which most closely resembles the actual facility.
2	Insert the J99343RC 4-2 terminal/intermediate repeater (nonloaded) into the MFT test extender and connect test extender into the proper slot of the MFT shelf or bay.

CHART 16 (Contd)

STEP	PROCEDURE
3	Set the switches on the J99343TB test extender as follows: **A-Side** — 2W/4W to 4W; 600/900 to 600; COMP NET IN/OUT to OUT **B-Side** — 2W/4W to 2W; 600/900 to 900; COMP NET IN/OUT to OUT Set switch on the J99380TB test extender as follows: S2 to NORMAL
4	On the B-side of the J99343TB test extender, terminate the cable facility in 900 ohms + 2.15 μF by inserting a 310 dummy plug into the T1R1 2W EQUIP jack. If using the J99380TB test extender, terminate the cable facility by inserting a 900 ohm + 2.15 μF terminating plug into J4. These terminations will permit positive identification of the 2-wire pair under test at the impedance compensator (see Section 332-205-500).
5	To prevent the repeater from singing during the setting of the 837D or J99380AA, remove the repeater from the test extender.
6	Have the 837D or J99380AA setting optimized using the procedures in Section 332-205-500 or 311-100-551.
7	After obtaining satisfactory terminal balance on the drop side of the 837D or J99380AA: (a) Remove the 310 dummy plug from the J99343TB test extender or the terminating plug from J4 of the J99380TB test extender. (b) Reconnect the repeater. (c) Terminate the drop side of the 837D or J99380AA in the proper impedance (600 or 900 ohms + 2.15 μF).
8	Optimize the 4240B PBN using the procedures in Part 8B (Chart 3) of this section.
9	Determine the 309B equalizer settings using the procedures in Part 9 (Chart 15) of this section.
10	After installing the equalizer settings, adjust the levels of the amplifier units using the procedures in Part 8 (Chart 7) of this section.
11	Insure that the circuit requirements are met, and touch up the 837D or J99380AA "R" potentiometer as required to improve the terminal balance.

11.04 The following procedure should be used for manual adjustment of the J99343RB or J99343RG 4-2 intermediate/terminal repeater (L) when used with 837A, B, E, F, G, or J99380AB, AC networks.

CHART 17

MANUAL ADJUSTMENT OF THE J99343RB OR J99343RG REPEATER AND 837A, B, E, F, G, OR J99380AB, AC NETWORKS

STEP	PROCEDURE
1	Choose and install the initial 4240A or 4240C network settings, using the table in Section 332-912-222 for the facility which most nearly matches the actual facility.
2	If the end section length adjacent to the 837-type or J99380-type network is known, the initial settings may be found in Sections 332-206-251 through -257.
3	If the end section length adjacent to 837-type or J99380-type network is unknown, the initial settings may be determined using the procedures in Section 332-205-500 or 311-100-552.
4	Insert the repeater into the test extender and plug test extender into the proper shelf position of the repeater.
5	Set the switches on the J99343TB test extender as follows: **A-Side**: 2W/4W to 4W; 600/900 to 600; COMP NET IN/ **B-side**: 2W/4W to 2W; 600/900 to 900; COMP NET IN/OUT to OUT Set switch on the J99380TB test extender as follows: S2 to NORMAL
6	On the B-side of the J99343TB test extender, terminate the cable facility in 900 ohms + 2.15 μF by inserting a 310 dummy plug into the T1R1 2W EQUIP jack. If using the J99380TB test extender, terminate the cable facility by inserting a 900 ohm + 2.15 μF terminating plug into J4. These terminations will permit positive identification of the 2-wire pair under test at the impedance compensator (see Section 332-205-500).
7	To prevent the repeater from singing during adjustment of the 837- or J99380-type network, remove the repeater from the test extender.

CHART 17 (Contd)

STEP	PROCEDURE
8	Optimize the 837- or J99380-type network settings using the procedures in Section 332-205-500 or 311-100-552.
9	After obtaining satisfactory terminal balance on the drop side of the 837- or J99380-type network: (a) Remove the 310 dummy plug from the J99343TB test extender or the terminating plug from J4 of the J99380TB test extender. (b) Reconnect the repeater in its shelf or bay mounting. (c) Terminate the drop side of the 837- or J99380-type network in the proper impedance (600 or 900 ohms + 2.15 μF).
10	Optimize the 4240A network using the procedures in Part 8B (Chart 2) of this section.
11	After setting the PBN and LBOC to their proper values, adjust the levels of the amplifier units using the procedures in Part 8D (Chart 7) of this section.
12	Insure that circuit requirements are met, and touch up the 837- or J99380-type network as necessary to improve the terminal balance.

12. REFERENCES

12.01 The following references may be referred to for additional information.

REFERENCE	TITLE
332-910-100	General Description of the Metallic Facility Terminal (MFT)
332-910-102	MFT Test Extender—Description and Operation
332-910-180	General MFT Applications Information
332-912-121	4-2 and 2-4 Wire Repeaters—Description
332-912-222	4-2 and 2-4 Wire Repeaters—Prescription Settings
SD-1C359-01	Metallic Facility Terminal Circuit
CD-1C359-01	Common Systems—Metallic Facility Terminal Circuit
332-610-500	Customer Premises Facility Terminal For MFT Plug-In Equipment Maintenance and Testing Information