

V4 TELEPHONE REPEATERS ENGINEERING LOSS AND GAIN CALCULATIONS

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SECTION 852-307-102

1. GENERAL

1.01 This section describes the loss and gain calculations for circuits that include V4 repeaters. It is a guide to circuit layout and design engineers and covers information applicable to the basic V4, 24V4, and 44V4 repeaters.

1.02 This section is reissued to include all available plug-in components and to provide current information. Since this is a general revision, change arrows have been omitted.

1.03 Selection of plug-in units, such as equalizers and terminating sets, is covered briefly. For more detailed information on selection, refer to Section 852-307-101.

1.04 Section 852-307-101 also outlines the three suggested systems which may be used for designating the screw-switch settings on the circuit layout form.

1.05 Gains, losses, and transmission levels are covered in this section in order to:

- (a) Provide plant and engineering personnel with ***Design Levels, Losses, and Gains*** for design layout purposes.
- (b) Provide plant personnel with ***Expected Measured Losses and Gains (EMLs and EMGs)*** for lineup and maintenance purposes.

2. DESIGN PROCEDURES

2.01 The design procedures include the use of a Design Layout Sheet made up of:

- (a) A sketch of the recommended circuit layout, showing the facilities and repeater points involved.
- (b) Five rows of figures keyed to the sketch and titled and numbered as follows:
 - (1) Design levels
 - (2) Design losses
 - (3) Design gains
 - (4) Expected measured losses

(5) Expected measured gains

2.02 Examples of the use of the Design Layout Sheet are shown in Charts 1, 2, and 3. These all show the maximum permitted levels into metallic facilities (see 4.02).

2.03 The Design Layout Sheet, with its corresponding LEVEL, LOSS, and GAIN rows, can be used to enter selected plug-in units and calculated or known levels or losses. The need for gain (227-type amplifier) or padding (849-type network) can then be calculated.

2.04 The need for gain or padding is governed by:

- (a) The design objective for net loss of the type of circuit to be installed, such as:

Interoffice trunks

Tandem trunks

Short-haul intertoll trunks

Toll connecting trunks

PBX tie trunks

Special service lines

Data service lines

- (b) Design levels (covered in detail in Part 4)

- (c) Gain required to overcome 1-kHz loss introduced by equalization.

3. SELECTING PLUG-IN UNITS

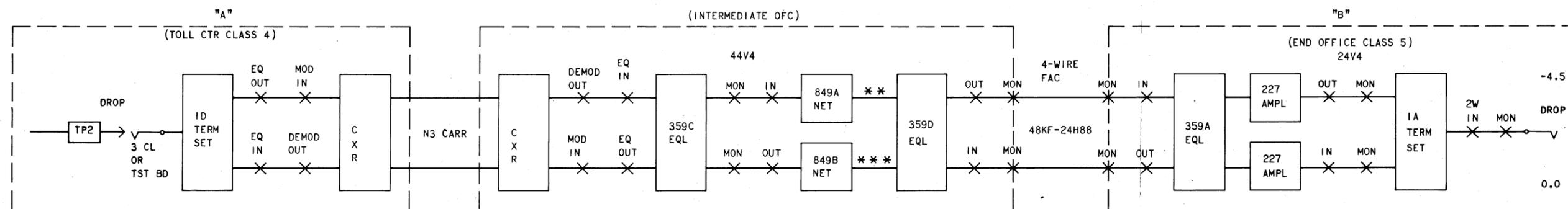
3.01 The selection of plug-in units in designing circuits using 24V4 or 44V4 repeaters is governed basically by the impedance and loss of the facilities to be used.

3.02 The basic uses and ***average*** electrical characteristics of each type of plug-in unit can be found in Table A.

3.03 The selection of plug-in units can result in many different combinations. The guides for selection are covered in detail in Section

V4 REPEATER
 DESIGN LAYOUT SHEET
 (EXAMPLE OF A TYPICAL TOLL CONNECTING TRUNK)

1	DESIGN LEVELS	A TO B →	0.0	-2.0	-16.0	+7.0	+6.0	-5.0	-4.5		
		B TO A ←	-4.5	-2.5	+7.0	-16.0	-5.0	+6.0	0.0		
2	DESIGN LOSSES	A TO B →	2.0	0.5	* 13.5	-	1.0	11.0	7.6	3.9	0.5
		B TO A →	2.0	0.5	* 9.0	-	9.6	1.4	11.0	-	3.9
3	DESIGN GAINS	A TO B ←			23.0				12.5		
		B TO A →			23.0				10.4		



EML AND EMG OF SEGMENTS											
4	EML	A TO B →	16.0			11.5		11.7			4.6
		B TO A ←	11.5			11.5		11.7			4.6
5	EMG	A TO B →			23.0					4.4	
		B TO A →			23.0					9.9	

SUGGESTED SEQUENCE

1. DETERMINE AND ENTER "DESIGN LEVELS" (ROW 1)
2. ENTER FIXED EQUIPMENT AND V4 COMPONENT LOSSES (ROW 2) (INCLUDES EQUALIZER LOSSES)
3. DETERMINE BY COMPUTATION OR SIMULATION AND ENTER FACILITY LOSS (ROW 2)
4. ANALYZE LEVELS AND LOSSES IN ROWS 1 AND 2 AND DETERMINE AND ENTER GAIN OR LOSS NEEDED TO MEET LEVELS-(ROW 3)
5. COMPUTE AND ENTER EXPECTED MEASURED LOSSES (EML) IN ROW 4
6. COMPUTE AND ENTER EXPECTED MEASURED GAINS (EMG) IN ROW 5

PARAGRAPH REFERENCE

- 4.01 THROUGH 4.07
- 5.01 THROUGH 5.04
- 5.05 THROUGH 5.19
- 5.20 AND 6.01 THROUGH 6.05
- 7.01 THROUGH 7.07
- 8.01 THROUGH 8.05

HYB LOSS + "89" PAD
 * $\begin{cases} 13.5 = 4.5 + 9.0 \\ 9.0 = 4.5 + 4.5 \end{cases}$
 ** -0.4 DB TRANSFORMER LOSS + 0.6 DB PAD
 *** -0.4 DB TRANSFORMER LOSS + 9.2 DB PAD

Chart 2—V4 Repeater-Design Layout Sheet (Example of a Typical Toll Connecting Trunk)

TABLE A
V4 PLUG-IN UNITS AND THEIR AVERAGE ELECTRICAL CHARACTERISTICS (7)

TERM. SETS	NOMINAL 2-WIRE IMPEDANCE (OHMS) (6)	(7) 2-WIRE DC RES. (OHMS)	PAD SOCKETS	SIMPLEX INDUCTOR (1)	1 kHz 2W - TO 4W POWER LOSS BETWEEN NOMINAL IMPEDANCES - (DB) (5)			OPTIONAL "SHORT" FOR INDUCTOR	MIDPOINT CAP. (UF)
					HYBRID ALONE	HYBRID WITH "AMPL" SCREWS DOWN	HYBRID WITH "NO AMPL" SCREWS DOWN		
1A	900	51.6	No	Yes	3.5	3.9	4.0	Yes	1
1B	600	42.8	No	Yes	3.7	4.4	4.5	Yes	1
1K	900	51.6	No	Yes	3.5	3.9	4.0	Yes	1
1L	600	42.8	No	Yes	3.7	4.4	4.5	Yes	1
HYBRID WITH FIXED IMPEDANCE-IMPROVING SHUNT									
1C	900	51.6	Yes	No	4.2	—	—	—	1
1D	600	42.8	Yes	No	4.5	—	—	—	1
1F	900	51.6	Yes	Yes	4.2	—	—	No	1
1G	900	51.6	Yes	No	4.2	—	—	—	1 or 4
1M	900	51.6	Yes	Yes	4.2	—	—	Yes	1
1N	600	42.8	Yes	Yes	4.5	—	—	Yes	1

AMPLIFIER (9)	USE	RESISTANCE IN SIMPLEX PATH (OHMS) (7)			
		INPUT AND OUTPUT IMPEDANCE (OHMS)	OUTPUT		
			INPUT	600-OHM WDG.	1200-OHM WDG.
227A	All Buried Cable	600 or 1200	8.5	17.5	23.75
227B	Aerial or Buried Cable	600 or 1200	8.5	17.5	23.75
227C	Aerial or Buried Cable	600 or 1200	8.5	17.5	23.75
227D	Aerial or Buried Cable	600 or 1200	8.5	17.5	23.75
227E	All Buried Cable	600 or 1200	8.5	17.5	23.75
227F	Aerial or Buried Cable	600 or 1200	8.5	17.5	23.75

NET.	4-WIRE FACILITY	FOR AMPL. SOCKET		1 kHz POWER LOSS BETWEEN NOMINAL IMPEDANCE (5) - DB	IMPEDANCE RATIO OF TRANSFORMER EQUIP.:LINE	RESISTANCE IN SIMPLEX PATH (OHMS) (7)	TYPICAL USE
		24V4	44V4				
849A	Loaded Cable H88 or D88	T	1 or 2	0.4 + Pad	600:1200	15.7	Transmitting into Loaded Cable
849B (8)	Loaded Cable H88 or D88	R	1 or 2	0.4 + Pad	600:1200	15.7	Receiving from Loaded Cable
849C	600 Ohm Equip. or NL Cable	T or R	1 or 2	Pad	No Trans.	No Tap	VF Extensions to Carrier Channels
849D (2)	Long Lengths NL Cable	—	—	0.5 + Pad	600:150	1.3	Combined Pad and 359B Equalizer
849E (2)	Short Lengths NL Cable	—	—	0.5 + Pad	600:600	6.25 (4)	Combined Pad and 359F Equalizer
849F	Loaded Cable H44	T	1 or 2	0.3 + Pad	600:600	1.5	Transmitting into Loaded Cable
849G	Loaded Cable H44	R	1 or 2	0.3 + Pad	600:600	1.5	Receiving from Loaded Cable
849H	Loaded or NL Cable	Used in 424V4 Repeater		—	—	22.0	Delayed Call 4-Wire Trunk Circuits

TABLE A (CONT)

<u>EQL.</u>	<u>4-WIRE FACILITY</u>	<u>1-kHz POWER LOSS BETWEEN NOMINAL IMPEDANCE (5) - DB</u>	<u>IMPEDANCE RATIO OF TRANSFORMERS (TWO) EQUIP:LINE</u>	<u>ADJUSTABLE</u>	<u>IMPEDANCE FACING FACILITIES (OHMS)</u>	<u>RESISTANCE PER TRANSFORMER IN SIMPLEX PATH (OHMS) (7)</u>
359A	Loaded H88 Gain Required (3)	6.2 to 9.2	— —	Yes	1200	No Tap
359B	Long Lengths Nonloaded	0.5	600:150	No	150	1.3
359C	600-ohm Equip. (Dummy)	0	— —	No	600	No Tap
359D	Loaded H88 with 849B Network	0 to 3.0	— —	Yes	1200	No Tap
359E	Short Lengths Loaded, Gain Req'd.	0	— —	No	1200	No Tap
359F	Short Lengths Nonloaded	0.5	600:600	No	600	6.75
359G	Loaded Cable or Carrier Channels, Data	10.2 to 19.7	— —	Yes	1200 (10)	No Tap
359H	Loaded Cable or Carrier Channels, Data	0.9 to 1.3	— —	Yes	600	No Tap
359J	Short Lengths Loaded Cable, No Gain	0	— —	No	1200	No Tap
359K	Loaded H44, Gain Required (3)	6.2 to 7.8	— —	Yes	600	No Tap
359L	Loaded H44, No Gain Required	0 to 1.6	— —	Yes	600	No Tap
359M	Long NL, Critical Voiceband Data	0.3	600:150	No	150	0.5
359N	Short NL, Critical Voiceband Data	0.3	600:600	No	600	1.5
359P	Unigauge (3)	6.2 to 24.5	— —	Yes	1200	No Tap
359R	Loaded Q44 (3)	6.2 to 21.0	— —	Yes	1200	No Tap

<u>NETWORK</u>	<u>APPLICATION</u>	<u>TRANSFORMER IMPEDANCE RATIO (OHMS) EQUIP:LINE</u>	<u>SIMPLEX RESISTANCE PER TRANSFORMER (OHMS) (7)</u>
4182A	Level Adjusting	— —	—
4182B	Level Adjusting and Impedance Matching	150:600 600:600 1200:600	1.8 3.5 5.5
4182C	Level Adjusting and Loss Equalization	1200:600	5.5

- NOTES:**
- (1) $2.5 \pm .25$ henrys at 60 mA; 74 ohms.
 - (2) For use in basic V4 repeaters; requires nonstandard cross-connections when used in receiving direction of transmission.
 - (3) Includes a 6.2-dB pad.
 - (4) Simplex resistance on pad side = 6.75-ohms plus effect of pad.
 - (5) This is the loss used in computation of levels.
 - (6) Nominal 4-wire impedance is 600-ohms for all terminating sets.
 - (7) For calculations concerned with signaling ranges, add 15% to the tabulated average values.
 - (8) Cannot normally be used in basic V4 repeater.
 - (9) 227A, B, and C amplifiers are rated mfr. disc.
227E replaces 227A
227F replaces 227B
227D replaces 227C
 - (10) When used in EQL 2 mounting position of 44V4B repeater.

852-307-101. Table A is provided here as a convenient reference.

3.04 Some plug-in units can be selected before the Design Layout Sheet is completed; others cannot. One must know whether gain or loss is needed before choosing an amplifier or an 849-type network.

4. DESIGN LEVELS AT 1 kHz

4.01 *For the purpose of this section*, the 1-kHz levels throughout the circuit will be referred to as "design levels." The design levels, along with the various known design losses, must be known in order to determine the need for gain or loss between the AMPL IN and AMPL OUT jacks. The design level at a point in a circuit is based on the average value of power passing that point when the circuit is energized with prescribed test power. In general, a circuit has two terminals at which it may be energized; hence, there are two levels at each point of a 2-wire portion of a circuit. Design levels are customarily expressed in dBm.

4.02 Levels that should be considered are:

- (a) Levels at transmitting and receiving ends of cable facilities, as covered in Section 852-307-101, Part 21. These are the maximum and minimum levels allowed for crosstalk reasons. For shorter repeater sections, lower than maximum levels are permitted into metallic facilities without lowering the minimum input levels.
- (b) Carrier input and output levels (see 4.03).
- (c) Test-tone levels and test pads (see 4.04 through 4.06).

4.03 When 24V4 or 44V4 repeaters are used to extend or to terminate carrier channels on voice facilities, the recommended input and output levels for the carrier facilities should be adhered to and entered in the appropriate block on the Design Layout Sheet.

4.04 Some trunks and special circuits are tested and lined up with a 1-kHz test tone sent at 0 dBm at the 0-dB transmission level point (TLP) and measured at the receiving end without test pads. Some toll connecting and tandem trunks are tested and lined up with -2 dBm test tone at the 0-dB TLP and with 2-dB test pads (TP2) at

the receiving end. This puts test tone throughout the circuit at levels that are closer to what they would be on a complete toll connection. Typical examples are shown in Fig. 1 and 2.

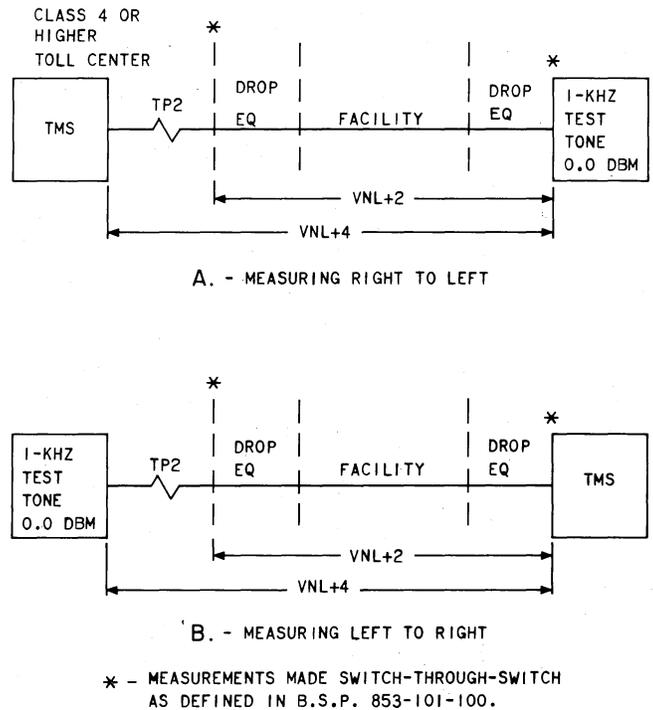


Fig. 1—TP2 Location-Toll Connecting Trunk (Toll Switch)

4.05 Local practices should be consulted to determine where 2-dB test pads (TP2) and -2 dBm test power are applied. The present system standard calls for -2 dBm test power and 2-dB test pads on intertoll trunks only. However, some operating companies have also applied them to toll connecting and tandem trunks.

4.06 Because of their effects on the levels at transmitting and receiving ends of carrier channels (-16 and +7) and 4-wire cable, it is important that test pads and test-tone levels be considered and entered in their appropriate location in the DESIGN LEVEL row.

4.07 The transmit and receive levels at each end of the circuit should be entered in the end spaces of row 1. The receive levels are, of course, governed by the design of the circuit and must

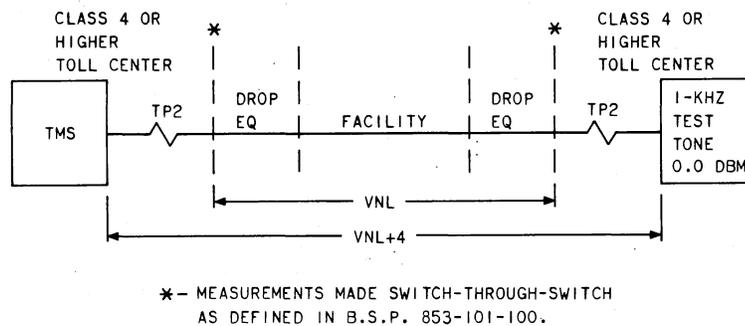


Fig. 2—TP2 Location-Intertoll Trunk

include any effects of test tones and test pads, as discussed in 4.04 through 4.06.

5. DESIGN LOSSES

5.01 Associated with the design sketch is row 2 for the entering of data which, for the purpose of this section, will be denoted "design losses." The "design losses" to be entered for a particular circuit would include all or some of the following:

- (a) Switching equipment (drop) loss
- (b) 4-wire terminating set (hybrid) loss
- (c) Equalizer loss
- (d) Facility loss
- (e) Pad loss.

5.02 The 1-kHz loss of a 1-type terminating set can be determined in Table A. Note that the loss varies not only by type but also, in the 1A, 1B, 1K, and 1L terminating set, according to the AMPL or NO AMPL screw settings.

5.03 The 1-kHz loss of equalizers, of course, must be included when making gain-loss calculations. The basic 1-kHz loss of each type equalizer is listed in Table A. As indicated in Table A, the 1-kHz loss of adjustable equalizers varies as equalization is adjusted. For example, the 1-kHz loss of the 359A or 359D equalizer has a 3-dB range, the loss itself depending upon the high-frequency adjustment. The low-frequency adjustment has practically no effect upon it. After the equalizer settings have been determined, either

by the tables referenced in Table R of Section 852-307-101 or by simulation, these tables can be used to determine the 1-kHz loss of the equalizer. Note that a 6.2-dB isolation pad is a fixed part of the loss of the 359A, K, P, and R equalizers.

5.04 The losses of the 359B and 359F equalizers, when used with 100 percent nonloaded cable, are covered in 5.16. When a 359B equalizer is used on nonloaded cable that is connected directly to loaded facilities and the loss is calculated, a "mean" loss of 0.6 dB should be taken for the 359B equalizer. When the facility loss is determined by simulation, the 359B equalizer is measured with and included as a part of the facility loss.

Facility Loss

5.05 The manner in which the facility design loss is determined depends first upon the type of facility to be used. In some cases, the loss can be completely calculated; but for others, simulation is more practicable.

5.06 For calculation purposes, it is necessary to know the insertion loss of the particular facility between its working impedances in the repeatered circuit. In the case of H88 or D88 loaded facilities, the insertion loss is practically equal to the attenuation, and either may be used. In the nonloaded cases, however, where the repeater impedances are purposely mismatched with the facilities in order to obtain loss-frequency equalization, it is necessary to use the insertion-loss information supplied in this section. This information should be applied to each repeater section separately.

5.07 The types of facilities and the methods for determining the 1-kHz "design loss" are:

- (a) All loaded. Two methods:
 - (1) Calculation
 - (2) Simulation
- (b) All nonloaded. Three methods:
 - (1) Use of charts
 - (2) Simulation
 - (3) Calculation
- (c) Combined loaded and nonloaded. One method:
 - (1) Simulation.

All Loaded—Calculation

5.08 The overall loss of the facility as used in circuit layout work includes attenuation at 68°F, reflection losses between unlike parts (parts consisting of different gauges, different loading systems, or both), reflection losses between facilities and repeaters, and interaction losses. Since interaction losses are usually small enough to neglect, they will not be considered further.

5.09 Attenuation losses per unit length are given in Table B. Determine the attenuation of each kind of cable within the repeater section by multiplying its length by the appropriate value in the table. Reflection losses are given in Table C. In computing the reflection losses between unlike facilities, the end section of each loaded facility was assumed to be one-half of a full loading section. If one or both of the actual end sections are less than 0.4 or more than 0.6 of a full loading section, calculations by means of Tables B and C may be in error. In such cases, measurement on a simulated layout is more reliable.

All Loaded—Simulation

5.10 To measure an H88 facility loss by simulation, set up the intended facility layout with networks of the 1A Artificial Cable Kit. Terminate one end of the facility at the T AMPL OUT jack of a 24V4 repeater, and terminate the other end at the R AMPL IN jack of the same repeater.

Equip the EQL socket with a 359J equalizer; the T AMPL socket with an 849A network; and the R AMPL socket with an 849B network. Put a 0-dB 89-type resistor in each network. Connect a 600-ohm oscillator to the T AMPL IN jack, and a 600-ohm measuring set to the R AMPL OUT jack. The 1-kHz loss measured between these two points, decreased by 0.8 dB, is the facility insertion loss. The 0.8 dB is the sum of the losses in the two 849-type network transformers.

All Nonloaded—Use of Charts

5.11 Figure 3 shows the combined loss of *equalizers and cables* of a repeater section for solid-gauge nonloaded facilities measured between 600-ohm impedances. Do not add reflection losses, since they are already included. Figure 3 should not be used for mixed-gauge facilities. Figure 4 shows the loss of *cable alone* between 900-ohm impedances, and Fig. 5 shows the loss of *cable alone* between 600-ohm impedances. Bridged tap losses depend on length and location of bridged taps and on the impedance of the cable terminations. Approximate losses are as follows:

Between Impedance (Ohms)	Loss/kft in dB
900/900	0.22
600/600	0.15
600/150	0.08
150/150	0.04

For mixed gauges, see Section 304-300-102 which includes losses of nonloaded cable between 900- and 600-ohm impedances. The rule for BRIDGED TAPS is also approximate and may cause errors as much as 0.5 dB in a given circuit.

All Nonloaded—Simulation

5.12 To measure mixed-gauge nonloaded facility plus equalizer loss by simulation, set up the intended facility layout with networks of the 1A Artificial Cable Kit. Connect one end of the facility to the T AMPL OUT jack of a 24V4 repeater, and connect the other end to the R AMPL IN jack of the same repeater.

TABLE B
1000-Hz ATTENUATION (dB)
NON-QUADED CABLE
68°F

Type of Loading	26 GA.				24 GA.				22 GA.		19 GA.				16 GA.	
	LC		HC		LC		HC		HC		LC		HC		LC	
	Mile	kf	Mile	kf	Mile	kf	Mile	kf	Mile	kf	Mile	kf	Mile	kf	Mile	kf
NL*	2.668	0.505	2.853	0.540	2.142	0.406	2.313	0.438	1.808	0.342	1.121	0.212	1.270	0.241	0.754	0.143
H88	1.679	0.318	1.791	0.339	1.134	0.215	1.215	0.230	0.789	0.149	0.375	0.071	0.423	0.080	0.206	0.039
D88	1.520	0.288	1.620	0.307	1.012	0.192	1.083	0.205	0.702	0.133	0.337	0.064	0.380	0.072	-	-
B88	1.296	0.246	1.375	0.260	0.864	0.164	0.917	0.174	0.598	0.113	0.294	0.056	0.331	0.063	0.177	0.034
H44	2.059	0.390	2.205	0.418	1.460	0.277	1.571	0.298	1.049	0.199	0.500	0.095	0.564	0.107	0.267	0.051

* Bridged-tap loss = 1.16 db per mile or 0.22 db per kf.

5.13 Equip the EQL socket with a 359F equalizer, and both amplifier sockets with 849C networks. Put a 0-dB 89-type resistor in each network. Connect a 600-ohm oscillator to the T AMPL IN jack, and a 600-ohm measuring set to the R AMPL OUT jack. Measure the 1-kHz loss between these two points. If this loss is 4.3 dB or less, the 359F equalizer is the proper type for use at both ends of this facility, and the measured loss, which includes an equalizer transformer at each end, is the proper figure to use on the Design Layout Sheets. If the loss is more than 4.3 dB, proceed to 5.14.

5.14 Replace the 359F equalizer with a 359B and measure the 1-kHz insertion loss. If this loss is more than 10.2 dB, the 359B equalizer is the proper type for use at both ends of this facility, and the measured loss is the proper figure to use on the Design Layout Sheets as facility plus equalizer losses. If the loss is 10.2 dB or less, proceed to 5.15.

5.15 If the loss is more than 4.3 dB with 359F equalizers but not more than 10.2 dB with 359B equalizers, it will be necessary to use a 359B at one end of the facility and a 359F at the other. Two 24V4 repeaters are needed in order to measure the combined facility and equalizer loss where different types of equalizers are used at the two ends. At one end of the facility, use a 359F; at the other end, use a 359B. The 1-kHz insertion loss, measured as before, is the proper figure to use on the Design Layout Sheets as facility plus equalizer losses.

All Nonloaded—Calculation

5.16 Calculation is the least accurate method of estimating losses of nonloaded facility mixtures. For approximate losses, compute the attenuation from Table B and add reflection losses from Table C. If the attenuation of any continuous length of the same gauge cable pair is 3 dB or less, ignore its reflection loss with an adjacent repeater or section of cable. In each direction of 4-wire transmission, the loss of a 359B or 359F equalizer is 0.5 dB when the cable is long enough to present characteristic impedance. This loss increases nonlinearly to 0.8 dB as cable length decreases. Where approximates are accurate enough, use 0.6 dB in each direction for a 359B or 359F equalizer. Figure 6 illustrates a method of calculating design losses of mixed-gauge nonloaded facilities.

5.17 For bridged tap loss, allow the loss given in 5.11 for the total amount of bridged tap per kilofoot regardless of the gauge and location of taps. Multiply the bridged tap factor by the total length of bridged tap in kilofeet as accurately as it is known, and round the answer to the nearest 0.1 dB.

5.18 The most accurate means in determining the loss of cable with bridged taps is by using the Universal Cable Circuit Analysis Program (UNICCAP). However, this will only be as accurate as the input data. See Section 856-100-100 for the description and use of UNICCAP.

Combined Loaded and Nonloaded—Simulation

5.19 Usually, the only practicable loaded-nonloaded mixtures in a repeater section are those made up predominantly of loaded cable, but containing short length of nonloaded cable at one or both ends. Since this situation requires simulation in order to determine the types and settings of equalizers, it is recommended that the receiving repeater gains be determined directly from the simulated setup. In general, the correct level is set up at the transmitting end of the repeater section. The receiving amplifier is then adjusted to give the desired output level, and its gain is measured. It must always be remembered that the loss of a loaded cable equalizer is included in a gain measurement of the amplifier with which it works. It must also be remembered that a correction must be made when 600-ohm oscillators or measuring sets are at ports of other impedances. This correction is discussed in the section on lineup of V4 repeaters (see 7.05).

Losses of 849-Type Networks

5.20 Calculations involving "design levels" and "design losses" for the Design Layout Sheet will, at times, result in a need for loss rather than for gain. Pad loss in V4 repeaters is provided by plugging 89-type resistors into 849-type networks or 1-type terminating sets, depending on the V4 component arrangements. When 1C, 1D, 1F, 1G, 1M, or 1N terminating sets are used, the 89-type resistor is plugged into the terminating set. When an 89-type resistor is plugged into a 1-type terminating set, the losses of the two should be combined for entry in the DESIGN LOSS row. When 1A, 1B, 1K, or 1L terminating sets are used, the 89-type resistor is plugged into an 849-type network located

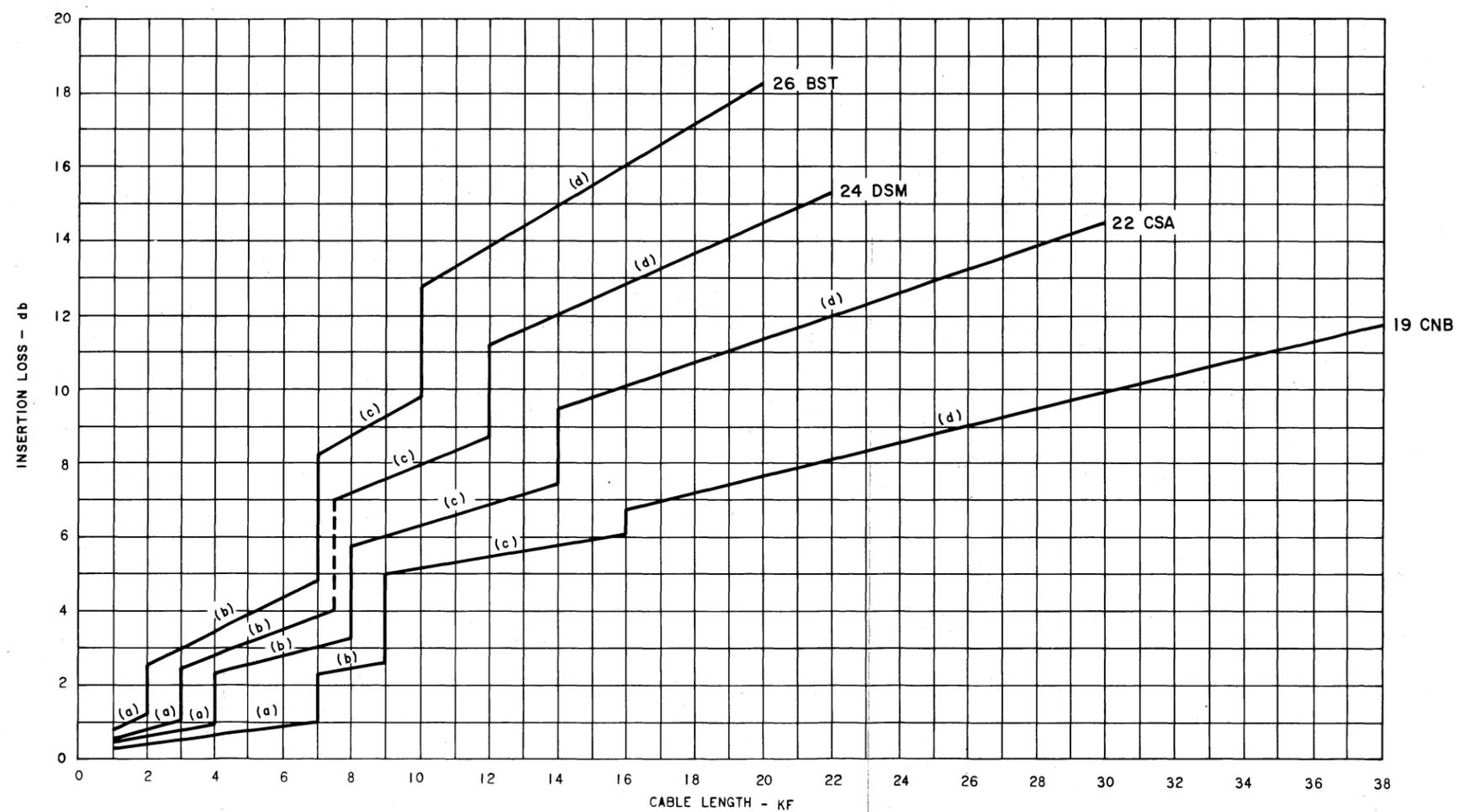
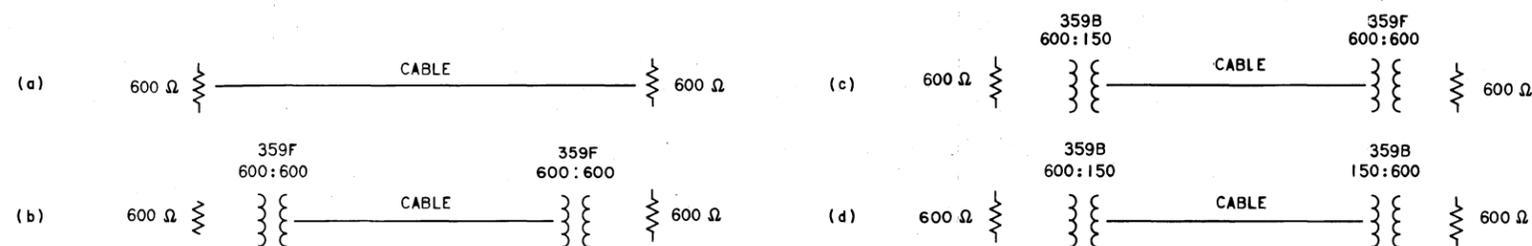


Fig. 3—1-kHz Insertion Loss of Nonloaded Cable (High-Capacitance) with Equalizers as Indicated

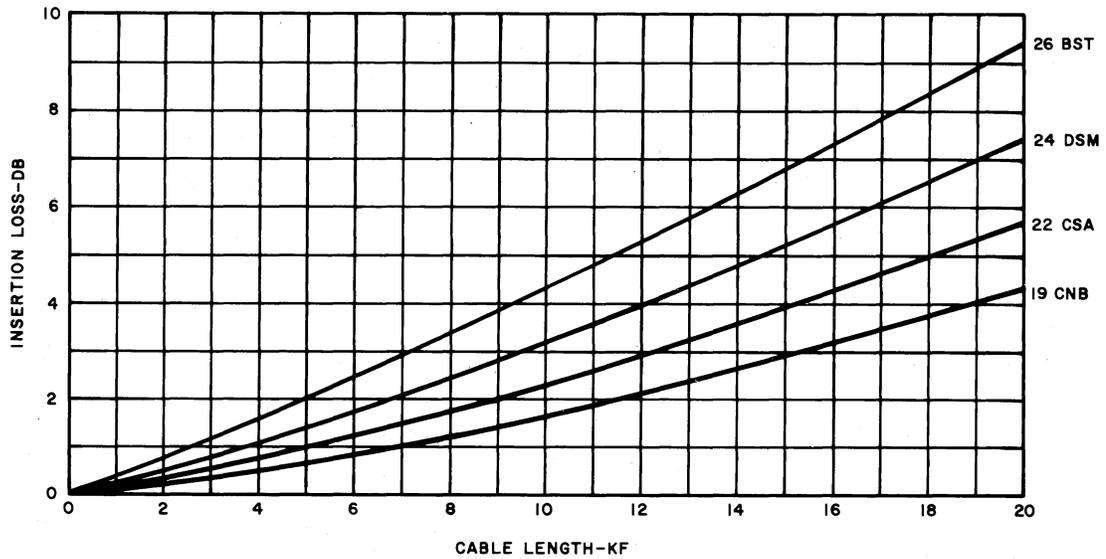


Fig. 4—1-kHz Insertion Loss of Nonloaded Cable Between 900-Ohm Impedances

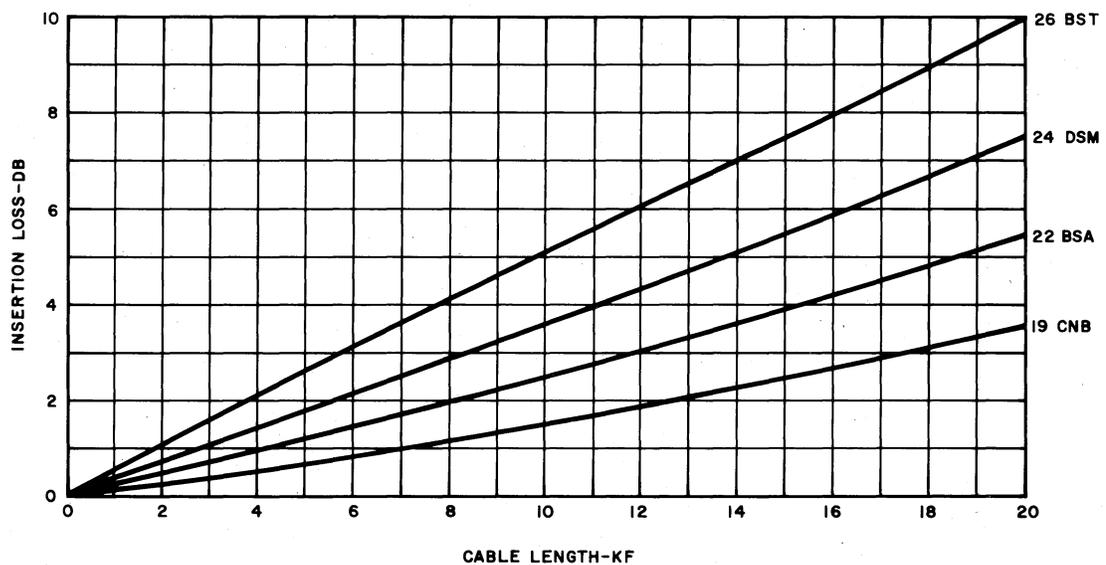


Fig. 5—1-kHz Insertion Loss of Nonloaded Cable Between 600-Ohm Impedances

in the AMPL socket. When the 89-type resistor is associated with the 849-type network, the "design loss" should include the losses of both. The losses of the 849-type networks are listed in Table A.

6. DESIGN GAINS

6.01 When all available "design levels" and "design losses" have been determined and entered

in their respective rows, it is then only a matter of inspection and simple calculation to determine the need for gain or additional loss in each repeater section.

6.02 When calculations of the "design levels and losses" result in a need for gain, it is, of course, provided by a 227-type amplifier.

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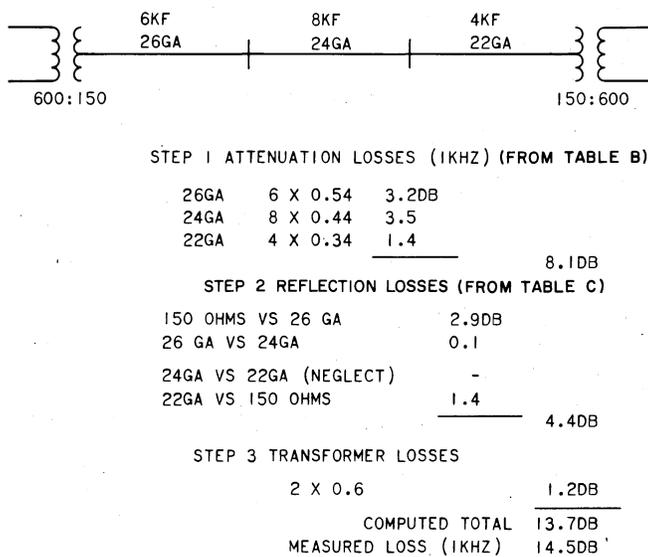


Fig. 6—Example of Loss Computation-Mixed-Gauge Nonloaded Facilities

6.03 The gain of each amplifier should be calculated and specified only after any equalizer settings and losses have been determined.

6.04 The screw-switch settings of amplifiers can be prescribed, but no attempt should be made to prescribe settings of potentiometers since guide marks are only approximate. They should be adjusted by test, as outlined in the lineup sections.

6.05 *The DESIGN GAIN is the "power gain" of the amplifier by itself. It does not include allowances by reflection and/or equalizer loss. It is to be used for design purposes only. The Expected Measured Gain (EMG), to be used for lineup, is explained in 8.01 through 8.05.*

7. EXPECTED MEASURED LOSSES

7.01 The Expected Measured Losses (EMLs) are the 1-kHz losses that should be measured between a 600-ohm oscillator and a Transmission Measuring Set (TMS) in the V4 test jacks.

7.02 The EMLs are entered in row 4 on the Design Layout Sheet.

7.03 EMLs between test jacks should be provided for maintenance purposes. The electrical location of the test jacks, when indicated on the

Design Layout Sheet, is helpful in determining what losses to include in the various EML segments.

7.04 The type of equalizer determines whether it is located on the amplifier side of the test jacks, and consequently, whether its loss is included in a measurement between AMPL IN and AMPL OUT jacks. For example:

(a) A loaded type equalizer is located on the amplifier side of the jacks, as shown in Fig. 7, and its loss (all in the receiving path, none in the transmitting) is included in AMPL IN-AMPL OUT measurements.

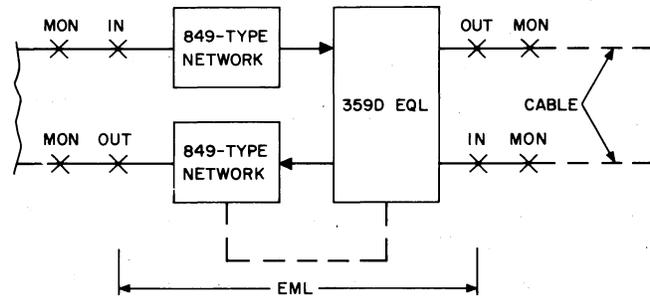


Fig. 7—Test Jack Location When Using 359D Equalizer

(b) A nonloaded-type equalizer is located on the line side of the jacks, as shown in Fig. 8, and its loss (in both the transmitting and receiving paths) is included *not* in AMPL IN-AMPL OUT measurements but in the facility loss measurements.

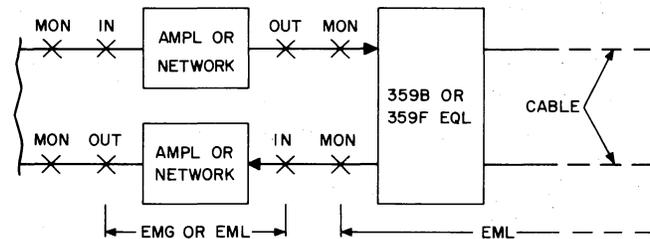
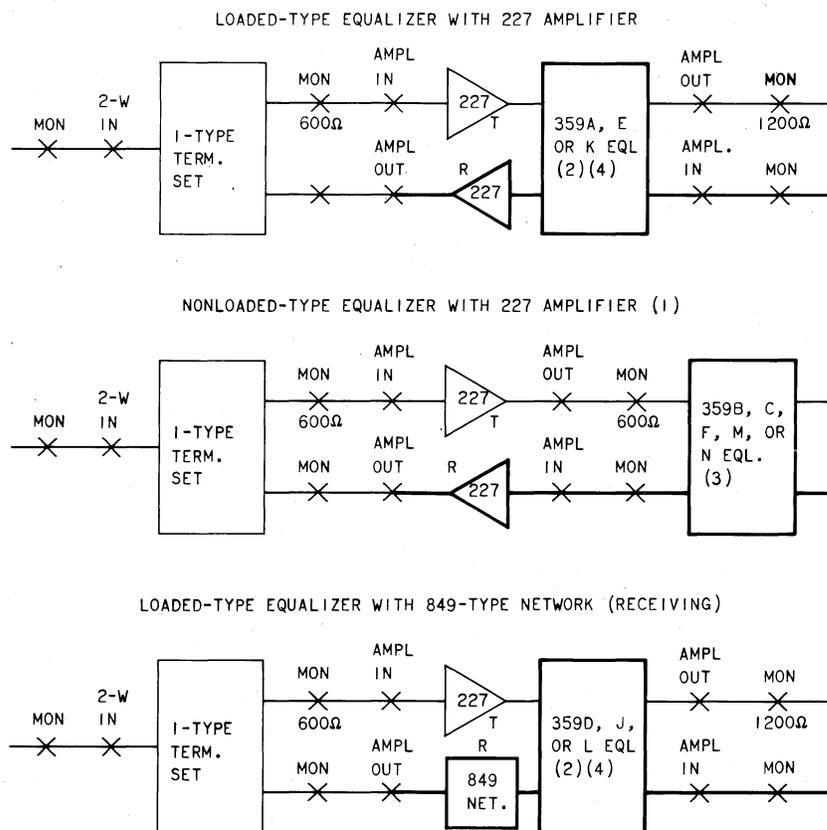


Fig. 8—Test Jack Location When Using 359B or 359F Equalizer

Figures 9 and 10 are provided as additional reference for determining electrical locations and respective impedances of test jacks in 24V4 and 44V4 repeaters having various types of plug-ins.



NOTES:

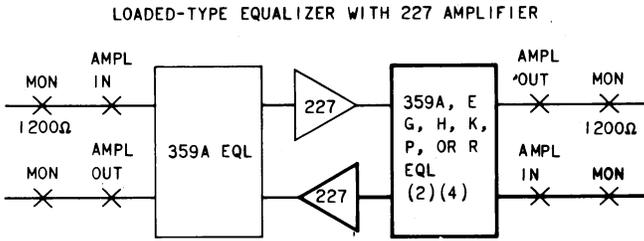
1. IF AN 849-TYPE NETWORK WERE USED, THE LOCATION AND IMPEDANCE OF THE TEST JACKS WOULD BE THE SAME.
2. THE 359A, D, E, J, K, AND L EQUALIZERS INSERT NO LOSS IN T DIRECTION.
3. THE 359B, F, M, AND N EQUALIZERS INSERT LOSS IN BOTH THE T AND R DIRECTIONS; THE 359C INSERTS NO LOSS.
4. THE 359K AND L EQUALIZERS PRESENT 600-OHM IMPEDANCE AT THE TEST JACKS.

⊗ INDICATES TEST JACKS.

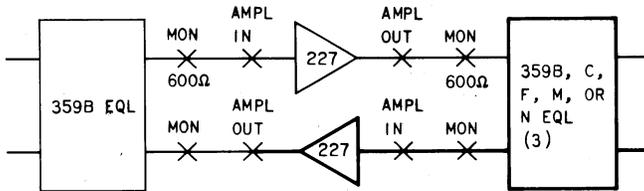
HEAVY LINES IN THE DIAGRAMS ARE THE PARTS OF CHIEF CONCERN. LIGHTER LINES ARE PUT IN MERELY FOR COMPLETENESS, AND DO NOT NECESSARILY INDICATE THE ONLY POSSIBLE ARRANGEMENT.

Fig. 9—Electrical Locations and Impedances of Test Jacks in 24V4 Repeater

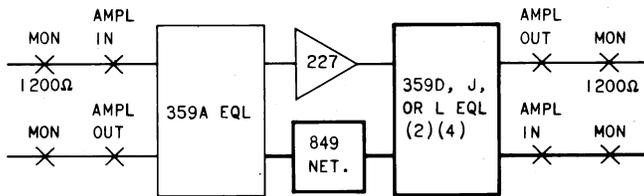
SECTION 852-307-102



NONLOADED-TYPE EQUALIZER WITH 227 AMPLIFIER (1)



LOADED-TYPE EQUALIZER WITH 849-TYPE NETWORK (RECEIVING)



NOTES:

1. IF AN 849-TYPE NETWORK WERE USED, THE LOCATION AND IMPEDANCE OF THE TEST JACKS WOULD BE THE SAME.
2. THESE 359-TYPE EQUALIZERS INSERT NO LOSS IN THE T DIRECTION.
3. THE 359B, F, M, AND N EQUALIZERS INSERT LOSS IN BOTH THE T AND R DIRECTIONS; THE 359C INSERTS NO LOSS.
4. THE 359H, K, AND L EQUALIZERS PRESENT 600-OHM IMPEDANCE AT THE TEST JACKS.

✕ INDICATES TEST JACKS.

HEAVY LINES IN THE DIAGRAMS ARE THE PARTS OF CHIEF CONCERN. LIGHTER LINES ARE PUT IN MERELY FOR COMPLETENESS, AND DO NOT NECESSARILY INDICATE THE ONLY POSSIBLE ARRANGEMENT.

Fig. 10—Electrical Locations and Impedances of Test Jacks in 44V4 Repeater

7.05 When 600-ohm equipment is used to test at ports of other impedances, corrections must be made in order to predict the expected measurements. Expected Measured Losses and Expected Measured Gains will differ from the actual losses and gains

in the circuit. The following mismatch losses are to be allowed for:

Impedance Ratio	Mismatch Loss-dB
600:150	1.9
600:900	.2
600:1200	.5
600:1400	.8

7.06 The EML of the 4-wire cable facility can be determined by:

- (a) Reference to Table D if the cable is all the same gauge.
- (b) Simulation where mixed-gauge facilities are involved.

Here again, the 1-kHz losses to be provided in the EML row should be based on 600-ohm measuring equipment. Note that the data provided in Table D are 1-kHz insertion losses between 600-ohm terminations. Data to be arrived at by simulation should be measured the same way.

7.07 Overall measured circuit losses are not covered in this section. As covered in other sections, they should be measured at their proper impedance.

8. EXPECTED MEASURED GAINS

8.01 Row 5 on the Design Layout Sheet is for entering data which, for the purpose of this section, will be called "Expected Measured Gains" (EMGs).

8.02 The EMGs are the 1-kHz gains which the circuit layout or design engineer expects the craftsman to measure when lining up the 227-type amplifiers, as outlined in the lineup sections.

8.03 The EMG is not necessarily the true amplifier gain (design gain) but may include the effects of equalizers and impedance mismatches. These effects should be taken into account when specifying the EMG on the Design Layout Sheet.

TABLE D
1-kHz INSERTION LOSS OF
H88 - LOADED CABLE - dB
BETWEEN 600 $\angle 0^\circ$ IMPEDANCES
(3-KF END SECTIONS)

KF	19CNB	22CSA	24DSM	26BST
12	2.0	2.9	3.8	5.3
18	2.3	3.5	4.9	6.9
24	2.4	4.0	5.9	8.7
30	2.6	4.8	7.4	10.9
36	3.3	6.0	8.9	13.0
42	4.1	7.0	10.4	15.1
48	4.7	7.9	11.7	17.1
54	4.9	8.7	13.0	19.1
60	5.2	9.5	14.4	21.1
66	5.7	10.4	15.8	23.2
72	6.4	11.4	17.2	25.2
78	7.0	12.3	18.6	27.2
84	7.5	13.0		
90	8.0	14.1		
96	8.5	15.0		
102	8.9			
108	9.4			
114	9.9			
120	10.4			
126	10.8			
132	11.3			
138	11.8			
144	12.3			
150	12.8			
156	13.3			

8.04 Here again, as with EMLs (7.05), to avoid confusion in making measurements, all test power is sent from 600-ohm ports of oscillators and received at 600-ohm ports of detectors. No attempt is made to match impedance of test gear to that of V4 apparatus. This simplification of measurements entails no sacrifice of accuracy; measurements made with unmatched test gear are just as predictable as those made with matched test gear. Suppose a "loaded" type of equalizer is chosen for a 24V4 repeater. This equalizer automatically selects the 1200-ohm amplifier ports for connection to the loaded cable by way of the test jacks on the line side. For EMG measurements, however, 600-ohm oscillator and detector ports are connected to these jacks. Therefore, mismatch (reflection) losses from 600 ohms to 1200 ohms must be taken into account when specifying the Expected Measured Gains in row 5. The mismatch losses to be included when specifying the EMGs are provided in 7.05.

8.05 When other amplifying equipment, such as carrier, is a part of the total design, its gains should be specified in the EMG row.