

METALLIC TELEGRAPH SYSTEM EQUALIZATION

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1. GENERAL

1.01 This section describes the methods of determining the constants of the equalizers for improving transmission over four-wire metallic-telegraph circuits. The equalizers are adjusted to give the minimum characteristic distortion as determined by transmission tests.

1.02 The circuit arrangements of the equalizers for various types of circuits are shown in Figs. 1, 2, and 3.

1.03 A discussion of the theory of characteristic distortion and its reduction by equalization is given in Section 312-006-100. The equalizer equipment is described in Section 312-200-102.

1.04 Equalization is accomplished by adjusting an electrical network at the receiving end of the line section. This alters the over-all transmission characteristic and so changes the wave-shape of the current which actuates the receiving relay. The objective is to so improve this wave-shape that the distortion in signals repeated by the relay will be a minimum. This result will be attained when the distortion of miscellaneous teletypewriter signals is made a minimum or when the characteristic distortion is a minimum as measured with the characters, Blank prebiased 20% spacing, Blank, T, O, M, V, Letters and Letters prebiased 20% marking.

1.05 Before proceeding with any equalization tests it should be determined that the circuit to be tested is in good condition and that the telegraph repeaters used in the tests are correctly wired. The relays used in the repeaters should be adjusted in accordance with the Bell System Practices covering relay tests. As there is a certain amount of variation of perform-

ance between various relays and various repeaters, it is desirable to make the equalization measurements and adjustments with relays and repeaters which are near the average, in performance, of those available for use on the group of circuits being equalized. This is to insure the best average fit between the equalized circuits and the terminal equipment. The selections should be made from groups of relays and repeaters as discussed in Paragraphs 3.06 and 3.07.

1.06 When the equalizer contains a d-c shunt, the current through the receiving relay will be reduced. If this current is reduced too far the vibrating-circuit current will become relatively so strong that distortion may result. The steady current in the receiving relay, therefore, should not be reduced below about 1 milliamperere. The final adjustment of the equalizer shunt resistance may thus involve a compromise between the distortion introduced when the line current is too small and the distortion introduced when the equalizer resistance is not set for full equalization. In general, it will be necessary to set an upper limit to the range of equalizer resistance at a value which does not reduce the current below 0.9 milliamperere with an outside air temperature of 100°F. or 1.1 milliamperere with 0°F. These figures have been chosen to take account of the usual difference between the temperature of the air and that of aerial cable. If there is a pilot wire regulator use the 0.9 milliamperere limit if the regulator is near the top step and the 1.1 milliamperere limit if near the bottom step.

1.07 Use 75 speed for equalization tests when there are any 75-speed circuits on the same route. If only 60-speed circuits exist on the route use 60 speed for equalization tests. Equalization accomplished at 75 speed is always good at 60 speed.

2. TESTING EQUIPMENT

2.01 The teletypewriter signals which are used for equalization are either the six characters which have only two transitions, namely, Blank, T, O, M, V, and Letters or miscellaneous teletypewriter signals such as the test sentence. The use of the test sentence gives results somewhat more quickly in some cases, particularly for circuits requiring simple equalizers, but the test characters afford considerable advantage from the standpoint of interpreting the results in order to arrive at the proper equalizer constants.

SECTION 312-200-500

2.02 The following equipment is the most suitable as a source of test characters, listed in the order of preference:

- (a) 100A Teletypewriter Test Distributor
- (b) 1A Teletypewriter Test Set
- (c) 14-type Transmitter-Distributor (Station Type) with 119-type Telegraph Signal Biasing or Distorting Set.

2.03 With the six teletypewriter signals, either a 161A1 Telegraph Station Test Set or a 118-type Transmission Measuring Set may be used for measurements at the receiving end, but the former is preferred for convenience and accuracy.

2.04 In cases where the signal-source equipment listed in Paragraph 2.02 is not available, the standard test sentence from a 110-type multiple sender may be used. This will require the use of a 118-type Transmis-

sion Measuring Set at the receiving terminal. In this case, the equalizer should be adjusted in accordance with the indications of the total distortion meter.

2.05 All distortion measurements should, if possible, be read to within 0.5%. If the transmitted test signal has a distortion of 0.5% or more, the measurement of the received signal should be corrected accordingly. Distortion of less than 0.5% in the transmitted signal may be neglected.

3. TESTING PROCEDURE

(A) General

3.01 Table I lists the approximate equalizer values as well as the maximum allowable distortion after equalization for various lengths of metallic circuits with various numbers of intermediate composite sets.

TABLE I

Sections: Miles	No. of ICX Points	Send On	Rec. On	Equalizer Approximate Resistance: Ohms			Fig.	Maximum Allowable Characteristic Distortion Per Cent ***
				R1*	R2			
50	0	OPCE	IPCE	4000	-	1	2	
75	1	OPCE	OPCE	600	-	1	2	
105	1	OPCE	OPCE	1600	2300	2	2	
110	1	OPCE	OPCE	1400	2000	2	3	
130	2	OPCE	IPCE	300	700	3	8	
150	2	OPCE	IPCE	0	400	3	12	
75	1	IPCE	IPCE	300	-	1	2	
90	1	IPCE	IPCE	1200	2000	2	2	
105	1	IPCE	IPCE	800	1700	2	3	
110	1	IPCE	IPCE	600	1000	2	4	

*These values recorded for general guidance only. Actual values for any line to be determined by test.

**For lengths over 75 miles, Fig. 2 may be required for 75 speed whereas for 60 speed Fig. 1 may be adequate.

***These values are for 60 speed and assume that corrections have been applied to remove bias. For 75 speed multiply by 1.25. For 100 speed multiply by 1.50.

3.02 When facilities using through-type repeaters are to be equalized, each section between repeaters should be equalized using terminal repeaters instead of through-type to meet the limits given in Table I. After all sections of the repeated facility have been equalized, the

through-type repeaters should be replaced and the over-all facility measured. The over-all characteristic distortion for such facilities should not exceed the sum of the maximum allowable values of characteristic distortion for the sections as given in Table I. This procedure has been found

reasonably satisfactory at 60 speed but if any cases should arise at 75 speed the latest information should be obtained.

3.03 In certain cases it may be found necessary to change the value of the condenser in the vibrating circuit of the through repeater to obtain satisfactory results. In the 20BX-type repeater the condenser may be changed from 3.0 mf to 1.0 mf and in the 20AX1 repeaters from 1.5 mf to 1.0 mf. In these cases tests should be made with both condenser values to insure that the minimum distortion is obtained. If the maximum distortion exceeds the sum of the distortions for the two sections, the equalizers involved should be readjusted to obtain better over-all equalization.

(B) Setup for Tests

3.04 The repeaters to be used in making equalization tests should be "average" terminal type repeaters equipped with "average" sending and receiving relays. These repeaters and relays should be selected as outlined in 3.06 and 3.07. In order to avoid unequal magnetic effects due to the influence of relays mounted adjacent to those under test, the repeaters which are located on the end bays and having adjacent relays mounted on one side only, should not be used for making equalization tests. Monitoring set cords should not be connected to the repeater line or loop jacks except temporarily as required.

3.05 At each terminal of the line facilities to be tested, connect the line facilities to the test terminal repeaters arranged for either half or full-duplex operation as desired. Terminate the S leg of the repeater in a noninductive TLT and adjust the loop current to 62.5 milliamperes. At the sending end, connect the signal source to the TLT associated with the S leg. At the receiving end, connect the measuring set to the TLT associated with the leg receiving the signals. When the transmitted signal is to be measured at the sending end, the measuring set should be connected to the TLT associated with the S leg at that point.

3.06 Average Relay - The relays to be used should all be within limits as tested on a 111A panel or its equivalent. The procedure for selecting an average relay is then as follows:

- (1) Set up a metallic-circuit between two adjacent offices.
- (2) At the sending end use one set of sending relays and send BLANK pre-biased 20% spacing, BLANK, T, O, M, V, LETTERS and LETTERS pre-biased 20% marking.

- (3) At the receiving office measure the distortion of the received signals, using a single receiving relay.
- (4) Using the same receiving relay, obtain similar measurements for each of six pairs of sending relays.
- (5) For each sent character separately, compute the average of the 6 values of distortion measured with the six pairs of sending relays.
- (6) By comparison of the average values with the measurements on individual relays, determine which pair of sending relays approaches most closely the average.
- (7) Using the pair of sending relays thus found to be average, send the same test characters and obtain distortion measurements using each of six receiving relays. Compute the averages and determine which is the average receiving relay.
- (8) Use the average pair of sending relays and the average receiving relay for the subsequent tests.

3.07 Average Repeater - Determine average sending and receiving repeaters for both ends of a section as follows:

- (1) Set up a metallic circuit between two offices.
- (2) Have the sending office send BLANK pre-biased 20% spacing, BLANK, T, O, M, V, LETTERS and LETTERS pre-biased 20% marking, from each of 4 repeaters selected for test.
- (3) At the receiving end, measure these signals through a single repeater and determine which of the 4 sending repeaters approaches most closely the average.
- (4) Using the sending repeater found to be average, send to four test repeaters at the receiving end and determine the average receiving repeater in a similar manner.
- (5) Reverse the direction of transmission and determine the average sending and receiving repeaters in this direction.

Note: It is possible that the average sending repeater at an office will not be the same one as the average receiving repeater at that same office.

- (6) Use the average repeaters for the succeeding tests.

FIG. 1
 FOR CABLE CKTS. WITH TCX POINTS ONLY
 AND FOR SHORT CABLE CKTS. WITH ONE ICX POINT

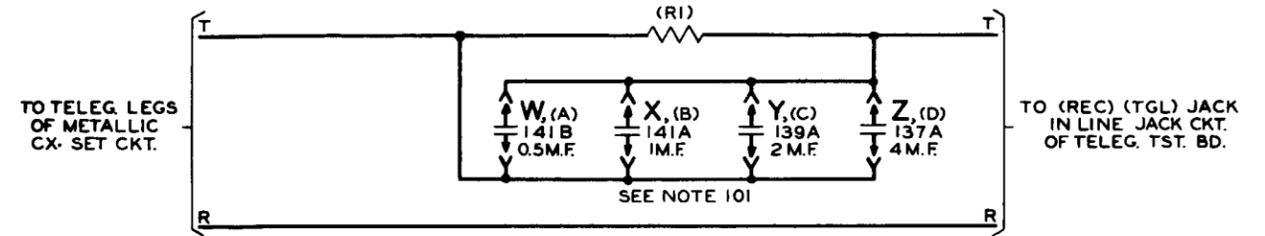


FIG. 2
 FOR CABLE CKTS WITH ONE ICX POINT

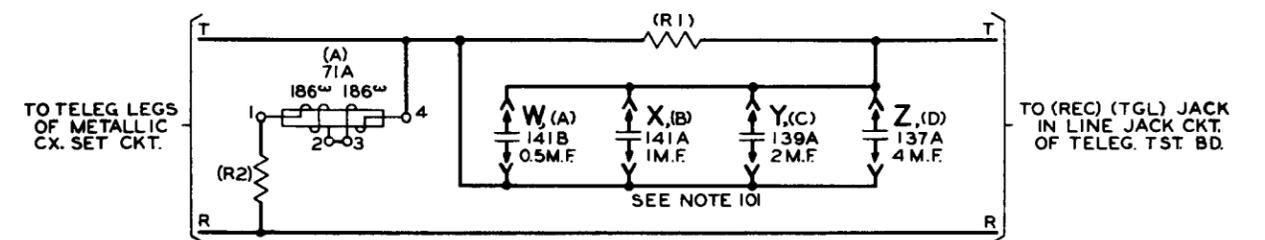
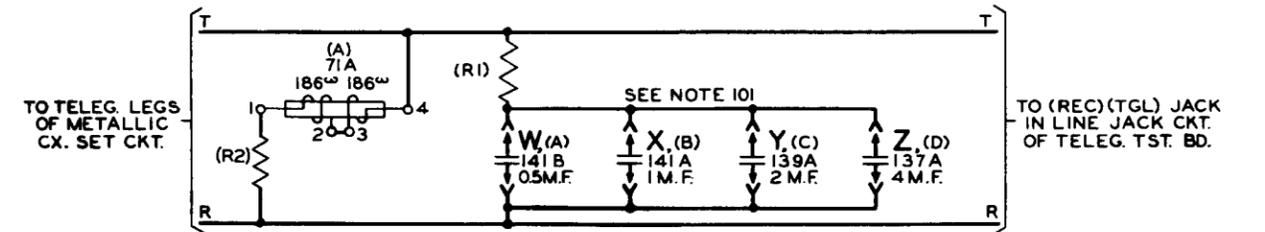


FIG. 3
 FOR CABLE CKTS. WITH TWO ICX POINTS



TELEGRAPH CIRCUIT EQUALIZATION
REPORT OF CHARACTERISTIC DISTORTION AND TRANSMISSION MEASUREMENTS

CIRCUIT NUMBER	STEP	EQUALIZER				TEST CHARACTERS								REC. CURR.	TRANS. MEAS.	PILOT WIRE STEP
		FIG.	R1	R2	C	O	M*	T	V*	BLANK		LETTERS				
			OHMS	OHMS	MFD					NB	20% S	NB*	20% M*			
MX 10 1-28-47	1		None			+ .5	+1.0	+ .5	+2.0	+1.5	-23.0	+9.0	+46.	2.8		
	2					+1.0	+ .5	+1.0	0	+1.0	-21.5	0	+21.0			
	3					-.5	+ .5	-.5	+2.0	+ .5	-1.5	+9.0	+25.			
	4					0	-1.0	0	-2.5	+1.0	-1.0	-9.5	-25.5			
MX 10 1-28-47	1	2	1700	2500		+2.5	+2.5	+2.5	+3.0	+2.5	-21.0	+6.0	+30.0	1.4		
	2					+1.0	+ .5	+1.0	0	+1.0	-21.5	0	+21.0			
	3					+1.5	+2.0	+1.5	+3.0	+1.5	+ .5	+6.0	+9.0			
	4					0	-.5	0	-1.5	0	-1.0	-4.5	-7.5			
MX 10 1-29-47	1	2	1700	2500	4	+3.5	+4.0	+3.0	+3.5	+3.0	-18.5	+ .5	+20.	1.3		
	2					+1.0	+ .5	+ .5	+ .5	+1.0	-21.0	+ .5	+20.			
	3					+2.5	+3.5	+2.5	+3.0	+2.0	+2.5	0	0			
	4					0	-1.0	0	-.5	-.5	0	+2.5	+2.5			
	1															
	2															
	3															
	4															

STEPS: 1-RECEIVED MEASUREMENT 2-SIGNAL SOURCE MEASUREMENT 3-PREBIAS AND SIGNAL SOURCE CORRECTION (CHANGE SIGN OF 2 AND ADD TO 1)
4-CHARACTERISTIC DISTORTION (CHANGE SIGN OF "O" IN 3 AND ADD TO OTHER TEST CHARACTERS. THEN CHANGE SIGN OF RESULT FOR STARRED COLUMNS)

SEND. TERM. Albany REPT. (TYPE) 20B1 N.K. COND.-(MDPT.)(LINE) CX SET.-(OPCE)(IPCE) TESTER _____
REC. TERM. Utica REPT. (TYPE) 20B1 CX SET.-(OPCE)(IPCE) TESTER _____ DATE 1-28-47
CABLE C+B GAUGE 19 LDG. H44 ICX AT Fonda TOT. LENGTH 93 TEST. APP. _____
REPORTING OFFICE _____