NOISE ISOLATION

CONTENTS

1. GENERAL

1.1 This section provides REA borrowers, consulting engineers, contractors and other interested parties with technical information for use in the design and construction of REA borrowers telephone systems.

It presents a discussion of a simplified method to isolate factors contributing to noise in telephone systems. It is intended to help plant people probe into and separate the probable causes and develop solutions for several common types of noise problems in both subscriber and trunk circuits.

1.2 Two methods will be discussed for application to subscriber circuits. One is used when testing on a working subscriber cable pair and the other is for use with an idle cable pair.

1.3 Noise isolation on trunk circuits requires a slightly different procedure than that followed with subscriber loop plant. The procedural differences occur when making the preliminary measurements.

2. NOISE ISOLATION (WORKING SUBSCRIBER LINE)

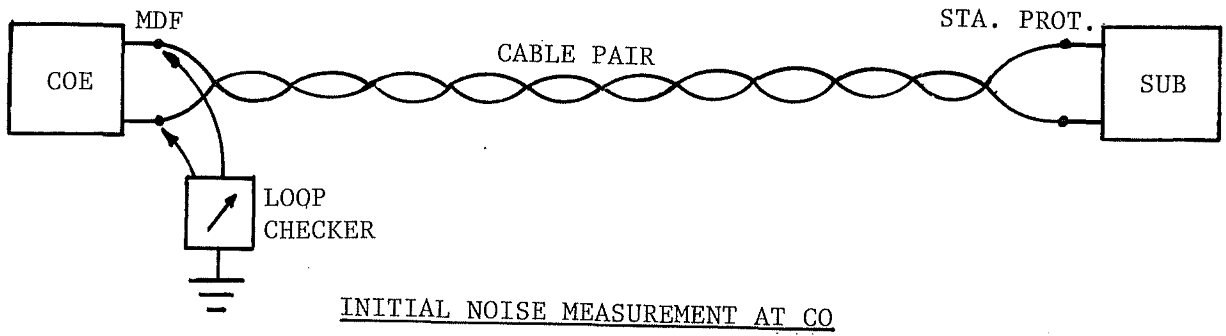
2.1 Tests may be made with either inexpensive loop checking equipment or with more sophisticated noise measuring sets and is directed toward the isolation of unbalances in the telephone circuit. (SEE REA STANDARD PC-4.) The method described is the initial phase of a noise investigation. It should be considered where the preliminary analysis of data taken at the subscribers premises has indicated a balance problem exists. The procedure is designed for use with shielded voice frequency cable facilities.

2.11 If there are voice frequency repeaters and/or loop extenders in the circuit being tested they should be removed from the circuit when working at or near the central offices to insure stability. When working at the subscriber end of the cable they can be left in the circuit.

2.12 When making the initial tests at the office always inspect the voice frequency repeaters to determine all settings are correct. Where screws are used for such settings be sure they are set down and making contact. Where the terminal switch is left or has vibrated open on one side the repeater will be unbalanced and may be contributing to the noise problem. Reports have been received that the screw type switches can open when exposed to vibration.

2.2 Begin testing by using the wire chiefs' test set or an insulation resistance test set to measure the insulation resistance or "leakage" on the pair. Measure tip to ring, tip to ground, and ring to ground resistances. The values measured should meet the objectives shown in REA Standard PC-4 (500 megohm miles) or infinity as measured with a wire chiefs' test set. If it is not, this problem should be corrected before proceeding further with isolation tests.

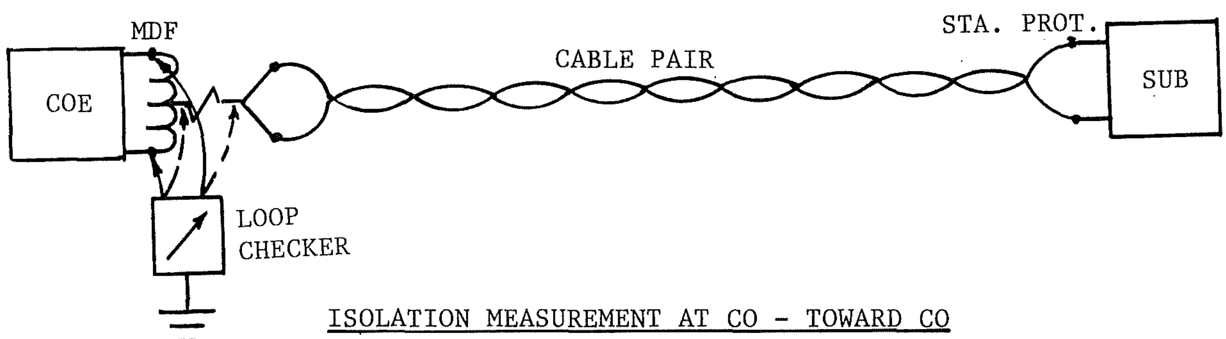
2.21 When the insulation resistance is accepteable, noise measurements may be started at the central office main distribution frame (MDF). Connect the test equipment to the cable pair tip and ring (T&R) as shown in Figure 1. Dial up the quiet termination and measure circuit or metallic noise (Nm) and record the measurement. This bridged measurement is not a valid measurement when using loop checking equipment due to the termination in the test equipment. With a conventional noise measuring set the bridging mode can be used which will yield a more accurate value of circuit noise. Power influence is not measured since it would only reflect the voltage drop across the office relay windings to ground. This reading is taken only to obtain an indication of the circuit noise level at the office.



INITIAL NOISE MEASUREMENT AT CO

FIGURE 1

2.3 Open the pair and connect the isolation set as shown in Figure 2 between the cable pair and the office at the MDF. See Appendix C for details of the isolation and/or termination set. Dial the quiet termination and measure circuit or metallic noise (Nm), longitudinal noise (NL), and power influence (PI) toward the CO; record the values and calculate the balance (Bal=PI-Nm). When measurements are made with a NMS, these measurements are made with C-message weighting. An additional measurement should be made of PI with 3 KHz Flat weighting to determine the fundamental frequency (60 Hertz) voltage level at this point.

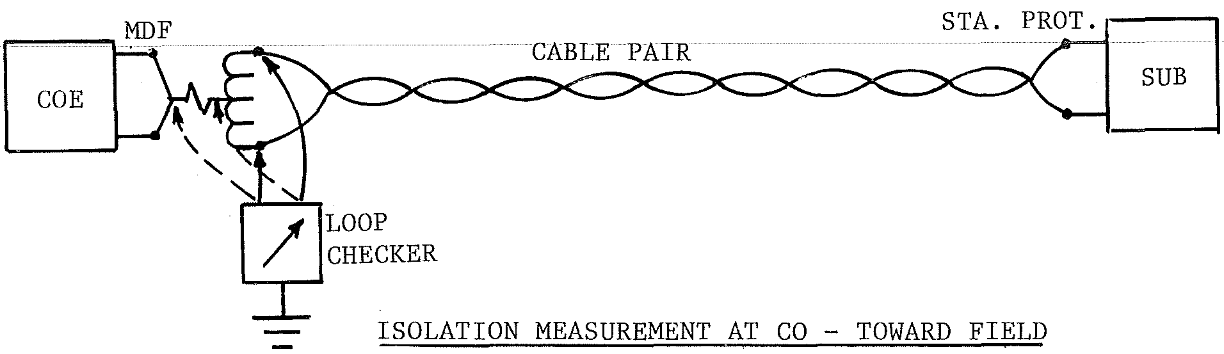


ISOLATION MEASUREMENT AT CO - TOWARD CO

FIGURE 2

(NOTE: Balance should be computed using the highest PI value. At the central office this will always be the PI derived from NL.)

2.31 Reverse the connections of the isolation set and loop checker as shown below (with a prewired switch); measure Nm, NL and PI toward the field recording the values and calculate the balance.



ISOLATION MEASUREMENT AT CO - TOWARD FIELD

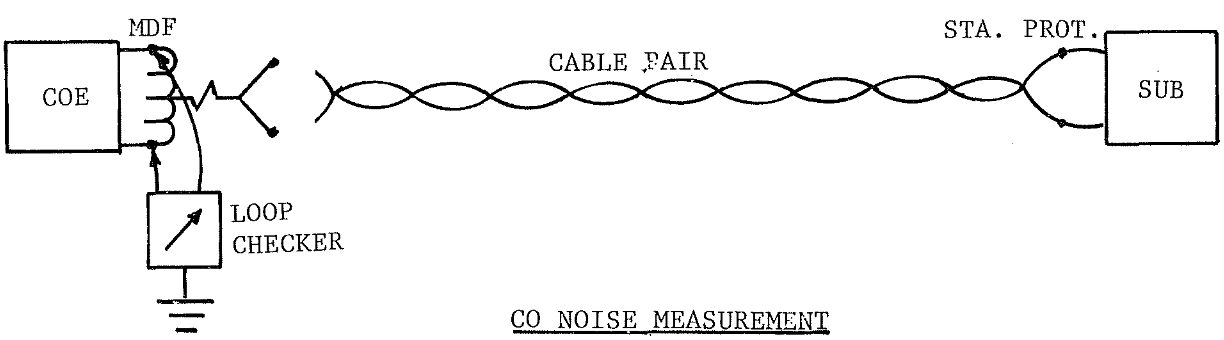
FIGURE 3

2.32 Review the Nm and balance. The problem should be in the direction of the highest measured Nm and lowest calculated balance. (PI should not have any significant change.)

2.33 If the highest Nm is toward the CO, disconnect the outside plant and remeasure Nm toward the CO as shown in Figure 4.

a. If the Nm stays about the same, the noise is being generated in the CO.

b. Should the Nm drop substantially, the CO may be unbalanced. (Without the longitudinal influence from the cable pair, there is no conversion from longitudinal to metallic noise).

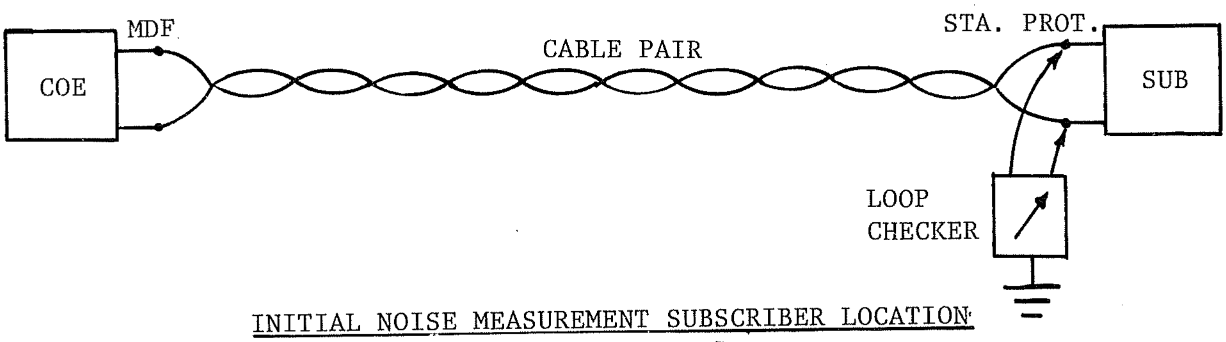


CO NOISE MEASUREMENT

FIGURE 4

2.4 At the subscriber's protector block as shown in Figure 5, measure and record loop current. Dial the milliwatt tone, measure and record the value(s). If the milliwatt supplies several frequencies, the frequency response of the circuit can be checked. This test is made to verify that the complaint is not the result of low transmission quality.

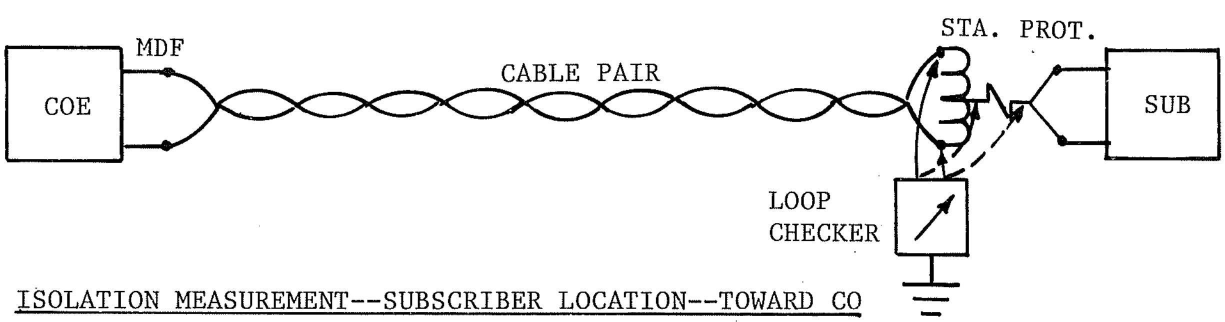
2.41 Next, dial the quiet termination, measure and record Nm, PI, and calculate the balance.



INITIAL NOISE MEASUREMENT SUBSCRIBER LOCATION
FIGURE 5

(These measurements are made at the subscriber's premises as a reference before any connections are disturbed. The results will also show any change in power influence level since the time initial measurements were completed during the initial repair call.)

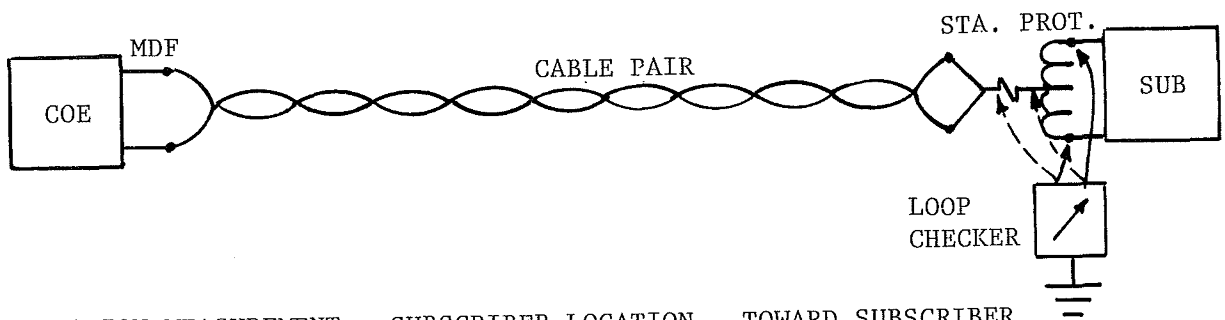
2.42 Disconnect inside wiring from the protector block and connect the isolation set between the two as shown in Figure 6. Dial the quiet termination, measure Nm, NL and PI toward the CO; record the values and calculate the balance.



ISOLATION MEASUREMENT--SUBSCRIBER LOCATION--TOWARD CO
FIGURE 6

(NOTE: There should be no NL found if bridged ringing is used. Should one be measured it indicates that there is a path to ground on the subscriber side of the measurement.)

2.43 Reverse the connections of the isolation set and loop checker as shown in Figure 7; measure Nm, NL and PI toward the subscriber; record the values and calculate the balance.



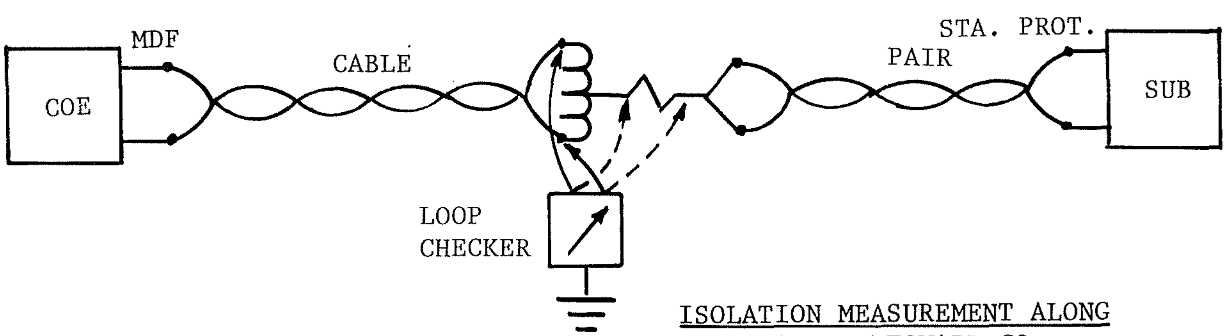
ISOLATION MEASUREMENT - SUBSCRIBER LOCATION - TOWARD SUBSCRIBER

FIGURE 7

2.44 Review the data from these measurements. Problem area should be in the direction of the highest Nm and lowest balance. (NOTE: PI should not change significantly and recorded results from either measurement should be essentially the same as those from measurement made without the isolation set. If this is not the case, perhaps there was a bad connection at the protector block).

2.5 When the review of data from the previous measurement indicates a balance problem in the direction of the CO, select another point closer to the CO to begin isolation measurements. If the subscriber drop is long, it might be at the point of junction between the drop and the cable. It might also be the juncture between two cable sizes or at a load point location.

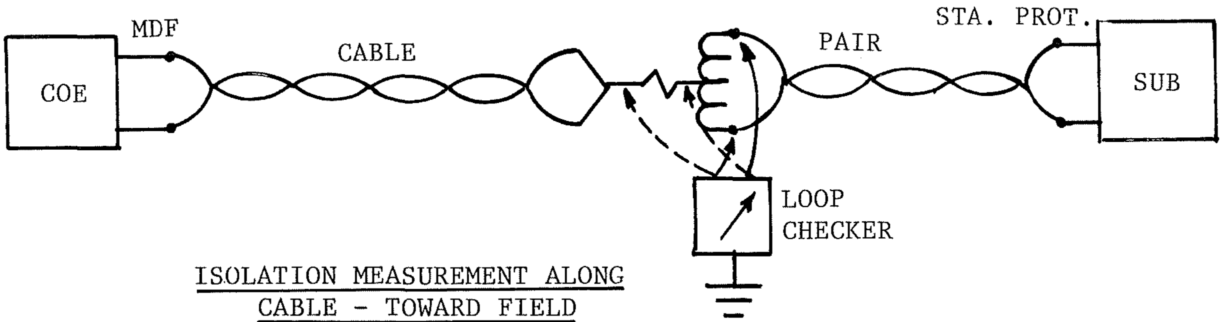
2.51 Cut the cable at the selected location and install the isolation set as shown in Figure 8. Dial the quiet termination, measure Nm, NL, and PI toward the CO, record the values and calculate the balance. The highest value of PI should be used to calculate the balance.



ISOLATION MEASUREMENT ALONG CABLE - TOWARD CO

FIGURE 8

2.52 Reverse the connections of the isolation set and loop checker as shown in Figure 9 and measure Nm, NL and PI toward the field. Record the values and calculate balance.



ISOLATION MEASUREMENT ALONG
CABLE - TOWARD FIELD
FIGURE 9

2.53 Review data from these measurements. The problem should be in the direction of the highest noise and lowest balance. Move in that direction to the next selected location; a junction where the cable size changes or a load point and repeat the above measurements. Continue with these isolation techniques until the section with low balance is located. It is possible that no single section can be pinpointed as being the major factor contributing to the noise problem.

2.531 If a single section can be identified as a major factor in a noise problem, further investigation should be made to determine the reasons. Additional tests of cable parameters should be made and fault locating techniques applied to pinpoint the location of the problem, (damaged cable, etc.)

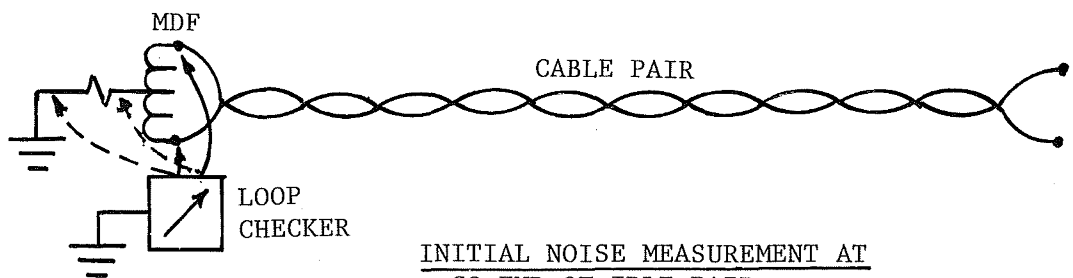
2.532 Noise problems may occur when the cable has not been damaged and the applicable cable specifications are met. This condition might occur when cable unbalances are on the same side (tip or ring) and add up on a systematic basis. Such a condition can be indicated in recorded data from isolation tests in two ways. One, if it is not possible to isolate the problem in a section of cable (all results show marginal balance in both directions) or two, if isolation procedures on several pairs in the cable are successful, but the problem on each pair is located in a different section along the route. Usually in these situations only a few pairs in the total cable will have noise problems.

2.533 When the condition described in Paragraph 2.532 is suspected, recorded isolation test data should be examined to determine if a tip and ring reversal might reduce the circuit noise to an acceptable level. Tip and ring reversals are described in Paragraph 15.04 and 15.05 of TE&CM Section 451.

3. Ξ ISOLATION (IDLE CABLE PAIR)

3.1 Begin testing by using the wire chief's test set or an insulation resistance test set to measure the insulation resistance or "leakage" on the pair. Measure tip to ring, tip to ground and ring to ground resistances. The measured values should meet the objectives shown in REA standard PC-4 or infinity as measured with a wire chief's test set. If it is not, the problem should be corrected before proceeding with isolation tests.

3.11 When the insulation resistance is acceptable, noise measurements may be started at the central office MDF. First, measure the resistance unbalance of the isolation and/or termination set with wheatstone bridge. See Appendix A for details of the isolation and/or termination set. Connect the cable pair to the termination set and ground the center tap as shown in Figure 10. Measure Nm, PI and NL, record the values and calculate the balance.

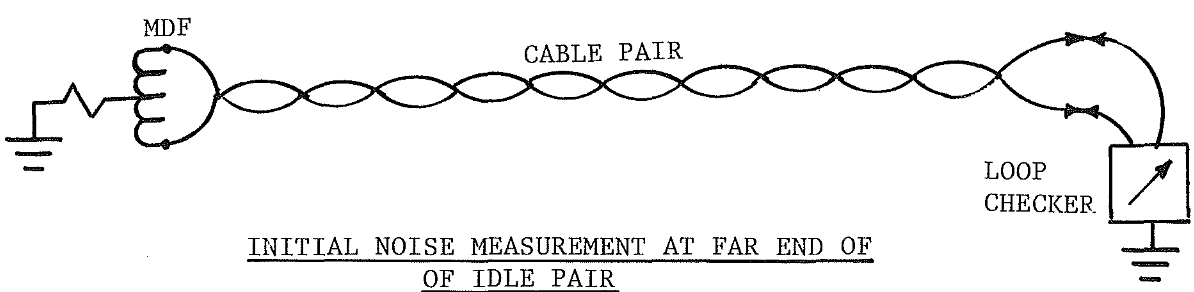


INITIAL NOISE MEASUREMENT AT
CO END OF IDLE PAIR

FIGURE 10

(NOTE: Balance should be computed using the highest PI value. At the central office this will always be the PI derived from the NL value.)

3.2 At the outermost appearance of the cable pair (this might be at the end of a drop at a subscribers premises) measure Nm and PI as shown in Figure 11. Record values and calculate balance. Measure the resistance unbalance with the wheatstone bridge and record the result.



INITIAL NOISE MEASUREMENT AT FAR END OF
OF IDLE PAIR

FIGURE 11

(These measurements are made for reference purposes. Subsequent measurements at the same location following corrective work will show the level of improvement.)

3.21 Analyze the data from this measurement and proceed as follows:

a. If balance is less than 60 dB, concentrate first on finding the unbalance and correcting it.

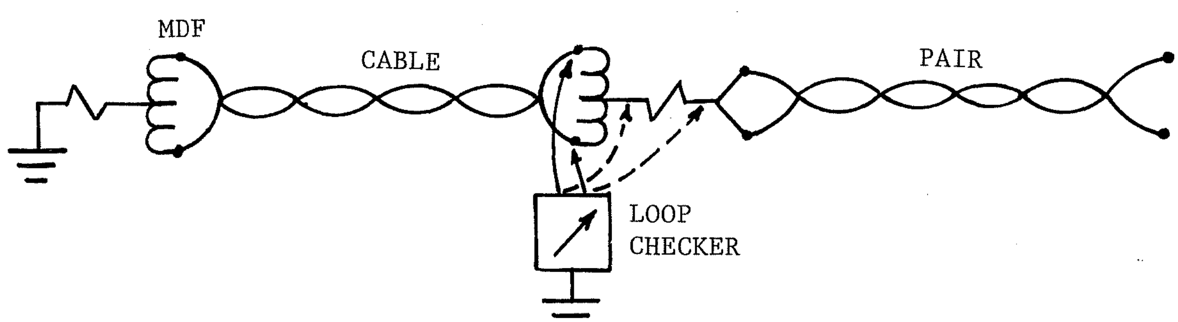
b. When balance is greater than 60 dB, but power influence is high, first determine that there are no shielding or bonding problems and then concentrate on reduction of the power influence.

c. If the circuit noise is low and the balance greater than 60 dB the problem may be intermittent. This could be the result of fluctuating power loads or shielding problems, for example.

3.22 Should isolation techniques be indicated before leaving this location, connect a termination (900 ohm resistor in series with a 2.16 μF capacitor) between the tip and ring of the pair being worked on. This will permit accurate measurements both toward the CO and the field from the location of isolation measurements.

3.3 When the review of data from the measurement indicates a balance problem, select a point in the direction of the CO to begin isolation measurements. If the subscriber drop is long it might also be the juncture between the drop and the cable. It might also be the juncture between two cable sizes or at a load point location.

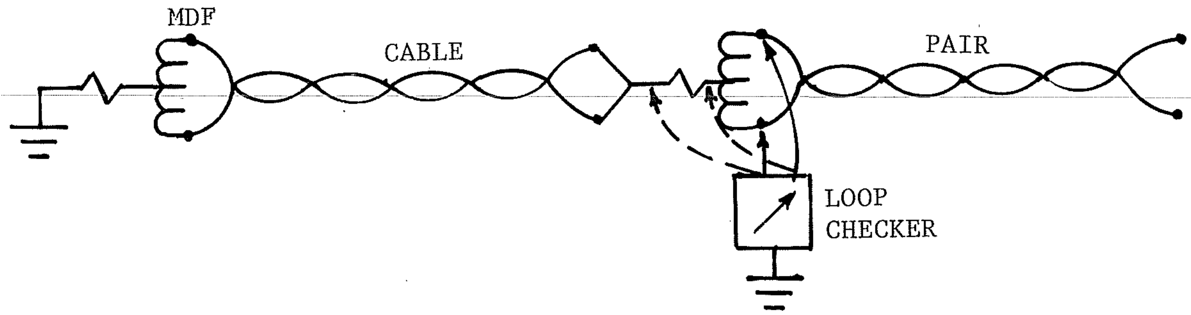
3.31 Cut the cable at the selected location and install the isolation set as shown in Figure 12. Measure Nm, NL and PI toward the CO. Record the values and calculate the balance. Highest value of PI should be used to calculate the balance. Measure the resistance unbalance with a wheatstone bridge and record the result.



ISOLATION MEASUREMENT ALONG CABLE - TOWARD CO

FIGURE 12

3.32 Reverse the connections of the isolation set and loop checker as per Figure 13 and measure Nm, NL and PI toward the field. Record the values and calculate the balance.



ISOLATION MEASUREMENT ALONG CABLE--FAR END
FIGURE 13

3.33 Review data from these measurements. The problem should be in the direction of the highest noise and lowest balance. Move in that direction to the next selected location; a juncture where the cable size changes or a load point and repeat the above measurements. Continue with these isolation measurements until the section with low balance is located. It is possible that no single section can be pinpointed as being the major factor in the noise problem.

3.331 If a single section can be identified as a major factor in a noise problem, further investigation should be made to determine the reasons. Additional tests of cable parameters should be made and fault locating techniques applied to pinpoint the location of the problem, (damaged cable, etc.).

3.332 Noise problems may occur then the cable has not been damaged and applicable cable specifications are met. This condition might occur when cable unbalances are on the same side (tip and ring) and add up on a systematic basis. Such a condition can be indicated in recorded data from isolation tests in two ways. One, if it is not possible to isolate the problem in a section of cable (all results show marginal balance in both directions) or two if isolation procedures on several pairs in the cable are successful, but the problem on each pair is located in a different section along the route. Usually in these situations only a few pairs in the total cable will have problems.

3.333 When the condition described in Paragraph 3.332 is suspected, recorded isolation test data should be examined to determine if a tip and ring reversal might reduce the circuit noise to an acceptable level. Tip and ring reversals are discussed in Paragraph 15.04 and 15.05 of TE¢CM 451.

3.4 Refer to REA TOM Section 1358.2 for a discussion of noise isolation.

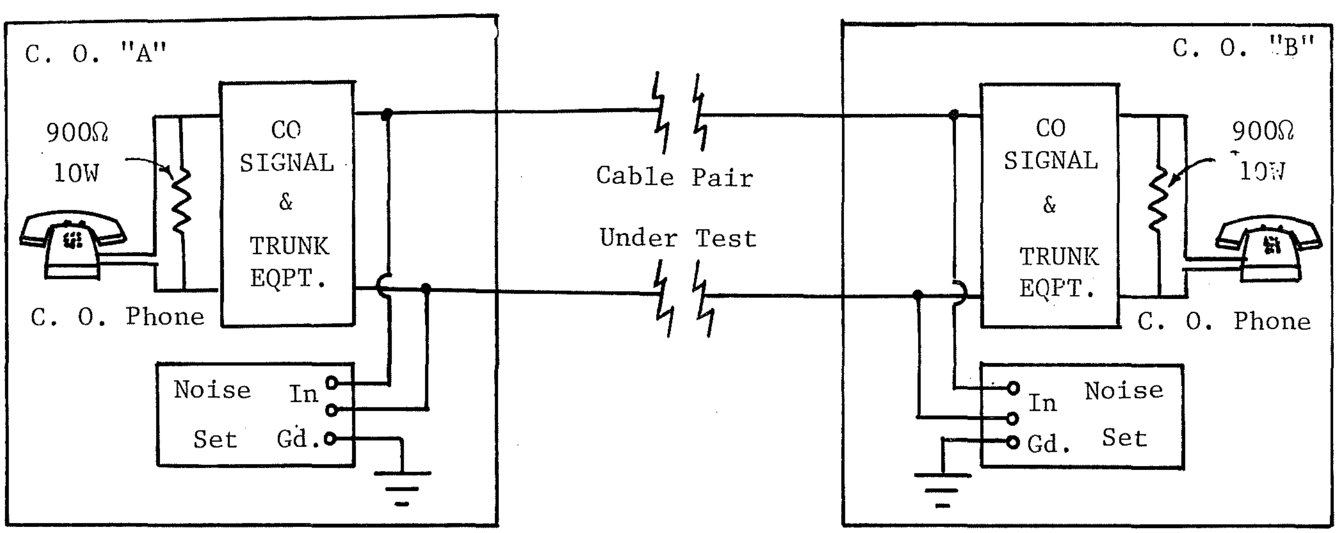
4. NOISE ISOLATION (TRUNK PAIR)

4.1 A trunk circuit is terminated in an office at each end and therefore has a low impedance to ground at each end. Series unbalances therefore located near either end of the trunk circuit may be major factor contributing to noisy trunks. Maximum conversion from longitudinal to metallic noise due to shunt unbalances in trunk circuits will occur in the middle of the circuit.

4.2 The majority of trunk circuits require tip and ring continuity for proper operation. For this reason it is not possible to use the termination set which shorts the T&R in one direction for isolation as it done with subscriber loops. See Appendix B for design of an isolation set which may be used for isolation tests on trunk cables.

4.3 The testing should begin by measuring the insulation resistance of the circuit with an insulation resistance test set. Measure tip to ring, tip to ground. Measured values should meet the objectives shown in REA Standard PC-4. If it does not, this problem should be corrected before proceeding further with isolation tests.

4.31 When the insulation resistance is acceptable noise measurements may be started. Measurements at the office main distribution frame (MDF) should be made at both ends of the cable. Connect the noise measuring set to the cable pair tip and ring (T&R) and to ground (G). (See REA Standard PC-4.) Call one office from the other over the trunk and place a 900 ohm $\pm$ 10 percent, 10-watt resistor across the T&R terminals of the telephone sets on both ends. Place both telephone sets on hook. Measure circuit noise and both noise-to-ground (C-msg.) and noise-to-ground (3-KHz Flat) at both ends of the cable. The balance will not be accurate due to the low impedance to ground so no decisions should be made at this time.



NOISE MEASUREMENT
TRUNK CIRCUITS

FIGURE 14

4.32 These tests are made to determine the overall performance of the trunk circuit before any connections are distributed. They are also reference points for comparision to determine effectiveness of corrective action.

4.4 Open the pair and connect the isolation set shown in Figure 15 between the cable pair and the office at the MDF at both ends of the trunk. Again call one office from the other over the trunk and place a 900 ohm ± 10 percent, 10-watt resistor across the T&R terminals of the telephone sets on both ends. (Call cannot be made if SF signaling is used.) Place both telephone sets on hook. Measure circuit noise (Nm-terminated), noise-to-ground (C-msg.), and noise-to-ground (3=KHz Flat), first toward the office and then toward the cable at both ends of the trunk as shown in Figure 15. Calculate the balance for the four sets of measurements.

4.41 Review Nm and balance values. The problem should be in the direction of the highest measured Nm and lowest calculated balance. There should be only a very slight change, if any, in the magnitude of noise-to-ground since the trunk isolation set provides little impedance to the flow of longitudinal noise currents.

4.5 Disconnect the cable at each end and terminate in the termination set as described in Appendix A. The resistor value, when required, between the center tap of the set and ground is determined by the type of signaling used. Proper values are shown in Table 1.

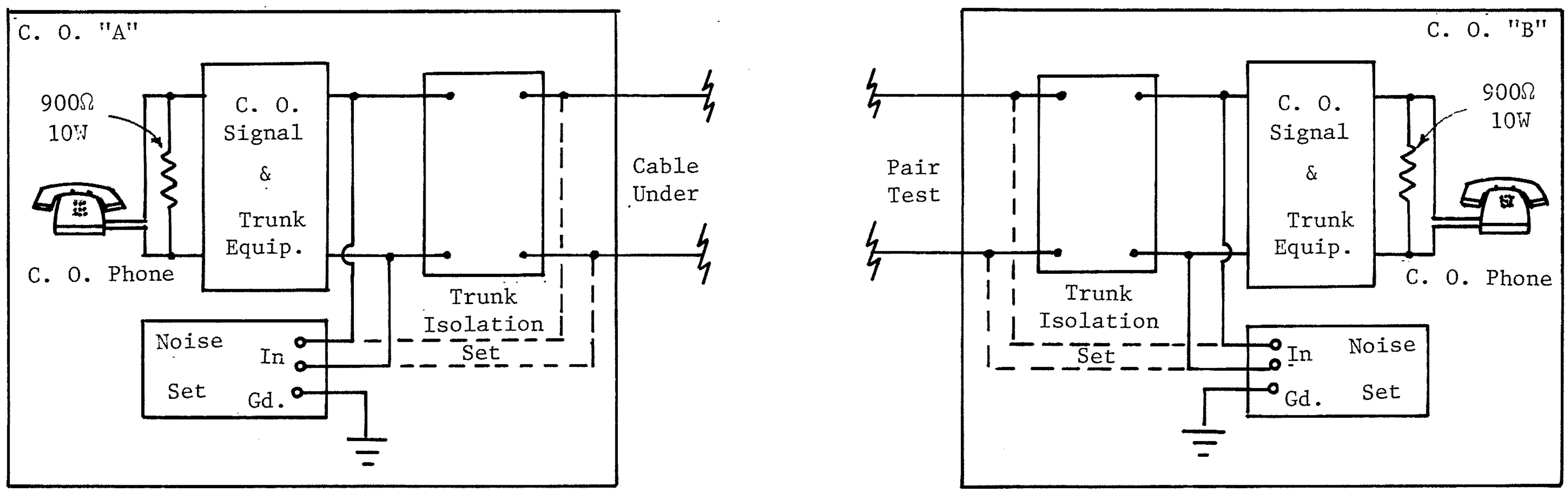
TABLE I

RESISTANCE VALUES BETWEEN CENTER TAP OF ISOLATION SET AND GROUND FOR VARIOUS SIGNALING TYPES

SIGNALING TYPE	RESISTANCE VALUE IN OHMS REP'T COIL	COMMERCIAL SET
DX	600	500
CX	100	0
SX	100	0
LOOP	100	0

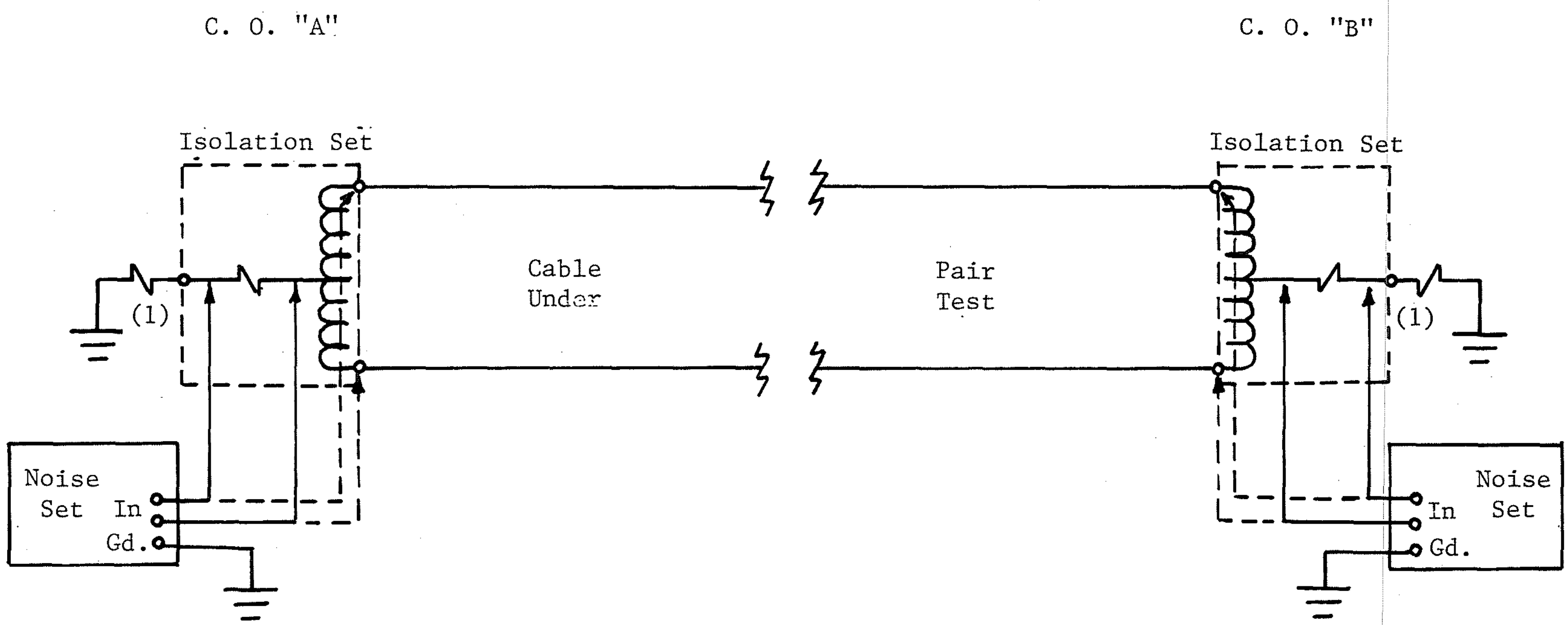
4.51 Measure Nm, Ng (C-msg), Ng (3-KHz Flat), NL (C-msg.) and NL (3-KHz Flat) at each end, as shown in Figure 16, and calculate the balance from the highest value of C-msg weighted power influence. Measure the resistance unbalance of the termination set with a wheatstone bridge.

4.52 If the recorded value Nm from these measurements is significantly lower than the initial values found with the trunk equipment connected and working, the problem is likely to be in the trunk equipment. Check to ascertain it has been correctly wired into the circuit.



NOISE ISOLATION TRUNK CIRCUITS

FIGURE 15

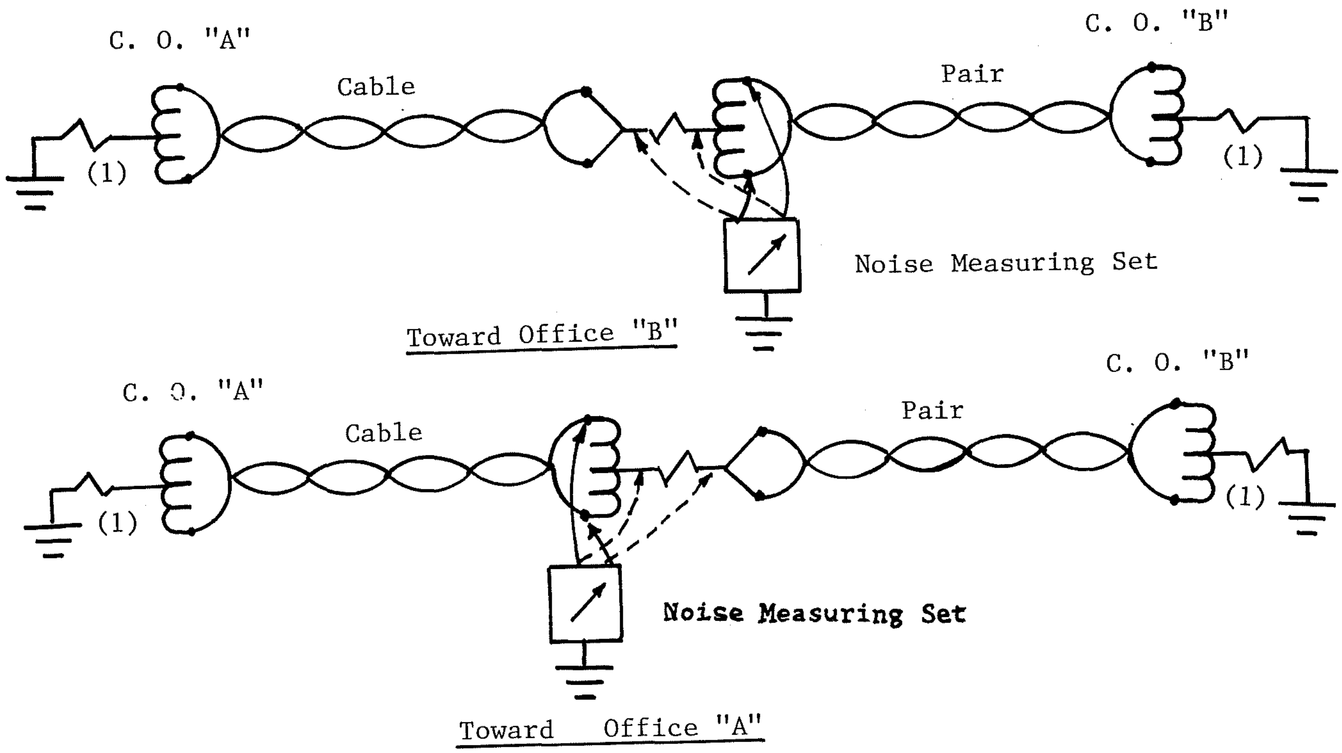


(1) See Table 1 for R value.

NOISE ISOLATION TRUNK CIRCUITS

FIGURE 16

4.6 Move to a location at the approximate center of the trunk cable or to the exchange boundary if two companies are involved and start isolation tests. Open the cable at the selected location and install an isolation set as shown in Figure 17. This isolation set is the one shown in Appendix "A". Measure Nm, NL and Ng in turn, toward Central office. Record the values and calculate balance. Measure resistance unbalance in both directions.



(1) See Table B1 for R value.

NOISE ISOLATION TRUNK CIRCUITS

FIGURE 17

4.61 Review the data from measurements. The problem should be in the direction of the highest noise and lowest balance. Move in that direction to the next selected location and repeat the above measurements. Load coil locations provide convenient locations for isolation measurements. Continue with these isolation measurements until the section with low balance is located. It is possible that no single section will be identified as the major factor in the noise problem.

4.62 If a single section can be identified as a major factor in a noise problem, further investigation should be made to determine the reasons. Additional tests of cable parameters should be made and fault locating techniques applied to pinpoint the location of the problem, (damaged cable, etc.).

4.63 Noise problems may occur when cable has not been damaged and applicable cable specifications are met. This condition might occur when cable unbalances are on the same side (tip or ring) and add up on a systematic basis. Such a condition can be indicated in recorded data from isolation tests in two ways. One, if it is not possible to isolate the problem in a section of cable (all results show marginal balance in both directions), or two, if isolation procedures on several pairs in the cable are successful but the problem on each pair is located in a different section along the route.

4.64 When the condition described in Paragraph 4.63 is suspected, recorded isolation test data should be examined to determine if a tip and ring reversal might reduce the circuit noise to an acceptable level. Tip and ring reversals are discussed in Paragraph 15.04 and 15.05 of TE&CM 451.

APPENDIX A
ISOLATION OR TERMINATION SET
SUBSCRIBER LOOP

1. GENERAL

1.1 The isolation or termination set is primarily a well balanced coil with a center tap. Depending on its connection in the circuit it may be used during noise isolation measurements or for terminating a circuit at an office during noise measurements.

1.2 Sets of this type are available commercially and can be quite sophisticated or they can be build by the telephone company from a well balanced repeating coil. The coil used in constructing the set should have a minimum balance of 70 dB.

1.21 Some commercial sets use a 200 x 200 ohm coil which enhances its use as a terminating set. They also have provision for dialing through the set, placing a termination across the tip and ring of the circuit, and for measurement of noise longitudinal. In addition, internal switching may be provided for the two directions of isolation tests, and termination applications with center tap grounded or floating.

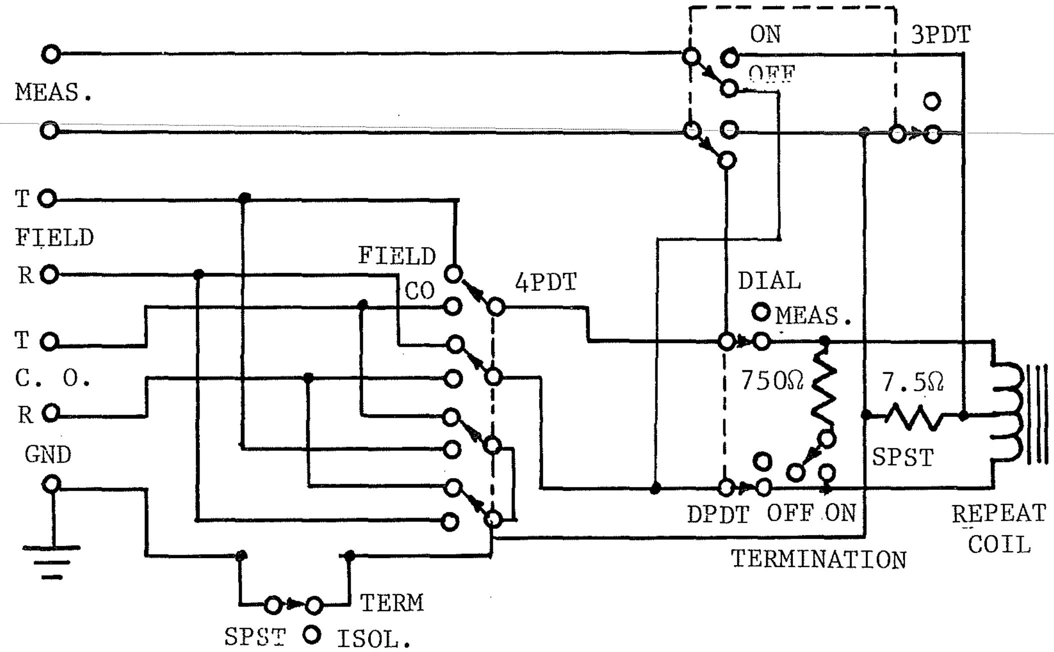
1.22 Sets built by the telephone company can be as sophisticated as necessary for their needs. When a repeating coil is used, it will be necessary to add 100 ohm resistor in series with the center tap to provide the same impedance to ground as the 200 x 200 ohm relay in the transmission bridge. A schematic diagram for an isolation or terminating set is shown in Figure A1.

1.23 Switches used in construction of an isolation set must be of high quality which will not become noisy after many operations.

1.3 Commercial sets utilize a 7.35 ohm resistor in series with the center tap of the coil for measurement of noise longitudinal. These sets are designed for use with inexpensive loop checking equipment which has an impedance of 735 ohms which is the geometric mean of 600 and 900 ohms. With the loop checker set to circuit noise, a measurement is made across the 7.35 ohm resistor. This is the longitudinal noise value.

1.31 The ratio of 735 ohms to 7.35 ohms is 100 to 1. On a voltage ratio basis this is 40 dB. Thus, to convert NL to PI, 40 dB is added to the measured value (NL + 40 = PI).

1.32 When conventional noise measuring equipment is used, the value of resistance in series with the center tap of the coil for precise measurements should be 6 ohms for 600 ohm terminated settings and 9 ohms for 900 ohm terminated. Use of the 7.35 ohm resistor with a NMS will result in an error of less than 2 dB for either the 600 or 900 ohm setting.



SCHEMATIC DIAGRAM - TERMINATION/ISOLATION SET

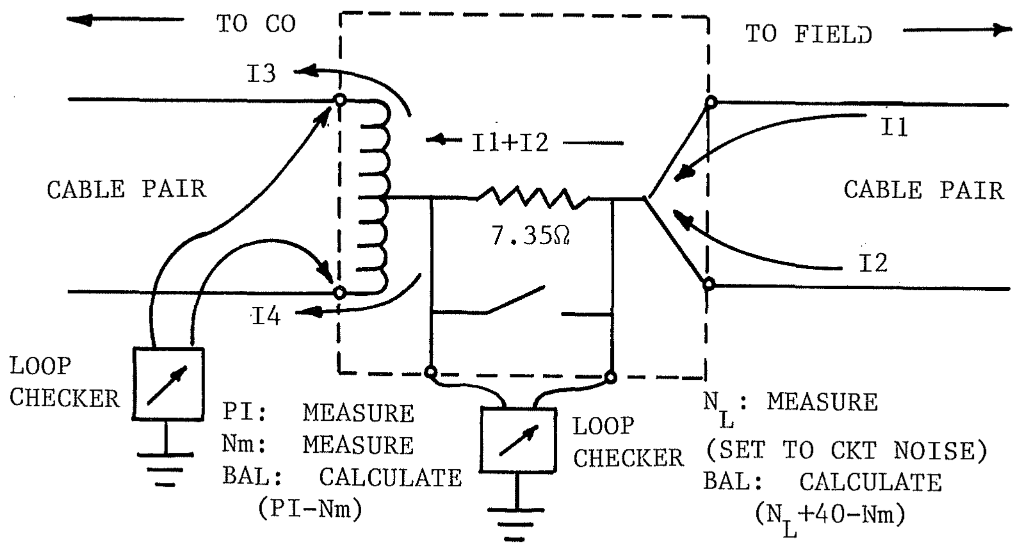
FIGURE A1

2. ISOLATION APPLICATION

2.1 Longitudinal noise currents travel along the tip and ring conductors almost equally. Unbalances result in small residual currents that flow in the metallic or loop circuit; this is circuit noise or noise metallic. The isolation sets utilize this longitudinal current so that balance measurements can be made in one direction with the normal longitudinal noise present.

2.11 Circuit noise can be measured on the coil side of the connection but not on the shorted side. Any unbalance on the shorted side of the set are masked and have no influence on the measurements on the coil side. Thus, the noise can be sectionalized (a) toward the CO, and (b) toward the field.

2.12 In the simplified drawing of an isolation set (Figure A2) the longitudinal noise currents I1 and I2 combine at the center tap of the coil. Even if I1 and I2 are not equal, this unbalance cannot affect measurements on the coil side. From the coil center tap the combined I1 and I2 divide into the two windings as I3 and I4. The balance of the cable pair toward the office determine how nearly equal I3 and I4 will be.



ISOLATION BOX

FIGURE A2

2.2 When power influence is measured or balance is calculated from measurements at or near the central office, they should be used for comparison only. Central office battery feed relays provide a low longitudinal impedance to ground (generally about 100 ohms). Power influence measured this way has very little absolute meaning. Power influence at such points can better be determined by using the isolation set and measuring circuit noise across the 7.35 ohm resistor in series with the center tap of the coil. This is a longitudinal current test and provides an indication of the power system influence. For purposes of calculating balance, noise longitudinal may be converted to power influence by adding 40 dB to the noise longitudinal value.

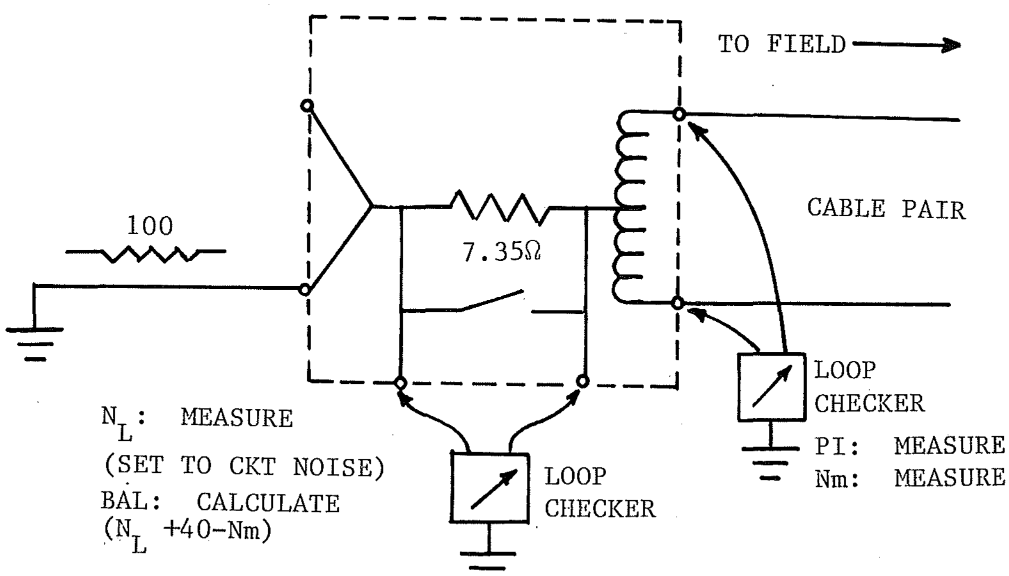
2.3 During noise isolation measurements both power influence and noise longitudinal measurements should be made. The highest value of power influence should be used for calculating balance. Noise longitudinal can provide the highest value of power influence from the central office to a point more than halfway to the subscribers location. Actual distance is a function of the location and magnitude of the power interference.

3. TERMINATION APPLICATION

3.1 When used as a termination set, the set replaces the central office equipment. This effectively removes any contribution to the overall noise from the equipment and allows testing of the cable alone. When the cable pair is terminated in this manner resistance unbalance may be measured through the termination with a wheatstone bridge.

3.2 If the coil used in the set has the same dc resistance as a battery feed relay, the center tap may be connected directly to ground. Should the coil have low dc resistance, a 100 ohm resistor should be connected between the center tap and ground to provide a longitudinal impedance to ground equivalent to a battery feed relay.

3.3 When connected as a termination as shown in Figure A3, the noise longitudinal test previously described can also be made. This type termination is valuable when determining locations for making tip and ring reversals and evaluating the effectiveness of such reversals after they have been made. Resistance unbalance may be measured through the termination set. When making noise isolation tests, resistance unbalance should be measured toward the office from each location that isolation measurements are made.



TERMINATED BOX

FIGURE A3

3.4 The idle pair technique is a more accurate measure of the cable since noise originating in the office and variables introduced by varying switching paths are effectively eliminated from the test circuit.

APPENDIX B
ISOLATION SET (TRUNK CIRCUIT)

1. GENERAL

1.1 Isolation techniques in working trunk circuits present a more complex problem than those applied to subscriber loops. An alternative isolation set should be used for measurement of trunk circuits which will eliminate these problems.

1.2 The set being considered will provide dc continuity end-to-end with minor effect on the longitudinal circuit. Thus, the signaling will function in the normal manner. The set will also provide a high impedance to the metallic circuit to provide separation between the two metallic sides of the circuit.

1.3 Complex terminations can be provided when required. These are designed to provide proper terminations for repeaters to keep them from singing.

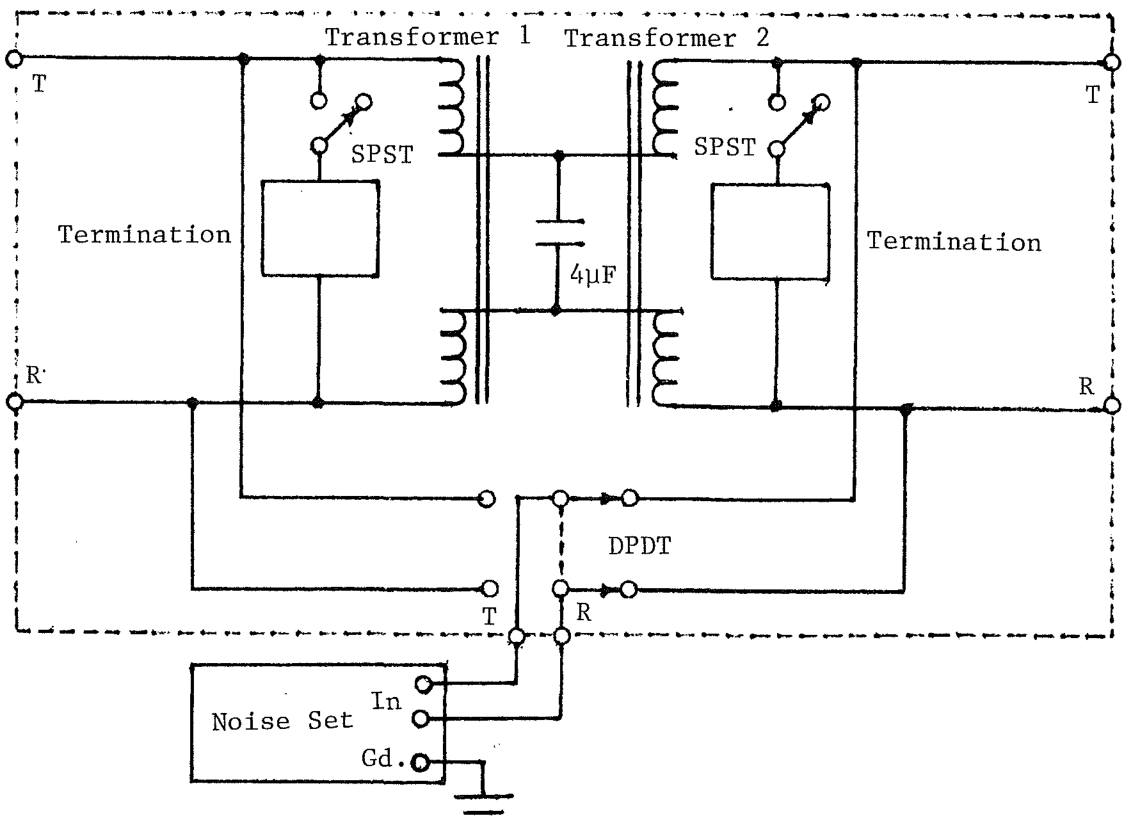
2. ISOLATION SET

2.1 The basic circuit for an isolation set which will maintain dc continuity and isolation between the two metallic sides of the circuit is shown in Figure B1.

2.2 The series-aiding coils of transformers 1 and 2 are not coupled but the opposing coils within each transformer are coupled. These transformers should have a minimum balance of 70 dB.

This provides:

(a) DC continuity of the trunk circuit with minor effect on the longitudinal circuit.



ISOLATION SET TRUNK CIRCUIT

FIGURE B1

(b) Metallic isolation between the two sides of the circuit is provided, facilitating application of noise isolation procedures.

(c) Proper metallic impedance is provided when working close to an office to maintain repeater stability.

2.3 This design could also be used during noise isolation measurements when testing near the central office on repeatered subscriber loops.

3. DESIGN CONSIDERATIONS

3.1 The longitudinal impedance must be low enough to provide little influence to the flow of longitudinal noise currents and to maintain dc continuity end-to-end. DC resistance should be as low as possible to enable other requirements to be met.