Section 451.8
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IMPROVED CABLE PAIR BALANCE BY CONDUCTOR REVERSAL

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. A step by step procedure is presented for improving cable pair balance through reversal of cable pair tip and ring conductors.

1.2 When cable pairs are identified in the field with less than 60 dB balance (TE&CM Section 451, Paragraph 12.7 (e)), measured to the office quiet termination, action should be initiated to improve the balance. Balance in decibels is defined as the noise-to-ground in dBrnc plus forty minus the circuit noise in dBrnc (dB (Balance) = N_g + 40 - CN). A proven and economical method for improving cable pair balance is by reversal of the tip and ring conductors near the center of the cable section(s) having significant capacitance and/or resistance unbalance (TE&CM Section 451, Paragraphs 15.04 and 15.05). The precise locations for conductor reversals may be identified by direct measurement of capacitance and resistance unbalance along the cable route. This operation requires many hours and is expensive. A proven alternative technique is presented in this section for determining the proper location(s) for conductor reversal along a cable route quickly and economically.

1.2.1 Before initiating a program of tip and ring conductor reversals, it should be determined that the recorded results of circuit noise measurements, to the quiet termination are indicating the true cable balance. There are factors included in this operational test that may mask the true cable balance.

1.2.2 Unbalanced central office can result in high circuit noise that may provide an erroneous indication of low cable balance. Measurements should be made at the central office MDF, using an isolation set as discussed in TE&CM Section 451.1, to determine the central office contribution to the overall circuit noise. If the central office equipment is unbalanced the cable pair should be disconnected from the equipment at the MDF and a termination set used in lieu of the quiet termaination. This technique is discussed in TE&CM Section 451.1 for the measurement of an idle cable pair.

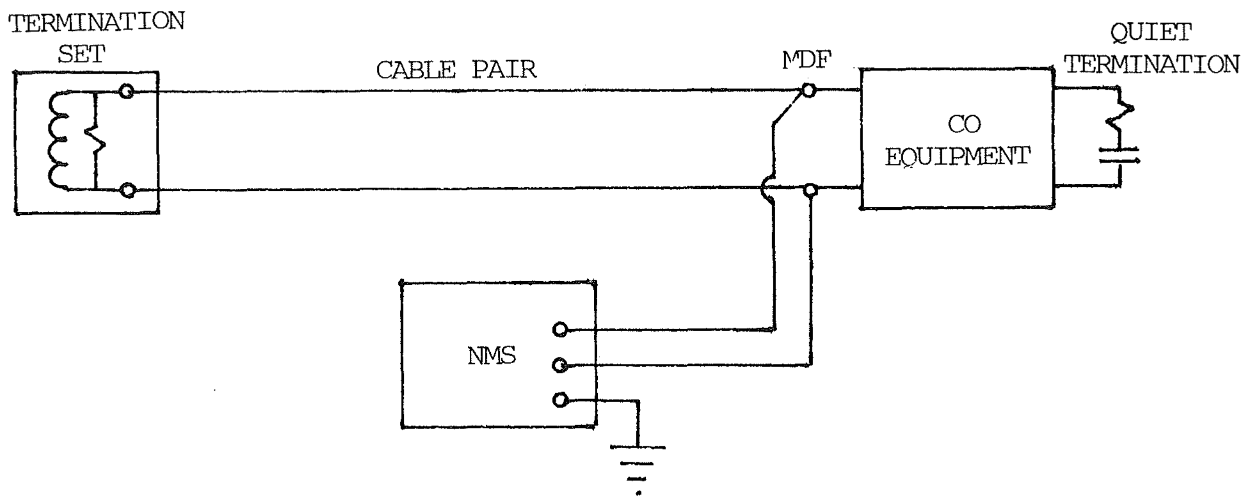
NOTE: When the power influence measured at the MDF on the central office side of the termination set exceeds 106 dBrn, 3 kHz, Flat, the inductors in the set may also saturate and generate noise. This would produce erroneous results. Where this level of power influence is found measure the set to determine if saturation is occuring. Connect the cable pair to the termination set at the office end and ground the center tap. Measure and record the circuit noise. Connect a longitudinal choke (TE&CM Section 451.4) between the termination set and the cable pair. Remeasure and record the circuit noise. If the noise level with the choke connected is 8 to 10 dBrnc lower than that without the choke saturation of the terminating set is indicated.

1.2.3 Unbalances in subscriber owned equipment, which may be connected to the circuit, can also result in high circuit noise and produce an erroneous indication of poor cable balance. A measurement performed at the subscriber station protector, using an isolation set, as discussed in TE&CM Section 451.1 will detect this. When unbalanced subscriber equipment is found it should be disconnected at the protector and the circuit remeasured to determine the cable balance.

1.2.4 When the circuit being tested is a multiparty line it should be determined that there are no ringer or tip conductor ANI connections to ground at each station location which might give an indication of low cable balance. If such connections exist they should be removed to insure the recorded results of measurements reflect the true cable balance.

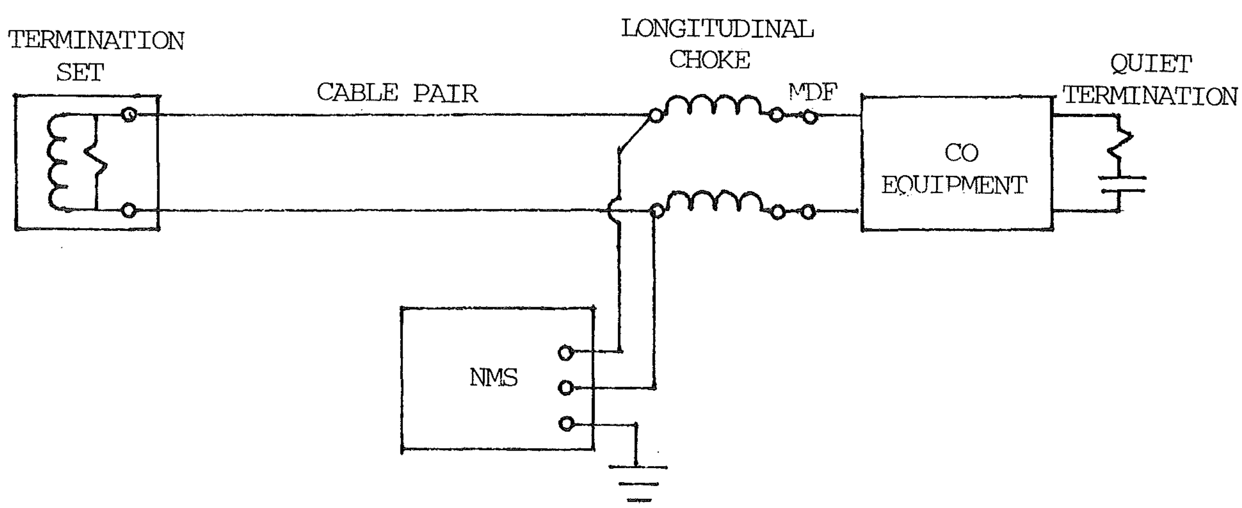
1.2.5 Loop treatment equipment, such as loop extenders and voice frequency repeaters, and electronic central office equipment can produce high noise levels, due to saturation, when exposed to excessive induced longitudinal 60 Hertz voltage on the cable conductors. This type problem must be identified so that appropriate remedial measures can be taken. The measurements discussed in Paragraph 1.2.2 may identify the saturation of central office equipment. Refer to note following Paragraph 1.2.2. With some types of loop treatment equipment a long cable loop is required to activate the device. Since the saturation effects may not occur unless the equipment is operational, this type measurement will not identify such a problem in loop treatment equipment.

1.2.5.1 There is a test procedure that will identify loop treatment equipment saturation. It is customary to measure several paths through the equipment. This is done to determine whether the saturation is occuring with all or part of the installed loop treatment equipment. First, install a termination set at the field end of a long unassigned cable pair. The center tap of the termination set should not be connected to ground. Then, connect a noise measuring set at the MDF to the desired line port. Set the noise measuring set for C-message weighting and to DIAL input. Dial the quiet termination and connect the cable pair terminated in the field to the noise measuring set input. The complete test configuration is shown in Figure 1. Switch the noise measuring set to BRDG input impedance, read and record the circuit noise. Next, disconnect the cable pair from the noise measuring set and connect a longitudinal noise choke, of the type discussed in TE&CM Section 451.4, between the noise measuring set and the central office equipment. Set the noise measuring set to DIAL input and again dial the quiet termination. Connect the terminated cable pair to the noise measuring set input. This complete configuration is shown in Figure 2. Switch the noise measuring set to BRDG input impedance, read and record the circuit noise. When a significant reduction in circuit noise occurs (20 to 30 dBrnc and above) saturation is indicated.



MEASUREMENT ONE TO DETECT
EQUIPMENT SATURATION

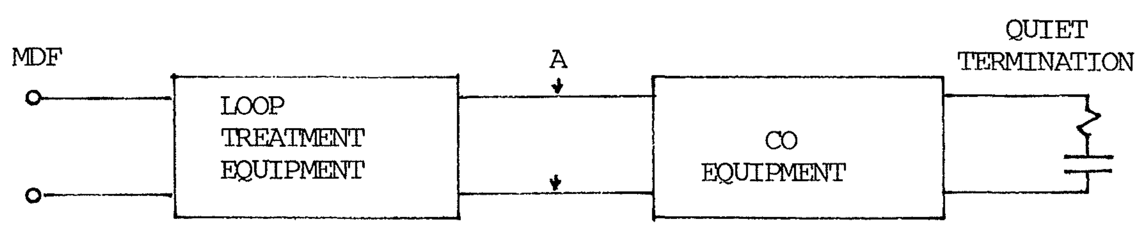
FIGURE 1



MEASUREMENT TWO TO DETECT
EQUIPMENT SATURATION

FIGURE 2

1.2.5.2 When the voice frequency repeaters installed in an office are the fixed gain variety a slight modification of the test procedure is required to avoid repeater instability. The circuit must be opened between the loop treatment and the central office equipment. This location is identified as point A in Figure 3. Connect the terminated cable pair and noise measuring set, switched for BRDG input impedance, to the field side of the loop treatment equipment at the MDF as shown in Figure 1. Dial the quiet termination at point A and, while holding the circuit with a butt-in test set, restore the connection to the loop treatment equipment. Remove the butt-in test set, read and record the circuit noise. After opening the circuit at point A install a longitudinal choke between the loop treatment equipment and noise measuring set as shown in Figure 2. Repeat the measuring procedure by dialing the quiet termination from point A and restoring the connection to the loop treatment equipment. After removing the butt-in test set, read and record the circuit noise. When a significant reduction in circuit noise occurs saturation is indicated.



POINT TO OPEN CIRCUIT

FIGURE 3

1.2.5.3 The problem is directly related to the level of induced longitudinal 60 Hertz voltage present on the cable conductors. The normal noise mitigation procedures, available to the telephone company, such as improved shielding, better grounding, etc., will not be effective. Since the problem can also related to power system balance, it should be discussed with the power company representatives. They can determine if the system can be rebalanced to provide long term relief. Power system loads, especially during periods of high demand for air conditioning and heating, are unpredictable and can change quite rapidly. Such conditions are beyond the control of the power companies in maintaining good system balance. In areas where these conditions exist the mitigation can only be accomplished by the telephone company.

1.2.5.4 There are two ways available reduce the level of induced longitudinal voltage appearing at the MDF. The appropriate one is determined by the number of cable pairs involved and/or the level of induced voltage to ground.

1.2.5.4.1 When there are many circuits involved or where the recorded or anticipated voltage to ground is 50 volts (126 dBrn 3 kHz Flat Power Influence) or higher a neutralizing transformer should be installed along the cable. The application of neutralizing transformers is discussed in TE&CM Section 451.5.

1.2.5.4.2 In those cases, which occur infrequently, where only a few circuits are involved and the anticipated voltage to ground is below 50 volts, longitudinal chokes can be utilized. The application of longitudinal chokes is discussed in TE&CM Section 451.4.

1.3 The procedure will most often be applied along newly installed cable plant, either filled or air core. The unbalanced pairs will be identified during cable acceptance testing if noise measurements are completed on all pairs in the cable. When noise is not measured on all pairs during acceptance tests, the unbalanced pairs will be found during loop checking measurements at the time the pairs are placed in service.

1.3.1 Unbalanced pairs in newly installed cable will be found most often along the longer rural routes where there are long lengths 3km (9.8kf) of cable having the same size and gauge. This is related to cable installation and manufacturing methods. All of the cable to be installed on a project is normally procured by a single order from one manufacturer. Depending on the size and gauge, it is likely that all or a high percentage of the total length for a given size and gauge will be produced during a single run from the same master reels. The number of reels that can be produced from a master reel is determined by the cable size and gauge being manufactured.

1.3.2 On a master reel the capacitance and resistance unbalance of each cable pair will appear on the same conductor, tip or ring, for the entire length of the reel. When the cable is installed in the field, it is customary to place the cable consecutively by reel numbers. This results in long lengths of cable which have unbalances on the same conductor (tip and ring) of the cable pair. The net effects of these unbalances may be cumulative and, depending on the magnitude, may result in some circuits having less than 60 dB balance. This can occur even though the individual reels meet all applicable specification requirements.

1.4 There will be occasions where the balance of working cable pairs, after being in service for several years, will deteriorate to a value below the 60 dB objective. Depending on the type cable (filled or aircore) this may be due to a cable problem. Defective splice connectors can also be a source of poor balance. Connector problems will normally occur on one or two pairs in a cable and can be located by applying the isolation procedures discussed in TE&CM Section 451.1.

1.4.1 The balance of filled cable pairs will normally not change after the cable has been installed and placed in service. This is because filled cable is not susceptible to moisture penetration. When apparent changes are found in filled cable, the splice connectors and equipment connected to the pair should be checked.

1.4.2 Changes of pair balance in air core cable are likely to occur after the cable has been installed and placed in service. The variations result primarily from moisture and occur more frequently in smaller pair count cable (below fifty pairs). These changes are usually not stable and deviations will continue with time as the moisture concentration or length of cable affected increase. While the reversal of tip and ring conductors will improve a noise problem of this type, the results are likely to be temporary.

1.5 It is necessary that tip and ring conductor reversals be clearly identified in the field to prevent any unintentional normalization at some later date. While many companies have used this technique successfully for several years without providing identification in the field, there is always some chance of accidental removal. This possibility is more probable where the technique is being introduced in companies where it has not previously been used. After extensive discussion with operating telephone company personnel methods for positive pair identification have been developed which will be discussed in Paragraph 3.

2. PROCEDURE

2.1 When cable pairs with less than 60 dB balance measured to the office quiet termination are found in the field, the procedure for noise reduction via reversal of tip and ring conductors should be initiated. It is assumed that the power influence, where excessive, has been reduced to an acceptable level through shield continuity verification (TE&CM Section 451.2), and grounding (TE&CM Section 451.7). It is further assumed the problem is not fundamental frequency related. The step by step procedure is simply and does not require complex calculations.

2.2 Two cable pairs are required; the pair being worked on and a pair for communicating between the two people involved. While the procedure could be completed by one person, a great amount of time and travel would be required. One individual is located at the subscriber location. Where a two-pair drop is used this location could be at the station protector. In the absence of a two-pair drop, the location will be at the point the drop is connected to the cable. The initial step is to connect a noise measuring set (may be a loop checker) to the pair with low balance. Read and record the power influence and circuit noise. Calculate and record the circuit balance (PI - CN = Balance). This is the reference or bench mark to which the results of subsequent measurements will be compared.

2.2.1 Where the cable pair being worked on is in service, it should only be removed from service for the short periods required for measurement or for making the conductor reversals at various locations. The subscriber should be notified prior to starting that his line is being worked on and again when all work has been completed. Measurements on working pairs are completed to the office quiet termination. Balance values for a single pair, measured to the quiet termination, may vary, if measurements are repeated, due to the variations in balance between switching paths in the office. Where the reversal produces an apparent improvement in balance of less than 2 dB the quiet termination should be accessed at least three more times to insure the improvement is not due to the balance of different switching paths.

2.2.2 With an unassigned telephone pair, a termination set (TE&CM Section 451.1) may be placed at the office since there is no requirement for maintaining service between measurements. This is recommended whenever possible and will result in completion of the desired work in the shortest time.

2.3 Following the completion of the reference measurement at the subscriber location, one person moves toward the office to the first loading coil location (nearest loading coil to the office). The other person remains at the subscriber location monitoring the communicating or talking pair. When the first person arrives at the loading coil location he advises the second person over the talking pair that he is ready. If working on a pair that is in service, the second person now determines if the pair is in use and, when it is clear, advises that the work may proceed. The loading coil locations are suggested since they are easily identified and at almost equal spacing. Other locations could be used where spacing between test points in nearly equal.

2.3.1 Cut the cable pair and resplice (tip to ring conductor and ring to tip conductor). Measure and record the power influence and circuit noise at the subscriber location. Calculate and record the cable pair balance. If this recorded balance is 60 dB or higher (65 dB or higher whom measured to a termination set) the work is terminated on the cable pair.

2.3.2 If the recorded balance from the second measurement is less than the objective, compare to the reference measurement (Paragraph 2.2) to determine if the pair reversal has produced any change in the overall cable pair balance. Where the recorded balance shows a significant improvement (greater than one dB), the tip and ring conductor reversal is left in place. When there has been no significant improvement (less than one dB), the conductor reversal is removed. Proceed to the next step.

2.4 The individual at the load coil location moves toward the field to the next load coil location. Repeat all steps of Paragraph 2.3. If the balance is now 60 dB or higher (65 dB or higher when measured to a termination set), the work is terminated (Paragraph 2.3.1). When balance is less than the objective, proceed as outlined in Paragraph 2.3.2. This is repeated at each load coil location until the circuit balance is acceptable.

2.5 Special Considerations: There will be some locations where several pairs in a cable will have low balance (less than objective). The first step is to group the pairs by length and appearance along the length of the cable. Secondly, select four or five that appear in the field in the same general area and find the farthest location from the office where all of them can be accessed. This location will be used as the test point. The first loading coil location out the office will be the point of first reversal. Proceed successively pair by pair outlined in Paragraph 2.3 at this location. Next, proceed as discussed in Paragraph 2.4 with any pairs which do not now have 60 dB or higher balance (65 dB when measured to a termination set).

2.5.1 The last step, after objective or higher balance has been attained for all of the pair at the test point, is to visit each subscriber location. At each measure and record the power influence and circuit noise. Calculate and record the circuit balance. If the balance of all cable pairs is acceptable, proceed to the next step. There may be an occasional pair which will have less than objective balance measured at the subscriber location. These will have to be handled as discussed in Paragraph 2.3 for individual pairs but only a single reversal will be required between the test point and the subscriber location.

2.5.2 When the balance of each pair reaches or exceeds the objective, determine the total number of tip and ring reversals completed on that pair. If the number of reversals is even, two or four, no further action is needed. An additional reversal should be made if the number of recorded reversals is odd, one or three, to insure proper tip and ring polarity at the subscriber(s) location. The additional reversal should be made at a point along the cable which will not degrade the balance. It also must be located between the office and the first subscriber location. Where it proves necessary to make a reversal between subscribers all drops on the field side of that point should be reversed at the point they are connected to the cable.

2.5.3 Select another group of pairs as in Paragraph 2.5 and proceed until all pairs have objective or higher balance.

2.6 The location of all tip and ring reversals should be entered and maintained in the appropriate cable records, staking sheets, route maps, etc., as required by the telephone company.

3. IDENTIFICATION

3.1 Positive identification of each splice where the tip and ring conductors of a cable pair have been reversed is recommended. The identification will clearly indicate to all people who might have reason to work in the splicing area that the pair reversal was made deliberately and should not be disturbed.

Otherwise, an employee might believe the reversal was a splicing mistake and accidently restore the splice to the normal state.

3.2 There is more than a single method for providing a positive identification of a splice where the tip and ring conductors of a cable pair have been reversed. Three equivalent methods are recommended in the following paragraphs. Other methods of positive identification using a bright orange color, acceptable to the telephone company and REA, may be used. The telephone company can select the one which will best fill the needs of that particular company.

3.2.1 Place a piece of 25mm (one inch) wide bright orange vinyl plastic tape around the cable pair adjacent to the splicing connector. It should be wrapped at least twice around the pair to insure good adherence of the tape to itself. The tape should be located 25-35mm (one to one and one-half inches) from the splice connector.

3.2.2 Place a bright orange tie-wrap around the cable pair adjacent to the splicing connector. The tie-wrap should be placed 25-35mm (one to one and one-half inches) from the splice connector.

3.2.3 Use bright orange splice connectors for completing the splice. The bright orange splice connectors are produced by painting standard splice connectors with a can of bright orange spray enamel.