LONGITUDINAL CHOKES

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 is written to provide information on the application of longitudinal chokes as a means of reducing telephone system noise.

1.2 Longitudinal chokes are two winding transformers that are connected in series with the telephone circuit. That is, one winding is connected in series with the tip conductor and the other in series with the ring conductor. The two windings are connected so that the transformer presents a high impedance to the flow of longitudinal ac current while not restricting the ac loop current.

1.3 The discussion will deal with the performance of longitudinal chokes in the presence of 60 Hertz ac current as a matter of convenience. These chokes operate in the same manner at higher frequencies, such as the harmonic frequencies of 60 Hertz and can be valuable in the suppression of longitudinal noise currents.

2. THEORY OF OPERATION

2.1 Figure 1 illustrates how longitudinal chokes function in a telephone circuit by providing a high longitudinal impedance to the flow of induced longitudinal noise currents. The open-circuit voltage to ground at the central office, for example, is 30 volts (60 Hertz). This can result in noise if harmonics are present, malfunction of signaling equipment or saturation of equipment resulting in the generation of harmonics. Longitudinal current

flowing through each of the transformer windings will induce a voltage in the other winding 180 degrees out of phase and in opposition to the fundamental voltage. After installation of a longitudinal choke, the voltage to ground might be in the order to 27 volts on the field side of the unit and only 3 volts on the office side. Thus, any noise that might be caused by excessive noise currents flowing through resistance unbalances in the central office equipment will be effectively mitigated. Effects of resistance unbalance in the cable circuit will also be reduced due to the resulting reduction in longitudinal noise current. The same performance occurs at the harmonis frequencies so that voice frequency noise is effectively reduced.

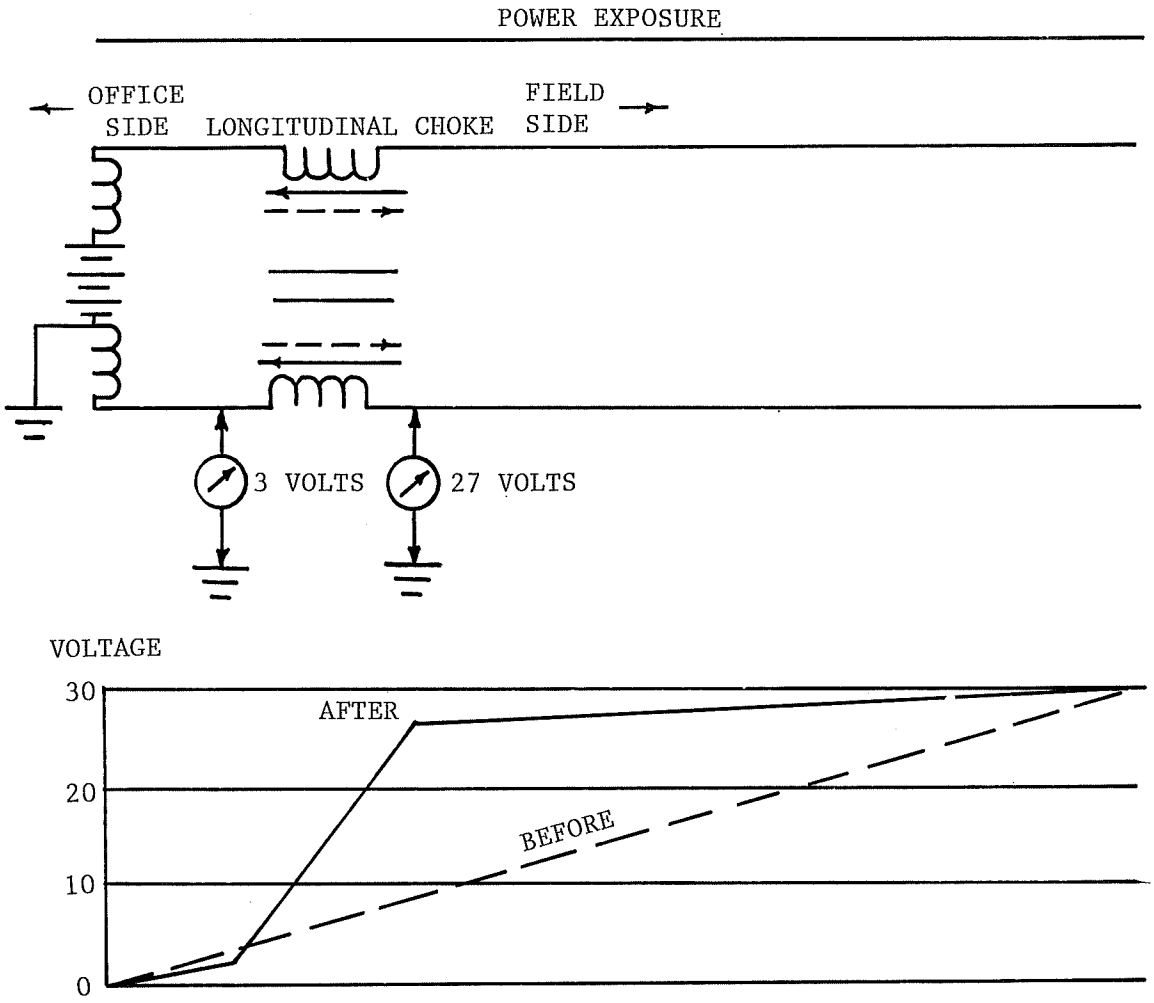

FIGURE 1: OPERATION OF LONGITUDINAL CHOKE

2.11 As discussed in Paragraphs 15.04 and 15.05 of TE&CM Section 451 conversion of longitudinal noise to circuit noise is due to resistance unbalance near the central office where longitudinal current is highest and due to capacitance unbalance near the subscriber where longitudinal voltage is highest. Installation of a longitudinal choke at the office results in a high ac voltage on the field side of the unit and reduction of ac current flowing through the equipment to ground. Should there be high capacitance unbalances to ground in the cable near the office, the higher voltage may be converted to circuit noise. It is indeed possible although extremely rare that in some cases the circuit noise, measured at the office, will be higher after the choke is installed.

2.12 At the subscriber end of the circuit the installation of the longitudinal choke will have no effect unless there is a low impedance path to ground. Installation of a longitudinal choke at the central office does not change the high impedance to ground at the subscriber end. A choke at the office makes the circuit appear to be similar to one that is open circuited at both ends. Voltage to ground will therefore be almost the same at both ends of the circuit as shown in Figure 1. If the circuit noise is the result only of high capacitance unbalance near the subscriber location, installation of a longitudinal choke will have no effect on overall circuit noise.

2.2 Longitudinal chokes are produced by several manufacturers. They can be applied to most types of metallic voice frequency circuits found in the telephone system, such as, subscriber loops, PABX trunks, and interoffice trunks. They can also be used to isolate signaling equipment from the effects of excessive ac voltages and currents.

3. APPLICATION GUIDELINES

3.1 Longitudinal noise chokes should normally be considered as an interim mitigation measure. In other words, a means of temporarily reducing noise to an acceptable level during the investigation of a noise problem. There will, of course, be some cases where the most economical solution may be the permanent application of longitudinal chokes.

3.2 Longitudinal chokes function best when installed at the central office near a low impedance path to ground. This insures adequate current for excitation of the unit.

3.3 There are 35- and 70-volt units available. The voltage rating is related to the linearity of current versus voltage for each unit. If a 35-volt unit is operated in a 50-volt environment it would require more excitation current to be as effective as a 70-volt unit with lower required excitation current.

3.4 Basic electrical characteristics, such as, dc loop resistance, resistance unbalance, insertion loss, maximum loop current, etc., will be specified by each manufacturer for his product. While all are basically similar some differences will be found in various units.

3.5 Typical noise excitation curves are shown in Figure 2. These indicate the magnitude of RMS ac current at 60 Hertz necessary to excite either a 35- or 70-volt unit at a particular 60 Hertz RMS voltage. The first part of both curves is linear, i.e., an equal change in excitation current results in an equal change in voltage. The length of the linear portion is the basis for calling one a 35-volt and the other a 70-volt unit.

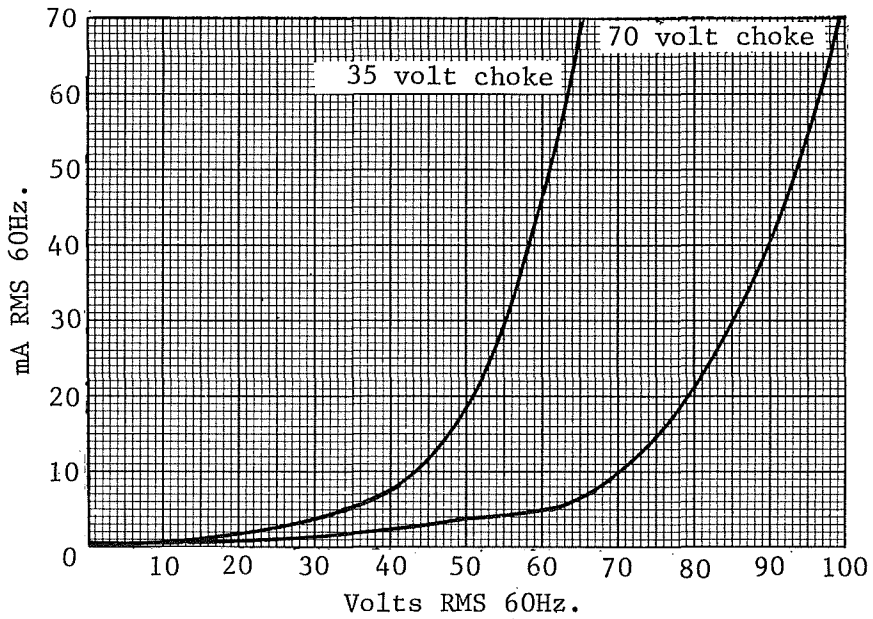

FIGURE 2: LONGITUDINAL NOISE CHOKE EXCITATION CURVES

Courtesy of SNC Manufacturing Co., Inc.

3.6 Following a determination that a longitudinal noise choke will be used for noise mitigation, a decision must be made as to which unit (35- or 70-volt) should be installed. The open-circuit voltage to the central office ground should be measured. For optimum results, the highest voltage to ground that will occur on the circuit is the value desired. It is desirable, where possible, to make measurements every half hour or to record the value with a recording voltmeter over a 24-hour period to find the "worst case" voltage to ground. Measurements should be made with a high impedance FET-type VOM or VTVM.

3.61 If the voltage is 15 to 25 volts, for example, and it is felt that the power influence is not likely to increase in the future a 35-volt unit could be used. Should the voltage be 30-volts or above, the 70-volt unit would be the logical choice. Some operating companies use only 70-volt units eliminating the need for decisions.

3.7 Installation of longitudinal noise chokes on circuits where longitudinal direct current can flow, such as with simplex power or signaling, ground start PBX trunks, etc., is not recommended. If such application is necessary, more excitation current will be required to excite the transformer. Figure 3 shows the increased alternating current required to excite a typical longitudinal noise choke with various levels of longitudinal direct current flowing in the circuit. For example, a 35-volt unit can be excited to 35-volts by 5 mA ac (from Figure 2). If 12 mA longitudinal direct current is flowing in this same circuit, it will require four times as much alternating current (20 mA) to excite the unit to 35-volts (from Figure 3).

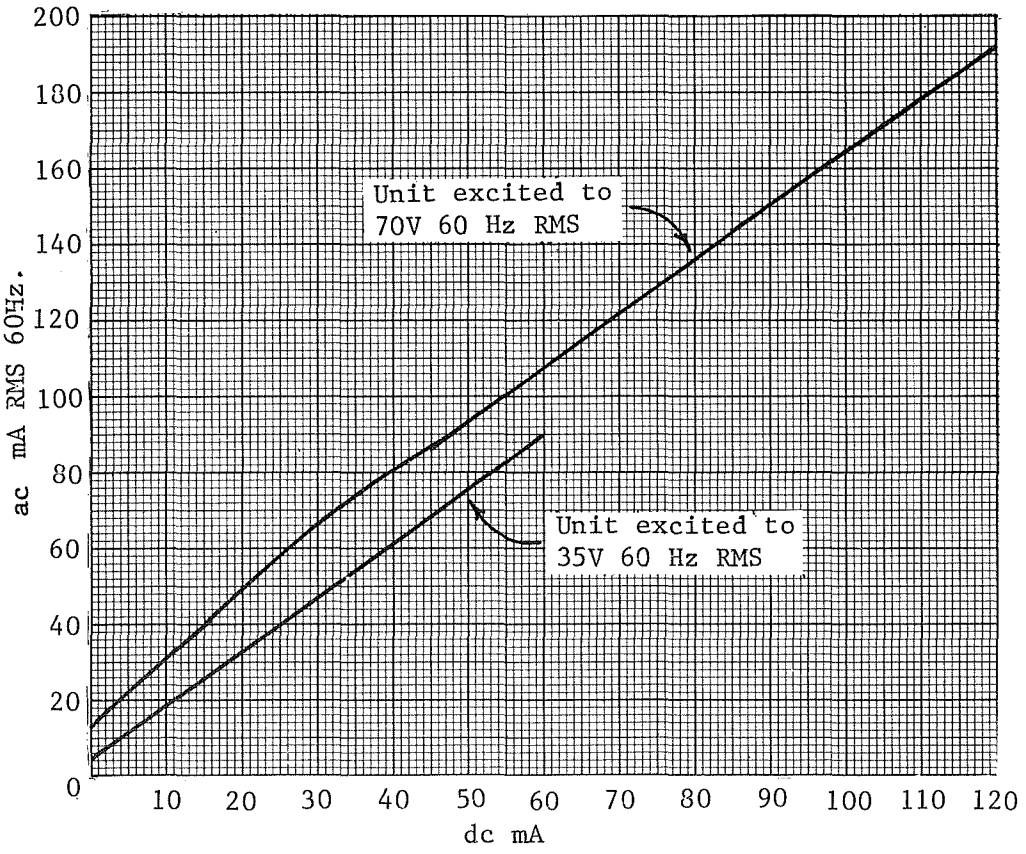

FIGURE 3: LONGITUDINAL NOISE CHOKES (EFFECT OF DC CURRENT)

Courtesy of SNC
Manufacturing Co., Inc.

3.8 Longitudinal noise chokes should not be installed on party line circuits with divided ringing. Installation of the chokes will result in the ringing on one side of the line producing a ring on the other side of the line, especially at higher ringing frequencies.

3.9 Prior to universal application of longitudinal noise chokes to a cable route a few units should be used to determine that they will indeed provide the desired results. As discussed above, the effectiveness of the noise choke in noise mitigation is determined by the type and location of the unbalance in the telephone system.

4. EXAMPLES OF APPLICATION

4.1 Subscriber Loops: Figure 4 shows a typical subscriber loop with a longitudinal noise choke installed which has a power exposure the entire length. The choke is placed on the central office side of the protection. The simplified graph below the schematic diagram shows the induced voltage (60 Hertz) to ground before and after installation of the longitudinal noise choke.

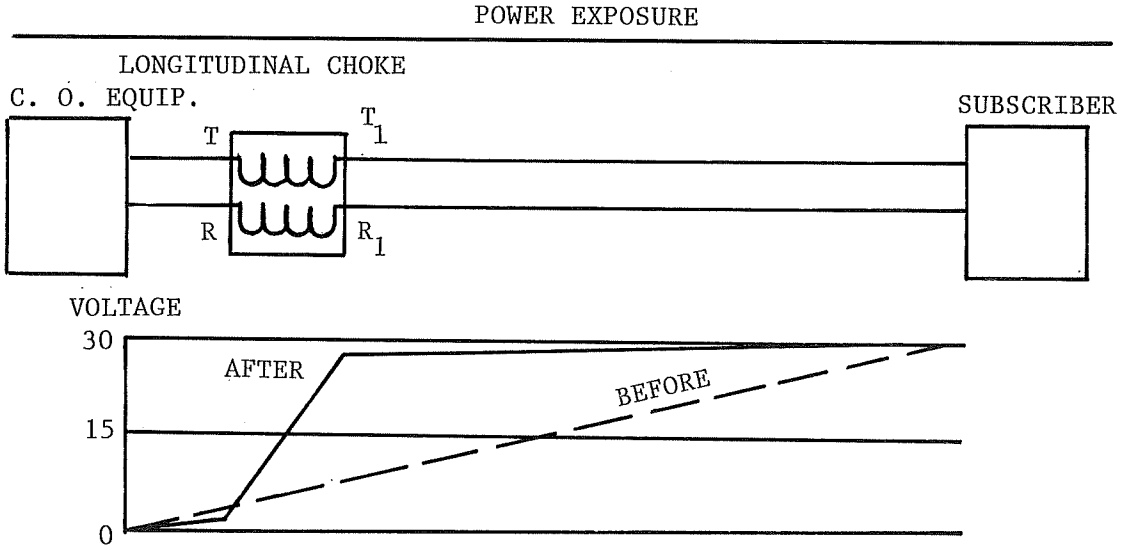

FIGURE 4: SUBSCRIBER LINE TREATMENT

Courtesy of SNC
Manufacturing Co., Inc.

4.11 The difference between the voltage to ground measurement on the tip (T_1) and ring (R_1) side of the line on the field side of the choke (27 volts) and the voltage to ground on the tip (T) and ring (R) side of the line on the office side of the line (3 volts) is the voltage across the noise choke (24 volts). This is a measure of the fundamental frequency (60 Hertz) voltage.

4.12 As discussed above, by introducing a high impedance to the flow of longitudinal noise current the choke effectively reduces circuit noise resulting from series (resistance) unbalances. The longitudinal voltage at the field side of the choke is considerably elevated. Thus, any shunt (capacitance) unbalances located near the office may result in circuit noise.

4.13 Fundamental (60 Hertz) voltage to ground at the subscriber location will be relatively unchanged as shown in Figure 4. Reduction in circuit noise at this location will also depend on the type and location of cable unbalance. If the circuit noise is the result of resistance unbalance located near or at the central office, a marked reduction in circuit noise at the subscriber end will be noted. Should the circuit noise be the result of capacitance unbalances located near the subscriber end of the cable, there may be little or no reduction found. This is why it is recommended that some be installed and measurements made to determine if they will be effective before any commitment is made to treatment of a total cable.

4.14 Should the basic problem to be solved involve malfunction of equipment at the central office, there is little doubt that installation of a longitudinal choke will correct it. Voltage to ground (60 Hertz) at the equipment will be significantly reduced and as a result there will also be a marked reduction in the 60 Hertz longitudinal current flowing through the equipment to ground. This does not imply that the problem in the equipment should not be located and corrected at which time the chokes should be removed.

4.2 PABX Trunks: A typical PABX trunk is shown in Figure 5 with a longitudinal choke installed and a power exposure for the entire length. This schematic assumes the PBX is either of the ground start signaling variety in which noise suppression might be desirable when the solid ground is connected to the circuit, or having a resistive ground during the talking condition. If there is no ground present it is doubtful if enough longitudinal alternating current will flow to excite the transformer. The choke should be placed on the PABX side of protection.

4.21 The simplified graph below the schematic diagram shows the induced 60 Hertz voltage to ground before and after the installation of the longitudinal choke. The difference between the voltage to ground measurement on the tip and ring (T_1 and R_1) side of the choke (30 volts) and the PABX tip and ring (T and R) side (3 volts) is the voltage across the noise choke (27 volts). This is a measure of the fundamental frequency voltage.

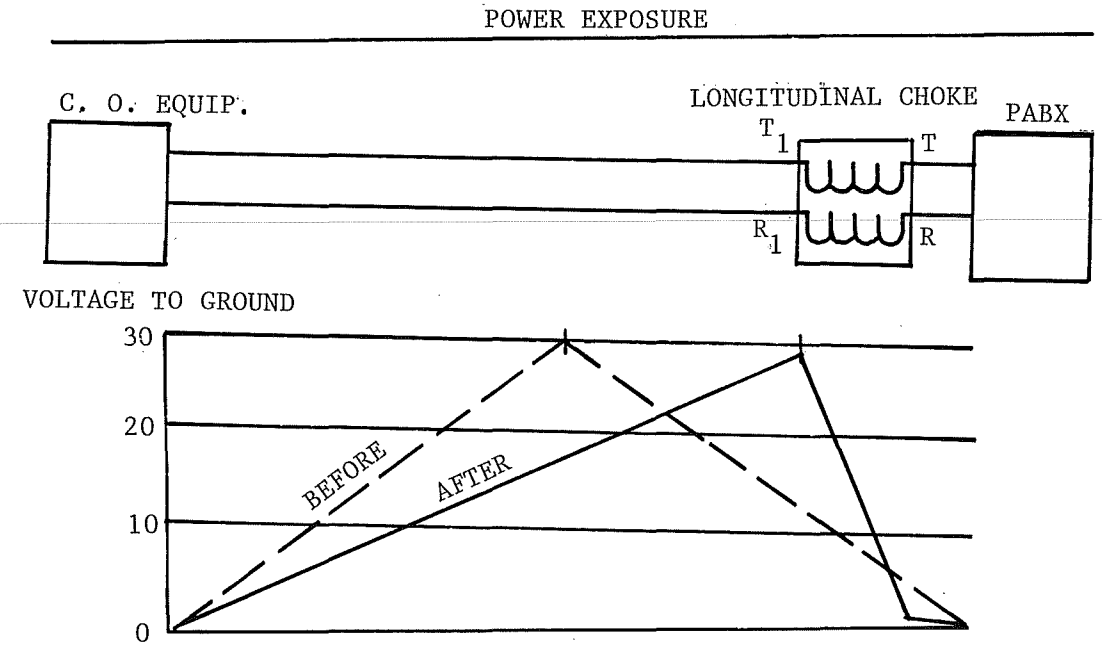

FIGURE 5: TREATMENT OF PBX/PABX EQUIPMENT

4.211 If the PABX is a ground start type additional excitation current will be necessary for effective operation. Reference to Figure 3 will show how much longitudinal alternating current will be required to excite the unit with the value of direct current existing.

4.212 If there is no ground at the PABX location, the trunk will be similar to the subscriber loop discussed in Paragraph 4.1 above. In these situations, longitudinal noise chokes should not be installed at the PABX end of the circuit.

4.22 Circuit noise resulting from resistance unbalances located near or at the PABX location will be significantly reduced when a path to ground exists. This is due to the reduction in the magnitude of longitudinal noise current. Circuit noise due to capacitance unbalances in the same locations may increase as a result of the elevated longitudinal voltage on the field side of the noise chokes.

4.23 Malfunctioning of PABX equipment due to excessive longitudinal 60 Hertz voltage and/or current will definitely be corrected by installation of longitudinal noise chokes where a path to ground exists. There will be a significant reduction in 60 Hertz voltage to ground on the PABX side of the transformer with an associated reduction in the flow of 60 Hertz longitudinal current.

4.3 Inter-Office Trunks: Figure 6 shows a typical intra-office trunk circuit with two longitudinal noise chokes installed, one at each office, with power influence along the entire length. Chokes should be installed on the office side of the MDF protection. The simplified graph below the schematic diagram shows the induced (60 Hertz) voltage to ground

before and after the installation of the noise chokes.

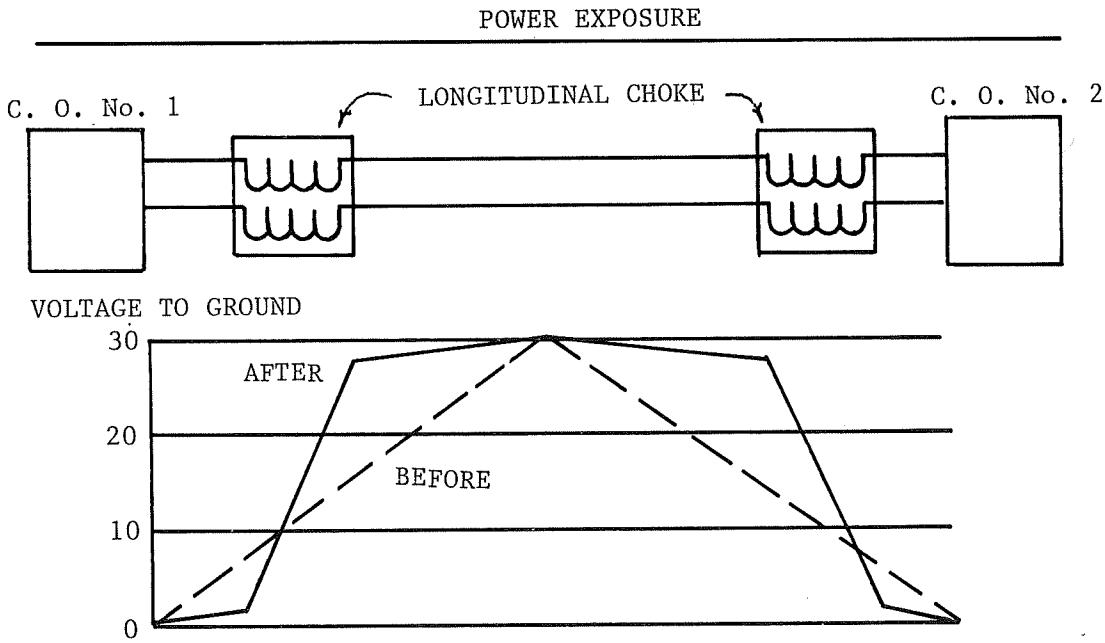

FIGURE 6: TRUNK TREATMENT

4.31 As in the subscriber loop, the difference between the voltage to ground measurement on the tip and ring (T_1 and T_2) side of the two chokes (28 volts) and the tip and ring (T and R) side of the two chokes (2 volts) is the voltage across the noise choke (28 volts). This measurement is of the fundamental frequency (60 Hertz) voltage.

4.32 Circuit noise resulting from resistance unbalances located near or at the two offices will be significantly reduced. This is due to the reduction in longitudinal noise. Circuit noise due to capacitance unbalances located near the offices may increase as a result of the elevated voltage on the field side of the noise chokes.

4.33 Malfunctioning of the trunk equipment in the offices due to excessive 60 Hertz voltage and/or current will definitely be corrected by installation of longitudinal noise chokes. There will be a significant reduction in 60 Hertz voltage to ground on the office side of the transformers with an associated reduction in the flow of 60 Hertz longitudinal current.

4.4 Signaling Equipment: Figures 7 and 8 show a typical installation of signaling equipment which may be sensitive to longitudinal alternating current and/or voltage. The circuit is exposed to power influence along the entire length. An example of such a condition might be the interface between a two-wire trunk and a carrier system in the field. The simplified graph below the schematic diagram shows the induced 60 Hertz voltage to ground before and

the installation of the longitudinal choke.

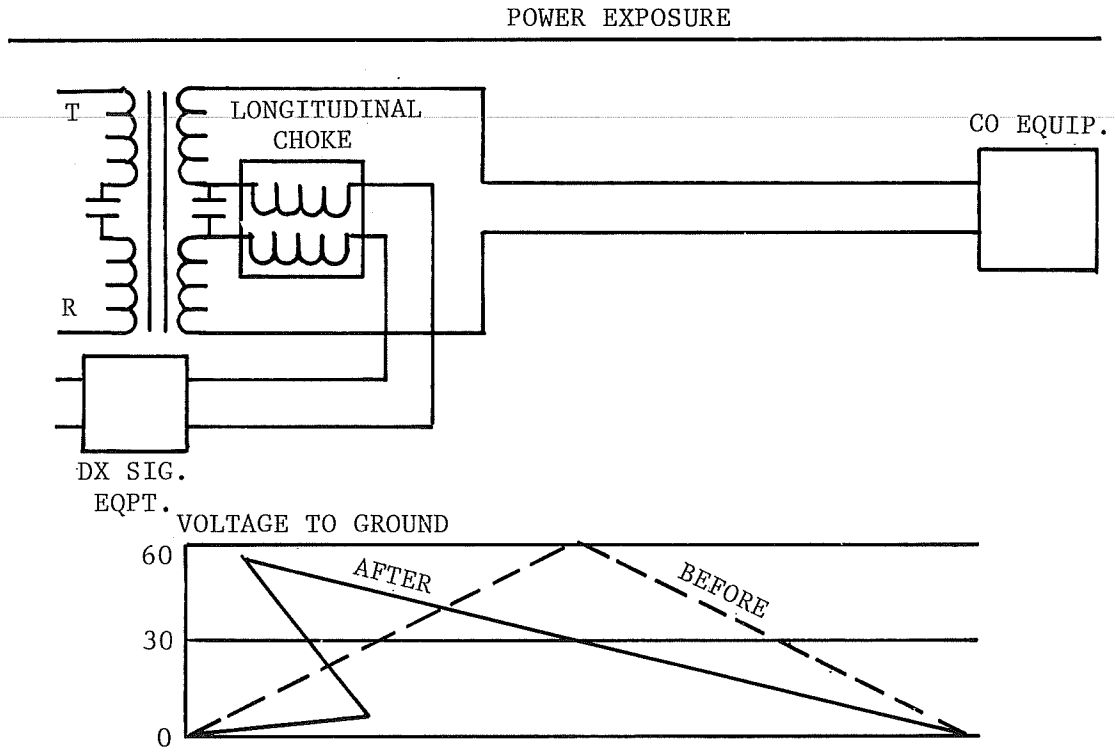

FIGURE 7: TREATMENT OF DX SIGNALING

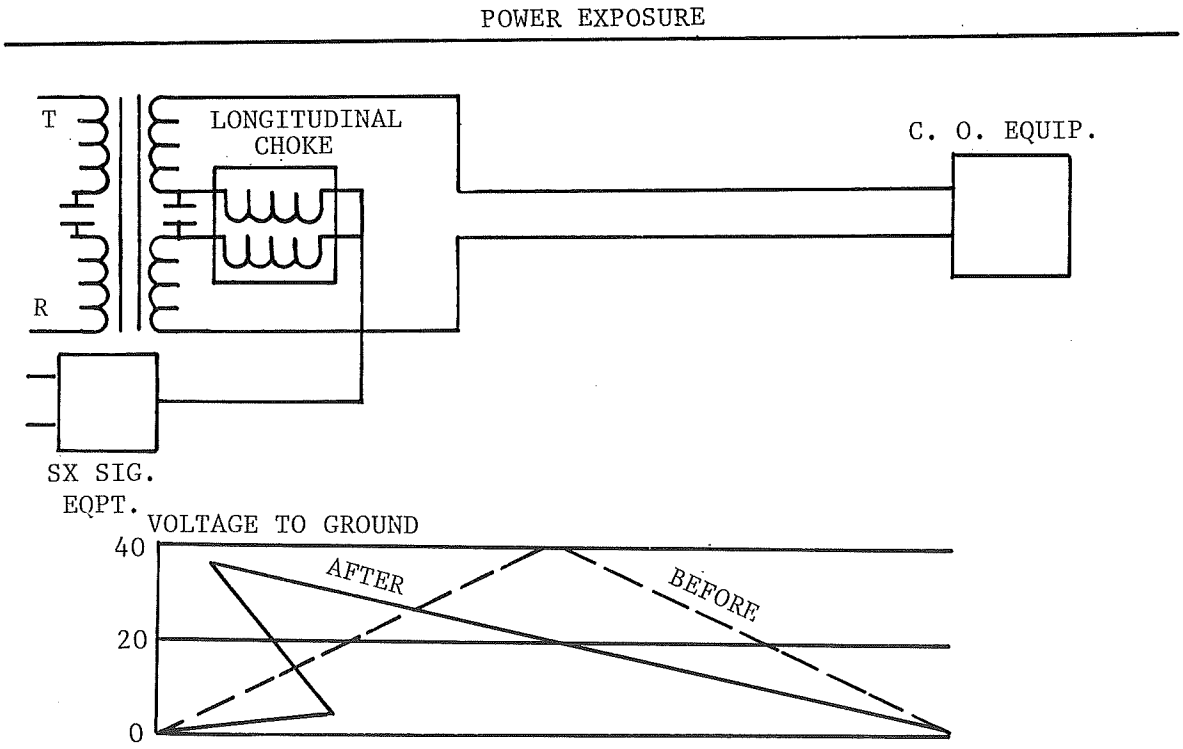

FIGURE 8: TREATMENT OF SX EQUIPMENT

4.41 The difference between the voltage to ground measurement on the field side of the choke (60 and 43 volts respectively) and the signaling equipment side (5 and 3 volts respectively) is the voltage across the longitudinal choke (55 and 40 volts respectively). This is a measurement of the 60 Hertz fundamental frequency voltage.

4.42 Installation of longitudinal chokes in this location is primarily to isolate malfunctioning equipment from excessive longitudinal voltage and current. The effects on noise, while negligible, would be subject to the same function discussed in Paragraph 3.3 above for trunk circuits. When installed in this manner, there will be a significant reduction of 60 Hertz voltag voltage to ground on the signaling equipment side of the transformer with an associated reduction in the flow of 60 Hertz longitudinal current.