

DX SIGNALING SYSTEM

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1. GENERAL

A. Introduction

1.01 This section describes the DX signaling system which is designed to pass supervisory and dial pulsing signals of telephone trunks over cable pairs used for voice transmission. It needs the two conductors of a cable pair and ground return to tie its terminals together and is not intended for open-wire facilities. DX signaling provides equal and independent action, in opposite directions, for 2-way signaling, has compensation for differences in ground potential, and does not require composite sets. Terminals of this system supplement trunk relay circuits arranged for E and M lead signaling and are joined to the latter for signaling with only these two leads. DX signaling uses 45- to 50-volt signal battery and allows conductor loop resistances of 0 to 5000 ohms. It is equipped to pass 2-way supervision and nominal 10 or 20 pps dial pulses with little signal distortion and without pulse repeating adjustments or pulse correctors. Moreover, these pulses are not impaired by the addition of E-type repeaters, nor by the signal by-pass circuits of V-type repeaters.

1.02 One conductor of a cable pair in the DX system carries the supervisory and pulsing signals; both conductors individually carry currents resulting from differences in terminal ground potentials and battery voltages so the current in the second conductor can cancel the effect of this unwanted current in the first conductor. With this

arrangement, DX signaling introduces less noise in adjacent circuits than loop (battery and ground) signaling. It is immune to the usual ac induction voltages. Each DX terminal circuit is joined to the line loop through the midpoints of a repeating coil that may serve also for impedance matching, signaling separation, and suppression of noise between office and line systems. Tied to the cable pair in this way and shunted by a 4 mf capacitor, DX signaling does not materially interfere with nor suffer impairment from voice transmission.

1.03 A symmetrical and balanced circuit of the same pattern as that used in composite (CX) signaling is employed in the DX system. Identical circuits face the line conductors at both terminals permitting full duplex signaling, that is, equal and independent signals in both directions. DX signaling has better operating margins than present forms of loop signaling because of the following design features:

- (a) Signal sending by transfer of a line conductor end potential from ground to battery or from battery to ground with contacts that maintain the same circuit and therefore the same current transition delay for the alternate conditions of signaling. This arrangement gives effective polar transmission and markedly reduces the amount of signaling distortion arising from variations in circuit resistance, inductance, and capacitance. Open and closed contact sending of necessity changes the transition time intervals, since one condition opens the dc circuit for inductance and the other condition shorts or shunts capacitance.
- (b) Signal receiving by operation or release of a polar relay with opposing windings arranged to cancel out the action of variations in the circuit components and office battery voltages. This differential operation results in less signaling distortion than is possible from the opposition of the force produced by current in a relay winding to that of spring pressure.
- (c) A balancing network with adjustment for the cable pair resistance to aid uniformity of signal circuit operation and reduce signal variations.
- (d) Effective signaling current confined to one wire of a pair so there is less resistance and more signal current for equivalent conditions than with loop signaling.

DX signaling circuits repeat 12 pps dial pulsing of 58 per cent break input with

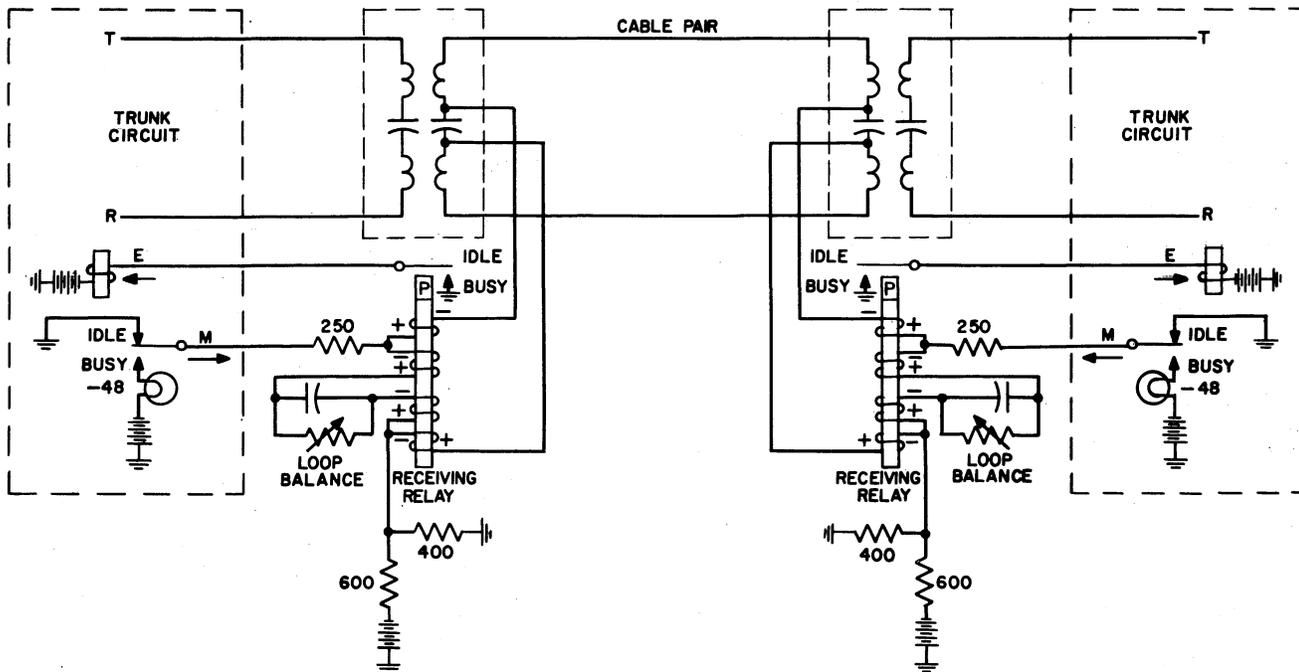


Fig. 1 - DX Signaling Circuit

pulse distortion within  $\pm 4$  per cent. This performance is better than that of most loop signaling circuits and is equal to that of intertoll CX signaling arrangements.

## B. Applications

1.04 The DX signaling plan, main circuit features and relation to trunk and repeating coil circuits are shown in Fig. 1. This system replaces SX and CX signaling as the standard for telephone trunks with cable conductor, nonphantom, line facilities, except where two signaling circuits per wire pair are required. It is used exclusively on cable conductors to achieve the advantage of their high insulation resistance. The range of DX signaling is less than that of CX or SX, but its small distortion permits the use of two DX circuits in tandem for one trunk, when this is required.

1.05 The DX signaling system is particularly suitable for automatic, multi-frequency, or dial pulsing trunk operation of the following types:

- (a) Short intertoll trunks.
- (b) 2-way exchange and tributary trunks.
- (c) Local and tandem trunks with high conductor loop resistance or equipped with E-type voice repeaters.

Standard circuits are available for these trunks with provision for E and M leads which allow use of DX signaling and with options for idle circuit termination which is required with low-loss transmission plans. The DX system allows origination of independent signals at either end, which is necessary for 2-way trunks, and adds flexibility to separate signaling circuits for one-way trunks.

1.06 At trunk section junction points, where one section uses E and M lead signaling, the DX system provides a more economical means for extending E and M signaling leads than by relay auxiliary pulse links, and assures proper termination of all carrier channels extended with cable pairs (Fig. 2).

## 2. EQUIPMENT DESCRIPTION

### A. General

2.01 There are two DX signaling equipment units. Primarily there is the DX signaling unit which is used for signaling between trunk circuits or for extending E and M leads from trunk circuits. The second unit is the signal lead extension circuit for extending E and M leads from signaling circuits. These equipment units are described separately in the following paragraphs.

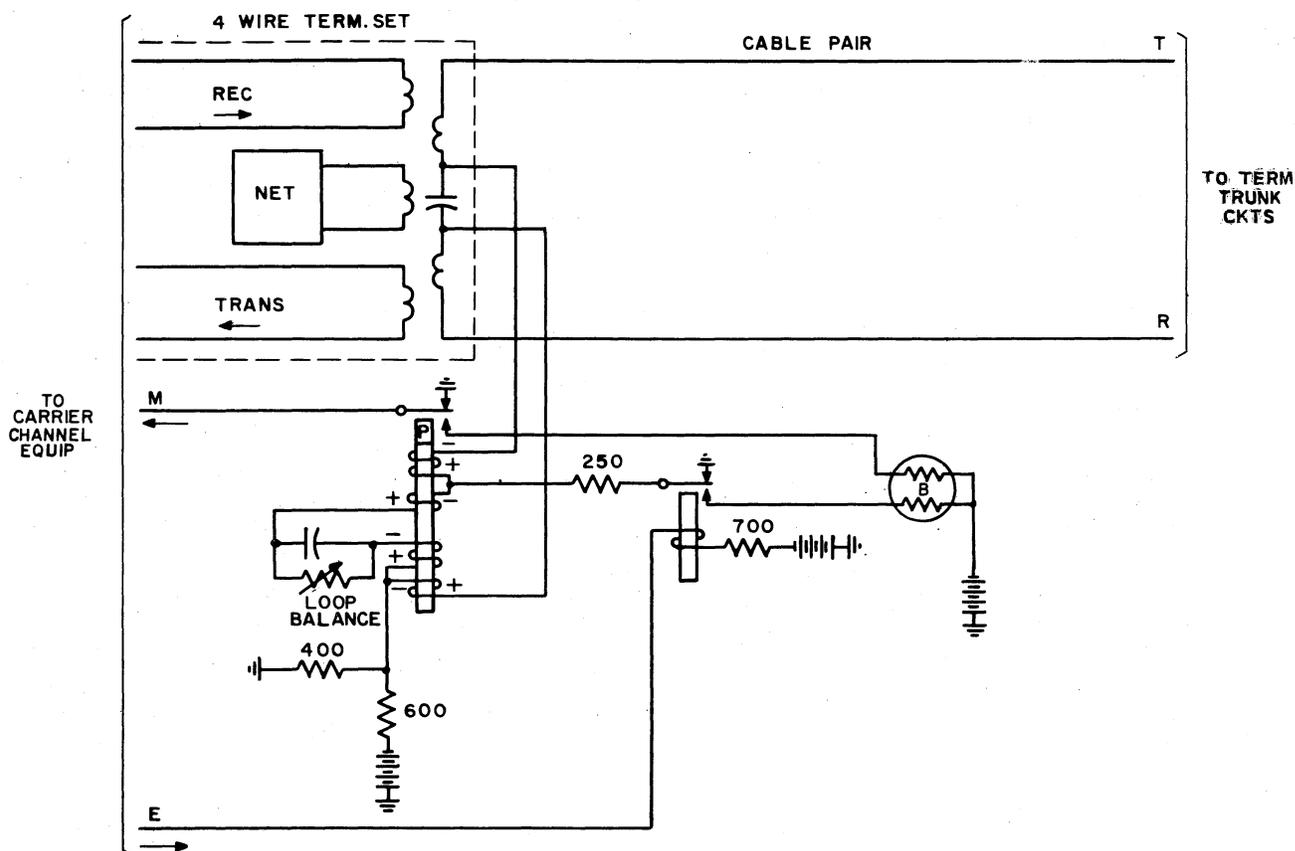


Fig. 2 - DX Signaling at Intermediate Point

### B. DX Signaling Unit

2.02 The DX signaling equipment unit consists of four circuits which occupy the space of two 2-inch by 23-inch mounting plates. One polar relay, five resistors, and two capacitors are the essential components of each circuit. A test jack is included to facilitate the testing and adjustment of the polar relay.

### C. Signal Lead Extension Unit

2.03 A relay is added to the basic DX signaling circuit to provide extension of E and M leads from signaling circuits. The DX signal lead extension unit comprises three of these circuits and occupies the space of three 2-inch by 23-inch mounting plates. The essential components of each circuit are: eight resistors, three capacitors, two relays, and a test jack for testing the polar relay.

## 3. METHOD OF OPERATION

### A. General

3.01 The DX signaling system employs E and M leads for transmitting signaling

information to and from the trunk circuits at each end of the loop. Signals to a distant office are passed from the trunk circuit as changes in potential (-48-volt battery, or ground) on the M lead of the signaling circuit. Received signals are transferred to the trunk circuit or ground potential in the form of an open circuit or ground potential. The conditions on the E and M leads are independent of each other. Moreover, the potential conditions on the M leads at opposite ends of the loop are independent of each other, thereby allowing for equal and simultaneous (full duplex) signaling in the two directions. The various functions of DX signaling are described in detail in the following paragraphs.

### B. Supervisory Signaling and Pulsing

3.02 Supervisory signals applied to the M lead of a signaling circuit are transmitted over the cable pair tip (T) conductor to the distant signaling circuit. A battery potential on the M lead has the effect of operating a receiving relay to indicate the off-hook (busy) condition. Under normal circumstances, the called end subsequently becomes busy and returns this signal to the calling office by application of battery to

its own M lead. The on-hook (idle) condition is transmitted as a ground potential on the M lead and can be originated at either end. Again, under normal operating conditions, this signal is subsequently returned by the receiving (called) end. It should be noted from this description of supervisory signaling that in normal use the M lead at each end of the transmitting facility has the same potential (either battery or ground) most of the time. DX signaling benefits from this fact, in that, no signaling current flows over the loop when the M lead at each end has the same potential.

3.03 When a receiving relay is operated by a signal from the distant office, it indicates this busy condition by grounding the E lead to its trunk circuit. Because of the comparatively low distortion introduced by the DX system, dial pulsing of 20 pps can be passed as ground pulses over the M lead. These are indicated at the receiving end as open pulses on the E lead.

#### C. Neutralizing Circuit

3.04 The maximum loop resistance for DX signaling is limited in order to assure good operating current for the receiving relay and a minimum distortion of the signal pulses. However, neither of these objectives could be assured if provision were not made for balancing the differences between ground potentials at each end of the loop. DX signaling uses the cable pair ring (R) conductor for this compensation. When there is no difference between ground potentials at either end of a loop, the R conductor carries no current. However, if there is a difference in ground potential, the R conductor will carry a current proportional to this difference in potential. This current has a biasing effect on the receiving relay at one end of the loop and an operating effect on the receiving relay at the other end. This just compensates for the current flowing over the T conductor (in the absence of signal current) which also results from the difference in ground potential but has the opposite effect on the receiving relays. With this circuit, differences in ground potential of  $\pm 45$  volts are allowable.

#### D. Balancing Network

3.05 The DX signaling circuit is considered balanced when the receiving relay at one end of a loop is independent of the condition (battery or ground potential) on its own M lead. This occurs when current in the operating winding of the receiving relay is canceled by the effect of its bias current for varying potentials on its M lead. This condition is achieved by a balancing network consisting of a number of resistors shunted by a capacitor. The impedance offered by this network, when properly adjusted, is such that any voltage on the M lead of its

associated relay will provide an equal amount of operating and bias current. The net effect of the potential on the M lead of the associated circuit is therefore zero.

3.06 The resistance in the balancing network is a function of the loop resistance. By strapping the resistors accordingly, a very close balance can be achieved. The capacitance in the balancing network is increased by 2 microfarads when exceptionally long loops are used or when two or more E-type repeaters are employed in the line facility.

#### E. Extension of E and M Leads

3.07 A signal lead extension circuit has been designed to interconnect a signaling circuit and a trunk circuit when the distance between them is too great to connect them directly through the E and M leads. In effect, this circuit is a pulse repeater for E and M lead signals. As shown in Fig. 2, it consists of the basic DX signaling circuit modified with an additional relay. With this circuit, signals received on the E lead from the signaling circuit will be retransmitted to the E lead of the trunk circuit. Also, signals transmitted over the M lead of the trunk circuit are retransmitted to the M lead of the signaling circuit.

3.08 Because of the low distortion characteristics of DX signaling, two DX signaling circuits can be used in tandem if necessary. The signal lead extension circuit provides an economical intermediate link in such situations. All the other features of DX signaling, such as the neutralizing circuit and balancing network, are included in the extension circuit.

### 4. MAINTENANCE

#### A. General

4.01 DX signaling circuits consist of relatively few components, occupy a small amount of space, and require little power. The balancing network is adjusted when the DX circuit is placed in service and does not require additional adjustment except when the line facility is altered. The comparatively greater operating margins provided for DX signaling assure reliability of performance.

#### B. Testing

4.02 Over-all trunk tests for checking signaling circuit performance of E and M leads at each terminal, as shown in an A200 series practice for toll trunks, are adequate and desirable for any DX signaling trunk. A test jack is included in each DX circuit for testing and adjusting the four-winding polar relay.