GTE LENKURT

DEMODULATOR

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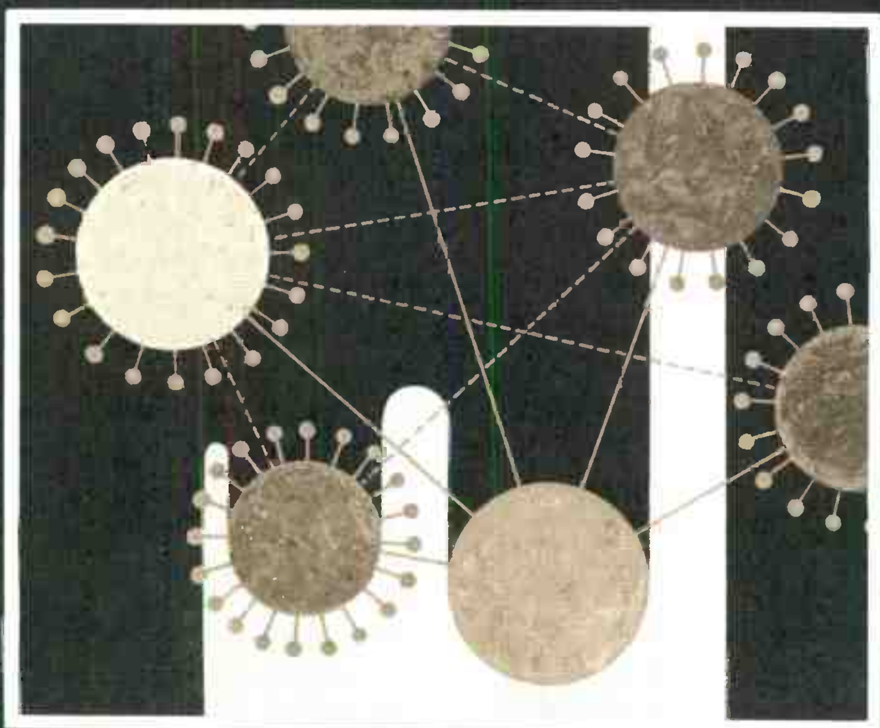
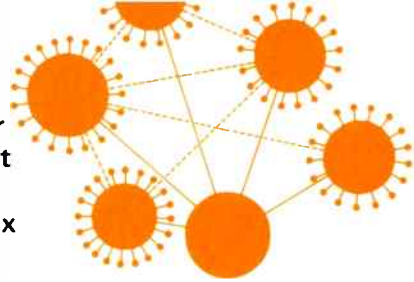
Some Fundamentals of Telephone Signaling



Even the earliest telephone had to have some way of signaling parties at the other end. Loop signaling is one of the simplest types of telephone signaling, yet it is the stepping stone that leads to more complex forms of signaling arrangements.



Even when Alexander Graham Bell spoke the first complete sentence into the first telephone, "Mr. Watson, come here, I want you," telephone signaling was involved. In this case the sound of Mr. Bell's voice and his words were the signaling which informed Mr. Watson that a message was to be communicated. This method of signaling was adequate for experimental purposes, but in later telephones it became necessary to announce an intent to communicate by means of visual or ringing devices, so that the called party could be alerted at some distance from the telephone instrument.

The basic concept of signaling may seem simple enough, but the process by which signaling is effected may range from the operation of a simple dc circuit, to a complex arrangement of steps performed over a maze of long distance trunk circuits. The whole gamut of signaling is inextricably tied to supervision, dialing, switching, timing, and ringing—subjects which in themselves could cause volumes to be filled with information.

Switching Functions

In a telephone system, all subscriber stations connect to a central office by means of relatively short lines called subscriber loops (see Figure 1). The central office provides the switching arrangements that enable any subscriber station connected to that office to be connected to lines leading to other subscriber stations which are also connected to that office, or to trunk lines that lead to other central offices in the same or distant cities (see Figure 2). Switching equipment at the central office can be either manual or automatic depending on whether switching is performed mainly by humans or by mechanical or electronic devices.

Manual Switching

Manual switching is performed by operators at central office switchboards. All subscriber lines in a local single office exchange terminate in at least two jacks on a switchboard. The jack mounted in the lower part of the switchboard panel (the answering jack) is associated with a signal lamp which lights when a subscriber wishes to attract the attention of the operator. The calling jack, which is mounted in the upper panel of a switchboard, is used by the operator to complete a connection to a subscriber's line when it is called by another station. In other than very small offices, each subscriber line appears at many other jack locations along the switchboard. The terminations are multipled so that any line is within reach of any operator.

The answering jacks and associated signal lamps in a multiple switchboard are divided among the operators, each of whom is responsible for answering signals from an average of two hundred subscribers. An operator is warned against plugging into a line that is busy by a "click" which is heard in the receiver of the headset when the plug touches the front portion of the calling jack.

Manual switching and automatic switching ultimately perform the same function—that of connecting the calling party to the called party—but the techniques for doing this are different, and the type of equipment used is entirely different.

Dialing Function

The address or dialing function in a telephone system directs the operation of the switching equipment in the automatic offices. Consequently, the evolution of the various switching systems has brought about changes in address signaling techniques. Address signals originate at the telephone dial, and consist of a train of dc pulses corresponding to the number dialed. Modern "touch calling" systems which use keys or pushbuttons instead of a rotary dial, employ tones at different frequencies rather than dc pulses.

In the step-by-step switching systems, the switching equipment responds directly to the dc pulses. However, in panel and crossbar switching systems, the switches cannot be controlled directly by the dial pulses, so these systems require a device known as a "register/sender" which stores the dial pulses and then controls the movement of the switches.

Four basic methods commonly used to transmit address or dialing signals for use by the various switching offices are dial pulsing, revertive pulsing, panel call indicator (PCI) pulsing, and multifrequency (MF) pulsing. Dial pulsing is the most commonly used method of transmitting address information—the numerical value of each digit is represented by the number of pulses in a train (one pulse represents 1, ten pulses represent 0). Dial pulsing is used in all types of switching offices.

Revertive pulsing was originally developed for use in panel switching offices. In this type of pulsing, the address pulses are not transmitted by the originating office. When a call is made, a loop to the distant office is closed. This starts the movement of a panel selecting switch at the distant office. As the selecting wipers pass each terminal, a commutator transmits pulses back to the register/sender at the originating office. When the proper number of these revertive pulses, corresponding to the called number, are received by the register/sender, a signal is sent back to the distant end to stop the movement of the selector. Revertive pulsing is used in certain crossbar offices as well as panel offices.

Panel call indicator (PCI) pulsing is a method of transmitting address signals between a dial office and a manual office. This technique converts pulses received from a dial office to lamp indications which appear on a switchboard. The switchboard operator then connects the incoming call to the called number and rings the subscriber.

Multifrequency (MF) pulsing transmits address pulses between switching offices. Digital information is transmitted in the form of short tone

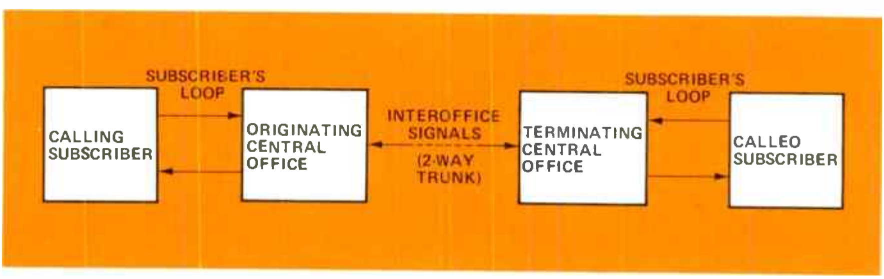


Figure 1. The subscriber's loop connects the telephone to the central office.

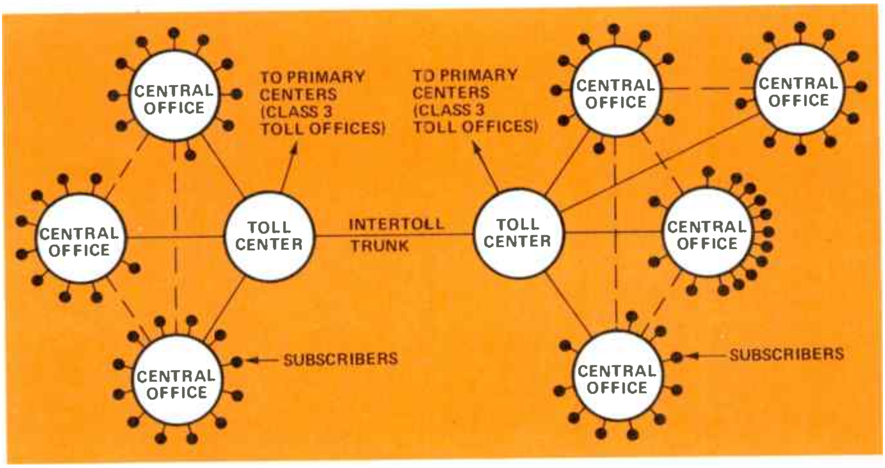


Figure 2. Subscriber stations are connected to other subscribers by a network of trunk lines.

bursts. Six signaling frequencies are used, each digit being represented by a combination of two of the six frequencies. The signaling frequencies fall within the speech band and are processed through the trunk in the same manner as speech signals. A form of multifrequency pulsing can also be used over subscriber loop circuits that use pushbutton telephones instead of the conventional rotary dial.

There are essentially two fundamental techniques used to derive signaling paths on telephone trunk circuits—loop signaling and E&M signaling. Loop signaling requires a dc loop, and is the method used in all subscriber loops and in most short-haul 2-wire trunks. E&M signaling is used with both ac and dc signaling systems, on 2-wire or 4-wire physical trunk circuits and on carrier derived trunk circuits. E&M signaling is standard for use in all intertoll trunks.

Subscriber Loop Signaling

A basic understanding of telephone signaling begins with dc loop signaling. The telephone loop is the closed circuit that is formed by the subscriber's telephone and the cable pair, and any other associated conductors necessary to make the connection to central office switching equipment. Loop signaling takes place over a telephone loop, and requires a metallic dc circuit to operate. Loop signaling systems generally signal by altering the current on the telephone loop. For example, the current flow may be made to change directions, change value, or turn on and off. These changes in current flow are detected by marginal or polar relays at the distant end of the trunk.

Loop signaling is one of the simplest forms of signaling in the telephone network, and is used in certain exchange trunks, short-haul, toll-connecting trunks, and one-way dialing toll trunks where 2-wire voice-frequency circuits are employed. The dc signaling current flows over the same conductors used for voice transmission. Some loop signaling methods include high-low, wet-dry, reverse battery, and grounded battery. Of these, reverse battery and battery-ground signaling (a variation of reverse battery signaling) are most commonly used.

The types of signals that are normally transmitted and received over subscriber's loops can be classified into three categories of local signals: supervisory signals, information signals, and control signals. Supervisory signals are initiated when a subscriber makes a request for service, retains or releases a connection, or recalls the telephone operator. Control signals provide directions for establishing the desired connection. Information signals notify subscribers as to the progress of their calls, and include audible ringing, dial tone, and line busy signals.

Common Battery Supervision

A type of supervision most often used in a subscriber's loop is "common battery supervision." The development of the common-battery system established the dc source in the central office, and eliminated the need for a hand-cranked magneto and dry cell battery at each telephone station. The central office battery performs essentially two functions: it puts current through the telephone microphone transmitter so that the speaker's voice will change the dc current when the sound waves strike the diaphragm in the microphone, and also gives on-hook or off-hook information to the central office. The telephone receiver does not require dc, since it is an ac device only.

In a common-battery system, dc power is supplied by the central office in the form of 24V or 48V. This "talking battery" supplies power for the telephone transmitter as well as power for signaling and ringing of telephone instruments. When the subscriber lifts the handset from its hook, a dc path is completed through a loop which consists of the customer's telephone, a dc source (battery) in the central office, and a line relay. When the loop is closed, the relay is energized, thus connecting the subscriber's line (or loop) to the operator's switchboard, or to automatic dial equipment. When the calling subscriber is finished with the call, the handset is replaced on the hook, thus breaking the circuit and allowing the relay to release the line.

Reverse Battery Signaling

The tip, ring, and sleeve (sometimes called C-lead) designations that make up a telephone line are derived from names associated with early switchboard systems. The subscriber's telephone loop was connected to trunk circuits by means of plugs that fitted into jacks located on the switchboard panels. The plug connectors bore the designations tip (T), ring (R), and sleeve (S), as shown in Figure 3. The tip and ring leads were used for voice transmission, while the sleeve was used as the control lead and make-busy lead. These designations remain today for lead reference (battery, ground, control), even though a manual switchboard may not be used with a system. To detect whether the called party's instrument is on-hook or off-hook, some means of supervision is required by the central office. Reverse battery signaling is widely used for this pur-

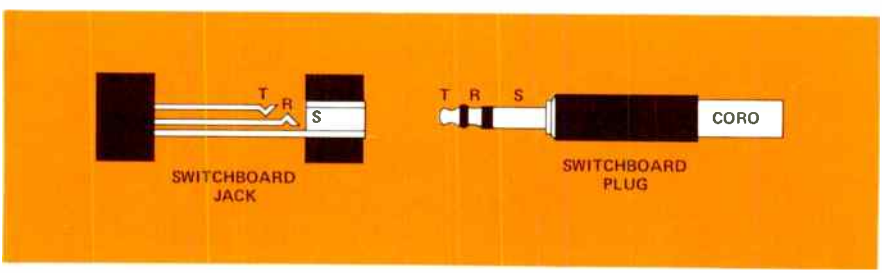


Figure 3. The tip (T), ring (R), and sleeve (S) designations of a telephone line originated from the contact descriptions on a telephone plug.

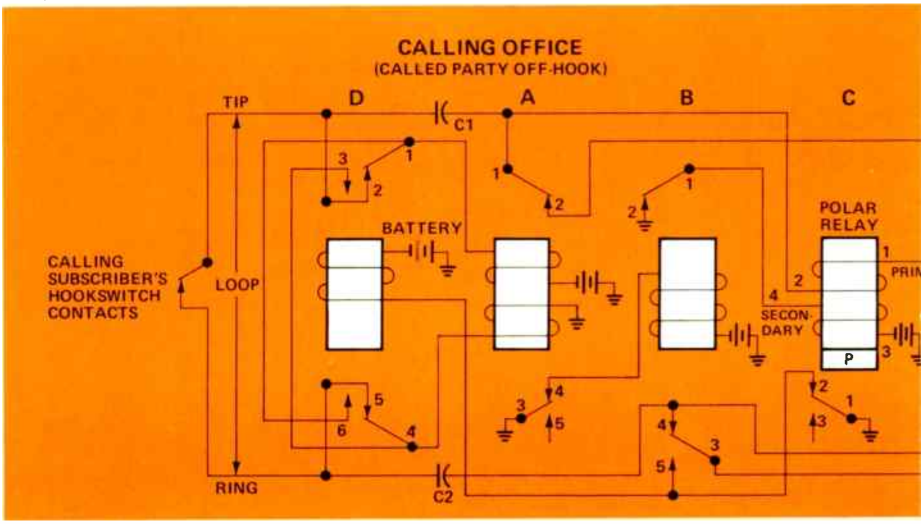


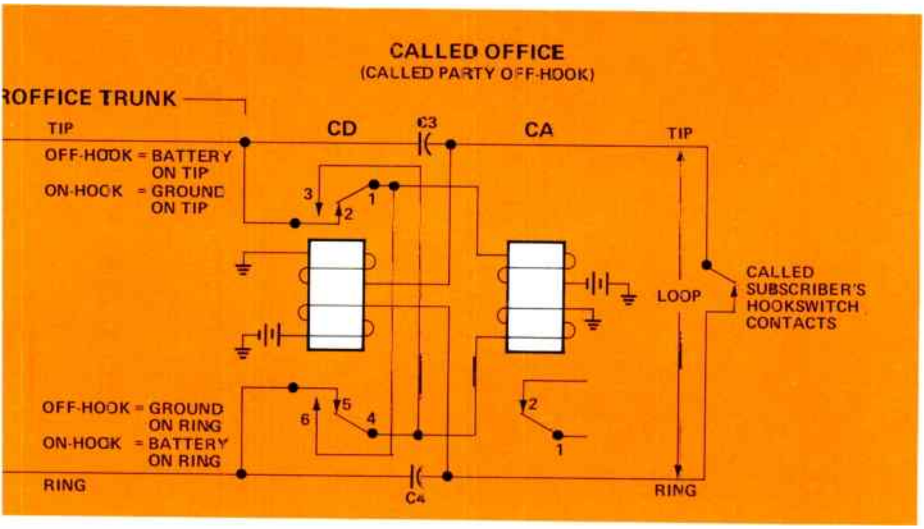
Figure 4. Trunk circuit using reverse-battery signaling.

pose. Reverse battery signaling is so called because battery and ground are reversed on the tip and ring conductors to change the dc signal in the direction of the calling end, from on-hook to off-hook. By means of current reversal, reverse battery signaling provides answering supervision (an indication that the called party has answered the call).

In crossbar and step-by-step switching offices, when an interoffice trunk is idle, there exists battery on the ring and ground on the tip of a telephone line. When the called party answers, talking battery is supplied from the central office. In answering a call, the called party operates a relay as the telephone goes off-hook. The operation of the relay reverses the polarity of the battery back to the originating office. The reverse current notifies the operator (if it is an operator-handled call), by turning off a lamp on the switchboard, that the called party has answered. The reverse battery action also gives notice to message accounting equipment that the called party has answered, and therefore, that the call was completed. This is necessary to enable proper charges to be made to the calling party. When the telephone is returned to an on-hook condition, current polarity again reverses.

In the trunk circuit of Figure 4, all dialing has been completed and the called party has answered. Relays A, B, C, and D are part of the calling party's trunk circuit. Capacitors C1 and C2 couple the voice frequency currents from the subscriber loop to the trunk circuit, but separate the dc control circuits. Relays CA and CD form part of the called party's incoming trunk circuit, while capacitors C3 and C4 couple the voice frequency currents from the trunk circuit to the called party's loop, but separate the dc control circuits. Relays A and B have no direct function in the battery-reversal operation, and remain as shown during the reversal process.

In the circuit of Figure 4, the battery polarity on the calling subscriber's loop is controlled by the called party. When the latter answers, relay CD operates. Contacts 1 through 6 of this relay act as a polarity reversing switch to reverse the trunk battery polarity furnished by relay CA. In the unanswered condition (CD released), the trunk has battery on the



ring and ground on the tip. Terminal 1 of the primary winding of polar relay C, is connected to battery furnished from the called office, due to the released condition of the CD relay. Battery is furnished from the CA relay via contacts 5 and 6 of the CD relay over the ring conductor, through contacts 3 and 4 of the B relay to terminal 1 of the C relay primary. Ground is furnished to terminal 2 of the C relay via the companion path on the tip conductor (contacts 2 and 3 of the CD relay from the ground winding of the CA relay). Under this condition (on-hook), the two windings of the C relay are opposing and the relay is released (contacts 1 and 2 open). The D relay is released and the calling subscriber's loop has ground on the tip and battery on the ring, via the D relay contacts 2, 3 and 5, 6.

When the called party goes off-hook, the telephone closes the loop to operate the CD relay, causing the battery furnished by the CA relay to reverse polarity on the trunk circuit via contacts 1, 2 and 4, 5 resulting in battery on the tip and ground on the ring of the trunk. This condition causes the C relay to operate, since the battery polarity now applied to the 1-2 winding is aiding that applied to the 3-4 winding. When contacts 1 and 2 of the C relay close, the D relay operates, closing contacts 1, 2 and 4, 5, opening 2, 3 and 5, 6. This results in battery polarity reversal to the calling party's loop, exactly as occurred upon operation of the CD relay in the trunks battery polarity. Other relays associated with the loop, detect this reversal for supervision or message-accounting purposes.

Signaling is much more than ringing a bell at the subscriber's telephone. The signaling process is dictated by the functions of supervisory, information and control signals. Signaling begins when a caller picks up his telephone and continues through the dialing process, and extends through those switching functions that ultimately connect the caller to the called party. Signaling functions, such as those which take place in subscriber loop signaling, play an important part in the overall plan of telephone signaling, since they are the starting point of what could be a series of complex steps in the signaling process of a telephone network.

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