INTEROFFICE SIGNALS AND SIGNALING SYSTEMS

CONTENTS PAGE

1. GENERAL

1.01 This section describes the various signaling systems and the types of signals used for interoffice signaling in the Bell System for both local and interexchange calls and for toll calls using the intertoll network. The nationwide intertoll network provides for customer dialing of calls to points outside the local or extended service area by direct distance dialing (DDD) and for operator dialing of such calls by "operator distance dialing." The intertoll network also provides customer international direct distance dialing (IDDD) for calls to more than 53 countries outside of the North American integrated DDD network.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 Interoffice signaling systems are used to convey information between two or more switching systems involved in a specific interoffice call. In providing signaling facilities and equipment for interoffice telephone service, it is necessary to consider signaling from the originating office to the terminating office as well as that of the customer loop. Customer loop signaling is described in Section 975-110-100. Sections 859-100-100, 859-210-101, 859-215-101, 859-215-102, and 859-230-101 provide engineering information for the various signaling systems.

1.04 The parameters of the various signaling systems described in this section are subject to change as new requirements and technology evolve. Signaling systems also change as technology advances. The information presented herein can only reflect their status at the date of this section.

1.05 Revertive pulsing, which was introduced in the early 1920s with the panel switching system, is discussed briefly in this section. The panel system is rapidly being replaced by switching systems using the latest technology such as the electronic switching system (ESS). Panel call indicator and panel call announcer are not discussed in this section because of their limited use in the telephone switching system.

1.06 Common control and noncommon control switching offices in the intertoll network are referred to in this section. By definition, common control is an automatic arrangement in which items of control equipment in a switching system are shared. They are associated with a given call only during the periods required to accomplish the control functions. All crossbar and electronic switching systems have common control. Step-by-step switching systems are noncommon control offices.

1.07 Signaling paths can be derived from any of four basic transmission mediums. Three of these are: metallic, analog carrier, and digital carrier. Each of these three mediums are further subdivided into various categories to cover the numerous types of applications. The fourth type of signaling medium is the recently developed Common Channel Interoffice Signaling (CCIS) System.

1.08 Today, there are essentially two fundamental techniques used to derive signaling paths on interoffice trunk facilities. The first of these is loop signaling and is the method used in most subscriber loops and 2-wire interoffice trunks. This technique requires either a dc metallic loop or a digital or analog carrier facility with the appropriate channel or signaling unit. The second technique, known as E&M, is used with 2-wire and 4-wire metallic trunks and on carrier derived trunk circuits. The actual form of the signal may be the result of either:

(a) The presence, or absence, or a change in direction of a dc current flow

(b) The presence or absence of ac signaling tones

(c) The amplitude of the signaling bit of an eight bit digital word in a digital bit stream.

1.09 There are four common signals which must be passed over trunks between switching offices involved in local interoffice calls or toll calls. These are supervisory, address, control, and status signals. Table A shows which direction these signals are transmitted and Table B explains the meaning of each signal.

1.10 ***Supervisory signals*** convey information regarding switchhook conditions (on-hook or off-hook states) at either end of a trunk. The most common supervisory signals in use today are connect, answer, and disconnect.

1.11 ***Address signals*** convey information which is necessary to establish the desired connection. The most common interoffice address signals in use today are dial pulse (DP) and multifrequency (MF).

1.12 ***Control signals*** condition trunk equipment at the calling and the called end to perform designated functions. Likewise, control signals are used to convey information from the called end to the calling end of a trunk to indicate the trunk equipment at the called end is ready to perform certain designated functions. Control signals also include network management signals which can be

TABLE A

NAME OF SIGNAL	ORIG LOCAL OFFICE (CLASS 5)	ORIGINATING TOLL OFFICE (CLASS 4 OR HIGHER)	THROUGH SWITCHING OFFICE (CLASS 3 OR HIGHER)	TERMINATING TOLL OFFICE (CLASS 4 OR HIGHER)	TERM. LOCAL OFFICE (CLASS 5)	REMARKS	SEE NOTE
A. SUPERVISORY							
Connect (Seizure)	→	→	→	→			
Answer	←	←	←	←		Used in Charging Control	1,6
Disconnect	→	→	→	→		Note 5	1
B. ADDRESS							
Dial Pulsing	→	→	→	→			2
Multi-frequency Pulsing	→	→	→	→			3
C. CONTROL							
Flash	→	→	→	→			
Wink Start	←	←	←	←			4
Delay Dial	←	←	←	←			
Start Dial	←	←	←	←		As required	
Key Pulsing (KP)	→	→	→	→			
Start Pulsing (ST)	→	→	→	→			
Stop		←	←	←		As required	7,8
Go		←	←	←			
Send Calling Number (ANI)	→ Operator Identification OR → Automatic Identification			} TSPS or CAMA			
Coin Collect	←	←	←	←			
Coin Return	←	←	←	←			
Ring Forward	→	→	→	→			
Ringback	←	←	←	←			
D. STATUS							
DIAL TONE	←						
Reorder	←	←	←	←			1
Line Busy	←	←	←	←			1
Audible Ringing	←	←	←	←			1

Notes:
1. This signal is simply relayed from office to office.
2. Connections must be established before remaining or regenerated digits are sent ahead.
3. Second off-hook signal causes release of sender and cut-through for talking or flashing.
4. Second dial tone is used in some cases, but is not satisfactory in ultimate.
5. To stop answering service or to release a locked-in hold condition. This signal is delayed by a timed release feature for an interval of about 10 to 32 seconds in some systems.
6. Answer supervision must be returned to the office where charging control is centered. It is desirable to return real or simulated answer supervision to the originating office in all cases except for noncharge calls, ie, information, intercept, repair service, etc.
7. Announcement may be by operator or by machine (recorded announcement).
8. Stop is returned when selector cuts in on the level having trunks which require this signal.

TABLE B

NAME OF SIGNAL	ON-HOOK	OFF-HOOK	DIRECTION CALLING OFFICE	CALLED OFFICE	USE OR MEANING	REMARKS	SEE NOTE
A. SUPERVISORY							
Connect (Seizure)		√	→		Requests service and holds connection.		
Answer		√	←		Called party has answered. Charged timing begins and depends on this signal.		
Disconnect	√		→		No service is desired. Message is completed. Release connection.		
B. ADDRESS							
Dial Pulsing	√	√	→		Indicates called number.		
Multifrequency Pulsing			→		Indicates called number.		
C. CONTROL							
Flash	√	√	←		Manually recalls operator to connection.		2
Wink Start		√	←		Called end ready for digits.		1
Delay Dial		√	←		Called end not ready for digits.		1
Start Dial	√		←		Called end ready for digits.		1
Key Pulsing (KP)			→		Prepares receiving circuit for digits. Unlocks MF receiver.	MF tone of 1100 + 1700 Hz.	
Start Pulsing (ST)			→		Indicates that all necessary digits have been sent.	MF tone of 1500 + 1700 Hz.	
Stop		√	←		Some digits received. Called end not ready for further digits.		1
Go	√		→		Called end ready for further digits.		1
Coin Collect			←		To collect coins deposited in coin box.	MF tone of 700 + 1100 Hz or winks.	
Coin Return			←		To return coins deposited in coin box.	MF tone of 1100 + 1700 Hz or winks.	
Ring Forward	√		→		Recalls operator forward to the connection.		
Ringback	√		←		Recalls operator backward to the connection.	MF tone of 700 + 1700 Hz or wink.	
Send Calling Number (ANI)			→		Indicates that the sender is ready to receive calling number.	Toll office requests ANI information	
D. STATUS							
Dial Tone		√	←		Serving office ready for digits		
Reorder		√	←		All trunks busy		
Line Busy		√	←		Called number busy		
Audible Ringing		√	←		Called number reached Ringing has started		

Notes:

1. In cordboard operation, the start-dialing, delay-dialing, stop and go signals are sometimes indicated to the operator on the calling cord lamp instead of the start-dial lamp. In TSP operation, these signals are indicated on KP and start lamps.
2. With Traffic Service Position (TSP) operation, the effect of flashing can depend upon the circumstanc[e] but in most instances, a flashing supervisory lamp will result.

used to control the bulk assignments of circuits or to modify the operating characteristics of selected switching systems in the intertoll network in response to overloads.

1.13 ***Status signals*** convey information regarding the progress or disposition of a call to the calling customer, PBX attendant, or the toll operator. Audible ringing and line busy tones are two commonly used status signals.

2. SUPERVISORY SIGNALS

2.01 Supervisory signals are used to convey information regarding a state or condition (on-hook or off-hook) existing at either end of a trunk or connection to a trunk or switching system at the called end. Supervisory signals used in interoffice signaling systems are composed of on-hook or off-hook signals. These terms are convenient for designating the two most common signaling states which will exist in a trunk. Supervisory signals which are on-hook/off-hook, or a combination of both, are connect (seizure), answer, and disconnect. Although wink, delay dial, stop-go, and flash are transmitted in the same manner, they are more properly defined as control signals since they provide auxiliary signals and actions not associated with seizure, answer, and disconnect.

2.02 Usually, if a trunk is not in use, it is signaling on-hook toward both ends. Seizure of the trunk at the calling end initiates an off-hook signal transmitted toward the called end. Likewise, if a trunk is in the condition of awaiting an answer from the called end, the called end is signaling on-hook to the calling end. Answer of the call results in the sending of an off-hook signal back toward the calling end. However, it should be noted that some 1-way loop incoming trunks (delay dial/loop reverse battery) can be arranged to signal off-hook toward the calling end when idle.

A. Connect (Seizure)

2.03 The connect signal is a sustained off-hook signal transmitted toward the called end of a trunk following its seizure. This signal indicates that the originating office wants service and the signal will continue as long as the connection is held. Momentary interruptions in the connect signal caused by dial pulses or the ring forward signal are ignored as far as the connect and disconnect functions are concerned. In 2-way operation, to avoid dual seizures of a trunk, the connect signal will make the trunk look busy at the called office.

B. Answer

2.04 An answer signal is a sustained off-hook signal transmitted from the called to the calling end of a connection. When the called customer answers, an off-hook signal is transmitted toward the calling office and to the office where automatic customer billing takes place. For billing purposes, the answer off-hook signal is distinguished from off-hook signals of shorter duration by the requirement that it must be continuous for a minimum interval ranging from 2 to 5 seconds.

C. Disconnect

2.05 A disconnect signal may originate from either the calling (calling party disconnect) or the called (called party disconnect) customer. A calling party disconnect signal is a sustained on-hook signal transmitted toward the called customer. This signal is an indication by the originating trunk circuit to the terminating trunk circuit that the connection is no longer needed. The disconnect time ranges from 150 to 800 milliseconds depending upon the type of switching system involved in the connection. The disconnect timing feature allows the trunk circuits to hold the established connection during ring forward signals (4.30) or false disconnects.

2.06 A called party disconnect signal is a sustained on-hook signal transmitted toward the calling customer. When the disconnect signal is sent, the message accounting or traffic service position office stops further charges to the calling customer.

3. ADDRESS SIGNALS

3.01 Address signals are those signals which contain information describing the telephone number or address of the called customer. Probably the most important and the most complicated signaling function is address, or as commonly referred to, "dialing." This function directs the operation of the switching equipment in the automatic offices. Consequently, the evolution of the various switching systems, from the early panel to the modern electronic switching systems office, has brought about changes in address signaling techniques.

3.02 Until 1978, the verbal addressing method was still used in some parts of the Bell System. When the calling customer went off-hook, the switchboard operator would come on the line and ask for the desired number. Today, on toll calls where the customer dials the digit 0, a toll switchboard operator will be alerted. The operator then verbally receives the calling information from the customer and manually addresses the call (by dialing or multifrequency pulsing) through the DDD network to the called customer. Where the Traffic Service Position System (TSPS) is available, the customer may dial the digit 0 plus the address information (seven or ten digits). The operator then performs the special operator service required by the calling customer and releases the connection. The called customer then goes off-hook and the connection is established.

3.03 Address signals which originate at the customers rotary dial set or a PBX dial, consist of a train of dc pulses corresponding to the number dialed. TOUCH-TONE® sets, or toll switchboard MF keysets, which use pushbuttons or keys instead of a dial, send audible tones at different frequencies rather than dc pulses. An address signal can vary from 1 to 11 digits depending upon the address information contained therein. For example, by dialing the digit 0, the calling party will be connected with an operator. Generally, 7-digit dialing will establish a local exchange call; 7- or 8-digit dialing will establish a toll call connection within the local area code; 10- or 11-digit dialing is required to establish a toll call outside the local area code. For international direct distance dialing (IDDD) calls, more than 11 digits may be required.

3.04 Three basic methods are used to transmit address signals between the various switching offices. These are dial pulsing (DP), multifrequency pulsing (MF), and revertive pulsing (RP).

A. Dial Pulsing

3.05 Dial pulsing is a means of signaling consisting of regular momentary interruptions of the direct current (DC) path at the sending end, in which the number of interruptions corresponds directly to the value of the dialed digit. The dial pulsing modes can be either loop or battery and ground.

3.06 Dial pulsing is used on trunks to step-by-step switching offices because the switching equipment cannot directly accept revertive pulsing (3.19) or multifrequency (MF) signals (3.10). Dial pulsing is also used, in some cases, on trunks to common control switching offices (panel, crossbar, or electronic) which are not arranged to receive MF signals.

3.07 When the calling customer is served by a step-by-step office, the number dialed may terminate in the same step-by-step office or lead to a distant office. If the number dialed leads to a distant office, the dial pulses are processed and relayed forward by an outgoing trunk circuit. At the distant office, the processed signal may either operate the switching equipment directly to the called number or be stored (registered) by equipment for further processing to reach the called number.

3.08 Control signals, ie, delay-dial/start-dial or wink start (4.03 through 4.11) are required in connection with dial pulsing if the sending and receiving offices are of the common control type. Wink start is the present recommended control signal. However, some older switching offices are unable to either accept it or to generate it. On some trunks, the incoming office equipment must be ready to receive pulsing, without the use of additional start-pulsing signals, after the connect signal is received. This is called immediate dialing and is most common on trunks to or from step-by-step to common control offices.

3.09 Dial pulsing can also be transmitted over analog (frequency multiplexed) or digital (time division multiplexed) carrier systems. The transmission of direct current (dc) dial pulses over an analog carrier system requires conversion of the dial pulse signals from a dc state into alternating current (ac) inband or out-of-band single-frequency pulses. Dial pulse transmission over a digital carrier system requires conversion of the dial pulses to a digital bit for inclusion in the eight bit digital word of the digital bit stream. In both systems the receiving terminal reconverts these signals into dc dial pulses to operate the switching equipment.

B. Multifrequency

3.10 Multifrequency (MF) pulsing accomplishes the address function, in both the toll and exchange network, with alternating current (AC) tones. MF pulsing transmits only numerical address information within the voiceband range. Therefore, another signaling system such as duplex (DX), single frequency (SF), loop, or digital encoding, must be provided for supervision and control signals.

3.11 The principal advantages of MF pulsing are speed, accuracy, and range. MF signaling also requires less setup time per call and, as a result, a relatively small number of MF senders or registers is required as common equipment to serve a large number of trunks. The MF pulses are usually generated by automatic equipment, although they may be generated manually.

3.12 The MF pulsing system is intended for transmitting address information from one switching system or a manual operating location to another switching system. A secondary use of MF pulsing is to transmit the number of the calling party from the local or serving office to the CAMA or TSPS office, or directly to the serving toll center for billing purposes. Local offices must be equipped with ANI (automatic number identification) equipment to use MF pulsing to transmit the calling customer's telephone number to the CAMA or TSPS office for billing purposes.

Sending

3.13 The MF signaling system transmits address information by combinations of two of five separate frequencies. Additional signals for control functions are provided by combinations using a sixth frequency. The six frequencies are spaced 200 Hz apart and provide up to 15 possible 2-frequency combinations. Ten combinations are used for digits 0 through 9 inclusive and one each for control signals. The beginning of an MF address transmission is indicated with a key pulse (KP) signal and the end with a start (ST) signal. See Table C. The remaining three combinations are used for special signals required in coin control, class marks, and route control functions.

3.14 Multifrequency signals are always received on a common control basis by an incoming register or sender. Therefore, control signals such as delay-dialing/start-dialing or wink start are always required with MF pulsing to assure transmission integrity and the availability of a receiving circuit at the incoming end. After MF pulsing has started, all digits are accepted without delay from the called end.

TABLE C

FREQUENCIES AND DIGIT CODES FOR MF PULSING

NUMERAL	CODE	FREQUENCIES
1	0 + 1	700 + 900
2	0 + 2	700 + 1100
3	1 + 2	900 + 1100
4	0 + 4	700 + 1300
5	1 + 4	900 + 1300
6	2 + 4	1100 + 1300
7	0 + 7	700 + 1500
8	1 + 7	900 + 1500
9	2 + 7	1100 + 1500
0	4 + 7	1300 + 1500
CONTROL		
KP	2 + 10	1100 + 1700
ST	7 + 10	1500 + 1700

Receiving

3.15 The MF receiver is associated with an incoming register or sender in the associated switching system. See Fig. 1. The MF receiver is automatically connected to a trunk when the associated switching system receives a trunk seizure signal from the SF or other trunk signal transmission system. The MF receiver detects the incoming MF pulses and translates them into corresponding DC signals. The DC signals are then passed to the associated switching equipment which uses them to initiate appropriate switching and other operations. After the MF receiver has performed its functions, the receiver is automatically disconnected from the trunk and becomes available to serve another trunk in a similar manner.

3.16 In an electromechanical switching system, the MF receiver is permanently associated with a particular incoming register, or the register portion of an incoming MF sender, to which it delivers its dc output indications. MF receivers associated with electromechanical switching systems will not respond to MF tones until unlocked by the KP tone. The unlocking process is effected entirely within the MF receiver although an exchange of signals between the receiver and switching equipment takes place while the KP signal is being received.

3.17 In an electronic switching system, the MF receiver is permanently associated with ferrod

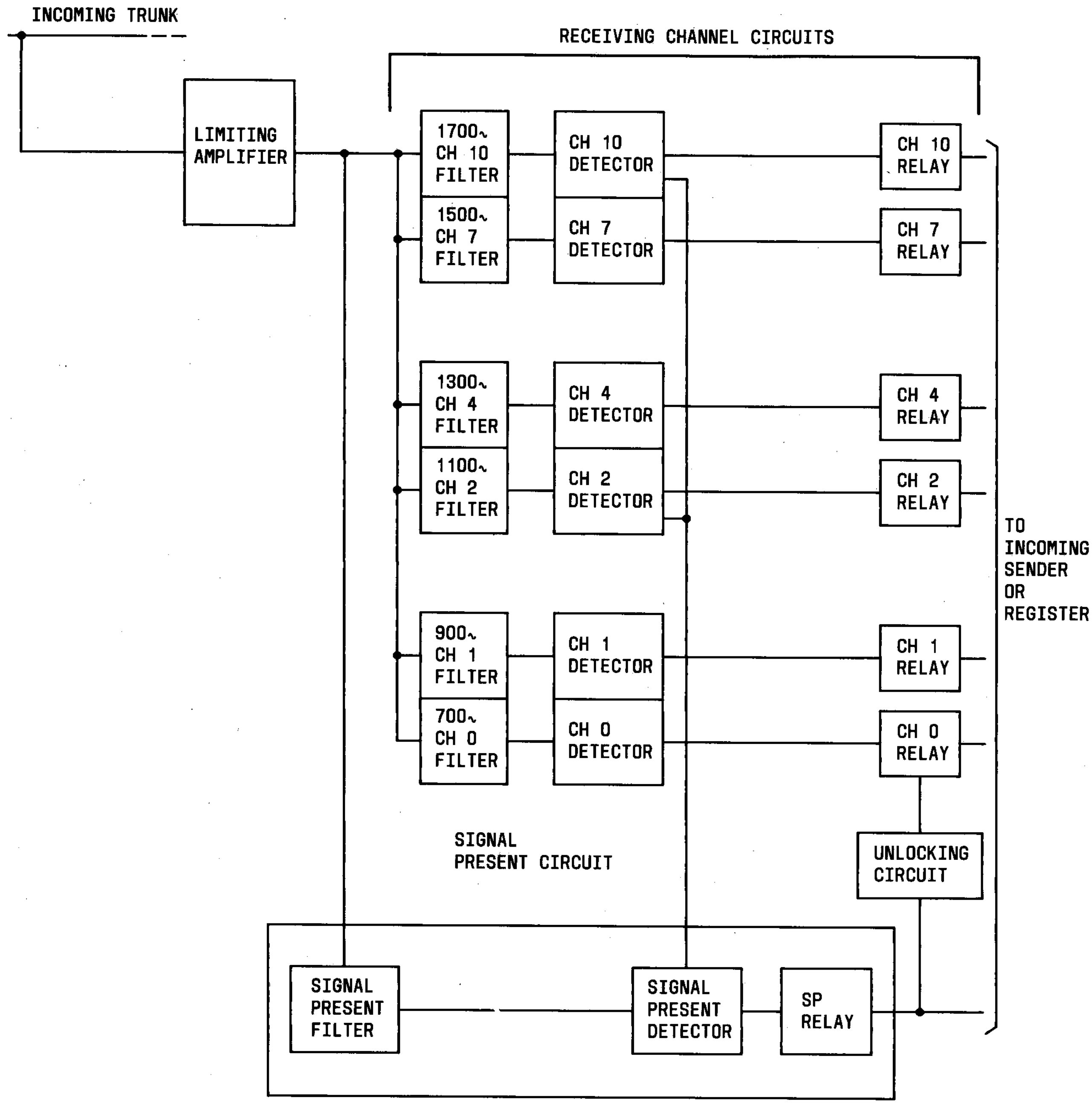


Fig. 1—MF Receiver—Simplified Block Diagram

sensors and scan points in a trunk frame scanner or master scanner. The MF receiver presents its dc output indications to the sensors. The scanner and associated circuits, in turn, transfer the dc indications to one or more registers. MF receivers associated with electronic switching equipment will respond to any valid MF tone. The receiver does not have to be unlocked by a KP tone in order to do so. However, the associated electronic switching equipment will ignore all signals from the MF receiver until the KP signal has been received and processed.

3.18 In both MF receiver applications, the receiver will accept and pass MF tones until the sender has received the start pulsing (ST) tone.

The requirement that a KP signal precede the MF address tones prevents the MF receiver from reacting to spurious speech currents and impulse noise. See Section 859-230-101 for a functional description of the MF signaling system.

C. Revertive Pulsing

3.19 Revertive pulsing provides a means for the originating office to control address signals at the terminating office. In this method of signaling, the originating office monitors pulses received from the terminating office and stops the distant selector or generator when a predetermined number of pulses has been received. Revertive pulsing is used in panel switching systems because it is the only type of interoffice address signals the system can send or receive. Because these systems are being replaced, the use of revertive pulsing is on the decline in the Bell System. Other switching systems such as No. 5 Crossbar, Crossbar Tandem, No. 4A Toll, and ESS have been equipped to use revertive pulsing if they are or have been required to interconnect with panel switching offices. The use of revertive pulsing is sometimes continued due to economic reasons after the panel office is removed. This is due to the interconnecting offices not being equipped with MF equipment because of the prior need to work into the panel switching systems.

3.20 The revertive pulsing signaling system differs from other signaling systems in that address signals with different functions are transmitted in each direction. In this system, the sender at the originating office initiates only start and stop signals and, in between, counts the revertive pulses sent back from the terminating office.

3.21 As shown in Fig. 2, the terminating office receives a start signal from the originating office. Equipment at the terminating office then generates revertive pulses in accordance with the address information. These pulses are sent back to the originating office. When the number of pulses received at the originating office corresponds to the address digit being transmitted, a stop signal is sent to the terminating office to end that phase of the operation. After the appropriate number of digits has been recorded in the terminating office equipment, an incoming advance pulse is returned to the originating office. The trunk is then ready to be connected through to the talking paths at each office. As can be seen in Fig. 2, revertive pulsing requires three signaling states for proper operation, ie, send forward, send back, and incoming advance.

4. CONTROL SIGNALS

A. Flash

4.01 With calls that require operator assistance, the customer can recall the switchboard or Traffic Service Position System (TSPS) operator by repeatedly depressing and releasing the station set switchhook. This action, in turn, causes a supervisory lamp at the switchboard or TSPS to flash on and off. The flashing lamp attracts the attention of the operator without causing premature disconnect of the trunk.

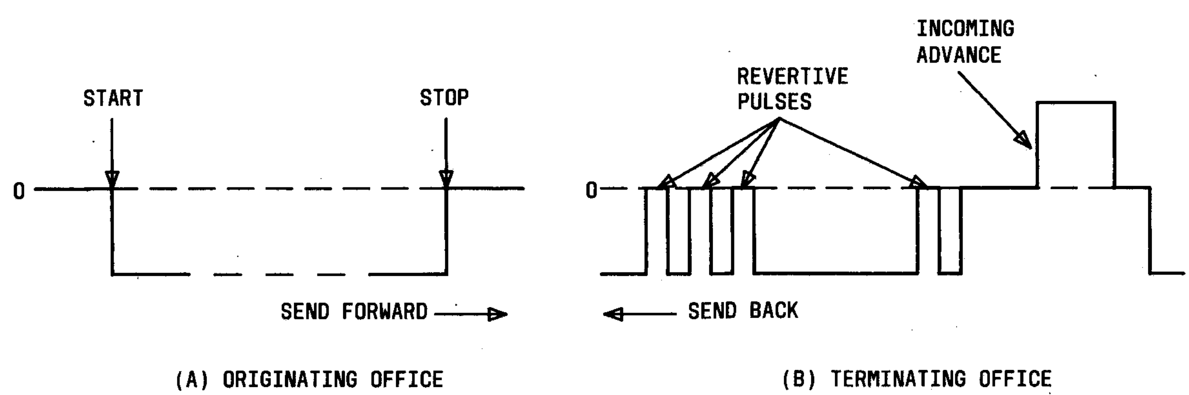


Fig. 2—Revertive Pulsing Signals

4.02 In the early intertoll network, flashing signals were transmitted between manual exchange or toll offices to flash supervisory lamps in the operator's cord circuit. Sixty flashes per minute indicated line busy and 120 flashes per minute indicated all trunks busy, no circuit, or reorder. With the introduction of customer direct distance dialing (DDD), tone was added to the flash to provide audible identifiable signals. However, where single-frequency (SF) signaling was used, the flash often removed all or part of the tone. Likewise, the tone could distort, or eliminate the flash in other cases. As a result, flash has been eliminated from all but operator assisted and some network maintenance trunks.

B. Wink Start

4.03 Wink start is the newer and preferred method of controlled outpulsing for electronic and electromechanical switching systems offices. It is also used for direct inward dialing (DID) and network inward dialing (NID) to modern PBXs. Wink start is one of three methods of controlled outpulsing. The other two older methods are delay dial and stop-go.

4.04 The wink start signal is a momentary timed interval off-hook signal, transmitted toward the calling office, when the called office is ready to receive pulsing. See Fig. 3. With wink operation, the trunk equipment at each office signals on-hook towards the other when in the idle condition. On receipt of a seizure signal, the called office initiates a request for a register or sender. However, the idle condition on-hook signal sent back to the calling office is maintained until the register or sender is attached at the called office and the idle on-hook signal is changed to off-hook (Fig. 3). The register or sender maintains the off-hook signal for a timed interval (minimum of 140 and a maximum of 290 milliseconds). The nominal wink signal is about 200 milliseconds for electromechanical offices and 150 milliseconds for electronic offices. The transitions from on-hook to off-hook to on-hook constitute the wink.

C. Delay Dial

4.05 Delay dial is an older method of partially controlled outpulsing still in relatively common usage between common control offices. This method, unless augmented by a signaling integrity check (4.09), is not as satisfactory as wink start since the originating office will outpulse after approximately 330 milliseconds if no delay dial signal is received. See paragraph 4.08.

4.06 In the delay-dial method of operation (Fig. 4), the calling office seizes a trunk toward the called office. The called office returns an off-hook signal (delay dialing) to indicate that it is not ready to receive pulses. The called office maintains the delay-dialing signal for a minimum duration of 140 milliseconds or until a register (or sender) is attached and ready to receive pulses. At that time, the called office sends an on-hook start dialing signal (4.11) to the calling office.

4.07 Most trunk circuits with loop signaling and those with E&M leads must receive the delay-dialing signal in less than 300 milliseconds after trunk seizure and must not receive start dial before 200 milliseconds. Some loop signaling trunks using delay dial must receive the delay-dial signal within 75 milliseconds of trunk seizure. With this arrangement, to meet the timing requirement, the called office trunk circuit is arranged to signal off-hook to the calling office when in the idle condition.

4.08 The speed at which the called office returns the delay-dial signal is especially important on trunks without signal integrity check (4.09). If no delay-dial signal is received within the trunk timing requirement, failure to receive the delay-dialing signal will allow the calling office sender to outpulse before the register (or sender) is attached at the called office. The call would then be routed to reorder or left uncompleted (high and dry). With signaling integrity check, but not retrial (second attempt), failure to receive the delay-dialing signal within the proper time will route the call to reorder and register a trouble indication. With signaling integrity check and retrial features, a slow return of the delay-dialing signal will register a trouble indication and retrial attempt.

Signaling Integrity Check

4.09 The signaling integrity check is a per-call test to determine the ability of the trunk to transmit signaling information. The test is made by a common control office (1.06) during the initial call setup to another switching system. It is associated with detection, identification, and recording of trunk/facility troubles as well as with a second attempt at call completion if the switching

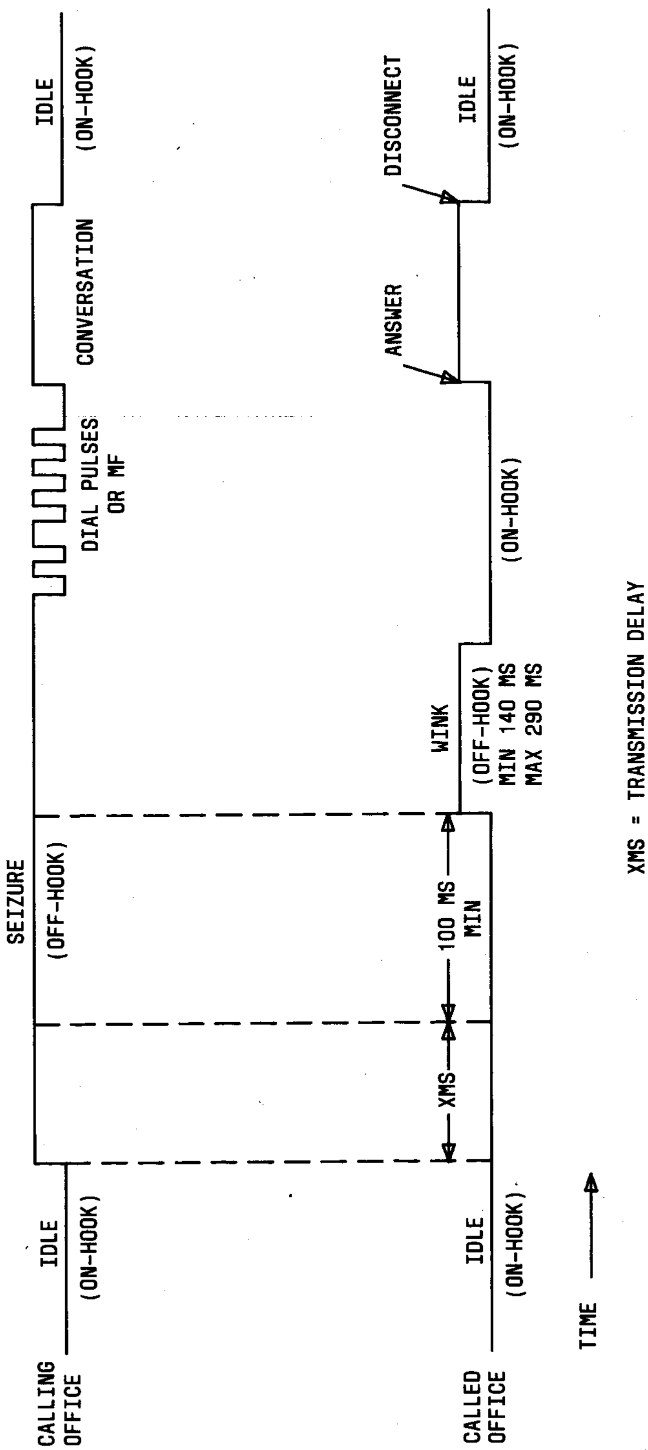


Fig. 3—Wink Start Signaling

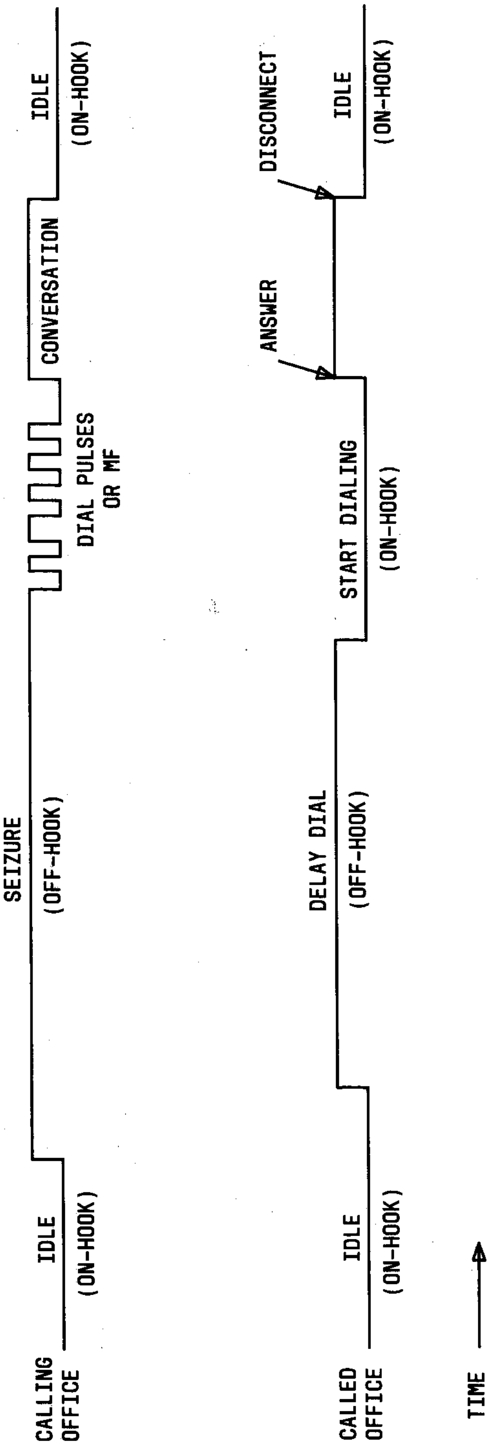


Fig. 4—Delay Dial Signaling

system has this capability. This test lessens the probability that customers will be left high and dry and it improves the call completion rate when the switching system has second attempt capability.

4.10 There are two basic types of signaling integrity check. The first and the most complete check requires a signaling response from the called office in the form of a delay dial or wink signal. The second requires circuit continuity and the correct polarity on the tip and ring of the trunk. The type of signaling integrity check varies between the various types of switching systems.

D. Start Dial

4.11 Start dialing is an on-hook signal transmitted from the called office to the calling office when the called office is ready to receive address information. A momentary delay, 70 to 200 milliseconds, is needed before dial or MF pulsing is started because the receiving circuits are sometimes momentarily disabled at the instant of the sending of the start dial signal to prevent registration of a false reflected pulse.

E. Key Pulsing

4.12 The key pulsing (KP) signal, sometimes referred to as an auxiliary signal, is a two-tone (1100 + 1700 Hz) multifrequency (MF) control signal which is transmitted to the called office prior to the address information. The KP signal, of approximately 55 milliseconds duration, is transmitted about 100 milliseconds after the start dialing signal has been received from the called office. At the called office, the MF receiver is connected to a trunk as part of a sender or register as required. The function of the KP signal will vary depending upon the type of switching system in the called office. In the electromechanical switching system office, the function of the KP signal is to unlock the MF receiver. In the electronic switching system office, the KP signal prepares the equipment to process address information. The MF receiver can then accept and pass on address information and the start (ST) signal to the associated sender or other connected equipment.

F. Start Pulsing

4.13 The start pulsing (ST) signal, sometimes referred to as an auxiliary signal, is a multifrequency (MF) control signal which is transmitted to the called office after the address information has been pulsed to the called office. The ST signal, which is a two-tone signal (1500 + 1700 Hz), informs the called sender that no more pulses are to be expected and closes the input gate to the MF receiver circuitry. This prevents noise or other random signals from activating the MF receiver circuitry.

G. Send Calling Number

4.14 Send calling number is an off-hook signal transmitted toward the calling local office from the centralized automatic message accounting (CAMA) or Traffic Service Position System (TSPS) office. This off-hook signal is transmitted after the address information has been received from the calling customer. This signal is the start signal for outpulsing automatic number identification (ANI) information. The calling number, although not needed to establish the connection, must be received by the CAMA or TSPS office for the system to rate the call and record the billing information. The calling number originates from the serving office ANI equipment and is received by the CAMA or TSPS office in multifrequency (MF) form.

4.15 ANI equipment is capable of identifying station numbers assigned to individuals, private branch exchange (PBX), or 2-party customers without the assistance of an operator. The ANI information, along with connect and disconnect timing information and called party number, is recorded on paper or magnetic tape to be processed later and properly bill the customer for the call.

4.16 If ANI equipment is not available, or if the calling customer is on a multiparty (four or more stations) line, the TSPS operator will verbally receive the station number from the calling party when the position is connected to the trunk. The operator then manually outpulses the calling number using an MF keyset. This method of operation is called operator number identification (ONI).

H. Stop-Go

4.17 Stop-go is a method of controlled outpulsing. This method of operation is only used when a step-by-step intertoll office (noncommon control) is a tandem between two common control offices, or a common control office and a terminating office not equipped for intermediate dial. In the stop-go method of operation, the stop signal is a timed off-hook signal sent from the tandem office toward the calling office to stop outpulsing. The go signal is an on-hook signal sent from the called office toward the calling office to resume pulsing. Stop-go operation cannot be used with local step-by-step tandem offices because the step-by-step selector circuits are not equipped to return a stop signal.

4.18 In the stop-go method of operation, the calling office outpulses the address information to the called office. After pulsing commences and the selector switch in the tandem step-by-step office (noncommon control) begins to rotate, a stop pulsing signal is sent by the selector circuit to the calling office. The stop signal is a timed off-hook signal approximately 330 milliseconds in duration. This signal indicates that the tandem step-by-step office is not yet ready to receive the remaining address information. Only one stop signal is required. If a second stop signal is received during the address period of the call, the call is routed to overflow.

4.19 The called office uses the delay-dial (4.05) method of controlled outpulsing on stop-go trunks. The delay-dial signal from the called office overlaps the stop signal at the tandem step-by-step outgoing trunk circuit. This prevents outpulsing until the register or sender is attached to the trunk at the called office. A start dialing on-hook signal from the called office is the go signal to the calling office to start pulsing. After receiving the go signal, the calling office delays outpulsing for a minimum period of 70 milliseconds. The go signal continues until the called station goes off-hook.

I. Coin Signals

4.20 Coin signals are audible signals produced by gongs or totalizers (tone pulse generators) in the coin telephone when nickels, dimes, or quarters are deposited by the customer. Signals for coin charging vary with the type of equipment used to provide service to the coin telephone station.

4.21 The procedure for charging the customer depends on whether the service is coin-first or dial-tone first. With coin-first service, the serving office does not see an off-hook signal until the proper initial deposit is made by the customer. The customer will then hear dial tone in the receiver. With dial-tone-first operation, no coin deposit is needed to obtain dial tone. As the coins are inserted, the totalizer signals the serving office with audible tones that the proper coin deposit has been made. The customer then proceeds with dialing the call in the normal manner.

4.22 Coin-first (prepay) telephones operate on a ground start basis, whereas dial-tone-first (postpay) telephones operate on loop start. Dial-tone-first service allows the customer to reach service numbers, such as 911 emergency services or an operator (by dialing 0), without coin deposits.

4.23 When the tones are introduced to the line, an operator at a toll or dial service attendant (DSA) switchboard, centralized automatic message accounting (CAMA), or traffic service position system (TSPS), checks the amount deposited. Section 964-310-100 provides information on coin calls with CAMA operation and Section 984-100-100 for TSPS operation.

4.24 With automated coin toll service (ACTS), most coin stations are handled through TSPS. This system will automatically quote charges, count coin deposits, exercise supervision, and control the coin station without operator assistance. Section 250-190-001 provides information on automated coin toll service feature for TSPS operation.

Coin Control

4.25 When coin station calls are made to other stations within the exchange area or to a distant station via the intertoll network, the usual supervisory on-hook, off-hook signals are required, plus additional signals for coin control purposes. Coin control is either a coin collect or coin return signal which can be generated by coin trunk circuits or auxiliary coin circuits for calls within the local exchange area. For toll calls, the coin collect or coin return signal can be generated at either an operator position or automatically by a traffic service position system (TSPS). Where carrier facilities are used between the operator and the serving office, the normal dc coin collect and coin return signals and the normal ringback (20 Hz) signal cannot be used. There are two methods of transmitting these signals on carrier. The first is "inband coin control" and the second is "multiple wink coin control."

4.26 When inband coin control is used, the MF inband signals are preceded by a gate opening on-hook (transitional off-hook, on-hook, off-hook) signal of 70 to 130 milliseconds duration. This signal is followed approximately 60 milliseconds later by MF coin collect (700 + 1100 Hz) or coin return (1100 + 1700 Hz) tones with a minimum duration of 900 milliseconds. When the coin control signal is received at the local serving office, the coin trunk circuit applies either coin collect or coin return potentials to the coin station exchange loop.

4.27 In the most modern TSPS arrangements, a multiwink signaling format is used to provide coin trunk signals. The multiwink system is a train of one to five on-hook winks which are transmitted from the TSPS to the local serving office. The multiwink system is used to signal respectively:

(a) Operator attached

(b) Operator released

(c) Coin collect

(d) Coin return

(e) Ringback.

The operator attached signal is used to enable the coin station to transmit coin deposit signals. It also disables the TOUCH-TONE keyset. The operator released signal is used to restore the TOUCH-TONE keyset in the coin station. Section 975-110-100 provides descriptive information of signals used from the local serving office to the coin station.

J. Ringback

4.28 The ringback signal is applied by an operator at a switchboard or TSPS position by operating a ringing key. The ringback signal sent over the trunk may utilize 20-Hz ringing, an on-hook wink, a gate-opening on-hook wink followed by inband MF tones, or in modern TSPS arrangements, by a train of five on-hook winks (4.27).

4.29 The ringback signal enables the operator to recall an attendant at a private branch exchange (PBX) to supply charge information for the immediate billing of a completed customer call. The ringback signal also allows the operator to recall a customer at a coin station who has gone on-hook without paying for overtime charges, or when the customer has gone on-hook after placing an emergency call without providing adequate information. Ringback is also used by the operator at the called end of an established connection to recall the calling operator.

K. Ring Forward

4.30 Ring forward is a timed on-hook signal, of 70 to 130 milliseconds duration, that is used by an operator at the calling office to recall an operator at the called office of an established connection. The ring forward signal is used on operator dialed exchange and toll calls which require the assistance of an inward or terminating operator to complete the connection. It is not required on an exchange or direct dialed toll call.

4.31 The principal use of ring forward today in the intertoll network is in connection with collect calls to coin telephone stations. The switchboard or TSPS operator at the calling end of a collect coin telephone call has no means for coin control at the called coin station; therefore, the calling operator must secure the assistance of an operator at the called office. Since the operator at the called office will not remain on the connection for the duration of the call, it is necessary to provide a ring forward signal for the calling operator to alert the called operator for any required coin functions.

5. STATUS SIGNALS

5.01 Status signals are audible tone signals which provide information to the calling customer or operator on the progress or disposition of the telephone call. Dial tone, reorder, line busy, and audible ringing are commonly used status signals.

5.02 The audible tone signals are derived from a precise tone plan based on four pure tones which are closely regulated, both in frequency and amplitude. These tones are 350, 440, 480, and 620 Hz. They are used singularly or in pairs to represent standard audible tone signals. The precise tone plan is for use in new electromechanical and all ESS offices. In the period of transition to the precise tones, the older tones will continue to be used. Except for dial tone, the new and old tones sound nearly alike. Standard levels for the precise tone plan have been established and are indicated in the paragraphs which follow.

Dial Tone

5.03 The dial tone signal is a composition of two frequencies, 350 and 440 Hz at a level of -13 dBm for each frequency. The difference in frequency of 90 Hz gives the tone its buzzing sound. The old dial tone signal consisted of 600 Hz modulated by 120 Hz supplied by a tone alternator, or 133 Hz when supplied from an interrupter. In systems using the old tone, the modulating frequency gave the dial tone its low pitched sound. Various other combinations were also used.

Reorder

5.04 The reorder signal, sometimes referred to as "overflow," is a low level tone interrupted at 120 IPM. The reorder signal is composed of two tones, 480 Hz and 620 Hz. Each tone is at a level of -24 dBm as measured where it is applied to the voice transmission path. This audible signal indicates that no interoffice trunk is available or the local switching paths to the serving office or equipment serving the called customer are busy.

Line Busy

5.05 The line busy signal is a low tone interrupted at equal tone-on and tone-off times of 60 IPM. The line busy signal is composed of two tones, 480 Hz and 620 Hz. Each tone is at a level of -24 dBm where it is applied to the voice transmission path. This audible signal indicates to the calling customer that the called subscriber line has been reached but that it is busy.

Audible Ringing

5.06 The audible ringing signal is composed of two low tones, 440 Hz and 480 Hz. Each tone is at a level of -19 dBm where it is applied to the voice transmission path. This audible signal indicates to the calling customer that the called line has been reached and ringing has started. It is also used on calls to operators (long distance, information, special service, etc) during the interval the customer is waiting for the operator to answer.

6. SIGNALING SYSTEMS

6.01 Trunk signaling systems transmit and receive supervisory, address, and control signals. Two basic methods of signaling are used to supply the supervisory, address, and control signals. The two methods are direct current (DC) and alternating current (AC). DC signaling is used primarily on short-haul trunks using metallic facilities to interconnect each end of the trunk. Systems such as loop reverse, high-low, or duplex (DX) use DC signaling. Other systems use AC signaling where DC signaling is not feasible or economical, such as long-haul or short-haul circuits on carrier facilities. AC signaling is used in systems such as inband, out-of-band, digital (signaling encoded as part of the digital bit stream), and common channel interoffice signaling (CCIS) which separates the signaling channel from the voice channel.

DIRECT CURRENT (DC) SYSTEMS

6.02 The DC loop signaling circuit must provide two functions at each end of the trunk. The two functions are trunk supervision and numerical signaling. A third function, revertive pulsing (3.19), is also required on trunks terminating in panel offices. Combinations of open/close, polarity reversal, and high/low current are used for distinguishing signals intended for one direction of signaling (eg, dial pulse signals) from those intended for the opposite direction (eg, answering signals). The most common facility utilizing DC signaling are short-haul trunks using metallic facilities. The principal loop signaling systems are described in the following paragraphs.

A. Loop Reverse Battery Signaling

6.03 The loop reverse battery signaling system employs combinations of open/close and polarity reversal to provide trunk supervision and numerical signaling. This system provides pulsing in one direction and supervision in the other direction. This system can only be used on 1-way trunks with either DP or MF address information.

6.04 A typical loop reverse battery signaling system is shown in Fig. 5. A trunk seizure at the calling office closes the loop by operating relay (A) at the called office. The (A) relay, which has battery and ground connected to the relay windings, follows the dial pulses (if dialed) to transmit the on-hook/off-hook signals from the calling office to the called office. When the called customer goes off-hook, the (S) relay in the called office trunk circuit operates and reverses the battery on the trunk. This reversal of battery provides supervisory on-hook/off-hook signals between the two offices and initiates calling party billing at the serving office or TSPS.

B. Battery and Ground Pulsing

6.05 Battery and ground pulsing is a method used to extend the range of loop reverse battery signaling when dial pulsing is used. This is accomplished by providing battery and ground at each end of the loop in a series aiding configuration. This method nearly doubles the current available in the loop.

6.06 A typical battery and ground pulsing application with loop supervision is shown in Fig. 6. When the calling customer goes off-hook, the (A) relay operates and causes the slow release (B) relay to operate which holds until the calling customer goes on-hook. Since the (B) relay is slow to release, the (C) relay will operate through the (A) relay contacts. On the first dial pulse open, the (A) relay will release, operating the (C) relay which holds during the digit. The (C) relay contacts apply battery and ground from office A, in addition to that from office B, to the trunk until the end of the pulse train. When dialing is completed, the (A) relay will make continuously, causing normal battery current from office B to flow on the trunk. At the calling end, a connect signal is indicated by closure of the customer loop. At the called end, an off-hook signal is indicated by polarity reversal.

C. High-Low Signaling

6.07 High-low signaling is a method of loop signaling in which a high-resistance bridge is used to indicate an on-hook condition and a low resistance bridge is used to indicate an off-hook condition. In this method, high-low signaling states are usually applied at the terminating end as a supervisory signal to the originating end. In other arrangements, the high-low signaling states may be applied at the originating end with other signaling schemes, such as reverse battery, applied at the terminating end.

6.08 A typical high-low reverse battery signaling application is shown in Fig. 7. This trunk has the capability for being made busy from the terminating end. At the originating office, the outgoing trunk circuit uses a high-low polar supervisory relay (usually 200, 30,000 ohms) to provide the on-hook, off-hook supervisory conditions. When the trunk is idle, reversing the battery at the terminating office operates the (CS) relay via the 30,000 ohm winding. This feature makes the outgoing trunk busy and is used for maintenance purposes. It is also used at the end of a charge call to make the outgoing trunk momentarily busy while the CAMA or TSPS office completes charging functions.

6.09 The reverse battery high-low signaling arrangement is used between a local office and an operator at a switchboard or an Automatic Intercept System. As shown in Fig. 8, the operator office responds to reversed battery and the local office to high-low supervision. When the calling customer goes off-hook, reversed battery is applied to the trunk conductors. At the operator-office end, the on-hook high resistance signal is changed to low resistance for off-hook. The trunk is now held by "joint control" and both the operator and the calling customer must go on-hook to release the trunk. The joint control feature allows the customer to recall the operator by flashing the switchhook without a premature disconnect. On a coin trunk, it allows the operator to ring back the customer at a coin telephone station after the customer has hung up.

D. E and M Lead Signaling

6.10 The E and M lead signaling systems derive their name from designations of the signaling leads on the circuit drawings covering these systems. In systems of early manufacture, the E&M lead signaling interface consisted of two leads between the switching equipment (drop side) and the signaling equipment (line side) of the trunk circuit. The M lead, which is used to transmit, carries signals from the switching equipment to the signaling equipment. The E lead, which is used to receive, carries signals from the signaling equipment to the switching equipment. A typical E and M lead signaling system between two offices is shown in Fig. 9.

6.11 The operation of this system is duplex, whereby information can be transmitted and received simultaneously in both directions independently and without interference. Signals transmitted from office A to office B leave on the M lead of the trunk circuit in office A and arrive on the E lead in office B. In the same manner, signals transmitted from office B leave on the M lead and arrive on the E lead at office A.

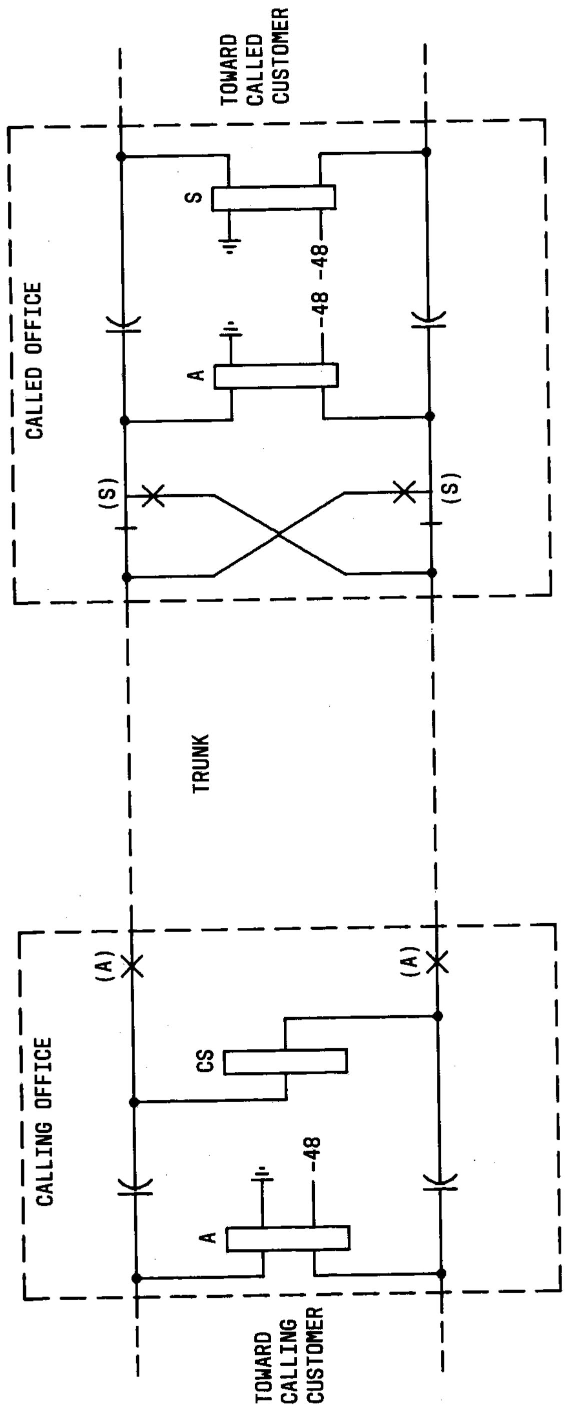


Fig. 5—Loop Reverse Battery Signaling

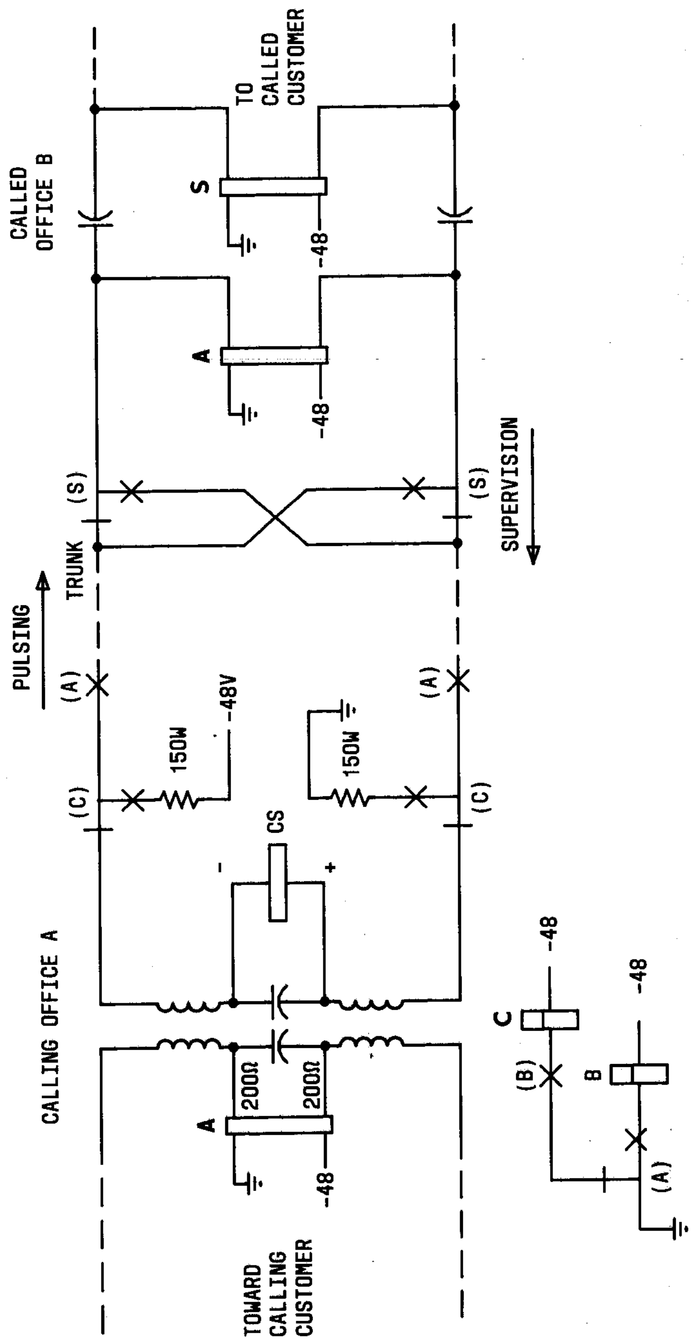


Fig. 6—Battery and Ground Pulsing

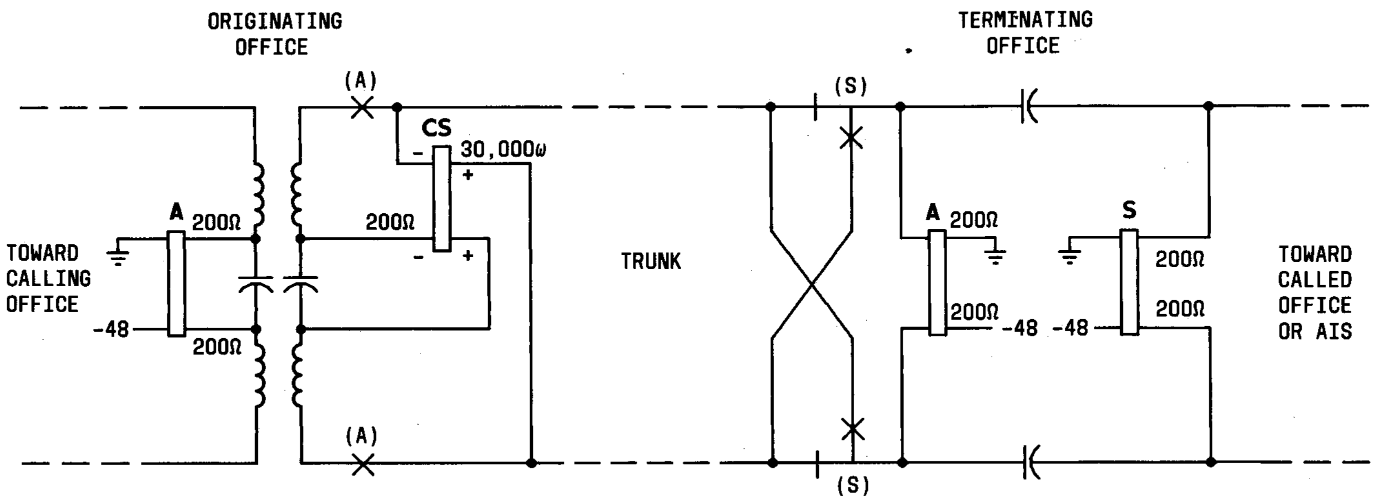


Fig. 7—High-Low Reverse Battery Signaling

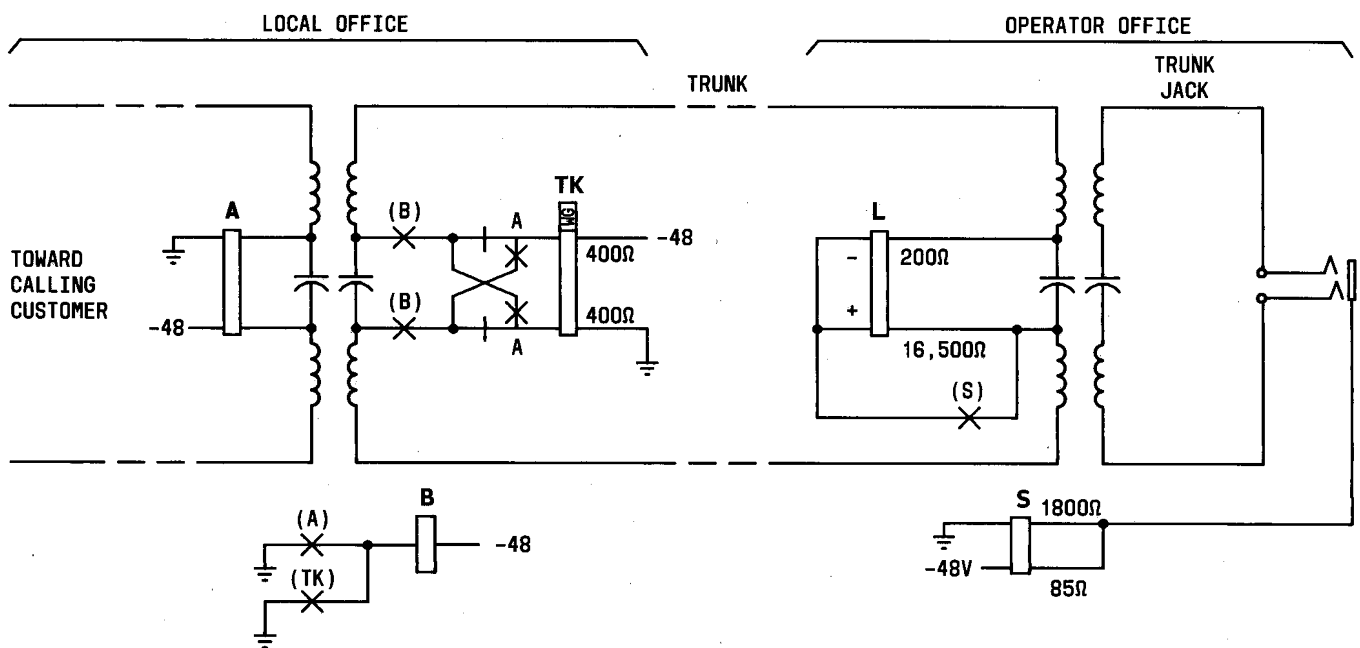


Fig. 8—Reverse Battery High-Low Signaling

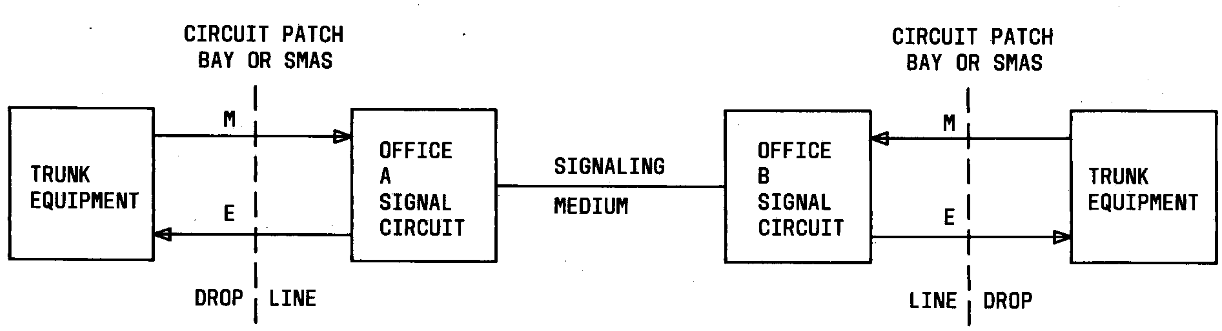


Fig. 9—E and M Lead Signaling

6.12 The designations "line" and "drop" are used respectively to designate the facility and switching side of the E&M lead signaling interface. It can be seen from Fig. 9 that signals applied from test equipment to the line side of the office signaling equipment must simulate those signals the trunk equipment would apply to the E&M leads under control from the switching system.

6.13 Early metallic E&M lead signaling circuits used only one lead for each direction of transmission. Current flowing between the switching equipment and the trunk equipment utilized a common ground return path. Therefore, the signaling leads were unbalanced and were more susceptible to inductive noise than if the two leads (tip and ring) were balanced as in the voice frequency transmission path.

6.14 The interconnection between signaling and trunk circuits with E- and M-type leads is accomplished with interface arrangements in electromechanical and electronic switching systems. At the present time, there are three standardized E and M lead interface arrangements in general use. These three types are designated Type I, Type II, and Type III interfaces. Other interface arrangements such as the pulse link repeater and the trunk link repeater are also used when interconnecting back-to-back E and M lead signaling systems or trunk circuits.

6.15 The Type I interface is the original 2-wire E and M lead signaling interface manufactured for use with electromechanical switching systems. This interface provided satisfactory operation for electromechanical switching systems but was not satisfactory for use with electronic switching systems. The Type II interface is a new interface manufactured for use with No. 4 ESS; however, it may be used with other electronic and electromechanical systems. The Type III interface was originally manufactured for use with No. 1 ESS. It is also used with No. 2 ESS and TSPS. However, the Type II interface is preferred and should be used in preference to the Type III interface where possible. For the M lead function, the Type I interface has one lead, Type II interface has two leads, and Type III interface has three leads.

6.16 By segregating certain functions in the trunk circuits and others in the signaling systems, the particular type of trunk circuit necessary for the circuit and any E and M lead signaling system can be interconnected with assurance that they will work together. Trunk and signaling circuits with E and M lead signaling may be connected directly only when they are of the same interface types. Circuits with nonmatching interface types are not to be connected directly. For nonmatching interfaces, connection can be accomplished by using an E and M lead applique circuit such as SD-99774-01. See Fig. 10. The particular connecting circuit depends upon the different signaling interface types that are to be connected. Additional information concerning the three types of interfaces and interface compatibility can be found in Section 179-100-100.

6.17 The requirement for back-to-back operation occurs frequently when circuits are built up between intertoll facilities in the same or adjacent buildings. Two E and M lead signaling circuits can be interconnected through a pulse link repeater (PLR) such as SD-96616-01 (Fig. 11A) or a Type II interface (SD-99774) shown in Fig. 11B. Likewise, two E and M lead trunk circuits can be interconnected through a trunk link repeater such as SD-1C601 (Fig. 12A) or a Type II interface shown in Fig. 12B.

E. Duplex (DX) Signaling

6.18 The duplex (DX) signaling system provides E and M lead signaling (6.10) over symmetrical and balanced metallic cable facilities. Identical circuits are interconnected to the line conductors at both ends of the trunk permitting full duplex signaling, whereby information can be transmitted and received simultaneously in both directions without interference. The DX system is also used to extend E and M leads from a signaling system, such as single frequency, to a distant trunk circuit when line resistance limitations prevent direct interconnection.

6.19 The DX signaling system is arranged to pass supervisory and dial pulsing signals over the same metallic facilities as used for the voice frequency transmission path. DX signaling does not materially interfere with or suffer impairment from voice transmission. The DX system requires both conductors of a two-wire or the two simplex leads of a 4-wire facility and common ground return to provide a dc path between both ends of the system. This arrangement provides equal and independent action in opposite directions for 2-way signaling and compensates for differences in ground

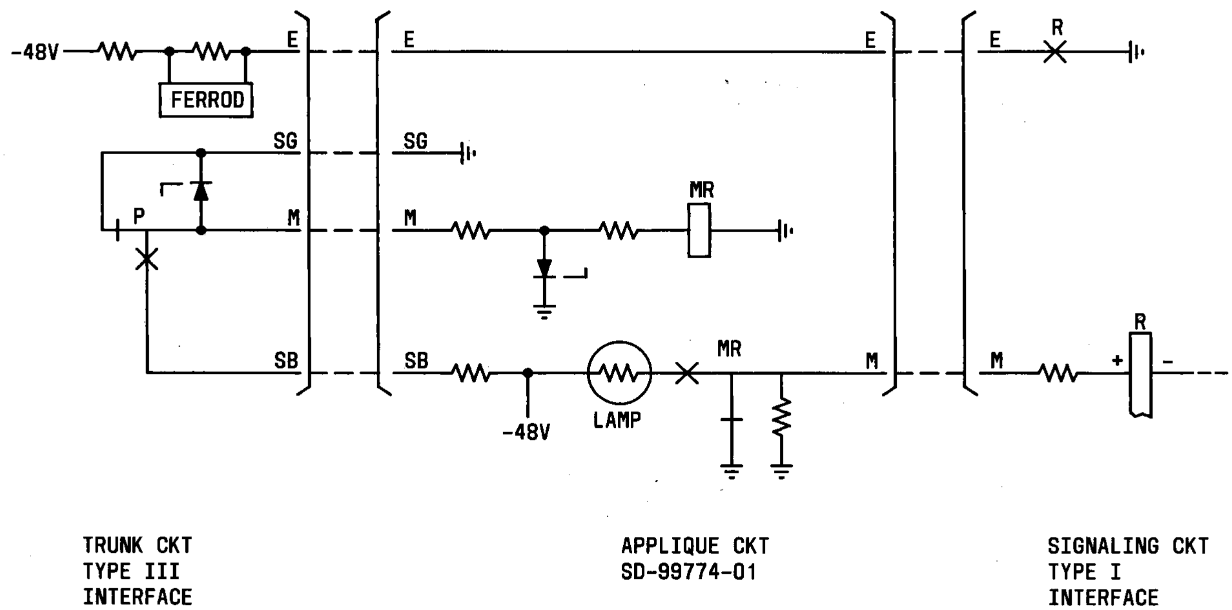


Fig. 10—Applique Circuit for Connecting Trunk and Signaling Circuits With Type I and Type III Interfaces

potential between both ends of the system. The terminals of this system provide leads for connection to the metallic facility and E and M leads for connection to the trunk circuit. See Fig. 13 for a simplified circuit diagram of the 2-wire DX signaling system.

6.20 One conductor of the interoffice metallic facility carries the supervisory and pulsing signals; both conductors individually carry currents resulting from differences in office ground and battery potentials and AC induction voltages. Therefore, the current in the second conductor tends to cancel the effect of the unwanted current in the first conductor. With this arrangement, DX signaling introduces less noise in adjacent circuits than loop reverse battery (6.03) or battery and ground pulsing (6.05) and is not significantly affected by the usual AC induction voltages.

6.21 Signaling is accomplished by alternate applications of battery and ground potential to a line conductor, using contacts which maintain the same circuit and, therefore, the same current transition delay for the alternate conditions of signaling. This arrangement markedly reduces the amount of signaling distortion arising from variations in circuit resistance, inductance, and capacitance. While these circuit parameters do introduce signaling delay times, the resulting percent break is essentially unaffected. Detailed descriptive information concerning the DX signaling system can be found in Sections 179-100-309 and 975-230-100.

ALTERNATING CURRENT (AC) SYSTEMS

6.22 Alternating current (AC) signaling systems provide a means to convey trunk supervision and address information over transmission facilities that exceed the range of DC systems. There are two basic types of AC signaling systems; inband which operates within the voice-frequency range and out-of-band which operates outside of the voice frequency range. Two-state AC signaling can handle trunk supervision and numerical signaling where the latter is coded by dial pulsing. Three state AC signaling is arranged to handle revertive pulsing trunks (3.19) and ground start foreign exchange trunks (Section 311-200-180).

6.23 On interoffice trunks, supervisory signaling is done with single frequency (SF), whereas numerical or address signals are usually done with multifrequency (MF) pulsing. Dial pulsing interoffice trunks use SF signaling to provide supervision and dial pulsing information. There are two basic types of MF signaling, TOUCH-TONE which is used on customer loops and MF pulsing (3.10) which

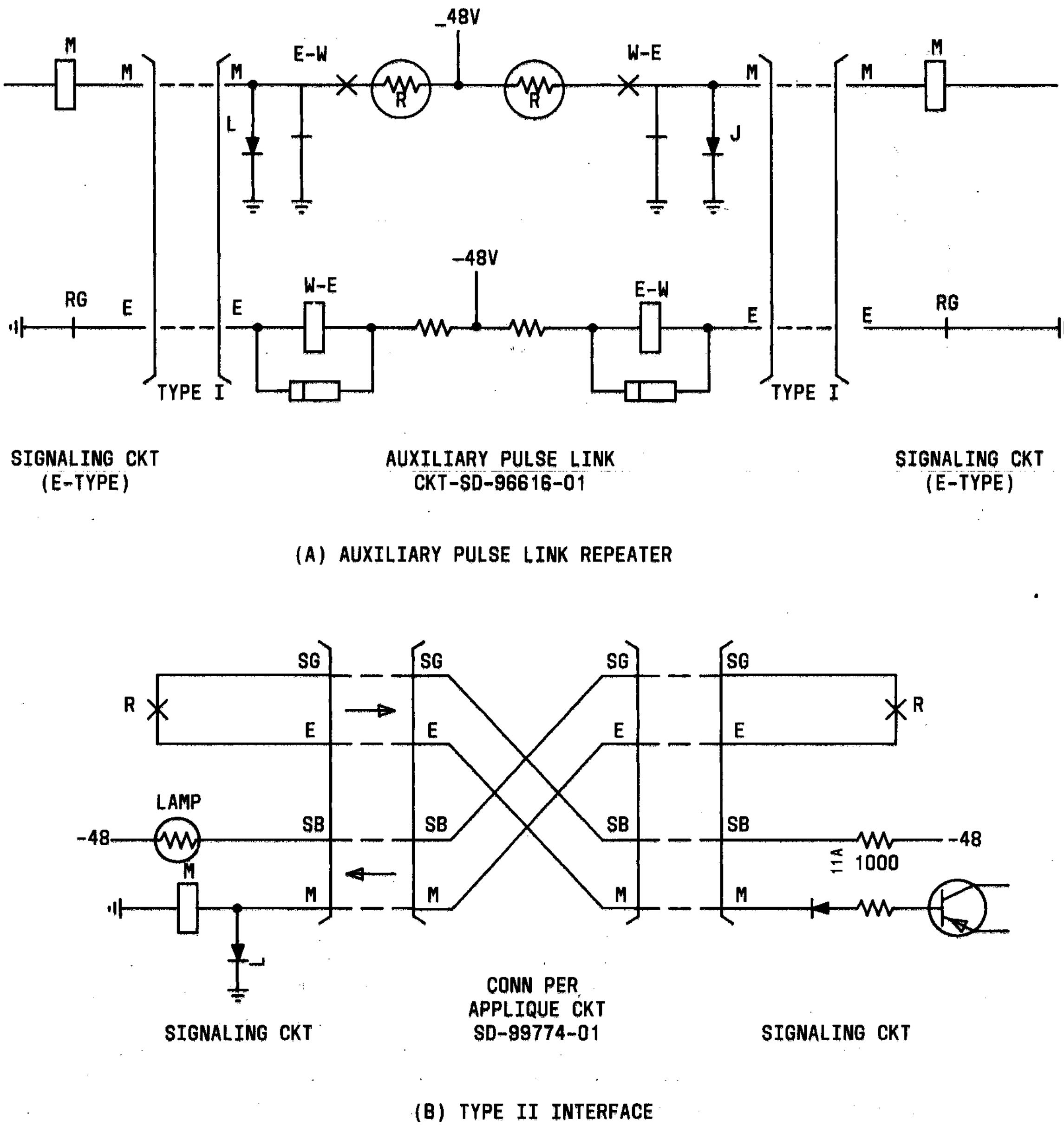
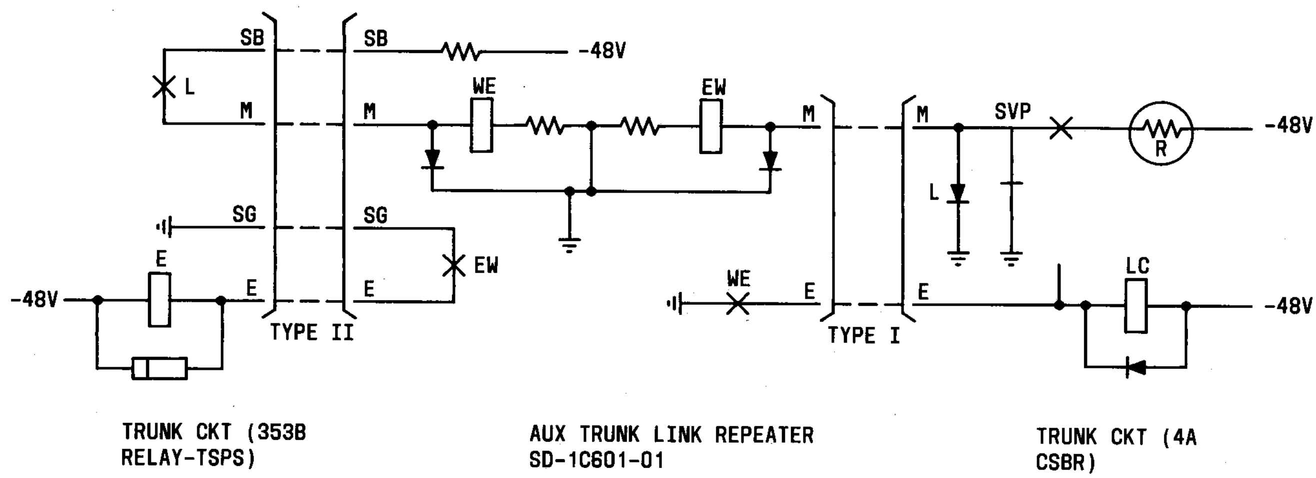


Fig. 11—Back-to-Back Operation of E and M Lead Signaling Systems

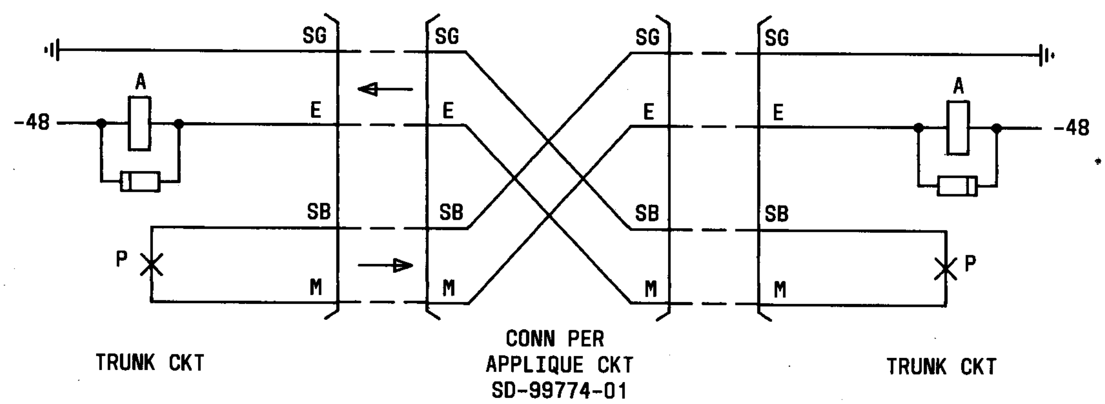
is used on interoffice trunks. These systems use a combination of two AC tones from either a station set to the serving office or from office to office for numerical signaling. They must be used in conjunction with a 2-state AC or DC system for supervisory signals. Detailed information on customer loop signaling is found in Section 975-110-100.

A. Inband Signaling Systems

6.24 Inband signaling systems provide a means for transmitting address, numerical, and supervisory signals through the standard voice channel medium. There are two basic types of inband signaling systems, the Multifrequency (MF)



(A) AUXILIARY TRUNK LINK REPEATER



(B) TYPE II INTERFACE

Fig. 12—Back-to-Back Operation of E and M Lead Trunk Circuits

Pulsing System (3.10) and the Single-Frequency (SF) System (6.27).

6.25 The effective bandwidth of the standard voice channel medium ranges from about 200 to 3200 Hz. Address and numerical signals transmitted by the MF system utilize the middle portion (700 to 1700 Hz) of this range. See Fig. 14. Supervisory and numerical signals transmitted by the SF system utilize the upper portion (usually 2600 Hz) of the voice channel range. (Inband SF signals are usually of the same amplitude as voice currents (-36 to -20 dBm0) so as to not overload voice amplifiers or cause crosstalk in adjacent channels. However, MF signals are transmitted at a higher level (-3 dBm0) to obtain maximum efficiency from common control equipment. This high level is tolerable because of the very short duration (less than 1 second) of the MF tone bursts.

6.26 Inband signaling systems have advantages which are as follows:

(a) Do not require additional channel bandwidth.

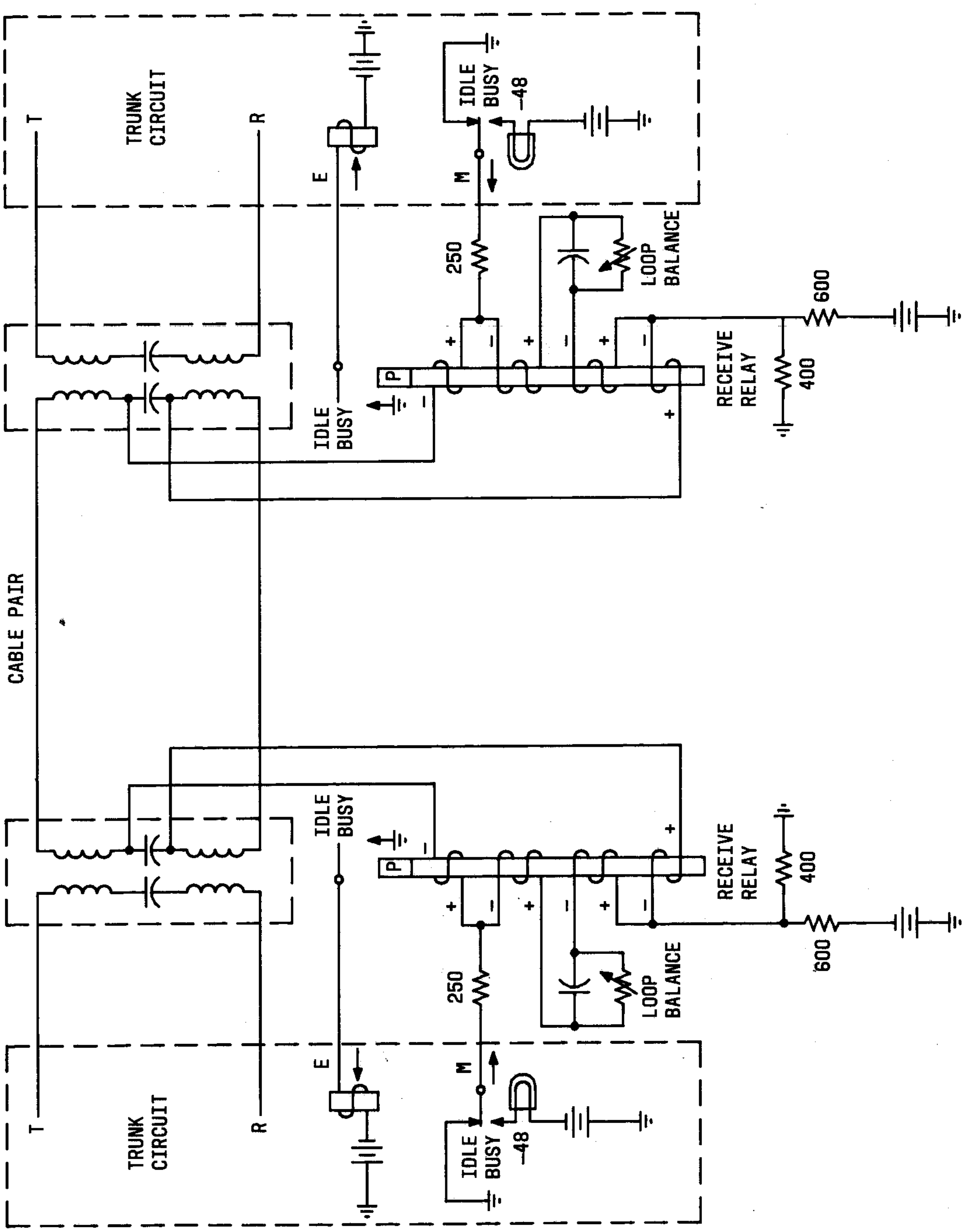


Fig. 13—Typical 2-Wire DX Signaling System

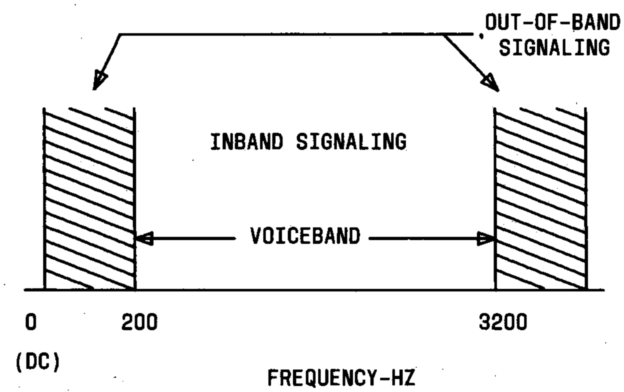


Fig. 14—Inband and Out-of-Band Signaling Frequency Spectrums

(b) The entire voice channel bandwidth is available for signaling.

(c) Since the signaling currents utilize the same path as the voice currents, amplifiers provided for voice also amplify signaling currents.

(d) Speed and simplicity of service restoration in case of trouble, since the signaling and voice currents occupy the same voice channel medium.

(e) It is not generally possible to set up a connection over which it is impossible to talk.

Single-Frequency Signaling

6.27 Single-frequency (SF) signaling systems provide a means of transmitting numerical and supervisory information for telephone switching systems over standard voice frequency transmission facilities on an AC inband (within voice frequency range) basis. Generally, the normal voice transmission path of a carrier or 4-wire metallic facility is used for transmission of the voice and SF tone signals.

6.28 Early SF systems utilized 1600, 2000, or 2400 Hz for line signaling. In modern day systems, 2600 Hz is employed for signaling in both directions on the transmission facility. Supervisory and numerical signals are reproduced by types E, F, or G inband signaling units located at each end of the trunk.

6.29 Basically, the SF system converts DC signals from connecting trunk or station equipment into an AC signal. The AC signal is then reconverted to the original DC state at the opposite end. The converted signal is used as required to perform connect (seizure), start dialing, wink, start pulsing, dial pulsing, stop dialing, ringing, answer, disconnect, ring forward, and ringback functions.

6.30 A 2-state signal of tone-on/tone-off in each direction corresponds to on-hook/off-hook signals, respectively, and is received by the connecting equipment. Therefore, a DC supervisory signal (loop or E and M) is converted into a 2600-Hz signal at one end of the trunk and reconverted to the original DC state at the other end. Likewise, 20-Hz ringing is converted to 2600-Hz tone-on signals, except in ground-start operation, the 2600-Hz signals are converted to 2600 HZ modulated at a 20-Hz rate. Detailed descriptive information concerning the type F and G signaling systems can be found in Sections 179-360-100 and 179-400-100 respectively.

B. Out-of-Band Signaling Systems

6.31 The Out-of-Band Signaling System provides a means of transmitting numerical and supervisory information for telephone switching systems outside of the standard voice frequency transmission facility on an AC basis. See Fig. 14. By broad definition, DC signaling systems, digital carrier systems, and common channel interoffice signaling (CCIS) are out-of-band systems.

6.32 The Out-of-Band Signaling System has several advantages, which are as follows:

(a) Freedom from the effects of speech, compandors, and echo suppressors

(b) Full utilization of normal voice channel bandwidth

(c) No need for filters to provide the signaling slot

(d) Reduces and simplifies the terminal equipment requirements.

6.33 Some disadvantages of the Out-of-Band Signaling System are as follows:

(a) Excessive maintenance

(b) Coordination of patching arrangements to keep signaling and speech channel intact (not a problem with CCIS).

(c) The possibility of switching to a trunk over which it is possible to signal but impossible to talk (not a problem with CCIS).

6.34 The Out-of-Band Signaling System is used with early analog carrier systems such as the O, ON, and N1 frequency multiplex carrier systems. The signaling system, which is part of the carrier terminal channel unit circuitry, utilizes a frequency of 3700 Hz which is outside of, but adjacent to the voiceband. E and M leads are extended as required from the channel unit to the associated trunk unit, DX signaling, or pulse link repeating circuit.

6.35 During the trunk-idle condition, the 3700-Hz tone is present in both directions of transmission. Supervisory signals are transmitted by interrupting the tone in a manner similar to that described for 2600-Hz SF (6.30). Since the signaling frequency is outside of the voiceband, no provision is required for protection against voice operation. Use of this system is declining and is being replaced by transistorized inband signaling systems such as type F and G SF units.

DIGITAL CARRIER SYSTEMS

6.36 Digital carrier systems utilize pulse code modulation (PCM) signals for transmission. The most common system that uses PCM is the T1 digital transmission line. This system was initially equipped with D1 channel banks to provide signaling and voice facilities for local interoffice trunking. However, with recent improvements in the channelizing equipment (D2, D3, and D4 banks), the T1 line is now used to provide toll connecting and foreign exchange trunks in addition to local trunks.

6.37 The T1 system provides 24 two-way telephone channels where each channel is encoded into 8 pulses. See Fig. 15. Address and supervisory signaling information is transmitted in each direction on one or two of the pulses (depending on the type of channel bank) and the voice information shares the others. In the twenty-fourth frame, an extra pulse is added for synchronization. This pulse is called a framing pulse and indicates that all 24 channels have passed through and another frame (24 channels) will start.

6.38 If the trunk is on-hook (idle), the signaling pulse is present. If the trunk is off-hook (busy), the signaling pulse is not present. In 3-state signaling, two of the pulses in each direction of transmission are used for signaling during a small part of the time. This second pulse is shared with the encoding of the voice information in five of six frames and contains signaling information each sixth frame. Further information on digital systems can be found in Section 365-100-100.

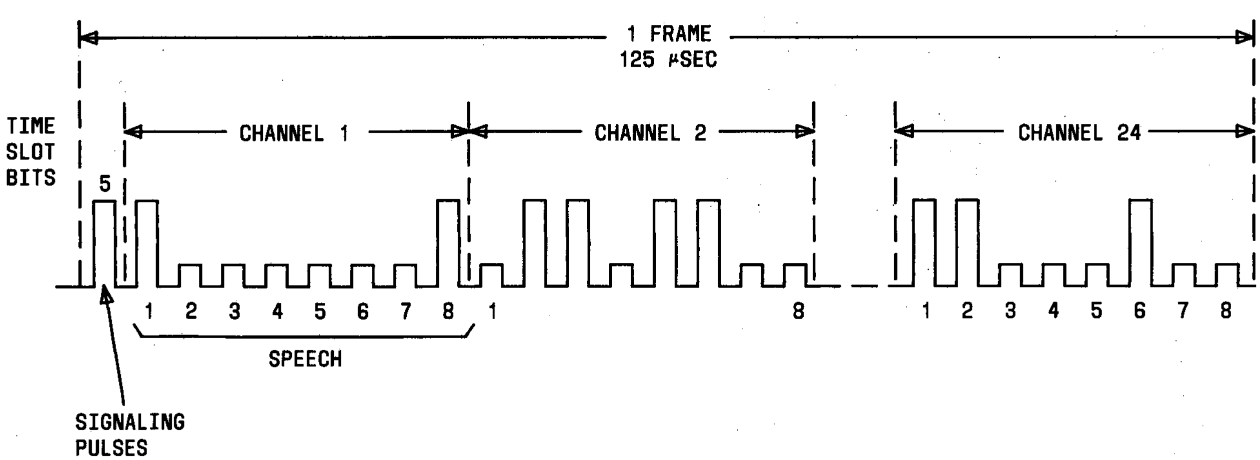


Fig. 15—Signaling and Framing Pulses—T1 Digital Line

COMMON CHANNEL INTEROFFICE SIGNALING

6.39 Common channel interoffice signaling (CCIS) is a system for exchanging information between processor-equipped stored program controlled (SPC) switching systems over a network of signaling links. All signaling data, including the supervisory and address signals necessary to control call setup and takedown, as well as network management signals, is exchanged by these systems over the signaling links instead of being sent over the voice path as done using inband signaling techniques.

6.40 Block diagrams for systems using inband signaling and CCIS are shown, respectively, in Fig. 16 and 17. With conventional inband signaling, a single-frequency (SF) unit is required at each trunk end. In addition, a number of multifrequency (MF) transmitters and receivers switched to these trunks are required to pass address information. With CCIS, both the SF units and MF equipment are supplanted by a signaling link between the two processors and a number of continuity-checking transceivers.

6.41 As shown in Fig. 17, the signaling link consists of two signaling terminals, two modems, and a voice-frequency link (VFL). The signaling terminals store both outgoing signaling messages awaiting transmission and incoming messages until ready to be processed. The terminals also perform error control through redundant coding and retransmission of signaling messages found to be in error. Each modem forms a digital-analog interface between the terminal and voice-frequency link.

6.42 Unlike conventional signaling systems which carry voice and control signals on the same trunks, CCIS transmits address signals (the dialed digits) and supervisory signals (on-hook/off-hook status of a customer's line) on data links that are separate from the voice network. Therefore, trunk failures can no longer be detected by the loss of supervision as is done with SF/MF signaling. Instead, a number of tone transceivers are provided which are connected to CCIS trunks during call setup to check the continuity of the voice path.

6.43 CCIS or data links currently operate at 2400 bits per second. This rate is sufficient to carry signaling functions for approximately 2250 trunks. The signaling terminals (Fig. 17) store both outgoing signaling messages awaiting transmission and incoming messages until ready to be processed. The terminals also perform error control through redundant coding and retransmission of signaling messages found to be in error. Each signal message contains one or more 28-bit signal units (20 information bits and 8 check bits). Supervisory signals are transmitted as single bits, whereas address signals require messages of several bits.

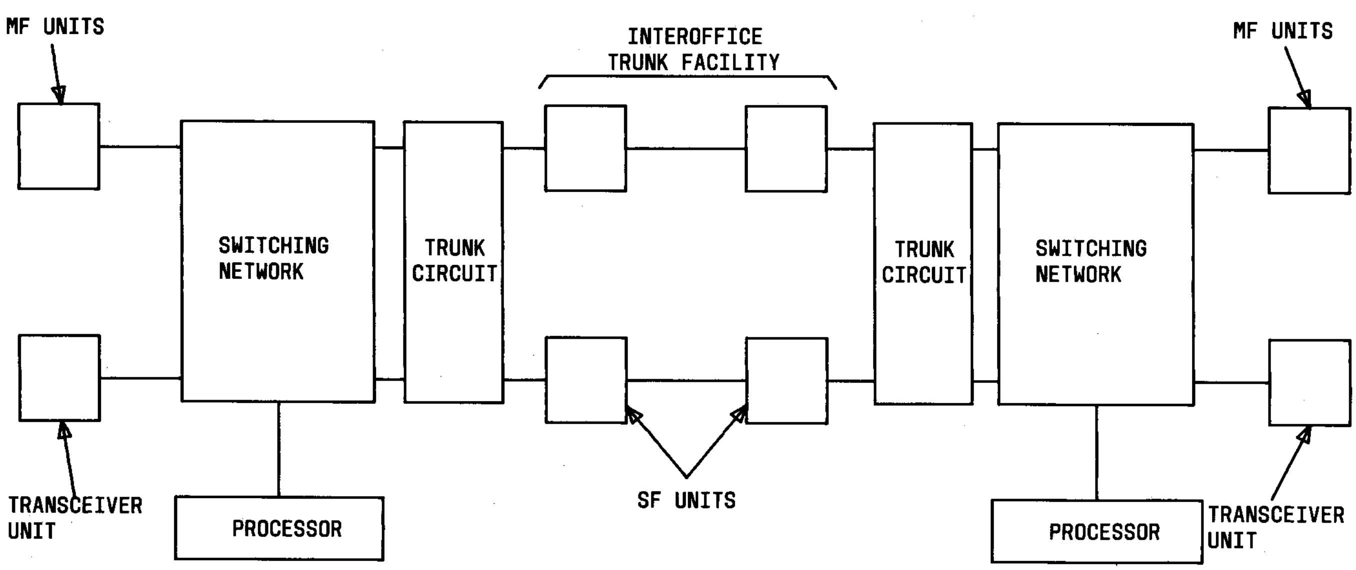


Fig. 16—SF and MF Inband Signaling—Simplified Block Diagram

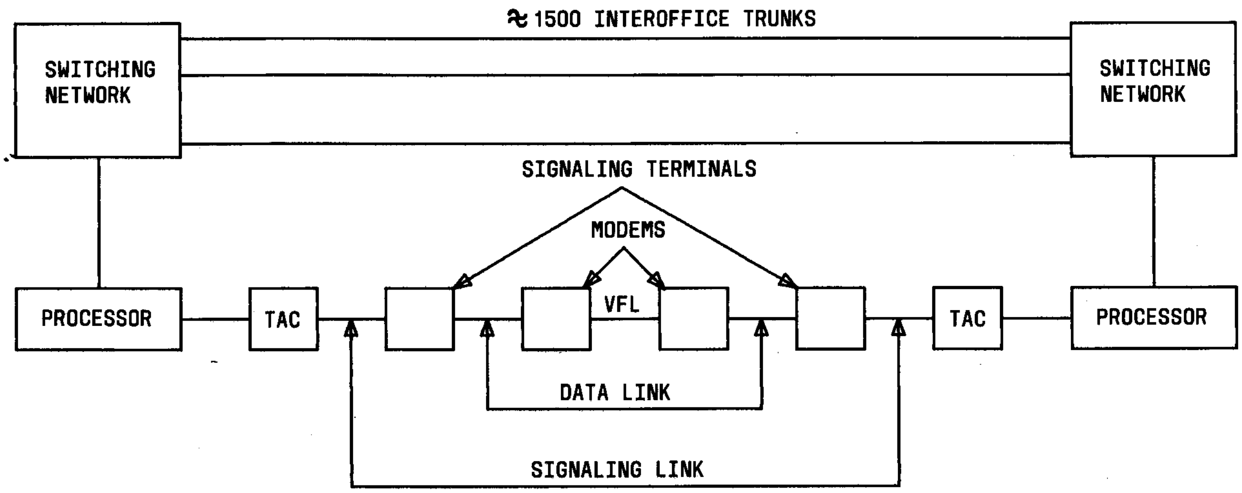


Fig. 17—CCIS Signaling—Simplified Block Diagram

Check bits detect errors and if any errors occur, the message is retransmitted.

6.44 Although a direct signaling link is shown in Fig. 17, the signaling information will normally be routed through one or two signal transfer points (STPs). These STPs act as signaling message processors which concentrate the signaling for a large number of trunks onto a few signaling links. With CCIS, the signaling for many trunks will be sent over the same signaling links. Therefore, all portions of the signaling network must be sufficiently redundant and diversified so as to insure signaling availability.

6.45 CCIS is discussed in further detail in Section 964-110-101. The only points discussed in this section will be signaling transfer points, No. 4A with Electronic Translator System (ETS) offices, and No. 4 Electronic Switching System (ESS).

Signal Transfer Points

6.46 The average trunk group between offices contains only about 27 trunks. Therefore, it is not economical to provide separate data links for each group of trunks. Instead, all of the signals for a number of trunk groups are carried on a single data link to a signal transfer point (STP). See Fig. 18. The STP is a stored program processor which receives and transmits the signaling functions to their proper destinations.

6.47 The nation is divided into ten signaling regions which have been chosen to correspond to the existing regions of the direct distance dialing hierarchy. All CCIS-equipped switching offices within a switching region concentrate the signaling traffic for all their CCIS trunks on access links (A-links). These A-links interface with a pair of regional STPs. The A-links are provided in fully redundant pairs, one A-link pair to each of the two STPs in the region. Between regions, one or more bridge links (B-links) connect each STP to all the STPs in the other regions. Each STP is connected to its mate STP in the region by cross links (C-links). These links provide alternate routing within the signaling network. Extension links (E-links) may be provided to interconnect a switching office in one region with an STP in another region. These E-links are provided where heavy traffic routing is anticipated. Fully associated links (F-links) may also be provided where heavy CCIS traffic between two switching offices justifies this dedicated link.

6.48 Duplicate STPs within each region and the various types of interconnecting links in the signaling network provide a large degree of redundancy. These duplicate STPs provide for reliable operation in case of equipment failure. Additional redundancy is achieved by providing A-links from each switching office to both STPs in the region. Greater redundancy and reliability are accomplished by providing duplicate voice-frequency links to each A-link and E-link. These duplicated

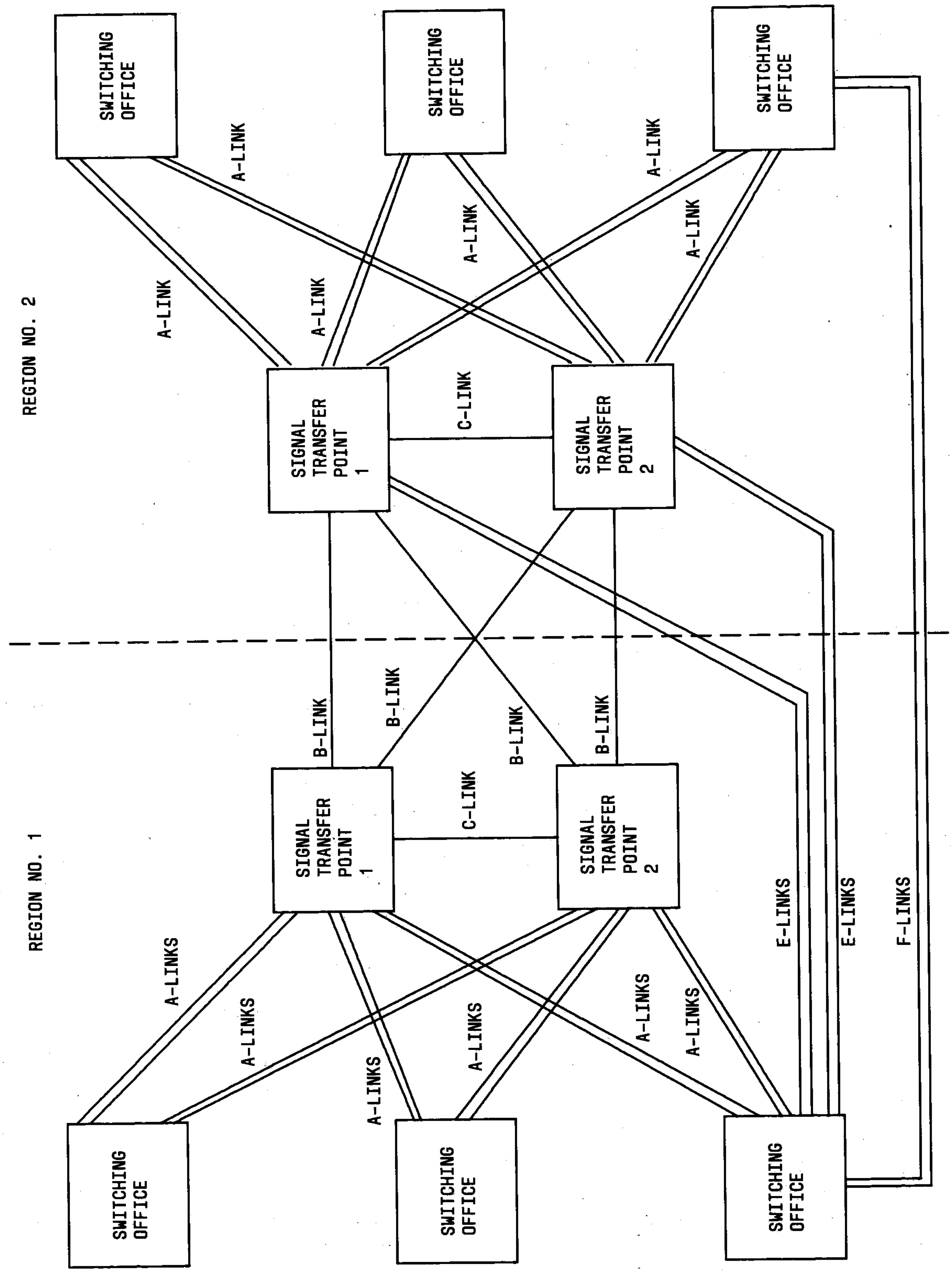


Fig. 18—CCIS Regional Switching Plan—Simplified Block Diagram

voice-frequency links are assigned diverse routes whenever possible. In the event of a failure or high error rate on the regular voice-frequency link, the reserve voice-frequency link is automatically switched into the signaling link. The capacity of the links and STPs is utilized in such a manner that a failure or blockage in any portion of the network will cause the signaling load to automatically be transferred to a backup configuration, thereby ensuring signaling integrity.

Number 4A With Electronic Translator System (ETS)

6.49 Common channel interoffice signaling (CCIS) is a new system that can be used in ETS offices equipped with peripheral bus computer (PCB) for exchanging information between switching systems. The system is used for exchanging such information as supervisory and address signals to control call setup and take down and network management signals. The information is sent over a network of signaling data links instead of the present voice path. CCIS passes signals at much higher speeds over the data links and it has more information carrying capacity. Another advantage is that the signaling for a large number of trunks can be sent over the same data links, and signals can be sent in both directions simultaneously.

No. 4 Electronic Switching System (ESS)

6.50 The No. 4 ESS is capable of using CCIS to pass address, supervisory, and control information when an interconnecting office is equipped for this type of signaling. CCIS employs a preselected signaling link to pass this information between offices.

6.51 The No. 4 ESS/CCIS function is similar to the 4A-ETS/CCIS with respect to the CCIS Signaling System. However, many of the features and controls that have been developed for CCIS have been incorporated as No. 4 ESS software functions.

6.52 As with the 4A-ETS switching offices, the No. 4 ESS switching office has a control office function with respect to the A-links, and in matters concerning signaling network integrity, is subordinate to the regional control STP in the signaling link control office plan. In many cases, the control office function, with respect to the message trunks, may not coincide with that of the signal links. This should not prove troublesome since isolating a trouble to either the trunk or the signaling link will indicate control responsibility.

Growth of CCIS

6.53 While faster signaling is one advantage of CCIS, its communications capability allows transmission of network management signals, leading to better call routing. CCIS also makes possible a variety of signals for new features and customer services. These include automated special billing services now requiring operator assistance, improved IN-WATS (toll free "800" calling) services, and inward call management services such as selective ringing.

6.54 While the initial application of CCIS is limited to the intertoll network, it is anticipated that by 1985 CCIS will have replaced present signaling systems on almost 85 percent of Bell System intertoll trunks. Planning is currently underway to extend CCIS technology to stored program controlled (SPC) local office signaling. The SPC network that will result from the interconnection of electronic switching systems, TSPS, and data bases by CCIS, will evolve as CCIS is implemented.

7. INTERNATIONAL TELEGRAPH AND TELEPHONE CONSULTATIVE COMMITTEE

7.01 The International Telegraph and Telephone Consultative Committee (CCITT) has the duty to study technical, operating, and tariff questions, and also to issue recommendations relating to telegraphy and telephone, including data and program services.

7.02 Since signaling systems used in various parts of the world differ both in principle and detail, the CCITT has standardized signaling systems for international use. These signaling systems provide the interface between switching systems and networks of widely different design.

7.03 CCITT Signaling System No. 5 was the first system standardized for intercontinental use. System No. 5 is an inband signaling system which is compatible with the transmission facilities used for intercontinental trunks, ie, 3-kHz spaced channel banks, PCM channel banks, satellite channels, and the Time Assignment Speech Interpolation (TASI) System. The address signals are coded in the multifrequency code used by the Bell System and are transmitted en bloc at a rate of ten digits per second. Address signals are sent link by link between registers only. Line or supervisory signals are sent using a 2-frequency continuous compelled arrangement. It is the system used today for nearly all intercontinental dial trunks.

7.04 The most advanced international signaling system is CCITT Signaling System No. 6. System No. 6 is the international common channel interoffice signaling (CCIS) system. Domestic CCIS is fully compatible with System No. 6 international CCIS. As with domestic CCIS, there is a rapid transfer of signals and capacity for many new signals in both directions. The data link operates at 2400 bits per second over analog channels (including 3 kHz spaced). Both associated and nonassociated modes of operation are provided. Since the signal path is independent of the transmission path of the trunks, trunks on any type of transmission facility can be served. A continuity check of the speech path of the trunks is provided during call setup.

8. REFERENCES

8.01 This section was developed from the following Bell System Practices. Refer to these practices for additional descriptive information on specific switching and signaling systems.

SECTION	TITLE
179-100-100	Transmission and Signaling Leads—Designations and Circuit Interfaces
179-360-100	Type F Signaling System— General Description
212-100-001	General Descriptive Information—No. 4A or 4M Toll Switching System
250-190-001	Automated Coin Toll Service Feature—Traffic Service Position System No. 1
333-200-100	CCIS (Common Channel Interoffice Signaling System)—General Description
365-170-100	D4 Channel Bank— General Description
951-330-100	Automatic Number Identification System—General Descriptive Information—Local Step-By-Step, Panel, and No. 1 Crossbar Offices
964-110-101	Common Channel Interoffice Signaling—No. 4A Toll Switching System—General Description
964-310-100	Centralized Automatic Message Accounting (CAMA)—No. 4A or 4M Toll Switching System—General Descriptive Information
975-110-100	Local Subscriber Loop Signals and Signaling Systems Used in Message Telephone Service—General Descriptive Information
975-210-100	Multifrequency Pulsing System General Descriptive Information
975-230-100	DX Signaling System—General Descriptive Information
981-013-100	Private Branch Exchange Arrangement for Automatic Number Identification (ANI) (SD-1E505-01)—General Descriptive Information
981-013-700	TOUCH-TONE Calling for PBX Systems—General Descriptive Information
981-601-100	Private Branch Exchange Arrangement for Automatic Number Identification (ANI) (SD-1E007-01)—General Descriptive Information
984-100-100	Traffic Service Position System No. 1—General Description