DESCRIPTION OF CIRCUIT ARRANGEMENTS FOR PROVIDING FOREIGN EXCHANGE AND OTHER SPECIAL ACCESS SERVICES

CONTENTS PAGE

1. GENERAL

1.01 This section describes the various special access circuit arrangements. It is based on overall circuit operation and conditions. The detailed description of specific equipment units is covered in the associated SD drawings and CD sheets.

1.02 The arrows ordinarily used to indicate changes have been omitted since this reissue covers a general revision.

1.03 A ***Special Access*** circuit performs basic functions very similar to the ordinary subscriber line, but it may provide any one or more of the following additional features:

- Additional signaling states (ground-start)
- Like functions over greater distances than the ordinary subscriber line (FX line)
- Special rate treatment (WATS or IN WATS)
- Remote and/or alternate answer of an incoming call to a main telephone (off-premises extension)
- Special call handling (LD lines).

1.04 The foregoing functions are described in detail in following paragraphs.

1.05 An ***IN WATS*** line permits callers within specified geographical regions to call the INWARD WATS customer without incurring a toll charge.

1.06 A ***foreign exchange line*** (FXL) provides service between a telephone, or a data set at a customer's location, and a distant central office which would not normally serve that customer's location.

1.07 ***PBX foreign exchange trunks*** (FXT) provide service between a PBX or ACD at a customer's location, and a remote central office which would not normally serve that customer's location.

1.08 An ***LD Line*** provides a direct connection from a manual or dial PBX to a toll switchboard, or from a telephone station to a toll switchboard. LD lines are commonly used at hotels and motels.

1.09 ***PBX off-premises station line*** (OPS) provides service between a PBX, and a PBX station, when the PBX station is located at some distance from the PBX.

1.10 ***An off-premises extension*** (OPX) is located at a point which is distant from the main station location. Bridge lifters may be required to reduce excessive bridging losses.

1.11 ***Secretarial service*** provides telephone answering service when a customer is not available to answer his calls. Lines similar to off-premises extension lines connect the customer's line to the secretarial service location, and usually terminate in a Secretarial Service switchboard. Here also, bridge lifters may be required to reduce excessive bridging losses.

1.12 A ***WATS line*** is similar to an FX line except that it is used exclusively for outgoing calls to the toll network. In some cases WATS lines will terminate in a local central office. Where the local central office is not arranged for WATS service, the WATS line is extended to a distant central office which is so arranged. WATS is the abbreviation for Wide Area Telecommunication Service.

1.13 ***PBX WATS trunks*** are similar to WATS lines, except that they connect a PBX, instead of a telephone, to a WATS central office and are used exclusively for outgoing calls from the PBX.

1.14 The telephone equipment at the customer's location may be a telephone set, a call director, key telephone equipment, a manual PBX, a dial PBX, an Automatic Call Distributing System (ACD), a Secretarial Service Switchboard, a data set, or combinations thereof.

1.15 ***Key Telephone Units*** (KTUs) are the equipment used at the customer's location to provide additional features normally associated with multibutton telephones. These features include—hold, audible and visual line signals, exclusion, conference, camp-on, add-on, dial intercom, and many others. Four discrete Key Telephone Systems currently exist. These are the 1A, 1A1, 1A2, and 6A systems. These systems differ in features available, equipment packaging, and physical mounting arrangements. Key Telephone Units are frequently used with PBX systems.

1.16 A ***Manual PBX*** is a switching system located on the customer's premises in which all connections, whether between two stations, or between stations and trunks, are made by a PBX attendant at one or more cord switchboards or cordless consoles.

1.17 A ***Dial PBX*** is a switching system located on the customer's premises in which the connections between two stations, or outgoing calls from stations to trunks may be machine switched under control of the PBX station dial. Incoming calls from central office trunks are received by the PBX attendant who extends them to the desired station via a cord switchboard or a console.

1.18 ***Centrex*** Service provides Direct Inward Dialing (DID) and Identified Outward Dialing (IOD) on central office trunks, as well as numerous other internal features in addition to the regular PBX-type services. Centrex service can be provided by certain central office switching systems (Centrex-CO), or by certain switching systems located on the customer's premises (Centrex-CU). The main advantages of centrex service are that PBX stations may be reached directly by any telephone user without requiring the services of a PBX attendant, and outgoing toll calls may be billed to the specific PBX station making the call.

1.19 An ***Automatic Call Distributor*** (ACD) is a switching system designed to distribute a large volume of incoming calls to a group of attendants in the approximate order in which the calls were received. ACDs are commonly used by airlines, retail stores, and others for handling order and information type calls.

1.20 ***Bridge lifters*** are devices which remove, either electrically or physically, bridged telephone pairs to reduce the transmission losses they produce. Relays, saturable inductors, and semiconductor devices are sometimes used. The 1574A inductor is a typical bridge lifter.

1.21 ***Contrast*** is defined as the difference in transmission volume levels observed by a telephone user on various calls from any one telephone.

1.22 ***Forward Disconnect*** is the release of a ground start central office trunk circuit at a dial PBX or ACD on an answered incoming call from the central office, regardless of any off-hook condition at the PBX or ACD. This release is initiated by the disconnect of the calling party and the resultant release of the central office switching equipment. When the C.O. switching equipment

releases, the tip conductor is opened toward the PBX or ACD, reducing conductor loop current to zero. The absence of loop current, and the removal of the tip ground, initiates the release of the ground start trunk circuit at the dial PBX or ACD, independent of any off-hook condition. Ground start dial long line circuits and other range extension equipment should repeat this forward disconnect signal.

1.23 ***Ringback*** is a feature which permits an operator to apply ringing current toward the station, after conversation has been completed on the connection, and the station has gone "on-hook". A typical application is one where a long distance operator rings back a PBX attendant in a hotel or motel, to give her time and charge information so that the party who made the call can be billed immediately if necessary.

1.24 Many PBXs have tie trunks to other PBXs. If these tie trunks are of the dial repeating type, a station in one PBX can dial a station in the other PBX directly. Other tie trunks of the ringdown and automatic type require the assistance of the PBX attendant for completion of calls to stations, and may require the assistance of the PBX attendant for selection at the originating end.

1.25 ***Toll Diversion*** is a feature by which selected PBX stations may make toll calls while other stations are prevented from doing so. Some toll diversion arrangements permit toll calls only to certain prespecified exchanges, or to certain prespecified area codes.

2. CIRCUIT OPERATION—GENERAL

2.01 Typical circuit arrangements for providing special access service are described in Parts 5 and 6 of this section. Circuit configurations are shown in Part 11.

2.02 One end of the special access circuit terminates at a customer's location and will be called the "station end" in this section. This end of the circuit receives 20-Hz ringing as a signal for an incoming call. It transmits rotary dial pulses or TOUCH-TONE® calling signals for an outgoing call, if dial outgoing service is provided.

2.03 The other end of the special access circuit will be called the "switching end." It receives rotary dial pulses or TOUCH-TONE calling signals from the "station end" and transmits 20-Hz ringing signals toward the station. This end of the circuit may be located at a serving toll center (STC), a local central office, or in the case of an off-premises station, at the PBX.

2.04 The term "facility", as used in this section, refers to all of the telephone plant between the serving central office or PBX, and the station. It may be a pair of wires, or several carrier systems in tandem on radio or wire lines.

2.05 The terms "off-hook" and "on-hook" are used in describing the general operation of special access circuits. When the station handset is removed from its cradle or switchhook, or when a PBX attendant inserts a plug into the trunk circuit jack, the circuit condition at the station end is said to be "off-hook." When the station handset is replaced on its cradle or switchhook, or when no plug is in the PBX jack, the circuit is said to be "on-hook" at the station end.

2.06 Completely different signaling requirements exist in the two different directions of transmission. 20-Hz signaling is used from the "switching end" toward the station end. Ground start signaling applications have an additional signal to indicate seizure. This is described in greater detail in Par. 3.05 through 3.09.

2.07 The off-hook and on-hook supervisory signals are sent from the "station end" toward the "switching end". They indicate seizure and disconnect respectively. Rotary dial pulses which control dial switching equipment are transmitted from the station as a rapid succession of "on-hook" and "off-hook" signals. Some circuits use TOUCH-TONE pulses. With this system, combinations of alternating current tones are used.

2.08 In those cases where DX signaling is used on a metallic facility, or carrier circuits using "In Band" or "Out of Band" signaling are used, it should be remembered that when a particular loop signal is applied at one end of the facility, that same signal will appear at the opposite end of the facility, regardless of its form between the two ends. Thus ideally, the line signaling system becomes transparent; that is, an open on the 2-wire side at one end of the circuit produces an open at the other end. Similarly the application of 20-Hz ringing at one end of the circuit causes 20-Hz ringing to appear at the other end. In actual

practice however, small changes do occur because of transit time through the facility, relay operate and release time, and other circuit response time.

3. DESCRIPTION OF LOOP-START AND GROUND-START SIGNALING

3.01 Loop-start signaling is the normal type of signaling between a central office and a noncoin, nondial PBX, subscriber station, or between a PBX and a PBX station. More simply, plain ordinary telephone service.

3.02 When the handset is removed from its cradle or switchhook at the station end, a resistance of approximately 150 ohms is placed across the line toward the switching end as a request for service.

3.03 Loop-start signaling is required when providing service to an off-premises PBX station (OPS), a foreign exchange line (FXL), or a manual Private Branch Exchange (PBX).

3.04 An incoming call to the station end is recognized by the receipt of the 20-Hz ringing signal only. The usual ringing signal consists of a 2-second ringing period followed by a 4-second silent period. A station line can be seized for as long as 4 seconds before a seizure can be recognized at the station. The person at the station may attempt to originate a call during this interval. This is not considered a problem since the person who is originating a call from the station end is usually the person to whom the call is being directed.

3.05 Ground-start signaling is required when providing service to a dial PBX, or to an ACD. Typical dial PBXs include the 701, 740, 756, 757 and 800A. Typical ACDs include the 2A and 3A.

3.06 In many ways a dial PBX is similar to a dial central office in that any one of the dial PBX stations can dial other telephones, and also originate and receive calls over the same trunk between the serving central office and the dial PBX. Since this trunk can be seized at either end it is apparent that special means must be taken to transmit seizure signals in each direction as quickly as possible. In the description of loop-start signaling it was noted that four seconds could elapse before the station end of the facility recognized a seizure by the switching end. ***Ground-start signaling eliminates the four-second seizure delay.*** When ground-start signaling is employed, the subscriber line circuit at the central office is modified by removing the ground which is normally connected to the tip conductor of the line in the idle or on-hook state. This standard modification is shown on the subscriber line circuit SD drawing for the particular switching system involved.

3.07 When the central office switching equipment seizes the trunk for a call toward the dial PBX, it immediately places a ground on the tip conductor. The trunk circuit at the PBX recognizes the presence of ground on the tip as a seizure signal and immediately makes itself unavailable to outgoing calls from the PBX. When the 20-Hz signal is received, a signal is given to the PBX attendant to indicate an incoming call.

3.08 An outgoing call from the PBX toward the central office causes a ground to be placed on the ring conductor toward the central office. The central office equipment recognizes this as a seizure signal and prepares itself to receive dialing. When it is prepared, it places a ground on the tip conductor toward the PBX and applies dial tone. The PBX trunk circuit in turn, recognizing the tip ground as a start-dial signal, closes the line through for dialing and removes the ground which it had placed on the ring conductor earlier. After dialing the call is completed in the usual way.

3.09 To repeat, the dial PBX recognizes ground on the tip conductor from the central office equipment as a seizure signal, the central office equipment recognizes ground on the ring conductor from the dial PBX as a seizure signal. Similarly, the dial PBX recognizes the removal of ground from the tip conductor as a disconnect signal, and the central office switching equipment recognizes the opening of the loop as a disconnect signal.

4. METALLIC LOOP SIGNALING LIMITATIONS

4.01 The maximum distance over which metallic loop signalling is used, may be limited by any one, or all of the following:

(a) Dial pulsing or TOUCH-TONE calling range

(b) Supervisory range

(c) Ringing range

(d) Ringing trip range

(e) Transmission considerations

4.02 Dial pulsing range is governed in part by the sensitivity and speed of the pulsing relay. It must maintain the per cent break of the dial pulses within the limits that the associated central office or dial PBX can accept. Other factors which may reduce rotary dial pulsing range include pulse distortion, pulse mutilation, or false pulse generation. These effects can be caused by the interaction of reactive components contained in voice repeaters, terminating sets, or trunk circuits, which are in the signaling path. When TOUCH-TONE calling is used, the dialing range is limited by the transmission capability of the TOUCH-TONE oscillator at the station with respect to its output at the available line current, the transmission loss of the facility, and the sensitivity of the TOUCH-TONE receiver.

4.03 Supervisory range is the range over which a circuit can detect off-hook and on-hook signals, which are seizure and disconnect signals, respectively. Supervisory signals are not critical with respect to per cent break and are normally detected by the same relay as dial pulses. The supervisory range of a specific circuit usually exceeds its dial pulsing range. Ground start circuits must detect the presence of ground on one conductor, and earth potential differences between the station and the central office may be a limiting factor.

4.04 Ringing range is determined by the RMS voltage of the ringing source, which may vary from 65 volts to 130 volts ac depending upon the type of ringing plant, and the current required to operate a station ringer within certain loudness limits. In the case of a PBX trunk, the ringing range is determined by the current required to operate a ringup relay with a safety margin for circuit variations.

4.05 Modern special access circuits are arranged to trip ringing during the ringing period and/or during the silent period of the ringing cycle. Ringing trip range for the ringing period is governed by the sensitivity of the tripping relay, the 20-Hz voltage, and the voltage of the superimposed dc component. If the ringing source does not have superimposed dc, tripping can occur only during the silent period of the ringing cycle. With the latter arrangement, if the station end goes off-hook during the ringing interval, the person answering will receive 20-Hz ringing in his ear for the remaining portion of the ringing period. Tripping during the silent interval is accomplished by the relay used for dial pulsing and supervisory signals as described in Par. 4.02 and 4.03.

4.06 Additional considerations in determining maximum metallic loop signaling range include insulation resistance between conductors or between either conductor and ground, supply voltage variation limits, effects of any impedance compensator and/or voice repeater equipment, induced 60-Hz ac voltages, extension ringers, and ringing bridges in PBX switchboard cord circuits.

4.07 All of these factors are taken into account in the preparation of long line circuit range charts and similar data that specifies the maximum range over which circuits will function properly, and the maximum number of links that may be connected in tandem.

5. DESCRIPTION OF CIRCUIT ARRANGEMENTS USING METALLIC LOOP SIGNALS

5.01 Fig. 1 shows a loop start signaling arrangement which permits the extension of signaling range beyond the normal limit of central office or PBX equipment on metallic loop facilities. A sensitive relay repeats the dial pulses toward the switching end and provides low resistance battery toward the station. This circuit also applies a fresh supply of 20-Hz ringing current toward the station as a seizure signal. It is capable of detecting an "off-hook" signal during the ringing period of the ringing cycle. The maximum signaling range of this arrangement is approximately 3000 ohms conductor loop resistance. When voice amplifier equipment such as an E6 repeater is used, the resistance of the repeater and its building out network must be included as a part of the maximum conductor loop range of the dial long line circuit. Not more than three of these circuits may be used in tandem unless dial pulse correction is provided.

5.02 Fig. 2 shows a ground-start signaling arrangement using metallic loop facilities. Circuit SD-96371-01 is used at the switching end and circuit SD-66192-01 or SD-66474-01 at an intermediate point or at the PBX or at both points. Circuit SD-66192-01 has the capability of recognizing an "off-hook" signal from the PBX during the ringing period of the ringing cycle. The other two circuits can trip ringing only during the silent interval and thus can cause ringing into the ear

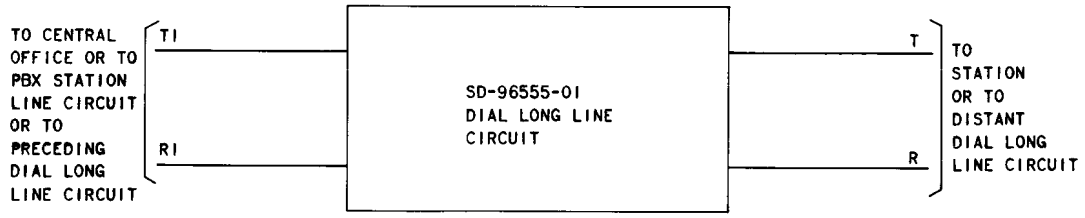


Fig. 1—Metallic Loop Signaling Loop Start

of a PBX attendant, if the call is answered during the ringing interval. Not more than three of these circuit arrangements should be used in tandem.

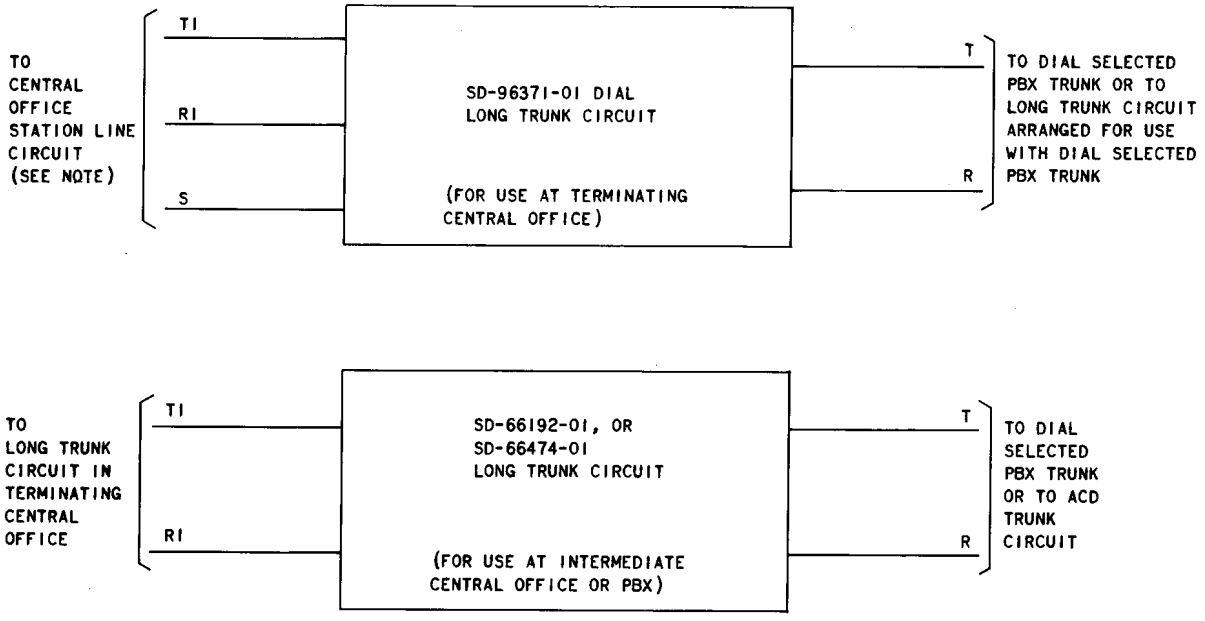
6. DESCRIPTION OF CIRCUIT ARRANGEMENTS USING OTHER SIGNALING METHODS

6.01 In each of the following circuit arrangements the limitations described in Part 4 apply to the metallic loop signaling portion of the circuit. In addition, the following limitations also apply:

(a) All special access circuits over which rotary dial pulsing occurs are arranged to work at a nominal 10 pulse per second dial pulsing rate. Where PBXs are equipped with 20 pulse per second dials, the dials must be replaced with 10 pulse per second dials when rotary dialing is used in the special access circuit.

(b) When special access circuits which employ E & M leads are used, the maximum resistance of each of these leads to the connecting circuit is limited to 25 ohms; unless specific circuits in a given combination permit a greater range.

6.02 A variety of circuits are used in the following arrangements. Because of the two basic



NOTE:
THIS CIRCUIT IS TO BE CONNECTED TO AN ORDINARY SUBSCRIBERS LINE CIRCUIT IN WHICH THE LINE RELAY OPERATES FROM A BRIDGE ACROSS THE "TI" AND "RI" LEADS. (THE SLEEVE LEAD PROVIDES THE EQUIVALENT OF GROUND START TYPE OPERATION).

Fig. 2—Metallic Loop Signaling Ground Start

types of facilities used, the signaling methods are divided into two general classes:

(a) ***DC signaling methods,*** such as CX, DX, and SX, are used on 2-wire or 4-wire metallic facilities.

(b) ***AC signaling methods,*** using tones, are required on carrier or nonmetallic facilities. This type of signaling may also be used on wire facilities. These tone signals are further classified as being in the voice band of frequencies, or out of voice band of frequencies ("inband" or "out of band" signaling). T1 carrier uses pulse code modulation. Its signaling is considered to be in the "out of band" category.

6.03 Fig. 3 and 4 show loop start signaling arrangements using circuits SD-96251-01 and SD-96252-01. These circuits convert the metallic loop signals to E & M lead signals and E & M lead signals to metallic loop signals. The E & M leads are in turn converted by other circuits for transmission through the facility as shown in Fig. 3 for metallic facilities and Fig. 4 for carrier facilities. These circuits may employ either one or two separate and distinct modes of operation, dependent upon whether the facility is metallic (dc signaling) or carrier (tone signaling). When dc signals are used on the facility, circuit SD-96251-01 applies battery on its M lead as a ringing signal, option K being used. Circuit SD-96252-01, at the station end, receives ground on its E lead as a ringing signal, Fig. F being used. When "out of band" AC tone signals are used, such as with O, ON, N1 and T1 carrier facilities, the signaling arrangement is different. Circuit SD-96251-01 applies ground on its M lead as a ringing signal, option J being used. Circuit SD-96252-01, at the station end, recognizes the absence of ground on its E lead as a ringing signal, Fig. E and J option being used. This latter arrangement eliminates the danger of falsely ringing the station because of carrier line "hits," carrier fading and carrier failure. This is referred to as the "tone off" option. Tables A and B summarize circuit conditions and indications for each arrangement.

6.04 The foregoing circuit arrangements are normally limited to relatively short-haul facilities because of signaling and transmission requirements. When the facility includes radio systems or carrier systems which require "inband" signaling capability, other signaling arrangements are used.

6.05 Single Frequency (SF) circuits are available which convert the metallic loop signals to 2600-Hz tone signals. This tone is "in band" and readily passes through the voice path, eliminating the need for pulse link or signal converter circuits at intermediate and terminal points of the facility when several carrier systems are used in tandem. The range of this method of signaling is limited only by the transmission capabilities of the entire circuit at the signaling frequency.

6.06 The SF units for use in special access circuits are designated E1P (SD-99779-01) for the switching end unit, and E1R (SD-99780-01) for the station end unit. These units provide the following principal features:

- Provision for either loop start, or ground start service, with no additional apparatus, by means of a switch on the front of each unit.
- Four-wire operation, permitting the use of four-wire extensions at either end of the circuit. This allows transfer of carrier gain, operation with echo suppressors, equalizers, or other four-wire transmission equipment.
- Capability of loop signaling on A&B leads (loop or ground start), or E&M lead signaling (loop start only).
- Compatible with E2L and E2S, and auxiliary units E2LA, and E2SA.
- Compatible with either 600-or 900-ohm termination because of the flexibility of the external terminating set.

6.07 Table C summarizes circuit conditions for loop start operation. Circuit arrangements for loop start operation are shown in Fig. 5.

6.08 Table D summarizes circuit conditions for ground start operation. Circuit arrangements for ground start operation are shown in Fig. 5.

6.09 Other single frequency signaling units are available, on an A & M basis, for use in special access circuit applications. These units are designated E2L (SD-98137-02) for the switching end unit, and E2S (SD-98138-02) for the station

end unit. These units provide loop start service and are arranged to plug into the standard E type signaling bay. Each unit contains a miniaturized 900-ohm 4-wire terminating set, a compromise network, and all circuitry to convert from metallic loop signaling to SF signaling, and from SF signaling to metallic loop signaling. These circuits function with any type of central office switching equipment. The E2L is located at the switching end of the facility and the E2S is located at the station end of the facility. The facility between these circuits must be 4-wire type although either a metallic or carrier facility, or a combination of both may be used. Standard carrier transmitting and receiving line levels are required. This circuit arrangement is shown in Fig. 6. Table C summarizes circuit conditions for this arrangement.

6.10 Caution must be exercised when testing or placing new units into service since they are shipped with both the loop start and ground start option straps in place, and are therefore inoperable until one or the other set of option straps is removed.

6.11 When ground-start signaling is required, auxiliary circuits are added to both the E2L and E2S to provide the additional capability for ground-start signaling. They are designated E2LA (SD-98142-02) and E2SA (SD-98140-02) and are connected to a socket on the associated E2L or E2S by means of a 6-inch plug-ended cord permanently attached. For this reason they must be plugged into the E type signaling bay in the position immediately adjacent to the associated E2L or E2S. This arrangement is shown in Fig. 7. Table E summarizes circuit conditions for this arrangement.

6.12 The E2SA can be arranged to respond to either a 20-Hz or a 40-Hz ringing signal. The standard arrangement uses a 20-Hz signal, and the E2SA is so wired. If the originating end transmits a 40 Hz ringing signal, the E2SA unit must be arranged accordingly. Instructions for this arrangement are covered on the drawing SD-98140-02.

6.13 Because of the design of the built-in terminating set in the E2L and E2S the ***minimum loss*** in the transmitting direction is 13 dB. This limits the 2-wire side to a maximum of 3 dB loss if standard transmission levels are to be obtained at the circuit test level points.

6.14 Echo suppressors must be located on the equipment side of SF signaling circuits at a 4-wire point. The E2L and E2S single frequency units are 2-wire on the equipment side, and no provision has been made for access to the built-in terminating set, hence echo suppressors cannot be used.

6.15 Another "inband," loop-start signaling arrangement is shown in Fig. 8. It is used where Echo Suppressor equipment is required or where the 3 dB limitation of the E2S presents transmission difficulty. This configuration uses an E2L at the switching end. At the station end an E3B-21 or equivalent, "talk off" improved, SF unit, a 1G 4-wire terminating set with a precision or compromise balancing network, and dial long line circuit SD-96252-01 are used. The options shown in Fig. 8 are used to permit this arrangement to function satisfactorily. An Echo Suppressor may be used at the station end if necessary. The insulation resistance of the 2-wire line from circuit SD-96252-01 to the station must not be less than 30,000 ohms to permit proper dial pulsing. The E1P and E1R units overcome the limitations of the E2L and E2S, and are therefore the recommended units for all special access applications.

6.16 Foreign exchange channel units are available for use with T1 carrier systems to convert the metallic loop signals to pulse code modulation (PCM) signals, and PCM signals to metallic loop-signals. They may be used for loop-start signaling applications. They may also be used for ground-start signaling applications subject to the following limitation. The present version of these units (SD-97208-01 Issue 6 and SD-97209-01 Issue 4) does not have the "forward disconnect" feature required for incoming calls to a dial PBX or ACD. The forward disconnect feature is described in Par. 1.22 and the circuit arrangements are shown in Fig. 9.

7. NONSTANDARD CIRCUIT ARRANGEMENTS

7.01 Several nonstandard circuit arrangements have been used to provide special access services. These arrangements are not shown on standard drawings because they present signaling difficulties.

7.02 One nonstandard arrangement involves the use of dial long line circuit SD-96251-01 together with an inband signaling unit, such as the X type (SD-56292-01), or E4B (SD-98124-03),

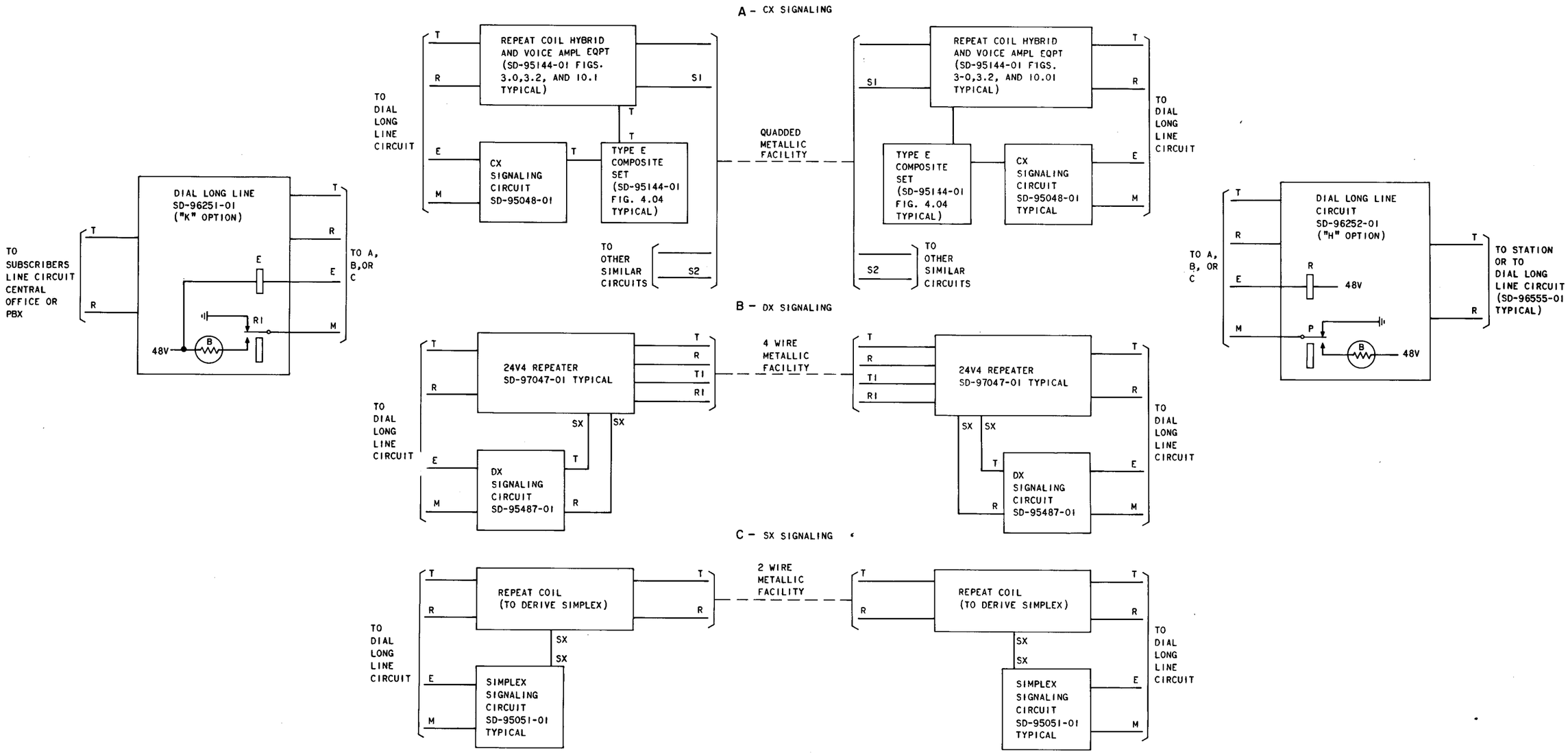


Fig. 3—CX, DX, and SX Signaling on Metallic Facilities Loop Start

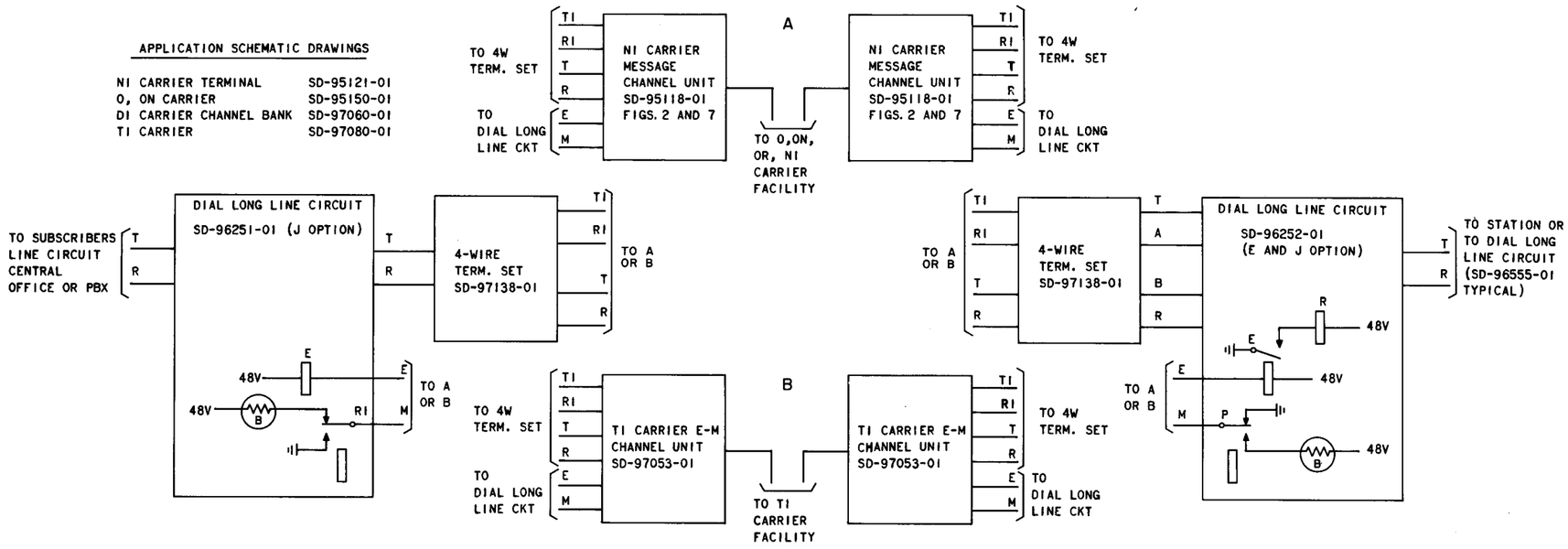


Fig. 4—Out-of-Band Signaling O, ON, N1, and T1 Carrier Systems Loop Start

TABLE A

SD-96251-01 OPTION K, SD-96252-01 FIG. F

(OPTION FOR DC SIGNALING ON WIRE FACILITIES)

SWITCHING END	1A TEST SET LAMP SIGNALS LINE DROP		SD-96251-01		SD-96252-01		1A TEST SET LAMP SIGNALS LINE DROP		STATION END
			E	M	E	M			
Idle	on	on	O*	G	O	G	on	on	on-hook
Ringing	on	off	O	B	G	G	off	on	on-hook
Talking	off	on	G	G	O	B	on	off	off-hook
Receiving & Dial Pulses	on & off	on	O & G	G	O	G & B	on	on & off	dialing

*B — battery, G — ground, O — open

TABLE B

SD-96251-01 OPTION J, AND SD-96252-01 FIG. E & J OPTION

(TONE OFF OPTION FOR USE WITH OUT-OF-BAND SIGNALING ON CARRIER FACILITIES)

SWITCHING END	1A TEST SET LAMP SIGNALS LINE DROP		SD-96251-01		SD-96252-01		1A TEST SET LAMP SIGNALS LINE DROP		STATION END
			E	M	E	M			
Idle	on	off	O*	B	G	G	off	on	on-hook
Ringing	on	on	O	G	O	G	on	on	on-hook
Talking	off	off	G	B	G	B	off	off	off-hook (talking)
Receiving & Dial Pulses	on & off	off	O & G	B	G	G & B	off	on & off	dialing

*B — battery, G — ground, O — open

at the switching end of the special access circuit. While SD-96251-01 will perform satisfactorily with some E & M lead signaling systems (see Par. 6.03), the combination of this circuit with an inband signaling unit is not satisfactory when dial outgoing service from the station end is required, ***and rotary dial pulsing is used.*** Difficulties are encountered in either the "tone on" or "tone off" mode of operation. The "tone on" mode of operation results in false rings to the station, "talk off" troubles,

TABLE C

LOOP-START

SWITCHING END	E1P OR E2L		E1R OR E2S		STATION END
	TRMT	RCV	TRMT	RCV	
Idle	—*	Tone	Tone	—	on-hook
Ringing	Tone	Tone	Tone	Tone	bell rings
Trips Ringing	Tone	—	—	Tone	Answer
Talking	—	—	—	—	Talking
Idle	—	Tone	Tone	—	on-hook
Applies Dial Tone	—	—	—	—	off-hook
Dial Pulses Registered	—	Pulses of Tone	Pulses of Tone	—	Dial Pulses
Talking	—	—	—	—	Talking

* — Indicates No Tone

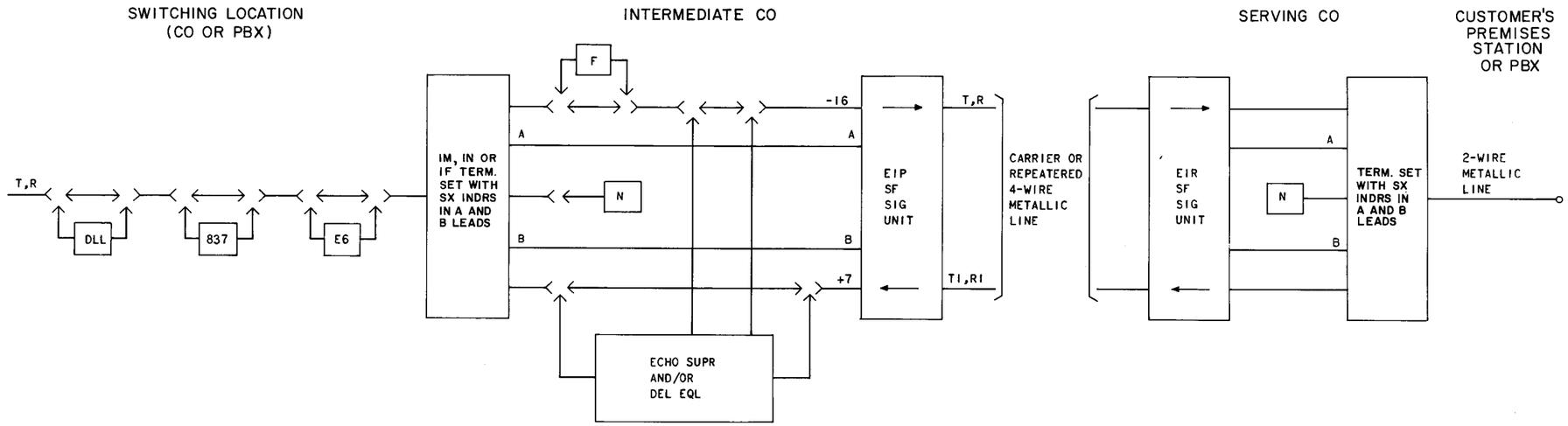
and voice transmission impairment. The "tone off" mode of operation causes dialing difficulties, resulting in reaching wrong numbers, or uncompleted calls. The standard arrangements shown in Fig. 5 or 6 are recommended for this application.

7.03 The E & M, trunk type, Single Frequency signaling units are capable of transmitting only 2 signals, "on-hook" or "off-hook;" one is represented by the transmission of tone, the other by no tone. In special access service it is necessary to transmit a ringing signal from the switching end toward the station end. If the removal of tone is used to represent the ringing signal, tone will be transmitted during both the idle and talking condition of the unit. This is referred to as "tone on" operation, and has the following disadvantages:

(a) Voice transmission is impaired. 2600-Hz tone is transmitted by the unit at the switching end during both the talking and idle state. The SF unit at the station end maintains a 2600-Hz band elimination filter in the transmission path during conversation, because it is receiving tone.

(b) The "talk off" susceptibility of the SF unit at the switching end is increased appreciably. Maximum "talk off" protection is provided by the SF units when no SF tone is transmitted in either direction. "Talk off" manifests itself as a false disconnect of the circuit, or clicks and thumps which are incipient disconnects, due to voice simulation of the 2600-Hz signaling tone.

(c) Ringing will be received at the station falsely. With "tone on" operation, the removal of tone causes ringing to be applied toward the station. Carrier failure or "hits" and "fades" in the carrier will remove the signaling tone simulating the legitimate "tone off" ringing signal.



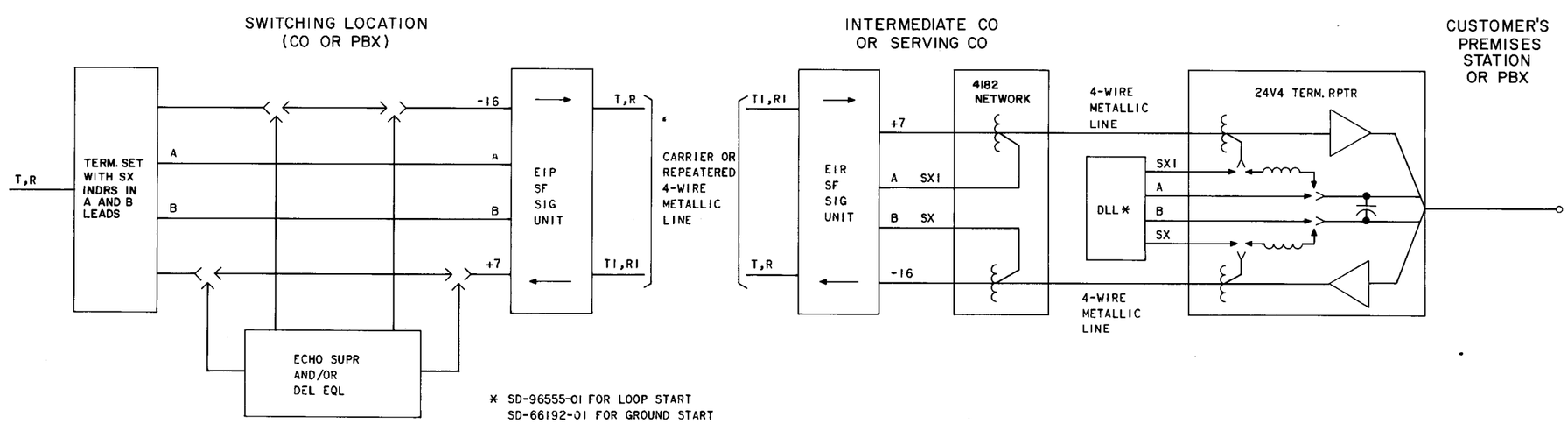


Fig. 5—Single Frequency Signaling Loop Start or Ground Start Using E1P-E1R

TABLE D

GROUND-START

SWITCHING END	E1P		E1R			STATION END
	TRMT	RCV	TRMT	RCV	ACTION	
Idle	Tone	Tone	Tone	Tone	Tip Open	on-hook
Seized for Term. Call	—*	Tone	Tone	—	Tip Closed	seized
Ringing Applied	Tone Modulated at 20 Hz for 2 sec., no tone for 4 sec.	Tone	Tone	Tone Modulated at 20 Hz for 2 sec., no tone for 4 sec.	Tip Closed & Ringing Applied	Visual & Audible Signal to PBX ATND
Trips Ringing		—	—		Tip Closed	Answer
Talking	—	—	—	—	Tip Closed	Talk
Idle	Tone	Tone	Tone	Tone	Tip Open	on-hook
Seized for Originating Call	Tone	—	—	Tone	Tip Open	off-hook
Tip Closed and Dial Tone Applied	—	—	—	—	Tip Closed	off-hook
Dial Pulses Received	—	Pulses of Tone	Pulses of Tone	—	Tip Closed	Dialing
Talking	—	—	—	—	Tip Closed	Talking
Disconnect	Tone	—	—	Tone	Tip Open	Releases
Idle	Tone	Tone	Tone	Tone	Tip Open	on-hook

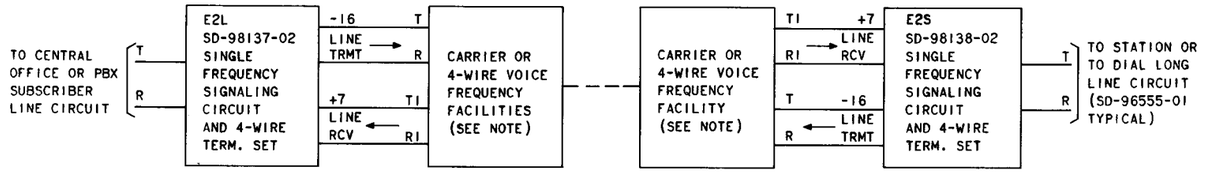
* — Indicates No Tone

TABLE E

GROUND-START

SWITCHING END	E2L		E2LA		E2S		E2SA	STATION END
	TRMT	RCV	TRMT	RCV	TRMT	RCV	ACTION	
Idle	—*	Tone	Tone	—	Tone	Tone	Tip Open	on-hook
Seized for Term. Call	—	Tone	—	—	Tone	—	Tip Closed	seized
Ringing Applied	Tone Modulated at 20 Hz for 2 sec., no tone for 4 sec.	Tone	—	—	Tone	Tone Modulated at 20 Hz for 2 sec., no tone for 4 sec.	Tip Closed & Ringing Applied	Visual & Audible Signal to PBX ATND
Trips Ringing		—	—	—	—		Tip Closed	Answer
Talking	—	—	—	—	—	—	Tip Closed	Talk
Idle	—	Tone	Tone	—	Tone	Tone	Tip Open	on-hook
Seized for Originating Call	—	—	Tone	—	—	Tone	Tip Open	off-hook
Tip Closed and Dial Tone Applied	—	—	—	—	—	—	Tip Closed	off-hook
Dial Pulses Received	—	Pulses of Tone	—	—	Pulses of Tone	—	Tip Closed	Dialing
Talking	—	—	—	—	—	—	Tip Closed	Talking
Disconnect	Tone	—	—	—	—	Tone	Tip Open	Releases
Idle	—	Tone	Tone	—	Tone	Tone	Tip Open	on-hook

* — Indicates No Tone



NOTE:
THE 4-WIRE VOICE FREQUENCY FACILITY MUST PROVIDE PROPER BANDPASS AND TRANSMISSION LEVELS FOR SF CIRCUITS.

Fig. 6—Single Frequency Signaling Loop Start Using E2L-E2S

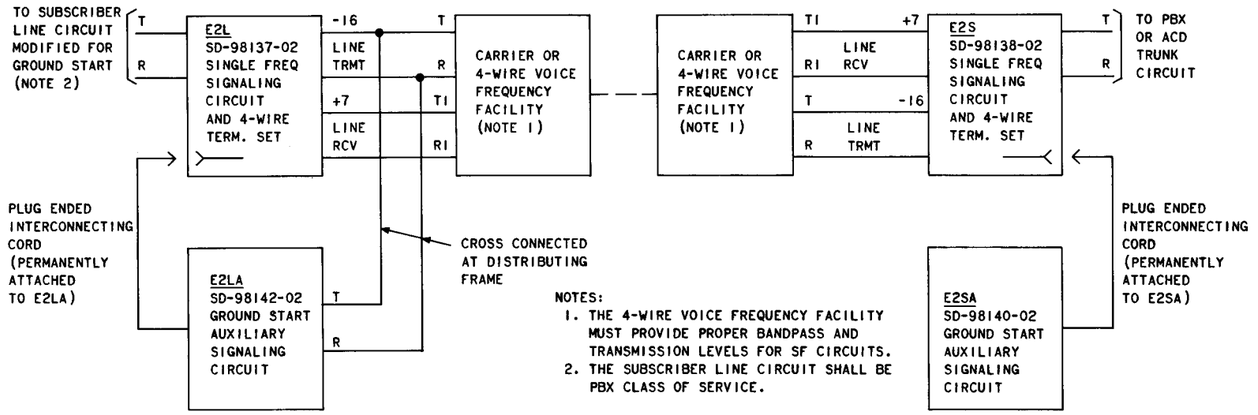
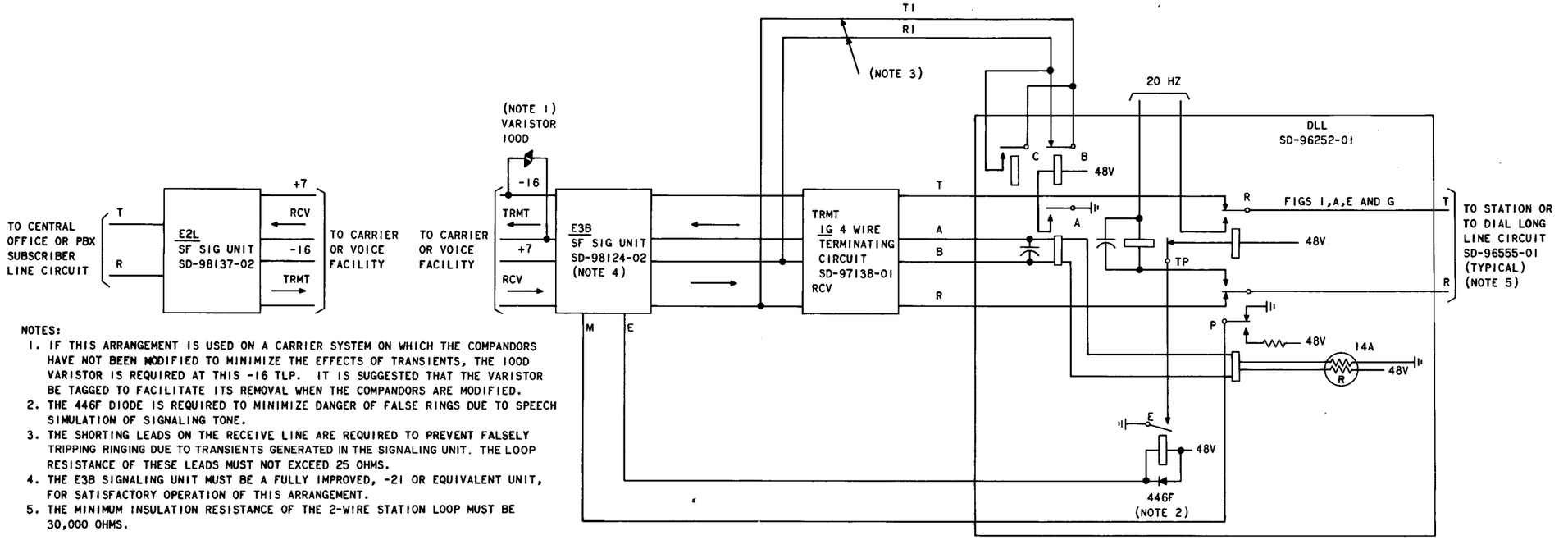


Fig. 7—Single Frequency Signaling Ground Start Using E2L-E2S and E2LA-E2SA



NOTES:

1. IF THIS ARRANGEMENT IS USED ON A CARRIER SYSTEM ON WHICH THE COMPANDORS HAVE NOT BEEN MODIFIED TO MINIMIZE THE EFFECTS OF TRANSIENTS, THE 100D VARISTOR IS REQUIRED AT THIS -16 TLP. IT IS SUGGESTED THAT THE VARISTOR BE TAGGED TO FACILITATE ITS REMOVAL WHEN THE COMPANDORS ARE MODIFIED.
2. THE 446F DIODE IS REQUIRED TO MINIMIZE DANGER OF FALSE RINGS DUE TO SPEECH SIMULATION OF SIGNALING TONE.
3. THE SHORTING LEADS ON THE RECEIVE LINE ARE REQUIRED TO PREVENT FALSELY TRIPPING RINGING DUE TO TRANSIENTS GENERATED IN THE SIGNALING UNIT. THE LOOP RESISTANCE OF THESE LEADS MUST NOT EXCEED 25 OHMS.
4. THE E3B SIGNALING UNIT MUST BE A FULLY IMPROVED, -21 OR EQUIVALENT UNIT, FOR SATISFACTORY OPERATION OF THIS ARRANGEMENT.
5. THE MINIMUM INSULATION RESISTANCE OF THE 2-WIRE STATION LOOP MUST BE 30,000 OHMS.

Fig. 8—Single Frequency Signaling Loop Start Using E2L, E3B, and DLL SD-96252-01

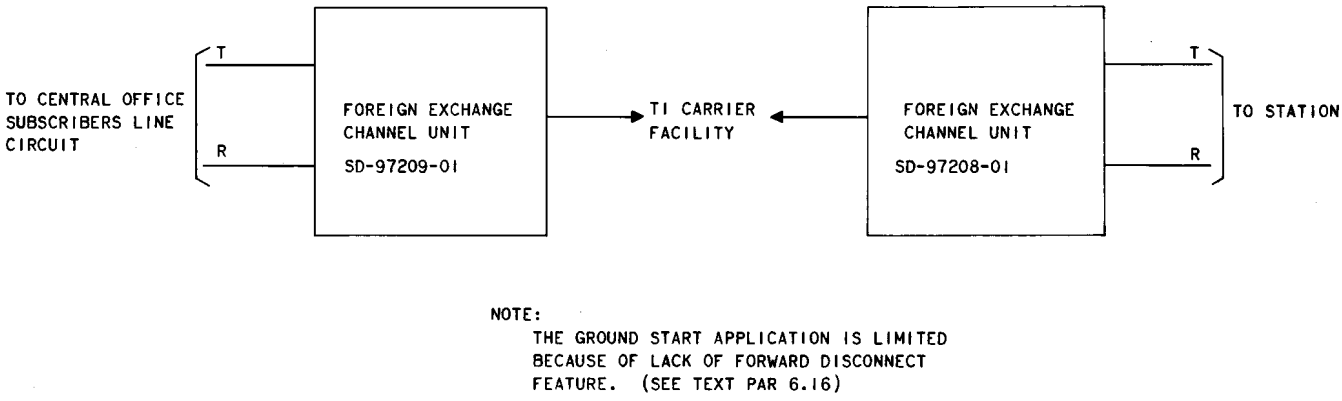


Fig. 9—T1 Carrier Foreign Exchange Channel Units Loop Start and Ground Start

7.04 In an attempt to eliminate the foregoing difficulties, the SF unit at the switching end is sometimes used in the "tone off" mode. In this arrangement it transmits 2600-Hz tone as a ringing signal, and does not transmit tone during idle or talking conditions. This eliminates the transmission impairment, "talk off" and false ringing difficulty, but presents dialing problems. Dial pulses in the form of 2600-Hz tone bursts are transmitted toward the SF unit at the switching end when it is not transmitting tone. This condition, in which battery is on its M lead, is the talking, or "off-hook" condition of the unit in its usual trunk application. These trunk type SF units are designed to be relatively insensitive to signaling tone frequencies in this condition. This is done to provide maximum protection (high guard) from speech simulation of signaling tones, which would otherwise cause false disconnects, or clicks and thumps during speech transmission periods. This reduced sensitivity to signaling tone introduces an appreciable delay in responding to a legitimate signal tone such as the short tone bursts representing rotary dial pulses. In the normal usage of these units in trunk applications, the delay does not involve dialing and has no appreciable effect on other signals such as disconnect and flashing. In special access applications of these trunk type units, the delay mutilates the dial pulses beyond the switching equipment's ability to recognize them. When modification of the unit is attempted to alleviate the dialing problem, the "talk off" performance of the unit is significantly impaired.

7.05 Another nonstandard arrangement makes use of Circuits ES-95668-01 or ES-65602-01, and ES-65625-01 or ES-65699-01, for ground start signaling applications. These circuits are modifications of SD-96251-01 and SD-96252-01. They are now rated "SPECIAL" since they were designed for a specific installation and are unacceptable for general application. One of the difficulties with these circuits is the lack of the "forward disconnect" feature. This presents difficulties which vary with the type of central office switching equipment involved and with the type of equipment at the customer's location. The absence of the forward disconnect feature prevents the PBX or ACD trunk circuit from releasing following an incoming call, which is abandoned by the calling party, after receiving an "off-hook" signal from the station end. This may occur as a result of a legitimate answer and completion to a PBX station by the PBX attendant, who is unaware that a disconnect has occurred, since no disconnect signal is received from the switching end. It may also occur as a result of a recorded announcement from an ACD. This will result in a new connection being established to the central office followed by the application of dial tone, and in certain types of central offices, the application of permanent signal tone. This condition continues until an "on-hook" signal is received from the station end. The permanent signal tone is a high level tone and may be induced into adjacent channels in the facility. These circuits require a facility arranged to accept the E & M leads. Facilities which require inband signaling cannot be used as discussed in Par. 7.03 and 7.04.

8. TRANSMISSION CONSIDERATIONS

8.01 Special access circuits are designed for low transmission loss with due consideration being given to singing margin, echo, crosstalk, noise and

contrast. Since transmission considerations vary with round trip delay time, special access circuits are divided into two general categories as follows:

DESIGNATION	ROUND TRIP DELAY
Short Haul	6 Milliseconds or less
Long Haul	More than 6 Milliseconds

8.02 The following tabulation indicates the order of magnitude values for facilities having round trip delays of six milliseconds:

30 miles of exchange paired cable, either loaded or nonloaded

40 miles of H88-50 Toll Cable

60 miles of H44-25 Toll Cable

200 miles of Carrier

90 miles of Carrier when two systems are used in tandem

Notes:

(a) Round trip delay of an N type carrier terminal is 2.3 milliseconds and is included in the above where applicable.

(b) Some delay equalization arrangements can add as much as four milliseconds of round trip delay to the circuit and should be included where applicable.

8.03 Short-haul circuits do not have appreciable echo problems since the loss required for singing margin exceeds that required for echo protection. Long-haul circuits, however, must have certain minimum losses to control echo effects. VNL design provides these minimum losses, and in some extreme cases echo suppressors are required.

8.04 Many special access circuits provide transmitter battery supply for telephone sets. The 500-type telephone set is equipped with a network which controls the efficiency of the set, depending upon the amount of current flowing through the station loop. Transmission objectives are normally based on optimum transmitter current of approximately 50 milliamperes, less current will reduce transmitter output, while greater current will reduce receiver efficiency. When TOUCH-TONE telephone sets are used, the output of the tone generator in the telephone set is reduced as the loop current increases at a rate approximately equal to that of the receiver efficiency in the telephone set. It becomes apparent that available loop current may be a limiting factor in special access circuits.

8.05 Most dial PBX attendants and ACD attendants telephone circuits have local transmitter battery supply and are therefore independent of loop battery supply.

8.06 PBX trunks and switchboard cord circuits reduce PBX station loop current. The trunk circuit offers series resistance, while the switchboard cord circuit, and some PBX trunk circuits associated with the PBX attendant console offer a shunt resistance. Both reduce the PBX station loop current. For further details, refer to the Section on this subject listed under Reference Material (10).

8.07 Because of the transmission requirements of special access circuits, it is frequently necessary to extend them to the customer's premises on a 4-wire basis.

9. TESTING AND OPERATING CONSIDERATIONS

9.01 The number of different arrangements available for providing special access service makes it very important that certain precautionary steps be taken. Some of the more important are:

(a) Check the SD Drawings and CD Sheets to ascertain that the proper options and figures are used.

(b) Visually check the equipment to ensure that the correct equipment and options are actually connected.

(c) The tester should familiarize himself with the various operating conditions of the circuit to be tested. A few brief notes pertaining to the operation of a specific circuit will quite often prove helpful in testing and servicing the circuit. These notes should be attached to the circuit layout card or sketch.

9.02 Circuit order tests should be made in accordance with the sections covering the type of facility assigned to the service. See Sections

331-100-500 and -501 and other sections as applicable for 1000-Hz transmission tests and noise measurements.

9.03 Local practices should be followed in removing circuits from service. It is important, however, that both ends of the circuit be made busy in those cases where it can be seized by switching equipment at either end.

9.04 Certain precautions should be observed when monitoring circuits. The circuit can be monitored at standard monitoring jack appearances of carrier channels and repeaters without affecting circuit operation or balance conditions. Monitoring across the 2-wire loops requires use of a high-impedance monitoring arrangement that does not place a direct current path across the loop.

9.05 In testing the signaling and supervisory functions of the special access circuit, the tester should place a call from a local telephone to the subscriber by dialing the number assigned to the circuit, or by having the operator make the connection. The subscriber should then be requested to place a call over the circuit to a telephone at the tester's location. During both calls all signaling and supervisory functions such as dialing, ringing, flashing, tripping, etc, should be checked. Overall signaling tests are described in BSP division 333.

9.06 In service, overall transmission measurements of special access circuits require several precautions to guard against erroneous results. In general, one must insure that a "seizure" or "off-hook" condition is provided at both terminals so as to remove signal tones, open idle circuit terminations, and cut through the transmission path. The test equipment should present the proper impedance.

9.07 At the station terminal, in loop-start or ground-start applications, both the milliwatt source and the transmission measuring set must be arranged for line holding so as to provide an operate path for the supervisory relay in the special access circuit. Examples of test equipment with this feature, as well as 900 ohms impedance are as follows:

23A Transmission Measuring Set

23B Transmission Measuring Set

TTS-4 Transmission Measuring Set

(Northeast Electronics)

KS-19353 Oscillator

9.08 The 21A TMS and 13A TMS ***do not*** provide a holding circuit and cannot be used except in conjunction with a device such as the 2AB auxiliary TMS or SD-96540-01 test termination circuit.

9.09 The preferred arrangement at the switching end is a connection through the central office switching equipment to a code 101 test line jack, or to a test jack similar to that provided by SD-98100-01, Fig. 7 or SD-67025-01. The test jack circuit provides the proper holding path to simulate an "off-hook" condition at the switching end of the circuit. This permits various tests such as two-way transmission measurements to be performed while maintaining the normal talking condition.

9.10 In some instances, the 2-wire side of special access circuits may have a jack appearance in a private line testboard. Care should be exercised in attempting to make transmission tests from this point. At the time this is written there are no standard arrangements at private line test boards to provide a holding circuit which supplies battery and ground to the special access circuit. If it becomes necessary to make tests from this location, local arrangements are required to insure proper relay operation in the special access circuit.

9.11 The E2L and E2S SF units contain strapping options associated with the built-in compromise network. They permit adding capacitance and are used to improve the return loss. They are particularly useful in the E2S when the special access station loop is nonloaded.

10. REFERENCE MATERIAL

Plant Series Sections

005-120-103	Winding and Spring Designations
179-100-301	▶Signaling and Transmission Systems Compatibility Information—General
179-100-302	T1 Carrier System—Signaling Compatibility
179-100-303	V4 Telephone Repeater—Signaling Compatibility

179-100-304	E-Type Signaling System—Signaling Compatibility
179-100-305	E-Type Repeater—Signaling Compatibility
179-100-306	F-Type Signaling System—Signaling Compatibility
179-100-308	Type F Signaling System—FU and Auxiliary Units—Signaling Compatibility◀
179-331-101	E1P Single-Frequency Signaling Unit—Description
179-332-101	E1R Single-Frequency Signaling Unit—Description
179-701-101	DC Signaling Systems—Description
179-702-101	CX and SX Signaling Systems—Description
311-350-100	Balance Test Considerations—PBX 4-Wire VNL Tie Trunks and Access Lines
311-350-500	Balance Test Procedure for PBX Switched 4-Wire
365-010-100	T1 Carrier System—Overall System—General Description
500-114-100	Ringing Limitations
534-362-071	◗No. 1 Crossbar Central Offices—Having 1300-Ohm Subscriber Conductor Loop—400-Ohm Talking Battery Feed Circuit—AC/DC or Superimposed Ringing—84- Through 88-Vac Component)—Office Voltage of 48 V (Floating)
534-362-073	Panel Central Offices—Having 1300-Ohm Subscriber Conductor Loop—140-Ohm Talking Battery Feed Circuit—AC/DC Ringing (84-Through 88-Volt AC Component)—48-Volt Minimum Office Voltage (Floating)
534-362-074	Panel Central Offices—Having 785-Ohm Subscriber Conductor Loop—50-Ohm Talking Battery Feed Circuit—AC/DC or Superimposed Ringing—84 Through 88 Volts (AC Component)—Minimum Office Voltage of 24.5 (Floating)
534-362-075	Panel Central Offices—Having 635-Ohm Subscriber Conductor Loop—50-Ohm Talking Battery Feed Circuit—AC/DC or Superimposed Ringing—(72-, 80-, 84-Volt Minimum AC Component)—Minimum Office Voltage of 21 V
534-362-076	No. 5 Crossbar Central Offices—Having 1360-Ohm Subscriber Conductor Loop—400-Ohm Talking Battery Feed Circuit—AC/DC Ringing (84- Through 88-Volt AC Component)—48 V Minimum Office Voltage (Floating)
534-362-077	No. 5 Crossbar Central Offices—Having 1430-Ohm Subscriber Conductor Loop—400-Ohm Talking Battery Feed Circuit—AC/DC Ringing (84- Through 88-Vac Component)—Office Voltage of 48 V (Floating)
534-362-079	Step-By-Step Line Finder Central Offices—Having 885-Ohm Subscriber Conductor Loop—400-Ohm Talking Battery Feed Circuit—AC/DC or Superimposed Ringing—(72-, 80-, or 84-Volt Minimum AC Component)—Office Voltage of 48 V (Floating)
534-362-081	Step-By-Step Line Finder Central Office—Having 1300-Ohm Subscriber Conductor Loop—400-Ohm Talking Battery Feed Circuit—AC/DC or Superimposed Ringing—(72-, 80-, or 84-Volt Minimum AC Component)—48-Volt Minimum Office Voltage (Floating)
534-362-152	Range Chart—Trunk and Station Conductor Loop Ranges for PBXs Connected to No. 1 Crossbar Central Offices Having 1300-Ohm Subscriber Conductor Loop—520-Ohm Talking Battery Feed Circuit—AC/DC or Superimposed Ringing (84- Through 88-Vac Component)—Office Voltage of 48 V (Floating)

536-580-110	558A PBX—Description of System Operation◀
851-310-101	Effect of PBX Trunk and Cord Circuits upon Station Loop Current
975-110-100	Local Subscriber Loop Signals and Signaling Systems
975-230-100	DX Signaling System
975-240-100	Type E Single-Frequency Signaling System
981-224-100	▶No. 400 Switching System◀
981-235-100	2A Automatic Call Distributing System
981-236-100	3A Automatic Call Distributing System
981-240-100	▶1A Telephone Answering System◀
981-531-100	557B PBX for Secretarial Answering Service—Description
981-610-100	701 and 711 PBX—General Description
981-660-100	756 PBX—General Description
981-662-100	757 PBX—General Description
981-680-100	▶770A PBX—General Description◀
981-705-100	800A PBX—General Description
981-706-100	▶801A PBX—General Description
981-709-100	805A PBX—General Description◀

Range Charts:

SD-96323-01	Range Chart for Dial Long Line Circuits—1200-Ohm Panel & Crossbar Central Offices
SD-96327-01	Range Chart for Dial Long Line Circuits—Dial PBXs
SD-96328-01	Range Chart for PBXs Using Dial Long Line Circuits SD-96234-01, SD-96252-01, etc.

11. TYPICAL CIRCUIT ARRANGEMENTS

11.01 The figures shown are examples of typical circuit configurations. These are not intended as a complete listing of all possible arrangements. They are representative of the various general configurations from which specific arrangements may be taken.