SIGNALING

TEST CONSIDERATIONS

VOICE AND VOICEBAND DATA CHANNELS

CONTENTS — PAGE

1. GENERAL

1.01 This section provides general information on signaling and signaling test considerations for voice and voiceband data channels. General test information is provided to network personnel responsible for the installation and maintenance of these channels. References are frequently made to customer or equipment operation sequences performed on the customer premises equipment (CPE) side of the network interface (NI). These are given for general informational purposes to provide a basic understanding of circuit operation. Actual responsibilities included in this practice are limited to the network side of the NI.

1.02 Whenever this section is reissued, the reason(s) for reissue will be given in this paragraph.

1.03 There are three broad areas of signaling: customer line signaling, interoffice trunk signaling, and customer-to-customer signaling. Customer line signaling is the communication between the customer's telephone set and the switching system serving the customer. An explanation of customer line signaling is covered in Section 975-110-100. Interoffice trunk signaling is concerned with the communication of call handling information between switching systems within the Public Switched Network (PSN). An explanation of interoffice signaling is covered in Section 975-120-100. Customer-to-customer signaling is the direct communications between two CPE locations without an intermediate access to the PSN. An explanation of customer-to-customer signaling is covered in this section and in Section 313-130-101.

A. Signaling and Supervisory Signals

1.04 ***Signaling:*** The paths can be derived from any of four basic transmission mediums: metallic, analog carrier, digital carrier, and Common Channel Interoffice Signaling (CCIS) System. Signaling is the process of transferring information over a distance to control the setup, holding, charging, and releasing of connections in a communications network.

1.05 ***Supervisory Signals:*** These signals are on-hook and off-hook conditions which provide circuit indications, such as circuit idle, circuit busy, seizure, and disconnect.

1.06 The restructuring of the special services requires a change in test procedures and type of test equipment used at customer premises (CP). This involves preservice (installation) and trouble (maintenance) testing, which is performed on network channels. Although specified transmission and signaling parameters remain basically the same, channel access and preservice tests have been changed significantly. Signaling and supervision tests must be made without the use of CPE, such as data sets, PBXs, and station sets. Simulation of these CPE supervision and signaling schemes will be addressed in this section.

B. Purpose of Signaling Test

1.07 Signaling tests are performed to ensure that the signaling functions of the channel operate in the prescribed manner. These tests must be made for each of the signaling states that will be encountered on the channel during its normal operation. If signaling exists in both directions on a channel, both directions must be tested and any failures to signal properly must be corrected before the channel is released to the customer. Most channels will transmit three types of signaling (ie, alerting, address, and supervision) for use by switching systems and station equipment. Signaling is often not symmetrical (ie, the signals are not the same in each direction nor are they used for the same purposes). As an example, a simple foreign exchange type service will have the central office (CO) sending ringing (alerting) and the station equipment sending on-hook/off-hook (supervision) and dialing (address), all of which must be tested to ensure proper operation of the channel to the customer.

1.08 In more complex channels, such as switched services networks [common control switching arrangements (CCSA) and enhanced private switched communications service (EPSCS)], there are necessary interactions between the network provided and CP switch. Certain electrical characteristics such as "handshake" protocols must now be tested with the use of test equipment.

2. TYPES OF SIGNALING

A. Loop Signaling

Loop-Start

2.01 Loop-start signaling is the normal type of signaling between a switching system and a customer telephone set. When the telephone is removed from its cradle or switchhook at the station end, a maximum resistance of 430 ohms is placed across the tip and ring conductors at the NI toward the switching end as a request for service.

2.02 Loop-start signaling is required when providing service for an off-premises PBX station, a foreign exchange line, or a manual PBX.

2.03 When the telephone is removed from its cradle, the off-hook signal is transmitted to the CO equipment as an indication of desired service. In turn, the CO equipment transmits a dial tone signal to the customer as an indication that the CO equipment is ready to receive the called number.

2.04 Address signals are normally applied to the loop by using a rotary dial or TOUCH-TONE* telephone set. In the off-hook condition, when the dial is pulled off normal and then released, the loop is opened and closed the number of times corresponding to the digit dialed. On a TOUCH-TONE telephone pad, a distinct 2-frequency tone is generated when the button for each digit is depressed. The total series of dc pulses or tones is considered the address or called number information.

2.05 When the telephone is returned to the cradle after the completion of the conversation, an on-hook signal is transmitted to the switching system. The on-hook signal starts the release of the CO equipment used to establish the connection.

2.06 An incoming call to the station end is recognized by the receipt of the ringing signal only. The usual ringing signal may be either a 20-Hz or 30-Hz (may be used in some operating companies)

*Trademark.

ringing voltage and 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 tried to originate a call from the station end is usually the person to whom the call was being directed.

Ground-Start

2.07 In many ways a dial PBX is similar to a dial CO 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 CO 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 to prevent a double ended originating connection (also sometimes known as "glare"). In the description of loop-start signaling, it was noted that 4 seconds could elapse before the station end of the facility recognized a seizure by the switching end. ***Ground-start signaling eliminates the 4-second seizure delay.*** When ground-start signaling is employed, the subscriber line circuit at the CO 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.

2.08 When the CO 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 ringing signal is received, a signal is given to the PBX attendant to indicate an incoming call. Modern PBXs, including the 800, 801, 805, 812 and DIMENSION®, do not have ringing detectors. If the tip ground persists for 1 second, it is assumed to be a legitimate call. The presence of ringing is ignored.

2.09 An outgoing call from the PBX toward the CO causes a ground through a resistance of 200 ohms minimum to 550 ohms maximum to be placed on the ring conductor toward the CO. The CO 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 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.

2.10 To repeat, the dial PBX recognizes ground on the tip conductor from the CO equipment as a seizure signal and the CO 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 CO switching equipment recognizes the opening of the loop as a disconnect signal. The PBX does not restore the trunk to the idle state until the tip ground from the CO is removed.

B. Loop Reverse Battery Signaling

2.11 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 dial pulse (DP) or multifrequency (MF) address information.

2.12 The direct inward dialing (DID) trunks with loop reverse battery signaling are used one way to complete calls from a CO directly to a PBX station by dialing the 3- or 4-digit station number directly into the PBX without the need for the PBX attendant. These DID trunks have all the qualities of interoffice trunks. They may operate delay-dial, wink-start, or immediate-dial [calls from step-by-step (SXS) COs or calls to SXS PBXs operate immediate dial only].

2.13 A trunk seizure at the calling office closes the loop by operating a relay at the called office. This 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, a 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.

2.14 The DID trunk supervision is accomplished using loop seizure/reverse battery signaling.

The PBX system must specify wink-start, delay dial, or immediate start operation when connected to common control central offices. This type of start operations is explained in paragraphs 2.15 through 2.19. This arrangement ensures that the dial pulse receiving equipment at the PBX is ready to receive the address information before it is sent from the central office. If the associated central office is SXS, there are no provisions for controlling the start of outpulsing from the central office. The PBX must prepare to receive address information during the interdigital dialing period or some or all of the pulses of the first digit will be lost. Although the detailed arrangements differ in the various PBX systems arranged for DID, they are generally comparable to the "bylink" arrangement used in central office switching systems.

2.15 ***Wink-Start:*** With wink-start operation, the trunk equipment signals an on-hook towards each end when in the idle condition. On receipt of a connect signal (off-hook from the originating office), the called office initiates a request for register (or sender), but the called office does not immediately return an off-hook signal to the originating office. The idle condition (on-hook) signal to the originating office is maintained until the register (or sender) is attached at the called office, at which time a wink-start signal is sent by the called office.

2.16 ***Delay-Dial With Integrity Check:*** With integrity check, the originating office will not outpulse until a delay-dial (off-hook) signal followed by a start-dial (on-hook) signal has been recorded at the originating office. This method is very much like wink-start operation.

2.17 In the delay-dial with integrity check method of controlled outpulsing, seizure of the trunk by the originating office causes the called office to return a delay-dial (off-hook) signal. However, the delay-dial signal does not have to be returned within a given interval (ie, 300 milliseconds). It can be delayed for a longer period since the originating office will not begin outpulsing until it has received an off-hook (delay-dial) signal followed by an on-hook (start-dial) signal. It is the performance of this positive signaling sequence from on-hook to off-hook to on-hook that verifies the "integrity" of the trunk.

2.18 The delay-dial signal in this method of controlled outpulsing must meet the following requirements:

(a) The off-hook must be a minimum of 140 milliseconds in duration.

(b) The off-hook to on-hook transition (start-dial) must not occur until:

(1) 210 milliseconds after the connect signal is received

(2) The register or sender is attached and ready to receive pulses.

It is desirable to minimize the post dialing delay by sending the off-hook to on-hook transition as soon as possible after the above requirements are met. The signaling system used with the transmission facility will distort the off-hook (delay-dial) signal as it is transmitted between offices. As a result, the originating office must recognize an off-hook as short as 100 milliseconds as a delay-dial signal.

2.19 ***Immediate-Dial Start:*** The immediate-dial start trunk groups employing common receiving equipment (such as senders or registers) may be equipped at the called end with fast links (or bylinks), with both the links and the common receiving equipment liberally engineered to minimize delays. Such groups are normally ready to receive pulsing in about 120 milliseconds after receipt of the connect signal. Immediate-dial is used with these trunks and is required for direct-dialed centralized automatic message accounting traffic from nonsenderized step-by-step offices to avoid the use of a second dial tone. In addition, dial pulsing trunks from common control offices to direct control switching systems which are ready to accept digits immediately after seizure need not employ delay-dial. Some advantage is realized, however, if delay-dial is employed for signaling integrity check purposes. Most trunks, in order to direct control switching systems, are ready to receive digits without delay and are normally in the start-dial, on-hook condition.

2.20 In No. 5 crossbar central offices arranged for line link pulsing, the DID trunk is called a line link pulsing trunk because the trunk is connected to the line side rather than the trunk side of the switching network. In some Bell Operating Companies (BOC), for No. 5 crossbar the pulsing can be closed to provide either loop pulsing or battery and ground pulsing. In the No. 1 Electronic Switching System (ESS) office, a regular loop-dial pulse trunk is used and connected to the trunk side of the switch. Start-dial supervision may be either a fixed 200 ms delay, wink-start, or delay-dial as determined by the capability of the PBX. In all other respects, the operation is identical.

C. Automatic Identified Outward Dialing (AIOD) Data Channel Simplex Signaling

2.21 The dc signaling over the data channel provides a ***bid*** signal for a data receiver at the AIOD central office, a ***ready*** signal as acknowledgement of the data receiver attachment, a ***disconnect*** signal, and a ***time out*** signal. This signaling is provided over the simplex (SX) of the data channel transmission path, and in some cases this signal is converted to single frequency (SF) signaling.

2.22 In the idle or standby state, the AIOD data channel equipment provides battery (−48 volts nominal) on the SX and the AIOD central office equipment provides a ground.

2.23 As a ***bid*** for a data receiver at the CO, the PBX changes the SX from battery to ground. When the CO has connected a data receiver and is ready to receive station and trunk identification information (frequency shift keying data), the CO changes the SX from ground to battery (−48 volts nominal). The SX current will be a minimum of 22 mA. At the conclusion of the data message, the PBX will transmit a ***disconnect*** signal (changes the SX from ground to battery).

2.24 The CO will transmit a ***disconnect*** signal (change the SX from battery to ground) after receipt of the data message. If no data is received from the PBX, the CO will send a time out ***disconnect*** signal (change the SX from battery to ground). The PBX cannot send a new ***bid*** signal for a minimum of 45 ms after receipt of the CO disconnect signal.

D. E and M Lead Signaling

2.25 The E and M lead signaling systems derive their name from certain historical designations of the signaling leads on the circuit drawings covering these systems. In systems of early manufacture, the E and M lead signaling interface consisted of two leads: the M lead which transmits battery or ground signals from the trunk circuit to the signaling system and the E lead which receives open or ground signals from the signaling system toward the trunk circuit. The near-end condition is reflected by the M lead and the far-end condition by the E lead.

2.26 There are a number of different types of signaling systems which employ E and M lead signals.

(a) E and M lead to duplex (DX) signaling converters to extend the E and M leads over a cable facility

(b) Built-in signaling arrangements using 3700 Hz employed in the O, ON, and N1 type carrier systems

(c) Digital (D type channel banks) E and M lead signaling channel units which encode the E and M lead information in the bit stream.

(d) In-band external SF signaling units of the E, F, G, or equivalent types.

2.27 The early E and M lead signaling arrangements used only one lead for each direction of signal transmission. Current flowing between the switching equipment trunk circuit and the signaling system utilized a common ground return path. At the present time there are five standardized E and M lead interface arrangements. These are designated types I through V. The Federal Communication Commission (FCC) Part 68 registration rules for category III service provides type I and type II A and B (E and M lead) signaling interface. The type I interface is the original 2-wire E and M lead signaling interface designed for use with electromechanical switching systems. Signaling from the switching equipment trunk circuit to the signaling system is over the M lead using nominal −48 volts for off-hook and local ground for on-hook. Signaling from the signaling system to the trunk circuit is over the E lead, using the signaling system ground for off-hook and open for on-hook.

2.28 The type II interface is a 4-wire fully looped, but nonsymmetrical arrangement. Signaling from the trunk circuit to the signaling system is by means of opens and closures across the M and SB leads for on-hook and off-hook, respectively. Since the signaling system supplies −48 volts to the SB lead, the effect is to signal on the M lead with battery for off-hook and open for on-hook. Signaling from the signaling system to the trunk circuit is by means of opens and closures across the E and SG leads for on-hook and off-hook, respectively. Since the trunk circuit supplies ground on the SG lead, the effect is to signal on the E lead with open for on-hook and ground for off-hook. Type II interface provides complete separation between the signaling system and trunk circuit power supplies. Registration rules also provide for the customer terminal equipment to provide either signaling system (type B) or trunk circuit (type A) E and M lead functions. The circuit design will require:

(a) DX-1 E and M lead (signaling system)

(b) DX-2 E and M lead (trunk circuit)

(c) Equivalent type I or II, A or B interface to meet the CPE.

The registered CPE is provided on A side (trunk circuit) or B side (signaling system) of the NI. The type I and II signaling interfaces with E and M leads are shown in Fig. 1.

E. Ringdown Signaling

2.29 The ***manual ringdown*** signaling for both 2-point and multipoint channels requires that the CPE provides a means for manually connecting ringing voltage to the channel. The duration and repetition of the ringing signal is under the control of the originator. Ringing will then be applied to all stations on the channel.

2.30 A code select service can be provided that will ring selected stations (code select ringdown) on a multipoint service. The customer selects the ringing code for each station or group of stations on the circuit. The codes are a series (normally 1 to 12) of ringing pulses. This information is then used to option the network ringing equipment. The repetition of the ringing signal is under the total control of the originator. The network equipment will count the number of rings produced from the CPE and ring only the station or stations assigned that code. The ring signal will usually be only one 2-second ringing signal. The CPE must provide means of locking this signal in if required.

2.31 The ***automatic ringdown*** signaling (2 point) channel eliminates the necessity of manually producing a ringing signal at the calling station. When the telephone at the calling station goes off-hook, loop current, as supplied from the network, will flow. This will provide a conversion within the network equipment to supply ringing voltage to the NI of the called station. When the called station answers, goes off-hook, the ringing is tripped or stopped and dc current flows in the called station loop as provided by the network to power the telephone. Both stations must then hang-up, go on-hook, before either station can originate a new call. For the normal 2-point service, the network supplies the dc power to operate the CPE (telephone set), the ringing power, and the ringing trip operation, using private line automatic ringing (PLAR) equipment.

2.32 A multipoint automatic ringdown service can be provided. Because the necessary signaling conversions take place within the CPE, the network design is identical to multipoint manual ringdown design.

3. SIGNALING MEASUREMENT CONSIDERATIONS AND TEST EQUIPMENT FUNCTIONAL REQUIREMENTS

3.01 Test equipment with additional functions over that generally available in the past will be necessary. The signaling measurement and simulations for tests are listed in the following paragraphs.

A. Range of Measurements for Test Equipment

3.02 Test equipment must be capable of measuring the following:

(a) DC current from 0 to 100 mA

(b) DC voltage from 0 to 100 volts

(c) AC voltage from 0 to 100 volts rms

(d) Pulsing (42 to 84 percent break)

- Loop signals
- E lead (ground)
- E and SG lead (short)
- M lead (battery)
- M and SB lead (short)

(e) Resistance measurements from 0 to 30k ohms

(f) Timers from 0.2 to 2.0 seconds.

B. Network Interface Requirements for Test

3.03 Test equipment must be capable of simulating the following electrical characteristics:

(a) Battery supply simulator (Fig. 2)

- Class A PBX port

- Class B PBX port
- Class C PBX port
- Typical switching equipment

(b) Loop and ground-start simulators (Fig. 3A for off-hook current and Fig. 3B for on-hook current condition)

(c) Manual on/off hook simulation for pulsing conditions [8 pulses per second (PPS) at 64 percent break and 11 PPS at 58 percent break]

- Loop signals with 300 ohms (Fig. 4)
- E lead (ground 150 ohms)
- E/SG lead (shorts 300 ohms)
- M lead (battery 42.5 volts and 60 ohms)
- M/SB lead (shorts 300 ohms)

(d) Ring tripping with 330 ohms simulator (Fig. 5)

(e) Ring simulator with ringer equivalent number (REN-3) (Fig. 6)

(f) Ringing voltage simulator (Fig. 7)

(g) Four-wire termination simulator (Fig. 8).

C. Test Access at Customer Premises

3.04 The test access at customer premises will be at the NI, consisting of a 66M3-50 connector block, or equivalent. This makes available, as appropriate, the tip and ring, tip 1 and ring 1, E and M, SB, and SG leads. Access to the interoffice channels is accomplished at the appropriate CO by means of Switched Maintenance Access System (SMAS) jacks, either local or remote, testboard type jacks, or other access points. The transmission path must be completed and the proper options applied to the transmission and signaling equipment before the signaling tests can be made. The transmission tests should be completed before the signaling tests, as the circuit must have continuity, proper network equipment, and equipment options, including gains and losses [especially when voice frequency (VF) signaling is employed].

4. CHANNEL TESTING VS SERVICE TESTING

4.01 As a result of regulatory actions, terminal equipment has been removed from the regulated entity of special services. The results of this action provides a family of channels with specified transmission and signaling parameters rather than the traditional specific services. The channels are still closely related to the services that they are intended to provide, but the channel is offered, not the specific service.

4.02 In the past, private line channels were tested through terminal equipment to provide test access for transmission, signaling, and supervision of the channel. This type of testing for terminal equipment contributed to the transmission performance of the overall service.

4.03 Since network is now providing a channel with certain specified capabilities rather than a private line service (such as a PBX tie trunk), it is the network's responsibility to assure the proper operation of the channel only. For a channel terminated at customer premises, this responsibility ends at the NI and does not include CPE.

5. GLOSSARY OF TERMS

5.01 The following abbreviations (terms) are used in this section.

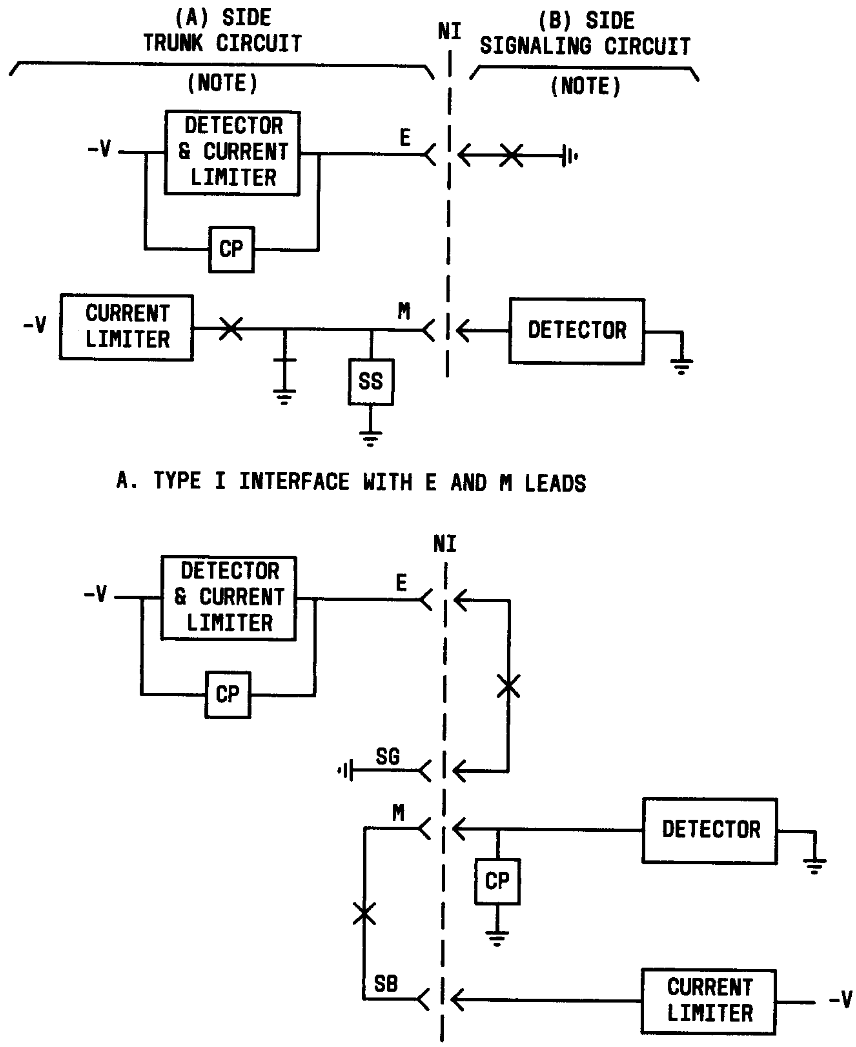
TERM	DEFINITION
AIOD	Automatic identified outward dialing
BOC	Bell Operating Company
CCIS	Common channel interoffice signaling
CCSA	Common Control Switching Arrangement
CO	Central office
CP	Customer premises
CPE	Customer premises equipment
DID	Direct inward dialing
DP	Dial pulse

TERM	DEFINITION
DX	Duplex
EPSCS	Enhanced Private Switched Communications Service
ESS	Electronic Switching System
FCC	Federal Communications Commission
MF	Multifrequency
NI	Network interface
PLAR	Private line automatic ringing
PPS	Pulses per second
PSN	Public Switched Network
REN	Ringer equivalent number
SF	Single frequency
SMAS	Switched Maintenance Access System
SX	Simplex
SXS	Step-by-step
VF	Voice frequency

6. REFERENCES

6.01 The following sections contain additional information about voice and voiceband data channels.

SECTION	TITLE
179-000-000	Numerical Index—Signaling Circuits and Associated Ringer Circuits
313-100-100	General Introduction, Preservice and Maintenance, Voice and Voiceband Data Channels
313-110-100	Transmission, Test Considerations, Voice and Voiceband Data Channels
313-120-100	Transmission Tests, Requirements and Limits, Voice and Voiceband Data Channels
313-120-101	Signaling Tests, Requirements and Limits, Voice and Voiceband Data Channels
313-130-100	Central Office, Transmission and Signaling Test Procedures, Voice and Voiceband Data Channels
313-130-101	Customer Premises, Transmission and Signaling Test Procedures, Voice and Voiceband Data Channels
332-000-000	Numerical Index—Voice-Frequency Telephone Repeaters, Pilot Wire Regulators, Echo Suppressors, Composite Sets and Associated Equipment
333-000-000	Numerical Index—Overall Signaling Arrangements and Testing
362-000-000	Numerical Index—Type N, O and ON Carrier Telephone Systems and Associated Equipment Components
363-000-000	Numerical Index—Pair Gain Systems
365-000-000	Numerical Index—Digital Transmission Systems
501-250-303	C-Type Ringers
660-000-000	Numerical Index—Test Center Operation
975-000-000	Numerical Index—Signaling Systems and General Descriptive Information



B. TYPE II INTERFACE WITH E AND M LEADS

LEGEND: CP = CONTACT PROTECTION
SS = SURGE SUPPRESSION
-V = -42.5 TO -52.5 VOLTS DC

NOTE: REGISTERED TERMINAL EQUIPMENT CAN BE (A) OR (B) SIDE OF NETWORK INTERFACE

Fig. 1—Type I and II Signaling Interface With E and M Leads

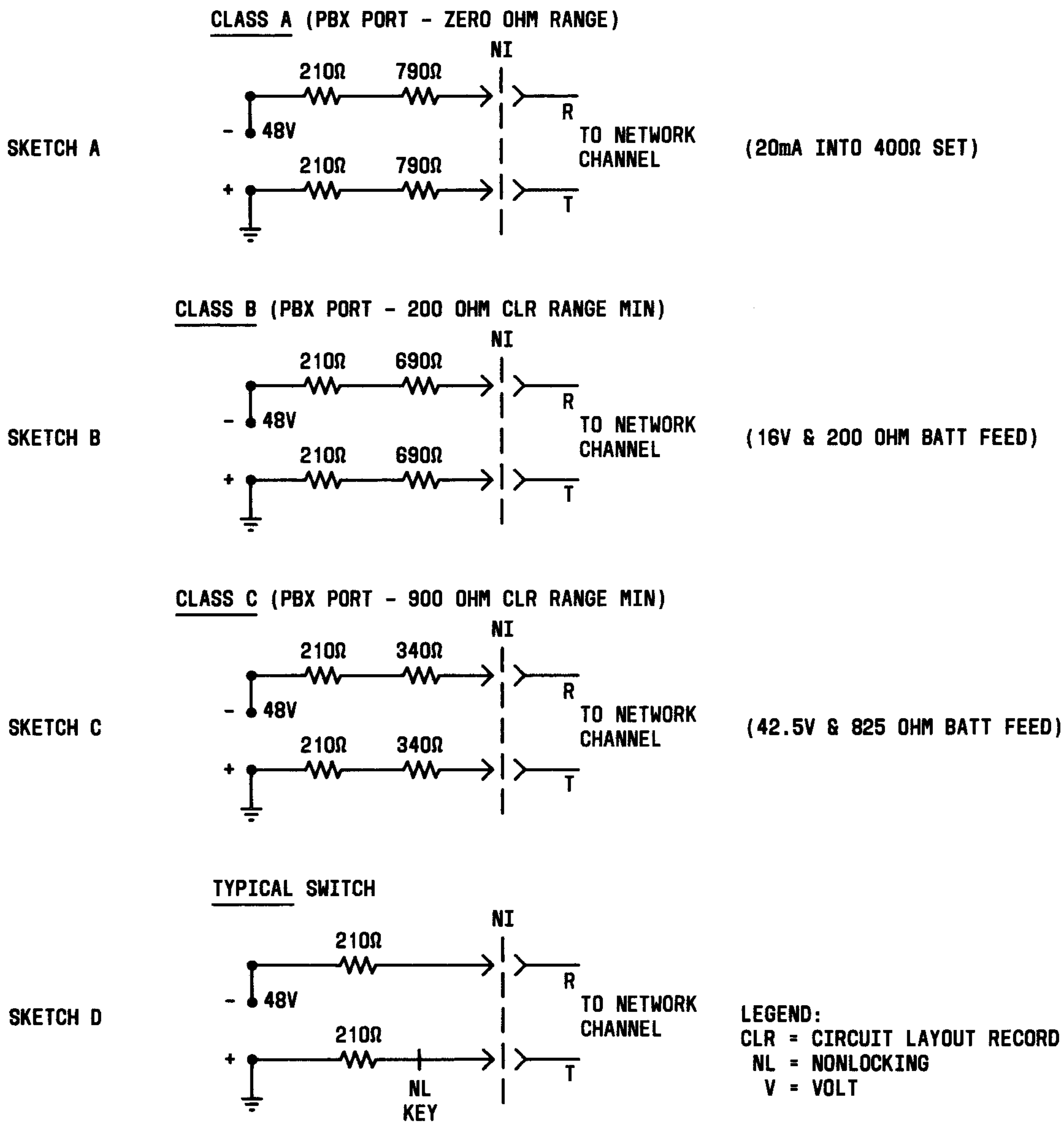


Fig. 2—Battery Supply Simulator for CPE

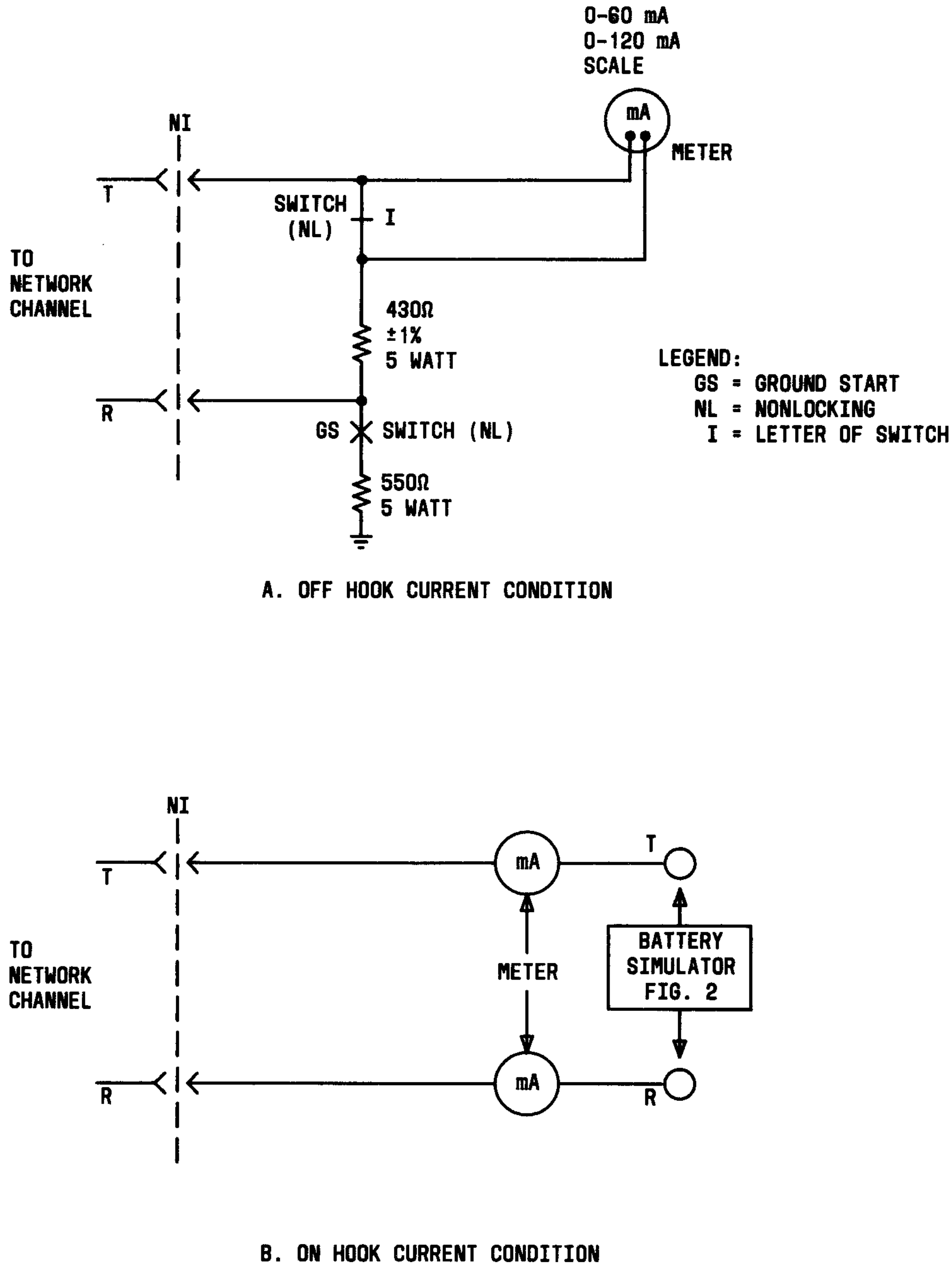
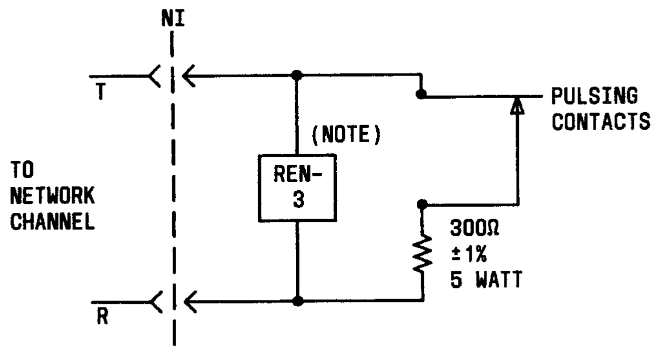


Fig. 3—Loop- and Ground-Start Current Simulators for CPE



NOTE:
THE "REN 3" INDICATES THE EQUIVALENT OF THREE C4A RINGERS CONNECTED IN PARALLEL. A C4A RINGER CAN BE SIMULATED BY CONNECTING A 3650-OHM 110-HENRY INDUCTOR IN SERIES WITH 0.45 μF CAPACITOR. THREE SUCH CIRCUIT ARRANGEMENTS CONNECTED IN PARALLEL CONSTITUTES WHAT IS REFERRED TO AS "REN 3".

Fig. 4—Dial Pulsing Simulator for CPE

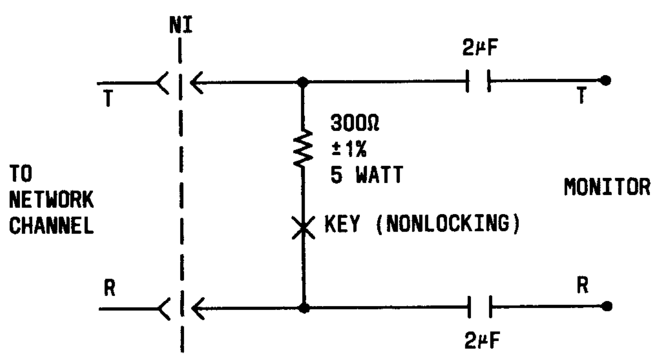
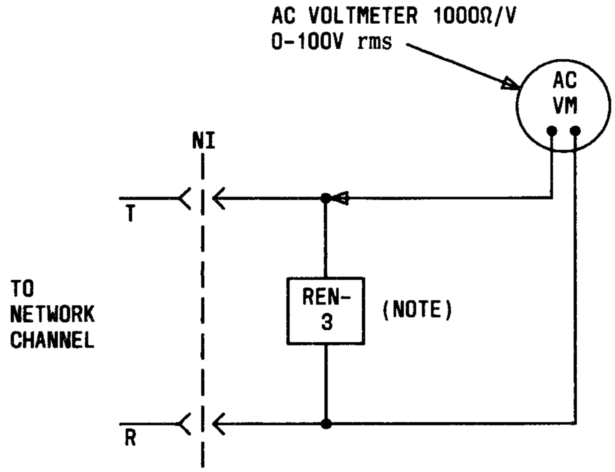


Fig. 5—Ringing Trip Simulator for CPE



NOTE:
THE "REN 3" INDICATES THE EQUIVALENT OF THREE C4A RINGERS CONNECTED IN PARALLEL. A C4A RINGER CAN BE SIMULATED BY CONNECTING A 3650-OHM 110-HENRY INDUCTOR IN SERIES WITH 0.45 μF CAPACITOR. THREE SUCH CIRCUIT ARRANGEMENTS CONNECTED IN PARALLEL CONSTITUTES WHAT IS REFERRED TO AS "REN 3".

Fig. 6—Ringer Simulator for CPE

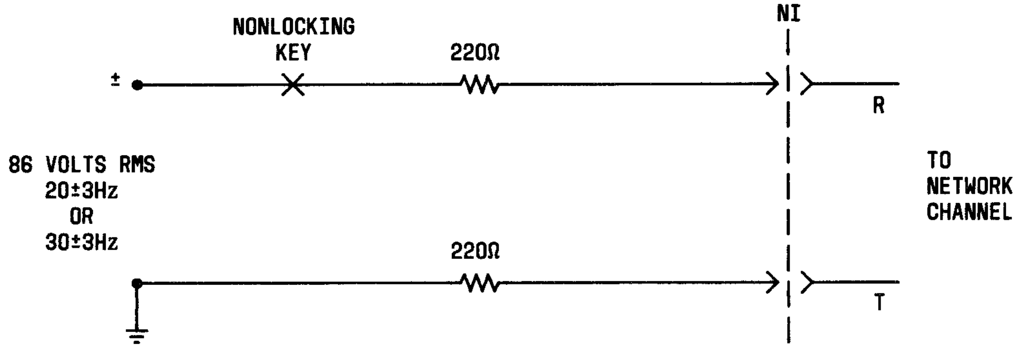


Fig. 7—Ringing Supply Voltage Simulator for CPE

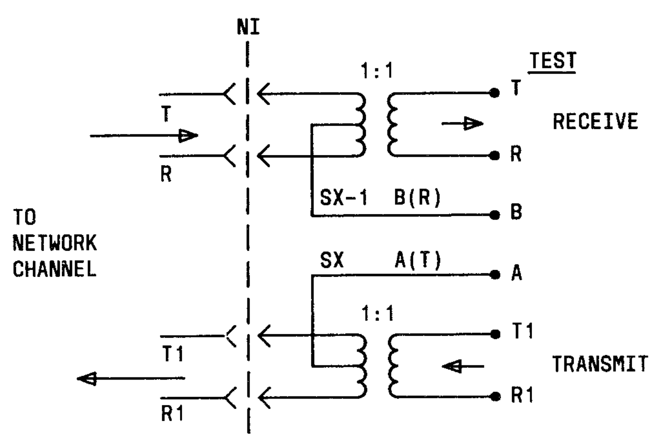


Fig. 8—4-Wire Termination Simulator for CPE