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APPLICATION NOTE

Configuring the 930A for Common PBX Metallic Signaling Interfaces

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Introduction

The Sage Model 930A Communications Test Set is renowned for its usefulness and versatility in testing switched voice services. This Application Note is intended to help you correctly set up a 930A for testing the variety of metallic analog circuit types interfacing PBX's (Private Branch Exchanges). ***Note:*** The descriptions and setup information described in this document can also be applied to the Sage Model 930i Communications Test Set.

Primer

For years, the telephone industry has provided -48 VDC for supervision, and you will see future paragraphs refer to it as *typically* being such. However, in the real world you will find -48 VDC is relative to conditions. It is PBX manufacturer relative. It can be loop length relative. It can even be relative to the quality of the available ground (that is, ground at the ground level of a 25 story high rise, may in fact not be the same ground found on the 25th floor. Fortunately, designers of the Sage 930A have taken such differences into consideration and provided Menu Option 7: Supervision Thresholds. We will get more into this function shortly.

To effectively use a 930A to test signaling and supervision on PBX circuits, you must be familiar with the front panel supervision control and indicators. Start by locating the stainless steel toggle switch near the bottom center of the Sage 930. Notice it has labels reading **On Hook** in the down position and **Off Hook** in the up position. Think of this switch as the equivalent of lifting the handset on your phone. Directly above this switch you will find a group of four LED's. The two on the left have the word **Orig** over them, and the two on the right have the word **Term** over them.

When a 930A is terminating one end of a circuit, the **Orig** side LED's reflect the 930's supervision state (on- or off-hook). Conversely, the **Term** LED's reflect the supervision state of the far end. For example, suppose you are using your 930A to emulate the PBX end of a DID trunk and you have the front panel "hook" switch in the on-hook (down) position. If you know the circuit is idle and you connect the 930A TR jack to the incoming loop, you should immediately see the "On-Hook" LEDs lit for both the **Orig** (930) side and **Term** (Central Office) side. On the other hand, if the **Term**-side *off*-hook LED is lit while the **Orig**-side *on*-hook LED is lit, you are receiving a loop closure (seizure) from the Central Office switch.

At times, you may encounter a condition where *none* of the LED's light on the **Orig** or **Term** side. This does not indicate a burned out LED as you might first suspect. It tells you the 930A accepted what you set as the physical trunk interface under the TRUNK TYPE button, then looked out and what it sees coming back does not fit what it expects. Rather than give you an erroneous reading, it merely turns the LED's off. On the other hand, it could actually send an LED to an **Off Hook** state when you know the trunk is idle, because it sees a voltage potential that it might expect during an **Off Hook** condition.

When you experience such indications, you should do the following: First, go back to TRUNK TYPE and verify you have this set correctly. If you see supervision states opposite of what you expect, you may be seeing the effects of a tip-ring turnover. To check, you can physically swap your cable connections to the circuit TR leads, OR you can select the **REVERSE LOOP** Trunk Type.

If you still haven't found the cause of the erroneous supervision state indication (and you're positive the circuit supervision is working okay) the problem may be an inappropriate Supervision

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Threshold setting in the 930A. Use Menu Option 6: DC VOLT/AMP METER, in combination with Menu Option 7: SUPERVISION THRESHOLDS to correct the problem. The DC VOLT/AMP METER function is useful for measuring the actual circuit voltages during the on- and off-hook states, and the SUPERVISION THRESHOLDS function allows you to temporarily alter what the 930A considers as on- and off-hook states. See **Appendix A** for more information on these two functions and how to use them.

LOOP START

General

Loop Start is the most basic and common analog interface today. It has been used for years to supply Plain Old Telephone Service (POTS) to residential customers and many small business customers. PBX's can have two types of loop start interfaces: 1) Trunk and 2) Line. The **Trunk** interface has a 900 ohm impedance and typically faces the local telephone company switch, while the **Line** interface has a 600 ohm impedance and connects to a user's telephone set.

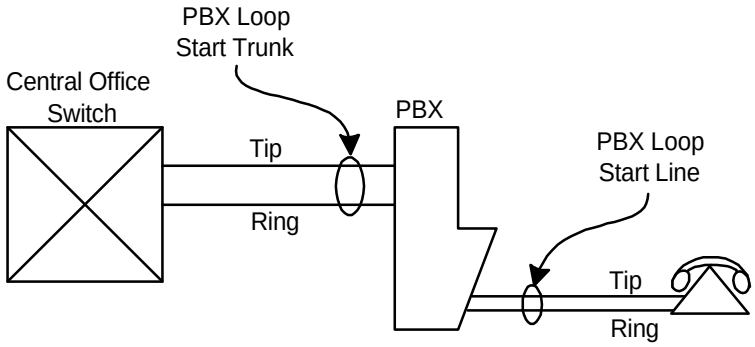


Figure 2 — Loop Start Interfaces

Trunk Interface Description

A PBX loop-start trunk employs a 2-wire Tip and Ring (TR) 900 ohm interface. The **signaling method** is very simple and straight forward. The Central Office end supplies -48 VDC to the Ring lead and Ground on the Tip lead of the facility. To go off-hook, the PBX end simply closes the loop through a signaling CONTACT to complete current flow through this loop. The Central Office end reverses the polarity of its facility battery feed to communicate an off-hook condition toward the PBX. **Dialing** is typically performed using DTMF or Dial Pulse digits.

> **Note:** This section covers normal Loop-Start trunks. DID (Direct Inward Dial) trunks are covered elsewhere in this Application Note.

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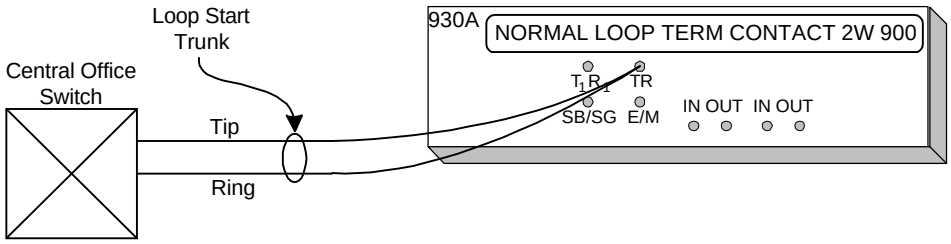


Figure 3 — Emulating the PBX End of a 2-Wire Loop Start Trunk

Remember that, in a normal loop-start trunk, the PBX end closes a CONTACT across Tip and Ring to go off-hook, and opens that contact to go on-hook. So, set the 930A Trunk Type to NORMAL, LOOP, TERM, ***CONTACT***, 2W 900 as shown in the steps below:

1. Repeatedly press the TRUNK TYPE button (top left black button on the front panel) until the red LED beside it illuminates. Note that three quick pushes of the Trunk Type button will force the 930A to this function, regardless of what menu it may have been in.

2. Repeatedly Press Softkey 1 (the leftmost unmarked dark grey key directly under the display) until the words **NORMAL LOOP** appear above it.

3. Next, press Softkey 4 (the far right unmarked dark grey key directly under the display) until the display reads **2W 900**.

4. Now, press Softkey 3 until the display reads **CONTACT**.

5. Finally, press Softkey 2 until the word **TERM** appears. The display should now look like the illustration below:

   NORMAL LOOP TERM CONTACT 2W 900

Now, you can connect a test cord from the front panel TR jack to the TR leads from the central office switch. The 930A supervision LED's should light, properly indicating the supervision state of the 930A (ORIG) and the switch (TERM). If they don't check your connections. If the connections are correct but the LED's still don't give proper indications, refer to APPENDIX A of this Application Note for trouble-shooting hints.

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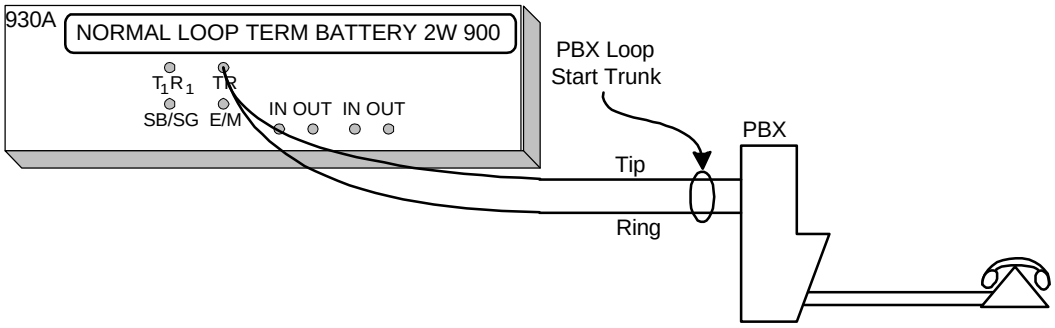


Figure 4 — Emulating the C.O. End of a 2-Wire Loop Start Trunk

Remember that, in a normal loop-start trunk, the Central Office sources battery voltage to the 2-wire loop. So, set the 930A Trunk Type to NORMAL, LOOP, TERM, ***BATTERY***, 2W 900 as shown in the steps below:

1. Repeatedly press the TRUNK TYPE button (top left black button on the front panel) until the red LED beside it illuminates.

2. Repeatedly Press Softkey 1 (the leftmost unmarked dark grey key directly under the display) until the words **NORMAL LOOP** appear above it.

3. Next, press Softkey 4 (the far right unmarked dark grey key directly under the display) until the display reads **2W 900**.

4. Now, press Softkey 3 until the display reads **BATTERY**.

5. Finally, press Softkey 2 until the word **TERM** appears. The display should now look like the illustration below:

   NORMAL LOOP TERM BATTERY 2W 900

Now, you can connect a test cord from the front panel TR jack to the TR leads from the PBX. The 930A supervision LED's should light, properly indicating the supervision state of the 930A (ORIG) and the switch (TERM). If they don't, check your connections. If the connections are correct but the LED's still don't give proper indications, refer to APPENDIX A of this Application Note for trouble-shooting hints.

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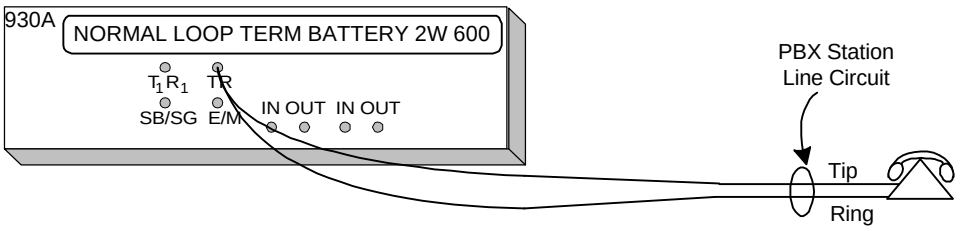


Figure 5 — Emulating the PBX End of a PBX Line Circuit

In a PBX line circuit, the PBX sources battery voltage to the phone attached to the 2-wire loop and the phone has an impedance of 600 ohms. So, set the 930A Trunk Type to NORMAL, LOOP, TERM, ***BATTERY***, 2W 600 as shown in the steps below:

1. Repeatedly press the TRUNK TYPE button (top left black button on the front panel) until the red LED beside it illuminates.

2. Repeatedly Press Softkey 1 (the leftmost unmarked dark grey key directly under the display) until the words **NORMAL LOOP** appear above it.

3. Next, press Softkey 4 (the far right unmarked dark grey key directly under the display) until the display reads **2W 600**.

4. Now, press Softkey 3 until the display reads **BATTERY**.

5. Finally, press Softkey 2 until the word **TERM** appears. The display should now look like the illustration below:

   NORMAL LOOP TERM BATTERY 2W 600

Now, you can connect a test cord from the front panel TR jack to the TR leads from the phone. The 930A supervision LED's should light, properly indicating the supervision state of the 930A (ORIG) and the switch (TERM). If they don't, check your connections.

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930A Setup — Emulating the Phone End of a PBX Line Circuit

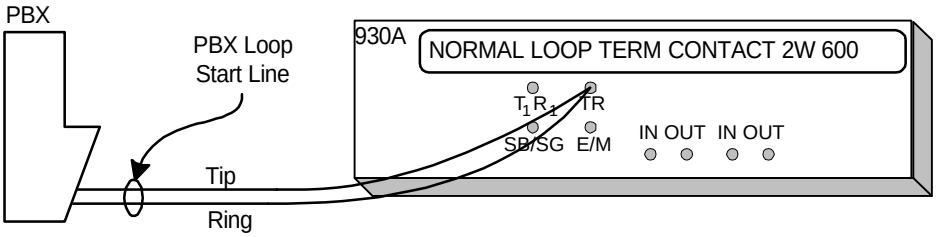


Figure 6 — Emulating the Phone End of a PBX Line Circuit

Remember that, in a 2-wire phone line, the phone end closes a CONTACT across Tip and Ring to go off-hook, and opens that contact to go on-hook. So, set the 930A Trunk Type to NORMAL, LOOP, TERM, ***CONTACT***, 2W 600 as shown in the steps below:

1. Repeatedly press the TRUNK TYPE button (top left black button on the front panel) until the red LED beside it illuminates. Note that three quick pushes of the Trunk Type button will force the 930A to this function, regardless of what menu it may have been in.

2. Repeatedly Press Softkey 1 (the leftmost unmarked dark grey key directly under the display) until the words **NORMAL LOOP** appear above it.

3. Next, press Softkey 4 (the far right unmarked dark grey key directly under the display) until the display reads **2W 600**.

4. Now, press Softkey 3 until the display reads **CONTACT**.

5. Finally, press Softkey 2 until the word **TERM** appears. The display should now look like the illustration below:

   NORMAL LOOP TERM CONTACT 2W 600

Now, you can connect a test cord from the front panel TR jack to the TR leads from the PBX line circuit. The 930A supervision LED's should light, properly indicating the supervision state of the 930A (ORIG) and the switch (TERM). If they don't check your connections. If the connections are correct but the LED's still don't give proper indications, refer to APPENDIX A of this Application Note for trouble-shooting hints.

Loop Start Hints

1. If you want to BRIDGE (i.e. half-tap) the 930A on to a working PBX phone circuit and capture digits from the phone using **OPTION MENU # 4: DIGIT RECEIVER**,
   a. Make sure the 930A Trunk Type is in BRIDGE mode to eliminate the possibility of interference or damage to the PBX or phone.
   b. If you want to capture digits from the phone, you must emulate the PBX. So, set the 930A Trunk Type to BATTERY mode.

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DID

(Loop Start with a Twist)

Trunk Interface Description

DID (Direct Inward Dial) is a one-way in-bound dial line to the PBX. Its purpose is to allow outside calls to be routed through a PBX, without the assistance of an operator.

Why call it loop start with a twist? For one thing, the BATTERY source is provided by the PBX instead of the Central Office. Also, this form of loop start circuit generally includes wink-start operation -- the "start dial" signal is a wink from the PBX. A bit twisted, don't you think?

The call set-up looks something like this: The Central Office seizes the loop by providing loop closure just like a telephone set going off hook. The PBX then returns the equivalent of dial tone by providing a momentary loop battery reversal for 150 — 250ms (also known as a wink). The Central Office then outpulses the last four to five digits of the called number. The PBX uses these digits to complete the routing directly to an internal station (telephone or equivalent).

Note: The mix of digits sent on DID lines is pretty well split 50/50 between dial pulse, and DTMF across the country. However, since wink start was not typically associated with the line side, some earlier switches had to treat DID facilities like trunks, where DTMF was not an available choice. Thus, dial pulse may be more prevalent in some areas. You may also encounter MF digits (though most PBX's don't have a method of provisioning to receive MF digits), so just be aware and verify things like this prior to cut date.

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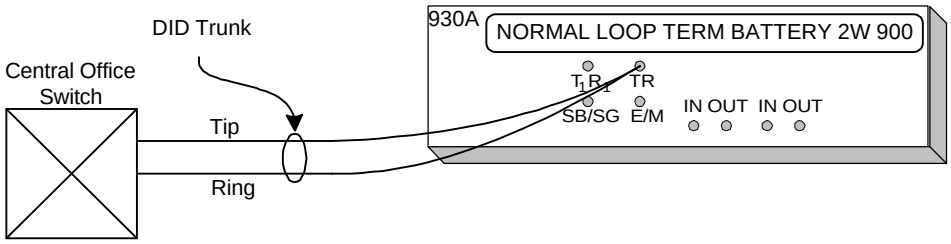


Figure 7 — Emulating the PBX End of a DID Trunk

Remember that, in a DID trunk, the PBX end sources the talk battery. So, set the 930A Trunk Type to NORMAL, LOOP, TERM, ***BATTERY***, 2W 900 as shown in the steps below:

1. Repeatedly press the TRUNK TYPE button (top left black button on the front panel) until the red LED beside it illuminates. Note that three quick pushes of the Trunk Type button will force the 930A to this function, regardless of what menu it may have been in.

2. Repeatedly Press Softkey 1 (the leftmost unmarked dark grey key directly under the display) until the words **NORMAL LOOP** appear above it.

3. Next, press Softkey 4 (the far right unmarked dark grey key directly under the display) until the display reads **2W 900**.

4. Now, press Softkey 3 until the display reads **BATTERY**.

5. Finally, press Softkey 2 until the word **TERM** appears. The display should now look like the illustration below:

   NORMAL LOOP TERM BATTERY 2W 900

Now, you can connect a test cord from the front panel TR jack to the TR leads from the central office switching machine. The 930A supervision LED's should light, properly indicating the supervision state of the 930A (ORIG) and the switch (TERM). If they don't, check your connections. If the connections are correct but the LED's still don't give proper indications, refer to APPENDIX A of this Application Note for trouble-shooting hints.

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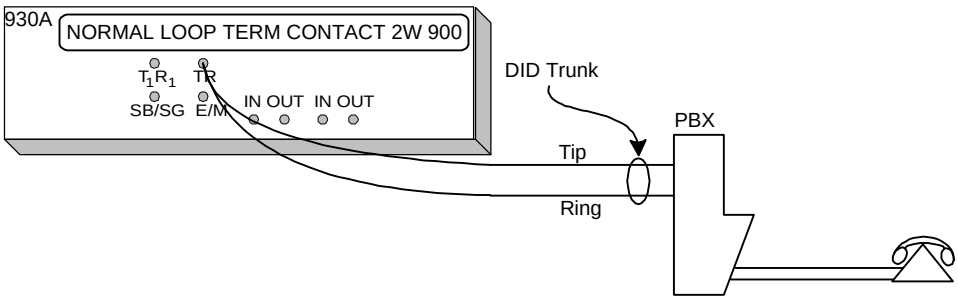


Figure 8 — Emulating the Central Office End of a DID Trunk

Remember that, in a DID trunk, the Central Office end does the loop closure. So, set the 930A Trunk Type to NORMAL, LOOP, TERM, ***CONTACT***, 2W 900 as shown in the steps below:

1. Repeatedly press the TRUNK TYPE button (top left black button on the front panel) until the red LED beside it illuminates. Note that three quick pushes of the Trunk Type button will force the 930A to this function, regardless of what menu it may have been in.

2. Repeatedly Press Softkey 1 (the leftmost unmarked dark grey key directly under the display) until the words **NORMAL LOOP** appear above it.

3. Next, press Softkey 4 (the far right unmarked dark grey key directly under the display) until the display reads **2W 900**.

4. Now, press Softkey 3 until the display reads **CONTACT**.

5. Finally, press Softkey 2 until the word **TERM** appears. The display should now look like the illustration below:

NORMAL LOOP TERM CONTACT 2W 900

Now, you can connect a test cord from the front panel TR jack to the TR leads from the PBX. The 930A supervision LED's should light, properly indicating the supervision state of the 930A (ORIG) and the switch (TERM). If they don't, check your connections. If the connections are correct but the LED's still don't give proper indications, refer to APPENDIX A of this Application Note for trouble-shooting hints.

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GROUND START

Trunk Interface Description

Ground Start is most commonly found in either PBX to Central Office, or Payphone facilities. In the PBX to Central Office world, ground start was first introduced as a method to arbitrate "glare" on two way dialing facilities, and as a mechanical method of extending answer supervision. "Glare" is defined as both ends of a facility trying to gain access to a circuit at the same moment in time.

In today's modern telephone environment, most Central Offices and PBXs have built in software intelligence designed to arbitrate "glare" (in other words, when both ends try to seize at the same moment, there is a software algorithm designed to tell one or the other to back off and select another choice). This intelligence has not always been available and a more mechanical means known as ground start was employed. This way, a Central Office or PBX can run tests for voltage potentials on individual leads prior to seizure. With this method, a trunk can be tested for idle, or determine if it is in the process of being seized by the far end, without barging into a call in progress. Because this was traditional, these types of trunks are common even today.

In the case of the Payphone, this provides a method of security to prevent users from gaining access to dial tone until money is deposited. Again, in today's more modern world, the payphones are smarter and able to prevent dial tone by means of internal software. But, tradition has preserved many of these lines as ground start signaling.

After you get past the single lead signaling (such as Ring ground, Tip closure), you will note how ground start signaling is very similar to loop start signaling. The noted difference being the initial process of seizure.

When the station (PBX) end or CONTACT end initiates seizure, rather than just closing Tip and Ring as a loop start does, it initially tests the Tip lead to insure it's not connected to ground. If open (no potential), the station end closes a contact on the Ring lead to ground. The Central Office end or BATTERY sourcing end, detects this Ring ground. It then closes the Tip lead to ground at the same time it applies dial tone (thus you see how the Tip ground can also be interpreted as a "receiver ready" condition. This was used in the days before a PBX had a means of detecting dial tone, and needed a more mechanical indication of when to begin dialing). When the PBX detects the Tip ground from the Central Office, it will close Tip and Ring as a loop, then remove the Ring ground.

NOTE: This last sentence is important to remember. The PBX **must not** remove Ring ground, until loop closure is complete (In other words, it better not go back to the idle state while going to loop closure. This is sometimes seen on digital T1 channels supporting ground start signaling. The PBX is not supposed to send A=0, B=1 (idle) while transitioning to A=1, B=1 (loop closure) from the A=0, B=0 (Ring ground) state).

When the Central Office or BATTERY sourcing end needs to initiate seizure, it first tests the Ring lead for a ground potential. If the Ring lead is open, the Central Office closes the Tip lead to ground, and applies ringing to the line. When the PBX answers, the Central Office does no more signaling beyond disconnecting the ringing generator (some Central Offices may in fact open the Tip lead for a very short interval 20 — 30ms, just as cut through from ringing occurs. This is known as an Open Switch Interval and is acceptable for this short duration.)

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The physical facility make-up for this trunk type is generally 2-wire (Tip and Ring) with a 900 ohm impedance.

From the Central Office direction, typically -48 VDC is applied to the Ring lead, and the Tip lead is left open (no potential, not grounded).

Dialing generally employs DTMF digits, although you will occasionally encounter Dial Pulse.

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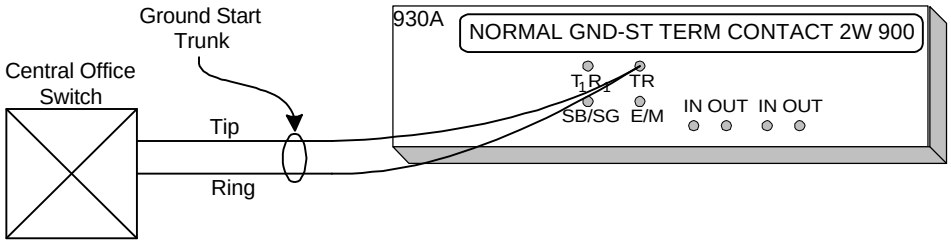


Figure 9 — Emulating the PBX End of a Ground Start Trunk

1. Repeatedly press the TRUNK TYPE button (top left black button on the front panel) until the red LED beside it illuminates. Note that three quick pushes of the Trunk Type button will force the 930A to this function, regardless of what menu it may have been in.

2. Repeatedly Press Softkey 1 (the leftmost unmarked dark grey key directly under the display) until the words **NORMAL GND-ST** appear above it.

3. Next, press Softkey 4 (the far right unmarked dark grey key directly under the display) until the display reads **2W 900**.

4. Now, press Softkey 3 until the display reads **CONTACT**.

5. Finally, press Softkey 2 until the word **TERM** appears. The display should now look like the illustration below:

NORMAL GND-ST TERM CONTACT 2W 900

Now, you can connect a test cord from the front panel TR jack to the TR leads from the Central Office. The 930A supervision LED's should light, properly indicating the supervision state of the 930A (ORIG) and the switch (TERM). If they don't check your connections. If the connections are correct but the LED's still don't give proper indications, refer to APPENDIX A of this Application Note for trouble-shooting hints.

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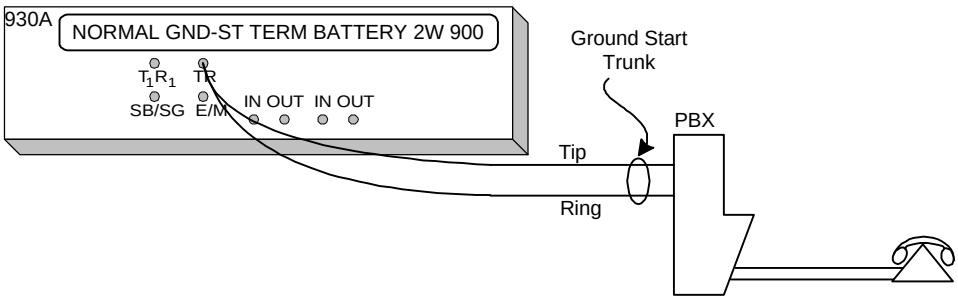


Figure 10 — Emulating the CO End of a Ground Start Trunk

1. Repeatedly press the TRUNK TYPE button (top left black button on the front panel) until the red LED beside it illuminates. Note that three quick pushes of the Trunk Type button will force the 930A to this function, regardless of what menu it may have been in.

2. Repeatedly Press Softkey 1 (the leftmost unmarked dark grey key directly under the display) until the words **NORMAL GND-ST** appear above it.

3. Next, press Softkey 4 (the far right unmarked dark grey key directly under the display) until the display reads **2W 900**.

4. Now, press Softkey 3 until the display reads **BATTERY**.

5. Finally, press Softkey 2 until the word **TERM** appears. The display should now look like the illustration below:

   NORMAL GND-ST TERM BATTERY 2W 900

Now, you can connect a test cord from the front panel TR jack to the TR leads from the PBX. The 930A supervision LED's should light, properly indicating the supervision state of the 930A (ORIG) and the switch (TERM). If they don't check your connections. If the connections are correct but the LED's still don't give proper indications, refer to APPENDIX A of this Application Note for trouble-shooting hints.

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APPENDIX A

Two Useful Functions

There are two Option Menu selections that are not often used, but can be very useful when interfacing the 930A to metallic analog circuits: 1) Menu Option 7 — Supervision Thresholds), and 2) Menu Option 6 — (DC Volt/Amp Meter). The Supervision Thresholds function allows you to modify the threshold values the 930A uses to determine when a circuit is on- or off-hook. The DC Volt/Amp Meter function allows you to measure the actual on- and off-hook voltages of the circuit.

Option Menu 6: DC VOLT/AMP METER

Begin by disconnecting the test cord to the T/R jack and perform a calibration. The 930A prompts you through the steps. After calibration is completed, press the Softkey under VOLTAGE. The display should read: MEASURE RING TO TIP = +XXVDC EXIT. If it displays any other state than RING TO TIP, press Softkey 1 or 2 until it displays RING TO TIP (Not RING TO GROUND, or TIP TO GROUND).

With the HOOK SWITCH placed in the **On Hook** position, record the voltage being displayed. Now place the HOOK SWITCH in the **Off Hook** position and record the voltage being displayed. You will need these recorded readings for use in the following menu.

Option Menu 7: SUPERVISION THRESHOLDS

As you open this menu by pressing any Softkey, the first display will read:
NO INDICATION IF LOOP < 3 V DEFAULT
Which makes sense — if you have less than three volts, you likely are looking into an open.

Press Softkey 1, 2 or 3 to proceed to the next menu. Now depending on whether you selected the Battery sourcing end, or the Contact closing end as the TRUNK TYPE, the displays will differ somewhat:

CONTACT:
ORIG OFF HOOK IF LOOP < 39 V DEFAULT
Which means the LEDs on the **Orig** side will display an off-hook state if the loop voltage drops below 39 volts, but will remain in the **On Hook** state as long as the voltage remains above 39 volts. Since, in this example, the 930A is set to emulate the CONTACT end, it considers the end which provides a loop closure (Contact closure) to be the **Orig** end. So, if you are bridged across a PBX telephone line, the **Orig** LED's indicate the on-/off-hook status of the phone. Similarly, if you are bridged across a DID (Direct Inward Dial) trunk, the **Orig** LED's indicate the supervision status of the Central Office (remember, on DID trunks, the PBX end sources battery, and the Central Office end does loop closures).

Suppose the voltage you recorded for the **Off Hook** condition while in Option Menu 6 was something above 39 volts? You will need to adjust this value accordingly, by punching in the value of the recorded voltage into the numeric keypad. This so the 930A LED's will track **On Hook** and **Off Hook** conditions properly. (Note: If you are using the 930A to emulate, this will likely not be a problem. Where this is most required is when you want the 930A to set in the bridge condition between two working facilities, and follow the supervision states from each end.)

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BATTERY:
ORIG OFF HOOK IF LOOP REVERSES
The Battery end of a circuit (usually the Central Office end, except for DID trunks) supplies -48 VDC on the RING lead, and Ground on the TIP lead. The only way, then, for the battery end to signal, is to reverse the potentials normally found on the TIP and RING (This is for example how a PBX issues a Wink on a DID trunk -- by momentarily reversing TIP and RING).

Press Softkey 1, 2, or 3 to proceed to next menu:

CONTACT:
TERM OFF HOOK IF LOOP REVERSES.

Since you have set the trunk type to Contact (thereby defining the **Orig** end as the Contact end), the 930A looks at the Central Office end as the **Term**, or terminate end. Again, the only way for the battery end to signal is to reverse the potentials normally found on the TIP and RING. There is no adjustment you can make in this field. This is for information only.

BATTERY:
TERM OFF HOOK IF LOOP <39 V DEFAULT

Since you have defined the **Orig** end as the battery sourcing end, the **Term** will be the station end device. When the station end goes OFF HOOK by completing a loop closure (closing a set of contacts), the loop voltage will fall. The 930A will display an off-hook condition on the **Term** side if the Tip-to-Ring voltage drops below 39 volts. If for some reason this is not a valid threshold for the circuit you are testing, you will need to adjust the OFF HOOK voltage in this menu.

Press Softkey 1, 2 or 3 to proceed to next menu:

CONTACT and BATTERY:
60 Hz SUPERVISION FILTER: ON OFF

This final menu will be the same whether you have set the Trunk Type up as the Contact end, or Battery sourcing end. If your anticipated method of addressing (dialing) on this facility is Dial Pulse, select OFF as the choice. If the signaling type is DTMF or MF, simply use the default ON as the choice.

If Ground Start is chosen as the TRUNK TYPE, you will note the screens in OPTION MENU 7 (SUPERVISION THRESHOLDS) will differ somewhat. The test set will be more concerned with things like Ring lead potentials, and Tip lead potentials. Simply work through each menu choice, just as I have shown here, using Menu Option 6 (DC VOLT/AMP METER) in to determine what each threshold should be.

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