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Technical Practice

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SYSTEM 640 DID TO LOOP START INTERFACE

Contents

1. General Description

1.1 PRACTICE This practice issue is released due to a change in the number of DID address digits that the System 640 will accept. Two digits are no longer accepted, seven digits now are.

1.2 PRODUCT OVERVIEW The System 640 is a specialized telecommunications interface device capable of allowing equipment intended for connection to loop start trunk circuits to be interfaced with Direct Inward Dial (DID) trunks. The DID trunks are provided by a telephone company central office (CO), to which the System 640 acts as a technically correct DID terminal device. To the loop start equipment, the System 640 looks like a standard loop start trunk, or specifically like an off-premise station (OPS) port on a PBX.

Operation commences when the CO seizes a DID trunk. If required, the System 640 sends back a wink to the CO. The CO then outputs pulse dial address signals that correspond to the telephone number dialed by the calling party. The System 640 decodes and stores this number, and starts ringing the associated loop port. Upon answer, the stored number is transmitted via DTMF tones to the loop equipment. Then 2-way audio is connected between the calling and the called parties. Either party going on-hook terminates the call in both directions.

The System 640 provides the correct protocols to the calling and called parties. The calling party hears the normal progress tones and is billed for the call only upon answer. Bridged ringing alerts the loop start equipment of an incoming call. The loop start equipment can answer an incoming call by simply going off-hook. Standard DTMF tones are sent to the loop start equipment to identify the incoming number. Reverse battery answer supervision is sent back to the CO. If the loop start equipment wants to hang up, it simply goes on-hook. If the calling party hangs up, the System 640 momentarily breaks loop current to the loop start equipment. Everything looks normal to both sides. No hardware and little or no software changes are required for the loop start equipment.

1.3 DESIGN PHILOSOPHY Our goal for the System 640 was to make it completely compatible with loop start equipment. We didn't want to get tricky, inventing new protocols, etc. An additional priority was making it easy to install and use. We think we achieved all that. We feel that this product will correctly connect to all CO DID trunks in the U.S. and Canada. All equipment intended for connection to loop start trunk lines should work correctly with the System 640.

1.4 NUMBER OF CHANNELS The System 640 provides four channels of interface circuitry. Up to four DID trunks can be connected, with one loop port associated with each DID trunk.

The System 640 dedicates one specific DID trunk to one respective loop port.

1.5 CO DID TRUNKS The System 640 interfaces with immediate and wink start CO DID trunk lines. The unit can be configured to accept 3, 4, 5 or 7 digit CO pulse dial address signals.

1.6 LED STATUS INDICATORS Nine LED status indicators are located on the System 640 circuit boards and are visible with the cover on or off. These LED's will greatly assist in determining the operating status of the System 640 during installation, testing and maintenance.

1.7 TELEPHONE LINE CONNECTIONS All interconnections are made via eight 6-position modular jacks. Four jacks are associated with the four DID trunks; four jacks are associated with the four loop ports. These jacks conform to the United States RJ11C and Canadian CA11A standards. The System 640 connects to the outside world using standard modular cords.

1.8 POWERING The System 640 requires an external source of 18Vac for operation. An 18Vac, 40VA modular transformer is shipped with each unit.

1.9 PHYSICAL DESCRIPTION The System 640 consists of a precision-fabricated steel enclosure containing three circuit boards. The System 640 measures 14.0-inches high (35.56cm), 10.0-inches wide (25.40cm), 2.5-inches deep (6.35cm), and weighs 9.5 pounds (4.3kg). The unit wall mounts with four #10 screws. An access hole in the bottom right corner of the enclosure facilitates entry of power and telephone line connecting cables.

1.10 FCC REGISTRATION The FCC Part 68 registration number is EPR5ZC-17261-PX-N, ringer equivalence 0.0B.

2. Applications

2.1 VOICE MESSAGING INDUSTRY A growing area of telecommunications work is the automatic sending and receiving of information between a human being and a computerized terminal device. In most instances, this terminal equipment is intended for direct connection to loop start telephone lines. The System 640 allows for the direct addition of DID capability to this equipment. The addition of the System 640 provides significantly enhanced features with little or no software changes on the loop equipment; in no way will the loop equipment require any hardware modifications. Contact Gordon Kapes, Inc. for confirmation of compatibility.

2.2 TEMPORARY DID TRUNK ANSWERING In certain situations, it may be necessary to have the capability to directly answer incoming DID calls. Obviously a PBX system set for DID service is a viable implementation. However, there are times when the cost of a PBX, or lack of availability, make the System 640 a good choice. Remember that the System 640 will not act as a tiny PBX and route incoming calls to different telephones. The four DID trunk ports on the unit connect incoming calls to the four dedicated loop ports. If single line telephones are to be connected to the loop ports, they must have ringers that will work correctly with the 90Vac, 60Hz ringing signals produced by the System 640. A 60Hz ringing signal will correctly activate most electronic key systems that might be connected to the loop ports. In an application such as this a switch on the unit can be set to disable the sending of DTMF address signals to the loop ports, thus preventing DTMF tones from being heard when an incoming call is answered.

2.3 DID BACKUP CAPABILITY The System 640 can serve as a backup for equipment that normally handles a facility's incoming DID traffic. Some operations, such as a public service or a hospital, require total redundancy to insure that incoming calls will be answered. A set of transfer relays (such as the BP-1 from Gordon Kapes, Inc.), a small uninterruptible power supply (UPS) system, an inexpensive electronic key system, and one or more System 640s will provide an excellent DID trunk backup system.

2.4 CO ADDRESS SIGNAL COMMUNICATION The System 640 uses a simple format to transmit the address signals sent by the CO onward to the equipment connected to the loop ports. The pulse dial address signals are the digits representing the telephone number dialed by the calling party. Upon receiving a call over the DID trunk, the System 640 rings the loop port. After the loop port is answered, a set of DTMF digits is automatically transmitted. The last digit sent is always "#," which informs the loop equipment all digits have been sent and signifies the end of the address signals. In this way, only the System 640 must be programmed with the number of digits the CO will send. If the CO sends four pulse dial digits, then the System 640 will send those four digits and a "#" at the end, using DTMF tones. After the DTMF tones are sent, the DID trunk is coupled with the loop port. The exact timing of this sequence is listed in the specifications section of this practice.

2.5 SPECIAL APPLICATIONS Special applications for the System 640 are possible. We encourage you to contact Gordon Kapes, Inc. with your specific requirements.

3. Limitations

3.1 ADDRESS SIGNALS The unit will not accept DTMF address signals from the CO. Only pulse dial address signals are accepted. (Of course once the call is in progress, DTMF tones generated by the calling or called party are transmitted.) The unit will only send the incoming address signals to the loop equipment using DTMF tones. Dial pulses will not be sent out over the loop circuits.

3.2 NUMBER OF CHANNELS The System 640 provides four channels of specialized interface. Additional channels can be provided by simply adding additional units. There is no expansion capability beyond four channels per unit.

3.3 NO FANCY CALL ROUTING The System 640 contains modular jacks to facilitate connection to four DID trunks and four loop devices. Each of the four DID trunks is dedicated for connection to one specific loop port. For instance, DID trunk number one connects only to loop port one; DID trunk two connects only to loop port two, and so forth. The System 640 is not meant to route calls using the incoming address signals. The incoming digits on a specific DID trunk are merely detected, stored, and sent on via the complementary loop port. The unit cannot route specific incoming numbers to a specific loop port.

3.4 BRIDGED RINGING The System 640 internal ringing generator is 90Vac, 60Hz instead of the more standard 90Vac, 20 or 30Hz. The loop ports use this 60Hz signal for bridged ringing to alert the connected device to an incoming call. This 60Hz signal is an approved ringing frequency, but cannot be guaranteed to "ring" all communications equipment. Standard

telephone sets with mechanical ringers will only give a slight buzz with 60Hz. Some older loop start equipment may not detect a 60Hz ringing signal. Check your specific equipment prior to connection. Virtually all telephones with electronic ringers and modern loop start equipment will correctly detect 60Hz ringing. If a situation does arise where 20 or 30Hz ringing is required, provision has been made for you to disconnect the internal 60Hz ring generator and provide your own source. Refer to the Installation section of this practice for details. In practice the 60Hz ringing should present very few problems.

3.5 UPS SYSTEM RECOMMENDED DID trunk specifications call for DID terminal equipment, such as the System 640, to keep correct loop voltage on the DID trunk at all times. Losing this loop voltage, even for a few minutes, can cause the CO to turn off the DID trunks, allowing no incoming calls. In most cases, contacting the local telephone company is necessary to get the trunks turned on again. If the power supplied to the System 640 is interrupted, the voltage to the trunks will also be interrupted, and the trunks may be "downed" by the CO. To prevent this from happening, make sure the transformer that provides power to the System 640 is plugged into a small UPS system, similar to those used with personal computers. The System 640 uses very little power (about 40 watts) and even the smallest of UPS systems should work fine.

4. An Overview of DID Trunks

4.1 BASIC UNDERSTANDING Most people are not familiar with how a DID trunk operates. A basic understanding will greatly reduce the desire to pull one's hair out, or to make threatening phone calls to Gordon Kapes, Inc. Unlike standard central office loop or ground start trunks, a DID trunk depends on many more signals originating from the terminal equipment. In our case, the terminal equipment is the System 640. Another frequently used piece of terminal equipment is a PBX system. For discussion purposes, we will contrast a loop start trunk with a DID trunk.

4.2 GROUNDWORK A loop start trunk and a DID trunk physically consist of two wires called tip and ring. All signals between the CO and the terminal equipment are carried over these two wires. In most cases, a loop start trunk can be used for incoming and outgoing calls. A DID trunk is used only for incoming calls. With a loop start trunk, the CO provides the power, loop current and voltage, for the trunk. In the idle, on-hook, state you will usually have ground on the tip lead and –48Vdc on the ring lead. This –48Vdc is sometimes called loop battery by the telco types. With a DID trunk, the terminal equipment is required to provide the power; the System 640 provides about –53Vdc and ground. In the active, off-hook state, the loop power is usually measured as loop current. Loop current usually ranges from about 18 to 80 milliamperes.

4.3 CALL ALERT With a loop start trunk, the CO alerts the terminal equipment that a call is coming in by applying a high voltage ringing signal across the trunk (usually 90Vac, 20Hz). With a DID trunk, the CO alerts the terminal equipment (remember, the System 640 is the terminal equipment) of an incoming call by placing a load across tip and ring (referred to as the CO seizing the DID trunk). This load looks just like a standard 500/2500-type single line telephone connected across the DID trunk's tip and ring leads. No ringing voltage is associated with a DID trunk!

4.4 INCOMING PATHS Normally there is a literal phone number associated with a loop start trunk. If you dial that number, the loop start trunk will "ring." A DID trunk must be considered as an incoming communications path between the local central office and the terminal equipment. It is impossible to "dial" directly to a DID trunk. When DID service is ordered from the local telephone company, a group of telephone numbers is designated as the numbers reserved for the customers' incoming calls. This is commonly called a "block" of DID numbers. Then, a number of physical paths, the actual DID trunks, are ordered to link the central office with the location of the terminal equipment. In general, the number of DID trunks ordered is just a fraction of the number of telephone numbers in the previously selected "block." For example, you might have reserved 100 numbers in your DID block, such as 432-2300 through 432-2399. In addition, you made the assumption that at any one time most of the numbers would not be in use. So, you chose eight DID trunks and you immediately went out and bought two System 640s! How do people dialing the 100 different numbers in your block get to the terminal equipment? The central office routes any call made to any of the 100 numbers over the much smaller number of DID trunks you have. Think of the DID trunk group as a means of funneling the incoming calls over just a few paths. Consequently, you don't need 100 separate telephone trunks connected to 100 channels of terminal equipment (ah...the beauty of DID trunks!).

4.5 ADDRESS SIGNALS How does the terminal equipment know what telephone number was actually dialed by the calling party? The central office uses what is called address signaling to transmit over the DID trunk the last digits of the number that was dialed. Address signaling is simply a fancy name for the CO "dialing" a number to the terminal equipment. The number of digits sent over the DID trunk is specified by the CO. In our example, the CO might send the last three digits of the number dialed by the calling party. The CO would send address signals for 300 through 399 corresponding the callers dialing 432-2300 through 432-2399. The System 640 can be set to operate correctly with 3, 4, 5 or 7 digit pulse dial address signals. In most cases, this address signaling is in the form of dial pulses, just like using a rotary dial telephone (remember them?). The CO rapidly breaks the flow of current in the DID trunk to tell the terminal equipment what number was dialed. In a few cases, the CO can be set to send DTMF address signals. (Touch-Tone is AT&T's registered trademark for DTMF signals.) The System 640 responds only to pulse dial address signals. In the case of a PBX, the address signals inform the PBX to what extension to transfer the incoming caller. In contrast, the System 640 receives the pulse dial address signals, temporarily stores them, rings the loop port associated with this DID trunk, and upon loop answer retransmits the address signals as DTMF tones. The equipment connected to the loop port then uses the DTMF signals as a guide for handling the call.

4.6 GETTING AN ANSWER When a call is made over a loop start trunk, the progress tones heard by the calling party are generated in the CO providing service to the terminal equipment. Progress tones are the audio signals you hear when you make a telephone call. Some common progress tones are audible ring, busy, and reorder (fast busy). For DID trunks,

progress tones are generated by the terminal equipment. The System 640 generates the progress tones that are sent over the DID trunks and are heard by the calling party.

4.7 ANSWER SUPERVISION For a call coming in over a loop start trunk, the telephone company is able to determine when the called party answers by simply detecting when current in the tip and ring leads starts to flow, i.e., when the called party's trunk goes off-hook. The telephone company can then start billing the calling party for the call. The billing stops when the trunk goes back on-hook. With a DID trunk, the terminal equipment must tell the CO when the call has actually been answered. Progress tones have to be sent back to the calling party by the terminal equipment, but billing must only be started when the called party actually answers. The terminal equipment tells the CO when the call is answered by reversing the direction of the current flow in the DID trunk. This is called reverse battery answer supervision. When the called party hangs up, the terminal equipment simply reverses the flow of current back to the original state. The CO detects this, stops billing, and disconnects the calling party. The CO and terminal equipment are now ready for another call. The System 640 performs the reverse battery answer supervision protocols for correct operation in the public switched telephone network.

4.8 IMMEDIATE AND WINK STARTS TRUNKS There are two general types of DID trunks: Immediate start and wink start. A wink is simply a momentary reversal in the flow of DID trunk tip and ring current. There is no such thing as a wink with a loop start trunk. In the case of an immediate start DID trunk, the CO does not wait for an acknowledgment from the terminal equipment before sending the address signals. The CO simply seizes the trunk by going off-hook, and after a short pause sends the address signals. With a wink start trunk, the CO first seizes the trunk, then waits for the terminal equipment to send a wink. By waiting for a wink, the CO is giving the terminal equipment a chance to say, "OK, I'm ready for your address signals, let me have 'em." Depending on the CO that supplies the DID trunk, a wink from the terminal equipment may or may not be required. A configuration switch on the System 640 allows you to interface with wink or immediate start trunks. As a sophisticated device, the System 640 will work correctly with either type of trunk; neither one is preferred.

4.9 CO CAPABILITIES The path between the CO and the terminal equipment always stays open with a loop start trunk. The CO tries to send incoming calls even if the terminal equipment has been accidentally disconnected, has a power failure, or is not processing calls correctly. In the case of a DID trunk, the CO must see the correct signals from the terminal equipment or the trunk will be electronically turned off. This is called downing a DID trunk or downing a DID trunk group. When this happens, the calling party will never reach the terminal equipment and will usually just hear a reorder (fast busy) progress tone sent by the CO. The reason that the CO will down a DID trunk is, quite simply, to protect itself. The CO has only so much electronic capability to process calls. If a DID trunk is not working correctly from the terminal equipment side, valuable parts of the CO can be tied up waiting for the expected signals. If the CO does not see loop current, or does not get a wink (if required), the trunk will be downed. How long before a trunk or trunk group is downed is determined by the CO. Modern electronic CO's may down a DID trunk within a few seconds; older CO's may scan for problems less frequently but usually not less than once a day. High traffic city CO's will tend to down trunks faster. A DID trunk that is downed is not really broken, but must be reset by calling the CO. It is very, very important to be on good terms with the personnel at your CO. Having to call a standard repair number to have your DID trunks reset can sometimes result in hours or days of delay. Use your smarts to obtain the number of your CO and life will be easier!

4.10 DOWNED TRUNKS There are several scenarios that could lead a CO to down your DID trunks. The easiest way is for the System 640s 18Vac power source to be accidentally or intentionally disconnected. The System 640 must be powered at all times to keep your DID trunks working. Also, it is normal to find the DID trunks in the downed state at the time the System 640 is first installed. The installer from the local telephone company will install the DID trunks on RJ11C jacks, test them, and then leave. There usually will be hours, or days between when the DID trunks are installed and when they are connected to the terminal device, such as the System 640. This subject is talked about at length in the installation section of this practice.

4.11 OTHER MYSTERIES Incoming calls over a group of loop start trunks usually act in a hunt group configuration. All calls are dialed to one main number, with the first trunk in the group being the main number. If the first trunk is busy, the call goes to the second trunk. If the first five trunks are busy, the call goes to the sixth trunk. Basically, calls coming in over most loop start hunt groups, look, starting at the main number, for the first free trunk. DID trunks usually have what is called a random select hunt group. They are not usually truly random but follow a circular pattern; an incoming call goes to the DID trunk that is next in line from the trunk that last had a call come in on it. If you watch incoming calls long enough you can usually see the pattern. There are cases where the CO provides DID trunk hunt groups that are truly random, or are similar to a loop start trunk hunt group. These variables make for interesting testing!

4.12 SUMMARY A DID trunk physically consists of two wires called tip and ring. A DID trunk is a means of concentrating calls to a group of phone numbers into a smaller number of communication paths. A DID trunk doesn't have a "phone number" of its own. A DID trunk is connected to a CO on one end and to a terminal device on the other. In our specific case, the terminal device is the System 640. The terminal equipment supplies the power for the trunk. The CO alerts the terminal equipment that a call is coming in by seizing the trunk, i.e., going off-hook. Usually the CO "randomly" selects which DID trunk out of the trunk group is seized. Depending on the type of DID trunk, the terminal equipment may send a wink (a momentary reversal of loop current) back to the CO. The CO then sends address signals, usually dial pulses, to the terminal equipment. These address signals represent the telephone number the calling party dialed. The terminal equipment then returns audible ring progress tone to the calling party until the called party answers. When the called party answers, the terminal equipment reverses the flow of current in the DID trunk to notify the CO to start billing the call. If the called party is the first to hang up, the terminal

equipment reverses the flow of loop current, notifying the CO to stop billing and disconnect the calling party. If the calling party hangs up first, the CO breaks the flow of DID loop current. The terminal equipment disconnects the called party and resets for another call. If the CO does not see the correct signals from the terminal equipment, the trunks may be electronically "downed." A request must be made to the telephone company for the trunks to be reset.

Use this highly exciting information to impress your friends at the next party you attend! It may be a good means of never getting invited again. If DID trunk talk is not enough to get you removed from their guest list, try carrying a calculator and a retractable key chain on your belt.

5. Installation

5.1 WORDS OF CAUTION As with any product, installing the System 640 requires a safety first approach.

Warning: Never install telephone wiring during a lightening storm. Never install telephone jacks in wet locations unless the jack is specifically designed for wet locations. Never touch non-insulated telephone wires or terminals unless the telephone line has been disconnected at the network interface. Use caution when installing or modifying telephone lines.

5.2 CHECKING FOR DAMAGE The System 640 should be inspected for damage immediately upon receipt. A claim should be filed with the shipper if damage is found. A replacement should be ordered if necessary.

5.3 ITEMS REQUIRED The following items were packed in your System 640 shipping carton:

Qty	Description
1	System 640 DID to Loop Start Interface
1	18Vac/40VA transformer
1	3-conductor power cord
8	6-position modular to modular cables
1	Mounting hardware kit
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Materials required to do a thorough installation:

Qty	Description
1	Basic set of tools
1	Single-line telephone with modular plug. Must have an electronic "bell" that rings with 90Vac, 60Hz, not one with a mechanical bell that requires 20/30Hz ringing.
1	Pulse dial telephone with modular cord or
1	Linepersons handset with modular plug
1	Telephone number of the local CO to insure that you can call and have the did trunks reset. Assume that the did trunks have been downed since the time of their installation.

5.4 MOUNTING The System 640 wall mounts using four #10 pan head screws of the type appropriate for the wall material. The cover is secured by tightening the two screws located on the top and on the bottom of the cover. Only the top screw must be removed prior to detaching the cover. The mounting location is dictated by two requirements: Access to an electrical outlet and access to the RJ11C/CA11A jacks that provide connection to the DID trunks and the loop start type equipment. A CA11A jack is Canada's equivalent of a U.S. RJ11C jack.

5.5 INTERCONNECTIONS All interconnections are made via one 3-position screw terminal strip, one 4-position terminal strip, and eight 6-position modular jacks.

5.6 CONNECTING POWER Select an AC outlet that is convenient to the System 640. The outlet should stay "hot" all the time; it should never be switched off. You'll be connecting one end of the 3-conductor power cord to earth ground and 18Vac from the transformer, the other end connects to the 3-position terminal strip on the System 640s power supply board. Find the end of the power cord that has the longer wires coming out of the cord's jacket. BE CAREFUL WORKING AROUND A LIVE AC OUTLET. Get help from an electrician if you are not qualified to work near AC power. Connect the green lead to a ground point on the AC outlet's electrical box. This could be the center screw holding the cover plate on, or another good ground point. Connect the two remaining leads to the load terminals on the 18Vac transformer. Do not plug in the transformer. Insert the other end of the power cord through the access hole on the bottom right side of the cabinet. Connect the three leads to the 3-position screw terminal strip located on the right side of the power supply board, just above the cable access hole. Connect the green lead to the ground, bottom, terminal. Connect the other two leads to the remaining two terminals. Recheck your connections. Remember that the green wire must connect to a good ground point. This ground is important for two reasons, as a safety ground and as a ground reference for the telephone lines. Failure to provide a good earth ground connection can result in incorrect operation. If you are not certain that the ground from the outlet is adequate, you should run a separate ground wire from a known good earth ground connection to the ground terminal on the power supply board's terminal strip. If you run a separate ground, you should not connect the green lead in the 3-conductor power cord at either end. Only the two power leads from the 18Vac transformer will connect to the terminal strip on the power supply board. Remember, at this time the transformer should not be plugged in.

5.7 TELEPHONE LINE CONNECTIONS Connection to the CO DID trunks and the loop equipment is made via eight 6-position modular jacks located on the Telephone Line Interface circuit board. The jacks are located on the upper-right side of the unit and are accessible only with the cover removed. Use the access hole in the lower right portion of the enclosure to correctly route the modular cable. Eight modular cable assemblies are provided for your connecting pleasure.

5.8 CONNECTING TO THE LOOP EQUIPMENT The four loop ports are accessed via four modular jacks, labeled Loop Port 1 through Loop Port 4. Using the aforementioned modular cables, use these jacks to connect to the loop equipment.

5.9 CONNECTING TO THE DID TRUNKS Four modular jacks, labeled DID Port 1 through DID Port 4, connect to the CO DID lines. In anticipation of the System 640 being installed, the local telephone company should have installed four RJ11C/CA11A jacks. Using the modular cables, connect DID trunk number 1 to DID Port 1 jack, DID trunk number 2 to DID Port 2 jack, etc.

5.10 CONNECTING AN EXTERNAL SOURCE OF RINGING VOLTAGE The power supply board contains a 90Vac, 60Hz ringing voltage generator. This ring signal is adequate for most installations. About the only loop start device that would not

respond to this signal is a single line telephone that contains an electromechanical bell. Frequently, a 20 or 30Hz signal is needed to ring this type of telephone. Telephones that actually have bells that ring, rather than chirp, bong, or tweet, are an endangered species and normally would not be encountered with the System 640! If your installation does require a 20 or 30Hz ringing signal, you must first obtain an external source of ringing voltage. Insure that the ringing generator has a floating, non-biased, output. The nominally 90Vac, 20 or 30Hz source must be entirely floating from ground or any other power supply voltage. Begin by insuring that the 18Vac transformer is not plugged into the AC outlet. From the factory, the internal ringing generator is linked using jumper wires into the System 640s circuitry. Remove these two jumper straps which are located on the power supply board's 4-position screw terminal strip. This terminal strip is located almost directly behind the 3-position terminal strip to which you previously connected power. With the external ringing generator turned off, use two wires to connect the output of the ringing generator to the two middle terminals on the terminal strip. Insure that the two wires enter the System 640 through the access hole. At this time do not activate the external ringing generator.

5.11 SECURING THE CABLES Now that all cables have been installed, use the nylon tie wraps, included in the installation kit, to secure the cables into the enclosures. Two tie wrap bases have been installed on the right side of the enclosure for this purpose.

5.12 SWITCH SETTINGS Four sections of DIP type switch SW1 must be set. Switch SW1 is located on the middle left side of the logic circuit board.

5.13 WINK OR IMMEDIATE START Switch 1 of SW1 (we'll call this SW1-1) configures the System 640 to interface with immediate start or wink start DID trunks. The trunks must all be immediate start, or must all be wink start; a mixture is not allowed. Set SW1-1 to OFF for immediate start trunks. Set SW1-1 to ON for wink start trunks.

5.14 NUMBER OF INCOMING DIGITS Switches SW1-2 and SW1-3 must be set to match the number of pulse dialed digits that are to be received from the CO over the DID trunk. Remember that DTMF address signals are not allowed. Refer to the following chart for setting the switches:

# of Digits	SW1-2	SW1-3
3	ON	OFF
4	OFF	ON
5	ON	ON
7	OFF	OFF

5.15 LOOP PORT DTMF DIGIT ENABLE Switch SW1-4 determines if the DTMF address signals are to be sent over the loop ports. Only in special cases will the digits NOT be sent. If the DTMF address signals are not sent, the loop port will still ring; but upon answer, no tones would be heard. Set SW1-4 to the ON position to enable the DTMF tones. SW1-4 placed in the ON position is the normal setting.

6. Testing and Operation

6.1 GENERAL You are now ready to do the preliminary tests. Take some time now to save lots of time later! As previously mentioned, you will need two telephones or one telephone and one linepersons handset. At this stage, the 18Vac transformer (and, if you have one, external ringing generator) should not be plugged in. The CO should not have been called to turn on (bring up, or reset) the DID trunks.

Important Note: The entire operation of the System 640 can be tested without being connected to the CO trunks or to the loop equipment that is attached to the loop ports. Don't add extra variables to the tests when you don't need to.

6.2 PREPARATION Backtrack a little now by unplugging all eight modular plugs going into the DID Port and Loop Port jacks. Make sure you label your plugs for easy identification. The cables should stay in place with the cable ties you previously installed.

6.3 18Vac TRANSFORMER Plug the 18Vac transformer into the wall outlet. The POWER LED on the power supply board should light. The eight status LEDs might momentarily light but within a few seconds all eight should be off. If you have installed an external ringing generator, you can plug that in now. The System 640 is now up and running! If the POWER LED does not light, go back and check your connections between the transformer and the power supply terminal strip. Insure that your wall outlet is indeed electrically "hot."

6.4 LOOP PORTS Plug the single line telephone with an electronic ringer into Loop Port 1 jack on the System 640. This telephone will act just like the loop equipment that will normally connect to the loop ports. Lift the handset. You should hear nothing except what is called sidetone, the condition when you talk into the handset's microphone and hear yourself in the earpiece. Sidetone lets you know that loop current is flowing. Looking at the status LEDs, observe that Loop Port 1 LED is flashing on and off; the other LEDs should be off. This LED is showing you an error condition; normally a loop port would only be off-hook while a call is in progress from the CO DID trunk. Hang up the single line telephone and the LED should stop flashing. Leave the telephone plugged into Loop Port 1 for later use.

6.5 SIMULATED CO Plug the pulse dial single line telephone into DID Port 1 jack. This telephone is acting just as the CO would. Listen to the earpiece immediately as you go off-hook. Hold the handset to your ear as you use your finger to hold the hook switch to the "on-hook" position. This makes it easy to go off-hook or on-hook while listening. Now go off-hook and listen. If you have selected wink start operation, you will hear a "click click," as the DID port's circuitry winks back to you in response to your going off-hook. After about three seconds, you will hear a reorder (fast busy) progress tone. If you have selected immediate start operation, you will not hear any clicks after going off-hook. After about three seconds, you'll hear a reorder (fast busy) progress tone. Hearing a reorder tone is normal in this case, because the System 640 expects to see the dial pulse address signals from the CO. The three seconds is a time-out period. Looking at the status LEDs observe that DID Port 1 LED is lit; the other LEDs should be off. This LED is showing you that the DID port is off-hook. Go on-hook again and the LED should go out. Leave the telephone plugged into DID Port 1.

6.6 TESTING EACH CHANNEL Make sure you know the number of digits the CO will be sending you, and that switches SW1-2 and SW1-3 have been set to match that number. Using the pulse dial telephone connected to DID Port 1, go off-hook and immediately dial a 3, 4, 5, or 7 digit number. The number

of digits must be the same as the CO will be sending over the DID trunks. The actual digits (0 through 9) you dial are not important; the number of digits you dial is. If you wait more than about three seconds between the digits you dial, you will again get the reorder (fast busy) progress tone. You are creating this error condition by your slow dialing. After you go off-hook and dial the correct number of digits, the telephone connected to Loop Port 1 will start to "ring." You will hear an audible ring progress tone in the earpiece of the telephone connected to DID Port 1. Answer the ringing telephone. What happens next depends on how you set SW1-4. If SW1-4 is ON, immediately after you answer the phone, you will hear a burst of DTMF tones from its earpiece. After the tones are sent, the two telephones will connect together, allowing you to have a nice conversation with yourself! If you set SW1-4 to the OFF position, the sending of DTMF tones is disabled. If SW1-4 is OFF, immediately after you answer the phone, the two phones will be connected together. In either case, a call between the two telephones is taking place. After answering the loop phone, the Loop Port 1 status LED will light. The DID Port 1 and Loop Port 1 LEDs will be steadily lit while the call is taking place. You can now hang up both telephones. You have tested the first channel. You have seen for yourself that a call coming in over the DID Port 1 will "ring" Loop Port 1. Check the other three channels to insure that each works correctly.

6.7 LEDs OFF You should now have completed "off-line" testing of the four channels. At this time the telephone used to test the loop ports should be disconnected. Connect the four modular plugs back into the loop ports, reconnecting your loop equipment. None of the loop port status LEDs should be blinking on and off. Remember that a blinking loop status LED means that its respective loop port has been brought off-hook by the connected equipment. You can proceed if all the status LEDs are off.

6.8 CONNECTIONS CONFIRMED We'll now check the link between the System 640 and the loop equipment. If you haven't already done so, set the loop equipment to answer after detecting ringing. Plug the pulse dial telephone into DID Port 1. Go off-hook and, as before, dial a 3, 4, 5, or 7 digit number. Audible ring progress tone should be heard and Loop Port 1 should start to ring. The loop equipment should answer, and if SW1-4 is set to ON, it should receive DTMF digits. If the loop equipment sends an audio message after answering you should hear it now. Hang up the pulse dial telephone and the loop equipment should disconnect. The status LEDs should act just as each did during previous tests. You have now confirmed the operation of channel one. Repeat this procedure for the other System 640 channels. When you are finished, disconnect the pulse dial telephone.

6.9 ACTIVATING DID TRUNKS You are now ready to get the CO DID trunks involved. Reconnect the four modular plugs into the DID Port jacks. You will most likely find that your DID trunks are in the downed state. After installation the CO would have placed the trunks out of service and they now need to be turned on again. You can see if they are working or not, simply by using an outside line to dial one of the numbers in the DID trunk group. Watch the status LEDs on the System 640 and see if any of the DID ports are seized. Most likely none will be; the CO will probably just return a reorder progress tone. Go ahead and call the telephone company and request your DID trunks be brought up and tested. Be sure that all trunks work by placing calls through all four ports. To do this you may need to place four DID calls at the same time, over four different outside lines. From the time the trunks are turned on, you cannot randomly disconnect them from the System 640. You risk having one or all the trunks downed. If you disconnect power from the System 640, even for a few seconds, you also risk having your trunks downed.

6.10 PROBLEMS If all of the previous tests went as described, you should now have calls being correctly processed by the System 640. Several simple problems could hinder operation. Insure that the setting of SW1-1 matches the wink or immediate start parameter of your CO DID trunks. Be certain that SW1-2 and SW1-3 are set for the number of digits the CO is sending you. Remember that the CO must be sending you pulse dial digits; DTMF digits are not accepted. The most likely cause of all problems is that the DID trunks are in the downed state. Work with your CO to get them brought up and tested with the System 640.

6.11 SECURE THE COVER Secure the cover onto the System 640 enclosure, being careful not to pinch any wires inside the enclosure.

6.12 MAINTENANCE There are no maintenance procedures for the System 640. However, you should store this practice where you can get at it, or make a copy of it for yourself!

7. Circuit Description

7.1 GENERAL DESCRIPTION The circuit description is intended to familiarize you with the System 640 for engineering, applications, and curiosity purposes. The System 640 consists of three circuit board assemblies linked together, and mounted in the enclosure. The three circuit board assemblies are the Power Supply, Logic, and Telephone Line Interface.

7.2 POWER SUPPLY BOARD The power supply board supplies unregulated +24Vdc, regulated +5Vdc, regulated –53Vdc, and 90Vac, 60Hz for operation of the System 640. WY The output voltages of the power supply board connect to the logic board via an 8-conductor connector and associated wiring. The input to the power supply board is 18Vac and earth ground. The incoming 18Vac connects to a power transformer boosting the voltage to 90Vac. This voltage is the internal ringing voltage. This ringing voltage connects to the 8-conductor output connector via a 4-position terminal strip. If an external source of ringing voltage is required, straps on the terminal strip are removed, disconnecting the internal ringing voltage, and allowing connection of the external source. The 18Vac is also used for the other power supply voltages. It first passes through a filter section to limit the amount of electromagnetic energy that can transmit out via the line cord. This keeps signals from within the System 640 from interfering with other equipment. The 18Vac, after passing through the input filter, is rectified using a full wave diode bridge and is capacitor filtered to produce unregulated +24Vdc. The unregulated +24Vdc is connected to the output connector and to the switching power supply section. The switching power supply circuit takes the unregulated +24Vdc and very efficiently converts it to regulated –53Vdc and unregulated +8Vdc. The switching power supply has an oscillator frequency of about 30kHz. The regulated –53Vdc is connected to the output connector for use by the Telephone Line Interface

Board as loop current. The unregulated +8Vdc connects to a linear regulator which produces regulated +5Vdc. This +5Vdc connects to the output and provides power for the logic circuitry. The LED indicator light on the power supply board is connected to the +5Vdc supply.

In general, most equipment failures occur because of poor power supply performance. Either the power supply fails or the equipment connected to it dies due to bad power. We, certainly understand the importance of a good power supply. The System 640 power supply has been designed with very few failure modes. There is little that will kill this supply.

7.3 LOGIC BOARD

Microcomputer and Support Circuitry: A 6803 series microprocessor (MPU) is used as the "heart" of the System 640. The MPU contains logic, clock, bidirectional port, and timer circuitry. A 4.9152 MHz crystal provides the time base for the MPU. The MPU selected is of HMOS construction which, although a power hog, is very reliable and not subject to some of the handling (and cost) problems of CMOS MPU's. The MPU addresses a memory integrated circuit which is permanently loaded with software set to execute all System 640 functions. Note that the software code is copyrighted by Gordon Kapes, Inc. (1988) with all rights reserved. A RAM integrated circuit is used by the MPU for data work space. Various logic integrated circuits interface the input and output signals to the MPU.

MPU Watchdog Timers: Two separate "watchdog" timers are used to prevent the System 640 from "locking up," a common downside of using MPU's. Through devious schemes devised by the software engineer, the software program continuously checks itself. Potential program dead ends are caught and the program will continue running. A hardware watchdog continuously watches for pulses to come out of the MPU. The pulses discharge an RC circuit connected to a comparator. If the MPU "locks" due to a power glitch, static discharge, or other conditions, the pulses stop, the RC circuit charges, and the state of the comparator changes. The comparator output is connected to the reset pin of the MPU, which resets and starts the MPU operating again.

Progress Tone Generation: An integrated circuit produces a continuous source of 440Hz + 480Hz pseudo sine waves. A 3.579545 crystal provides the time base for this integrated circuit. This audio tone source is fed to four sections of an operational amplifier. Logic signals from the MPU turn the op amp sections on and off, creating the cadence of progress tones heard on the DID trunks.

DTMF Address Signal Generation: A DTMF generator integrated circuit produces the DTMF digits that are sent over the loop ports. The clock signal produced by the progress tone generator integrated circuit is fed to the DTMF generator as a time base. Logic signals from the MPU select which digit to produce and for what interval.

LED Indicators: Eight LED indicators serve as port status indicators. MPU directed logic signals, via eight sections of integrated circuit latch, drive the LEDs. The on or off condition of the LEDs is purely a function of software commands.

7.4 TELEPHONE LINE INTERFACE BOARD Two line interface circuits are used: One for the DID ports and the other for the loop ports. There are four of each of these circuits on the Telephone Line Interface Board.

DID Port: A conventional battery feed circuit with a split primary, 600 ohm to 600 ohm transformer, is used. Two power resistors couple –53Vdc and ground to the transformer center taps, and then through the transformer windings to two contacts on the loop relay. The loop relay controls the polarity of the loop current. An MPU derived signal from the Logic Board controls the state of the relay. A breakdown resistor is connected across the tip and ring leads to provide surge protection. An optocoupler, in series with the –53Vdc path, detects off-hook and provides this information to the MPU. The secondary of the transformer connects to the wiper of a relay contact. The relay contact connects the secondary of the DID port transformer to either the progress tone source, or the secondary of the loop port transformer. An MPU derived signal from the logic board controls the state of the relay contact.

Loop Port: A conventional battery feed circuit with a split primary, 600 ohm to 600 ohm transformer, is used. Two power resistors, higher in resistance than in the trunk interface circuit, couple –53Vdc and ground to the transformer center taps, and then through the transformer windings to two contacts on the ring relay. An MPU derived signal from the logic board controls the state of the ring relay. A breakdown resistor is connected across the tip and ring leads to provide surge protection. An optocoupler, in series with the –53Vdc path, detects off-hook and provides this information to the MPU. The secondary of the transformer connects to the wiper of a relay contact. The relay contact connects the secondary of the loop port transformer to either the DTMF source, or the secondary of the DID port transformer. A previously mentioned MPU derived signal controls the state of the relay contact.

The DID port and loop port circuits provide eight sets of tip and ring signals. Six-position modular jacks provide the connections to the outside world. The four jacks associated with the DID ports have tip connected to pin 3 and ring connected to pin 4. This provides for correct connection to RJ11C/CA11A jacks using standard reversing modular cords. The four jacks associated with the loop ports have tip connected to pin 4 and ring connected to pin 3. This provides for correct connection to loop terminal equipment designed for connection to RJ11C/CA11A jacks via standard reversing modular cords. Actually, the DID port jacks look like the mirror image (reverse) of an RJ11C/CA11A; the loop port jacks look like RJ11C/CA11A jacks.

8. Specifications

DIMENSIONS
14.00 inches high (35.56cm)
10.00 inches wide (25.40cm)
2.50 inches deep (6.35cm)

WEIGHT
9.5 pounds (4.3kG)
12.5 pounds (5.7kG) shipping weight

MOUNTING
Wall mounted with four #10 screws appropriate for the wall material

ENVIRONMENTAL
Operating: 5 to 40 degrees C, 0 to 95% noncondensing

TELEPHONE LINE CONNECTIONS
Eight 6-position modular jacks, one per DID port and loop port connection. Jacks comply with United States FCC RJ11C and Canadian DOC CA11A specifications.

POWER REQUIREMENT
18Vac, 50/60Hz, 40 watts maximum
18Vac, 40VA transformer shipped with unit

OPTIONAL EXTERNAL RINGING VOLTAGE SOURCE
90Vac, 20/30Hz, 1 watt minimum, isolated from all other voltage sources or ground, i.e., floating

PROGRESS TONES
Audible Ring: 440Hz + 480Hz, 1 second on, 3 seconds off, continuous
Error (Reorder): 440Hz + 480Hz, 0.25 seconds on, 0.25 seconds off, continuous

PROGRESS TONE LEVEL AT DID TRUNK INTERFACE
–13.5dB (reference 1mW into 600 ohms)

DTMF DIGIT LEVEL AT LOOP INTERFACE
–9dB (reference 1mW into 600 ohms)

NUMBER OF CHANNELS
Four

DID PORT PARAMETERS
Loop Voltage: –53Vdc
Loop Current: 40mA, 200 ohms across tip and ring
24mA, 1000 ohms across tip and ring
19mA, 1640 ohms across tip and ring
15mA, 2200 ohms across tip and ring
47mA, 0 ohms (short) across tip and ring
Impedance: 600 ohms

LOOP PORT PARAMETERS
Loop Voltage: –53Vdc
Loop Current: 28mA, 200 ohms across tip and ring
19mA, 1000 ohms across tip and ring
13mA, 2200 ohms across tip and ring
32mA, 0 ohms (short) across tip and ring
Impedance: 600 ohms
Ring Signal (Internal Generator): 90Vac, 60Hz, 1 watt
Ring Duration: 1 second on, 3 seconds off
Answer Detect: during ring and silent interval

RINGER LOAD
One standard ringer can be correctly driven by each of the four loop ports. This would correlate with the loop equipment connected to the loop port having an FCC (United States) Ringer Equivalence of 1.0 or less, or a DOC (Canada) LN of 100 or less. This also correlates to having a minimum ringer load impedance of 7.5K ohms (7.5K ohms in series with 2.2uf).

LOOP PORT DISCONNECT PARAMETERS
DID Trunk disconnecting while call is in progress causes 1 second break in loop port loop current.
Equipment connected to loop port can initiate disconnect by breaking loop port loop current 300mSec minimum

DID PORT DISCONNECT PARAMETERS
Loop port equipment disconnecting while call is in progress causes DID port loop current polarity to reverse to idle state
CO can initiate disconnect by breaking DID loop current 300mSec minimum

DID TRUNK TYPE
Selectable, wink or immediate start. One switch selects for all four channels, i.e., all trunks wink start or all trunks immediate start.

WINK DURATION
200mSec

DID TRUNK ADDRESS SIGNALING
Pulse dial address signaling only
DTMF digits from central office not accepted
Dial Pulse Range: 8 to 12 pulses per second
Break Interval: 42 to 84%
Maximum Time Between Digits: 3 seconds

NUMBER OF INCOMING DIGITS
Switch selectable: 3, 4, 5, or 7. One switch selects for all four channels, i.e., all trunks 3 pulse dial digits, all trunks 4 pulse dial digits, etc.

LOOP PORT ADDRESS SIGNALS
System 640 sends DTMF address signals only. Pulse dial address signals are not generated.
DTMF Digit Duration: 100 milliseconds (mSec)
DTMF Interdigital Duration: 100 mSec
Loop port DTMF address signals can be disabled using one switch. All four channels are controlled via that one switch.

LOOP PORT ADDRESS SIGNAL END DELINEATOR
To give equipment connected to a loop port an indication that the last DTMF address signal has been sent, a 100 mSec burst of DTMF digit "#" is sent 100 mSec after last DTMF address signal

INTERVAL BETWEEN LOOP PORT OFF-HOOK AND GENERATION OF DTMF ADDRESS SIGNALS
1 second

INTERVAL BETWEEN DTMF "#" TRANSMISSION AND CONNECTION OF DID PORT AUDIO TO LOOP PORT AUDIO
500 mSec

DID PORT TO LOOP PORT THROUGH TRANSMISSION LOSS
3.2dB maximum

BILLING PROTECTION
Complies with reverse battery answer supervision and disconnect protocols

FCC REGISTRATION
Registration Number: EPR5ZC-17261-PX-N
Ringer Equivalence: 0.0B

REGULATORY COMPLIANCE
Complies with United States FCC Part 15, Subpart J, Class A
Complies with Canadian DOC Rules

9. Incorrect Operation

9.1 MAJOR PROBLEMS Most system-wide problems relate to incorrect switch settings. Four sections of DIP switch SW1 must be set. Three of these switches are set to match the DID trunk parameters. The fourth switch enables or disables the sending of DTMF tones out of the loop ports. Refer to the Installation section of this practice for detailed information.

9.2 DOWNED TRUNKS If the DID trunks are temporarily disconnected from the System 640, or power to the System 640 is disconnected, the CO may stop DID trunk operation. Insure that the power source to the System 640 is not getting turned off accidently. You might consider adding a UPS power source. If the trunks are downed, you will have to contact the CO to have them reset. CO downing of the DID trunks is discussed in detail in other parts of this practice.

9.3 COMMUNICATION PROBLEMS Make certain that the loop equipment connected to the loop ports are set up to correctly "read" the DTMF digits. In most cases, simple software changes will solve DTMF reception problems.

10. Repair and Replacement

10.1 NOT SO FAST Statistically, most equipment returned to Gordon Kapes, Inc. for repair actually has nothing wrong with it. A telephone call to Gordon Kapes, Inc. technical support can often help to get the equipment operating correctly. We don't mind spending time with our customers getting a site up and running.

10.2 SEND IT BACK If you determine that the System 640 is defective, return for repair or replacement according to the Gordon Kapes, Inc. Warranty/Repair and Return policy.

10.3 ONLY WE FIX IT In the event repairs are ever needed on your System 640, they should only be performed by Gordon Kapes, Inc. or an authorized representative. For further information, contact Gordon Kapes, Inc.

11. FCC Requirements

11.1 TYPE OF SERVICE Your System 640 is designed to be used on standard device telephone lines. The System 640 connects to telephone lines by means of standard jacks called USOC RJ11C. Connection to telephone company-provided coin service (central office implemented systems) is prohibited. Connection to party line service is subject to state tariffs. Connection to coin service party lines is not specified but could prove interesting.

11.2 TELEPHONE COMPANY PROCEDURES The goal of the telephone company is to provide you with the best service it can, within the constraints of receiving a good return on shareholder equity. In order to do this, it may occasionally be necessary for them to make changes in their equipment, operations, or procedures. If these changes might effect your service or the operation of your equipment, the telephone company will give you notice, in writing, possibly in advance, to allow you to make any changes necessary to maintain uninterrupted service.

If you have any questions about your telephone line, such as how many pieces of equipment you can connect to it, the telephone company will provide this information upon request. In certain circumstances, it may be necessary for the telephone company to request information from you concerning the equipment which you have connected to your telephone line. Upon request of the telephone company, provide the FCC registration number and the ringer equivalence number (REN) of the equipment which is connected to your line; both of these items are listed on the equipment label.

11.3 IF PROBLEMS ARISE If any of your telephone equipment is not operating properly, you should immediately remove it from your telephone line, as it may cause harm to the telephone network. If the telephone company notes a problem, they may temporarily discontinue service. When practical, they will notify you in advance of this disconnection. If advance notice is not feasible, you will be notified as soon as possible. When you are notified, you will be given an opportunity to correct the problem and be informed of your right to file a complaint with the FCC. You have the right to remain silent, if you waive your right to remain silent...

Specifications and information contained in this technical practice subject to change without notice.