

# ISDN Installation Using the CraTek™ CT-100 Subscriber Loop Test Set



This application note focuses briefly on the CT-100's ISDN testing capabilities, highlighting typical tasks encountered when turning up and reliably maintaining ISDN access services.

### Why ISDN?

Integrated Services Digital Network, or ISDN, has been gaining popularity of late as standards converge and tariffs get approved by local PUCs. With Basic Rate ISDN, two high-speed digital channels co-exist for simultaneous 64 kbps (64 kilobits-per-second) phone calls, while a separate 16 kbps channel is used for call management (call setup, tear-down, etc.). These three channels are time-multiplexed (see Figure 1) over a single twisted pair in the local loop.

As an "integrated" network, ISDN is able to efficiently handle a wide range of services, or types of information (i.e., voice, data, image, and video) over a standard interface. Furthermore, circuit costs are reduced, capacity of the copper plant is better used, and data integrity is increased.

The CraTek™ CT-100 Subscriber Loop Test Set was designed to meet the evolving needs of the telephony craftsman responsible for turning up advanced services on the subscriber loop. Unlike Plain Old Telephone Service (POTS), the installation and maintenance requirements for services like Basic Rate ISDN go beyond those of a simple butt set. Yet the familiarity and ease of use of an analog butt-in is the foundation for CraTek CT-100's success as the industry's standard ISDN Portable Test Set.

The CT-100 was designed with extensive telephone company involvement. Requirements for portability, reliability, and ruggedness went hand-in-hand with high expectations for standards compliance and performance. Since its introduction, the CT-100 has also been continually enhanced, based on routine customer feedback, and the on-going evolution of ISDN standards.

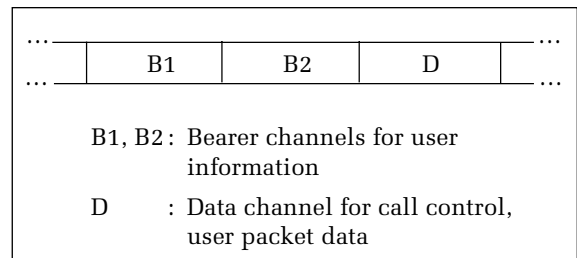


Figure 1. Three virtual channels time-multiplexed over a single twisted pair.



Figure 2. The presence of sealing current indicated in the home display.



Figure 3. Checking for sealing current to verify an ISDN connection.

### ISDN Installation

In order to install and verify a new ISDN line, a crafts technician must typically complete several steps once the cable pair has been assigned:

1. Set up.
2. Verify connectivity.
3. Verify "Dial Tone".
4. Verify line quality.

**Collecting Information – Setting up the CT-100.** The CT-100 was designed to perform all the tasks necessary to turn-up and verify ISDN lines quickly and efficiently. The first step is to make sure that your work order has all the information necessary to set up the CT-100. You'll need to input the following information:

- Line coding scheme (2B1Q or AMI)
- Switch type (NI-1, AT&T, or NorTel Custom)
- SPIDs/DNs
- Basic service (voice, data, packet)
- Service details (TEIs, call appearance)

This information is input into the CT-100 with the **EASY CONFIGURE (SETUP, \*)** menu that prompts the user for all the information typically required. After the instrument is set up, all current settings may be viewed with **EASY VIEW (MEASURE, 2, 2)**.

**Verify Connectivity.** Once physically connected to the line, there are two indications that the CT-100 has

established communication with the Central Office (CO). The first is the sealing current indicator on the last line of the display (Figure 2), or in the sealing current measurement menu (Figure 3). The second is the "U" Sync LED (for the U interface), or the "T" Sync LED for the S/T interface. A green light on the appropriate LED indicates correct basic communication with the central office. The CT-100 automatically begins this synchronization process when connected to an active ISDN line.

Once synchronized to the line, a data link between the terminal equipment and switch must be established. This "Layer 2" process includes assigning a unique Terminal Endpoint Identifier, or TEI number, to each terminal connected to the S/T loop (remember, ISDN allows up to eight TE devices to be attached to a single subscriber loop in what is known as a "multi-point" configuration). Again, this is typically done automatically. The TE requests a number from the switch, which responds by assigning a TEI for it to use. Once established, this TEI helps insure messages and other user data gets routed to the appropriate device.

Now that the data link is in place, the TE is ready to transmit and receive call setup and control information (Layer 3 protocol). Figure 4 illustrates a typical call setup process, where messages are transmitted between the telephone and the network.

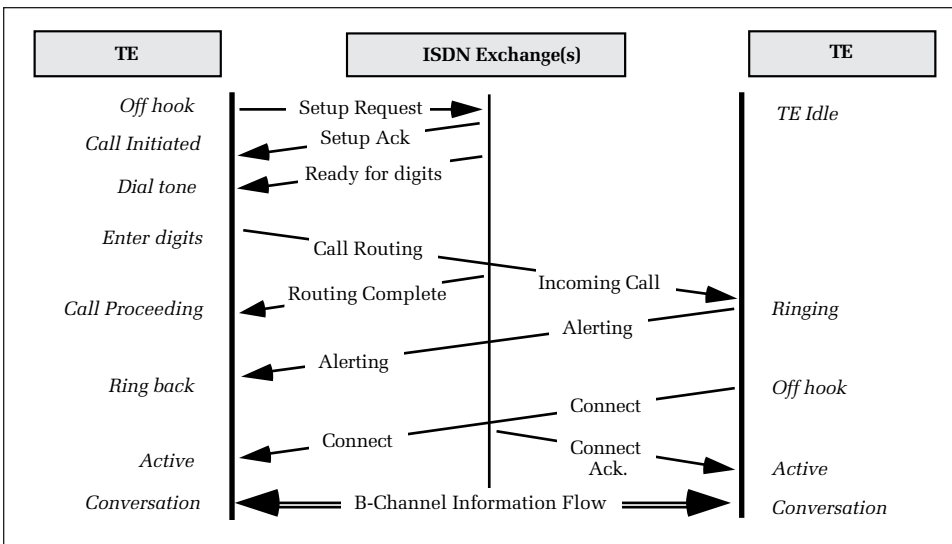


Figure 4. A typical call setup is accomplished by several messages being sent between the telephone and CO.



Figure 5. The SPID has been sent and a response from the switch is pending.



Figure 6. The CT-100 has received an acknowledgement, turning on dial tone.

At this point, the CT-100 attempts to initialize the connection by sending the SPID (see SPID: Service Profile Identifier sidebar). The SPID can also be sent manually to verify correctness (Figure 5).

**Drawing Dial Tone.** The next step is to verify that the line has been provisioned correctly by “drawing dial tone”

and attempting to go “off hook”. The CT-100 can verify:

- Voice call (CSV)
- Data calls (CSD)
- Packet calls
- Perform mixed service checks
- Dual-channel calls

In order for the user to hear dial tone, a call setup request must first be initiated (i.e., going off-hook), then be acknowledged by the central office (i.e., that the switch is ready to begin receiving digits). It’s the receipt of this positive acknowledgement that directs the TE to turn on dial tone (Figure 6).

## Subscriber Loop Network Elements

In order to explain the process involved with making an ISDN phone call, a basic understanding of subscriber loop network elements and the role of each is required. The diagram below illustrates a typical ISDN digital subscriber loop.

The CT-100 is designed to operate as a TE device (telephone), an NT1, or as both (TE + NT1). In this way, the test set eliminates the need for additional customer premise equipment when turning up a new line. It can also be used to help troubleshoot problems at various points along the subscriber loop (e.g., “U” or “S/T” interfaces).

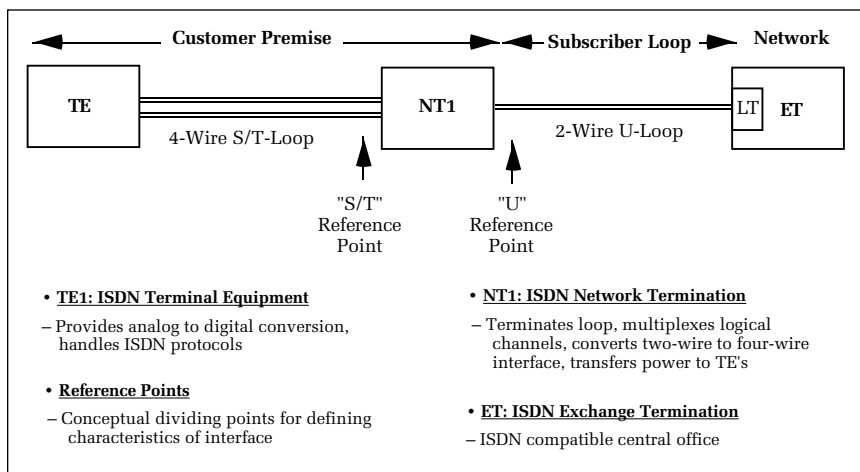
The technician should also be aware of how ISDN protocol (or standards) are described – typically as one of three “layers” which are required for an ISDN call. These layers include:

- A “physical” layer, or Layer 1 (which involves the electrical connection, line coding schemes, and data rates).
- A “data link” layer, or Layer 2 (which handles such concerns as addressing, flow control, and error checking).
- A “network” layer, or Layer 3 (which defines how calls are setup, maintained, and released).

Using the CT-100, we can trace through a typical call setup procedure to better illustrate these various protocol layers and their roles.



The CT-100's Home screen displays the current instrument operating mode – in this case, the CT-100 is functioning as both the TE and NT1.



The ISDN Digital Subscriber Loop is defined to include various customer premise equipment, as well as standard “reference” points or interfaces.

You will always hear dial tone for a successful call setup using voice or 3.1 kHz audio, but may not for Circuit Switched Data (CSD) calls. The CT-100 also displays other causes preventing dial tone (Figure 7).

Occasionally, the network may deny a call setup request or terminate a call in process. When such a situation occurs, the network transmits a “cause” message to the originating party as an explanation for why a particular action was taken. When received by the CT-100, it captures and displays this information both on-screen and

in a measurement menu. Figures 8 and 9 illustrate examples of cause messages being received after attempting to initiate a call.

Since the CT-100 can establish and maintain two simultaneous calls, it can be used to verify mixed-bearer service capability. Select the appropriate bearer service for each call (Figure 10), and establish both calls.

Another type of call which can be made with the CT-100 is a D-channel “packet-switched” call. With ISDN, the D-channel can also be used for sending user information at rates up to 9600

baud. By specifying the CT-100’s “D-channel Packet Data” selection, the test set can initiate a packet-switched call by dialing a device capable of answering on the D-channel. A “fox” message can then be sent to verify data transmission. Any incoming packet data is also displayed (Figure 11).

For more extensive D-channel transmission testing, an RS-232 interface (Option 2A) can also be added to the test set for connecting an external computer to the D-channel.

**Verify Line Quality.** Once the craftsperson has successfully placed calls over an



Figure 7. In addition to colored LED status lights, call progress is also indicated when off-hook.



Figure 8. The call setup request was rejected, in this case due to an invalid SPID entry (National switch).



Figure 9. The requested bearer service is not authorized for the line (in this case, a circuit-switched data call was requested on a line provisioned for voice calls only).



Figure 10. Verifying a circuit-switched data call involves selecting a new bearer service.

### SPID: Service Profile Identifier

Many ISDN lines require the end user to enter what’s known as a SPID before the line can be used. The SPID is part of a line’s translations, and is used by the switch to verify the type of facilities, or features, for which a particular line has been provisioned.

When a SPID is required and not entered correctly, the switch will deny call setup requests and respond with a cause message such

as “Requested Facility Not Subscribed” or “Call Rejected.”

Typical SPID formats are as follows:

The SPID is entered using the

CT-100’s Setup menu (SETUP 2,5). Once sent to the switch, the CT-100 also indicates whether the SPID was accepted, not required, or rejected by the switch.

Switch Type	Typical Format	Example
AT&T 4ESS Multi-point*	01 + 7 digit DN + 0	01-677-0048-0
Northern DMS-100	Area Code + 7 digit DN + 0	503-677-0048-0
National ISDN-1	01 + 7 digit DN + 000	01-677-0048-000

\* AT&T point-to-point lines do not require a SPID.



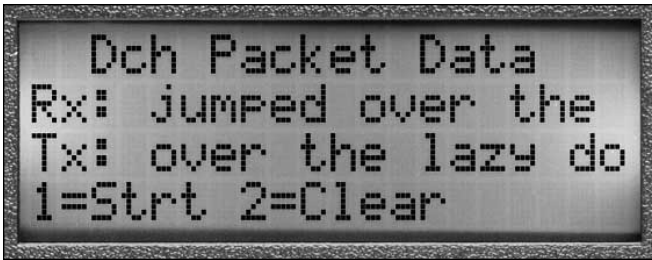


Figure 11. D-channel packet call capability being verified (here shown displaying the last characters of a fox message).



Figure 12. Monitoring bit errors using the CT-100's integrated BER testing.



Figure 13. After running for one minute, 99 block errors were detected (18 errored seconds).

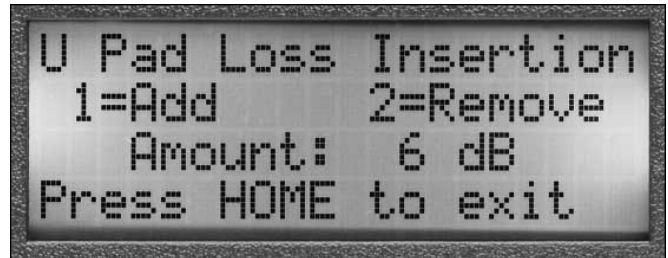


Figure 14. Troubleshooting a marginal cable pair by setting loss insertion equal to 6 dB.

ISDN line, there are several other tasks which may be performed to verify the quality of the service being provided to the customer. These tasks include performing:

- Single B-channel BERT using a loopback call
- Automatic dual B-channel BERT
- NEBEs and FEBEs
- Attenuation

Bit Error Rate Testing (BERT) involves generating and receiving a specific bit pattern and comparing the outgoing bit pattern (Figure 12) to the returned-bit pattern. This test can be performed two ways: calling a loopback test line (such as a "108 Test Line") or performing the Automatic Dual-Channel BERT in which the CraftTek automatically verifies both B-

channels simultaneously with the touch of a button.

The CT-100 also performs block error tests to measure the line's ability to reliably transmit and receive data. Block errors, which include NEBEs (Near End Block Errors) and FEBEs (Far End Block Errors) are monitored as part of the ISDN protocol standard (Figure 13). Near end refers to check-sum errors in blocks of data coming toward you; far end errors are ones identified at the other end of the subscriber loop.

Attenuation can be used to identify marginal line performance. For example, attenuation can be added to an existing line (Figure 14) and the impact can be monitored using the BERT.

### Load Coil Detection

The CT-100 can also be used to transmit a 40 kHz signal on a dry pair. The 40 kHz tone is transmitted to the CO over the U-interface. A user at the CO can then measure the signal level on that interface. Since load coils will not pass the signal, this can be used to detect the presence of a load coil on the line.

### Checking Other Performance Parameters

Finally, the CraftTek CT-100 performs other tests vital to ensuring customer satisfaction with the service that you are providing:

- **Feature Translation.** Services such as "Call Forwarding" or "Conference Calling", using the CT-100's ability to transmit feature buttons.
- **Power Sources.** Checking a variety of power sources since the CPE is powered locally with ISDN.

### RS-232 Serial Interface Troubleshooting

The CraftTek CT-100's RS-232 interface (Option2A) allows the user to connect an external device to the portable test set over a serial interface. This option provides two capabilities: The first is data sourcing, providing enhanced testing of ISDN D-channel packet data capabilities. The other capability is data logging, allowing the user to record results of installation and troubleshooting tasks.

**Packet Data Testing Over RS-232.** In the data sourcing mode, the RS-232 interface allows the user to connect a terminal and initiate X.25 packet-switched data calls over an ISDN data channel. This mode is useful when accessing packet gateways requiring more than a simple phone number (e.g., passwords), or to more fully verify D-Channel user applications.

The operator connects the computer's serial interface to the unit's auxiliary jack (DB25-to-RJ45 adaptors included). A PC communications software package can then be used to send standard Hayes-compatible modem commands to setup and maintain a D-channel packet call.

**D-Channel Monitor.** In the data logging mode, the user can use the RS-232 port to connect a printer or terminal

directly to the CT-100. Details such as call setup, signaling protocols, and measurement results can be recorded for later analysis. Figures 16, 17, and 18 provide examples of the type of information available when operating in the data logging mode. This mode of operation allows the user to monitor the events that are taking place on the D-Channel.

For instance, the CraftTek CT-100 might be used to monitor a line over an extended period, recording time-stamped events such as synchronization loss or data transmission errors. A problem call could be documented from call setup to teardown to trace CPE or switch-related trouble, in the absence of more complex protocol analyzers. Or the technician may simply use the data logging mode to record results of the service verification procedures when on-site.

**Easy Installation.** The RS-232 interface board is installed in a separate option slot inside the unit, and is accessed via the existing Auxiliary port on the base of the instrument. Hardware kits are available for easy field upgrading of existing instruments. The interface is fully isolated as well, preventing the risk of damage occurring if devices are directly coupled (e.g., ground loops).

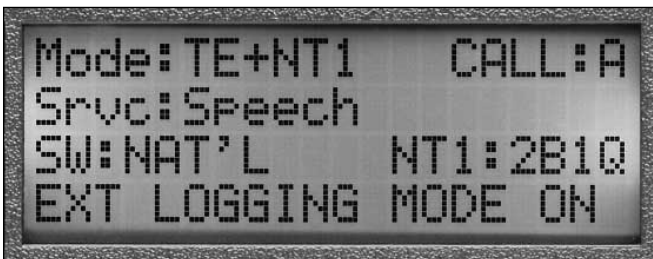


Figure 15. The CraftTek CT-100's Home screen displays the current instrument operating mode. The last line of the display indicates that data logging has been enabled.

14:36:25	[A] CALL Off-Hook	
14:36:25	[A] CALL U1:	Call Init.
	Bearer Svc:	SPEECH
	Bch Request:	ANY
	Directory Num:	5551212
	Call Appearance:	1
	SPID:	01555121200
	Switch Type:	National ISDN 1
14:36:25	[A] CALL U2:	Overlap Sending
14:36:31	[A] CALL U3:	Out. Call Proc.
	Number:	5559999
14:36:35	[A] CALL U10:	Call Active

Figure 16. Example of ISDN call progress.

00:03:25	PHYS	NEBE/FEBE Test	
	Started		
	Test Duration:		00:01:00
	U pad attenuation:		0 dB
00:03:35	PHYS	NEBE Error:	3
00:03:38	PHYS	NEBE Error:	1
00:04:25	PHYS	NEBE/FEBE Stopped	
	Elapsed Time:		00:01:00
	U pad attenuation:		0 dB
	NEBEs:	4	Error Sec. 2
	FEBEs:	0	Error Sec. 0

Figure 17. Example of logging block errors.

14:43:01	[B] BERT Test Started	
	Rate:	64K
	B-Channel:	B1
	SPID:	01555121200
14:43:02	[B] BERT Framed	
14:43:02	[B] BERT Status:	0.00E-03
14:43:02	[B] BERT Status:	0.00E-04
14:43:04	[B] BERT Status:	0.00E-05
14:43:19	[B] BERT Status:	0.00E-06
14:43:32	[B] Bit Errors Inserted	
14:43:32	[B] BERT Error:	1
14:44:01	[B] BERT Stopped -- Results:	
	Bit Error Rate:	2.61E-07
	Bit Errors:	1
	Errored Seconds:	1
	Blocks Received:	1929
	Block Errors:	1
	Sync Losses:	0
	Severely Errored Seconds:	0

Figure 18. Example of results from BER test

## **EBS (P-Phone) Service Verification**

*NOTE: While not part of a typical ISDN installation, EBS is a service that can be tested and repaired using the CraftTek CT-100.*

Enhanced Business Service (otherwise known as “EBS” or “P-Phone”) is an analog Centrex offered by Northern Telecom (NORTEL). It operates over a single-pair subscriber wire loop which provides for full-duplex audio conversations as well as a secondary signaling channel. This secondary channel is a half-duplex, 8 kHz amplitude-shift-keyed signal, which is used to transmit signaling information to and from the NORTEL switch and the CPE. Thus, the craftsman is faced with a more complex servicing task when deploying and maintaining P-Phone lines.

When configured with the optional EBS interface card (Option 3B), the CraftTek CT-100 is capable of emulating an EBS primary phone set, as well as several types of add-ons. A simple set-up menu allows the user to select between a primary set, select add-on sets (18-, 20-, and 36-button), or a “monitor” mode which allows pas-

sive monitoring of both voice and signaling channels.

Unlike most EBS test sets on the market today which merely draw dial tone and place calls, the CraftTek CT-100 portable test set adds crucial measurement and debug capabilities to aid the crafts technician.

In a typical EBS operating mode, the CraftTek CT-100 begins in place of the primary set, allowing the user to go off-hook and place calls. Feature keys can be sent to emulate setting up multiple call appearances and verifying features such as call forwarding, hold, and release. The unit’s LCD display simulates the display unit of the EBS primary phone, showing such information as the number being dialed, the calling party’s number, and other information sent by the CO switch for display.

**Powerful Troubleshooting Tool.** The CT-100 provides several important measurement capabilities to aid in EBS service verification and troubleshooting.

DC line voltage and polarity can be measured to verify that the voltage found on tip and ring is within operation specifications. (Showing red for reversed, green for cor-

rect).

The peak signal level of the 8 kHz secondary channel must also fall within certain parameters for proper signaling between CO and CPE. The measurement is made in terms of dB loss, with zero dB being calibrated to the nominal signal level found at the central office. Signal loss due to loop imperfections or extended length from the CO, as well as performance margin of the existing loop, can be quickly analyzed using this measurement.

Another useful tool for troubleshooting is to monitor messages that are being sent over the signaling channel. The CraftTek CT-100 captures and displays in real-time these hex data message elements being sent from the CO switch. One display allows the information to be viewed in raw hex data form (with the most recent 14 message elements displayed on screen). Another displays the same hex data in a decoded format (for example a hex value of “48” decoded is “Save Indicator Reset”). A buffer also retains the most recent 99 decoded message elements received for review.

## Conclusion

The CraftTek CT-100 offers a unique combination of convenience and performance to meet the evolving needs of the telephone craftsman. In addition to ISDN capabilities described in this application note, the CT-100 excels in supporting Northern Tele-

com's Enhanced Business Services (P-Phone), as well as new CLASS offerings for POTS (Calling Line, Calling Name Identification).

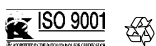
The CT-100's strengths include:

- The convenience of an integrated, easy-to-use test tool.
- Its ruggedness to withstand the rigors of the craft environment.
- The flexibility to ensure your investment is protected as standards evolve and service needs change.
- Its backing by Tektronix' full service and support.

## For further information, contact Tektronix:

**World Wide Web:** <http://www.tek.com>; **ASEAN Countries** (65) 356-3900; **Australia & New Zealand** 61 (2) 888-7066; **Austria** 43 (1) 7 0177-261; **Belgium** 32 (2) 725-96-10; **Brazil and South America** 55 (11) 3741 8360; **Canada** 1 (800) 661-5625; **Denmark** 45 (44) 850700; **Finland** 358 (9) 4783 400; **France & North Africa** 33 (1) 69 86 81 81; **Germany, Eastern Europe, & Middle East** 49 (221) 94 77-0; **Hong Kong** (852) 2585-6688; **India** 91 (80) 2275577; **Italy** 39 (2) 250861; **Japan** (Sony/Tektronix Corporation) 81 (3) 3448-4611; **Mexico, Central America, & Caribbean** 52 (5) 666-6333; **The Netherlands** 31 23 56 95555; **Norway** 47 (22) 070700; **People's Republic of China** (86) 10-62351230; **Republic of Korea** 82 (2) 528-5299; **Spain & Portugal** 34 (1) 372 6000; **Sweden** 46 (8) 629 6500; **Switzerland** 41 (42) 219192; **Taiwan** 886 (2) 765-6362; **United Kingdom & Eire** 44 (1628) 403300; **USA** 1 (800) 426-2200

**From other areas, contact:** Tektronix, Inc. Export Sales, P.O. Box 500, M/S 50-255, Beaverton, Oregon 97077-0001, USA (503) 627-1916



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