ISDN Basic Access Components of the Design of ISDN Peripherals

ABSTRACT

Integrated Services Digital Network (ISDN) customer premise equipment has not been readily available mainly because of lack of services across ISDN islands and the lack of ISDN connection over the ''last mile'' to the subscribers home. For their part, the Central Office switch manufacturers have recently demonstrated inter-working of services across wide geographical areas. Also, the semiconductor vendors have now produced VLSI transmission devices to allow field trials of ISDN services to the subscribers home. The basic components for building ISDN peripherals (VLSI components, signaling software modules and data communciation modules) have been demonstrated in early equipment used in field trials. The next phase is to develop ISDN products that are cost competitive with present equipment (analog phones and MODEMs) which are attempting to offer similar services using older technologies. In order to protect investments, inter-working of Non-ISDN equipment (e.g., Feature phones and FAX machines, Personal computers) with ISDN equipment is essential for the foreseeable future.

INTRODUCTION

ISDN provides an integrated set of services for voice and non-voice applications over an end-to-end digital network. The main objectives of the ISDN's User-to-Network Interface (UNI) are the following: to provide access to a wide range of services; to support universal portable terminals; and to provide a cost effective connection to the digital network. Until recently two interfaces were defined; Basic Rate Interface and Primary Rate Interface and these are part of Narrow-band ISDN (N-ISDN). Recently Broad-band ISDN (B-ISDN) standards are being defined for multi-megabit transmission rates and the standards appear to follow a similar reference model as N-ISDN. B-ISDN is beyond the scope of this paper.

Both Basic and Primary interfaces use B-(Bearer) channels and D-(Delta) channels. The B-channel is a 64 kilobit-per-second (kb/s) circuit switched channel used for voice or data. The D-channel is a message-based 16 kb/s (for BRI) or 64 kb/s (for PRI) channel used for signaling and packet switched data.

The UNI standards are defined in terms of a layered protocol based on the Open System Interface (OSI) reference model of the International Standards Organization (ISO).

Layer 1, the physcial layer defines electrical and mechanical characteristics. It also includes channel structure, line coding, cable configuration etc. Layer 2 or the data link layer's function is to provide error free link to the upper layers of the protocol. The Link Access Procedure for D-channel (LAPD) has been standardized. Other, similar procedures exist for the B-channel operation. The layer 3 protocol on the D-channel carries either signaling or data information.
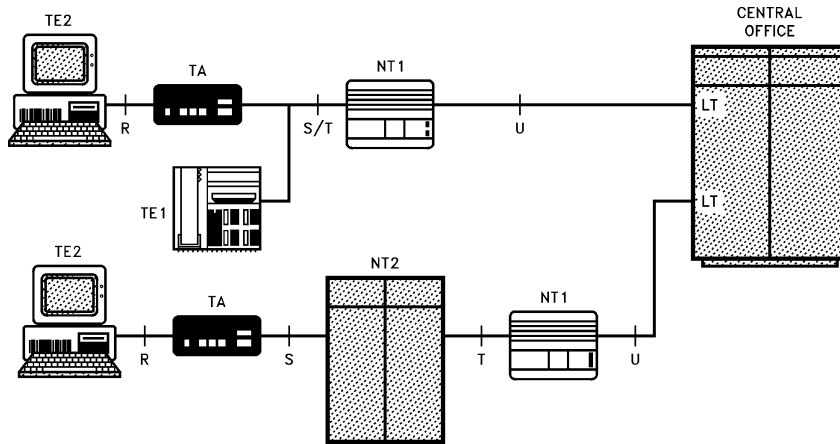
A thorough understanding of the basic standards and basic service capabilities related to the User-to-Network Interface (UNI) at the BRI is essential in developing equipment for this market. The protocol standards and physical layer components for the Basic Rate Access are discussed. The design concepts of ISDN peripherals using these components is developed. The most common ISDN equipment are: ISDN phones, Terminal Adapters (stand-alone or PC based), NT1 units, and Repeaters. The protocols for data communication are outlined. The use of ISDN hardware technology in Analog Pairgain market is explored. Finally, interworking of todays analog equipment such as Feature phones, and Fax machines with ISDN equipment is explained.

BRI REFERENCE POINTS

Standard configurations of BRI have been defined. They contain reference points indicated in *Figure 1*. A set of standards have been defined for compatibility at these reference points.

R— Existing interface specification covering standards such as RS232c, V.35, X.21.

S— ISDN terminal or terminal adapter interface, characterized by four wires, (2B + D) user rate, 192 kb/s line rate (including overhead) and up to 8 physical terminals on a passive bus network.

T— Normally, the T-reference point is the same as the S reference point for Basic access; however, if an optional network termination (NT2) is provided on basic access, some differences are possible.

U— This interface is characterized by point-to-point network, 2 wires, (2B + D) user rate, 80 Kbaud or 160 kb/s (including overhead).

TE1 — ISDN terminal equipment
TE2 — Existing terminal equipment, e.g., VT100, PCs
TA — ISDN terminal adapter; adapts existing terminals to ISDN
NT1 — Network terminating equipment converts loop transmission U interface to S/T interface
NT2 — Additional network termination; for example, a PBX to convert primary rate access to basic rate access
LT — Line Terminator in the local telephone exchange

FIGURE 1. ISDN Basic Rate Interface Reference Points

BRI CAPABILITIES

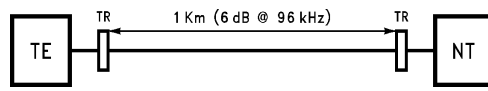BRI access capabilities and typical examples of their use are as follows:

- 16 kb/s D-channel signaling and up to 9.6 kb/s user data
- 80 kb/s D-channel signaling and B-channel voice or data e.g., an ISDN phone
- 144 kb/s D-channel for signaling and two B-channels for voice and/or data e.g., Voice/Data terminal.

The B-channels carry 64 kb/s user-information, such as circuit-switched voice or end-to-end data in a form that the two ends understand. The D-channel is used as a signaling channel between the terminal and network equipment. It is used for setting up calls, allocating B-channels for the TEs, terminating calls and so forth; using the layered LAPD protocol.

In addition to signaling, the D-channel can also carry low speed packet switched data. Terminal Adapters designed to handle up to 9.6 kb/s user data over the D-channel could provide a cost effective MODEM replacement solution for the ISDN world. Applications for D-channel data will include transaction-oriented messages, transmitting information from personal identity cards and telemetering data. Unlike B-channels, the packet switched data on the D-channels may be multiplexed providing multiple logical channels for packet switched calls from the end-user.
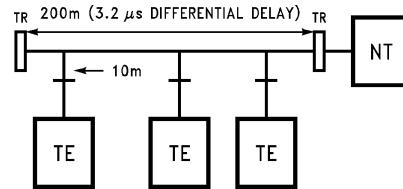
S/T INTERFACE CHARACTERISTICS

The basic rate interface at the S/T interface offers point-to-point and multi-point network configurations as illustrated in *Figure 2*. In the multi-point network called a passive bus, up to 8 terminals can be attached to one Network Terminator Unit (NT1 or a Line card).
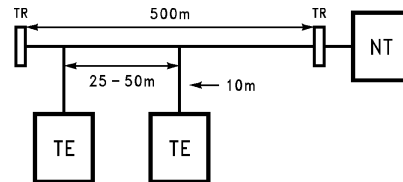

(a) Point-to-Point

(b) Short Passive Bus

(c) Extended Passive Bus

TR — Termination Resistor (100Ω)
TE — Terminal Equipment
NT — Network Termination

FIGURE 2. S/T Interface Network Configurations

The basic access rate at the S/T interface has a line rate of 192 kb/s consisting of 2B + D-channels (144 kb/s) plus 48 kb/s channel capacity which is used for framing, maintenance, and house keeping.
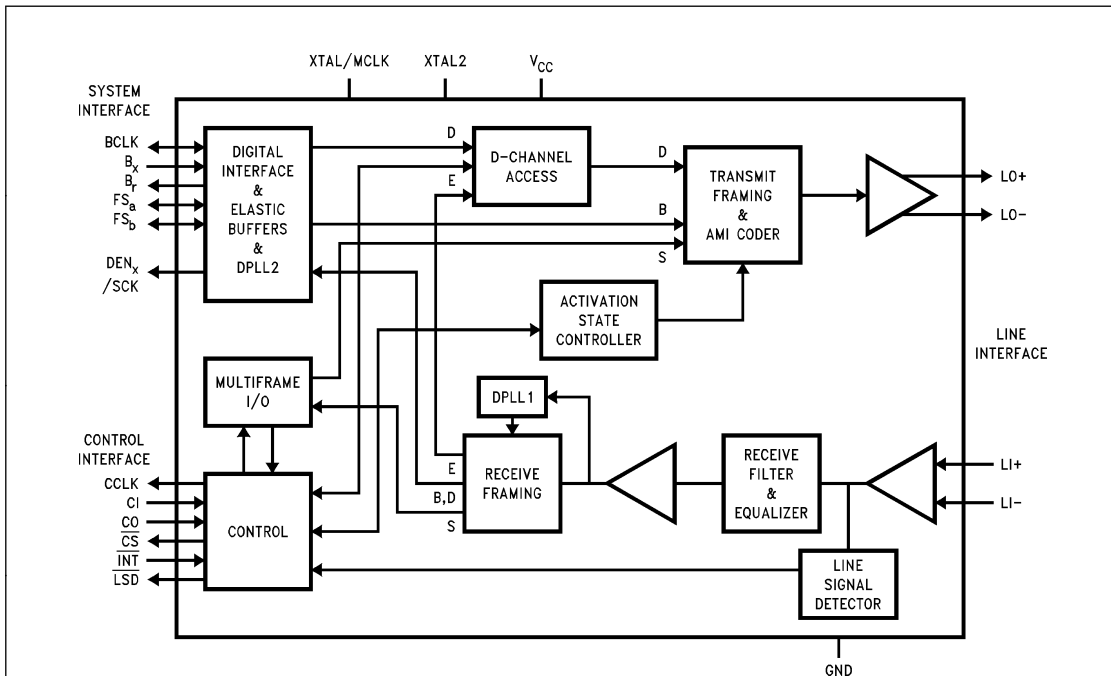
FIGURE 3. TP3420, Single Chip S Interface Transceiver

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One of the framing bits is used to carry slow speed (800 b/s each) maintenance channels over a 20-frame structure. The "Q" bit (from the TE) is used to request test loopbacks at the NT1 and the "SC1" and "SC2" bits (from the NT) are used to acknowledge the loopback requests as well as provide performance information from the network to the TE.

Multiple TEs on the S/T interface passive bus use a protocol to gain access to the common D-channel in an orderly and controlled fashion using statistical multiplexing. This procedure ensures that even when two or more terminals try to gain access to the D-channel simultaneously, one terminal will be successful in transmitting bits on the D-channel while the other terminal(s) back off.

There are two classes of D-channel Access; Signaling packets are Class 1 messages and all other packets (e.g., X.25 packets) are Class 2 messages. The Class 1 messages have a higher priority than the Class 2 messages; the priority mechanism is handled at layer 1. The network switch interrogates the signaling information and acts on it, but routes the packet data information to a Packet Handler which may reside within ISDN or outside of ISDN (e.g., Telenet, Tymenet).

S/T Interface Transceiver

The S/T interface transceiver needs to work over a number of network configurations as indicated in *Figure 2*. The point-to-point network may extend to 1.0 km and result in 6 dBs of signal attenuation. National Semiconductor Corp's. (NSC) S Interface Device SID transceiver (block diagram in *Figure 3*) incorporates an adaptive equalizer and low jitter clock recovery circuits to provide good performance over the extended range conditions. On the passive bus the sig-

nal attenuation is not severe but the pulse shape at the NT's receiver is very distorted because pulses arriving from multiple TEs (located at different points on the bus) are scattered over a time window of up to 3.2 μs. Sampling of the incoming data at a fixed time is recommended to achieve good performance under these conditions. Mixed analog and digital signal processing techniques are used to achieve the high degree of performance. The SID device was jointly developed with SGS-Thomson Microelectronics, and is available from both companies.

U INTERFACE CHARACTERISTICS

The U interface is a two-wire interface that consists of the local telephone line (also known as a Digital Subscriber Loop, DSL) to the customer's home or office. In North America, the T1 ANSI committee adopted a U interface standard (T1-601-1988) specifying: 2B1Q encoding, 10^{-7} bit error rate, 13 to 14 dBm pulse power level (over a 0–40 kHz spectrum), 2.5V nominal peak pulse voltage. Since the original specification of 1988, the ANSI committee has added new maintenance mode requirements on the NT equipment (detailed in the T1-601-1991 revision).

In 1983 Bellcore performed a survey of existing subscriber loops and identified 15 worst-case loops having different combinations of wire gauges, lengths, bridge taps and impedance characteristics. It is expected that U interface transceivers which work with these lines, will work over 99 percent of the subscribers lines in North America. *Figure 4* shows 4 of those loop configurations. Loop 1 has the longest range (18 kft) and hence the most attenuation. Loop 3 has multiple bridge taps causing multiple reflections of outgoing pulses as well as distortions of the incoming pulses from the far end.
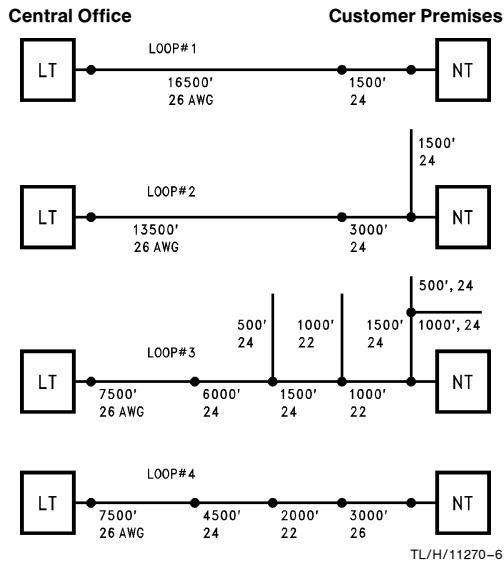
Other countries are developing their own worst-case DSL test loops to ensure acceptable performance within their environments. Unfortunately, current recommendations from CCITT for the U interface still allows the use of either 2B1Q or 4B3T line codes and thus some incompatibilities could exist across international borders. Since 50 percent of the world's digital lines are in North America, (which has settled on the 2B1Q standard) high volume production should make 2B1Q the most cost-effective encoding scheme for operating companies world-wide. A number of vendors have U interface transceivers using 2B1Q line code.

AWG—American Wire Gauge

FIGURE 4. ANSI U Interface Loops for Testing Received Signal Performance #1 to #4

Echo Cancellation

Full duplex transmission over two wires is achieved using echo cancellation techniques (see *Figure 5*). A transformer Hybrid circuit performs a 4-to-2 wire bridge and with proper matching of impedances, the transmitted signal is coupled to the line and the received signal is coupled to the receiver of the device. However, due to imperfect impedance matching to the characteristic impedance of every DSL, a substantial amount of the near end transmitted signal is reflected back into the receiver of the same device. The reflected signal is known as Near End Echo (É). Some additional reflections occur at points of impedance discontinuity e.g., at wire joints as well as at the far end point. These far end Echoes suffer severe signal attenuation and thus are not a dominant source of signal imperfection.

An adaptive Hybrid circuit can provide a better matching of the impedances at the low end of the frequency band where much of the 2B1Q energy lies. A digital Echo canceller (composed of a finite response filter) is used to generate a complete replica of the Echo (É) coming back into the receiver. The replica of the echo is subtracted from the total received signal (R), thus extracting the far end signal (F).

An equalizer processes the far end signal to remove inter-symbol interference and allow correct detection of the far end transmitted data. Timing is also recovered from the incoming waveform to perform optimum echo cancellation and equalization. The convergence of adaptive loops of echo-cancellation, equalization, automatic gain control as well as timing recovery impose many challenges to the transceiver designers.

E - Local Transmitter Echo   EC - Echo Canceller
É - Internally generated replica of Echo   EQ - Equalizer
F - Far End signal   HY - 4w-to-2w Hybrid
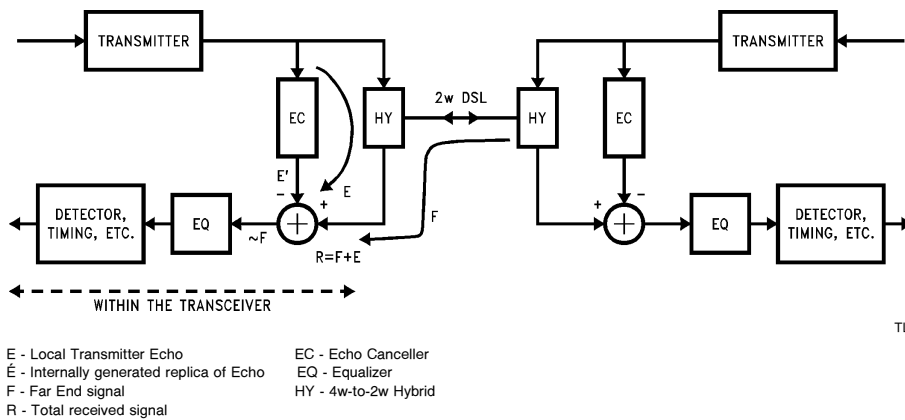R - Total received signal

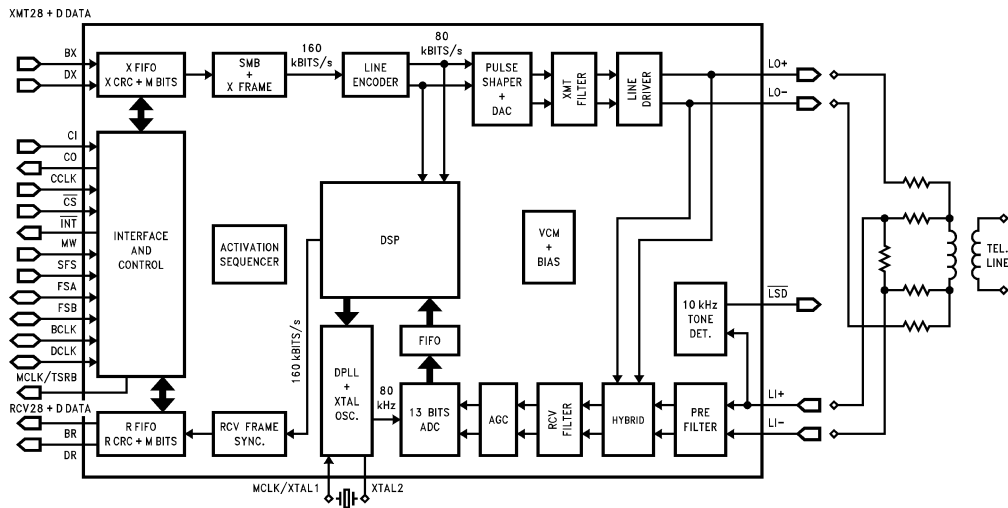**FIGURE 5. 2-Wire Operation Using Echo Cancellation**

FIGURE 6. TP3410, Single Chip U Interface Transceiver

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U Interface Transceiver

National Semiconductor's U Interface Device UID, is an example of a single chip implementation of the U interface standard (Block diagram in *Figure 6*). It incorporates very high performance signal processing (equalization, echo cancellation and clock recovery) using both analog and digital techniques, to achieve good performance over the demanding conditions of the subscriber loop plant.

The TP3410 UID incorporates two echo-canceller circuits. One is an analog adaptive hybrid, providing 20 dB of echo cancellation and the other is a fully digital echo-canceller rejecting the remaining echo from the received signal. The device was jointly developed with SGS-Thomson Microelectronics, and is available from both companies. The chip implements multiple chip-to-chip interfaces supporting programmable time slot access as well as interfacing to the European GCI format.

ISDN SOFTWARE

Layer 1 Device Drivers

Layer 1 firmware consists of drivers for the transceivers. They control the activation of the physical layer, guide the data routing, process and communicate maintenance channel information. NSC's SID and UID transceivers have a high degree of automation and require little interaction with the drivers.

Layer 2 Protocols for an ISDN TE

The ISDN layer 2 is a Data Link Control Layer. CCITT Q.921 standard (and the TR268 Bellcore standard) specifies the use of HDLC framing in the Link Access Procedure for D-channel, commonly known as LAPD. LAPD provides in-sequence, error-free transmission of packets. LAPD can handle multiple logical links. For ISDN BRI, there are at least three logical links running on the D-channel; one for signaling functions (SAPI = 0, TEI = a), {SAPI is Service Access Point Identifier and TEI is Terminal Endpoint Identifier} one for maintenance functions (SAPI = 63, TEI = 127), and one for D-channel packet data (SAPI = 16, TEI = b). "a" and "b" are arbitrary, but valid TEI values, in the range 1–126 and denote a particular terminating entity which may

be a physical unit (signaling for a phone) or a physical port (as in the case of the D-channel data).

The X.25 B channel data termination at Layer 2 requires implementation of the Link Access Procedures of CCITT recommendation X.25, more commonly referred to as LAPB. Like LAPD, LAPB also provides in-sequence, error-free frames to the higher layers. LAPB can only handle one logical link at Layer 2. Other terminal adaptation protocols are discussed in a later section.

Layer 3 Protocol Functions

The ISDN D-channel signaling termination at Layer 3 requires implementation of the Protocol Control procedures of CCITT recommendation Q.931 and Q.932. These procedures include setting up and tearing down local access connections between the terminal and the Central Office. These connections can be for voice or data services and can be requested for B or D-channels.

The present Central Office Switches (e.g., AT&T 5ESS and NTI DMS100) do not fully implement the CCITT layer 3 signaling standard (Q.931, Q.932). Therefore, present ISDN equipment needs firmware which is tailored to communicate with a particular switch at a time. The use of down-loadable PC based software or changeable EPROMs are methods being used to allow portability to different switch connections.

For X.25 data calls, all packets must be processed by the Layer 3 Packet Layer Protocol. These procedures include setting up and tearing down virtual circuits between end-to-end X.25 terminals.

Selection of Data Protocols

One of the hurdles facing the widespread deployment of ISDN is the confusion over terminal adapter techniques. While X.31 standard has been adopted for connection of X.25 terminals to packet switches via the ISDN, the situation for the majority of terminals which will require circuit-switched access is far less certain. Currently there exist proprietary schemes; AT&T DMI mode 2 (and mode 3) and Northern Telecom's T-link, which are already deployed in the network.

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At the national and international level there are two other standards; V.110 and V.120. The V.120 specification (driven primarily by companies in US) is based on adapting LAPD protocol to work on the B-channel thereby utilizing the advantages of an accepted packet oriented, rate adaptation protocol. Rate adaptation from slow speed (e.g., 2.4 kb/s) to 64 kb/s is achieved by simply stuffing HDLC Flags between packets containing data. It also provides mechanisms for flow control, and supports error free, multiple logical channels for one or more applications running over a single B-channel.

The V.110 specification (which evolved from the ECMA-102 European standard), is based on a 80-bit frame, in which incoming data is repeated (e.g., a 1200 b/s data bit is repeated 8 times) to make up the 80-bit frame. Some bits in the frame are reserved for carrying modem control signals, frame synchronizing pattern and end-to-end flow control. An advantage of V.110 is that the protocol can be implemented in silicon, but the disadvantage is there is no provision for error checking and re-transmission to ensure error free, end-to-end transmission.

ISDN Service	TA Procedures	R Ports	ISDN Channels
Circuit Switched	V.120 (U.S.)	V.24, V.35	B, H
	V.110 (Europe, Japan)	V.24, V.35	B
	DMI-1[AT&T]	V.35	B
	DMI-2[AT&T]	V.24	B
	T-Link [NT1] (Canada, U.S.)	V.24, V.35	B
	X.30 (Europe, Japan)	X.21	B
Packet Switched	X.32, X.25 Circuit Mode	X.25	B
	X.32, X.25 Packet Mode	X.25	B, D, H

FIGURE 7. Table of Data Protocols

ISDN CUSTOMER PREMISE EQUIPMENT

ISDN NT1

In simple terms, the NT1 unit is just an unintelligent box which converts from the 2 wire "U" interface to the 4 wire "S" interface. However, multiple options on implementing this function are possible.

NT1 in Europe

In Europe, this equipment is owned by the Telephone operating company who guaranty service up to and including the equipment. The customer attaches his Terminal Equipment (PC, workstation, multiplexors etc.) to this NT1 unit at the "S" interface point. The operating company will supply DC power to the NT1 unit via the signaling pair. Due to the limitation on the amount of power supplied, the NT1 unit is kept as simple as possible. It supports the minimal of loop maintenance features (such as B-channel loopbacks and some error performance monitoring functions).

NT1 in North America

In the USA, the NT1 is not owned by the RBOCs; the customer buys the equipment on the open market, installs and maintains this unit.

The NT1 is locally powered. In addition, the NT1 could provide power to a terminal (such as a phone). The NT1 units can be rack mounted and a common large battery associated with the rack would supply power to the "emergency" phones in case of local power failure at the terminal sites.

Since the NT1 is owned by the customer much like the telephone equipment, the operating companies (RBOCs) have put in a requirement that the NT1 should support some maintenance modes which can be remotely exercised by the field personnel in case of a reported fault condition. The test equipment, tapped on to the line (either at the central office or somewhere along the path to the customer premises) will send DC trigger pulses (similar to the dial pulse stream used in the phone system today) to control the maintenance modes of the NT1 unit (see *Figure 8*).

When an NT1 receives 6 trigger pulses it should enter a "Quiet mode" in which it should ignore any signals that may be present on the line. The tester may be performing Return Loss measurement or Impedance tests. With the detection of 8 trigger pulses, the NT1 should enter the "Insertion Loss Test mode" during which it transmits a known signal pattern which the tester at the far side uses to determine the acceptability of signal loss down the cable. Detecting 10 pulses causes the NT1 to enter the "Normal" mode in which it responds to the normal activation sequence signals originating from the central office line card.
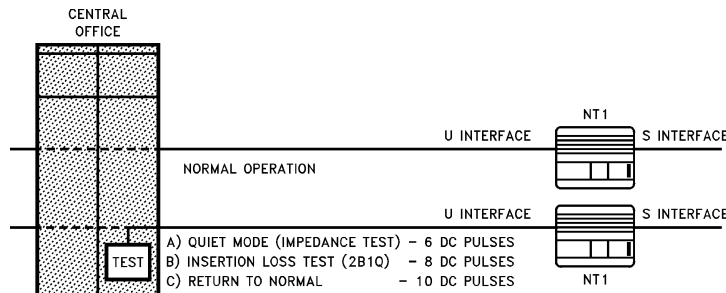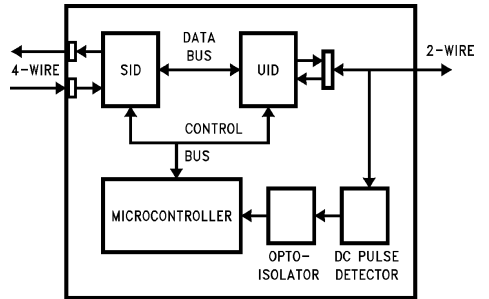

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FIGURE 8. Maintenance Modes of NT1 Unit in USA

NT1 Implementation

An example of an NT1 is shown in *Figure 9*. It consists of a U interface transceiver, an S interface transceiver and a low cost micro-controller. Some discrete circuitry is required to detect sealing current and the DC trigger pulses. An Opto-isolator converts the high voltage DC pulses to TTL level which are filtered and processed by the micro-controller. The firmware keeps count of the trigger pulses and performs the necessary actions.
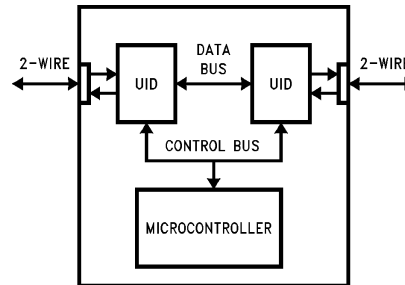

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FIGURE 9. NT1 Unit in USA

The firmware also monitors the activation states for both the S/T and the U loops, and responds to test loopback and performance monitoring messages from either the Central office equipment or the user terminal equipment.

In Europe, the maintenance requirements of an NT1 are minimal and so for this case the NT1 microcontroller can be run at a very low frequency to conserve power.

U Interface Repeater

A U interface repeater is necessary to extend the range to the subscriber beyond the 18 kft range limit of each DSL section. A repeater is implemented by connecting two UIDs back-to-back as shown in *Figure 10*. A simple 8-bit micro-controller performs the loop maintenance functions as well as the normal activation/deactivation sequences.

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FIGURE 10. U Interface Repeater Application

Pairgain Application

Increasing demand for additional phone line services has forced the RBOCs to produce Pairgain standards. They make use of the 2B1Q transmission technique (as defined in ANSI T1-601) to transport two digitally multiplexed voice channels (carried over the B1 and B2 channels) from a Central Office Terminal (COT) to a Remote Terminal (RT).

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FIGURE 11. Pairgain Application Using 2B1Q U Interface

Two voice CODECS are connected to the remote end (one on each B-channel) to output analog voice. Full SLIC functions give the features of a full RJ11c port to the subscriber allowing him access to two analog lines which originated as a single 2 wire line from the central office. See *Figure 11*.

Methods of carrying Call progress information such as Ringing, Busy etc., are generally proprietary and may make use of either the D-channel or the EOC maintenance channel.

TERMINAL EQUIPMENT IMPLEMENTATION

The general term ISDN Terminal Equipment (TE) implies ISDN phones, ISDN phones with data capability and various types of Terminal Adapters (TA). For all these solutions, it is convenient to have a common, flexible, cost effective and yet high performance solution for the ISDN "S" interface connectivity at all the three protocol layers of ISDN.

Figure 12 shows a typical implementation of the heart of an ISDN terminal equipment. The NSC TP3420 "S" Interface Device (SID) implements all the layer 1 functions specified in CCITT 1.430. All activation and "D" channel access algorithms are handled automatically within the device so as to minimize the interaction with the controlling microprocessor. Complementing the transceiver, is the HPC16400E, Integrated Communications Controller. The HPC16400E consists of a 16-bit CPU core (with 8-bit or 16-bit external data bus) and a number of internal peripherals. The two internal HDLC controllers and four associated DMA controllers handle data transfer with minimal interrupt overhead. In addition, there is a full UART, four timers and a serial decoder to implement multiple chip to chip interfaces. The HPC16400E with its software handles D channel signaling as well as different rate adaption protocols such as X.25, DMI modes 2 or 3, V.120 and V.110 on one of the B channels.

RJ11c Port

Today's voice and data communication equipment use analog phone lines accessed through a RJ11c jack in the wall. The decline in the cost of this equipment, as well as a large investment in feature phones, fax machines and data MODEMS, forces the co-existence of ISDN services as well as todays services. Hence, a number of today's ISDN terminal adapters provide a RJ11c port, to allow access to this equipment.

To provide this port, it is necessary to implement a simplified analog line card functions. A CODEC device (such as TP3076 COMBO) converts the analog signals into PCM digital signals which will be transported over ISDN. Further a Subscriber Line Interface Circuit (SLIC) provides 4-to-2 wire conversion, Ringing signal and perhaps sufficient DC power source to supply current to a simple analog phone. The Ringing signal needs to be high voltage to activate the circuits in today's equipment such as Fax machines and MODEMs.

A DTMF transceiver is necessary to detect DTMF signaling tones originating from these equipments and then call progress tones (e.g. trunk busy) need to be sent back to the equipment to provide status of the call. Additional software is required to convert the DTMF signals to ISDN D-channel messages to initiate a call and, similarly, returning call progress messages are converted to call progress tones.

Attaching PSTN Equipment to ISDN

Figure 13 and *14* show a couple of scenarios of connecting today's equipment to ISDN lines. In the first case a fax machine/MODEM or phone is connected to a RJ11c port of an "S" interface terminal adapter. In this case the terminal adapter could be a stand-alone box providing multiple RS232c/V.35 ports with a RJ11c port.
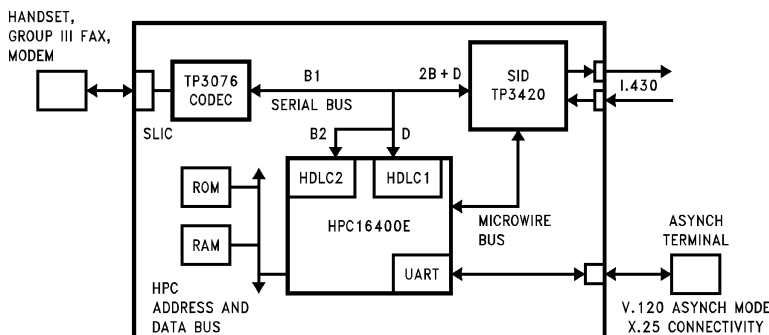

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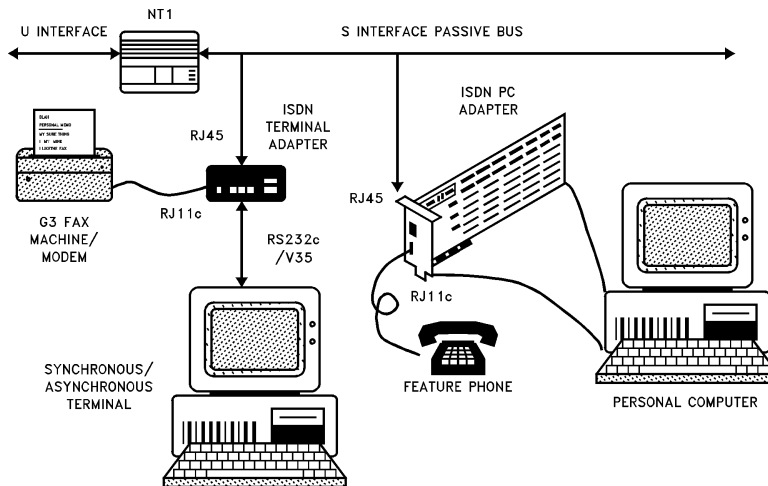
FIGURE 12. Core of ISDN Terminal Equipment

FIGURE 13. ISDN Terminal Adapter Connecting to Analog Equipment

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NT1 Function in a Terminal Equipment

In the USA, some Terminal Equipment may contain the NT1 function, and hence will be directly connected to the "U" interface. This saves the cost of having a separate NT1 unit and have to provide the S interface connection in the TE. This type of equipment has two drawbacks though. One is that it can only be used in the USA and not in Europe or Japan where the NT1 needs to be a separate physcial unit owned by the local telephone company. Secondly, the "S/T" bus is eliminated and thus there is no local sharing of the 2B + D Basic Access channels.

This type of TE with a direct U interface output is likely to be most popular in the ISDN to the Home market where ISDN terminal with a RJ11c jack to connect to an analog phone is a possible scenario (see *Figure 14*). This unit (card) would also be required to support the maintenance modes and functions described for a regular NT1 unit.

ISDN Multiplexors and Concentrators

For small businesses, ISDN Basic Rate Multiplexors will allow multiple terminals to share a few Basic Access lines.

This allows the use of existing terminals and phones onto the ISDN network through one box. The Multiplexors may provide full Rate adaption from Asynchronous and Synchronous RS232c and V.35 data streams to ISDN 64 kb/s synchronous rates. This kind of product would contain multiple SIDs or UIDs to connect to the ISDN network and RS232c and V.35, and RJ11c ports to inter-connect to present day equipment.

INTER-OPERABILITY AND CONFORMANCE TESTING

ISDN equipment adapting to the national and international standards for signaling and rate adaption is essential to ensure compatibility between equipment from different vendors. ISDN users' groups such as the ISDN users' Forum and DMI users' group are working towards implementation agreements to allow inter-operability between different vendors equipment designed to the same standard. Switch independent Conformance tests to ISDN standards have been developed in the ISDN Implementer groups.

Bellcore have established conformance testing labs to certify customer premise equipment for use with individual central office switches.
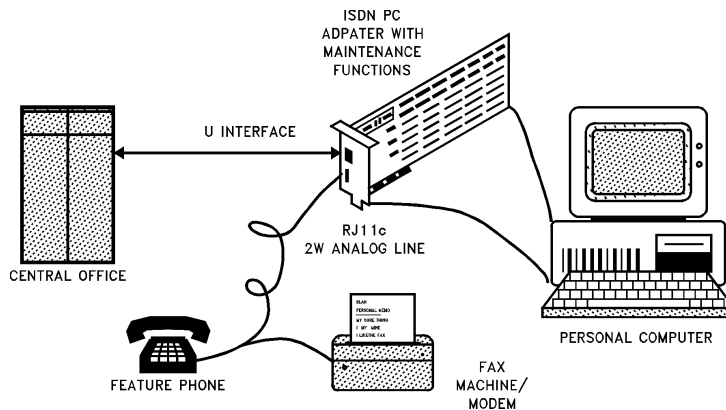

FIGURE 14. U Terminal Adapter for the Individual Subscriber

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CONCLUSION

Regional Bell operating companies have started to provide ISDN lines and services to the home subscriber on a limited basis. Competitive tariffing of new integrated services (including slow-scan video) may be needed to spur the widespread acceptance of ISDN.

As the ISDN equipment becomes accepted, the expected high volume will lower the cost of highly integrated silicon solutions, which will in turn drive the overall equipment cost down to compete with current phone equipment and high speed MODEMs. A low cost NT1 equipment whether standalone or embodied within a terminal equipment is essential to bring ISDN services to the home.

REFERENCES

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2. CCITT Recommendations: V.110, V.120 - Data Communication Protocols [1988 Blue books].

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