



Infinity Series H.110 Basic Rate ISDN Board

TECHNICAL MANUAL

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258M001B

Note: This manual refers to the revised board using the T8105 switching chip, Blackfin DSPs, and the HFC8S BRI Interface chip. As these chips are different than those used on earlier boards, there may be minor differences in the operation of the board. Those using the earlier revision should use the 258M001A revision of this manual. The revised board is functionally equivalent to the earlier board with the exception that the voice record and playback capabilities have been added. Specifically, this manual refers to firmware versions 02.0b and later.

Note: The rear board used with this revision of the BRI board has also been revised and is incompatible with earlier revisions. The front board **MUST** be used with the revised rear board and **MAY NOT** be used with earlier versions of the front board. The revised rear board **MAY NOT** be used with earlier versions of the front board. Installing incompatible front and rear boards **WILL** result in damage to both boards.

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Infinity Series H.110 Basic Rate ISDN Board Technical Manual

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• 4145 North Service Road, Suite 200 • Burlington, Ontario L7L 6A3 •

• 258M001B •

The H.110 Basic Rate ISDN Board

FCC Part 15 Requirements

WARNING: This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

FCC Part 68 Registration

This equipment is registered with the FCC under Part 68 as a component device for use with any generic PC Type computer or compatible. In order for FCC registration of this product to be retained, all other products used in conjunction with this product to provide your telephony function must also be FCC Part 68 registered for use with these hosts. If any of these components are not registered, then you are required to seek FCC Part 68 registration of the assembled equipment prior to connection to the telephone network. Part 68 registration specifies that you are required to maintain the approval and as such become responsible for the following:

- any component device added to your equipment, whether it bears component registration or not, will require that a Part 68 compliance evaluation is done and possibly that you have testing performed and make a modification filing to the FCC before that new component can be used;
- any modification/update made by a manufacturer to any component device within your equipment, will require that a Part 68 compliance evaluation is done and possibly that you have testing performed and make a modification filing to the FCC before the new component can be used;
- if you continue to assemble additional quantities of this compound equipment, you are required to comply with the FCC's Continuing Compliance requirements.

The telephone company has the right to request the registration information.

The Digital I/F FIC code for this equipment is 02IS5.

The Service Order code for this equipment is 6.oP.

The network Interface Jack for this equipment is an RJ49C.

The telephone company has the right to temporarily discontinue service. They are required to provide notification and advise of the right to file a complaint.

The H.110 Basic Rate ISDN Board

Changes to the BRI protocols offered by the telephone company may require changes to the setup parameters of the board. The board may cease functioning until such changes are made.

In case of trouble, you may be required to disconnect the board from the telephone lines until the problem is resolved.

Connection to telephone company coin service is prohibited.

Connection to party lines is subject to state tariffs.

The authorized repair center is:

American Tel-A-System, Inc.
800-356-9148
4800 Curtin Drive
McFarland, WI 53558

There are no user serviceable components on the board. All repairs should be accomplished by returning the board to Amtelco with a description of the problem.

WARNING: This device contains Electrostatic Sensitive Devices. Proper care should be taken when handling this device to avoid damage from static discharges.

Canadian Customers

CP-01, Issue 8, Part 1

Section 14.1

Notice: “The industry Canada label identifies certified equipment. This certification means that the equipment meets certain telecommunications network protective, operational and safety requirements as prescribed in the appropriate Terminal Equipment Technical Requirements document(s). The Department does not guarantee the equipment will operate to the user’s satisfaction.

Before installing this equipment, users should ensure that it is permissible to be connected to the facilities of the local telecommunications company. The equipment must also be installed using an acceptable method of connection. The customer should be aware that compliance with the above conditions may not prevent degradation of service in some situations.

Repairs of certified equipment should be coordinated by a representative designated by the supplier. Any repairs or alterations made by the user to this equipment, or equipment malfunctions, may give the telecommunications company cause to request the user to disconnect the equipment.

Users should ensure for their own protection that the electrical ground connections of the power utility, telephone lines and internal metallic water pipe system, if present, are connected together. This precaution may be particularly important in rural areas.

CAUTION: Users should not attempt to make such connections themselves, but should contact the appropriate electric inspection authority, or electrician, as appropriate.

European Approvals

CE Approval



This apparatus is approved by CTR3 for connection to an ISDN using ISDN basic access as specified in this section under the conditions set out in this document.

This apparatus, when operated as ISDN terminal equipment has been designed for operation on EURO ISDN S0 basis connections for point to multipoint connections, S0 PABX connections complying with EURO ISDN and for EURO ISDN S0 point to point connections. It supports most of the services of the EURO ISDN standard (ETSI DSS1). Furthermore, point to point connections are also supported.

EN55022 EMC declaration

This is a class B product. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures.

No changes or modifications to the BRI card are allowed without explicit written permission from American Tel-A-Systems, Inc., as these could void the end user's authority to operate the device.

• x •

Product Safety

The ISDN cord(s) must remain disconnected from the telecommunications system until the card has been installed within a host which provides the necessary protection of the operator.

If it is subsequently desired to open the host equipment for any reason, the ISDN cord(s) must be disconnected prior to effecting access to any internal parts which may carry telecommunications network voltages.

This board is not intended to be connected directly to the PSTN network. Connection must be made by way of an approved NT-1 interface device. It is the responsibility of the NT-1 to provide primary high voltage protection.

1.0 Introduction

The Infinity Series H.110 Basic Rate Interface ISDN Board is designed to provide thirty-two Basic Rate ISDN (Integrated Services Digital Network) interfaces connected to the H.110 bus on a board with the *CompactPCI* bus form factor. Each interface or port provides a D channel for call control signaling and two 64 kbps. B channels for either speech or circuit switched data. Each port can be independently configured as either a TE (Terminal Equipment) or NT (Network Termination) interface. The board provides complete support for the ISDN Layer 1 and Layer 2 protocols, as well as optional support for the Layer 3 protocols as defined in Q.931. In addition, the board is equipped with several DSP's to provide tone generation and detection.

The H.110 bus was devised by the Enterprise Computer Telephony Forum (ECTF) to provide a single telecom bus for the entire industry. It is intended for add-in boards using the *CompactPCI* form factor. A variety of boards are available from a number of different vendors. The H.110 specifications also provides for hot swap capabilities for use in high availability applications.

The board is equipped with a processor that can be used to control the lower level functions of the board. The host PC controls the board using messages passed through dual-ported RAM. The board shares a common message passing and control scheme with other Infinity Series H.110 boards.

1.1 Features and Capabilities

This section presents an overview of the features and capabilities of the Infinity Series H.110 Basic Rate Interface ISDN Board.

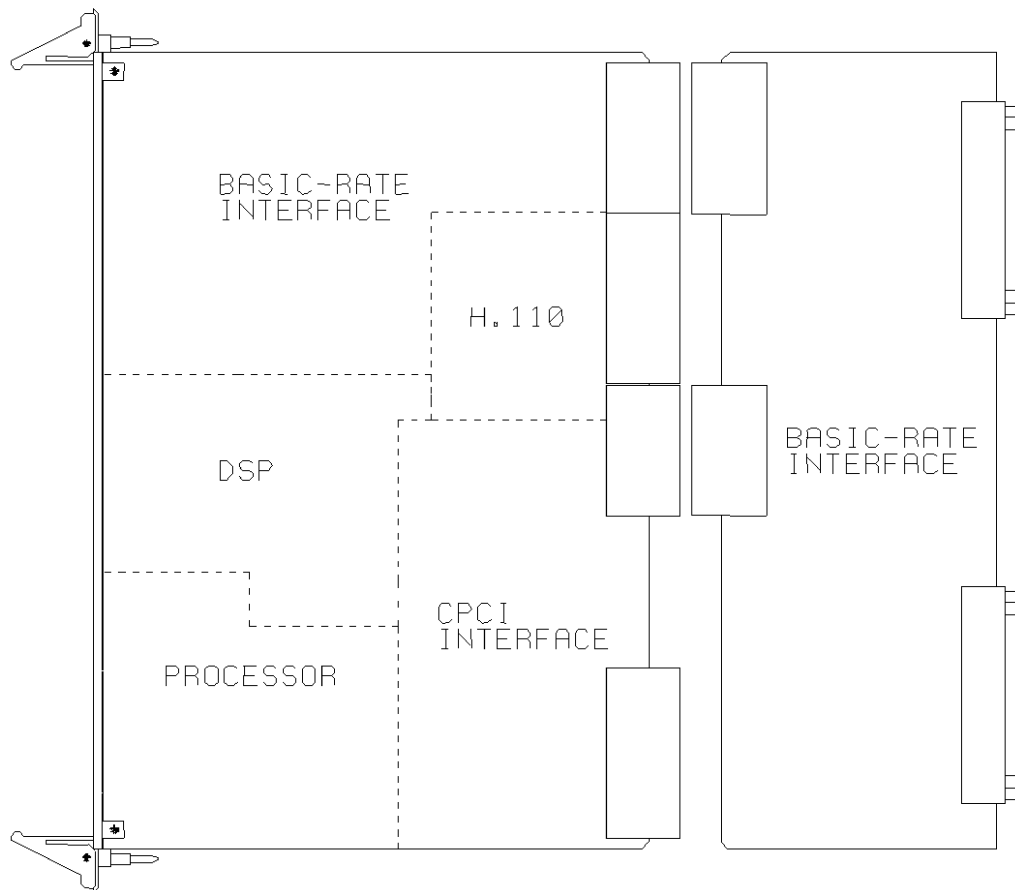


Figure 1: The H.110 Basic Rate ISDN Board Functional Areas

1.1.1 The Physical Interface

Thirty-two independent ports are provided on the board. Each port on the board provides a complete S/T Basic Rate ISDN interface. This interface can be configured under software control as either a piece of terminal equipment to interface to a central office or PBX, or as a network termination to interface to terminal equipment such as ISDN phone sets or ISDN modems. Layer 1 support is provided by the board to handle all the details of framing and clocking.

The H.110 Basic Rate ISDN Board

Each port provides two independent B1 channels which operate at 64 kbps. These channels can be switched to the H.110 bus, to each other, or to one of the DSP resources. In addition, there is a 16 kbps D channel which is used for signaling.

1.1.2 Signaling Protocols

ISDN uses the LAPD protocol on the D channel for call control. The Layer 2 protocol defines the mechanism used for the exchange of messages between terminal equipment and the network termination. The board manages the details of this protocol while providing commands to control aspects such as TEI (Terminal Endpoint Identifier) address management.

Call control is handled by the exchange of Layer 3 messages as defined by the Q.931 standard. The H.110 BRI Board allows the application to directly read and write the raw binary information field of these messages. Optionally, a higher level interface is provided that masks some of the details of these messages, making for a simplified applications interface. This is done through the use of “D” messages.

1.1.3 DSP Functions

The H.110 BRI ISDN Board is equipped with DSP's that performs a variety of functions. DTMF and Energy detectors are available for each B channel. DTMF generators are available for each B channel for signaling purposes. Call Progress tones are also available, with dial-tone, busy, reorder, and audible ringback being provided as well as silence and a 1004 Hz. calibration tone. Additionally, 64 channels of voice record and 64 channels of voice playback are available.

1.1.4 The H.110 Bus

The H.110 bus is a digital bus for transporting PCM (Pulse Code Modulation) signals between telephony boards. It was created by the ECTF to provide a common bus structure for future development that

would end the “bus wars” between the various legacy busses such as the SCbus and the MVIP bus.

PCM is a standard method of digitizing phone signals. It involves encoding each channel at an 8 kHz rate using eight bits. The signals from multiple channels are then combined into a frame. On the H.110 bus, each frame consists of 128 channels or timeslots. The bit rate of the H.110 bus is 8.192 MHz. Thirty-two wires, also called streams, each carrying 128 timeslots, are combined to form the bus, and provide a total of 4096 timeslots. Two timeslots are required for a full conversation, one for each talker.

In addition to the streams, a number of other signals necessary to maintain synchronization between all the boards in the system are carried on the bus. These signals provide the clocking and framing information. Redundant clocks are provided to aid in recovery if the primary clock should fail.

The H.110 bus consists of backplane connections on a 6U *CompactPCI* backplane that is used to interconnect the boards in the system. The CT Bus connections are made through the J4/P4 connector. The electrical and mechanical requirements of H.110 boards are tightly specified to insure the reliability and consistent performance of the CT Bus in any valid configuration of conforming boards.

1.1.5 Clock Modes

The H.110 BRI Board can operate in a variety of clock modes. Modes are available so that the master clock can either be derived from the H.110 bus, one of the Basic Rate Interfaces, or be provided by the H.110 BRI Board. The clock redundancy and clock fallback functions of the H.110 bus are also supported so that the H.110 BRI Board can be set to provide a clock to the H.110 bus if the master clock on that bus should fail.

1.1.6 Hot Swap Capability

The H.110 Specification includes “hot swap” capability. This capability

allows for the insertion and removal of boards from a live system. Not only are there provisions for controlling the electrical signals to prevent disruption when inserting and removing boards, but also for informing drivers and applications so that the board resources can be managed as they are added or deleted. Each H.110 board is provided with a blue LED that is used to inform an operator when it is safe to insert or remove a board.

1.1.7 Message Passing

The board occupies 8K of memory space on the host PC. This 8K may reside anywhere within the PC's address space. As a *CompactPCI* board, the address and interrupt of the board is assigned at boot time. The message passing scheme used by the Infinity Series H.110 BRI Board is identical to that of the other Infinity Series H.110 boards, allowing for the easy combination of a variety of Infinity Series H.110 boards in a single system.

The message passing scheme and message syntax of Infinity Series H.110 boards is similar to that of the older Infinity Series H.100 boards and XDS series of MVIP and SCbus boards. This facilitates the easy migration from ISA and PCI systems to designs using *CompactPCI* boards

1.1.8 Flash EAROM for Firmware

The firmware for both the main processors and for the DSP's is contained in Flash EAROM. This allows for easy upgrades of the firmware on the board in the field without requiring time consuming downloads every time a system boots. Once reprogrammed, the new firmware is retained even when the power is removed. The original, factory programmed firmware is also retained on board and can be accessed by installing a jumper.

1.1.9 EEPROM for Configuration Information

ISDN interfaces can require a substantial amount of information to be programmed into the system. These includes items such as the SPIDs

(Service Profile Identifiers) and DNs (Directory Numbers) associated with each interface as well as board configuration information such as the type of port (NT or TE) and the protocol level supported. To reduce the burden on the application, the board has an EEPROM capable of providing non-volatile storage for this information. This allows the board to automatically configure itself upon a restart.

1.2 How to Use This Manual

The first five sections in this manual are organized in the order you should read and use them to get started with your H.110 BRI ISDN Board. We recommend that you begin with these three steps.

1. Follow the instructions in section 2.0 (Quick Start) and 3.0 (Installation). These sections will tell you if your board is operating correctly within your system. You don't need to be familiar with the board's command set to complete this step.
2. Read section 4.0 (Initialization) to initialize the board within your system. Your application must perform these initialization procedures whenever the computer is powered up in order for the board to communicate with application.
3. Read section 5.0 (Communications with the Computer) for an overview of how to communicate with the H.110 BRI ISDN Board. Section 5.0 includes a summary of the commands for constructing your application and details concerning system interrupts.

Before you can actually build your application, read section 6.0 (The H.110 Bus and Clock Modes), 7.0 (Layer 1 and Layer 2 Protocols), 8.0 (Using "D" Messages for Layer 3) and 9.0 (Controlling the B-Channels). These sections explain, with practical examples, how the H.110 BRI ISDN Board operates and how to use the command set to achieve the desired results.

Section 10.0 explains diagnostic and error messages that may occur.

Introduction

• 1-7 •

The Appendix contains information on power requirements and interfacing that will be helpful installing your H.110 BRI ISDN Board.

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2.0 Quick Start

This section describes the first steps you should perform to determine if your Infinity Series H.110 Basic Rate ISDN Board is communicating correctly with your *CompactPCI* system. You can perform this quick check without connecting any cables.

The exact procedure will vary depending on which operating system you are running. For each operating systems, drivers are required to interface to the boards. The drivers supplied by Amtelco have tests built into them to verify communications with the boards. These drivers also come supplied with utility programs that allow the developer to test communications with the board. Please consult the appropriate documentation for the driver and operating system you are using.

Quick Start Procedure

1. With the chassis power off, insert the board into a slot. Note that the rear board **MUST BE** inserted into the corresponding rear slot for the board to function.
2. Turn on the computer.
3. If the Amtelco driver is not already installed, install it now, following the instructions supplied with the driver.
4. Most Amtelco drivers will display a list of boards that are installed (see the documentation for the particular driver that you are using). If the H.110 Basic Rate ISDN Board is listed, skip to step 6.
5. If the board is not listed, there may be a problem with the board not being seated correctly in the backplane. There may

The H.110 Basic Rate ISDN Board

also be a problem with a memory or interrupt conflict. Power down the chassis and check that the board is properly seated in the connector and repeat steps 1-4. If this does not remedy the problem, try removing any other computer telephony boards in the system. If your chassis is unable to find the board, consult the number at the end of this section.

6. Run the program “xdsutil” supplied with the driver. Send the message “IN” to the H.110 Basic Rate ISDN Board. The board should respond with the message “IA”.
7. Send the message “VC” to the board. Verify that the Receive Message reads: VCxxxxvvvvHBNA (where xxxvvvv is a variable indicating the firmware version).
8. If the Communications screen shows the correct command responses, your H.110 Basic Rate ISDN Board is communicating with the host. You may now power down the computer and attach the necessary cables (see section 3.4)

For technical assistance, call Amtelco at 1-608-838-4194 ext.168.

3.0 Installation

This section describes how to install your Infinity Series H.110 Basic Rate ISDN Board into your computer and how to use the jumpers, headers, and connectors. Before you begin the installation procedure, be sure to test the board as described in section 2.0 (Quick Start).

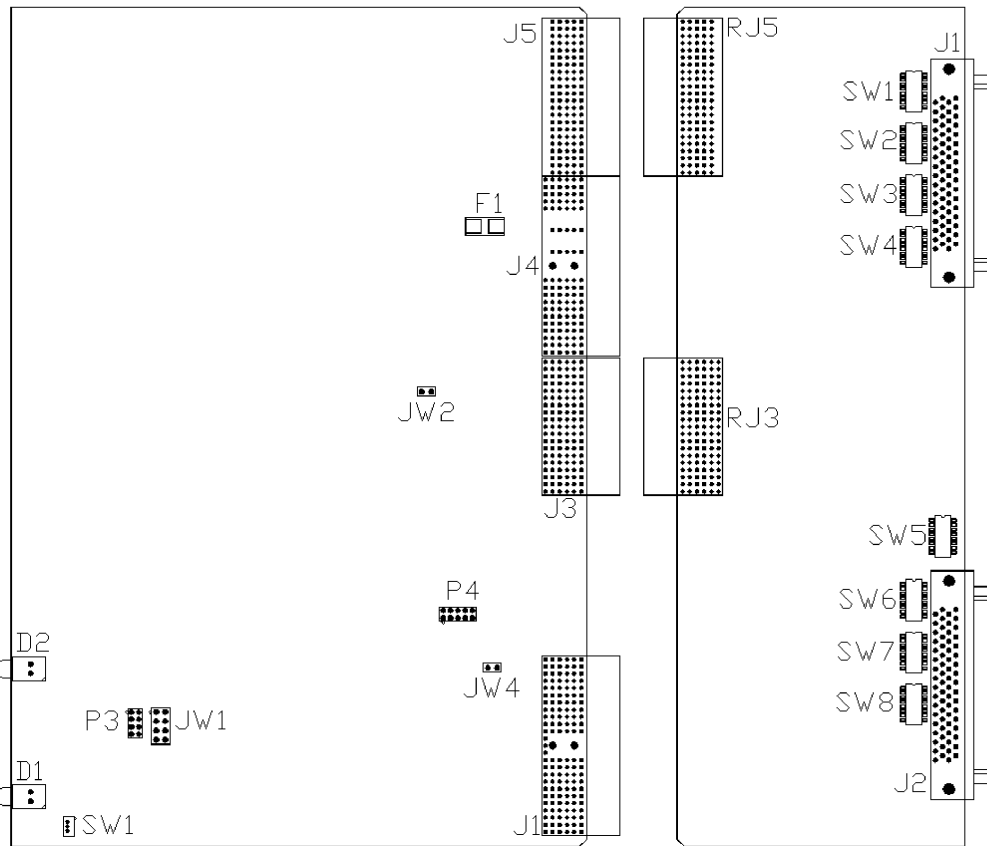


Figure 2: Location of Jumpers, Headers, Switches, and Connectors

The H.110 Basic Rate ISDN Board

The Infinity Series H.110 Basic Rate ISDN Board actually consists of two boards. The front board which contains the processor, DSP's, switching, HDLC controllers, and logic. The rear board contains the interface and connectors to the Basic Rate Interface ports.

3.1 PCI Configuration

As Infinity Series boards conform to the PCI standards, there are no switches to set to configure the H.110 BRI Board's memory address, I/O addresses, or interrupt. The host processor's bios will automatically configure the board at boot time to avoid conflicts with other boards in the system.

3.2 Jumpers & Headers for the Front Board

The following is a complete list of all jumpers for the H.110 BRI ISDN Board:

- JW1-1** Firmware Select. If firmware has been downloaded to the board, this jumper selects whether the downloaded firmware or the factory default firmware is used. When this jumper is installed, the factory default firmware is executed whenever the board is reset. When the jumper is not installed, the downloaded firmware will be executed after a reset if it is present. If no downloaded firmware is present, the factory default firmware is executed after reset.

- JW1-2** Undefined, reserved for future use

- JW1-3** Undefined, reserved for future use.

- JW1-4** Undefined, reserved for future use.

- JW2** DSP Firmware Select. Two separate firmware programs are included in the EAROM, one for the board processor and one for the DSP. If JW1-2 is installed and downloaded DSP firmware is present, the factory DSP firmware is executed after reset. Otherwise, the downloaded firmware is executed if present. See JW1-1.
- JW4** PCIXCAP/M66EN Bypass. When installed, the board will ignore the state of PCIXCAP and M66EN. This may be necessary when hot inserting the board into an older backplane that does not correctly implement these signals. When not installed, the board uses these signals during hot insertion to determine if the board can operate in the selected slot. The jumper is normally not installed.
- P3** Diagnostic port. Never install jumpers here
- P4** This header is used for programming internal logic and should never be jumpered.

3.3 Jumpers & Connectors for the Rear Board

- J1** Basic Rate ISDN Connections for port 0-15. This connector is a 68 pin SCSI-3 type connector. It contains two pairs for each Basic Rate ISDN port or interface on the board. See Figure 3.
- J2** Basic Rate ISDN Connections for ports 16-31. This connector is a 68 pin SCSI-3 type connector. It contains two pairs for each Basic Rate ISDN port or interface on the board. See Figure 3.
- SW1-8** These switches terminate the individual BRI ports. Termination is required if the port is to be used as an NT (network termination) or if it is the last or only TE (terminal equipment) on the interface. The switches should be set on

when termination is required. Each port requires two switches with port 0 using the first pair of jumpers on SW1, and port 31 using the last pair of jumpers on SW8.

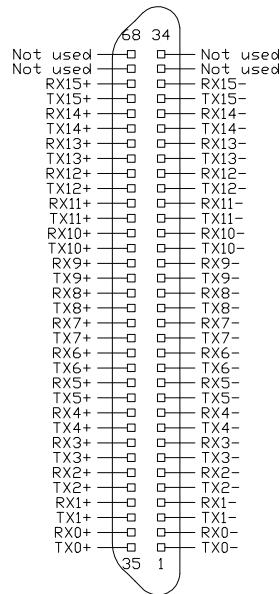


Figure 3: J1 & J2 Pin Assignments

3.4 Installation

Note: The front board **MUST BE** used with the appropriate revision rear board. Installing an incompatible revision board **WILL** result in damage to both boards.

To install the H.110 BRI ISDN Board in your system:

1. Do not connect the board to the PSTN. Follow the quick check procedures described in section 2.0.
2. If the quick check is successful, turn off the chassis power and remove the board from the chassis.
3. Install any necessary board jumpers. See section 3.2 for jumper configurations.

The H.110 Basic Rate ISDN Board

4. Reinsert the front board into the chassis. Seat it properly in a slot in the chassis and secure it with the front panel handles. Do not connect the board to the PSTN.
5. Insert the rear board into the corresponding slot on the rear panel. The rear board **MUST** be inserted for the front board to function.
6. Connect the host chassis to the mains supply using a socket-outlet with protective earthing connection and connect any additional protective earthing used.
7. Connect the telephone cables to J1 & J2. The telephone cable terminates in a 68 pin SCSI-3 male connector. Secure with mounting screws.

If it is subsequently desired to open the host equipment chassis for any reason, the PSTN cable must be detached prior to effecting access to any internal parts which may carry telecommunications network voltages.

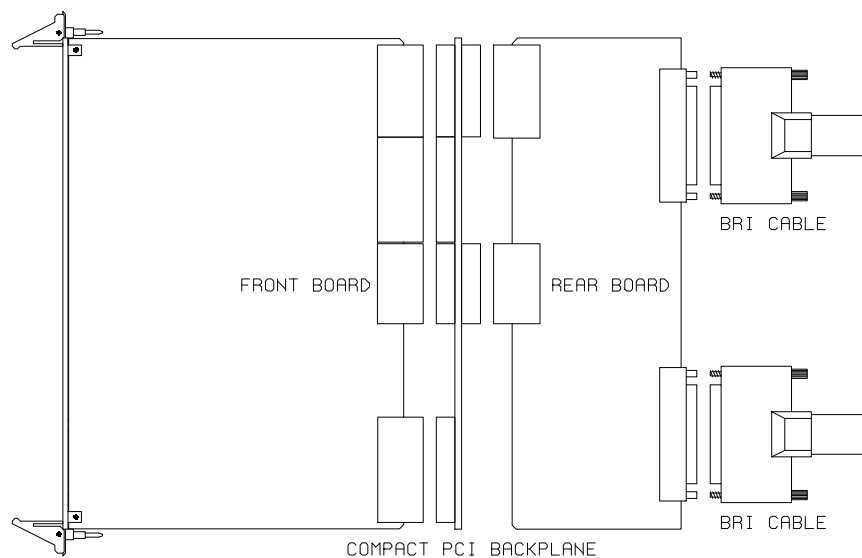


Figure 4: Installing Cables on J1 and J2

The H.110 Basic Rate ISDN Board

3.5 Hot Swapping a Board

The Infinity Series H.110 Basic Rate ISDN Board can be “hot swapped,” that is it can be removed from a functioning system without turning the power off or interrupting applications. However, to be able to do this, the host processor must be equipped with suitable hot swap drivers as well as a hot swap manager which will alert applications when a board has been inserted or removed from the system so that resources can be properly managed. It is beyond the scope of this manual to describe the operation of either the hot swap driver or hot swap manager.

Each H.110 board is equipped with a switch linked to the lower ejector tab and a blue LED. This combination is used to coordinate the actions of an operator with the system software. When inserting a board, the board is pushed in part of the way until the blue LED is illuminated. The insertion may then be completed. When the connection process is complete, the LED will go out. To remove a board, the lower ejector handle is depressed until it is in the unlatched position. When the blue LED comes on, the board may be removed from the system.

The rear board **MUST ALWAYS** be inserted **BEFORE** the front board, and removed **AFTER** the front board.

To install the front board in a system under power:

1. Insert the board with the ejector tabs spread apart until partially engaged.
2. Wait until the blue LED is illuminated.
3. Finish inserting the board by pushing the ejector tabs towards each other. The LED should then go out.

To remove the front board from a system under power:

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1. Depress the lower ejector tab until it is in the unlatched position.
2. Wait until the blue LED is illuminated.
3. Finish removing the board by spreading the ejector tabs apart until the board is ejected.

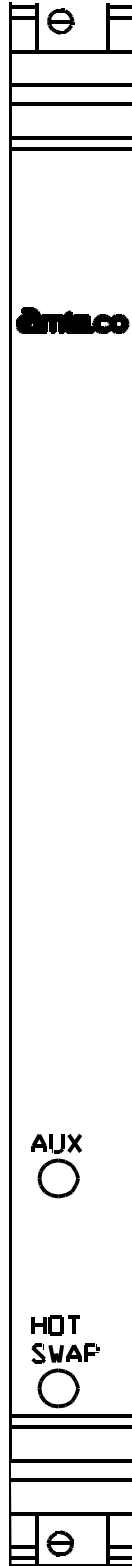
To insert the rear panel board into a system under power:

1. The rear board should be disconnected from the PSTN. Make sure there is no board in the corresponding front panel slot.
2. Insert the rear board.
3. Connect the telephone cables to J1 & J2. The telephone cable terminates in a 68 pin SCSI-3 male connector. Secure with mounting screws.
4. Insert the front board as described above.

To remove a rear panel board from a system under power:

1. Remove the front board as described above.
2. Disconnect the PSTN cables from J1 and J2.
3. Remove the rear board from the system.

Figure 6: Front Panel with Aux and Hot Swap LED and top and bottom ejector handles



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4.0 Initialization

This section describes the procedures necessary to initialize the system and enable the host computer to communicate with the Infinity Series H.110 Basic Rate ISDN Board. XDS drivers will implement some of these procedures.

4.1 PCI Initialization

The system BIOS is responsible for recognizing *CompactPCI* boards and mapping them into the I/O and memory spaces as required. It is also responsible for assigning interrupts to the board. This is done through a set of on board registers which contain information specifying the memory, I/O, and interrupt needs of the board. A set of BIOS functions exist for accessing this information. A detailed description of these functions can be found in the *PCI BIOS Specification* published by the PCI SIG, the PCI Special Interest Group.

Normally, the drivers supplied by Amtelco will take care of the process of finding Infinity Series boards and establishing communications. The information in the rest of this subsection is for background only.

The configuration registers of every *CompactPCI* board contain a vendor ID and device ID code. These codes are unique to each board vendor. All Infinity Series H.110 boards have the same vendor and device IDs. The vendor ID is 14E3h and the device ID is 0101h. A BIOS function exists that will find each instance of a particular vendor and device ID, and which returns with a bus and device number. The bus and device number is then used in functions to read the configuration registers.

The configuration registers contain information on the base address of the memory and I/O assigned to the board by the BIOS. A PCI board may

have up to six different base addresses. On Infinity Series H.110 boards, the first two base addresses are used by the PCI bus interface logic. The third base address which is contained in registers 18-1Bh contains the memory location of the dual-ported memory that is used to pass messages. The fourth base address contains the address of the DSP dual ported memory that is used for the voice record and playback feature. The interrupt information is contained in register 3Ch. The information in these configuration registers can be used by a driver to address the board.

4.2 Initialization Commands

The H.110 BRI ISDN Board is initialized by sending a sequence of command messages to the board. The process of sending messages is described in detail in Section 5.0, but normally it is accomplished either with a low-level driver XMT command or the API function **xds_msg_send**. Response messages are read using the low-level driver RCV command or the API function **xds_message_receive**.

To enable communications with the H.110 BRI ISDN Board, an **IN** command message should be sent to the board. The board will respond with an **IA** message.

The board may be reset using the command message **RA**. The board will respond with an **RA** message.

Your application can now configure the H.110 BRI Board using these commands

<u>Command</u>	<u>Purpose</u>
SCmsabb(c)	Sets the clock mode for the board. The parameter <i>m</i> is the clock-mode. The parameter <i>s</i> is the clock sub-mode. The parameters <i>a</i> , <i>bb</i> , and <i>c</i> are used to specify additional clock control information such as clock rates, local network, and CT_NETREF settings. The default mode on power-up or restart is mode 0.

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See section 6.0 of this manual for details of clock mode arguments.

SEx Sets the encoding mode for the board. The parameter *x* can be either M for Mu-Law as used in North America and Japan, or A for A-Law as used in Europe and Asia. The default value is for Mu-Law.

SFb(xx...xx) Sets the power feed enable for each port in a bank of sixteen on the board. The H.110 BRI ISDN Board can supply PS1 power for terminal devices connected to ports configured as an NT. The bank *b* can be either “L” for the ports 0-15 or “H” for ports 16-31. The parameter can be “F” to turn the power feed off, “N” to turn it on, or “*” for no change. The port type parameter must be included of each of the 16 ports in the bank.

SSxy Set Layer 2 system options. *x* and *y* can take values of 0 or 1. If *x* is a 1, timer TWAIT is disabled, and a TE port will not automatically request a TEI assignment. Option *y* controls the form of the TEI Check Response message. If this option is a 0, all TEI's are reported in a single message, if a 1, each TEI is reported in a separate message. The defaults are 0 for both options.

STb(xx...xx) Set the port type for each port in a bank of sixteen on the board. The bank *b* can be either “L” for the ports 0-15 or “H” for ports 16-31. Port types can be “N” for NT or network termination, “T” for TE or terminal equipment, or “U” for undefined for unused ports. An “*” may be used to indicate no change. The N type is used when interfacing to terminal equipment such as ISDN station sets or ISDN modems. The T type is used when interfacing to the central office equipment or when the board is acting as a terminal device. The

port type parameter must be included of each of the 16 ports in the bank.

If the optional Layer 3 support is to be used, it will be necessary to set several additional parameters for each port or B channel. The following commands are used for that purpose:

SLb(l1..l2) This command is used to set the protocol level supported by the board for each port in a bank of sixteen. The bank b can be either “L” for ports 0-15 or “H” for ports 16-31. The choices are:

- 2 - Layer 2 support only
- 3 - Layer 3 support
- A - AT&T Custom protocol support
- D - NI-1 support (DMS-100 & 5ESS switches)
- E - CACH EKTS support
- N - NI-1 support (Siemens EWSD switch)

If Layer 2 support is selected, it is the responsibility of the application to compose and interpret the Q.931 messages using the auxiliary mailboxes. Layer 3 support is provided through the “D” messages. (See section 8.0). The D protocol level option should be selected for Layer 3 support when operating as a TE connected to a Nortel DMS-100 or Lucent 5ESS switch. This option controls some aspects of TEI and directory number usage as implemented by these switches. The Siemens EWSD switch will operate with either the 3 or N setting which are equivalent. The default is Layer 2 support. The protocol level parameter must be included for each of the 16 ports within the bank.

SDxx(dn)/(spid) This command sets the default directory number and SPID for each B channel xx. For a port defined as an NT, only the directory number is specified. This is the

number that will be used as the default called directory number for calls originating on the port. For ports defined as a TE, it will be necessary to define both a SPID and a directory number. The directory number will be the calling number used for calls originating from the port. If only a single SPID is required for the interface, this should be defined for the B1 channel. If two SPID's are required, the voice SPID should be defined for the B1 channel and the data SPID for the B2 channel. Directory numbers are seven digits in length and SPIDs are 10-14 digits.

4.3 Configuration Memory

Much of the configuration information used to initialize the board is fixed in nature, such as the port types, SPID's and Directory Numbers. To simplify initialization of the board, the configuration can be stored in an onboard EEPROM. This information can be recalled upon a restart of the board eliminating the need to send this information to the board each time an application runs. To control the EEPROM, three commands are provided. These are:

- SMS** This command saves the current configuration including port types, the protocol level, SPID's and Directory Numbers.
- SML** This command will cause the configuration saved in the EEPROM to be loaded into the processor memory. It is not necessary to use this command on a restart as the information saved in the EEPROM will automatically be loaded into the processor memory.
- SMC** This command will clear the EEPROM. If this command is used, the board will not read the EEPROM on a power up or restart and all required configuration information will have to be sent from the application.

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Initialization

If the board configuration is saved in the EEPROM, it will still be necessary to send the **IN** and **SC** messages to enable messages and set the clock mode.

5.0 Communicating with the Host

This section describes how the host computer communicates with the Infinity Series H.110 Basic Rate ISDN Board. It includes the definitions for the H.110 BRI Board commands and responses along with a description of the mailboxes used for messaging.

The board is controlled by the host computer through a system of four mailboxes. The messages consist of short NUL-terminated ASCII strings, which are easy for the host software to compose and parse. The board is capable of buffering up to eight messages in either direction and can drive an interrupt line when it has a message for the host. Messages may not exceed 32 characters.

There are two main mailboxes, one for messages to the board and one for messages from the board, and two flags associated with them. A 00h in a flag byte indicates the mailbox is free, a non-zero value indicates that the mailbox is occupied. The mailboxes and their flags are contained in an 8K block of dual-ported memory at the following offsets:

receive mailbox	1F80h
transmit mailbox	1FC0h
transmit flag	1FFCh
receive flag	1FFEh

The board's base address is determined by reading PCI Configuration Space offset 18h. The 32-bit value at this location is the base address for the dual-ported memory on the board.

To send a message, the message is placed in the mailbox and the flag is set to 01h. To read a message, the message is removed from the mailbox and the flag is cleared to 00h. This will clear the interrupt hardware.

In addition to the two main mailboxes, there are two auxiliary mailboxes that are used for passing Layer 3 messages to and from the board. These mailboxes are only used in conjunction with the “LC” and “LR” command and response messages in the main mailboxes. Each of these auxiliary mailboxes begins with two bytes indicating the length of the Layer 3 message (low order byte first) and 260 bytes for the body of the message (the maximum size of a information field for Q.931 messages). The mailbox for messages to the board has an offset of 1400h and the mailbox for messages from the board is at an offset of 1600h.

To send a Layer 3 message, the transmit flag for the main mailbox must be clear. The message and its length is first placed in the auxiliary mailbox. An “LC” or “LR” command is then placed in the main mailbox, and finally, the transmit flag is set to 01h. It is important that both the Layer 3 message and the command be placed in the appropriate mailboxes before the transmit flag is set.

The presence of a Layer 3 message from the board is indicated by either an “LC” or “LR” message in the main mailbox. The Layer 3 message must be read before the receive flag is cleared. Failure to do so may result in the message being overwritten.

5.1 Commands and Responses Protocol

This section describes the necessary step-by-step procedures for the host to send a command to the board and to remove a response from the board.

5.1.1 Sending Commands to the Board

The basic steps to sending a command to the H.110 BRI ISDN Board are:

1. Build a command. Broadly speaking, a command is a string of ASCII characters with a NUL (00h) termination character.

2. Check the transmit flag. If the flag is 0, continue with the next step to put the command in memory. If the flag is not 0, wait until the flag is 0.
3. Insert the command in transmit mailbox memory beginning at the address of the transmit mailbox.
4. Write 01h to the transmit flag. This notifies the board that a message is waiting.

5.1.2 Reading Messages From the Board

1. Check the receive flag. If the flag is 0, there is no message. If it is non-zero, a message is waiting. Continue with the next step to read the message.
2. Remove the message from memory, starting at the address of the receive mailbox. Messages are NUL terminated ASCII strings.
3. Write 0h to the receive flag.

5.1.3 Reading Board Information

A range of board information is included in memory so that it can be checked without sending a message:

<u>Type of Information</u>	<u>Offset Address</u>
Board ID	1F00-1F03
Firmware Version	1F04-1F07
Shelf and Slot ID	1F08-1F09
Number of B-channels	1F10-1F11
Clock mode settings	1F18-1F1B
Board configuration	1F1C-1F1E
Clock status bits	1F1F

The board stores its identity upon power up or a hardware restart. The

phrase **Restart HB 00 (c) Amtelco 1999** appears in the receive mailbox. The receive flag is not set and no interrupt is generated.

5.2 Interrupts

The H.110 Basic Rate ISDN Board can generate an interrupt to the PC indicating that a message is available. The interrupt for PCI boards is assigned by the BIOS or Operating System at boot time. The assignment is dependent on which PCI slot the board is in. The interrupt line is usually shared by more than one device. If multiple Infinity Series boards are installed they may or may not all share the same interrupt line.

In order for an Infinity Series board to send interrupts to the PC, the PCI Interface circuit on the board must be programmed to enable interrupts. This is accomplished by setting bits 0 and 3 in the board's Interrupt Control/Status Register. This is a byte-wide register located at an offset of 69h from PCI Base Address 0. PCI Base Address 0 is contained in PCI Configuration Space register 10h. The Base address is a 32-bit value and is mapped into memory.

When an Infinity Series board sends a message, it generates a local interrupt to the PCI Interface circuit on the board. If the PCI Interface circuit has been programmed to generate interrupts to the PC, the local interrupt is passed through to the PC. When the PC receives an interrupt, its Interrupt Service Routine (ISR) should check the Infinity board's receive flag to see if a message is pending (i.e. the receive flag is non-zero). It should then process the message for the board and write a 0 to the board's receive flag.

5.2.1 Interrupt Initialization

1. Clear the board's receive flag.
2. Read the PCI Base Address 0 from PCI Configuration Space offset 10h (this must be a 32-bit access).

3. Set bits 0 and 3 of PCI Base Address 0 + 69h. Do not modify any other bits in this register. This register is a byte-wide memory mapped register.

5.2.2 Step-by-Step Interrupt Processing Summary

1. Check to see if the receive flag is non-zero.
2. Remove the message from the receive mailbox.
3. Write 0h to the receive flag.
4. Re-enable the interrupt controller on the PC.

5.3 Commands and Responses

This section gives a general overview of the H.110 BRI ISDN Board commands and responses. The commands are grouped by function and then listed in alphabetical order by two-letter command. Refer to sections 7.0 through 10.0 for examples and explanations of how to use these commands.

5.3.1 Characteristics of Command Strings

- < All commands consist of null (00h) terminated ASCII strings.
- < There are no spaces or other delimiters between parameters in the commands.
- < All letters in command strings must be UPPERCASE unless otherwise noted.
- < Lowercase monospaced letters (such as `xx`) in the following command references represent parameters within commands. Each letter represents one ASCII digit.

< Numeric parameters are always hexadecimal numbers.

5.3.2 Command Parameters

The table below documents the common parameters for many of the commands listed in the next sections. Other less common parameters are defined with individual commands.

Common Command Parameters

Parameter	Definition	Values
xx	B-Channel number	00-3Fh
dd	D-Channel number, port	00-1Fh
b	Bank of 16 ports Low - (0-15), High (16-31)	L = (00-0F) H = (20-2F)
sstt	H.110 bus stream & timeslot number, ss = stream and tt = timeslot on stream	ss = 00-1Fh tt = 00-7Fh
aabb	H.110 bus stream & timeslot number, aa = stream and bb = timeslot on stream	aa = 00-1Fh bb = 00-7Fh
bsstt	MVIP-95 terminus, b = bus ss = stream, tt = timeslot	b = H, L ss = 00-1F tt = 00-7F

5.3.3 Commands from the Host to the H.110 BRI Board

Note that sections 7.0-9.0 of this manual provides supplemental information for the commands and messages documented here.

B-Channel Commands

CAxxsstt	set B-channel xx to listen to stream ss timeslot tt
CCxxssttaabb	connect B-channel xx to stream ss timeslot tt and from stream aa timeslot bb
CDxx	disconnect B-channel xx
CExxdd	enable energy detection for B-channel xx, look for energy of duration dd
CExxF	disable energy detection for B-channel xx
CHxx	put B-channel xx on hold
CLxx	set B-channel xx to detect DTMF digits, play dial tone
CLxxo	set B-channel xx to detect DTMF digits option o F - turn detection off M - monitor mode, maintain existing connections Q - regular mode, suppress dial tone
CPxxy	give B-channel xx call progress tone y where y values are 0 - dial tone 1 - reorder 2 - busy 3 - audible ringback 4 - Digital Milliwatt 5 - silence 6 - ETSI dial tone 7 - congestion tone 8 - ETSI busy tone 9 - ETSI ringback A - U.K. ringback B - Japanese ringback
CSxxsstt	play call progress tone to stream ss timeslot tt, timeslot 20-25h
CTxx(ds)	send dial string ds to B-channel xx, valid tones in string are: 0-9, *, #, A-D, U - upper tone (941 Hz.), L - lower tone, (697 Hz.), X - short pause, P - long pause
CXxxsstt	set B-channel xx to transmit on stream ss timeslot tt

Layer 3 “D” Commands for NT Ports

DAxxps	ALERTing message on B channel xx, progress p, signal s
DBxxA=ca(a)	AT&T call appearance select, call appearance ca optional adjunct control (a)
DBxxCA	AT&T Conference Acknowledge on B channel xx
DBxxCRcc	AT&T Conference Reject, cause cc
DBxxDA	AT&T Drop Acknowledge on B channel xx
DBxxDR	AT&T Drop Reject on B channel xx
DBxxFbmsff(i)	AT&T Feature Indication, button type b, module m, status type s, feature number ff, opt. ind. status i
DBxxGrirt(A=ca)	AT&T Associated, call ref. rr, associated type t, optional call appearance ca (type = setup)
DBxxHA	AT&T Hold Acknowledge on B channel xx
DBxxHRcc	AT&T Hold Reject on B channel xx, cause cc
DBxxK	AT&T Redirect on B channel xx
DBxxRA	AT&T Reconnect Acknowledge on B channel xx
DBxxRRcc	AT&T Reconnect Reject, cause cc
DBxxTA	AT&T Transfer Acknowledge on B channel xx
DBxxTRcc	AT&T Transfer Reject, cause cc
DBxxX(a)(b)(c)	AT&T INFO display fields a, b, and c
DCxx	CONNect message on B channel xx
DDxx	DISConnect message on B channel xx, normal clearing, tones off
DDxxcc(s)(rr)	DISConnect message on B channel xx, cause cc, optional signal s, optional call reference rr
DExxHrr	KEY HOLD on B channel xx, call reference rr
DExxNnrr	EKTS NOTIFY on B channel xx, notification n, call reference rr
DExxSb/#	KEY SETUP, bearer capability b, called #
DExxSb(/#)A=ca	KEY SETUP on B channel xx, bearer capability b, optional called #, call appearance ca
DFxxffa	Feature Indication activation a for feature indicator ff on B channel xx
DGxxArr	RETRieve ACKnowledge on xx, call ref. rr
DGxxRccrr	RETRieve REJect call reference rr on B channel xx, cause cc

DHxx	HOLD message on B channel xx
DHxxA	HOLD ACKnowledge message on B channel xx
DHxxRcc	HOLD REJect message on B channel xx, cause ss
DIxxBerr	INFORmation message, channel id c, call ref. rr
DIxxD	INFORmation message, send display text in buffer
DIxxPps	INFORmation message, progress p, signal s
DIxxQq(C)	INFORmation message on B channel xx, information request q, opt. C if request complete
DIxxS(spид)	INFORmation message, send SPID
DIxxT(text)	INFORmation message, send display text
DNxxn	NOTIFY, notification indicator n
DNxxTrr#	NOTIFY, call ref. rr, transfered call number # (DMS-100)
DPxxp(s)	CALL PROCeeding message on B channel xx, progress p, signal s opt.
DPxxPccp(s)	PROGress message on B channel xx, cause cc, progress p, signal s opt.
DPxxPccps(Ttext)	PROGress message with optional text
DQxx	SPID/DN query
DRxxcc(rr)	RELEase COMplete message on B channel xx, cause cc, opt. call reference rr
DSxxbps(#)(/#)	SETUP message, bearer capability b, progress indicator p, signal s, opt. calling #, opt. called /#
DSxxbps(#)A=ca	SETUP message, bearer capability b, progress p, signal s, opt. calling #, call appearance ca
DSxxbps#Rr#	SETUP message, bearer capability b, progress indicator p, signal s, calling #, redirect reason r, redirect number # (DMS-100)
DTxxCI	Clear Display text for line l (1 or 2, 0 clears all text) on B channel xx
DTxxLl(text)	Set Display Text for line l (1 or 2) to text on B channel xx
DXxx	Status Query for channel xx

Layer 3 “D” Commands for TE Ports

DAxx(rr)	ALERTing message B channel xx, opt. call ref. rr
DBxxC	AT&T Conference on B channel xx
DBxxD	AT&T Drop on B channel xx
DBxxFff	AT&T Feature Activation, feature ff
DBxxGrrA	AT&T Associated Acknowledge, call reference rr
DBxxH	AT&T Hold on B channel xx
DBxxMS(spId)	AT&T Management Info on B channel xx, SPID
DBxxRrr	AT&T Reconnect, call reference rr
DBxxSs	AT&T switchhook, switch hook status s
DBxxT	AT&T Transfer on B channel xx
DCxx(rr)	CONNect message B channel xx, opt. call ref. rr
DDxx	DISConnect message B channel xx, normal clearing
DDxxcc	DISConnect message on B channel xx, cause cc
DFxxff	Feature activation for feature key ff, B channel xx
DGxxrr	RETRieve on B channel xx, call reference rr
DHxx	HOLD message on B channel xx
DHxxA	HOLD ACKnowledge message on B channel xx
DHxxRcc	HOLD REJect message on B channel xx, cause ss
DIxxS	INFORmation message, send default SPID
DIxxS(spId)	INFORmation message, send SPID
DKxxk(k)	INFORmation message, keypad digit(s) k
DPxx	CALL PROCEeding message on B channel xx
DQxx	SPID query
DRxxcc(rr)	RELEase COMplete message on B channel xx, cause cc, call reference rr opt.
DSxxb(D#)	SETUP message, bearer capability b, overlap sending, opt. calling party #
DSxxb(D#/#)	SETUP message, bearer capability b, opt. calling party number D#/, called party number
DSxxbA=ca	SETUP message, bearer capability b, call appearance ca, Overlap sending (AT&T Custom)
DSxxb(#)#A=ca	SETUP message, bearer capability b, opt. called party number #, call appearance ca (CACH EKTS)
DYxx(spId)	REGISTER message on B channel xx, opt. SPID

Interrupt Control Commands

IN enable transmit interrupts and messages
IF disable transmit interrupts and messages

Layer 3 Message Commands

LCddsstt Layer 3 command for D channel dd, ss = SAPI, tt = TEI
LRddsstt Layer 3 response for D channel dd, ss = SAPI, tt = TEI

MVIP Compatibility Commands

MDhhD Disable DTMF detector hh (MVIP) (00-3F)
MDhhE Enable DTMF detector hh (MVIP) (00-3F)
MEhhdd Enable Energy detector hh (MVIP) (00-3F) duration dd
MEhhF Disable Energy detector hh (MVIP) (00-3F)
MGhh(ds) Generate the dial string (ds) with generator hh (MVIP) (00-3F)
MObssttD Set_output disable mode, bsstt - output terminus
MObssttEbsstt Set_output enable mode, bsstt - output terminus, bsstt - input terminus
MObssttPpp Set_output pattern mode, bsstt - output terminus, pp - pattern value
MTD Disable output to the CT Bus (tristate)
MTE Enable output to the CT bus (tristate)

Query Commands

QHHsstt Query T8105, sstt - H.110 bus stream & timeslot
QHLsstt Query T8105, sstt - local bus stream & timeslot
QHR00rr Query T8105, 00rr = register address
QL Query geographical information (shelf & slot)
QObsstt Query Output for terminus bsstt
QPdx(msg) Send message to DSP d, send only bits 0-3 of x

Reset Commands

RA reset all (resets ports, DSP functions, H.110 bus)
RBxx reset B-channel xx (Layer 3)

RD reset DSP (resets DSP chip only)
RIdd deactivate port dd Layer 1 (NT ports only)
RLdd reactivate port dd Layer 1 (NT ports only)
RPdd reset port dd

Setup Commands

SCmsabb(c) Set clock mode m, submode s, arguments a, bb & c
SDxx(#)/(SPID) Set the default directory number and SPID for B channel xx
SEa Set Encoding mode a, M = Mu-Law, A= A-Law
SFb(xx..xx) Set battery feed enable for each port of bank b where x values are: F - off, N - on, * - don't care
SLb(ll..ll) Set protocol layer for each port of bank b (L or H) where l values are:
2 - Layer 2 support
3 - Layer 3 support
A - AT&T Custom support
D - DMS-100 Switch support
E - CACH EKTS support
N - National ISDN-1 support
SMC Clear the EEPROM configuration contents
SML Load the EEPROM contents onto the board
SMS Save the configuration in EEPROM
SSxy Set Layer 2 system options x & y
STb(xx...xx) Set port types for each port of bank b (L or H) where x values are:
N - Network Termination
T - Terminal Equipment
U - Undefined/unused
* - No change to port type

TEI Management Commands

TAdd Request TEI assignment for port dd (TE only)
TCdd Request a TEI check for port dd (NT only)
TDddtt Disconnect Link for TEI tt on port dd
TDddP Disconnect Packet Data Link on port dd
TEddtt Establish Link for TEI tt on port dd

TEddP	Establish Packet Data Link on port dd
TFddtt	Set Fixed TEI tt for port dd, tt = 0-3F
TPddtt	Set Packet TEI tt for port dd, tt = 0-7E
TQdd	Request TEI assignments on port dd
TRddtt	Remove TEI tt on port dd, tt = 7F remove all (NT only)
TVddtt	Verify TEI tt on port dd (TE only)

Version Requests

VA	Checksum of alternate segment request
VC	Version request
VD	DSP version request

Download Commands

@xxxx	Download 1K block to address xxxx
@Es	Erase segment s
GA	Jump to Alternate Program
GM	Jump to Main Program
@Ws	Write from RAM to segment s

Diagnostics

XLddm	Loopback test on port dd, mode m, where m = 0 - no loopback 1 - B1 channel 2 - B2 channel 3 - both channels
XPxxsstpp	Output pattern pp to H.110 bus using timeslot xx
XTddm	Test mode m on port dd, where m = 0 - normal, no test 2 - 96 kHz output

5.4.4 Responses from the H.110 BRI ISDN Board**Acknowledgments**

IA	acknowledge interrupts enabled
RA	reset all acknowledged
RPdd	reset port dd acknowledged
SMx	EEPROM operation x = 0 - failure, 1 success

Layer 3 “D” Responses for NT Ports

DAxxrr	ALERTing on B channel xx, call reference rr
DBxxCrr	AT&T Conference on B channel xx, call ref. rr
DBxxDrr	AT&T Drop on B channel xx, call ref. rr
DBxxFff	AT&T Feature Activation, feature ff
DBxxGrrA	AT&T Associated Acknowledge, call ref. rr
DBxxHrr	AT&T Hold on B channel xx, call ref. rr
DBxxMEuutt	AT&T Management Info, endpoint identifier USID uu, TID tt
DBxxMS(spId)	AT&T Management INFO, SPID
DBxxMO	AT&T Management INFO, other messages
DBxxRrr	AT&T Reconnect on B channel xx, call ref. rr
DBxxSs	AT&T Switchhook on B channel xx, switchhook s
DBxxTrr	AT&T Transfer, call reference rr
DCxxrr	CONNect on B channel xx, call reference rr
DCxxArr	CONNect ACKnowledge on B channel xx, call ref. rr
DDxxcc(rr)	DISConnect B channel xx, cause cc, opt. call ref. rr
DExxArr	KEY SETUP ACKnowledge , call reference rr
DFxxff	Feature activation for feature key ff on B channel xx
DGxxrr	RETRieve on B channel xx, call reference rr
DHxxrr	HOLD message on B channel xx, call reference rr
DHxxArr	HOLD ACKnowledge message on B channel xx, call reference rr
DHxxRccrr	HOLD REJect message on B channel xx, cause cc, call reference rr
DIxxFee	INFORMation message, undocumented, value ee
DIxxS(#)	INFORMation message, SPID
DKxxk	INFORMation message, keypad element k
DPxxrr	CALL PROCEEDing message on B channel xx, call

	reference rr
DQxx(spId/DN)	SPID & DN received for B channel xx, response to DQ query (DN is default called #)
DRxxR(rr)	RELEase message, optional call reference rr if call not assigned to a B-channel
DRxxcc(rr)	RELEase COMplete message B channel xx, cause cc, opt. call ref. rr if call not assigned to a B-channel
DSxxb	SETUP message, bearer capability b
DSxxb(D#)	SETUP message, bearer capability b, assigned B channel xx, optional calling party #
DSxxb(D#)C(#)	SETUP message, bearer capability b, optional calling party #, called # (Enbloc sending)
DSxxbK(#)(D#)	SETUP message, bearer capability b, keypad #'s, optional calling party number
DSxxbA=ca	SETUP message on B channel xx, bearer capability b, call appearance ca (AT&T Custom)
DSxxb(C#)A=ca	SETUP message on B channel xx, bearer capability b, opt. called #, call appearance ca (CACH EKTS)
DSxxbD#(C#)A=ca	SETUP message on B channel xx, bearer capability b, calling #, opt. called #, call appearance ca
DSxxbKk(D#)A=ca	SETUP message on B channel xx, bearer capability b, keypad digits k, opt. calling #, call appearance ca
DXxxccssrr	STATUS message on B channel xx, cause cc, call state ss, call reference rr
DYxxrr(spId)	REGister message on xx, call reference rr, SPID

Layer 3 “D” Responses for TE Ports

DAxxpsrr	ALERTing on B channel xx, progress indicator p, signal s, call reference rr
DBxxA=ca(a)	AT&T Call appearance, call appearance ca, optional adjunct control (a)
DBxxCArr	AT&T Conference Acknowledge, call ref. rr
DBxxCRccrr	AT&T Conference Reject, cause rr, call ref. rr
DBxxDArr	AT&T Drop Acknowledge, call ref. rr
DBxxDRrr	AT&T Drop Reject, call ref. rr
DBxxFbmsff(i)	AT&T Feature Indication, button type b, module m, status type s, feature number ff, opt. ind. status i

DBxxGrrt(A=ca)	AT&T Associated, call ref. rr, associated type t, optional call appearance ca
DBxxHArr	AT&T Hold Acknowledge, call ref. rr
DBxxHRccrr	AT&T Hold Reject, cause cc, call ref. rr
DBxxKrr	AT&T Redirect, call reference rr
DBxxMC	AT&T Management Info, call status information
DBxxMEuutt	AT&T Management Info, endpoint identifier, USID uu, TID tt
DBxxMS	AT&T Management INFO, SPID request
DBxxRA	AT&T Reconnect Acknowledge
DBxxRRccrr	AT&T Reconnect Reject, cause cc, call ref. rr
DBxxTArr	AT&T Transfer Acknowledge, call ref. rr
DBxxTRccrr	AT&T Transfer REject, cause cc, call ref. rr
DCxxpsrr	CONNect on B channel xx, progress p, signal s, call reference rr
DCxxArr(n)	CONNect ACKnowledge on B channel xx, call ref. rr, optional notification indicator
DDxxccs(rr)	DISConnect on B channel xx, cause cc, signal s, opt. call ref. rr
DExxHrr	KEY HOLD on B channel xx, call reference rr
DExxSrrb/#	KEY SETUP on B channel xx, call reference rr, bearer capability b, called #
DExxSrrb(/#)A=ca	KEY SETUP on B channel xx, call reference rr bearer capability b, opt. called #, call appearance ca
DFxxffa	FEature INDication activation for feature indication ff on B channel xx
DGxxArr(n)	RETRieve ACKnowledge on B channel xx, call reference rr, optional notification indicator n
DGxxRccrr	RETRieve REJect on B channel xx, cause cc, call reference rr
DHxxrr	HOLD message on B channel xx, call reference rr
DHxxArr	HOLD ACKnowledge message, call reference rr
DHxxRccrr	HOLD REJect message on B channel xx, cause cc, call reference rr
DIxxCccdd	INFORmation message, Cause cc, diagnostic dd
DIxxEuutt	INFORmation message, Endpoint Identifier, User Service ID uu, Terminal ID tt

DIxxPps	INFORmation message, progress p, signal s
DIxxQqq(Euutt)	INFORmation request, query item qq, opt. Endpoint Identifier, USID uu, TID tt
DIxxRr#	INFORmation, redirect reason r, redirect number #
DIxxS(#)	INFORmation message, SPID
DNxxn(#)(/#)	NOTIFY message on B channel xx, notification indicator n, opt. calling #, opt. called #
DNxxT(#)	NOTIFY, transfer, transfer # (DMS-100)
DPxxps	CALL PROCeeding message on B channel xx, progress indicator p, signal s
DPxxPccps	PROGress message on B channel xx, cause cc, progress indicator p, signal s
DQxx(spId/DN)	SPID & DN assigned to B channel xx, response to DQ query
DRxxR(rr)	RELEase message, optional call reference rr if call not assigned to a B-channel
DRxxcc(rr)	RELEase COMplete message B channel xx, cause cc, opt. call ref. if call not assigned to a B-channel
DSxxbps#(/#)	SETUP message, bearer capability b, assigned B channel xx, progress indicator p, signal s, calling #, called number
DSxxbps(#)A=ca	SETUP message, bearer capability b, progress p, signal s, opt. calling #, call appearance ca (CACH EKTS & AT&T Custom)
DSxxrrbps#(/#)	SETUP message, no B-channel, call ref. rr
DSxxApsrr	SETUP Acknowledge, progress p, signal s
DTxxLl(text)	Display text line l (1 or 2) on B channel xx
DXxxccssrr	STATUS message on B channel xx, cause cc, call state ss, call reference rr

Error Messages

ECxx	Clock error bit xx
EDddy	Diagnostic error y on port dd
ELddy	Layer 1 or 2 error y on port dd
EMddy	MDL error y on port dd (Layer 2 protocol errors)

Layer 3 Message Received Response

LCddsstt Layer 3 command on D channel dd, ss = SAPI, tt = TEI
LRddsstt Layer 3 response on D channel dd, ss = SAPI, tt = TEI

Query Responses

QHHsstllllcstttddd Reply to T8105 H.110 bus query, llll - location, cstt - stream & timeslot, control & valid bit, tttt - tag, dddd - data memory contents
QHLssttctsttdd Reply to T8105 local bus query, cstt - source stream & timeslot & control bits, dd - data memory contents
QHR00rrdd Reply to T8105 register query, rr - reg., dd - data
QLaabb Reply to location query, shelf aa, slot bb
QObssttm(bsstt) Query_output reply, bsstt - output terminus, m - mode (bsstt) input terminus
QPd(text) DSP diagnostic responses from DSP d

B-Channel State Change Messages

SCxx connect on B-channel xx acknowledged
SExx tone string on B-channel xx completed
SEXhh tone string from generator hh ended
SHxx hold on B-channel xx acknowledged
SIxx disconnect on B-channel xx acknowledged
SLxx listen on B-channel xx acknowledged
SPxxr energy detection on port xx, r = 1 energy detected, r = 0 energy ended
SPXhhr energy detector hh results r
STxxd DTMF digit d detected on B-channel xx
STXhhd DTMF digit d detected by detector hh (MVIP)
SXxx transmit on B-channel xx acknowledged

TEI Management Response Messages

TAddtt TEI tt assigned to port dd
TQdd(8tt's) TEI's assigned on port dd, tt = FF not assigned
TRddtt TEI tt removed from port dd, if tt = 7F, all TEI's removed

Diagnostic Responses

VAxxxx Checksum of the alternate segment

VCxxxxyyyyHBNA Version response

xxxx = checksum of main segment, yyyy = version number, HB = board type, N = national standard, A = revision

VDxxxx DSP version xxxx

U(msg) An undefined or unparseable message response

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6.0 The H.110 Bus & Clock Modes

The Infinity Series H.110 Basic Rate ISDN Board provides a means of connecting BRI B-channels to the digital H.110 computer telephony bus. Through this bus, the B-channels can be connected to other H.110 compatible boards. To accomplish this, the board has complete access to all streams and timeslots on the bus. It is capable of operating in a variety of clock modes compatible with H.110 operation.

6.1 The H.110 Bus

The H.110 bus consists of 32 Pulse Code Modulation (PCM) streams operating at an 8.192 MHZ. clock rate. Each stream contains 128 timeslots, for a total of 4096 timeslots. In addition to the PCM data signals, there are a number of bit, frame, and network reference signals that are used to synchronize the operation of multiple boards.

For the purposes of commands, a particular H.110 timeslot is referred to by a four digit hexadecimal number. The first two digits are the stream number, while the last two digits are the timeslot within the stream. Streams range from 00h to 1Fh, and timeslots from 00-7Fh.

The physical H.110 bus is a backplane connection using the J4/P4 connector. The H.110 specification defines allowable impedance and signal lengths on each board so that additional bus termination is not needed to insure the proper operation of the bus. The maximum length of the bus (24.8 in.) and the maximum number of slots (21) are also specified.

Different length pins are also used on the various connectors. This is done so that the various signals are staged in the correct order.

6.2 Clock Modes

The H.110 bus specification defines a variety of clock signals. Two clock signals CT bus A and CT bus B are provided for redundancy. In addition, two signals called CT_NETREF_1 and CT_NETREF_2 are defined which may be referenced to an external clock source such as a T1 or E1 span. These signals exist to aid in recovery if the primary clock source should fail.

The clock mode must be set before any connections can be made with other boards. The clock mode is set using the Set Clock command “SCmsabbc”, where m is the clock mode, s is the sub-mode, and a, bb, and c are additional arguments used to select clock sources and specify compatibility modes. This command takes the same form on all Infinity Series H.100 boards. Because of this, some of the possible options are not relevant to the H.110 boards, but the format is retained to make it easier to create applications that are portable between the two bus structures.

The default clock mode on a power up is to provide a local clock, but to neither source clock signals to the bus or derive the clock from the bus. The possible clock modes are:

- 0 no clocks to or from the bus
- 1 clocks slaved to the CT bus
- 2 the board is clock master CT bus clock A
- 3 the board is clock master CT bus clock B
- 4 the board is secondary master for CT bus clock A
- 5 the board is secondary master for CT bus clock B

Connections are possible only when all boards within a system are synchronized to the same clock. Only one board in a system can provide the H.110 bus clock. The other boards in the system must slave their internal clocks to the master. If the H.110 Basic Rate ISDN Board is to use the H.110 bus clock, this clock must be provided by another board before switching can be accomplished.

6.2.1 Slave Mode

In the Slave Mode, the H.110 Basic Rate ISDN Board derives its clocks from one of the clock signals on the CT bus. The clock signal is selected with the submode argument in the **SC** command. The possible clock signals are:

- 0 - CT bus clock A
- 1 - CT bus clock B
- 6 - CT bus clock A, auto-fallback mode
- 7 - CT bus clock B, auto-fallback mode

Argument *a* is used to set the CT_NETREF mode, while argument *bb* is used to select the source of CT_NETREF. The choices for argument *a* are:

- 0 - No CT_NETREF output
- 1 - CT_NETREF_1 output is enabled
- 2 - CT_NETREF_2 output is enabled

It should be noted that CT_NETREF_2 is defined only for the H.110 bus and not the H.100 bus. The CT_NETREF source is specified by argument *bb*, and can be any of the Basic Rate ISDN interfaces that is operating as TE (terminal equipment).

6.2.2 Primary Master Mode

In modes 2 or 3, the board supplies the CT master clocks A or B respectively. Other boards on the H.110 bus will synchronize to one of these clocks. The source of the clock is selected by the submode argument *s*. The choices are:

- 0 - freerun, the board's internal clock
- 1 - CT_NETREF_1
- 2 - CT_NETREF_2 (not present on the H.100 bus)
- 3 - a local network, any TE BRI interface
- 4 - a local network (TE port) with auto-fallback to CT_NETREF_1

5 - a local network (TE port) with auto-fallback to CT_NETREF_2

For submode 1 and 2, argument bb will select the frequency of the CT_NETREF signal. The choice is:

00 - 8 kHz. (frame rate)

Note that on this board other CT_NETREF rates are not supported.

For submodes 3-5, argument bb will select one of the Basic Rate ISDN interfaces. This interface must be operating as a TE (terminal equipment). For submodes 4 and 5, the optional argument c will specify the frequency of the selected CT_NETREF source.

For all modes, argument a should be set to 0. On H.100 boards, this argument is used to select the legacy bus compatible clocks that the board will supply. As the H.110 bus is not compatible with the SC or MVIP bus, the only valid option is 0, no compatibility clocks provided.

6.2.3 Secondary Master Modes

When a board is operating as a secondary master, it uses the other clock signal as a source, i.e. if a board is the secondary master for CT clock B, it uses CT clock A as a source and provides CT clock B. If the primary clock fails, the secondary master then becomes the clock master. Typically, one board will be set as the master for clock A and another board as the secondary master for clock B, or vice versa. If the clock source specified by the submode is either of the CT_NETREF signals or a local network, the board will automatically fall-back on that source if the primary clock should fail. If set to free-run, it will fall back to a PLL that was locked to the primary master clock.

In all secondary master modes, if the primary master fails, the board will automatically become the new primary master. If the original primary master is restored, the clock mode for the original secondary master must be reset.

When operating in secondary master mode, submodes 0-3 are valid, and the arguments a and bb are the same as when operating as a primary master.

6.2.4 Clock Fallback

The H.110 Specification details a scheme for automatically recovering from a clock failure. One of the CT bus clocks, either A or B is designated the master clock. The other clock is the secondary master and is generated by a different board than the primary clock. While the primary clock is valid, the secondary clock is locked to it. If the primary clock should fail, the secondary clock takes over using a local oscillator, CT_NETREF_1, CT_NETREF_2, or a local network as the source. Boards that are slaves should automatically fall back to the secondary clock. After a failure of the master clock, system software should designate new primary and secondary clocks. The new primary may be the previous secondary clock master. For Infinity Series H.110 boards, this will involve sending a set clock command with the new primary clock information.

When an Infinity Series board is set for automatic fallback, the board will automatically switch to the secondary clock if the primary clock fails. When this occurs, the board will send an “EC” message indicating the failure. When the application designates a new primary master, it should send a new clock mode command to the board even though auto-fallback may have occurred.

6.2.5 Clock Errors

If the board detects a problem with the clocks, it will generate a clock error, which notifies the application that it should take appropriate action. Clock errors are reported in the Clock Error Bit message, ECxx where the xx is a hexadecimal value in which each bit identifies the specific error. A value of 1 indicates an error condition. The bits are as follows:

<u>bit</u>	<u>Error Description</u>
0	CT bus clock A

1	CT bus clock B
2	SCbus clocks
3	MVIP bus clocks
4	CT_NETREF1 or CT_NETREF2 error
5	Frame Boundary

As the SC and MVIP bus signals are not present, bits 2 and 3 can be ignored. Note that bit 4 indicates the state of CT_NETREF1 unless the board is generating a clock from CT_NETREF2.

6.3 Configuration Information

Information on the clock mode setting, stream rates, and other configuration settings is available in the dual-ported memory in an eight byte block beginning at an offset of 1F18h. The first four bytes are the clock mode, the submode, and the a and bb arguments from the set clock command **SC**. The next byte contains the stream rate information from the **SB** command with bits 0-1 containing the value for streams 0-3, bits 2-3 for streams 4-7, and so on. On H.100 boards the sixth byte is used to indicate the state of the H.100 and MVIP termination and can be ignored for H.110 boards. If bit 7 of the seventh byte is 1, bits 0-3 indicate the BRI interface that is providing the reference for clocks on the board. If bit 7 is 0, the clocks are not being derived from an interface. The eighth byte contains the clock error status bits. These are in the same order as in the **EC** clock error message (Sec. 6.2.5).

6.4 Hot Swap

Hot swapping is the capability of being able to insert or remove a board from a live system without having to power down or interrupt the operation of the system. The H.110 specification provides for hot swap capabilities, and these are implemented on the H.110 Basic Rate ISDN Board.

Each board has a switch that is linked to the ejector tab. This switch is used to assert a signal called ENUM# when a board is inserted or about to

be removed. Each board also has a blue LED which is used to indicate the status of the board. Upon insertion, this LED is illuminated until the hardware connection process is complete. The LED is then turned off. When removing the board, the ejector tab is partially depressed to signal that the board is to be removed. The blue LED will then be illuminated indicating that it the board may be fully removed.

The ENUM# signal is used to notify a Hot Swap Driver of the impending insertion or removal of the board. It is the responsibility of the driver to take what ever steps are necessary to connect or disconnect the hardware.

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7.0 Layer 1 & Layer 2 Protocols

Basic Rate ISDN conforms to a model defined in a set of standards (I.430, Q.921, Q.931 etc.) that is composed of a number of layers dealing with the physical interface, peer to peer signaling and call control. The Infinity Series H.110 Basic Rate ISDN Board provides most of the control over the first two layers and optionally provides an interface to deal with the details of the third or call control layer. This section will give a brief description of the first two layers and how they relate to the inter-workings of the board and the application. It is not meant as an exhaustive reference or definition. For this, the reader is referred to the relevant specifications or Bellcore documents.

7.1 Layer 1

The physical characteristics of the Basic Rate Interface are defined by I.430 and are referred to as Layer 1. Layer 1 deals with the functions of timing and synchronization. It also provides the following services, activation/deactivation, D-channel access for signaling, transmission of the B and D channels, and Layer 1 status indication to Layer 2.

On the H.110 Basic Rate ISDN Board, the details of Layer 1 operation are carried out by the hardware and the on board processor and are largely hidden from the application. However, error messages will be sent to indicate a change of status that might affect the operation of the interface. Examples are the loss or restoration of synchronization. Details of these messages may be found in Section 10.2.

Activation, deactivation, and synchronization are achieved through the exchange of bit specific bit patterns referred to as INFO signals. These are:

INFO0	No signal (either side)
INFO1	Positive ZERO, negative ZERO, six ONEs repeated (TE side)
INFO2	Frame with all bits of the B, D and D-echo channels set to ZERO, bit A set to ZERO (NT side)
INFO3	Synchronized frames with operational data on the B and D channels (TE side)
INFO4	Frames with operation data on the B, D, and D-echo channels, bit A set to ONE (NT side)

Layer 1 operation is described by a state machine model. This model has a different sequence of states depending on whether the device is a TE (terminal equipment) or NT (network termination). The states for the TE device are referred to as F states while the NT states are G states. The states are:

TE States

F1	Inactive
F2	Sensing
F3	Deactivated
F4	Awaiting a signal, transmitting an INFO1
F5	Identifying input, awaiting an INFO2 or INFO4
F6	Synchronized, INFO2 detected, transmitting INFO3, awaiting an INFO4
F7	Activated, INFO 4 detected, transmitting INFO3
F8	Lost framing, awaiting resynchronization by INFO2 or INFO4 or deactivation by INFO0

NT States

G1	Deactivated
G2	Pending activation transmitting INFO2, awaiting INFO3
G3	Activated transmitting INFO4, INFO3 detected
G4	Pending deactivation

On the H.110 Basic Rate ISDN Board, the Layer 1 states sequencing proceeds automatically at the chip level without requiring the intervention of the application. However, indications of a change of state are reported

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in “EL” messages. In addition, the current state of each port is available to the application in the dual-ported memory. For details on this, see Section 7.3.

7.2 Layer 2

Layer 2 deals with the exchange of messages between peer devices and is referred to as the Data Link Layer. It is defined by the Q.921 specification. The protocol for the establishment of data links and the exchange of messages is called LAPD. On a Basic Rate Interface, LAPD messages or frames are exchanged over the 16 kHz. D-channel.

More than one data link can be active on a D-channel at the same time. In fact, in normal operation, at least three data links are required, one for Layer 2 management, one for network broadcast messages, and one for a user device. The data links are identified by a two part address called the Data Link Connection Identifier or DLCI. The two parts are the Service Access Point Identifier or SAPI, and the Terminal Endpoint Identifier or TEI. SAPI values can have a range of 0-63 and TEI values can range from 0-127. However, for the purposes of the Basic Rate ISDN interfaces only a limited number of possibilities are available. These are:

SAPI = 63, TEI = 127	Layer 2 management procedures
SAPI = 0, TEI = 127	Group TEI for broadcast messages
SAPI = 0, TEI = 0-126	Individual TEI's for terminal equipment for call control procedures
SAPI = 16, TEI = 0-126	Packet communication

LAPD messages or frames can take three formats. Information or I frames are used to perform information transfers between Layer 3 entities. Supervisory or S frames are used to perform data link supervisory control functions such as the acknowledgment of I frames, requesting the retransmission of I frames, or request the suspension or resumption of the transmission of I frames. The third format is Unnumbered or U frames which provide additional data link control functions and unnumbered information transfers for unacknowledged information transfers.

Supervisory Frames

- RR** Receive Ready, used to acknowledge I frames
RNR Receiver Not Ready, used to suspend transmission
REJ Reject, reject an I frame due to an error

Unnumbered Frames

- SABME** Set Asynchronous Balanced Mode Extended Command
DISC Disconnect Command
UA Unnumbered Acknowledgment Response
DM Disconnect Mode Response
UI Unnumbered Information Command
FRMR Frame Reject Response

To exchange Information frames, a data link must first be established. This is done by a terminal requesting a TEI using a UI frame. The network can grant the TEI also using a UI frame. There are a number of possible states a data link can have once a TEI has been assigned. To exchange I frames, the link must be in the multi-frame established state. This is achieved by one end or the other sending an SABME frame and receiving a UA response. Once the data link is in the multi-frame state it can remain there indefinitely unless an error is detected or a request is made to disconnect from the multi-frame state.

Each I frame contains two state variables N(S) and N(R) which are sequence numbers for the I frame sent and the next I frame that is expected to be received. The supervisory frame that acknowledges the I frame has corresponding variables. These are used to insure that no I frames are lost. They can also be used to request the retransmission of an I frame should an error in transmission occur. Each frame also includes Frame Check Sequence or FCS field to insure the integrity of the I frame contents.

The H.110 Basic Rate ISDN Board manages all the details of the Layer 2 protocol. For ports set as TE's, a SABME frame is automatically sent upon assignment of a TEI to put the data link into the multi-frame established state. Acknowledgments and supervisory frames are sent as needed and recovery procedures initiated without requiring the intervention

The H.110 Basic Rate ISDN Board

of the host application. The necessary timers are maintained on the board to handle retransmissions as specified by Q.921. Under normal circumstances, an application need only deal with the information field using the “LC” and “LR” commands and responses (see section 7.5).

The LAPD protocol provides for the establishment of multiple data links through the assignment and management of TEI's. Provisions exist for detecting the assignment of the same TEI to multiple devices, and the removal of that TEI to correct the situation. Each piece of terminal equipment should have a unique TEI so that the network termination can distinguish between different terminals. It is, however, possible for a terminal to have more than one TEI. As an example, under National ISDN 1 one TEI may be required for control of speech calls and another for circuit switched data (this requirement is switch dependent).

The H.110 Basic Rate ISDN Board supports up to seven TEI's per port in addition to the group TEI and the Layer 2 DLCI at (63,127). An additional Packet TEI is also supported (see section 7.5). A single TEI is automatically requested by the board if the port is set as a TE, but additional TEI's can be requested (see section 7.4).

It is not necessary for the application to deal directly with the Layer 2 data link states. However, the state information for the seven supported TEI's is available in the dual-ported memory. For details see section 7.3. If a Layer 2 error condition is detected that can not be handled with the normal recovery procedures, an “EM” error message will be sent by the board to the application allowing the application to take further action such as initiating a TEI management procedure or restarting the port. See section 10.2 for details of these messages.

7.3 Layer 1 & Layer 2 States

Each of the thirty-two ports has a byte of memory reserved in the dual-ported memory for Layer 1 information beginning at an offset of 1D00h. The bytes are arranged sequentially by port so that the first port is at an offset of 1D00h, the second at 1D01h and so on. If the port is an NT, the

most significant bit will be set to 1. For a TE port, this bit will be a 0. The lower four bits represent the F or G state as defined in section 7.1. Thus, state F7 will be represented by a 07h and state G3 will be represented as an 83h.

Each port also has eight bytes reserved for Layer 2 state information beginning at an offset of 1C00h. The first seven bytes for a port represent the Layer 2 states for each of the seven possible TEI's. The last byte of the eight is the Layer 2 state of the Packet Data Link. These states are:

- 1 TEI unassigned
- 2 Awaiting TEI assignment
- 3 Awaiting TEI establishment
- 4 TEI assigned, a TEI has been assigned, but multi-frame operation has not been established
- 5 Awaiting multi-frame operation, an SABME frame has been sent and awaiting a UA frame acknowledgment
- 6 Awaiting release form multi-frame state, a DISC frame has been sent and awaiting a DM frame
- 7 Multi-frame operation, exchange of I frames is possible
- 8 Timer recovery, a timer has expired and recovery procedures are in progress

7.4 TEI Management

While the board handles the basic procedures of TEI assignment, it is the responsibility of the application to manage the process and keep track of which TEI's have been assigned for use in sending and receiving Layer 3 messages. A number of command and response messages have been provided to facilitate this function.

TEI's come in two types. One type, fixed TEI's are in the range 0-63 and are assigned by presubscription to a piece of terminal equipment. The value of a fixed TEI is usually set in the terminal by some means such as a set of switches or fixed in non-volatile memory. The second type of TEI's are assigned dynamically from the range 64-126. These TEI's are

negotiated between the TE and NT every time the TE powers up, restarts, or otherwise needs a new TEI. The TEI assigned to a particular piece of terminal equipment may be different each time assignment takes place. Dynamically assigning TEI's is the preferred method.

If a port is set as a TE, the board will automatically request a single TEI upon power up or resetting unless the Layer 2 system option 1 is set to "1" with the **SS** command. There will be a delay of a random interval of up to 15 seconds before this request is made. This delay is part of the Bellcore specifications for an ISDN BRI terminal and the timer used is called **TWAIT**. The purpose of this delay is to prevent too many terminals from requesting TEI assignment at a time in cases such as the restoration after a power outage. This delay can be eliminated by the application sending a TEI assignment request command. Once this has been done, **TWAIT** is no longer active. If needed, additional TEI's up to seven can be requested by the application. As each TEI assignment is made, a message informing the application of the assignment is sent by the board.

If a port is set as an NT, it will grant TEI requests up to the limit of seven TEI's for the port. TEI values are granted sequentially beginning at 64 and wrapping around at 126. Resetting the port or removing TEI's does not alter the sequence. Each time a TEI is assigned, a message is sent to the application reporting the assignment. The application can request the removal of a specific TEI or of all TEI's if an error in TEI assignment is suspected.

The command message to request a TEI assignment takes the form **TAxx** where xx is the port number in hexadecimal notation. Thus, "TA0A" is a request for a TEI assignment for the eleventh port (ports are numbered 00-1F). TEI assignment requests can only be made for TE ports. If a TEI is assigned, the board will send a message of the form **TAxxtt** where xx is the port number and tt is the TEI assigned in hexadecimal. This message is sent both by a TE port being granted a TEI and an NT port granting the TEI. An example would be "TA0A40" which would indicate that a TEI of 64 has been assigned to or by the eleventh port.

A fixed TEI can be assigned to a port by using the fixed TEI command.

This command takes the form **TFxxtt** where xx is the port number and tt is the TEI number in the range 00-3F. This command does not automatically place the data link in the multi-frame established state, but instead puts it in the TEI assigned state. It is not necessary to issue this command for an NT port, as the board will automatically reserve space for a fixed TEI upon receiving a message with a TEI in the range of fixed TEI's. However, space can be reserved by the command before receiving a message. This may be desirable, as fixed TEI's count toward the limit of seven TEI's per port.

The application can request the removal of a TEI by issuing the TEI removal command for an NT port. This command is of the form **TRxxtt**, where xx is the port and tt is the TEI. If the TEI value is 127 or 7Fh, all TEI's on that port will be removed. If a TE port receives a request to remove a TEI it will send a response message of the form **TRxxtt** to the application where xx is the port number and tt is the TEI value. If this value is 7F, the request was to remove all TEI's.

If there is a question of whether all TEI's are currently valid, the application can request a TEI check be performed by sending a command of the form **TCxx** where xx is the port number. This can only be done for NT ports. If the check detects any TEI's that are assigned to multiple devices or that are not assigned, it will remove them. The application can verify the validity of a TEI on a TE port by sending a command of the form **TVxxtt**. The NT on the far end will then initiate a TEI check procedure. The TEI Check response can take one of two forms. The default form is to include all TEI's in a single TEI Check Response message. The alternate form is for each TEI to be reported in a separate TEI Check Response message. Either form is correct and central office equipment should respond correctly to both, however, this may not be the case with some older equipment, and so the option is provided.

The Layer 2 System Option command is used to control the Layer 2 behavior. This command takes the form **SSxy** where x and y control the first and second option and can take the values 0 or 1. The first option, if set to 1 disables the timer TWAIT and therefore disables the automatic TEI request for a TE port. The second option controls the form of the TEI

Check Response message. If the option is set to 0, one response message is sent containing all TEI's, if the option is set to 1, each TEI is reported in a separate message. The default for these options is 0, and in most cases it will not be necessary to issue this command.

The application can query the board at any time for the TEI's that are assigned. This is done by sending a command of the form **TQxx** where xx is the port number. The response will take the form **TQxxtttttttttttttt**, where xx is the port number and each tt pair is one of the eight TEI's. The Packet TEI is the last one. If a TEI is not assigned, the value returned for that TEI will be "FF". As an example, a port with the TEI's 64 and 65 assigned would return "TQxx4041FFFFFFFFFFFF". This command can be issued for either a TE or an NT port.

Normally, once a TEI is assigned, the data link is in the multi-frame established state. However, the link can be disconnected or reestablished by using commands of the form **TDxxtt** and **TExxtt** where xx is the port number and tt is the TEI. A data link that is disconnected is placed in the TEI assigned state. If an attempt is made to send a Layer 3 message on a data link in the TEI assigned state, an attempt to reestablish the multi-frame established state will automatically be made by the board.

7.5 The Packet Data Link

One Data Link is reserved for sending X.31 Packet Data using the D Channel. The TEI for this data link is managed in a slightly different manner than the other seven data links. The TEI will default to a value of 0 on a power up or restart of the board. The Packet TEI can be set to any value in the range 00-126 using a command of the form **TPxxtt** where xx is the port number and tt is the TEI. If a fixed packet TEI is used, the TEI may be set to any value in the range 00-63. If dynamic TEI's are to be used for packet data, then it will be necessary to set the TEI to the same value as one of the seven data links. This can be done after the TEI has been assigned.

The Packet Data Link is put in the Multi-frame Established state by sending

a message of the form **TExxP** where xx is the port number. The link can be disconnected by sending a message of the form **TDxxP**. Packet messages are sent using the “LC” command as described in the next section. The SAPI for these messages must be 16 (10h) and the TEI must match that set using the “TP” command. The packet messages can be up to 260 octets long.

7.6 Sending and Receiving Layer 3 Messages

When the protocol level for a port is set at Layer 2 using the “SL” command, Layer 3 messages are sent and received using the auxiliary mailboxes. To send a message, the application must first check to make sure that the transmit flag is 0. The contents of the information field are placed in the auxiliary transmit mailbox at an offset of 1402h bytes. The length of the information field is placed at an offset of 1400h bytes. This is a sixteen bit value with the low order byte first. An “LC” message of the form **LCxxsstt** is then placed in the main transmit mailbox where xx is the port number, ss is the SAPI, and tt is the TEI of the data link to be used. The transmit flag is then set to 01h.

When a Layer 3 message is received, an “LC” message of the form **LCxxsstt** will be placed in the receive mailbox. This indicates that a Layer 3 message for the DLCI (ss,tt) on port xx is available in the auxiliary receive mailbox. The length of the message will be at an offset of 1600h and the contents of the information field will begin at 1602h.

There is no restriction on the contents of the Layer 3 message other than a maximum length of 260 octets. Messages may be sent for any DLCI with a SAPI of 0 and an assigned TEI or a SAPI of 16 and the Packet TEI, as well as DLCI's (0,127) and (63,127).

As an example to send a Q.931 CONNect message for a call reference of 1, the following bytes would be place in the auxiliary mailbox:

offset	bytes	description
1400h	04h	length
1401h	00h	high order byte of length
1402h	08h	Q.931 message
1403h	01h	call reference length of 1
1404h	81h	call reference of 1
1405h	07h	CONNect message type

To send this message with a DLCI of (0,64) on port 3, the command “LC030040” would then be placed in the main transmit mailbox and the transmit flag would then be set to 01h. Receiving a message is the mirror image of this process.

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8.0 Using “D” Messages for Layer 3

8.1 Q.931 Messages

Call control for ISDN interfaces is handled at the Network Layer, also known as Layer 3. The specification that defines the message set used for call control is Q.931. Specifics for the U.S. implementation of the Basic Rate interface can be found in the Bellcore documents *Generic Guidelines for ISDN Terminal Equipment on Basic Access Interfaces (SR-NWT-001953)* and *National ISDN Generic Guidelines for ISDN Terminal Equipment on Basic Rate Interfaces (SR-NWT-002661)*. These latter two documents give details of the messaging on services of the National ISDN-1 specification which is to be supported by most switch and terminal equipment manufacturers in the U.S.

The message set defined in Q.931 consists of a number of command messages to establish and break down a call. These include **SETUP** to initiate a call, **ALERTing**, **CALL PROceeding**, and **PROGress**, to handle the various stages involved in accepting or rejecting a call, **CONNect** to complete the connection, and **DISConnect**, **release**, and **RELEASE COMplete** to break down a call. Additional messages are provided as acknowledgments, **SETUP ACKnowledge** and **CONNect ACKnowledge**.

Features beyond the basics of making a call are supported by additional messages. A call may be placed on hold and retrieved using the messages **HOLD** and **RETrieve**. These messages have corresponding acknowledgment messages, **HOLD ACKnowledge** and **RETRIEVE ACKnowledge**, as well as rejection messages, **HOLD REJect** and **RETrieve REJect**. **INFORMation** messages can be used for a variety of purposes such as sending text for display, activating features or indicators,

or exchanging configuration information such as SPID's. Additional messages are defined for maintenance or management purposes including **NOTIFY**, **STATus**, **STATus ENQuiry**, **FACILITY** and **REGister**.

In addition to the basic codes for the various message types, each Q.931 message consists of a number of information elements. These information elements are used to contain items such as the called and calling numbers, whether a call is speech or data, the B channel involved, and other information about the progress of a call. For some messages such as the SETUP message a large number of information elements are possible, many of which are optional or only used for certain types of calls. As an example a typical SETUP message from a central office switch contains eight information elements and ninety octets of information.

Each active call has a call reference that is part of every Q.931 message dealing with that call. This allows for the juggling of multiple calls on an interface. The call reference is granted by the originating party and remains in effect until the call is finally released, no matter what happens in the interim. However, a call reference is only valid at that particular interface in messages between the network termination and the terminal equipment.

Q.931 also describes a state model for the progress of a call. The states are defined by which type of message has been received or sent. State information may be exchanged through STATus messages as a check on the operation of the terminal and to insure that the terminal and network are in agreement on the condition of a particular call. For each state of a call, only certain message types are appropriate.

8.2 “D” Command & Response Messages

The Q.931 message set can be complicated, with many options and information elements to deal with. On the H.110 Basic Rate ISDN Board, an application can directly access the information field of a Q.931 message by using the Layer 2 support level. In some cases this may be desirable when dealing with equipment that does not support National ISDN 1 or has non-standard features or messages. However, the H.110 BRI Board does

provide a simpler interface through the Layer 3 support level for those instances when only simple call control is needed for equipment that conforms to NI-1.

The Layer 3 support level is achieved using “D” channel commands and responses. These messages consist of an initial “D”, a second character indicating the Q.931 message type, for example an “A” for an ALERTing message or a “C” for a CONNect message, a two digit number indicating the B channel, and for some messages additional arguments. Each of these additional arguments are typically encoded as a single character or as a pair of hexadecimal digits in the case of the Cause element or Call references. The intent is to keep the messages short and simple with only the necessary information and allow the on board firmware to fill in the details of the actual Q.931 messages sent. The “D” messages are also similar in their organization to other XDS messages such as the “C” and “S” messages used to control the B-channel connections on the H.110 BRI Board and ports on other XDS line boards. This simplifies the overall task of the application.

“D” channel messages and the corresponding Q.931 messages are given in the following list:

DAxx	ALERTing
DCxx	CONNect
DCxxA	CONNect ACKnowledge
DDxx	DISConnect
DFxx	Feature activation or indication using an INFORMation message
DGxx	RETRieve
DGxxA	RETRieve ACKnowledge
DGxxR	RETRieve REJect
DHxx	HOLD
DHxxA	HOLD ACKnowledge
DHxxR	HOLD REJect
DIxx	INFORMation
DKxx	Keypad element INFORMation message
DNxx	NOTIFY

DPxx	CALL PROCeeding
DPxxP	PROGress
DRxx	RELease or RELease COMplete
DSxx	SETUP
DXxx	STATus
DYxx	REGister

Because of the fact that the required information elements in specific messages are not identical for the network and terminal or user side, the argument details are different of NT and TE ports. A complete list of messages and arguments can be found in section 5.4.

To further simplify the application interface, the board will automatically send an acknowledgment message. A CONNect ACK is sent where needed in response to a CONNect message. A RELease is sent in response to a DISConnect, and a RELease COMplete is sent in response to a RELease message. A SETUP ACK or a CALL PROCeeding message is sent in response to a SETUP message from a terminal.

The on board firmware normally hides call references from the application. Calls are instead associated with B channels. If incoming calls do not have a B channel assignment, the board will make that assignment. However, when the association of a call and a B channel is not maintained, as in the case when a call is placed on hold, the call reference is passed on to the application so that it can be used to track the calls progress or be used to retrieve the call. Call references are used more extensively with EKTS and CACH EKTS.

The “D” message set provides the application with a simple interface that gives the application complete control of the call but frees it and the programmer from being forced to deal with the details of coding Q.931 messages.

8.3 Information Elements

Information elements are used to encode information that may be required to handle a call. In “D” messages on the H.110 BRI Board, these elements are represented by single argument characters. Only those elements that are needed are included in the messages. Elements that are unambiguous or constant are encoded by the board in the Q.931 messages but are not part of the “D” messages. Some elements that are rarely used such as sub-addresses are not part of the “D” message scheme. Details on which arguments are used in which specific message can be found in Section 5.4.

8.3.1 Bearer Capability

Bearer capability is used to describe the type of call being placed. This argument is present in both SETUP commands and responses. The four options for bearer capability are:

- A** 3.1 kHz audio, 64 kbps, circuit mode, Mu-Law
- D** Unrestricted digital information, 64 kbps, circuit mode
- R** Rate adaption from 56 kbps, 64 kbps, circuit mode
- S** Speech, 64 kbps, circuit mode, Mu-Law

8.3.2 Cause

The Cause element is present in a number of different messages. Its purpose is to give a reason why a particular message such as a DISConnect was issued. Some causes such as Normal Clearing are part of a normal call while other causes may indicate an error condition. The cause element is quite lengthy, and therefore the argument is represented by a two digit hexadecimal number in “D” messages. The first digit of the cause serves to divide the causes into different classes, i.e. a ‘0’ indicates a cause related to dialing. The list of causes are:

- 01** Unallocated Number
- 02** No route to specified transit network

03	No route to destination
06	Channel unacceptable
07	Call awarded and being delivered in an established channel
10	Normal clearing
11	User busy
12	No user responding
13	User alerting, no answer
15	Call rejected
16	Number changed
1A	Non-selected user clearing
1B	Destination out of order
1C	Invalid number format (incomplete address)
1D	Facility rejected
1E	Response to STATus ENquiry
1F	Normal, unspecified
22	Circuit/channel congestion
29	Temporary failure
2A	Switching equipment congestion
2B	Access information discarded
2C	Requested channel not available
2F	Resource unavailable, unspecified
32	Requested facility not subscribed
39	Bearer Capability not authorized
3A	Bearer Capability not presently available
3F	Service or Option not available, unspecified
41	Bearer capability not implemented
45	Requested facility not implemented
4F	Service or option not implemented, unspecified
51	Invalid call reference value
58	Incompatible destination
60	Mandatory information element is missing
61	Message type non-existent or not implemented
63	Information element non-existent or not implemented
64	Invalid information element contents
65	Message not compatible with call state
66	Recovery of timer expiry
6F	Protocol error, unspecified

7F Interworking, unspecified

8.3.3 Directory Numbers

The called or calling numbers in “D” messages are represented by the string of digits. Additional information that is encoded into the information element such as the type of number or numbering plan are added by the firmware based on the context and length. For NT ports, presentation of calling numbers is always allowed as the application has control of presenting this number. If the default called number is used, it is considered part of a Local ISDN numbering plan. For TE ports, the numbering plan of the called number is based on the length, with numbers shorter than 7 digits being considered private plans, 7 digit numbers local, 10 digit numbers national and longer numbers international.

8.3.4 Feature Keys & Indication Status

Feature Keys are keys on a station set that can be used to signal the network that a specific feature should be implemented. Feature codes range from 0 to 63 and are encoded as two hexadecimal digits in “DF” messages. The exact meaning of a feature key code is dependent both on context and on the particular piece of network equipment involved.

Feature Indicators are lights or other indicators on ISDN Station sets. These can be used for a variety of purposes such as indicating a feature such as conferencing is in use or that messages are waiting. The encoding of the meaning of a particular feature is both hardware dependent and system dependent, that is the same code may represent different things on different station sets. However, the status of the indicator is restricted to four choices. These are:

- I** Idle or off
- A** Active or on constantly
- Q** Prompt, a fast blink
- P** Pending, a slow blink

8.3.5 Progress Indicator

Progress indicators are used to indicate something about the nature of the interworking of a call. This can be information about the fact that the call may not be an end to end ISDN call, or it may indicate the presence of inband information such as call progress tones or announcements. This element is present only in commands to NT ports or responses on TE ports as it is never found in messages sent by a user. The codes for a progress indicator are:

- C** Call is not end to end ISDN, call progress information may be available inband
- D** Destination address is non-ISDN
- O** Origination address is non-ISDN
- I** Inband information or appropriate pattern now available
- W** Delay in response at destination interface
- N** no progress indicator

8.3.6 Signal

The Signal data element is used to inform a terminal that a condition exists in which a user should be alerted by an audible tone or signal. There are two instances in which the Signal element is used. One is in a SETUP message to a terminal indicating the presence of a terminating call. In this instance the Signal takes the place of ringing on an analog line to alert the user of an incoming call. The second instance is in messages to a terminal originating a call to inform the user of the progress of the call. This takes the place of the traditional inband call progress tones such as dial tone, busy, ringback, and reorder. The messages that the Signal may appear in are ALERTing, CALL PROCEEDing, PROGRESS, CONNECT, DISCONNECT, RELEASE, and RELEASE COMPLETE. The Signal element may be present at the same time that the Progress Indicator indicates inband signaling and tones are present in band. The signal codes in “D” messages are:

For SETUP messages

- N** Normal Alerting
- D** Distinctive Alerting
- S** Special Alerting
- I** Intercom Alerting
- R** Reminder Ring
- F** Alerting Off

For other messages

- D** Dial Tone
- R** Ringback
- N** Network Congestion/Reorder
- B** Busy Tone
- C** Confirmation Tone
- W** Waiting Call
- F** Tones Off

While most ISDN Station sets support different ring patterns and tones for the various codes, sets from different manufacturers do not necessarily use the same tone patterns for the different alerting codes.

8.4 SPIDs & Endpoint Identifiers

Service Profile Identifiers or SPIDs are numbers that are programmed into terminals and sent to the network switch to identify a specific terminal device so that it can be associated with the features subscribed to by that terminal. The SPID is usually an 11 to 14 digit number of which the first 10 digits are normally the Directory Number for the interface. The remaining digits are used to identify the different terminal devices on the interface. In the NI-1 specification, one or two SPIDs can be associated with a Basic Rate Interface. The SPIDs can be associated with two pieces of terminal equipment, or the same TE can have two SPIDs. Some CO switches require that one SPID be used for Speech or Audio calls and the other SPID be used for Data calls.

Terminal equipment designed for NI-1 will send its SPID or SPIDs upon assignment of TEI's during power up or a resetting of the interface. A separate data link and TEI will be associated with each SPID. The TE will expect to receive an Endpoint Identifier for each SPID from the network switch in reply, and will not function until it receives an INFOrmation message with that element. The Endpoint Identifier consists of two number, the User Service Identifier or USID and the Terminal Identifier or TID. These are not to be confused with the SPID or TEI. The network switch may or may not use the Endpoint Identifier in call processing messages.

For ports that are set as TEs, the SPID is sent to the network switch by using a message of the form **DIxxS** where xx is one of two data link arguments that are of the same form as the B-channels associated with the port. If no number follows the “S”, the board will use the default SPID programmed into the board using the “SD” command (see section 4.3). If no default is programmed, the SPID digits must follow the “S”. The Endpoint Identifier reply will be in a response message of the form **DIxxEuutt** where xx is the data link argument, uu is the USID, and tt is the TID. Both of these numbers are in hexadecimal. Note that the SPID for the even data link argument is used for speech and audio calls and the SPID for the odd data link argument is used for data calls. If only one SPID is defined, it is used for both and should be assigned to the even data link.

For terminal equipment connected to ports defined as NT, the programmed SPID can be any number with at least 12 digits. Only the last digit is used. The SPID for speech or audio calls for the first terminal should have a “1” as the twelfth digit. If the terminal uses a separate SPID for data calls, this should have a “2” as the twelfth digit. A second terminal should have a “3” as the twelfth digit. The board will automatically respond with an Endpoint Identifier messages. Endpoint identifiers are assigned on a fixed basis based on the SPID.

8.5 Directory Numbers

Each B-channel has a default directory number associated with it. These numbers are set using the “SD” command (see section 4.3). This number is a seven digit number. On TE ports, it is used for the calling number element in the SETUP message for calls originating from the port. If no number is defined for the default, the calling number element will be absent from the SETUP message. For NT ports, the directory number is used for the default called number element in SETUP messages for calls originating from the board and terminating on the terminal. If the application wishes to use a number other than the default, this can be encoded in the “DS” message after the calling number with a “/” as a separator.

8.6 Display Text

Many ISDN terminals have the ability to display several lines of text. This text can contain information about the caller, the status of the call, or features. Text can be sent to a terminal in an INFOrmation message or it can be included as an information element in another message. Most displays have one or two lines of twenty characters and this has been assumed for the purposes of the “D” message set. When text information is sent to the a port set as a TE, this text will be passed on to the application in one or more “D” messages.

Text can be sent to a terminal in several ways using “D” commands. The simplest way for one line of text to be sent is with a “DI” command of the form **DIxxT(text)**, where xx is the B-channel and (text) is text of up to 20 characters. If there is no call currently associated with the B channel, the INFOrmation message will be sent without a call reference. However, if a call is present, the message will be sent with a call reference and will be associated with the call. This may affect how the terminal displays the text. To send multiple lines of text, each line can be set up using a command of the form **DTxxL1(text)** for the first line and **DTxxL2(text)** for the second line. This will place text in a buffer. The text can then be sent with a command of the form **DIxxB**.

Text can be sent as part of the SETUP message by filling the buffer as described above before sending the “DS” command. The buffer is checked to automatically include any text when the SETUP message is composed. The buffer is cleared when a call is released on that B-channel.

It is also possible to include a single line of text in a PROGRESS message by sending a command of the form **DPxxPpsT(text)** where p is the progress indicator and s is the signal.

Text that is sent to a port set as a TE will be passed to the application in a response message of the form **DTxxLI(text)** where l is the line number and xx is the B channel associated with either the call or the SPID. A single line of text in an ALERTing or PROGRESS message will become part of the “DA” or “DP” message after the signal character.

8.7 NT Call Handling Examples

This section and the one that follows will give some simple examples of the “D” messages that would be sent and received for a typical speech call. Only the “D” messages are shown. The “C” messages used to establish the audio paths will be explained in section 9.0.

8.7.1 A Call Terminating at a Terminal

In this example, a call is placed to an ISDN terminal, is answered, and then disconnected by the terminal hanging up. The B1 channel of the fourth BRI port is used.

<u>commands</u>	<u>responses</u>	<u>description</u>
DS06SNN7654321		SETUP message
	DA0603	ALERTing message
	DC0603	CONNect message
	DD0610	DISConnect message
	DR060F	RELease COMplete

In the “DS” command, the 06 indicates the B channel, in this case the B1 channel for the fourth port, the “S” indicates a bearer capability of speech, the first “N” indicates that there is no progress indicator, the second “N” indicates normal alerting, and the calling number is 7654321. The terminal sends an ALERTing message indicating that it has accepted the call and is alerting the user. The CONNect message indicates the user has answered the call. The DISConnect occurs when the user hangs up. The cause code indicates normal clear. This causes the board to send a RELease message. The terminal finally responds with a RELease COMplete message to end the call. The cause code is unspecified.

8.7.2 A Terminal Originating a Call

In this example, a call is placed from the terminal. The terminal is using overlap sending. In overlap sending, the dialed digits are sent in one or more INFormation message until the network has enough digits to complete the call. It is also possible for one or more of the digits to appear as a Keypad element in the SETUP message. In this case the “DS” message might take the form **DS06SK7654321**. A third possibility is that the entire called number is present. This is called “enbloc” sending. With enbloc sending the “DS” message would appear as “DS06SC7654321” and no more digits would be expected.

<u>commands</u>	<u>responses</u>	<u>description</u>
	DS06SD5551000	SETUP message
	DK067	Keypad message
	DK066	Keypad message
	...	keypad messages
	DK061	Keypad message
DA06IR		ALERTing message
DC06		CONNect message
DD0610		DISConnect message
	DR06R	RELease message

The initial SETUP message indicates that this is a speech call. The digits following the “D” are the calling party number. The board selected the B1 channel as it was not in use. It sent a SETUP ACK message in response

indicating that dial tone was present. The Keypad messages are the digits as they dialed. These are sent by the terminal as INFOrmation messages with a Keypad element. When enough digits have been dialed to complete the call, an ALERTing message is sent with the progress indicator for inband tones and the signal indicating ringback. A CONNect follows when the call is answered. A “DD” command is issued with a cause of normal clearing to end the call. The terminal responds with a RELease message. This causes the board to send a RELease COMplete message to end the call.

8.8 TE Call Handling Examples

Call handling from the perspective of the TE side is similar to that for an NT. However, there are some differences in which messages are sent and which information elements are present.

8.8.1 Originating a Call

In this example, the board is originating a call. As the board is a piece of automatic equipment, it is assumed that the “enbloc” sending method is always used for originating calls.

<u>commands</u>	<u>responses</u>	<u>description</u>
DS10S5551000		SETUP message
	DP10NF	CALL PROCeeding message
	DA10IR	ALERTing message
	DC10NF01	CONNect message
	DD1010N	DISConnect message
	DR100F	RELease COMplete message

The SETUP command indicates that the call is a speech call to 5551000. There are no progress indicator or signal elements. The network responds with a CALL PROCeeding message with no progress indicator and a tones off signal. This means that the network has accepted the call and is passing it on. When the terminal at the far end has accepted the call and is alerting

the user, an ALERTing message is sent with a progress indicator of inband tones and a ringback signal. The CONNect is sent after the far end answers the call. When the far end disconnects the network sends a DISConnect to the board with a cause of normal clearing and a signal of tones off. This causes the board to send a RELease. The network then responds with a RELease COMplete message to end the call. This has a cause value of unspecified and a signal of tones off.

8.8.2 A Terminating Call

SETUP messages from the network always use “enbloc” sending to send the called number. The SETUP message is broadcast with the group TEI. It is up to the terminal to accept the call if the called number is part of its programming.

<u>commands</u>	<u>responses</u>	<u>description</u>
	DS10SNN5551000/5552000	SETUP message
DA10		ALERTing message
DC10		CONNect message
	DC10A81	CONNect ACKnowledge
DD1010		DISConnect
	DR10R	RELease

In this example, the SETUP message from the network indicates a speech call with no progress indicator and no signal. The calling number is 5551000 and the called number is 5552000. The application sends a “DA” command to cause an ALERTing message to be sent. There are no arguments for the alerting message for a TE port. A CONNect follows which causes the network to respond with a CONNect ACKnowledge. The terminal sends a DISConnect message with normal clearing to hang up on the call. The network responds with a RELease which causes the board to send a RELease COMplete to end the call.

8.9 HOLD & RETrieve

An active ISDN call can be placed on hold to free up a B-channel for use by another call. The held call remains active and retains its call reference, but the connection is broken. The connection can be restored by retrieving the call and assigning a new B-channel for the circuit. This does not have to be the same B-channel as was originally used.

A terminal connected to an NT port can initiate a hold by sending a HOLD message. This results in the “D” response message **DHxxrr**, where xx is the B-channel and rr is the call reference. The call reference is important as it is the only way a call can be retrieved once it is placed on hold. Once a call has been placed on hold, it is the responsibility of the application to retain the call reference until the call is retrieved or released. To confirm the hold, the application would send a message of the form **DHxxA** to acknowledge the hold. If it did not want to accept the hold, it would send a message of the form **DHxxRcc**, where cc is the reason the hold was rejected. Once the HOLD ACK message has been sent, the B-channel is available for a new call.

To retrieve the held call, the terminal would send a RETrieve message. This would cause a “D” response message of the form **DGxxrr**, where xx is the B-channel and rr is the call reference. If the terminal did not choose a B-channel, the board would assign one if available. To allow the retrieval, the application would send the command **DGxxArr**. To reject the retrieval, the application would send the command **DGxxRccrr** where cc is the cause for rejecting the retrieval.

When the port on the H.110 BRI Board is a TE, it can request that a call be placed on hold in a similar manner. The application would send a command of the form **DHxx** where xx is the B-channel of the call to be held. If the network responds with a HOLD ACK, the board would send a response message of the form **DHxxArr** where rr is the call reference. A rejection would result in a response message of the form **DHxxRccrr**, where cc is the cause for rejection.

The call would be retrieved by the application sending a command of the form **DGxxrr**, where xx is an available B-channel and rr is the call reference of the held call. This message should not be sent if a B-channel is not available. If the call is retrieved the network will send a RETrieve ACK message which will result in a response message of the form **DGxxArr**. If the network sends a RETrieve REJect message, the response message would be **DGxxRccrr**, where cc is the cause for the rejection.

In the examples above, it is the terminal that initiates the hold. It is also possible for the network side to place a call on hold to free the B-channel. However, only the terminal side can retrieve a call.

It is possible to release a held call by sending a RELEase COMplete. This might be done if the far end disconnects. In this case, the “DR” command or response message would include not only the cause, but the call reference. It would be of the form **DRxxccrr**, where rr is the call reference.

8.10 EKTS, CACH EKTS, and AT&T Custom

Electronic Key Telephone Service or EKTS and Call Appearance Call Handling Electronic Key Telephone Service of CACH EKTS are ISDN services which allow a group of ISDN BRI station sets emulate a key telephone system. These services provide a means for the handling of multiple calls as well as for the appearance of the same call on multiple station sets. The procedures for Basic EKTS are similar to those for Basic Call Handling, and require no special setup. CACH EKTS uses an information element called the call appearance to associate calls with a specific button on the station set. To use CACH EKTS, the protocol level for the port must be set to “E”, and a call appearance argument must be present in SETUP commands. This argument takes the form **A=ca** where ca is the call appearance.

The AT&T Custom Protocol predates National ISDN-1, but is still deployed on many AT&T switches and PBXs. In some ways it resembles CACH EKTS in that it uses call appearances for handling calls. While

based on Q.931 it uses many network specific extensions for features such as conferencing and transferring calls. To use the AT&T Custom Protocol, the protocol level for the port must be set to “A”.

The details of how to use the H.110 Basic Rate ISDN Board with EKTS, CACH EKTS, and AT&T Custom Protocol are beyond the scope of this document and may be found in the *XDS Layer 3 ISDN Protocol Software Reference Manual (251M031)*.

8.11 Call Processing Errors

Calls do not always progress smoothly. Sometimes there is an error in dialing, the called number is busy, or no route may be available. It is also possible for a terminal to request a facility that is not supported or subscribed to. Switching errors can occur or some other problem may arise creating an error situation.

In these cases the network will send a PROGRESS message. This message will indicate the nature of the problem and for speech or audio calls may indicate the presence of an inband tone or message. To send a PROGRESS message to a terminal, the application would send a command of the form **DPxxPccps**, where xx is the B-channel of the call, cc is the cause of the PROGRESS message, p is the progress indicator, and s is the signal if any.

As an example, the message **DP06P11IB**, would indicate that the terminal trying to place a call on the B1 channel of the fourth port has dialed a busy number (cause 11). Many ISDN Station sets will display an error message based on the cause. The “IB” indicates that there is an inband tone present and that the tone is busy. It is the application’s responsibility to provide the inband signal using a “CP062” command (see section 9.0).

For ports set as a TE, a response of the form **DPxxPccps** will indicate that a problem has occurred. The cause will be indicated by the cc, and the progress indicator and signal will indicate if any error tones or messages are available.

9.0 Controlling the B-Channels

This section describes the process used for controlling the B-channels on the Infinity Series H.110 Basic Rate ISDN Board. The steps necessary for configuring a board will be described. Basic functions such as making a connection, playing call progress and DTMF tones, and detecting DTMF tones and energy will be described. In addition, examples of making incoming and outgoing calls combining several functions are included. Control of the B-channels is completely independent of call control procedures involving Layer 3 messages. Neither “LC” or “D” commands affect the switching of the B-channels, and the commands described in this section do not result in any Layer 3 Q.931 messages being sent.

9.1 Overview of the Command Structure

The command set described in this section are called the “C” Commands. Each of these commands instructs the board to take all the actions necessary to perform a function such as making a connection, playing a tone, or detecting DTMF digits. Thus, the command to detect DTMF digits will play dial tone to the B-channel, connect it to a DTMF detector, and activate that detector.

Many of the commands use a common form for the various arguments. The B-channel number is usually the first argument, and will be between 00 and 1F. Two B-channels are allocated to each port, with the B1 channels having even numbers and B2 channels having odd numbers. Thus, B-channels 00 and 01 are the B1 and B2 channels for port 0, 02 and 03 are the B-channels for port 1, and so on through 3E and 3F which are the B-channels for port 1F.

The arguments used to define the source or destination consist of a four digit hexadecimal number. The first two digits are used to indicate the

stream. There are 32 streams defined on the H.110 bus and these range from 00 to 1F. The last two digits are used to indicate the timeslot. H.110 streams have 128 timeslots ranging from 00-7Fh. As an example, the argument **712** would refer to stream 7, timeslot 12h, or 18 decimal.

9.2 MVIP-95 Compatibility Commands

Several commands exist for compatibility with the MVIP-95 driver specification. This specification uses the concept of a “terminus” to define an input or output timeslot. The terminus argument consists of three parts, a bus, a stream within the bus, and a timeslot on that stream. In MVIP compatibility messages, a terminus is represented by a five character string. The first character indicates the bus. Valid bus selections are “H” for the H.110 CT bus, and “L” for the local bus. The local bus provides connections to the B-channels and DSP resources as shown in the following table:

Local Stream	Input	Output
0	B-channels 00-1F	B-channels 00-1F
1	B-channels 20-3F	B-channels 20-3F
2	voice ports 00-1F	voice ports 00-1F
3	voice ports 20-3F	voice ports 20-3F
4	none	call progress tones 0-1F
5	DTMF & Energy detectors 00-3F	DTMF generators 00-3F

In the MVIP compatibility mode, connections are controlled using the Set Output command **MO**. This command takes the form **MObssttm**, where “bsstt” is the output terminus being controlled, and m is the mode. Valid modes are “D” for disable, “E” for enable, and “P” for pattern output. In the enabled mode, the input terminus follows the mode character, and in the pattern mode, a two digit hexadecimal number representing the value

of the byte to be output follows the mode. As an example, the message “MOH0123EL0000” would enable a connection from the B1 channel of the first BRI interface to the H.110 timeslot 23h, stream 1. Connections can be made between the H.110 bus and the local bus, or between timeslots on the local bus.

In the MVIP compatibility mode, additional commands are needed to control the DSP resources. The DTMF detectors are controlled with a command of the form **MDhhm** where hh is the detector number or handle and m is the mode, either “D” to disable or “E” to enable the detector. When a detector is enabled, detected digits are reported in a message of the form **STXhhd** where hh is the detector number and d is the digit. The Energy detectors are controlled with a command of the form **MEhhdd** where hh is the detector number and dd is the minimum duration of the signal to be detected in .1 second increments. To disable an energy detector, the command takes the form **MEhhF**. To generate DTMF digits the command takes the form **MGhh(string)** where hh is the generator and “string” is the string of DTMF digits. This string may include pauses. Completion of the string is indicated by a message of the form **SEXhh** where hh is the generator number. To access the DSP resources, a “MO” Set Output command must be issued to connect the resource to the desired B-channel or H.110 timeslot as well as issuing the resource control command. It is the responsibility of the application to manage the DSP resource in the MVIP compatibility mode.

As an example of detecting digits in the MVIP compatibility mode:

<u>commands</u>	<u>responses</u>	<u>description</u>
MOL0000EL0400		connect B-channel 00 to dial tone
MOL0501EL0000		connect DTMF detector 1 to B-channel 00
MD01E		enable DTMF detector 1
	STX011	digit 1 detected
MOL0000D		disable dial-tone
	STX012	digit 2 detected
	STX013	digit 3 detected
MOL0501D		disable input to detector 1

MD01D

disable DTMF detector 1

A query command **QObsstt** is also available to query the state of the output terminus “bsstt”. This command corresponds to the Query_Output command in the MVIP-95 specification. The response takes the form **QObssttm(bsstt)** where “bsstt” is the output terminus, “m” is the mode, and if the mode is enable, the second “bsstt” is the input terminus.

9.3 Configuring the Board

Several steps are necessary when configuring the board. The most important item is to select the clock mode. Only one board in the system can generate the Master Clock. If available, an E1, T1, or Primary Rate ISDN board should serve as the master. If no such board exists in the system, and one or more of the Basic Rate ISDN ports configured as a terminal equipment interface is connected to the public switched telephone network, then one of these ports should be the source of the master clock. (See Sec. 6.2 for clock mode details) The clocks must be configured before any switching can take place.

Several other steps may be necessary to configure individual ports. A port can be configured as unused or undefined, a network termination, or as terminal equipment. The “**ST**” command is used to configure the ports. It consists of a character to specify the a bank of sixteen ports followed by sixteen characters representing the port type, one for each port. The bank is specified by either an “L” for the low bank (ports 0-15) or an “H: for the high bank (ports 16-31.) An “N” defines a port as a “network termination” or NT, a “T” as “terminal equipment” or TE, and a “U” as undefined or unused. As an example, if the first four ports are to operate as TEs, the next four as NTs, and the rest as unused ports, then the “ST” message to be sent would be:

STLTTTTNNNNUUUUUUUU

If the “D” command set is to be used for call control, it will also be necessary to set the protocol level of the ports. This is done with an “**SL**”

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message. Like the “ST” message, the “SL” message has a character specifying the bank followed by sixteen characters that act as arguments for each of the ports. For the “SL” message the choices are “2” if only “LC” messages are to be used for call control, “3”, “A”, “D”, “E”, or “N” if “D” messages are to be used. The “A” is used for AT&T Custom switches, “D” for DMS-100 or 5ESS switches with National ISDN software, “N” for other National ISDN switches, and “E” if “D” messages are used and the port is being used for CACH EKTS. The default is “2”.

The port type and protocol level information can be stored in the EEPROM to be loaded automatically on power up or a restart. See Section 4.3 for details.

9.4 Using the “C” Commands

The B-channels on the H.110 Basic Rate ISDN Board can be set to provide full-duplex connections as well as half-duplex connections in either direction. They can also be used to send DTMF and call progress tones as well as provide DTMF and energy detection.

Changes in the B-channel state are reported in state change messages. These consist of the letter “S” followed by a letter indicating the change, the B-channel number, and an optional information character. An example is the message **SI00** which indicates that B-channel 00 has returned to the idle state.

9.4.1 Making a Connection

A two-way connection can be made with a port using the Connect Command “CC”. This command takes the form **CCxxssttaabb**, where xx is the B-channel number, sstt is the destination stream and timeslot and abb is the source stream and timeslot to be connected to. As an example, the message **CC0001020304** would connect B-channel 00 with timeslot 2, stream 1 being the transmit timeslot and timeslot 4, stream 3 the receive timeslot. Note that if a transmit timeslot had been reserved for the port

using the “SX” command or if this had been done by a timeslot assignment program associated with a driver, the transmit timeslot portion of this command will be ignored and the reserved timeslot will be used. In addition to two-way connections, one-way connections are also possible in either direction. The Audit command “CA” is used to create a connection from a timeslot to a port. This command takes the form **CAxxsstt**, where xx is the B-channel number, ss is the stream, and tt the timeslot of the timeslot being audited. As an example, **CA000201** would direct timeslot 1 of stream 2 to B-channel 00.

The Transmit command “CX” is used to setup a B-channel to transmit towards the H.110 bus. This command takes the form **CXxxsstt** where xx is the B-channel number, ss is the stream and tt is the destination timeslot. As an example of using a B-channel as an input, if B-channel 01 is to transmit on timeslot 5 of stream 6 the command **CX010605** would be sent.

A connection will be broken by a Disconnect command. The Disconnect command “CDxx” will disable the B-channel output and any H.110 bus connection. An idle state change message “SIxx” will signal that the B-channel has returned to the idle state. .

A Hold or other B-channel command, such as playing a call progress tone, will also break a connection. The Hold command “CHxx” will disable audio to and from the B-channel. If the B-channel was connected to the H.110 bus, a silence pattern will be output to the H.110 bus. This pattern can be disabled by a “CDxx” command. It will also be cleared if a connect or disconnect command is issued for the B-channel.

9.4.2 Call Progress Tones

The on-board DSP can be used to play any of the standard Call Progress tones to a B-channel. The tones supported are dial tone, busy tone, reorder tone, and audible ringback. Silence and a calibration tone of 1004 Hz. can also be played. The Call Progress command “CP” is used to play tones. This message is of the form **CPxxt**, where xx is the B-channel and t is the code of the tone. For example, the command **CP002** will play busy tone to

B-channel 00. The tone will stop playing if another command is issued for the B-channel such as a connect.

9.4.3 Sending DTMF Tones

A string of DTMF tones can be sent using the “**CT**” command. Any of the 16 DTMF tones can be sent. Pauses may be embedded that are one or ten digit times (.2 or 2 sec.) Single tones of 697 and 941 Hz. are also possible. The tone string length can be up to 27 characters long. The command consists of **CT** followed by the B-channel number and the string of tones. As an example, the command **CT039P7654321** would send the digit “9”, pause two seconds, and then send the digits “7654321”.

On receiving the command, the board will respond with an “**SL**” state change message to indicate that the B-channel is listening to a DTMF generator. When the tone string has finished, the board will send an “**SE**” message to indicate the string is ended and place the B-channel in the hold state.

9.4.4 Detecting DTMF Tones

The on-board DSP can be used to detect DTMF tones on a B-channel. The Listen for DTMF command takes the form **CLxxo**, where xx is the B-channel number and o is an option. If no option is given, dial tone will automatically be played to the B-channel until the first tone is detected. If the option is “Q”, then no dial tone will be played. If the option is “M”, then detection will take place without interrupting existing connections. The “F” option will disable detection that is in progress. As an example, the message **CL00** will enable DTMF detection on B-channel 00 and play dial tone.

As each tone is detected, the board will send a Tone detected state change message of the form **STxxd** where xx is the B-channel number and d is the tone. As an example, the message **ST005** indicates that the digit 5 has been detected on B-channel 00. All sixteen DTMF tones can be detected. Detection will remain active until a command is issued for the B-channel.

9.4.5 Detecting Energy

Each B-channel is equipped with an energy detection function. The energy detector can be set to look for audio energy with a minimum duration time. When a continuous audio signal has been detected for that time, a message is sent. Another message is sent when the audio signal stops. This feature can be used to monitor for dial tone restoration or call progress tones. Energy detection does not affect existing connections and can be used in conjunction with DTMF detection.

To enable energy detection on a B-channel the energy command “**CE**” is used. This command takes the form **CExxdd** where xx is the B-channel number and dd is the duration in steps of 100 msec. The range is from .1 to 22.3 seconds or from 01 to DF. For example, the command **CE0714** would enable energy detection on B-channel 7 with a duration of 14h or 2 seconds. When a signal is detected the message would take the form **SP071** in this example where the “1” indicates detection. A “0” would indicate that the signal has stopped.

Energy detection will be disabled when the B-channel changes state due to a command. It can also be disabled without affecting the B-channel state by sending a command where the duration is replaced by a single character “F”. In the example above, this would be **CE07F**.

9.4.6 An Example of Originating a Call

The following is an example of the steps involved in a terminal originating a call. Both the “C” commands and state change messages will be shown. The “D” messages will also be shown to show the relative timing. The dialed digits will be detected, ringback played, and finally a connection made and broken when the phone hangs up.

<u>commands</u>	<u>responses</u>	<u>description</u>
CP060	DS06S	SETUP message
	SL06	play dial tone
	DK061	tone being played
CP065		the digit "1" dialed
		dial tone removed, silence played
	SL06	tone played to B-channel
	DK062	the digit "2" detected
CP063	DK063	the digit "3" detected
		play audible ringback
DA06IR		ALERTing message
CC0601020304 DC06	SL06	tone played to B-channel
		connect the B-channel
		CONNect message
	SC00	connection confirmation
	DD0610	DISConnect message
	DR060F	RELease COMplete
CD06		disconnect the B-channel
	SI06	B-channel returned to idle state

9.4.7 An Example of Receiving a Call

This example shows the steps involved in a terminal receiving a call. First, ringing will be generated, then the port will be connected, and finally disconnected when a far end disconnect is detected.

<u>commands</u>	<u>responses</u>	<u>description</u>
DS06SNN7654321		SETUP message
	DA0601	ALERTing message
	DC0601	CONNect message
CC0601020304		connect the B-channel
	SC06	connection confirmation
DD0610F		DISConnect message
	DR06R	RELease message
CD06		disconnect the port
	SI06	B-channel in idle state

9.4.8 An Example of Detecting DTMF Digits

Once a connection has been established, there may be a need to detect DTMF digits. An example is when the call is not an end to end ISDN call, and there is a need for the far end to signal the near end. In this example, DTMF detection is turned on, a string of digits is detected and then the connection is reestablished. Note that no “D” commands are issued because the call state has not changed.

<u>commands</u>	<u>responses</u>	<u>description</u>
CL06		listen for DTMF command with dial tone
	SX06	DTMF detection enabled
	ST061	the digit “1” is detected, dial tone removed
	ST062	the digit “2” is detected
	ST063	the digit “3” is detected
CC0601020304		reestablishment of connection
	SC06	connection confirmation

9.5 Voice Resources

The H.110 BRI Board is equipped with 64 channels of voice record and 64 channels of voice playback capability. The operation of these channels is beyond the scope of this document. For further information consult the appropriate driver and library manuals for the operating system being used.

10.0 Diagnostics & Error Messages

10.1 Diagnostic Commands

Several diagnostic commands are available:

- VA** Used to request the checksum of the firmware in the alternate segment of the board. This is returned in a message of the form `VAxxxx` where `xxxx` is the checksum of the firmware in the alternate segment of ROM.
- VC** Used to request the version of the firmware on the board. A message of the form `VCxxxxyyyyHBNA` is returned, where `xxxx` is the checksum of the firmware stored in the main segment of ROM, `yyyy` is a four-digit version number, `HBNA` indicates the board type and version (*CompactPCI BRI*, North American firmware). This message takes the same form with all Infinity Series boards, and can be used to determine the configuration of the system.
- VD** Used to request the version of the DSP software. This is returned in a message of the form `VDxxxx`, where `xxxx` is the version number. All DSP's on the board use the same software version.
- QHbssttr** Queries the T8105 switching chip, for bus `b`, stream and timeslot `sstt`. The bus value `b` can be "H" for the H.110 bus, "L" for the local bus, or "R" for the control registers. For the H.110 bus, the contents are returned in a message of the form `QHsstt1111csttttttddddd` where `1111` is

the connection memory location, *cstt* are the control bits, source stream and timeslot, and valid bit, *tttt* is the connection memory tag, and *dddd* is the contents of data memory 1 and data memory 2. If the timeslot is not found, only a location value of 01FF is returned. For the local bus the results are returned as a 24 bit value *csttdd* in a message of the form *QHLssttcsttdd* where *cstt* is the source stream and timeslot and *dd* is the data memory contents. The register results are returned as an 8 bit value in a message of the form *QHR00rrdd* where *rr* is the register address and *dd* is the data. This command refers to the details of the internal switching circuitry, and is ordinarily of limited use to the application.

QL This message queries the geographical shelf and slot information. The information is returned in a message of the form *QLaabb* where *aa* is hexadecimal value of the shelf address bits and *bb* is the value of the slot address bits.

10.2 Error Messages

The board will detect a number of error conditions and respond with appropriate error messages. These messages are:

ECxx A clock error bit event *xx* has occurred. The value *xx* is a hexadecimal number where the bits are (a bit value of 1 is an error)

<u>bit</u>	<u>description</u>
0	CT bus clock A
1	CT bus clock B
2	SCbus clocks (not applicable on H.110 boards)
3	MVIP bus clocks (not applicable on H.110 boards)
4	CT_NETREF1 or CT_NETREF2 error
5	Frame Boundary

ELxxe An error has been detected in either Layer 1 or Layer 2 for port xx. The specific error is indicated by the value of e:

- 1: Synchronization has been restored
- 2: Slip has been detected
- 3: T3 has expired, Layer 1 deactivated
- 4: T4 has expired, persistent Layer 1 error
- 5: A Layer 2 N(R) state variable recovery has taken place
- 6: A Layer 2 TEI assignment request has been denied
- 7: An error has occurred writing to the ISDN interface chip. The board should be reset using the RA command.
- 8: Layer 1 anomaly has occurred, no action needed

EMxxe A Layer 2 protocol error has occurred on port xx. The error is indicated by the value of e. This corresponds to the Management Data Layer Indication in parentheses as defined by Q.921:

- 1: MDL error (A) unsolicited supervisory response (F=1)
- 2: MDL error (B) or (E) unsolicited DM response
- 3: MDL error (C) or (D) unsolicited UA response
- 4: MDL error (F) peer initiated reestablishment (SABME)
- 5: MDL error (G) or (H) unsuccessful retransmission of SABME or DISC
- 6: MDL error (I) unsuccessful retransmission of a status enquiry
- 7: MDL error (J) N(R) state variable error
- 8: MDL error (K) receipt of FRMR response

SM0 An EEPROM operation has failed. This indicates that either a read or write to the EEPROM was unsuccessful.

SM1 An EEPROM operation successfully completed.

U[cmd] If the board does not recognize a command message, or if it does not have the appropriate number of arguments, the same message will be returned by the board preceded by a U to indicate an undefined message.

10.3 Diagnostic Tests

Several diagnostic tests can be run on the BRI ports to check the operation of the port or the attached wiring. The commands to initiate these tests are:

XLxxm This test puts port xx in the loopback mode specified by m:

- 0: no loopback
- 1: loopback of channel B1 at the S/T interface
- 2: loopback of channel B2 at the S/T interface
- 3: loopback of both B channels

XTxxm This test can be used to output a square wave on port xx. The test mode is specified by m:

- 0: normal, no test output
- 2: 96 kHz output

10.4 Auxiliary LED

SIm This message sets the mode for the AUX LED on the front panel. The default mode is for the LED to be under the control of the on board processor. When under the control of the processor, the LED normally blinks green. If any defined interface is not in the “up” state, it will blink yellow. During a restart it will be solid green, and it will be solid yellow during a reset using the “RA” command. The LED

can be controlled by the application by sending a message of the form SLM where m is:

- 0 LED off
- 1 LED solid green
- 2 LED solid yellow
- 3 LED blinking green
- 4 LED blinking yellow
- X LED controlled by on board processor

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Appendix A: Environmental Specifications

The Infinity Series H.110 Basic Rate ISDN Board meets the following environmental specifications:

TEMPERATURE EXTREMES:

Operating: 0EC (+32EF) to +50EC (+122EF).

Storage: -40EC (-40EF) to +70EC (+158EF).

AMBIENT HUMIDITY:

All boards will withstand ambient relative humidity from 0% to 95% non-condensing in both operating and storage conditions.

MECHANICAL:

All Infinity Series H.110 boards conform to the PCI-SIG mechanical specifications for 6U *CompactPCI* cards.

MTBF:

50,000 hours.

ELECTRICAL REQUIREMENTS:

+5 volts $\pm 5\%$ @ 2.0 amps maximum.

-48 volts, maximum current per port 100 mA.

+3.3 volts, -5 volts, and ± 12 volts are not required.

TERMINAL EQUIPMENT COMPATIBILITY:

The following ISDN Station sets have been tested for compatibility with the “D” message set:

AT&T 8510T AT&T Custom Protocol
Fujitsu SRS-1050V and SRS-1050D National ISDN
Cortelco CI1800-MOE-25D and CI3000-MOE-25D
Lodestar LTI-1001LS and LTI-1501-LS Telesets
Tone Commander 6210T

The Lodestar set has been marketed by a number of other companies, but the firmware for these models may be different than the LTI-1001LS