



Infinity Series H.100 Basic Rate ISDN Board

TECHNICAL MANUAL
(EUROISDN VERSION)

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257M028C

Note: This manual refers to the revised board using the T8105 switching chip, Blackfin DSP and the HFC8S BRI Interface chips. As these chips are different than those used on earlier boards, there may be minor differences in the operation of this board. Those using the earlier revision should use the 257M002B revision of this manual. The revised board is functionally equivalent to the earlier board with the exception of the addition of voice record and playback capabilities. Specifically, this manual refers to firmware versions 3.1c and later.

In addition to the revision of this board with the EX386 processor, there is a subsequent revision of the board using an ARM processor that is functionally equivalent and is also covered by this version of the manual.

Contents

1.0	INTRODUCTION.....	1-1
1.1	Features and Capacities.....	1-2
1.1.1	The Physical Interface.....	1-2
1.1.2	Signaling Protocols.....	1-3
1.1.3	DSP Functions.....	1-3
1.1.4	The H.100 bus.....	1-3
1.1.5	Clock Modes.....	1-4
1.1.6	Message Passing.....	1-5
1.1.7	Flash EAROM for Firmware.....	1-5
1.1.8	EEPROM for Configuration Information.....	1-5
1.2	How to Use This Manual.....	1-6
2.0	QUICK START.....	2-1
3.0	INSTALLATION.....	3-1
3.1	PCI Configuration.....	3-2
3.2	Jumpers & Headers.....	3-2
3.3	Connectors: P2, P5, J1 and J1A.....	3-3
3.4	Installation.....	3-5
4.0	INITIALIZATION.....	4-1
4.1	PCI Initialization.....	4-1
4.2	Initialization Commands.....	4-2
4.3	Configuration Memory.....	4-6
5.0	COMMUNICATING WITH THE PC.....	5-1
5.1	Commands and Responses Protocol.....	5-2
5.1.1	Sending Commands to the Board.....	5-2
5.1.2	Reading Messages from the Board.....	5-3
5.1.3	Reading Board Information.....	5-3
5.2	Interrupts.....	5-4
5.2.1	Interrupt Initialization.....	5-5
5.2.2	Step-by-Step Summary.....	5-5

5.0	COMMUNICATING WITH THE PC (CONTINUED):	
5.3	Commands and Responses.....	5-6
5.3.1	Characteristics of Command Strings.....	5-6
5.3.2	Command Parameters.....	5-6
5.3.3	Commands from the PC to the H.100 BRI Board.....	5-7
	▶ B-Channel Commands.....	5-7
	▶ Layer 3 “D” Commands for NT Ports.....	5-8
	▶ Layer 3 “D” Commands for TE Ports.....	5-10
	▶ Interrupt Control Commands.....	5-12
	▶ Layer 3 Message Commands.....	5-12
	▶ MVIP Compatibility Commands.....	5-12
	▶ Query Commands.....	5-12
	▶ Reset Commands.....	5-13
	▶ Setup Commands.....	5-13
	▶ TEI Management Commands.....	5-14
	▶ Version Requests.....	5-14
	▶ Download Commands.....	5-14
	▶ Diagnostics.....	5-14
5.3.4	Responses from the H.100 BRI ISDN Board.....	5-15
	▶ Acknowledgments.....	5-15
	▶ Layer 3 “D” Responses for NT Ports.....	5-15
	▶ Layer 3 “D” Responses for TE Ports.....	5-17
	▶ Error Messages.....	5-19
	▶ Layer 3 Messages Received Response.....	5-19
	▶ Query Responses.....	5-19
	▶ B-Channel State Change Messages.....	5-19
	▶ TEI Management Responses.....	5-20
	▶ Diagnostic Responses.....	5-20
6.0	THE H.100 BUS & CLOCK MODES.....	6-1
6.1	The H.100 Bus.....	6-1
6.1.1	Legacy Bus Compatibility.....	6-2
6.2	Clock Modes.....	6-3
6.2.1	Slave Mode.....	6-4
6.2.2	Primary Master Mode.....	6-5
6.2.3	Secondary Master Mode.....	6-6
6.2.4	Clock Fallback.....	6-7
6.2.5	Clock Errors.....	6-7
6.3	Configuration Information.....	6-8

The H.100 Basic Rate ISDN Board

7.0	LAYER 1 & LAYER 2 PROTOCOLS.....	7-1
7.1	Layer 1.....	7-1
7.2	Layer 2.....	7-3
7.3	Layer 1 & Layer 2 States.....	7-6
7.4	TEI Management	7-7
7.5	The Packet Data Link.....	7-10
7.6	Sending and Receiving Layer 3 Messages.....	7-10
8.0	USING “D” MESSAGES FOR LAYER 3.	8-1
8.1	Q.931 Messages.....	8-1
8.2	“D” Command & Response Messages.....	8-3
8.3	Information Elements.....	8-5
8.3.1	Bearer Capability.....	8-5
8.3.2	Sending Complete.....	8-6
8.3.3	Cause.....	8-6
8.3.4	Progress Indicator.....	8-8
8.3.5	Subscriber Numbers.....	8-8
8.3.6	Subaddresses.....	8-9
8.3.7	Date/Time.....	8-9
8.4	Default Subscriber Numbers.....	8-9
8.5	Display Text.....	8-10
8.6	User-User Information.....	8-10
8.7	NT Call Handling Examples.....	8-11
8.7.1	An Originating Call.....	8-11
8.7.2	A Terminating Call.....	8-12
8.8	TE Call Handling Examples.....	8-13
8.8.1	Originating a Call.....	8-13
8.8.2	A Terminating Call.....	8-14
8.9	Call Rearrangement.....	8-15
8.10	HOLD & RETrieve.....	8-17
8.11	FACILITY Messages.....	8-19
8.12	Call Processing Errors.....	8-21
8.13	Layer 3 Timers.....	8-22

9.0	CONTROLLING THE B-CHANNELS.....	9-1
9.1	Overview of the Command Structure.	9-1
9.2	Legacy Computer Telephony Busses.....	9-2
9.2.1	SCbus Compatibility.	9-2
9.2.2	SCbus Timeslot Assignment.	9-3
9.2.3	MVIP Compatibility.	9-4
9.2.4	MVIP Compatibility Commands.....	9-5
9.3	Configuring the Board.	9-7
9.4	Using the “C” Commands.	9-9
9.4.1	Making a Connection.....	9-9
9.4.2	Call Progress Tones.....	9-10
9.4.3	Sending DTMF Tones.	9-11
9.4.4	Detecting DTMF Tones.....	9-11
9.4.5	Detecting Energy.	9-12
9.4.6	An Example of Originating a Call	9-12
9.4.7	An Example of Receiving a Call.....	9-13
9.4.8	An Example of Detecting DTMF.....	9-14
9.5	Voice Resource.	9-14
10.0	DIAGNOSTICS & ERROR MESSAGES.	10-1
10.1	Diagnostic Commands.....	10-1
10.2	Error Messages.....	10-3
10.3	Diagnostic Tests.....	10-5
APPENDIXES:		
A.	Environmental Specifications.	A-1

Infinity Series H.100 Basic Rate ISDN Board Technical Manual (EuroISDN Version)

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257M028C

The H.100 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.

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.

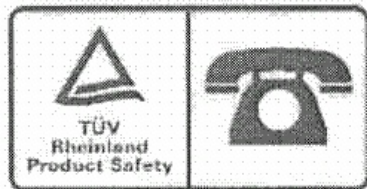
Before installing this equipment, users should ensure that it is permissible to be connected to the facilities of the local telecommunications company. The equipment must also be installed using an acceptable method of connection. The customer should be aware that compliance with the above conditions 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.

Approvals



prior to February 2017

post February 2017

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.

The H.100 Basic Rate ISDN Board

• 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.100 Basic Rate Interface ISDN Board is designed to provide either four or sixteen Basic Rate ISDN (Integrated Services Digital Network) interfaces connected to the H.100 bus on a board with the PCI 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 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 and ETS-300-102. The board is equipped with DSP resources to provide tone generation and detection.

The H.100 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 PCI form factor. A wide variety of boards are available from a number of different vendors. The H.100 bus also has compatibility modes that allow for connection to legacy computer telephony busses such as the MVIP-90 bus and SCbus.

The board is equipped with a processor that can be used to control the lower level functions of the board. Depending on the revision level, this may be either a 386 or an ARM processor, but functionally, the revisions are the same. 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.100 boards. This scheme is also compatible with legacy XDS boards for the MVIP-90 bus and SCbus.

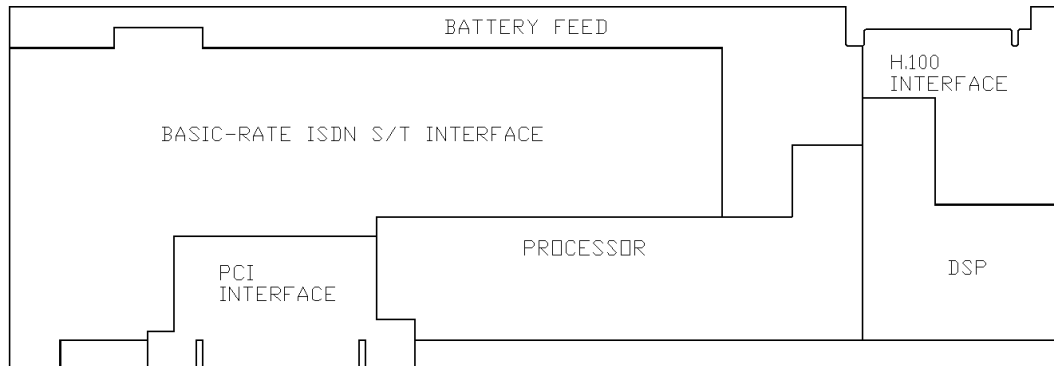


Figure 1: The H.100 Basic Rate ISDN Board Functional Areas

1.1 Features and Capabilities

This section presents an overview of the features and capabilities of the Infinity Series H.100 Basic Rate Interface ISDN Board.

1.1.1 The Physical Interface

Four or sixteen 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.

Each port provides two independent B1 channels which operate at 64 kbps. These channels can be switched to the H.100 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.

The H.100 Basic Rate ISDN Board

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.100 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.100 BRI ISDN Board is equipped with DSPs that perform 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 ETSI standard dial-tone, congestion, busy, and audible ringback being provided as well as silence and a 1004 Hz. calibration tone. Additionally, 32 channels of voice record and 32 channels of voice playback are available.

1.1.4 The H.100 Bus

The H.100 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.100 bus, each frame consists of 128 channels or timeslots. The bit rate of the H.100 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. For compatibility purposes with legacy busses, the first sixteen streams can also run at either 2.048 or 4.096 MHz. with 32 or 64 timeslots respectively.

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. For interoperation with the SCbus, MVIP bus, or H.MVIP bus a number of compatibility clock signals are also defined.

The H.100 bus consists of a 68 conductor ribbon cable that is used to interconnect the boards in the system. This cable connects to a header at the upper right hand edge on each board.

1.1.5 Clock Modes

The H.100 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.100 bus, one of the Basic Rate Interfaces, or be provided by the H.100 BRI Board. The clock redundancy and clock fallback functions of the H.100 bus is also supported so that the H.100 BRI Board can be set to provide a clock to the H.100 if the master clock on that bus should fail.

1.1.6 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 PCI board, the address and interrupt of the board is assigned at boot time. The message passing scheme used by the Infinity Series H.100 BRI Board is identical to that of the other Infinity Series H.100 boards, allowing for the easy combination of a variety of Infinity Series H.100 boards in a single system.

The message passing scheme and message syntax of Infinity Series H.100 boards is similar to that of the older XDS series of MVIP and SCbus boards. At the driver and API level, support is provided for both series of boards so that the H.100 boards may interoperate with legacy boards using a common interface.

1.1.7 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.

1.1.8 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 subscriber 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.100 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 you power-up your PC in order for the board to communicate with the PC.
3. Read section 5.0 (Communications with the PC) for an overview of how to communicate with the H.100 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.100 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.100 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. The Appendix contains information on power requirements and interfacing that will be helpful installing your H.100 BRI ISDN Board.

2.0 Quick Start

This section describes the first steps you should perform to determine if your Infinity Series H.100 Basic Rate ISDN Board is communicating correctly with your PC system. You can perform this quick check without securing the board to the PC chassis or 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. Make sure the PC power is off, then insert the board into a PCI slot.
2. Turn on your PC.
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.100 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 motherboard. There

The H.100 Basic Rate ISDN Board

may also be a problem with a memory or interrupt conflict. Power down the PC 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 PC 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.100 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: VCxxxxvvvvPBEA where xxxvvvv is a variable indicating the firmware version. The four port version will read VCxxxxvvvvPBE4. The sixteen port board with ARM processor will read VCxxxxvvvvPBNB.
8. If the Communications screen shows the correct command responses, your H.100 Basic Rate ISDN Board is communicating with the PC. 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.100 Basic Rate ISDN Board into your PC 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).

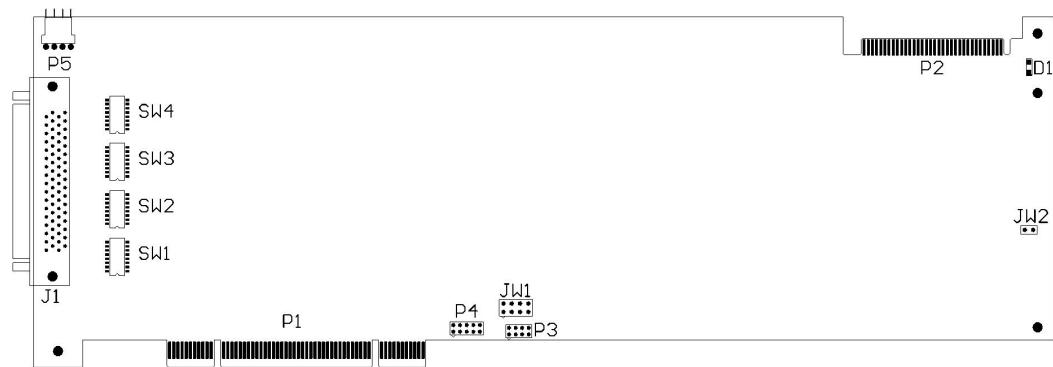


Figure 2a: Location of Jumpers, Headers, and Connectors on boards with the 386 processor

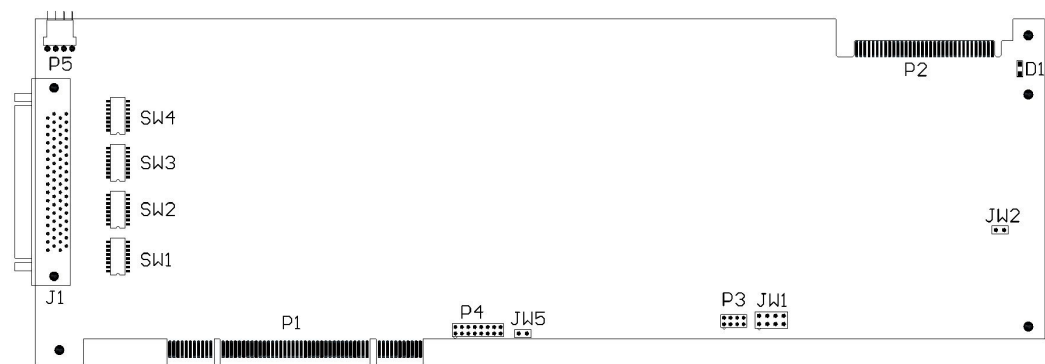


Figure 2b: Location of Jumpers, Headers, and Connectors on boards with the ARM processor

The H.100 Basic Rate ISDN Board

3.1 PCI Configuration

As Infinity Series boards conform to the PCI standards, there are no switches to set to configure the H.100 BRI Board's memory address, I/O addresses, or interrupt. The PC's bios will automatically configure the board at boot time to avoid conflicts with other boards in the system.

3.2 Jumpers & Headers

The following is a list of jumpers for the H.100 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. 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.
- JW3** This jumper is used for factory testing and should not have jumpers installed.

The H.100 Basic Rate ISDN Board

- JW5** For factory use only. Never install jumpers here. Only present on boards with the ARM processor.
- SW1-4** 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 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 switches on JW1, and port 15 using the last pair of switches on JW4.
- P3** Diagnostic port. Never install jumpers here.
- P4** This header is used for programming internal logic and should never be jumpered.

3.3 Connectors: P2, P5, J1 and J1A

- P2** H.100 bus. The H.100 bus connector (P2) is a standard H.100 bus header. Use an H.100 bus ribbon cable to connect the H.100 Basic Rate ISDN Board to other H.100 boards within the same PC chassis.
- P5** Power connector. This connector is used to supply power for the PS1/PS2 power feed for ports configured as NT. If PS1/PS2 power feed is not being used, this connector is not needed. The pins on this connector are:

pin 1	- 48 Volts
pin 2	telephone ground
pin 3	ring voltage (not used)
pin 4	telephone ground

One of the following (J1 or J1A) will be present depending on the number of ports:

J1 Basic Rate ISDN Connections. 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.

J1A Basic Rate ISDN Connections for the four port board. This connector consists of four RJ-45 type connectors, one of each Basic Rate ISDN interface. See Figure 4.

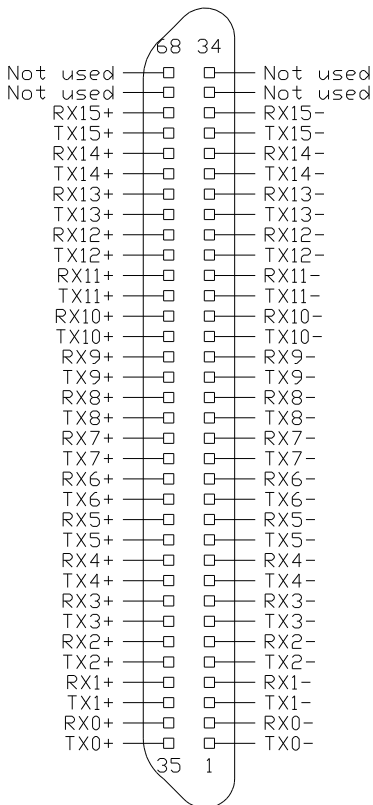


Figure 3: J1 Pin Assignments

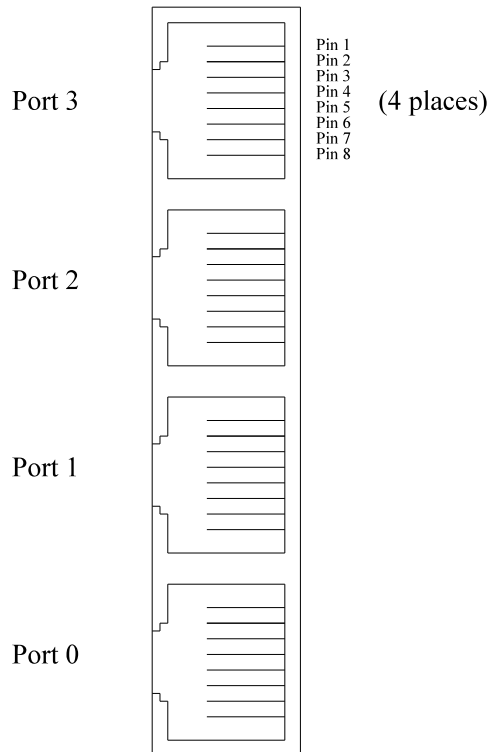


Figure 4: J1A Connector and Pin Assignments

Connector J1A on the four port board is wired as a network termination.

pin 1 no connect
pin 2 no connect
pin 3 Receive-
pin 4 Transmit+
pin 5 Transmit-
pin 6 Receive+
pin 7 Power Source 2-
pin 8 Power Source 2+

3.4 Installation

To install the H.100 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 to verify the operation of the board.
2. If the quick check is successful, turn off the PC power and remove the board from the chassis.
3. Install any necessary board jumpers. See section 3.2 for jumper configurations.
4. Reinsert the board into the chassis. Seat it properly in a PCI slot in the PC chassis and tighten the screw in the back of the board to secure it. Do not connect the board to the PSTN.
5. Connect the H.100 cable to P2. If needed, connect the 48 V. power supply cable to connector P5.

6. Reinstall the PC cover. Connect the PC to the mains supply using a socket-outlet with protective earthing connection and connect any additional protective earthing used.
7. Connect the telephone cable to J1. The telephone cable terminates in a 68 pin SCSI-3 male connector. Secure with mounting screws. On the four port board, the connection is made using RJ-45 cables connected to J1A.

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.

4.0 Initialization

This section describes the procedures necessary to initialize the system and enable the PC to communicate with the Infinity Series H.100 Basic Rate ISDN Board. XDS drivers will implement some of these procedures.

4.1 PCI Initialization

The system BIOS is responsible for recognizing PCI 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 PCI board contain a vendor ID and device ID code. These codes are unique to each board vendor. All Infinity Series H.100 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.100 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 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.100 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.100 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.100 Basic Rate ISDN Board using these commands

<u>Command</u>	<u>Purpose</u>
SCmsabb(c)	Sets the clock mode for the board. The parameter m is the clock-mode. The parameter s is the clock sub-mode. The parameters a, bb, and c are used to specify additional clock control information such as compatibility modes, clock rates, local network, and CT_NETREF settings. The default mode on power-up or restart is mode 0. See section 6.0 of this manual for details of clock mode arguments.
SBabcd	This command is used to define the clock rate for the lower 16 streams for compatibility with the SCbus or MVIP bus. The parameters a, b, c, d are used to set the rate for streams 0-3, 4-7, 8-11, and 12-15 respectively. The default value is 8.192 MHz. The possible settings are: 0 - 2.048 MHz., 32 timeslots per stream 1 - 4.096 MHz., 64 timeslots per stream 2 - 8.192 MHz., 128 timeslots per stream
SDxx(nn...n)	This command sets the default subscriber number to nn...n for B channel xx. The subscriber number can be up to 15 digits long. Normally the same number will be used for both B-channels on a port. For TE ports, the number will be the default calling party number for outgoing calls. For NT ports, it will be the default called party number for outgoing calls.
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 A-Law.

SF(xx...xx) Sets the power feed enable for each port on the board. The H.100 BRI ISDN Board can supply power for terminal devices connected to ports configured as an NT. The parameter can be “F” to turn the power feed off, “N” to turn it on, or “*” for no change. On sixteen port boards, this parameter controls PS1 and a parameter must be included for each of the 16 ports. On four port boards, the first four parameters control PS1 power for the ports and the second four parameters control PS2 power.

SSabcdefgh Set Layer 2 & 3 system options. Characters a-h can take values of 0, 1, or *. ‘*’ will leave the option unchanged. If a is a 1 a TE port will not automatically request a TEI assignment. Option b 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. Option c controls called party number checking in the point-to-multipoint mode. If set to 0 the called party number in incoming messages will be checked against the default subscriber numbers for that interface. If there is not a match, no response will be sent. If the options is set to 1, no checking occurs. Option d selects the subaddress format. If set to 0, the NSAP format is chosen, otherwise a user defined format is indicated. The defaults are 0 for all options. Option e will disable the Layer 3 timers if set to 1. The remaining options are currently undefined and should be set to 0.

ST(xx...xx) Set the port type for each port on the board. 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 for each of the ports on the board.

STab Controls termination. Parameters a and b control termination for the H.100 and MVIP bus respectively. When set to E, termination is enabled and when set to D, termination is disabled. Boards on the end of the H.100 cable should have termination enabled. When operating in MVIP compatibility mode, the MVIP termination should be enabled when the following condition exists:

For systems with five or fewer MVIP Bus connections and less than 90 pF load on the clock lines, it is adequate to place the circuit board that is the master clock source at one end of the cable and provide termination on the circuit board which is physically at the other end of the cable.

On systems with more than five MVIP connections or more than 90 pF load on the clock lines, both ends of the cable should be electrically terminated with the 1000 Ohm/ 1000 pF termination. No other boards should terminate these lines.

SXstt This command is used to set the base timeslot on the SCbus when reserving timeslots to transmit on. The parameters s and tt are hexadecimal numbers setting the lowest timeslot of the block of timeslots reserved

for the board. This command should only be used when operating in the SCbus mode.

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:

SL(II...II) This command is used to select the protocol level supported by the board. The choices are 2 for Layer 2 support, 3 for Layer 3 support, or P for Layer 3 support in a point to point configuration. 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 default is Layer 3 support. Note, that when operating as a TE port, the board is not certified for use when only Layer 2 protocol support is selected. The protocol level parameter must be included for each of the ports on the board.

4.3 Configuration Memory

Much of the configuration information used to initialize the board is fixed in nature, such as the port types and subscriber numbers. To simplify initialization of the board, the configuration can be stored in an on board 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, and subscriber 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.

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.

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5.0 Communicating with the PC

This section describes how the PC communicates with the Infinity Series H.100 Basic Rate ISDN Board. It includes the definitions for the H.100 BRI Board commands and responses along with a description of the mailboxes used for messaging.

The board is controlled by the host PC 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

The H.100 Basic Rate ISDN Board

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” 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” 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 PC 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.100 BRI ISDN Board are:

The H.100 Basic Rate ISDN Board

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
Processor Type ('A' if ARM)	1F0F
Number of transmit timeslots	1F10-1F11
Base timeslot	1F12-1F13

Clock mode settings	1F18-1F1B
Board configuration	1F1C-1F1E
Clock status bits	1F1F
ID Code (Serial Number)	1F30-1F3F

Note: The number of reserved transmit timeslots, and base timeslots are used only in the SCbus compatibility mode when reserving transmit timeslots.

The board stores its identity upon power up or a hardware restart. The phrase **Restart PBA (c) Amtelco 2007** appears in the receive mailbox on boards with the 386 processor (for boards with the ARM processor the phrase is **Restart PBNB (c) Amtelco 2011**). The receive flag is not set and no interrupt is generated.

5.2 Interrupts

The H.100 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. Read and then 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.100 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.

Common Command Parameters

Parameter	Definition	Values
xx	B-Channel number	00-1Fh(16 port) 00-07h(4 port)
dd	D-Channel number, port	00-0Fh(16 port) 00-03h(4 port)
sstt	H.100 bus stream & timeslot number, ss = stream, tt = timeslot on stream	ss = 00-1Fh t t = 00-7Fh
aabb	H.100 bus stream & timeslot number, aa = stream, 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 PC to the H.100 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
CPxyy	Give B-channel xx call progress tone y where y values are: 0 - dial tone 6 - ETSI dial tone 1 - reorder 7 - congestion tone 2 - busy 8 - ETSI busy tone 3 - audible ringback 9 - ETSI ringback 4 - Digital Milliwatt A - U.K. ringback 5 - silence B - Japanese ringback
CSxxsstt	play call progress tone to stream ss timeslot tt, xx values 20-25h correspond to progress tones 0-5
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

DAxx(p)	ALERTING message B channel xx, opt. progress p
DCxx(p)	CONNECT message B channel xx, opt. progress p
DCxxpD(date)	CONNECT B channel xx, progress p, date/time (yymmddhhmm)
DDxx	DISCONNECT message B channel xx, normal clearing
DDxxcc(p)rr	DISCONNECT message B channel xx, cause cc, opt. progress p, opt. call reference
DFxxcrrid(tt)	FACILITY message B chan. xx, component type c, call reference rr, invoke tag id, tag value tt

DFxxErridee	FACILITY, error, call ref rr, invoke id, error ee
DFxxFEidee	FACILITY message B channel xx, call forwarding, return error, invoke tag id, error tag ee
DFxxFRid	FACILITY message, call forwarding, return results, invoke tag id
DFxxRrrid	FACILITY, return results, call ref. rr, invoke id
DGxxA	RESUME ACKnowledge B channel xx
DGxxArr	RETRIEVE ACKnowledge B chan. xx, call ref. rr
DGxxRcc	RESUME REJect B channel xx, cause cc
DGxxRccrr	RETRIEVE REJect message, cause cc, call ref. rr
DHxxA	HOLD ACKnowledge message B channel xx
DHxxA	SUSPEND ACKnowledge message B channel xx
DHxxRcc	HOLD REJect message B channel xx, cause cc
DHxxRcc	SUSPEND REJect message B channel xx, cause cc
DIxxcc	INFORmation message, cause value cc
DIxxccKkk	INFORmation message, cause cc, Keypad Facility digits kk
DIxxKkk	INFORmation message, keypad facility digits kk
DIxxT	INFORmation message, send display text in buffer
DKxxk	INFORmation, called # digit(s) k
DKxxC(k)	INFORmation, sending complete, called # digit(s) k
DNxxR	NOTIFY, call resumed
DNxxS	NOTIFY, call suspended
DNxxnn	NOTIFY message, notification indicator nn
DPxx(p)	CALL PROCEEDING message on B channel xx, optional progress p
DPxxPccp	PROGRESS message B channel xx, cause cc, progress p
DQxx	Query default subscriber number of B channel xx
DRxxcc(rr)	RELEASE COMPLETE message B channel xx, cause cc, optional call reference rr
DSxxbp	SETUP message, bearer capability b, progress p

DSxxbp(#)/#	SETUP message, bearer capability b, progress p, opt. calling #, called#
DSxxbp(#)C#	SETUP message, bearer capability b, progress p, opt. calling #, sending complete, called #
DSxxbpKk,(#)/#	SETUP message, bearer capability b, progress indicator p, keypad facility digits k, opt. calling #, called #
DTxxA(text)	Add text to the buffer for B channel xx
DTxxL(text)	Place a line of text in the buffer for B channel xx
DTxxC	Clear display text buffer for B channel xx
DUxxA(text)	Add User-User text to the buffer for B channel xx
DUxxL(text)	Place a line of User-User text in the buffer for B channel xx
DXxx	STATUS ENQUIRY for B-channel xx
DZxx	RESTART on B channel xx pair, both B channels
DZxxC	RESTART indicated B channel

Layer 3 “D” Commands for TE Ports

DAxx(p)	ALERTING message B channel xx, opt. progress p
DCxx(p)	CONNECT message B channel xx, opt. progress p
DDxx	DISCONNECT message B channel xx, normal clearing
DDxxcc(p)(rr)	DISCONNECT message B channel xx, cause cc, opt. progress indicator p, opt. call reference rr
DFxxcrrid(tt)	FACILITY message B chan. xx, component type c, call reference rr, id tag id, operation or error tag tt
DFxxDid/#	FACILITY, call deflection, invoke id, deflect #
DFxxFIidopb(#/)#	FACILITY message, call forwarding, invoke, invoke tag id, operation o, procedure p, basic service b, opt. forwarding #/, subscriber number
DFxxKBidrr	FACILITY, begin3PTY, invoke id, call ref. rr
DFxxKEidrr	FACILITY, end3PTY, invoke id, call ref. rr
DFxxTidrr	FACILITY, call transfer, invoke id, call ref. rr

DGxxrr	RETRIEVE message B channel xx, call ref. rr
DGxxS(id)	RESUME message B channel xx, opt. call identity string id
DHxx	HOLD message B channel xx
DHxxS(id)	SUSPEND message B channel xx, opt. call identity string id
DIxxcc	INFORMaTION message, cause cc
DIxxccKkk	INFORMaTION message, cause cc, keypad facility digits kk
DIxxKkk	INFORMaTION message, keypad facility digits kk
DKxxk	INFORMaTION message, called number digits k
DKxxC	INFORMaTION message, sending complete
DPxx(p)	CALL PROCEEDING message B channel xx, opt. progress p
DPxxPccp	PROGRESS message B channel xx, cause cc, progress p
DQxx	Query default subscriber number for B channel xx
DRxxcc(rr)	RELEASE message B channel xx, cause cc, call reference rr opt.
DRxxcc(rr)	RELEASE COMPLETE message B channel xx, cause cc, call reference rr opt.
DSxxb(p)	SETUP message B channel xx, bearer capability b, opt. progress p
DSxxbp(#)/#	SETUP message, bearer capability b, progress p, opt. calling #, called #
DSxxbp(#)C#	SETUP message, bearer capability b, progress p, opt. calling #, sending complete, called #
DsxxbpKk,(#)/(#)	SETUP message, bearer capability b, progress p, keypad facility digits k, opt. calling number #, opt. called number /#
DUxxA(text)	Add User-User text to the buffer for B channel xx
DUxxL(text)	Place a line of User-User text in the buffer for B channel xx
DXxx	STATUS ENQUIRY B channel xx
DZxx	RESTART on B channel pair xx, both B channels

DZxxC RESTART on indicated B channel

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

MVIP Compatibility Commands

MDhhD Disable DTMF detector hh (MVIP) (00-1F)
MDhhE Enable DTMF detector hh (MVIP) (00-1F)
MEhhdd Enable Energy detector hh (MVIP) (00-1F)
 duration dd
MEhhF Disable Energy detector hh (MVIP) (00-1F)
MGhh(ds) Generate the dial string (ds) with generator hh
 (MVIP) (00-1F)
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.100 bus stream & timeslot
QHLsstt Query T8105, sstt - local bus stream & timeslot
QHR00rr Query T8105, 00rr - register address
QObsstt Query Output for terminus bsstt
QPdx(msg) Send message to DSP d, send only bits 0-3 of x
QXxxx Query SCbus transmit timeslot for B-channel xxx

Reset Commands

RA	reset all (resets ports, DSP functions, H.100 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

SBabcd	Set bit rate for streams 0-3, 4-7, 8-11, and 12-15 0 - 2.048 MHZ. 1 - 4.096 MHZ. 2 - 8.192 MHZ.
SCmsabb(c)	Set clock mode m, submode s, arguments a, bb & c
SDxx(nn...n)	Set the default subscriber number for B channel xx
SEa	Set Encoding mode a, M = Mu-Law, A= A-Law
SF(xx..xx)	Set battery feed enable for each port where x values are: F - off, N - on, * - don't care
SL(l1...l1)	Set protocol layer for each port where l values are 2 - Layer 2 support 3 - Layer 3 support P - Layer 3 point to point support
SMC	Clear the EEPROM configuration contents
SML	Load the EEPROM contents onto the board
SMS	Save the configuration in EEPROM
SSxyz	Set Layer 2 & 3 system options x, y, & z
ST(xx...xx)	Set port types for each port where x values are: N - Network Termination T - Terminal Equipment U - Undefined/unused * - No change to port type
STab	Set bus termination, a = H.100 bus, b = MVIP bus
SXstt	Set SCbus base timeslot to stream s, timeslot tt

TEI Management Commands

TAdd	Request TEI assignment for port dd (TE only)
TCdd	Request a TEI check for port dd (NT only)
TDdttt	Disconnect Link for TEI tt on port dd
TDddP	Disconnect Packet Data Link on port dd
TEdttt	Establish Link for TEI tt on port dd
TEddP	Establish Packet Data Link on port dd
TFdttt	Set Fixed TEI tt for port dd, tt = 0-3F
TPdttt	Set Packet TEI tt for port dd, tt = 0-7E
TQdd	Request TEI assignments on port dd
TRdttt	Remove TEI tt on port dd, tt = 7F remove all (NT only)
TVdttt	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.100 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.100 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

DAxxpr	ALERTING B channel xx, progress p, call ref. rr
DCxxpr(#)	CONNECT B channel xx, progress p, call ref. rr, opt. connected #
DCxxArr	CONNECT ACKnowledge B channel xx, call ref. rr
DDxxcc(p)(rr)	DISConnect B channel xx, cause cc, opt. progress p, optional call reference rr
DFxxerrid(tt)	FACILITY message B channel xx, component type c, call reference rr, id tag id, operation or error tag tt
DFxxDid/#	FACILITY, call deflection, invoke id, deflect #
DFxxFIidopb(#/#)	FACILITY message, call forwarding, invoke, invoke tag id, operation o, procedure p, basic service b, opt. forwarding #/, subscriber number
DFxxKBidrr	FACILITY, begin3PTY, invoke id, call ref. rr
DFxxKEidrr	FACILITY, end3PTY, invoke id, call ref. rr
DFxxTidrr	FACILITY, call transfer, invoke id, call ref. rr
DGxxrr	RETRIEVE message B channel xx, call ref. rr
DGxxS(id)	RESUME message B channel xx, opt.call identity string id
DHxxrr	HOLD message B channel xx, call ref. rr
DHxxS(id)	SUSPEND message B channel xx, opt. call identity string id
DIxxcc	INFORMATION message, cause cc
DIxxccKkk	INFORMATION message, cause cc, keypad facility digits kk

DIxxKkk	INFORmation message, keypad facility digits kk
DKxxk	INFORmation message, called number digit(s) k
DKxxC(k)	INFORmation message, sending complete, optional called number digit(s) k
DPxx(p)	CALL PROCEEDING message B channel xx, optional progress p
DPxxPccp	PROGRESS message B channel xx, cause cc, progress p
DQxx(nn...n)	Default subscriber number for B channel xx, response to query
DRxxcc(rr)	RELEASE COMPLETE message, cause cc, opt. call reference rr if call not assigned to a B-channel
DRxxRcc(rr)	RELEASE message, cause cc, optional call reference rr if call not assigned to a B-channel
DSxxbp(#)	SETUP message B channel xx, overlap sending, bearer capability b, progress p, opt. calling party #
DSxxbp(#)/#	SETUP message, en bloc sending, bearer capability b, progress p, optional calling party #, called #
DSxxbp(#)C#	SETUP message, bearer capability b, progress p, optional calling party #, sending complete, called #
DsxxbpKkk,(#)/#	SETUP message, bearer capability b, keypad facility digits kk, optional calling party #, called party #
DSxxAprr	SETUP ACKnowledge message, prog. p, call ref. rr
DUxxl(text)	User-User information from message line l
DXxxccsrr	STATUS message B channel xx, cause cc, call state ss, call reference rr
DZxxA0	RESTART ACKnowledge, indicated B-channel
DZxxA6	RESTART ACKnowledge, both B-channels

Layer 3 “D” Responses for TE Ports

DAxxpr	ALERTING B channel xx, progress p, call ref. rr
DCxx(p)	CONNect B channel xx, opt. progress indicator p
DCxxpD(date)	CONNect B channel xx, progress p, date/time (yymmddhhmm)
DCxxArr	CONNect ACKnowledge on B channel xx, call ref. rr
DDxxcc(rr)	DISConnect B channel xx, cause cc, opt. call ref. rr
DFxxcrrid(tt)	FACILITY message B channel xx, component type c, call reference rr, id tag id, operation or error tag tt
DFxxErridee	FACILITY, error, call ref rr, invoke id, error ee
DFxxFEidee	FACILITY message B channel xx, call forwarding, return error, invoke tag id, error tag ee
DFxxFRid	FACILITY message, call forwarding, return results, invoke tag id
DFxxRrrid	FACILITY, return results, call ref. rr, invoke id
DGxxA	RESUME ACKnowledge on B channel xx
DGxxArr	RETRIEVE ACK on B channel xx, call ref. rr
DGxxRcc	RESUME REJect on B channel xx, cause cc
DGxxRccrr	RETRIEVE REJect B chan. xx, cause cc, call ref. rr
DHxxA	SUSPEND ACKnowledge message on B channel xx
DHxxArr	HOLD ACK message on B channel xx, call ref. rr
DHxxRcc	SUSPEND REJect message B channel xx, cause cc
DHxxRccrr	HOLD REJect B channel xx, cause cc, call ref. rr
DIxxcc	INFORmation message, cause cc
DIxxccKkk	INFORmation message, cause cc, keypad facility digits kk
DIxxKkk	INFORmation message, keypad facility digits kk
DKxxk	INFORmation message, called number digit(s) k

DKxxC(k)	INformation message, sending complete, optional called number digit(s) k
DNxxR	NOTIFY message, call resumed
DNxxS	NOTIFY message, call suspended
DNxxnn	NOTIFY message, notification indicator value nn
DPxx(p)	CALL PROCEEDING message B channel xx, optional progress indicator p
DPxxPccp	PROGRESS message B channel xx, cause cc, progress indicator p
DQxx(nn...n)	Default subscriber number for B channel xx, response to query
DRxxcc(rr)	RELEASE COMPLETE message, cause cc, opt. call reference rr if call not assigned to a B-channel
DRxxRcc(rr)	RELEASE message, cause cc, optional call reference rr if call not assigned to a B-channel
DSxxbp	SETUP message assigned B channel xx, bearer capability b, progress p
DSxxbp(#)/#	SETUP message, bearer capability b, progress p, optional calling party #, opt. called #
DSxxbp(#)C#	SETUP message, bearer capability b, progress p, optional calling party #, sending complete, called #
DsxxbpKkk,(#)/#	SETUP message, bearer capability b, keypad facility digits kk, optional calling party #, called party #
DSxxAprr	SETUP ACKnowledge message, prog. p, call ref. rr
DTxxl(text)	Display text from message line l
DUxxl(text)	User-User information from message line l
DXxxccsrr	STATUS message B channel xx, cause cc, call state ss, call reference rr
DZxxA0	RESTART ACKnowledge, indicated B-channel
DZxxA6	RESTART ACKnowledge, both B-channels

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
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Query Responses

QHHsstllllcstttttddddd	Reply to T8105 H.100 bus query, llll location, cstt - stream & timeslot, control & valid bit, tttt - tag, dddd - data memory contents
QHLssttcsttdd	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
QObssttm(bsstt)	Query_output reply, bsstt - output terminus, m - mode, (bsstt) input terminus
QPd(text)	DSP diagnostic responses from DSP d
QXxxxstt	SCbus transmit timeslot for port xxx
QXxxxZ	No SCbus transmit timeslot set for port xxx

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
VCxxxxyyyyPBEA Version response, 16 port board, 386 processor
xxxx = checksum of main segment, yyyy = version number, PB = board type, E = EuroISDN standard, A = revised board, 386 processor
VCxxxxyyyyPBEB Version response, 16 port board, ARM processor
VCxxxxyyyyPBE4 Version response, 4 port board, 386 or ARM
VDxxxx DSP version xxxxx
U(msg) An undefined or unparseable message response

6.0 The H.100 Bus & Clock Modes

The Infinity Series H.100 Basic Rate ISDN Board provides a means of connecting BRI B-channels to the digital H.100 computer telephony bus. Through this bus, the B-channels can be connected to other H.100 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.100 operation. In addition, the board is capable of interoperating with legacy MVIP and SCbus boards.

6.1 The H.100 Bus

The H.100 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 interoperation with the legacy SCbus, MVIP-90 bus and the H-MVIP bus there are some additional clock signals that are included on the bus.

For the purposes of commands, a particular H.100 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.100 bus is a 68 conductor ribbon cable that connects the various boards in the system. As in any such bus, termination is important for its proper operation. The board at each end of the H.100 cable must have the proper termination installed or enabled, while any board between the ends must not terminate the bus. For the H.100 Basic

Rate ISDN Board, termination is enabled using a command of the form **STab** where a controls the H.100 termination and b the MVIP bus termination. Termination is enabled if a is “E” and disabled if a is “D”.

6.1.1 Legacy Bus Compatibility

The H.100 specification provides for inter-operability with several common legacy PCM busses. These include the SCbus, the MVIP-90 bus and the H-MVIP bus. Because these busses run at different bit rates than the 8.192 MHZ. of the H.100 bus, provisions exist in the specification to run the first 16 streams at either 4.096 MHZ. or 2.048 MHZ. For inter-operability with the SCbus, these streams typically should be run at 4.096 MHZ. (2.048 MHZ. and 8.192 MHZ are also possible choices) and with the MVIP-90 bus they should be run at 2.048 MHZ. H-MVIP runs these streams at either 2.048 or 8.192 MHZ. depending on whether MVIP-90 compatibility is desired.

On the H.100 Basic Rate ISDN Board, the bit rate of the first 16 streams is set using the “SB” command. This command takes the form **SBabcd** where the parameters a, b, c, and d select the bit rate for streams 0-3, 4-7, 8-11, and 12-15 respectively. The choices for these parameters are:

- 0 - 2.048 MHZ.
- 1 - 4.096 MHZ
- 2 - 8.192 MHZ.

Thus to operate with the SCbus at 4.096 MHZ. the command would be **SB1111** and to operate with the MVIP-90 bus **SB0000**. The default selection for these streams is the H.100 rate of 8.192 MHZ.

When operating in a compatibility mode, the timeslot in board commands range from 00 to the maximum number of timeslots allowed by the bit rate. At 2.048 MHZ. timeslots within a stream are numbered 00-1Fh and at 4.096 the timeslots are 00-3Fh. MVIP bus streams are numbered 00-0Fh. This numbering corresponds to the DSo/DSi

convention according to the following table:

H.100 stream	MVIP-90 stream	MVIP-95 stream	H.100 stream	MVIP-90 stream	MVIP-95 stream
00h	DSo0	HDS0	08h	DSo4	HDS8
01h	DSi0	HDS1	09h	DSi4	HDS9
02h	DSo1	HDS2	0Ah	DSo5	HDS10
03h	DSi1	HDS3	0Bh	DSi5	HDS11
04h	DSo2	HDS4	0Ch	DSo6	HDS12
05h	DSi2	HDS5	0Dh	DSi6	HDS13
06h	DSo3	HDS6	0Eh	DSo7	HDS14
07h	DSi3	HDS7	0Fh	DSi7	HDS15

6.2 Clock Modes

The H.100 bus specification defines a variety of clock signals. Two clock signals CT bus A and CT bus B are provided for redundancy. In addition, a signal called CT_NETREF is defined which may be referenced to an external clock source such as a T1 or E1 span. This signal exists to aid in recovery if the primary clock source should fail. The specification also includes clock signals for compatibility with both the MVIP-90 and SCbus.

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. 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.100 bus clock. The other boards in the system must slave their internal clocks to the master. If the H.100 Basic Rate ISDN Board is to use the H.100 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.100 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
- 2 - SCbus clock at 2 MHZ.
- 3 - SCbus clock at 4 MHZ.
- 4 - SCbus clock at 8 MHZ.
- 5 - MVIP-90 clock signal
- 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. It is included for upward compatibility. 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.100 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, any TE BRI interface with auto-fallback to CT_NETREF

For submode 1 and 2, argument *bb* will select the frequency of the CT_NETREF signal. The choices are:

- 00 - 8 kHz. (frame rate)

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

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

For all modes, argument a will select the legacy bus compatible clocks that the board will supply. The options are:

- 0 - no compatibility clocks
- 1 - SCbus clocks at 2 MHZ.
- 2 - SCbus clocks at 4 MHZ.
- 3 - SCbus clocks at 8 MHZ.
- 4 - MVIP 90 clocks
- 5 - H-MVIP clocks

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 source 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, the arguments s, a, and bb are the same as when operating as a primary master.

6.2.4 Clock Fallback

The H.100 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, 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.100 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	Master PLL error
5	Frame Boundary

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. Bits 0 and 1 of the sixth byte indicate the state of the H.100 and MVIP termination, respectively, with a value of 1 being the enabled state. 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).

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.100 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 and 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.100 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:

The H.100 Basic Rate ISDN Board

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.100 Basic Rate ISDN Board, the Layer 1 states sequencing

The H.100 Basic Rate ISDN Board

proceeds automatically at the chip level without requiring the intervention of the application. However, indications of a change of state are reported 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 and ETS 300-125. 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.100 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 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.

The H.100 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). Note that for normal operation, only a single TEI is required.

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 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 from 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 for point to multipoint connections. For point to point connections, a fixed TEI of 0 is used.

If a port is set as a TE, the board will automatically request a single TEI upon power up or resetting if a TEI has not previously been assigned unless the Layer 2 system option 1 is set to "1" with the **SS** command. If configured as a point to point connection, the TEI 0 will be used. 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. If a port is configured as a point to point connection, the first TEI will be set to 0.

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 00-0B). 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, disables the automatic TEI request for a TE port if set to 1. 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 **TQxxtttttttttttttttt**, 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 "TQxx4041FFFFFFFFFFFFFF". This command can be issued for either a TE or an NT port.

Normally, once a TEI is assigned, the data link is placed 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 European implementation of the Basic Rate interface can be found in the European Telecommunication Standard documents *Integrated Services Digital Network (ISDN); User-network interface layer 3 Specifications for basic call control ETS 300 102*.

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 suspended and resumed using the call rearrangement messages **SUSPEND** and **RESUME**. These messages have corresponding acknowledgment messages, **SUSPEND ACKnowledge** and **RESUME ACKnowledge**, as well rejection messages, **SUSPEND REJect** and **RESUME REJect**. A call may also be put on hold or retrieved with the **HOLD** and **RETRIEVE** messages. These messages also have corresponding acknowledge and reject

messages. **FACILITY** messages are used for supplementary services. **INFORMATION** messages can be used for a variety of purposes such as sending text for display, keypad facility, or called number digits. Additional messages are defined for maintenance or management purposes including **NOTIFY**, **STATUS**, **STATUS ENQUIRY**, and **RESTART**.

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.100 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 EuroISDN messages or has non-standard features or messages. However, the H.100 Basic Rate ISDN 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 the EuroISDN specification.

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.100 Basic Rate ISDN 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

The H.100 Basic Rate ISDN Board

DDxx	DISCONNECT
DFxx	FACILITY
DGxx	RETRIEVE
DGxxS	RESUME
DGxxA	RESUME or RETRIEVE ACKnowledge
DGxxR	RESUME or RETREIVE REJect
DHxx	HOLD
DHxx	SUSPEND
DHxxA	HOLD or SUSPEND ACKnowledge
DHxxR	HOLD or SUSPEND REJect
DIxx	INFORmation
DKxx	Called number element INFORmation message
DNxx	NOTIFY
DPxx	CALL PROCEEDING
DPxxP	PROGRESS
DRxx	RELEASE or RELEASE COMPLETE
DSxx	SETUP
DXxx	STATUS
DZxx	RESTART

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 held, 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.

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.100 Basic Rate ISDN 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 three options for bearer capability are:

- A** 3.1 kHz audio, 64 kbps, circuit mode, A-Law
- D** Unrestricted digital information, 64 kbps, circuit mode
- S** Speech, 64 kbps, circuit mode, A-Law

8.3.2 Sending Complete

The Sending Complete information element is included when the sender knows that the information in the called party number information element is sufficient to complete the call. It is not necessary to include this element, and the user or network may determine when sufficient address digits have been received by examining the digits themselves.

8.3.3 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
- 26** Network out of order
- 29** Temporary failure
- 2A** Switching equipment congestion
- 2B** Access information discarded
- 2C** Requested channel not available
- 2F** Resource unavailable, unspecified
- 31** Quality of service unavailable
- 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
- 42** Channel type not implemented
- 45** Requested facility not implemented
- 46** Only restricted digital information bearer capability is available
- 4F** Service or option not implemented, unspecified
- 51** Invalid call reference value
- 52** Identified channel does not exist
- 53** A suspended call exists, but this call identity does not
- 54** Call identity is in use
- 55** No cal suspended
- 56** Call having the requested call identity has been cleared
- 58** Incompatible destination
- 5B** Invalid transit network selection
- 5F** Invalid message, unspecified
- 60** Mandatory information element is missing
- 61** Message type non-existent or not implemented
- 62** Message not compatible with call state or 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

8.3.4 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
- R** Return to ISDN
- I** Inband information or appropriate pattern now available
- N** no progress indicator

8.3.5 Subscriber Numbers

The called or calling numbers in “D” messages are represented by strings 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. For TE ports, the numbering plan of the called number is based on the length, with numbers shorter than 8 digits being considered private plans, 8 to 11 digit numbers part of an ISDN plan, and other numbers of unknown numbering plan.

8.3.6 Subaddresses

Both the Calling and Called Party Numbers may include subaddress information elements. The board supports the NSAP subaddress type in the IDI format. The presence of a subaddress is indicated by a hyphen “-“ followed by the subaddress digits in either a command or response message. As an example in the message

DS02SN5551000-123/5551212-456

“123” is the calling party subaddress and “456” is the called party subaddress.

8.3.7 DATE/TIME

Date and time information can be sent from an NT port in a CONNect message to set the internal clock of a terminal. The information for this element takes the form “Dyymmddhhmm” where yy is the year, mm is the month, dd is the day, hh is the hour, and mm is the minute. All values are in hexadecimal notation, and the hours are in 24 hour format.

8.4 Default Subscriber Numbers

Default subscriber numbers can be programmed for each B channel, using the “SD” command. For TE ports, this number is used as the calling party information element if no other number is specified. For NT ports, the number is used for the called party information element if another number is not specified in the SETUP message generated by a “DS” command.

The default subscriber number can be up to 15 digits long. Normally, the same subscriber number is used for both B channels of a port. The default subscriber number is saved in the EEAROM and is retained when the board is powered down. The application can use the “DQ” command to query the current default subscriber number.

8.5 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. Display text can be up to 80 characters. As this is longer than allowed in a command or response message, the text is broken up into shorter pieces.

Each B-channel has a text buffer associated with it. Text can be placed in this buffer using commands of the form **DTxxL(text)** and **DTxxA(text)**. Once text has been placed in the buffer, the next command that sends a message for that call will include the text in the buffer as part of the Layer 3 message. Once sent, the text buffer will be cleared. The text can also be sent with a command of the form **DIxxT**. The command **DTxxC** will clear the buffer.

Text that is sent to a port set as a TE will be passed to the application in a response message of the form **DTxxl(text)** where l is the line number and xx is the B channel associated with the call.

8.6 User-User Information

The User-User information element is supported in those messages where it is allowed as defined in *ETS 300-102*. It is handled in a manner similar to that of the Display Text information element as described in the previous section except that User-User information may be passed

in both directions. Note that Display Text and User-User information elements may not both be sent in the same message due to memory limitations. The board supports the IA5 protocol for User-User information.

The command to place information to be sent in the buffer has the form **DUxxL(text)** while the command to append additional text takes the form **DUxxA(text)**. This information will be sent in the next Layer 3 message for which the User-User information element is supported.

If a User-User information element in the IA5 protocol format is present in a received message, it will be indicated in a response message of the form **DUxxl(text)** where l is the line number and xx is the B-channel associated with the call. The User-User text is broken up into lines of 27 characters to fit within the 32 character limit of the mailboxes.

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 An Originating Call

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>
DS06SN7654321C		SETUP message
	DA06N01	ALERTing message
	DC06N01	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 “N” indicates that there is no progress indicator, the “C” indicates sending is complete, and the calling number is 7654321. The default called party number was used. 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 Terminating 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 in the SETUP message. In this case the “DS” message might take the form **DS06bp/765**. 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 “DS06bp/7654321” and no more digits would be expected. The calling party number is often included as part of the message. This number will precede the “/” or “C” character.

<u>commands</u>	<u>responses</u>	<u>description</u>
	DS06SO5551000	SETUP message
	DK067	INFOrmation message
	DK066	INFOrmation message
	...	INFOrmation messages
	DK061	INFOrmation message
DA06I		ALERTing message

DC06	CONNeCT message
DD0610	DISConnect message
DR0610	RELEase message

The initial SETUP message indicates that this is a speech call. The progress indicator “O” indicates that the originating party was not ISDN. The digits following the “O” 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 INFOrmation messages are the digits as they dialed. These are sent by the terminal as INFOrmation messages with a called party number element. When enough digits have been dialed to complete the call, an ALERTing message is sent with the progress indicator for inband tones. 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>
DS10SNC5551000		SETUP message, sending complete
	DP10	CALL PROCeeding message

Using “D” Messages for Layer 3

DA10I03	ALERTing message, inband tones, call ref. 03
DC10	CONNect message
DD1010N	DISConnect message
DR100F	RELease COMplete message

The SETUP command indicates that the call is a speech call to 5551000 with no progress indicator. The “C” indicates that a Sending Complete information element should be included to indicate that all the address digits have been sent. The network responds with a CALL PROCEEDing message with no progress indicator. 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. 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. 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.

8.8.2 A Terminating Call

SETUP messages from the network normally 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>
	DS10SN5551000/5552000	SETUP message
DA10		ALERTing message
DC10		CONNect message
	DC10A81	CONNect ACKnowledge
DD1010		DISConnect
	DR1000	RELease

In this example, the SETUP message from the network indicates a speech call with no progress indicator. 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. 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 Call Rearrangement

An active ISDN call can be suspended to free up a B-channel for use by another call. The suspended call remains in the network, but the connection is broken. Once suspended, the call reference is released. The connection can later be resumed, assigning a new B-channel for the circuit. This does not have to be the same B-channel as was originally used. The call may also be resumed on another interface, allowing the call to be accessed by another user.

To keep track of suspended calls, an information element known as the “call identity” is used. This element consists of up to eight IA5 characters. It is included in the original SUSPEND message. The identical call identity element is then used in the RESUME message to reestablish the call. A null call identity may also be used, but this will limit the number of calls that can be suspended to one. The call identity should be chosen in such a way as to be unique on the user-network interface on which the user resides.

A terminal connected to an NT port can initiate a suspension by sending a SUSPEND message. This results in the “D” response message **DHxxS(id)**, where xx is the B-channel, and (id) is the call identity string. Once a call has been suspended, it is the responsibility of the application to retain the call identity until the call is resumed. To confirm the suspension, the application would send a message of the

form **DHxxA** as an acknowledgment. If it did not want to accept the suspension, it would send a message of the form **DHxxRcc**, where cc is the reason the hold was rejected. Once the SUSPEND ACK message has been sent, the B-channel is available for a new call.

To reestablish the suspended call, the terminal would send a RESUME message. This would cause a “D” response message of the form **DGxxS(id)**, where xx is the B-channel, and (id) is the call identity string. If the terminal did not choose a B-channel, the board would assign one if available. To allow the reestablishment the application would send the command **DGxxA**. To reject the reestablishment, the application would send the command **DGxxRcc** where cc is the cause for rejecting the reestablishment.

When the port on the H.100 Basic Rate ISDN Board is a TE, it can request that a call be suspended in a similar manner. The application would send a command of the form **DHxxS(id)** where xx is the B-channel of the call to be suspended and (id) is the call identity string. If the network responds with a SUSPEND ACK, the board would send a response message of the form **DHxxA**. A rejection would result in a response message of the form **DHxxRcc**, where cc is the cause for rejection.

The call would be retrieved by the application sending a command of the form **DGxxS(id)**, where xx is an available B-channel and (id) is the call identity string used to originally suspend the call. This message should not be sent if a B-channel is not available. If the call is reestablished the network will send a RESUME ACK message which will result in a response message of the form **DGxxA**. If the network sends a RESUME REJECT message, the response message would be **DGxxRcc**, where cc is the cause for the rejection.

8.10 HOLD & RETRIEVE

Some EuroISDN switches and terminals support procedures to hold and retrieve a call in addition to the call rearrangement procedures using the SUSPEND and RESUME messages described in the previous section. Call Hold (CH) is a Supplementary Service. The HOLD and RETRIEVE messages and associated procedures are described in ETS 300 196-1.

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.100 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 **DHxxA**. A rejection would result in a response message of the form **DHxxRcc**, 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.

The command and response messages to acknowledge or reject a hold or retrieval request take the same form as those for suspend or resume requests. The firmware uses the call state of the specified B-channel to determine which Layer 3 message is intended. That is, if a call is in the suspend request (U15) or resume request (U17) states, the call rearrangement forms are used.

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.

8.11 FACILITY Messages

Some Supplementary Services such as conferencing use the FACILITY message for invoking the service. When used as such, FACILITY message include a component tag to specify the type of FACILITY message, an invoke identifier which is used to associate responses with the invocation message, and, depending on the type of component, an operation or error value. The FACILITY message also includes the call reference number of the call for which the service is being invoked.

The command and response messages for FACILITY messages take the form **DFxxcrrid(tt)** where xx is the B-channel, c is the component type, id is the invoke identifier and tt is the operation or error value. Four types of components exist. These are:

I	invoke
R	return result
E	return error
J	reject

A supplementary service is requested using an invoke component. A number in the range of 00-7F is chosen to identify the invocation. This number is chosen to be unique to an exchange of an invoke and return components, and is usually incremented by one for each invocation. The invoke component will also include an operation value. This value specifies the supplementary service being requested.

The response to an invoke FACILITY message is a FACILITY message with a return result, return error, or reject component. Only the invoke identifier are included in return result or reject components. A return error component also includes an error value. A return result component indicates that the invoke request has been granted, while a reject component rejects the request. A return error component indicates that the service requested is not available. Two error values are defined by ETS 300 102:

- 01 not supported, user not subscribed (or not provided by the network)
- 02 provided by the network but rejected by the called user

Conferencing is an example of a supplementary service. A conference can be made between a call placed on hold and the call currently connected to. The operation value of a conference is 04. In the following example, a call will be placed to a terminal. The terminal will answer, place the call on hold, and place a second call. The terminal will then request a conference between the two calls.

<u>commands</u>	<u>responses</u>	<u>description</u>
DS00SN5551234		SETUP message 1st call
	DA00N09	ALERTING message
	DC00N09	CONNECT message
	DH0009	HOLD message
DH00A		HOLD ACKnowledge
	DS00SN7733100	SETUP message 2nd call
	DK005555678	INFO 2nd number dialed
DA00		ALERTING message
DC00		CONNECT message
	DF00I093404	FACILITY, invoke conf.
DF00R0934		FACILITY, return results

The first call was placed on hold. The call reference for this call was 09. A second call was placed by the terminal to 555-5678. This call was answered. The terminal then invoked service 04 for call reference 09 with an invoke id of 34. A FACILITY message with a return result component was then sent to indicate the conference request was accepted.

Additional forms of the commands and responses are available for services such as Call Forwarding. A full discussion of the FACILITY message and Supplementary Services is beyond the scope of this document. Additional information about the implementation of these

services can be found in *XDS Layer 3 ISDN Protocol Software (251M031B)*.

8.12 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 **DPxxPccp**, where xx is the B-channel of the call, cc is the cause of the PROGRESS message, and p is the progress indicator.

As an example, the message **DP06P11I**, 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 “I” indicates that there is an inband tone present. 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 **DPxxPccp** 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.

8.13 Layer 3 Timers

Several timers are specified at Layer 3 to deal with cases where the expected response is not received. These timers prevent calls from just hanging indefinitely. If the timer times out, a specific action is taken to either elicit a response or clear the call. The following table lists the supported timers:

Timer	timeout value	cause for initiation	cause for termination	action on expiry
1st T303	4 sec.	SETUP is transmitted	CALL PROC, ALERTing, CONNect or RELease COMplete	retransmit SETUP
2nd T303	4 sec.	SETUP retransmitted	as above	send RELease
T305	30 sec.	DISConnect sent	DISConnect, RELease, RELease COMplete	send RELease
1st T308	4 sec.	RELease sent	RELease, RELease COMplete	retransmit RELease
2nd T308	4 sec.	RELease retransmitted	as above	send RESTART
T310	NT - 10 s. TE - 120 s.	CALL PROC. received	ALERTing, CONNect or DISConnect	send DISConnect
T316	120 sec.	RESTART	RESTART ACK	retransmit RESTART
T322	4 sec.	STATUS ENQUIRY	STATUS, DISC. RELease RELease COMplete	send DISConnect

No action relating to the board is required on the part of the application when a timeout occurs, as the firmware will send the appropriate message. Of course the application must take the appropriate internal actions such as removing a call from internal tables or clearing the near end connection.

When a timer times out, the board will send a message of the form:

ETxxe

where xx is the B-channel, and e is a value specifying the timer. The values of e are:

- 0** T303 has expired the first time
- 1** T303 has expired the second time
- 2** T310 has expired
- 3** T305 has expired
- 4** T308 has expired the first time
- 5** T308 has expired the second time
- 6** T316 has expired
- 7** T322 has expired

The Layer 3 timers may be disabled by setting system option e to 1.

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9.0 Controlling the B-Channels

This section describes the process used for controlling the B-channels on the Infinity Series H.100 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 1E and 1F which are the B-channels for port 0F. On the four port boards the B channels are numbered 00-07.

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.100 bus and these range from 00 to 1F. The last two digits are used to indicate the timeslot. H.100 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 Legacy Computer Telephony Busses

The H.100 bus specifications make provisions for connecting to legacy computer telephony busses such as the SCbus and the MVIP bus. When interoperating with the SCbus or MVIP bus, the first 16 streams are used for connecting to the legacy bus, and these streams may operate at less than the 8.192 MHZ. bus rate. This means that there will be fewer than 128 timeslots per stream.

9.2.1 SCbus Compatibility

The SCbus is a 16 stream bus. Each stream on the bus normally operates at 4.096 MHZ. and has 64 timeslots per stream for a total of 1024 timeslots. However, the SCbus may optionally run at either 2.048 MHZ. with 32 timeslots per stream for a total of 512 timeslots or 8.192 MHZ. with 128 timeslots per stream and a total of 2048 timeslots on the 16 streams. When inter-operating H.100 Basic Rate ISDN board with the SCbus at either 2.048 or 4.096 MHZ. the bit rate on the lower 16 H.100 streams must be set appropriately using the “SB” command.

The SCbus uses a 26 conductor ribbon cable. Because of this, an adapter must be used between the P2 connector on the H.100 board and the SCbus.

9.2.2 SCbus Timeslot Assignment

Typically, drivers and libraries conforming to the SCbus specification use a scheme called “timeslot assignment” to insure that no two devices are transmitting on the same timeslot. Not only will having two transmitters on the same timeslot degrade audio signals, but they also may damage some SCbus boards. To prevent this, each device or “port” is assigned a unique timeslot to transmit on during boot-up. For purposes of timeslot assignment, each B-channel can be considered a port.

Transmit timeslots are reserved on the H.100 Basic Rate ISDN board using the “SX” command. The same command is used to reserve timeslots on XDS SCbus boards. The command takes the form **SXstt** where s is the stream and tt is the timeslot on that stream of the timeslot reserved for the first port on the board. As an example, if the first timeslot reserved for the board is 100 in decimal, then the message **SX124** would be sent (timeslot 100 corresponds to stream 1, timeslot 24h).

When timeslots have been assigned, the actual output timeslot value is no longer used in commands that control outputs to the CT bus. Instead, the B-channel or port number is used. This port number will range from 0 to 31 and will be represented in stream timeslot notation (0stt) in the commands. In this notation, the ports will run from 0000-001F.

Normally, the timeslot assignment process is carried out as part of the initialization and loading of the driver. A configuration file is used to specify the number of timeslots to be reserved for the board. The function **xds_xmt_timeslot** is used for finding the transmit timeslot of a port. To aid this process, information on the number of reserved timeslots and the base timeslot is presented in the dual-ported memory. This information is available at the following locations:

1F10h	total number of timeslots for the board
1F12h	1st timeslot assigned to the board

The command **QXstt** can also be used to inquire as to which timeslot is reserved for a port stt. The reply takes the form **QXsttabb** where a is the stream and bb is the timeslot on the stream that is reserved for stt. If no timeslots have been reserved on the board, the response will take the form **QXsttZ**.

9.2.3 MVIP Compatibility

The MVIP-90 bus has 16 streams with 32 timeslots each. The streams run with a bit rate of 2.048 MHZ. When the H.100 Basic Rate ISDN Board is inter-operating with the MVIP bus, the bus rate on the lower 16 streams must be set using the “SB” command.

The MVIP-90 bus uses a 40 pin ribbon cable. To connect the H.100 Basic Rate ISDN Board to the MVIP-90 bus an adapter must be used. The MVIP rules for termination must also be followed (see Section 4.2).

Timeslots on the MVIP bus are normally paired, that is timeslot x on DSoy is paired with timeslot x on DSiy. One timeslot of a pair must be defined as an input and the other as an output. With most MVIP boards, an attempt to use both timeslots of a pair as inputs or as outputs will result in a conflict. The table in Section 6.1.1 gives the association between H.100 stream numbers and the DSi and DSo streams.

MVIP-90 applications normally assign timeslots dynamically. Connections that are not enabled are tri-stated.

The H-MVIP bus has 24 streams. The H-MVIP specification has several modes. One mode is compatible the MVIP-90 specification, that is the lower 16 streams run at a 2.048 MHZ. rate while streams 16-23 run at 8.192 MHZ. This mode can be treated as the MVIP-90 case. In another mode, all 24 streams run at the same 8.192 MHZ. rate as the

H.100 bus. In this case, only the physical cabling between the H-MVIP bus and the H.100 bus and clock issues need to be addressed.

9.2.4 MVIP 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.100 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	voice ports 00-1F	voice ports 00-1F
2	none	call progress tones 0-1F
3	DTMF & Energy detectors 00-1F	DTMF generators 00-1F

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.100 timeslot 23h, stream 1. Connections can be made between the H.100 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.100 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>
MOL0000EL0200		connect B-channel 00 to dial tone
MOL0301EL0000		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
MOL0301D		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. It should be noted that boards on the SCbus may fail to operate unless a master clock is provided, therefore, when inter-operating with SCbus boards, it may be necessary to configure the clock on the H.100 Basic Rate ISDN Board before trying to download software or issue commands to other boards on the SCbus. It is also important that the board providing the master clock be configured **last** after all other boards have had their clock modes set. This is required for the proper operation of the SC2000 chip used to interface to the SCbus on most SCSA boards.

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 characters, one for each port, representing the port type. 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:

STTTTNNNNUUUUUUUU

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” message. Like the “ST” message, the “SL” message has four or 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” or “P” if “D” messages are to be used. The “3” is used for point to multipoint connections, and “P” is used for point to point connections. The default is “3”.

If terminals are to be powered from the board, the power feed control is done with an “SF” command. The sixteen port board can provide PS1 power while the four port board can provide PS1 or PS2 power on a port by port basis. For the sixteen port board, the “SL” message consists of sixteen characters, one for each port, which can be either “N” for on, “F” for off, or “*” for no change. For the four port board, the first four characters control PS1 power, and the second four control PS2 power. Each port should only have one type of power feed enabled at a time. Undefined ports or ports set to type TE should not have the power feed enabled.

The port type, protocol level, and power feed 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.100 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.100 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.100 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.100 bus, a silence pattern will be output to the H.100 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 as well as the ETSI equivalents. 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>
	DS06SN	SETUP message
CP060		play dial tone
	SL06	tone being played
	DK061	the digit "1" dialed
CP065		dial tone removed, silence played
	SL06	tone played to B-channel
	DK062	the digit "2" detected
	DK063	the digit "3" detected
CP063		play audible ringback
DA06I		ALERTing message
	SL06	tone played to B-channel
CC0601020304		connect the B-channel
DC06		CONNect message
	SC00	connection confirmation
	DD0610N	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>
DS06SN7654321		SETUP message
	DA06N01	ALERTing message
	DC06N01	CONNect message
CC0601020304		connect the B-channel
	SC06	connection confirmation
DD0610F		DISConnect message
	DR0600	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 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.100 EuroISDN Board is equipped with 32 channels of voice record and 32 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 `VCxxxxyyyyPBEA` is returned, where `xxxx` is the checksum of the firmware stored in the main segment of ROM, `yyyy` is a four-digit version number, `PBEA` indicates the board type and version (PCI BRI EuroISDN firmware, revised board). For boards with the ARM processor, the board type is `PBEB`. For four port boards the board type is `PBE4`. 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.

QHbsst Queries the T8105 switching chip for bus *b*, stream and timeslot *sstt*. The bus value can be “H” for the H.100 bus, “L” for the local bus, or “R” for the control registers. For the H.100 bus, the contents are returned in a message of the form *QHHssttllllcsttttttddddd* where *llll* is the connection memory location, *cstt* are the control bits, source stream and timeslot, and valid bit, *tttttt* is the connection memory tag, and *ddddd* is the contents of data memory 1 and data memory 2. If the timeslot is not found, only a location value of 1FF 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.

QXxxx Queries the transmit timeslot reserved for B-channel *xxx*. This command is only valid if the board is operating in SCbus mode. The reply takes the form *QXxxxstt* where *stt* is the stream and timeslot for the B-channel. If no timeslot is assigned, the reply will be *QSxxxZ*. This command is common to all Infinity Series boards operating in the SCbus mode and all XDS SCSA boards. While the B-channel number has three digits to allow for boards with up to 1024 channels, only the values 000 through 01F are valid for the H.100 Basic Rate ISDN Board.

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
3	MVIP bus clocks
4	Master PLL 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

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Appendix A: Environmental Specifications

The Infinity Series H.100 Basic Rate ISDN Board meets the following environmental specifications:

TEMPERATURE EXTREMES:

Operating: 0°C (+32°F) to +50°C (+122°F).

Storage: -40°C (-40°F) to +70°C (+158°F).

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.100 boards conform to the PCI-SIG mechanical specifications for full-length PCI cards.

MTBF:

50,000 hours.

ELECTRICAL REQUIREMENTS:

+5 volts $\pm 5\%$ @ 1.5 amps maximum.

-48 volts, maximum current per port 100 mA.

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

The H.100 Basic Rate ISDN Board

TERMINAL EQUIPMENT COMPATIBILITY:

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

Doro Graces Professional ISDN Telefon Type IT-228

MFN alpha euro 30 a/b

Olympia Berlin 2000

Siemens Profiset 71

Tiptel 195