



Infinity Series H.100 E&M Board

TECHNICAL MANUAL

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257M014E

This manual applies to the H.100 PCI version with the 386 processor, the H.100 PCI version with the ARM processor, and the H.100 PCIExpress version with the ARM processor. Because of the differences between the processors, there are minor differences in the firmware. These differences have been noted where appropriate.

Note that this manual refers boards with voice. As these boards have different switching and DSP hardware than earlier versions, some sections do not apply to earlier boards.

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Infinity Series H.100 E&M Board Technical Manual

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American Tel-A-System, Inc.

800-356-9148

• 4800 Curtin Drive • McFarland, WI 53558 •

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

• 257M014E •

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.

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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.

Product Safety

The PSTN cord(s) and telephony power supply 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 PSTN cord(s) and telephony power supply 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.

The H.100 E&M Board

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.

The PC chassis containing this device shall be placed in a secured location with access restricted to qualified service personnel.

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European Approvals

CE Approval



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 H.100 E&M 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.

Notice: The PC chassis containing this device shall be placed in a secure location with access restricted to qualified service personnel.

Declaration of Conformity

PCI Board

Model Number: 257L059 XDS H.100 8 Port E&M Board

PCIExpress Board

Model Number: 259L030 XDS H.100 8 Port E&M Board

Standards to which the conformity is declared: EN55022,
EN50082-1 and EN60950

The undersigned declares that the equipment specified above:

- conforms to the above Standards,
- is in conformity to all the essential requirements of
Directive 1999/5/EC.

Manufacturer: Amtelco

Company name: American Tel-A-Systems Inc.
DBA - Amtelco

Address: 4800 Curtin Drive
McFarland, Wisconsin 53558
USA



Signature:

Printed Name: Paul N. Henning

Position: Director of Research and Development

Date: 30 May 2002

The H.100 E&M Board

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The H.100 E&M Board

1.0 Introduction

The Infinity Series H.100 E&M Board is designed to provide eight E&M interfaces connected to the H.100 bus. Each interface or port provides both audio transmission and control support for basic line functions such as hook status indication and detection for Type I and Type V interfaces. The board is equipped with DSP resources to provide tone generation. Each port can be programmed to conform to various national standards and practices.

There is a version of the board in both the PCI bus and the PCI Express form factor. This manual covers both versions. For the purposes of this manual, the PCI and PCI Express busses will be referred to as the PCI bus except where it is important to differentiate between them. This manual also is applicable to an earlier version of the board with an Intel 386 processor and voice resources.

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 or PCI Express 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. 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.

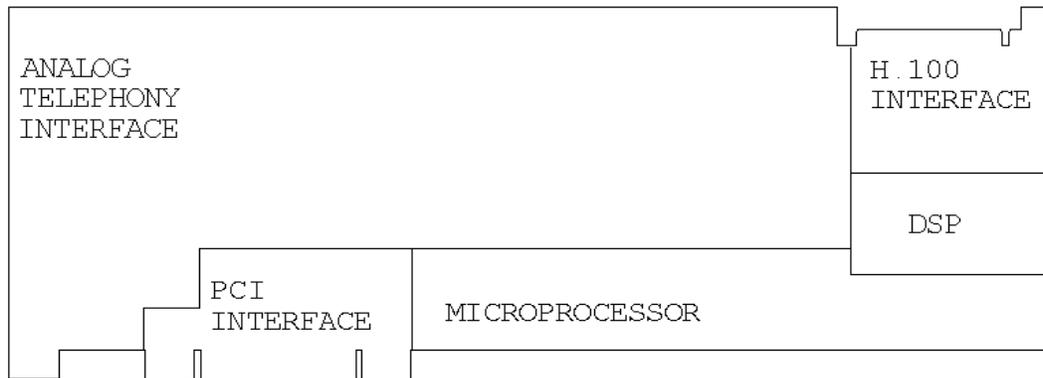


Figure 1: The H.100 E&M Board Functional Areas

1.1 Features and Capabilities

This section presents an overview of the features and capabilities of the Infinity Series H.100 E&M Board.

1.1.1 The E&M Interface

Eight independent ports are provided on the board. Each port on the board provides a complete E&M interface, including both the audio and signalling (E and M leads) connections. Type I and Type V E&M interfaces are supported for either the trunk or the signalling side of the connection. The audio may be transmitted using either a 2-wire or a 4-wire interface. The 4-wire interface separates the transmit and receive pairs. The signalling and audio interface type are software selectable on a port by port basis without using jumpers.

The on board firmware provides support for the common address signalling protocols such as immediate start, wink start, and delay-dial for both incoming and outgoing calls. Incoming calls can use either DTMF or pulse signalling of the address digits. Outgoing calls are limited to DTMF address digits. All timing is handled by the on board processor. For special applications such as interfacing to two-way radio transceivers, the M-lead can be controlled directly by the application.

1.1.2 DSP Functions

The H.100 E&M Board is equipped with a DSP that performs a variety of functions. DTMF and Energy detectors are available for each port. DTMF generators are available for each port for signaling purposes. Call Progress tones are also available, with dial-tone, busy, reorder, and audible ringback being provided as well as silence and a 1004 Hz. calibration tone. European ETSI call progress tones are also available. In addition, the DSP has voice record and playback capabilities which are beyond the scope of this document.

1.1.3 Transceiver Support

The H.100 E&M Board has a number of features that have been added to facilitate interfacing with transceivers used in two-way communications systems. These added features include, programmable echo suppression, a push to talk feature that uses the M-lead to key the transmitter when voice energy is detected, and 2100 Hz. tone detection to disable echo suppression when connected to a modem. These features may be enabled on a per port basis.

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 E&M 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 or be provided by an internal source on the H.100 E&M Board. The clock redundancy and clock fallback functions of the H.100 bus are also supported so that the H.100 E&M 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 or PCI Express board, the address and interrupt of the board is assigned at boot time. The message passing scheme used by the Infinity Series H.100 E&M 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

To reduce the burden on the application, the board has an EEPROM capable of providing non-volatile storage for configuration information. This information includes the port types, timing requirements, and address signalling protocols. This configuration information, when saved, is automatically restored on a restart, allowing the board to automatically configure itself without host intervention.

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 E&M 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 E&M 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 sections 6.0 (The H.100 Bus and Clock Modes) and 7.0 (Using the E&M board). These sections explain, with practical examples, how the H.100 E&M Board operates and how to use the command set to achieve the desired results. Section 8.0 explains diagnostic and error messages that may occur.

The Appendix contains information on power requirements and interfacing that will be helpful when installing your H.100 E&M Board.

2.0 Quick Start

This section describes the first steps you should perform to determine if your Infinity Series H.100 E&M 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 system, 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 or PCI Express slot as appropriate.
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 E&M 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 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 E&M Board. The board should respond with the message “IA”.
7. Send the message “VC” to the board. Verify that the Receive Message reads: VCxxxxvvvvPEB (where xxxxxvvvv is a variable indicating the firmware version). Note that the 386 version will report as PEA.
8. If the Communications screen shows the correct command responses, your H.100 E&M 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 E&M 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).

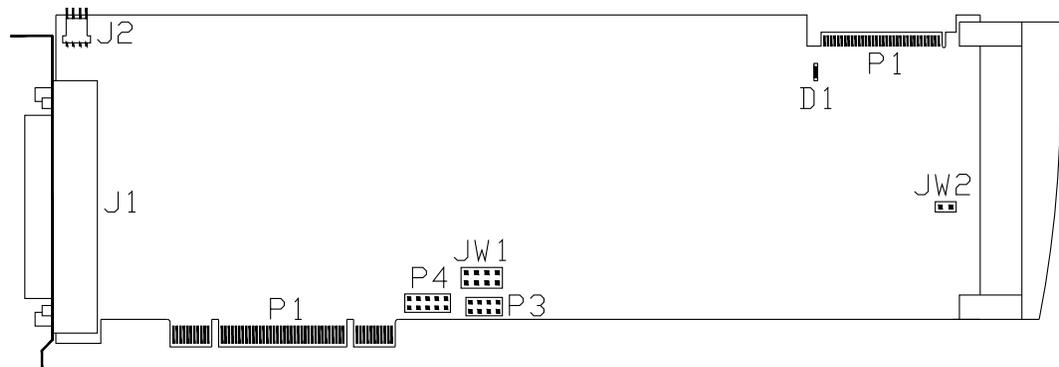


Figure 2: Location of Jumpers, Headers, & Connectors for boards with the 386 processor

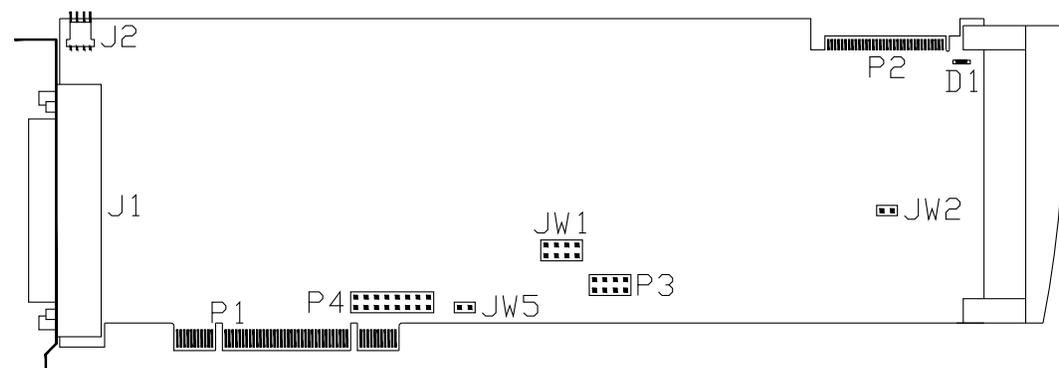


Figure 2a: Location of Jumpers, Headers, & Connectors for boards with the ARM Processor

3.1 PCI Configuration

As Infinity Series boards conform to the PCI and PCI Express standards, there are no switches to set to configure the H.100 E&M 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 complete list of all jumpers for the H.100 E&M Board:

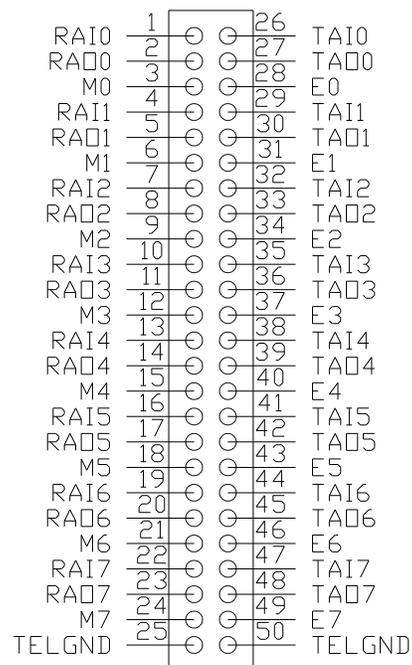
- JW1-1** Firmware Select. If firmware has been downloaded to the board, this jumper selects whether the downloaded firmware or the factory default firmware is used. When this jumper is installed, the factory default firmware is executed whenever the board is reset. When the jumper is not installed, the downloaded firmware will be executed after a reset if it is present. If no downloaded firmware is present, the factory default firmware is executed after reset.
- JW1-2** Undefined, reserved for future use.
- JW1-3** Undefined, reserved for future use.
- JW1-4** Undefined, reserved for future use.
- JW2** DSP Firmware Select. Two separate firmware programs are included in the EAROM, one for the board processor and one for the DSP. If JW2 is installed and downloaded DSP firmware is present, the factory DSP firmware is executed after reset. Otherwise, the downloaded firmware is executed if present

- JW5** This jumper is used for factory testing and should not have jumpers installed.
- 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, J1, and J2

- 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 E&M Board to other H.100 boards within the same PC chassis.
- J1** Analog telephone connections. This connector is a standard RJ21 type 50 pin connector. Each port occupies three pairs in order. See Figure 3.

Figure 3: RJ21 J1 Pin Assignments



J2 Power connector. This connector is used to supply power for the signaling. The pins on this connector are:

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

3.4 Installation

To install the H.100 E&M Board in your system:

1. Do not connect the board to the PSTN. Follow the 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 or PCI Express slot as appropriate 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 telephony power supply cable to connector J2. Do not connect the telephony power supply to the PC.
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. Connect the telephony power supply to the PC.

Installation

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7. Connect the telephone cable to J1. The telephone cable terminates in an RJ-21 male connector. Secure with mounting screws.

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

The PC chassis containing this device shall be placed in a secure location with access restricted to qualified service personnel.

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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 E&M 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 ID. The vendor ID is 14E3h. For the PCI version of the board, the device ID is 0101h, while for the PCI Express version the device ID is 0301h. 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 E&M 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 E&M 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 E&M Board using these commands

| <u>Command</u> | <u>Purpose</u> |
|-------------------|--|
| SCmsabb(c) | Sets the clock mode for the board. The parameter <i>m</i> is the clock-mode. The parameter <i>s</i> is the clock sub-mode. The parameters <i>a</i> , <i>bb</i> , and <i>c</i> are used to specify additional clock control information such as |

The H.100 E&M Board

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

SEx

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

SS(xx...xx)

Set the signalling type for each port on the board. Port types can be "S" for Type I, signalling, "T" for Type I, trunk, "V" for Type V, or "N" or "U" for undefined for unused ports. This command will not take effect until after an "RA" or "RP" command or the next command that changes the state of the M-lead. See Appendix C for an explanation of the various signalling types.

ST(xx...xx)

Set the port type for each port on the board. Port types can be "2" for 2-wire, "4" for 4-wire, "R" for 4-wire Radio Interface, "N" for 2-wire interface with direct M-lead control, or "U" for undefined for unused ports. An "*" may be used to indicate no

change. The “2” and “4” types are used when the M-lead is controlled by the internal state machine. The “N” and “R” types are used when the M-lead is to be controlled directly from the application as when interfacing to radio equipment where the M-lead controls transmission. 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.

4.3 Configuration Memory

Much of the configuration information used to initialize the board is fixed in nature, such as the port configuration, port gains, address signalling protocols and hook status timing. To simplify initialization of the board, the configuration can be stored in an onboard EEPROM. This information can be recalled upon a restart of the board eliminating the need to send this information to the board each time an application runs. To control the EEPROM, three commands are provided. These are:

SMS This command saves the current configuration information..

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 E&M Board. It includes the definitions for the H.100 E&M 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

and the flag is cleared to 00h. This will clear the interrupt hardware.

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 E&M Board are:

1. Build a command. Broadly speaking, a command is a string of ASCII characters with a NUL (00h) termination character.
2. Check the transmit flag. If the flag is 0, continue with the next step to put the command in memory. If the flag is not 0, wait until the flag is 0.
3. Insert the command in transmit mailbox memory beginning at the address of the transmit mailbox.
4. Write 01h to the transmit flag. This notifies the board that a message is waiting.

5.1.2 Reading Messages From the Board

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

3. Write 0h to the receive flag.

5.1.3 Reading Board Information

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

| <u>Type of Information</u> | <u>Offset Address</u> |
|------------------------------|-----------------------|
| Board ID | 1F00-1F03 |
| Firmware Version | 1F04-1F07 |
| Processor identifier | 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 PEB (c) Amtelco 2010** appears in the receive mailbox. On the 386 version of the board the phrase is **Restart PE (c) Amtelco 2001**. The receive flag is not set and no interrupt is generated.

5.2 Interrupts

The H.100 E&M 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. Clear bits 0, 2, and 3 of PCI Base Address 0 + 4Dh. Clear bits 1 and 3 and set bits 0 and 6 of PCI Base Address 0 + 4Ch. Do not modify any other bits in these register. These registers are byte-wide memory mapped registers.

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 E&M Board commands and responses. The commands are grouped by function and then listed in alphabetical order by two-letter command. Refer to sections 6.0 through 8.0 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 | port number | 00-07h |
| sstt | H.100 bus stream & timeslot number, ss = stream, tt = timeslot on stream | ss = 00-1Fh 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 E&M Board

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

Port Commands

| | |
|---------------------|---|
| CAxxsstt | Set Port xx to listen to stream ss timeslot tt |
| CBxx | Set Port to hold if not busy, else return SBxx |
| CCxxssttaabb | Connect Port xx to stream ss timeslot tt and from stream aa timeslot bb |
| CDxx | Disconnect Port xx |
| CExxdd | Enable energy detection for Port xx, look for energy of duration dd |
| CExxF | Disable energy detection for Port xx |

| | |
|-------------------------------|---|
| CFxxd | Generate a hook flash on port xx of duration d |
| CGxxf | Generate guard tone sequence on xx for function f |
| CGxxX | Stop guard tone sequence on port xx |
| CHxx | Put Port xx on hold |
| CIxx | Disable output to CT bus |
| CKxx(ds) | Send an MF-R1 string ds to port xx, valid digits are 0-9, *, #, K, P, and S |
| CLxx | Set Port xx to detect DTMF digits, play dial tone |
| CLxxo | Set Port xx to detect DTMF digits, option o F - turn detection off M - monitor mode, maintain existing connections Q - regular mode, suppress dial tone |
| CMxx | Enable audio for port xx, no switching or control |
| CPxxxy | Give Port xx call progress tone y where y values are North American tones ETSI tones 0 - dial tone 6 - ETSI dial tone 1 - reorder 7 - ETSI 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 20-2Bh correspond to progress tones 0-B |
| CTxx(ds) | Send dial string ds to port 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, N - North American dial tone, E - European dial tone, a-i, special & programmable tones |
| CVxxffffllffffllnnffrr | Generate a custom tone on port xx ffff = freq. 1st/2nd tone, ll = level 1st/2nd tone nn = on duration, ff = off duration, rr = repetitions |
| CXxxsstt | Set Port xx to transmit on stream ss timeslot tt |
| CYxxD | Disable PTT function on port xx |
| CYxxE | Enable PTT function on port xx |

CZxxD Disable Echo Suppression on port xx

CZxxE Enable Echo Suppression on port xx

Interrupt Control Commands

IN Enable transmit interrupts and messages

IF Disable transmit interrupts and messages

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) dur. 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 stream and timeslot

QHLSstt Query T8105, sstt = local bus stream and timeslot

QHR00rr Query T8105, rr = control 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 Port xxx

Reset Commands

RA Reset all (resets ports, DSP functions, H.100 bus)

RD Reset DSP (resets DSP chip only)

RPxx Reset port xx

Setup Commands

- SAxxmtmrr** Set AGC for port xx, m = mode,
A - AGC, + - positive gain, - - negative gain;
tt = transmit gain, rr = receive gain in .5 dB steps
- 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
- SDttffffllffffllnnff** Set custom dialed digit tone tt
ffff = freq. 1st & 2nd tone, ll = level 1st & 2nd
tone
nn = on duration, ff = off duration
- SEa** Set Encoding mode a, M = Mu-Law, A = A-Law
- SHxxaabb** Set hookflash detect times for port xx
aa = minimum time, bb = maximum time
- SIttffffllffffllnnffnnff** Set custom information (call progress) tone
ii
ffff = freq. 1st & 2nd tone, ll = level 1st & 2nd
tone
nn = 1st & 2nd on duration, ff = 1st & 2nd off
duration
- SMC** Clear the EEPROM configuration contents
- SML** Load the EEPROM contents onto the board
- SMS** Save the configuration in EEPROM
- SPxxidn(o)** Set port to address signaling protocol where
i - incoming protocol (D, I, or W)
d - digit format (P for pulse, T for DTMF tone, M
for MF-R1)
n - number of address digits (X for each MF-R1
digit is to be reported individually)
o - optional outgoing protocol (D, I, or W)
D - delay dial, I - immediate start, W - wink start

| | |
|--------------------|--|
| SS(xx...xx) | Set signaling type for each port where x values are: N - No signaling type set S - Type I, Signaling interface (CO side) T - Type I, Trunk interface (CPE side) V - Type V, both sides U - Undefined/unused * - No change to port type |
| ST(xx...xx) | Set port types for each port where x values are: 2 - 2-Wire interface 4 - 4-Wire interface N - No Port type defined (2-wire, direct control) R - Radio interface port (4-wire, direct control) U - Undefined/unused * - No change to port type |
| STab | Set bus termination, a = H.100 bus, b = MVIP bus, E - enable, D - disable |
| SXstt | Set SCbus base timeslot to stream s, timeslot tt |
| SX | Clear SCbus base timeslot |
| SYD | Disable 2100 Hz. detection mode |
| SYE | Enable 2100 Hz. detection mode |
| SZm | Select Call Progress tone set, m = N, North American, m = E, ETSI |

M-Lead Control Commands

| | |
|-------------|---|
| XCxx | Close M-lead relay (off-hook) for port xx |
| XOxx | Open M-lead relay (on-hook) for port xx |

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 segment s |

5.3.4 Responses from the H.100 E&M Board

Acknowledgments

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

Error Messages

| | |
|-------------|-----------------------|
| ECxx | Clock error bit xx |
| ETxx | Incoming DID timeout |
| EWxx | Outgoing wink timeout |

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, 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 |

Port State Change Messages

| | |
|------------------|---|
| SBxx | Port xx is busy (response to CBxx message) |
| SCxx | Connect on Port xx acknowledged |
| SDxx(ddd) | DID address digits ddd detected on port xx |
| SExx | Tone string on Port xx completed |
| SEXhh | Tone string from generator hh ended (MVIP mode) |
| SFxx | Port xx off-hook |
| SHxx | Hold on Port xx acknowledged |
| SIxx | Disconnect on Port xx acknowledged |
| SLxx | Listen on Port xx acknowledged |
| SMxx | Audio enable on Port xx acknowledged |
| SNxx | Port xx on-hook |
| SPxxr | Energy detection on port xx, r = 1 energy detected, r = 0 energy ended |
| SPXhhr | Energy detector hh results r, (MVIP mode) |
| SQxx | Hook flash detected on port xx |
| STxxd | DTMF digit d detected on Port xx |
| STXhhd | DTMF digit d detected by detector hh (MVIP) |
| SXxx | Transmit on Port xx acknowledged |

Diagnostic Responses

| | |
|----------------------|---|
| VAxxxx | Checksum of the alternate segment |
| VCxxxxyyyyPEA | Version response, xxxx = checksum of main segment, yyyy = version number, PEA = board type, (PEB on ARM boards) |
| VDxxxx | DSP version xxxx |
| U(msg) | An undefined or unparseable message response |

6.0 The H.100 Bus & Clock Modes

The Infinity Series H.100 E&M Board provides a means of connecting analog E&M ports to the digital H.100 computer telephony bus. Through this bus, the E&M ports 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 E&M

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 E&M 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 ranges 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 E&M 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 E&M 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. As the H.100 E&M Board does not connect to any external digital networks, only the no CT_NETREF output selection is valid. The CT_NETREF source is specified by argument bb, and should always be set to 00.

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

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

- 00 - 8 kHz. (frame rate)

Note that on earlier boards other CT_NETREF rates were supported, but that this is not possible with the current switching chip.

Submode 0 should only be chosen if there are no other boards in the system that can derive clocks from an external digital network.

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 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 | CT_NETREF 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. The seventh byte will always be 0 for the H.100 E&M Board as the board can not derive clocks from an external network. 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 Using the E&M Board

This section describes the process used for controlling the ports on the Infinity Series H.100 E&M 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, as will echo suppression and the push to talk feature used for interfacing to two-way radio systems. Examples of making incoming and outgoing calls combining several functions are included.

7.1 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 port, connect it to a DTMF detector, and activate that detector.

Many of the commands use a common form for the various arguments. The port number is usually the first argument, and will be between 00 and 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 **0712** would refer to stream 7, timeslot 12h, or 18 decimal.

7.2 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.

7.2.1 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 E&M 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.

7.2.2 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.

Transmit timeslots are reserved on the H.100 E&M 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 port number is used. This port number will range from 0 to 7 and will be represented in stream timeslot notation (0stt) in the commands. In this notation, the ports will run from 0000-0007.

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**.

7.2.3 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 E&M 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 E&M 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 DSi. 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.

7.2.4 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 analog ports and DSP resources as shown in the following table:

The H.100 E&M Board

| Local Stream | Input | Output |
|--------------|-------------------------------|---------------------------|
| 0 | ports 00-07 | ports 00-07 |
| 1 | voice ports 00-1F | voice ports 00-1F |
| 2 | none | call progress tones 00-0B |
| 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 port 00 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. To enable audio, it is also necessary to issue a **CMxx** command.

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 port 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 port 00 to dial tone |
| MOL0301EL0000 | | connect DTMF detector 1 to port 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.

7.3 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 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 E&M 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 audio interface for each port as well as signaling behavior. It consists of characters, one for each port, representing the port type. A “2” defines a port as a 2-wire E&M port, a “4” as a 4-wire E&M port, an “R” as a 4-wire Radio Interface port, and an “N” or “U” as undefined or unused. A 2 or 4 wire E&M port couples the E and M leads to a state machine controlled by the on board processor. This state machine will automatically disable the audio and put the M-lead in the on-hook state if it senses that the E-lead had returned to the onhook state. The M-lead will also be placed in the off-hook state whenever a port is connected or placed on hold. The Radio Interface port type is used to connect to equipment such as a radio transceiver that requires that the M-lead be controlled independent of the port state, for example, to control transmission on a transceiver. This port type allows the M-lead to be controlled directly from the application. Changes in the E-lead will be reported, but will not affect the port state. The radio port type has a 4-wire audio interface. The “N” type provides the same behavior with a

2-wire interface. As an example, if the first four ports are to operate as 4-wire E&M ports, the next two are to operate as 2-wire ports, and the rest as unused ports, then the “ST” message to be sent would be:

ST444422NN

There are a number of different types of E&M ports, the difference being mainly in how the E and M leads are referenced to ground and -48 V. The different types are designated with Roman numerals, i.e. “Type V”. The H.100 E&M Board supports the Type I and Type V interfaces. The Type I interface is asymmetrical, that is there is a signaling and trunk side which do not reference the E and M leads in the same manner. A signaling interface can not be connected to another signaling interface. The Type V interface is symmetric. To select the signaling type, the “SS” command is used. As with the “ST” command, this command consists of one character to select the interface type for each port. The choices are, “S” for Type I - signaling, “T” for Type I - trunk, “V” for type V, and “N” or “U” for undefined or unused. As example, the command:

SSSTSTVVNN

would set ports 0 and 2 to Type I-signaling, ports 1 and 3 to Type I-trunk, ports 4 and 5 to Type V and port 6 and 7 to none or unused. This command will not take effect until after an “RA” or “RP” command or the next command that changes the state of the M-lead. Further details on the E&M interface types can be found in Appendix C.

The port type, signaling interface, and address protocol information can be stored in the EEROM to be loaded automatically on power up or a restart. See Section 4.3 for details.

7.4 Using the “C” Commands

The analog ports on the H.100 E&M 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 port state are reported in state change messages. These consist of the letter “S” followed by a letter indicating the change, the port number, and an optional information character. An example is the message **SI00** which indicates that port 00 has returned to the idle state.

7.4.1 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 port 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 port 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 port 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 port 00.

The Transmit command “**CX**” is used to setup a port to transmit towards the H.100 bus. This command takes the form **CXxxsstt** where xx is the port number, ss is the stream and tt is the destination timeslot. As an

example of using a port as an input, if port 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 port output and any H.100 bus connection. An idle state change message “**SIxx**” will signal that the port has returned to the idle state.

A Hold or other port command, such as playing a call progress tone, will also break a connection. The Hold command “**CHxx**” will disable audio to and from the port. If the port 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 port.

7.4.2 Hook Status

The E-lead is used by the far end for signaling purposes. The state of the E-lead is reported with hook-status messages. These take the form “**SFxx**” for off-hook, and “**SNxx**” for on-hook where xx is the port number. If a port is set to either the 2-wire or 4-wire types, a transition from the off-hook to the on-hook state will cause the port to disconnect, i.e. the M-lead will be returned to the on-hook state, and the audio will be disconnected. When a disconnect command is issued to a port, it will not return to the idle state until the E-lead is in the on-hook state. This will be indicated by an “**SI**” message. For the Radio Interface type, the state of the E-lead will be reported with “**SF**” and “**SN**” messages, but the M-lead and audio will not be affected. It should be noted that as the audio is carried separately from the signaling leads, audio may pass when the far end is on hook.

7.4.3 Call Progress Tones

The on-board DSP can be used to play any of the standard Call Progress

tones to a port. The tones supported are dial tone, busy tone, reorder tone, and audible ringback. Silence and a calibration tone of 1004 Hz. can also be played. A set of tones compatible with ETR 187 may also be selected for use in Europe along with several ringback formats. The Call Progress command “**CP**” is used to play tones. This message is of the form **CP τ xx**, where xx is the port and τ is the code of the tone. For example, the command **CP002** will play busy tone to port 00. The tone will stop playing if another command is issued for the port such as a connect. To select which set of tones to use, the “**SZm**” command is used, where m is either an ‘N’ for North American tones or ‘E’ for ETSI tones. This selection may be saved to EEPROM.

7.4.4 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 port 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 port 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 port in the hold state.

7.4.5 Detecting DTMF Tones

The on-board DSP can be used to detect DTMF tones on a port. The Listen for DTMF command takes the form **CLxxo**, where xx is the port number and o is an option. If no option is given, dial tone will automatically be played to the port 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 port 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 port number and d is the tone. As an example, the message **ST005** indicates that the digit 5 has been detected on port 00. All sixteen DTMF tones can be detected. Detection will remain active until a command is issued for the port.

7.4.6 Detecting Energy

Each port 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 port the energy command “**CE**” is used. This command takes the form **CExxdd** where xx is the port 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 port 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 port changes state due to a command. It can also be disabled without affecting the port state by sending a command where the duration is replaced by a single character

“F”. In the example above, this would be **CE07F**.

7.4.7 Hook-Flash Detection & Generation

Some equipment can generate a short on-hook signal to get the attention of the controlling software for purposes such as initiating a transfer or answering a waiting call. When this is done on ports that are of the 2 or 4 wire type a message of the form “**SQxx**” where xx is the port number is generated. The application can then take appropriate action. It should be noted that when a hook flash is detected, the board takes no other action other than sending the message.

The timing of the flash or pause signal may vary with switch type and country. To allow for these variations, the hook-flash timing can be changed on a port by port basis. This is done with a command of the form “**SHxxaabb**” where xx is the port number, aa is the minimum time and bb is the maximum time for the hook flash in 10 msec. increments. On-hook signals of less than the minimum time will be ignored, those that are greater than the maximum will be treated as a disconnect. For example, the message “**SH00284B**” would set the minimum time for port 00 to 400 msec. and the maximum time to 750 msec. The hook flash timing parameters may be saved in EEROM.

A hook flash can also be generated on the M-lead. This is done with a command of the form “**CFxxd**” where xx is the port number and d is the duration in .1 sec. increments.

7.4.8 Address Signaling Protocols

E & M interfaces are sometimes used to interface to PBX's or channel banks. In these applications, a single interface may be used to channel calls to more than one destination or for more than one phone number. In these applications which are sometimes called Direct Inward Dialing or DID, one or more digits of information is sent by the originating

interface to indicate the ultimate destination. These digits are referred to as “address” digits and can be sent as either DTMF or MF-R1 signals on the audio pairs or as pulses on the E-lead. There are several standard protocols that define the timing of the digits, i.e. the time from the off-hook signal till the digits can begin and the time between digits, and the form of the acknowledgment or ready signal sent by the destination interface.

The acknowledgment, if required, takes the form of a momentary off-hook signal or “wink” on the M-lead. If no acknowledgment is required before the digits are sent, it is referred to as “immediate start”. If a “wink” is required, it is referred to as “wink start.” The “wink” is typically 200 msec. long. A variation called “delay dial” starts the wink and ends it when the digit detector is ready to accept digits.

To set the protocol for a port, a command of the form “**SPxxidno**” is used where xx is the port number, i indicates the protocol for incoming calls, d indicates whether the digits are sent by DTMF or pulses, n is the number of digits, and o indicates the protocol if any for outgoing calls. The protocol is indicated by an “I” for immediate start, a “W” for wink start, or a “D” for delay dial start. A “T” is used to indicate DTMF tone digits, an “M” for MF-R1 digits, and a “P” for pulsed digits. The number of digits indicated by n is typically 3 or 4, but can be any number from 1 to 15. If the interface is not used for outgoing calls or if the outgoing protocol is immediate start, the o parameter can be omitted from the message. As an example, to set port 0 for 4 DTMF digits, wink start, the command would be **SP00WP4**.

When a protocol is set for a port, the on board processor takes care of all of the timing and acknowledgments. When the digits are received, they will be indicated in a message of the form **SDxxdd...d** where xx is the port number and dd...d are the collected digits. The message will not be sent until all of the digits are received. If an off-hook is detected, but the address digits do not follow within 10 seconds, an error of the form **ETxx** will be reported.

When making an outgoing call, the “CT” command can be used to send the address digits (sec. 7.4.4). The board will wait until the acknowledgment is received before sending the digits. If a wink is expected, and not received within 10 seconds, an error message of the form **EWxx** will be reported.

7.4.9 MF-R1 Signaling

In addition to DTMF or “touch tone” digits, the E&M board can send and receive MF or “multi-frequency” digits. MF uses a different set of frequencies than DTMF. In North America, the MF-R1 protocol is used, while in Europe and most of the rest of the world the MF-R2 protocol is used. The H.100 E&M Board supports the MF-R1 protocol. To enable the reception of MF digits in addressing signaling, the digit format should be set to “M” in the “SP” command.

The MF-R1 format defines several tone pairs in addition to the digits 0-9 that are used to indicate the beginning and end of the address digit string. These tone pairs are called KP, ST, and STP which are represented by “K”, “S”, and “P” respectively. KP is used to indicate the start of the digit string and the STP the end of the number. In an alternate format where both the calling and called numbers are sent, the ST is used to separate the two number strings and to indicate the end of the address digits. The board will not include the KP, ST or STP in the “SD” message, and will separate the two numbers, if present, with a “/” character.

As there are a number of different variations of the MF-R1 format, an option has been included which causes the board to send each digit as received. This allows the application to interpret the address digit string. To set this option, the argument for the number of digits in the “SP” command should be set to “X”.

The H.100 E&M Board is also capable of sending MF-R1 digits. This is done with a command of the form **CKxxddd...** where xx is the port

number and the ddd... is the digit string to be sent. Typically, an MF string begins with a KP and ends with an STP, though there are variations on this format. As an example, to send the string of digits 1, 2, 3 framed by a KP and ST on port 04, the command would be “CK04K123P”.

7.4.10 Direct Control of the M-Lead

For some applications such as controlling a two-way radio transceiver, it may be desirable for an application to directly control the M-lead. This is possible for ports set to type “R” or “N”. The command to put the M-lead in the off-hook state is of the form “XCxx” where xx is the port number. The command to put the M-lead in the on-hook state has the form “XOxx”. These commands will not affect the audio portion of the interface.

7.4.11 Push To Talk Feature

To facilitate interfacing to radio transceivers, the H.100 E&M Board includes a Push To Talk feature which may be used to key the transceiver when voice energy is detected on the outgoing timeslot of a port. When enabled, the M-lead will be asserted only when this voice energy is detected. To enable the feature on a port, a command of the form **CYxxE** is sent, where xx is the port number. The feature may be disabled by sending a command of the form **CYxxD**. Ports for which the Push To Talk feature will be enabled should be set for direct control of the M-lead by setting them to type “N” or “R” (see previous section). The “XC” command should be issued during the radio session as the Push To Talk will not function if the M-lead is in the open state. The session may be ended by sending an “XO” command.

7.4.12 Guard Tone Sequence Generation

The H.100 E&M Board is capable of generating a guard tone sequence

for controlling radio transmitters. This sequence consists of a high level 2175 Hz tone for 120 msec. followed by a function tone for 40 msec. to select a channel followed by a low level continuous 2175 Hz. guard tone for the duration of the transmit audio.

The command to generate this sequence takes the form **CGxxf** where xx is the port number and f is the function tone. The function tone argument has a range of 0-Fh with 0 generating a 1950 Hz. tone, F generating a 450 Hz. tone, and the values in between generating tones in decreasing steps of 100 Hz. A command of the form **CGxxX** is used to turn off the low level guard tone.

To use this command, the port must first be placed in the Connect State using either the “CC” or “CM” commands. If the “CM” command is used, the audio path is controlled with “MO” commands. When a “CG” command is issued, the high level and function tones are played and then the connection is reestablished with the low level guard tone superimposed on the output. When a “CGxxX” command is issued, the superimposed tone is removed but the connection remains. Therefore it is only necessary to issue a single “CC” or “CM” command at the beginning of the call.

Following is an example using the “CC” command for channel 4, 1750 Hz. The transmitter is keyed twice before the call is disconnected.

| <u>commands</u> | <u>description</u> |
|-----------------|-------------------------------------|
| CC0001000200 | the connection is established |
| CG003 | the 1st guard tone sequence is sent |
| CG00X | the low level guard tone is removed |
| CG003 | the 2nd guard tone sequence is sent |
| CD00 | the port is disconnected |

Note that when the port is disconnected, the guard tone is automatically removed.

7.4.13 Echo Suppression

Echo Suppression may be enabled on a per port basis. When activated, it will compare the audio signal in the transmit and receive directions and suppress the receive signal if certain conditions are met. Echo suppression is enabled with a command of the form **CZxxE** where xx is the port number. Once enabled, it may be disabled using a command of the form **CZxxD**. It may also be enabled in the opposite direction by sending a command of the form **CZxxX**.

7.4.14 2100 Hz. Detection

When using echo suppression, it may be desirable to disable it on a per call basis for calls involving modems. This may be determined by detecting the 2100 Hz. tone generated by a modem at the far end. The 2100 Hz. tone detection on the H.100 E&M Board uses the DTMF detector and the column detector normally used to detect tones A, B, C, and D. 2100 Hz. detection is enabled using a command of the form **SYE** and disabled with a command of the form **SYD**. This command controls all of the detectors on the board. The detection on a port is enabled using the standard DTMF detection commands “**CL**” or “**MD**”. If a 2100 Hz. tone is detected it is reported with the DTMF tone detection message “**ST**” with a tone of A.

7.4.15 Automatic Gain Control

The H.100 E&M Board is equipped with an Automatic Gain Control (AGC) function through the on-board DSP. The AGC can control either the transmit or receive direction or both. It is also possible for the AGC circuit to supply a fixed amount of gain or loss in either or both directions.

The AGC function is controlled using the “**SA**” command. Each port can be controlled independently. Gain or loss in the fixed mode is

available in .5 dB steps over a range of +/- 20 dB. This command takes the form “**S***xxmtmrr*” where *xx* is the port number, *m* is the mode, and *tt* and *rr* are the gain parameters for the transmit and receive directions respectively. The mode settings can be “A” for AGC on, “+” for positive gain, and “-” for negative gain. The gain parameter is specified in .5 dB steps as a two digit hexadecimal number in the range 00-28.

7.5 Examples

This section gives detailed example of various situations typical of the operation of the board.

7.5.1 An Example of an Inbound Call

The following is an example of the steps involved in a port receiving an inbound call. Both the “C” commands and state change messages will be shown. The dialed digits will be detected, ringback played, and finally a connection made and broken with a disconnect command.

| <u>commands</u> | <u>responses</u> | <u>description</u> |
|-----------------|------------------|---------------------------------------|
| | SF06 | off-hook message |
| CL06 | SX06 | set up DTMF detection, play dial tone |
| | ST061 | detection confirmation |
| | ST062 | the digit “1” detected |
| | ST063 | the digit “2” detected |
| CP063 | | the digit “3” detected |
| | SL06 | play audible ringback |
| CC0601020304 | | tone played to port |
| | SC00 | connect the port |
| CD06 | | connection confirmation |
| | SI06 | disconnect the port |
| | | port returned to idle state |

7.5.2 An Example of an Outgoing Call

This example shows the steps involved in a port making an outgoing call. First, the port will go off-hook and digits will be sent, then the port will be connected to, and finally disconnected when a far end disconnect is detected.

| <u>commands</u> | <u>responses</u> | <u>description</u> |
|-----------------|------------------|-------------------------------|
| CT001234 | | go off-hook, send digits 1234 |
| | SL00 | digits being sent |
| | SE00 | completion of digit sending |
| | SF06 | off-hook message |
| CC0601020304 | | connect audio to the port |
| | SC06 | connection confirmation |
| | SN00 | on-hook detected |
| CD06 | | disconnect the port |
| | SI06 | port in idle state |

7.5.3 An Example of Receiving Address Digits

In this example an incoming call is received using a DID address protocol. The call is answered and disconnected.

| <u>commands</u> | <u>responses</u> | <u>description</u> |
|-----------------|------------------|-----------------------------|
| | SD001234 | digits 1234 received |
| CP063 | | play audible ringback |
| | SL06 | tone played to port |
| CC0601020304 | | connect the port |
| | SC00 | connection confirmation |
| CD06 | | disconnect the port |
| | SI06 | port returned to idle state |

7.5.4 An Example of a Hook-Flash

This example shows what might happen if a hook flash is used to get the attention of the application to perform some action such as transferring a call. The hook flash will be received, digits will be detected and then processed.

| <u>commands</u> | <u>responses</u> | <u>description</u> |
|-----------------|------------------|---------------------------------------|
| CH00 | | send off-hook |
| | SF00 | port goes off-hook |
| CC0001000200 | | port connected to caller |
| | SC00 | connection confirmation |
| | SQ00 | hook-flash detected |
| CL00 | | Set up DTMF detection, play dial tone |
| | SX00 | detection confirmation |
| | ST001 | digit "1" detected, dial tone removed |
| | ST002 | digit "2" detected |
| | ST003 | digit "3" detected |
| CH00 | | hold command to end detection |
| | SH00 | hold confirmation |
| | SN00 | on-hook detected |
| CD00 | | disconnect command |
| | SI00 | disconnect confirmation, port idle |

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8.0 Diagnostics & Error Messages

8.1 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 `VCxxxxyyyyPEB` is returned, where `xxxx` is the checksum of the firmware stored in the main segment of ROM, `yyyy` is a four-digit version number, `PEB` indicates the board type (H.100 ARM E&M Board). This message takes the same form with all Infinity Series boards, and can be used to determine the configuration of the system. Note that the board ID is `PEA` for boards with the 386 processor.
- 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.
- QHbsstt** Queries the T8105 switching chip, for bus `b`, stream and timeslot `sstt`. The bus value `b` can be either "H" for the H.100 bus or "L" for the local bus, or "R" for control registers. For the H.100 bus, the contents are returned in a message of the form `QHHssttllllcsttttttdddd`,

where `llll` is the connection memory location, `csst` are the control bits, stream and timeslot and valid bit, `tttt` is the connection memory tag, and `dddd` is the contents of data memory 1 and data memory 2. If the timeslot is not found, only a location value of `01FF` is returned. For the local bus, the results are returned as a 24 bit value `csstdd` in a message of the form `QHLssttcsttdd`, where `csst` 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 an application.

QXxxx Queries the transmit timeslot reserved for port `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 port. 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 port number has three digits to allow for boards with up to 1024 channels, only the values 000 through 007 are valid for the H.100 E&M Board.

8.2 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 | CT_NETREF error |
| 5 | Frame Boundary |

ETxx Address digits were not received on port xx within 10 seconds on an incoming call using a DID address protocol.

EWxx A wink was not detected when placing an outgoing call on port xx when the outgoing protocol was set to either Delay-Dial or Wink Start.

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.

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Appendix A: Environmental Specifications

The Infinity Series H.100 E&M 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 or PCI Express cards.

MTBF:

50,000 hours.

ELECTRICAL REQUIREMENTS:

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

-5 volts, +3 volts, and ± 12 volts are not required.

-48 volts maximum current per port 30 mA.

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Appendix B: Custom Tones

The DSP firmware provides a wide variety of dialed and information tones that should cover the majority of situations. However, for those cases when the standard set of tones is not sufficient, it is possible to modify these tones to provide custom capabilities.

The standard set of informational or call progress tones consist of the twelve tones listed in the table below. For backward compatibility, an alternate set of tones is provided where tones 0-6 conform to the ETSI standards. The tone set is selected by using the **SZ** command. These tones can be played to a port using the **CP** command. Any one of these twelve tones 0-B may be modified by using the **SI** command to create a custom call progress tone. However, if this is done, the original tone will no longer be available.

Standard Call Progress Tones

| tone | N.A. tones | ETSI tones | tone | N.A.tones | ETSI tones |
|------|-------------------|-------------------|------|-------------------|-------------------|
| 00h | dial tone | ETSI dial tone | 06h | ETSI dial tone | silence |
| 01h | reorder | congestion tone | 07h | congestion tone | dial tone |
| 02h | busy tone | ETSI busy tone | 08h | ETSI busy tone | reorder |
| 03h | ringback | ETSI ringback | 09h | ETSI ringback | busy tone |
| 04h | digital milliwatt | U.K ringback | 0Ah | U.K. ringback | ringback |
| 05h | silence | Japanese ringback | 0Bh | Japanese ringback | digital milliwatt |

The command to create a custom call progress tone takes the form

SIttffffllffffl~~nn~~ff~~nn~~ff

where tt is the number of the tone, ffff are the first and second frequencies used to make the tone, ll is the level of the first and second frequencies in -dBm, and nn and ff are the on and off times of the tone in 50 msec. increments. To create complex cadences, a second on and off time may be specified. The frequency range is from 0000-0CFFh or 0 to 3327 Hz. The levels ll of the two frequency components are given in -dBm and have a range of 00-3Eh or 0 dBm to -62 dBm. A value of 3Fh will disable the frequency allowing a single frequency tone to be created. The on and off times are specified in 50 msec. increments and have a range of 00-FEh or 50-12700 msec. A duration of value of 0FFh will cause a continuous tone.

As an example, the command **SI04028A1001A41005050000** will change the digital milliwatt (tone 04) to a tone composed of the frequencies 650 and 420 Hz. each at -16 dBm with a cadence of 250 msec. on and 250 msec. off.

Custom tones can also be created for use with the **CT** command. The standard set of tones consists of 27 tones plus 4 tones that are reserved for custom programming as given in the following table. The first 16 tones are the standard DTMF tones. The next four tones are used to provide a lower and upper single frequency tone and a short and long pause. The next seven tones are used for the Call Waiting and Caller ID functions. The four remaining tones are reserved for user programming.

Any of these 31 tones may be customized using the **SD** command, however if one of the standard tones is modified, it is no longer available. It is therefore not recommended that the standard tones (00-1Ah) be modified if it can be avoided. The form of the command to modify a tone is:

SDtfffflffffllnff

where *tt* is the tone, *ffff* is the first and second frequencies used to make the tone, *ll* is the level of the first and second frequencies, and *nn* and *ff* are the on and off durations of the tone. The on and off times are specified in 10 msec. steps with a range of 00h-FFh or 10 to 2550 msec. The ranges for the other arguments are the same as for the **SI** command.

Standard Dialed Digit Tones

| Tone | Char. | Description | Tone | Char. | Description |
|------|-------|-------------|------|-------|-------------------|
| 00 | 0 | DTMF 0 | 10 | L | 697 Hz. |
| 01 | 1 | DTMF 1 | 11 | U | 941 Hz. |
| 02 | 2 | DTMF 2 | 12 | X | .2 sec pause |
| 03 | 3 | DTMF 3 | 13 | P | 2 sec. pause |
| 04 | 4 | DTMF 4 | 14 | N | dial tone |
| 05 | 5 | DTMF 5 | 15 | E | ETSI dial tone |
| 06 | 6 | DTMF 6 | 16 | a | 440 Hz. .1/.1 |
| 07 | 7 | DTMF 7 | 17 | b | 440 Hz. .1/.03 |
| 08 | 8 | DTMF 8 | 18 | c | 440 Hz. .3/.1 |
| 09 | 9 | DTMF 9 | 19 | d | 440 Hz. .3/.03 |
| 0A | A | DTMF A | 1A | e | 2130/3750 Hz. .08 |
| 0B | B | DTMF B | 1B | f | 2130/3750 .1/.05 |
| 0C | C | DTMF C | 1C | g | DTMF D .06 on |
| 0D | D | DTMF D | 1D | h | user tone 1 |
| 0E | * | DTMF * | 1E | i | user tone 2 |
| 0F | # | DTMF # | 1F | | unavailable |

As an example, to modify the first user programmable tone, the command **SD1B028A1001A4100505** would create a tone composed of the frequencies 650 and 420 Hz. at -16 dBm with an on and off duration of 50 msec. To send this tone to a port, the command would be **CT00f**.

It is also possible to send a custom tone on a one time basis to a specific port. The command to do this takes the form:

CVxxffffllffffllnnffrr

where xx is the port number, ffff and ll are the frequencies and levels of the first and second tone as in the commands above, nn and ff are the on and off durations of the tone pair, and rr is the number of times the tones repeat. The on and off times are specified in 50 msec. steps and have a range of 00-50h or 0 msec. to 4.0 sec. The number of repetitions ranges from 01-0FFh. If a value of 00h is used the digit will be played one time. The frequencies and levels have the same ranges as for the **SI** command.

As an example, the command **CV04028A0A01A40A050507** would send a tone consisting of 650 and 420 Hz. at -10 dBm, on and off durations of 250 msec. and repeating a total of seven times to port 4.

Appendix C: E&M Interfaces

E&M interfaces have a long history of usage in connecting various pieces of analog equipment together or to the public switched telephone network. The important features of the E&M interface is that it separates the audio transmission path from the signaling leads, and that positive supervision is provided by the signaling leads in both directions, that is that either side of the connection can indicate an on-hook and an off-hook state.

The hook status signaling is carried on two leads, the E-lead which is the signal in one direction and the M-lead in the other direction. The origin of this nomenclature is that the E-lead is the signal for the listening or “Ear” direction, while the M-lead is the signaling for the talking or “Mouth” direction. However, as the E&M interface is bidirectional, much confusion can result as to which lead is which. The earliest forms of E&M interfaces were asymmetrical, with one side referred to as the trunk circuit and the other side the signaling circuit. Different signaling systems were used in each direction. In these interfaces, the M-lead carried the signaling information from the trunk to the signaling circuit and the E-lead carried information from the signaling circuit to the trunk circuit. Some later versions of the interfaces are symmetrical, which makes the determination of which lead is the M-lead and which the E-lead more ambiguous. For purposes of the H.100 E&M Board, the lead used to signal is always referred to as the M-lead and the lead on which a signal is received is always called the E-lead. This is due in part to the fact that a port can be configured as either the trunk or the signaling side under software control which will change the form of the signal, but not the actual wire carrying the signal.

The E&M interface has evolved over the years with a number of

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different variations in use. These different variations are distinguished from one another by referring to them as “Type” followed by a Roman numeral, i.e. Type I or Type II. Each type has a specific scheme of referencing the E and M leads to ground, battery, or open for the on-hook and off-hook cases. Types I and V use only a single lead in each direction, while Types II, III, and IV use additional leads, referred to as the SB and SG leads, which essentially serve as ground references.

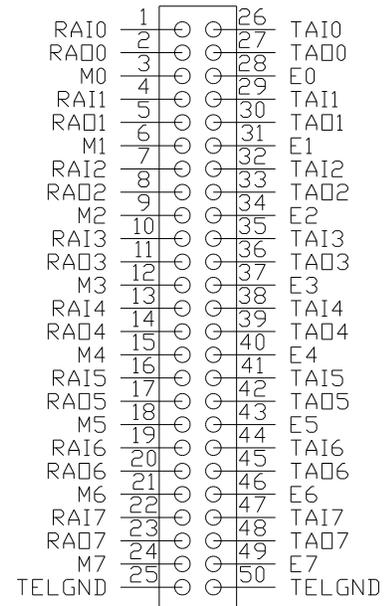
The H.100 E&M Board can support the Type I and Type V interfaces. Type I has both a Trunk and a Signaling side which are different. The Type V interface is symmetrical, that is both sides are identical. In the case of a Type V interface, the M-lead of one side can be connected to the E-lead of the other side and vice versa. The following table lists the interfaces and the signals present for the on-hook and off-hook states.

E&M Signaling States

| Type | Lead | On-hook State | Off-hook State |
|-----------------------|--------|---------------|----------------|
| I - Trunk Circuit | M-lead | Ground | Battery |
| I - Signaling Circuit | E-Lead | Open | Ground |
| V - Both | Both | Open | Ground |

Unless equipment using the E&M interface is well documented, it can sometimes be difficult determining exactly which lead is which. The pinout in the figure below gives the pins for the signaling (M-lead) and sensor (E-lead) on the H.100 E&M Board.

Figure 4: P1 RJ21 Pin Assignments showing the signaling (M-lead) and sensor (E-lead) pins



A volt meter and the following table can be used to determine which type of interface is being used by equipment that is to be connected to. It can also be used to determine which lead on the H.100 board to connect to.

| Type | Lead | On-hook State | H.100 Lead |
|---------------------|--------|---------------|------------|
| I-Trunk Circuit | E-Lead | -48 V | M-lead |
| | M-Lead | Ground | E-Lead |
| I-Signaling Circuit | E-Lead | Open | E-Lead |
| | M-Lead | Ground | M-Lead |
| V-Trunk Circuit | E-Lead | -48 V | M-Lead |
| | M-Lead | Open | E-Lead |
| V-Signaling Circuit | E-Lead | Open | E-Lead |
| | M-Lead | -48 V | M-Lead |

Note, that for a Type I interface, the port on the H.100 E&M board must be set to the opposite side from the equipment to be connected to. For example, if the equipment is configured as a Trunk Circuit the port must be configured as a Signaling Circuit.

The signaling that can take place over these leads can indicate the on-hook or off-hook states. They can also be used to transmit “winks” used as acknowledgments or ready signals in address protocols, or as hook-flashes which are sometimes used to get the attention of a piece of equipment to set up a transfer or conference. E&M interfaces are also used to interface phone equipment to two-way radios. In this case, the signaling lead takes the place of a “push-to-talk” switch.

The audio portion of an E&M interface is carried on one or two pairs of wires, and are referred to as 2-wire or 4-wire interfaces. Note that this does not include the E and M leads. In the 2-wire case, the single pair carries audio in both directions much like a standard loop. In the 4-wire case, one pair is used for the audio in each direction. Note that the transmit pair on one side is connected to the receive pair on the other side of the interface. In both cases, the audio pair is “dry”, that is no talk battery is present.

On the H.100 E&M Board, the interface is configured using the **SS** and **ST** commands. The **SS** command is used to configure the E&M leads, i.e. the type of interface. The command consists of “SS” followed by a letter for each of the ports on the board designating the type. The choices are “S” for a Type I Signaling Circuit, “T” for a Type I Trunk Circuit, “V” for a Type V Trunk Circuit, and an “N” or “U” for not used or undefined. As a Type V Signaling Circuit is the same as the Trunk Circuit except that the pins are switched around, there is not a separate choice for this.

The audio portion of the interface is configured with the **ST** command. This command consists of “ST” followed by a character for each of the ports indicating the configuration of that port. The choices are “2” for

a 2-wire E&M interface, “4” for a 4-wire interface, “R” for a 4-wire radio transceiver interface, and an “N” or “U” for not used or undefined. The type “R” or radio interface decouples the E and M leads from the state machine controlling the connection. The M-lead is controlled using the “XC” and “XO” commands. Normally, radio transceiver interfaces are 4-wire. If a 2-wire interface is desired where the E and M leads are decoupled from the state machine, type “N” can be used.

As an example, the following commands will configure the ports as follows:

Port 0 - Type I - Trunk Circuit, 2-wire
Port 1 - Type I - Signaling Circuit, 2-wire
Port 2 - Type I - Trunk Circuit, 4-wire
Port 3 - Type I - Signaling Circuit, 4-wire
Port 4 - Type V -Trunk Circuit, 2-wire
Port 5 - Type V - Trunk Circuit, 4-wire
Port 6 - Type V - Trunk Circuit, 4 -wire Radio Interface
Port 7 - undefined

SSTSTSVVVN configures signaling
ST224424RN configures audio and port behavior

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