# MON960

**Debug Monitor**

*User’s Guide*

Order Number: 484290-006

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Preface

Purpose
This manual describes the MON960 debug monitor. It is written for engineers designing systems based on i960® processors. Look in your Getting Started with the i960 Processor Development Tools manual for a complete list of i960 processor and tool manuals.

Audience
To use this product, you must be familiar with your host operating system, the architecture of the i960 processor, and i960 processor program development tools. This manual assumes that you know techniques for writing and debugging software, though not necessarily using Intel debugging tools.

Notational Conventions
The following notational and terminology conventions are used throughout this manual:

i960 Cx/Jx/Hx processor refers generically to the following i960 processors:
• CA, CF
• JA, JD, JF
• HA, HD, HT
i960 Kx processor refers generically to the i960 KA, KB, SA, and SB processors

target processor refers to the i960 processor on the target board. This processor can be any of the following i960 family:

- CA, CF
- JA, JD, JF
- HA, HD, HT
- KA, KB
- SA, SB
- RP

This type style indicates an element of syntax, a reserved word, a keyword, a filename, computer output, or part of a program example. The text appears in lowercase unless uppercase is significant.

1 is lowercase letter L in examples

1 is the number 1 in examples

O is the uppercase letter O in examples

0 is the number 0 in examples

This type style indicates the exact characters you type in examples.

This type style indicates a place holder for an identifier, an expression, a string, a symbol, or a value. Substitute one of these items for the place holder.

[] means the syntactic symbols enclosed by the braces are optional.
Preface

{} means you must select one, and only one, of the syntactic symbols enclosed in the braces.

| means exclusive or. Select only one of the syntactic items on opposite sides of the bar.

Contents

This guide includes the following chapters:

Preface
This preface describes the contents of this user's guide.

Chapter 1: Getting Started
The Getting Started chapter explains how to install MON960 files. Read this chapter if you plan to retarget the monitor, update existing monitor files, or build tools in CTOOLS from source.

Chapter 2: Overview
Chapter 2 describes how the components of the monitor function together to support software debugging.

Chapter 3: Using the Monitor
Chapter 3 describes the user interface and how to perform simple debugging tasks.

Chapter 4: Monitor Commands
Chapter 4 details the MON960 commands in alphabetical order.
Chapter 5: Retargeting the Monitor

Chapter 5 explains how to modify the source files and create a monitor specific to your target board.

Chapter 6: Theory of Operation

Chapter 6 describes the MON960 source code, its structure and uses. Chapter 5 describes how to modify the source code to run on an i960 processor board. You need the information in this chapter only if you are using the monitor on an evaluation board other than a Cyclone or Cyclone PCI.

Chapter 7: The MON960 Application Environment

Chapter 7 explains how to set up your debug environment.

Chapter 8: Host Debugger Interface (HDI)

This chapter describes the Host Debugger Interface (HDI). It is used by debuggers to control a remote target board based on the i960 processor.

Appendix A: Target Board Notes

This appendix provides information specific to target boards the monitor supports.

Appendix B: MONDB Execution Utility

This appendix describes the MONDB utility, which enables a host system to download and execute an application program on a target board.
Customer Service

If you need service or assistance with the MON960 debug monitor, see Chapter 3 of the *Getting Started with the i960 Processor Development Tools* guide.

Related Publications

This manual contains the information needed to use the MON960 debug monitor. Chapter 2 of your *Getting Started* guide lists the titles and brief descriptions of related manuals and books. For information on ordering Intel publications, contact your local Intel sales office or write to the Intel Literature Sales Department, P.O. Box 7641, Mt. Prospect, IL 60056-7641 or call 1-800-548-4725.
The following sections describe installing the MON960 files on UNIX* and Windows* 95/Windows NT* 4.0 host systems.

Host System Requirements

The amount of disk space required to install the MON960 files depends on which product components you choose to install. To install MON960 with source code on UNIX or Windows requires approximately 10 megabytes. On a UNIX host, you can opt not to install source; installing the MON960 files on UNIX without source requires approximately seven megabytes. On Windows, you must install the source code.

Why Install the Source and ROM Hex Files

MON960 is available as a separate product, and is also included in the CTOOLS software development toolset. MON960 includes source code and ROM hex files for the evaluation boards identified in Chapter 2.

Typically, you install MON960 files for one of three reasons:
1. You are already using MON960 with an Intel or Cyclone evaluation board and want to update your version of MON960.
2. You plan to modify the MON960 source code for your target environment.
3. You plan to build tools in CTOOLS from source. Source for the HDIL and HDILCOMM libraries, used to build gdb960 and MONDB, also resides on the MON960 installation media.
Preparing for Installation on UNIX

1. Back up any previously installed versions of the MON960 files.
2. Determine the installation directory for the MON960 files. It should be the same directory in which you installed CTOOLS. Ensure that you have write permission on this directory.
   — If you want to install the new MON960 release files in an existing \texttt{intel960} directory, you must first remove MON960 from this directory.
   — If you want to retain the MON960 files in an existing directory, either move them or choose another location in which to install the new version.
3. Determine your interrupt key sequence (usually Ctrl-C) by using \texttt{stty}.
4. Determine the name of your system's tape device.
5. Place the installation tape in the tape device.
6. Decide if you need to install source code for MON960, or ROM image files. The installation script prompts you to enter this information.
   — Source code for the MON960 monitor allows you to modify the monitor for your target environment.
   — MON960 ROM image files provides the monitor for use on Intel evaluation boards.

NOTE. You can repeat the installation program later if you need components of MON960 that you omit during the initial installation.

Installing on UNIX Hosts

1. Change directory (\texttt{cd}) to an empty or temporary directory.
2. Extract the installation script from the tape device, using the tape device name you determined in step 4 (above). Enter:
   \begin{verbatim}
   tar xvf tape_device install.mon
   \end{verbatim}
3. To save time during tape scanning, watch for the message:
   x install.mon, num bytes, num media blocks
   After you see this message, you may optionally enter your interrupt key sequence, using the sequence you determined in step 3 (above) and continue to the next step.

4. Execute the installation program. Enter:
   ./install.mon

5. When prompted for the installation directory, specify the directory in which to install MON960. Entering a Carriage Return specifies the default /usr/local/intel960. You can also specify a full path name to install the MON960 files in a custom location (e.g., /usr/projects/pl/ctools).

6. If the directory you specify has files in it, a warning similar to the following appears:
   WARNING: Directory dirname is not empty.
   Attempting to install will corrupt your files.
   Do you wish to proceed (y/n)?
   Default is [n]
   Entering y may overwrite or remove the old files in the directory and may cause an installation failure. If you enter n, the installation script prompts you for a new location to install the MON960 files.
   The installation script continues, prompting you for the following information:
   — Tape device (default provided)
   — Host and operating system (table provided)
   — Whether or not to install source code for MON960 (default and table provided)
   — Whether or not to install source code for MON960 ROM images
   During installation, the system displays several progress indicator messages related to the renaming of files. No action is required in response to these messages. A message notifies you when the installation is complete.
If you want MON960 to be owned by root with a Group ID of bin, have your system administrator make that change now.

Preparing for Installation in Windows

Determine the installation directory for the MON960 files. By default, the installation program places the files in C:\intel960. You can also specify a custom directory when the installation program prompts you. (If you want to save a previous version of the MON960 files, you must copy it to a different directory, or specify a different installation directory for the new version.)

Installing on Windows Hosts

To install the MON960 files on a Windows host, insert Disk 1 into your diskette drive and enter drive:install. Respond to the prompts as appropriate for your installation.

What’s Next?

If your target board is one supported by MON960, go to Chapter 3, Using the Monitor. If your target board is not supported, go to Chapter 5, Retargeting the Monitor.
Overview

Product Summary

This manual describes the MON960 Debug Monitor. This monitor can help you debug software for embedded systems based on the i960 processor. The monitor resides on an i960 processor target board and lets you control the operation of the processor on that board.

With the monitor, you can test your hardware by displaying and changing memory, displaying and changing registers, and disassembling memory.

You can also test your software by downloading application programs, then stepping through the program, tracing values, and setting breakpoints.

The monitor offers two ways to communicate:

1. Using a communications program on your host computer, or using a terminal through a serial cable. This interface gives you the full capabilities of the MON960 monitor, but is available only with serial communication.

2. With a software debugger, such as gdb960, using a software interface called the Host Debugger Interface (HDI). This option lets you choose either PCI or serial communication channels, plus access to the full capabilities of the software debugger. The gdb960 software debugger is part of CTOOLS960 and GNU/960.

You can also download and execute programs with the MONDB execution utility (provided with MON960) running on a host system. MONDB is discussed in Appendix B of this guide.
Monitor Features

The monitor user interface supports the following features:

- Memory Display. You can display memory in several forms, including floating-point numbers.
- Disassembly. You can display memory as assembler instructions.
- Memory modification. You can modify bytes and 32-bit words in memory.
- Register display and modification.
- Stepping. You can single-step through program execution.
- Breakpoints. You can set two instruction breakpoints with most i960 processors. In addition, you can set two data breakpoints for the i960 Cx, Jx, and RP series processors. The i960 Hx series processors supports six instruction and data breakpoints.
- Serial or PCI communication. Host debuggers can interface with the monitor through a serial cable or PCI bus.
- Downloading. You can download application programs to RAM, flash, or EEPROM.
- Parallel Downloading. When using serial communication, you can also download application programs over a parallel cable for greater speed in downloading. Parallel download is described in Chapter 2.
- A single low-level library supplied by MON960. You do not need board-specific libraries to manage timers, flash memory, and other features.

Components of the Monitor

This section describes each component of the monitor and the host software that interfaces to the monitor. Figure 2-1 illustrates the monitor components and their interfaces.
Monitor Core

The monitor core controls the basic operations of the monitor:

- initializing the processor
- starting execution
- handling faults and trace events
• saving and restoring user registers, setting and clearing hardware breakpoints
• reading and writing to user memory
• handling runtime requests from the application

When the terminal interface or host interface needs to take steps that affect the application, it calls the Core to perform the action. This arrangement enables the monitor to operate consistently, regardless of the interface used.

The user registers are copied into a global array when the application stops, and they can be accessed by any part of the monitor. However, all access to user memory is performed by calls to the Core. In this way, access operations to user memory are controlled. For example, each call to write to user memory is checked to see if it affects EEPROM, and then the appropriate routine is called. For detailed information about the monitor core, refer to Chapter 6, *Theory of Operation*.

**User Interface**

The User Interface (UI) is the monitor code that communicates with a terminal. The User Interface parses ASCII commands from the user and calls the monitor core to complete the requested actions. It translates information or status from the Core into ASCII output.

**Host Debugger Interface Library**

The Host Debugger Interface Library (HDIL) implements the Host Debugger Interface (HDI), which is described in Chapter 8. This interface provides a high-level abstraction of the target. It can be linked into any 80960 debugger that uses the Host Debugger Interface to access its execution environment.

The library generates messages to the target to perform actions required by calls. In addition, it:
• maintains a software breakpoint table.
• maintains a memory cache.
• maintains a register cache.
Overview

- handles runtime service requests from the application while it is running.
- provides a mechanism to interrupt the application while it is running.

The software breakpoint table is used for the following purposes:

- When the debugger requests user memory, the library replaces any software breakpoints in the memory with the original code.
- When a software breakpoint is encountered, the library adjusts the IP back to the address of the breakpoint.
- When execution is resumed after a software breakpoint is encountered, the library (in cooperation with the target) restores the original instruction, steps over the instruction, restores the breakpoint, and continues execution, if appropriate.

Host Interface

The host interface processes messages from HDIL. It interprets the command code, extracts the arguments from the message, and calls the monitor core to complete the required actions. It responds to HDIL with a message containing the status of the command and any results.

Downloading

The monitor and HDIL support downloading programs to a target using one of three communication media:

1. serial
2. parallel
3. PCI bus

Of these three, only serial download is available from the monitor's user Interface.
Serial Download

Serial download is automatically available from any host debugger that supports serial communication. Serial download is also available from the User Interface with the following restrictions:

- A communications or terminal emulation program that supports Xmodem transfer protocol must be used to connect to the UI, and
- The UI only downloads programs in Common Object File Format (COFF). (ELF and b.out formats are not supported.) Furthermore, the UI only downloads COFF programs with object records in little-endian host and target byte order.

Regardless of whether a debugger or the UI is used for serial download, the target must provide a serial port connector and hardware to which the monitor's serial communication API has been ported. With regard to debuggers, HDIL must have been modified for the host's serial I/O API. Appropriate hosts include:

- AIX* 3.2
- HP-UX* 9.X
- Solaris* 2.4
- SunOS* 4.1.X
- Windows 95 and Windows NT

Parallel Download

Host debuggers may choose to augment serial communication with parallel download. The target must provide a parallel port connector and hardware to which the monitor's parallel download API is ported. Additionally, HDIL must have been modified for the host's parallel I/O API. Appropriate hosts include:

- AIX 3.2
- HP-UX 9.X
- Solaris 2.4
- SunOS 4.1.X
- Windows 95 and Windows NT
Windows parallel download rates of as much as 40 Kbytes per second are possible, while some UNIX hosts support more than 200 Kbytes per second.

**PCI Download**

The PCI bus typically provides download transfer rates that range from hundreds of Kbytes per second for small programs to more than one Mbyte per second for large programs.

PCI download is available to any host debugger that supports PCI communication. Host debuggers may choose not to support PCI communication, but rather to augment serial communication with PCI download.

These are the requirements for using PCI communications:

- The target must provide PCI hardware to which the monitor's PCI communication API is ported.
- The host must provide a PCI bus and PCI-compliant BIOS.
- HDIL must have been modified for both the host and target's PCI I/O API.

Currently, only the Cyclone PCI 80960DP, target and Windows host combination meets these requirements.

**Board Configurations**

The monitor supports the following target boards:

<table>
<thead>
<tr>
<th>Processor Board Name</th>
<th>Board Abbreviations</th>
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<tbody>
<tr>
<td>Cyclone EP80960BB, PCI80960DP (Sx, Kx, Cx, Jx, Hx)</td>
<td>CYSX, CYKX, CYCX, CYJX, CYHX</td>
</tr>
<tr>
<td>Cyclone IQ80960RP (RP)</td>
<td>CYRP</td>
</tr>
</tbody>
</table>

*Note: This guide refers to the Cyclone and Cyclone PCI boards as the Cyclone boards.*

To use the monitor on a target board other than those listed, you must first modify, or retarget, the monitor program for your board. Steps for completing that task are described in Chapter 5, *Retargeting the Monitor.*
**MONDB TCP/IP Communications Support**

With version 3.1 of MONDB, a host can share an evaluation board with another workstation. The host workstation must run the MONDB server software along with the software shown in Figure 2-2. The remote workstation communicates with the server via TCP/IP to access the evaluation board. When needed, the server downloads the remote workstation’s code to the evaluation board via PCI or serial connection. For more information on using this feature, see Appendix B.

![Figure 2-2 TCP/IP Server/Workstation Communication](image-url)
ApLink Support

MON960 supports ApLink, a software and hardware debug probe for the i960 processors. Because ApLink includes the MON960 debug monitor on board, it makes i960 processor software development as simple as self-hosted development on a PC or workstation. By using ApLink, you avoid having to port software or design specialized hardware into the target system to use the monitor. Note that Intel does not ship ApLink source code in standard MON960 releases. For more information on ApLink, contact your local Intel sales representative.

ApLink works with source-level debuggers, such as gdb960. The source-level debugger must support the Host Debugger Interface Library (HDIL).
Purpose

This chapter explains how to use the MON960 debug monitor’s user interface (UI) to perform simple debugging tasks. You can connect the target board to a terminal and use the monitor to set breakpoints, step through programs, and examine memory and processor registers. You can also use the monitor with a host system running a terminal program and download application programs using Xmodem protocol.

If you are using a Cyclone evaluation board as your target, the source and hexadecimal files that contain MON960 have been built for you and reside in the directory you specified during installation. You need only produce new EPROMs from the hexadecimal files and install those EPROMs on your target board. The Specifying Build Options section, in Chapter 5, has information about producing new EPROMs for your target board.

Connecting to the User Interface

Complete these steps:

1. Connect a serial cable from the host system to the target board. See your target board documentation for details.

2. Run any standard terminal emulation program such as Windows Terminal, and connect to the port where the target board cable is connected.
3. Set your communications settings to the following:
   - 9600 to 115,200 baud
   - Data bits = 8
   - Stop bits = 1
   - No parity
   - Flow control = XON/XOFF

4. Enter six carriage returns (\texttt{<Enter>}).
   MON960 responds with an invocation header and a command prompt.
   You are now ready to enter any of the commands described in the sections that follow.

Setting Breakpoints

The monitor enables you to set instruction breakpoints using the \texttt{break} command with the address of the instruction. For example, the following command sets an instruction breakpoint at address 8000040H:

\texttt{=>break 8000040}

You can set up to two instruction breakpoints on the i960 Sx, Kx, Cx, Jx, and RP processors. The Hx processor supports six instruction breakpoints.

Enter \texttt{break} with no address to display current breakpoints.

Enter \texttt{delete [address]} to delete a breakpoint.

The \texttt{break} command sets a hardware instruction breakpoint using the breakpoint register in the processor. This type of breakpoint stops execution after the instruction is executed. See the \texttt{break} command in Chapter 4 for more information on hardware instruction breakpoints.

You can also set software breakpoints, which stop before executing the instruction where they are set. The monitor itself has no command to set software breakpoints. Instead, software breakpoints are handled by the
host system via the Host Debugger Interface Library (HDIL). See the Host Debugger Interface Library section in Chapter 8 for more information on the HDIL. You can also set a software breakpoint manually using the User Interface, as follows:

1. Replace the instruction where you want to break with a `mark` or `fmark` instruction.
2. After execution stops at the breakpoint, replace the `fmark` instruction with the original instruction word and set the instruction pointer back to that instruction.
3. Single-step over the instruction with the `step` command. If you want to retain the breakpoint, replace the instruction with the `fmark` instruction again.

If you are using the i960 Cx, Jx, or RP processor, up to two data breakpoints are available as well. If you are using the i960 Hx, six data breakpoints are available. This type of breakpoint stops execution when an address you specify with the `bdata` command is either read from or written to. See the `bdata` command in Chapter 4 for more information on data breakpoints.

**Displaying Memory**

The monitor’s memory-display commands let you display memory in several different formats, ranging from single bytes to quad words.

The following command displays four bytes of memory, beginning at `80000004h`, and displays printable ASCII characters within those four bytes.

```
dbyte 80000004#4
08008004 : 63  c
08008005 : 61  a
08008006 : 67  g
08008007 : 68  h
```
The following command displays four quad words of memory beginning at 80000010h:

```
=dquad 80000010#4
08008010 : 080064e8 8c603000 00001000 5908408c
08008020 : 5c601e01 6563028c 5ca81615 8a0a3200
08008030 : 080064e8 8c603000 00001000 5908408c
08008040 : 5c601e01 6563028c 5ca81312 8c083000
```

Each memory-display command uses a single memory-access instruction to access memory. For example, the `dquad` command invokes a four-word burst fetch on the burst bus of the i960 processor. The memory display address must be aligned on a natural boundary.

The `dasm` command lets you disassemble i960 instructions stored in memory. The monitor displays valid instructions in assembly-language format, and invalid instructions in the assembly format `.word` with the invalid instruction following in hexadecimal.

See Chapter 4 for more information on memory display commands.

**Trace Events**

The `step` command single-steps and breaks after every instruction. The monitor also supports the following types of instruction traces:

- **Branch trace** breaks every time a branch is taken. A conditional branch must take the branch for a branch trace to occur. Branch-and-link instructions do not cause a branch trace to occur. The `trace branch on` command turns on branch tracing.

- **Call trace** breaks after any type of call or branch-and-link instruction. The next instruction to be executed is the first instruction in the routine that was called. The `trace call on` command turns on call tracing.
Return trace breaks any time a return instruction is executed. No return trace is generated for a return from a branch and link. The `trace return on` command turns on return tracing.

Supervisor call trace breaks on supervisor calls that cause the processor to change from user mode to supervisor mode. The monitor, by default, leaves your program running in supervisor mode, so there is no mode change and this trace fault does not occur. If the program changes to user mode and then does supervisor calls, this trace fault occurs if the supervisor call trace is enabled. A supervisor return to user mode also triggers a supervisor trace event. The `trace supervisor on` command enables supervisor call tracing.

After issuing a trace command, use the `go` command to continue executing the program. When a trace event occurs, program control returns to the monitor so you can look at memory or registers and determine the state of the program. See Chapter 4 for more information on the `trace` command.

### Loading MON960 Into Flash

Some i960 processor-based boards contain flash memory that you can use to run MON960. For example, the Cyclone boards with Cx, Hx and Jx CPU modules have flash memory. These boards are designed so that the flash memory can appear at memory locations E0000000H and F0000000H. You can load the flash memory with a PROM programmer just like an EPROM, or you can load it while it is in the board. To load MON960 into flash memory while it is in the board, you must have another program or monitor installed that can do that. For example, if you
are using the Cyclone board with a Cx CPU module, and you have a previous version of MON960 installed in the CPU module, you can use it to load the current MON960 into the expansion flash sockets.

**Downloading MON960 to an Evaluation Platform**

The sections that follow provide step-by-step instructions for updating the version of MON960 in the PCI80960DP and IQ80960RP evaluation platforms assuming a PC host environment.

**PCI80960DP Evaluation Platform**

**NOTE.** In order to write to flash on your Cyclone base board, you need a 12 volt power supply. Also, These instructions are used with the CTOOLS 5.0 and MON960 3.1 toolsets and later.

1. Identify the flash on the Cyclone base board.
   
   A blank flash chip ships on each Cyclone evaluation baseboard in socket U22. To write MON960 to flash, you must move the blank flash from socket U22 to socket U27.

2. Set the Cyclone baseboard voltage to 12 volts.
   
   Locate the four-position DIP switch labeled S1. Flip S1.1 to the ON position. This enables VPP to the Cyclone base board flash.

3. Power up the Cyclone evaluation base board.
   
   Locate the four-pin connector that interfaces to a secondary power supply labeled J6. Three of the connector pins connect to +5 VDC, +12 VDC and ground. (On the PCI-SDK Platform, +12 VDC and +5 VDC power is supplied through the edge connector.)
4. Edit `Version.c`. (Optional only if you rebuild MON960 from source.)

- Change directories to where the `version.c` file resides. The default installation directory for CTOOLS is:

  `c:\intel960\src\mon960\common`

  `Version.c` contains the following information:

  ```c
  const char mon_version_byte = nn; /* version n.n = nn */
  const char base_version[] = "MON960 n.n.n";
  const char build_date[] = __DATE__;
  ```

- Change the file contents to reflect that this is your version of MON960. For example, change

  ```c
  const char base_version[] = "MON960 n.n.n";
  ```

  to:

  ```c
  const char base_version[] = "MY MON960";
  ```

- Save `Version.c`.

5. Build the new MON960 from source (optional).

By default the source for MON960 is located at:
`c:\intel960\src\mon960\common`. You may use the pre-built version of MON960 there, or build a custom version. To create a custom version:

- Copy `makefile.xxx` to

  `c:\intel960\src\mon960\common\makefile`

  where `xxx` is one of the following make files

  - `makefile.ic` (ic960 interface, COFF format)
  - `makefile.ice` (ic960 interface, ELF format)
  - `makefile.gnu` (gcc960 interface, COFF format)
  - `makefile.gne` (gcc960 interface, ELF format)
• Issue the commands:

```
nmake -f makefile cyhx
```

This creates a file called `cyhx.fls`.

1. Write the flash.

To write the flash, use the `mondb.exe` utility located in the `intel960\bin\` directory. If you are going to use the pre-built MON960 files, they are located in the `intel960\roms\` directory. For example, if you used the default installation directory and are using the pre-built MON960 files for the 80960Hx, enter:

```
mondb -ser com1 -par lpt1 -ef -ne c:\intel960\roms\cyhx.fls
```

The options in this command are:

- `-ser com1` use serial port 1
- `-par lpt1` use parallel port 1
- `-ne` no execute
- `-ef` erase flash
- `cyhx.fls` input flash filename

Note also that if you built a version of MON960 from the source code as described previously, the `cyhx.fls` file will be located in the `c:\intel960\src\mon960\common\` directory.

2. Set board voltage back to +5 VDC.

Locate the four-position DIP switch labeled S1. Flip S1.1 to the OFF position. This disables VPP to Cyclone EP base board flash and protects your flash. Note that the PCI80960DP and i960 Hx evaluation platforms do not boot when VPP is enabled and MON960 is running from the evaluation board flash.

3. Set board to boot from U27 socket.

Locate the four-position DIP switch labeled S1. Set S1.3 ROMSWAP to the ON position. This exchanges the addresses of the CPU Module
Using the Monitor

ROM and the base board ROMs. When the switch is OFF the processor boots from the CPU Module ROM; when the switch is ON the processor boots from the base board ROMs.

4. Reset base board.

   Locate the reset button labeled S2. Use this button to manually reset the Cyclone base board and boot from the base board ROMs.

IQ80960RP Evaluation Platform

1. Identify the flash on the Cyclone base board.

   A blank flash chip ships on each Cyclone evaluation baseboard in socket U4. To write MON960 to flash, you must add a blank flash in socket U3.

2. Set the Cyclone baseboard voltage to 12 volts.

   Locate the four-position DIP switch labeled SW1. Flip SW1.1 to the ON position. This enables VPP to the Cyclone base board flash.

3. Power up or reset the host to reset the Cyclone base board.

   On the IQ80960RP Platform, +12 VDC and +5 VDC power is supplied through the edge connector.

4. Edit Version.c. (Optional only to rebuild MON960 from source.)

   • Change directories to where the version.c file resides. The default installation directory for CTOOLS is:

   \intel960\src\mon960\common

   Version.c contains the following information:

   const char mon_version_byte = nn; /* version n.n = nn */
   const char base_version[] = "MON960 n.n.n";
   const char build_date[] = __DATE__;
- Change the file contents to reflect that this is your version of MON960. For example, change
  
  ```c
  const char base_version[] = "MON960 n.n.n";
  ```
  
  to:
  
  ```c
  const char base_version[] = "MY MON960";
  ```
- Save `Version.c`.

5. Build the new MON960 from source (optional).

   By default the source for MON960 is located at:
   `c:\intel960\src\mon960\common`. You may use the pre-built version of MON960 there, or build a custom version. To create a custom version:
   - Copy `makefile.xxx` to
     
     ```
     c:\intel960\src\mon960\common\makefile.
     ```
     
     where `xxx` is one of the following make files
     - `makefile.ic` (ic960 interface, COFF format)
     - `makefile.ice` (ic960 interface, ELF format)
     - `makefile.gnu` (gcc960 interface, COFF format)
     - `makefile.gne` (gcc960 interface, ELF format)
   - Issue the commands:
     
     ```
     nmake -f makefile cyrp
     ```
     
     This creates a file called `cyrp.fls`.

6. Write the flash.

   To write the flash, use the `mondb.exe` utility located in the `intel960\bin\` directory. If you are going to use the pre-built MON960 files, they are located in the `intel960\roms` directory. For example, if you used the default installation directory and are using the pre-built MON960 files for the 80960RP, enter:
   
   ```
   mondb -ser com1 -ef -ne c:\intel960\roms\cyrp.fls
   ```
The options in this command are:

- `-ser com1` use serial port 1
- `-ne` no execute
- `-ef` erase flash
- `cyrp.fls` input flash filename

Note also that if you built a version of MON960 from the source code as described previously, the `cyrp.fls` file will be located in the `c:\intel960\src\mon960\common\` directory.

7. Set board voltage back to +5 VDC.

Locate the four-position DIP switch labeled SW1. Flip S1.1 to the **OFF** position. This disables VPP to Cyclone EP base board flash and protects your flash.

8. Set board to boot from U3 socket.

Locate the four-position DIP switch labeled SW1. Set SW1.3 ROMSWAP to the **ON** position. This exchanges the addresses of the U4 and U3 ROMs. When the switch is **OFF** the processor boots from the U4 ROM; when the switch is **ON** the processor boots from the U3 ROM.

9. Reset the base board.

Reset the base board by rebooting the host PC. There is no reset switch on the IQ80960RP evaluation board.
Monitor Commands

This provides you with detailed information on the MON960 commands, including the elements of the command language, an overview of the commands, as well as a complete command reference.

Elements of the Command Language

The elements of the command language include names, addresses, and numbers, as described in the following sections.

Names

Names include command names and options. The monitor parses the command line using only the first two characters of names. Therefore, you can enter just the first two letters of each command or option. For example, the following two commands are equivalent:

```plaintext
=>trace branch on
=>tr br on
```

Register names cannot be abbreviated.

Addresses

Addresses used in commands are hexadecimal and are accepted either with or without a leading zero.
Numbers

Numbers used in display commands, other than addresses, are decimals unless otherwise noted. The default number of items displayed (for example, bytes or words) is one, unless you specify a number.

Overview of Commands

Below is a listing of all MON960 commands, in their abbreviated forms:

- `ap en`
- `ap sw`
- `ap rs`
- `ap wt`
- `bd [address]`
- `br [address]`
- `cf`
- `da [address] #instructions`
- `db address [#bytes]`
- `dc address [#characters]`
- `dd address [#doublewords]`
- `de address`
- `di address [#words]`
- `di register`
- `do [offset]`
- `dq address [#quadwords]`
- `dp`
- `ds address [#shortwords]`
- `dt address`
- `ef`
- `fi address1 address2 worddata`
- `fl address [#longreals]`
- `fr address [#reals]`
- `fx address [#extendedreals]`
- `go [address]`
- `he [command]`
- `la register value`
- `lm register value`
- `mb address`
- `mc region value`
- `md address hex-value`
Monitor Commands

md register hex-value
mo address [#words]
mo register
po
pm [address] [hex value]
pp bus# device# [function#]
pt [address] [hex value]
ps [address]
qu
rb
re
rs
st [address]
tr [option {on|off}]
ve

Tables 4-1 through 4-4 group the MON960 commands according to function and give a brief description of each command.

Table 4-1 Execution and Break Commands

<table>
<thead>
<tr>
<th>Entry</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bdata</td>
<td>Sets a data breakpoint.</td>
</tr>
<tr>
<td>break</td>
<td>Sets an instruction breakpoint.</td>
</tr>
<tr>
<td>delete</td>
<td>Deletes a breakpoint.</td>
</tr>
<tr>
<td>go</td>
<td>Starts program execution.</td>
</tr>
<tr>
<td>pstep</td>
<td>Single steps one instruction or procedure.</td>
</tr>
<tr>
<td>step</td>
<td>Single steps one instruction.</td>
</tr>
<tr>
<td>trace</td>
<td>Sets trace options.</td>
</tr>
<tr>
<td>Entry</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>cflash</td>
<td>Checks flash memory.</td>
</tr>
<tr>
<td>dasm</td>
<td>Displays memory as assembler instructions.</td>
</tr>
<tr>
<td>dbyte</td>
<td>Displays memory in bytes.</td>
</tr>
<tr>
<td>dchar</td>
<td>Displays memory as ASCII characters.</td>
</tr>
<tr>
<td>ddouble</td>
<td>Displays memory in double words.</td>
</tr>
<tr>
<td>display</td>
<td>Displays memory or registers.</td>
</tr>
<tr>
<td>download</td>
<td>Downloads a program.</td>
</tr>
<tr>
<td>dquad</td>
<td>Displays memory in quad words.</td>
</tr>
<tr>
<td>dshort</td>
<td>Displays memory in short words.</td>
</tr>
<tr>
<td>dtriple</td>
<td>Displays memory in triple words.</td>
</tr>
<tr>
<td>eflash</td>
<td>Erases flash memory.</td>
</tr>
<tr>
<td>fill</td>
<td>Fills memory.</td>
</tr>
<tr>
<td>flong</td>
<td>Displays long real floating point numbers.</td>
</tr>
<tr>
<td>freal</td>
<td>Displays real floating point numbers.</td>
</tr>
<tr>
<td>fxreal</td>
<td>Displays extended real floating point numbers.</td>
</tr>
<tr>
<td>la</td>
<td>Sets a logical memory address register.</td>
</tr>
<tr>
<td>lm</td>
<td>Sets a logical memory mask register.</td>
</tr>
<tr>
<td>mbyte</td>
<td>Modifies one byte of memory.</td>
</tr>
<tr>
<td>mc</td>
<td>Sets a memory configuration register.</td>
</tr>
<tr>
<td>md</td>
<td>Modify register or one word of memory.</td>
</tr>
<tr>
<td>modify</td>
<td>Modifies memory or registers.</td>
</tr>
<tr>
<td>posttest</td>
<td>Runs the target post test.</td>
</tr>
<tr>
<td>registers</td>
<td>Displays registers.</td>
</tr>
</tbody>
</table>
Monitor Commands

Table 4-3  Monitor Environment Commands

<table>
<thead>
<tr>
<th>Entry</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>help or ?</td>
<td>Displays help on monitor commands.</td>
</tr>
<tr>
<td>rb</td>
<td>Reboots the target board and communications link.</td>
</tr>
<tr>
<td>rs</td>
<td>Resets the target board.</td>
</tr>
<tr>
<td>version</td>
<td>Displays the monitor version.</td>
</tr>
<tr>
<td>.</td>
<td>Repeats the previous command.</td>
</tr>
</tbody>
</table>

Table 4-4  ApLink Support Commands

<table>
<thead>
<tr>
<th>Entry</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ap en</td>
<td>Modifies bits in the ApLink mode register.</td>
</tr>
<tr>
<td>ap sw</td>
<td>Moves an ApLink monitor from its boot-up region to a new memory region.</td>
</tr>
<tr>
<td>ap rs</td>
<td>Manipulate an ApLink-compatible monitor.</td>
</tr>
<tr>
<td>ap wt</td>
<td></td>
</tr>
</tbody>
</table>

Alphabetical Command Reference

The MON960 commands are listed in alphabetical order. The entries include the command syntax and examples of using the commands. The examples include output from the monitor.
ap en

This command modifies bits in the ApLink mode register. *It should only be used in conjunction with an ApLink-compatible target.* The valid range of the bit parameter is 2-4 and the valid range of the value parameter is 0-1.

- Bit 2 - Enable ApLink (Active Low)
- Bit 3 - Enable Timer interrupts (Active Low)
- Bit 4 - Enable Serial Break interrupt (Active Low)

Refer to the *ApLink User's Guide* for further details.

**Example**

=> ap en 3 0

ap sw

This command moves an ApLink monitor from its boot-up region to a new memory region and simultaneously switches to one of ApLink’s supported modes. The valid range of the region parameter is 1-1e; the valid range of the mode parameter is 1-2.

For mode 2, all of the ApLink hardware except the ROM emulation SRAM is moved to the new address region. The user can then download new startup code into the SRAM from the IMI region.
Monitor Commands

For mode 1, all of the ApLink hardware is moved to the new address region so that the user's startup code in the IMI region can be tested from ROM. Refer to the ApLink User's Guide for further details.

Example

=> ap sw 2 2

ap rs
ap wt

These commands are used to manipulate an ApLink-compatible monitor that meets the following preconditions:
1. It is modes 1 or 2, and
2. It has a new IMI in ROM or downloaded in the appropriate processor boot region.
ap wt causes the monitor to configure itself internally in user mode (e.g., application mode) and then wait for a hardware reset. ap rs causes the monitor to configure itself in user mode and then immediately reset the target from the new IMI.

NOTE. ap wt causes the monitor to wait indefinitely for a target hardware reset. In other words, the UI does not prompt for further input until you complete a manual hardware reset.
### bdata

*bdata*

**bd [address]**

The *bd* command sets a data breakpoint at the specified address. The monitor stops execution when the specified address is either read from or written to. This command applies only to the i960 Jx/Cx/RP processors, which have two hardware data breakpoints. The i960 Hx processor supports six breakpoints. If you omit an address, the monitor displays the current data breakpoints. To delete a data breakpoint, use the `delete` command.

**Example**

`=>bd 801c000`

### break

**break**

**br [address]**

The *br* command sets an instruction breakpoint. The *address* must be on an instruction boundary. You can set up to two instruction breakpoints on the i960 Kx, Sx, Cx, Hx, and Jx processors. Enter *br* with no *address* to display all current breakpoints. To delete a breakpoint, use the `delete` command.

**Example**

`=>br 8008000`
cflash

cf

The cf command checks to see if the flash memory is blank. When it is not blank, the monitor displays the first and last addresses of programmed memory and the total size of the flash memory.

Example

=> cf
Flash is programmed between 0x10000000 and 0x10005820
EEPROM size is 0x20000

dasm

dasm [address] #instructions

The dassm command disassembles instructions beginning at the specified address. The default address is the current instruction pointer. The address must be on a word boundary.

Example

=> da 8008000 2
08008000 : 5c601e01 mov 1, r12
08008004 : 6563028c modpc r12, r12, r12
dbyte

db address [#bytes]

The db command displays memory in bytes beginning at the specified address. The display includes ASCII characters, if printable.

Example

=>db 8008006 2
08008006 : 63 c
08008007 : 65 e

dchar

dc address [#characters]

The dc command displays memory as ASCII characters.

Example

=>dc A000C000 10
A000C000 : ..FC..-x..
**dd double**

The `dd` command displays memory in double words at the specified address. The `address` must be aligned on a two-word boundary.

**Example**

```plaintext
=> dd 8008000 2
08008000 : 5c601e01 6563028c
08008008 : 5ca81615 8c083000
```

**delete**

The `de` command deletes an instruction breakpoint (for the Jx/Cx/Hx processor, a data breakpoint) at the specified address.

**Example**

```plaintext
=> de 8008000
```
display

```
di address [#words]
```

The `di` command displays memory in words beginning at the specified address. The `address` must be aligned on a word boundary.

Example

```
=> di 8008000 2
08008000 : 5c601e01
08008004 : 6563028c
```

di register

The `di` command displays the contents of the specified register. The `registers` command displays the valid register names.

Example

```
=> di pfp
pfp : 0801c500
```

download

```
do [offset]
```

The `do` command downloads a COFF file using the Xmodem protocol. The `offset` is added to each word in the COFF file to form the actual load address. This feature enables you to download position-independent code, or download code to EEPROM that can be jumpered for different addresses. When the monitor downloads a COFF file, it automatically sets the IP to the start address given in the file.
Example

-->do
Downloading

(Invoke local download here. Bring
the host side into the foreground
running Xmodem and download the
file.)

-- Download complete --
Start address is : 8008000

Downloading Flash Memory

The monitor supports programming flash memory when it is available on
the target board. Any memory-write command or download command
programs the flash memory when the address falls within the memory
space of the flash. The monitor checks to see that the flash memory is
erased before attempting to program it. If the flash is not erased, the write
fails.

dp

----------

dp

Displays the current PRCB address.
dquad

dq address [#quadwords]

The dq command displays memory in quad words beginning at the specified address. The address must be aligned on a four-word boundary.

Example

=>dq 80008000
08008000 : 5c601e01 6563028c 5ca81615 8c083000
08008010 : 080064e8 8c603000 00001000 5908408c

dshort

ds address [#shortwords]

The ds command displays memory in short words beginning at the specified address. The address must be aligned on a two-byte boundary.

Example

=>ds 8008000 2
08008000 : 1e01
08008002 : 5c60
dtriple

dt address

The dt command displays memory in triple words beginning at the specified address. The address must be aligned on a four-word boundary. This alignment indicates that you can display only one triple word at a time.

Example
=>dt 8008000
08008000 : 5c601e01 6563028c 5ca81615

eflash

ef

The ef command erases flash memory. The monitor prints an error message if the board does not support flash memory or the flash memory cannot be erased.

fill

fi address1 address2 worddata

The fi command fills memory from address1 to address2 with the word value of worddata. If address1 = address2 then the monitor fills one word at address1. The address1 must be aligned on a word boundary.
**Example**

=>fi 8008000 800800c a5a5a5a5

---

**flong**

`fl address [#longreals]`

The `fl` command displays long real (64-bit) floating-point numbers beginning at the specified address. The `address` must be aligned on a two-word boundary.

**Example**

=>fl 8008000 2  
08008000 : 2.46506565e180  
08008008 : -0.10557101e-249

---

**freal**

`fr address [#reals]`

The `fr` command displays real (32-bit) floating-point numbers beginning at the specified address. The `address` must be aligned on a word boundary.

**Example**

=>fr 8008000  
08008000 : 6.02300001e23
**Monitor Commands**

---

**fxreal**

`fx address [#extendedreals]`

The `fx` command displays extended real (80-bit) floating-point numbers beginning at the specified address. Although extended real numbers are 10 bytes, they must be aligned on quad word boundaries.

**Example**

```text
=>fx 8008000 2
08008000 : 5.03696464e 19
08008010 : 6.40306565e 84
```

---

**go**

`go [address]`

The `go` command begins execution at the specified address. Enter `go` with no address to begin execution at the current IP. When the monitor downloads a COFF file, it automatically sets the IP to the start address given in the file. See Chapter 7 for more information on program execution.

**Example**

```text
=>go 10008000
```
help

he [command]

The *he* command displays help for a specified command. If you omit a command, the monitor displays a summary of all commands.

**Example**

```shell
=>he rs
rs
    Resets the board.
```

la

la regno value

The *la* command sets the contents of the specified logical memory address register to the designated value. The valid range of *regno* is 0-1. This command is valid for Jx/Hx processors only. Both command arguments are assumed to be hex constants.

**NOTE.** It is important for consistent monitor operation that you use this command correctly.

**Example**

```shell
=>la 0 a0000002
```
**Monitor Commands**

---

**lm**

`lm regno value`

The `lm` command sets the contents of the specified logical memory mask register to the designated value. The valid range of `regno` is 0-1. This command is valid for Jx/Hx processors only. Both command arguments are assumed to be hex constants.

**NOTE.** It is important for consistent monitor operation that you use this command correctly.

**Example**

`=> lm 0 f0000001`

---

**mbyte**

`mb address`

The `mb` command modifies one byte of memory. The memory `address` is designated in hexadecimal. When the monitor displays the specified address, you can enter a value in hexadecimal (34 in the example).

**Example**

`=> mb 2800800c
2800800c : 34`
mcon

mc region value

The mc command sets the memory configuration register for the specified region to the specified value. The valid range of region is 0 to 0xf. This command is valid for the Cx/Hx/Jx processors only. When used for the Jx processor, the region is automatically divided by two to map to the supported range of that processor. Both command arguments are assumed to be hex constants.

NOTE. It is important for consistent monitor operation that you use this command correctly.

Example

=>mc a 800000

modify data

md address | register hex-value

The md command modifies one word in memory. When the monitor displays the current value of the specified address, you can enter a new value. Press Enter to leave the location unchanged.

Example

=>md 801c000 15

0801c000 : 00000002 : 5
0801c004 : 00000100 :

This example changes the contents of 0801c000 to 5 and leaves the contents of 0801c004 unchanged.
*Programming Flash Memory.* The monitor supports programming flash memory if it is available on the target board. Any memory-write command or download command programs the flash memory when the address falls within the memory space of the flash. The monitor checks to see that the flash memory is erased before attempting to program it. If the flash is not erased, the write fails.

`md register hex-value`

Modifies the specified register. When the monitor displays the current value of the register, you can enter a new value. Press Enter to leave the register unchanged. The monitor cannot modify floating-point registers from the user interface.

The `registers` command displays the valid register names.

The register value is not changed until the application program resumes execution.

**NOTE.** *The mb and mo commands are not allowed in MONDB using the -d option. Use the md command instead.*

**Example**

`=>md g0 12fffff78`
modify

`mo address [#words]`

The `mo` command modifies one or more words in memory. When the monitor displays the current value of the specified address, you can enter a new value. Press Enter to leave the location unchanged.

**Example**

```mo 801c000 2
0801c000 : 00000000 : 5
0801c004 : 00000100 :
```

This example changes the contents of 0801c000 to 5 and leaves the contents of 0801c004 unchanged.

**Programming Flash Memory.** The monitor supports programming flash memory if it is available on the target board. Any memory-write command or download command programs the flash memory when the address falls within the memory space of the flash. The monitor checks to see that the flash memory is erased before attempting to program it. If the flash is not erased, the write fails.

`mo register`

Modifies the specified register. When the monitor displays the current value of the register, you can enter a new value. Press Enter to leave the register unchanged. The monitor cannot modify floating-point registers from the user interface.

The `registers` command displays the valid register names.

The register value is not changed until the application program resumes execution.
Monitor Commands

Example

`=>mo r10`
`r10 : 00008000 : 1`

---

**po**

`po`

*follow menu steps if applicable*

The `po` command runs the target’s power-on self test. The menus step you through tests for each hardware component of the board. For more information about setting up diagnostics, refer to Chapter 5 in this guide.

---

**pstep**

`ps [address]`

The `ps` command steps over a procedure. If the instruction is `call`, `callx`, `calls`, `bal`, or `balx`, the entire called procedure is executed and execution stops before the next instruction after the procedure. Otherwise, one instruction is executed. When execution stops, the monitor displays the next instruction to be executed.

Since this command uses a software breakpoint, which requires updating the instructions, do not use it if the code is in ROM. If you do try to use it in ROM code, the monitor reports a write verification error and does not start execution.
pm

pm [address] [hex value]
Displays the PCI shared memory space at offset address or writes a word at offset address.

Example
=>pm 0:1234

pt

pt [address] [hex value]
Displays the PCI register space at offset address or writes a word to the register at offset address.

Example
=>pt 0:1234
Monitor Commands

pp

```plaintext
pp bus# device# [function#]
```

Displays the PCI config space for the PCI device specified by the bus, device, and function numbers. This option is for use with an i960 RP processor only.

**Example**

```plaintext
=> pp 0 E 0
```

qu and rb

```plaintext
qu/rb
```

The `qu` or `rb` command resets the target board and leaves it waiting for autobaud from a host or terminal. If you want to continue using a terminal, press Enter two or three times to initiate the monitor sign-on. `rb` is retained for compatibility. See also the `rs` and `rb` commands.
**registers**

The `re` command displays the contents of all registers.

**Example**

```
=>re

  g0 : 00000000 g1 : 00000000 g2 : 00000000 g3 : 00000000
  g4 : 00000000 g5 : 00000000 g6 : 00000000 g7 : 00000000
  g8 : 00000000 g9 : 00000000 g10: 00000000 g11: 00000000
  g12: 00000000 g13: 00000000 g14: 00000000 fp : 0801c540
  pfp: 0801c500 sp : 0801c580 rip: 08000004 r3 : 00000000
  r4 : 00000000 r5 : 00000000 r6 : 00000000 r7 : 00000000
  r8 : 00000000 r9 : 00000000 r10: 00000000 r11: 00000000
  r12: 00000000 r13: 00000000 r14: 00000000 r15: 00000000
  pc : 001f0003 ac : 3b001001 tc : 00000000
  fp0: 0.000000e 0
  fp1: 0.000000e 0
  fp2: 0.000000e 0
  fp3: 0.000000e 0
```

**rs**

The `rs` command resets the target board. This command retains the current baud rate and prints the monitor sign-on. It does not leave the target waiting for autobaud. See also the `rb` command.
Monitor Commands

---

**step**

`st [address]`

The `st` command single-steps one instruction starting at the current IP or specified address. When execution stops, the monitor displays the next instruction to be executed.

**Example**

=>`st 8000000`  
`08000004 : 6563028c  modpc r12, r12, r12`

---

**trace**

`tr [option [on|off]]`

The `tr` command turns a trace `option` on or off as follows:

- **branch**: breaks every time a branch is taken.
- **call**: breaks after any type of call or branch-and-link instruction.
- **return**: breaks any time a return instruction is executed.
- **supervisor**: breaks on supervisor calls from user mode.

To display the current value of all trace options, enter `trace`. Enter `trace option` without `on` or `off` to display the status of the specified option.

To start execution with the specified trace options, use the `go` command.
Example

```plaintext
=>tr br on
branch trace on
call trace off
return trace off
supervisor trace off
```

version

```plaintext
ve
```

The `ve` command displays the MON960 version number.
This chapter explains how to retarget the MON960 debug monitor to run on a non-Intel board. Intel boards include the Cyclone and Cyclone PCI (refer to Table 5-1). This chapter also explains how to produce new EPROMs for supported boards.

To retarget the monitor, you modify Intel-supplied source files to specify addressing for your board's memory configuration. You can then use a make utility to build a revised monitor that runs on your target board. This chapter describes the following steps to retarget the monitor:

1. copying and modifying the board-specific source files
2. editing the makefile
3. copying the linker-directives file
4. configuring the makefile
5. making the monitor files
6. producing and installing new EPROMs containing the monitor program
7. verifying monitor operation (if in User Interface mode)

Types of Source Files

The source code for the monitor is in the mon960/common directory. The monitor contains three classifications of files as follows.

- files pertaining to all i960 processor targets (board-independent)
- files that depend on the target type (board-specific)
- hardware-specific files, such as the 82c54 and 85c36 timers
When you retarget, you usually change the board-specific files, and you may add hardware-specific files. In this manual, `board` is a place holder for the name of your board. The following table lists the supported board names with the abbreviations that can substitute for `board`:

### Table 5-1  List of Board Names and Abbreviations

<table>
<thead>
<tr>
<th>Processor Board Name</th>
<th>Board Abbreviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cyclone EP80960BB, PCI80960DP</td>
<td>(CYSX, CYKX, CYCX, CYJX, CYHX)</td>
</tr>
<tr>
<td>(Sx, Kx, Cx, Jx, Hx)</td>
<td></td>
</tr>
<tr>
<td>• Cyclone IQ80960RP (RP)</td>
<td>CYRP</td>
</tr>
</tbody>
</table>

**Note:** This guide refers to the Cyclone and Cyclone PCI boards as the Cyclone boards.

### Code Areas Affected by Retargeting

When you retarget the monitor, the following areas of code may require modification:

- memory configuration, which includes the following:
  - memory configuration in `monboard.ld`
  - bus configuration in `board.h` (for the Cx/Jx/Hx/RP only)
  - hardware-dependent addresses and constants in `board.h`

For more information, refer to the *Memory Configuration* section later in this chapter.

- board-specific data in `board_hw.c`, which includes the following, described in the *Board-specific Data* section:
  - processor architecture, variable `arch`
  - architecture name, variable `char arch_name[]`
  - board name, variable `char board_name[]`

- hardware-dependent routines, including, but not limited to:
  - the device-driver routines in `82510.c` or `16552.c`, described in the *Serial Device Driver Routines* section
  - the LED routines in `leds_sw.c`, described in the *Routines in leds_sw.c* section
Retargeting the Monitor

— the routines for using flash memory, described in the Routines in flash.c section
— the parallel and PCI download routines. The parallel download routines are described in the Routines in paradrvr.c section. For information on the PCI download routines, see the section titled MON960 Support for PCI Communication in Chapter 6.

The following sections discuss the portions of the monitor code that require modification, and suggest modifications to that code.

Modifying Board-specific Files

To retarget the monitor for your board:

1. Duplicate the board-specific files that best match your hardware, renaming these files to identify your target board. For use in these examples, let's say your target is a Fred board containing an i960 Cx chip.

<table>
<thead>
<tr>
<th>File Name</th>
<th>Contents and Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>board.h</td>
<td>hardware addresses and values</td>
</tr>
<tr>
<td></td>
<td>Example: copy cycx.h and rename it fred.h</td>
</tr>
<tr>
<td>board_hw.c</td>
<td>board name, architecture name, initialization,</td>
</tr>
<tr>
<td></td>
<td>reset, and hardware interface routines</td>
</tr>
<tr>
<td></td>
<td>Example: copy cycx_hw.c and rename it fred_hw.c</td>
</tr>
<tr>
<td>monboard.ld</td>
<td>monitor linker-directives file for the board</td>
</tr>
<tr>
<td></td>
<td>Example: copy moncycx.ld and change it to monfred.ld</td>
</tr>
</tbody>
</table>

2. Modify the new board-specific files to support your target.

3. Select or add the hardware-specific files that support your target board's features. Hardware-specific files are in the board-independent MON960 source code.
4. Change the makefile to reflect your new board name and the files you selected to support it. Refer to the section later in this chapter titled Creating the ROM Image.

5. Use the make command to build your retargeted MON960 files. Refer to the section titled Creating the ROM Image later in this chapter.

Board-specific Files

**board.h**

*board.h*, the board-specific include file, contains the following information:

- constants that specify information about your board's hardware addresses. You must change these constants to describe the target board.

- constants you must define in order to use the monitor's flash memory routines. Refer to the section later in this chapter titled *Routines in flash.c*.

- constants that specify some of the fields of the boot control table (for the i960 Cx/Jx/Hx/RP processors only). The boot control table fields specified in *board.h* determine the board's bus configuration. Refer to the next section, *board_hw.c*, for more information on those constants.

- if your board uses the 82510 UART, definitions of constants that support its use. Refer to the *Serial Device Driver Routines* section for more information.

  Note: If your board uses another serial device, you must provide the driver to support it.

- if your board uses the 16552 DUART, definitions of constants that support its use. Refer to the *Serial Device Driver Routines* section for more information.
• `#define` values used by the routines in `leds_sw.c`. Those routines are used to access and manipulate the LEDs on the board. Refer to the section *Routines in leds_sw.c* for more information.

• if your board supports parallel download, definitions of constants that support its use. Refer to the section in this chapter titled *Routines in paradvr.c* for more information.

• if you use the timer driver 82c54.c (EPCX) or 85c36.c (CYCX), definitions of the following values that support its use:

<table>
<thead>
<tr>
<th>Value</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIMER_BASE</td>
<td>base address for timer chip</td>
</tr>
<tr>
<td>CRYSTAL_TIME</td>
<td>timer clock input frequency in MHz</td>
</tr>
<tr>
<td>TIMER_0_VECTOR</td>
<td>interrupt vector set by MON960, e.g. 0XD2</td>
</tr>
<tr>
<td>TIMER_1_VECTOR</td>
<td>interrupt vector set by MON960, e.g. 0XC2</td>
</tr>
<tr>
<td>TIMER_0_IRQ</td>
<td>interrupt pin used by this timer</td>
</tr>
<tr>
<td>TIMER_1_IRQ</td>
<td>interrupt pin used by this timer</td>
</tr>
<tr>
<td>TIMER_0_OFFSET</td>
<td>register address offset for each timer</td>
</tr>
<tr>
<td>TIMER_1_OFFSET</td>
<td>register address offset for each timer</td>
</tr>
</tbody>
</table>

*board_hw.c*

**Variables**

The *board_hw.c* file contains variables that specify information about your board. You must change the contents of these variables to describe the target board.
### Variable Description

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>int arch</code></td>
<td><code>arch</code> specifies the processor architecture. The value of <code>arch</code> must be one of the following:</td>
</tr>
<tr>
<td></td>
<td>• ARCH_CA</td>
</tr>
<tr>
<td></td>
<td>• ARCH_HX</td>
</tr>
<tr>
<td></td>
<td>• ARCH_JX</td>
</tr>
<tr>
<td></td>
<td>• ARCH_RP</td>
</tr>
<tr>
<td></td>
<td>The value of <code>arch</code> is used by the monitor and host to determine what registers and other capabilities your board has.</td>
</tr>
<tr>
<td></td>
<td>If your target has a CA or CF processor, use ARCH_CA. These values are defined in hdi_arch.h in hdil/common. Do not add an architecture type since the host-side debuggers depend on these values.</td>
</tr>
<tr>
<td><code>char arch_name[]</code></td>
<td><code>arch_name</code> contains the name of the processor architecture (Cx, Jx, Hx, or RP). The name is printed in a banner across the screen when the monitor starts up.</td>
</tr>
<tr>
<td><code>char board_name[]</code></td>
<td><code>board_name</code> contains the name you specified for your board. The name prints in a banner across the screen when the monitor starts up.</td>
</tr>
<tr>
<td><code>char target_common_name[]</code></td>
<td><code>target_common_name</code> is a shortened version of <code>board_name[]</code>. <code>target_common_name</code> is reported to debuggers using the hdi_get_monitor_config() service.</td>
</tr>
</tbody>
</table>
ADDR unwritable_addr is the address of a read-only memory location that does not fault the processor or hang the target hardware when written to. This information is reported to debuggers via the `hdi_get_monitor_config()` service. Set this variable to -1 if an unwritable address is not available.

A date string, located in `bld_date.c`, prints in the banner when the monitor starts up. You may use this variable to track retargeting code revisions.

For the i960 Jx/Cx/Hx/RP processor, the file `board_hw.c` also contains the boot control table. This table is declared `const` because it must be in ROM, where it is read during processor initialization. During Monitor initialization, it is copied to RAM, so the monitor may change fields as required during operation. The fields of the control table that specify the bus configuration are specified using defined constants from `board.h`. If you need to change the bus configuration, do so in that file. Make any other changes to the control table either in `board_hw.c`, or at runtime in `init_hardware`. 
Routines

The `board_hw.c` file contains the following initialization routines that you might need to change when retargeting the monitor:

```c
void init_hardware(void)
int get_int_vector(int)
void init_imap_reg(PRCB *)
void board_reset(void)
int clear_break_condition(void)
void board_go_user(void)
void board_exit_user(void)
```

These routines isolate target-hardware dependencies in the monitor. If necessary, modify these files to conform to the capabilities of your target board. Below is an explanation of each routine in `board_hw.c`.

**init_hardware()**

```c
void init_hardware(void)
```

This routine initializes the target board. The routine writes the processor interrupt control registers with values applicable to the board. It also initializes other board resources. See the programmer's reference manual for your processor for information on programming the interrupt control registers.

Before calling the `init_hardware()` routine, the monitor establishes most of its own default variables. Thus, the values of these default variables can be changed, if necessary, in the `init_hardware()` routine.

The `init_hardware()` routine must not initialize any hardware devices that are not required for the operation of the monitor. Initializing these other devices should be left to the application that is downloaded to the target board once the monitor is running.
get_int_vector()

int get_int_vector(int)

This routine returns the vector number of the interrupt that is generated when a break is received by the serial port. The argument is not used.

When the Host Debugger needs to interrupt the application, it sends a break signal to the target system. You can program a universal asynchronous receiver transmitter (UART) to generate an interrupt when it receives a break. The priority of this interrupt must be as high as possible to ensure that the debugger can interrupt the application and regain control even when the processor is running at high priority. If possible, use priority 31 for the Kx version and NMI for the Jx/Cx/Hx/RP version.

This feature is not necessary for the basic operation of the monitor. If get_int_vector() returns 0, this feature is disabled. You can code this routine to return 0 until the rest of the monitor is working properly. If this routine returns 0, then do not program the UART to generate any interrupts.

The init_hardware() routine configures the interrupt mechanism. The get_int_vector() routine returns the interrupt vector number assigned to the UART, and the monitor fills in the appropriate interrupt vector into the interrupt table. The serial_open() routine configures the UART to generate an interrupt when a break is received.

If your target board requires special processing to clear the UART or an interrupt controller, do that processing in the clear_break_condition() routine. The monitor calls this routine to perform any special processing required to clear an interrupt condition.

init imap_reg()

void init imap_reg (PRCB *prcb)

This function is required for the i960 Jx/Cx/Hx/RP processors only.
This routine initializes the proper IMAP register field in the control table used for the monitor's interrupt. The routine is called at initialization and when the PRCB is changed. The routine is passed a pointer to the new PRCB, which it uses to locate the new control table.

You need not change this code if you define `BRK_PIN` and `BRKIV` correctly for your target board. If your target board uses NMI for the monitor's interrupt, this routine does not need to set up for the next interrupt.

**board_reset()**

```c
void board_reset (void)
```

This routine resets the monitor target. The routine does not return a value. If the target hardware does not support resetting the processor, this routine restarts the i960 processor.

To restart the i960 Jx/Cx/Hx/RP processor, this routine calls the following routine:

```c
send_sysctl(0x300, reinit, &rom_prcb)
```

See your processor user's manual for information on the `sysctl` instruction.

**clear_break_condition()**

```c
int clear_break_condition(void)
```

This routine clears an interrupt from the serial port. The routine is called when an interrupt is received from the serial port. It completes any special processing required to clear the interrupt condition in the UART or interrupt controller. It must ensure that any null characters or framing errors created by the start or end of the break are cleared in the UART. In the example code, this work is done by the `serial_intr()` routine in the `82510.c` file.

If the interrupt was caused by a break received from the host, the routine returns `TRUE`. If the interrupt was caused by some other condition, such as overrun, the routine returns `FALSE`. 
NOTE. You need not program the UART to generate an interrupt on overrun or other error conditions. However, some UARTs do not allow you to disable these interrupts, so the monitor ignores them.

**board_go_user()**

```c
void board_go_user(void)
```

The monitor calls this routine each time execution returns to the application program. You can use this routine to light an LED to indicate that the application program is running, or perform other board-specific requirements to execute an application program. On the i960 Jx/Cx/Hx/RP processor, if the break interrupt priority is not NMI, this routine enables the appropriate interrupt in the saved copy of the IMSK register, as in the following code:

```c
register_set[REG_IMSK] |= IMSK_VAL;
```

**board_exit_user()**

```c
void board_exit_user(void)
```

This function performs any required board-specific actions when execution returns from the application to the monitor. The routine is called when execution returns to the monitor.

**Memory Configuration**

**monboard.ld**

This linker-directives file is specified in the makefile by the line `BOARD_ROM_LD=filename`. For example, make a copy of `moncycx.ld` in which you have modified the memory ranges specified at the beginning of the file. The linker-directives file is discussed further in the next section, *Defining Memory Configuration.*
Defining Memory Configuration

Define the target memory configuration by assigning values to the following memory configuration variables in `monboard.ld`, the linker-directives file (for example, `moncycx.ld`):

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ibr</td>
<td>address of initialization boot record (Cx/Jx/Hx/RP only). The ibr addresses are listed below and should never be changed.</td>
</tr>
<tr>
<td>eprom</td>
<td>base address and size of EPROM space. The size requirement for the monitor is approximately 100 kilobytes. You can reduce the monitor size by linking without some of the features, for example, the User Interface. Removing all available features results in a minimum monitor size of 32 kilobytes. See the <em>Specifying Makefile Build Options</em> section for more information on building a minimum monitor. See the <em>Creating the ROM Image</em> section for directions on using the makefile to relink the monitor.</td>
</tr>
<tr>
<td>data</td>
<td>base address and size of monitor initialized data space. The size requirement is about one kilobyte.</td>
</tr>
<tr>
<td>bss</td>
<td>base address and size of monitor uninitialized data space. The size requirement is about 12 kilobytes.</td>
</tr>
</tbody>
</table>

**Processor ibr Address**

- Cx 0xffffff00
- Jx/Hx/RP 0xfeffff30

**Table:**

<table>
<thead>
<tr>
<th>Processor</th>
<th>ibr Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cx</td>
<td>0xffffff00</td>
</tr>
<tr>
<td>Jx/Hx/RP</td>
<td>0xfeffff30</td>
</tr>
</tbody>
</table>
If you have room, reserve a portion of the beginning of RAM to enable future expansion. For example, reserve 32 kilobytes to accommodate the monitor made with all features enabled.

Several other symbols are defined in the linker-directives file:

pre_init set to the address of the pre-initialization code, if it is required. See the Board Initialization section for information on this pre-initialization code.

initial_stack defines the stack that is used after initialization. Define it as _monitor_stack.

_checksum value placed in the initial memory image (IMI) as part of the checksum.

You can edit the linker-directives file to change the addresses for some of these variables to match your target board. If you are retargeting the monitor for i960 Jx/Cx/Hx/RP evaluation boards, the board.h file defines the bus configuration values for the processor. When you change the settings in the monboard.ld file, duplicate those changes in the board.h file as well.

The cx_ibr.c/jx_ibr.c/hx_ibr.c/rp_ibr.c file contains the initialization boot record for the i960 Cx/RP/Hx/RP processor. You need not change this file because the code is recompiled using the definitions in board.h. See the programmer’s reference manual for your processor for information on the initialization boot record.

The monitor normally resides in EPROM on the target board. The monitor stores its own data and a copy of the i960 processor data structures in target RAM. Figure 5-1 shows the memory configuration for the Cyclone i960 Sx, Kx, Cx, Jx, and Hx boards. Figure 5-2 shows the memory configuration for the i960 RP Cyclone board.
Figure 5-1  Memory Map for Cyclone i960 Sx/Kx/Cx/Jx/Hx Boards

- CPU Module Flash Boot ROM for 80960Cx/Jx/Hx
- Expansion Flash ROM
- Reserved
- Squall Module
- Reserved
- Parallel Port
- CIO
- Serial Port
- DRAM
- Reserved
- CPU Module Flash Boot ROM for 80960Kx/Sx
Creating the ROM Image

After modifying source files as necessary for your target board, create the ROM image of the monitor according to the following steps:

1. Edit the makefile.
2. Copy the linker-directives file (`monboard.1d`).
3. Configure the makefile.
4. Make the monitor files using a make utility.
5. Produce new EPROMs.
6. Install new EPROMs.

MON960 includes a makefile that can build a monitor for any of the evaluation boards in the `/mon960/common` directory.

The supplied makefile can build MON960 for any of the supported boards. For example, if you want to build MON960 for a Cyclone board with a Cx CPU module, either use the supplied makefile, or configure a new one as described in the following steps; then type `make cycx`. If you do not change the makefile, advance to the step on the next page called `Configure the Makefile`. If you do change the makefile, go to the next step, `Edit the Makefile`.

NOTE. The makefile has been tested on UNIX systems with the standard `make` utility, and on Windows systems with the Microsoft `make` utility, `NMAKE`, R1.20. If you use some other make utility, the makefile may require modification.

To use the supplied makefile, do the following:

**Edit the Makefile**

If you have retargeted the monitor, edit the makefile as follows:

1. Duplicate the group of `make` commands for the evaluation board that is most similar to your target board. For example, if your target board uses the i960 Cx processor, duplicate the group of make commands under the heading CYCX Evaluation Board.

2. Replace all the `board` strings in your new commands with the appropriate string for your target board. For example, replace all occurrences of **CYCX** with **FRED** and all occurrences of **cycx** with
Fred. You may want to remove lines from the makefile. For example, you may not want the `FRED_POST_OBJCSF...` command if you do not intend to write power-on self-tests for your target board.

3. Edit the line `BOARD_OBJCSF...` to match the characteristics of your target board and desired monitor. For example, the CYCX line is as follows:

```
CYCX_OBJCSF= $(CX_BASE_OBJCSF) $(CX_HI_OBJCSF)
 $(CX_UI_OBJCSF) $(CYCX_BOARD_OBJCSF)
 $(COMMON_C145_OBJCSF) $(CYCX_TEST_OBJCSF)
```

If you do not want to link in the User Interface, replace `$(CX_UI_OBJCSF)` with `$(NO_UI_OBJCSF)`. Therefore, a reasonable line might be:

```
CYCX_OBJCSF= $(CX_BASE_OBJCSF) $(CX_HI_OBJCSF)
 $(NO_UI_OBJCSF) $(CYCX_BOARD_OBJCSF)
 $(CYCX_TEST_OBJCSF) $(COMMON_C145_OBJCSF)
```

**Copy the Linker-directives File**

If you have retargeted the monitor, you also need to make a copy of the linker-directives file that reflects the memory configuration of your target board. The linker-directives file is specified in the makefile by the line `BOARD_ROM_LD= filename`. For example, make a copy of `moncycx.ld` in which you have modified the memory ranges specified at the beginning of the file.

For a detailed explanation of the memory configuration variables in the linker-directives file, refer to the section earlier in this chapter called *Defining Memory Configuration*.

**Configure the Makefile**

Configure the makefile by entering the following command. Its variables are described below.

```
make make [HOST=host] [TOOL=tool] [obj_fmt=format]
```
Variable | Description
--- | ---
host | signifies the host computer, UNIX or Windows, on which you are running the make utility.
tool | signifies the toolset you are using to build the monitor. The tool option can be any of the following:
intel | used to build with the CTOOLS960 tools
gnu | used to build with the GNU/960 tools
format | specifies the object module format as either:
elf | generates ELF object modules
coff | generates COFF object modules

The defaults for the make command are unix, gnu and coff.

This make command creates a new makefile that enables the appropriate make commands for your combination of host and toolset. The original makefile is saved as Makefile.old.

**The Minimum Monitor**

Include the following in your makefile to build a minimum monitor. You may use m_epcx and an example of a minimal monitor.
Table 5-2 Minimum makefile Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>XX_UI_OBJS</td>
<td>adds the modules that create the MON960 User Interface</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>XX_HI_OBJS</td>
<td>adds the modules that provide the MON960 Host Debugger Interface</td>
</tr>
<tr>
<td>PCI_OBJS</td>
<td>allows the use of PCI communication</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>SERIAL_OBJS</td>
<td>allows the use of serial communication</td>
</tr>
<tr>
<td>NO_PARALLEL_OBJ</td>
<td>added to the BOARD_OBJS list suppresses the use of parallel code</td>
</tr>
<tr>
<td>NO_FLASH_OBJS</td>
<td>disables flash memory</td>
</tr>
<tr>
<td>NO_TIMER_OBJS</td>
<td>disables use of your target’s timers</td>
</tr>
<tr>
<td>NO_POST_OBJS</td>
<td>prevents the use of power-on self test with your monitor</td>
</tr>
<tr>
<td>NO_APLINK</td>
<td>omits the code for ApLink support</td>
</tr>
<tr>
<td>XX_BASE_OBJS</td>
<td>include the basic object files</td>
</tr>
<tr>
<td>board_hw.o</td>
<td>includes the correct board initialization code</td>
</tr>
<tr>
<td>FIRST_OBJS</td>
<td>includes the monitor’s initialization boot record and startup code</td>
</tr>
</tbody>
</table>

Specifying Makefile Build Options

You may want to specify build options in the makefile, depending on available EPROM space and the desired functionality of your target board. Specifying these build options adds functionality, but the tradeoff may be increased EPROM space requirements or decreased performance. The following paragraphs describe the build options that you may enable or disable in the makefile for each target board.
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>XX_UI_OBJS</td>
<td>adds the modules that create the MON960 User Interface</td>
</tr>
<tr>
<td>NO_UI_OBJS</td>
<td>suppresses the User Interface</td>
</tr>
</tbody>
</table>
| HELP in UI_MAIN.C      | includes online help in the User Interface. This option is enabled in this file as the default. If you are short of EPROM space, you may want to comment the following line in UI_MAIN.C: 
                          #DEFINE HELP                                                                                                                                   |
| XX_HI_OBJS             | adds the modules that provide the MON960 Host Debugger Interface                                                                                                                                 |
| NO_HI_OBJS             | suppresses the Host Debugger Interface                                                                                                                                                               |
| TARGET PARA.O in the BOARD_OBJS list | adds the code that creates the parallel download functionality of the monitor                                                                                                                     |
| NO_PARALLEL_OBJ in the BOARD_OBJS list | suppresses use of parallel code                                                                                                                                                                 |
| ALLOW_UNALIGNED        | causes the monitor to support unaligned references to memory. For the Jx/Cx/Hx/RP architecture, this also sets the Mask Unaligned Fault bit in the PRCB                                                 |
| Commented ALLOW_UNALIGNED | causes the monitor to generate an error when the user requests an unaligned memory access. On the Jx/Cx/Hx/RP architecture, this clears the Mask Unaligned Fault bit in the PRCB, causing the processor to fault if the application makes an unaligned reference. |

continued ➔
### Table 5-3 Optional makefile Symbols (continued)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>This option is enabled (defined) in the makefile as the default:</td>
</tr>
<tr>
<td></td>
<td>ALLOW_UNALIGNED= - DALLOW_UNALIGNED</td>
</tr>
<tr>
<td>NO_PCI_OBJS</td>
<td>suppresses the use of PCI communication</td>
</tr>
<tr>
<td>PCI_OBJS</td>
<td>allows the use of PCI communication</td>
</tr>
<tr>
<td>Uncommenting the lines</td>
<td>enables the use of Jx, Hx, or RP on-chip timers</td>
</tr>
<tr>
<td>TIMER_HW=$(TARGET)timr.o and HJ_TIMER=-DHJ_TIMER</td>
<td></td>
</tr>
<tr>
<td>Uncommenting the line</td>
<td>allows the use of the Cyclone board 85c36 timers</td>
</tr>
<tr>
<td>TIMER_HW=$(TARGET)8536.o</td>
<td></td>
</tr>
<tr>
<td>FLASH_OBJS</td>
<td>enables the use of flash memory</td>
</tr>
<tr>
<td>NO_FLASH_OBJS</td>
<td>disables flash memory</td>
</tr>
<tr>
<td>SERIAL_OBJS</td>
<td>allows the use of serial communication</td>
</tr>
<tr>
<td>_NO_SERIAL_OBJS</td>
<td>disables serial communication</td>
</tr>
<tr>
<td>TIMER_OBJS</td>
<td>allows the use of your target's timers</td>
</tr>
<tr>
<td>NO_TIMER_OBJS</td>
<td>disables the timers</td>
</tr>
<tr>
<td>POST_OBJS</td>
<td>adds power-on self test code to your monitor</td>
</tr>
<tr>
<td>NO_POST_OBJS</td>
<td>prevents the use of power-on self test with your monitor</td>
</tr>
<tr>
<td>USER_COMM</td>
<td>sets the make file to link a user program to MON960, using a specified communication channel</td>
</tr>
<tr>
<td>USER_OBJS</td>
<td>lists the user program objects used to link into MON960</td>
</tr>
</tbody>
</table>
You may also add LED functionality to your board by adding the following to the `board.h` file. The default is no LED functionality.

### Table 5-4 LED Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWITCH_ADDR</td>
<td>allows you to use the target board's switches</td>
</tr>
<tr>
<td>LED_8SEG_ADDR</td>
<td>allows you to use the eight-segment LED on your board</td>
</tr>
<tr>
<td>LED_1_ADDR</td>
<td>allows you to use the individual LEDs on your board</td>
</tr>
<tr>
<td>BLINK_PAUSE</td>
<td>allows you to use blink-pause-wait loops to distinguish LED changes</td>
</tr>
</tbody>
</table>

### Make the Monitor Files Using a Make Utility

You are now ready to make the monitor files. Enter the command:

```
make board
```

`board` is the name you used when you edited the makefile (for example, `fred`).

This command creates the following output files:

- `board` the COFF file containing the complete monitor.
- `board.ima` the binary image file of the complete monitor.
- `board.hex` the Intel hexadecimal object-file format that contains the complete monitor.

This command creates additional, smaller `.hex` files if the specified target board is a Cyclone with an Sx or Kx CPU module, which uses multiple EPROMs. These `.hex` files contain the same information as `board.hex`, but split the information across the EPROMs.
Most PROM programmers can use hexadecimal-format files.

This command also creates a `board.fls` file for the Cyclone board, which is the COFF file prepared for downloading into flash memory on those target boards.

**Produce New EPROMs**

After using the makefile to produce the `.hex` file, you can program any EPROMs needed for your target board using the `.hex` file and a PROM programmer. Intel provides separate `.hex` files for 3960 Cx, Hx, Jx, and RP modules. Each file supports both standalone and PCI boards. You can use the single `.hex` file if your PROM programmer can split the code among the EPROMs.

**Install the New EPROMs**

Finally, install the EPROMs on your target board as follows:

1. Write the monitor image into the EPROM(s) needed for your target using a PROM programmer and the `.hex` file generated by the makefile.
2. Install the EPROM(s) on your target board. Then, connect your target board to a terminal using an RS-232C cable. Ensure that the monitor is running properly on your target board as described in the *Verifying Monitor Operation* section.
NOTE. Although you could run the gdb960 debugger now, do not do so until you have used MON960 enough to be sure that your retargeting was successful. The debugger adds levels of complexity that can interfere with verifying that the monitor is running correctly.

### Debugging the Monitor

Once the monitor is in EPROM on the target board, you can connect a terminal to the target board and power up the target board. If your terminal is set to 9600 baud, you should see the string `MON960` after the system initializes. If your terminal is set to some other baud rate, this string displays only nonsensical characters. In either case, press Enter six times. The monitor signs on with the monitor version number listed in the sign-on line in the form:

```
Mon960 monitor for the Intel i960 processor
Version version board_name date
Copyright 1995, Intel Corporation
```

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>processor</code></td>
<td>is the name of the i960 processor type.</td>
</tr>
<tr>
<td><code>version</code></td>
<td>is the version number of the monitor core.</td>
</tr>
<tr>
<td><code>board_name</code></td>
<td>is the value of the variable <code>board_name</code> specified in the <code>board_hw.c</code> file.</td>
</tr>
<tr>
<td><code>date</code></td>
<td>is the build date of the monitor.</td>
</tr>
</tbody>
</table>

The following sections can help you isolate problem areas in the code.

### Verifying Monitor Operation

To verify that the monitor is running correctly on your target board, perform the following operations with the User Interface commands listed in Chapter 4. Many of these operations are also discussed in Chapter 3.

1. Read memory from EPROM space.
2. Read memory from flash space.
3. Read memory from RAM space.
4. Write data to RAM space.
5. Write data to flash space.
6. Check flash memory.
7. Erase flash memory.
8. Download code to RAM space using the serial interface.
9. Set a breakpoint.
10. Execute to the breakpoint.
11. Display the registers.
14. Delete the breakpoint.
15. Download code to the flash space using the serial interface.
16. Download code to RAM and/or flash space using the parallel interface. Perform the download using the MONDB utility described in Appendix B.

NOTE. On the Cyclone boards with a Cx, Hx, Jx, RP CPU module, you can download the <board>.fls file, and then use the ROM swap switch to boot the monitor out of flash memory instead of EPROM. See the Loading MON960 Into Flash section in Chapter 3 for instructions on loading MON960 into flash memory.

Troubleshooting Host-target Serial Communication Problems
The following problems can occur between the host and the target.
You do not see the Mon960 string when connected at 9600 baud.
Check the following:

- That the baud rate of the terminal is 9600 baud. At other baud rates, you do not see the Mon960 message, because it prints before autobaud is done.
- That the terminal program, if you are using one, is configured to use the proper communications port.
- That the serial connection is correct. See the user manual for the board for information on the serial-cable connection. Be sure to use a null-modem adapter, if necessary.

If you have retargeted the monitor, check the following:

- Monitor initialization routines.
- Your serial_init() routine, and serial_open() if you changed it.
- Your serial_putchar() routine, and serial_write(), if you changed it.
- If you changed serial_open() routine, ensure that it sets the baud rate to 9600 and calls serial_write() with the Mon960 string.

You see the Mon960 string, but do not see the sign-on message when you press the Enter key.

Check the following:

- Your serial_getc() routine, and serial_read(), if you changed it.
- Your serial_set() routine, and serial_baud(), if you changed it.

You must always press Enter six times to get a response. The autobaud mechanism cannot recognize the baud rate fully when you enter only one character. You must enter the subsequent Enter key presses within one second after the first for the multiple entry to be recognized.

A terminal works properly, but MONDB does not connect.

The MONDB program is the download-and-go software utility included with the monitor.

- Check the specification of the communications port to MONDB.
Retargeting the Monitor

• Try a lower baud rate. Some hosts cannot keep up at the maximum supported baud rate.
• Check that the code in `serial_read()` that handles timeouts is the same as the code provided.
• Check the routine `calc_looperms()`.
• If you are using a non-standard communications board in your Windows, or UNIX host, check your supported configurations.
• Check the `-freq` invocation option. The `freq` option sets the serial crystal frequency. A non-standard communications board is one that does not use a 1.8432 MHz crystal.

PCI Retargeting

If your PCI hardware includes two mailbox registers and a doorbell register, change just the addresses for `CYCLONE_TARGET_STATUS_MB` and `CYCLONE_TARGET_DATA_MB` in the `board.h` include file. The 80960RP and PLX9060 chip provide this support. Otherwise, rewrite the routines in `pcidrvr.c` (see Chapter 6) to match your PCI hardware.

<table>
<thead>
<tr>
<th>Target</th>
<th>Resource(s)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclone PCI80960DP</td>
<td>Mailbox registers 6 &amp; 7 and doorbell bits 30 &amp; 31 in both the local-to-PCI and PCI-to-local doorbell registers.</td>
</tr>
<tr>
<td>Cyclone IIQI80960RP</td>
<td>Inbound Mailbox register 1 and outbound Mailbox register 1. Doorbell interrupt bits 30 &amp; 31 in both the local-to-PCI and PCI-to-local doorbell registers. For more information on these registers, refer to the ATU chapter in the <em>i960 RP Processor User’s Manual</em>.</td>
</tr>
</tbody>
</table>

* These hardware resources are reserved exclusively for MON960 and should not be modified by programs executing on the target.
Board Initialization

At reset, the i960 processor completes a checksum self-test, reads pointers from the initial memory image (IMI), and then begins executing user instructions at the boot address. Boards designed for the i960 architecture normally include a mechanism to signal assertion of the i960 processor FAIL# pin. The Intel evaluation boards implement this mechanism with an LED. This mechanism enables you to determine if the processor successfully read the IMI and reached the boot address.

The boot address is _start_ip in the init.s file. Normally, this file needs no modification. The code in init.s checks the symbol pre_init to see whether any code must be executed before monitor initialization. If pre_init is not zero, init.s calls this code via the instruction balx pre_init,g14.

The pre_init() routine performs any functions that must be completed before monitor initialization. For example, it may perform DRAM initialization or board-level self-tests, such as memory tests or ROM checksum verification.

The pre_init() routine may be written in assembly language, since it is entered via a branch-and-link instruction. The routine must preserve the global registers g14 and g11. The g14 register is used as the return address, and the g11 register contains processor revision information for processors that support revision information.

The pre_init() routine can be written in C, but it requires special considerations, such as:

- Some boards need initialization before using RAM.
- Static data is not initialized.
- The runtime library is not initialized.
- The arithmetic controls register is not initialized.
- The pre_init() routine is called with a balx instruction, and it must save registers g14 and g11 (described previously).
- No stack is available, so you should not use stack or call instructions.
NOTE. For all i960 compilers, if you want to call a C language routine, you must save the value of g14 in another register and then clear the g14 register before the call. The pre_init() routine must not call any C library routines, because they are not yet initialized.

Put any initialization routines and non-application initialization routines that need not be completed before monitor initialization in the init_hardware() routine. The init_hardware() routine is called from main and can use C and C library support.

After the pre-initialization code returns, the init.s file sets up the stacks, initializes the C run-time environment, copies the processor data structures to RAM, and re-initializes the processor for the new data structure locations.

Finally, init.s branches to _main, which calls the init_hardware() routine in the board_hw.c module. If necessary, you can modify the init_hardware() routine and other hardware-dependent routines in board_hw.c.

The next two sections describe board-specific data and routines in board_hw.c that might need modification.

Routines in leds_sw.c

The routines listed in this section are for accessing and manipulating the LEDs on the board. The LEDs provide diagnostic information. All the routines in this section are based on #define values from board.h. These functions are for display purposes only and may be stubs that do not affect monitor operation.

The following routines are in the file mon960/common/leds_sw.c:
- unsigned char read_switch ()
- void blink (int n)
- void blink_hex (int n, int size)
void blink_string (char *cha_ptr, int size)
void fatal_error (char id, int a, int b, int c, int d)
void led (int n)
void led_debug (char id, int a int b int c int d)
void led_output (char id, int a int b int c int d)
void leds (int val, int mask)
void pause()

NOTE. If your code does not define a particular address in Table 5-6, the code does nothing with it.

The following table provides a listing of defined symbols and their uses:
### Define Symbols for LED Use

<table>
<thead>
<tr>
<th>Define Symbol</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWITCH_ADDR</td>
<td>Byte address at which to read switch values</td>
</tr>
<tr>
<td>LED_8SEG_ADDR</td>
<td>Byte address at which to write eight-segment values</td>
</tr>
<tr>
<td>LED_1_ADDR</td>
<td>Byte address at which to write first ( N ) LEDs</td>
</tr>
<tr>
<td>LED_2_ADDR</td>
<td>Byte address at which to write second ( N ) LEDs</td>
</tr>
<tr>
<td>LED_3_ADDR</td>
<td>Byte address at which to write third ( N ) LEDs</td>
</tr>
<tr>
<td>LED_4_ADDR</td>
<td>Byte address at which to write fourth ( N ) LEDs</td>
</tr>
<tr>
<td>LEDS_SIZE</td>
<td>Number of LEDs per address</td>
</tr>
<tr>
<td>LEDS_MASK</td>
<td>Mask LED( __ )SIZE bits for writes to LEDS__n_ADDR</td>
</tr>
<tr>
<td>LEDS_ON_0</td>
<td>Defines 0 as turning on LEDs. 0 normally turns off LEDs</td>
</tr>
<tr>
<td>BLINK_PAUSE</td>
<td>Loop count so LEDs may be seen.</td>
</tr>
<tr>
<td>DOT</td>
<td>Eight-segment LED display &quot;.&quot; (dot)</td>
</tr>
<tr>
<td>CLR_DISP</td>
<td>Clear eight-segment LED display</td>
</tr>
<tr>
<td>DISPLAY0 to DISPLAYF</td>
<td>Display eight-segment LED value corresponding to value represented in the name of the define symbol</td>
</tr>
</tbody>
</table>

**read_switch**

```c
unsigned char read_switch ()
```

This routine obtains user input through the switches. That information is used to determine the initialization selection for the board. The routine returns the inverted value read from the dipswitch defined in `<board>.h` as `SWITCH_ADDR`. 
**blink**

`void blink (int n)`

This routine is used to display information on seven-segment LEDs. For example, displaying an 8 on an LED could signify that board initialization is complete. The routine displays the number long enough for the user to read it, and then erases it from the LED.

**blink_hex()**

`void blink_hex (int n, int size)`

This routine displays user-readable hex number for debugging. It blinks hex value `n` for size digits onto an eight-segment LED, or individual LEDs. The sequence is a long pause, then a series of size hex digits, followed by another pause while the user reads the output.

**blink_string()**

`void blink_string (char *cha_ptr, int size)`

This routine displays a string value used for debugging. Either the string displays on the eight-segment LED, or individual LEDs display the upper ASCII hex digit, followed by the lower ASCII hex digit, for size number of bytes.

**fatal_error()**

`void fatal_error(char id, int a, int b, int c, int d)`

The monitor calls this function if an unrecoverable error occurs. This routine does not return.

Currently used `id` values are 1 through 4. The `id` values 5 through 127 are reserved for future use by MON960, and the values 128 through 255 are available for user-defined error handling. The following table provides a list of values for `id`, the contents of the other parameters, and a description of the cause of each error.
Table 5-6  Arguments for fatal_error()

<table>
<thead>
<tr>
<th>id</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>fault_type</td>
<td>ip</td>
<td>pc</td>
<td>fp</td>
<td>Unhandled fault</td>
</tr>
<tr>
<td>2</td>
<td>vector #</td>
<td>ip</td>
<td>pc</td>
<td>fp</td>
<td>Unhandled interrupt</td>
</tr>
<tr>
<td>3</td>
<td>no other args</td>
<td></td>
<td></td>
<td></td>
<td>HI console output failed</td>
</tr>
<tr>
<td>4</td>
<td>no other args</td>
<td></td>
<td></td>
<td></td>
<td>Board reset failed</td>
</tr>
</tbody>
</table>

If the monitor is not connected to a Host Debugger, the `fatal_error()` routine attempts to print the message for id to standard output. Then the eight-segment LED displays three seconds of blank followed by the contents of each argument to `fatal_error()`. The display separates each argument from the next by displaying a period. The values in id and A through D appear in hexadecimal. The following table shows the sequence of display:

Table 5-7  LED Display for fatal_error()

<table>
<thead>
<tr>
<th>Display:</th>
<th>Argument Represented:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 seconds blank</td>
<td></td>
</tr>
<tr>
<td>.</td>
<td>id (2 hex digits)</td>
</tr>
<tr>
<td>.</td>
<td>A (eight hex digits)</td>
</tr>
<tr>
<td>.</td>
<td>B (eight hex digits)</td>
</tr>
<tr>
<td>.</td>
<td>C (eight hex digits)</td>
</tr>
<tr>
<td>.</td>
<td>D (eight hex digits)</td>
</tr>
</tbody>
</table>
led()

void led(int n)

This routine displays $n$ as a hex digit to the LEDs defined in board.h as either LED_8SEG_ADDR or LED_1_ADDR. If $n$ is greater than 16, a dot displays in the eight-segment LED. Entering -1 clears the display.

led_debug

void led_debug (char id, int a int b int c int d)

This routine uses LED output to display the ID and the four values, if SWITCH_ADDR is defined. It loops displaying these values until any switch is changed. If SWITCH_ADDR is not defined, the routine loops four times displaying these values.

led_output()

void led_output (char id, int a int b int c int d)

This routine displays multiple values for debugging. The ID displays as two hex characters on the eight-segment or individual LED; the four and abcd values display as eight-digit hex values. A long pause precedes the hex digits.

void leds()

void leds(int value, int mask)

Use this function with an $n$-segment bar LED. The mask specifies which segments are being changed, and the value specifies the new value for the segments. A value of 1 indicates the segment is lit. A bitwise and is performed on the value and mask to determine whether each segment is lit or extinguished. For example, the call leds(4, 5) extinguishes segment 0 (bit 0 of mask is 1 and bit 0 of value is 0) and lights segment 2 (bit 2 of mask and bit 2 of value are both 1). All other segments are unchanged. The segments currently used are:
8-Segment LED or Value | Description
--- | ---
LED 0 on or 1 | in `serial_read()`
LED 1 on or 2 | in `serial_write()`
LED 2 on or 4 | application is executing
LED 3 on or 8 | parallel or PCI download is in progress

If no LEDs are available, or fewer than four user LEDs are available on the board, and an eight-segment LED is available, this routine uses the eight-segment LED to display value and adds the dot.

**pause()**

```c
void pause()
```

This routine causes a delay so values in LEDs are visible before they change. The following table provides pause times and speeds for various architectures:

<table>
<thead>
<tr>
<th>Table 5-8</th>
<th>Pause Times for Pause Routine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Times</strong></td>
<td><strong>Architecture</strong></td>
</tr>
<tr>
<td>0x10000 for 16 to 20 MHz</td>
<td>Kx or Sx</td>
</tr>
<tr>
<td>0x40000 for 25 to 33 MHz</td>
<td>Jx, Hx, Cx, RP</td>
</tr>
</tbody>
</table>

**Serial Device Driver Routines**

The monitor code includes I/O device drivers for the Intel 82510 UART and the National Semiconductor 16552 and 16550 DUARTs. The driver routines are in the `82510.c` (UART) and `16552.c` (both DUARTs) files, respectively.
If your board uses the 82510 UART, you must modify the definitions of the following constants in the board-specific include file (`board.h`):

<table>
<thead>
<tr>
<th>Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I510BASE</td>
<td>the base address of the 82510</td>
</tr>
<tr>
<td>I510DELTA</td>
<td>the spacing between the hardware registers</td>
</tr>
<tr>
<td>XTAL</td>
<td>the frequency of the baud rate crystal as defined by the hardware</td>
</tr>
<tr>
<td>ACCESS_DELAY</td>
<td>the number of memory cycles between UART accesses</td>
</tr>
</tbody>
</table>

If your board uses the 16552 DUART, you must modify the definitions of the following constants in the board-specific include file:

<table>
<thead>
<tr>
<th>Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUART</td>
<td>the base address of the 16552</td>
</tr>
<tr>
<td>DUART_DELTA</td>
<td>the spacing between the hardware registers</td>
</tr>
<tr>
<td>XTAL</td>
<td>the frequency of the baud rate crystal</td>
</tr>
<tr>
<td>DFLTPORT</td>
<td>the port to use, defined as <code>CHAN1</code> or <code>CHAN2</code></td>
</tr>
<tr>
<td>ACCESS_DELAY</td>
<td>the number of memory cycles between UART accesses</td>
</tr>
</tbody>
</table>

If your board uses a 16550 DUART, set `DUART_DELTA=1`, `DFLTPORT=CHAN2`, and use `CHAN2` for I/O.

The serial driver is separated into two modules: the routines in `serial.c` and the routines in either `82510.c` or `16552.c`.

The `serial.c` file contains high-level routines that are not specific to a particular UART, but can be implemented differently on some boards. You normally do not change `serial.c` unless your board or UART has unusual requirements. The calling conventions for the routines in `serial.c` are listed below:

```c
int calc_looperms(void)
```
int serial_baud(int port, unsigned long baud)
int serial_open(void)
int serial_read(int port, unsigned char *buf, int len, int timo)
int serial_write(int port, const unsigned char *buf, int len)

Routines in 82510.c and 16552.c

The files 82510.c and 16552.c contain low-level, device-specific routines. These files have to be changed to work with any other type of UART. The routines in 82510.c and 16552.c are listed below:

serial_getc()

int serial_getc(void)

This routine returns a character received if one is immediately available; otherwise it returns -1.

serial_init()

void serial_init(void)

This routine initializes the serial port. It is called by serial_open().

serial_intr()

int serial_intr(void)

The clear_break_condition() routine calls this routine when the monitor is entered because of a break interrupt from the serial port. It waits for the end of the break and clears the UART FIFO. It returns TRUE if the interrupt was caused by a BREAK condition. See clear_break_condition() for more information.
serial_loopback()

```c
void serial_loopback(int flag)
```

If `flag` is true, this routine enables loopback mode in the UART; otherwise the routine disables it. This routine is called by `calc_looperms()`. If your UART does not support loopback mode, you must change `calc_looperms()` in `serial.c`.

serial_putc()

```c
void serial_putc(int c)
```

This routine transmits the character.

serial_set()

```c
void serial_set(unsigned long baud)
```

This routine sets the baud rate for the serial port. Called by `serial_open()` and `serial_baud()`.

**Routines in flash.c**

The following routines are in the file `mon960/common/flash.c`:

```c
int check_eeprom (ADDR addr, unsigned long length)
int erase_eeprom (ADDR addr, unsigned long length)
void init_eeprom ( )
int is_eeprom (ADDR addr, unsigned long length)
int write_eeprom (addr start_addr, const void * data_arg, int data_size)
```

Flash memory is electrically erasable and programmable memory (EEPROM). Flash is useful for testing boot code and other non-volatile code that would usually be programmed into EPROM. The Cyclone evaluation boards feature flash memory. They use the Intel 28F020.
devices, so the programming algorithms in the monitor are for the Intel family of flash memory. Flash memory requires special programming and erasure algorithms. The monitor uses algorithms taken from the *Using the 28F020 Flash Memory, volume 1* (order number 210830-013).

The routines in `flash.c` can be used with any board that has one or more banks of supported bulk erase flash. The memory can be 1, 2, or 4 bytes wide. The driver erases and programs all devices in parallel.

You must define the following constants in the board-specific include file (`board.h`):

<table>
<thead>
<tr>
<th>Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>flash_ADDR</code></td>
<td>the base address of the flash memory.</td>
</tr>
<tr>
<td><code>FLASH_WIDTH</code></td>
<td>the number of devices that are accessed in parallel.</td>
</tr>
<tr>
<td><code>PROC_FREQ</code></td>
<td>the processor frequency in MHz. If you do not define <code>PROC_FREQ</code>, the flash initialization code calibrates the timing loop using <code>timer.c</code>. This process works properly even if you change to a processor with a different frequency. Note that the timer is used only during initialization; it is available to the application after that.</td>
</tr>
<tr>
<td><code>FLASH_TIME_ADJUST</code></td>
<td>set to 1. Or, if the routine is too fast for flash memory, set this to a higher number to increase flash delay times.</td>
</tr>
<tr>
<td><code>NUM_FLASH_BANKS</code></td>
<td>the number of flash banks on the board. The default setting is 1. Flash devices connected in sequence.</td>
</tr>
<tr>
<td><code>FLASH_ADDR_INCR</code></td>
<td>the size of each flash bank, expressed in bytes. This constant is used only if the board has more than one flash bank.</td>
</tr>
</tbody>
</table>

If you use this driver with a board that has more than one bank of flash, MON960 assumes that the banks’ addresses are continuous.
check_eeprom()

int check_eeprom(ADDR addr, unsigned long length)

This function checks to see if the memory at the specified address is flash memory and then checks to see if that memory is erased.

It returns one of the following values:

OK      EEPROM is erased
ERR     EEPROM is not erased or is not flash memory (ADDR addr, unsigned long length).

If addr is equal to the constant NOADDR, this routine checks all of the EEPROM. Otherwise, it checks from the specified address.

This routine sets cmd_stat to E_EEPROM_ADDR if the memory specified is not EEPROM. The routine sets cmd_stat to E_NO_FLASH if flash memory is not supported by this monitor or no flash memory is installed on the board. If the EEPROM is not erased, this routine sets cmd_stat to E_EEPROM_PROG and sets the following global variables:

eeprom_prog_first
eeprom_prog_last

erase_eeprom()

int erase_eeprom(ADDR addr, unsigned long length)

This routine erases the EEPROM at address addr to addr+length-1. It returns one of the following values:

OK      EEPROM is erased
ERR     EEPROM is not erased or is not flash memory (ADDR addr, unsigned long length).

If addr is equal to the constant NOADDR, this routine erases all of the EEPROM. Otherwise, it erases from the specified address.
If `length` is 0, `erase_eeprom()` erases the smallest erasable block starting with `addr`. If `length` is not 0, it must match exactly the length of one or more erasable blocks starting at `addr`. If these conditions are not met, the routine sets `cmd_stat` to `E_EEPROM_ADDR` and returns `ERROR` without attempting any erasure.

### `init_eeprom()`

```c
void init_eeprom(void)
```

The `init_hardware()` routine calls this function to determine the amount of flash memory on the board and initialize the values needed to program the flash memory.

This routine sets the variable `eeprom_size` to the size of EEPROM available. The `init_eeprom()` routine is not required if `init_hardware()` does not call it.

### `is_eeprom()`

```c
int is_eeprom(ADDR addr, unsigned long length)
```

This function checks whether the region of memory specified by `addr` and `length` is EEPROM. It returns `TRUE` if the region is EEPROM, `FALSE` if it is not, and `ERROR` if it is partially EEPROM and partially not. This function is called by `check_eeprom()`.

### `write_eeprom`

```c
int write_eeprom (addr start_addr, const void * data_arg, int data_size)
```

This routine writes the data at `data_arg` to start addr for data size bytes. It returns one of the following values:

- **OK**: Data was written at `data_arg`.
- **ERR**: Data was not written at `data_arg`.
Local Routines in flash.c

The local routines in the flash.c file are not intended for your use. They are documented here simply for your reference.

long loopcnt(int t)
int program_zero(ADDR addr, unsigned long length)
int program_word(ADDR addr, FLASH_TYPE data, FLASH_TYPE mask)
long time(int loops)

loopcnt()

long loopcnt(int t)

This routine returns the delay constant required to delay t microseconds. It uses the time constants calculated by init_eeprom().

program_zero()

int program_zero(ADDR addr, unsigned long length)

This function programs the specified region of memory with zeros. The erase_eeprom() routine calls this function to clear the flash memory before programming it.

program_word()

int program_word(ADDR addr, FLASH_TYPE data, FLASH_TYPE mask)

This function programs the specified address of flash with the specified data value. addr indicates the flash address to program. FLASH_TYPE data is the size of flash word, either 1, 2, or 4 bytes. The mask parameter indicates the bytes to change in the word. This function is called by program_zero() and write_eeprom().

time()

long time(int loops)
This function returns the length of delay time in nanoseconds for a delay loop of the specified length. The function uses the bentime default timer defined in timer.c. The time() routine is called by init_eeprom().

Routines in paradrvr.c

The routines in the paradrvr.c file are:

```c
void parallel_init
void parallel_err
int parallel_read(unsigned char * data, unsigned int size, unsigned short * crc)
```

**parallel_init()**

```c
void parallel_init()
```

This routine initializes the parallel device on board call before each parallel download. You must define the following constants in the board-specific include file:

```c
PP_DATA_ADDR   PP_ERR_BIT
PP_STAT_ADDR   PP_POUT_BIT
PP_CTRL_ADDR   PP_SEL_BIT
```

Furthermore, if your parallel hardware does not automatically toggle the ACKNOWLEDGE bit during an I/O transfer, you must uncomment/define PP_ACK_BIT and PP_NO_ACK_STROBE. (Refer to the code in parallel_read for examples of use.) Finally, if your parallel transfers proceed erratically, define the macro SECOND_CHECK_PP_READ_STATUS, which causes the monitor to read the status register twice for each transfer.

**parallel_err()**

```c
void parallel_err()
```

This routine sets the error status set for a bad parallel message.
**parallel_read()**

```c
int parallel_read(unsigned char * data, unsigned int size, unsigned short * crc)
```

This routine reads `size` bytes from the parallel port into `data`. If `crc` is not `NULL`, the routine adds `data` to `crc`. This routine returns `OK` or `ERR`. If `ERR` is returned, a serial break has interrupted `parallel_read()`. This routine can be found in `paradrvr.c`.

**Parallel Download Example Code**

In the MON960 software, three functions provide the parallel interface in `paradrvr.c`:

- `parallel_err()` sets the error bit so the host reverts to serial communications in the event of an error.

- `parallel_init()` identifies and initializes the parallel port to transfer communication from serial to parallel and to possibly test for connection to the appropriate port. This routine may be null if no initialization is needed.

- `parallel_read()` reads data sent from the host application through the parallel port.

To see how MON960 reads from a parallel device, refer to the actual source code in `paradrvr.c` in the `mon960/common` directory.
This chapter explains the theory and design of the monitor source code. The source code provides examples of the following:

- processor initialization
- fault handling
- stack switching
- use of the i960 processor debug features
- interrupt handling
- application parallel downloading
- general programming of the i960 processor

The information in this chapter is not required to retarget or use the monitor.

System Initialization

The monitor provides an initial memory image, a processor control block, a control table (for the i960 Jx/Hx/Cx/RP processors), a system address table (for the Kx/Sx processors), a system procedure table, a fault table, and an interrupt table. These data structures are in ROM during the initial boot.

The monitor uses the following initialization data structures for the Jx/Hx/Cx/RP processors:

- 12 word initialization boot record (IBR) located at address 0xffffff00.
- Processor control block (PRCB). This table is located on a quad-word boundary and is 40 bytes long.
- System procedure table (SPT). This table is located on a quad-word boundary and is a minimum of 48 bytes long.
MON960 Debug Monitor User's Guide

- Control table. This table is located on a quad-word boundary. This table is 112 bytes long.
- Interrupt table located on a word boundary.
- Supervisor stack pointer.
- Fault table.
- Interrupt stack pointer.

The monitor uses the following initialization data structures on the i960 Kx/Sx processors:
- Eight checksum words located at address 0.
- System address table (SAT). This table is located on a four-kilobyte boundary and is 176 bytes long. In the monitor, it is located at address 0 with the checksum embedded in its first eight words. (These eight words would not otherwise be used in the SAT.)
- Processor control block (PRCB). This table is located on a quad-word boundary and is 172 bytes long.
- System procedure table (SPT). This table is located on a quad-word boundary and is a minimum of 48 bytes long.
- Interrupt table. This table is located on a word boundary.
- Supervisor stack pointer.
- Fault table.
- Interrupt stack pointer.

See the reference manual for your processor for more information on the contents of these initialization elements.

The init.s file contains the monitor's initializations for the i960 processor. Table 6-1 lists the monitor initialization routines and tasks each routine performs. Note that the main program name has changed to mon960_main. This allows you to easily link your program into MON960.
### Table 6-1 Monitor Initialization Routines

<table>
<thead>
<tr>
<th>Routine</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>start_ip()</td>
<td>Call <code>pre_init</code> for board-specific initializations (enable RAM, self-test).</td>
</tr>
<tr>
<td></td>
<td>Initialize <code>monitor</code> data in RAM.</td>
</tr>
<tr>
<td></td>
<td>Copy processor data structures to RAM.</td>
</tr>
<tr>
<td></td>
<td>Call <code>set_prcb</code> to initialize the system tables.</td>
</tr>
<tr>
<td></td>
<td>Reinitialize the processor, using <code>sysctl (Jx/Hx/Cx/RP)</code> or <code>IAC (Kx/Sx)</code></td>
</tr>
<tr>
<td></td>
<td>Call <code>fix_stack</code> to turn off the interrupted state and change to the <code>monitor</code> stack.</td>
</tr>
<tr>
<td></td>
<td>Branch to main.</td>
</tr>
<tr>
<td>mon960_main()</td>
<td>Call the <code>init_regs</code> routine.</td>
</tr>
<tr>
<td></td>
<td>Call <code>init_hardware</code> for board-specific initialization.</td>
</tr>
<tr>
<td></td>
<td>Call the <code>init_monitor</code> routine.</td>
</tr>
<tr>
<td></td>
<td>Call <code>monitor</code>.</td>
</tr>
<tr>
<td>init_regs()</td>
<td>Initialize user register set.</td>
</tr>
<tr>
<td>init_monitor()</td>
<td>Use boot value of g0 to determine processor stepping</td>
</tr>
<tr>
<td></td>
<td>(Jx/Hx/Cx/RP only).</td>
</tr>
<tr>
<td></td>
<td>Call <code>get_int_vector</code> and set up break interrupt vector.</td>
</tr>
<tr>
<td></td>
<td>Call the <code>com_init</code> routine.</td>
</tr>
<tr>
<td>monitor()</td>
<td>Call <code>com_reset</code> to initialize communications if this is the first <code>monitor</code> entry.</td>
</tr>
<tr>
<td></td>
<td>Call <code>hi_main</code> if connected to host debugger.</td>
</tr>
<tr>
<td></td>
<td>Call <code>ui_main</code> if not connected to host debugger.</td>
</tr>
<tr>
<td>com_init()</td>
<td>Initialize the communication system.</td>
</tr>
<tr>
<td></td>
<td>Initialize the serial port.</td>
</tr>
<tr>
<td>com_reset()</td>
<td>Wait for host or terminal connection and set baud rate.</td>
</tr>
</tbody>
</table>
When the monitor begins initialization, it copies the initialized data area (data section) from ROM to RAM, so initialized variables have the correct initial values. Then the monitor initializes the bss section to 0.

The processor control block (PRCB) contains information for transferring program control when the processor encounters a change of state (e.g., an interrupt, fault, or system call). The PRCB contains pointers to the other major data structures that the processor uses to handle these state changes. The PRCB is cached on chip at processor initialization, but must be located in RAM before changes can be made to data structures. The other tables also must be moved to RAM to enable substitution of the default entries. Once the new PRCB is in RAM, the monitor changes the pointers in the PRCB to reflect the fact that the other tables are located in RAM.

The processor continues to use the old PRCB for state changes until otherwise notified. To notify the processor of the new PRCB now located in RAM, the monitor issues a reinitialize sysctl or IAC telling the processor to use the new PRCB.

After the reinitialization, the processor is in an interrupted state, running on the interrupt stack. To get out of the interrupted state, the code in the monitor sets up a simulated interrupt record on the stack in preparation for simulating a return from interrupt. The return from interrupt bit is set in the previous frame pointer (PFP). The desired process controls and arithmetic controls are set up in the simulated interrupt record. The return (from interrupt) loads the process control and arithmetic control registers from the interrupt record. The code to do this step is in the fix_stack() routine in the init.s file.

The process controls are set so that the monitor runs at priority 31 with tracing turned off. With priority set at 31, only a non-maskable interrupt, such as BREAK over the serial line, takes precedence. The arithmetic controls are set up so that all of the floating point and integer fault masks are set. The fault masks enable the processor to continue executing when questionable arithmetic results are obtained.
The monitor User Interface calls one of the following routines when it finishes initialization and each time the application stops:

```c
void hi_main(const STOP_RECORD *stop_reason)
void ui_main(const STOP_RECORD *stop_reason)
```

For the first call after initialization, `stop_reason` is `NULL`; otherwise it contains information about why the application stopped. These calls do not return a value.

The `ui_main()` routine is called when the serial autobaud mechanism recognizes a carriage return, indicating that a terminal is attached, or after an `rs` command from the terminal interface. Otherwise, `hi_main()` is called to connect to a debugger.

**Faults**

The monitor requires the use of the trace-fault entry in the fault table. A trace fault is generated whenever the processor encounters a breakpoint or trace condition. On the i960 Jx/Hx/Cx/RP processor, the trace-fault entry references procedure 255 in the system procedure table. On the Kx/Sx, the trace-fault entry references procedure 0 in the trace-fault procedure table. The trace-fault procedure table is used because tracing must be disabled when a trace fault is taken. On the Kx/Sx, tracing is disabled when any type of fault is taken.

The monitor also initializes all other fault entries. On the Kx/Sx, these entries are initialized to the same trace fault procedure table entry as the trace fault. On the i960 Jx/Hx/Cx/RP processor, all other fault entries are initialized to system procedure 256. The default handler enters the monitor and reports the fault. The application is free to changes these entries to its own system procedures or local fault handlers. On the Kx/Sx, the trace fault procedure table is in ROM. Therefore, if the application changes a fault entry to call its own supervisor procedure entry, it must change the second word of the fault entry to `0x27f` to reference the regular system procedure table.
The i960 processor recognizes three types of stacks: the user stack, the supervisor stack, and the interrupt stack. The monitor defines these three stacks, which can be used by the application program, but it does not use any of them. The monitor explicitly changes to its own stack (monitor_stack) and does not use supervisor calls, so the processor never implicitly changes to one of the other stacks while the monitor is running. However, if an interrupt programmed by the application occurs while the monitor is running, the processor changes to the interrupt stack to service the interrupt. Figure 6-1 shows the Application Stack and monitor Stack. In the section labeled Application Stack is whichever of the three stacks the application program is using when a fault occurs.
Figure 6-1    Stack Switch

- Points to Previous Frame
- Points to Program Faulting Frame
- Points to Application Program Frame

Application Stack:
- PFP
- SP
- RIP
- Local Register Space for This Frame
- Stack Space for Application Program Frame
- Fault Data
- Process Controls
- Arith Controls
- Fault Instr Addr
- Local Register Space for Fault Handler

Monitor Stack:
- PFP (0)
- Local Register Space for Mon960 Frame

Low Memory
- Application Program Frame
- Fault Record
- This Address is Reported by Fault Handler
- Mon 960 Frame
- Monitor Stack

High Memory
- Fault Handler Frame (Discarded by Fault Handler)
The processor uses the interrupt stack after a reset. The monitor switches to `monitor_stack` when it takes the processor out of its initial interrupted state. See the System Initialization section for more information on initialization.

The monitor runs as much in its own stack space as possible. When a fault occurs, the processor creates the fault record and stack space for the fault handler at the end of the faulting frame. The monitor then switches the Stack Pointer (SP) to point to `monitor_stack` immediately upon entering the fault handler. The stack switch is done with the `switch_stack()` routine in the `entry.s` file.

When starting the application program, the monitor switches the frame pointer and stack pointer to `user_stack`. When returning to the application program after a breakpoint, the monitor restores the stack pointer and frame pointer to their values before the breakpoint.

**Program Execution**

The monitor is transparent and non-intrusive to application programs. When you are debugging a program under the monitor (setting breakpoints, displaying registers, displaying memory, single-stepping), the processor actually alternates between executing your application program and executing the monitor.

Programs linked to run with the monitor must be linked with the `crt960.o` and `libll.a` library files. The `libll.a` file provides links between low-level I/O routines in the monitor and the high-level C library I/O calls.

The run-time initialization for your program is provided by `crt960.o`. Your application program is sandwiched between a startup routine and an exit routine. The startup routine sets up the stack and the arithmetic-controls register, initializes the libraries, and calls `main()`. If `main()` ever returns, the startup routine calls `exit()`.
When you debug a program using the monitor, and a breakpoint or trace event occurs, the monitor changes to its own stack, flushes the cached local register sets to their respective stack frames, and stores the global registers in memory to preserve the current state.

When you use the `go` command to continue execution from the current instruction pointer, the monitor switches control back to the application program. The monitor loads all the registers with the correct values stored in memory and starts the application running with a return from fault. This fault return switches the stack back to the application stack.

**System Calls**

The `libll.a` file is a library that provides the links between low-level I/O routines in the monitor and the high-level C library I/O calls like `printf()`. The routines in the `libll.a` file all result in system calls through the system procedure table to the routines in the monitor that handle the actual operations. The monitor half of the routines are located in the files `runtime.c`, `hi_rt.c`, and `ui_rt.c`. Each routine in `runtime.c` determines whether the request must be passed to the host system or handled by the monitor terminal interface, and calls the corresponding routine in `hi_rt.c` or `ui_rt.c`.

For example, suppose the application program calls `printf()`. After formatting output, `printf()` calls `write()`. The `write()` routine is in the `libll.a` library. Both of these routines are linked with the application program. The `write()` routine executes a `calls` instruction to the monitor entry point called `_sdm_write`. The behavior of `_sdm_write` depends on whether the application was started from the terminal interface or the host interface.

If the application was started from the terminal interface and the file descriptor (`fd`) is `STDOUT` (with value 1), the monitor writes the contents of the buffer to the terminal. If the application was started from the host interface, the monitor sends a packet to the host containing the arguments and the contents of the buffer. The host processes the runtime request and returns a response.
The monitor Core delays processing of unhandled interrupts that occur during a runtime request until the host has responded to the request. That is, it notes that the interrupt occurred, and returns from the interrupt handler; then when the runtime request or response is completed, the monitor Core responds as if the interrupt occurred at that time.

The system call returns 0 for success. Otherwise it returns an error code. The library routine places this error code in the global variable \texttt{errno}, and returns \texttt{-1}.

This sequence of calls is illustrated in Figure 6-2.

\textbf{Figure 6-2} \hspace{1em} MON960 System Call Sequence

![MON960 System Call Sequence Diagram](diagram.png)
When the monitor is not controlled by a host-based debugger, the only requests that can be executed are `read()` with `fd = 0`, `write` with `fd = 1` or `fd = 2`, and `isatty()`, which returns `TRUE` when `fd` is 0, 1, or 2. Other requests or argument values return with an appropriate error status. The include file `sdm.h` contains the following system calls to support the C compiler libraries:

```c
int _sdm_open(const char *filename, int mode, int cmode, int *fd)

int _sdm_read(int fd, char *buf, int size, int *nread)
int _sdm_write(int fd, const char *data, int size, int *nwritten)

int _sdm_lseek(int fd, long offset, int whence, long *new_offset)

int _sdm_close(int fd)

int _sdm_isatty(int fd, int *result)

int _sdm_stat(const char *path, void *bp)
int _sdm_fstat(int fd, void *bp)
int _sdm_rename(const char *old, const char *new)
int _sdm_unlink(const char *path)
int _sdm_time(long *time)

int _sdm_system(const char *cp, int *result)

int _sdm_arg_init(char *buf, int len)
void _sdm_exit(int exit_code)
```

Note that with release 3.1, the names of these library functions have been changed from `sdm*` to `_sdm*`. This allows a user program linked into MON960 to make all library calls.

**Downloading with Xmodem**

When the monitor is executing in User Interface mode and receives a download command, it waits for the terminal program to initiate the Xmodem protocol. The terminal program sends the COFF file in 128-byte
packets. As the monitor receives each packet, it verifies the checksum at the end of the packet. If the checksum is correct, the monitor sends an acknowledge (ACK) signal back to the terminal program. If the checksum is incorrect, the monitor sends a negative acknowledge (NAK) and the terminal program retries the packet.

As the monitor successfully receives each packet, it locates the text and data sections of the COFF file and copies the contents to the proper memory locations.

After the last packet is sent and acknowledged, the terminal program sends an end of transmission (EOT), and the monitor returns to the terminal interface prompt.

In contrast, the host interface in the monitor, which is employed by the debugger, for example, does not use the download command or the Xmodem protocol. The debugger uses the write_mem command to write the code and data to target memory.

**High Speed Downloading**

The monitor allows parallel or PCI downloading of executable files to the target. For additional information on downloading, see Chapters 2, 4, and Appendix B.

**Parallel Download**

A host application initiates a parallel download by calling hdi_download() and passing appropriate information in the fast_config parameter (a pointer to a DOWNLOAD_CONFIG structure). The following pseudo code shows example initialization:

```c
#include <hdil.h>

DOWNLOAD_CONFIG cfg;

cfg.download_selector = FAST_PARALLEL_DOWNLOAD;
```
Theory of Operation

```c
cfg.fast_port = "lpt1"; /* typical for Windows, Unix
device names vary */ ...

hdi_download(..., &cfg, ...);

hdi_init_app_stack();

...
```

Alternately, a host application may choose to bypass `hdi_download()` and perform the file transfer using its own loader. In that case, the following series of HDI calls may be used to effect a parallel download:

1. Optionally determine whether the target is capable of parallel download operations:
   ```c
   if (hdi_fast_download_set_port(PARALLEL_CAPABLE) == OK) {
     ...
   }
   ```

2. Call `hdi_fast_download_set_port()` with a properly initialized `DOWNLOAD_CONFIG` structure:
   ```c
   #include <hdil.h>
   `DOWNLOAD_CONFIG` cfg;
   cfg.download_selector = FAST_PARALLEL_DOWNLOAD;
   cfg.fast_port = "lpt1"; /* typical for dos */
   if (hdi_fast_download_set_port(&cfg) == OK) {
     ...
   }
   ```

3. Actually download the executable by calling `hdi_mem_write()` to write text and data sections to target memory, and by calling `hdi_mem_fill()` to fill target memory with a single value.

4. Close the parallel download communication channel and then establish a small bootstrap stack for the application:
   ```c
   hdi_fast_download_set_port(END_FAST_DOWNLOAD);
   hdi_init_app_stack();
   ```
PCI Download

A host application initiates a PCI download by calling hdi_download() and passing appropriate information in the fast_config parameter (a pointer to a DOWNLOAD_CONFIG structure). Because HDI permits specification of a PCI device address in one of three ways, initializing the DOWNLOAD_CONFIG structure requires more work than parallel download. The comments at the bottom of the COM_PCI_CFG data structure in hdi_com.h describe all three addressing scenarios. For the purpose of discussion here, the following pseudo code illustrates PCI download. It selects the target using the simplest possible PCI address -- the default PCI vendor ID.

#include <hdil.h>

DOWNLOAD_CONFIG cfg;

cfg.download_selector = FAST_PCI_DOWNLOAD;
cfg.fast_port = PCI_UNUSED_FAST_PORT;
cfg.init_pci.comm_mode = COM_PCI_MMAP; /* or COM_PCI_IOSPACE */
strcpy(cfg.init_pci.control_port, last_4_chars_of_controlling_serial_port);
cfg.init_pci.func = COM_PCI_DFLT_FUNC;
cfg.init_pci.bus = COM_PCI_NO_BUS_ADDR;
cfg.init_pci.vendor_id = COM_PCI_DFLT_VENDOR; /* currently Cyclone */ ...
hdi_download(..., &cfg, ...);

hdi_init_app_stack();
...

Again, a host application may choose to bypass hdi_download() and perform the PCI file transfer using its own loader. In that case, use the following series of HDI calls to effect a PCI download:
1. Optionally determine if the target is capable of PCI download operations:
   
   ```c
   if (hdi_fast_download_set_port(PCI_CAPABLE) == OK) {
   ...
   }
   ```

2. Call `hdi_fast_download_set_port()` with a properly initialized `DOWNLOAD_CONFIG` structure:
   
   ```c
   #include <hdil.h>
   DOWNLOAD_CONFIG cfg;
   cfg.download_selector = FAST_PCI_DOWNLOAD;
   cfg.fast_port = PCI_UNUSED_FAST_PORT;
   strcpy(cfg.init_pci.control_port, last_4_chars_of_controlling_serial_port);
   if (hdi_fast_download_set_port(&cfg) == OK) {
   ...
   }
   ```

3. Actually download the executable by calling `hdi_mem_write()` to write text and data sections to target memory and by calling `hdi_mem_fill()` to fill target memory with a single value.

4. Close the PCI download communication channel and then establish a small bootstrap stack for the application:
   
   ```c
   hdi_fast_download_set_port(END_FAST_DOWNLOAD);
   hdi_init_app_stack();
   ```
Monitor Core Source

The source files that make up the monitor core are:

- `aplnksup.c`
- `ghist.c`
- `kx_break.c`
- `no_timer.c`
- `asm_supp.s`
- `go_user.c`
- `leds_sw.c`
- `pci.c`
- `bentime.c`
- `hj_timer.c`
- `main.c`
- `rp.s`
- `break.c`
- `hx.s`
- `mem.c`
- `rp_break.c`
- `commcfg.c`
- `hx_break.c`
- `monitor.c`
- `rp_cpu.c`
- `cx.s`
- `hx_ibr.c`
- `no_aplnk.c`
- `rp_step.c`
- `cx_break.c`
- `hx_step.c`
- `no_flash.c`
- `runtime.c`
- `cx_ibr.c`
- `init.s`
- `no_ghist.c`
- `serial.c`
- `cx_step.c`
- `jx.s`
- `no_pci.c`
- `set_prcb.c`
- `entry.s`
- `jx_break.c`
- `no_post.c`
- `timer.c`
- `fault.c`
- `jx_ibr.c`
- `no_post.s`
- `unimplmt.c`
- `flash.c`
- `jx_step.c`
- `no_serl.c`
- `version.c`
- `float.s`
- `kx.s`
- `no_time.c`

The rest of this section describes the variables and routines the Core provides to the terminal interface and host interface.

### Variables

The following global variables are defined by the monitor core. They are for use by other parts of the monitor. They cannot be used by the application.

- `int cmd_stat;`  
  Error status of the last call to the monitor core.

- `int break_flag;`  
  Set to `TRUE` when break is received on the RS232 port.

- `int break_vector;`  
  Serial break interrupt vector.

- `UREG register_set;`  
  Saves values of application's registers.
FPREG fp_register_set [NUM_FP_REGS];  Saves values of application's floating point registers.

const int have_data_bpts;  TRUE when this architecture supports data breakpoints.

const char base_version[];  Contains a version string of the board-independent portion of the monitor.

int host_connection;  TRUE when the monitor is connected to a host debugger.

char *step_string;  String containing stepping information for the i960 Jx/Hx/Cx/RP processor. The value is NULL when the processor is not a Jx/Hx/Cx/RP processor, or when stepping information is not available.

**Routines**

The following routines are defined by the monitor core for use by other parts of the monitor. They must not be called by the application.

**prepare_go_user()**

```c
int prepare_go_user(int mode, int bp_flag,
                   unsigned long bp_instr)
```

Starts executing the application. This call does not return unless an error occurs.

The argument `mode` is one of the following:

- `GO_RUN`
- `GO_SHADOW`
- `GO_STEP`
- `GO_NEXT`
- `GO_BACKGROUND`

See the description of the `hdi_targ_go()` routine in Chapter 8 for more information on the values of `mode`. 

When `bp_flag` is TRUE, the `go_user()` routine steps over a software breakpoint at the current IP. The variable `bp_instr` is the original instruction word that was replaced by the breakpoint. When `bp_flag` is FALSE, `bp_instr` is ignored.

**load_mem()**

```c
int load_mem(ADDR addr, int mem_size, void *buf,
             int buf_size)
```

Reads `buf_size` bytes of memory into `buf` from `addr`, using `mem_size` byte read instructions.

**store_mem()**

```c
int store_mem(ADDR addr, int mem_size, void *data,
              int data_size, int verify)
```

Writes `data_size` bytes of memory at `addr` from `data`, using `mem_size` byte write instructions. When `verify` is TRUE, verifies that the data was stored correctly.

**fill_mem()**

```c
int fill_mem(ADDR addr, int mem_size, void *data,
             unsigned long data_size, int count)
```

Fills memory with `count` copies of data, using `mem_size` byte write instructions and verifies that the data was stored correctly.

**copy_mem()**

```c
int copy_mem(ADDR dest, int dest_mem_size, ADDR src,
             int src_mem_size, int length)
```

Copies `length` bytes from `src` to `dest`, using `src_mem_size` byte read instructions and `dest_mem_size` byte write instructions and verifies that the data was stored correctly.

**verify_mem()**

```c
int verify_mem(ADDR addr, int mem_size, void *data, int data_size)
```
Compares `data_size` bytes of memory at `addr` to `data`, using `mem_size` byte read instructions.

**set_bp()**

```c
int set_bp(int type, int flags, ADDR addr)
```

Sets a breakpoint at `addr`. The variable `type` is `BRK_HW` or `BRK_DATA`. When `type` is `BRK_HW`, `addr` must be aligned on a word boundary. See the `hdi_bp_set()` routine in Chapter 8 for a description of `flags`. Note that the monitor does not support setting and clearing software breakpoints. Instead, the host handles software breakpoints. See the Host Debugger Interface Library section for information on the host debugger interface library.

**set_break_vector**

```c
void set_break_vector(int new_vector, PRCB *prcb)
```

Initializes the Break interrupt vector in the interrupt table used by `PRCB`. When `PRCB` is `NULL`, the current `PRCB` is used. When `new_vector` is `-1`, the current `break_vector` is used.

**clr_bp()**

```c
int clr_bp(ADDR addr)
```

Clears the breakpoint set earlier at `addr`.

**bptable_ptr()**

```c
const struct bpt *bptable_ptr()
```

Returns a pointer to the table of hardware and DATA breakpoints.

The following routines are in the system procedure table, so you can call them from your application. These routines also are used internally by the monitor.

**get_prcbptr()**

```c
PRCB *get_prcbptr()
```

Returns a pointer to the `PRCB` currently in use.
set_prcb()
void set_prcb (PRCB *new_prcb)

Initializes any required fields in new_prcb.

set_mon_priority()
void set_mon_priority (unsigned int priority)

Sets the minimum priority of the monitor. When the monitor is entered
due to a breakpoint or other reason, it raises the current processor priority
to this value, when the processor priority was lower.

get_mon_priority()
unsigned int get_mon_priority()

Gets the minimum priority of the processor while in the monitor.

User Interface Source

The source files that make up the User Interface are:

ui_main.c     parse.c     ui_break.c     convert.c
dis.c         disp_mod.c   download.c    trace.c
io.c          perror.c     fp.c          no_fp.c
ui_float.s    ui_rt.c     no_float.s    ui_stub.c
no_post.c

In monitor commands, all arguments represented by address or offset
must be written in hexadecimal, and any argument preceded by a “#” must
be written in decimal. Brackets “[ ]” indicate that an argument is optional.
When executing a command, any omitted, required argument results in an
error message stating that arguments are missing. The monitor commands
are detailed in chapter 4 of this guide.
Host Interface Source

The source files that make up the host interface are:

- hi_main.c
- hi_rt.c
- cx_cpu.c
- kx_cpu.c
- no_para.c
- fastdown.c
- paradrvr.c
- jx_cpu.c
- hi_stubs.c
- no_pci.c
- pcidrvr.c
- hx_cpu.c
- rp_cpu.c

Host-target Communications System

The communications system provides reliable, uniform communications routines that send and receive data records of various lengths between the host and the target. Both the host and target send and receive records and both initiate communication. Nearly all transfers from the target to the host, however, are responses to commands issued by the host.

This interface is independent of the underlying implementation, and can select among multiple communications paths at runtime. The higher layers of the debugger (including HDIL) need not know what communications path is in use. The code that implements the communications interface layer is generic for all hosts, targets, and communications paths.

The monitor uses an error-detecting communications protocol to ensure that all data sent between the monitor and the debugger is received correctly. All data transmitted is enclosed in a packet, which includes fixed values to ensure synchronization and a CRC to ensure data integrity. Every packet must be acknowledged by the receiver (ACK) when its correctness is verified. If an incorrect packet is received, the receiver responds with a negative acknowledge (NAK), and the sender retransmits the packet.

In the master-slave protocol of the monitor, the host is the default master. The monitor acts as master only while executing user code, during which time the host responds only to runtime service requests from the target.
The current implementation of the packet layer is for byte stream communications using serial or PCI hardware. The same packet layer is used by both the ends of the channel. The packet layer can be replaced for other types of communications paths (for example, Ethernet). More than one packet layer can be linked into the debugger, so that the communications interface layer can select the appropriate packet layer when the debugger is invoked by the user.

**Serial Device Driver**

The serial device driver is used by the serial packet layer; other packet layers can have the device specific code built into them or can have other device driver requirements. The serial device driver is also used in the target by the terminal interface to read ASCII user commands and write output. The implementation of the serial device driver is completely specific to a particular target board or host/operating system.

**Communications Hardware Requirements**

Hardware requirements for parallel and PCI download are discussed in Appendix B of this guide.

**Communications Packet Structure**

The monitor ensures the integrity of serial transfer records by enclosing them in packets. Each packet has a header, a data field, and a CRC (cyclical redundancy check). Table 6-2 lists the packet fields and value ranges.
Table 6-2  Packet Field Values

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>start of header</td>
<td>0x1</td>
</tr>
<tr>
<td>encoded_length_low</td>
<td>0x60 - 0x9f</td>
</tr>
<tr>
<td>encoded_length_high</td>
<td>0x60 - 0x9f</td>
</tr>
<tr>
<td>packet_number</td>
<td>0x0 - 0xff</td>
</tr>
<tr>
<td>start of text</td>
<td>0x2</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
<tr>
<td>(data)</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
<tr>
<td>end of text</td>
<td>0x3</td>
</tr>
<tr>
<td>crc_low</td>
<td>0x0 - 0xff</td>
</tr>
<tr>
<td>crc_high</td>
<td>0x0 - 0xff</td>
</tr>
</tbody>
</table>

The record length, encoded in the `encoded_length_low` and `encoded_length_high` fields, is between 0 and 4095 bytes. To derive this value from the encoded information in the packet, do the following:

1. Subtract 0x60 from each of the `encoded_length` bytes, giving a six-bit value between 0x0 and 0x3f.
2. Concatenate the two resultant six-bit units ( `_low` to the lower end and `_high` to the higher end).
3. Read the result as a 16-bit value, filling the most-significant four bits with zero-bits.

The packet number is used to check for repeated packets. If a message contains only one packet, the packet number is zero. Otherwise the numbers start at one and increment for each packet that is part of the same message.

The 16-bit CRC is computed on all bytes of the packet except the three constant bytes and the CRC bytes.
Serial Autobaud

The monitor adjusts automatically to the host baud rate. The monitor calls the `serial_baud()` routine to set the baud rate to a known rate and then waits for a byte from the host. Based on the byte the monitor receives, it determines the baud rate the host is using and calls `serial_baud()` again to set that baud rate. At 9600 baud, the byte transmitted by the host is `0x5a`. The Monitor responds with an ACK (`0x06`).

The RS-232 table supports baud rates from 1200 to 115200 baud. Additionally, this RS-232 table supports autobaud from a terminal by pressing Enter.

The host and the target must use the same table. Note that the baud rate range supported by the table does not imply that any given host or target supports these rates.

MON960 Support for PCI Communication

In MON960, three files support PCI communication:

- `commcfg.c` contains the code that determines whether the host requests serial or PCI communication.
- `cl45_hw.c` or `cyrp_hw.c` and `pci_serv.c` contains the PCI initialization code for the Cyclone PCI80960DP or 80960RP evaluation boards respectively.
- `pcidrvr.c` contains the MON960 PCI driver code. This code is specific to the PLX PCI9060 chip or the 80960RP CPU chip and contains the following routines:
### Table 6-3  pcidrvr.c Routines

<table>
<thead>
<tr>
<th>Routine</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>pci_supported</td>
<td>determines whether the target supports PCI</td>
</tr>
<tr>
<td>pci_inuse/pci_not_inuse</td>
<td>sets/resets the in-use status bit</td>
</tr>
<tr>
<td>pci_init</td>
<td>initializes the PCI interface</td>
</tr>
<tr>
<td>pci_connect_request</td>
<td>completes the host connection</td>
</tr>
<tr>
<td>pci_err</td>
<td>sets the error status bit and resets the data transfer status bits</td>
</tr>
<tr>
<td>pci_intr</td>
<td>resets doorbell bit 31 to turn off the interrupt</td>
</tr>
<tr>
<td>pci_write_data_mb</td>
<td>writes a 32-bit value to verify that the PCI download serial channel is correct</td>
</tr>
<tr>
<td>pci_read</td>
<td>reads data from the host</td>
</tr>
<tr>
<td>pci_write</td>
<td>writes data to the host</td>
</tr>
<tr>
<td>pci_dev_open</td>
<td>opens the PCI bus for PCI communication</td>
</tr>
<tr>
<td>pci_dev_close</td>
<td>ends PCI communication</td>
</tr>
<tr>
<td>pci_dev_read</td>
<td>reads packets using the PCI bus</td>
</tr>
<tr>
<td>pci_dev_write</td>
<td>writes packets using the PCI bus</td>
</tr>
</tbody>
</table>
Purpose

This chapter discusses the application’s execution environment, compiling an application, and related topics.

Execution Environment

The monitor sets up an environment for your application program. Your program can use this environment or create its own.

The monitor sets up the following:
- process control block (PRCB)
- system procedure table
- fault table
- interrupt table
- control table (Cx, Hx, Jx, and RP only)
- user stack, supervisor stack, and interrupt stack

System Procedure Table

The system procedure table has space for all 260 possible entries. The monitor reserves entries 220-259. The application can fill in the rest of the table with the values it requires. The monitor provides default routines for all system procedure table entries.
Fault Table

The fault table contains entries that point to the monitor's fault entry point. Entry 1 (trace fault) is reserved by the monitor. The rest of the entries can be changed by the application to point to its own fault handlers. The monitor provides a default fault handler for every entry in the fault table.

Interrupt Table

The interrupt table contains entries that point to the monitor's interrupt entry point. One entry is reserved by the monitor for the break key, which is used to break into the monitor during program execution. (For Cx, Jx, RP, and Hx targets, the break is typically NMI, while for Kx and Sx targets the break is typically \texttt{int0}.) The number of the reserved entry is the value returned by the \texttt{get_int_vector} routine, which is specified during retargeting. (See Chapter 5 for information on retargeting.) The application can change the rest of the entries.

\begin{footnotesize}
\textbf{NOTE.} The monitor provides a default interrupt handler for each interrupt vector.
\end{footnotesize}

Control Table

The control table for the i960 processors Cx, Jx, RP, and Hx is defined by the retargeting code. The monitor reserves the first four words and the BPCON register to support instruction and data breakpoints. The monitor uses the interrupt configuration registers to enable the BREAK interrupt, if the BREAK interrupt is not connected to NMI. The application must modify only those bits that it requires in the interrupt configuration registers so it does not disturb the monitor's interrupt. The rest of the control registers can be changed by the application as required.
Monitor Stacks

The monitor provides three stacks:
1. a user stack (_user_stack)
2. a supervisor stack (_trap_stack)
3. an interrupt stack (_intr_stack).

These stacks are defined in init.s. The frame pointer and stack pointer are initialized to point to the user stack. The pointer to the supervisor stack is in the system procedure table. This stack is used only if the application changes to user mode and then does a supervisor call. The pointer to the interrupt stack is in the PRCB, and has been cached by the processor when the application begins executing.

Changing the Environment

The i960 processors store various system environment information in the PRCB. The processors cache the PRCB on-chip, not in regular memory. Some applications change the environment (e.g., alter entries in the interrupt table). The PRCB makes such changes.

Change system information in one of two ways. One method allows changes to a value pointed to by a field in the PRCB. The second method allows changing of a field value in the PRCB.

Changing a Value Pointed to by a Field in the PRCB

To change a field value pointed to by the PRCB (e.g., write a new entry to the interrupt table), perform the following steps:
1. Call get_prcbptr() (system call 245) to get the address of the PRCB into register g0. The address of the Interrupt Table is stored in the PRCB.
2. Read the correct field of the PRCB to get the address of the Interrupt Table.
3. Write the new entry into the field of the Interrupt Table. Be careful not to overwrite one to MON960's reserved entries in any of the system tables.
**Changing a Value in a Field of the PRCB**

To create a new Interrupt Table by writing a new value in the Interrupt Table Base Address field of the PRCB itself, perform the following steps:

1. Create a new Interrupt Table in memory.
2. Call `get_prcbptr()` to get the address of the PRCB into register `g0`.
3. Write the address of your Interrupt Table into the appropriate field of the PRCB.
4. Call `set_prcb()` to let MON960 write its reserved entries into all PRCB related structures, including your new Interrupt Table.
5. Re-cache the processor. For an i960 Cx, Jx, Hx, or RP processor, execute the `sysctl` instruction. For an i960 Kx or Sx processor, execute the `IAC` instruction. See your processor user’s manual for details about these instructions.

**Creating a New PRCB**

In some situations, you may choose to create a new PRCB before making any modifications to the PRCB fields. To connect a new PRCB, perform the following steps:

1. Build your own PRCB in RAM.
2. Initialize the newly created PRCB pointers to the system data structures (e.g., the fault table, the interrupt table, and the system procedure table).
3. Fill in the data structures with your own values or existing table values.
4. Confirm that your PRCB contains valid fields, including pointers to all the appropriate tables for your processor architecture’s PRCB.
5. Call `set_prcb()` with the address of your new PRCB in register `g0`.
6. Re-cache the processor. For an i960 Cx, Jx, Hx, or RP processor, execute the `sysctl` instruction. For an i960 Kx or Sx, execute the `IAC` instruction. See your processor reference manual for details about these instructions.
NOTE. For the i960 Kx/Sx processors, the pointer to the system procedure table (SPT) is not in the PRCB. Rather, it is in the system address table (SAT) located in ROM. Therefore, the system procedure table cannot be relocated. However, the system procedure table can be written to. The address of the SPT is stored at offset 120 decimal in the SAT. Because the SAT is always at location 0 in ROM, your reinitialize IAC call must always use 0 for the SAT.

To use the C equivalents to calls 244 and calls 245 (set_prcb and get_prcbptr, respectively), include the file:

```
../../mon960/common/sdm.h
```

When a system call 244 (calls 244) is made, the following actions occur:

- The entry in the new interrupt table corresponding to the monitor's BREAK interrupt is set to point to the monitor's BREAK interrupt handler (usually the NMI interrupt).
- The trace fault entry in the new fault table is set to point to the monitor's trace fault handler.
- For i960 Cx, Jx, Hx or RP processors, entries 220 to 259 in the new system procedure table are set to the addresses of the monitor's system procedures. These are MON960's reserved entries.
- For i960 Cx, Jx, Hx or RP processors, the IP Breakpoint, Data Address Breakpoint, and Breakpoint Control entries of the old Control Table are copied into the new Control Table.

For Cx, Jx, or Hx processors, if you define an interrupt other than NMI for breaking into the debugger (ctrl-break), after a "SYSCTL reinitialize" instruction, the imap register needs to be set appropriately. Additionally, after a SYSCTL reinitialize, the stack pointer is set to the interrupt stack. However, it is possible to save the sp and fp registers to memory before issuing the SYSCTL reinitialize and then to restore them or set them to some other appropriate values afterwards.
After reinitialization, the state of the processor (process-controls register) is as follows:

- The trace-enable bit is set to 0. This must be set to one in order for breakpoints to occur in the debugger. Use a `modpc` instruction, as shown in the following example.
- The priority field (process priority) is set to 31. Lower this priority if you have interrupts set at lower priorities.
- The state-flag (state of the processor) is set to 1 (interrupted). Change this to 0 (executing) if necessary. This change is made in the `modpc` instruction in the example below.
- The trace-fault Pending Flag (bit 10), is set to 0 (No Fault Pending).
- The execution-mode bit is set to 1 (supervisor mode).

The following assembler code example shows the use of system call 244 (`set_prpcb()`) and system call 245 (`get_prpcbptr()`). It uses the Jx-, Hx- or Cx-specific instruction `sysctl` to cause the processor to reread the PRCB.

```
.global_change_prpcb
_change_prpcb:
lda 245, g1            #system call to get_prpcb,
calls g1                #it returns the
current PRCB            #in g0.
st g0, _save_prcb       #store current PRCB
                        #address

#At this point, a new fault table, interrupt table,
#system table, or control table may be installed using
#the pointer to the current PRCB in g0.
lda 244, g1            #system call to set_prpcb to
                         #inform the monitor that
                         #PRCB has been changed.
                         # Do a sysctl to cause the processor to re-read the PRCB
ld _save_prcb, r5       #PRCB address
lda restart_label, r4   #next instruction to execute
                        #after sysctl
```

```
lda 0x300, r3 #message type 300 for flushreg
st fp, __save_fp #save current fp to be restored after sysctl
st sp, __save_sp #save current sp to be restored after sysctl
sysctl r3, r4, r5
restart_label:
ld save_sp, sp
ld save_fp, fp
mov 0x1, r10
lda 0x2001, g13 #turn off interrupt bit and set trace enable bit, using the modpc instruction
modpc g13, g13, r10
mov r7, r7 #NOP instructions to allow the modpc instruction to complete.
mov r7, r7
mov r7, r7
mov r7, r7
.
.
.
.

If the application already knows the address of the PRCB, it is not necessary to do a `get_prcbptr()` call. The application can place the address of its new PRCB into `g0` and then call `set_prcb()` to inform the monitor that it is changing the PRCB. The monitor fills in the reserved fields in the tables with its required values. The application can then use a reinitialize IAC or `sysctl` instruction to cause the processor to read the new PRCB.

When the monitor starts executing your program, it sets the trace-enable bit in the process controls register, and sets the trace-controls register according to the trace mode enabled. The breakpoint trace bit is always set. The application must not change the trace-controls register or clear the trace-enable bit in the process controls register. Note, however, that a
reinitialize `sysctl`, a reinitialize IAC, or an interrupt clears the trace enable bit. The application should use the `modpc` instruction to set the trace-enable bit after any of these events.

## Libraries

This section describes the libraries that can be linked with an application so that it can work with the MON960 monitor.

### libll

The library provided with the compiler, `libll.a`, is a low-level library that works with the high-level libraries provided with the compiler. This library contains the entry points described in the *i960 Processor Library Supplement*, listed in your *Getting Started* guide. Each routine in the library makes a call through the system procedure table to the monitor, which completes the operation. Although the routines in this library can be called by the high-level library, they can also be called directly by the application, if desired.

In addition to the routines required by the high-level library, the `libll.a` file contains the following routines. The file `sdm.h` contains declarations of these routines as well as their system-procedure table indexes.

```c
void *get_prcbptr()
```

Returns the address of the currently active PRCB. The current PRCB is initialized by the monitor, but either a debugger or the application program can change it. (In the latter case, the application must inform the monitor that it is changing the PRCB by calling `set_prcb()`.) This routine can be used to access and change non-reserved fields in the PRCB and associated tables (system procedure table entry #245).

Informs the monitor that the application is about to change to a new PRCB. This must be done before doing a reinitialize IAC or a `sysctl` initialize. This enables the monitor to properly make use of the new tables. It also enables the monitor to fill in the values of required fields, so the application does not have to be dependent on a particular implementation of the monitor (system procedure table entry #244).

Sets the minimum priority of the monitor. When the monitor is entered due to a breakpoint or other reason, it raises the current processor priority to this value, if the priority was lower. The default value is 31, which means that all maskable interrupts are disabled while the monitor is running (system procedure table entry 247). If you want all interrupts enabled while in the monitor, set this value to 0. Do this when your interrupt handlers are fully debugged.

Returns the monitor priority described above (system procedure table entry 248).

These routines are in the `libmon.a` file.

These routines use a 32-bit interrupting timer.
init_bentime()

unsigned int init_bentime(x)
int x; /* unused */

This routine must be called before the first call to bentime(). It starts the
 timer and returns an unsigned integer that is the overhead in microseconds
 for the call to bentime().

NOTE. The argument x is unused, but is kept for compatibility.

bentime()

unsigned int bentime(void)

This routine returns the current timer value in microseconds. Note that the
timer is free running, so a call to bentime() returns only the current value
of the timer.

term_bentime()

void term_bentime(void)

This routine disables the bentime() timer interrupt and shuts down the
timer.

Non-interrupting Benchmark Timer

These routines use the 32-bit timer.

init_bentime_noint()

unsigned long init_bentime_noint(MHz)
int MHz; /*unused*/

This routine must be called before the first call to the bentime_noint()
routine. It starts the timer and returns an unsigned long integer value that
is the overhead in microseconds for the call to the bentime_noint() routine.
The argument MHz is unused, but is kept for compatibility. Instead, eight MHz is assumed.

**bentime_noint()**

```
unsigned long bentime_noint(void)
```

This routine returns the current timer value in microseconds. Note that the timer is free running, so a call to `bentime_noint()` returns only the current value of the timer.

**init_flash()**

```
init_flash(void)
```

This flash routine initializes the flash timer. It must be called before any other flash routines are called.

**program_flash()**

```
program_flash(start_addr, dataptr, bytes)
```

```
unsigned int start_addr;
unsigned int *dataptr;
int bytes;
```

This flash routine programs the flash memory at the `start_addr` for the given number of `bytes`. The `dataptr` argument is a pointer to the data to be copied.

**erase_flash()**

```
int erase_flash(void)
```

This flash routine erases the flash space using a whole-chip erase.

**set_mon_timer()**

**init_P_timer()**

**term_P_timer()**

These routines are used only by ghist960.
The rest of the library routines and system calls support the C compiler libraries.

### Compiling an Application Program

This section illustrates how to compile application programs using MON960. The `hello.c` file provided with the monitor source serves as an example to illustrate compiling.

---

**NOTE.** This section contains examples for the Intel compiler and iC-960 compiler driver. If you are using another compiler, consult your compiler manual for the correct syntax for compiler command lines.

---

To compile a program for running on the monitor, ensure that you have installed the compiler correctly and set the `I960BASE` environment variable.

The `hello.c` file provided with the monitor source turns the benchmark timer on and calls `puts("hello world!\n")`. It also calls `printf()` to output the time it took to print the message. You can compile `hello.c` without benchmark timing by deleting the timing code.

The following command line compiles `hello.c` for executing using the i960 SA architecture on the Cyclone cysx board:

```
ic960 -TCYSX -ASA -O2 -o hello.sa hello.c
```

- `-Tcysx` specifies the `cysx.ld` linker-directive file in the `I960BASE/lib` directory. The `cysx.ld` file links in `crt960.o` and `libll.a` from the `I960BASE/lib` directory.
- `-ASA` specifies the i960 SA architecture.
- `-O2` selects optimization level 2. (O is the capital letter Oh.)
-o hello.sa specifies hello.sa as the output file.

When you retarget the monitor, you must also change the linker-directive file used to link the applications to be debugged. The linker-directive file specifies what memory is available on the target board for the application, and where the base of the application stack is.

Interrupts

By default, the monitor starts executing the application at interrupt priority 31. Therefore, only priority 31 interrupts (and NMI for i960 Jx/Cx/Hx/RP processors) are serviced. You can set the priority of the application program in the process controls register by using the modpc instruction. The following code segment sets the program priority to zero:

```assembly
ldconst 0x001f0000, g0
ldconst 0, g1
modpc g0, g0, g1
mov g0, g0 #Note that the modpc instruction can
take up to 4 clock cycles to complete
mov g0, g0 #execution.
mov g0, g0
```

A protection fault occurs if the modpc is executed from user mode, so ensure that your program is in supervisor mode when changing priority. The monitor runs applications in supervisor mode by default. For more information on how the processor handles interrupts, see your architecture-specific manuals.

The monitor provides a default interrupt handler for each interrupt vector. The default handler stops execution and indicates that an unexpected interrupt was received. If an unexpected interrupt is received while the monitor is running, it is treated as a fatal error.

The application program must change any interrupt vectors it uses to point to its own interrupt handlers. A method for making that change is found in the set_timer_interrupt() routine, found in timer.

The set_timer_interrupt() routine first locates the interrupt table to enter a new vector into the table. The system call get_prcbptr() returns
the PRCB address. The PRCB contains a pointer to the interrupt table. This pointer can be used to replace the given entry in the interrupt table with a vector that points to the new interrupt routine. The following code replaces the default handler for the vector timer_vector in the interrupt table with the timer-interrupt routine timer_isr():

```c
#include "i960.h"
#include "sdm.h"
PRCB *prcb;  
INTERRUPT_TABLE *int_table;  
prcb = (PRCB *)get_prcbptr();  
int_table = prcb->interrupt_table_adr;  
int_table->interrupt_proc[timer_vector - 8] = timer_isr;
```

Note that 8 is subtracted from the interrupt vector number because interrupt_proc is defined in i960.h to point to the first usable vector, vector 8. For more information on the interrupt table, see your processor manual.

In a similar fashion, if you want to provide a fault handler, you can access the fault table through the PRCB to replace an entry in the fault table. This accessing technique is useful for writing application-specific fault handlers.

### Debugging Interrupt Routines

When debugging interrupt handlers, three different scenarios are possible involving interaction between the monitor and the interrupt routine. They are:

1. **The user program is running, an interrupt occurs, and a breakpoint is set in the interrupt routine**—When the breakpoint in the interrupt routine is hit, the break occurs. At that point you can perform normal debugger activities. To prepare an interrupt procedure for debugging, see the section below.

2. **The monitor has control and an interrupt occurs**—This is okay as long as there are no breakpoints of any kind in the interrupt routine. The interrupt is serviced and the monitor resumes upon completion of the interrupt.
3. The monitor has control, an interrupt occurs, and a breakpoint is set in the interrupt routine—This does not work and results in the monitor losing information about the state of the application. If you are using gdb960, or another host-based debugger, the host and target may lose communications. By definition, the monitor has control of the target except during a go command.

To avoid the third situation while the monitor has control, the processor priority must exceed the priority of any interrupts you are debugging. By default, the monitor priority is 31, and no interrupts occur while the monitor is running. (If the serial port interrupt is not NMI, the monitor priority is lowered to enable that interrupt.) If you have interrupts that you want serviced while the monitor has control, you can lower the monitor priority, but you cannot set breakpoints in those interrupt handlers. The monitor priority can be changed from the application by calling the system procedure set_mon_priority (system procedure table entry 247). If you are using a host-based debugger, it may have an option or command to set the monitor priority.

Due to the way the i960 processor family handles interrupts, you must set up the interrupt routine preamble correctly if you want to break inside the interrupt routine. When an interrupt occurs, the processor clears the trace-enable flag in the process-controls register. This disables all tracing features, including breakpoints. Therefore, your interrupt handler must set the trace-enable bit in order for a breakpoint to be recognized. Otherwise, the breakpoint is not recognized and your interrupt handler does not work properly because one of the instructions has been replaced with the breakpoint instruction. The following example uses the modpc instruction to set the trace-enable bit and the required additional mov instructions to allow the modpc instruction to complete:

```assembly
mov 1, r3
modpc 1, 1, r3
mov r3, r3
mov r3, r3
mov r3, r3
mov r3, r3
```
Faults and Interrupts While Executing

When a fault or interrupt occurs while the application program is executing and the application has not installed a handler for that fault or interrupt, the monitor stops execution and displays information about the fault or interrupt. The monitor also displays the address where the fault record or interrupt record was saved on the stack. This address is above the current sp, because the monitor unwinds the stack to the point where the fault or interrupt occurred. The address displayed is of the last four words of the fault record. Some types of faults store additional information below this address. See your architecture-specific manuals for information on the format and contents of the fault record.

The monitor saves the values for fp, ip, and other registers that they had just before the fault occurred. If you want to see the values of any registers inside the fault or interrupt handler, you can install a handler in the table and set a breakpoint at the first instruction of the handler.

i960 Processor Cache Invalidation by MON960

The i960 Jx/Cx/Hx/RP processor's instruction cache is invalidated by the monitor whenever the monitor passes control to the application. (This code is located in file entry.s in the routine _exit_mon().) Invalidating the cache is necessary because, while in the monitor, memory may have been changed (e.g., by setting a breakpoint). This invalidation may conflict with your use of the cache. In particular, if you use the cache to store interrupt handlers in the i960 Jx/Cx/Hx/RP processor, you will want to change the way the monitor invalidates the cache.

This can be done by changing the assembly routine flush_cache(), which is in the file ca.s for the i960 Jx/Cx/Hx/RP architecture. As provided, this routine executes a sysctl instruction to invalidate the cache. Alternately, you can force the contents of the cache to be discarded by executing a sufficient number of NOP instructions to fill the entire available instruction cache. For example, if you configure the Jx/Cx/Hx's instruction cache for a 512-byte load-and-lock cache (to contain your
interrupt handler) and a 512-byte normal cache, you should replace the
sysctl1 instruction in flush_cache() with 128 NOP instructions. (You
can use MOV G0,GO as an NOP. Each such instruction occupies four bytes
of the cache. It therefore takes 128 four-byte instructions to fill the 512-
byte normal cache.)

Note that if you configure the entire i960 Jx/Cx/Hx/RP instruction cache
for your interrupt handler, you can completely eliminate the
flush_cache() routine since there is no normal instruction cache
needing to be flushed.

System Calls

The following system procedures are called by the monitor. The monitor
provides stubs for these procedures. The application program can replace
these entries in the custom procedure table with the addresses of its own
routines by writing into the appropriate SPT fields. The base address
of the SPT is stored in the PRCB for Jx/Cx/Hx processors and in the SAT for
Kx/Sx processors.

app_exit_user(258) This entry is called by the monitor each
time it regains control from the
application due to a breakpoint,
single-step operation, or other reason.
This entry can complete a task such as
disabling a real-time clock while the
application is not running.

app_go_user(259) This entry is called by the monitor each
time it transfers control to the
application. This entry can perform a
task such as re-enabling a real-time
clock that was disabled while the
monitor was running.
If there is some action you want to perform each time any application is entered or exited, then you can change the routines `board_go_user()` or `board_exit_user()` in the file `board_hw.c` before you build the monitor.

**NOTE.** When using the i960 Cx, Jx, Hx, or RP processor, be careful to enter addresses for `app_go_user()` and `app_exit_user()` into the SPT after each call to `set_prcb()`. The monitor uses `set_prcb()` to initialize all monitor-reserved entries in the SPT. Therefore, when calling `set_prcb()` after modifying the SPT for custom `app_go_user()` and `app_exit_user()` routines, the new entries are overwritten by `set_prcb()`. See the Changing the Environment section in this chapter for details on `set_prcb()`.

### Reserved Registers

There are several registers and fields of processor-defined tables that MON960 reserves for its use. It expects the application to preserve the value of these registers and fields. In addition, the operation of the application must not depend on the values of these locations.

**NOTE.** This list omits obvious items, such as the fact that disabling all interrupts prevent the BREAK signal from interrupting the application, and that changing the memory region configuration for the monitor’s memory region(s) to an invalid value causes the monitor to fail.

#### Process-controls Register - Trace-enable Bit Only

If the application examines the value of the PC register, its operation must not depend on the value of the trace-enable bit. If the application changes the PC register using the `modpc` instruction, the trace-enable bit in the mask value must be clear, so the trace-enable bit in the PC register is not
changed. If the application changes the image of the PC register on the stack during an interrupt or fault handler, it must do the operation in such a way that the saved image of the trace-enable bit is not changed.

**Trace-controls Register**

This register must not be changed by the application, and the application must not depend on its value.

**Trace Entry in Fault Table**

This entry must not be changed by the application. If the application must provide its own fault table, it must call `set_prcb()` before reinitializing the processor with the new fault table. The `set_prcb()` routine initializes the trace-fault entry in the new fault table to the proper value.

**Interrupt Table - UART Interrupt Vector**

This entry should not be changed by the application if you use the BREAK signal to interrupt the application and return to the monitor. The number of this entry is defined during retargeting; it is the value returned by the `get_int_vector()` function.

**Internal Data RAM - UART Interrupt Vector**

On the i960 Jx/Hx/Cx/RP processors, the NMI vector that is cached at location 0 in the internal data RAM must not be changed if the UART interrupt is connected to NMI and you use the BREAK signal to interrupt the application and return to the monitor. If the UART interrupt is not connected to NMI, and the interrupt vectors are cached in internal data RAM (by setting the Vector Cache Enable bit in the Interrupt Control Register), the application must not change the location that corresponds to the UART interrupt vector.
Interrupt-control Register

On the i960 Kx/Sx processors, the field of this register that pertains to the UART interrupt must not be changed by the application if you use the BREAK signal to interrupt the application and return to the monitor. The value of this field is defined during retargeting; it is set by the function `init_hardware()`.

Interrupt-mask Register

On i960 Jx/Hx/Cx/RP processors, the bit of this register that pertains to the UART interrupt must not be changed if you use the BREAK signal to interrupt the application and return to the monitor. The bit used is defined during retargeting. If the UART interrupt is NMI, all bits of this register are available to the application.

PRCB

If any fields of the PRCB must be changed, the application must make its required changes and then call `set_prcb` before reinitializing the processor with the new PRCB. This process enables the monitor to ensure that all of its reserved fields are initialized with the proper value before the processor is reinitialized.

Control Table - Interrupt-mapping Registers

On i960 Jx/Hx/Cx/RP processors, the field of the register that pertains to the UART interrupt must not be changed if you wish to use BREAK to interrupt the application and return to the monitor. The field used is defined during retargeting. If the UART interrupt is NMI, all fields of these registers are available to the application.

Control Table - Interrupt-control Register

On i960 Jx/Hx/Cx/RP processors, if the application sets the vector-cache-enable bit in the interrupt control register, it must copy the interrupt vector that corresponds to the UART interrupt from the interrupt table to the proper location in internal data RAM. This is not necessary if the UART interrupt is NMI. It is also not necessary if `set_prcb` is called after setting the bit in the control table.
Control Table - Breakpoint Registers

On i960 Jx/Hx/Cx/RP processors, the four breakpoint registers (IPB0, IPB1, DAB0, and DAB1) and the breakpoint control register (BPCON) must not be changed by the application. If the application wishes to provide its own control table, it should call `set_prcb` before reinitializing the processor with the new control table. `set_prcb` copies the proper values from the previous control table to the new one.

System Procedure Table - Entries 220-252

These entries are used by `libll` to call the monitor and should not be changed by the application if it uses `libll` or calls the monitor for services (such as to obtain the location of the PRCB). These entries can be called directly by the application if the proper calling sequence is observed.

System Procedure Table - Entries 253-257

These entries are reserved by the monitor and should not be used by the application. Note: entries 254 (`mon_entry`) and 257 (`sdm_exit`) can be called by the application to exit and return to the monitor.

System Procedure Table - Entries 258-259

These entries should not be called by the application. They are hooks that are called by the monitor at certain times. They can be changed by the application. See the System Calls section in this chapter for more information on these entries.

Monitor Data Area

The area of memory that is specified during retargeting for the monitor's data area is reserved and must not be modified by the application. It is usually the first 32K of dram.
Linking the Monitor with an Application

The monitor can be included with your final application. This enables you to use it for field testing. MON960 lets you link a normal user program directly including all the normal library support. The program generated goes through normal MON960 initialization and then starts the user code at the Normal entry routine main(). All library feature i.e. terminal interactions files that require a debugger return error until a debugger interrupts the running user code. After your code is running you may use the normal break interrupt to connect the exit your code and enter MON960 using a debugger. Then you debug you code normally and all file and terminal actions work i.e. messages to the user.

The procedure to link you code to mon960 is as follows using the supplied hello.c sample program.

1. In the Makefile uncomment the two lines by removing the #.

   ```
   #USER_COMM = -DSERIAL_USER_CODE -DBAUD_9600
   #USER_OBJJS = crtmon.o hello.
   ```

   Crtmon.s is a special version of crt960.s that allows the linking of your code with mon960. Replace hello.o with the list of user object modules that make up your program.

   The entry routine _main() is called from crtmon.s to start the user program.

2. In the moncyxx.ld file you must uncomment the 7 lines between #heap and #syslib. This set the heap and stack used created by crtmon.s for the user program an includes all the libraries for the user code.

3. In the MON960 source file monitor.c use the defines in Makefile to execute the user code, set the monitor communication path to serial or PCI and if serial sets the serial baud rate. This must be the communication path and baud rate you set your debugger to use. There is no connect sequence as your user code runs immediately, so before calling the user code monitor.c hard codes the communication parameters into MON960.
4. Make the Makefile. Make the target file (i.e., make cyhx). Use the flash MON960/User_code to test, burn it into the baseboard flash and test it.

5. Boot from the new flash. MON960 should do its normal initializing, call \texttt{crtmon.o} to create the user heap and stack and then calls \texttt{main} in the user code. Led 3 should be on signifying a user program is running. All SDM calls return ERR because no debugger is present to handle these requests. To debug your code set you debugger to the correct communication parameters you set in \texttt{monitor.c} and use and interrupt to connect. Using MONDB the command parameters would be:

\begin{verbatim}
mondb -ser -b 115200 -it -d'
\end{verbatim}

Led 3 should be off and you should be connected with all debugging capabilities available. If you use the debugger to continue running your program all SDM calls will work. On exit from the debugger the board is usually reset which starts your user code running.

6. Test the hello/MON960 code.
   
   \begin{itemize}
     \item Download the cyhx.fls to your board:
       \begin{verbatim}
       mondb -ser -b 9600 -par -ef -ne cyhx.fls
       \end{verbatim}
     \item Switch the boot rom switch to boot from the baseboard flash.
     \item Reset the board. Led 3 should go on.
     \item Interrupt the hello program:
       \begin{verbatim}
       mondb -ser -b 155200 -it -d
       \end{verbatim}
   \end{itemize}

7. Test using the following sequence, re display the registers, step shows trace mode works, go shows go mode works and printing from the program is available. Ctrl-c shows interrupts still work and finally exiting from mondb restarts hello, led 3 is on.

\begin{verbatim}
re
st
go
CTRL-c
qu
\end{verbatim}
Purpose

This chapter contains information on the Host Debugger Interface (HDI) used by the gdb960 software debugger and the MONDB execution utility.

The Host Debugger Interface is a procedural interface for controlling a remote target board based on the i960 processor. This interface is implemented by the Host Debugger Interface Library (HDIL). The HDI interprets the command code, extracts the arguments from the message, and calls the monitor core to complete the required actions. It responds to the HDIL with a message containing the status of the command and any results. Using the Host Debugger Interface, you can develop your own debugger. The MONDB source is provided as a simple example of how to use this interface.

The interface exports the following routines:

- `hdi_aplink_enable()`
- `hdi_aplink_switch()`
- `hdi_aplink_sync()`
- `hdi_async_input()`
- `hdi_bp_del()`
- `hdi_bp_rm_all()`
- `hdi_bp_set()`
- `hdi_bp_type()`
- `hdi_convert_number()`
- `hdi_cpu_stat()`
- `hdi_download()`
- `hdi_eeprom_check()`
- `hdi_eeprom_erase()`
- `hdi_fast_download_set_port()`
- `hdi_flush_user_input()`
See the Host Debugger Interface Library Routines section for information on these routines. Declarations of these routines and of any data types and constants required to use them are in the include file hdil.h, and other files that are included by hdil.h.

All multi-byte data passed to these routines or returned from them is in host byte order, with the exception of floating-point register values. The data is changed to or from i960 processor byte order as required by the library. The floating-point register format returned by hdi_regfp_get() or passed to hdi_regfp_put() is an array of bytes in the order used by the i960 processor architecture. The interpretation of the value must be made by the debugger.

Multi-word data is handled as individual words. When hdi_mem_read(), hdi_mem_write(), or hdi_mem_fill() is passed a mem_size value greater than four, the data is interpreted as an array of words; the byte order within each word is adjusted, but the order of words is not changed. This process agrees with the i960 Jx/Hx/Cx/RP processor implementation of big-endian memory regions, but may not agree with the host’s interpretation. This situation can be handled by the debugger if necessary.

The Host Debugger Interface reserves all external symbols starting with hdi_ or _hdi_.

hdi_get_arch()   hdi_set_lmadr()
hdi_get_gmu_reg() hdi_set_lmmr()
hdi_get_gmu_regs() hdi_set_mcon()
hdi_get_message() hdi_set_mmr_reg()
hdi_get_monitor_config() hdi_set_prcb()
hdi_get_monitor_priority() hdi_set_region_cache()
hdi_get_region_cache() hdi_signal()
hdi_get_stop_reason() hdi_sysctl()
hdi_iac() hdi_targ_go()
hdi_init() hdi_targ_intr()
hdi_init_app_stack() hdi_term()
hdi_inputline() hdi_ui_cmd()
hdi_invalid_arg() hdi_update_gmu_reg()
hdi_version()
Types and Variables

The following types, defined in the hdil.h include file, are used by several of the routines defined in the host-debugger interface. Additional types are described with the routines that use them.

```c
typedef unsigned long   ADDR;
typedef unsigned long   REG;
typedef REG             UREG[NUM_REGS];
```

The Host Debugger Interface defines the `hdi_cmd_stat` variable, which provides the debugger with additional information when errors occur. The interface routines normally return a value indicating only whether the call failed or succeeded. This variable contains additional information about the last failure detected by the library.

The `hdi_cmd_stat` variable is a type `int` variable that contains an error number isolating the cause of the failure. Each error number is associated with a symbolic name, beginning with the prefix `E_`, and defined in the hdil.h file. Each routine description in the Host Debugger Interface Library Routines section includes a list of the possible error numbers to which `hdi_cmd_stat` can be set if the routine fails. The value of `hdi_cmd_stat` is not meaningful after a call to a library routine that does not return a failure status.

The description of each procedure contains a list of the error codes that it can generate. Each procedure can also set `hdi_cmd_stat` to `E_COMM_ERR`, `E_COMM_TIMO`, or `E_INTR`. Table 8-1 describes each error code.
Table 8-1  Error Codes

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Message String [Extended Description]</th>
</tr>
</thead>
<tbody>
<tr>
<td>E_ALIGN</td>
<td>Address not properly aligned</td>
</tr>
<tr>
<td>E_APLINK_REGION</td>
<td>Region conflicts with dedicated processor resources [An attempt was made to switch to a memory region dedicated to CPU operation, e.g., boot region, internal RAM region, or Jx MMR region.]</td>
</tr>
<tr>
<td>E_APLINK_SWITCH2</td>
<td>Only one switch command allowed following reset</td>
</tr>
<tr>
<td>E_ARCH</td>
<td>Processor architecture does not support specified operation</td>
</tr>
<tr>
<td>E_ARG</td>
<td>Invalid argument</td>
</tr>
<tr>
<td>E_ARGEXPECTED</td>
<td>Argument expected</td>
</tr>
<tr>
<td>E_BAD_CMD</td>
<td>Unsupported command</td>
</tr>
<tr>
<td>E_BAD_CONFIG</td>
<td>Unknown device or illegal configuration [Invalid serial configuration or device name detected during serial port open.]</td>
</tr>
<tr>
<td>E_BAD_MAGIC</td>
<td>File %s is not an i960 executable (bad magic number) [Substitution parameter reports actual file name.]</td>
</tr>
<tr>
<td>E_BPNOTSET</td>
<td>No breakpoint at that address</td>
</tr>
<tr>
<td>E_BPSET</td>
<td>Breakpoint exists at that address</td>
</tr>
<tr>
<td>E_BPUUNAVAL</td>
<td>All breakpoints of the specified type are already in use</td>
</tr>
<tr>
<td>E_BUFOVFLH</td>
<td>Buffer overflow in host</td>
</tr>
<tr>
<td>E_BUFOVFLT</td>
<td>Buffer overflow in target</td>
</tr>
<tr>
<td>E_COMM_ERR</td>
<td>Communication failure [Communication link exists but is faulty. Reset the monitor and try again.]</td>
</tr>
</tbody>
</table>

continued ☛
<table>
<thead>
<tr>
<th>Error Code</th>
<th>Message String [Extended Description]</th>
</tr>
</thead>
<tbody>
<tr>
<td>E_COMM_PROTOCOL</td>
<td>Communication protocol unspecified or unsupported [The host debugger either configured HDI for an unsupported communication protocol or else failed to initialize this setting.]</td>
</tr>
<tr>
<td>E_COMM_TIMO</td>
<td>Communication timed out [No communication link exists. Reset the monitor and try again.]</td>
</tr>
<tr>
<td>E_CONTROLLING_PORT</td>
<td>Specified target not controlled by communication port [A PCI download was directed to a target that is not controlled by the debugger's active serial port connection. This is either an internal error or the user's environment contains multiple PCI targets and the address of the desired board has been incorrectly specified.]</td>
</tr>
<tr>
<td>E_EEPROM_ADDR</td>
<td>Invalid EEPROM address or length</td>
</tr>
<tr>
<td>E_EEPROM_FAIL</td>
<td>Attempt to erase or program EEPROM failed</td>
</tr>
<tr>
<td>E_EEPROM_PROG</td>
<td>EEPROM is not erased</td>
</tr>
<tr>
<td>E_ELF_CORRUPT</td>
<td>ELF file %s is corrupt: %s [During a download, an ELF executable (file name given as first substitution parameter) had invalid object records (the nature of the problem is described in the second substitution parameter).]</td>
</tr>
<tr>
<td>E_FAST_DNLOAD_ERR</td>
<td>Fast download error bit set by MON960 [The monitor detected an invalid PCI or parallel port download protocol state. This problem can result from an internal software error or malfunctioning communication hardware. Check the physical communication media (e.g., parallel cable), reset the monitor and try again.]</td>
</tr>
</tbody>
</table>

continued ☛
## Table 8-1  Error Codes (continued)

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Message String [Extended Description]</th>
</tr>
</thead>
<tbody>
<tr>
<td>E_FAST_DOWNLOAD_BAD_DATA_CHECKSUM</td>
<td>Data CRC does not match data at download port. [During a PCI or parallel download, the monitor detected a checksum mismatch between host and target data. This problem can be caused by unstable target memory or malfunctioning communication hardware. Check the physical communication media (e.g., parallel cable), reset the monitor and try again.]</td>
</tr>
<tr>
<td>E_FAST_DOWNLOAD_BAD_FORMAT</td>
<td>Non download message at fast download port. [During a PCI or parallel download, the monitor detected an invalid message sequence. This problem can be caused by an internal software error or malfunctioning communication hardware. Check the physical communication media (e.g., parallel cable), reset the monitor and try again.]</td>
</tr>
<tr>
<td>E_FILE_ERR</td>
<td>%s: Error reading file %s [Reported by host when a file read operation fails. The first substitution parameter lists the expanded system error code. The second substitution parameter reports the actual file name.]</td>
</tr>
<tr>
<td>E_GMU_BADREG</td>
<td>The specified GMU register does not exist</td>
</tr>
<tr>
<td>E_INTR</td>
<td>Function terminated by keyboard interrupt</td>
</tr>
<tr>
<td>E_NOMEM</td>
<td>Unable to allocate memory on the host</td>
</tr>
<tr>
<td>E_NOTRUNNING</td>
<td>Target is not running [Operation attempted that requires running application.]</td>
</tr>
<tr>
<td>E_NO_FLASH</td>
<td>Target flash region is not functional flash memory</td>
</tr>
<tr>
<td>E_NO_PCIBIOS</td>
<td>PCI BIOS unavailable [PCI communication attempted on host that has no detectable PCI BIOS.]</td>
</tr>
<tr>
<td>E_NUM_CONVERT</td>
<td>Invalid numeric value</td>
</tr>
<tr>
<td>E_OLD_MON</td>
<td>Not supported in old monitor</td>
</tr>
</tbody>
</table>

continued
Table 8-1  Error Codes (continued)

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Message String [Extended Description]</th>
</tr>
</thead>
<tbody>
<tr>
<td>E_PARA_DNLOAD_TIMO</td>
<td>Parallel download timeout [The target did not respond to a parallel download request. Check cable connections, reset the monitor, and retry.]</td>
</tr>
<tr>
<td>E_PARALLEL_DOWNLOAD_NOT_SUPPORTED</td>
<td>Target does not support parallel downloads [The monitor does not contain code to support parallel download. Rebuild the monitor to include an appropriately configured driver.]</td>
</tr>
<tr>
<td>E_PARA_NOCOMM</td>
<td>Parallel communication unsupported for host OS and/or host parallel HW. [Parallel communication has not been ported to your host and/or the specified parallel port/device.]</td>
</tr>
<tr>
<td>E_PARA_SYS_ERR</td>
<td>%s: Parallel comm system error %s [ Reported by host for various problems related to parallel communication. The first substitution parameter lists the expanded system error code; the second substitution parameter reports the condition that triggered the error ]</td>
</tr>
<tr>
<td>E_PARA_WRITE</td>
<td>Parallel communication I/O error: write mismatch [The host detected that the requested write byte count did not match the actual number of bytes transferred. Check cable connections and try again.]</td>
</tr>
<tr>
<td>E_PCI_ADDRESS</td>
<td>Invalid PCI address component specified</td>
</tr>
<tr>
<td>E_PCI_CFGREAD</td>
<td>Error reading PCI configuration space [A PCI BIOS read operation failed.]</td>
</tr>
<tr>
<td>E_PCI_CFGWRITE</td>
<td>Error writing PCI configuration space [A PCI BIOS write operation failed.]</td>
</tr>
<tr>
<td>E_PCI_COMM_NOT_SUPPORTED</td>
<td>Target does not support PCI communication [The monitor does not contain code to support PCI communication. Rebuild the monitor to include an appropriately configured driver.]</td>
</tr>
<tr>
<td>Error Code</td>
<td>Message String [Extended Description]</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E_PCI_COMM_TIMO</td>
<td>PCI communication timeout [The target did not respond to a PCI communication protocol request. Reset the monitor and retry.]</td>
</tr>
<tr>
<td>E_PCI_HOST_PORT</td>
<td>PCI comm unsupported for host OS on specified target [Host-based PCI communication has not been ported to the specified PCI device.]</td>
</tr>
<tr>
<td>E_PCI_MULTIFUNC</td>
<td>PCI device not multi-function [Requested PCI bus address specifies multi-function selection, but target is single function.]</td>
</tr>
<tr>
<td>E_PCI_NODVC</td>
<td>No PCI device at specified address</td>
</tr>
<tr>
<td>E_PCI_SRCH_FAIL</td>
<td>Search for specified PCI device failed</td>
</tr>
<tr>
<td>E_PHYS_MEM_ALLOC</td>
<td>Unable to allocate mapped, physical memory</td>
</tr>
<tr>
<td>E_PHYS_MEM_FREE</td>
<td>Unable to free mapped, physical memory</td>
</tr>
<tr>
<td>E_PHYS_MEM_MAP</td>
<td>Physical memory mapping unavailable [A request for PCI communication via memory-mapped I/O failed because the host environment does not support such access.]</td>
</tr>
<tr>
<td>E_PORT_SEARCH</td>
<td>Cannot locate controlling communication port [A PCI download was directed to a target that is not controlled by the debugger’s active serial port connection. This is either an internal error or the host’s controlling serial port is connected to a target not accessible from the PCI bus (e.g., a target in another PC).]</td>
</tr>
<tr>
<td>E_READ_ERR</td>
<td>Error reading target memory</td>
</tr>
<tr>
<td>E_RESET</td>
<td>Target was reset [The host interrupted the monitor, which reset the target. Requires special target hardware.]</td>
</tr>
<tr>
<td>E_RUNNING</td>
<td>Target is running [The requested operation is only allowed when the target is not running.]</td>
</tr>
</tbody>
</table>

continued
Table 8-1  Error Codes (continued)

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Message String [Extended Description]</th>
</tr>
</thead>
<tbody>
<tr>
<td>E_SWBP_ERR</td>
<td>Unable to write software breakpoint (write verification error)</td>
</tr>
<tr>
<td>E_SYS_ERR</td>
<td>%s: System error %s [Reported by host for various operating system-related problems. The first substitution parameter lists expanded system error code; the second substitution parameter reports the condition that triggered the error.]</td>
</tr>
<tr>
<td>E_TARGET_RESET</td>
<td>Target was in reset state, board was reset [The target was asynchronously placed in a reset state via a hardware reset or power cycle, and host-to-target communication was successfully re-established. To completely recover from this event, reset the host and HDI to their initial states (reset the HDI by calling hdi_reset()).]</td>
</tr>
<tr>
<td>E_VERIFY_ERR</td>
<td>Write verification error [Target memory did not read back as written.]</td>
</tr>
<tr>
<td>E_VERSION</td>
<td>Not supported in this version</td>
</tr>
<tr>
<td>E_WRITE_ERR</td>
<td>Error writing to target memory</td>
</tr>
</tbody>
</table>
Imported Routines

The Host Debugger Interface requires the debugger to supply the following routines:

**hdi_cmdext()**

```c
int hdi_cmdext(int arg, unsigned char *buf, int size)
```

This routine enables the debugger to define or redefine runtime requests received from the target while the application is running. The `hdi_cmdext()` routine is called for any requests that are not recognized by the HDI implementation. Requests are defined by the first byte of the message. Requests in the range of 0x80-0xff are guaranteed not to be used by HDI. The debugger can also arrange that `hdi_cmdext()` be called for every request from the application. The `hdi_cmdext()` routine can handle a request and return `TRUE`, or it can return `FALSE` and allow normal processing of the request to continue. The library provides a stub for this routine, which is used if the debugger does not define it.

This routine is called with `arg = HDI_EINIT` when target execution is started. In this call, `buf` and `size` are not used. When this call returns `TRUE`, `hdi_cmdext()` is called again each time a service request is received from the application. In these calls, `arg = HDI_EPOLL`, and `buf` and `size` are the buffer containing the request. The `hdi_cmdext()` routine returns `TRUE` to indicate that it has handled the request. When it returns `FALSE`, the request is processed normally.

When an unrecognized request is received from the application, `hdi_cmdext()` is called with `arg = EDATA`. As with `HDI_EPOLL`, `buf` and `size` are the buffer containing the request. Again, `hdi_cmdext()` returns `TRUE` to indicate that it has handled the request. When it returns `FALSE`, normal error processing for an unrecognized request occurs.
Note that it is possible for `hdi_cmdext()` to be called twice for a single request. When `hdi_cmdext()` is called with `arg=HDI_EPOLL` and it returns `FALSE`, the request is examined by the HDI. When the request turns out to be unrecognized by the HDI, then `hdi_cmdext()` is called again, this time with `arg=HDI_EDATA`.

The `hdi_cmdext()` routine is called with `arg=HDI_EEXIT` before `hdi_targ_g()` returns, whether or not target execution stopped normally. In this call, `buf` and `size` are not used.

The constants `HDI_EINIT`, `HDI_EPOLL`, `HDI_EDATA`, and `HDI_EEXIT` are defined in the include file `hdil.h`.

### hdi_get_cmd_line()

```c
void hdi_get_cmd_line(char * buf, int size)
```

This routine is called by the `hdi_targ_go()` routine when the user application requests its command-line arguments. The `hdi_get_cmd_line()` routine returns a null-terminated ASCII string of no more than `size-1` characters from the application’s command line and places it in `buf`. This string normally consists of the executable file name followed by arguments separated by spaces. However, it is not interpreted by the HDI, and can be in whatever format the application expects.

### hdi_put_line()

```c
void hdi_put_line(const char * msg)
```

This routine is used by the library to print an informational or error message to the console. `msg` is a null-terminated string.
**hdi_user_get_line() and hdi_user_put_line()**

```c
int hdi_user_get_line(char *buf, int size)
void hdi_user_put_line(const char *data, int size)
```

These routines are called by the `hdi_targ_go()` routine when the user application performs I/O on `stdin` or `stdout`. The `hdi_user_get_line()` routine gets a line of no more than `size` characters from the user input and copies it into `buf`. It does not need to add a null terminator to the data read. It returns the number of characters read. It returns 0 when no characters were read before end-of-file, and -1 on error.

The `hdi_user_put_line()` routine writes `size` bytes pointed to by `data` to the user output. The data is not null-terminated.

**Host Debugger Interface Library Routines (HDIL)**

This section explains the routines defined by the Host Debugger Interface. Most routines return special error values, via `hdi_cmd_stat`, when they fail. The failure values are listed with each routine. The meaning of each error value is listed in the Error Codes table in this chapter.

---

**NOTE.** Many routines can return the error `E_TARGET_RESET`. This error is a result of one of two cases: Either the target reset button was pressed or there was a power cycle on the target. These conditions cause the message from HDIL to time out. At that point, HDIL automatically attempts to re-establish communication. When HDIL succeeds, `E_TARGET_RESET` is returned. However, the host must then reset itself to the initial target state. HDIL must be cleared. An easy way to clear the HDIL is to call the `hdi_reset()` routine.
**hdi_aplink_enable**

```c
int hdi_aplink_enable (unsigned long bit, unsigned long value)
```

This function, which should only be used in conjunction with an ApLink-compatible target, modifies bits in the ApLink mode register. The valid range of the `bit` parameter is 2-4, and the valid range of the `value` parameter is 0-1. The returned value, either `OK` or `ERR`, indicates whether or not the requested operation was successful. Refer to the *ApLink User’s Guide* for further details.

Failures: `E_VERSION`, `E_ARG`

**hdi_aplink_switch**

```c
int hdi_aplink_switch(unsigned long region, unsigned long mode)
```

This function relocates an ApLink monitor from its boot-up region into a new memory region and simultaneously switches to one of ApLink’s supported modes. The valid range of the `region` parameter is 0x1-0x1e, and the valid range of the `mode` parameter is 0-4. The returned value is `OK` or `ERR`, indicating whether or not the requested option was successfully executed. Refer to the *ApLink User’s Guide* for further details.

Failures: `E_VERSION`, `E_ARG`, `E_APLINK_REGION`, `E_APLINK_SWITCH2`

**hdi_aplink_sync**

```c
int hdi_aplink_sync (int sync_type)
```

This function is used to manipulate an ApLink-compatible monitor that meets the following preconditions:

- it must be mode 1 or 2
- it must have a new IMI downloaded into the appropriate processor boot region.
Assuming the monitor meets these conditions, `hdi_aplink_sync()` may be called with either an `HDI_APLINK_WAIT` or `HDI_APLINK_RESET` parameter. The former parameter causes the monitor to configure itself internally in user mode (i.e., application mode), and then waits for a hardware reset. The latter parameter causes the monitor to configure itself in user mode and then immediately reset the target from the new IMI. The returned value, either `OK` or `ERR`, indicates whether or not the requested operation was successful.

**NOTE.** The `HDI_APLINK_WAIT` parameter causes `hdi_aplink_sync()` to wait indefinitely for a target hardware reset. In other words, the host debugger does not return from this call until a manual hardware reset occurs.

Failures: `E_VERSION`

### hdi_async_input()

```c
void hdi_async_input()
```

Calling this routine during debugger initialization causes HDI to accept asynchronous application input (e.g., typeahead) via future calls to `hdi_inputline()`. See the description of that routine in this chapter for more details.

### hdi_bp_del()

```c
int hdi_bp_del(ADDR addr)
```

This routine deletes the breakpoint at target address `addr`. The returned value is `OK` or `ERR`, indicating whether or not the breakpoint was deleted.

Failures: `E_BPNOTSET`, `E_RUNNING`
hdi_bp_rm_all()

int hdi_bp_rm_all()

This routine removes all known hardware and software breakpoints. It is not an error to call this routine when no breakpoints are set.

The returned value is FALSE when no breakpoints were set. The returned value is TRUE when all breakpoints were successfully deleted, and ERR when any breakpoint could not be deleted.

Failures: E_RUNNING

hdi_bp_set()

int hdi_bp_set(ADDR addr, int type, int flags)

This routine sets a breakpoint at addr. The type value indicates the type of breakpoint to set. The following values are valid:

- BRK_SW: fmark breakpoint
- BRK_HW: hardware instruction breakpoint
- BRK_DATA: hardware data breakpoint (available on i960 Jx/Hx/Cx/RP only)

flags provides additional information about a breakpoint. Currently, this argument has meaning only when the value of type is BRK_DATA. Then flags indicates the type of accesses to addr that cause a breakpoint, as follows:

- DBP_S: store access
- DBP_SL: store or load access
- DBP_SLF: store, load, or fetch access
- DBP_ANY: any access

No more than one breakpoint can be set at any given address. When type is BRK_SW, or BRK_HW, the address must be aligned on a word boundary. The returned value is OK or ERR, indicating whether or not the breakpoint could be set.
Failures: EALIGN, E_BPUNAVAIL, E_BPSET, E_ARCH, E_ARG, E_RUNNING

**hdi_bp_type()**

```c
int hdi_bp_type(ADDR addr)
```

This routine returns the type of breakpoint currently set at `addr`, or `BRK_NONE` when no breakpoint is set there. See the `hdi_bp_set()` routine in this section for a list of legal breakpoint types.

This routine does not communicate with the target, and therefore cannot fail.

**hdi_convert_number()**

```c
int hdi_convert_number(const char *num,
                        long  *arg,
                        int    arg_type,
                        int    base,
                        const char *error_prefix);
```

This routine converts an ASCII numeric string to an [unsigned] long in the specified base. The routine ensures that the string contains only legal digits for the specified base and, when using ANSI C libraries, that the result does not overflow.

- `num` is an ASCII numeric string to be converted to an [unsigned] long.
- `arg` is the converted value of `num`, returned by reference. The `arg_type` is `HDI_CVT_UNSIGNED` or `HDI_CVT_SIGNED`. It specifies the sign of the returned result. The conversion is implemented using the host’s C libraries. Consequently, `arg_type` is meaningful only for those Kernighan and Ritchie-based implementations that do not accept a leading + or - when converting a string to an unsigned numeric value.
- `base` is a numeric base to be passed to conversion routines. If the host C compiler is Kernighan and Ritchie-based, the only acceptable bases are 8, 10, and 16. Otherwise, acceptable bases are 2-36.
When the `error_prefix` is not NULL, this function prints out an error message, using `error_prefix` as a leader string, whenever a conversion cannot be performed. Note that the `error_prefix` may be set to point at a null character string (""), in which case this routine outputs the default error message with an empty leader.

The returned value is **OK** or **ERR**, indicating whether or not errors were detected.

**Failures:**

**E_NUM_CONVERT**

### hdi_cpu_stat()

```c
int hdi_cpu_stat(CPU_STATUS * cpu_status)
```

This routine reports the addresses of the various CPU objects listed in the `CPU_STATUS` struct. The single argument indicates where the information should be placed. It is a pointer to a structure of the following type:

```c
typedef struct {
    ADDR cpu_prcb; /* address of PRCB */
    ADDR cpu_sptb; /* address of system procedure table */
    ADDR cpu_ftb; /* address of fault table */
    ADDR cpu_itb; /* address of interrupt table */
    ADDR cpu_isp; /* address of interrupt stack */
    ADDR cpu_sat; /* address of system address table */
        /* (KX and SX only) */
    ADDR cpu_ctb; /* address of control table */
        /* (Jx/Hx/Cx/RP only) */
} CPU_STATUS;
```

Values that are meaningless for the processor under test are undefined.

Since the addresses of these data structures can be changed under software control, the contents of a structure returned by a call to `hdi_cpu_stat()` should be discarded (and re-read) when the target is run.
hdil_download()

int hdi_download(const char *filename,
                  ADDR *start_ip,
                  unsigned long textoff,
                  unsigned long dataoff,
                  int zero_bss,
                  DOWNLOAD_CONFIG *fast_config,
                  int quiet);

This routine downloads the contents of a COFF, ELF, or b.out file
specified by filename; both the target and host object records may be in
either big- or little-endian format. The entry point address of the
downloaded application is returned in the word pointed to by \textit{start_ip}.
To support Position Independent Code (PIC) and Position Independent
Data (PID) applications, \textit{textoff} and \textit{dataoff} are added to the
application’s physical text and data addresses, respectively. Specify
\textit{textoff} and \textit{dataoff} as 0 (zero) when \textit{filename} is not PIC/PID. The
\textit{zero_bss} flag applies only to COFF files and, when \textit{TRUE}, causes HDI to
explicitly zero the application’s BSS. Lacking this feature, ELF and b.out
applications must explicitly zero BSS at startup, which is the default
behavior for applications linked with Intel’s startup module (\texttt{crt960.o}).
Normally, status messages track the progress of the download, but when
the quiet flag is \textit{TRUE}, these status messages are suppressed.

Note that if the target destination memory is EEPROM, the EEPROM is
programmed; if the EEPROM is already programmed, the download fails.
Since the download is implemented as a series of \texttt{hdi_mem_write()}
calls, part of EEPROM can be programmed before a failure occurs.

The returned value is \texttt{OK} or \texttt{ERR}, indicating whether or not \textit{filename} was
successfully downloaded.

The download may be completed via a serial, parallel, or PCI
communication channel, as specified by the \textit{fast_config} parameter.
Serial Download

If the host debugger has opened a serial communication channel with the target, a serial download is specified by calling `hdi_download` with the `fast_config` parameter set to the value `NO_DOWNLOAD_CONFIG` (defined in `hdil.h`). In this situation, the HDI uses the serial channel currently open to download data.

Parallel Download

A parallel download is best illustrated by the following code fragments:

```c
#include <hdil.h>
DOWNLOAD_CONFIG cfg;
cfg.download_selector = FAST_PARALLEL_DOWNLOAD;
cfg.fast_port = "lpt1"; /* typical for Windows, Unix device names vary. */
...
hdii_download(...,&cfg,...);
...
```

PCI Download

The host initiates a PCI download by calling `hdi_download()` and passing appropriate information via the `fast_config` parameter. HDI permits one of the three PCI device address specifications listed below:

1. an absolute PCI bus address (specified as an address triple)
2. a specific PCI vendor and device ID
3. the default PCI vendor and device ID

Consequently, initializing the `fast_config` structure for a PCI download takes more work than for a serial or parallel download. The comments at the bottom of the `COM_PCI_CFG` data structure in `hdil_com.h` describe all three addressing scenarios. (Note that `COM_PCI_CFG` is a member of the `fast_config` data structure.) The following pseudo code illustrates a PCI download. It selects the target using an absolute address comprised of bus 0, device 0xC, function 0.
#include <hdil.h>

DOWNLOAD_CONFIG cfg;
    cfg.download_selector  = FAST_PCI_DOWNLOAD;
    cfg.fast_port          = PCI_UNUSED_FAST_PORT;
    cfg.init_pci.comm_mode = COM_PCI_MMAP;
    /* or COM_PCI_IOSPACE */
    strcpy(cfg.init_pci.control_port,
            last_4_chars_of_controlling_serial_port);
    cfg.init_pci.bus       = 0;
    cfg.init_pci.dev       = 0xc;
    cfg.init_pci.func      = 0;
...
    hdi_download(..., &cfg, ...);
...

Failures:

- E_EEPROM_PROG
- E_BAD_MAGIC
- E_EEPROM_FAIL
- E_READ_ERR
- E_WRITE_ERR
- E_ARG
- E_VERIFY_ERR
- E_RUNNING
- E_FILE_ERR
- E_NOMEM

various parallel and PCI communication failure codes

**hdi_eeprom_check()**

```c
int hdi_eeprom_check(ADDR address,
            unsigned long length, unsigned long *eeprom_size,
            ADDR prog [2])
```

This routine checks whether the specified area of memory on the target board is EEPROM and whether it is erased. It returns OK when the memory is EEPROM and is erased. The value of `eeprom_size` is set to the total size of the EEPROM on the board. This routine returns ERR in the following cases and sets `hdi_cmd_stat` to the value indicated:

- The target board or monitor does not support EEPROM. (Sets `hdi_cmd_stat` to E_NO_FLASH.)
- The region of memory is not entirely EEPROM. (Sets `hdi_cmd_stat` to E_EEPROM_ADDR.)

...
Host Debugger Interface (HDI)

- The memory address or length is not aligned on a programmable boundary (board-specific). (Sets `hdi_cmd_stat` to `E_ALIGN`.)
- The region of memory is EEPROM but is not entirely erased. (Sets `hdi_cmd_stat` to `E_EEPROM_PROG`.) In this case, `prog[0]` is set to the lowest and `prog[1]` to the highest address programmed.

The `address` value can be `NO_ADDR`, indicating that all of EEPROM will be checked. The `length` value can be 0, indicating that the smallest block of EEPROM starting at `address` will be checked. When the address is `NO_ADDR`, `length` is ignored.

Failures: `E_VERSION`, `E_EEPROM_ADDR`, `E_EEPROM_PROG`, `E_ALIGN`, `E_RUNNING`, `E_NO_FLASH`

**hdi_eeprom_erase()**

```c
int hdi_eeprom_erase(ADDR address,
                     unsigned long length)
```

This routine erases the specified area of EEPROM on the target board. The `address` value is the address of the first byte of EEPROM to be erased. It must be the address of the beginning of an erasable block of EEPROM or `NO_ADDR`, indicating that all of EEPROM is to be erased.

The `length` value is the number of bytes of EEPROM to be erased. The `length` must include exactly one or more erasable blocks of EEPROM. The `length` value can be 0, indicating that the smallest erasable block of EEPROM starting at address is to be erased. When `address` is `NO_ADDR`, `length` is ignored. When these conditions are not met, `hdi_cmd_stat` is set to `E_EEPROM_ADDR`.

To erase a specific flash chip, specify a `length` integer value of -1 to -16, where -1 is the first flash chip in the address sequence and -2 is the second, etc.

The returned value is `OK` or `ERR`, indicating whether or not the request was successful.

Failures: `E_VERSION`, `E_EEPROM_ADDR`, `E_EEPROM_FAIL`, `E_RUNNING`, `E_NO_FLASH`
hdi_fast_download_set_port()

int hdi_fast_download_set_port(DOWNLOAD_CONFIG *cfg)

This routine is normally called by hdi_mem_write() and
hdi_mem_fill() to initiate and terminate a high speed download via a
PCI bus or parallel port. Usually, hdi_fast_download_set_port()
exists as an internal HDI service that debugger clients do not directly
invoke.

However, debugger clients may use hdi_fast_download_set_port() to
determine if a target is PCI- or parallel-download-capable. In this
situation, the calling sequence is as follows:

#include "hdil.h"
if (hdi_fast_download_capable(PARALLEL_CAPABLE) == OK) {
    /* parallel download supported by target */
}
if (hdi_fast_download_capable(PCI_CAPABLE) == OK) {
    /* PCI download supported by target */
}

Failures: various parallel and PCI communication failure
codes

hdi_flush_user_input()

void hdi_flush_user_input()

Calling this routine clears the fixed location buffer used by
hdi_inputline(). See the description of that routine in this chapter for
more details.

hdi_get_arch()

int hdi_get_arch(void)

This routine returns an integer constant describing this monitor’s i960
processor architecture. The range of values that this routine returns are
defined in the include file hdi_arch.h.
hdi_get_gmu_reg

int hdi_get_gmu_reg(int type, int regnum, HDI_GMU_REG *reg)

This routine reads the current value and current enable status of the specified Guarded Memory Unit (GMU) register from the processor hardware and copies them into the structure reg. A GMU is available only on Hx processors.

Values of type are:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDI_GMU_DETECT</td>
<td>Sets up a memory detection low-address/high-address register pair</td>
</tr>
<tr>
<td>HDI_GMU_PROTECT</td>
<td>Sets up a memory protection address/mask register pair</td>
</tr>
</tbody>
</table>

The return value is OK or ERR.

Failures: E_ARCH, E_ARG, E_GMU_BADREG

hdi_get_gmu_regs

int hdi_get_gmu_regs(HDI_GMU_REGLIST *reglist)

This routine reads the current values and current enable statuses of all the Guarded Memory Unit (GMU) registers from the processor hardware and copies them into the structure reglist.

The return value is OK or ERR.

Failures: E_ARCH

hdi_get_message()

const char *hdi_get_message()

This routine returns a pointer to a string containing a message about the last error encountered by an HDIL operation. It uses hdi_cmd_stat to determine the nature of the error. The string is usually a static message, as described in Table 8-1. The string can also contain additional formatted information, such as the address of the failure.
This routine does not communicate with the target and therefore cannot fail.

**hdii_get_monitor_config()**

```c
int hdi_get_monitor_config(HDI_MON_CONFIG *config_info)
```

*hdii_get_monitor_config* returns selected monitor configuration information, as specified in the *include* file *hdi_mcfg.h*. This information is often used for internal configuration of a host debugger or for querying monitor attributes in a regression test environment. The MONDB utility provides command line options to display the HDI_MON_CONFIG information that a target returns. Refer to Appendix B in this guide for more information on MONDB.

Failures:  

**E_VERSION**

**hdii_get_monitor_priority()**

```c
int hdi_get_monitor_priority(int *priority)
```

The returned value is, by reference, the monitor’s current priority.

Failures:  

**E_RUNNING**

**hdii_get_region_cache()**

```c
int hdi_get_region_cache(REGION_CACHE cache_vector)
```

This routine returns, by value, the size of the HDI region cache vector and, by reference, a copy of the vector’s current contents. Refer to the description of *hdii_set_region_cache* for a detailed explanation of HDI region caching.

**hdii_get_stop_reason()**

```c
const STOP_RECORD * hdi_get_stop_reason()
```

This routine returns either the *stop_record* for the last program stop or a NULL pointer if host-target communication fails.
hdi_iac()

int hdi_iac(ADDR destination, const unsigned long iac[4])

This routine can be used only for the i960 Kx/Sx processors. It causes the
target processor to issue the specified IAC at the specified address. The
destination address can refer to the processor itself or to an external agent.
If the destination is 0, it is changed to the address for an internal IAC. The
meaning of the IAC and the address are specific to the processor and the
target hardware, and are not specified by the interface.

This routine is not required for debugger operation, and cannot be
implemented in all implementations of this interface. Certain IACs can be
prohibited by the interface library (e.g., Reinitialize) and others can cause
undefined results (e.g., Interrupt).

The returned value is OK or ERR, indicating whether or not the operation
was successful.

Failures: E_ARCH, E_RUNNING

hdi_init()

int hdi_init(HDI_CONFIG * config, int * arch)

This routine initializes the interface and establishes communication with
the target. The int pointed to by arch is filled in by hdi_init(), and is
returned with a code indicating the type of i960 processor in the board.
The possible values (defined in hdi_arch.h) are:

ARCH_KA
ARCH_KB
ARCH_CA
ARCH_SA
ARCH_SB
ARCH_JX
ARCH_HX
ARCH_RP
The config structure contains various targeted configuration values.

```c
typedef struct {
    int reset_time;
    int intr_trgt;
    int breakcauses_reset;
    int mon_priority;
    int tint;
    int no_reset;
} HDI_CONFIG;
```

When intr_trgt is TRUE, the host sends an interrupt to the target before starting communications. You can use this to cause the application to pass control to the monitor if the target boots into the application program.

The reset_time value is the time in milliseconds to wait after resetting the target before starting communication. Specify -1 to use the three-second default value.

When breakcauses_reset is TRUE, it means that a break signal from the host causes a reset in the target, rather than an interrupt.

The mon_priority field sets the interrupt priority of the processor while it is running the monitor code. The valid value range is 0 to 31. If you specify -1, 31 (the default) is used. This disables all interrupts except NMI and priority 31. If you have interrupts that must execute while the monitor has control, use this field to set the priority of the monitor to a lower value. You cannot debug interrupt routines with a priority greater than this value, since the monitor will not be able to interrupt this routine.

When no_reset is TRUE, HDI does not reset the target after establishing a communication connection. This field is most useful in conjunction with intr_trgt. Note that if hdi_init() determines that the target is currently in the reset state, no_reset is ignored.

The tint field is no longer used.

Failures:

E_BAD_CONFIG
**hdi_init_app_stack()**

```c
int hdi_init_app_stack()
```

This routine sets a user application to use the monitor’s dedicated user stack. It sets the user `fp` to `_hdi_fp_initial_monitor` and the `sp` to `_hdi_sp_initial_monitor`. The routine returns `OK` or `ERR`. Note that the stack established by this routine:

- is small and in the monitor’s address space
- is intended for use as a so-called bootstrap stack
- initializes only `sp` and `fp`. Ffp initialization (say, to zero) is the client’s (e.g. the debugger’s) responsibility

An application should use this stack only long enough to set up a larger stack in its own address space. For example, one of the first tasks application init code performs should be creating a new stack in application address space.

Suggested use for debugger clients:

```c
hdi_download(...)  
hdi_init_app_stack() /*Establish application’s initial, bootstrap stack */  
hdi_put_reg(REG_PFP, 0)  
...  
if (executing application)  
    hdi_targ_go(...) /*App sets up own stack in init code*/
```

**hdi_inputline()**

```c
void hdi_inputline(char *buffer, int length)
```

The `buffer` contains data to be sent to an application’s `stdin` stream. The `length` is the number of data bytes in the buffer. Maximum input buffer is `MAX_MSG_SIZE` bytes.

The host debugger has elected to support asynchronous input (i.e., typeahead) from its User Interface (e.g., an I/O window in a GUI). In that case, the debugger uses `hdi_inputline()` to pass asynchronous input to the HDI, which buffers it and passes it to the application’s `stdin` stream when requested by the target.
To configure HDI to support asynchronous input, these steps are required:

1. After debugger and HDI initialization, but before an application is executed, the debugger calls `hdi_async_input()` to signal its request for asynchronous input.

2. Each time an application is downloaded or restarted, the debugger calls `hdi_flush_user_input()` to discard data buffered in `hdi_inputline()`.

3. Finally, the debugger must start applications in the background (i.e., pass `GO_BACKGROUND` requests to `hdi_targ_go()`).

Note: Even when configured to use asynchronous input, HDI still calls `hdi_user_get_line()`. However, the information returned by this call is ignored. In this situation, a debugger may want to take advantage of this "dummy" call to manage its asynchronous input queue.

### hdi_invalid_arg()

```c
void hdi_invalid(const char * err_prefix)
```

This routine sets `hdi_cmd_stat` to `E_ARG` and if `error_prefix` is not null, HDIL prints out a message containing `error_prefix`.

### hdi_mem_copy()

```c
int hdi_mem_copy(ADDR destination, ADDR source, 
                 unsigned long size, int dst_mem_size, 
                 int src_mem_size)
```

This routine copies `size` bytes of target memory from target address `source` to target address `destination` using memory access instructions of the sizes specified. On the i960 Jx/Hx/Cx/RP processor, if the source and destination memory are not the same byte order, the `mem_size` values will affect the pattern written to the destination. If the destination of the copy is EEPROM memory, the memory is programmed. If the EEPROM is already programmed, the copy fails.

The returned value is `OK` or `ERR` indicating if the copy was successful.
Failures: 
E_EEPROM_PROG, E_EEPROM_FAIL,
E_READ_ERR, E_WRITE_ERR, E_VERIFY_ERR,
E_RUNNING, E_ALIGN

**hdi_mem_fill()**

```c
int hdi_mem_fill(ADDR address,
    const void *patternp,
    int patternsize, unsigned long patterncount,
    int mem_size)
```

This routine writes to target memory starting at address `address`, with the pattern pointed to by `patternp`, which is `patternsize` bytes long, for `patterncount` iterations. `Patternsize` must be >0 and <256. The `mem_size` variable specifies the size of the objects that make up the pattern, and the size of the write instructions used to write the pattern into target memory. Pattern size must be a multiple of `mem_size`. Also, when unaligned memory accesses are disabled in the monitor:

- If `mem_size` is 12, `address` must be a multiple of 16, and `patternsize` must be 12. Otherwise:
- Both `address` and `patternsize` must be multiples of `mem_size`.

If the memory to be filled is EEPROM, the EEPROM is programmed. If the EEPROM is already programmed, the command fails.

The returned value is **OK** or **ERR**, indicating whether the write was successful.

Failures: 
E_EEPROM_PROG, E_EEPROM_FAIL,
E_READ_ERR, E_WRITE_ERR, E_ARG,
E_VERIFY_ERR, E_RUNNING, E_ALIGN

**hdi_mem_read()**

```c
int hdi_mem_read(ADDR address,
    void *bufferp, unsigned int size,
    int bypass_cache, int mem_size)
```

This routine reads `size` bytes of target memory starting at target address `address` into the buffer specified by `bufferp`.
The value of `mem_size` can be 0, 1, 2, 4, 8, 12, or 16. This value specifies the size, in bytes, of memory access instruction to use and of the objects written. When unaligned memory accesses are disabled in the monitor:

- if `mem_size` is 12, `address` must be a multiple of 16 and `size` must be 12, or
- both `address` and `size` must be multiples of `mem_size`

If `mem_size` is 0, the data written is the same as if `mem_size` were 1, but the monitor is not constrained to use 1-byte memory access instructions. If `bypass_cache` is `TRUE`, the request is sent directly to the monitor without checking for a cache hit, or filling the cache (useful for reading memory-mapped I/O). In this context, `cache` refers to HDI’s local memory cache and is unrelated to the i960 processor cache.

Failures:

| E_ALIGN | E_READ_ERR | E_RUNNING |

**hdi_mem_write()**

```c
int hdi_mem_write(ADDR address,
                 const void *bufferp,
                 unsigned int size, int verify,
                 int bypass_cache, int mem_size)
```

This routine writes `size` bytes from the buffer pointed at by `bufferp` into target memory, starting at target address `address`. If the memory to be written to is EEPROM, the EEPROM is programmed. If the EEPROM is already programmed, the write fails.

When `verify` is set to `TRUE`, the monitor reads back memory after it is written to verify that the write was successful. In general, `verify` should be set to `TRUE`, except when writing to memory-mapped I/O. Since the verify operation is done by the monitor, there is no significant time cost.

The value of `mem_size` can be 0, 1, 2, 4, 8, 12, or 16. This value specifies the size, in bytes, of memory access instruction to use and of the objects written. When unaligned memory accesses are disabled in the monitor:

- if `mem_size` is 12, `address` must be a multiple of 16 and `size` must be 12, or
- both `address` and `size` must be multiples of `mem_size`
If \textit{mem\_size} is 0, the data written is the same as if \textit{mem\_size} were 1, but the monitor is not constrained to use one-byte memory access instructions. When \textit{bypass\_cache} is \texttt{TRUE}, the request is sent directly to the monitor without checking for a cache hit, or filling the cache (useful for reading memory-mapped I/O). In this context, \textit{cache} refers to HDI’s local memory cache and is unrelated to the i960 processor cache.

Failures:

\begin{verbatim}
E_EEPROM_PROG, E_EEPROM_FAIL,
E_READ_ERR, E_WRITE_ERR, E_VERIFY_ERR,
E_RUNNING, E_ALIGN, E_BPSET
\end{verbatim}

\textbf{hd\_opt\_arg\_required()}

\begin{verbatim}
int hd\_opt\_arg\_required(const char * arg, const char * err_prefix)
\end{verbatim}

This routine checks for a required argument in string \texttt{arg}. An argument is specified with a dash (-) or forward slash (/) followed by a string. When the string contains no arguments, this routine sets \texttt{hdi\_cmd\_stat} to \texttt{E_ARG\_EXPECTED} and when \texttt{err\_prefix} is not null, HDIL displays an error message displaying \texttt{err\_prefix}.

\textbf{hd\_poll()}

\begin{verbatim}
const STOP\_RECORD *hd\_poll()
\end{verbatim}

This routine should be called periodically by the debugger tool after it starts execution by calling \texttt{hdi\_targ\_go()} with the \texttt{GO\_BACKGROUND} bit set. It checks for and handles a stop message or runtime requests from the target. The returned value is the same as that described for \texttt{hdi\_targ\_go()}. If the application is still running, the stop reason is \texttt{STOP\_RUNNING}.

If \texttt{hdi\_signal()} has been called and the application is still running, \texttt{hd\_poll()} sends an interrupt to the target to return control of the target to the monitor. A subsequent call to \texttt{hd\_poll()} handles the stop message.

Failures:

\begin{verbatim}
E_NOTRUNNING, E_RESET
\end{verbatim}
hdi_reg_get()

int hdi_reg_get(int regname, REG *regval)

This routine retrieves the current value of the i960 register specified by regname from the monitor’s copy of the user program’s registers and stores the value at the location specified by regval. The following are valid values of regname:

- REG_R0 or REG_PFP
- REG_R1 or REG_SP
- REG_R2 or REG_RIP or REG_IP
- REG_R3 - REG_R15
- REG_G0 - REG_G14
- REG_G15 or REG_FP
- REG_PC
- REG_AC
- REG_TC
- REG_SF0 - REG_SF4
- REG_FP0 - REG_FP3

The routine fails if the specified register is not supported on the target architecture.

NOTE. The register set is cached on the host, so it is not inefficient to request one register at a time, or to call this routine repeatedly for a single register. There is no need for the debugger to cache the values of the registers.

The returned value is OK or ERR, indicating whether or not the register was retrieved successfully.

Failures: E_ARCH, E_ARG, E_RUNNING

hdi_reg_put()

int hdi_reg_put(int regname, REG regval)
This routine changes the value of the user register designated by `regname` to `regval`. See the description of the `hdi_reg_get()` routine for valid values of `regname`. The routine fails if the specified register does not exist on the target architecture.

The returned value is `OK` or `ERR`, indicating whether or not the register was set successfully.

**Failures:**

- `E_ARCH`
- `E_ARG`
- `E_RUNNING`

### `hdi_regfp_get()`

```c
int hdi_regfp_get(int fpregnum, int format, 
                 FPREG *fpregval)
```

These routines retrieve and change the current value of the i960 floating point register specified by `fpregnum`. Valid values of `fpregnum` are 0 through 3, corresponding to registers `fp0` through `fp3`. These routines fail with the `E_ARCH` error if the target architecture does not support floating point.

The format argument indicates the format of the floating point value to be used. Supported formats are `FP_80BIT` and `FP_64BIT`. `FP_80BIT` specifies IEEE 80-bit extended real format. `FP_64BIT` specifies IEEE 64-bit long real format. Both formats are represented as an array of bytes in the i960 processor byte order. For `hdi_regfp_get()`, when the `FP_64BIT` format is requested, the target also provides the values of the floating point flags resulting from the conversion (bits 16 through 20 of the arithmetic controls register). Note that either format is meaningless to the host without further software processing, unless the host supports IEEE floating point format.
A register may be retrieved and set using either format. If a register is set using one format and then retrieved using another format, the value is sent to the target for conversion. If a register is set using the `FP_64BIT` format and then immediately retrieved using the same format, the value of the flags field will be 0.

Failures:  
E_ARCH, E_ARG, E_RUNNING

### hdi_regs_get()

```c
int hdi_regs_get(UREG regval)
```

This routine copies the current values of the user register set from the monitor’s copy into the array `regval`. The floating point registers (if any) are not returned.

`UREG` is an array of unsigned longs (32-bit values). An individual register value can be accessed by indexing the array with a register name from the list presented in the description of the `hdi_reg_get()` routine. The order in which the registers appear in the array is as follows: `r0-r15, g0-g15, pc, ac, tc, sf0-sf4`. Entries for registers not supported on the target architecture are meaningless.

Failures:  
E_RUNNING

### hdi_regs_put()

```c
int hdi_regs_put(const UREG regval)
```

This routine copies the values in the array `regval` into the user register set. The floating point registers are not changed. See the description of the `hdiRegs_get()` routine for information on the type `UREG`. Entries for registers not supported on the target architecture are ignored.
NOTE. The debugger can get better performance if you use `hdi_reg_put()` to change an individual register, since `hdi_regs_put()` assumes that all the registers have changed. You can read all the registers with `hdi_regs_get()` and change them individually with `hdi_reg_put()`.

The returned value is **OK** or **ERR**, indicating whether or not the registers were set successfully.

Failures: **E_RUNNING**, **E_ALIGN**

**hdi_reset()**

```c
int hdi_reset()
```

This routine resets the interface library and the target and reestablishes the default environment. This includes deleting any breakpoints and discarding any cached memory or registers. The monitor does a hardware reset on the target, if possible; otherwise it reinitializes the processor as if from a cold start. The returned value is **OK** or **ERR**, indicating whether the target was reset successfully.

NOTE. Many routines can return the error **E_TARGET_RESET**. This error is a result of one of two cases: Either the target reset button was pressed or a power cycle occurred on the target. These conditions cause the message from HDIL to time out. At that point, HDIL automatically attempts to re-establish communication. If HDIL succeeds, **E_TARGET_RESET** is returned. However, the host must then reset itself to the initial target state. HDIL must be cleared. An easy way to clear the HDIL is to call the `hdi_reset()` routine.
**hdi_restart()**

```c
int hdi_restart()
```

This routine should be called when you restart the application from the beginning or load a new application. The routine re-initializes the HDI’s I/O descriptors.

**hdi_set_gmu_reg**

```c
int hdi_set_gmu_reg(int type, int regnum, HDI_GMU_REG *regval)
```

This routine initializes a new Guarded Memory Unit (GMU) register of the specified type. A GMU is available only on Hx processors. Values of type are:

- **HDI_GMU_DETECT**: Sets up a memory detection low-address/high-address register pair
- **HDI_GMU_PROTECT**: Sets up a memory protection address/mask register pair

The parameter `regnum` specifies the register to initialize. Each protection type has its own set of register numbers, starting at 0. An **E_GMU_BADREG** error occurs if there is no such register in the current hardware.

The parameter `regval` is a pointer to an initialized `HDI_GMU_REG` structure. The bit layout of `regval.access` is given in the *i960 Hx Microprocessor User’s Manual*. The register is enabled when the value of `regval.enabled` is non-zero; the register is disabled when the value of `regval.enabled` is 0.

The return value is **OK** or **ERR**, indicating whether or not the GMU register was successfully initialized.

Failures: **E_ARCH, E_ARG, E_GMU_BADREG**
**hdi_set_lmadr()**

```c
int hdi_set_lmadr(unsigned int lmreg, unsigned long value)
```

This routine places a value in a Jx/Hx/RP processor’s logical memory address register (LMADR). This function is primarily for users of the ApLink target, since ApLink cannot know in advance how the memory of the target being tested will be configured.

The `lmreg` field defines the Jx/Hx/RP logical memory address register number to write to.

The `value` defines what to write to `lmreg`.

The returned value is **OK** or **ERR**, indicating whether or not the value was written successfully. When the returned value is **ERR**, it includes an appropriate HDI error code via the `hdi_cmd_stat` routine, as follows:

- **E_ARCH** the function is valid for Hx/Jx/RP processors only
- **E_ARG** the `lmreg` specified is out of range

**hdi_set_lmmr()**

```c
int hdi_set_lmmr(unsigned int lmreg, unsigned long value)
```

This routine places a value in a Jx/Hx/RP processor’s logical memory mask register (LMMR). This function is primarily for users of the ApLink target, since ApLink cannot know in advance how the memory of the target being tested will be configured.

The `lmreg` field defines the Jx/Hx/RP logical memory mask register number to write to.

The `value` defines what to write to `lmreg`.

The returned value is **OK** or **ERR**, indicating whether or not the value was written successfully. When the returned value is **ERR**, it includes an appropriate HDI error code via the `hdi_cmd_stat` routine, as follows:
Failures:

- **E_ARCH** the function is valid for Hx/Jx processors only
- **E_ARG** the `lmreg` specified is out of range

### hdi_set_mcon()

```c
int hdi_set_mcon(unsigned int region, unsigned long value)
```

This routine writes a value to a specified memory control register and, in the case of the Cx processor, tells the processor to reload that register. This function is primarily for users of the ApLink target, since ApLink cannot know in advance how the memory of the target being tested will be configured.

The `region` field defines the memory region to write the value to. The valid value range is 0 to 15. For the Jx processor, this value is divided by two before being written into the processor’s control tables.

The `value` defines what will be written into the processor’s memory control tables.

The returned value is **OK** or **ERR**, indicating whether or not the value was written successfully. When the returned value is **ERR**, it includes an appropriate HDI error code via the `hdi_cmd_stat` routine, as follows:

Failures:

- **E_ARCH** the function is valid for Cx/Hx/Jx processors only
- **E_ARG** the region specified is out of range
**hdऴ_set_mmr_reg()**

```c
int hdऴ_set_mmr_reg(ADDR mmr_offset, REG new_value, REG mask, REG *old_value)
```

This routine allows the client to modify the memory mapped register (MMR) via execution of a `sysctl` instruction, rather than a simple processor write. Note that when a `mask` value of 0 is used, this routine can only be used to read the MMR.

The `mmr_offset` is the offset into the MMR (e.g. the address) to modify. The `new_value` is the new value to place in the MMR. This parameter is irrelevant if a mask value of 0 is used.


The `old_value` is the value of MMR (`mmr_offset`) before it is modified. It is returned by reference.

Failures: **E_ARCH**

**NOTE. This routine can be used only with an i960 Jx or Hx processor.**

**hdऴ_set_prcb()**

```c
int hdऴ_set_prcb(ADDR prcb)
```

This routine reinitializes the processor using the PRCB specified. The debugger or user must ensure that the PRCB and associated data structures are set up correctly before calling this routine. Before reinitializing the processor, the monitor changes the values of any fields that it requires in the PRCB or associated data structures.

The returned value is **OK** or **ERR**, indicating whether or not the request was successful.

Failures: **E_RUNNING**
hdi_set_region_cache()

void hdi_set_region_cache(REGION_CACHE cache_vector)

This routine permits the host debugger to enable or disable HDI memory caching region by region. Setting an array element of the cache_vector to a nonzero value enables HDI memory caching for that region. Likewise, clearing an array element disables caching for that region. It is often highly desirable to disable caching when accessing memory-mapped hardware.

If the bypass_cache function parameter is set when hdi_mem_write or hdi_mem_read is called, memory will not be fetched from HDI’s internal cache, regardless of what caching attributes have been specified via hdi_set_region_cache. In other words, the bypass_cache function parameter temporarily overrides attributes set using hdi_set_region_cache.

NOTES.
1. HDI memory caching is unrelated to processor caching.
2. By default, HDI memory caching is enabled for all memory regions.

hdi_signal()

void hdi_signal()

The debugger calls this routine to interrupt a call to the interface when the user types Ctrl+C, or to interrupt a target that has been started in the background. (Refer to the description of hdi_targ_go() for more details on starting a target in the background.)

To interrupt a call to the interface, hdi_signal() is normally called from an interrupt or signal handler. HDIL finishes any transaction currently in progress, and returns. If HDIL is completing the last transaction of an operation, the operation finishes successfully, and HDIL returns a success status. If the HDIL request is not completed successfully, HDIL returns an error code, and hdi_cmd_stat() is set to E_INTR.
If `hdi_signal()` is called again before the operation completes, HDIL returns immediately. This can leave the target in an unknown state, and it may need to be reset by hand. You can press **Ctrl+C** twice to regain control immediately when the target is hung. In Windows, normally the keyboard must be polled to allow Windows to check for **Ctrl+C**. This polling is done by calling `kbhit()` in the inner loop of the communications system while it is waiting for a response from the target. When you press **Ctrl+C**, Windows calls the interrupt handler that the debugger has configured to handle **Ctrl+C**, which in turn should call `hdi_signal()`.

### hdi_sysctl()

```c
int hdi_sysctl(int type, int f1,
               unsigned int f2, unsigned long f3,
               unsigned long f4)
```

This routine can be used only for the i960 Jx/Hx/Cx/RP processors. It causes the target processor to issue `sysctl` with the specified arguments. The meaning of the `sysctl` is specific to the processor, not the interface.

This routine is not required for debugger operation, and need not be used in all implementations of this interface. Certain message types can be prohibited by the interface library (e.g., Reinitialize) and others can cause undefined results (e.g., Request Interrupt).

The returned value is **OK** or **ERR**, indicating whether or not the operation was successful.

**Failures:**
- `E_ARCH`
- `E_RUNNING`

### hdi_targ_go()

```c
const STOP_RECORD *hdi_targ_go(int mode)
```

This routine begins (or resumes) execution of user code in the target. It flushes to the target any commands that have been cached, and directs the target to resume executing the user code at the address currently in the target’s `ip` register.
This routine continues from a software breakpoint: It single-steps through the instruction where the breakpoint occurred, re-inserts the fmark instruction, and continues the user code according to mode.

The value of \textit{mode} is one of: \texttt{GO\_RUN}, \texttt{GO\_STEP}, \texttt{GO\_NEXT}, or \texttt{GO\_SHADOW}. You can modify any of these values by Oring in the \texttt{GO\_BACKGROUND} bit. When this bit is set, \texttt{hdi\_targ\_go()} starts execution and then returns immediately without waiting for the target to stop. If execution is expected to stop or if runtime requests are expected, the debugger tool must call \texttt{hdi\_poll()} to handle the target’s response. You can also use the \texttt{GO\_BACKGROUND} option to exit from the debugger and leave the application running in the target, if execution is not expected to stop and no runtime requests need to be handled.

The \texttt{GO\_SHADOW} option is similar to \texttt{GO\_RUN}, except that it may have additional effects defined by the target.

\texttt{GO\_STEP} halts execution after a single machine instruction has been executed. \texttt{GO\_NEXT} is like \texttt{GO\_STEP}, except that it steps over subroutine calls. It executes a single instruction unless that instruction is a subroutine call, in which case it executes to the instruction following the subroutine call. Subroutine calls include the i960 processor instructions \texttt{call}, \texttt{callx}, \texttt{calls}, \texttt{bal}, and \texttt{balx}.

The debugger can cause execution to halt after other trace conditions by setting the user’s \texttt{tc} register before calling this routine.

Once the user code is running, if the \texttt{GO\_BACKGROUND} bit is not set, \texttt{hdi\_targ\_go()} waits for the target to re-enter the monitor. Meanwhile, it handles runtime service requests from the application program. When \texttt{hdi\_signal()} is called, \texttt{hdi\_targ\_go()} attempts to interrupt the target (which should return it to the monitor). The \texttt{hdi\_targ\_go()} routine then waits for the target to reenter the monitor. When \texttt{hdi\_signal()} is called again, the entire operation is aborted and \texttt{hdi\_targ\_go()} returns NULL.

The \texttt{hdi\_targ\_go()} routine returns NULL if the user program cannot be started or if the host cannot maintain communications when the user program stops; otherwise, it returns a pointer to a data structure describing the reason the application program stopped.
The format of this structure is as follows:

```c
typedef struct {
    unsigned long reason;
    struct {
        unsigned long exit_code; /* STOP_EXIT */
        ADDR sw_bp_addr;        /* STOP_BP_SW */
        ADDR hw_bp_addr;        /* STOP_BP_HW */
        ADDR da0_bp_addr;       /* STOP_BP_DATA0 */
        ADDR da1_bp_addr;       /* STOP_BP_DATA1 */
        struct { /* STOP_TRACE */
            unsigned char type;
            ADDR ip;
        } trace;
        struct { /* STOP_FAULT */
            unsigned char type;
            unsigned char subtype;
            ADDR ip;
            ADDR record;
        } fault;
        unsigned char intr_vector; /* STOP_INTR */
    } info;
} STOP_RECORD;
```

The value of `reason` indicates the reason the program halted. It is bit encoded with one or more of the following values:

- **STOP_TRACE**  Trace fault
- **STOP_BP_SW**  Software breakpoint (fmark executed)
- **STOP_BP_HW**  Hardware breakpoint
- **STOP_BP_DATA0**  Data address breakpoint
- **STOP_BP_DATA1**  Data address breakpoint
- **STOP_CTRLC**  Debugger interrupted execution
- **STOP_EXIT**  Program finished executing and called _exit()
- **STOP_FAULT**  Unclaimed fault
- **STOP_INTR**  Unclaimed interrupt
**STOP_MON_ENTRY**  
Program called `mon_entry()` to enter the monitor

**STOP_RUNNING**  
Target was left running (by `GO_BACKGROUND` or `GO_SHADOW`)

**STOP_UNK_SYS**  
Application called an obsolete or reserved system procedure

**STOP_UNK_BP**  
Breakpoint was not set by debugger; used in conjunction with `STOP_BP_SW`

The stop reason is bit-encoded because the application can stop for more than one reason. The stop cause should be tested with a statement such as:

```c
if (stop_reason.reason & STOP_TRACE) {
    /* Handle trace stop */
}
```

A direct comparison should be done only to determine whether the target stopped for a single reason, rather than multiple reasons.

**NOTE.** The value of `STOP_RUNNING` is 0. That is, if no stop reasons are encoded, the target is running. Therefore, this value must always be checked with a direct comparison.

The structure `info` provides additional information about the halt on a reason-by-reason basis, as indicated by the comment to the right of each member. The contents of fields that do not correspond to a bit set in `reason` are undefined. The stop reasons `STOP_CTRL_C, STOP_MON_ENTRY, STOP_RUNNING, and STOP_UNK_SYS` do not have any additional information.

The `exit_code` value is the argument passed by the program to the `exit()` routine. The value of `exit_code` is the same as register `g0`.

The `intr_vector` value is the interrupt vector at which the unclaimed interrupt was received. (An interrupt is unclaimed if the application program did not install an interrupt handler for the interrupt in question.)
The value of `trace.ip` is the address of the instruction that caused the trace fault. The value of `trace.type` indicates the type of trace fault that occurred. Legal values are:

- `TRACE_STEP`: instruction trace
- `TRACE_BRANCH`: branch trace
- `TRACE_CALL`: call trace
- `TRACE_RET`: return trace
- `TRACE_PRERET`: pre-return trace
- `TRACE_SVC`: supervisor trace

Any combination of breakpoints can occur at the same time, so each is reported independently. The value of `sw_bp_addr` is the address of the `mark` or `fmark` instruction that caused the breakpoint. This is the same as the IP if the software breakpoint was set by `hdi_bp_set()`; otherwise, the IP is the address of the instruction after the breakpoint.

A software breakpoint is reported if the next instruction to be executed is a `mark` or `fmark` when the application stops for some other reason. If the breakpoint was not set by `hdi_bp_set()`, and execution is continued without adjusting the IP to the address after the breakpoint, the breakpoint is reported again. The `hw_bp_addr` value is the address of the instruction that triggered the breakpoint. This is not the same as the IP since a hardware breakpoint takes place after the instruction is executed. The value of `da0_bp_addr` or `da1_bp_addr` is the address whose access caused the data breakpoint to occur.

The variables `fault.type` and `fault.subtype` are the fault type and subtype extracted from the fault record. The values and their meanings are described in the reference manual for the processor. The value of `fault.ip` is the address of the instruction that caused the fault. The value of `fault.record` is the address of the fault record, which can be used for extracting additional information.

The `hdi_targ_go()` routine indicates failure by returning `NULL`.

Failures: `E_ARG`, `E_RUNNING`, `E_RESET`
hdi_targ_intr()

const STOP_RECORD *hdi_targ_intr()

This routine attempts to interrupt the code running on the target board, returning the board to monitor control.

It is normally called internally by hdi_targ_go() when hdi_signal() is called while the target is running. It is exported as a debugger-callable entry point in case an internal attempt to interrupt the target fails and you can make the target interruptable (e.g., by reconnecting a loose RS232 cable). You can then enter a debugger command that calls this routine to regain control of the target.

The returned value is the same as that described for hdi_targ_go(). Normally, reason is STOP_CTRLC. However, if the application stops for some reason other than the interrupt, that reason is reported instead.

Failures: E_NOTRUNNING, E_RESET

hdi_term()

int hdi_term(int term_flag)

This routine must be called before the debugger exits. The routine terminates the interface sub-system and releases system resources. When term_flag is FALSE, and the target is not running an application, hdi_term() removes any software breakpoints in target memory and resets the target board, leaving it in the auto-bauding state for the next process that connects to it. When term_flag is TRUE, hdi_term does not communicate with the target. This can be used if the debugger knows that the target is hung.

The returned value is OK or ERR, indicating whether or not hdi_term() successfully removed software breakpoints and reset the target. The interface to the target is closed in either case.
**hdi_ui_cmd()**

```c
int hdi_ui_cmd(const char *cmd)
```

This routine sends the ASCII command to the user interface in the monitor. ASCII output from the monitor is passed to `hdi_put_line()`.

Failures: `E_VERSION`, `E_RUNNING`, `E_RESET`

**hdi_update_gmu_reg()**

```c
int hdi_update_gmu_reg(int type, int regnum, int enable)
```

This routine updates an existing Guarded Memory Unit (GMU) register of the specified `type`. A GMU is available only on Hx processors.

Valid values of `type` are `HDI_GMU_DETECT` or `HDI_GMU_PROTECT`. The value of `regnum` is the register to be updated. An `E_GMU_BADREG` error occurs if there is no such register in the hardware for the given `type`.

The register is enabled when the value of `enable` is non-zero; the register is disabled when the value of `enable` is 0.

The return value is `OK` or `ERR`, indicating whether or not the GMU register was successfully updated.

Failures: `E_ARCH`, `E_ARG`, `E_GMU_BADREG`

**hdi_version()**

```c
int hdi_version(char *buffer, int len)
```

This routine returns a null-terminated ASCII version string suitable for displaying in a banner. It first copies the HDIL version string into `buffer`. It then gets the version string from the target and appends it to `buffer`. The value of `len` indicates the length of the buffer in bytes.
The returned value is **OK** or **ERR**, indicating whether or not the request was successful. If the command fails because of buffer overflow, the buffer contains the initial \( len - 1 \) bytes of the version string(s). If the command fails due to a communications failure, the buffer contains the HDIL version string only. In all cases, the buffer is null-terminated.

Failures: 

**E_RUNNING, E_BUFOVFLH**

### HDIL Support for PCI Communication

On Win32 hosts, the PCI driver is composed of two parts:

The first part, `pci_drvr.c` contains the driver routines. They support PCI communication to a PLX PCI9060 interface chip or the 80960 RP chip. For Windows 95, `pci_drvr.c` contains the BIOS calls written in inline assembly language. For Windows NT, `pci_drvr.c` uses a device driver that calls the HAL interface.
### pci_drvr.c PLX Driver Routines

<table>
<thead>
<tr>
<th>Routine</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>pci_cyclone_init</td>
<td>initializes a Cyclone baseboard with PLX PCI bridge chip installed to provide PCI download</td>
</tr>
<tr>
<td>pci_intr_trgt</td>
<td>sets doorbell interrupt bit 31 to stop the target</td>
</tr>
<tr>
<td>pci_cyclone_err</td>
<td>sets the error bit and resets all other data transfer bits to off</td>
</tr>
<tr>
<td>pci_cyclone_connect [BL2]</td>
<td>sets the PLX PCI bit for inuse and error, then waits for the target to reset the error bit</td>
</tr>
<tr>
<td>pci_cyclone_disconnect</td>
<td>resets the PLX PCI inuse bit</td>
</tr>
<tr>
<td>pci_cyclone_put</td>
<td>writes data to the Cyclone board</td>
</tr>
<tr>
<td>pci_cyclone_get</td>
<td>reads data from the Cyclone board</td>
</tr>
<tr>
<td>pci_cyclone_direct_put</td>
<td>writes directly to the i960 processor’s memory space, rather than passing data through mailbox registers</td>
</tr>
<tr>
<td>pci_get_reg</td>
<td>returns the value of a specified PLX register</td>
</tr>
<tr>
<td>pci_put_reg</td>
<td>writes a value to a PLX register</td>
</tr>
<tr>
<td>pci_disp_regs</td>
<td>displays the contents of the PLX PCI registers</td>
</tr>
<tr>
<td>pci_driver_routines</td>
<td>fills in the list of PCI drivers for a PLX interface</td>
</tr>
<tr>
<td>in_portd</td>
<td>uses inline assembly code to send data to the system</td>
</tr>
<tr>
<td>out_portd</td>
<td>uses inline assembly code to get data from the Cyclone board</td>
</tr>
</tbody>
</table>
The second part, `win_pci.c`, contains all Win32 BIOS interface routines and the common interface routines for PCI download and PCI, including:

<table>
<thead>
<tr>
<th>Routine</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>pci_cyclone_init</code></td>
<td>initializes the PLX driver</td>
</tr>
<tr>
<td><code>pci_cyclone_connect</code></td>
<td>sets the in-use and error status bits, and waits for the error bit to be turned off</td>
</tr>
<tr>
<td><code>pci_cyclone_disconnect</code></td>
<td>sets the in-use status bit off</td>
</tr>
<tr>
<td><code>pci_cyclone_err</code></td>
<td>sets the error status bit and resets the data transfer status bits</td>
</tr>
<tr>
<td><code>pci_cyclone_get</code></td>
<td>reads data from the target</td>
</tr>
<tr>
<td><code>pci_cyclone_put</code></td>
<td>writes data to the target</td>
</tr>
<tr>
<td><code>pci_cyclone_direct_put</code></td>
<td>writes data directly to the target memory using the PCI bus</td>
</tr>
<tr>
<td><code>pci_cyclone_target_intr</code></td>
<td>sets the doorbell bit 31 to interrupt the target</td>
</tr>
<tr>
<td><code>plx_driver_routines</code></td>
<td>fills in the FAST_INTERFACE structure with pointers to the PLX PCI9060 drivers.</td>
</tr>
<tr>
<td><code>pci_get_reg</code></td>
<td>returns a PLX register value</td>
</tr>
<tr>
<td><code>pci_put_reg</code></td>
<td>sets the PLX PCI9060 register to a value</td>
</tr>
<tr>
<td><code>pci_disp_regs</code></td>
<td>displays all the PLX PCI9060 register (debug display)</td>
</tr>
</tbody>
</table>
Cyclone Evaluation Boards

This appendix describes MON960’s use of the Cyclone evaluation board LEDs and DIP switches during boot-up and normal operation.

PCI80960DP Evaluation Boards

This section describes the PCI80960DP standalone and PCI evaluation boards.

Power-on Self-tests

The self-test (POST) for the Cyclone board is called from the user interface command `po`.

Table A-1 Cyclone Board DIP Switches

<table>
<thead>
<tr>
<th>Switch ON</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW1-1 VPP ON</td>
<td>Allows programming of baseboard flash using 12 volts.</td>
</tr>
<tr>
<td>SW1-2 NMI ON</td>
<td>Determines that UART uses NMI; MON960 works whether SW2 is on or off. If</td>
</tr>
<tr>
<td></td>
<td>SW2 is off, then UART uses the CPU module interrupt.</td>
</tr>
<tr>
<td>SW1-3 ROM Swap OFF</td>
<td>Boots from the CPU module flash memory. If SW3 is on, you must boot from</td>
</tr>
<tr>
<td></td>
<td>baseboard flash.</td>
</tr>
<tr>
<td>SW1-4 OFF</td>
<td>Not used.</td>
</tr>
</tbody>
</table>
Table A-2  Cyclone Board LEDs

<table>
<thead>
<tr>
<th>LED</th>
<th>When lit, Indicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>MON960 is listening at the serial port.</td>
</tr>
<tr>
<td>1</td>
<td>MON960 is writing to the serial port.</td>
</tr>
<tr>
<td>2</td>
<td>An application program is being executed.</td>
</tr>
<tr>
<td>3</td>
<td>MON960 is listening for a parallel download.</td>
</tr>
</tbody>
</table>

Note that LED 0 is the one closest to the serial port. During boot-up the LEDs indicate the following conditions:

- LED 0 on after CIO chip initialization
- LED 1 on after Memory test passed
- LED 2 on after Flash, Squall module, and UART initialization
- LED 3 on after PCI initialization
- all LEDs off after MON960 complete initialization

MON960 flashes all LEDs on, then off, for PCI, LSERR and PCI DEADLOCK interrupts using the i960 Cx/Jx/Hx CPU modules. Thereafter, the LEDs indicate the conditions shown in Table A-2.

IQ80960RP Evaluation Boards

This section describes the IQ80960RP PCI evaluation boards.

Power-on Self-tests

The self-test (POST) for the Cyclone board is called from the user interface command po.
Table A-3  Cyclone Board DIP Switches

<table>
<thead>
<tr>
<th>Switch ON</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW1-1 VPP OFF</td>
<td>When on, lets you erase the baseboard flash.</td>
</tr>
<tr>
<td>SW1-2 ROM Swap OFF</td>
<td>When off, the board boots from the flash in socket U4. When on, the board boots from the flash in socket U3.</td>
</tr>
<tr>
<td>SW1-3 ROM Disable OFF</td>
<td>Disables booting from either flash.</td>
</tr>
<tr>
<td>SW1-4 OFF</td>
<td>Not used.</td>
</tr>
</tbody>
</table>

Table A-4  Cyclone Board LEDs

<table>
<thead>
<tr>
<th>LED</th>
<th>When Lit, Indicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>MON960 is listening at the serial port.</td>
</tr>
<tr>
<td>1</td>
<td>MON960 is writing to the serial port.</td>
</tr>
<tr>
<td>2</td>
<td>An application program is being executed.</td>
</tr>
<tr>
<td>3</td>
<td>MON960 is listening for a parallel download.</td>
</tr>
<tr>
<td>4-7</td>
<td>Only used during boot-up.</td>
</tr>
</tbody>
</table>

Note that LED 0 is the one closest to the serial connector. During boot-up, the Cyclone IQ80960RP baseboard LEDs (eight small red LEDs) indicate the following conditions:

- LED 0-2 on when memory tests are complete
- LED 3 on when core initialization is complete
- LED 4 on when flash initialization is complete
- LED 5 on when ATU and MU initialization is complete
- LED 6 on when bridge initialization is complete
- LED 7 on when the UART test has passed
- all LEDs off when tests are complete

Thereafter, the LEDs indicate the conditions described in Table A-4.
The MONDB execution utility included with MON960 enables a host system to download and execute an application program on the target board running MON960. Once the program downloads, you can use MONDB to initiate the User Interface (UI) debugging mode. The UI is explained further in Chapter 4 of this guide.

MONDB supports both serial and PCI communication between the host and target. You can also use TCP/IP to allow a remote workstation to connect to a MONDB server. The MONDB server uses serial or PCI communications to download the remote workstation’s software to the evaluation board. This feature lets you share an evaluation board with a group of workstations.

MONDB supports Position Independent Code (PIC) and Position Independent Data (PID). Additionally, MONDB supports erasing flash before a download. While the target is running, MONDB processes runtime requests from the application program. When the application completes, MONDB exits. The exit status of MONDB is the same as that of the application program.

MONDB options, plus the program and any optional arguments, may be placed within an environment variable called MONDB. MONDB reads and parses environment variable settings before parsing its command line. Consequently, options and/or a load command tail specified at the command line always override environment variable settings.

Downloads can be completed using a serial or parallel port, or the PCI bus. MONDB’s downloading features support the following:
- on Windows systems, PCI download to Cyclone PCI baseboards.
- parallel download on selected UNIX hosts.
- downloading programs in ELF and b.out formats, as well as COFF.
• downloading programs in big- or little-endian host object file format.
• 57600 and 115200 serial baud rates on selected UNIX hosts. Refer to the section titled *Communicating from UNIX Hosts at 57600 or 115200 Baud.*

If you connect to a target using serial communication, but do not specify a baud rate, MONDB supplies the following default baud rates:
• for UNIX hosts, 38400
• for Windows hosts, 115200

When running a program, you may interrupt it by pressing CTRL-C or CTRL-break. If the target does not respond, then pressing CTRL-C or CTRL-break three more times causes MONDB to exit.

MONDB consists of these source files, which are divided into functional areas.

- **Mondb.c** contains the init code, mainline debugger interface, program execution, return and interrupt code.
- **Options.c** contains all the option parsing routines.
- **Tables.c** contains all the CPU table display code.
- **Tcp.c** contains all the TCP/IP init, client, and server code.
- **Aplink.c** contains all the Aplink code.
- **Usage.c** contains all the help message display code.
- **Verstr.c** contains the code that generate a `version.c` file for version information.

**TCP/IP Communication**

MONDB supports a client/server mode of operation using the TCP Internet Protocols (AF_INET, SOCK_STREAM) to establish the connection. The same MONDB executable may be invoked as either the client or the server depending on the command line options used at startup.
The operation of MONDB in client/server mode is completely transparent to the user with the exception of the command line options required. The server must have a target i960 board installed and be ready for communication via serial or PCI connection prior to starting the client.

The MONDB TCP/IP client communication software is implemented as a standard driver that is part of the HDILCOMM library. The MONDB server communication software is implemented as an integral part of the MONDB source code. Both client and server systems must have standard TCP/IP communication software installed in order for MONDB to function in TCP/IP mode.

The client HDILCOMM packets, which are normally sent directly to the target board via SERIAL or PCI connection, are encapsulated into standard TCP/IP packets and sent to the server where they are extracted and forwarded to the target board via serial or PCI connection, depending on how the MONDB server was invoked. Response HDILCOMM packets from the target board are received by the MONDB server, encapsulated into standard TCP/IP packets, and sent to the client for processing.

**Hardware Requirements**
- PC or UNIX workstation for client operation.
- PC or UNIX workstation for server operation.
- i960 evaluation board installed on server machine.
- Network adapter cards on both client and server.

**Software Requirements**
- TCP/IP software installed on both client and server.

**Server Semantics**

Invoke the MONDB executable with the `-srv` option and one of the standard target board communication options (serial or PCI). The `-srv` option must be immediately followed by two arguments. The first argument is the name of the server machine that directly corresponds to that machine’s IP address. The second argument is the server port number.
that is used to establish the client/server connection. Note that selecting a port number is left to the operator, there is no standard port reserved for this type of connection. For example:

```
mondb -pci -srv computerXYZ.company.com 1234
```

**Client Semantics**

Invoke the MONDB executable with the `-tcp` option only. Place the same two arguments that were used to invoke the server immediately after the `-tcp` option. The first argument being the machine name of the server and the second being the port number to be used for establishing the connection. For example:

```
mondb -tcp  computerXYZ.company.com  1234
```

**PCI Communication**

PCI communication is supported for the following hosts and hardware:

- any Windows-hosted PC with a PCI bus, and a PCI-compliant BIOS.
- any MON960-based target that includes a PCI interface.

Intel’s Cyclone baseboards meet these requirements, using PLX’s PCI 9060 PCI bus master interface chip. Note that the Cyclone baseboard requires a PC host that has sufficient physical space to accept a full-sized PCI card.

**Hardware Requirements**

To support PCI communication, the target must be connected to a PCI bus. Furthermore, a communication driver is required to interface the target to the host.
Software Requirements — PCI Driver Installation

Windows NT requires that the PCI driver (pci_wnt.sys) is installed before any PCI functions can operate. Windows 95 does not need its VXD driver (pci_w95.vxd) for operation, however, downloads run five times faster when the VXD driver is available. The Windows 95 VXD just needs to be copied to any directory in your path. To install the Windows NT device driver you need to run `reg_ntdd.exe` from a command window and then reboot your system. Run this program with two parameters `reg_ntdd (pci_wnt.sys directory) (WinNT directory)`. See `set_ntdd.bat` for an example assuming `pci_wnt.sys` in the “Intel tools directory/bin”. These files are in the directory “..\bin” usually c:\inte960\bin. If `pci_wnt.sys` is in C:\inte960\bin then to install the NT drive you type the following in a command window

```
reg_ntdd c:\intel960 %SystemRoot%
```

Note that `reg_ntdd` looks for `pci_wnt.sys` in the bin directory under directory specified. After running `reg_ntdd` you must shutdown and restart your NT system. Now the driver is loaded after every NT boot. You can verify this by looking in the Control Panel Devices icon. Look for `PCI_WNT` in the device list and it should be started and automatic.

Mechanics

If your PC host and target meet the requirements for PCI communication, consider the advantages of its increased host-to-target transfer rates. Set up PCI communication according to the following steps:

1. Turn off the power to the PC.
2. Install an appropriate target in an empty PCI bus slot in the PC host.
3. Turn on the power to the PC.
Semantics

You can use any of three methods to establish PCI communication with a target:

1. To connect to the single Cyclone PCI card in the PC, use the -pci option.
2. To select one of \( n \) targets, all made by the same manufacturer, use the -pcib option to select a target by absolute bus address.
3. To select a target from a unique collection of hardware devices, select the target by its vendor and device ID, using the -pciv option.

Example

```
>mondb -pci myprog myarg
```

This example connects to the single Cyclone PCI target in the host PC, and downloads and executes `myprog`. All communication between the host and target transmits over the PCI bus.

Serial Communication

Serial communication is available on all hosts supported by the i960® processor tool chain. Serial communication is supported for all targets that meet the hardware requirements described next.

Hardware Requirements

To support serial communication, the host must be connected to the target by CTOOLS960 or GNU/960 through a serial cable. This implies that the target is equipped with both an RS-232 connector and supporting hardware, and that the monitor’s serial communication API has been ported to the target hardware. Since the serial protocol shared between host and target does not use hardware or software flagging, no special modifications are required for the serial cable connecting the host and target.
NOTE. Be sure to disable hardware or software flagging for the serial port that you will use to communicate with the target. This is not usually a concern for Windows, but can be an issue for some UNIX hosts.

Windows Serial Communication Example
> mondb -ser com1 myprog myarg

This example connects to a target using the COM1 serial port, downloads myprog, and executes it. All communication between host and target transmits through the serial cable.

UNIX Serial Communication Example
> mondb -ser /dev/ttya myprog myarg

This example connects to a target using the /dev/ttya serial port, downloads myprog, and executes it. All communication between host and target transmits through the serial cable.

Windows PCI Download

If a target supports PCI communication, but application requirements make it undesirable for the monitor to tie up the PCI bus with I/O and various service requests (e.g., register dumps), then PCI download can be used to augment serial communication.

Hardware Requirements

The hardware requirements are the same as those previously described for both PCI and serial communication.

Mechanics

If your Windows host and target meet the requirements for PCI download, connect a serial cable between the host and target and ensure that the target is connected to a PCI bus. The serial cable is used by the host to
establish the initial connection with the target, to service interrupts and breaks, and to transfer all non-download data between host and target. The PCI bus is used only to download programs to the target.

**Example**

`> mondb -ser com2 -pci myprog myarg`

This example connects to a Cyclone PCI target via the COM2 serial port, downloads *myprog* to the target using the PCI bus, and executes the program. All I/O generated by *myprog* is serviced via COM2.

**Windows Parallel Download**

Parallel download can be used to augment serial communication. Parallel download transfer rates are up to ten times the speed of the fastest Windows serial transfer.

**Hardware Requirements**

To support parallel download, a host parallel port host must be connected to a target's parallel port via an appropriate cable, which is typically double male, 25-pin, and wired straight through. The target must include a receive-only or bi-directional parallel port connector and supporting hardware, and the monitor's parallel download API must be ported to the target hardware.

**Mechanics**

If your Windows host and target meet the requirements for parallel download, consider the advantages of its increased host-to-target transfer rates. To use parallel download, you must connect both a serial cable *and* parallel cable between the host and target. The serial cable is used by the host to establish the initial connection with the target, service interrupts and breaks, and to transfer all non-download data between host and target. The parallel cable is used *only* to download programs to the target.
Example
> mondb -ser com1 -par lpt1 myprog myarg

This example connects to a target via the COM1 serial port, downloads myprog via the LPT1 parallel port, and subsequently executes myprog. All I/O generated by myprog is serviced via COM1.

UNIX Parallel Download

Parallel download is up to 50 times faster than the fastest UNIX serial transfer rate. UNIX parallel download is supported for selected hosts and hardware, including:

- RS6000 workstations running AIX 3.2 or 3.25
- HP 9000/700 workstations running HP-UX 9.X
- Sun SPARCstation 4/5/10/20/Classic/LX running either SunOS 4.1.3 (or a later version), or Solaris 2.4 (or a later version), and using the manufacturer’s built-in parallel port.

The 4/5/10/20 SPARCstations usually require an adapter cable purchased from Sun Microsystems. This cable permits Sun’s miniaturized parallel port connector to interface with an industry-standard DB25 connector. The relevant part number for this adapter is X975 A/C4, and it can be ordered from Sun Express (1-800-873-7869).

- Sun SPARCstation 1/2/4/5/10/20/1000/classic/LX running SunOS 4.1.3 (or a later version) and using an SBUS add-in parallel card supplied by MAGMA. Intel has tested the following products from MAGMA and found them acceptable:
  - Parallel Sp (a single parallel port)
  - 2+1 Sp (a single parallel port, and two high-speed serial ports)

Other MAGMA SBUS cards that Intel has not tested, but that should also support parallel download include:

- Dual Parallel Sp (two parallel ports)
- 2+8 Sp (two parallel ports, and eight high-speed parallel ports)
Hardware Requirements

For host-to-target communications to support parallel download, both a parallel port and a serial port must be available. The normal parallel port cable is a double male, 25 pin straight through cable. Use parallel download with any MON960-based target that includes a UNIX-compatible, receive-only or bi-directional parallel port. Intel’s Cyclone baseboards meet those requirements.

Mechanics

If your UNIX host and target meet the requirements for parallel download, consider the advantages of its increased host-to-target transfer rates. To use parallel download, you must connect both a serial cable and a parallel cable between the UNIX host and target. The serial cable is used by the host to establish the initial connection with the target and to transfer all non-download data between host and target. The parallel cable is used only to download program(s) to the target.

NOTE. The information in this chapter assumes that you can connect a serial cable between a UNIX host and a target.

Selecting the Parallel Port On Your UNIX Host

- Sun workstations using the manufacturer’s built-in parallel port will probably provide only one parallel port connector; it is typically accessed as /dev/bpp0 (bpp means bi-directional parallel port). Users of this host/hardware combination need do nothing to set up the port.
  For Sun workstations that have a MAGMA parallel port and driver software installed, the port is usually accessed as either /dev/pm00 or /dev/pnm00. Either device should work, so use the one that yields the fastest download. Beyond installing the MAGMA add-in card and its driver, no other port configurations are necessary.
AIX hosts probably provide only one parallel port connector, but it is usually not configured. To configure it, use the `smit` system tool’s System Management menu to add a printer/plotter. Set up the following characteristics:

<table>
<thead>
<tr>
<th>Setup Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printer/Plotter Type</td>
<td>opp</td>
</tr>
<tr>
<td>Printer/Plotter interface</td>
<td>parallel</td>
</tr>
<tr>
<td>Parent adapter</td>
<td>ppa0</td>
</tr>
<tr>
<td>port number</td>
<td>p</td>
</tr>
<tr>
<td>Send all characters to printer unmodified?</td>
<td>yes</td>
</tr>
</tbody>
</table>

The defaults are sufficient for the other fields in these setup screens. Once created, the parallel port is typically accessed as `/dev/lp0` (but `smit` lists the name of the port that it creates). If you have trouble with this task, consult with your system administrator.

An HP 700 host usually provides only one parallel port connector, but it can be accessed using a number of drivers. Therefore, the user must select a driver that uses a **BUSY** handshake. Determine the proper driver as follows:

1. List all available parallel devices using this command:
   ```
   % ls -l /dev/ptr* /dev/plt* /dev/par* /dev/scn*
   ```
2. Look at each device's minor number. Any device number that ends in 2 has a driver that uses the **BUSY** handshake. Select a likely candidate and see if it works with MONDB.

The following example listing shows the likely candidates flagged with an asterisk:

   ```
   % ls -l /dev/scn* /dev/par* /dev/ptr* /dev/plt*
   /dev/par* not found
   * crw-rw-rw- 2 audit kmem 11 0x206002 Dec 18 19:27
   /dev/plt_parallel
   crw-r--r-- 2 audit kmem 1 0x204004 Jul 16 1991
   /dev/plt_rs232_a
   crw-r--r-- 2 audit kmem 1 0x205004 Jul 16 1991
   /dev/plt_rs232_b
   ```
Default Serial and Parallel Port Devices

On selected hosts, MONDB supplies default serial and parallel port names when arguments to the `-ser` and `-par` options are omitted. Selected hosts and defaults are specified in the following tables:

### Table B-1 Default Serial Port Devices

<table>
<thead>
<tr>
<th>Host Hardware and Operating System</th>
<th>Default Serial Port (-ser)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC, Windows 95/NT</td>
<td>com1</td>
</tr>
<tr>
<td>SPARCstation, SunOS 4.1.3 (or later)</td>
<td>/dev/ttya</td>
</tr>
<tr>
<td>SPARCstation, Solaris 2.4 (or later)</td>
<td>/dev/ttya</td>
</tr>
<tr>
<td>HP 9000/700 Workstation, HP-UX 9.X</td>
<td>/dev/tty00</td>
</tr>
<tr>
<td>RS6000 Workstation, AIX 3.2 &amp; 3.25</td>
<td>/dev/tty0</td>
</tr>
</tbody>
</table>

### Table B-2 Default Parallel Port Devices

<table>
<thead>
<tr>
<th>Host Hardware and Operating System</th>
<th>Default Parallel Port (-par)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC, Windows 95/NT</td>
<td>lpt1</td>
</tr>
<tr>
<td>SPARCstation, SunOS 4.1.3 (or later)</td>
<td>/dev/bpp0</td>
</tr>
<tr>
<td>SPARCstation, Solaris 2.4 (or later)</td>
<td>/dev/bpp0</td>
</tr>
<tr>
<td>HP 9000/700 Workstation, HP-UX 9.X</td>
<td>/dev/ptr_parallel</td>
</tr>
<tr>
<td>RS6000 Workstation, AIX 3.2 &amp; 3.25</td>
<td>/dev/lp0</td>
</tr>
</tbody>
</table>
Invocation Syntax

```
mondb option... [application [argument]...]
```

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>option</td>
<td>is any valid MONDB invocation option.</td>
</tr>
<tr>
<td>application</td>
<td>is the name of the application to download to the target board. If no application is specified, MONDB connects to the target, and prints the MONDB, MON960, and HDIL version numbers. Then, MONDB processes all other command line options, and exits.</td>
</tr>
<tr>
<td>arguments</td>
<td>are the arguments passed to the downloaded program.</td>
</tr>
</tbody>
</table>

TCP/IP Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-srv name port</td>
<td>Starts the MONDB program in TCP server mode. name represents the server name, which corresponds directly to the machine’s IP address. port represents an arbitrary selection left to the operator but it must not conflict with any other active port on the server.</td>
</tr>
<tr>
<td>-tcp name port</td>
<td>Starts the MONDB program in TCP client mode. name represents the name used when invoking the MONDB server to which you are connecting. port represents the port number used when the MONDB server was invoked.</td>
</tr>
</tbody>
</table>
# PCI Options

MONDB recognizes the following PCI options on Windows hosts:

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-pci</code></td>
<td>Selects a target connected to the host’s PCI bus. This option specifies selecting the target using an algorithm that searches for the first available Cyclone PCI baseboard.</td>
</tr>
<tr>
<td><code>-pcib bus_no</code></td>
<td>Selects a target connected to the host’s PCI bus. The target PCI device is selected using an absolute PCI bus address. All arguments are specified in hex.</td>
</tr>
<tr>
<td>`-pcic {io</td>
<td>mmap}`</td>
</tr>
<tr>
<td><code>io</code></td>
<td>Specifies communicating via I/O space (use in/out instructions to access the PCI device).</td>
</tr>
<tr>
<td><code>mmap</code></td>
<td>Specifies communicating via memory-mapped access.</td>
</tr>
</tbody>
</table>

**Options:**

- `-pci`  
- `-pcib bus_no`  
- `-pcic {io | mmap}`  

**Notes:** Memory-mapped access is used automatically when possible.

This option is not useful for the real mode versions of MONDB (versions built with 16-bit versions of Microsoft C). This is because I/O space access is the only feasible real mode communication interface.

The prebuilt version of `mondb.exe` supplied with each release of MON960 is a real mode application and, consequently, does not support memory mapped I/O (`mmap`).
-pcif [vendor_id device_id]  Dumps a list of all PCI devices that match the specified vendor and device ID, which must be specified in hex. If the vendor and device ID are omitted, default values are chosen to list Cyclone PCI baseboard(s). When the listing is complete, the tool immediately exits. The location of each PCI device is listed as a triple:

<PCI bus no> <PCI device no> <PCI function no>

Also listed: PCI Vendor and Device ID, Status and Command Registers, Class Code, Revision ID, and Header. This information can be used in conjunction with the -pcib or -pciv options to select a specific card when more than one MON960-compatible PCI target is present.

-pcil [bus_no]  Dumps a list of all PCI devices for the specified bus. The default bus is 0. Specifying a bus_no value of -1 enables all devices on all 256 buses in the PCI address to be listed. When the listing is complete, the tool immediately exits. The listing uses the same format as that used by the -pcif option.

-pciv vendor_id device_id  Selects a target connected to the host’s PCI bus. The target PCI device is selected by specifying a PCI vendor and device ID. All arguments are specified in hex. For this option, MONDB searches the PCI bus for the first available target that matches the specified vendor and device ID.

**Parallel Download Options**

-par [port]  Uses the specified parallel port for program download. Use LPT1 through LPT3 on Windows, and an appropriate device path on UNIX, e.g., /dev/ttya. The defaults are listed in Tables B-1 and B-2.
Communication Protocol Options

MONDB recognizes the following invocation options:

- `at timeout` Specifies the number of milliseconds the host or target waits to acknowledge that it has received a packet. The valid range of milliseconds is from 1 to 65,535. The default is 5000.

- `hpt timeout` Specifies the number of milliseconds the host waits for a reply packet from the target. The valid range of milliseconds is from 1 to 65,535. The default is 5000.

- `mpl length` Specifies the maximum number of bytes for a packet. The valid range of packet sizes is from 2 to 4095. The default is 4095. Decreasing the packet size increases the chance of receiving a good packet in a heavily loaded environment.

- `mr retries` Specifies the maximum number of times for the protocol to retry failed data exchanges. The valid number of tries is from 1 to 255. The default is five. Increasing the retry count increases the possibility of receiving a good packet in a heavily loaded environment.

- `tpt timeout` Specifies the number of milliseconds the target waits for a reply packet from the host. If the host has several applications running, you may need to increase this value. The valid range of milliseconds is from 1 to 65,535. The default is 5000.
**Serial Communication Options**

- **-b rate** sets the baud rate to *rate*. MONDB supports baud rates of 1200, 2400, 4800, 9600, 19200, and 38400 on both Windows and UNIX. On Windows and selected UNIX hosts, 57600 and 115200 are also supported. The default is 38400 on UNIX hosts, and 115200 on Windows hosts.

- **-ser [port]** specifies the name of the serial port. Use `COM1-4` on Windows. The name of the port varies on UNIX. See your system administrator for the name of the port. The defaults are listed in tables B-1 and B-2 in this chapter.

**Miscellaneous Options**

- **-d** After download, if any, initiates the User Interface (UI) debugging mode. The UI mode is the same as the terminal interface. For more information on the UI, see Chapter 4 of this manual. To exit from the MONDB UI mode, type `quit`.

- **-ef [1..16]** Erases flash memory before downloading. To erase a specific flash chip, specify a value of 1 to 16, where 1 is the first flash chip in the address sequence and 2 is the second, etc. The default value (i.e., no chip number given) erases all flash chips.

- **-it** Interrupts a target. This option assumes that the target is running a program.

- **-ip start-ip** Specifies the start address to be used instead of the one in the object file. This option can be used to start execution when no object file is specified. The value of `start-ip` must be hexadecimal.
If you do not specify an object file and do not use the \texttt{-ip} or \texttt{-d} option, MONDB connects to the target, prints the MONDB version number and monitor version number, and exits.

\begin{itemize}
    \item \texttt{-ne} No execution. MONDB downloads the application program, but does not start program execution.
    \item \texttt{-pic offset} Downloads text sections to the object file address plus the value of \texttt{offset}. The value of \texttt{offset} must be in hexadecimal.
    \item \texttt{-pid offset} Downloads data sections to the object file address plus \texttt{offset}. The value of \texttt{offset} must be in hexadecimal.
    \item \texttt{-pix offset} Downloads to the object file address plus \texttt{offset}. The value of \texttt{offset} must be in hexadecimal.
    \item \texttt{-q} Specifies quiet mode. This mode suppresses messages from MONDB. Output from the application is not affected.
    \item \texttt{-rt secs} Wait the specified number of seconds for the target to reset. The range of \texttt{secs} is 1-60 seconds; the default value is 3.
    \item \texttt{-ta} Displays target attributes in verbose format and exits. The reported information is described in the HDI include file \texttt{hdi_mcfg.h}.
    \item \texttt{-tan} Displays target attribute name only, and exits. Displays the common target name, such as \texttt{cyjx}.
    \item \texttt{-tat} Displays target attributes in terse format, and exits. The reported information is described in the HDI include file \texttt{hdi_mcfg.h}.
\end{itemize}
-v960 Displays version information for MONDB and
  exits the program.

-x Exits after the application begins executing.
  Runtime requests from the application are not
  serviced. The exit status is 0 if execution
  succeeds, and -1 if not.

MONDB Commands

This section provides a list of debugging command available through
MONDB that are not supplied by the monitor.

PCI display commands

PH [addr [hex value]] Display PCI register space from Host
  side.

  No parameters is display the first 128
  bytes in the register space. [addr hex
  value] changes the register at offset addr
to hex value

PT [addr [hex value]] Display PCI register area from the target
  side. No parameters is display the first
  256 bytes in the register space. [addr
  hex value] changes the register at offset
  addr to hex value

PM [addr [hex value]] Display PCI shared memory from target
  side. No parameters is display the first
  256 bytes in the memory space. [addr
  hex value] changes the register at offset
  addr to hex value.
Display of i960 chip tables for the Cx, Jx, Hx, and RP CPUs.

TA Display a list of target board attributes as used by debuggers

TF Display the Fault Table address and all its entries

TI Display the interrupt table, pending priorities, all entries, all interrupt registers, and a list of active interrupts. You can verify an interrupt is correctly set using this command.

TM Display all MMR entries by name and offset.

TP Display the PRCB table address and all its entries.

TS Display the system procedure table address, supervisor stack pointer and all the table entries.

Miscellaneous commands.

DF Download i960 program to flash.

MM $addr$ {value} Display/change memory-mapped register, where $addr$ represents its 4-digit hex offset, and $value$ represents the value that you would like to write to the register.

QU Quit MONDB.

SC $filename$ Reads and executes commands from a file.
Examples of Using MONDB

Windows PCI Downloading

`> mondb -ser com1 -pci myprog`

This example debugs the program `myprog`, downloading to the Cyclone PCI baseboard target currently controlled via COM1.

`> mondb -ser com1 -pcib 0 c 0 myprog`

This example downloads `myprog` to the PCI target controlled via COM1 and located at PCI bus address `0` (bus#), `0xc` (device#), `0` (function#).

`> mondb -ser com2 -pciv 8086 8 myprog`

This example downloads `myprog` to a PCI target controlled via COM2 with vendor ID `0x8086` and device ID `0x8`.

`> mondb -ser com2 -pci -par lpt1 myprog`

This example contains an error: It specifies more than one download channel.

UNIX Parallel Downloading (SPARCstation 5)

`> mondb -ser /dev/ttyb -par /dev/bpp0 myprog myarg`

This example uses MONDB to download and execute the application `myprog`. The host-to-target serial connection is made using `/dev/ttyb` at 38400 baud (the default), but `myprog` is downloaded much more quickly using the parallel communication channel `/dev/bpp0`. 
Communicating from UNIX Hosts at 57600 or 115200 Baud

You can communicate with a target at 57600 or 115200 baud on selected UNIX hosts (the target must have a UART that supports communication at those baud rates). Supported UNIX host/hardware combinations include:

- HP 700 running HP-UX 9.X
- SPARCstation running either SunOS 4.1.3 or later, or Solaris 2.4 or later, with a MAGMA 2+1 Sp SBUS card installed
- SPARCstation running either SunOS 4.1.3 or later, or Solaris 2.4 or later, with a MAGMA 8+2 Sp SBUS card installed
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