Ashling Product Brief APB213

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PathFinder-XD for MIPS™ support for Broadcom Devices

Contents

1. Introduction

This Ashling Product Brief describes how to use Ashling's PathFinder-XD source-level debugger (v1.0.6 or later) and the Opella-XD debug probe with Broadcom BMIPS5000 devices which support On-chip Trace (Zephyr) such as the BCM742xx family

PathFinder-XD is a C/C++/Assembly debugger based on the Eclipse framework and supports debugging using the QEMU software simulator (www.qemu.org) or the Ashling Opella-XD Debug Probe connected to MIPS™ powered target hardware. PathFinder-XD supports both "bare-metal" (no target operating system) and Embedded Linux based debugging.

The Ashling Opella-XD as shown below is an entry-level Debug Probe for the MIPS family which connects to the host PC via a USB2.0 HS interface. Opella-XD uses the MIPS EJTAG core extension to provide a comprehensive set of debug features and supports all EJTAG versions from 2.0 onwards.

Figure 1. The Ashling Opella-XD Debug Probe

2. Installation

PathFinder-XD can be hosted under Windows™ or x86 based Linux and installation requires full administrative privileges.

2.1 PathFinder-XD Windows™ Installation

Run the `SETUP.EXE` program from the Windows directory on the supplied CD (or download) and follow the on-screen instructions. Windows XP, Vista and 7 are supported (32-bit and 64-bit versions)

2.2 PathFinder-XD Linux Installation

Run the `./SETUP32` (32-bit Linux) or `./SETUP64` (64-bit Linux) program from the supplied CD (or download) and follow the on-screen instructions. PathFinder-XD for MIPS is tested on the following Linux platforms:

- Fedora 13/Ubuntu 10.04 LTS 32-bit/64-bit versions

Please note that the 64-bit Linux version of PathFinder-XD for MIPS requires the 32-bit library package `ia32-libs` library, hence, make sure this is installed in your system. For example, to install on Ubuntu/Debian, issue the following command:

```
> $sudo apt-get install ia32-libs
```

2.3 Opella-XD USB Driver Installation

2.3.1 Windows™ USB Driver Installation

When you first connect Opella-XD to your PC you will get a **New USB hardware found** message and will be prompted to install the appropriate USB drivers. The Ashling Opella-XD drivers are supplied on your Ashling CD and installed in your installation directory. Direct the Windows **Hardware Installation Wizard** to your installation directory so that it can locate the necessary drivers and complete the installation. Windows only needs to perform this operation the first time you connect your Opella-XD to the PC. The Opella-XD USB driver is called `libusb0.sys` (`libusb0_x64.sys` for 64-bit operating systems).

2.3.2 Linux x86 USB Driver Installation

Opella-XD uses the `libusb` driver (http://libusb.sourceforge.net/). By default, the driver is stored in: `/usr/lib`

Check for this as follows:

```
$ ls /usr/lib/libusb* /usr/include/usb.h
```

If you see `/usr/include/usb.h` and `libusb-0.1.so.4.4.0` or higher, then they are installed on your system and you can skip the next section on libusb installation

Please note: If `/usr/lib/libusb` directory does not include a file titled `libusb.so` (exact filename), then create a symlink as follows:

```
$ln -s /usr/lib/libusb-0.1.so.4.4.0 /usr/lib/libusb.so
```

2.3.2.1 Ubuntu/Debian libusb installation

Install `libusb` using the following command:

```
$ sudo apt-get install libusb-dev
```

If `/usr/lib/libusb` directory does not include a file titled `libusb.so` (exact filename), then create a symlink as follows:

```
$ln -s /usr/lib/libusb-0.1.so.4.4.0 /usr/lib/libusb.so
```

2.3.2.2 Fedora/other distribution libusb installations

Download the latest `libusb` from http://libusb.sourceforge.net/ and install as follows:

```
$ tar zxf libusb-0.1.12.tar.gz (use appropriate version number)
$ ./configure --prefix=/usr
$ make
$ make install
```

If `/usr/lib/libusb` directory does not include a file titled `libusb.so` (exact filename), then create a symlink as follows:

```
$ln -s /usr/lib/libusb-0.1.so.4.4.0 /usr/lib/libusb.so
```

2.3.2.3 Setting permissions

1. Ensure that Opella-XD is connected to the PC, connected to the target and that the target is powered.
2. To ensure the current `$USER` has access to the Opella-XD device, we recommend using the Linux utility `udev` (requires kernel 2.6 or later).
3. Ensure `udev` is installed and running on your system by checking for the `udev` daemon process (`udevd`) e.g.:
   ```
   $ ps –aef | grep udev
   ```
4. Create an `udev` rules file to uniquely identify the Opella-XD device and set permissions as required by owner/ groups. An example `udev` file is supplied (`60-ashling.rules)` which identifies Opella-XD device (by Ashling's USB Product ID and Vendor ID).
5. The rules `file` must then be copied into the rules directory (requires root permission) e.g.:
   ```
   $ sudo cp ./60-ashling.rules /etc/udev/rules.d
   ```

3. Debugging with PathFinder-XD

In this section, we will look at using PathFinder-XD and Opella-XD with the Broadcom BCM7420 board in "bare-metal" mode i.e. debugging target applications which do not use an operating system.

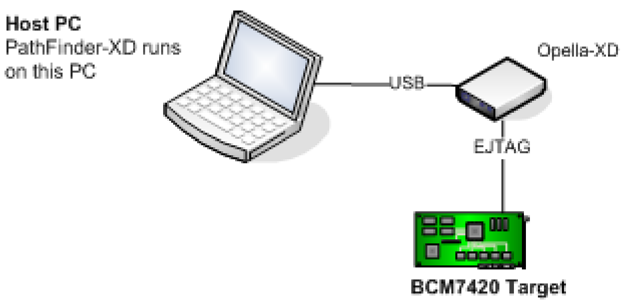

Figure 2. BCM74xx Debugging with Opella-XD

3.1 Connecting Opella-XD to the Target

Opella-XD is designed to connect to your PC via the USB cable, and your target via the supplied EJTAG cable. Pin 1 of the Ashling EJTAG Cable Connector is clearly identified by a ⇧ on the connector; this should mate with pin 1 on your target's EJTAG connector. Please note the following recommended target connection sequence:

1. Ensure your target is powered off.
2. Connect Opella-XD to your PC using the supplied USB cable and ensure Opella-XD's **Power** LED is on.
3. Connect Opella-XD to your target using the supplied EJTAG cable.
4. Power up your target.

3.1.1 Verifying Opella-XD is properly connected to your host PC

PathFinder-XD is supplied with an Opella-XD diagnostic command-line executable ("`OPXDDAIG.exe`" for Windows and "`OPXDDIAG.`" for GNU/Linux x86). OPXDDIAG is run from a command-shell and can be used to test and verify your Opella-XD is installed and working correctly (including the USB driver) . To run all tests, enter:

- `opxddiag --diag 1`

Running with-out any parameters displays all available options

- `opxddiag`

3.2 Using PathFinder-XD

3.2.1 Getting started/configuring PathFinder-XD

1. To get started, run PathFinder-XD 

2. PathFinder-XD will then load. If this is your first-time running, then you will be prompted to specify your Workspace (default directory for projects etc). Accept the default which is located in PathFinder-XD's installation directory.

In PathFinder-XD, create a **New Target Configuration** via the **Target** menu:

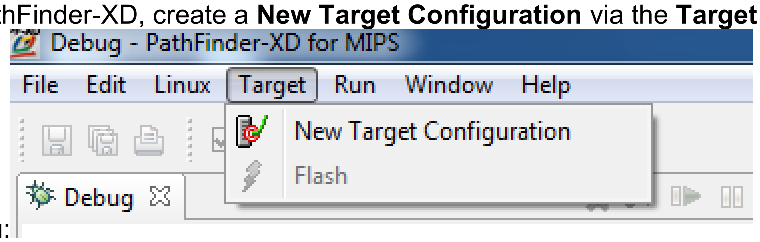

Figure 3. Target Configuration

and **s**elect the **Debug using Debug Probe** option as shown below:

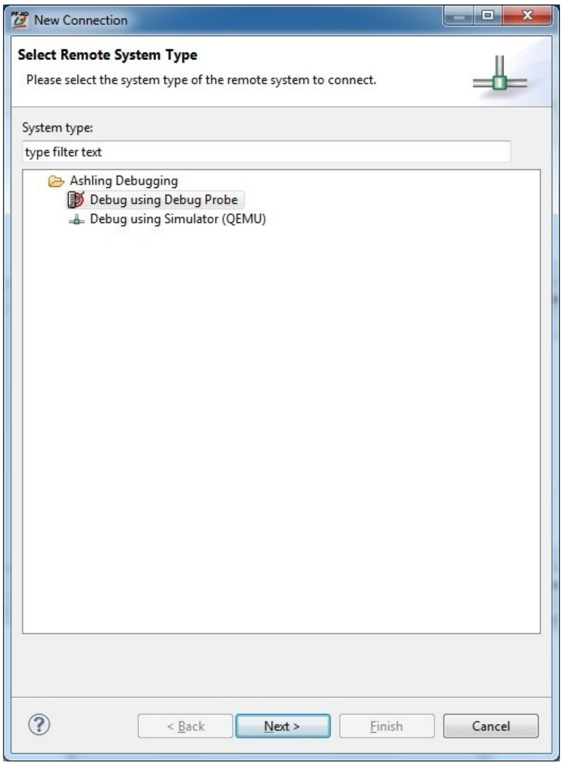

Figure 4. Debug using Debug Probe

3. Click **Next** to configure Opella-XD settings as shown below:

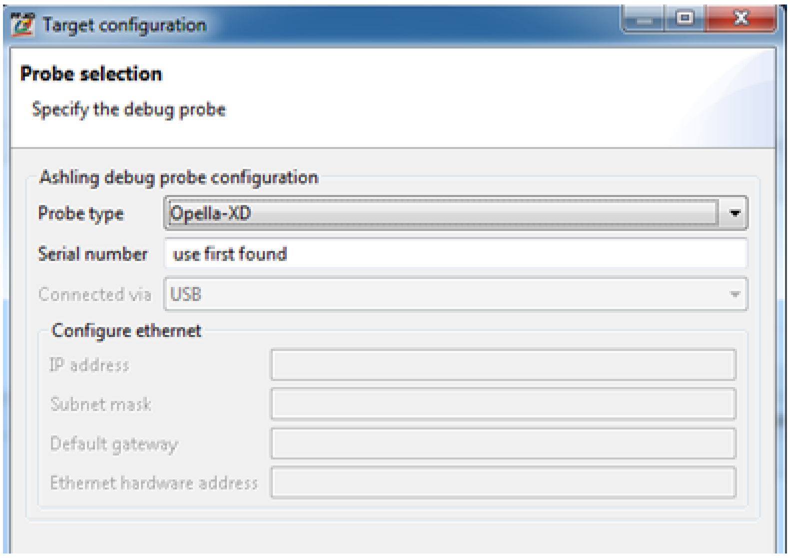

Figure 5. Probe selection

Settings include:

- **Probe type:** The actual Ashling Debug Probe Type to use as the target connection. Select **Opella-XD**.
- **Serial number:** The serial number of the Debug Probe to use. Specify the serial number or **use first found** and click on **Next**.

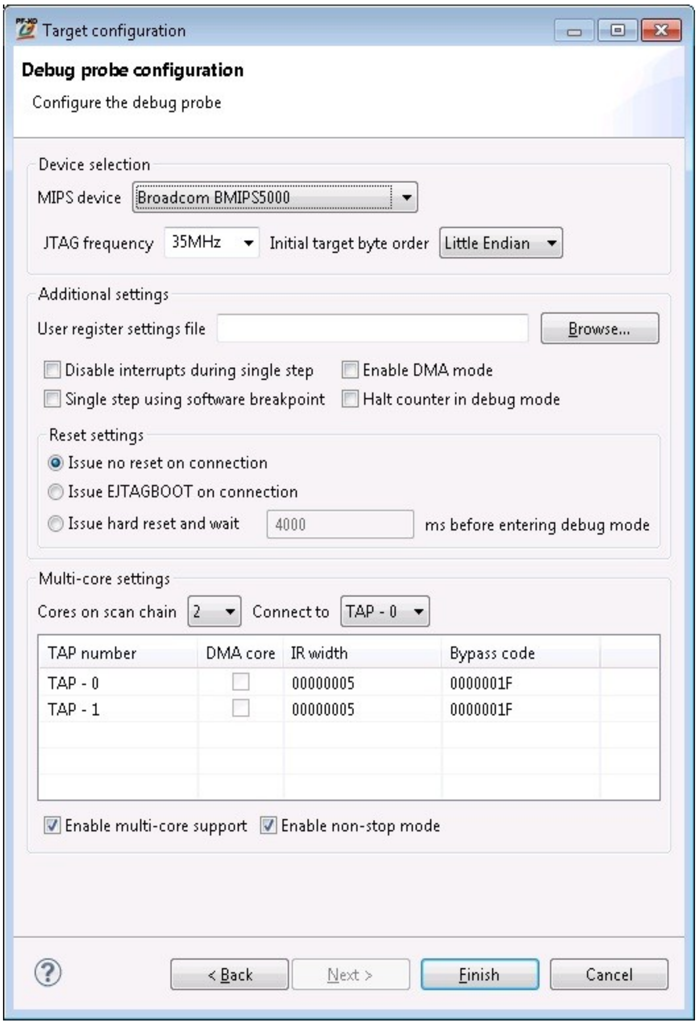

Figure 6. Debug probe configuration

The **Debug probe configuration** settings include:

- **MIPS device:** specifies the MIPS device type you wish to debug. In this example, Broadcom BMIPS5000 is selected.
- **JTAG frequency:** specifies the JTAG TCK frequency to be used for communicating with the EJTAG interface on your MIPS device.
- **Initial target byte order:** allows you to specify the memory Endianess of your target system.
- **User register settings file:** group allows you to initialise other registers or memory locations on PathFinder-XD invocation and after reset. The **Browse…** button allows these register values to be loaded from a simple text file. The text file format is:
  ```
  Name  Size Address Value
  ```
  (all values are in HEX). For example, the following text file initialises the R0, R1, R2 and R3 registers:
  ```
  R0 0x00000004 0xb800380c 0x18000000
  R1 0x00000004 0xb8003808 0x00000006
  R2 0x00000004 0xb8004018 0x00000800
  R3 0x00000004 0xb800401c 0x0000000c
  ```
- **Disable interrupts during single step:** allows you to disable interrupts when single stepping at assembly level (MIPS instruction level). When checked, PathFinder-XD automatically disables interrupts prior to an assembly level single step and re-enables them after the single step is complete.
- **Enable DMA Mode:** enables DMA mode for high-speed transfer between the debug probe and your target. DMA Mode is only available on systems with EJTAG DMA support.
- **Single step using software breakpoint:** allows you to specify that PathFinder-XD should use software breakpoints for single-stepping (i.e. PathFinder-XD should not use the EJTAG hardware based single-step command).
- **Halt counters in debug mode:** allows you tell PathFinder-XD to halt the MIPS Count register(s) (via writing to the Configuration register) whenever your program is halted. There is a slight delay between your program halting and the write to the Configuration register. Note that the **Registers** window always shows your application values for the Configuration register.

- **Issue no reset on connection**: will ensure no hardware reset is issued when you connect to your target (note that this feature requires updated Opella-XD firmware (v1.1.1 or later) which is supplied with PathFinder-XD v1.0.6 or later).
- **Issue EJTAGBOOT on connection**: will issue a hardware reset and halt the target at the reset location.
- **Issue hard reset and wait 'N' ms before entering debug mode**: will issue a hardware reset and wait the specified number of ms before entering debug mode. This mode is also known as NORMALBOOT.
- **Multi-core:** allows you to select the core you wish to debug for multi-core devices. The BCM7420 device has two cores (or hardware threads) and the first one (TAP-0) is chosen in this example. **Section 4 Multi-core support** explains the remaining parameters of **Multi-core**.

The settings shown are suitable for the BCM7420 target board. Click **Finish** when done.

4. PathFinder-XD will now create a new **Target Debugger** setting in its **Remote Systems** Window as shown below:

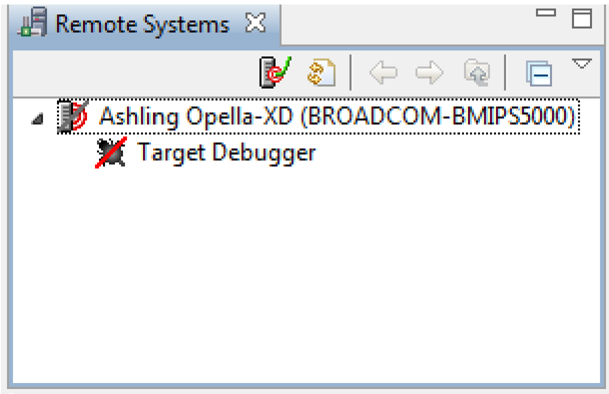

Figure 7. Remote Systems Window

Right-click on **Target Debugger** and click **Connect to** invoke the Opella-XD target connection. Once invoked, the **Remote Systems** window will update as follows:

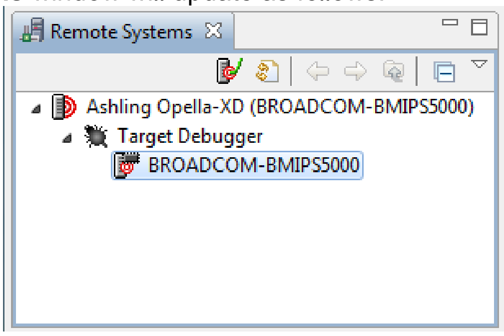

Figure 8. Remote Systems Window showing target connection

If PathFinder-XD fails to connect to the target, then:

1. Make sure the Opella-XD is properly connected to both the host PC and the target (using the proper polarity on the EJTAG connector) as previously outlined
2. Run the OPXDDIAG utility to ensure Opella-XD is functional and the USB driver is properly installed as previously outlined.
3. Make sure your target board is powered up.

3.2.2 Downloading your program to the target

1. We can now download a program to the target by right-clicking over **BMIPS5000** and selecting **Download and Launch** as follows:

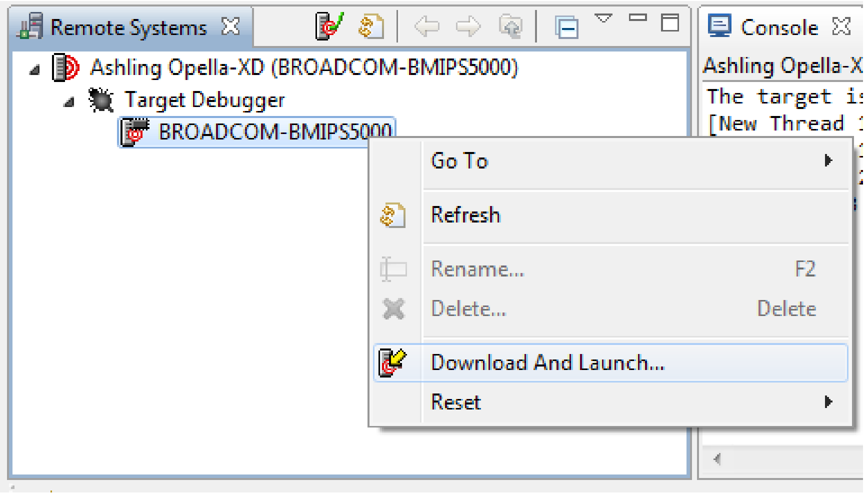

Figure 9. Download and launch

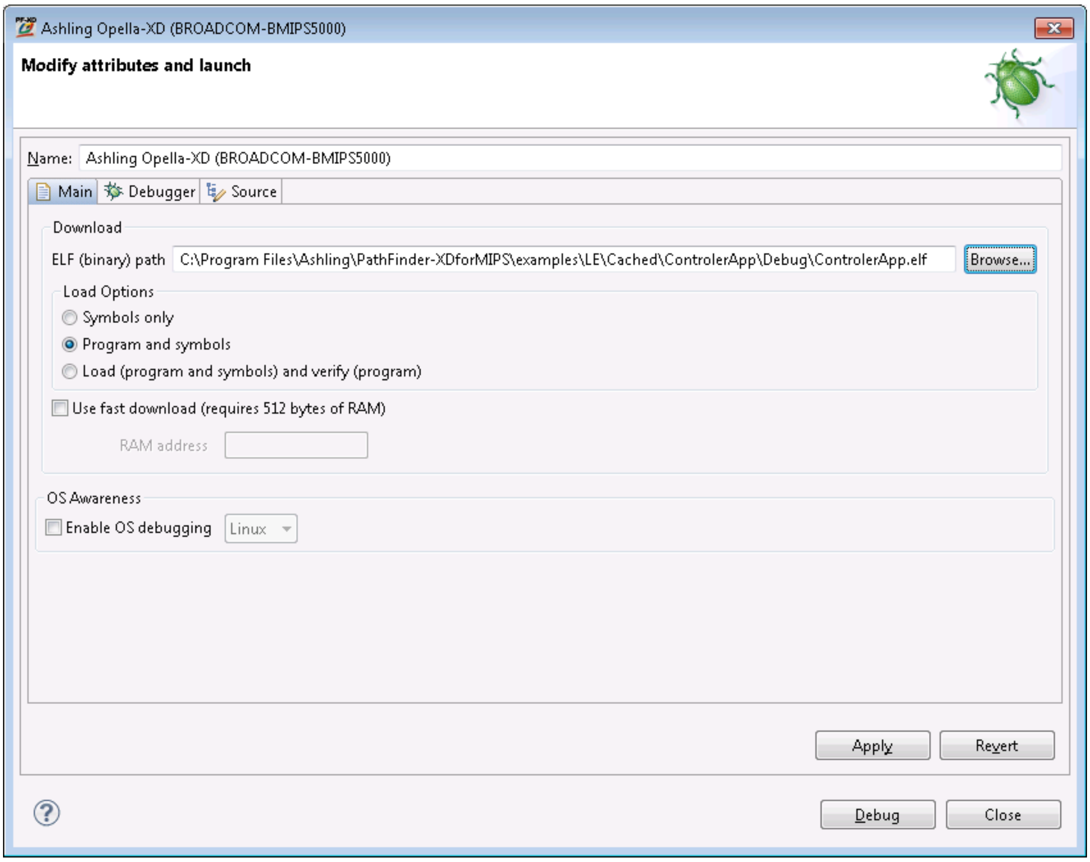

Figure 10. Specifying Target Program to Download

Specify the program to use and press Debug to download to the target board. In this APB, we are using the `examples\LE\Cached\ControlerApp\Debug\ControlerApp.elf` example which is supplied with PathFinder-XD and is suitable for running on all Broadcom 74xx targets. Specify the program to use (**ELF (binary) path**) and press **Debug** to download to the target board.

Note:

- PathFinder-XD supports ELF/DWARF format files which should be compiled/linked with debug information. For example, when using the GNU tool-chain, add the compiler gcc switch **"-gdwarf-2"** (generate DWARF2 format debug symbols) when compiling all files you wish to be able to debug. Compiler optimisations should not be used as they can cause misalignment between the generated symbolic information and the actual generated machine code thus causing problems when debugging.
- When debugging existing flash based code, you should select **Symbols only**. This ensures no code is downloaded to your target system (it is already there in flash) and that PathFinder-XD just extracts the source-file and symbol information from the specified ELF file.

- When downloading program and symbols, you can verify that target memory matches the original ELF file code contents by choosing the **Load (program and symbols) and verify (program)** option, however, note that this option increases the overall time due to the verification step.
- **Use fast download**… will improve your overall program download time, however, it requires that PathFinder-XD download and use a small 512 byte helper-routine to target RAM at the address specified. Make sure you chose a suitable 512 byte RAM location that is not used by your application, as PathFinder-XD does not preserve contents.

2. PathFinder-XD will now download the program and update its Windows as follows allowing you to start your Debug session:

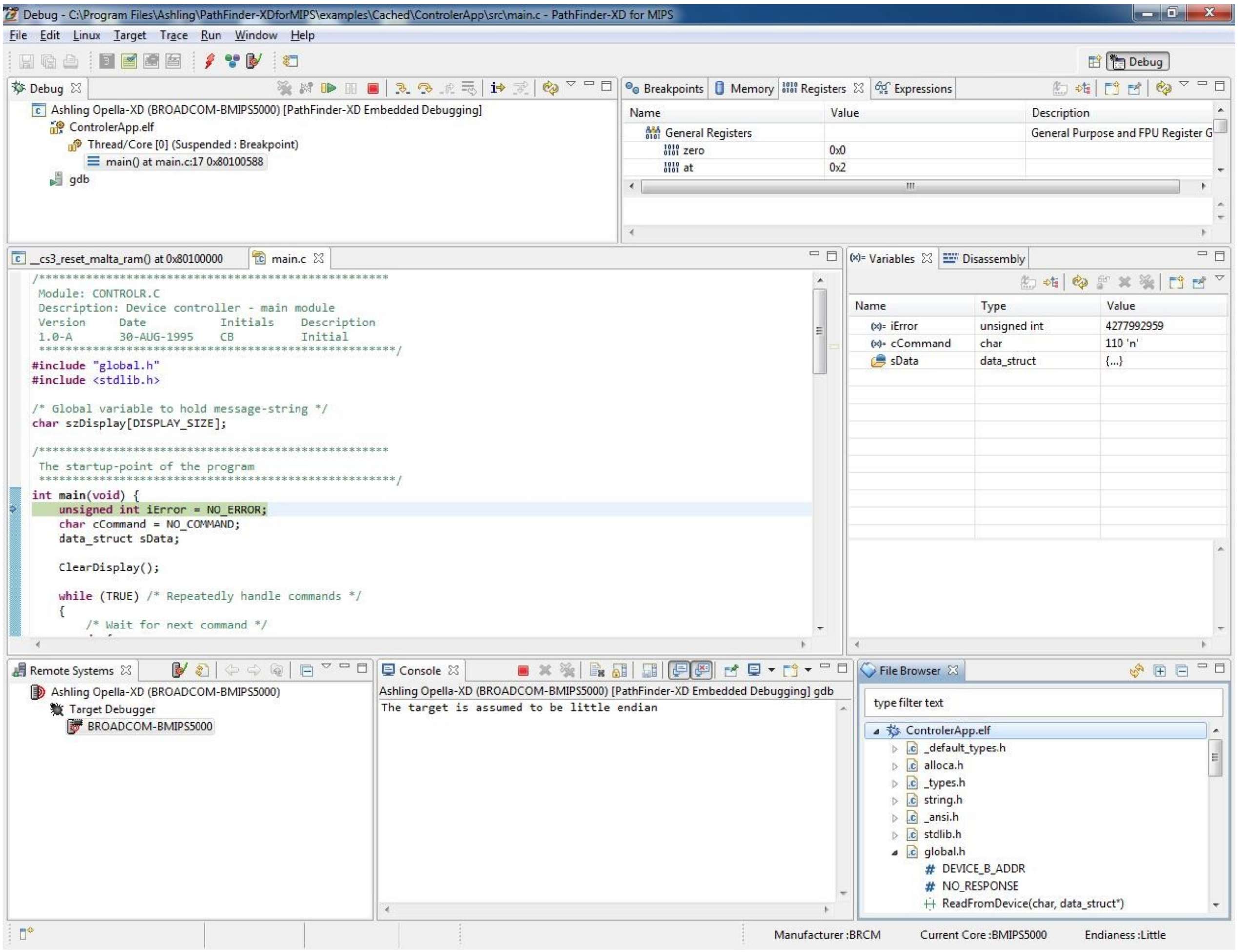

Figure 11. PathFinder-XD after program download

3.2.3 Controlling program execution/using breakpoints

1. You can control execution (start, stop, step etc.) using the Debug bar:

where the buttons are as follows:

 **Go**

 **Stop/Halt**

 **Step Into, Over and Return (Out)**

 **Terminate** (this button actually terminates the debug session meaning we have to **Download and Launch** again)

Figure 12. Execution Control

When setting/toggling breakpoints in the Source and Disassembly Windows, make sure the mouse pointer is hovering over the left-most column (known as the ruler) of the Window as shown below:

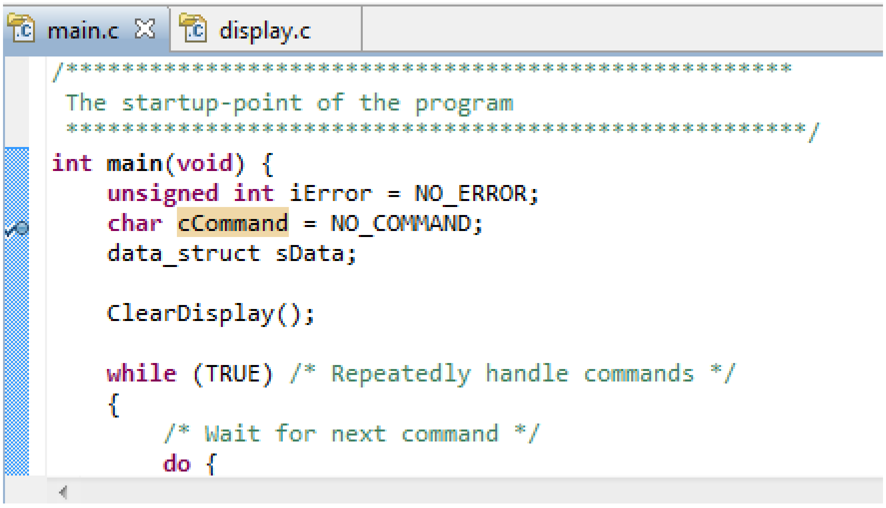

Figure 13. Setting a breakpoint

By default, PathFinder-XD sets a software breakpoint. You can set a hardware breakpoint via the right-mouse menu.

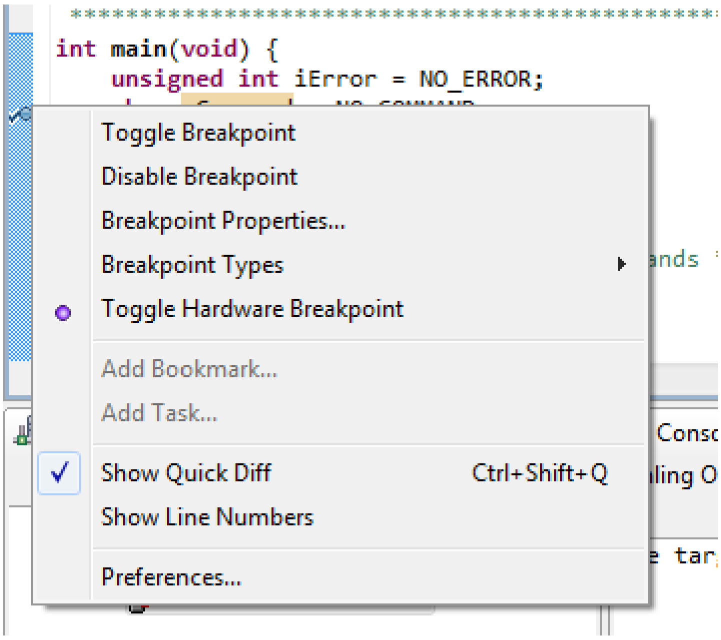

Figure 14. Setting a Hardware Breakpoint

The set breakpoints will be shown in the **Breakpoints** view as below:

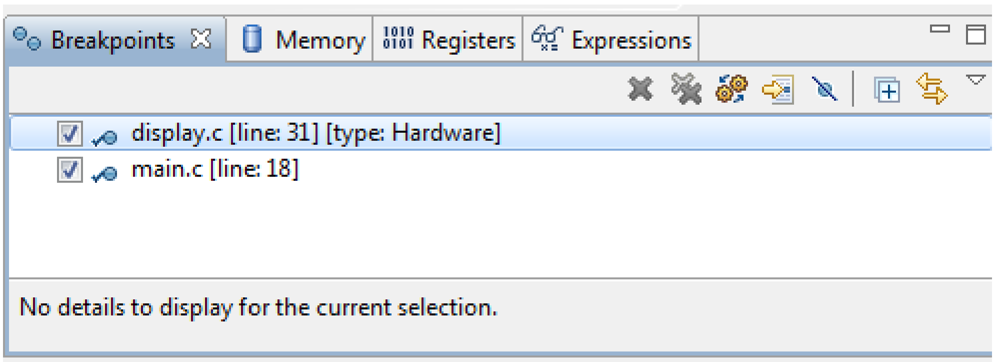

Figure 15. Setting a Hardware Breakpoint

2. Breakpoints can also be set via the **Run|Breakpoint Configuration** dialog. This allows software (RAM) and hardware (RAM/ROM) based breakpoints to be set. Advanced hardware breakpoints (including data access and conditional breakpoints) are also supported.

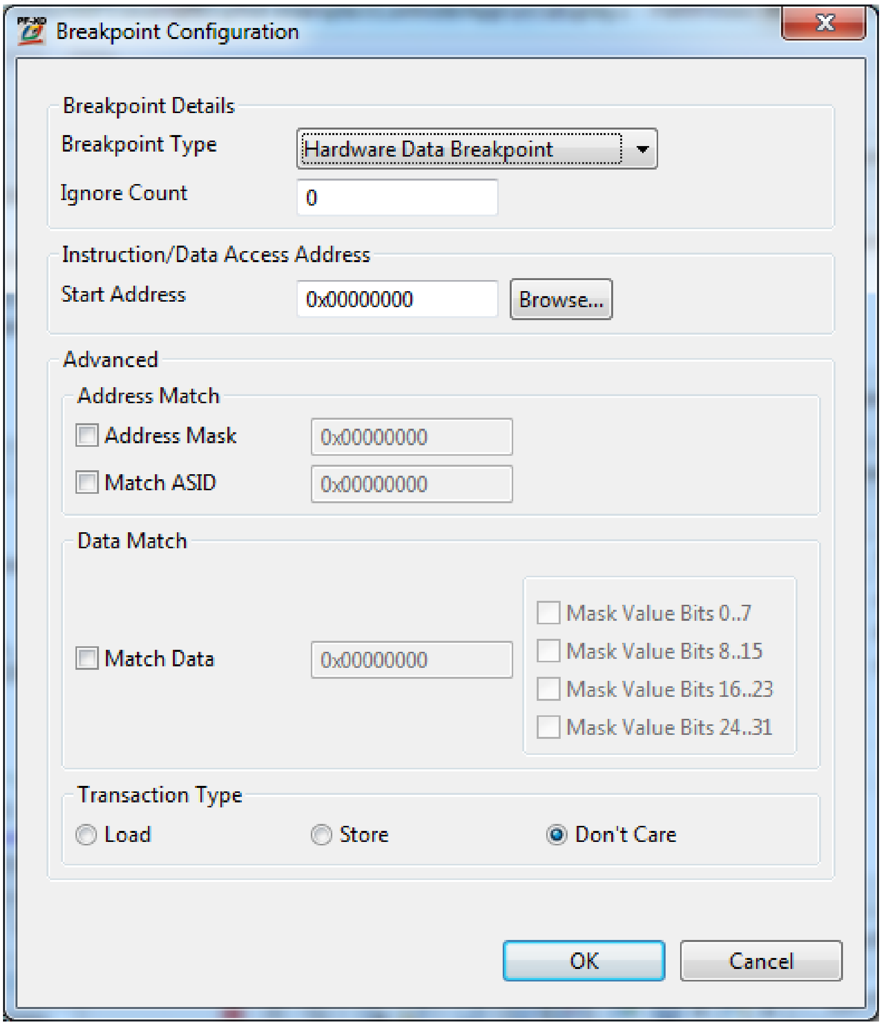

Figure 16. PathFinder-XD Breakpoint Configuration

Note: BRCM devices do not support core-specific breakpoints.

3.2.4 File Browser

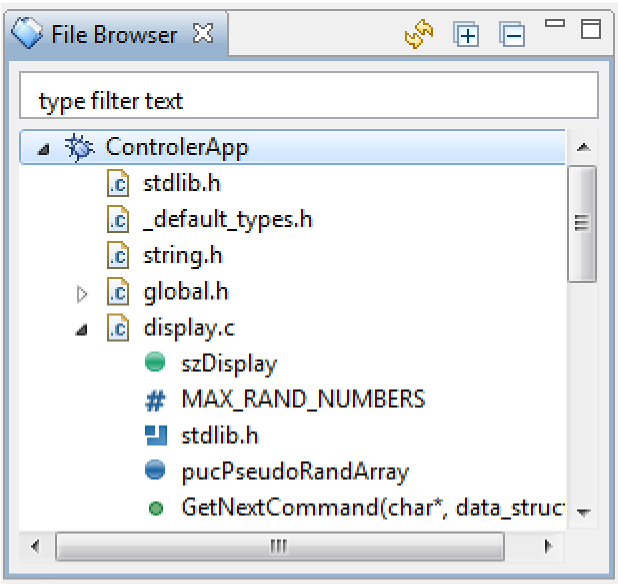

Figure 17. PathFinder-XD File Browser View

This view shows an overview of all the source-files associated with your loaded program and is populated automatically. Each file can be expanded to view its functions, variables etc. The right-mouse menu option **Show Functions Only** can be used to restrict contents to functions only. Double-clicking a file will open it in the **Source** view.

If the source file cannot be found (e.g. are not present in the build path), then the **Source** view will show the following:

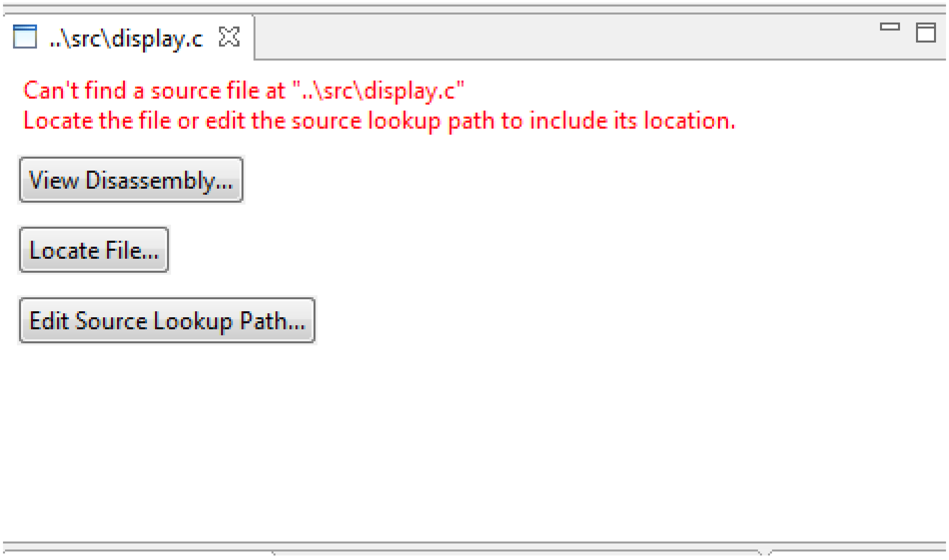

Figure 18. PathFinder-XD Source View

Choose either of the options, **Locate File…** or **Edit Source Lookup Path …** and map the required source file.

Edit Source Lookup Path… will open the following dialog

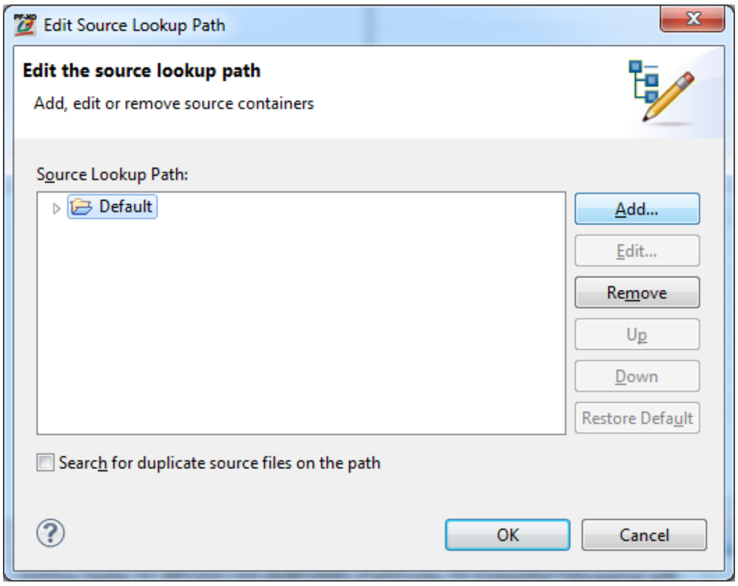

Figure 19. PathFinder-XD Source Lookup Path dialog

Click **Add** to open the dialog **Add Source** shown in following figure. Choose **File System Directory** and browse to the folder where the source files are present and click **OK**. Performing **Refresh** ( in **File Browser**) will now update the **File Browser** view with the newly found source/symbol information.

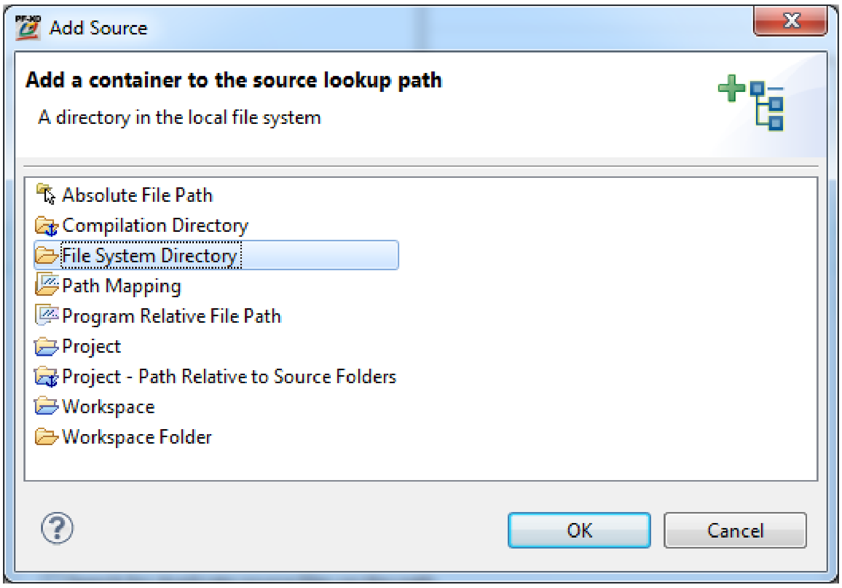

Figure 20. PathFinder-XD Add Source dialog

To set breakpoints (software/hardware) from **File Browser**, right click on any symbol and choose the appropriate option.

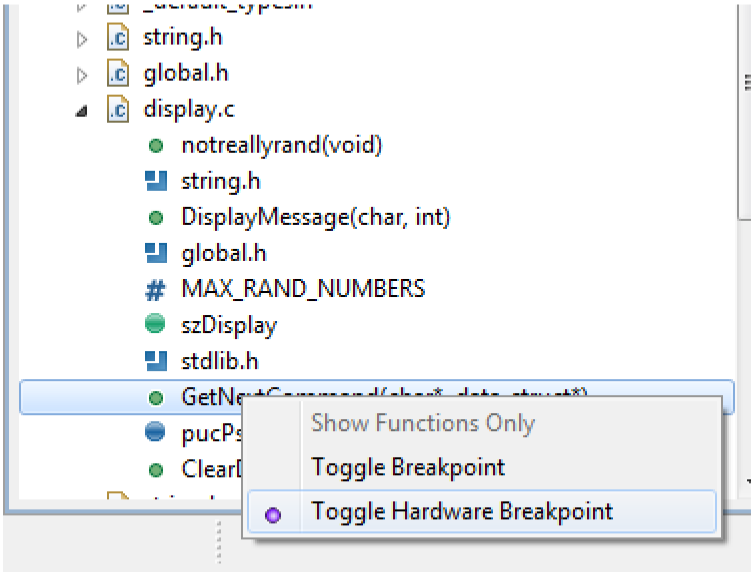

Figure 21. PathFinder-XD Setting a Breakpoint

Search or filtering is also possible within the **File Browser** as shown below.

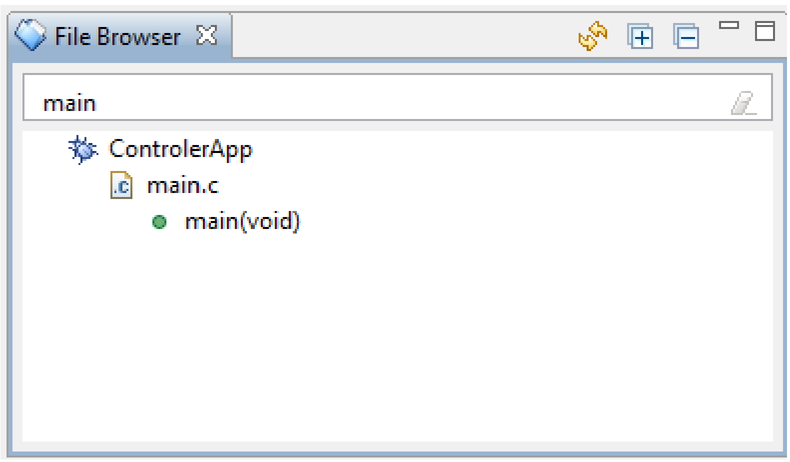

Figure 22. PathFinder-XD File Browser View showing 'main'

3.2.5 Watching program variables

1. To watch a variable or expression, select it using the mouse and **Add Watch Expression** via the right-mouse button menu as shown below:

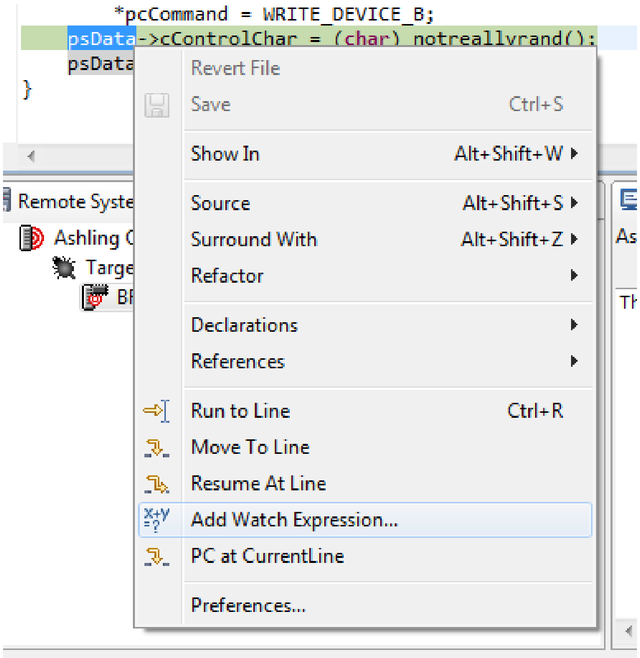

Figure 23. Adding a Watch Expression

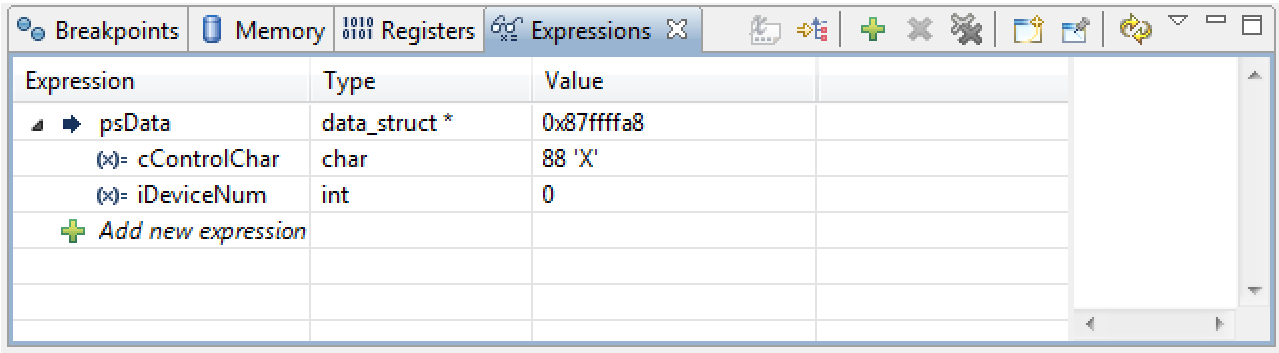

Figure 24. Expression window showing watched expression

You can also quickly watch an expression by hovering the mouse pointer over it as shown below:

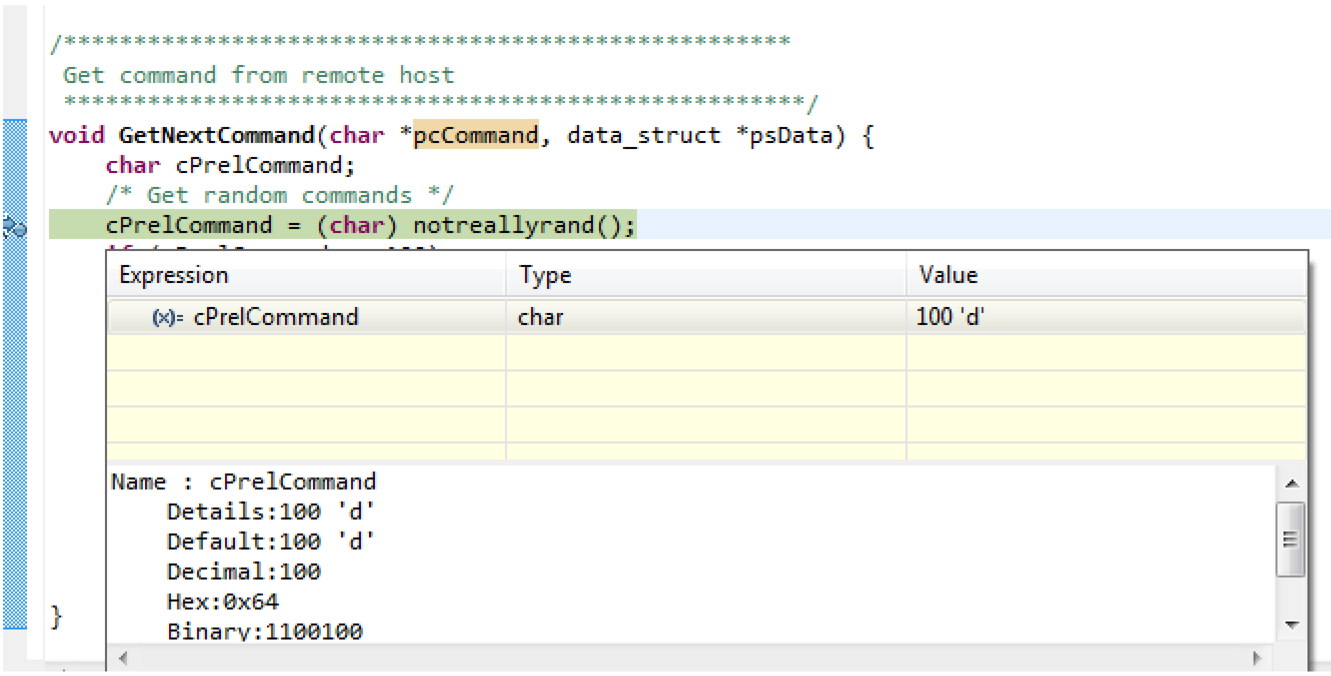

Figure 25. Quick watch via mouse hover

3.2.6 Viewing memory

1. Memory can be viewed via **Window|Show View|Memory**.

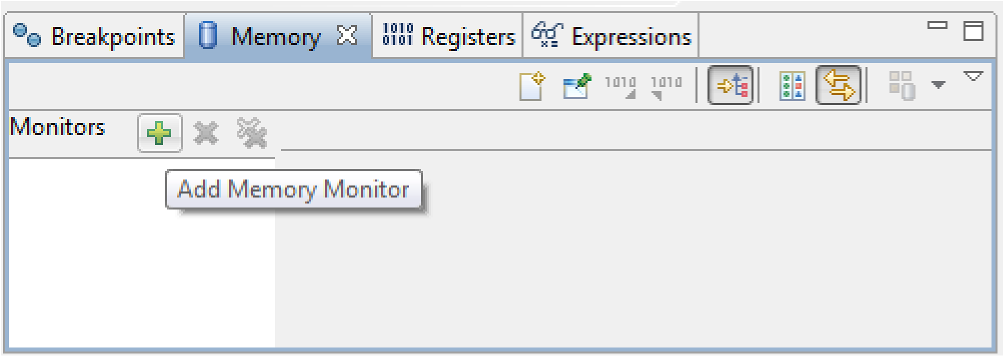

Figure 26. PathFinder-XD Memory View

Add a **Memory Monitor** and specify the address you wish to view (0xA000-0000 in the below example).

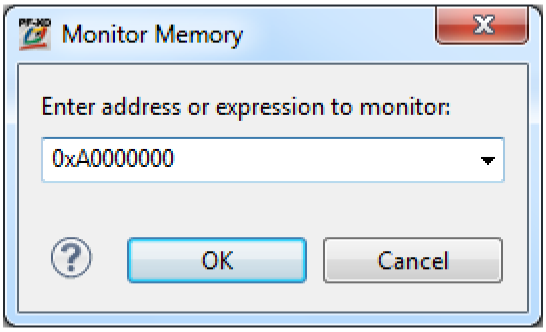

Figure 27. Adding a Memory Monitor

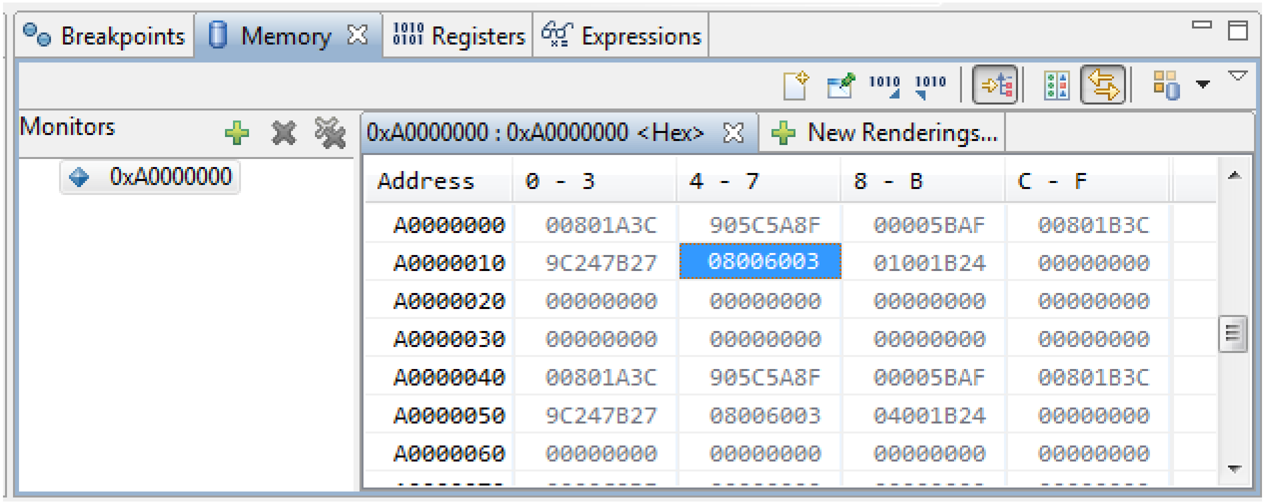

Figure 28. Memory Window showing contents at 0xA000-0000

Full point-and-click in-line editing is supported for writable target memory locations. Select **New Renderings** to show memory as Hex, ASCII etc.

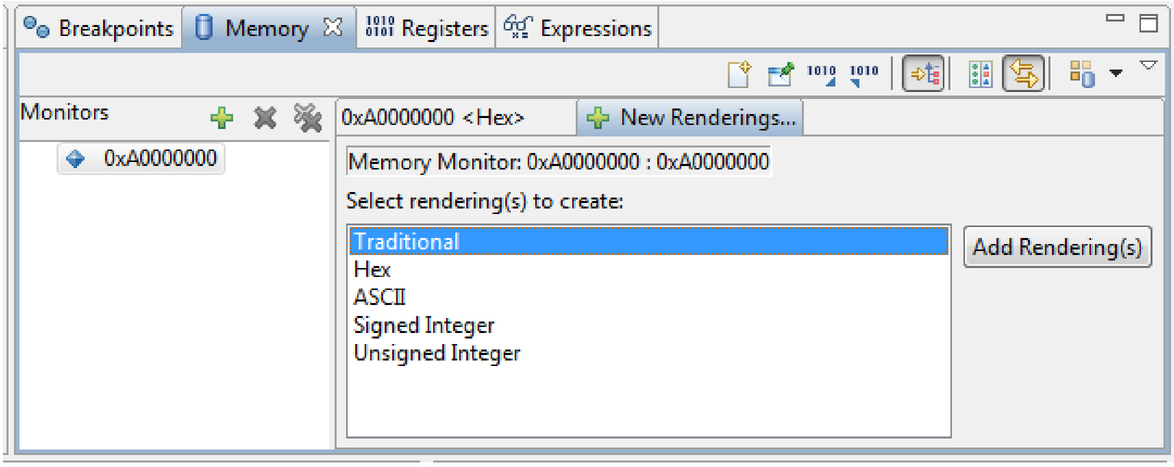

Figure 29. Selecting Memory Renderings

3.2.7 Viewing registers

1. **Register** and **Peripheral** views can be opened via **Window|Show View**. General registers are shown in the **Register** view. CP0 etc. registers are shown in the **Peripheral Registers** view. All views are in-line editable.

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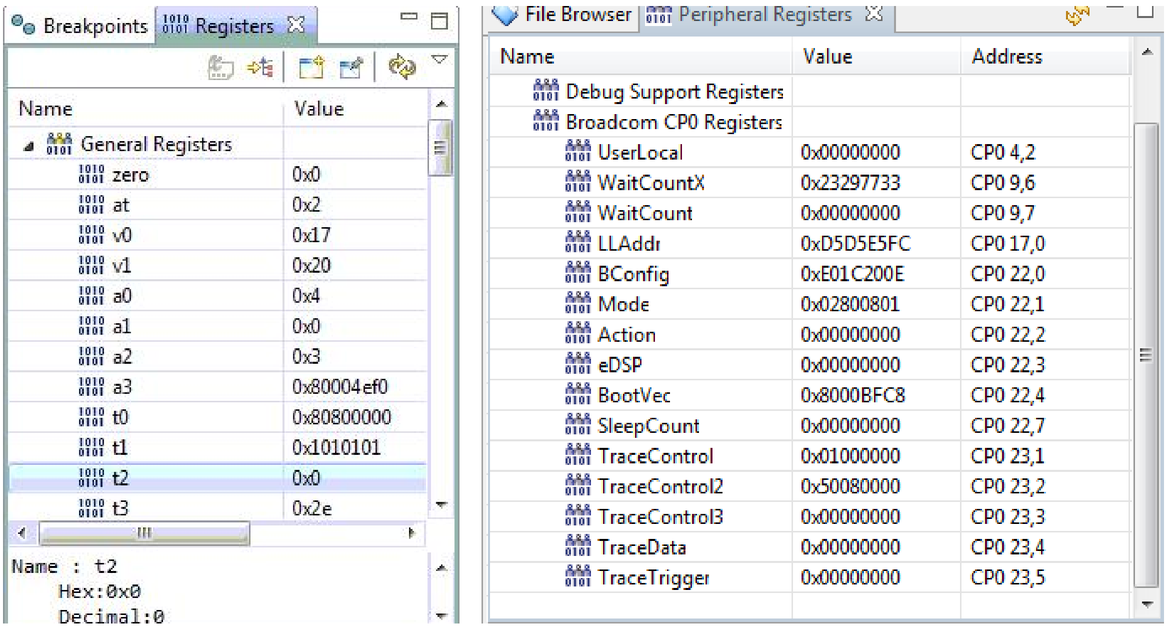


Figure 30. Registers

3.2.8 Using the console

1. PathFinder-XD supports a Console which can be opened from the **Window** menu. The **Console** allows you to enter debug commands and view their output. The GNU GDB syntax is fully supported. See here for details: http://sourceware.org/gdb/current/onlinedocs/gdb/index.html or for a handy quick-reference card see here: http://users.ece.utexas.edu/~adnan/gdb-refcard.pdf

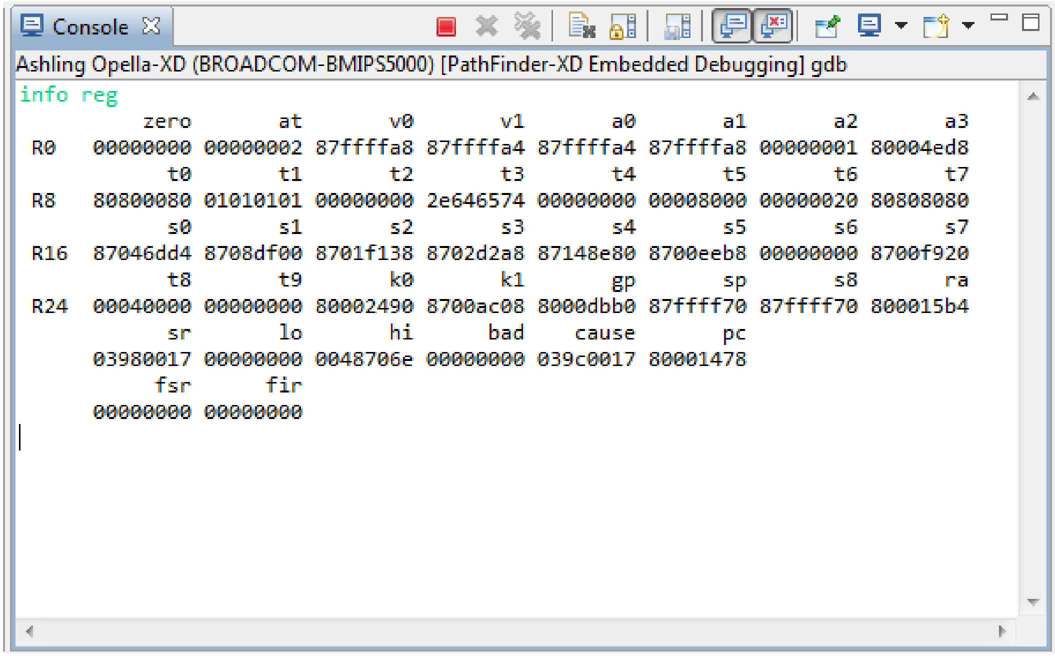

```
Console
Ashling Opella-XD (BROADCOM-BMIPS5000) [PathFinder-XD Embedded Debugging] gdb
info reg
          zero       at       v0       v1       a0       a1       a2       a3
 R0   00000000 00000002 87ffffa8 87ffffa4 87ffffa4 87ffffa8 00000001 80004ed8
            t0       t1       t2       t3       t4       t5       t6       t7
 R8   80800080 01010101 00000000 2e646574 00000000 00008000 00000020 80808080
            s0       s1       s2       s3       s4       s5       s6       s7
 R16  87046dd4 8708df00 8701f138 8702d2a8 87148e80 8700eeb8 00000000 8700f920
            t8       t9       k0       k1       gp       sp       s8       ra
 R24  00040000 00000000 80002490 8700ac08 8000dbb0 87ffff70 87ffff70 800015b4
            sr       lo       hi      bad    cause       pc
      03980017 00000000 0048706e 00000000 039c0017 80001478
           fsr      fir
      00000000 00000000
```

Figure 31. PathFinder-XD Console showing the output of the `info reg` command

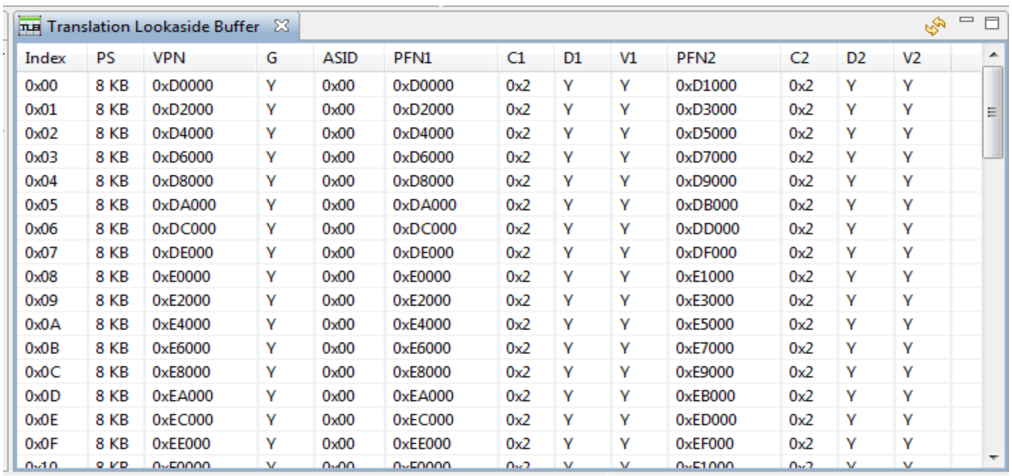
2. For example, to dump **16 w**ords of memory in he**x** format from 0xA0004200, enter the e**x**amine command as follows:

```
x /16wx 0xA0004200
0xa0004200: 0x00000000  0x00000000  0x74697257  0x20676e69
0xa0004210: 0x41206f74  0x6f632020  0x656c706d  0x2e646574
0xa0004220: 0x00000000  0xa0004228  0x00000004  0xa0004238
0xa0004230: 0x00000000  0x00000000  0x00000000  0x00000000
```

3. Console commands can also be stored in a text file (GDB script file) and executed from PathFinder-XD's **Run** menu.

3.2.9 Viewing the Translation Lookaside Buffer (TLB)

1. The **Translation Lookaside Buffer** view (open from the **Window|Show View** menu) shows the contents of the TLB. Right-mouse menu options allow to conveniently setup the TLB to sensible defaults (i.e. perform no mappings) and edit entries.

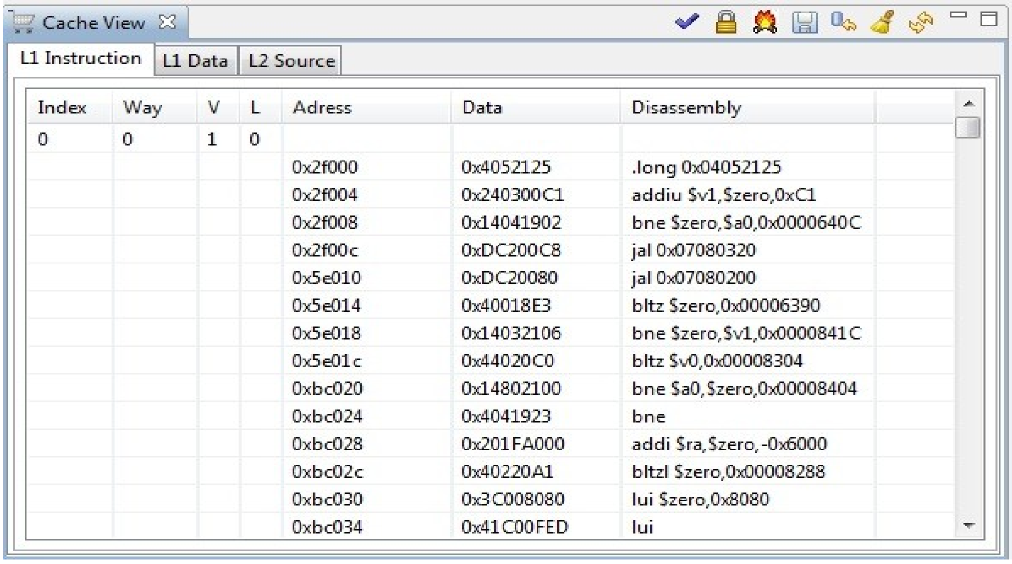


Index	PS	VPN	G	ASID	PFN1	C1	D1	V1	PFN2	C2	D2	V2
0x00	8 KB	0xD0000	Y	0x00	0xD0000	0x2	Y	Y	0xD1000	0x2	Y	Y
0x01	8 KB	0xD2000	Y	0x00	0xD2000	0x2	Y	Y	0xD3000	0x2	Y	Y
0x02	8 KB	0xD4000	Y	0x00	0xD4000	0x2	Y	Y	0xD5000	0x2	Y	Y
0x03	8 KB	0xD6000	Y	0x00	0xD6000	0x2	Y	Y	0xD7000	0x2	Y	Y
0x04	8 KB	0xD8000	Y	0x00	0xD8000	0x2	Y	Y	0xD9000	0x2	Y	Y
0x05	8 KB	0xDA000	Y	0x00	0xDA000	0x2	Y	Y	0xDB000	0x2	Y	Y
0x06	8 KB	0xDC000	Y	0x00	0xDC000	0x2	Y	Y	0xDD000	0x2	Y	Y
0x07	8 KB	0xDE000	Y	0x00	0xDE000	0x2	Y	Y	0xDF000	0x2	Y	Y
0x08	8 KB	0xE0000	Y	0x00	0xE0000	0x2	Y	Y	0xE1000	0x2	Y	Y
0x09	8 KB	0xE2000	Y	0x00	0xE2000	0x2	Y	Y	0xE3000	0x2	Y	Y
0x0A	8 KB	0xE4000	Y	0x00	0xE4000	0x2	Y	Y	0xE5000	0x2	Y	Y
0x0B	8 KB	0xE6000	Y	0x00	0xE6000	0x2	Y	Y	0xE7000	0x2	Y	Y
0x0C	8 KB	0xE8000	Y	0x00	0xE8000	0x2	Y	Y	0xE9000	0x2	Y	Y
0x0D	8 KB	0xEA000	Y	0x00	0xEA000	0x2	Y	Y	0xEB000	0x2	Y	Y
0x0E	8 KB	0xEC000	Y	0x00	0xEC000	0x2	Y	Y	0xED000	0x2	Y	Y
0x0F	8 KB	0xEE000	Y	0x00	0xEE000	0x2	Y	Y	0xEF000	0x2	Y	Y
0x10	8 KB	0xF0000	Y	0x00	0xF0000	0x2	Y	Y	0xF1000	0x2	Y	Y

Figure 32. PathFinder-XD TLB Window

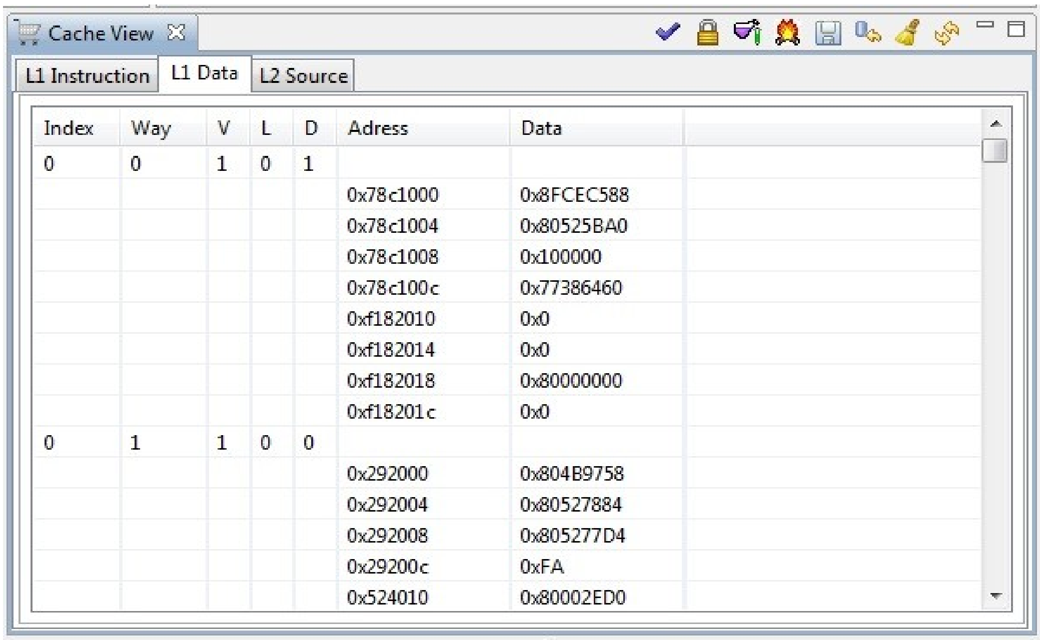
3.2.10 Viewing cache

1. The **Cache View** (open from **Window|Show View** menu) displays the contents of all caches including the primary L1 caches (data cache and instruction cache) and secondary L2 caches (if present). Each cache is shown in a separate tab. Each view shows the cache entry (instruction/data), physical address, index, way and status (**V**alid, **L**ocked, or **D**irty). Instruction disassembly is also show for the Instruction cache. Cache contents may also be saved to a file.



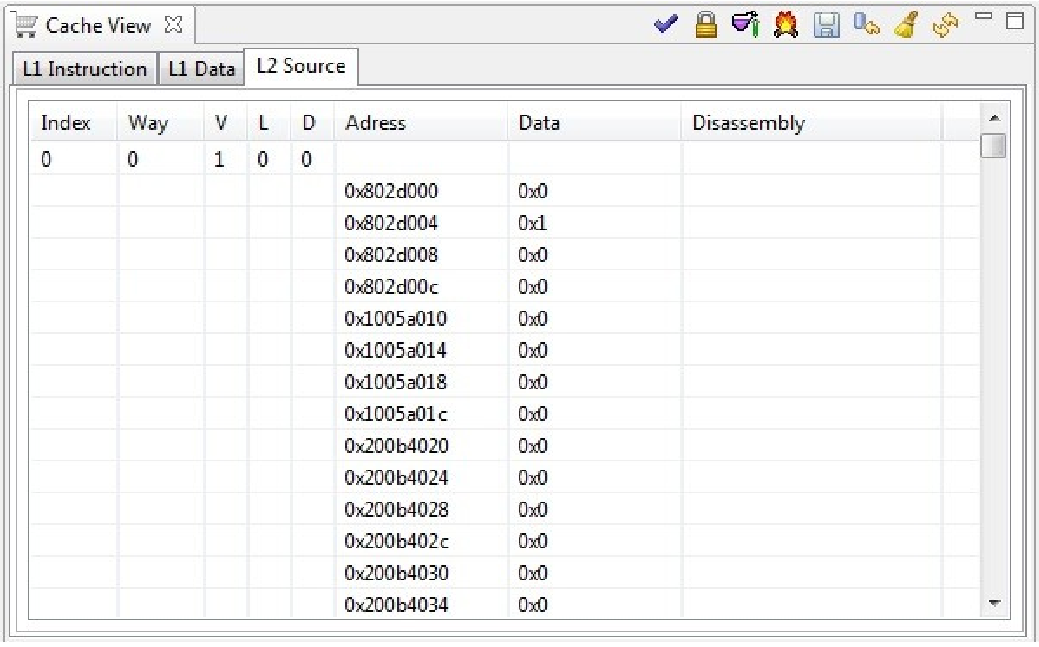
Index	Way	V	L	Adress	Data	Disassembly
0	0	1	0			
				0x2f000	0x4052125	.long 0x04052125
				0x2f004	0x240300C1	addiu $v1,$zero,0xC1
				0x2f008	0x14041902	bne $zero,$a0,0x0000640C
				0x2f00c	0xDC200C8	jal 0x07080320
				0x5e010	0xDC20080	jal 0x07080200
				0x5e014	0x40018E3	bltz $zero,0x00006390
				0x5e018	0x14032106	bne $zero,$v1,0x0000841C
				0x5e01c	0x44020C0	bltz $v0,0x00008304
				0xbc020	0x14802100	bne $a0,$zero,0x00008404
				0xbc024	0x4041923	bne
				0xbc028	0x201FA000	addi $ra,$zero,-0x6000
				0xbc02c	0x40220A1	bltzl $zero,0x00008288
				0xbc030	0x3C008080	lui $zero,0x8080
				0xbc034	0x41C00FED	lui

Figure 33. Instruction cache



Index	Way	V	L	D	Adress	Data
0	0	1	0	1		
					0x78c1000	0x8FCEC588
					0x78c1004	0x80525BA0
					0x78c1008	0x100000
					0x78c100c	0x77386460
					0xf182010	0x0
					0xf182014	0x0
					0xf182018	0x80000000
					0xf18201c	0x0
0	1	1	0	0		
					0x292000	0x804B9758
					0x292004	0x80527884
					0x292008	0x805277D4
					0x29200c	0xFA
					0x524010	0x80002ED0

Figure 34. Data cache



Index	Way	V	L	D	Adress	Data	Disassembly
0	0	1	0	0			
					0x802d000	0x0	
					0x802d004	0x1	
					0x802d008	0x0	
					0x802d00c	0x0	
					0x1005a010	0x0	
					0x1005a014	0x0	
					0x1005a018	0x0	
					0x1005a01c	0x0	
					0x200b4020	0x0	
					0x200b4024	0x0	
					0x200b4028	0x0	
					0x200b402c	0x0	
					0x200b4030	0x0	
					0x200b4034	0x0	

Figure 35. Secondary cache

2. The **Cache** window allows you to perform the following actions for the currently viewed cache:

   Show Valid only

   Show Locked only

   Show Dirty only

   Invalidate currently selected cache memory

   Save View to a .CSV file

   Load/initialise cache from a previously saved .CSV file

   Clear view

   Refresh view (re-read cache from target)

4. Multi-core support

PathFinder-XD can debug multiple cores simultaneously. Details regarding multi-core configuration and debug operations follow:

4.1.1 Multi-core configuration

Multi-core configuration is done via the **Target Configuration Wizard**. See portion marked in RED in below figure.

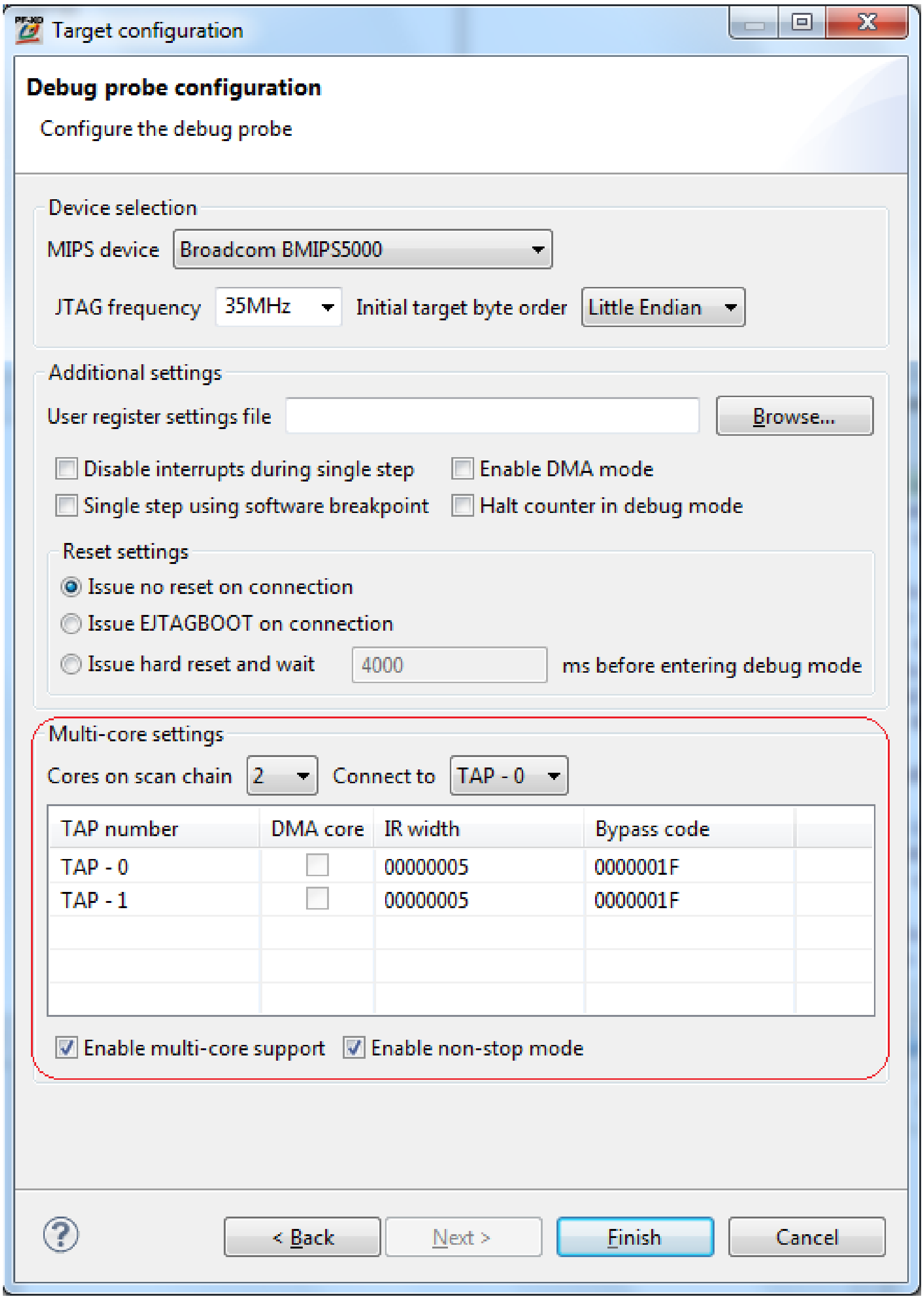


Figure 36. Target Configuration Wizard

Multi-core configuration settings include:

- **Cores on scan chain:** specifies the total number of cores on the JTAG scan-chain
- **Connect to:** select the core to which you need to connect initially
- **Enable multi-core support:** enables multi-core debugging. If unchecked, only the core selected via **Connect to** can be debugged.
- **Enable non-stop mode:** allows examination of halted cores context without intruding/halting other running cores i.e. you can halt individual cores/threads without affecting other cores/threads. By default, this mode is on.

All entries are automatically set to sensible defaults when you select the BRCM device.

4.1.2 Debugging multiple cores simultaneously

All active cores will be listed in the **Debug** view as shown in the following figure e.g. TAP-0 is shown as Thread/Core [0] and TAP-1 as Thread/Core [1]:

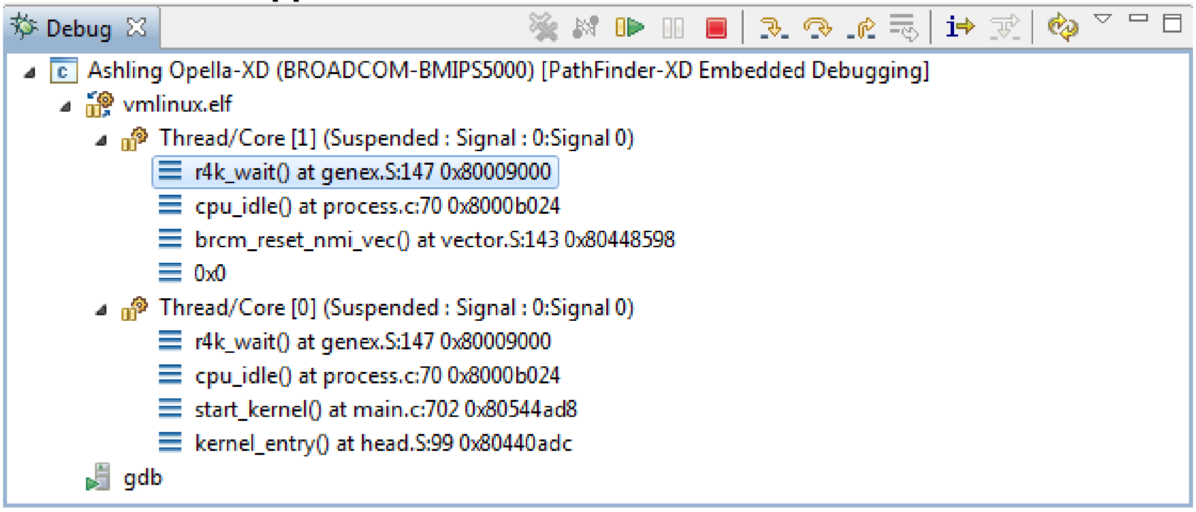


Figure 37. Target Configuration Wizard

In **non-stop mode** debugging, separate run control buttons  are available for all active cores.

1. To control all cores simultaneously, click on the root in the **Debug** view (**vmlinux.elf** in the above figure).

2. To control a specific core (and not halt/intrude other running cores), click on the specific core in the **Debug** view (**Thread/Core[1]** or **Thread/Core[0]** in the above figure).

Non-stop mode requires that the target device supports non-stop debugging. When the target does not support this feature (e.g. BRCM7400), the run control buttons are common to all cores (hardware threads) e.g. when one core is halted, all the other cores are also halted (aka all-stop mode).

4.1.3 Examining individual core context

All debug views (**Memory, Registers, Variables** etc.) update when a particular core is selected in the **Debug** view.

4.1.4 Pin and clone support

Pin and clone allows comparison of views from multiple cores. PathFinder-XD supports **cloning** debug views and **pinning** to cores (or hardware threads), thereby allowing core context comparison as depicted in the following figure.

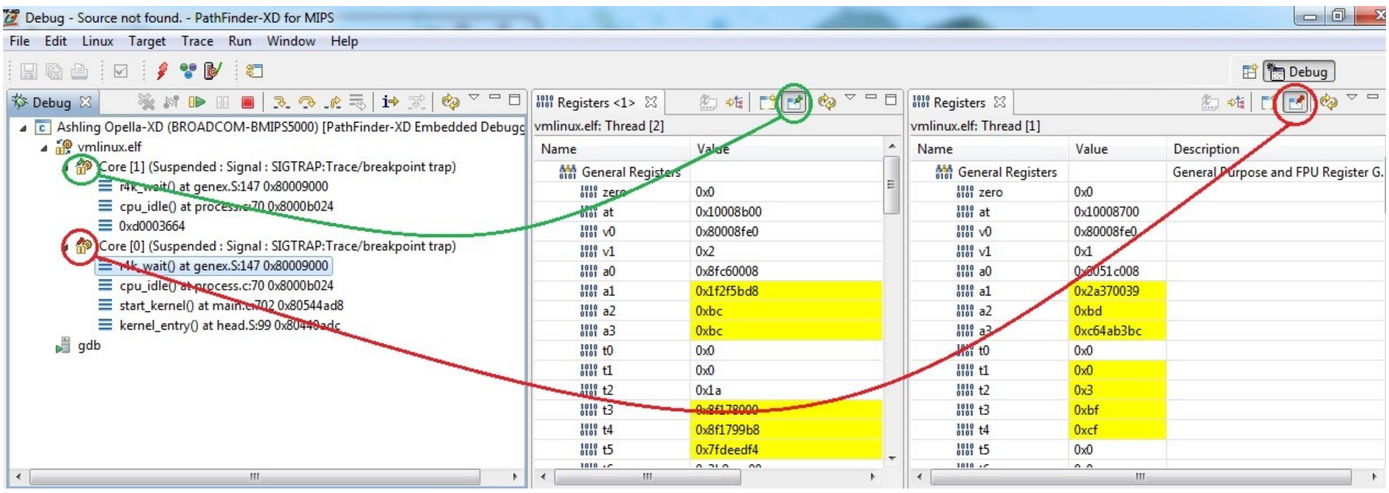


Figure 38. Pin and Clone

The pin colour (e.g. red or green) in the **Debug** view matches the pin colour in the corresponding cloned view e.g. the **Registers** or **Registers <1>** views in the above figure.

5. Trace support

PathFinder-XD supports Broadcom's Zephyr trace. This is a powerful on-chip trace implementation that allows real-time capture of code and data trace for all hardware threads (or cores). Captured Zephyr trace data is stored on the target's L2 cache (up to 128KB can be allocated for trace) and can be accessed and displayed in PathFinder-XD via the target's EJTAG debug port (using the Opella-XD connection).

5.1 Enable/configure trace

1. Trace can be enabled as shown below:

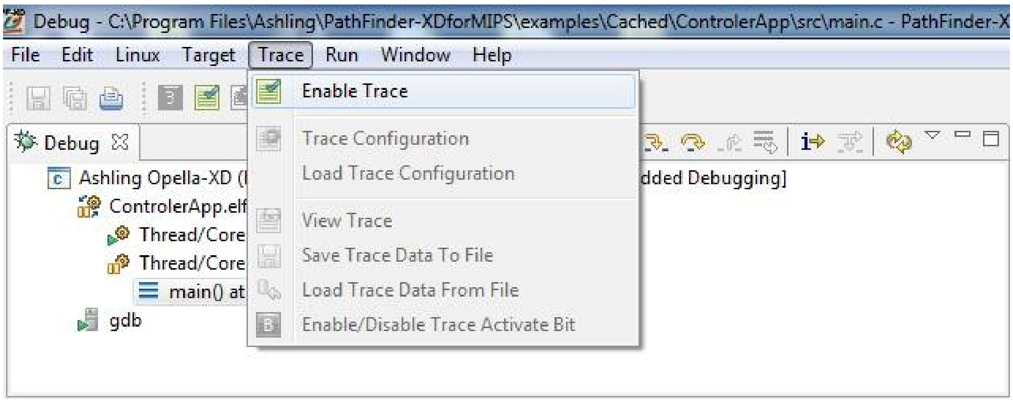


Figure 39. Enable trace

Enable Trace will configure trace with the default/current settings. When configuring for the first time, the **Trace Configuration** dialog will pop up. Subsequently, this can be accessed using the **Trace Configuration** option from the **Trace** menu as shown in following figures:

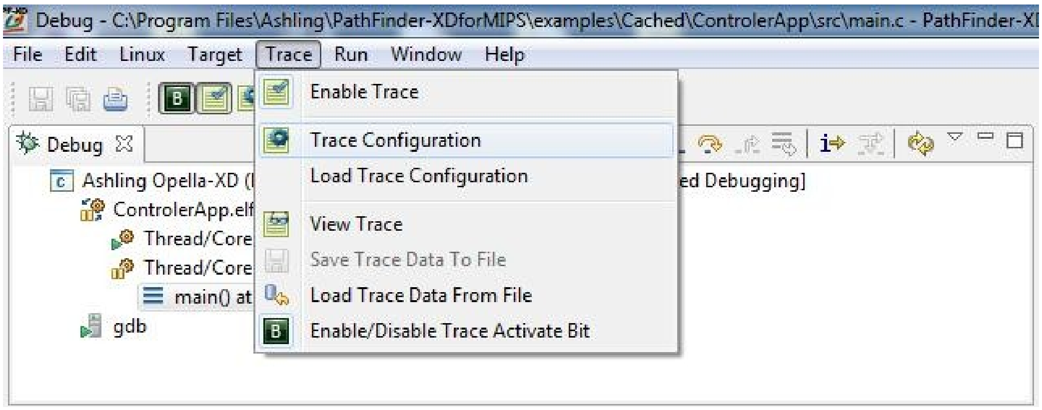


Figure 40. Trace Configuration

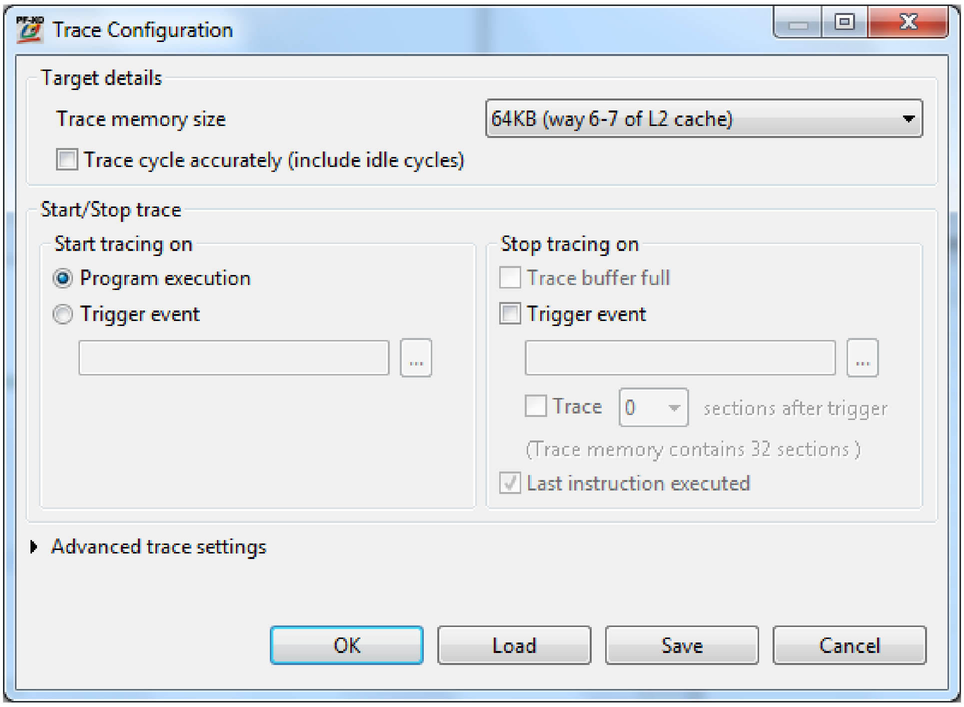


Figure 41. Trace Configuration dialog

Trace Configuration settings include:

- **Trace memory size:** allows you to choose the portion of L2 cache to be used as trace buffer.
  Note: Please ensure that your application does not use this portion!
- **Trace cycle accurately (include idle cycles):** enables cycle accurate tracing (accurate but limits trace capacity, as more information is stored)
- **Start/Stop trace:** allows you to tell PathFinder-XD when to start tracing and stop tracing.

Click **Advanced trace settings** to expand the configuration dialog:

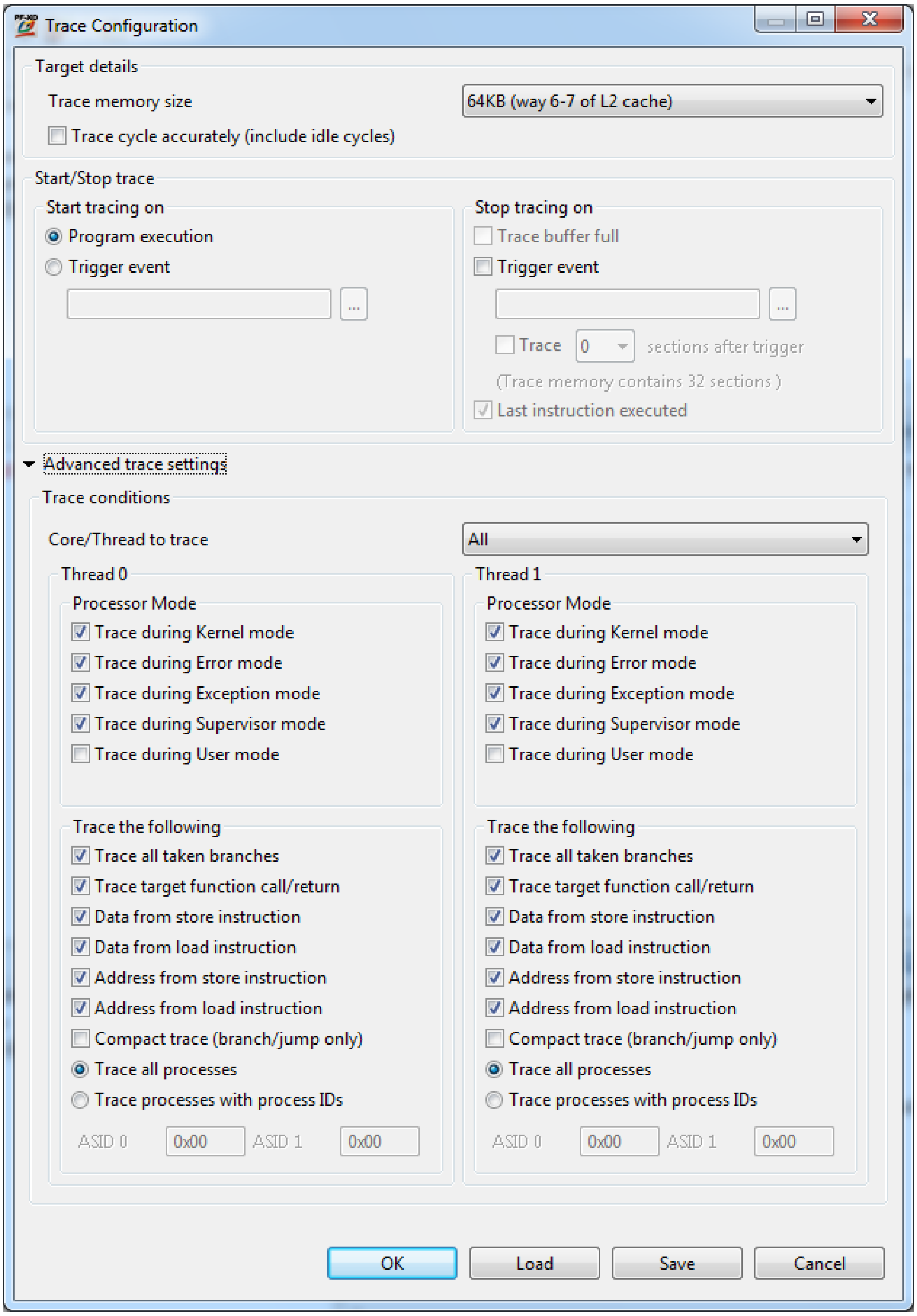


Figure 42. Trace Configuration dialog – expanded view

Advanced trace settings include

- **Core/Thread to trace:** allows you to choose the threads to trace.
- **Thread0:** All settings under **Thread0** are specific to Thread 0. You can choose when to trace (**Processor mode)** and what to trace (**Trace the following**). The different options available are shown in above figure. Process specific tracing is possible by specifying **ASID0** and **ASID1** values. Similar settings exist for **Thread1** as well.

*Note: As of writing, **Compact Trace** mode is not supported.*

2. All user Trace Configuration selections can be saved to a file and subsequently restored using the **Save** and **Load** buttons in the **Trace Configuration** dialog.

5.2 Viewing trace

1. Once captured, trace information is shown in the Trace perspective (**Trace|View Trace**) as follows:

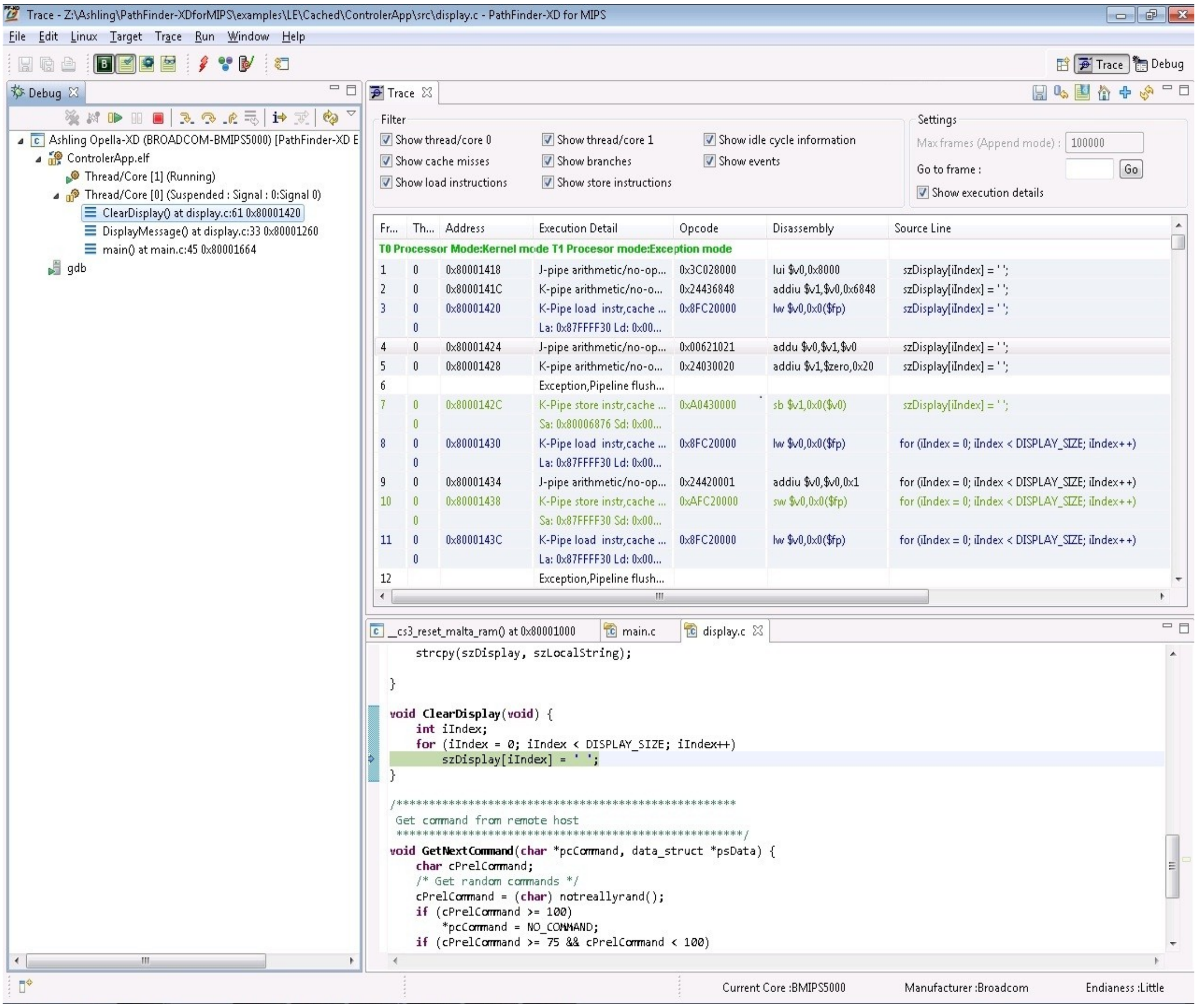


Figure 43. Trace Perspective

The Trace window shows the reconstructed trace information in a human-readable, high-level format. Information is reconstructed using the previously downloaded .ELF file; if the captured code information is not from within this .ELF file, then PathFinder-XD reads target memory to determine the actual executed code. Accessing target memory requires more time to populate the view, however, it allows support for both kernel and application code trace reconstruction when the target is running Linux.

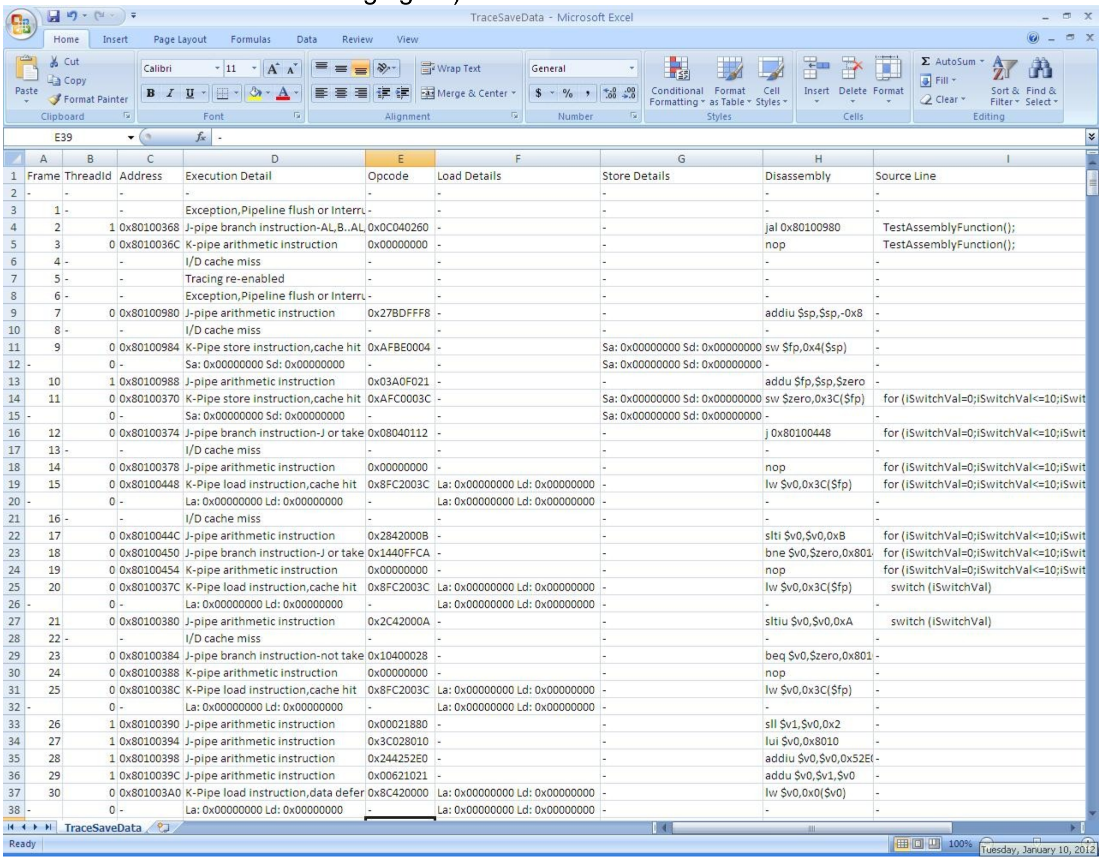
Trace information can be filtered (i.e. removed from the window) via the **Filter** control. Information is colour-coded as follows:

- All branch instructions are shown in red
- All load instructions are shown in blue
- All store instructions are shown in green
- All T0/T1 instructions are identified by separate background shades

Double-clicking on a line on the Trace window updates the Source window below to show the equivalent line.

5.3 Saving trace

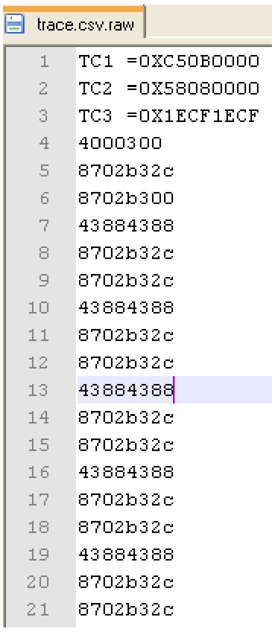
1. Trace information (exactly as shown in the window) can be saved to a .CSV file and reloaded into PathFinder-XD (using  on the Trace window). CSV format allows logging of trace information for off-line viewing (e.g. using Microsoft Excel as in the following figure).



Frame	ThreadId	Address	Execution Detail	Opcode	Load Details	Store Details	Disassembly	Source Line
-	-	-	-	-	-	-	-	-
1	-	-	Exception,Pipeline flush or Interru	-	-	-	-	-
2	1	0x80100368	J-pipe branch instruction-AL,B..AL,	0x0C040260	-	-	jal 0x80100980	TestAssemblyFunction();
3	0	0x8010036C	K-pipe arithmetic instruction	0x00000000	-	-	nop	TestAssemblyFunction();
4	-	-	I/D cache miss	-	-	-	-	-
5	-	-	Tracing re-enabled	-	-	-	-	-
6	-	-	Exception,Pipeline flush or Interru	-	-	-	-	-
7	0	0x80100980	J-pipe arithmetic instruction	0x27BDFFF8	-	-	addiu $sp,$sp,-0x8	-
8	-	-	I/D cache miss	-	-	-	-	-
9	0	0x80100984	K-Pipe store instruction,cache hit	0xAFBE0004	-	Sa: 0x00000000 Sd: 0x00000000	sw $fp,0x4($sp)	-
-	0	-	Sa: 0x00000000 Sd: 0x00000000	-	-	Sa: 0x00000000 Sd: 0x00000000	-	-
10	1	0x80100988	J-pipe arithmetic instruction	0x03A0F021	-	-	addu $fp,$sp,$zero	-
11	0	0x80100370	K-Pipe store instruction,cache hit	0xAFC0003C	-	Sa: 0x00000000 Sd: 0x00000000	sw $zero,0x3C($fp)	for (iSwitchVal=0;iSwitchVal<=10;iSwit
-	0	-	Sa: 0x00000000 Sd: 0x00000000	-	-	Sa: 0x00000000 Sd: 0x00000000	-	-
12	0	0x80100374	J-pipe branch instruction-J or take	0x08040112	-	-	j 0x80100448	for (iSwitchVal=0;iSwitchVal<=10;iSwit
13	-	-	I/D cache miss	-	-	-	-	-
14	0	0x80100378	J-pipe arithmetic instruction	0x00000000	-	-	nop	for (iSwitchVal=0;iSwitchVal<=10;iSwit
15	0	0x80100448	K-Pipe load instruction,cache hit	0x8FC2003C	La: 0x00000000 Ld: 0x00000000	-	lw $v0,0x3C($fp)	for (iSwitchVal=0;iSwitchVal<=10;iSwit
-	0	-	La: 0x00000000 Ld: 0x00000000	-	La: 0x00000000 Ld: 0x00000000	-	-	-
16	-	-	I/D cache miss	-	-	-	-	-
17	0	0x8010044C	J-pipe arithmetic instruction	0x2842000B	-	-	slti $v0,$v0,0xB	for (iSwitchVal=0;iSwitchVal<=10;iSwit
18	0	0x80100450	J-pipe branch instruction-J or take	0x1440FFCA	-	-	bne $v0,$zero,0x801	for (iSwitchVal=0;iSwitchVal<=10;iSwit
19	0	0x80100454	K-pipe arithmetic instruction	0x00000000	-	-	nop	for (iSwitchVal=0;iSwitchVal<=10;iSwit
20	0	0x8010037C	K-Pipe load instruction,cache hit	0x8FC2003C	La: 0x00000000 Ld: 0x00000000	-	lw $v0,0x3C($fp)	switch (iSwitchVal)
-	0	-	La: 0x00000000 Ld: 0x00000000	-	La: 0x00000000 Ld: 0x00000000	-	-	-
21	0	0x80100380	J-pipe arithmetic instruction	0x2C42000A	-	-	sltiu $v0,$v0,0xA	switch (iSwitchVal)
22	-	-	I/D cache miss	-	-	-	-	-
23	0	0x80100384	J-pipe branch instruction-not take	0x10400028	-	-	beq $v0,$zero,0x801	-
24	0	0x80100388	K-pipe arithmetic instruction	0x00000000	-	-	nop	-
25	0	0x8010038C	K-Pipe load instruction,cache hit	0x8FC2003C	La: 0x00000000 Ld: 0x00000000	-	lw $v0,0x3C($fp)	-
-	0	-	La: 0x00000000 Ld: 0x00000000	-	La: 0x00000000 Ld: 0x00000000	-	-	-
26	1	0x80100390	J-pipe arithmetic instruction	0x00021880	-	-	sll $v1,$v0,0x2	-
27	1	0x80100394	J-pipe arithmetic instruction	0x3C028010	-	-	lui $v0,0x8010	-
28	1	0x80100398	J-pipe arithmetic instruction	0x244252E0	-	-	addiu $v0,$v0,0x52E(	-
29	1	0x8010039C	J-pipe arithmetic instruction	0x00621021	-	-	addu $v0,$v1,$v0	-
30	0	0x801003A0	K-Pipe load instruction,data defer	0x8C420000	La: 0x00000000 Ld: 0x00000000	-	lw $v0,0x0($v0)	-
-	0	-	La: 0x00000000 Ld: 0x00000000	-	La: 0x00000000 Ld: 0x00000000	-	-	-

Figure 44. Saved Trace .CSV file

2. When the user saves a CSV file, a raw trace file is also created in the same directory with the extension .csv.raw. This is an ASCII text file which shows the L2 cache trace memory as a list of 32-bit words in hexadecimal format.



```
trace.csv.raw
TC1 =0XC50B0000
TC2 =0X58080000
TC3 =0X1ECF1ECF
4000300
8702b32c
8702b300
43884388
8702b32c
8702b32c
43884388
8702b32c
8702b32c
43884388
8702b32c
8702b32c
43884388
8702b32c
8702b32c
43884388
8702b32c
8702b32c
```

Figure 45. Trace .CSV.RAW file

5.4 Known issues with trace

The BMIPS5000 Zephyr on-chip trace implementation has the following known issues as of writing:

1. Compact Trace Mode is not supported.

2. **Data access** based triggers are supported; however, **Instruction execution** based triggers do not work reliably and should not be used (due to silicon issues).

3. 128KB Upper trace configuration will not work reliably (due to silicon issues)

4. If you are debugging the Linux kernel, then you may experience a kernel crash if trace is configured either before booting or after booting. This is a known silicon issue and the following workaround should be used:

   - Enable and configure trace as normal before booting/running the kernel
   - Temporarily disable trace via the **Enable/Disable Trace Activate Bit** (via **Trace** Menu or button) Boot/run the kernel until it is 'up'.
   - Now enable trace via the **Enable/Disable Trace Activate Bit** (via **Trace** Menu or button)

5. PathFinder-XD supports simultaneous tracing of both kernel and a single application, however, simultaneous tracing of multiple applications is not supported.

6. Embedded Linux debugging support

PathFinder-XD (v1.0.6 or later) supports Embedded Linux Debugging for kernels based on v2.6.26 or later. Both Standard (non-SMP) and SMP Linux debugging are fully supported.

Support works in two modes:

- Stop-mode: Debugging is done via the on-chip debug interface (e.g. via Opella-XD) and the whole system is halted (e.g. kernel and applications) whenever a breakpoint is taken.
- Run-mode: Debugging is done purely in software (i.e. no Opella-XD is required) via a target serial/Ethernet interface and requires an application (GDB server) running on the target. In run-mode, the kernel continues to run when an application breakpoint is taken.

Stop-mode debugging is useful for bringing up the kernel as it only requires a functional on-chip debug interface and allows debug from reset. Stop-mode can also be used for process debugging, however, the kernel/interrupts etc. will not continue to run when halted (unlike run-mode). When stop-mode debugging a process, PathFinder-XD automatically scans the kernel MMU mapping for that process and sets up the MIPS core TLB to allow debug access to the process's memory area. Run-mode debugging requires that the kernel is up and running and allows non-intrusive debug of a process (i.e. the kernel will continue to run even when a process is halted). Run-mode also supports thread-aware breakpoints and simultaneous debug of multiple processes.

6.1 Hardware Setup

This section demonstrates SMP Linux Debugging using PathFinder-XD and Opella-XD connected to a **Connect 20 Software Development Platform** (the 'target'). This platform is powered by a Broadcom BCM7420 dual-threaded 750MHz MIPS device (http://02f0fbc.netsolstores.com/broadcomopenset-topbox-connect20.aspx) running Linux Kernel v2.6.37.

Ashling provides the associated Linux Kernel sources files for download at `http://www.ashling.com/support/MIPS/Connect20/MIPS_CONNECT20_LINUX_v2.6.37.zip` and these should be installed by unzipping to your local hard-disk (ensure you preserve the directory structure as present in the ZIP file i.e. `C:\MIPS_CONNECT20_LINUX_v2.6.37\`). These sources are needed for source-level debug of the kernel and they also include some examples that demonstrate other PathFinder-XD features.

6.1.1 Connect 20 Software Development Platform Setup for Embedded Linux debugging

For Embedded Linux debugging, setup your hardware as shown below.

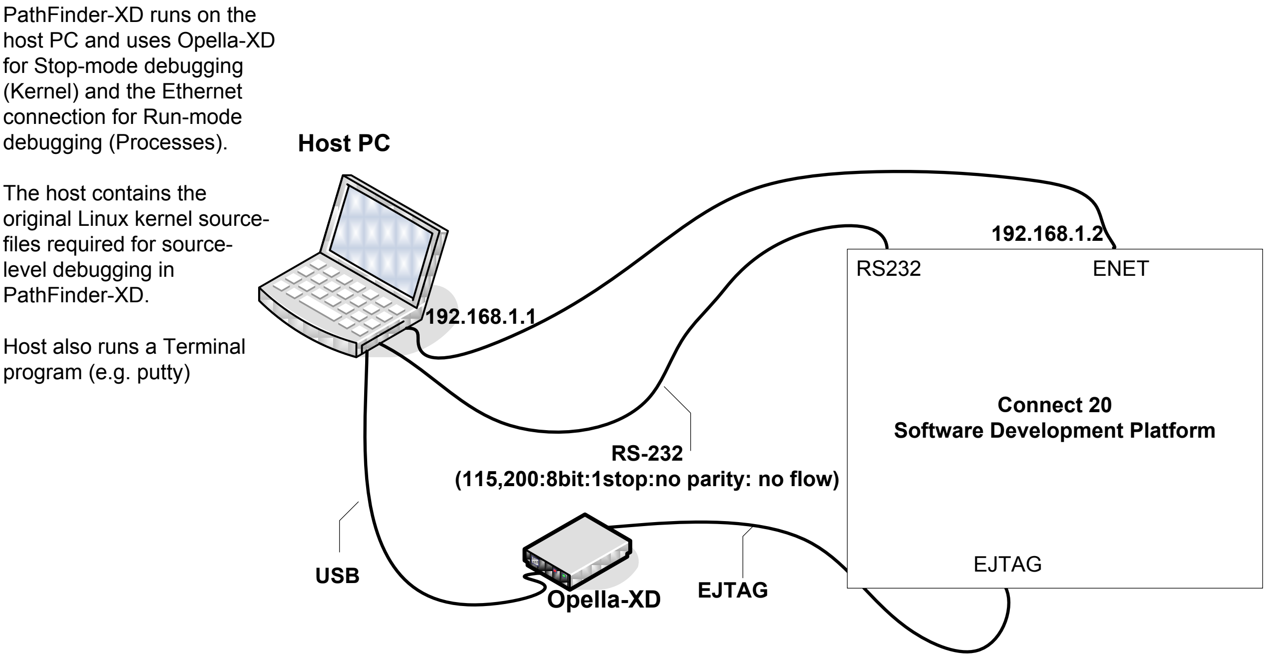


Figure 46. Embedded Linux Demo setup

6.1.2 Setting up Putty

You will need a terminal program (e.g. putty) running on your host PC to show the target's Linux shell (and status messages during boot). The terminal should be configured as per the RS-232 settings shown below.

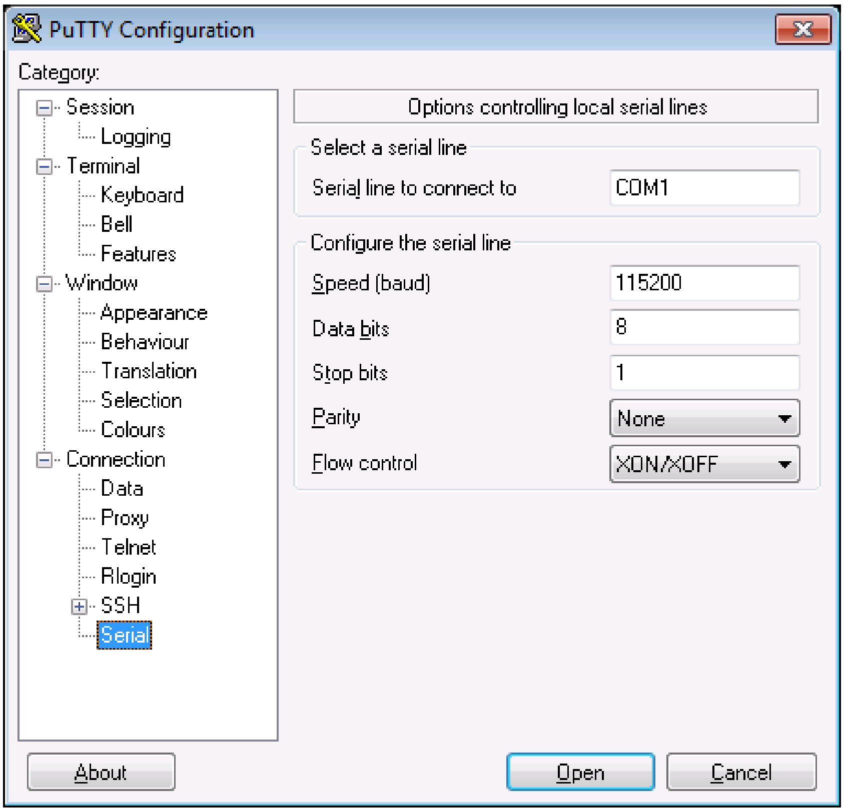


Figure 47. Setting up Putty

6.1.3 Setting up network between host and target

Setup the IP address of the host computer (running PathFinder-XD) as shown below:

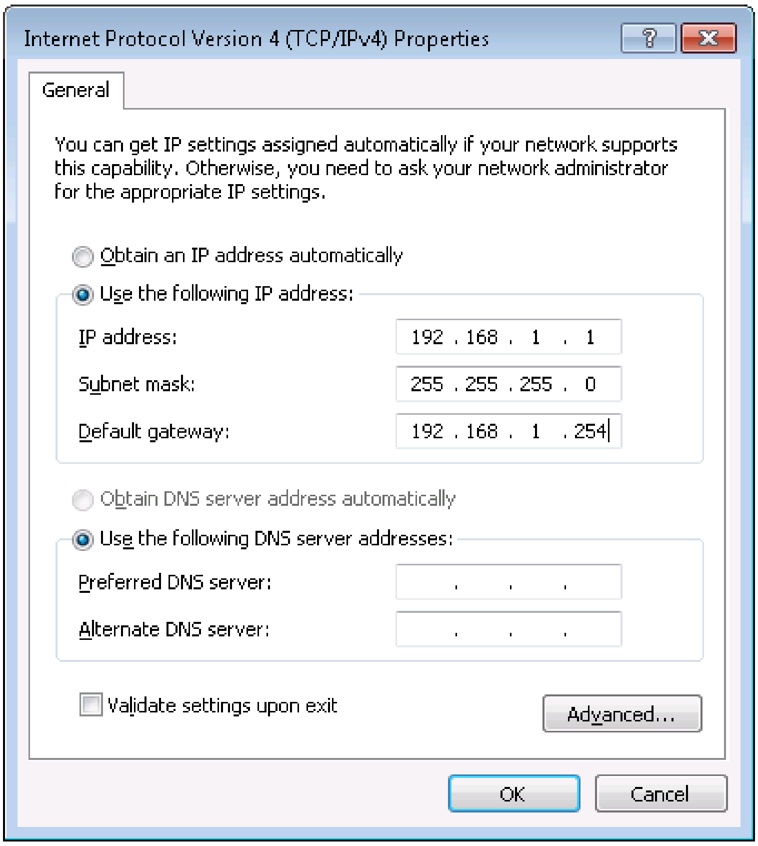


Figure 48. IP address configuration at Host

When the target is powered on a factory programmed Linux image (from flash memory) is loaded. Press **`Ctrl+C`** to cancel automatic start-up which will allow us to setup the target IP address and load the kernel from our host PC (using tftp)

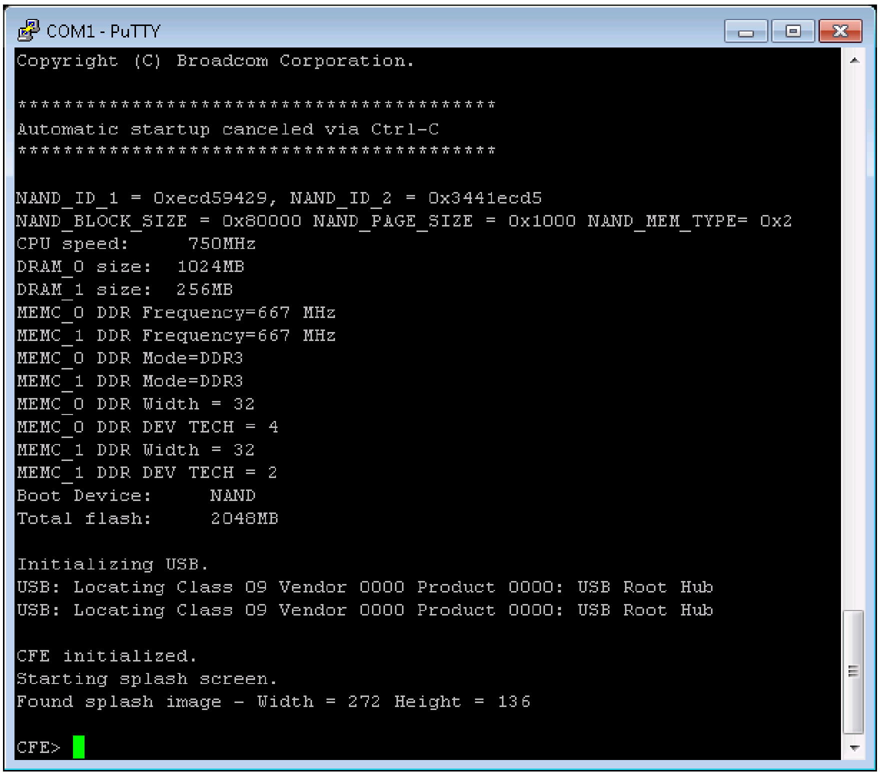


Figure 49. Connect 20 Boot Loader prompt

Setup the target IP address using the below boot loader command:

```
ifconfig eth0 -addr=192.168.1.2 -mask=255.255.255.0 -gw=192.168.1.254
```

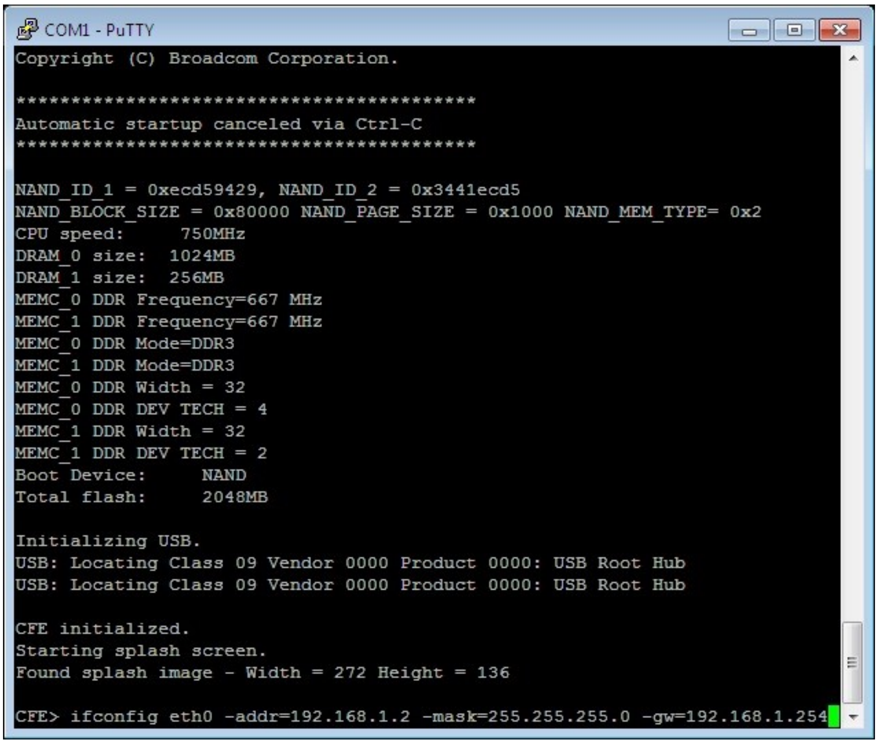


Figure 50. Target IP address Configuration

Verify we can communicate with the host PC using `ping` as follows:

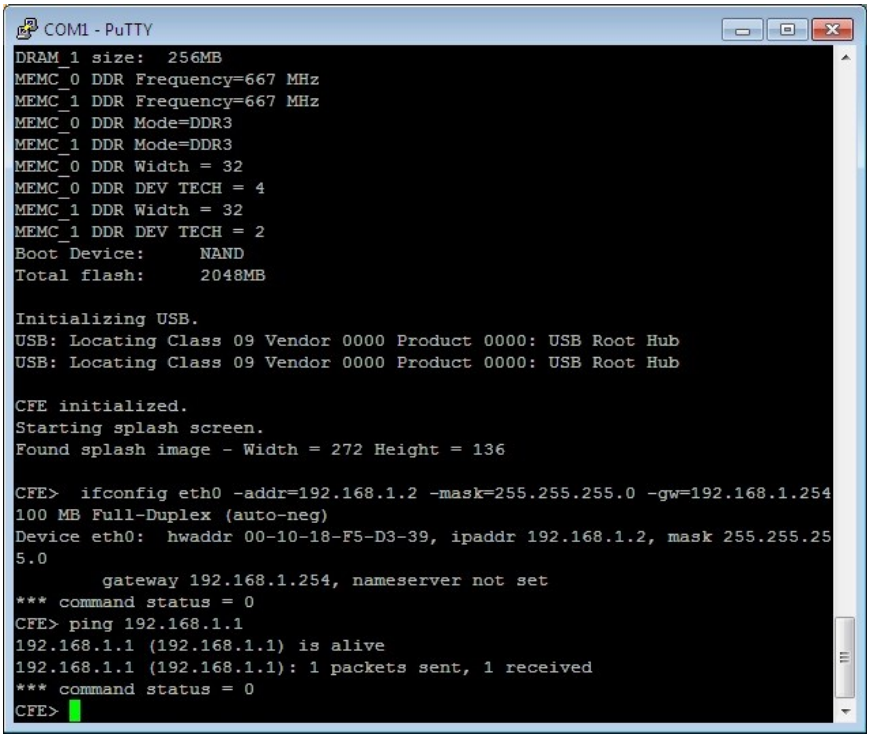
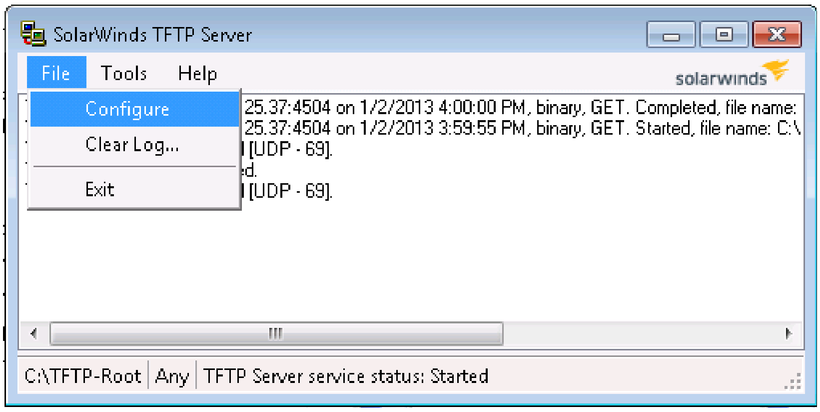


Figure 51. Pinging to the host

Note: If `ping` fails, then please recheck your host computer IP settings and your firewall.

6.1.4 Installing TFTP Server on the host PC

Download and install TFTP server from: http://www.softpedia.com/progDownload/SolarWinds-TFTP-Server-Download-81432.html. Run `TFTPServer.exe` from the installation directory (`C:\Program Files\SolarWinds\TFTPServer`) and start TFTP Server via **File | Configure | Start** option. This will create a TFTP root directory in `C:\TFTP-Root`.



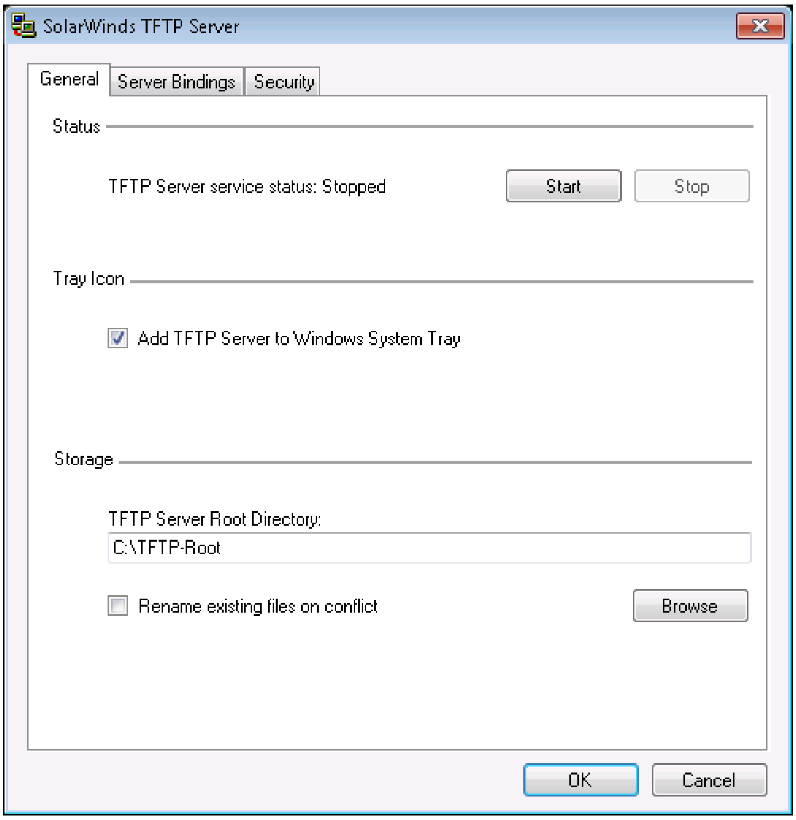


Figure 52. TFTP Server Configuration

Now copy the Linux ramdisk image (`vmlinuz-initrd-7420c0`) image from `C:\MIPS_CONNECT20_LINUX_v2.6.37\` to the `C:\TFTP-Root` directory.

6.1.5 Loading the Linux Image using TFTP

The Linux ramdisk image (contains kernel and file system) can now be loaded to the target using the below boot loader command:

```
boot -z -elf 192.168.1.1:vmlinuz-initrd-7420c0 'smp bmem=0'
```

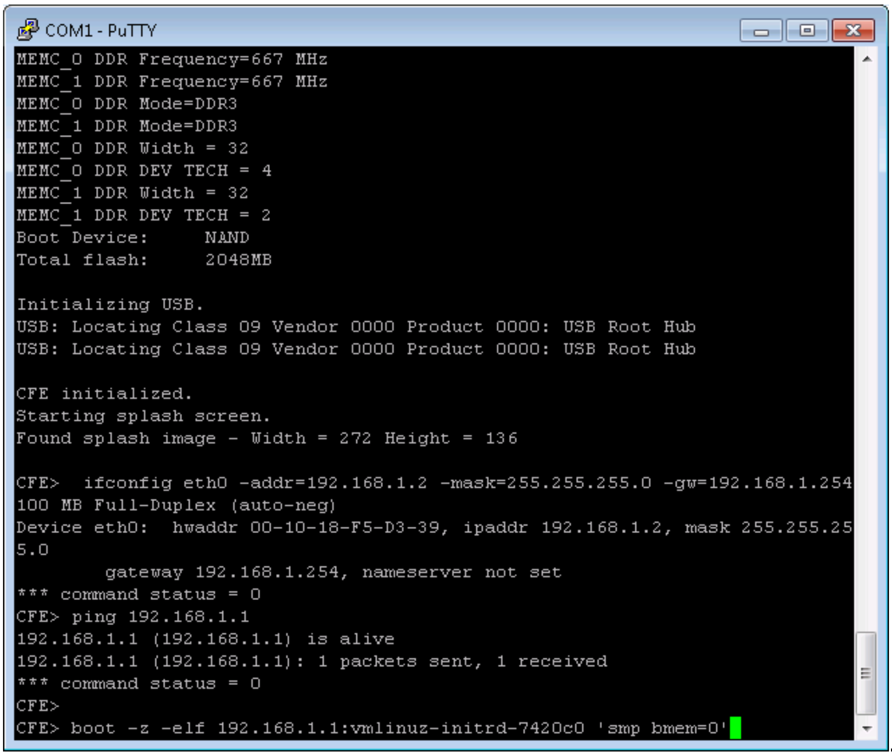


Figure 53. Loading Linux Image via TFTP

Linux will then be loaded as shown below.

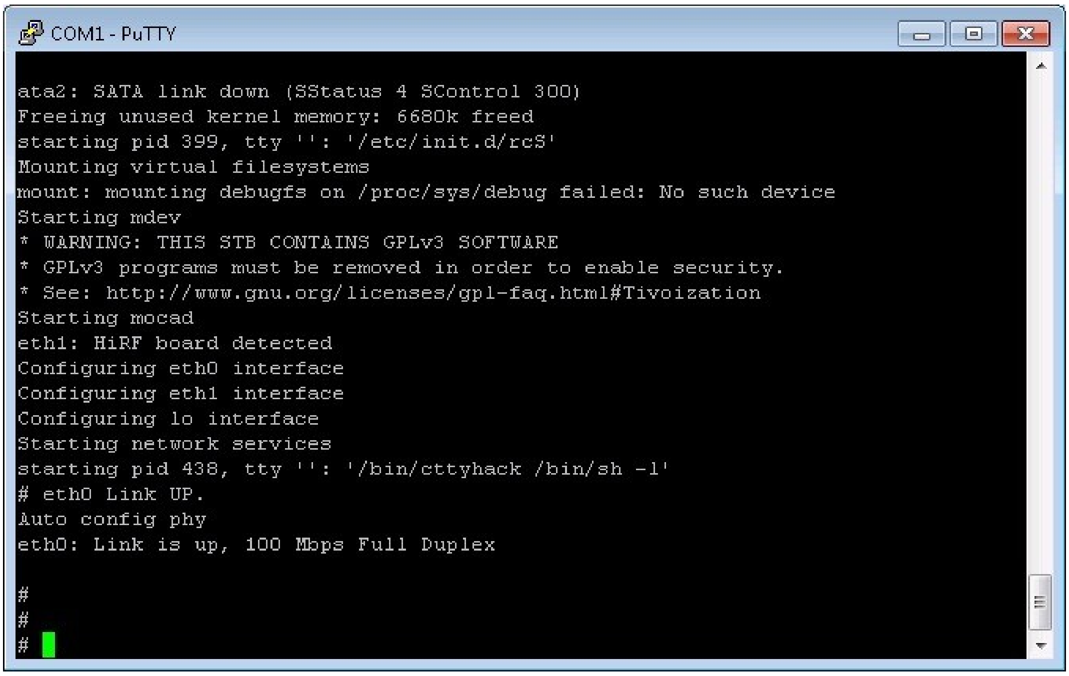


Figure 54. Linux shell on Connect 20 Target

Setup the target IP address again (the previously set IP will have been lost when Linux is reloaded) using:
`ifconfig eth0 192.168.1.2`

6.2 Preparing for debugging

This section is necessary only if you are building/using your own kernel; the version supplied by Ashling includes all of the following requirements.

6.2.1 Building with debug symbols

Your kernel, modules, processes, libraries, drivers etc. must be built with debug symbols as PathFinder-XD needs to access global structures and variables etc. to support Linux debugging.

Note: Debug symbols for Linux kernel (`vmlinux`) are required to debug user-mode applications in stop-mode (to allow PathFinder-XD to handle memory mapping which requires kernel symbols). Kernel symbols are not required for run-mode debugging.

- For the kernel, run make menuconfig, select Kernel hacking, enable Kernel debugging and Compile the kernel with debug and run make to rebuild the kernel with debug symbols.

- For non-kernel items, add the compiler gcc switch **`-g`** (which will generate debug symbols) to your makefile and rebuild.

6.2.2 On-demand paging (for stop-mode debugging only)

Linux uses "on-demand paging", meaning a process' (and its dependant libraries') code, data and stack are not actually paged into memory until they are first used. This can cause problems when you wish to "stop-mode" debug a process from its initialisation as it may not yet be present in memory. For example, you cannot set software breakpoints which require patching of the software breakpoint instruction into the appropriate process' memory location until the actual associated process code page is in memory. Depending on the size of your target's memory space and your Memory Management Unit (MMU) configuration, you may or may not have this issue. If you do have this issue, then Ashling provide a kernel patch that will force all of a process' code, data and stack pages into memory. This file is installed with PathFinder-XD and is called `ash_load_process_pages.c`. Installing the patch requires that you modify some existing kernel files and rebuild; please refer to the file for full details.

Note: This patch is required only for stop-mode debugging.

6.3 Stop-mode Debugging

The following features are supported:

- Linux Kernel debugging:
  - Debug modules built as part of the Kernel
- Linux dynamically loadable Modules/Driver debugging:
  - List all inserted modules
  - Debug an already inserted module
  - Debug a module from **`init_module()`**
- Linux process (application) and library debugging:
  - List all running processes and threads
  - Debug a running process
  - Debug a process from **`main()`**
  - Debug shared libraries

6.3.1 Sample Stop-mode Linux Debugging Session

This section demonstrates Linux Kernel Debugging using PathFinder-XD and Opella-XD connected to a Connect 20 target running v2.6.37 Linux Kernel. Make sure that your hardware is configured as per **6.1.1**

Connect 20 Software Development Platform Setup for Embedded Linux debugging**.**

1. In PathFinder-XD, create a **New Target Configuration** via the **Target** menu

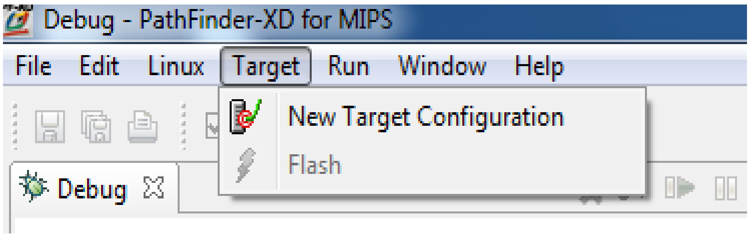


Figure 55. Target Configuration

and select the **Debug using Debug Probe** option as shown below

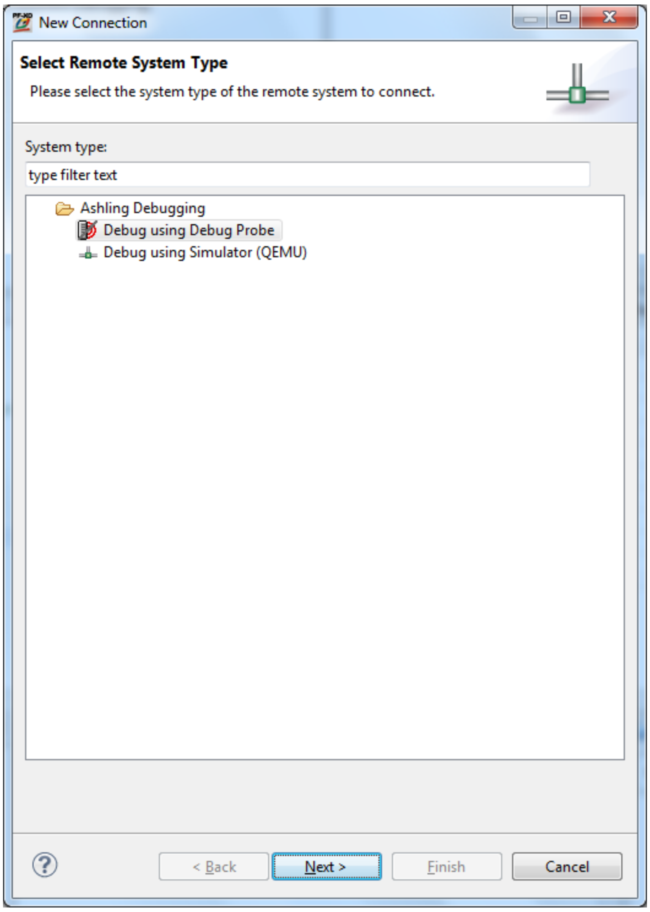


Figure 56. Debug using Debug Probe

2. Click **Next** and we can now configure our Opella-XD settings as shown below:

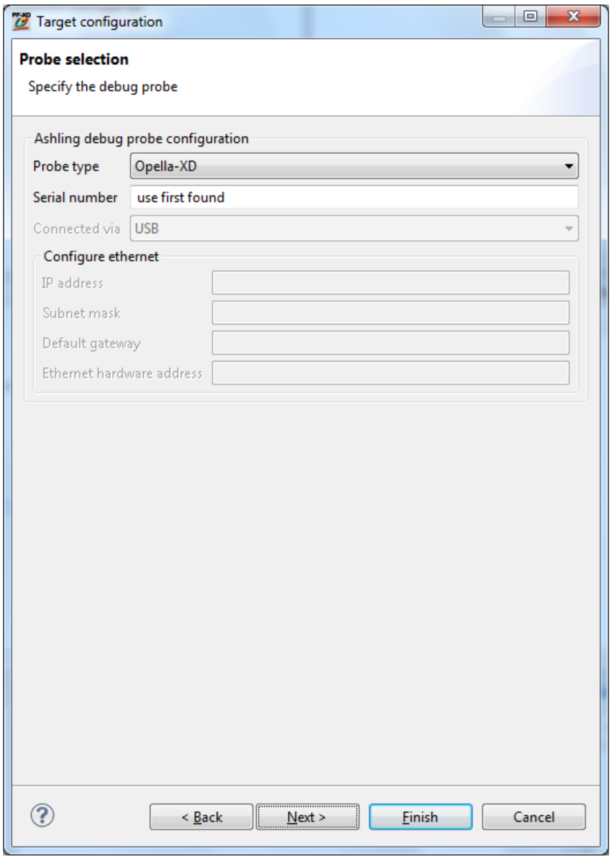


Figure 57. Probe selection

Settings include:

- **Probe type:** The actual Ashling Debug Probe Type to use as the target connection. Select **Opella-XD**
- **Serial number:** The serial number of the Debug Probe to use. Specify the serial number or **use first found** and click on **Next**

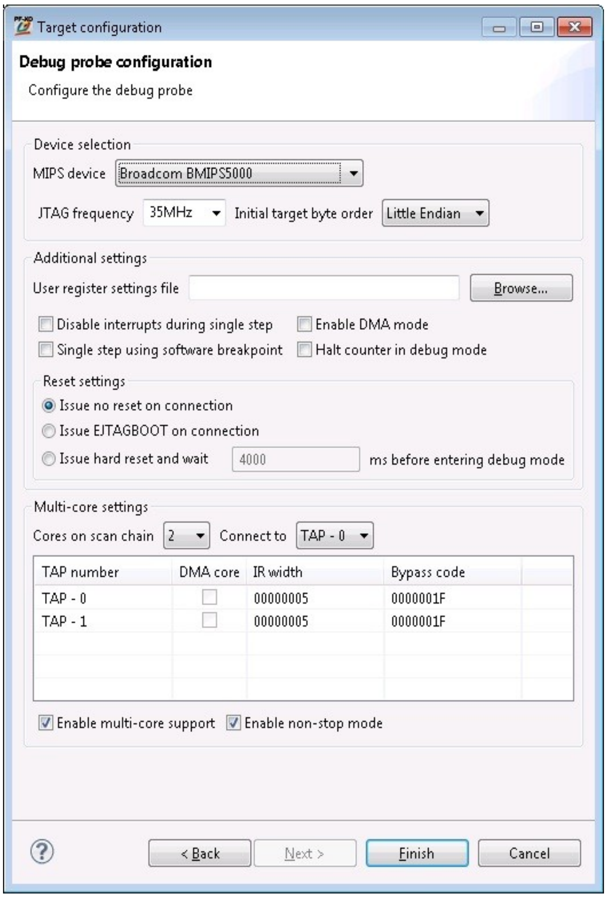


Figure 58. Target Configuration

The **Debug probe configuration** settings include:

- **MIPS device:** specifies the MIPS device type you wish to debug. In this example, Broadcom BMIPS5000 is selected.
- **JTAG frequency:** specifies the JTAG TCK frequency to be used for communicating with the EJTAG interface on your MIPS device
- **Initial target byte order:** allows you to specify the memory Endianess of your target system.
- **User register settings file:** group allows you to initialise other registers or memory locations on PathFinder-XD invocation and after reset. The **Browse…** button allows these register values to be loaded from a simple text file. The text file format is:
  `Name  Size Address Value`
  (all values are in HEX). For example, the following text file initialises the R0, R1, R2 and R3 registers:
  ```
  R0 0x00000004 0xb800380c 0x18000000
  R1 0x00000004 0xb8003808 0x00000006
  R2 0x00000004 0xb8004018 0x00000800
  R3 0x00000004 0xb800401c 0x0000000c
  ```
- **Disable interrupts during single step:** allows you to disable interrupts when single stepping at assembly level (MIPS instruction level). When checked, PathFinder-XD automatically disables interrupts prior to assembly level single step and re-enables them after the single step is complete.
- **Enable DMA Mode:** enables DMA mode for high-speed transfer between the debug probe and your target. DMA Mode is only available on systems with EJTAG DMA support.
- **Single step using software breakpoint:** allows you to specify that PathFinder-XD should use software breakpoints for single-stepping (i.e. PathFinder-XD should not use the EJTAG hardware based single-step command).
- **Halt counters in debug mode:** allows you tell PathFinder-XD to halt the MIPS Count register(s) (via writing to the Configuration register) whenever your program is halted. There is a slight delay between your program halting and the write to the Configuration register. Note that the **Registers** window always shows your application values for the Configuration register.
- **Issue no reset on connection**: will ensure that no hardware reset is issued when you connect to your target (note that this feature requires updated Opella-XD firmware (v1.1.1 or later) which is supplied with PathFinder-XD v1.0.6 or later).
- **Issue EJTAGBOOT on connection**: will issue a hardware reset and halt the target at the reset location.
- **Issue hard reset and wait 'N' ms before entering debug mode**: will issue a hardware reset and wait the specified number of ms before entering debug mode. This mode is also known as NORMALBOOT.
- **Multi-core:** allows you to select the core you wish to debug for multi-core devices. The BCM7420 device has two cores (or hardware threads) and the first one (TAP-0) is chosen in this example.
- **Enable multi-core support:** enables multi-core debugging. Check this as we want to debug both cores (threads) in the BCM7420 device.

- **Enable non-stop mode:** allows examination of halted cores context without intruding/halting other running cores i.e. you can halt individual cores/threads without affecting other cores/threads. By default, this mode is on.
  The settings shown are suitable for Connect 20 target board. Click **Finish** when done.

3. PathFinder-XD will now create a new **Target Debugger** setting in its **Remote Systems** Window as shown below:

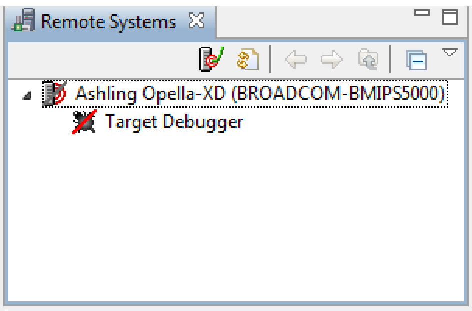


Figure 59. Remote Systems Window

Right-click on **Target Debugger** and click **Connect to** invoke the Opella-XD target connection. Once invoked, the **Remote Systems** window will update as follows:

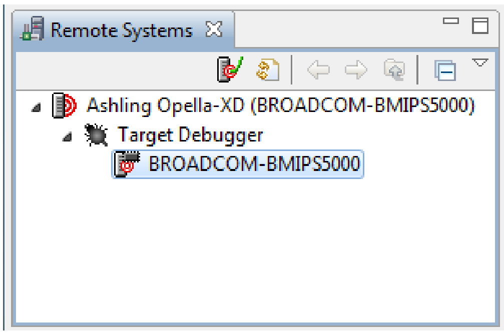


Figure 60. Remote Systems Window showing target connection

4. We can now download a program to the target by right-clicking over **BMIPS5000** and selecting **Download and Launch** as follows:

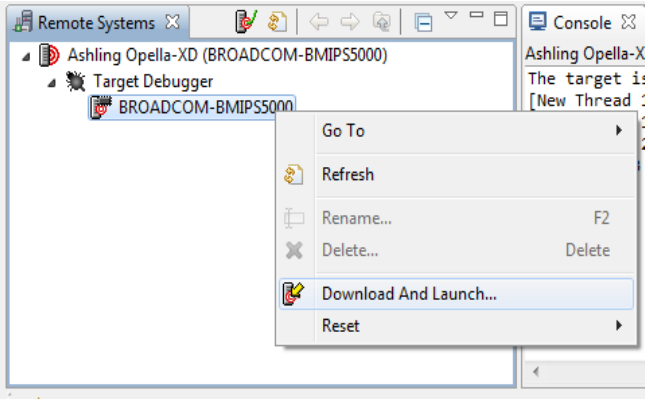


Figure 61. Download and launch

6.3.1.1 Loading kernel symbol information to PathFinder-XD

First, enable Linux debugging via the **Enable OS debugging** check box (this ensures that PathFinder-XD will add the **Linux** specific menu allowing you to perform Module and Process debugging). In this example, our Linux kernel binary image and root file system are loaded via tftp to the Connect 20 board; hence, we only need to select **Symbols only** (for the kernel image) into PathFinder-XD to allow symbolic kernel debug.

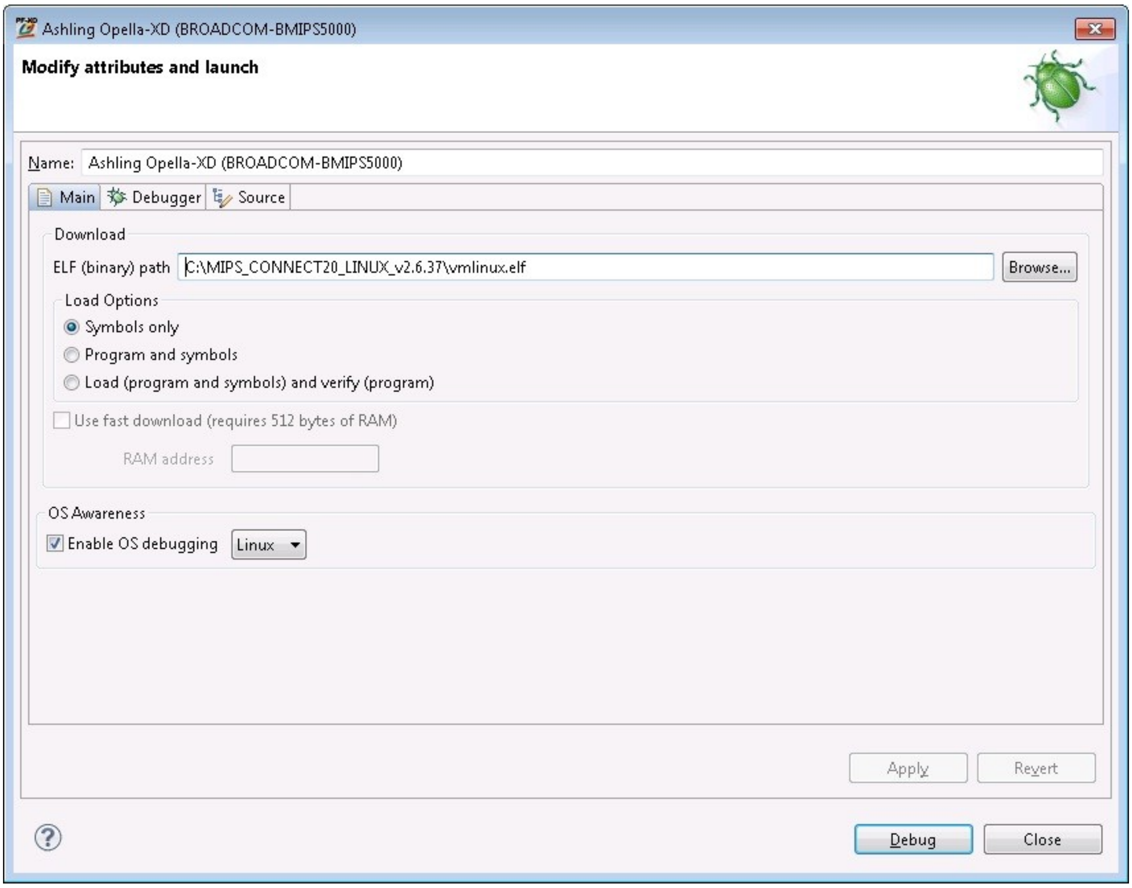


Figure 62. Loading the kernel symbols

Select the **Debugger** tab and make sure that `mips-linux-gnu-gdb.exe` is specified as the **GDB debugger**

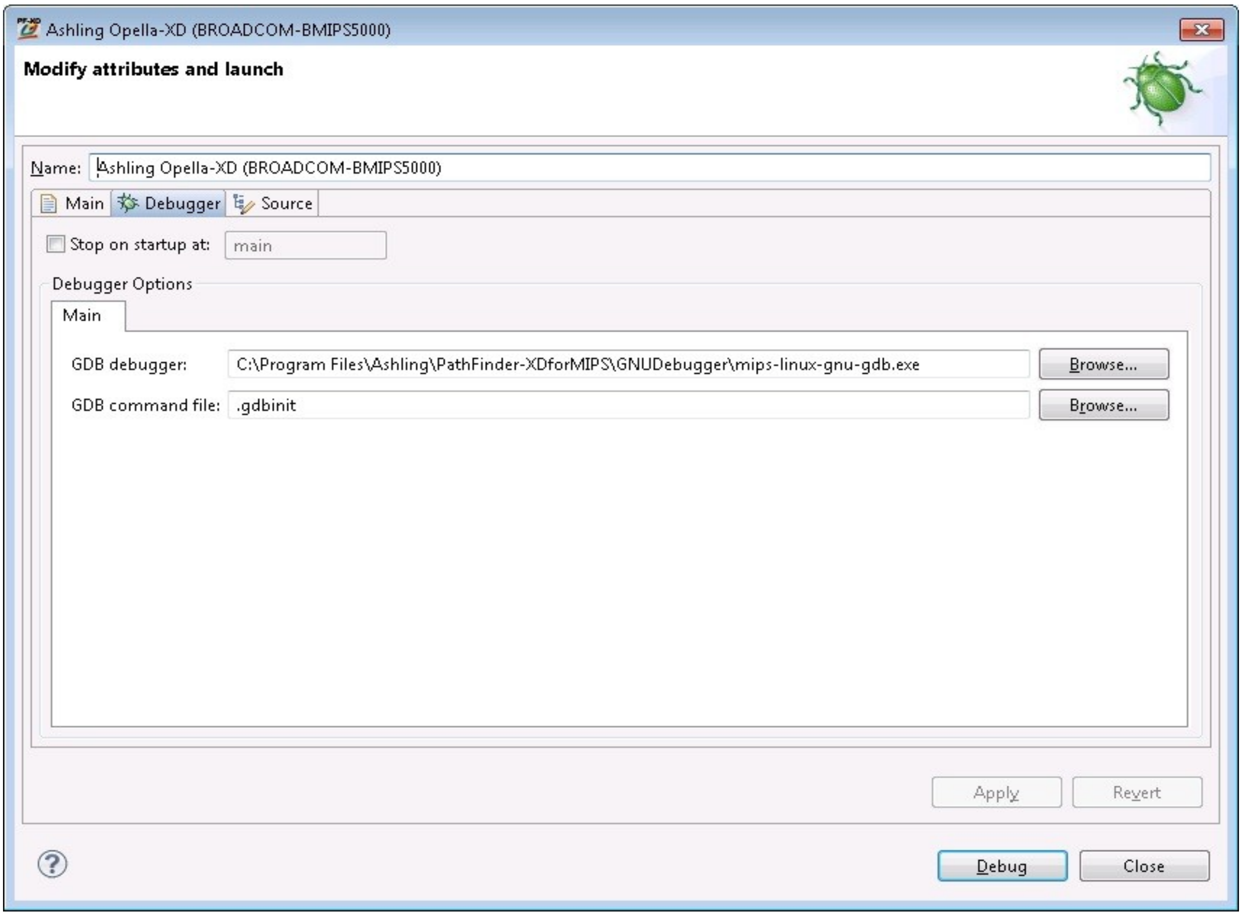


Figure 63. Specifying the correct GDB debugger

Select **Debug** and then execute the target (Run). The kernel will boot and show status in your terminal window.

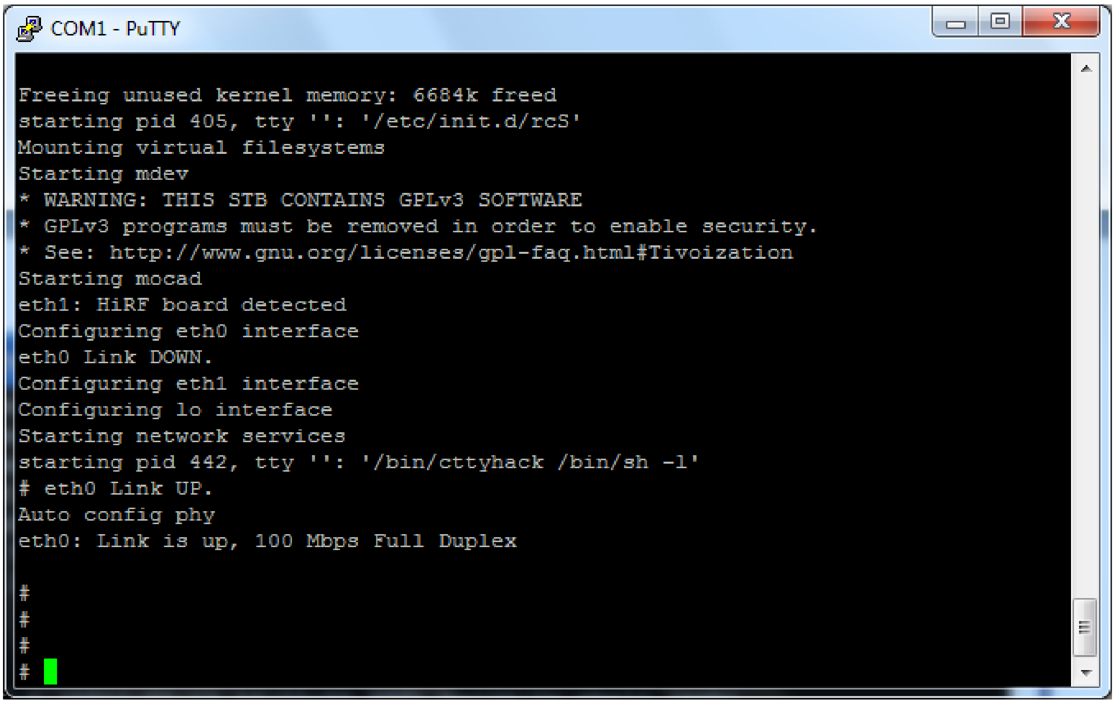


Figure 64. Connect 20 Linux shell

Once the kernel is booted, we can halt it within PathFinder-XD by pressing Stop/Halt. PathFinder-XD then updates as follows:

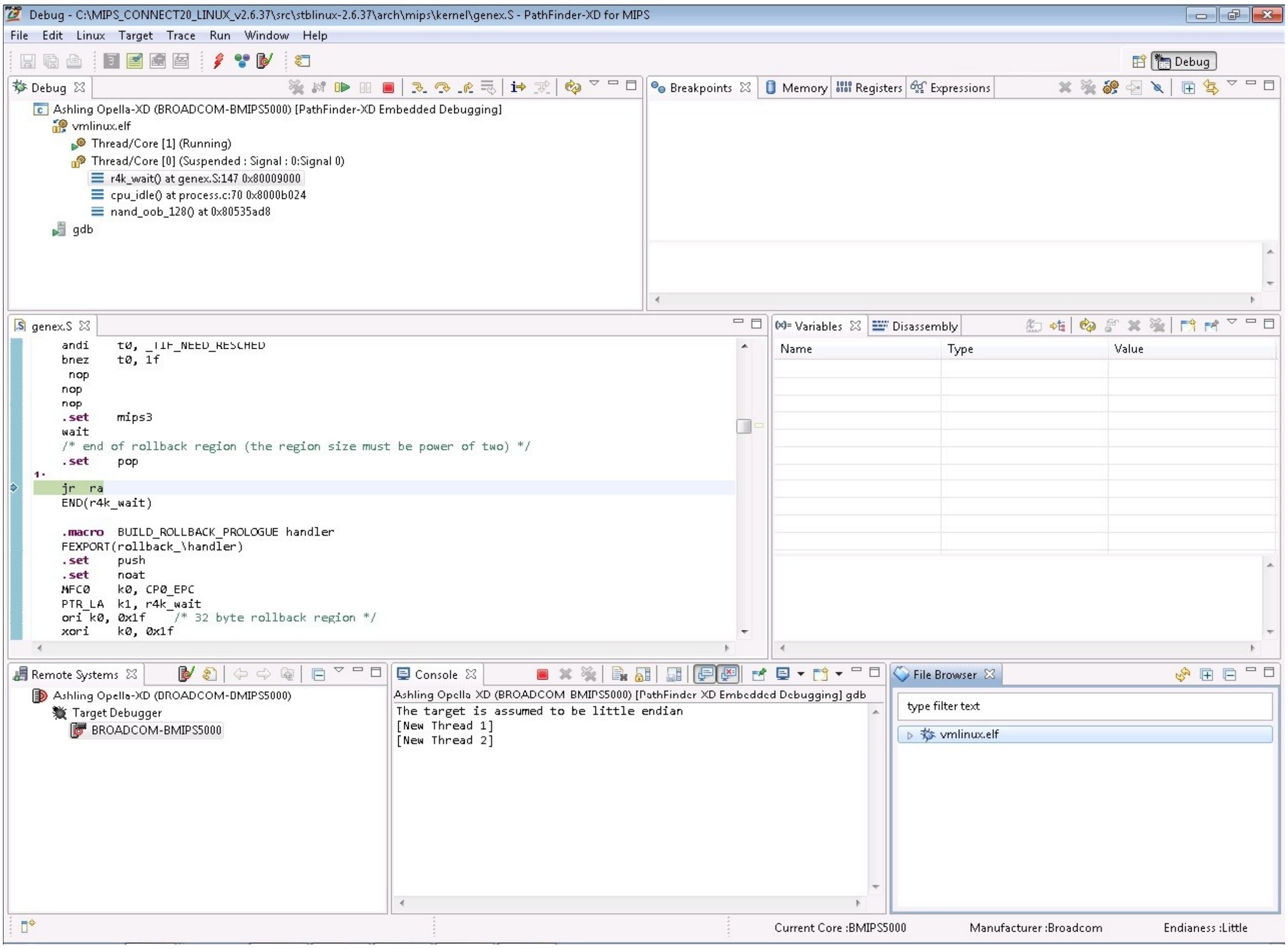


Figure 65. PathFinder-XD after halting the kernel

Notice the following windows:

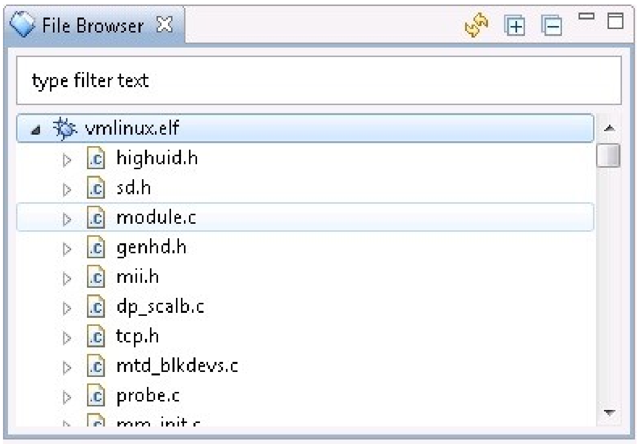
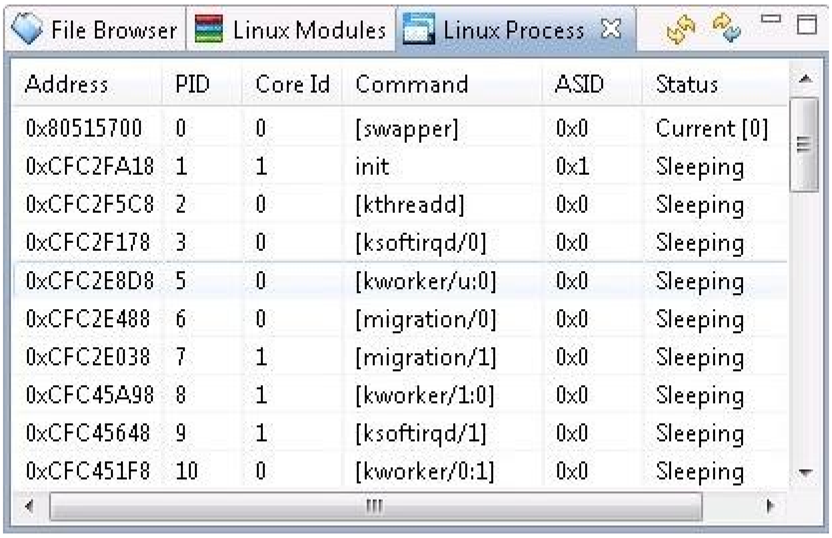


Figure 66. File Browser window showing all kernel source-files



Address	PID	Core Id	Command	ASID	Status
0x80515700	0	0	[swapper]	0x0	Current [0]
0xCFC2FA18	1	1	init	0x1	Sleeping
0xCFC2F5C8	2	0	[kthreadd]	0x0	Sleeping
0xCFC2F178	3	0	[ksoftirqd/0]	0x0	Sleeping
0xCFC2E8D8	5	0	[kworker/u:0]	0x0	Sleeping
0xCFC2E488	6	0	[migration/0]	0x0	Sleeping
0xCFC2E038	7	1	[migration/1]	0x0	Sleeping
0xCFC45A98	8	1	[kworker/1:0]	0x0	Sleeping
0xCFC45648	9	1	[ksoftirqd/1]	0x0	Sleeping
0xCFC451F8	10	0	[kworker/0:1]	0x0	Sleeping

Figure 67. Linux Process window showing all processes (enabled via Linux menu)

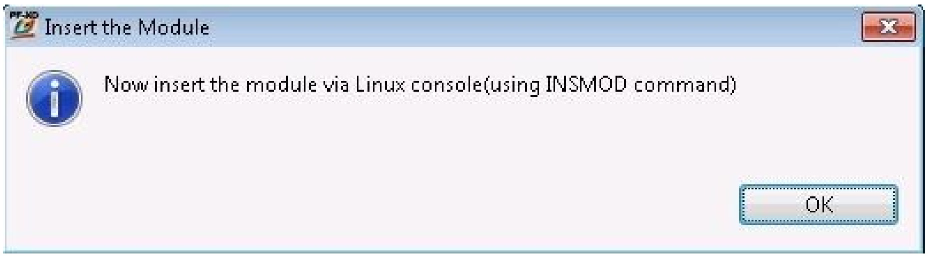
Full kernel source-level debug is now possible.

6.3.1.2 Debug a module from `init_module()`

Use the **Linux|Modules|Debug A Module From Initialisation** menu to debug a module from its `init_module()` entry point as follows:

Figure 68. Specifying the module to debug

Once specified, you now need to insert the module via the console as follows:




```
# insmod chardev.ko
chardev: module license 'unspecified' taints kernel.
Disabling lock debugging due to kernel taint
```

Figure 69. Inserting (running) the module

PathFinder-XD then halts the module at `init_module()` allowing module debug as shown below:

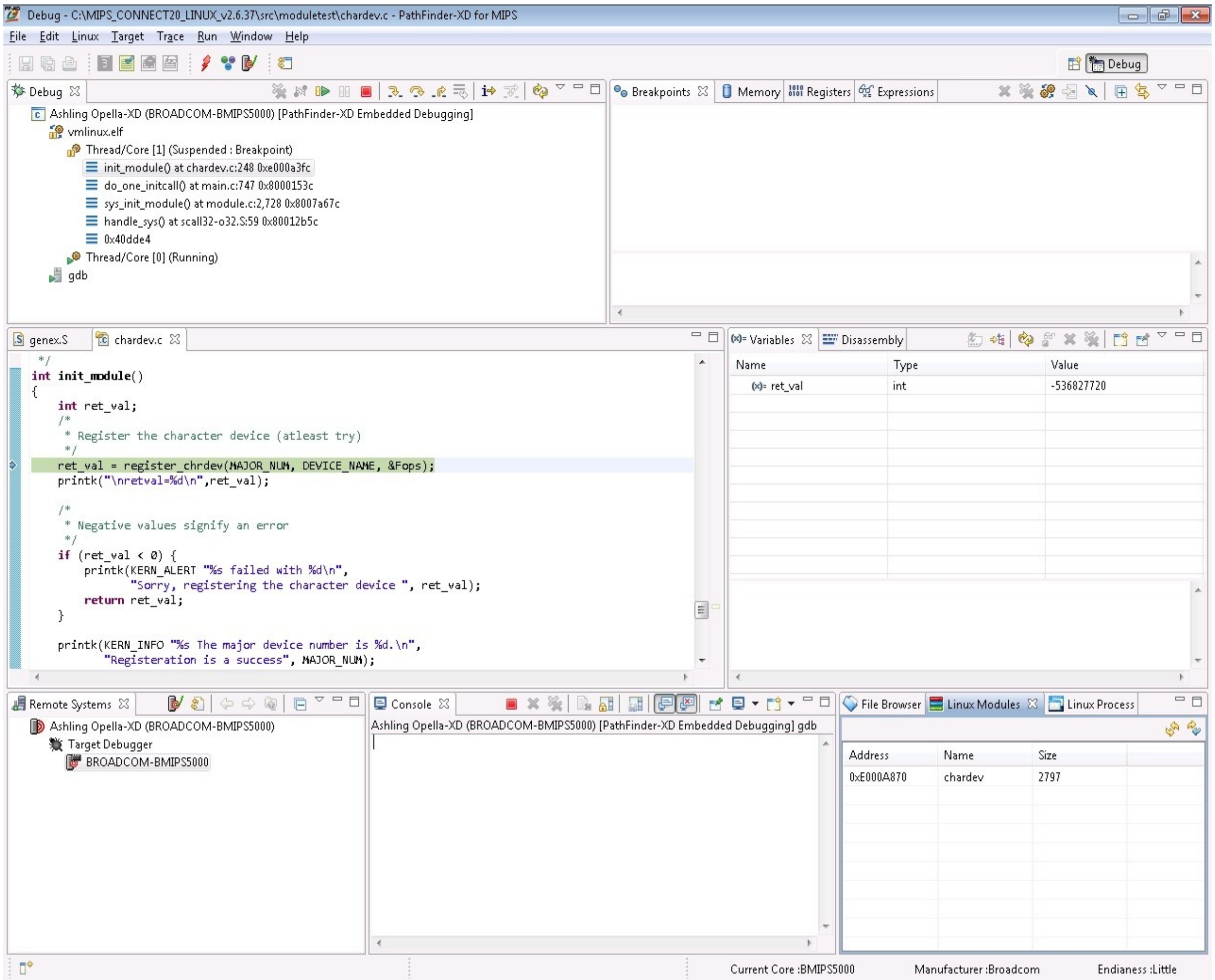


Figure 70. PathFinder-XD halted at `init_module()` ***allowing module debug***

PathFinder-XD's **File Browser** view will also update to show the source files associated with the module:

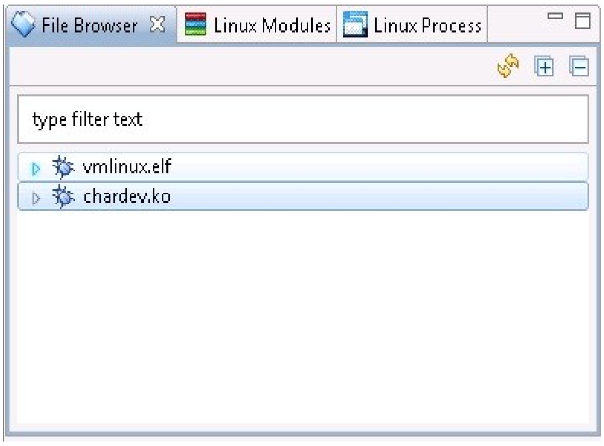


Figure 71. File Browser window showing modules sources

And the **Linux Modules** window will now list the new module:

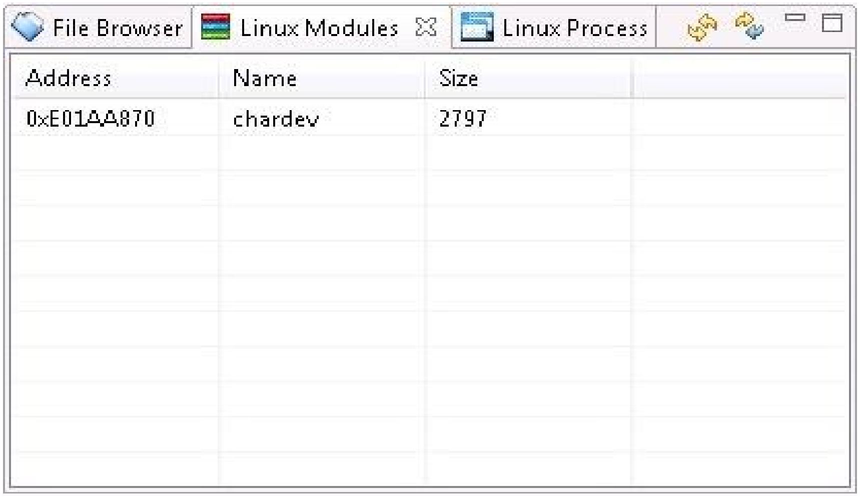
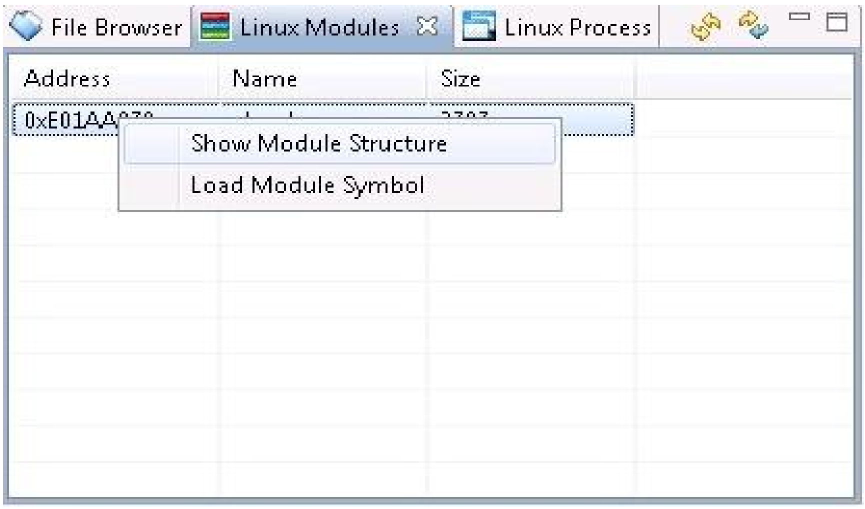


Figure 72. Linux Modules window listing the new module

You can also view the internal module kernel structures via the right-mouse button menu as follows:



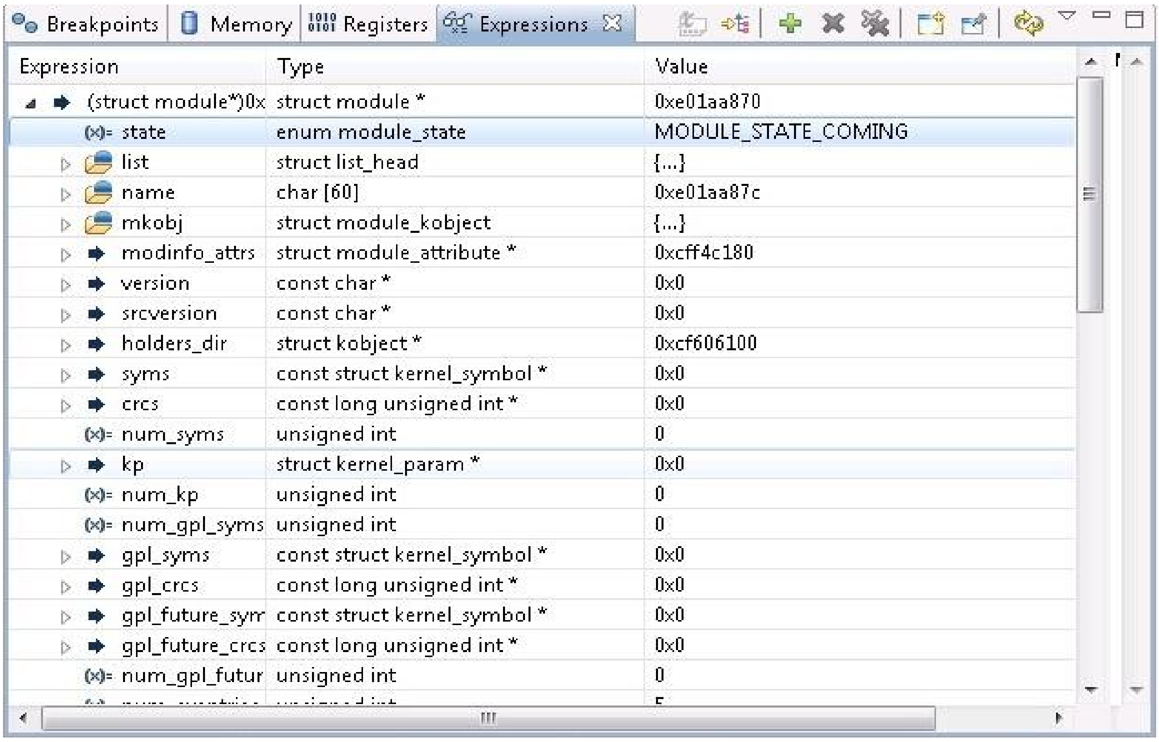


Figure 73. Viewing the internal kernel module structures

In addition, you can load module symbols for a module that is already loaded, using the **Load Module Symbol** option in the right-mouse button menu.

6.3.1.3 Debugging a process from main()

Use the **Linux|Processes|Debug A Process From `main()`** to debug a process from its entry point as follows:

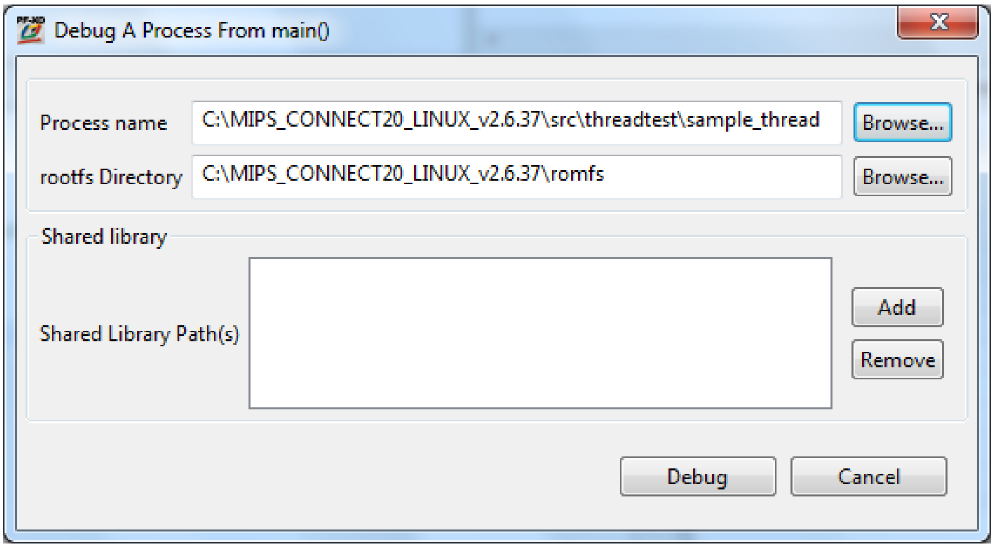


Figure 74. Debugging a process from `main()`

rootfs Directory specifies where the root file-system (`rootfs`) resides in your host machine. This location is needed for loading shared library symbols in PathFinder-XD. Once specified, you need to run the process from the console as follows:

Press **OK** and PathFinder will run Linux allowing you to execute the process as follows:

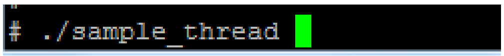


Figure 75. Running the process

PathFinder-XD then halts the process at `main()` function as shown below:

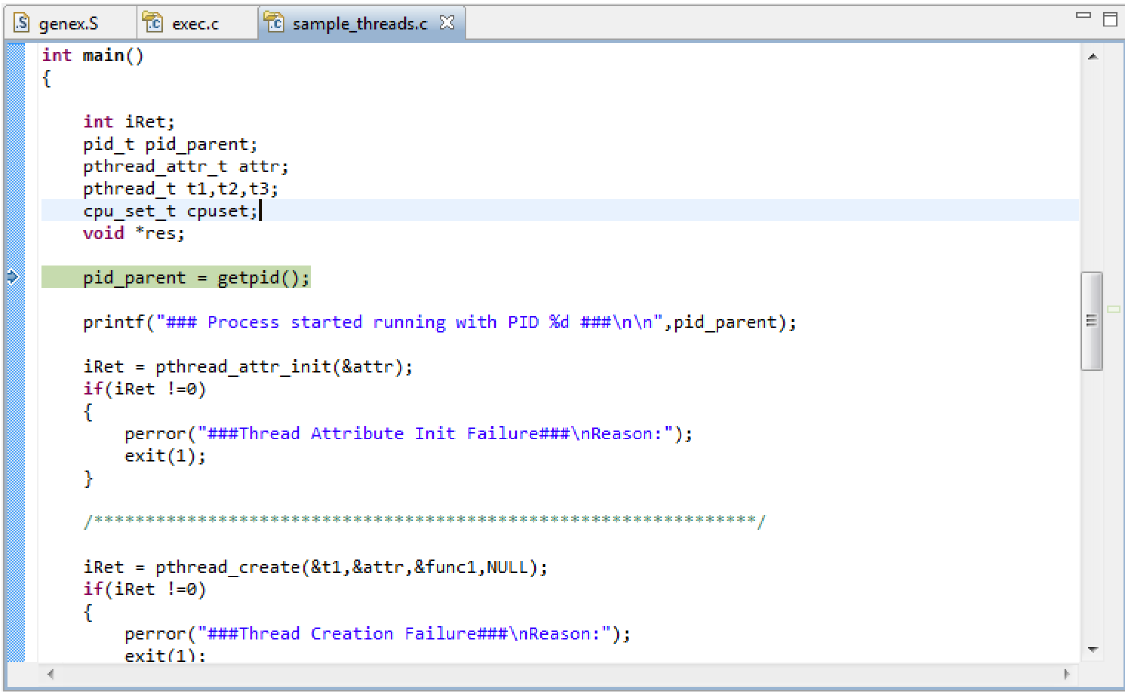


Figure 76. PathFinder-XD halted at the process's `main()` function

The **File Browser** window will update to show the process' source code. Note: To exit the application, press `Ctrl+C` from the Linux console.

6.3.1.4 Debugging a running process

You can load the symbols for a running process via the Linux Process window. Right-click on the process and select **Load Process Symbol**:

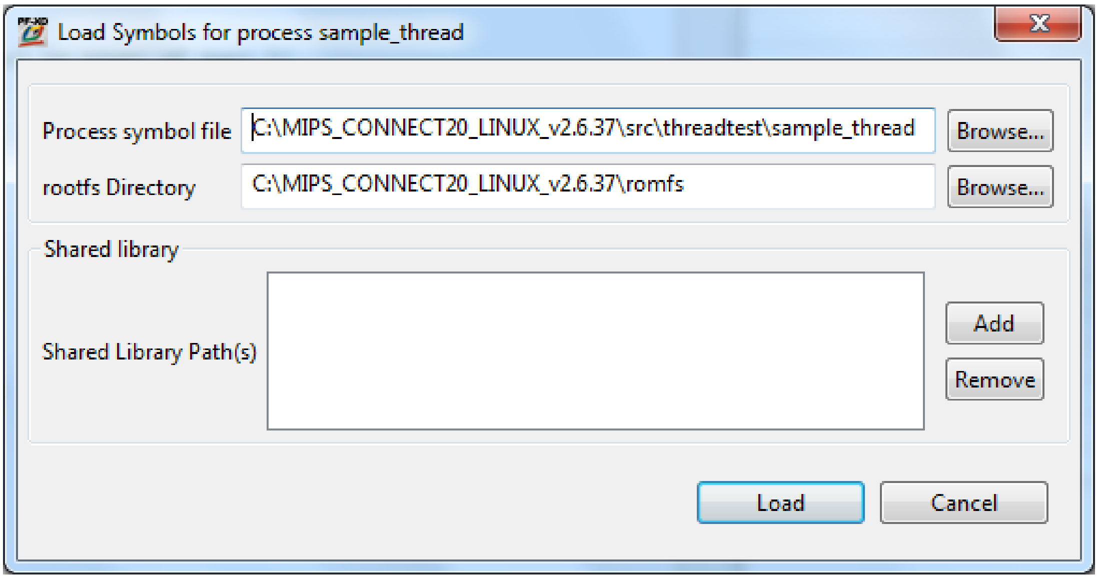


Figure 77. Loading a process's symbols

It is recommended that you use hardware breakpoints when debugging a running process (i.e. do not use software breakpoints as the process may not be paged in at this point). Once the hardware breakpoint has been taken, the process is in memory, hence, you can use software breakpoints.

6.3.1.5 Library debugging

Debugging of libraries is handled seamlessly without any extra requirements/setup.

6.4 Run-mode Debugging

Run-mode debugging is done via a target Serial/Ethernet interface and requires an application (GDB server) running on the target. In run-mode, the kernel continues to run when a process (application) breakpoint is taken. Run-mode debugging requires that the kernel is up and running, and allows non-intrusive debug of process (i.e. the kernel will continue to run even when a process is halted).

6.4.1 Sample Run-mode Linux Debugging Session

This section demonstrates Linux Process Debugging using PathFinder-XD and Opella-XD connected to a Connect 20 target running v2.6.37 Linux Kernel. The example will demonstrate debugging of a Process and a Module (that contains functions called from the Process). Kernel/Module level debugging is done via the Opella-XD; Process debugging is done via an Ethernet connection to the target.

As before, we have to prepare our kernel for debug, download it to the target, execute it and load the kernel symbols into PathFinder-XD. See previous sections. Once these steps are complete, we are ready to begin debugging our Module and Process as follows:

6.4.2 Copying the necessary files to the target

Ashling provides a precompiled version of the GNU `gdbserver` (v7.2 or later) to support run-mode debugging. By default, this is included in the root file-system provided by Ashling for debugging the Connect 20 board; hence, no copying is necessary.

When debugging your own target, note that the `gdbserver` application is installed with PathFinder-XD in `PathFinder-XDforMIPS\target\linux\gdbserver` and versions are supplied for big/little endian and `libc/uclibc` target libraries.

6.4.3 Debugging the Module and Process

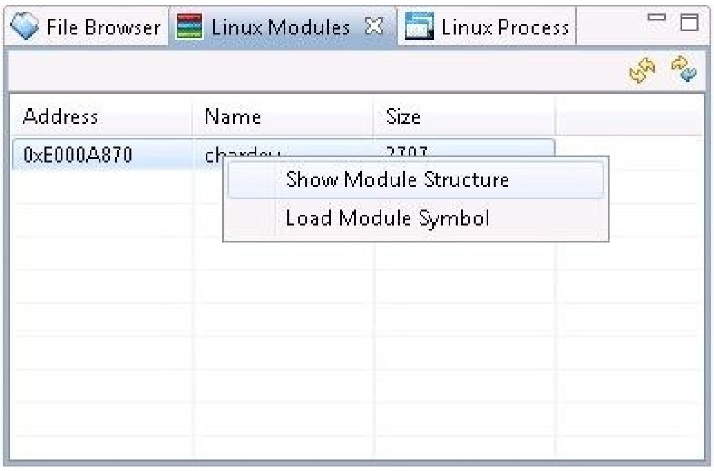
1. First, load the Module (using `insmod`) from our Linux shell as follows:

```
# insmod chardev.ko
chardev: module license 'unspecified' taints kernel.
Disabling lock debugging due to kernel taint
```

Figure 78. Loading the Module to be debugged

Note: Do not attempt to load a module twice, as debugging will not work correctly (use `rmmod chardev.ko` if you need to remove or unload the module)

2. Now, halt the kernel in PathFinder-XD and load the Module symbols from within the PathFinder-XD **Linux Modules** window:



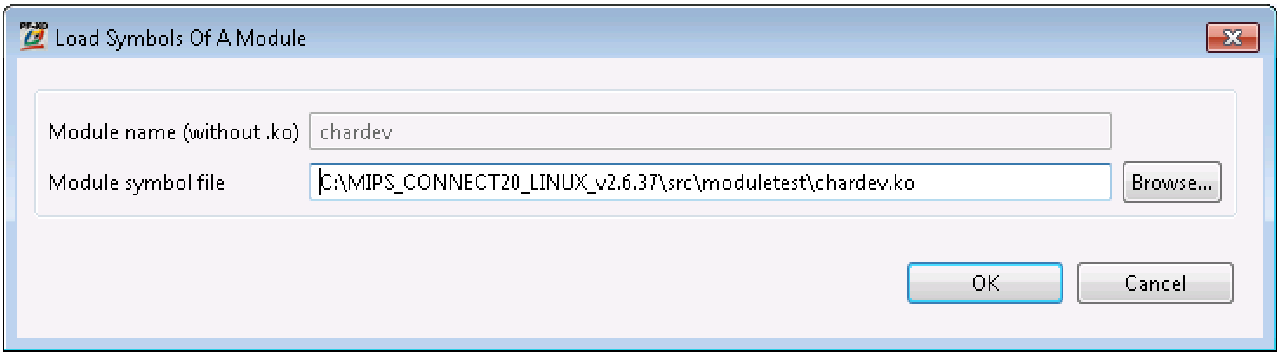


Figure 79. Loading the Module symbols

3. Notice how the **File Browser** now shows the Module and Kernel symbols:

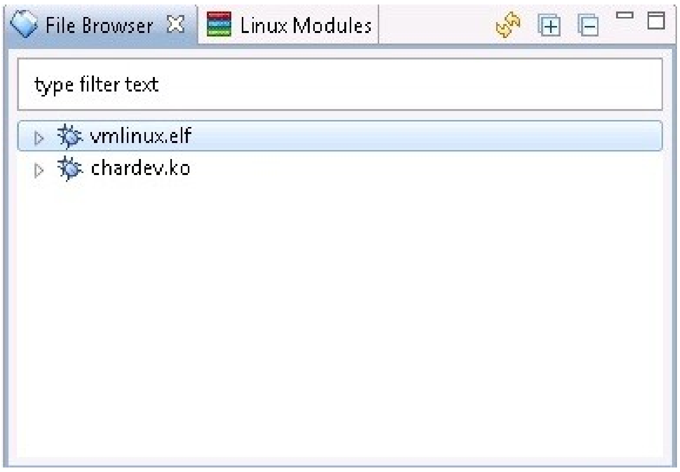


Figure 80. File Browser showing Kernel and Module symbols

We can double-click on the Module to list the files and double-click on a source-file to show it in the Source Window. In the below example, we have opened the Module source-file `chardev.c` and set a breakpoint at the function `device_read` that we wish to debug (i.e. when this function is called from the Process).

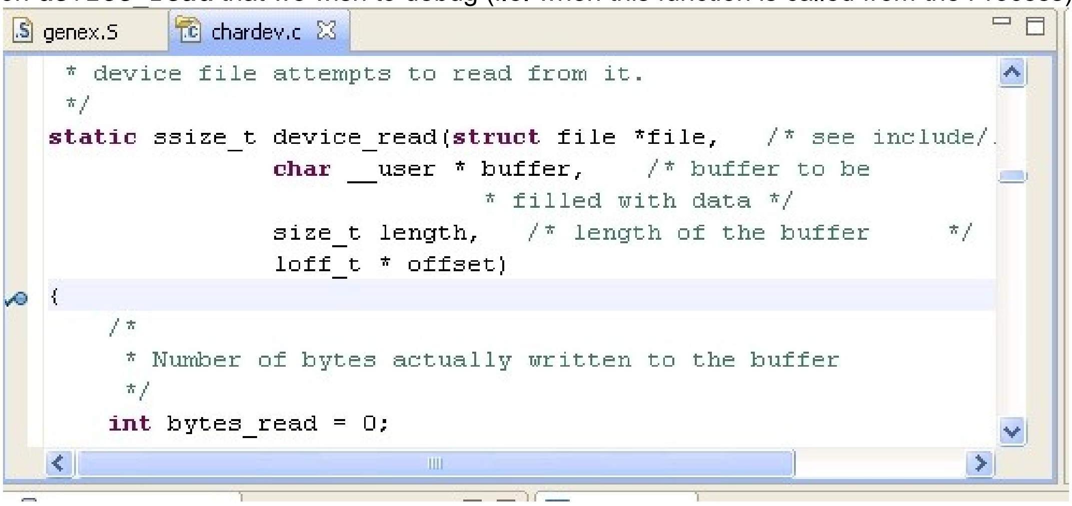


Figure 81. Setting a Breakpoint in the Module

4. Next, run the kernel in PathFinder-XD

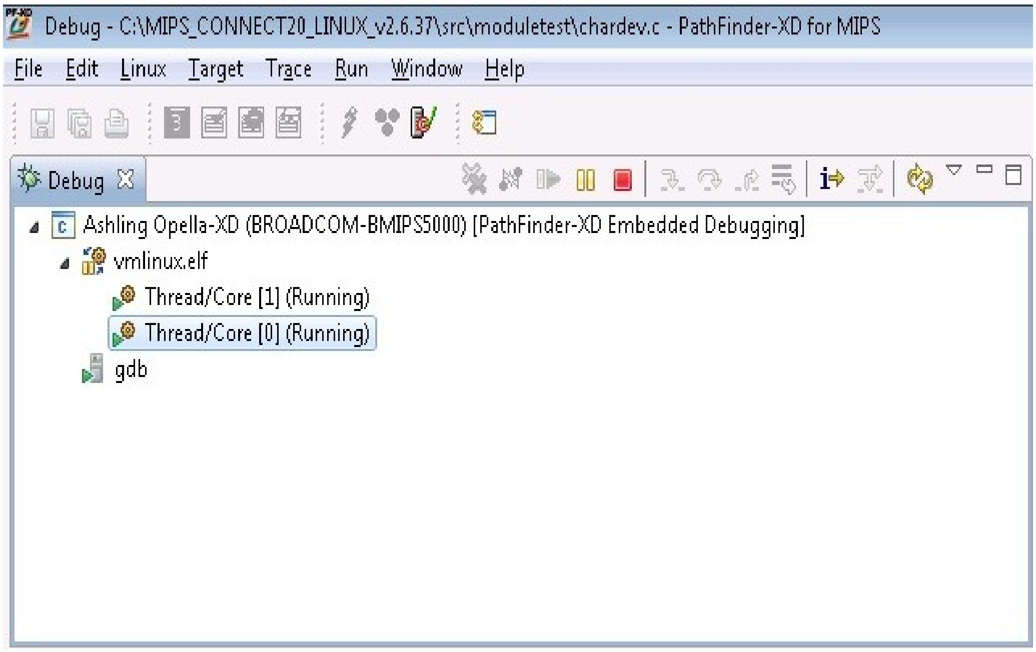


Figure 82. Running the Kernel

and launch gdbserver on the target (i.e. in the Linux shell) specifying the Process we wish to debug (`ashtestapp`). Notice how we tell `./gdbserver` which port to listen on (1234)

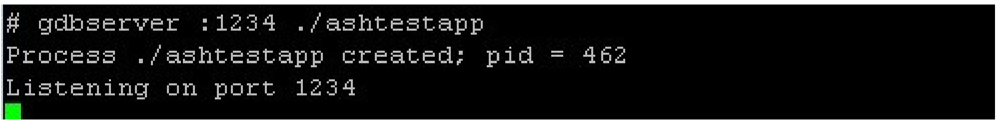


Figure 83. Launching the Process

5. Next, **Debug A Process in Run-mode** using PathFinder-XD (the kernel is now running) as follows:

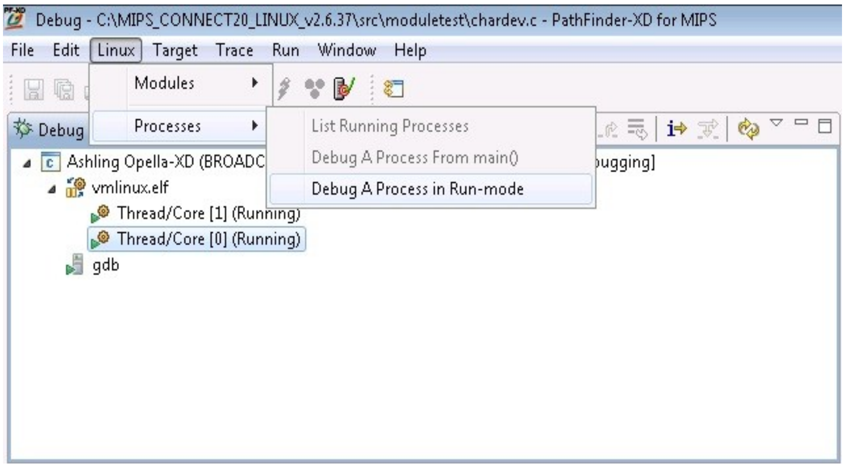


Figure 84. Debugging a Process in Run-mode

We need to specify

a. the Process:

Figure 84. Specifying the Process

b. the location of the shared libraries:

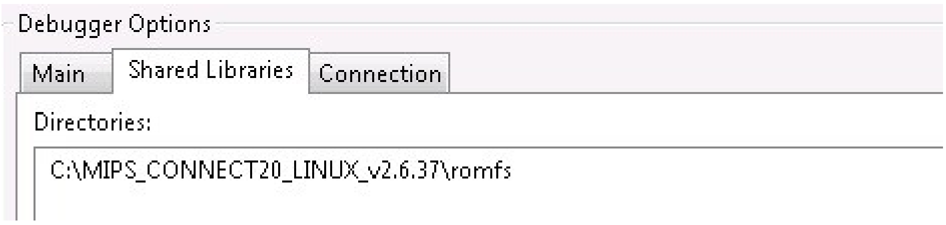


Figure 85. Specifying the Share Library location

c. and finally, the connection mechanism (TCP in our example) and IP address of the target system (i.e. the Connect 20 at 192.168.1.1 which is running gdbserver on port 1234):

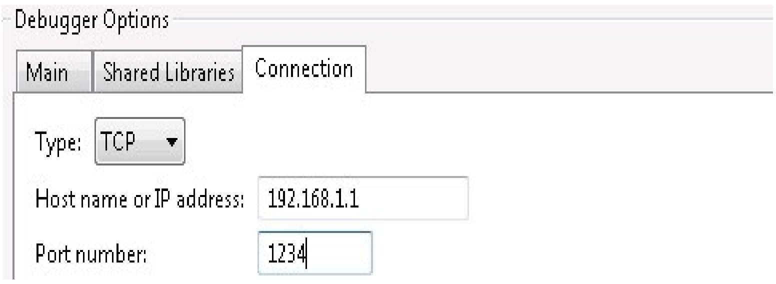


Figure 86. Specifying the Connection mechanism

Make sure that `mips-linux-gnu-gdb.exe` is specified as the **GDB debugger** (default) and press **Debug** to start debugging the Process.

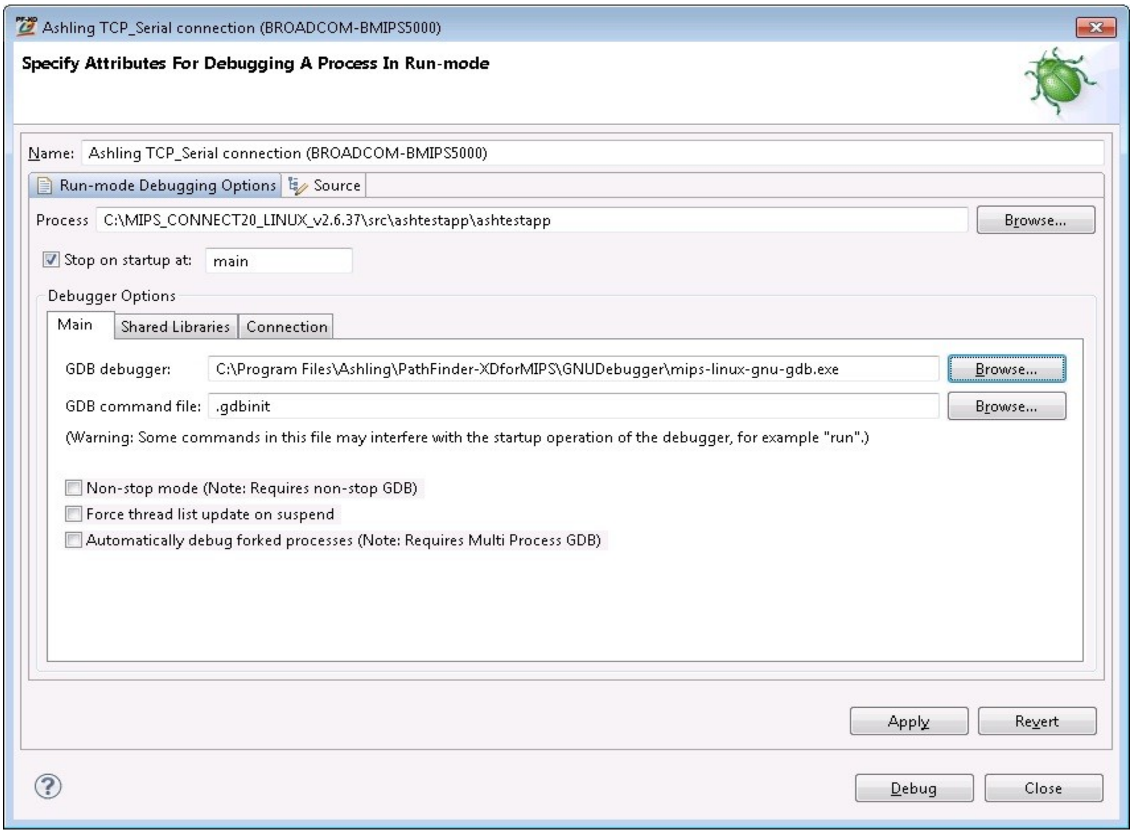


Figure 87. Debugging a Process in Run-mode dialog

6. PathFinder-XD will now update as follows:

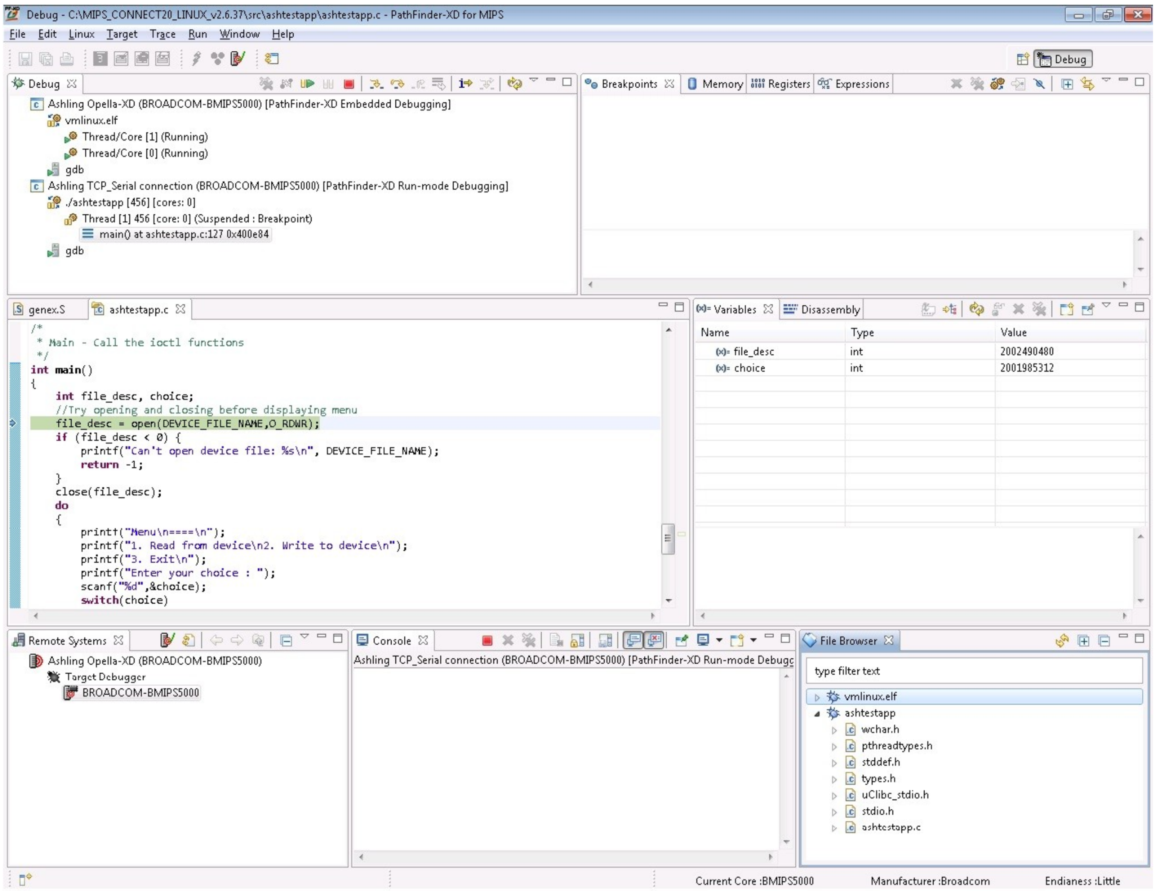


Figure 88. PathFinder-XD in Run-mode

Notice how:

- The **Debug** window shows both the Kernel (Embedded Debugging) and Process (Run-mode Debugging) status:

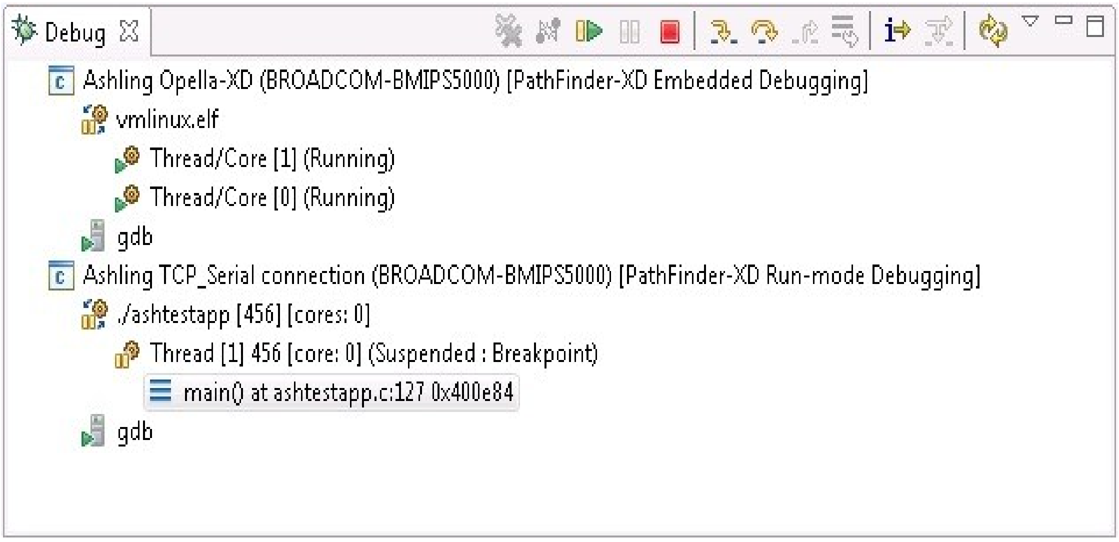


Figure 89. PathFinder-XD Debug Window showing Kernel and Process (Kernel Run-mode) status

- The **File Browser** shows the Module, Process and Kernel sources:

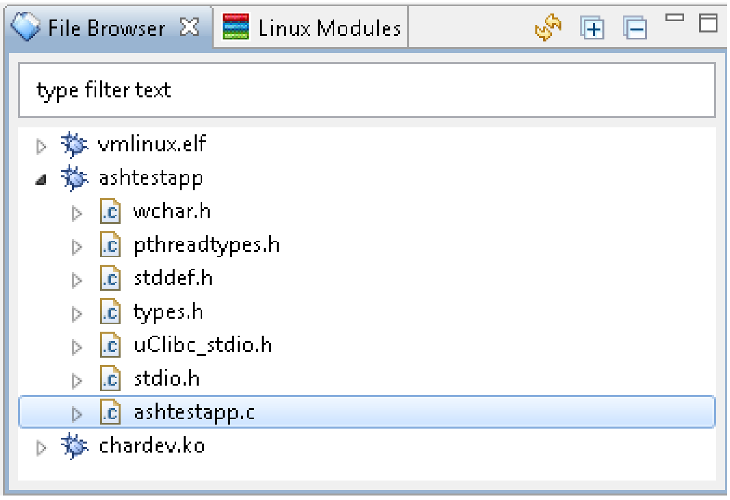


Figure 90. PathFinder-XD File Browser showing Module, Process and Kernel sources

- The **Source** window shows the source code for our **Process** from `main()`

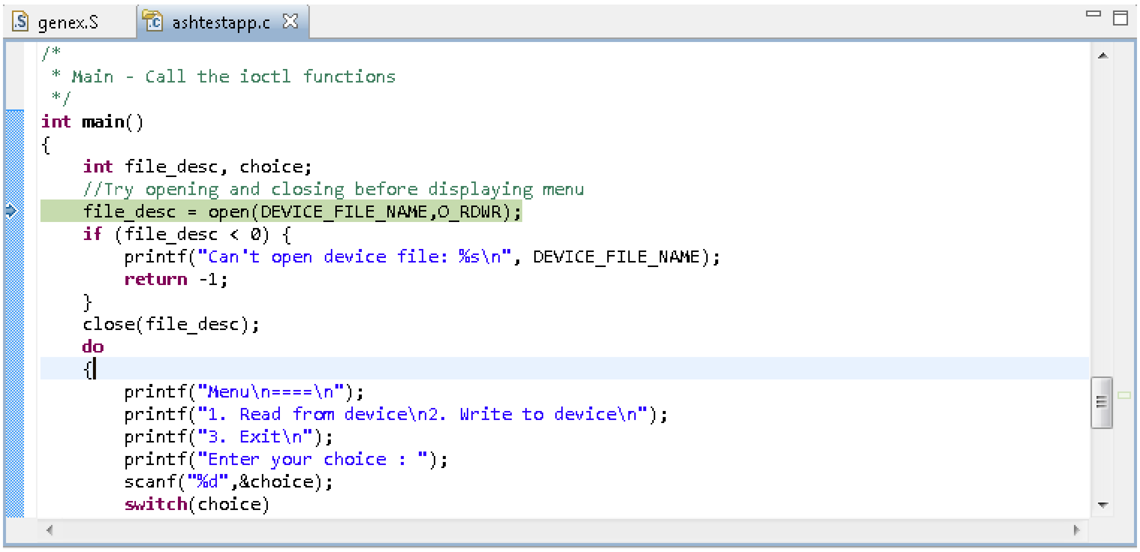


Figure 91. Process Source

We can now debug our Process as normal with the Kernel running in the background.

When our Process calls functions located in the Module which have a breakpoint set, then the Module/Kernel will halt and PathFinder-XD's Debug window will update as follows:

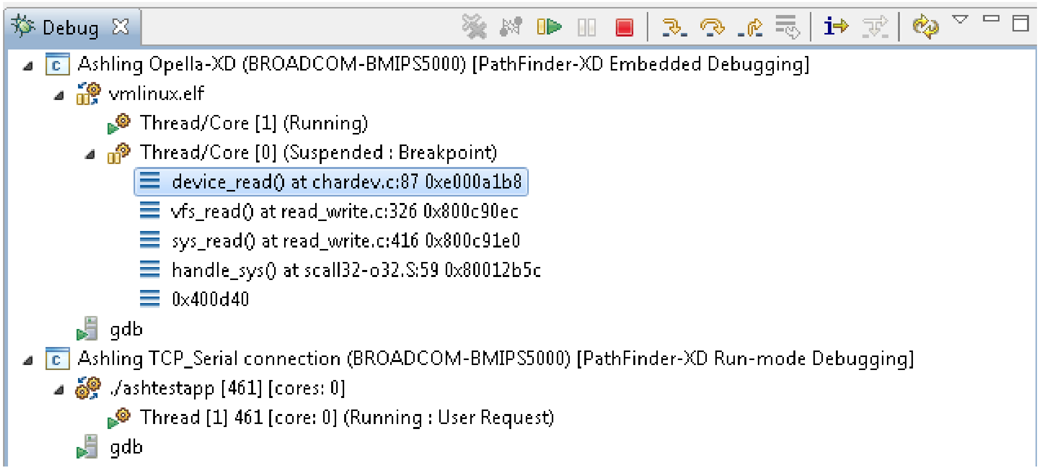


Figure 92. PathFinder-XD Debug Window showing the Kernel halted

Notice how the Kernel is now shown as halted (i.e. PathFinder-XD has automatically switched from run-mode to stop-mode as the kernel is halted due to the breakpoint in the Module). This demonstrates how PathFinder-XD easily switches between stop-mode and run-mode within the same debug session.

6.5 Application specific hardware breakpoint

This section demonstrates how to setup application specific hardware breakpoints in PathFinder-XD for MIPS. For example, this feature allows you to set a breakpoint in a module that is only taken when that module is called by a specific application. Each application has a unique ASID (Application Specific ID) which is used to qualify breakpoints.
Our example will use the `chardev` module and the `ashtestapp` application. The `write_device` function of module can be accessed via `ashtestapp` or using the `echo` command. In this example, we will put an application specific BP in `write_device` and illustrate that this breakpoint is not taken when this function is accessed via `echo` command.

1. First, load the Module (using `insmod`) via Linux shell as follows:

```
# insmod chardev.ko
chardev: module license 'unspecified' taints kernel.
Disabling lock debugging due to kernel taint
```

Figure 93. Loading the Module to be debugged

Note: Do not attempt to load a module twice, as debugging will not work correctly (use `rmmod chardev.ko` if you need to remove or unload the module)

2. Halt the kernel in PathFinder-XD and load the Module symbols via PathFinder-XD **Linux Modules** view:

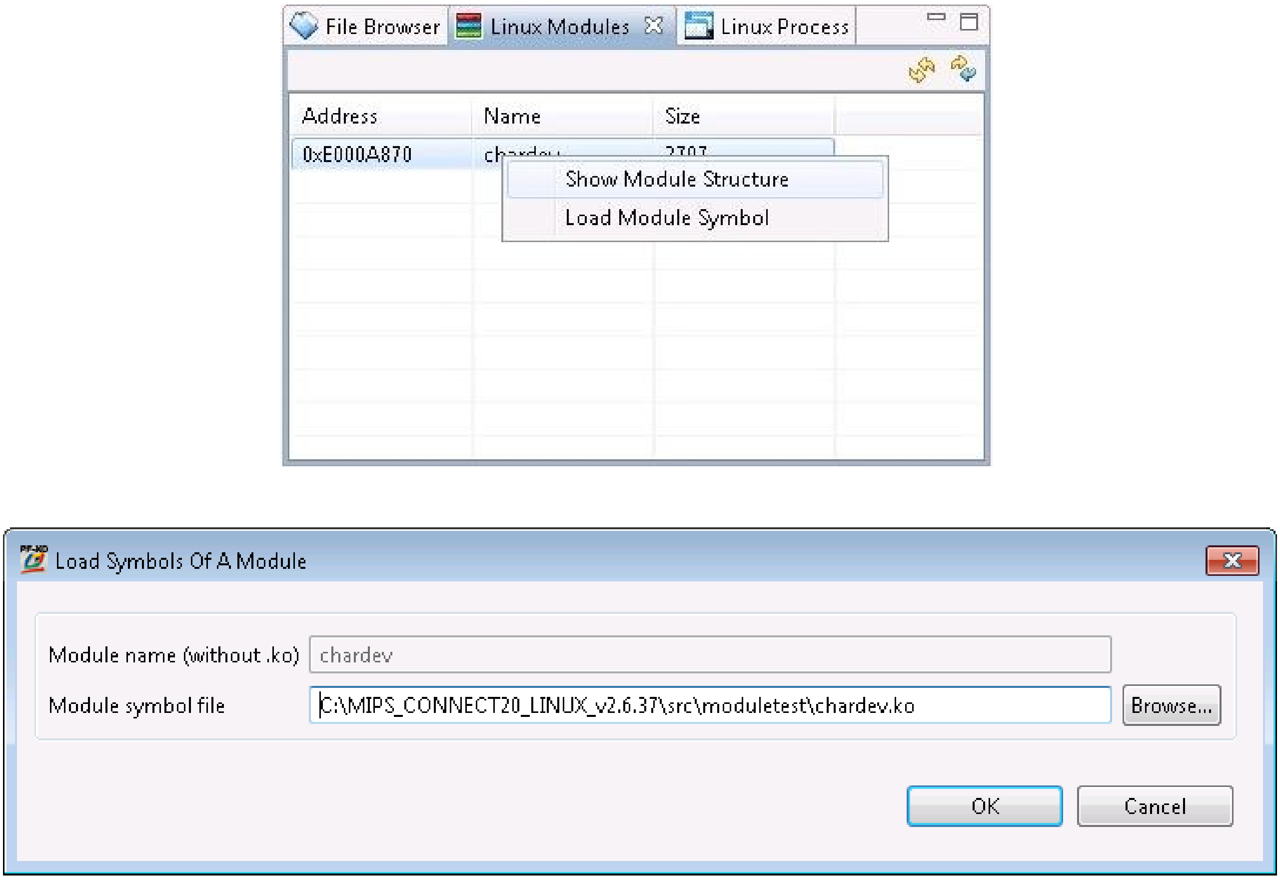


Figure 94. Loading the Module symbols

3. Resume the target and start the test application (`ashtestapp`) that uses module

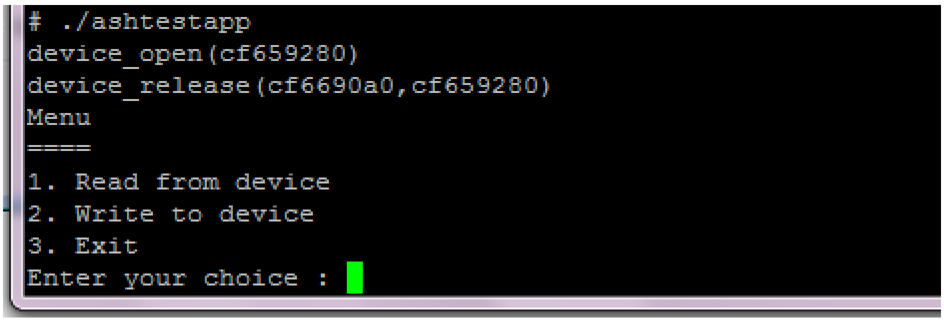


Figure 95. Executing application

4. Halt the kernel in PathFinder-XD, and note down the ASID of `ashtestapp` using process list

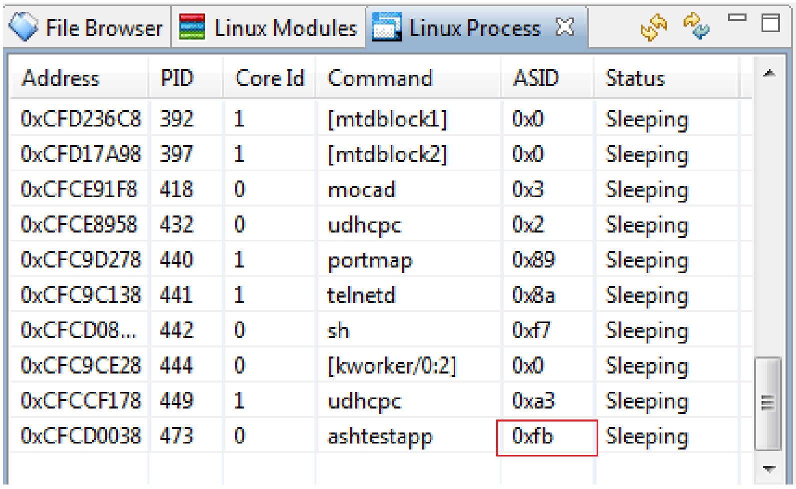


Figure 96. Note ASID of the process

5. Set a hardware Instruction breakpoint in `device_write` function with the process ASID specified

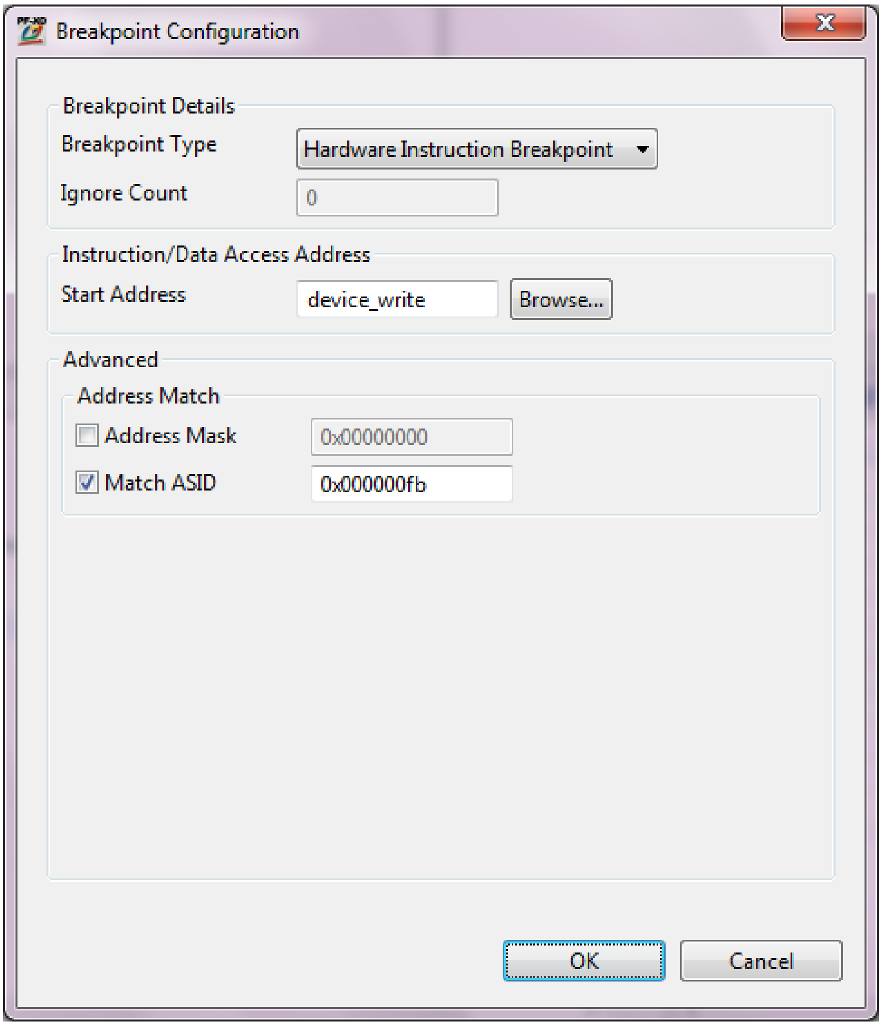


Figure 97. Set hardware breakpoint

6. Resume the target and choose option 2 from application and notice that the breakpoint is taken

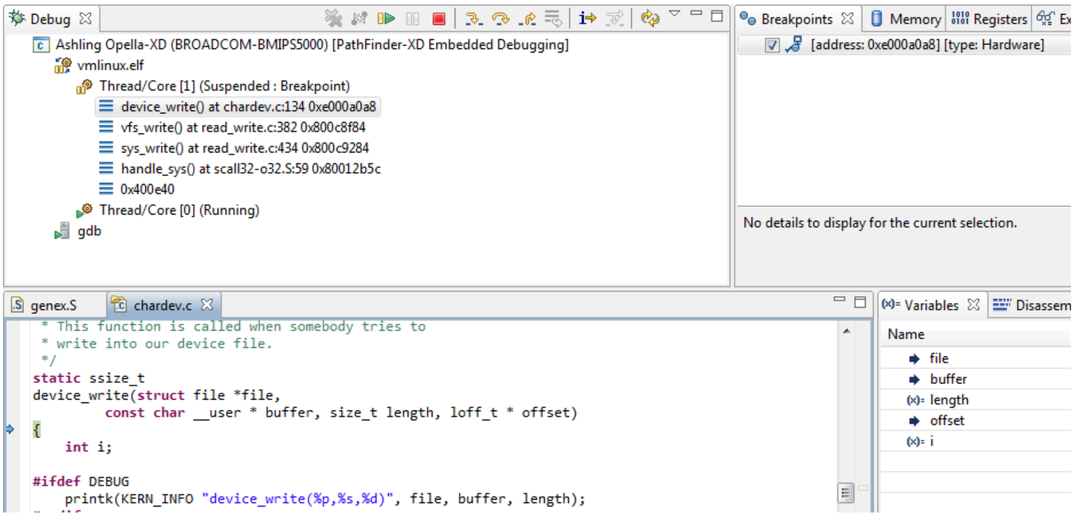


Figure 98. Breakpoint is taken by device_write

7. Now, resume the target and put the application to the background by pressing `Ctrl+Z`

8. Try writing to the device using the `echo` command and notice that the breakpoint is not taken.

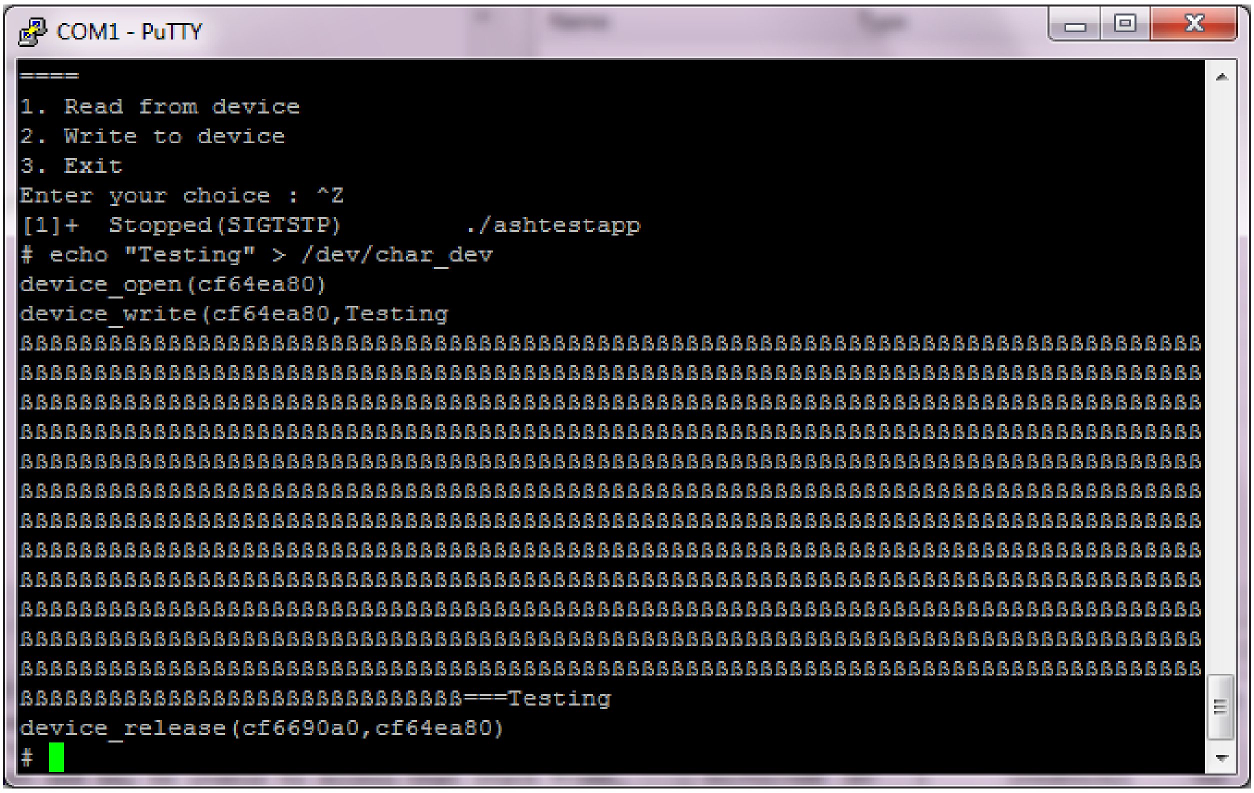


Figure 99. Executing application

9. Restore the application to the foreground using the `fg` command

10. Choose option 2 from application and note that the breakpoint is again taken.

6.6 Known Issues in SMP Linux Debugging

1. SMP Linux kernel stepping will not work when common code (e.g. a module or a driver) is simultaneously accessed by both threads/cores. This will result in an “Error 45: Command not allowed...” message which will be displayed in the GDB console view in PathFinder-XD. If this is an issue then select all-stop mode in the **Target Configuration** dialog (i.e. uncheck **Enable non-stop mode**) as shown below:

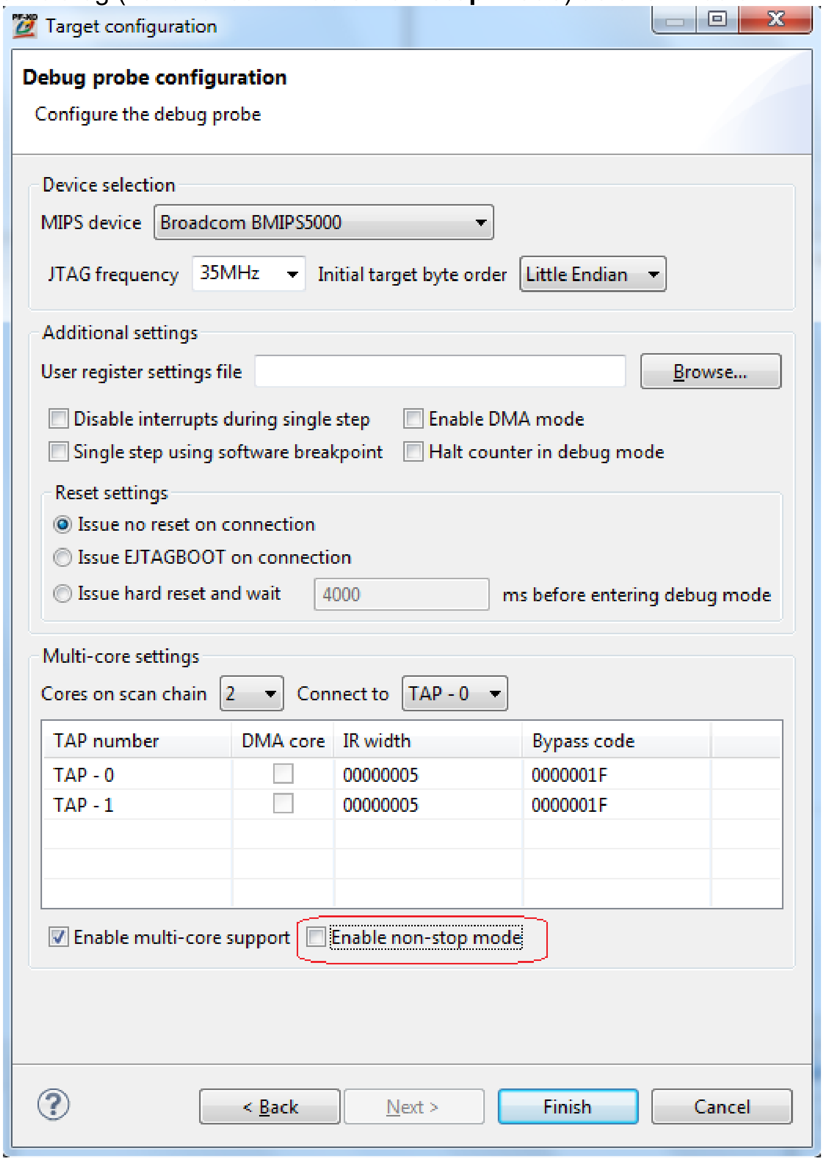


Figure 100. All-stop mode configuration

2. If a GDB crash occurs during SMP debugging then just re-launch the application being debugged using **Download and Launch** option; there is no need to exit and restart PathFinder-XD.

3. When multi-core debugging, the **Debug view** may sometimes not be updated automatically after stepping. Use the refresh  button in the **Debug view** to force a manual update.

7. Conclusion

This APB shows the debugging capabilities of PathFinder-XD when used in-conjunction with the advanced features of the Broadcom BMIPS5000 on-chip debug interface. Powerful features such as multi-core debug, real-time trace capture and Embedded Linux debugging are easily configured and used from within PathFinder-XD’s user-interface. These features allow real-time, non-intrusive debug and analysis of your Broadcom based embedded application thus helping you to achieve on-time delivery to market. We hope you like it! Please send your feedback to hugh.okeeffe@nestgroup.net

Doc: APB213-PF-XD_MIPS_BRCM.DOC, Hugh O’Keeffe, Ashling Microsystems