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Using VxWorks 7 BSP with the Zynq-7000 AP SoC

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Summary

VxWorks® is a multicore-capable Real-Time Operating System (RTOS), commonly used in fully featured embedded subsystems where a commercial runtime software and tool chain solution is required. Supporting a variety of CPU architectures, most notably the ARM Cortex™-A9 MPCore as available in the All Programmable Zynq®-7000 SoC platform. This application note focusses on using the all new (circa 2014) VxWorks 7 offering on this platform, for guidance on using the maturing VxWorks 6.9 release refer to XAPP1158 [Ref 1].

Introduction

This application note comprises the following major sections:

- VxWorks Project Types
- Source Build Project – Creation, Configuration and Build
- Kernel Image Project – Creation, Configuration and Build
- Target Bring-Up – Local and Network Boot
- Software Application (Generic) – Creation, Development and Debug
- Software Application (Peripheral Access) – Creation, Development and Debug (ZC702 Only)
- Appendix A: Development Environment Installation
- Appendix B: Customizing uBoot for the Avnet Mini-ITX Development Kit

Hardware and Software Requirements

Hardware Requirements (Optional)

1. Xilinx ZC702 Development Kit (XC7Z020-1CLG484)
2. Avnet Mini-ITX Development Kit (XC7Z045-2FFG900)

Software Requirements

1. Wind River Workbench 4.0
   (See Appendix A: Development Environment Installation for installation instructions.)
2. TFTP server application, such as tftpd32
3. Serial communication utility, such as Tera Term

VxWorks Project Types

VxWorks Source Build (VSB)

These are the kernel libraries. VxWorks 6.9 and previous versions ship with standard prebuilt libraries, but it might be useful to change the configuration/sources of a VSB to rebuild them for a specific need.

You must build custom libraries if you want to vary from the default binaries shipped with your platform. For example, if you want to change the default settings for endianness, enable SMP support, or enable real-time process support, you must specify the appropriate options and build custom libraries. To build custom libraries, you must create, configure, and compile a VxWorks source build (VSB) project.

VxWorks Image Project (VIP)

This is the image that you build and run on the target. It contains the kernel, BSP, architecture support, and VxWorks middleware (stacks, standard programs, etc.). It might also contain a specific type of read-only file system that is linked with the image (romfs).

A VxWorks image project (VIP) is used to create a version of VxWorks using components based on the precompiled libraries provided in the VxWorks installation. A VIP can use the standard components that are delivered with binary libraries, or it can be based on a VxWorks source build (VSB) project.

Downloadable Kernel Module (DKM)

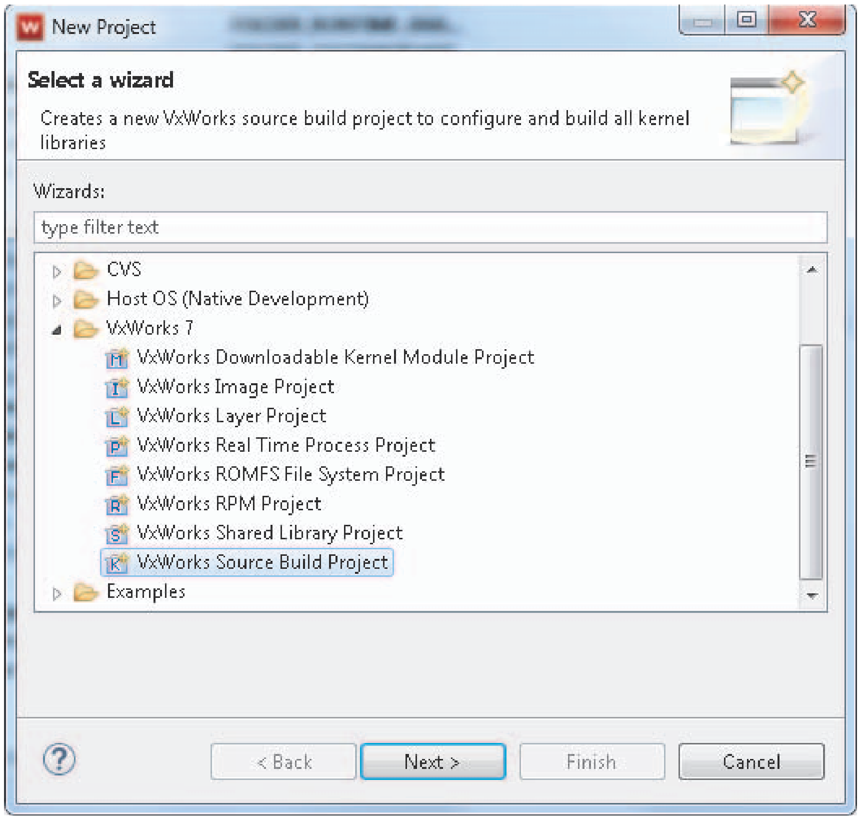
This is similar to kernel modules in Linux (binaries that you can load and unload on-the-fly to add symbols to the kernel). This can be used to dynamically load applications/drivers that run in kernel space.

You can use DKM projects to manage and build modules that exist in the kernel space. You can separately build the modules, run, and debug them on a target running VxWorks, loading, unloading, and reloading on-the-fly. Once your development work is complete, the modules can be statically linked into the kernel, or they can use a file system if one is present.

Source Build Project – Creation, Configuration and Build

This section explains how to create, configure and build a VxWorks Source Build (VSB) image from the Zynq-7000 BSP that is natively installed with the Wind River environment. Such must be created before creating a VxWorks kernel image. These steps explain how to achieve this:

1. Invoke **Wind River Workbench** and open a new or existing workspace.
2. Select **File** > **New** > **Project**. The new project wizard opens.
3. Under **VxWorks 7**, select the **VxWorks Source Build Project**, as shown in Figure 1.


New Project

Select a wizard

Creates a new VxWorks source build project to configure and build all kernel libraries

Wizards:

type filter text

- CVS
- Host OS (Native Development)
- VxWorks 7
  - VxWorks Downloadable Kernel Module Project
  - VxWorks Image Project
  - VxWorks Layer Project
  - VxWorks Real Time Process Project
  - VxWorks ROMFS File System Project
  - VxWorks RPM Project
  - VxWorks Shared Library Project
  - VxWorks Source Build Project
- Examples

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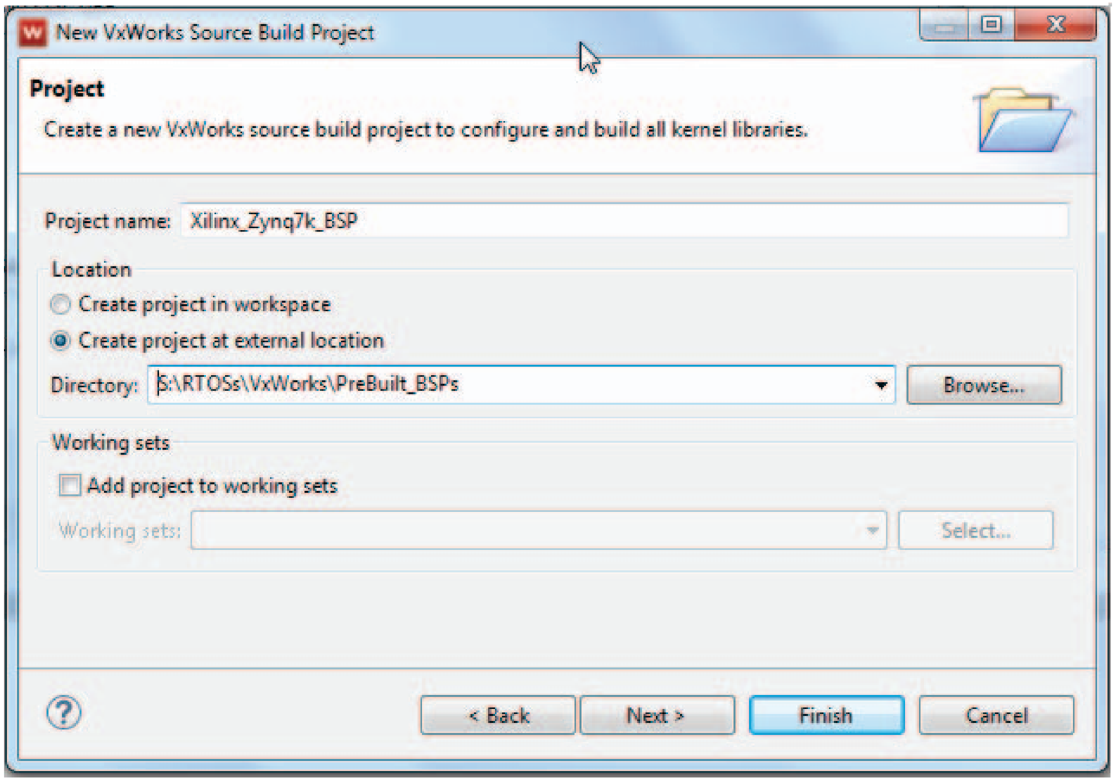
Figure 1: **Selecting the VxWorks Source Build Project**

3. Click **Next**. The *New VxWorks Source Build Project* wizard dialog box opens, as shown in Figure 2.


New VxWorks Source Build Project

Project

Create a new VxWorks source build project to configure and build all kernel libraries.

Project name: Xilinx_Zynq7k_BSP

Location

( ) Create project in workspace

(•) Create project at external location

Directory: S:\RTOSs\VxWorks\PreBuilt_BSPs

Working sets

[ ] Add project to working sets

Working sets:

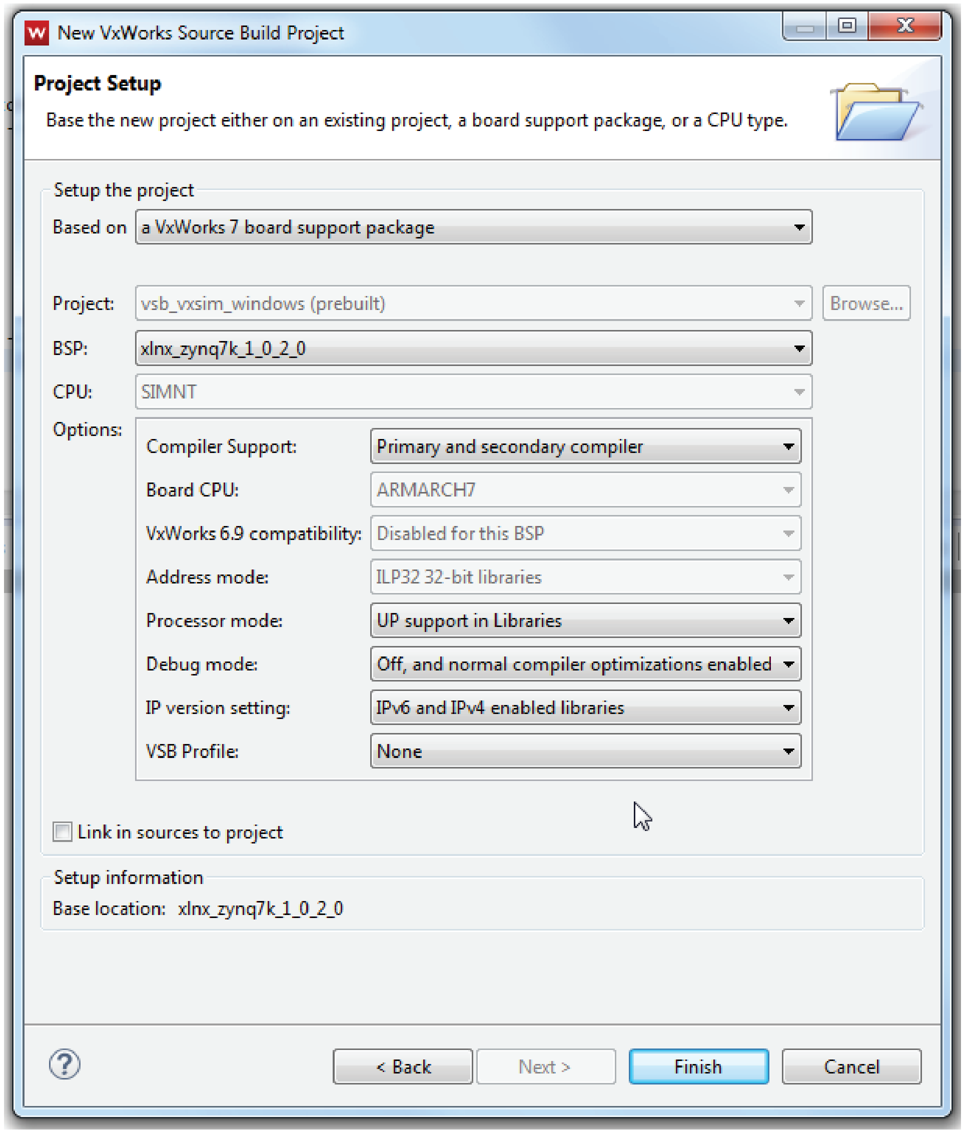
Figure 2: **New VxWorks Source Build Project Wizard Dialog Box**

4. Enter a project name, for example, `Xilinx_Zynq7k_BSP`, and click **Next**.

RECOMMENDED: It is highly recommended that this be located outside of your workspace to enable reuse across developments – it is a 'one off build stage' and build times can approach 10-20 minutes.

5. Select the appropriate Zynq BSP in the **BSP:** drop down menu, as shown in Figure 3. This would be `xlnx_zynq7k_?_?_?_? | avnet_mini_itx_7z_?_?_?_?` for the pre-installed BSPs. Click **Finish**.

   Note: BSP versions evolve and might be updated from that which is available at time of publication of this application note. Select that which is most suitable to your development.



Project Setup

Base the new project either on an existing project, a board support package, or a CPU type.

Setup the project

Based on	a VxWorks 7 board support package
Project:	vsb_vxsim_windows (prebuilt)
BSP:	xlnx_zynq7k_1_0_2_0
CPU:	SIMNT

Options:

Compiler Support:	Primary and secondary compiler
Board CPU:	ARMARCH7
VxWorks 6.9 compatibility:	Disabled for this BSP
Address mode:	ILP32 32-bit libraries
Processor mode:	UP support in Libraries
Debug mode:	Off, and normal compiler optimizations enabled
IP version setting:	IPv6 and IPv4 enabled libraries
VSB Profile:	None

☐ Link in sources to project

Setup information

Base location: xlnx_zynq7k_1_0_2_0

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Figure 3: **Selecting the BSP and Creating Source Build Project for the Zynq-7000 AP SoC**

After a few seconds, the BSP project is created in the *Project Explorer* window.

6. Right-click **Xilinx_Zynq7k_BSP** and select the **Properties** option.
7. The *Properties view for Xilinx_Zynq7k_BSP* wizard opens. Click **Build Properties** and change the *Build command* to **make -jN** where N is the number of cores in your host machine. This speeds up the build time. Give the N value with respect to the host machine configuration and click **Apply**.

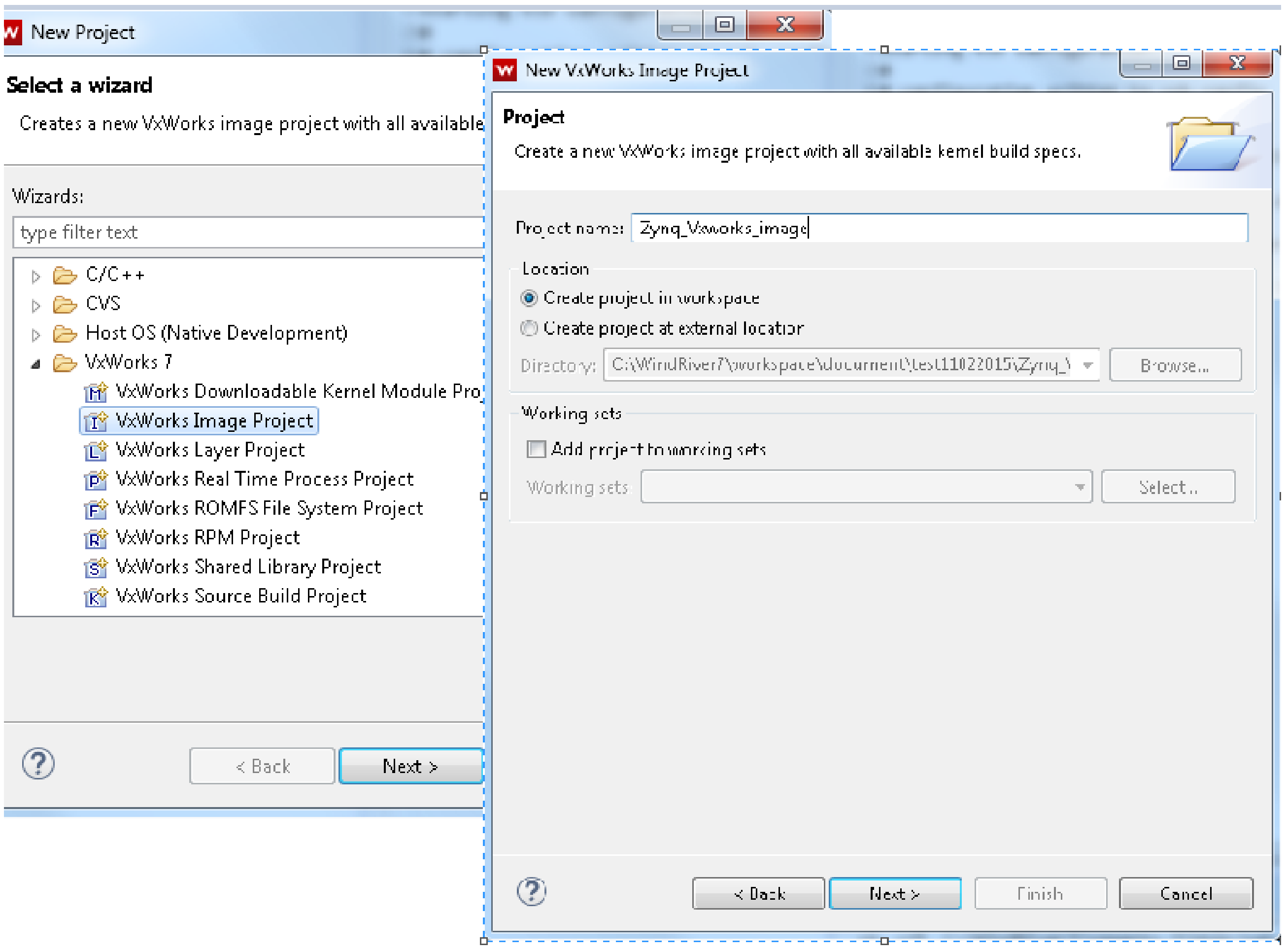
8. A confirmation wizard then opens, select **Yes** and then click **OK**. This reduces the BSP build time.
9. Now build the VSB Project. Right-click the project (**Xilinx_Zynq7k_BSP**) in the *Project Explorer* window and select the **Build Project** option. A parallel build enable confirmation box is launched, select **Yes**.
10. It takes 10 -20 minutes for the BSP build process to complete. After completing the build process, create the VxWorks kernel image by following the procedures in the following section.

    Note: At time of publication, there are some minor ignorable build errors. Wind River is working on clearing these issues

Kernel Image Project – Creation, Configuration and Build

This section explains how to create a VxWorks kernel image from the VxWorks Source Build Project (VSB) created in the previous stage. It also explains how to configure the VxWorks kernel for the specific implementation requirements.

1. In the Wind River Workbench main context menu, select **File** > **New** > **Project**. The *New Project Wizard* opens as shown in Figure 4.


New Project

Select a wizard

Creates a new VxWorks image project with all available

Wizards:

type filter text

- C/C++
- CVS
- Host OS (Native Development)
- VxWorks 7
  - VxWorks Downloadable Kernel Module Pro
  - VxWorks Image Project
  - VxWorks Layer Project
  - VxWorks Real Time Process Project
  - VxWorks ROMFS File System Project
  - VxWorks RPM Project
  - VxWorks Shared Library Project
  - VxWorks Source Build Project

New VxWorks Image Project

Project

Create a new VxWorks image project with all available kernel build specs.

Project name: Zynq_Vxworks_image

Location

(●) Create project in workspace

( ) Create project at external location

Directory: C:\WindRiver7\workspace\document\test11022015\Zynq_\

Working sets

[ ] Add project to working sets

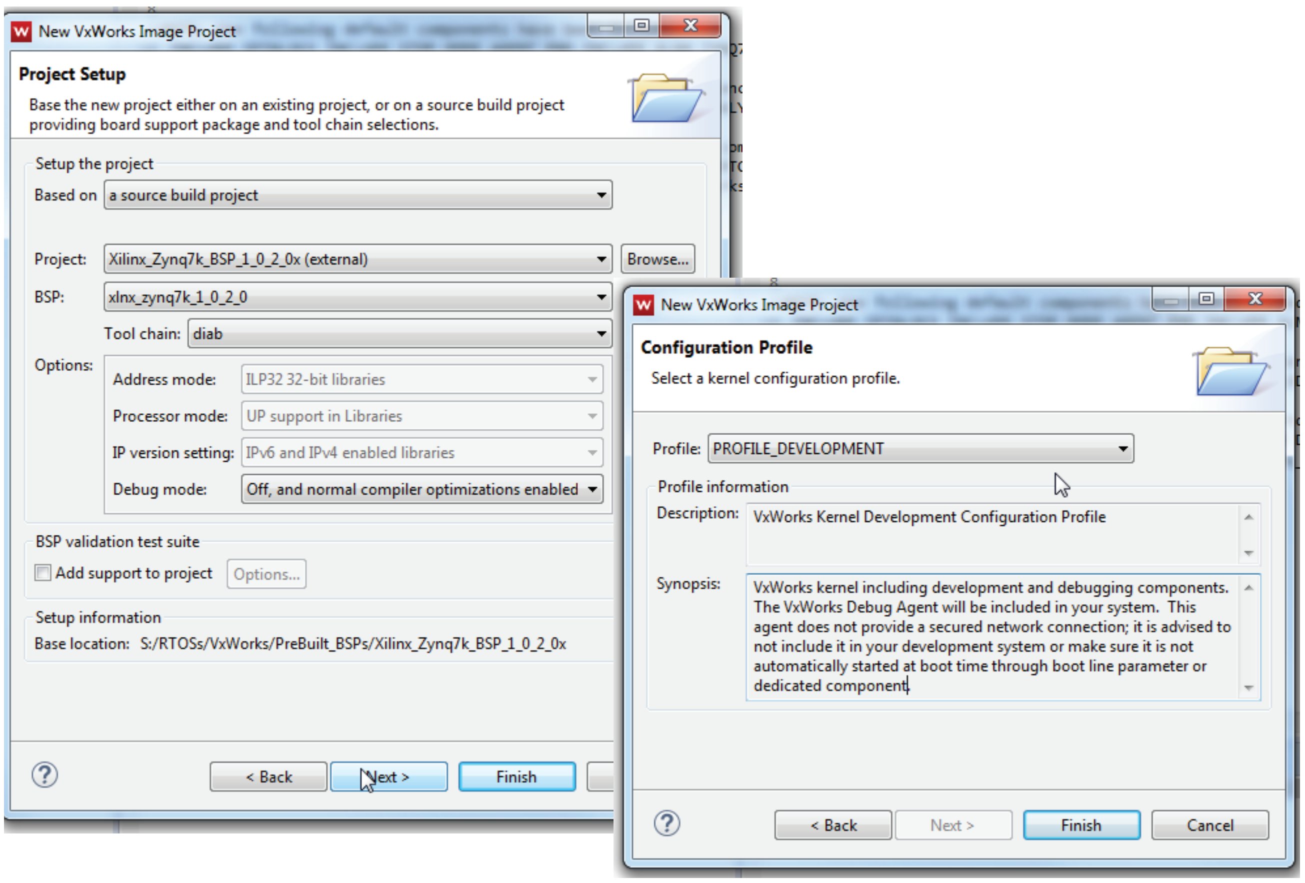
Working sets:

Figure 4: **Creating the New VxWorks Kernel Image Project for the Zynq-7000 AP SoC**

2. Under *VxWorks 7*, select **VxWorks Image Project** and click **Next**. A New *VxWorks Image Project Wizard* opens (also shown in Figure 4).

3. Enter a project name (for example: *Zynq_VxWorks_image*) and click **Next**.

4. For "Project" browse to your prebuilt VSB project directory location. Once selected, a single BSP will be listed and that should match your choice made in the previous VSB build guidelines section. (See Figure 5.) Click **Next**.



Project Setup

Base the new project either on an existing project, or on a source build project providing board support package and tool chain selections.

Setup the project

Based on: a source build project

Project: Xilinx_Zynq7k_BSP_1_0_2_0x (external)

BSP: xlnx_zynq7k_1_0_2_0

Tool chain: diab

Options:

Address mode: ILP32 32-bit libraries

Processor mode: UP support in Libraries

IP version setting: IPv6 and IPv4 enabled libraries

Debug mode: Off, and normal compiler optimizations enabled

BSP validation test suite

Add support to project

Setup information

Base location: S:/RTOSs/VxWorks/PreBuilt_BSPs/Xilinx_Zynq7k_BSP_1_0_2_0x

Configuration Profile

Select a kernel configuration profile.

Profile: PROFILE_DEVELOPMENT

Profile information

Description: VxWorks Kernel Development Configuration Profile

Synopsis: VxWorks kernel including development and debugging components. The VxWorks Debug Agent will be included in your system. This agent does not provide a secured network connection; it is advised to not include it in your development system or make sure it is not automatically started at boot time through boot line parameter or dedicated component.

Figure 5: **Configuring the Profile Development for VxWorks**

5. From the *New VxWorks Image Project* wizard, select **PROFILE_DEVELOPMENT** (Figure 5).

6. Click **Finish**. This creates the kernel image project in the *Project Explorer* window.

Note: The reference file `target.ref` in the generated VxWorks Image Project (see Figure 6) describes all of the flow and configuration options.

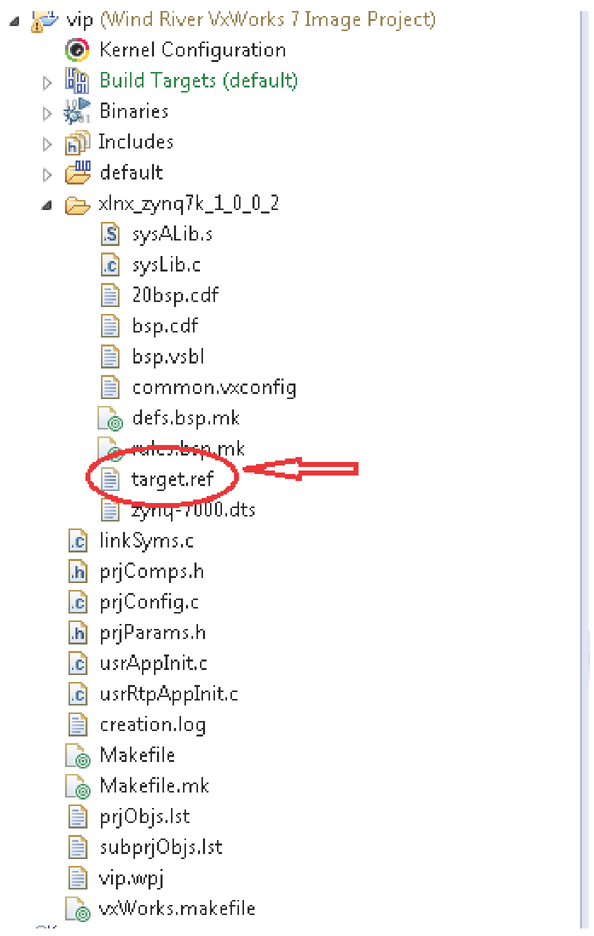


Figure 6: **BSP Reference File Location**

7. Before building the kernel image, these symbols must be added into the kernel configuration:

• INCLUDE_STANDALONE_SYM_TBL	– Includes the Zynq-7000 AP SoC symbol table
• INCLUDE_IFCONFIG	– Configures the Ethernet (ifconfig)
• INCLUDE_DEBUG_AGENT_START	– Includes debug services
• INCLUDE_DEBUG_AGENT	– Includes debug services

For example, the following steps detail how to achieve this for the first symbol:

a. Open the Kernel configuration by expanding the *Zynq_VxWorks_Image Project* in the *Project Explorer* window and click on the kernel configuration. The *Component* wizard, which lists kernel components, opens in the workspace.

b. Hover the mouse over the *Description* headline in the Component wizard and then right-click as highlighted in the Figure 7.

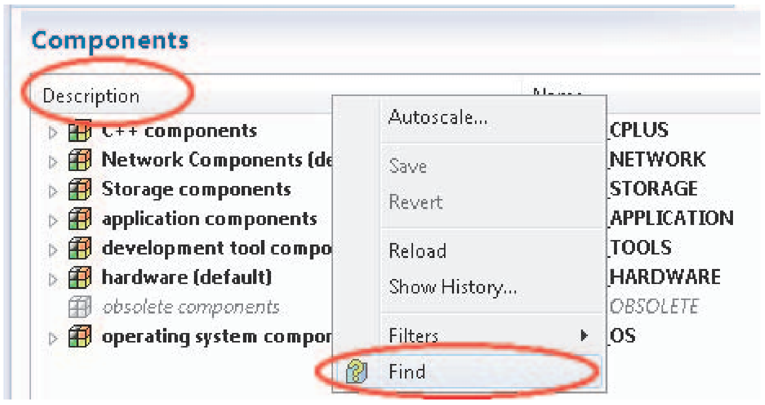
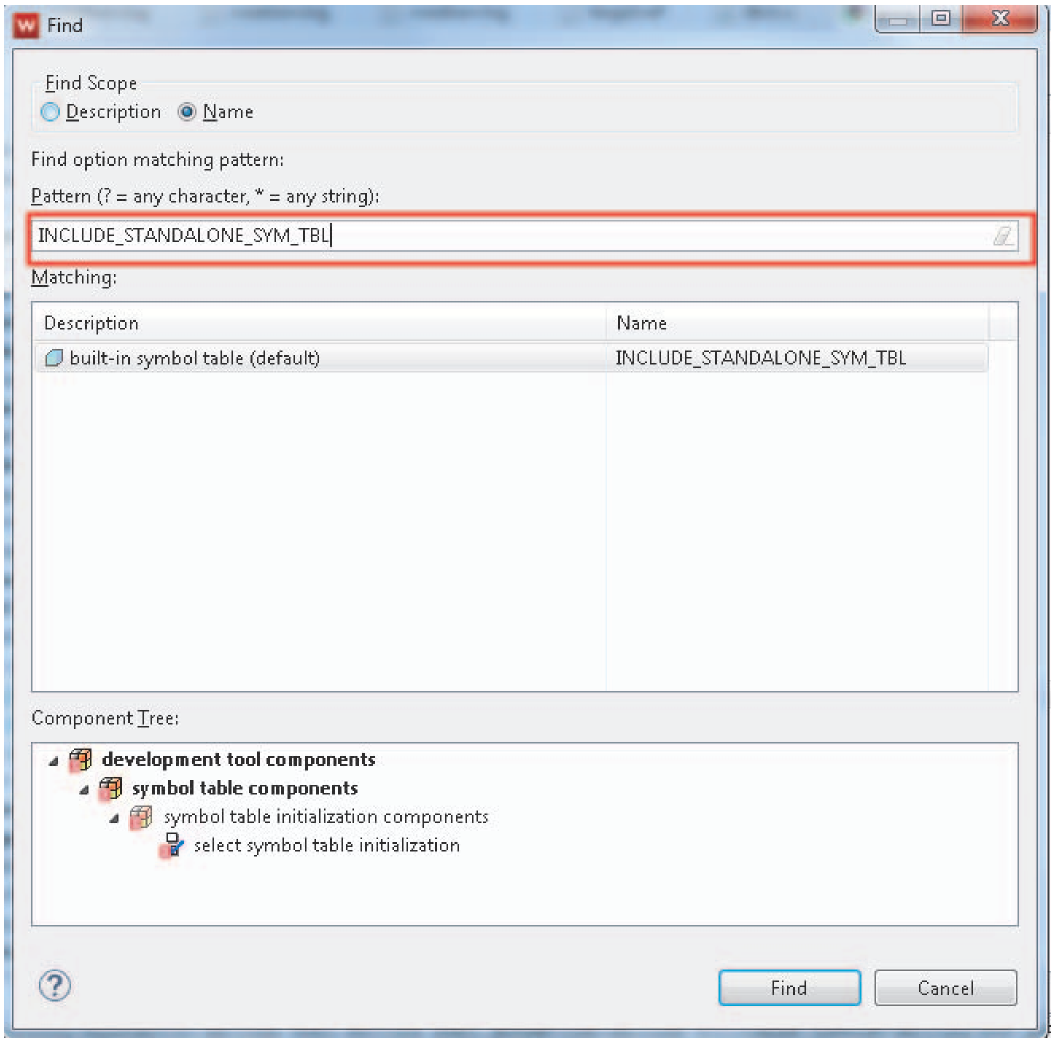


Figure 7: **Finding the Kernel Symbol in the VxWorks Kernel Configuration**

c. Click the **Find** option. The *Find* window opens. Enter the string `INCLUDE_STANDALONE_SYM_TBL` in the text box as highlighted in Figure 8.


Find

Find Scope
Description [✓ Name]

Find option matching pattern:

Pattern (? = any character, * = any string):

INCLUDE_STANDALONE_SYM_TBL

Matching:

Description	Name
built-in symbol table (default)	INCLUDE_STANDALONE_SYM_TBL

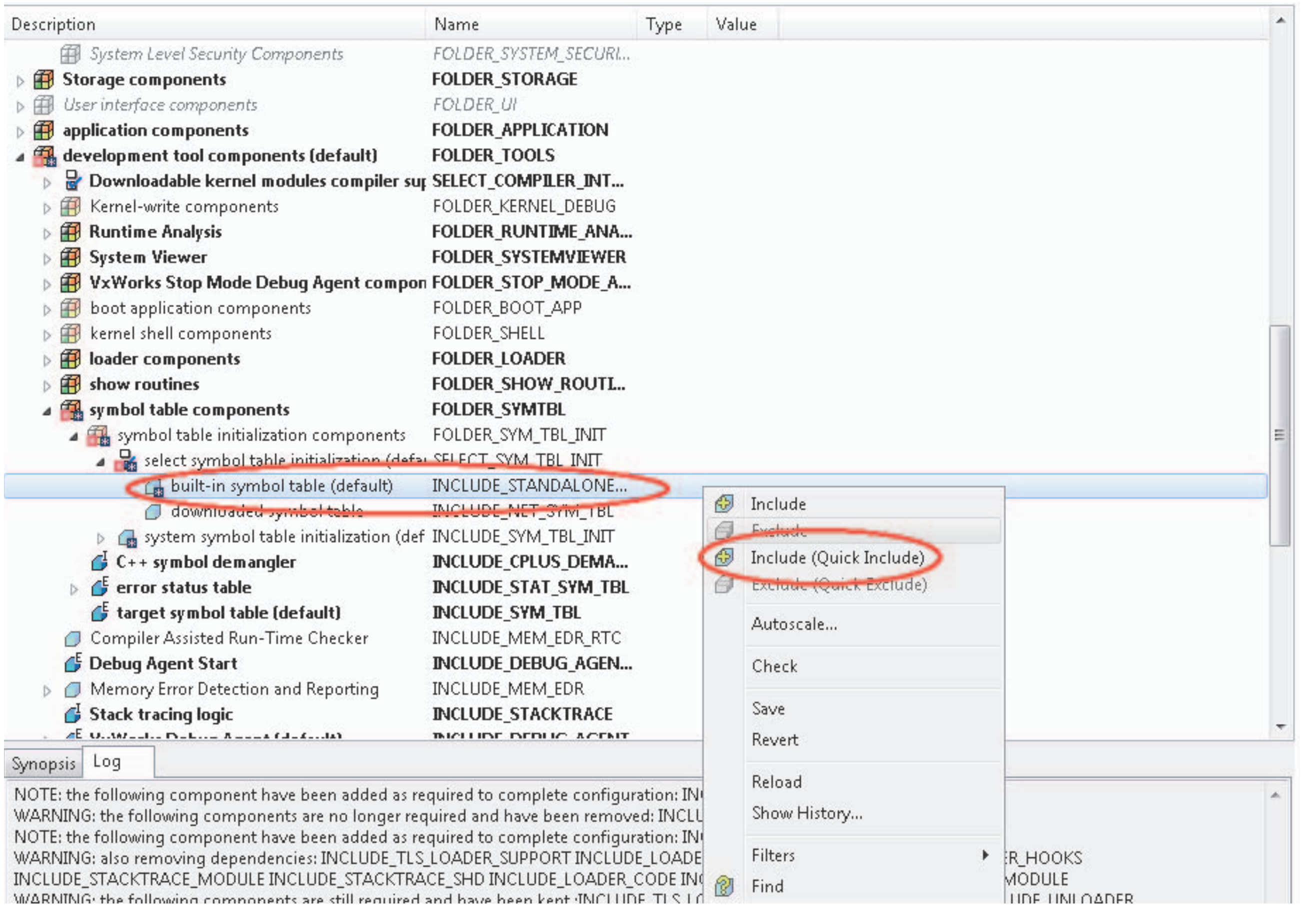
Component Tree:

- development tool components
  - symbol table components
    - symbol table initialization components
      - select symbol table initialization

Figure 8: **Entering the Kernel Symbol in the VxWorks Kernel to Find Configuration**

d. Click **Find**. The INCLUDE_STANDALONE_SYM_TBL symbol is found and displayed in the *Matching:* window, as shown in Figure 8.

e. Right-click INCLUDE_STANDALONE_SYM_TBL and select the **Include (Quick Include)** option as highlighted in Figure 9.



Description	Name	Type	Value
System Level Security Components	FOLDER_SYSTEM_SECURI...		
Storage components	FOLDER_STORAGE		
User interface components	FOLDER_UI		
application components	FOLDER_APPLICATION		
development tool components (default)	FOLDER_TOOLS		
Downloadable kernel modules compiler sup	SELECT_COMPILER_INT...		
Kernel-write components	FOLDER_KERNEL_DEBUG		
Runtime Analysis	FOLDER_RUNTIME_ANA...		
System Viewer	FOLDER_SYSTEMVIEWER		
VxWorks Stop Mode Debug Agent compon	FOLDER_STOP_MODE_A...		
boot application components	FOLDER_BOOT_APP		
kernel shell components	FOLDER_SHELL		
loader components	FOLDER_LOADER		
show routines	FOLDER_SHOW_ROUTI...		
symbol table components	FOLDER_SYMTBL		
symbol table initialization components	FOLDER_SYM_TBL_INIT		
select symbol table initialization (defau	SELECT_SYM_TBL_INIT		
built-in symbol table (default)	INCLUDE_STANDALONE...		
downloaded symbol table	INCLUDE_NET_SYM_TBL		
system symbol table initialization (def	INCLUDE_SYM_TBL_INIT		
C++ symbol demangler	INCLUDE_CPLUS_DEMA...		
error status table	INCLUDE_STAT_SYM_TBL		
target symbol table (default)	INCLUDE_SYM_TBL		
Compiler Assisted Run-Time Checker	INCLUDE_MEM_EDR_RTC		
Debug Agent Start	INCLUDE_DEBUG_AGEN...		
Memory Error Detection and Reporting	INCLUDE_MEM_EDR		
Stack tracing logic	INCLUDE_STACKTRACE		

```
NOTE: the following component have been added as required to complete configuration: IN
WARNING: the following components are no longer required and have been removed: INCLU
NOTE: the following component have been added as required to complete configuration: IN
WARNING: also removing dependencies: INCLUDE_TLS_LOADER_SUPPORT INCLUDE_LOADE        ER_HOOKS
INCLUDE_STACKTRACE_MODULE INCLUDE_STACKTRACE_SHD INCLUDE_LOADER_CODE IN             MODULE
```

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Figure 9: **Including the Kernel Symbols**

f. Repeat these steps for each of the remaining symbols.

Note: The VxWorks ARM BSP uses a Device Tree Blob (DTB) to describe device specific information, and there are two methods to load the DTB:

- Embedded: The DTB is embedded in the VxWorks image
- Independent: An independent file is created for the DTB.

This application note uses the independent DTB method to load the DTB.

8. In the *Project Explorer* window, move the mouse over to the image project (**Zynq_VxWorks_image**), right-click and select **Build Project** as shown in Figure 10. It takes few seconds for the kernel image to be built.

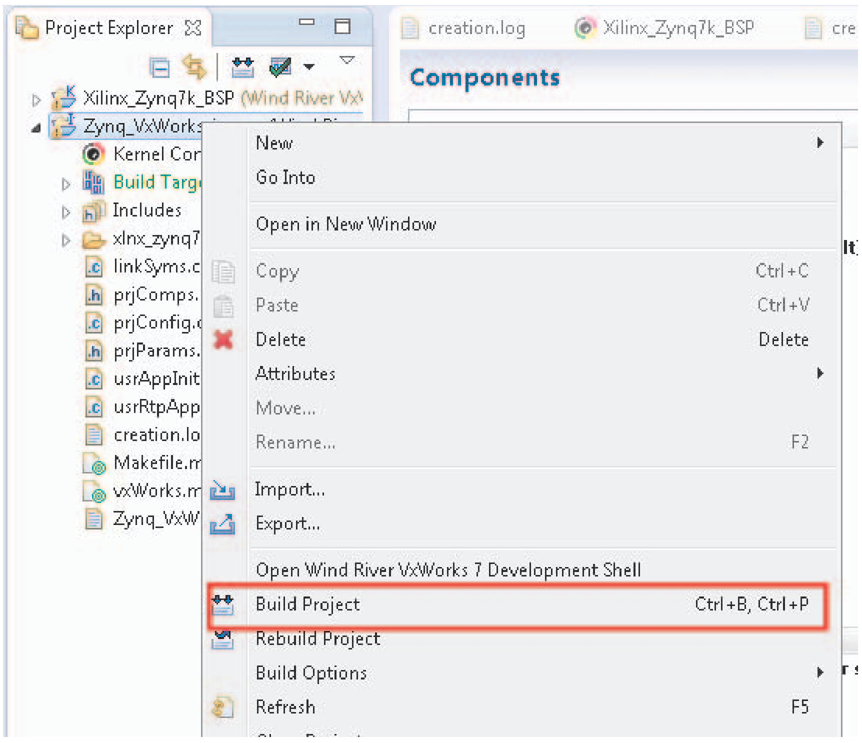


Figure 10: **Building the VxWorks Kernel Image Project**

9. Expand the *Build Targets* (default) which is present under the *Zynq_VxWorks_image* in the *Project Explorer* window.

10. Right-click **uVxWorks** and select the **Build Target** option as show in the Figure 11. On completion the *uVxWorks* and *<BSPIncludedDeviceTree>.dtb* images are created at directory location `<WorkspacePath>\<KernelImageProjectName>\default`.

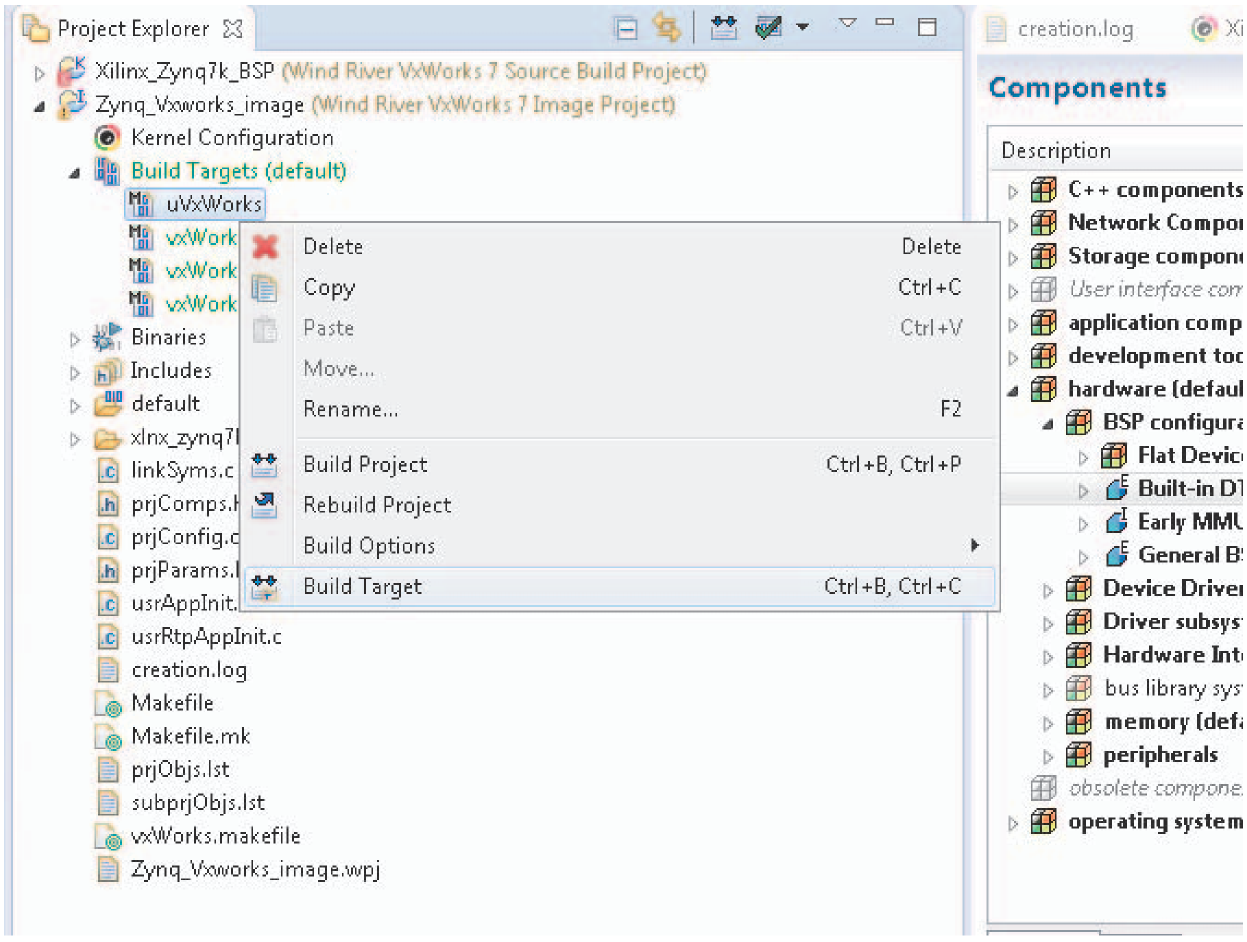


Figure 11: **Building the Kernel Image**

Target Bring-Up – Local and Network Boot

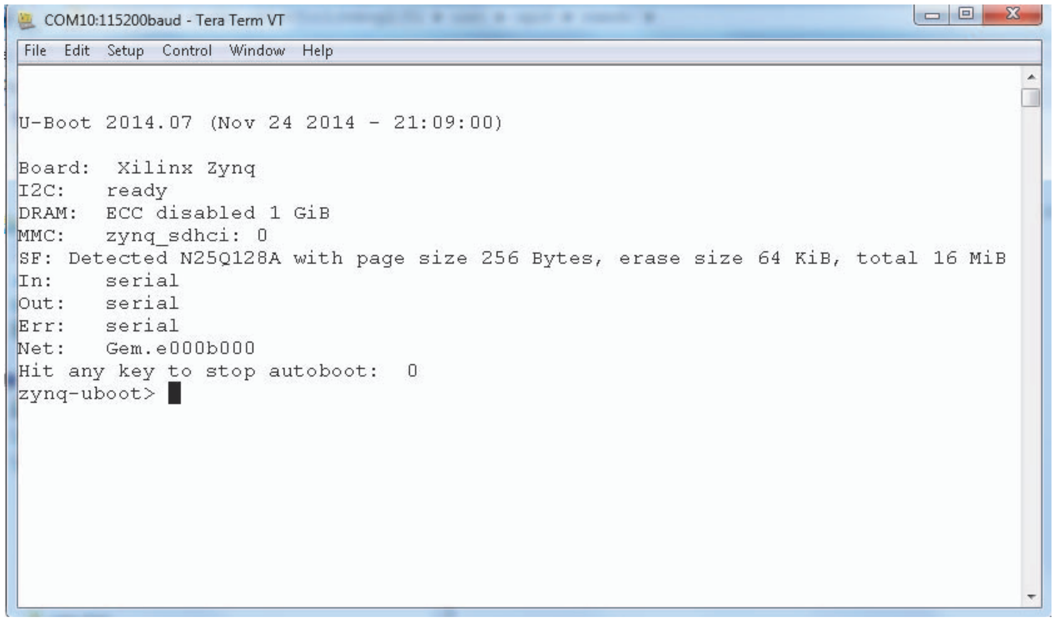
This section explains how to run the VxWorks image on the Zynq-7000 AP SoC using different boot modes. A boot image (BOOT.BIN) must be created using the first stage boot loader (FSBL), the PL bit stream (optional and needed if there is any PL logic), and u-Boot. u-Boot subsequently loads the VxWorks image and hands-off execution control to the VxWorks image. Suitable image stitching is a feature of the “bootgen” utility present in Xilinx's Software Development Kit (XSDK), however prebuilt images are provided in the Wind River Workbench install for the aforementioned development boards.

For custom boards, a customized FSBL that matches the base hardware must be used and thus a boot image (boot.bin) must be specifically created, including the FSBL and a suitable uBOOT second stage loader. Guidance on how to include this can be found in the *Xilinx Software Development Kit (SDK) User Guide (UG1145)* [Ref 2].

Booting VxWorks (Common)

uBoot can source the VxWorks boot image and device tree from either a local nonvolatile storage device or from network-attached storage, but the initial device boot files MUST be local on the onboard SD card (or Quad-SPI).

1. Copy the files for your reference board from `<InstallDirectory>\vxworks-7\pkgs\os\board\arm\<Board>\_bootloader\*.bin` and rename to "boot.bin". See Local Boot (SD Card Example), page 15 for additional files to copy if planning a full local boot.
2. Connect a power cable and a USB UART cable to the board.
3. See `target.ref` as highlighted earlier for guidance on how to configure the board's boot switches for SD/QSPI, as required. Full details and explanations can also be found in the corresponding board's user guides (see the support page and the *ZC702 Evaluation Board User Guide* (UG850) [Ref 3]).
4. Open a serial terminal emulator, choose the appropriate COM port, and set the baud rate to 115,200.
5. Turn on the ZC702 board after inserting the SD card.
6. Stop the Auto boot process of u-boot by pressing the keyboard **Return** key.
7. The u-boot execution prompt is displayed, as shown in Figure 12.


COM10:115200baud - Tera Term VT
File Edit Setup Control Window Help

```
U-Boot 2014.07 (Nov 24 2014 - 21:09:00)

Board:  Xilinx Zynq
I2C:    ready
DRAM:   ECC disabled 1 GiB
MMC:    zynq_sdhci: 0
SF: Detected N25Q128A with page size 256 Bytes, erase size 64 KiB, total 16 MiB
In:     serial
Out:    serial
Err:    serial
Net:    Gem.e000b000
Hit any key to stop autoboot:  0
zynq-uboot> 
```

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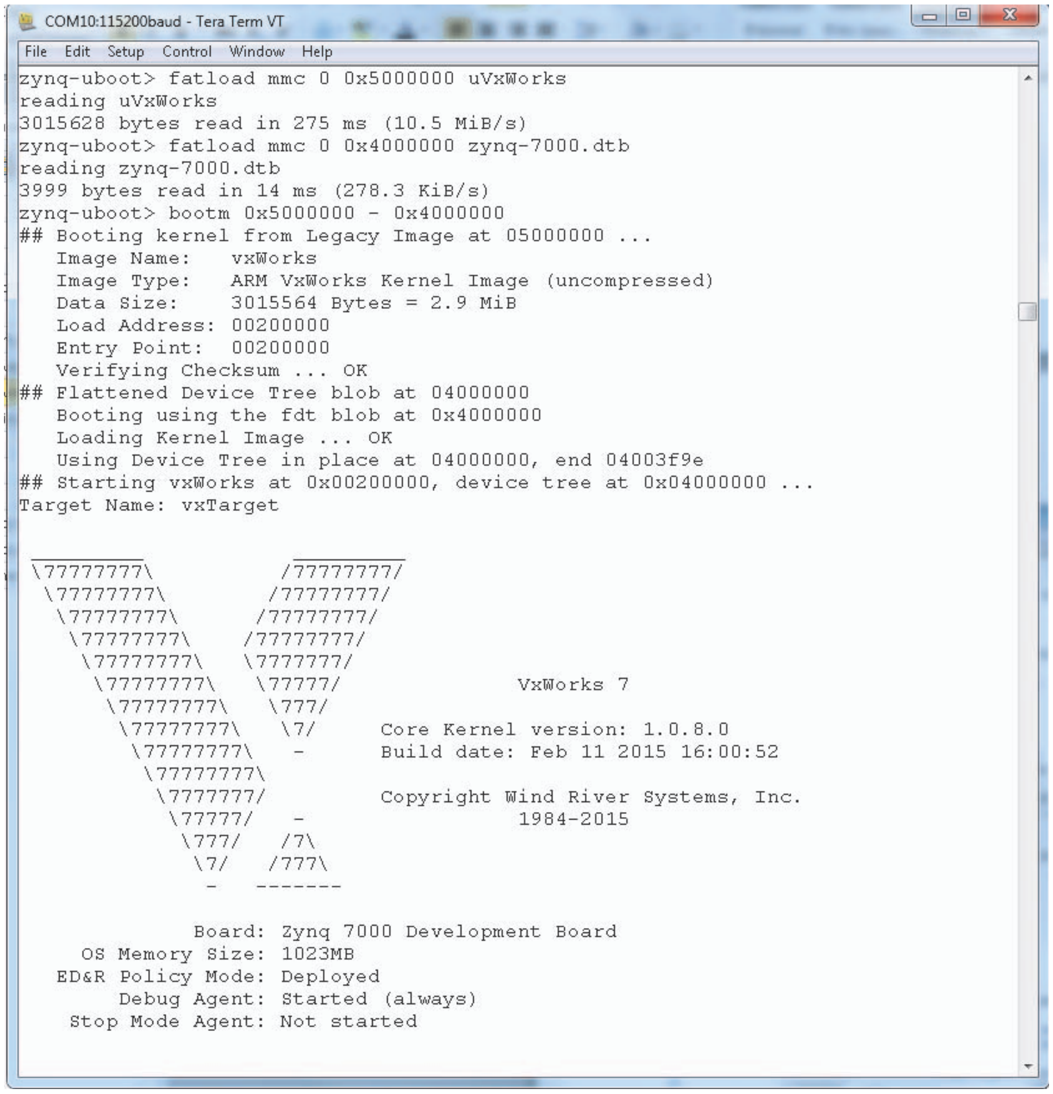
Figure 12: **U-Boot Execution Prompt**

Local Boot (SD Card Example)

For a local boot, complete the steps in Booting VxWorks (Common), page 14 and then:

1. Ensure that the `uVxWorks` and `<BSPIncludedDeviceTree>.dtb` files are copied onto an SD card from the directory path **\<workspace>\<KernelImageProjectName>\default.**
2. Assuming u-boot has booted, enter **fatls mmc 0** at the prompt. The list of files present in the SD card is displayed.
3. Enter the **fatload mmc 0 0x5000000 uVxWorks** command at the Zynq u-boot prompt. This command copies the uVxWorks image to address `0x5000000` of the target memory space.
4. Enter the **fatload mmc 0 0x4000000 <BSPIncludedDeviceTree>.dtb** command at the Zynq u-boot prompt. This command copies the DTB image to address `0x4000000` of the target memory space.

5. Enter the **bootm 0x5000000 - 0x4000000** command at the Zynq u-boot prompt. The VxWorks image boots and echoes the output as shown in Figure 13.


COM10:115200baud - Tera Term VT
File Edit Setup Control Window Help

```
zynq-uboot> fatload mmc 0 0x5000000 uVxWorks
reading uVxWorks
3015628 bytes read in 275 ms (10.5 MiB/s)
zynq-uboot> fatload mmc 0 0x4000000 zynq-7000.dtb
reading zynq-7000.dtb
3999 bytes read in 14 ms (278.3 KiB/s)
zynq-uboot> bootm 0x5000000 - 0x4000000
## Booting kernel from Legacy Image at 05000000 ...
   Image Name:   vxWorks
   Image Type:   ARM VxWorks Kernel Image (uncompressed)
   Data Size:    3015564 Bytes = 2.9 MiB
   Load Address: 00200000
   Entry Point:  00200000
   Verifying Checksum ... OK
## Flattened Device Tree blob at 04000000
   Booting using the fdt blob at 0x4000000
   Loading Kernel Image ... OK
   Using Device Tree in place at 04000000, end 04003f9e
## Starting vxWorks at 0x00200000, device tree at 0x04000000 ...
Target Name: vxTarget


 _________            _________
 \77777777\          /77777777/
  \77777777\        /77777777/
   \77777777\      /77777777/
    \77777777\    /77777777/
     \77777777\   \7777777/
      \77777777\   \77777/              VxWorks 7
       \77777777\   \777/
        \77777777\   \7/     Core Kernel version: 1.0.8.0
         \77777777\   -      Build date: Feb 11 2015 16:00:52
          \77777777\
           \7777777/         Copyright Wind River Systems, Inc.
            \77777/   -                 1984-2015
             \777/   /7\
              \7/   /777\
               -   -------

              Board: Zynq 7000 Development Board
     OS Memory Size: 1023MB
   ED&R Policy Mode: Deployed
        Debug Agent: Started (always)
    Stop Mode Agent: Not started
```

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Figure 13: **VxWorks SD Boot Mode Execution on the Zynq-7000 AP SoC**

Network Boot (TFTP Example)

To boot from the network, complete the steps in Booting VxWorks (Common), page 14 and then:

1. Identify the IP address of you host machine ensuring connection to the same ethernet subnet as your target board, or establish a point-to-point connection.

   Note: The IP addresses used in this application note are just used as an example. You need to change the network parameters according to your actual situation. An incorrect setting for the *bootargs* parameter can cause the procedure to fail.

2. Start the TFTP server with administrator permissions (right-click the tftp application > run as administrator) on the host machine. Store the path **`\<workspace>\<KernelImageProjectName>\default`** where the uVxWorks, <BSPIncludedDeviceTree> images are present. Ensure that a local firewall allows tftp to be used on your machine (or disable this firewall temporarily).

3. At the u-boot prompt, enter these commands to set the network IP addresses in the u-boot environment:

   setenv ipaddr 192.168.88.169

   setenv serverip 192.168.88.170

   setenv gatewayip 192.168.88.1

   setenv blocksize 512

   saveenv

   Network parameters are saved in the u-boot environment.

4. Update and save the *bootargs* to the u-boot environment by entering these commands at the u-boot prompt:

   setenv bootargs 'gem(0,0)host:vxworks h=192.168.88.170 e=192.168.88.169:fffffe00 g=192.168.88.1 u=target pw=vxTarget f=0x0'

   Note: This must be written/pasted on one line for the terminal CLI.

   saveenv

5. Download the uVxWorks image from your host machine to address `0x5000000` of the target memory location using this command:

   tftpb 0x5000000 uVxWorks

6. Download the Device Tree Blob image from the host machine to address `0x4000000` of the target memory location using this command:

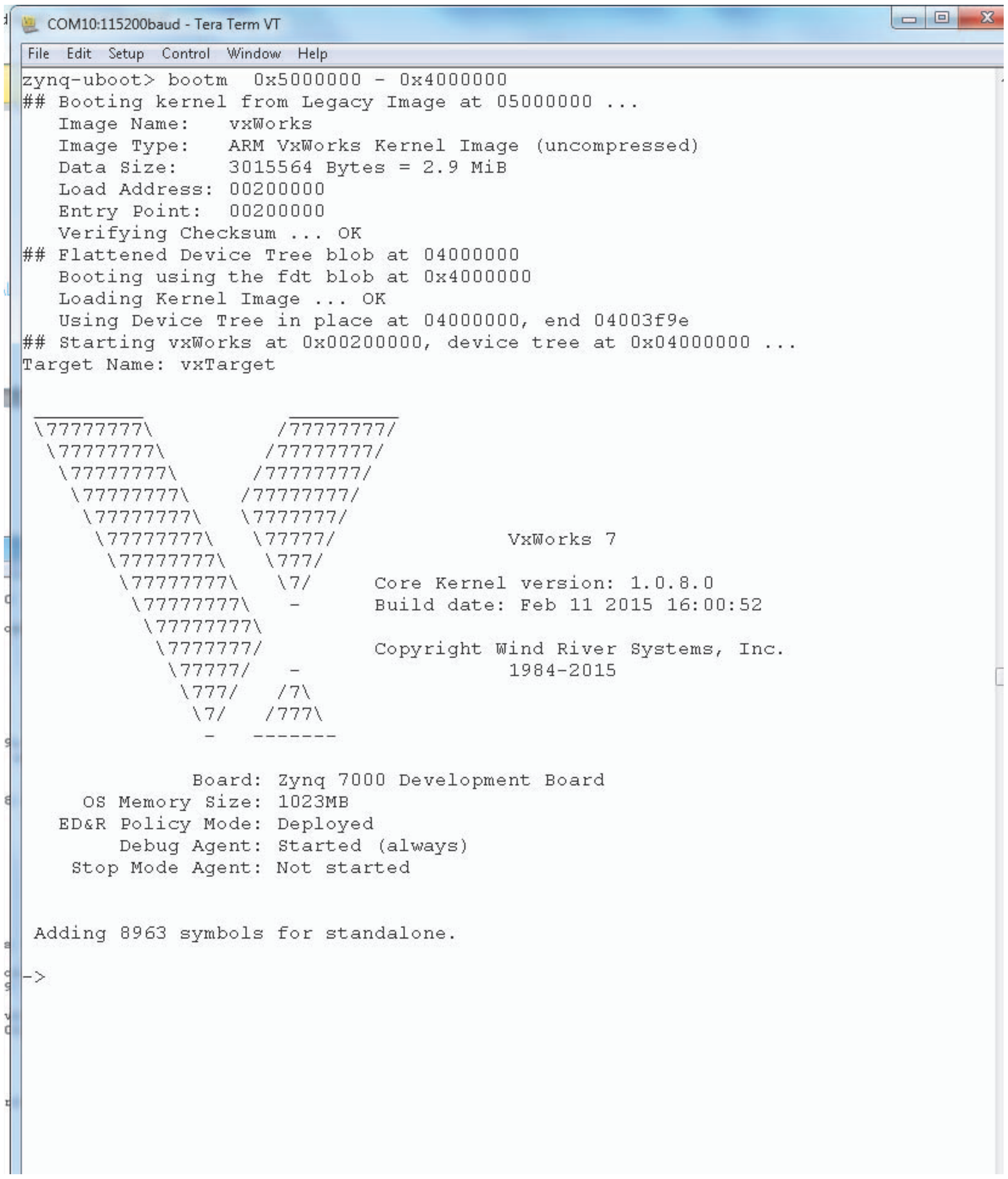
   tftpb 0x4000000 <BSPIncludedDeviceTree>.dtb

7. When the downloading process has completed run the image by entering this command at the u-boot prompt:

   bootm 0x5000000 - 0x4000000

   This results in the VxWorks kernel booting and you can see the boot logs on the serial console.

8. At the end of the VxWorks kernel boot process the serial console display should be similar to the example shown in Figure 14.


COM10:115200baud - Tera Term VT
File Edit Setup Control Window Help

```
zynq-uboot> bootm  0x5000000 - 0x4000000
## Booting kernel from Legacy Image at 05000000 ...
   Image Name:   vxWorks
   Image Type:   ARM VxWorks Kernel Image (uncompressed)
   Data Size:    3015564 Bytes = 2.9 MiB
   Load Address: 00200000
   Entry Point:  00200000
   Verifying Checksum ... OK
## Flattened Device Tree blob at 04000000
   Booting using the fdt blob at 0x4000000
   Loading Kernel Image ... OK
   Using Device Tree in place at 04000000, end 04003f9e
## Starting vxWorks at 0x00200000, device tree at 0x04000000 ...
Target Name: vxTarget

 _________            _________
 \77777777\          /77777777/
  \77777777\        /77777777/
   \77777777\      /77777777/
    \77777777\    /77777777/
     \77777777\   \7777777/
      \77777777\   \77777/              VxWorks 7
       \77777777\   \777/
        \77777777\   \7/     Core Kernel version: 1.0.8.0
         \77777777\   -      Build date: Feb 11 2015 16:00:52
          \77777777\
           \7777777/         Copyright Wind River Systems, Inc.
            \77777/   -                 1984-2015
             \777/   /7\
              \7/   /777\
               -   -------

              Board: Zynq 7000 Development Board
        OS Memory Size: 1023MB
      ED&R Policy Mode: Deployed
         Debug Agent: Started (always)
       Stop Mode Agent: Not started


 Adding 8963 symbols for standalone.

->
```

x1258_18_031715

Figure 14: **VxWorks TFTP Boot Completion on the Zynq-7000 AP SoC**

9. This display indicates that the VxWorks kernel is up and running and the VxWorks shell can be used to issue commands. Enter **help** for an overview of the available commands that are supported by this kernel.

Establishing a Network Connection to VxWorks

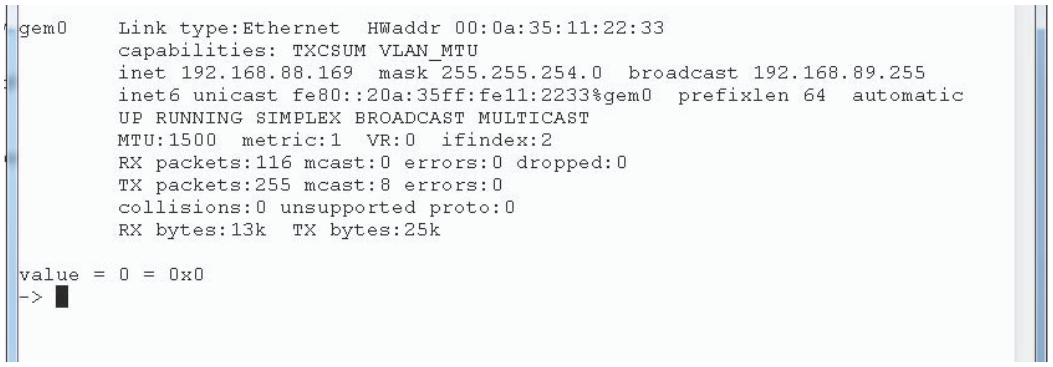
1. Enter this command to set the IP address of the target, again substituting as appropriate to your environment:

   ifconfig "gem0 192.168.88.169"

   The actual IP address can be shown by entering:

   ifconfig

   The IP address configuration is displayed, an example is shown in Figure 15.



```
gem0    Link type:Ethernet  HWaddr 00:0a:35:11:22:33
        capabilities: TXCSUM VLAN_MTU
        inet 192.168.88.169  mask 255.255.254.0  broadcast 192.168.89.255
        inet6 unicast fe80::20a:35ff:fe11:2233%gem0  prefixlen 64  automatic
        UP RUNNING SIMPLEX BROADCAST MULTICAST
        MTU:1500  metric:1  VR:0  ifindex:2
        RX packets:116 mcast:0 errors:0 dropped:0
        TX packets:255 mcast:8 errors:0
        collisions:0 unsupported proto:0
        RX bytes:13k  TX bytes:25k

value = 0 = 0x0
->
```

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Figure 15: **IP Address Configuration for the ZC702**

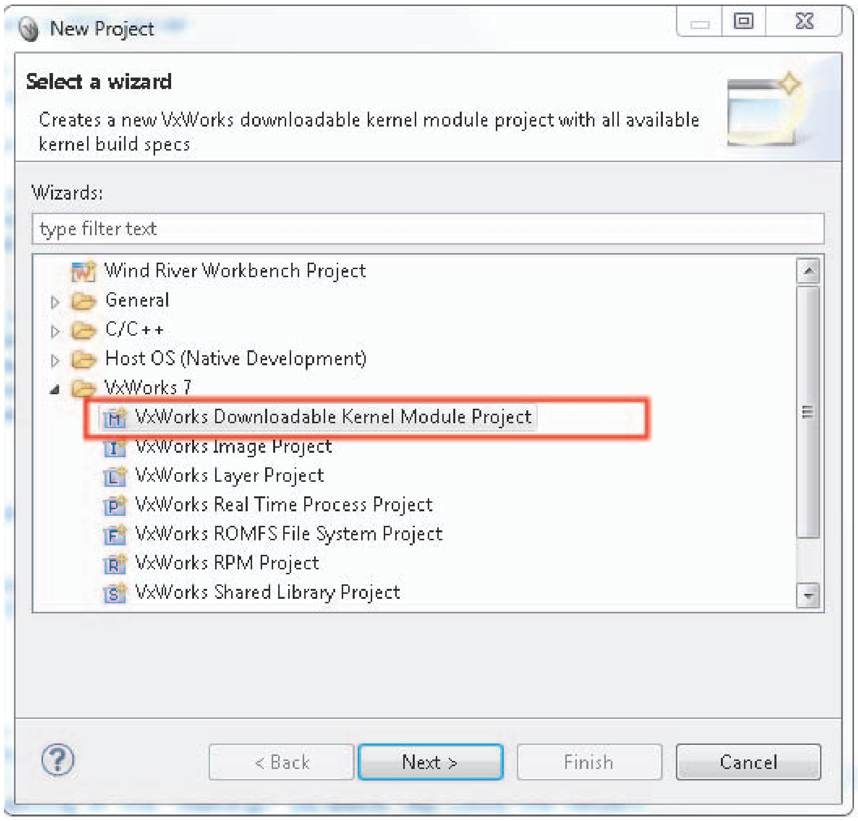
Software Application (Generic) – Creation, Development and Debug

This section describes how to create, build, download, and debug a simple *Hello_World* application using the Wind River Workbench. Before executing the follow steps ensure that the VxWorks kernel image is executing on the target and that an Ethernet connection is present between the host and the target.

Create and Build an Application

The following steps describe how to build and download a small *Hello_World* application to the remote target after you have set up and are running VxWorks.:

1. Select **File** > **New** > **Project** > **VxWorks Downloadable Kernel Module Project**, as shown in Figure 16.


New Project
Select a wizard
Wizards:
type filter text
Wind River Workbench Project
General
C/C++
Host OS (Native Development)
VxWorks 7
VxWorks Downloadable Kernel Module Project
VxWorks Image Project
VxWorks Layer Project
VxWorks Real Time Process Project
VxWorks ROMFS File System Project
VxWorks RPM Project
VxWorks Shared Library Project
< Back
Next >
Finish
Cancel

Creates a new VxWorks downloadable kernel module project with all available kernel build specs

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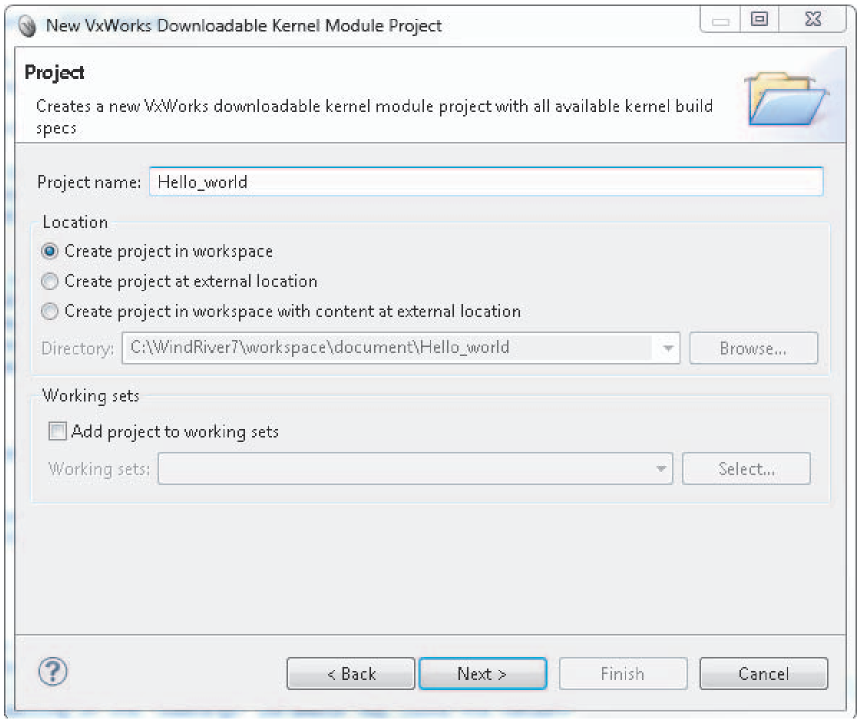
Figure 16: **Wizard for Selecting the Downloadable Kernel Module Project**

2. Click **Next** and enter a project name; for example, **Hello_world** (see Figure 17).


New VxWorks Downloadable Kernel Module Project

Project

Creates a new VxWorks downloadable kernel module project with all available kernel build specs

Project name: Hello_world

Location

- [✓] Create project in workspace
- Create project at external location
- Create project in workspace with content at external location

Directory: C:\WindRiver7\workspace\document\Hello_world

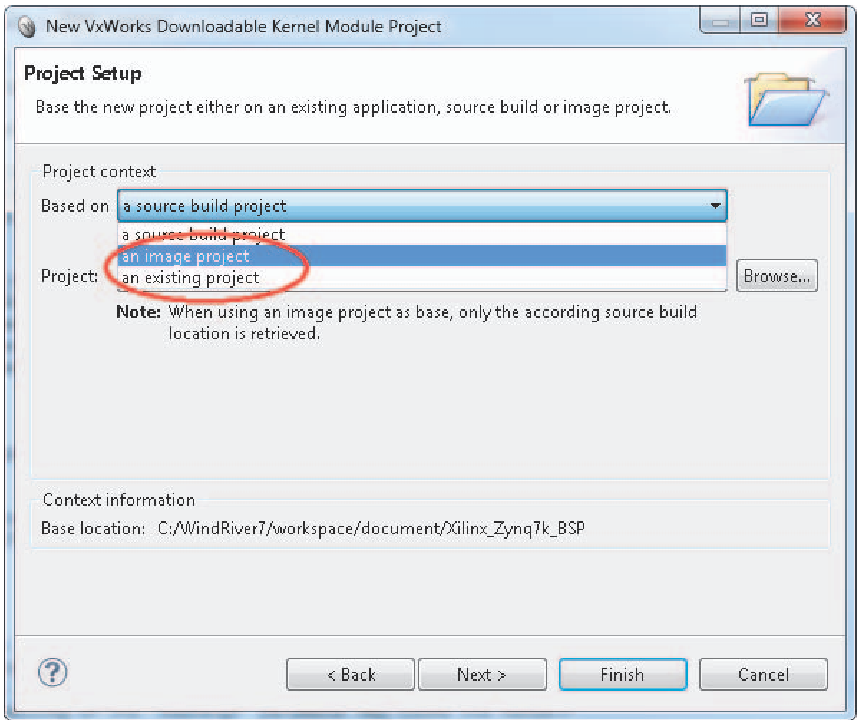
Working sets

- [ ] Add project to working sets

Working sets:

Figure 17: **Naming the Kernel Downloadable Module**

3. Click **Next** and select **an image project** in the *Project context/Based on* drop down menu, then click **Finish** (see Figure 18). A *Hello_world* project opens in the *Project Explorer* window.


New VxWorks Downloadable Kernel Module Project

Project Setup

Base the new project either on an existing application, source build or image project.

Project context

Based on: a source build project

Project:

Note: When using an image project as base, only the according source build location is retrieved.

Context information

Base location: C:/WindRiver7/workspace/document/Xilinx_Zynq7k_BSP

Figure 18: **Selecting The Image Project**

4. Expand the *Hello_world* project and click the **`dkm.c`** file. This is the C application file. It can be renamed for your application by right-clicking on it, selecting the **rename** option, and entering a new name; for example **hello_world.c**. Enter the following code in this file:

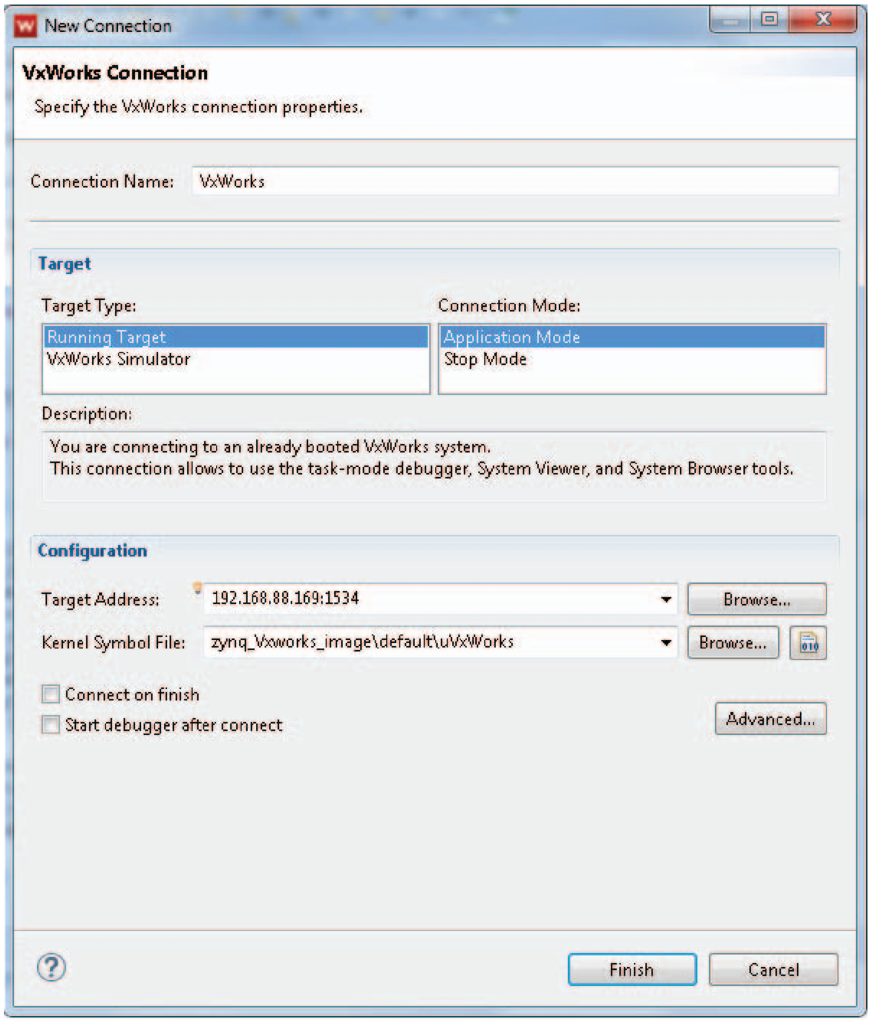
```
#include <stdio.h>
void hello()
{
        while(1)
        {
                printf("Hello Wind River\n");
        }
}
```

5. To build the application, right-click **hello_world.c** and select the **Build Project** option.

Debug an Application using Wind River Workbench

Perform the following steps to debug the *Hello_World* application built in Create and Build an Application.

1. Click **New Connection**, (located on the top left side, under the menu option of the Wind River Workbench) to launch and configure the connection wizard. A *New Connection* wizard opens.
2. Select *Target Type:* **Running Target** and *Connection Mode:* **Application Mode**, as show in the Figure 19.



VxWorks Connection

Specify the VxWorks connection properties.

Connection Name: VxWorks

Target

Target Type: Running Target (selected), VxWorks Simulator

Connection Mode: Application Mode (selected), Stop Mode

Description:

You are connecting to an already booted VxWorks system.
This connection allows to use the task-mode debugger, System Viewer, and System Browser tools.

Configuration

Target Address: 192.168.88.169:1534

Kernel Symbol File: zynq_Vxworks_image\default\uVxWorks

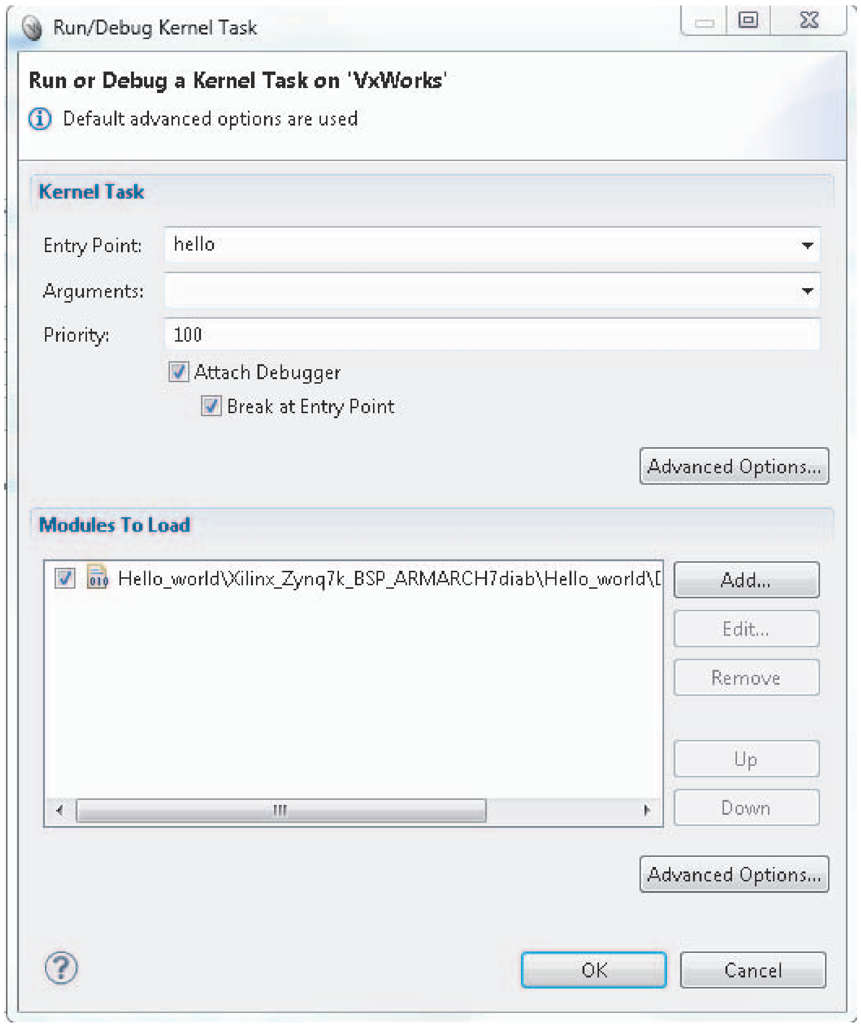
Connect on finish

Start debugger after connect

Figure 19: **Configuring the Debug Setup**

3. Enter the target board's IP address and port number (192.168.88.169:1534 for example) as the *Target Address* and browse to the kernel image which is present under the path `\<KernelImageProjectName>\default\uVxWorks` in the in kernel symbol file option, as shown in Figure 19. Click **Finish**.
4. Connect the board by clicking the connect symbol located beside the **New Connection** option:

   You now have a properly established connection between the target and the Workbench, and are ready to debug the application.
5. Right-click on the *Hello_world* project and select the **Run/Debug Kernel Task** option.
6. Enter the first C function name that would get executed at running time of your application in the **Entry Point** option in the *Run/Debug Kernel Task* wizard. For the *hello_world.c* application, **hello** is the starting function. Also select the **Attach Debugger** and **Break at Entry Point** check boxes as shown in Figure 20.


Run/Debug Kernel Task

Run or Debug a Kernel Task on 'VxWorks'

Default advanced options are used

Kernel Task

Entry Point: hello

Arguments:

Priority: 100

[✓] Attach Debugger

[✓] Break at Entry Point

Modules To Load

[✓] Hello_world\Xilinx_Zynq7k_BSP_ARMARCH7diab\Hello_world\[

Figure 20: **Launching the Debug Kernel Task**

7. Click **OK**. Application execution is stopped at the entry function hello (). The serial terminal connected to the board displays the following message:

   ```
   Break at 0x005060e0: hello        Task: 0x201fe5e8 (tHello)
   ```

   Note: The message can differ slightly as it depends on your Kernel settings. It just indicates that a task was downloaded and stopped for debug.

8. In the debug window, click **Run**. The terminal window displays **Hello Wind River**.

Software Application (Peripheral Access) – Creation, Development and Debug (ZC702 Only)

This section explains how to modify the *Hello_World* application to access the GPIO peripheral on the ZC702 board. MIO pin 10 is connected to an LED (DS23) on the ZC702 board. All of the peripheral address space is listed in the *Zynq-7000 All Programmable SoC Technical Reference Manual* (UG585) [Ref 4]. From that list, the base address of the GPIO peripheral is `0XE000A000`.

To access MIO pin 10 as an output, the following configuration must be implemented:

1. Set the direction to *output* by writing a `1` to bit 10 of the *gpio.DIRM_0* register.
2. Enable the output by writing a `1` to bit 10 of the *gpio.OEN_0* register.
3. Write a `1` to bit 10 of the *gpio.DATA_0* register to control the LED.

The default configuration of the VxWorks BSP MMU table allows access to a limited set of addresses space in the Zynq-7000 AP SoC. You can access these limited set of addresses with their physical addresses directly from the user space. If you need to access the addresses which are not in this set, then that particular physical address needs to mapped to the addresses of the VxWorks BSP MMU table. This mapping is done using the API *pmapGlobalMap();*". You can check the list of default access addresses provided by entering the command **vmContextShow** at the VxWorks command prompt.

The following code snippet illustrates the configuration procedure:

```
#include <stdio.h>
#include <vxWorks.h>
#include <vmLibCommon.h>
#include <pmapLib.h>
// Zynq-7000 GPIO Peripheral Details
#define GPIO_BASE 0xE000A000
#define GPIO_DIRM_0 0x00000204/sizeof(UINT32)
#define GPIO_OEN_0 0x00000208/sizeof(UINT32)
#define GPIO_DATA_0 0x00000040/sizeof(UINT32)
// Physical Address Mapping Library Wrapper Function
UINT32 *phyTovirt (UINT32 phyaddr,size_t size)
{
     UINT32 *virtAddr;
     virtAddr = (UINT32 *)pmapGlobalMap ((PHYS_ADDR) phyaddr,(size_t) size,
     MMU_ATTR_SUP_RW | MMU_ATTR_CACHE_OFF | MMU_ATTR_CACHE_GUARDED);

     if (virtAddr == PMAP_FAILED)
     {
           printf ("pmapGlobalMap returned ERROR.\n");
           return 0;
     }
     else
     {
           printf("virtual address is %p.\n",virtAddr);
     }
     return virtAddr;
}
main()
{
     // Zynq-7000 GPIO Peripheral Configuration through Virtual Address Space
     UINT32 *GPIO_BASE_virtaddr = phyTovirt(GPIO_BASE,0x1000);
     UINT32 val=0xffffffff;
     // Set GPIO Bit10 Direction to Out
     sysOutLong(GPIO_BASE_virtaddr + GPIO_DIRM_0, 0x00000400);
     // Set GPIO Bit10 OEn to Enable Output Driver
     sysOutLong(GPIO_BASE_virtaddr + GPIO_OEN_0, 0x00000400);
     while (1)
     {
           // Toggle GPIO content by XOR'ing value
           sysOutLong(GPIO_BASE_virtaddr + GPIO_DATA_0, val);
           sleep(1);
           val ^=0xffffffff;
     }
     return OK;
}
```

Save this file, then build and debug this application following steps 7 to 10 of the previous section, Debug an Application using Wind River Workbench. The result is that the LED toggles every second.

Conclusion

This application note describes the procedures to use the Wind River Workbench to configure, build, compile, and debug the VxWorks BSP, kernel image, user space VxWorks RTOS application, and access the Zynq-7000 AP SoC processing system peripherals from user space by using the kernel services. These procedures support the building of a real-time system solution using a Zynq-7000 AP SoC and VxWorks RTOS. Example source code is provided to enable you to quickly start software development using the Wind River Workbench.

References

1. *Using VxWorks BSP with Zynq-7000 AP SoC* (VxWorks 6.9) (XAPP1158)
2. *Xilinx Software Development Kit (SDK) User Guide* (UG1145)
3. *ZC702 Evaluation Board for the Zynq-7000 XC7Z020 All Programmable SoC User Guide* (UG850)
4. *Zynq-7000 All Programmable SoC Technical Reference Manual* (UG585)
5. *Zynq-7000 All Programmable SOC: Concepts, Tools and Techniques (CTT)* User Guide (UG873)
6. *Vivado Design Suite User Guide - Embedded Processor Hardware Design* (UG898)
7. *Vivado Design Suite Tutorial - Embedded Processor Hardware Design* (UG940)
   -Lab 1: Building a Zynq-7000 Processor Design
8. *Zynq-7000 All Programmable SoC Software Developers Guide* (UG821)
   -Chapter 3: Boot and Configuration
   -Appendix A: Using Bootgen
9. Wind River support at http://www.windriver.com/company/contact/
   -VxWorks Device Driver Developer's User Guide, 6.0
   -VxWorks Application Programmer's User Guide 6.7
   -Wind River Workbench User's Guide, 3.1

Appendix A: Development Environment Installation

VxWorks is provided as an integral part of a comprehensive Eclipse-based development environment, namely "Wind River Workbench". Offering project management, development and debug capabilities – all of which are leveraged throughout the remainder of this application note. Follow the these steps to install the environment:

1. Browse to Wind River's Electronic Software Download portal at https://wrsn.windriver.com/esd/faces/esd.jsp?orderNo=5006754&val=316861-108-SHQE-C7LHN.
2. Create a new account (or log in if you already have a Wind River Online support account).
3. Once logged in, click the download button and follow the instructions for installing your Wind River products. Make sure that the Xilinx Zynq-7000 Board Support Package (BSP) is selected at the time of Wind River product installation. For further details refer to Wind River support at http://www.windriver.com/company/contact/.
4. Activate the products through the Wind River licensing portal at http://www.windriver.com/licensing.

Appendix B: Customizing uBoot for the Avnet Mini-ITX Development Kit

This appendix explains how to make the BOOT.BIN with a u-boot source. Wind River modified the vendor-supplied u-boot source code to support booting up the uVxWorks image.

1. You can retrieve the U-boot source code from the Xilinx repository by using this command: **git clone git://git.xilinx.com/u-boot-xlnx.git**
2. Download package *Zynq_Mini-ITX_z7045_Ubuntu_FAT_v2013_4.zip* from: http://www.zedboard.org/support/design/2056/17
3. Checkout the u-boot source code and switch the git branch to a particular version of u-boot source by using this command:
   cd u-boot-xlnx and git checkout -b xilinx-v2013.4

   Note: Refer to document *Ubuntu_on_Zynq_Tutorial_03.pdf* located in the `Zynq_MiniITX_z7045_Ubuntu_FAT_v2013_4` folder for detailed information and follow the same steps to configure any version of u-boot to support the Zynq-Mini-ITX development board.
4. Unzip the file `Zynq_Mini-ITX_z7045_Ubuntu_FAT_v2013_4.zip` and find files `boards.cfg` and `zynq_mitx.h` in the *Zynq_Mini-ITX_z7045_Ubuntu_FAT_v2013_4* directory and copy `boards.cfg` to the top directory and `zynq_mitx.h` to the */include/configs* directory of the u-boot source code.
5. Compile the u-boot source code to generate the u-boot executable. Before this install the proper cross compiler, assuming your cross compiler is called, for example, *arm-xilinx-linux-gnueabi-gcc*. You can compile u-boot source code by entering the following series of commands: `

```
export CROSS_COMPILE=arm-xilinx-linux-gnueabi-

make distclean

make zynq_mitx_config

make
```

6. After executing this series of commands, a file with the name *u-boot* is created. Rename the u-boot file **u-boot.elf**.
7. Use the `zynq_fsbl.elf` file from the *`Zynq_Mini-ITX_z7045_Ubuntu_FAT_v2013_4`* directory and the `u-boot.elf` file created in above steps to create the BOOT.BIN image. The BOOT.BIN image needs to be packaged by the Xilinx tool *bootgen*, available in the Xilinx SDK tool.

Revision History

The following table shows the revision history for this document.

Date	Version	Revision
05/08/2015	1.0	Initial Xilinx release

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