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Mastering AMD MicroBlaze™ Processor: The PetaLinux Class

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Objective

The objective of this lab are:

1. Create an AMD MicroBlaze™ processor system using AMD Vivado™ software
2. Create a PetaLinux project for the AMD MicroBlaze processor
3. Update the PetaLinux to support SPI and I^2C interfaces
4. Develop SW and Debug SW application using AMD Vitis™ software
5. Develop a boot image for the development board

Development Tools

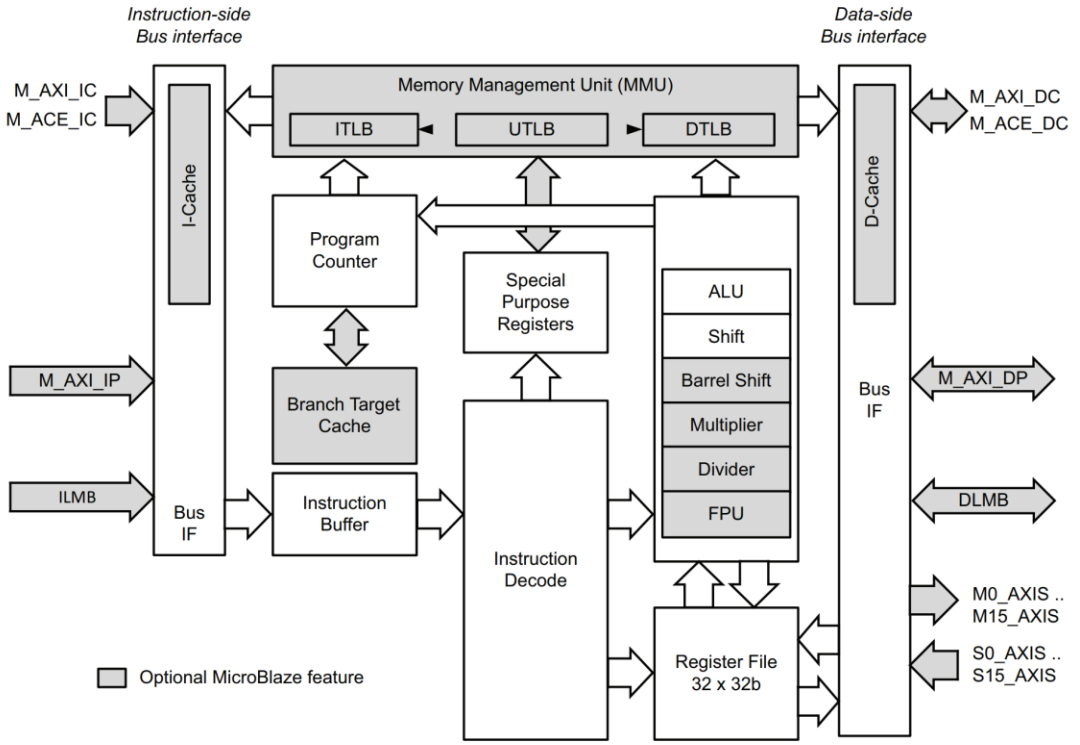
To complete this lab, we will need the following tools installed:

1. AMD Vivado™ software (version 2023.2)
2. AMD Vitis™ software (version 2023.2)
3. PetaLinux 2023.2

You will need a either a native Linux development environment or virtual machine for the PetaLinux project creation. See my Hackster project here for step-by-step instructions on creating a VM.

AMD MicroBlaze™ Processor

- Softcore processor
- Harvard Architecture
- Scalable from small micro to running Linux
- Performance scales with configuration options
- Can be implemented in TMR solution (very useful for high rel)



What is PetaLinux? (A set of tools)

A build system:

- A set of open-source cross-platform development command line and menu tools for use running under an x86 Linux Host OS
- Just six PetaLinux commands (with many options):

`petalinux-create`, `petalinux-config`, `petalinux-build`, `petalinux-boot`, `petalinux-package`, `petalinux-util`

- The build system tailors embedded Linux to run on many different AMD platforms: AMD Zynq™ MPSoC, AMD Zynq 7000 SoCs and the AMD MicroBlaze™ processor. See: https://www.xilinx.com/support/answers/71653.html
- PetaLinux tools now use the open-source community Yocto system since v2016.3
  - This is very useful for embedded Linux developers!
- Also includes an emulator (QEMU) that can emulate PetaLinux under x86 Linux
  - Very useful for Kernel and some device driver development

What is PetaLinux? (What comes with it)

Source code, libraries, applications and Yocto recipes

- Mostly open-source based with a few exceptions for some hardware drivers
- PetaLinux includes and manages the Linux kernel sources and libraries
- Various hardware drivers and modules
- Traditional Linux applications and utilities

Through Yocto, PetaLinux can make use of additional embedded Linux applications beyond what AMD supplies.

- More on that later!

A more complete list of what is included by AMD can be found here:

https://www.xilinx.com/support/answers/71653.html

What is PetaLinux? (What goes in the firmware)

Includes Bootloaders, Trusted Platforms

- U-Boot, FSBL, Arm® Trusted Firmware,

AMD Vivado™ Software Hardware Designs

- PetaLinux device drivers work with Vivado IP blocks
- PetaLinux imports hardware designs into the PL (FPGA)

A Linux OS that runs on the AMD Zynq™ MPSoC, AMD Zynq 7000 SoC (or AMD MicroBlaze™ processor) CPUs

- 2018.3 uses Linux Kernel version 4.14
- For single or multiple CPUs

Linux applications, device drivers and lots of configuration files

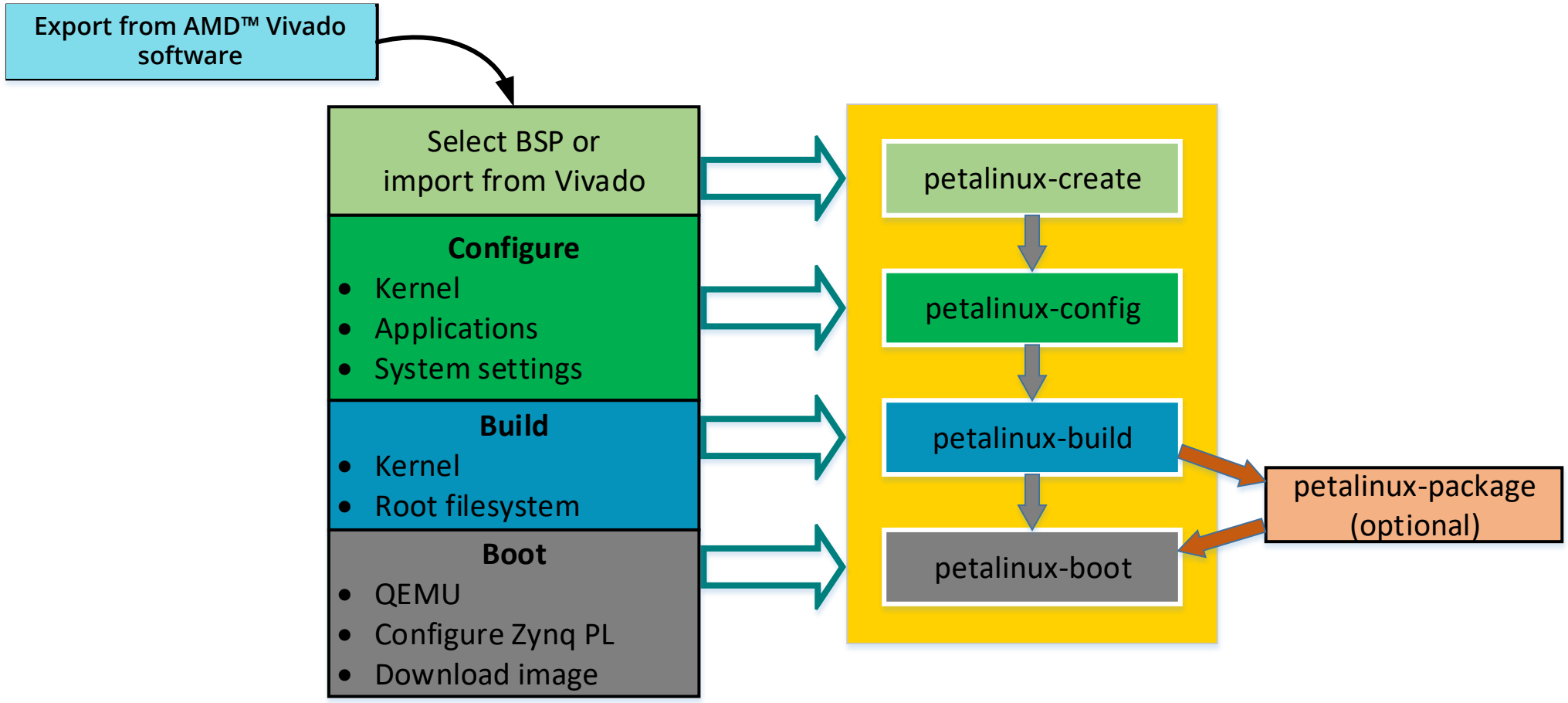
Detailed hardware and memory requirements can be found here: http://www.xilinx.com/cgi-bin/docs/rdoc?v=latest;d=ug1144-petalinux-tools-reference-guide.pdf

This is User Guide 1144: it is THE master reference book for PetaLinux!

PetaLinux Tools Testing, Release, and Documentation

- u-boot, Linux kernel, Xen hypervisor
  - Sources:
    - Kernel.org + AMD patches
  - Testing:
    - AMD silicon and AMD reference board features
  - Documentation:
    - Source code
    - Open source communities/forums
    - Answer Records for select interim issues
- Linux file system
  - Sources:
    - Yocto community code base
  - Testing:
    - Build verification
    - Testing of unique software and features from AMD
  - Release strategy:
    - Bug fixes with next Yocto release integration
  - Documentation:
    - Source code
    - Open source communities/forums

PetaLinux Tools Flow



What is The Yocto Project?

The Yocto Project is an open source collaboration project that provides templates, tools and methods to help you create custom Linux-based systems for embedded products regardless of the hardware architecture. It was founded in 2010 as a collaboration among many hardware manufacturers, open-source operating systems vendors, and electronics companies to bring some order to the chaos of embedded Linux development.

It's a framework, not a distribution

- Allows users to create ***their own*** distributions
- Contains reference distributions

Commonly used by several organizations:

- Wind River Linux
- Mentor Embedded Linux
- Just about everyone else…

Uses a build tool called **bitbake**

PetaLinux 2018.3 abstracts most of the bitbake details, commands, etc.

Why Yocto?

The challenge…

- Linux is becoming increasingly popular for embedded systems
- Non-commercial and commercial embedded Linux has many distros

Leads to the result…

- Developers spend lots of time porting or making build systems
- Leaves less time/money to develop interesting software features
- The industry needs a common build system and core technology
- Industry leaders joined together in 2010 to form the Yocto Project

With these benefits…

- Less time spent on things which don't add value (build system, core Linux components)
- Linux grows more in embedded
- More time spent on product differentiation and interesting software

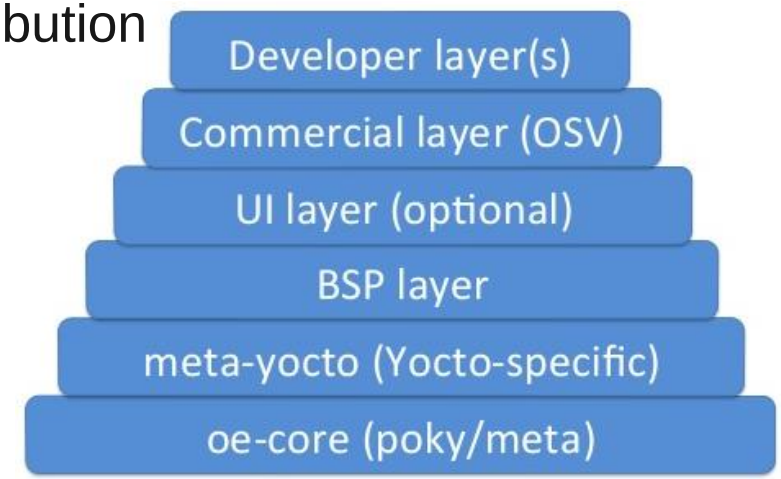
Yocto Layers, Recipes, and Bitbake

Yocto builds and assembles Linux images based on ***layers***

- Layers are named **meta-*something***, such as:
  - **meta-*yocto*, meta-*xilinx*, meta-*xilinx-tools*,** etc.

Layers consist of ***recipes***

- Recipes describe individual components of a target Linux distribution
- Can be written to do all sorts of things:
  - Apply source code patches to the kernel
  - Copy files to a target root filesystem
  - Build / install user applications
  - *Build and install kernel drivers for wireless modules*

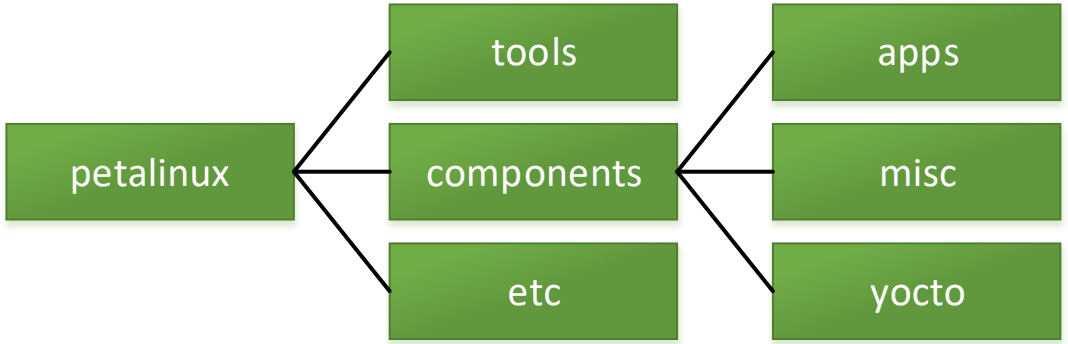


PetaLinux 2018.3 specifics

- Bitbake is abstracted using familiar commands, e.g. petalinux-build, etc.
- Layer set aside for user customization: <project>/project-spec/meta-user

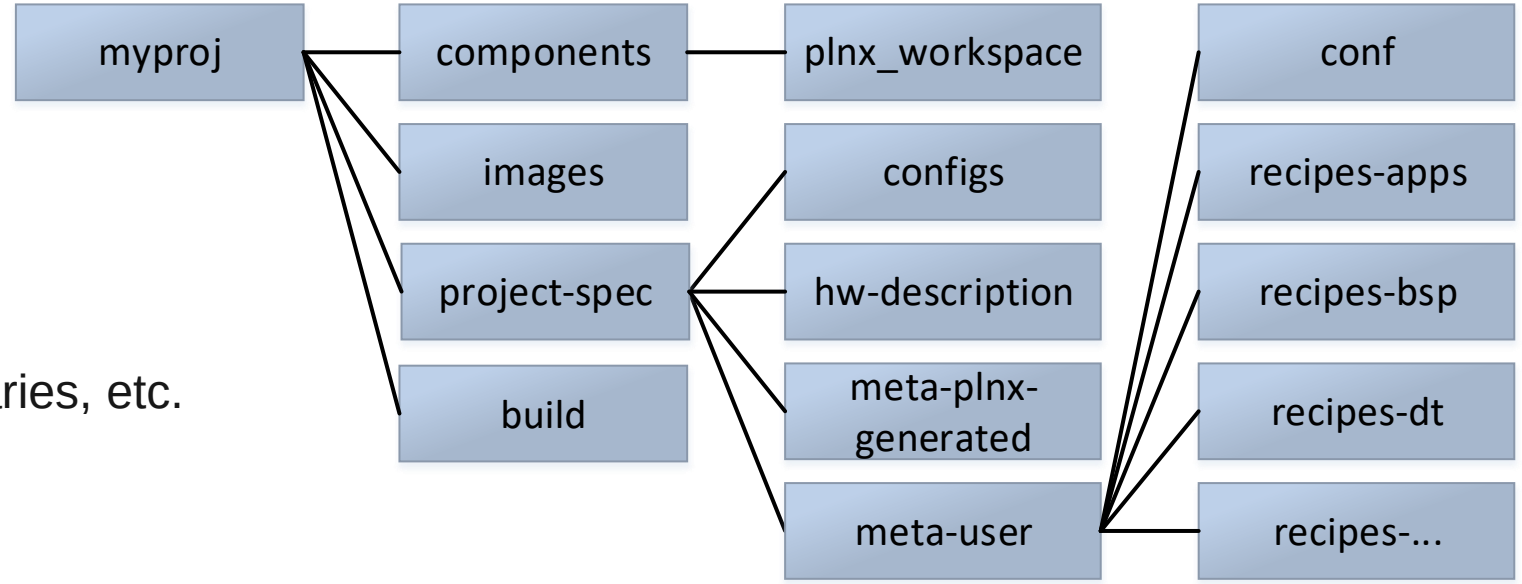
PetaLinux Install and Project Taxonomy

Tools and default source components in install area

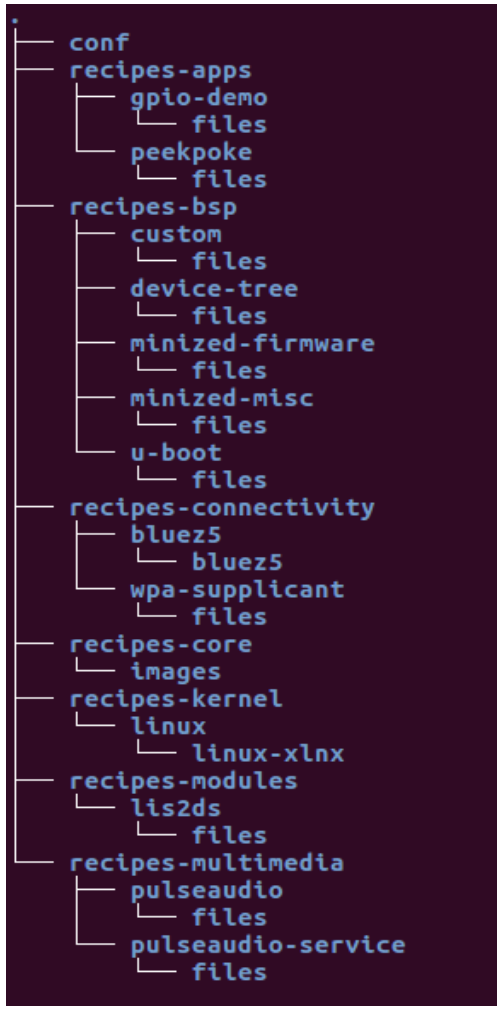


Per-project directory

- Configuration files
- Custom recipes
  - Applications, scripts, libraries, etc.
- Build products



PetaLinux Project Example



meta-user Sub-folder Name	Purpose
recipes-apps	Custom user applications
recipes-bsp	Customizations to the u-boot bootloader, device tree, hardware platform and user file additions to the root file system
recipes-connectivity	Networking protocols and support files
recipes-core	Configuration files to tell PetaLinux what recipes to add to the system
recipes-kernel	Kernel patches to correct, customize or enhance baseline kernel functionality
recipes-modules	Custom device drivers
recipes-multimedia	Custom application and support files for multimedia functionality

Device Tree

DTS file

- Device Tree Source
- Textual description of system device tree

DTB

- Device Tree Blob
- Compiled, binary representation of the DTS

DTC

- Device Tree Compiler
- Provided in PetaLinux installation
- Converts the DTS to a DTB
- Can de-compile a DTB back to a DTS

Device Tree Structure

A DTB is provided to the kernel at boot time

- » Kernel startup code parses the tree
- » Instantiates and initializes kernel appropriately
  - System memory location/size
  - Device types, address mappings, configuration options

Kernel infrastructure binds drivers to devices

- » Matched against the "compatible" property in the device node
- » Device driver declares known "compatible" devices

Greatly simplifies the problem of device ↔ driver binding

Device Tree Source Example (shown on right)

```
40 &sdhci0 {
41     status = "okay";
42     bus-width= <4>;
43     xlnx,has-cd = <0x0>;
44     xlnx,has-power = <0x0>;
45     xlnx,has-wp = <0x0>;
46     non-removeable;
47     wifi-host; /* adding for compatibility w/ bcmdhd driver */
48 };
49
50 /* Define the external I2C devices and their names and addresses */
51 &axi_iic_0 {
52     #address-cells = <0x1>;
53     #size-cells = <0x0>;
54     compatible = "xlnx,xps-iic-2.00.a";
55     i2c5@1d {
56         #address-cells = <0x1>;
57         #size-cells = <0x0>;
58         compatible = "stm,lis2ds12";
59         reg = <0x1d>;
60     };
61 };
62
63 /* QSPI addresses are defined with petalinux-config, but here they are overwritten so that one can
   program the flash internally */
64 &qspi {
65     #address-cells = <1>;
66     #size-cells = <0>;
67     flash0: flash@0 {
68         compatible = "micron,m25p80";
69         reg = <0x0>;
70         #address-cells = <1>;
71         #size-cells = <1>;
72         spi-max-frequency = <50000000>;
73         partition@0x00000000 {
74             label = "boot";
75             reg = <0x00000000 0x00ff0000>;
76         };
77     };
78 };
```

Device Tree Creation

PetaLinux includes an automated device tree generator

- Generates device tree based on hardware design
- All IP cores and properties exported in DTS

Kernel build process compiles DTS → DTB and links into kernel image

- Auto-generated DTS files in <petalinux_project>/components/plnx_workspace/device-tree-generation/
  - Do not edit! Auto-generated on import of hardware platform from Vivado
- User-editable system-top.dts DTS file in <petalinux_project>/project-spec/meta-user/recipes-dt/device-tree/files/
  - User overwrite of default parameters and addition of new parameters
  - Changes to the system-top.dts will not be overwritten by subsequent petalinux-config

Role of the BSP

- Setting up the device tree for a board is important, as it can take considerable time.
- It is unlikely there will only ever be one project created
- The Board Support package provides a portable way of configuring Petalinux projects for the board with all the interfaces and applications correctly set up
- Single petalinux command can be used to create the BSP

Key Concept: Memory Management Unit

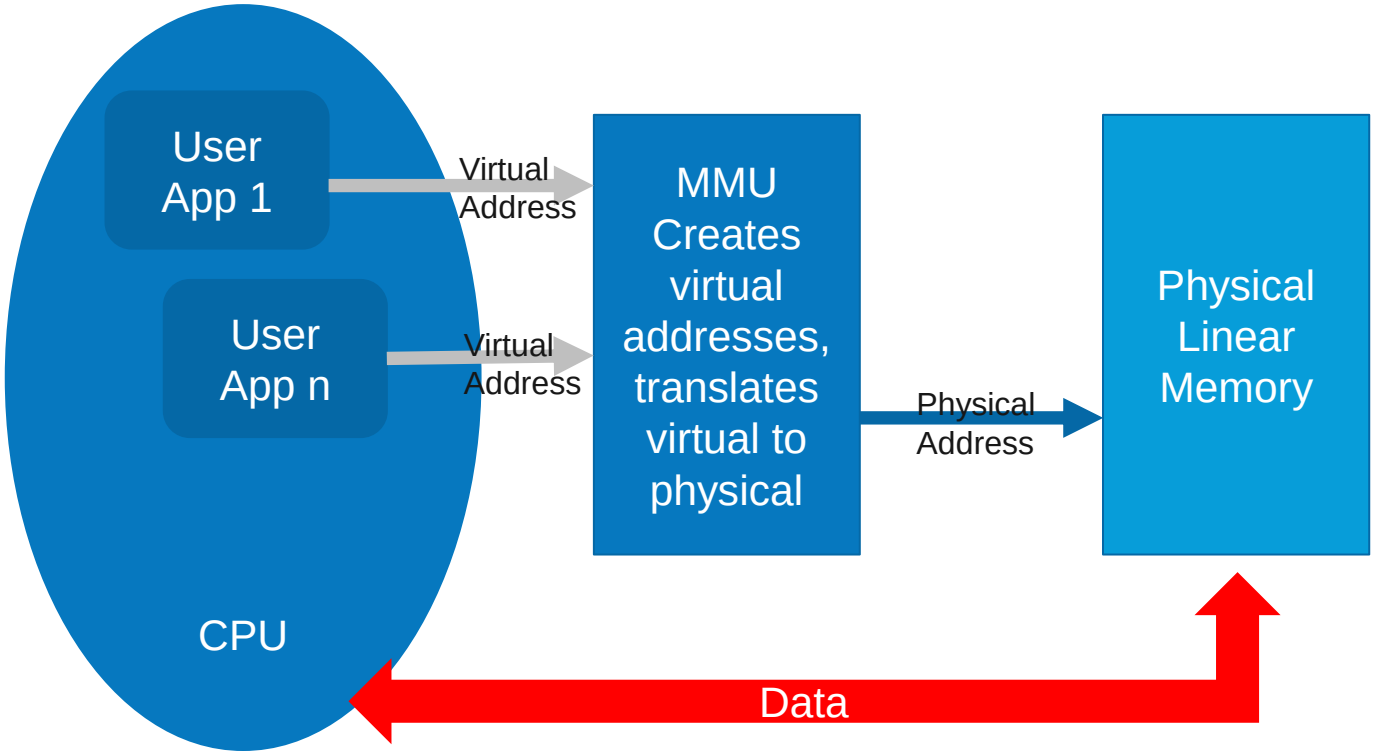
User applications access program and data from virtualized (pseudo) addresses

The MMU unit of the AMD Zynq™ MPSoC is the translator from virtual to physical addresses

Each user program runs as if it is the only program on the CPU

Each user program has its own unique memory mapped address space

Simplified Operation:



PetaLinux and Yocto Bitbake

PetaLinux commands abstract the details of the bitbake commands

- Creation of new software applications, kernel modules (drivers), scripts, etc.
- Add new bitbake recipes
- Additions to configuration menus
- Build, clean, config
- Installation onto the root file system

Easy edits to makefile and recipe as application complexity grows

- Add source files, etc.

PetaLinux command to build the root file system becomes bitbake command…

```
$ petalinux-build -c rootfs
```

```
$ bitbake petalinux-user-image -c do_rootfs
```

What is in a Bitbake Recipe?

Descriptive information about the package

The version of the recipe

Existing Dependencies

Where the source code resides

Whether the source code requires any patches

How to compile the source code

Where on the target machine to install the package being compiled

Simple Bitbake Recipe

Open

```
#
# This file is the lsm6dsl-sensor recipe.
#

SUMMARY = "Simple lsm6dsl-sensor application"
SECTION = "PETALINUX/apps"
LICENSE = "MIT"
LIC_FILES_CHKSUM = "file://${COMMON_LICENSE_DIR}/MIT;md5=0835ade698e0bcf8506ecda2f7b4f302"

SRC_URI = "file://main.c \
           file://Makefile \
                  "

S = "${WORKDIR}"

FILES_${PN} += "/home/root/*"

do_compile() {
             oe_runmake
}

do_install() {
             install -d ${D}${bindir}
             install -m 0755 lsm6dsl-sensor ${D}/home/root/
}
```

Location and MD5 checksum of the license file for the application

Location of the source file(s) and Makefile

Recipe instructions

Specify where the application should be installed

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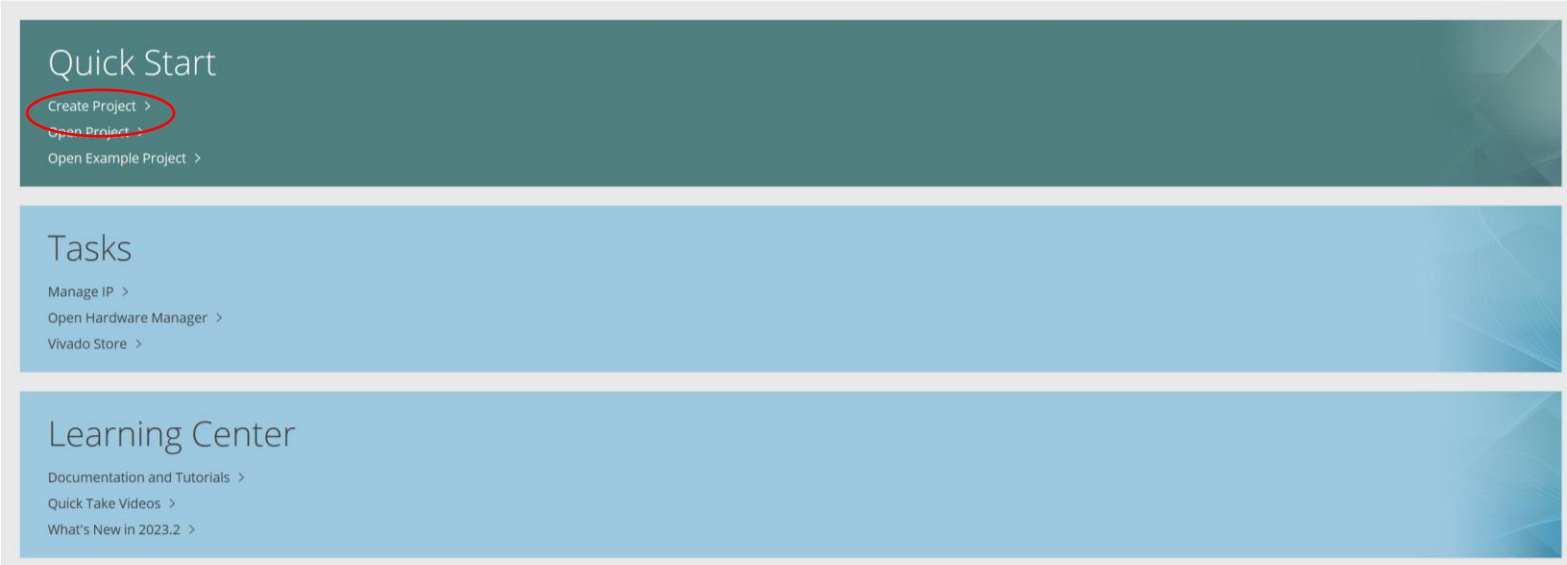
Embedded Linux Lab

Lab: Embedded Linux

1. Open AMD Vivado™ software (version 2023.2)

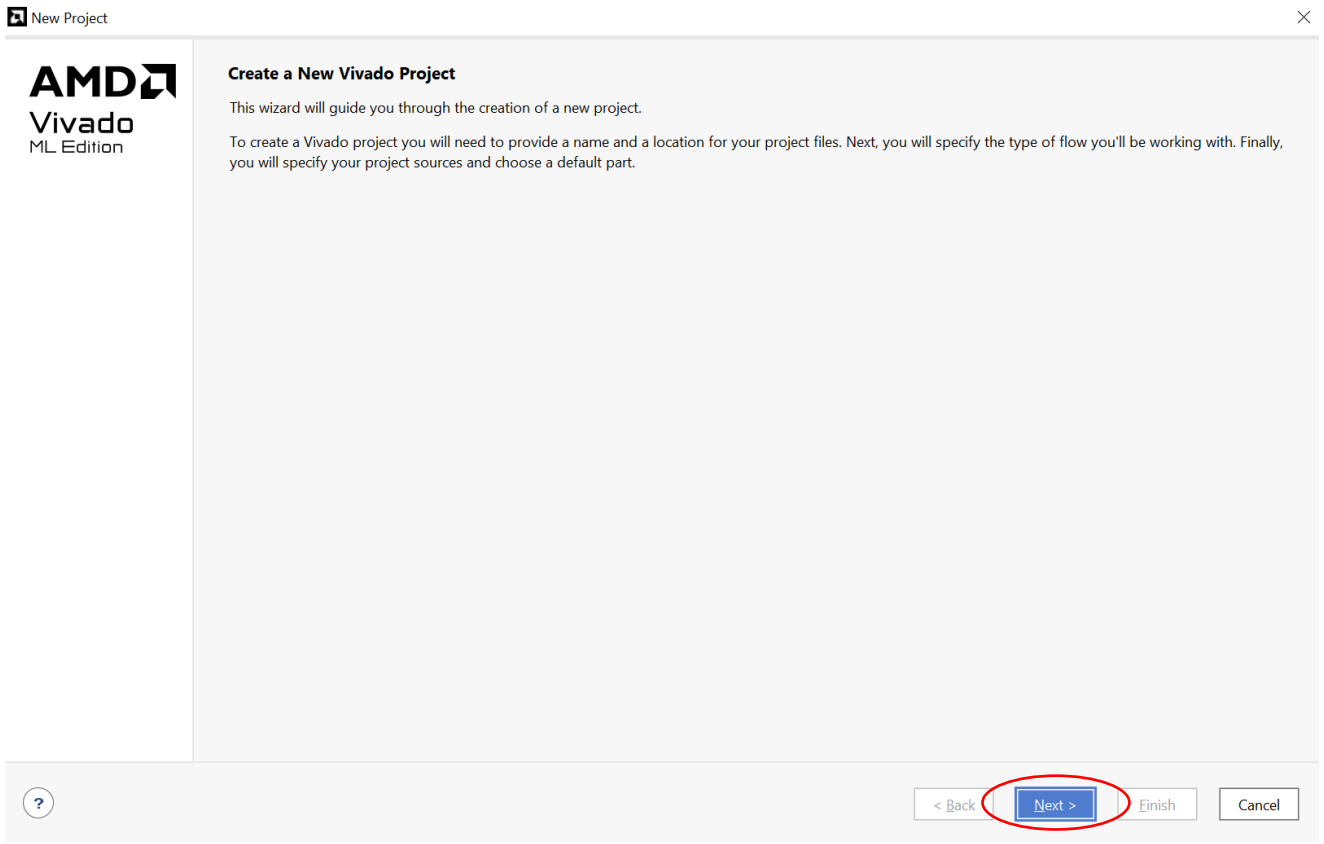
2. Click create new project

AMD
Vivado
ML Edition



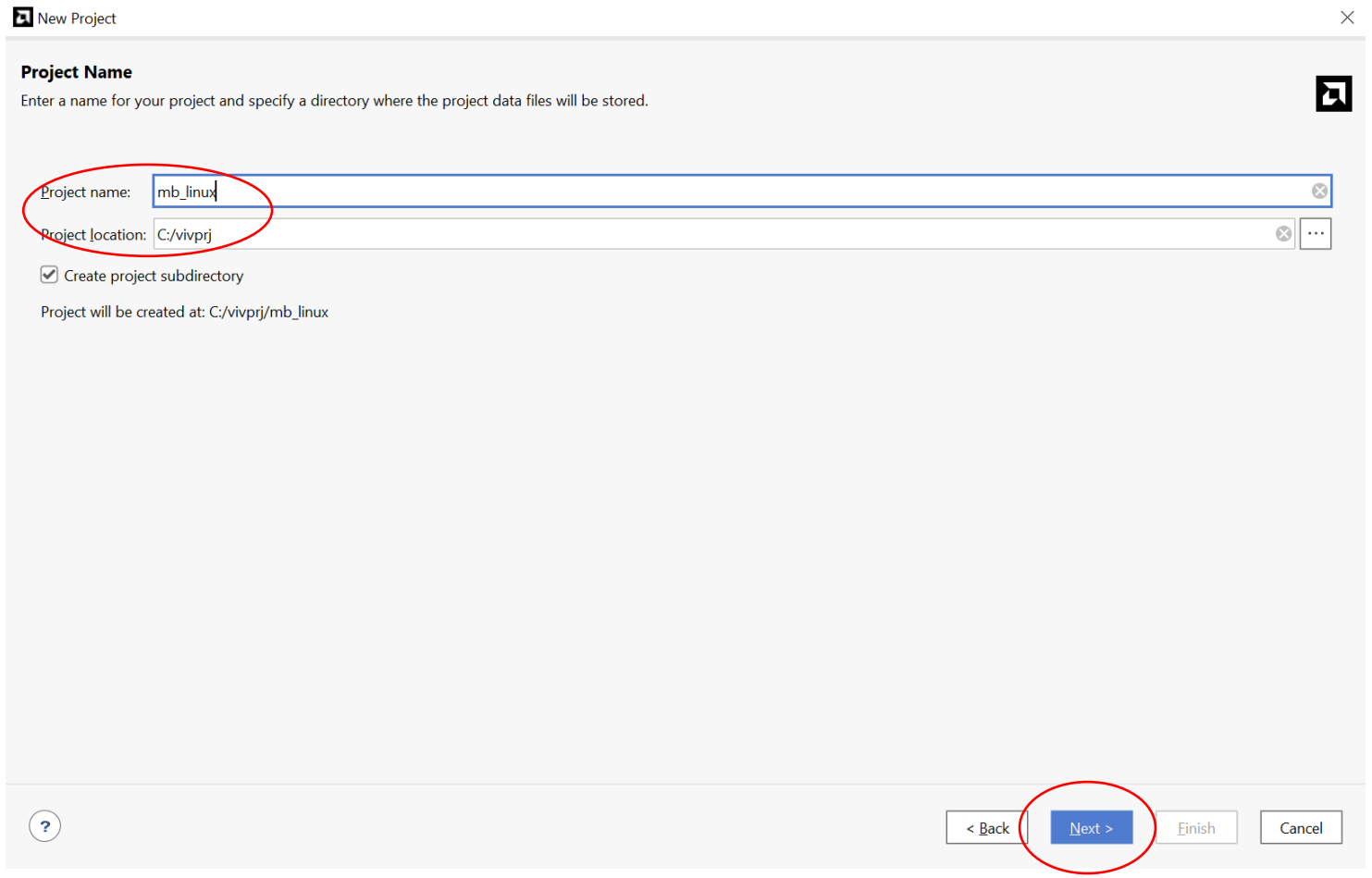
Lab: Embedded Linux

1. Click Next



Lab: Embedded Linux

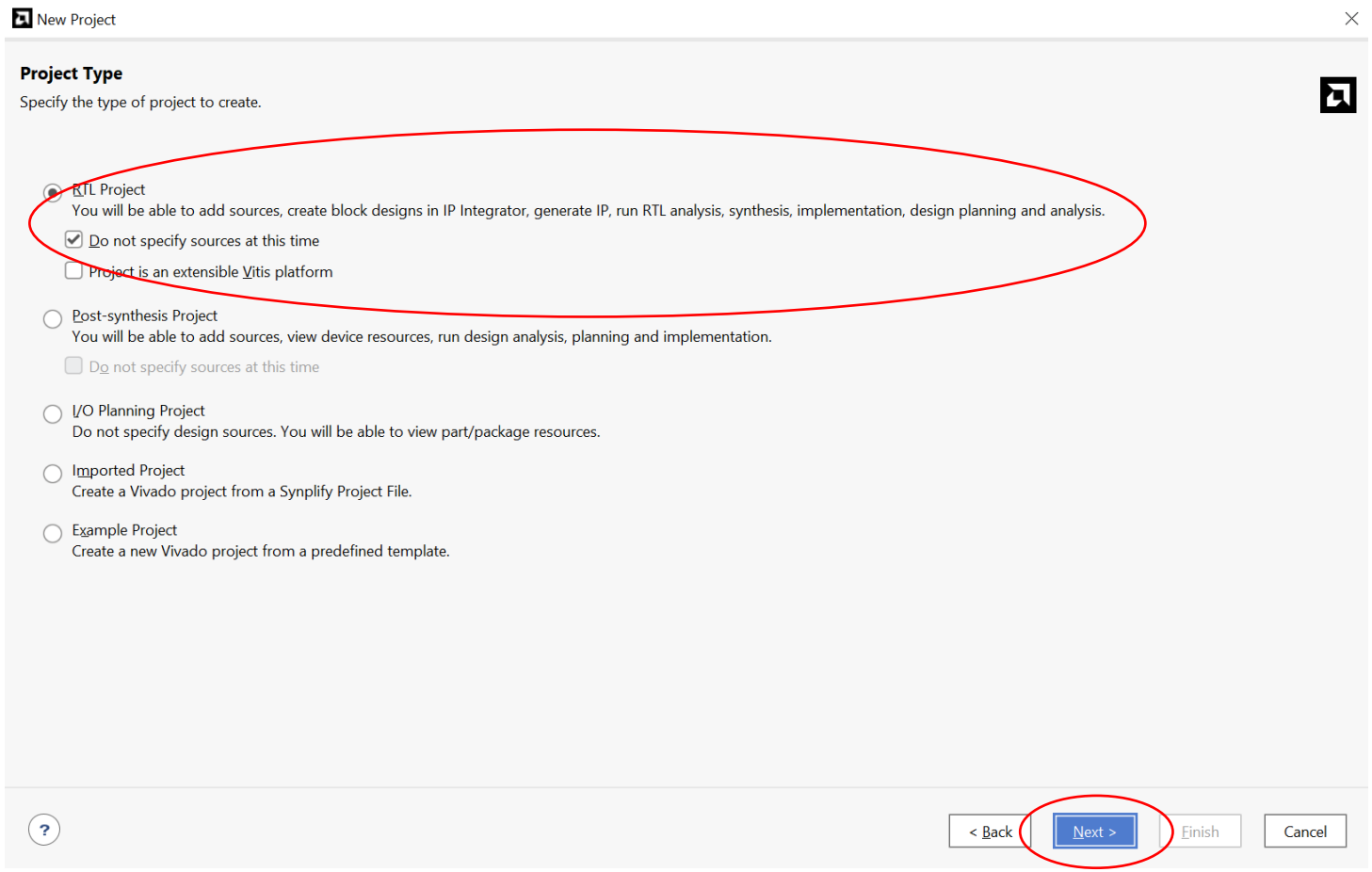
1. Enter a project name e.g. mb_linux
2. Enter a project location
3. Click next



Lab: Embedded Linux

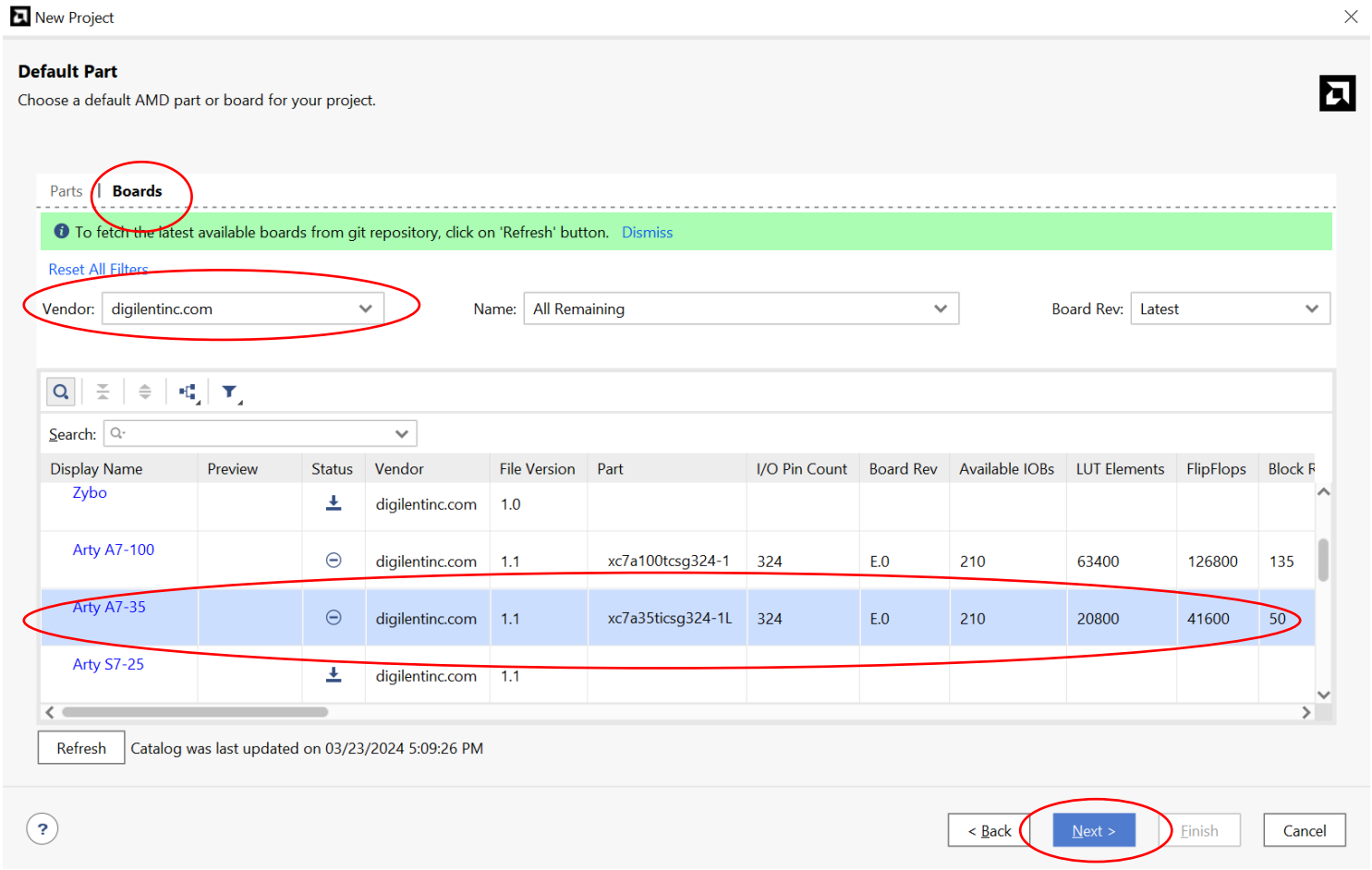
1. Select RTL project and ensure option "*Do not specify sources at this time*" is checked

2. Click Next



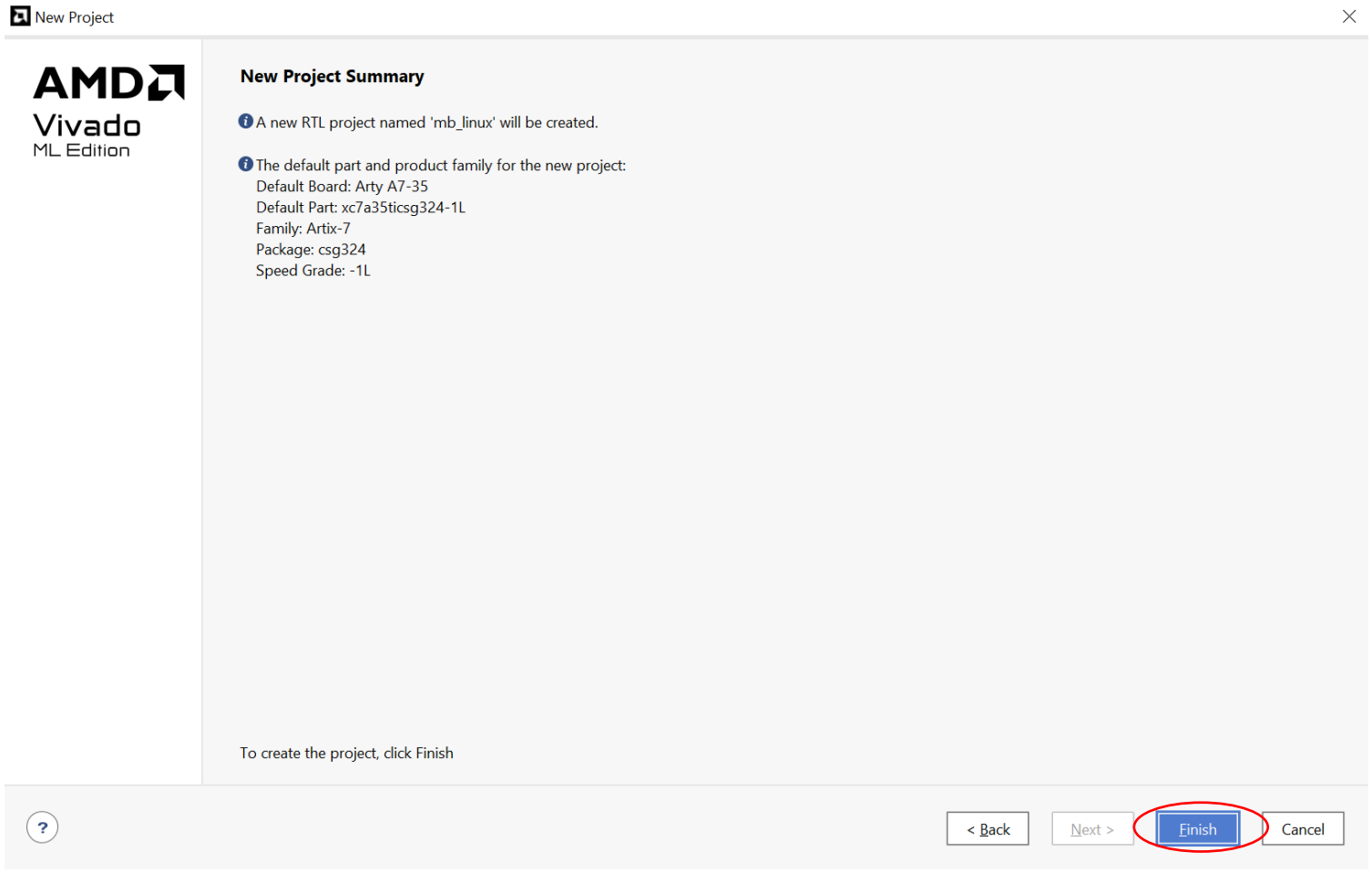
Lab: Embedded Linux

1. Click on boards
2. Select DigilentInc.com as the vendor
3. Select the Arty A7-35 or A7-100
4. Click Next



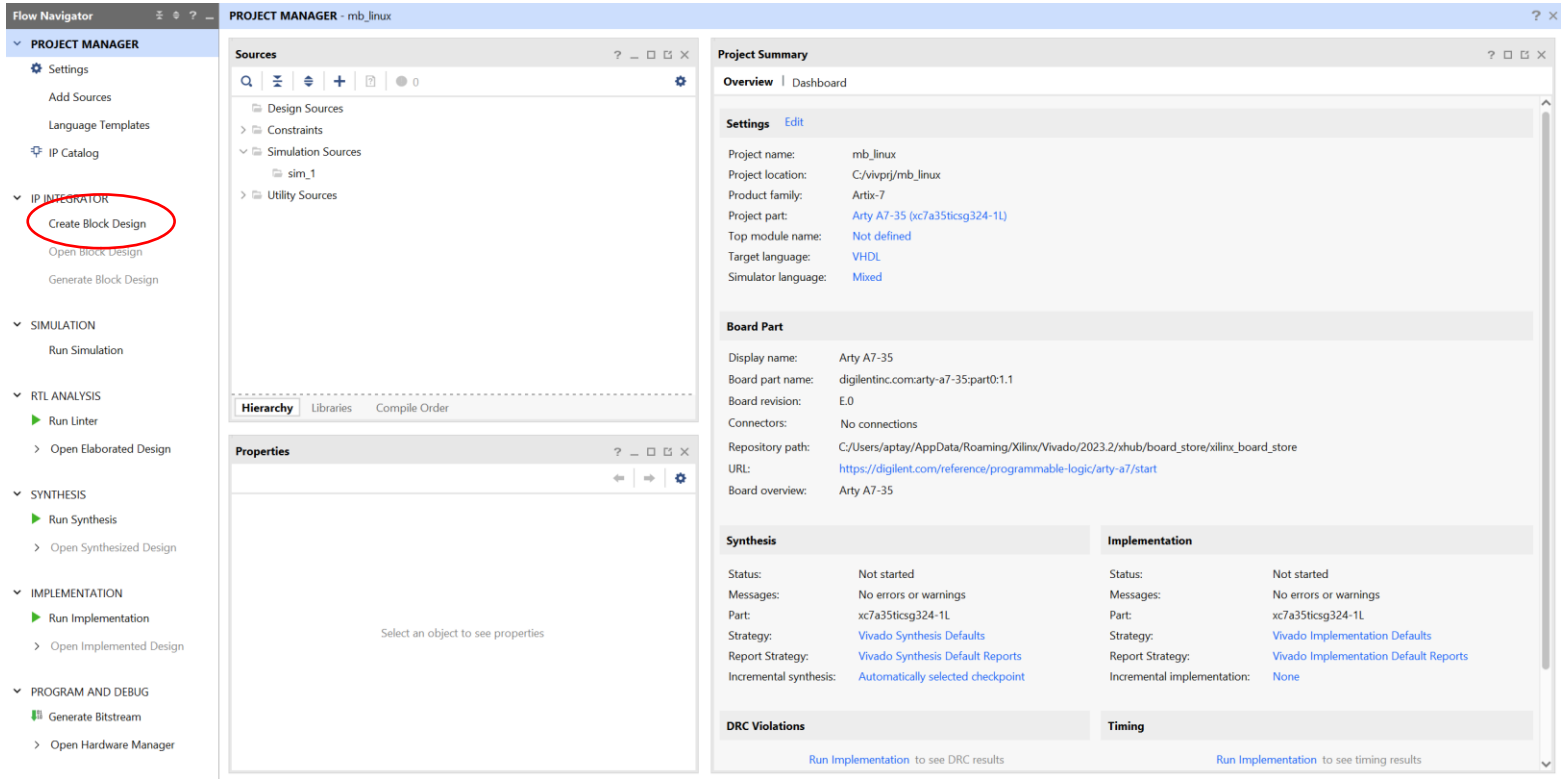
Lab: Embedded Linux

1. Click Finish



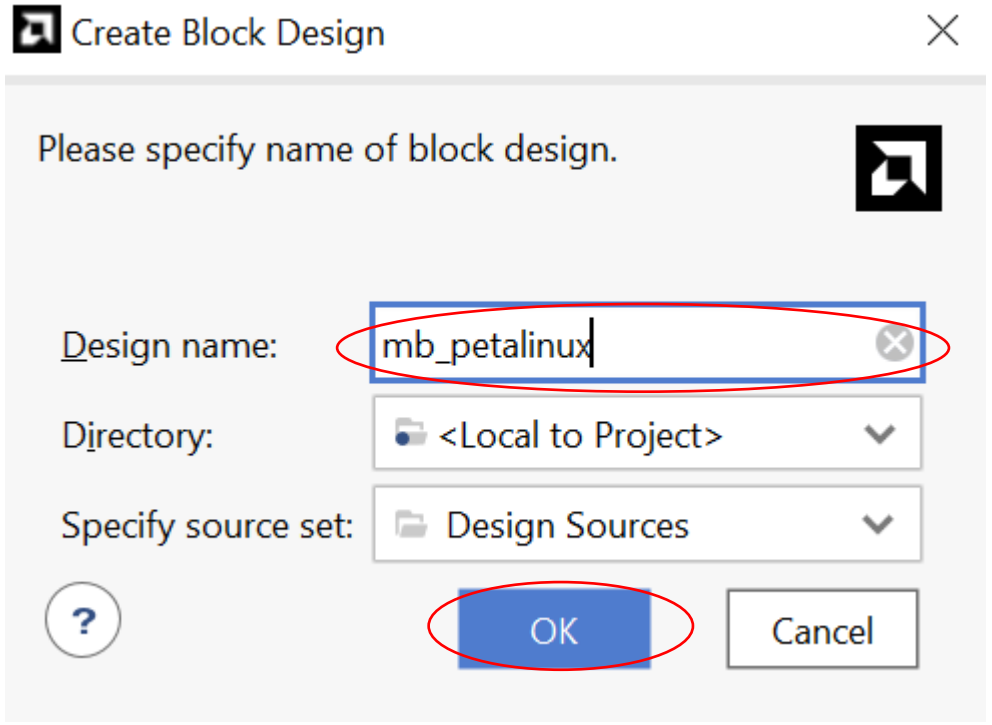
Lab: Embedded Linux

1. Click Create Block Diagram



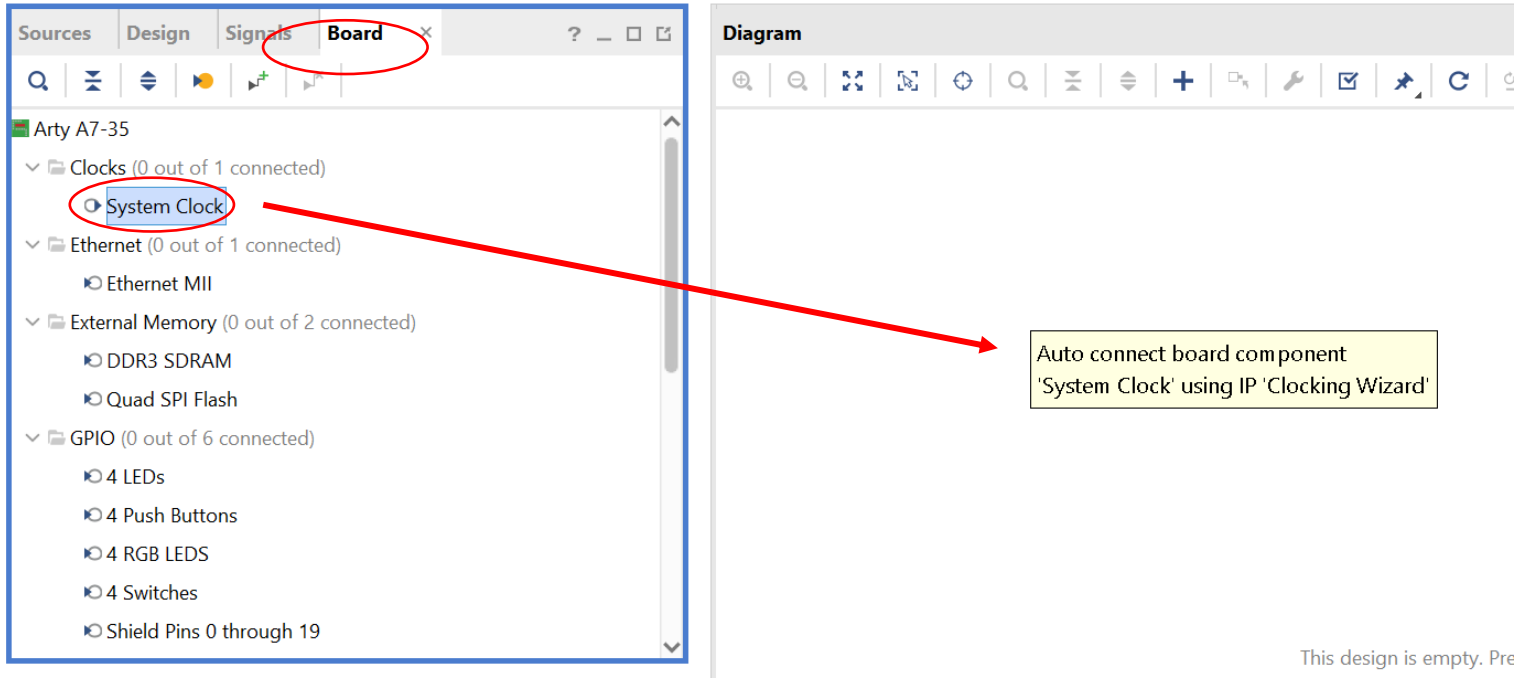
Lab: Embedded Linux

1. Enter the design name mb_petalinux
2. Click OK



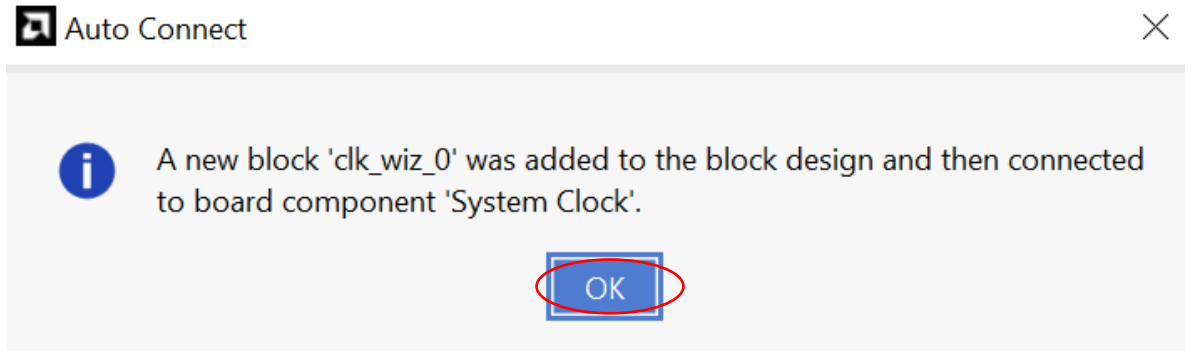
Lab: Embedded Linux

1. On the board tab, select the System Clock left click, hold and drag on to the diagram



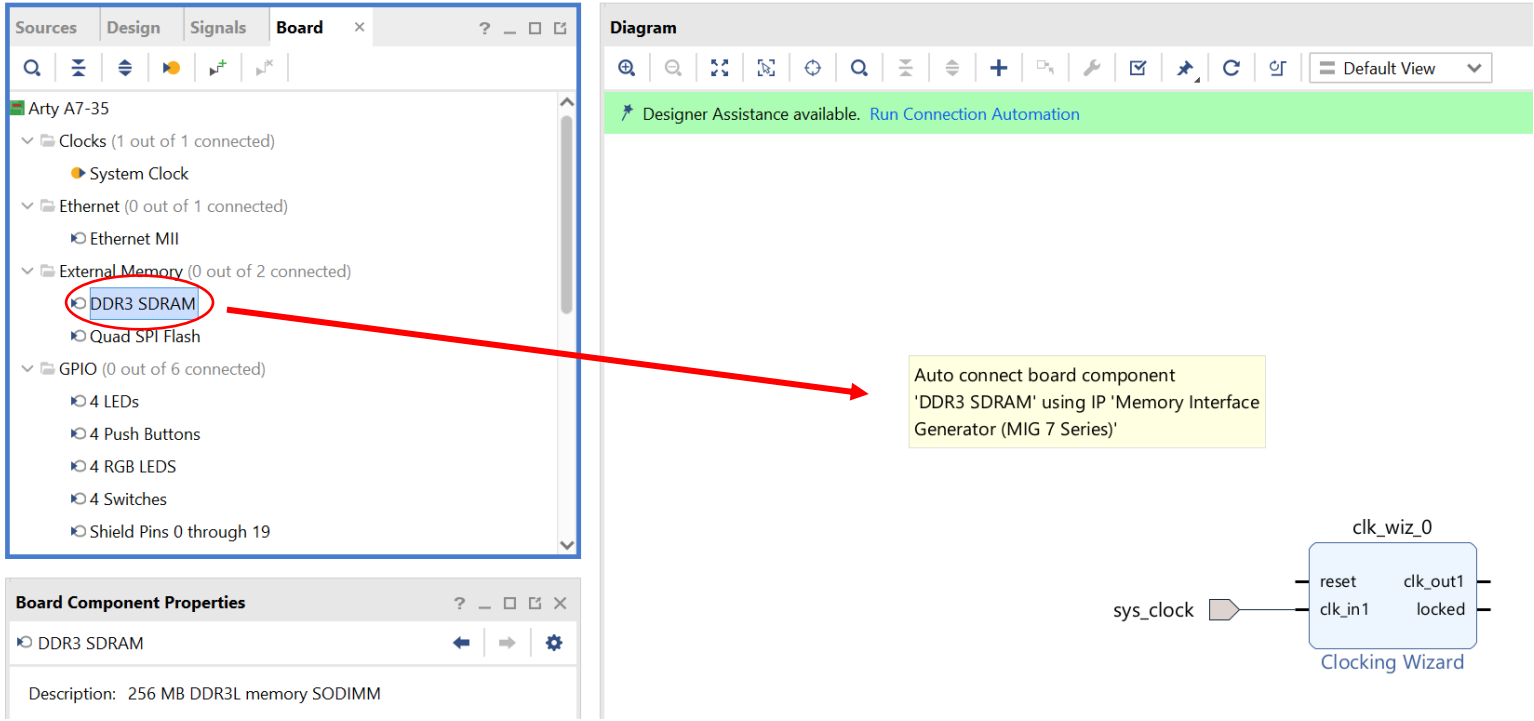
Lab: Embedded Linux

1. Click OK



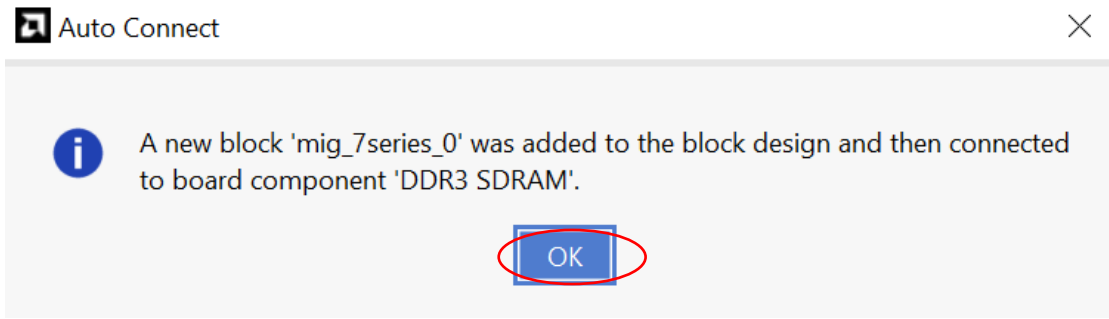
Lab: Embedded Linux

1. On the board tab, select the DDR3 SDRAM left click, hold and drag on to the diagram



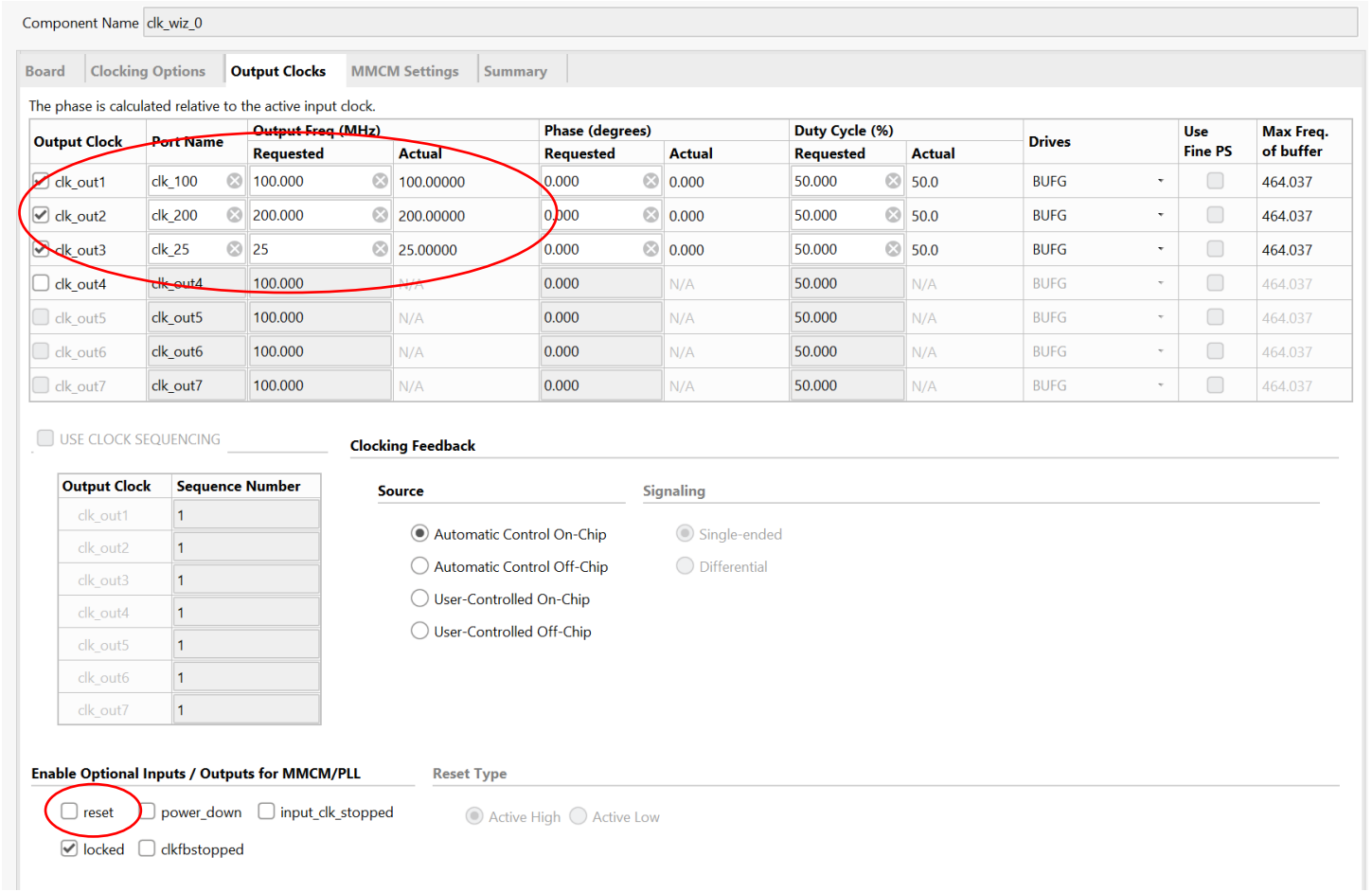
Lab: Embedded Linux

1. Click Ok



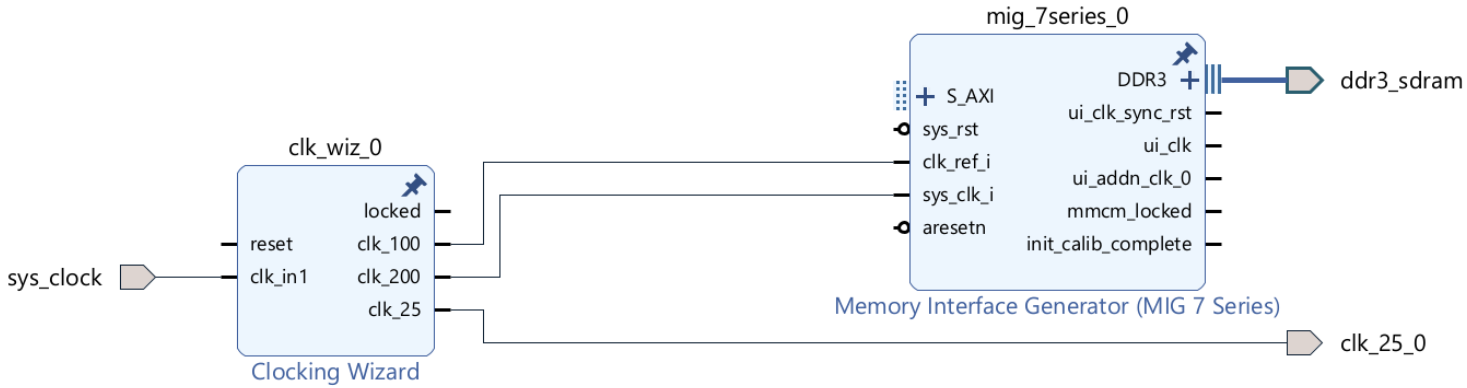
Lab: Embedded Linux

1. Re-customize the clock wizard
2. Set clk1 100 MHz
3. Set clk2 200 MHz
4. Set clk3 25 MHz
5. Uncheck the reset
6. Click OK



Lab: Embedded Linux

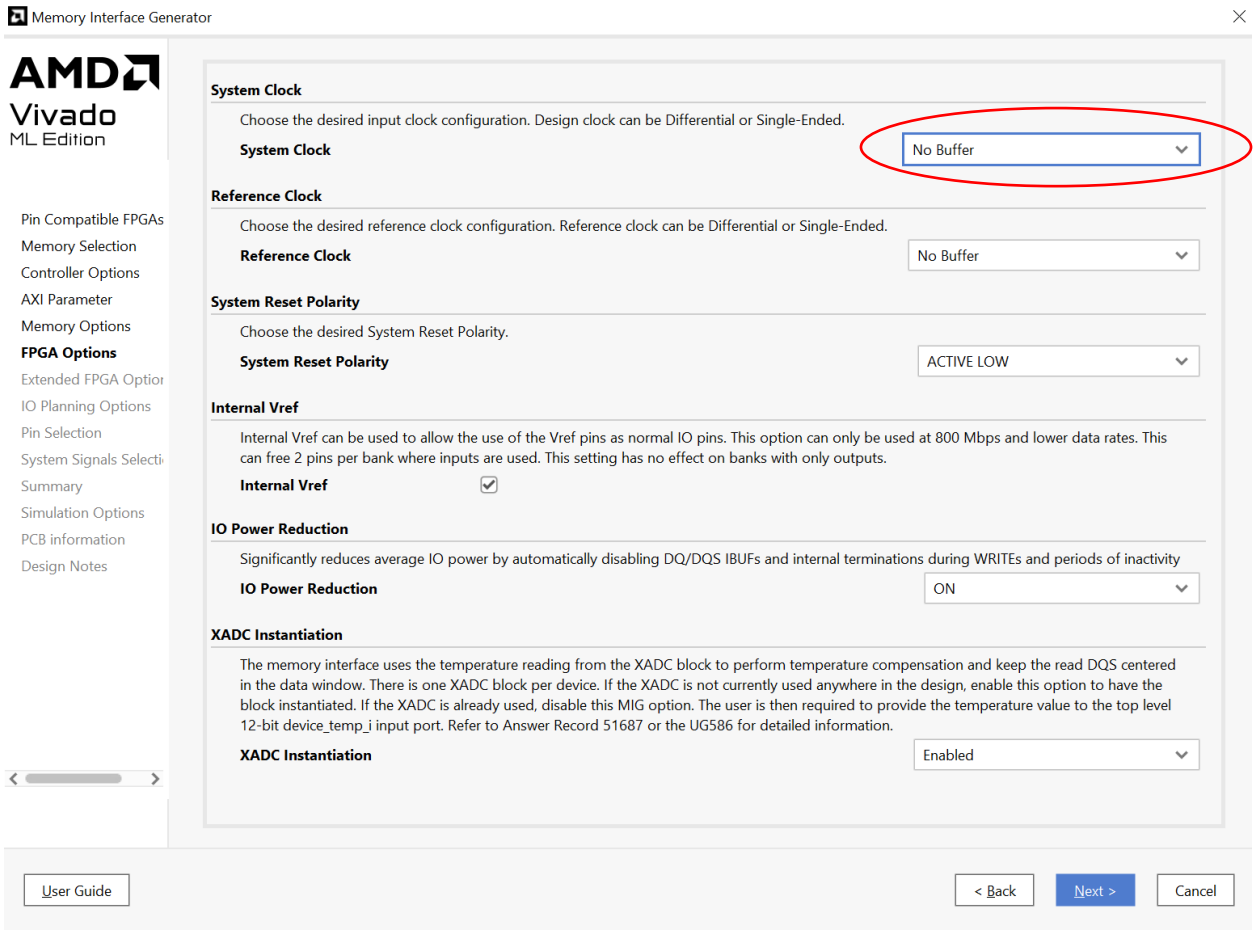
1. Delete the connections on the MIG
2. Connect 100MHz to clk_ref_i
3. Connect 200MHz to sys_clk_i
4. Make Clock 25MHz external



Lab: Embedded Linux

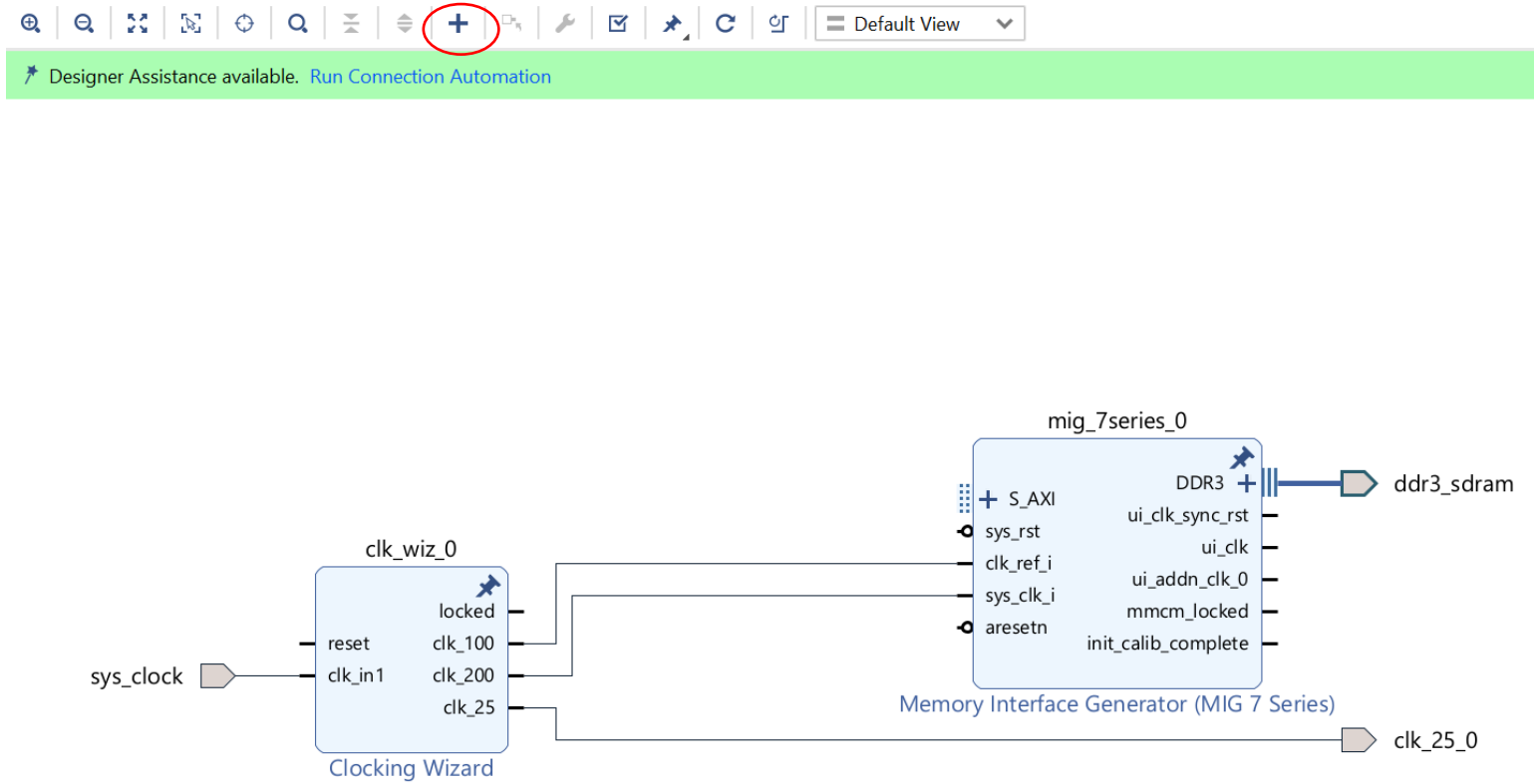
1. Double click on the MIG DDR3 and on the FPGA options page

2. Change the system clock to no buffer



Lab: Embedded Linux

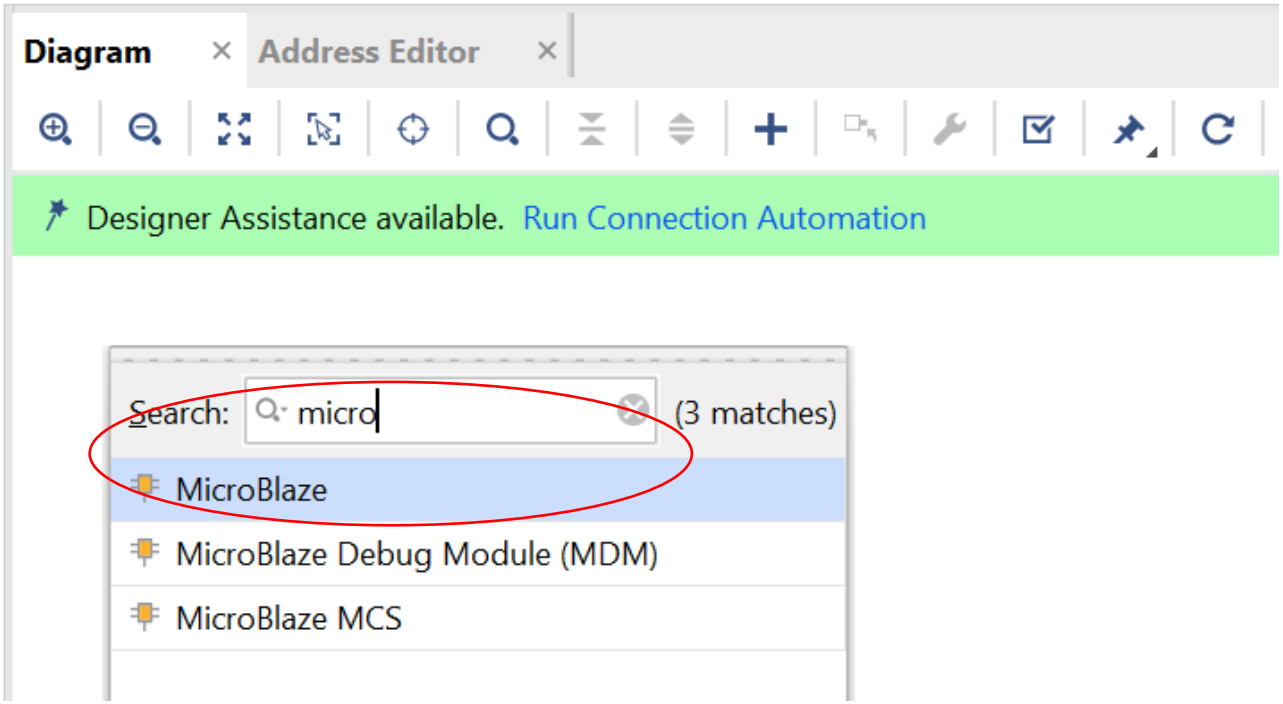
1. Click on the + symbol to open the IP selection library



Lab: Embedded Linux

1. In the search bar enter “Micro”

2. Select MicroBlaze and double click on it.

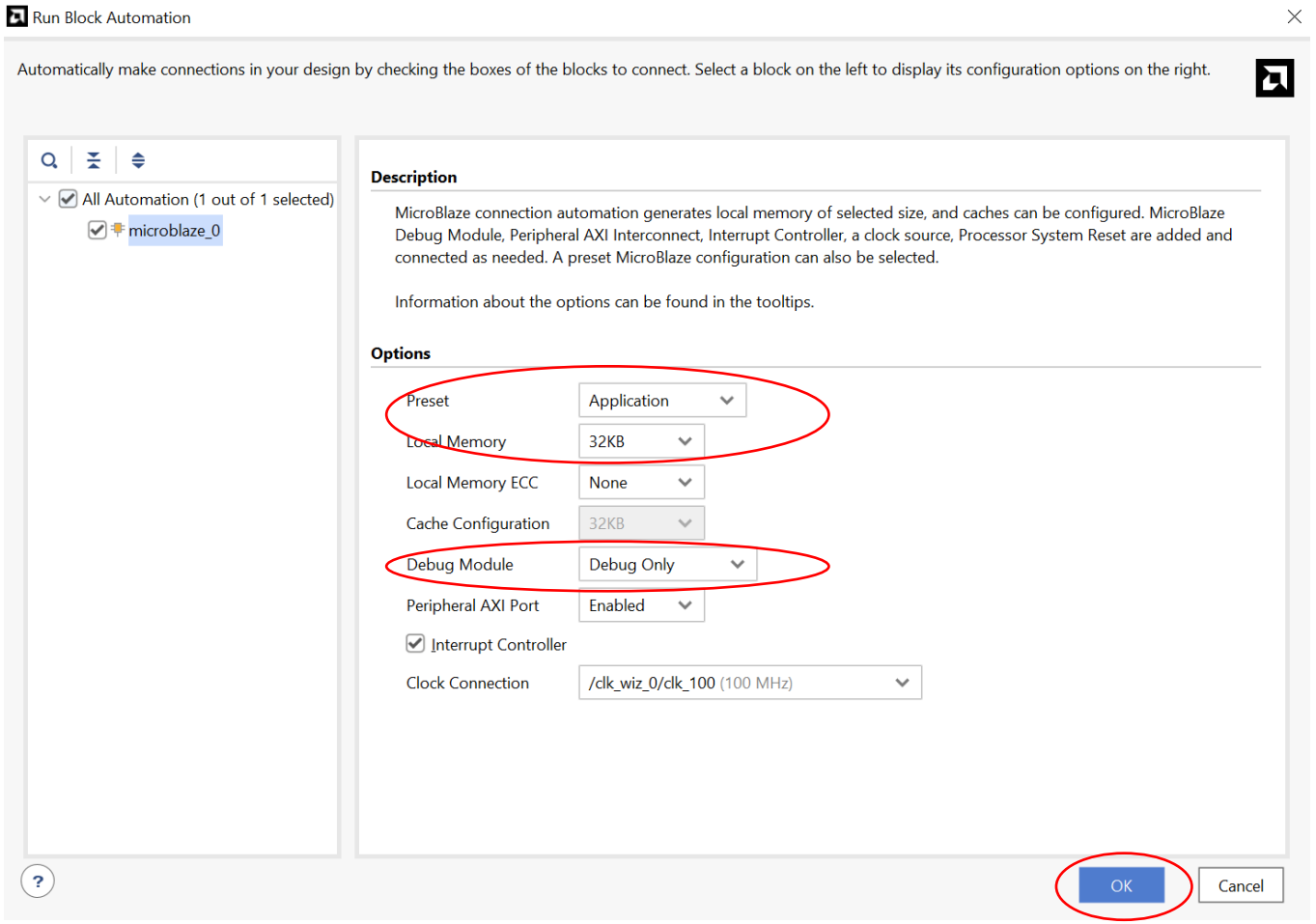


Lab: Embedded Linux

1. Click on Run Block Automation

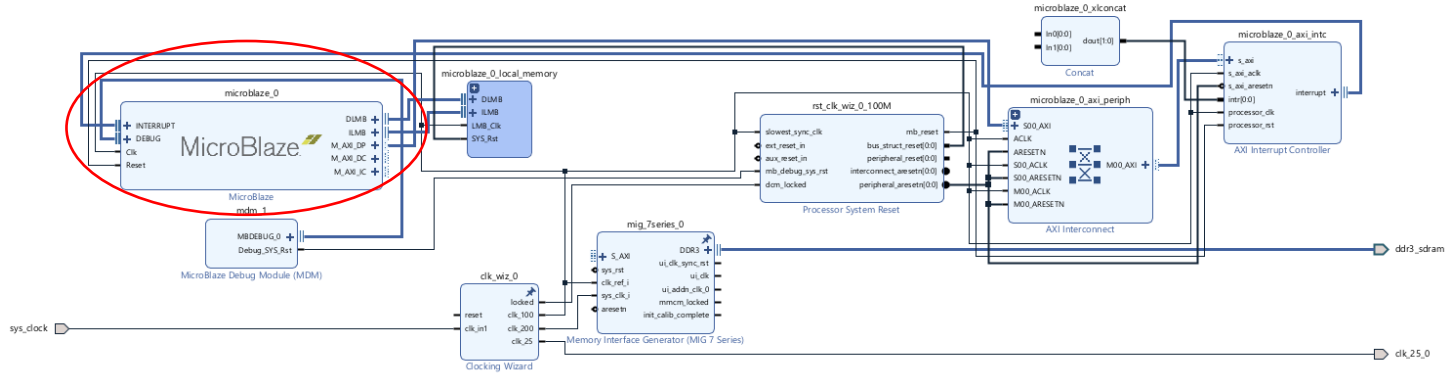
Lab: Embedded Linux

1. Select the preset to Application
2. Set Local Memory to 32KB
3. Set Debug Mode to Debug Only



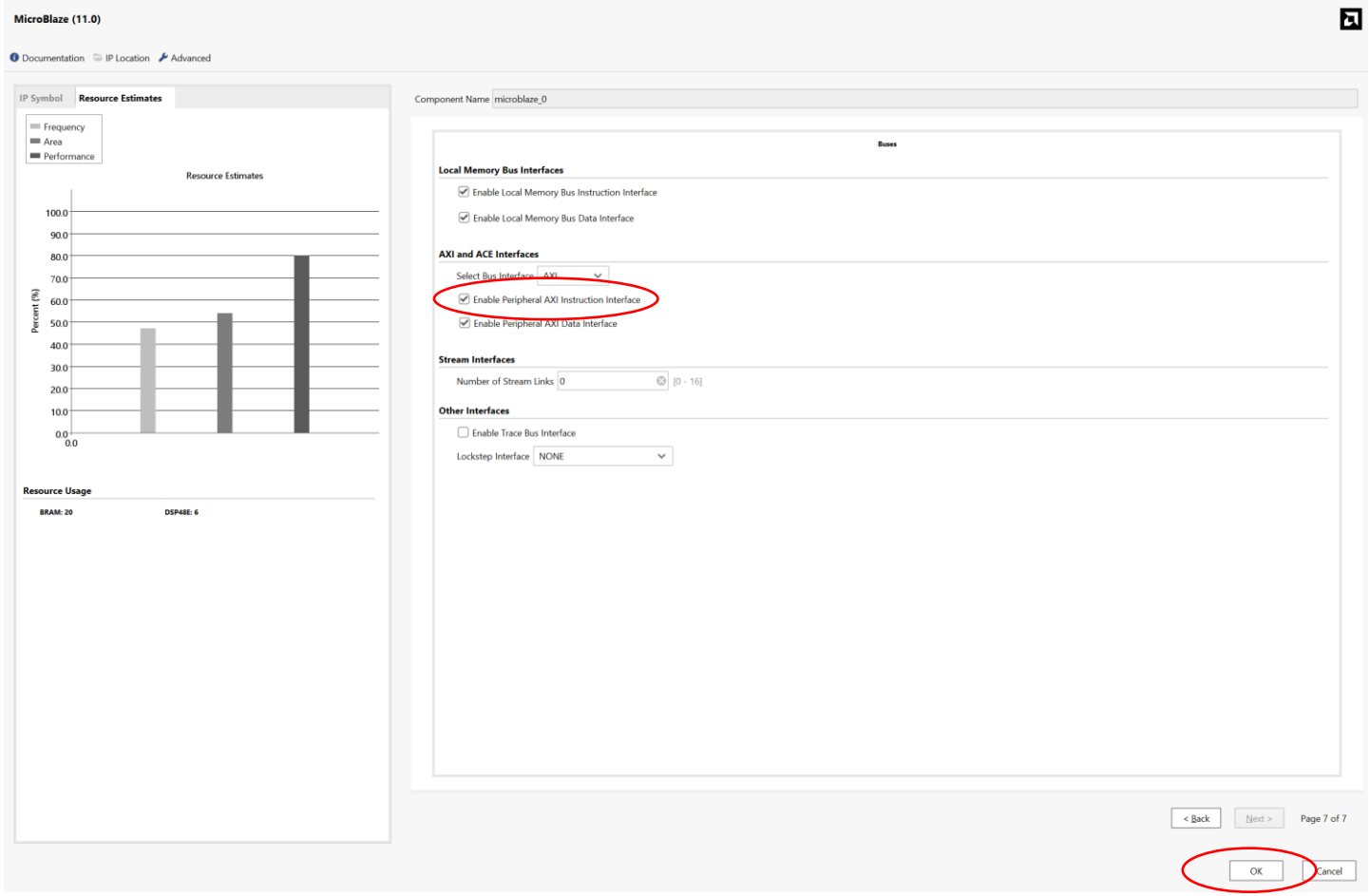
Lab: Embedded Linux

1. Double click on the MicroBlaze to re-customize



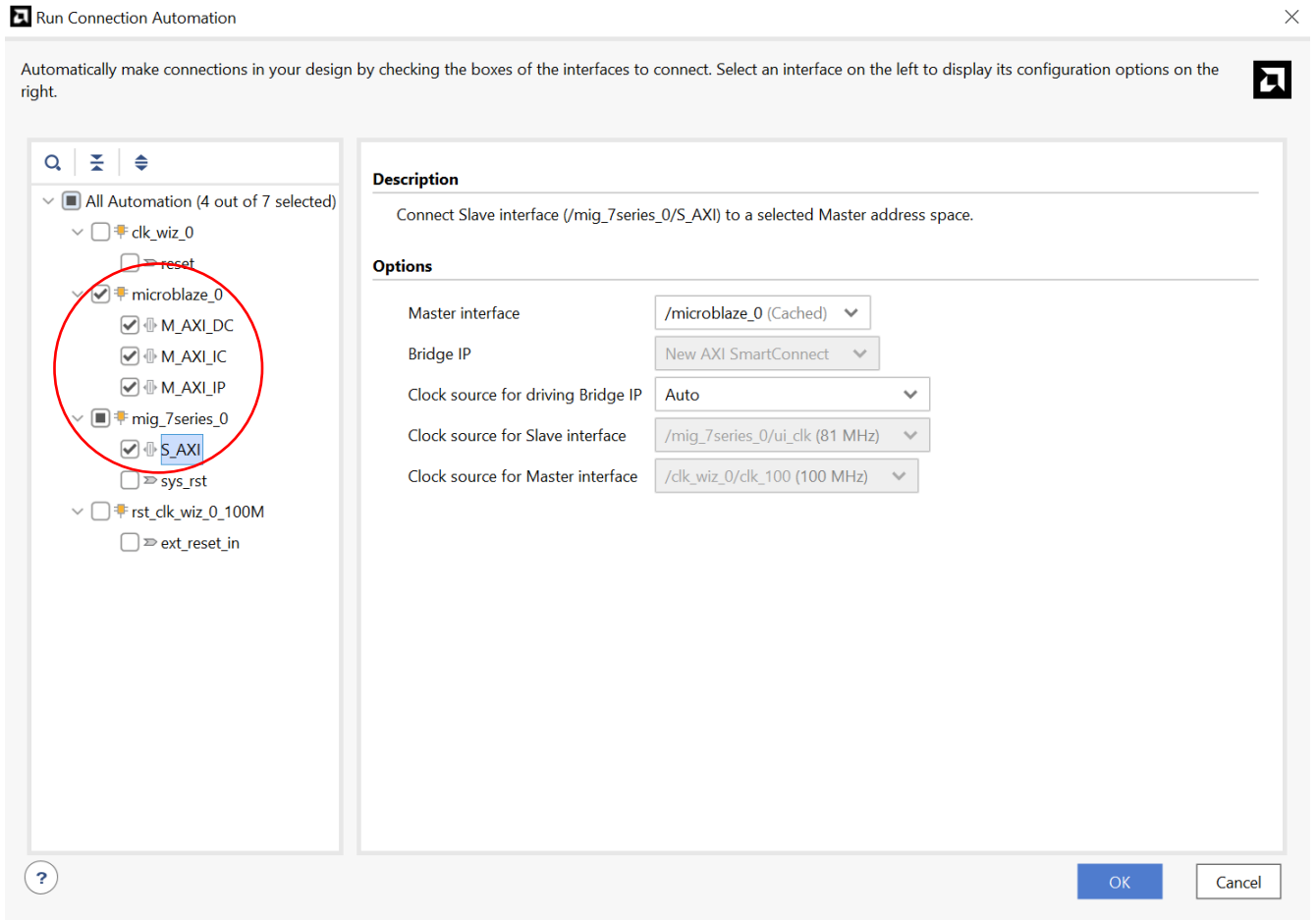
Lab: Embedded Linux

1. On page 7
2. Enable the Peripheral AXI Instruction Interface
3. Click OK



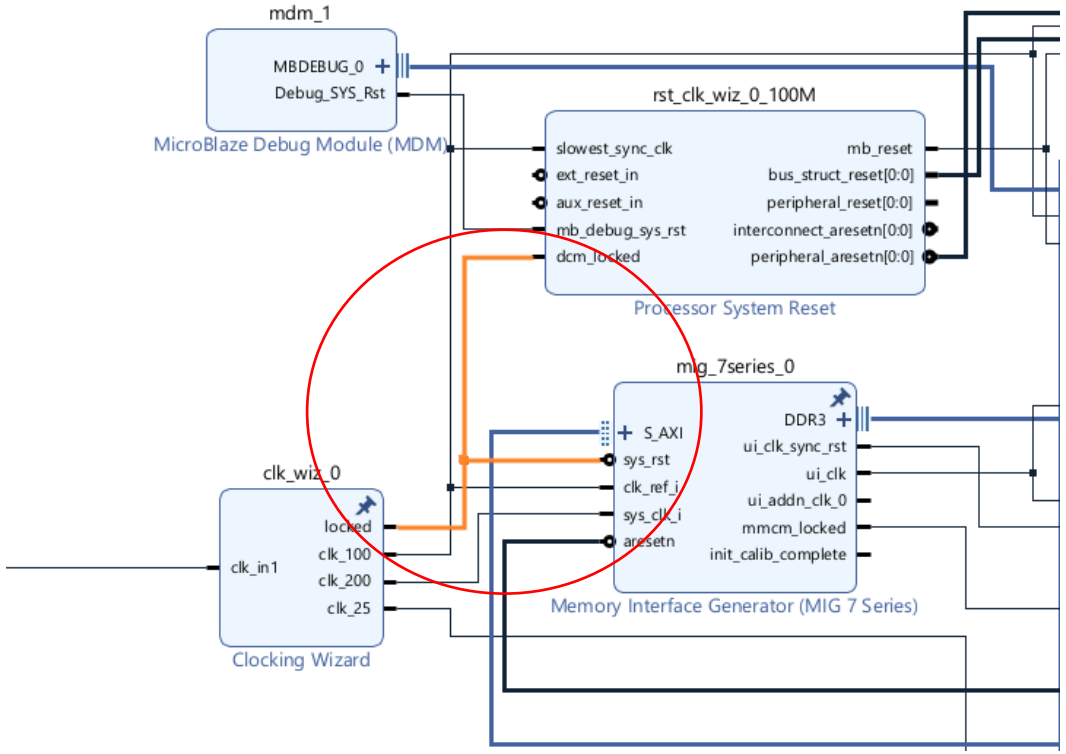
Lab: Embedded Linux

1. Click Next



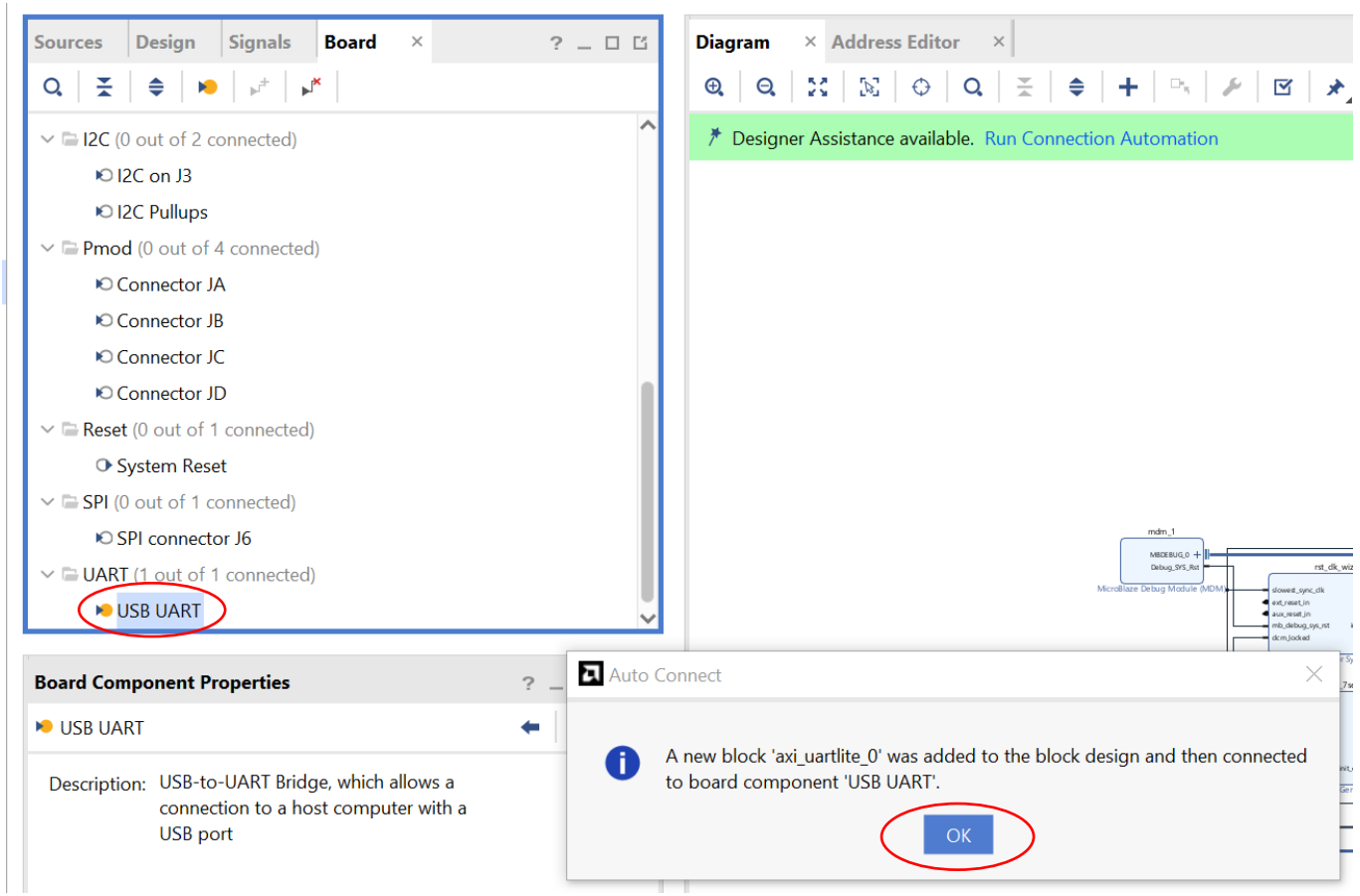
Lab: Embedded Linux

1. Connect the clk wizard locked signal to the sys_rst on the MIG7



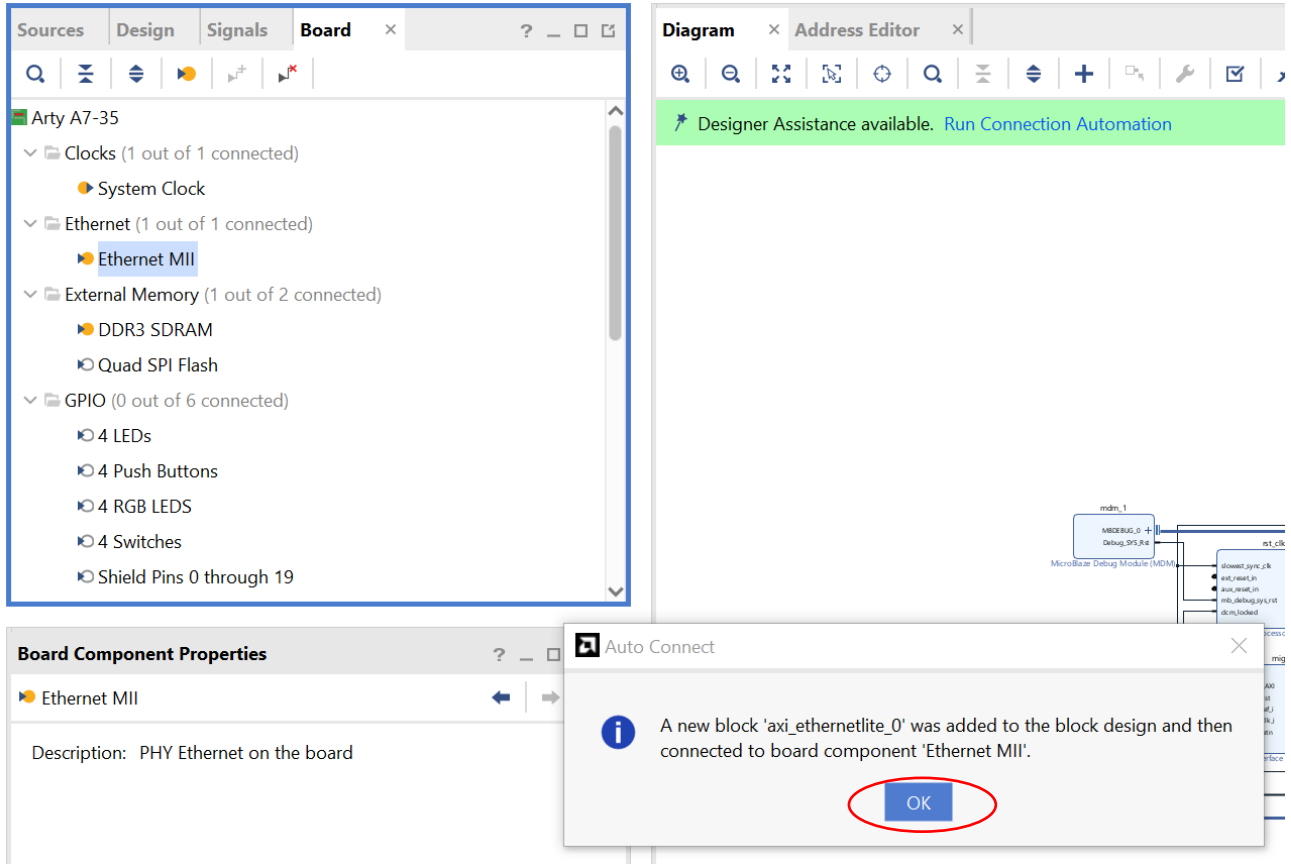
Lab: Embedded Linux

1. From the boards tab add in the USB Uart to the diagram
2. Click OK



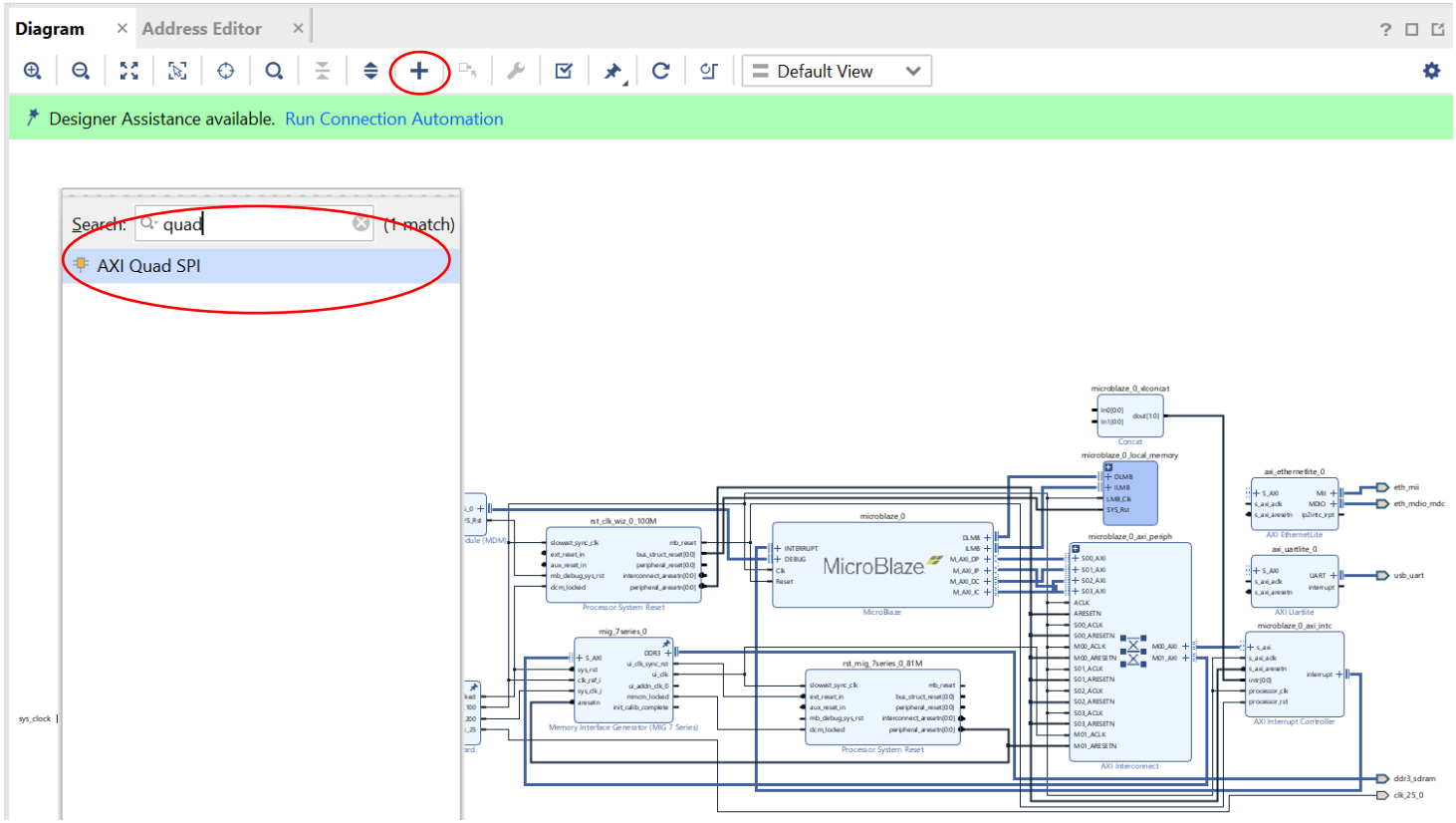
Lab: Embedded Linux

1. From the boards tab drag over the Ethernet MII onto the diagram
2. Click OK



Lab: Embedded Linux

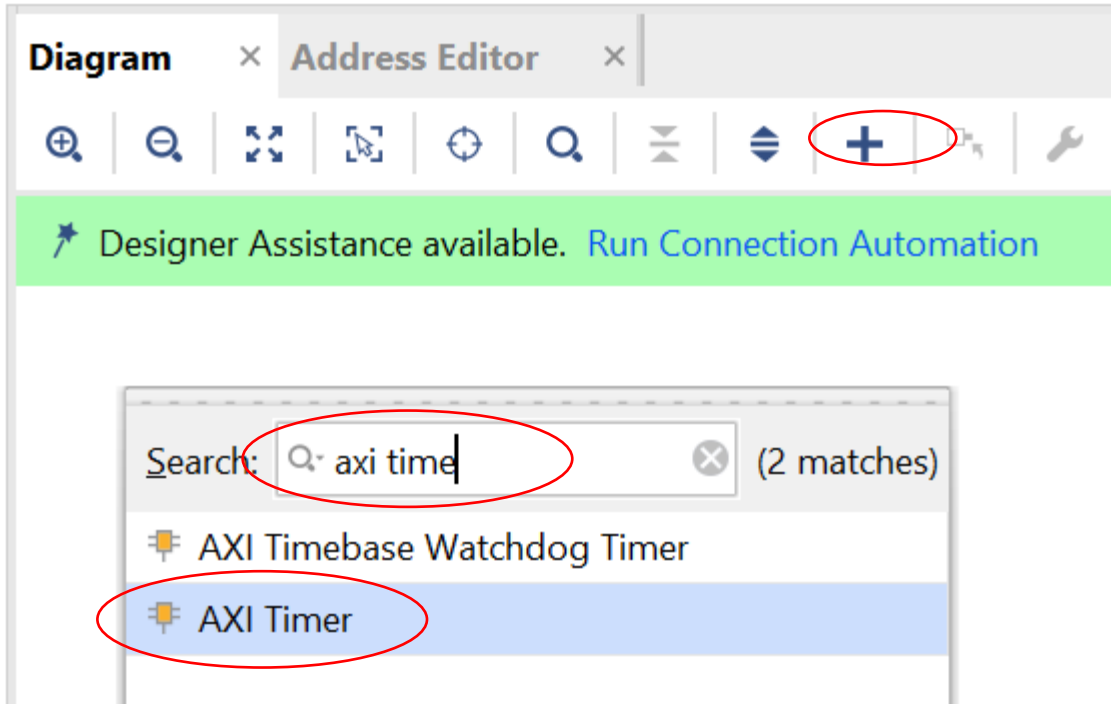
1. Click on the + and in the search box type
2. Quad
3. Select the AXI Quad SPI
4. Double Click on it to add into the diagram



Lab: Embedded Linux

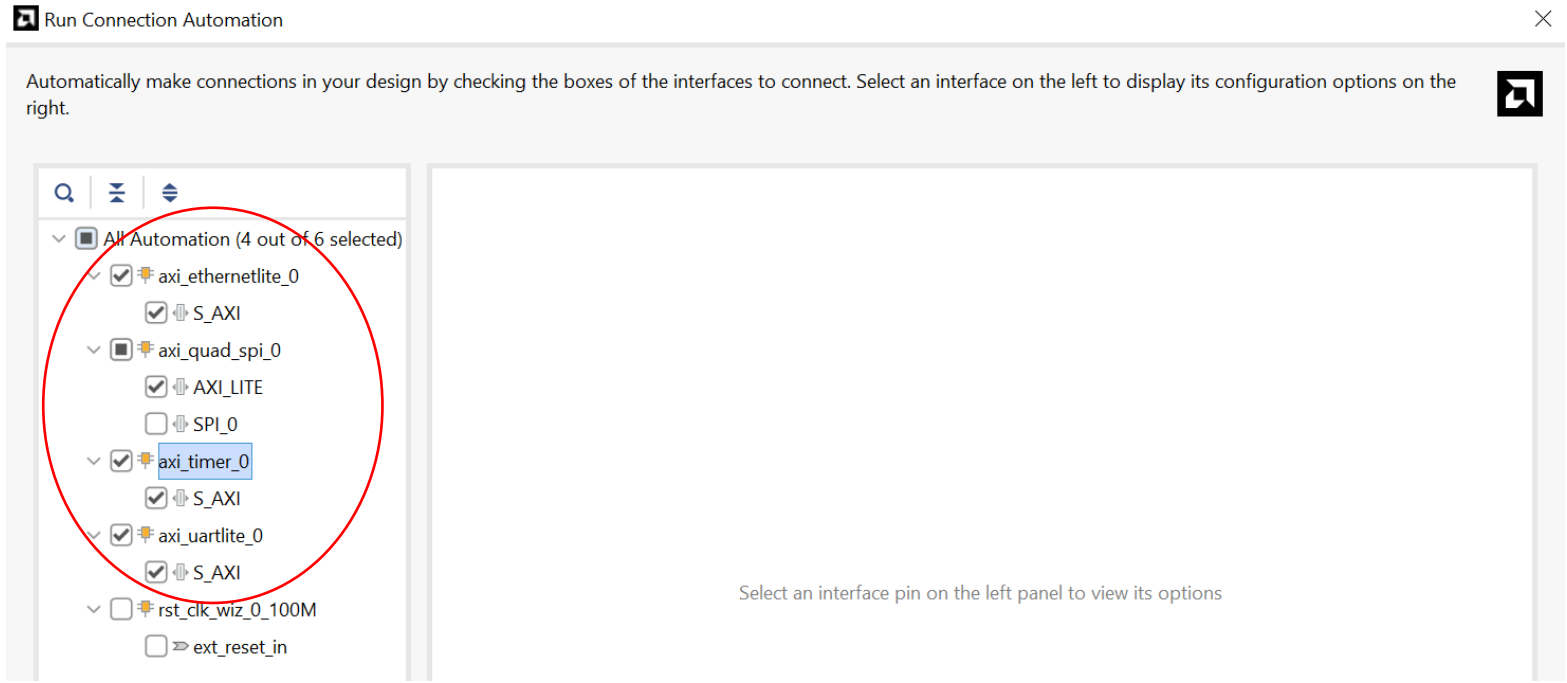
1. Click on the + symbol enter AXI Timer in the search bar

2. Double click on the AXI Timer to add into the diagram



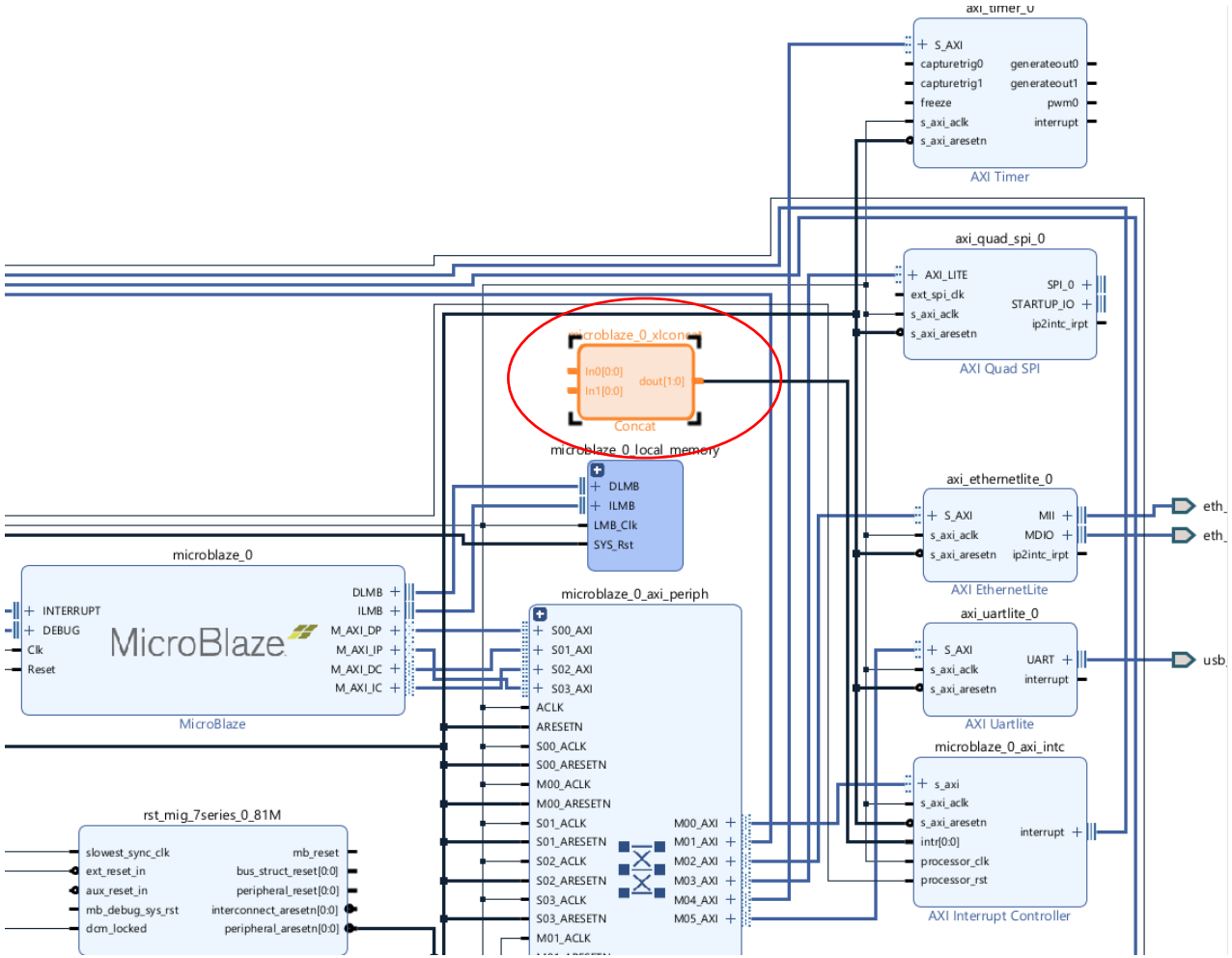
Lab: Embedded Linux

1. Run the block automation
2. Select the AXI Interfaces
3. Click OK



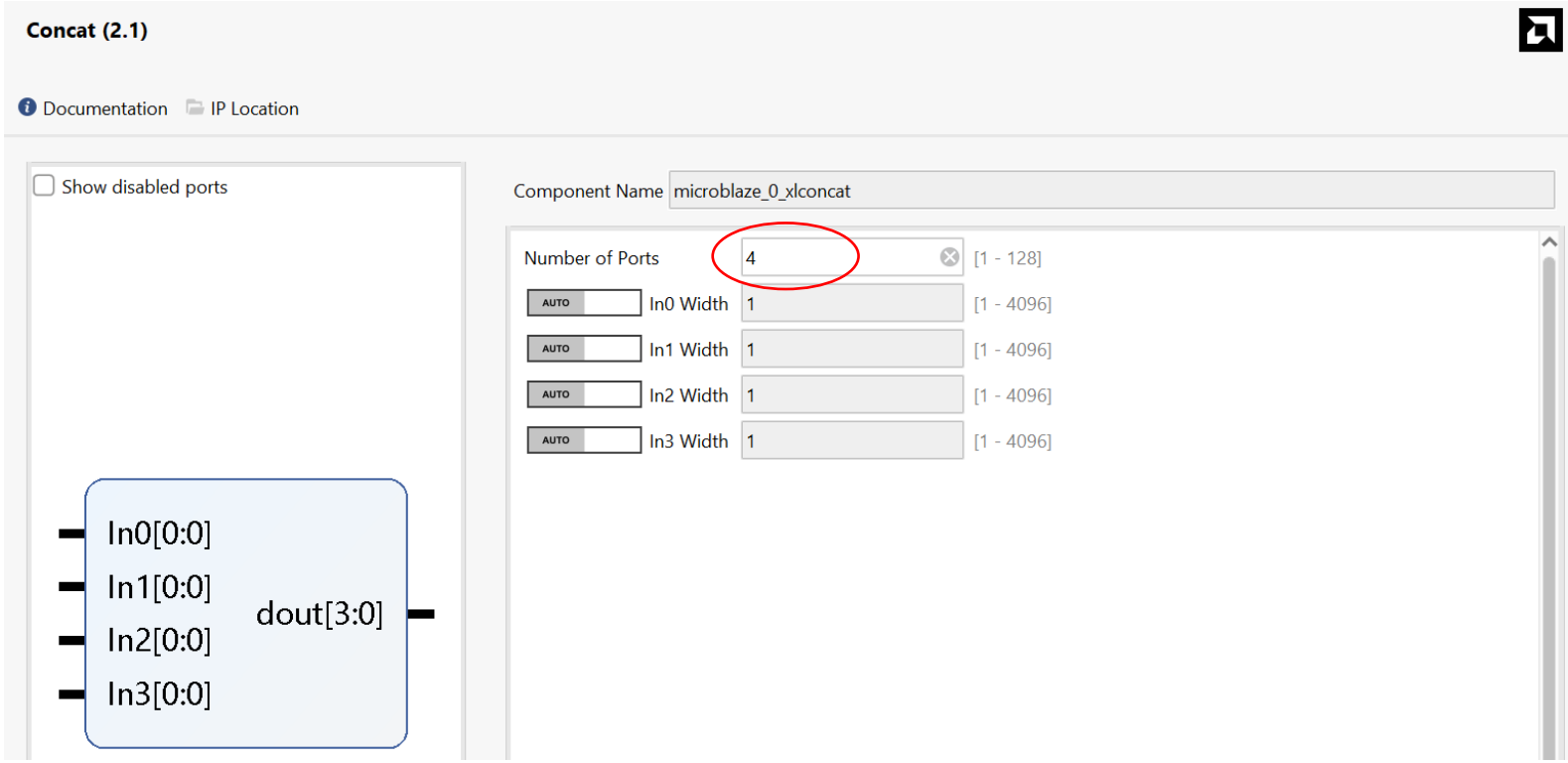
Lab: Embedded Linux

1. Double click on the Concatenate block



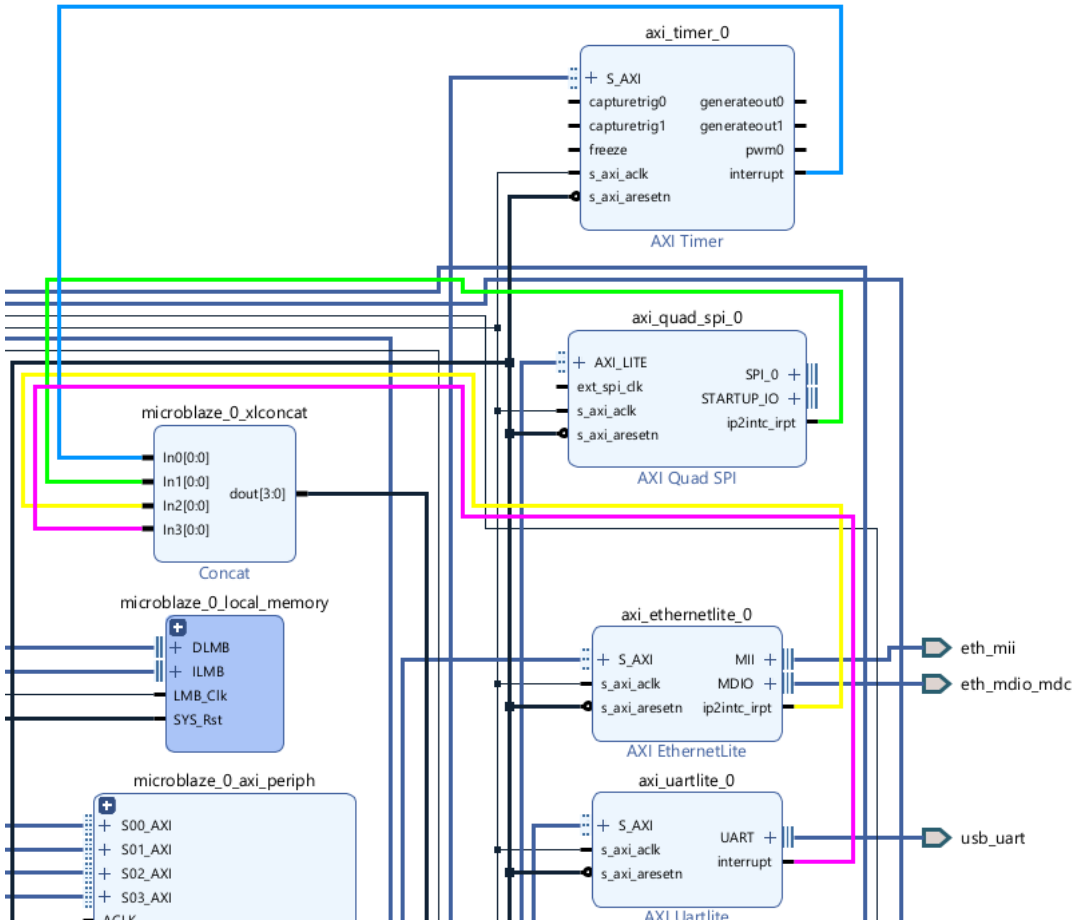
Lab: Embedded Linux

1. Change the number of ports to four



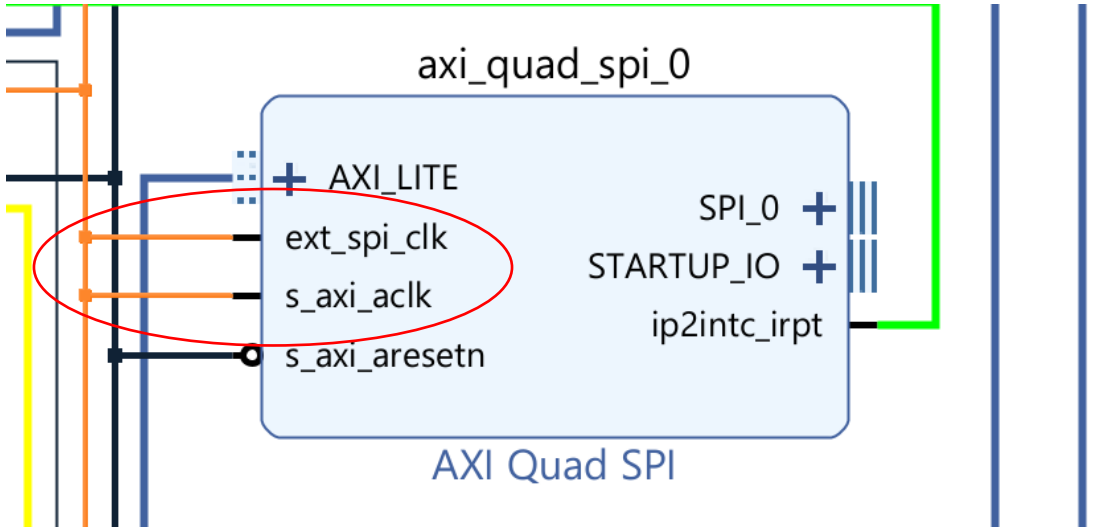
Lab: Embedded Linux

1. From the AXI Timer, AXI Quad SPI, AXI Ethernet and AXI UARTLite connect the interrupts to the concatenate block



Lab: Embedded Linux

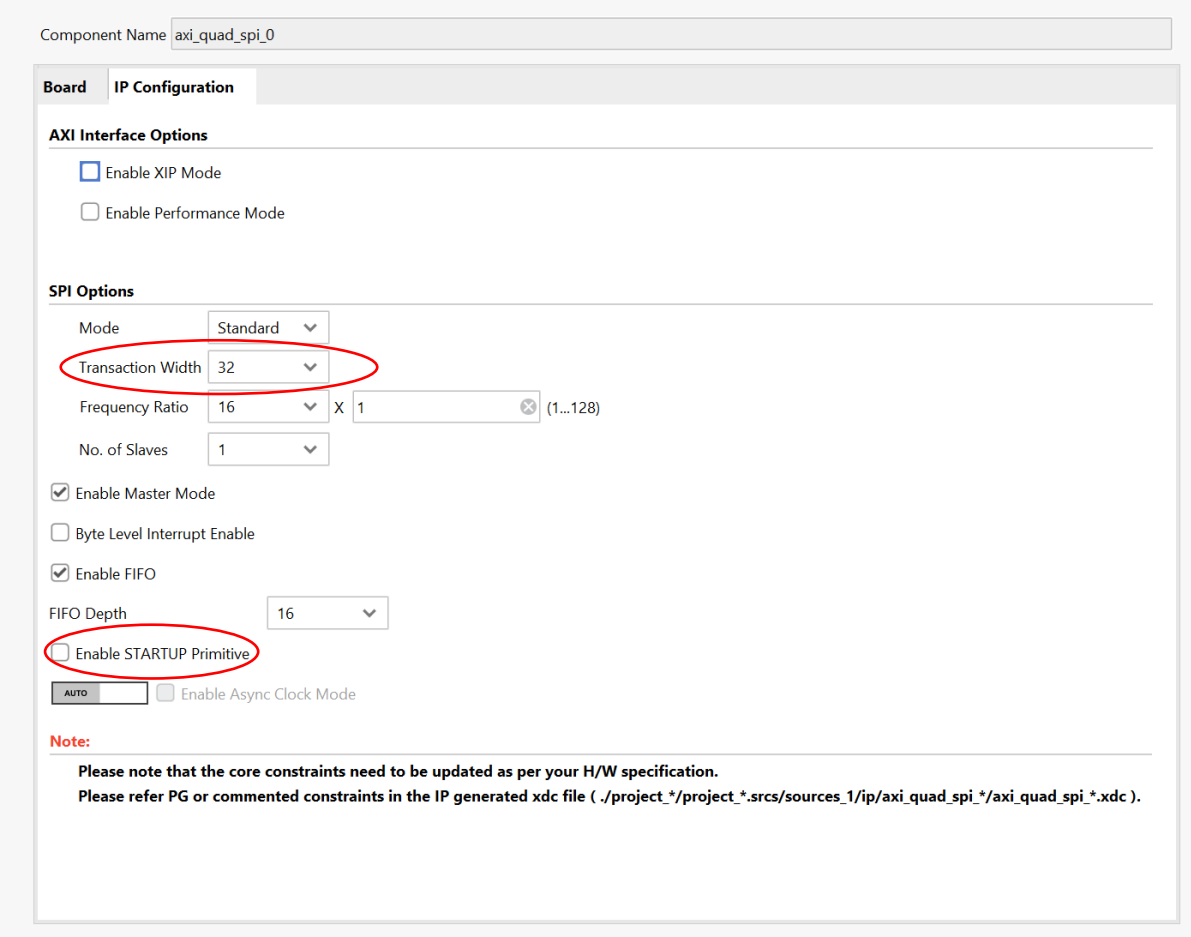
1. On the Quad SPI ensure the ext_spi_clk is connected to the s_axi_clk



Lab: Embedded Linux

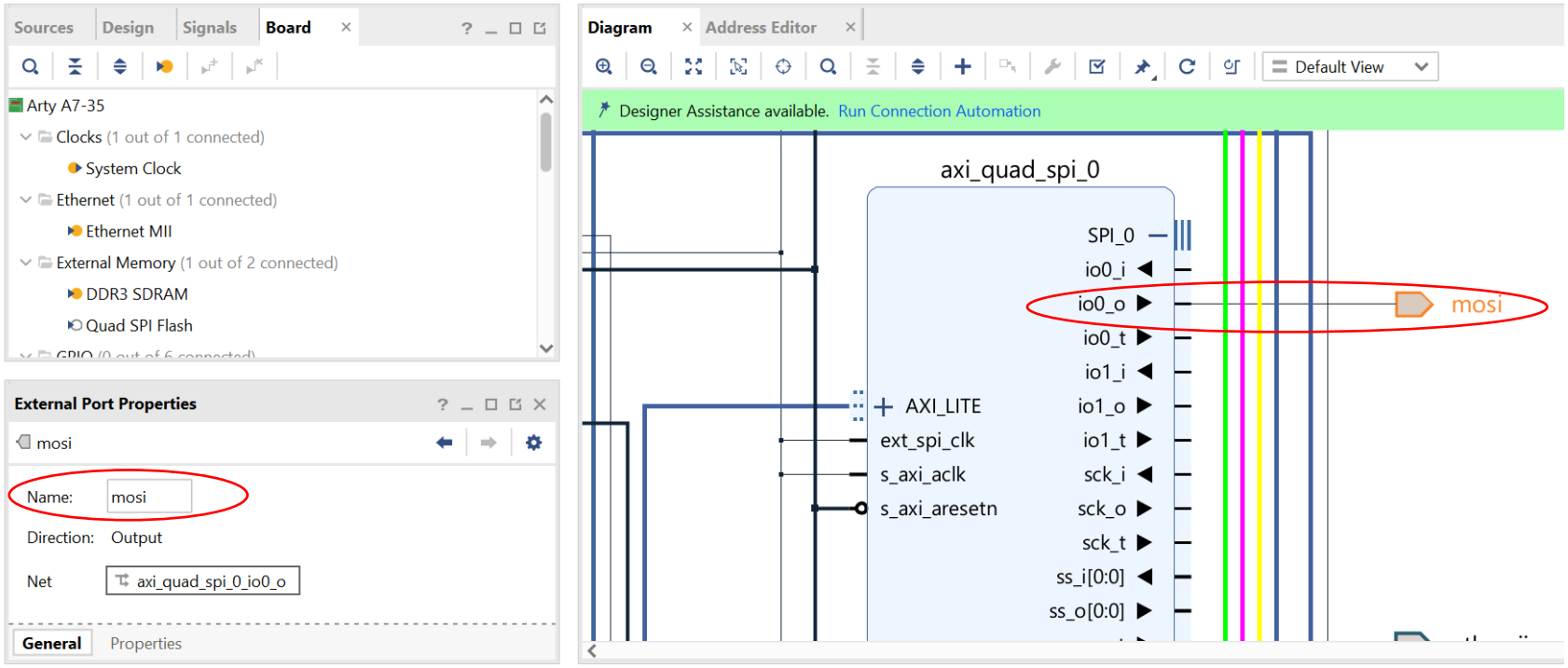
1. Re-customize the AXI Quad SPI to disable the Start up Primitive

2. Set the Transaction width to 32 bits



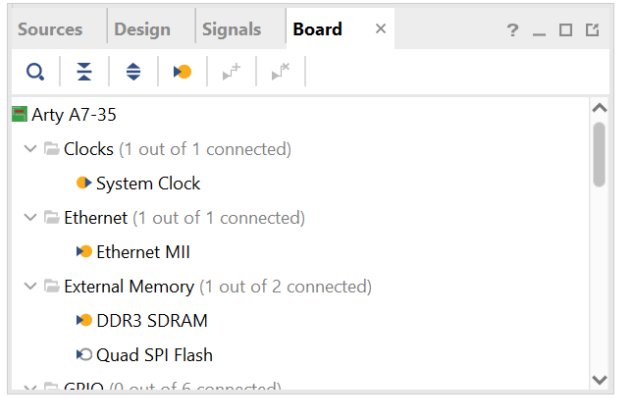
Lab: Embedded Linux

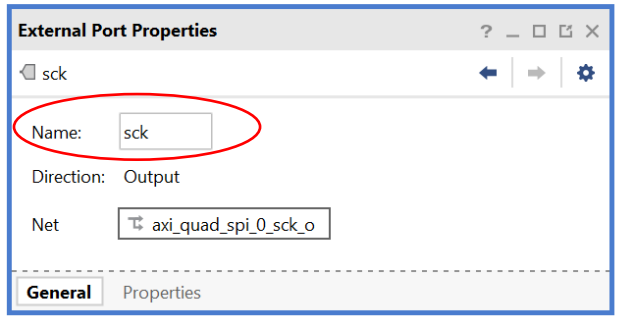
1. Expand the SPI_0 port
2. On Io0_o make it external
3. Name it MOSI

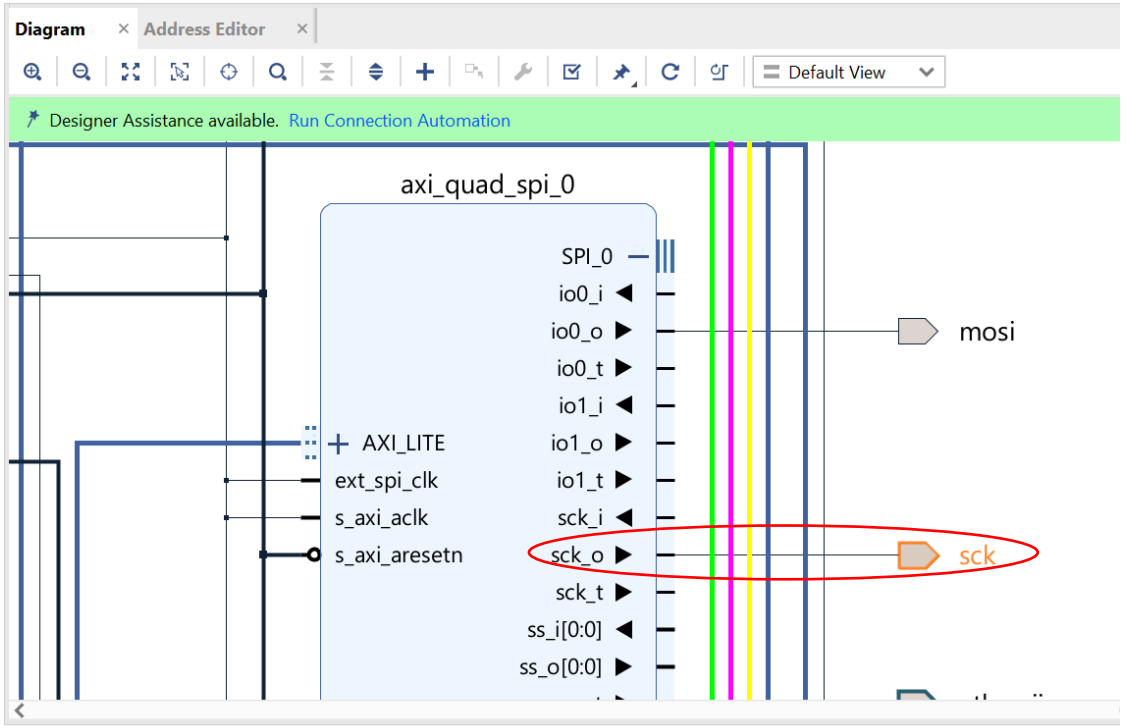


Lab: Embedded Linux

1. Make SCLK_0 external
2. Rename it sck

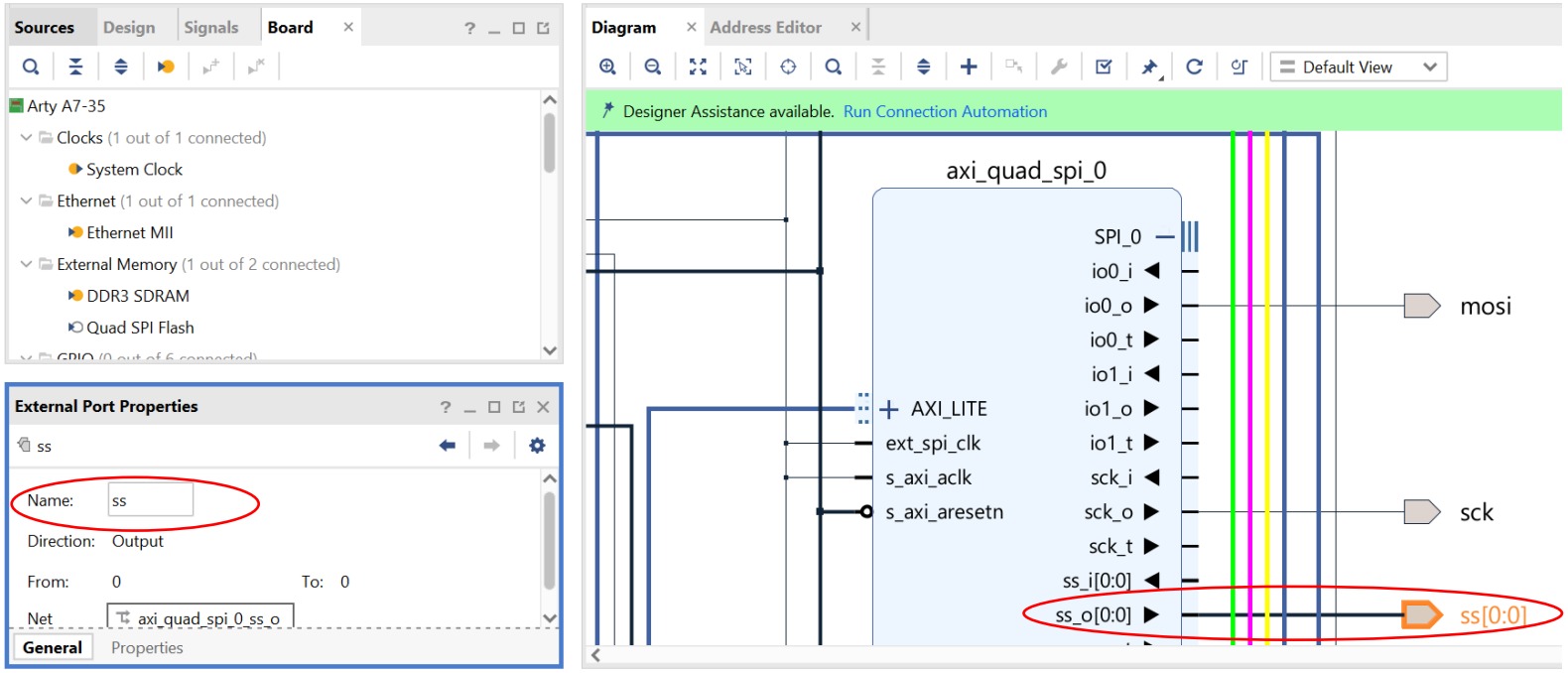






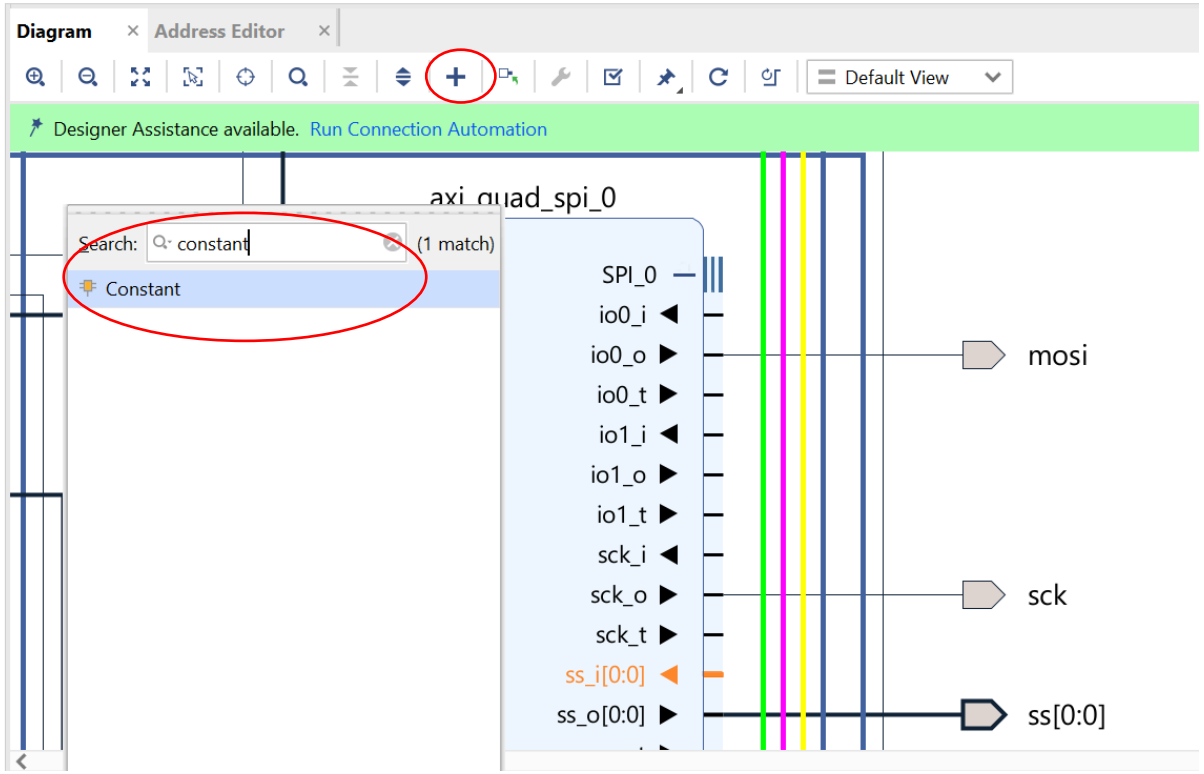
Lab: Embedded Linux

1. Do the same for SS_0
2. Rename it ss



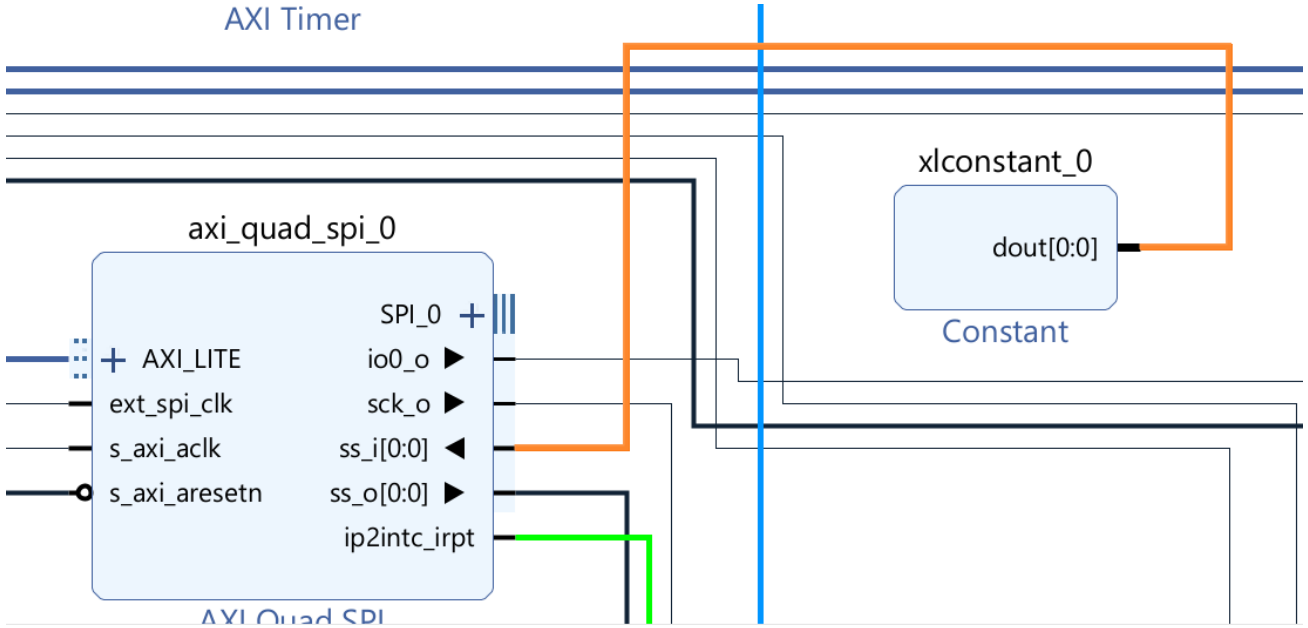
Lab: Embedded Linux

1. Click + and type in constant in the search box
2. Double click on constant and add it into the design
3. Connect it to signal SS_i



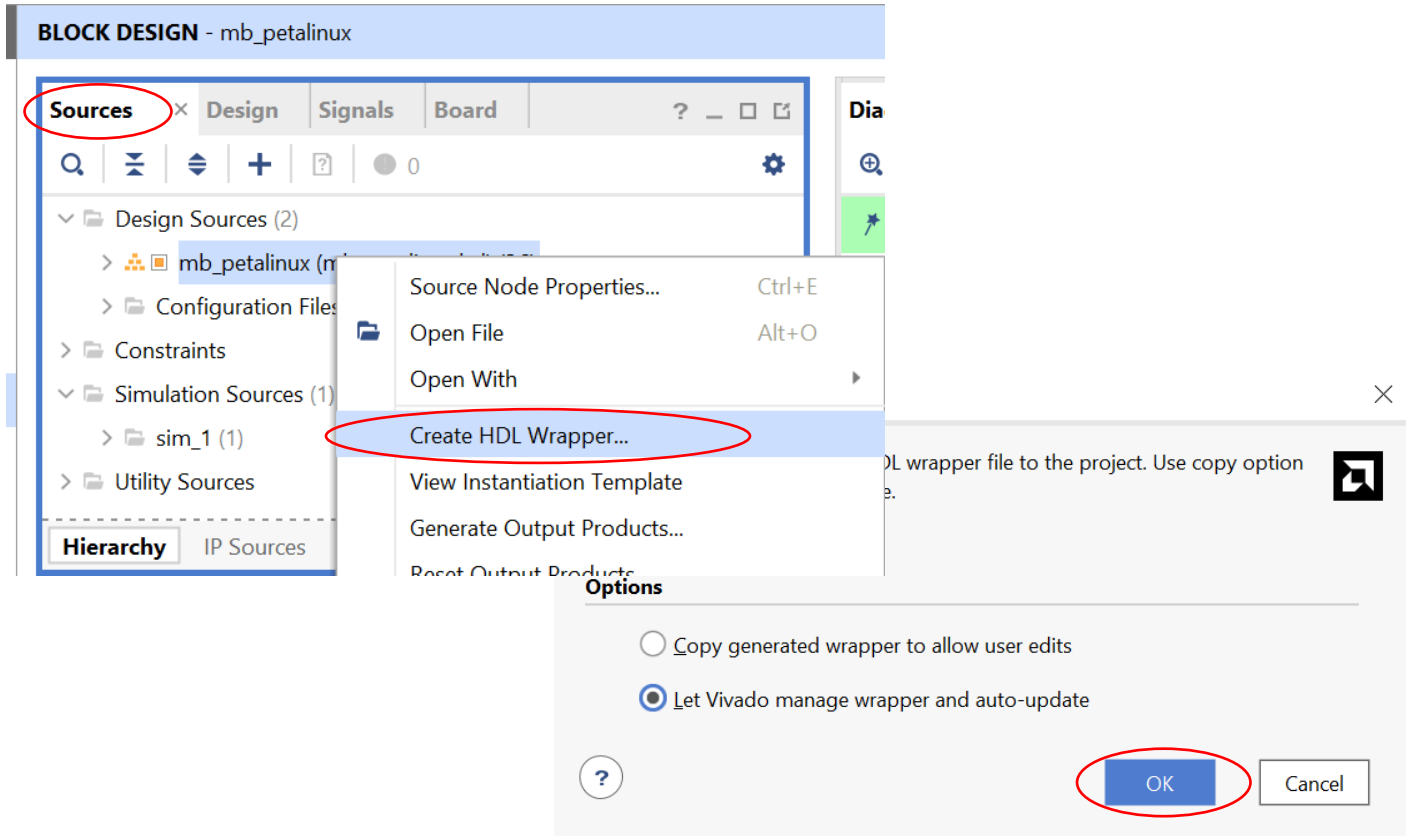
Lab: Embedded Linux

1. The design should look as shown



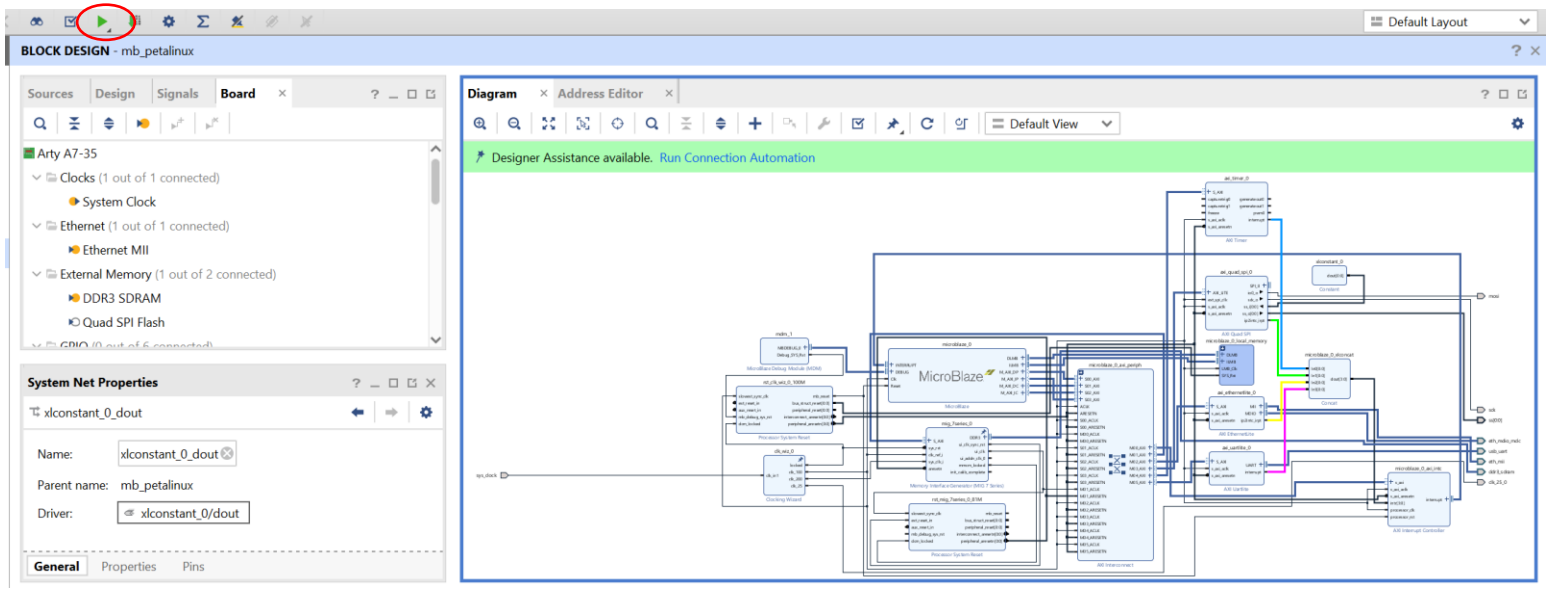
Lab: Embedded Linux

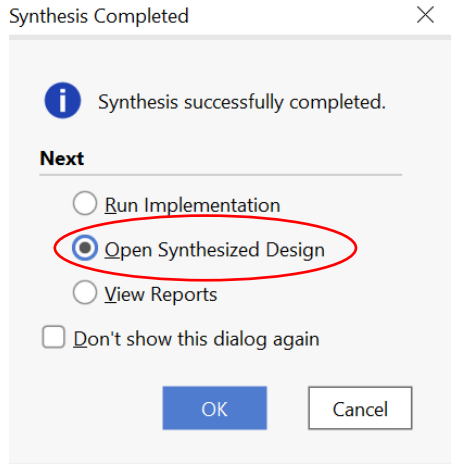
1. Select Sources, right click on the block diagram.
2. Select Create HDL Wrapper
3. When prompted allow the AMD Vivado™ software to manage the file



Lab: Embedded Linux

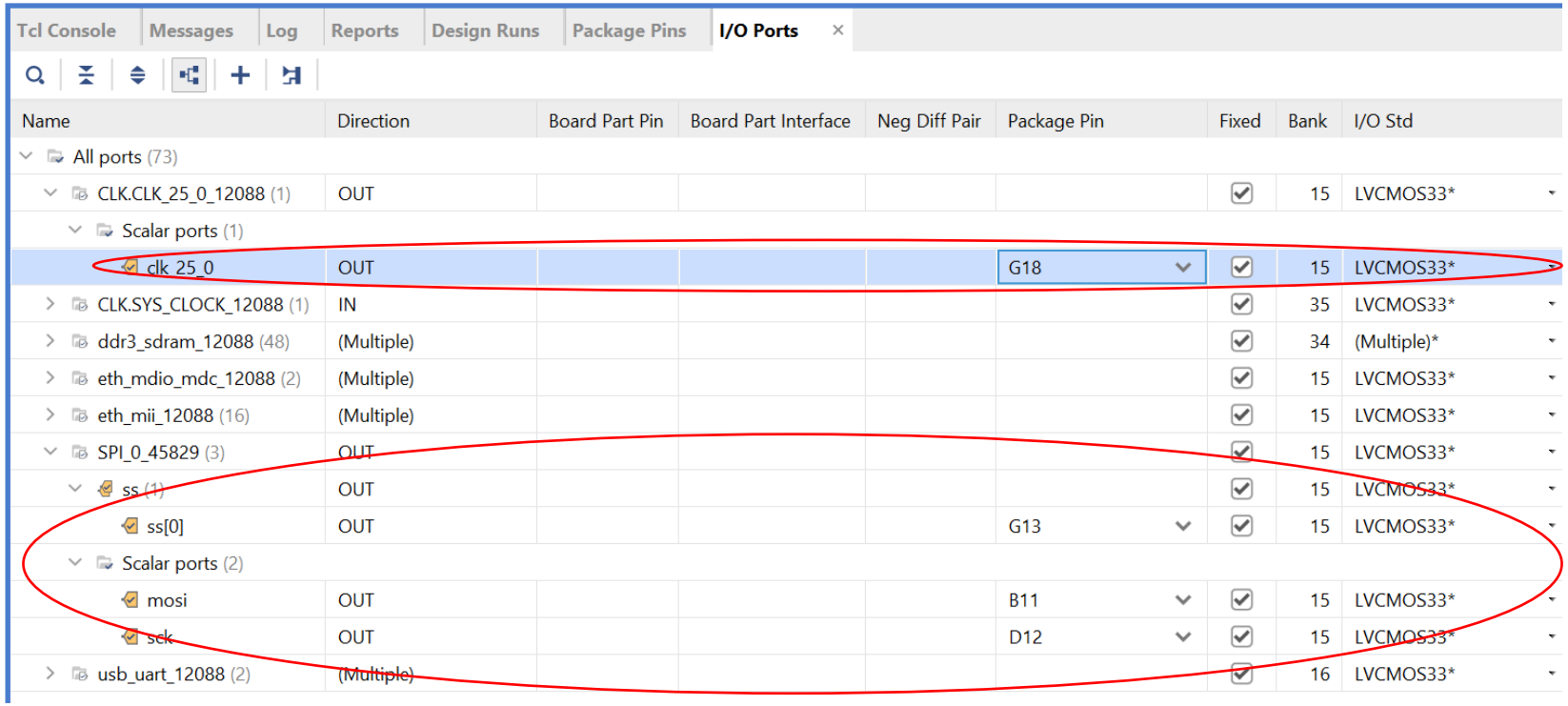
1. Run the Synthesis
2. Once the synthesis is completed, open the synthesis view





Lab: Embedded Linux

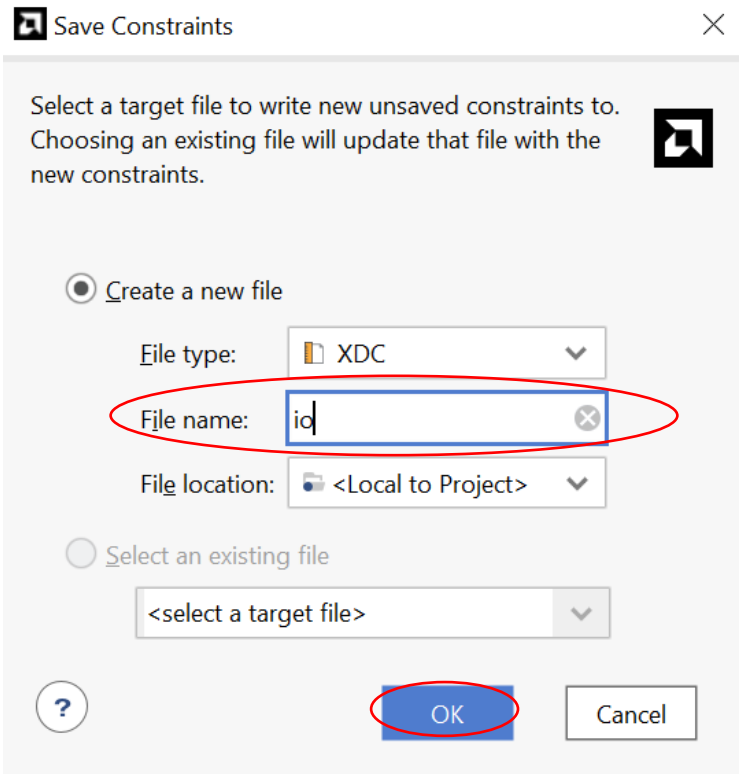
1. Set the IO pin allocation and IO standard as shown opposite



Name	Direction	Board Part Pin	Board Part Interface	Neg Diff Pair	Package Pin	Fixed	Bank	I/O Std
All ports (73)								
CLK.CLK_25_0_12088 (1)	OUT					☑	15	LVCMOS33*
Scalar ports (1)								
clk_25_0	OUT				G18	☑	15	LVCMOS33*
CLK.SYS_CLOCK_12088 (1)	IN					☑	35	LVCMOS33*
ddr3_sdram_12088 (48)	(Multiple)					☑	34	(Multiple)*
eth_mdio_mdc_12088 (2)	(Multiple)					☑	15	LVCMOS33*
eth_mii_12088 (16)	(Multiple)					☑	15	LVCMOS33*
SPI_0_45829 (3)	OUT					☑	15	LVCMOS33*
ss (1)	OUT					☑	15	LVCMOS33*
ss[0]	OUT				G13	☑	15	LVCMOS33*
Scalar ports (2)								
mosi	OUT				B11	☑	15	LVCMOS33*
sck	OUT				D12	☑	15	LVCMOS33*
usb_uart_12088 (2)	(Multiple)					☑	16	LVCMOS33*

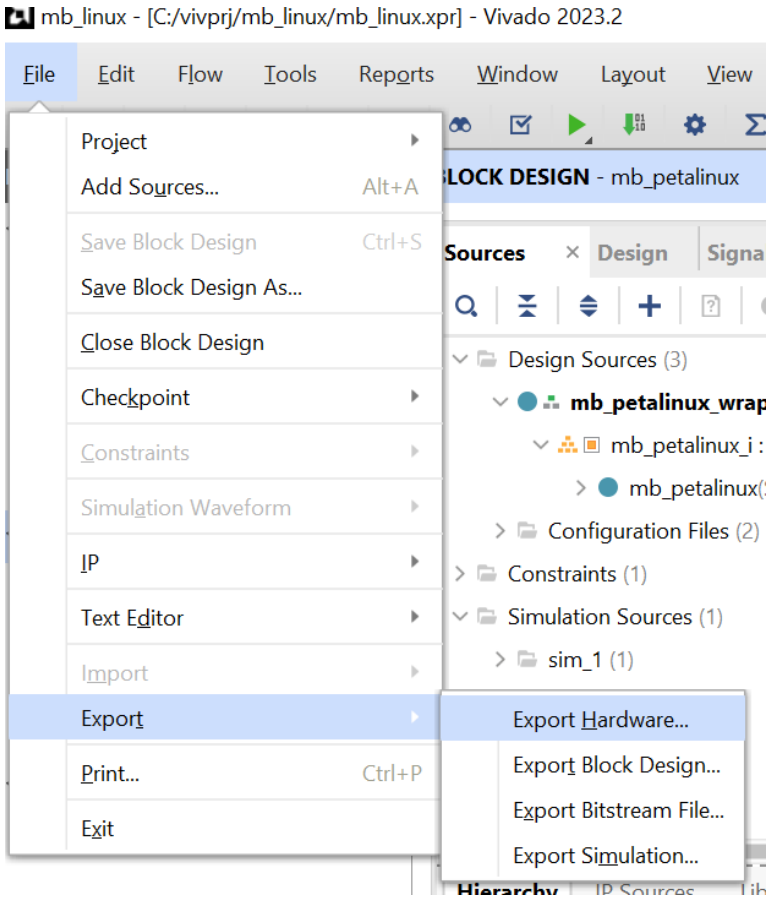
Lab: Embedded Linux

1. Click save and in the prompt add in the file name IO and save it.



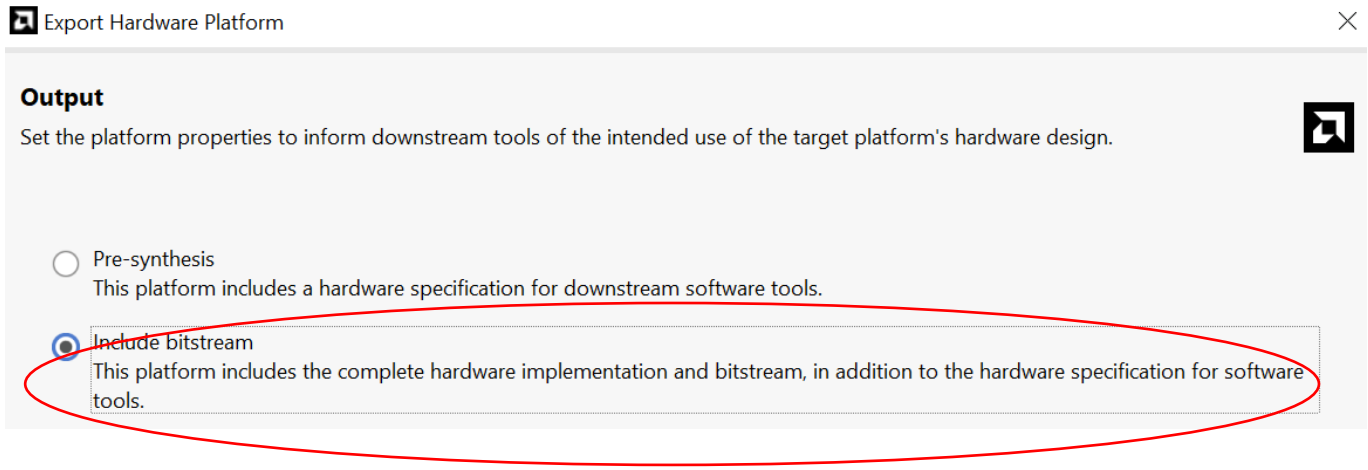
Lab: Embedded Linux

1. Once the bitstream is generated. Export the XSA.



Lab: Embedded Linux

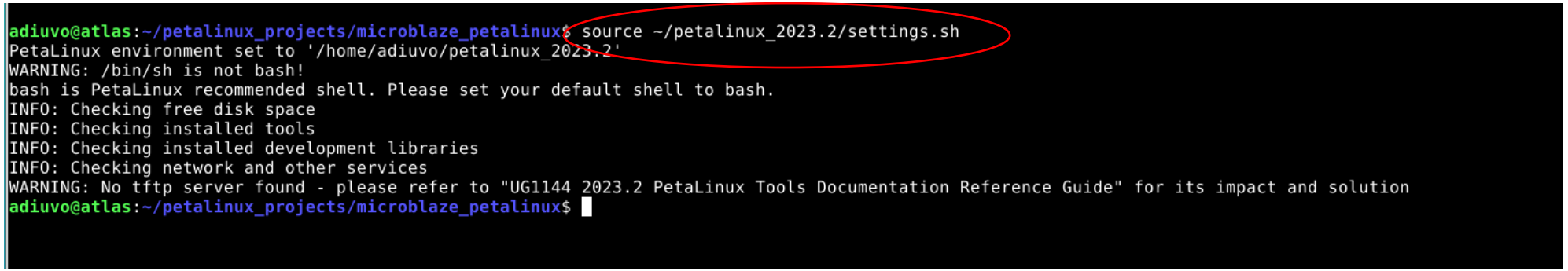
1. Check the option to include the bitstream



Lab: Embedded Linux

1. Open a terminal in the folder you want to create the project on the Linux machine

2. Source the settings script to set up the PetaLinux 2023.2 settings



Lab: Embedded Linux

1. Create a new project targeting the AMD MicroBlaze™ processor in PetaLinux

```
adiuvo@atlas:~/petalinux_projects/microblaze_petalinux$ petalinux-create --type project --template microblaze --name mb_linux
INFO: Create project: mb_linux
INFO: New project successfully created in /home/adiuvo/petalinux_projects/microblaze_petalinux/mb_linux
adiuvo@atlas:~/petalinux_projects/microblaze_petalinux$
```

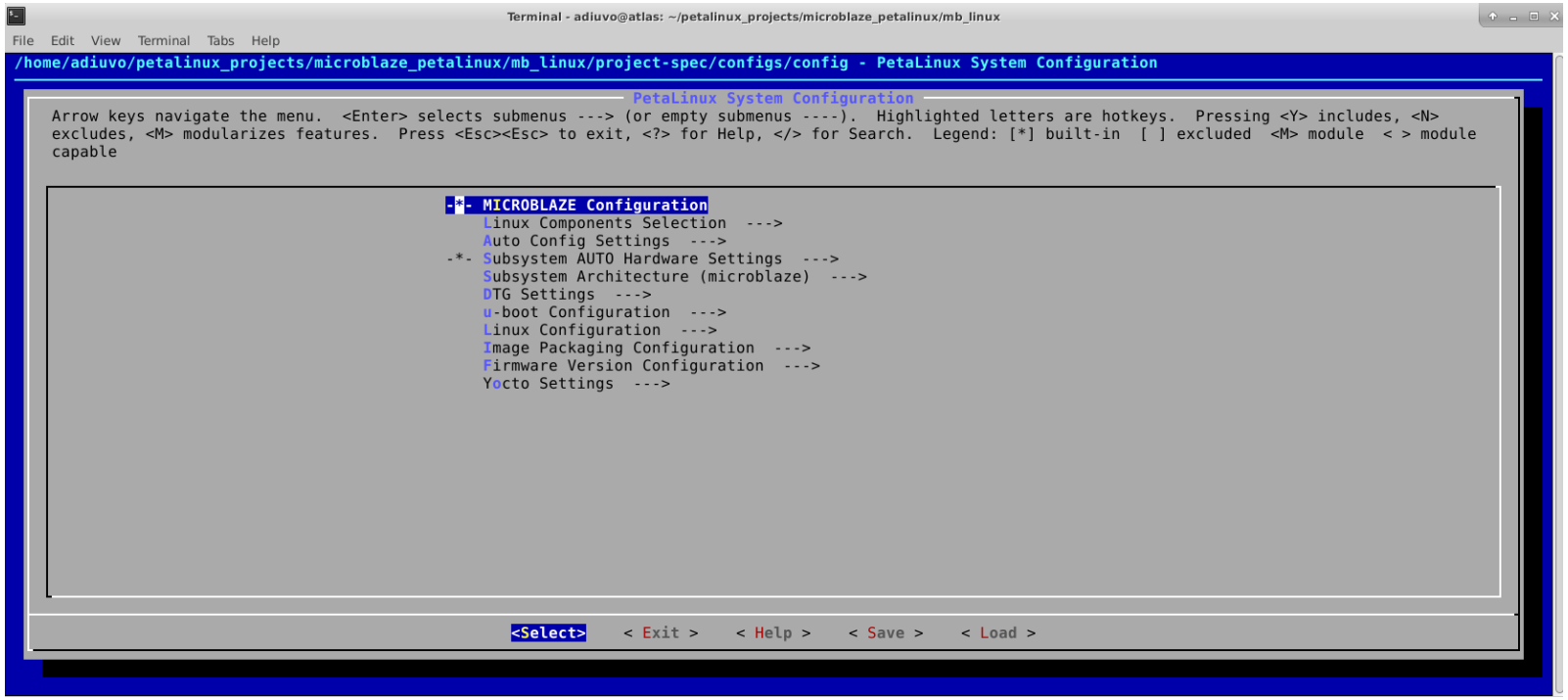
Lab: Embedded Linux

1. Load in the configuration from the XSA which has just been created in the AMD Vivado™ software

```
adiuvo@atlas:~/petalinux_projects/microblaze_petalinux/mb_linux$ petalinux-config --get-hw-description=../
[INFO] Sourcing buildtools
[INFO] Getting hardware description...
INFO: Renaming mb_petalinux_wrapper.xsa to system.xsa
[INFO] Extracting yocto SDK to components/yocto. This may take time!
[INFO] Generating Kconfig for project
[INFO] Menuconfig project
[INFO] Generating kconfig for rootfs
[INFO] Silentconfig rootfs
[INFO] Adding user layers
[INFO] Generating machine conf file
[INFO] Generating plnxtool conf file
[INFO] Generating kernel configuration files
[INFO] Generating u-boot configuration files
[INFO] Generating workspace directory
[INFO] Successfully configured project
```

Lab: Embedded Linux

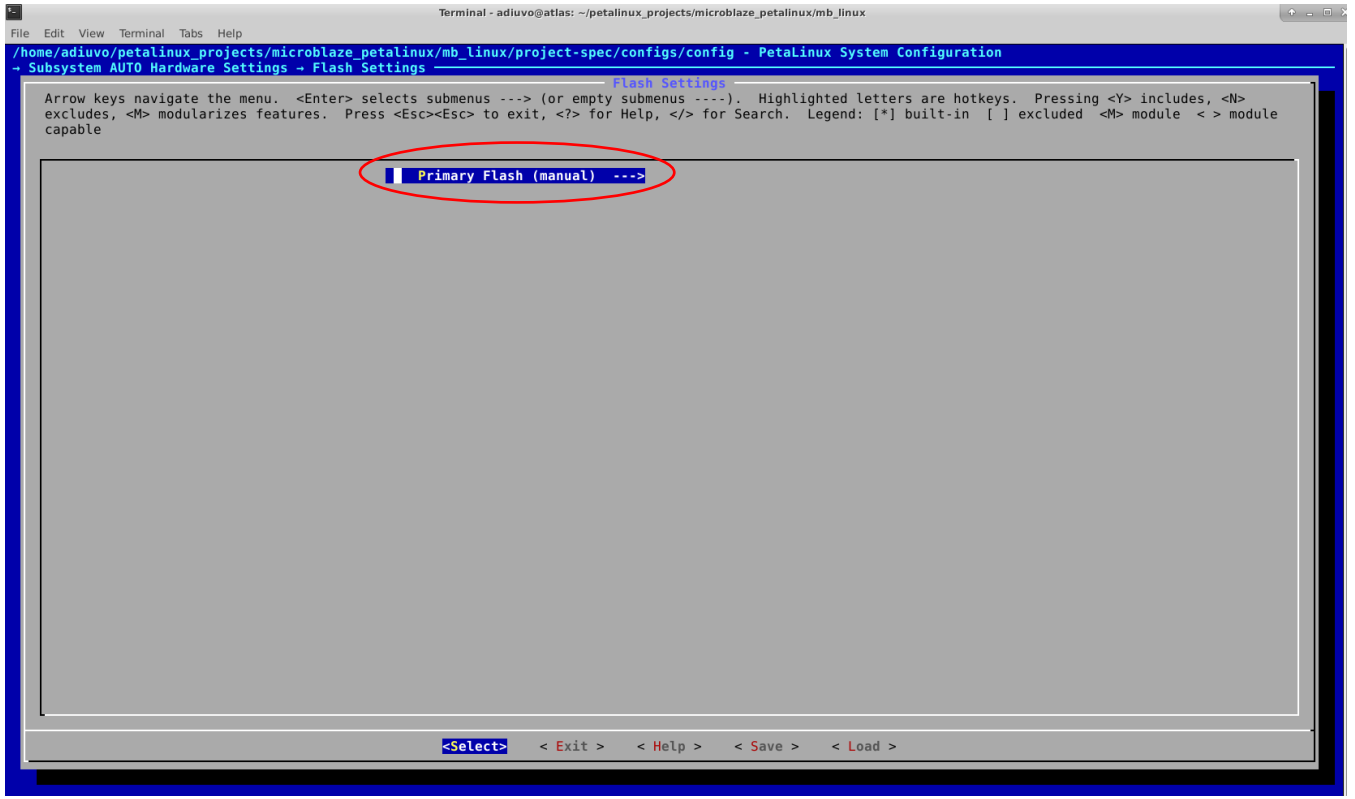
1. This will open the project settings



Lab: Embedded Linux

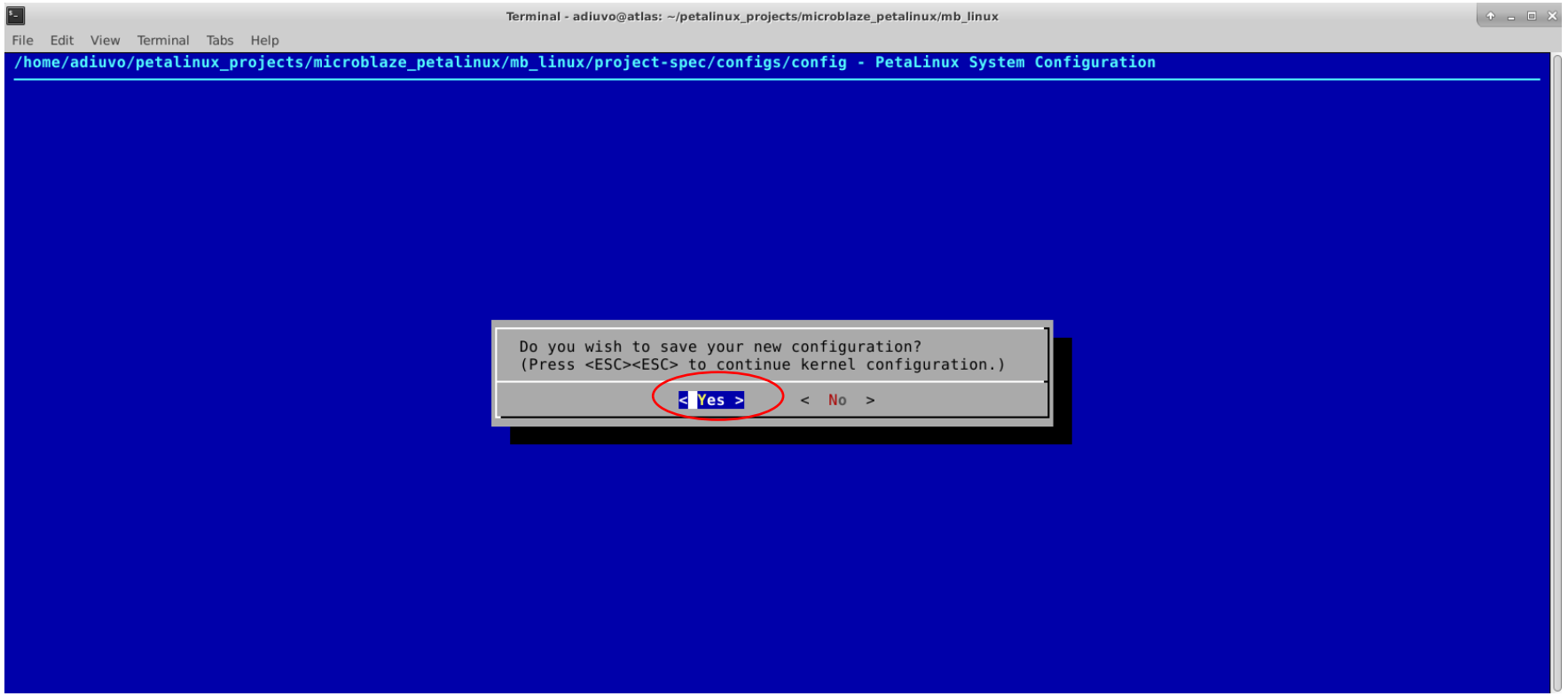
1. Under Subsystem Auto Hardware Settings, change the primary flash settings to manual

2. This stops it trying to use the AXI QSPI flash for boot



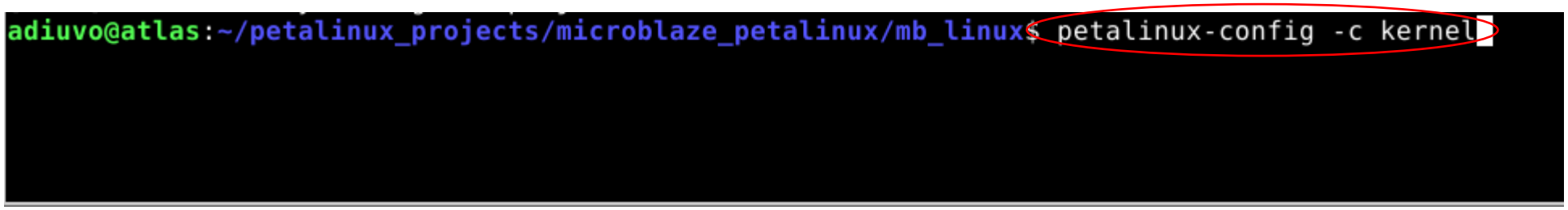
Lab: Embedded Linux

1. Navigate to the exit and save the changes



Lab: Embedded Linux

1. Enter the command below to customize the kernel (this might take several minutes to complete)



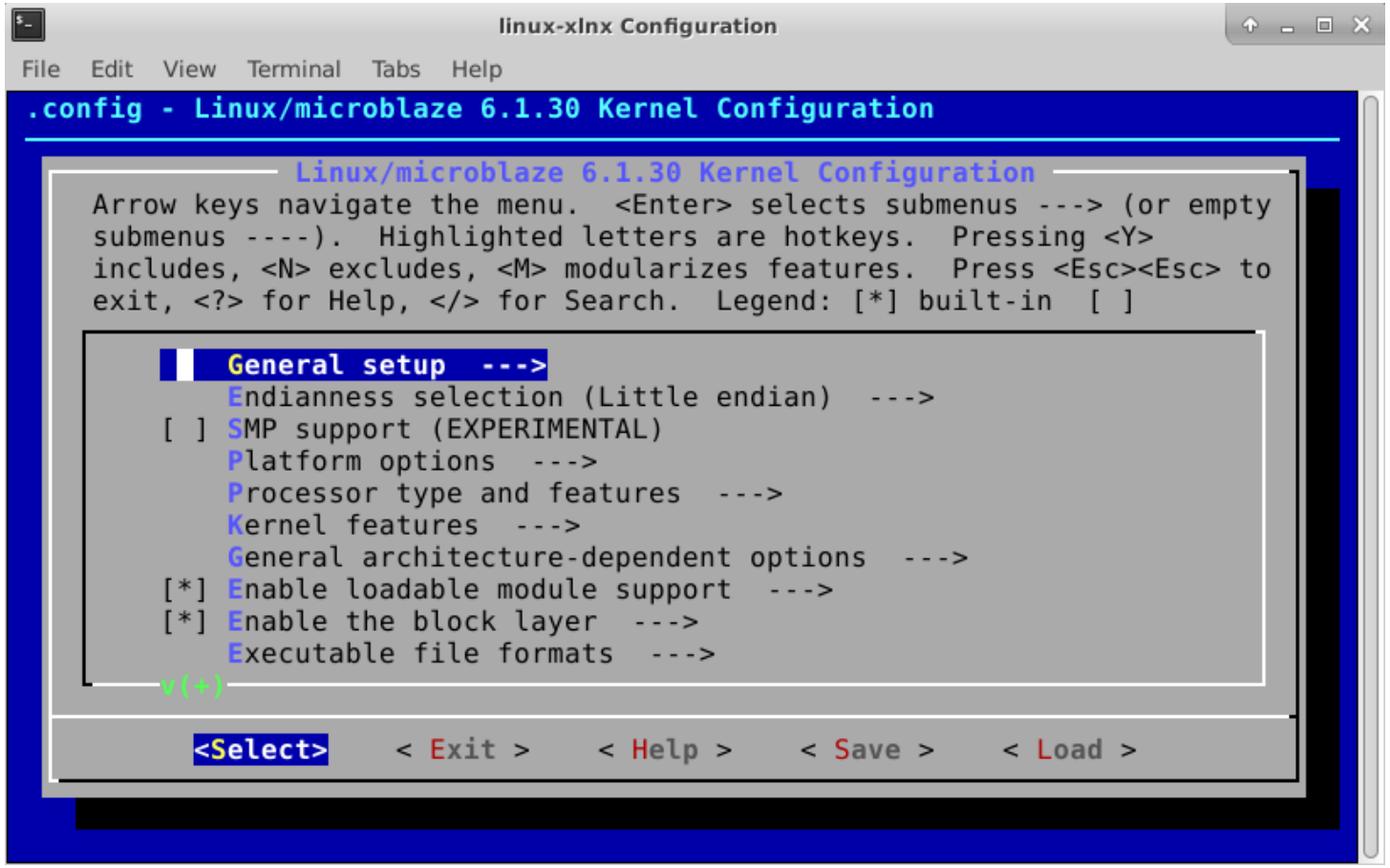
Lab: Embedded Linux

1. You will see lots of information downloaded

```
adiuvo@atlas:~/petalinux_projects/microblaze_petalinux/mb_linux$ petalinux-config -c kernel
[INFO] Sourcing buildtools
[INFO] Silentconfig project
[INFO] Silentconfig rootfs
[INFO] Generating machine conf file
[INFO] Generating plnxtool conf file
[INFO] Generating kernel configuration files
[INFO] Generating u-boot configuration files
[INFO] Generating workspace directory
[INFO] Configuring: kernel
[INFO] bitbake virtual/kernel -c cleansstate
NOTE: Started PRServer with DBfile: /home/adiuvo/petalinux_projects/microblaze_petalinux/mb_linux/build/cache/prserv.sqlite3, Address: 127.0.0.1:38731, PID: 20686
Loading cache: 100% |                                                                                                                               | ETA:  --:--:--
Loaded 0 entries from dependency cache.
Parsing recipes: 100% |###############################################################################################################################| Time: 0:00:35
Parsing of 4400 .bb files complete (0 cached, 4400 parsed). 6339 targets, 892 skipped, 1 masked, 0 errors.
NOTE: Resolving any missing task queue dependencies
NOTE: Fetching uninative binary shim file:///home/adiuvo/petalinux_projects/microblaze_petalinux/mb_linux/components/yocto/downloads/uninative/3dd82c3fbdb59e87bf091c
3eef555a05fae528eeda3083828f76cd4deaceca8b/x86_64-nativesdk-libc-3.9.tar.xz;sha256sum=3dd82c3fbdb59e87bf091c3eef555a05fae528eeda3083828f76cd4deaceca8b (will check PR
EMIRRORS first)
Initialising tasks: 100% |#############################################################################################################################| Time: 0:00:00
Sstate summary: Wanted 0 Local 0 Mirrors 0 Missed 0 Current 0 (0% match, 0% complete)
NOTE: No setscene tasks
NOTE: Executing Tasks
NOTE: Tasks Summary: Attempted 3 tasks of which 0 didn't need to be rerun and all succeeded.
[INFO] bitbake virtual/kernel -c menuconfig
NOTE: Started PRServer with DBfile: /home/adiuvo/petalinux_projects/microblaze_petalinux/mb_linux/build/cache/prserv.sqlite3, Address: 127.0.0.1:45095, PID: 21951
Loading cache: 100% |#################################################################################################################################| Time: 0:00:01
Loaded 6338 entries from dependency cache.
Parsing recipes: 100% |###############################################################################################################################| Time: 0:00:02
Parsing of 4400 .bb files complete (4399 cached, 1 parsed). 6339 targets, 892 skipped, 1 masked, 0 errors.
NOTE: Resolving any missing task queue dependencies
Initialising tasks: 100% |#############################################################################################################################| Time: 0:00:01
Checking sstate mirror object availability: 100% |#####################################################################################################| Time: 0:00:02
Sstate summary: Wanted 137 Local 0 Mirrors 136 Missed 1 Current 0 (99% match, 0% complete)
NOTE: Executing Tasks
Setscene tasks: 137 of 137
Currently  1 running tasks (619 of 620)  99% |##################################################################################################################### |
0: linux-xlnx-6.1.30-xilinx-v2023.2+gitAUTOINC+a19da02cf5-r0 do_menuconfig - 5m35s (pid 3363)
```

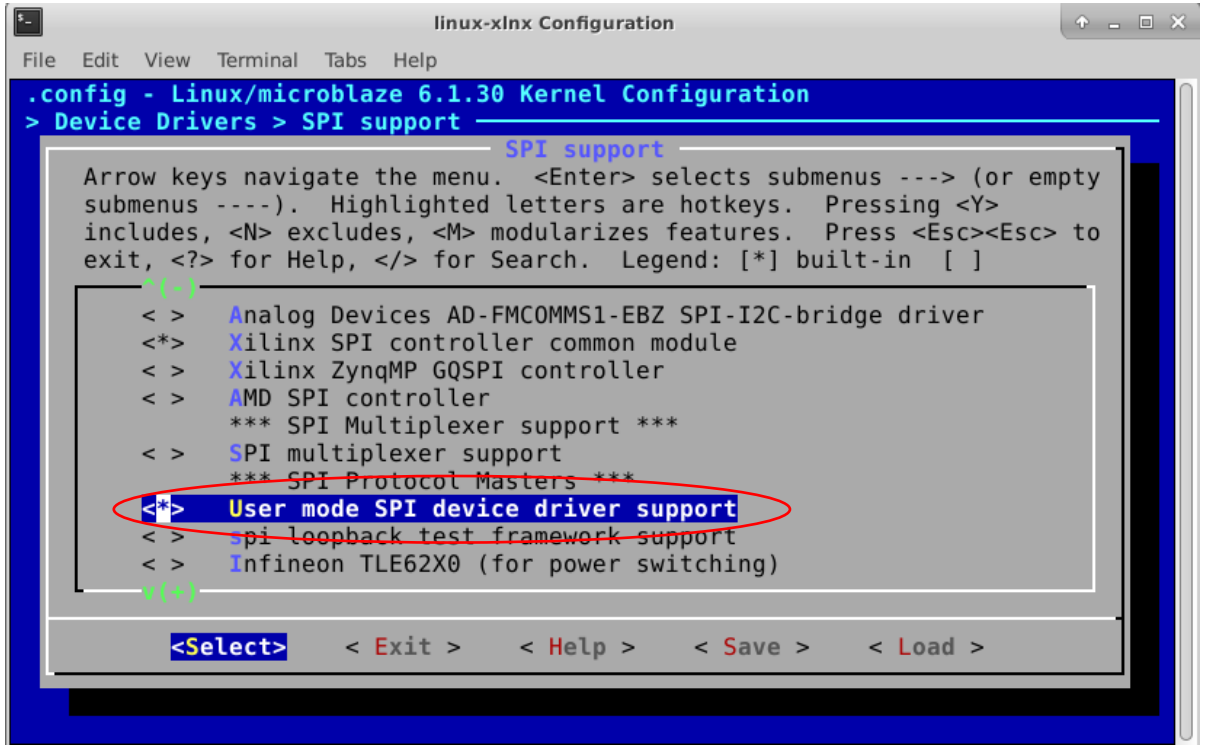
Lab: Embedded Linux

1. The kernel configuration will open



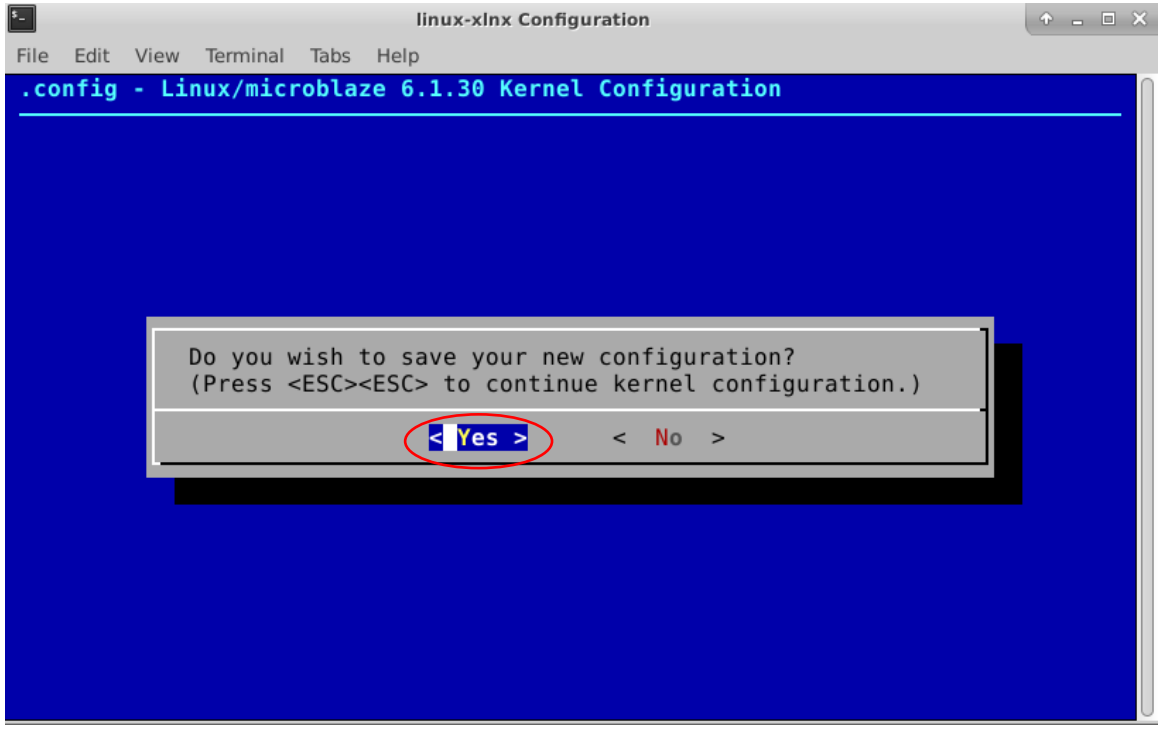
Lab: Embedded Linux

1. Navigate to the Device Drivers SPI Support and enable the user mode SPI device driver support



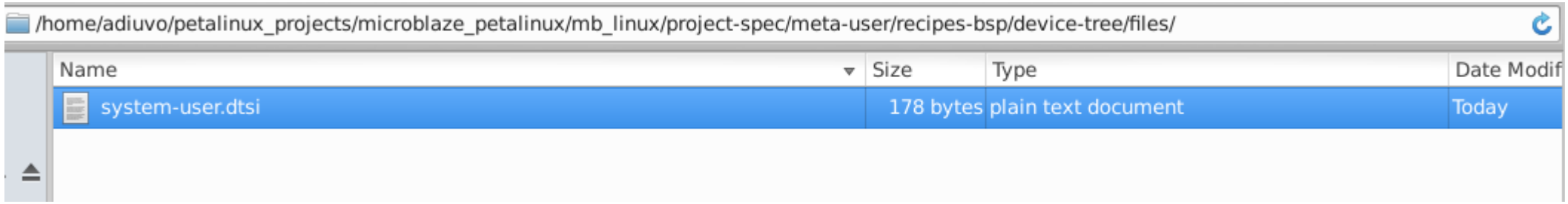
Lab: Embedded Linux

1. Exit and save the configuration



Lab: Embedded Linux

1. Open the system-user.dtsi file under the meta-user layer – only files under here can be manipulated by the user



Lab: Embedded Linux

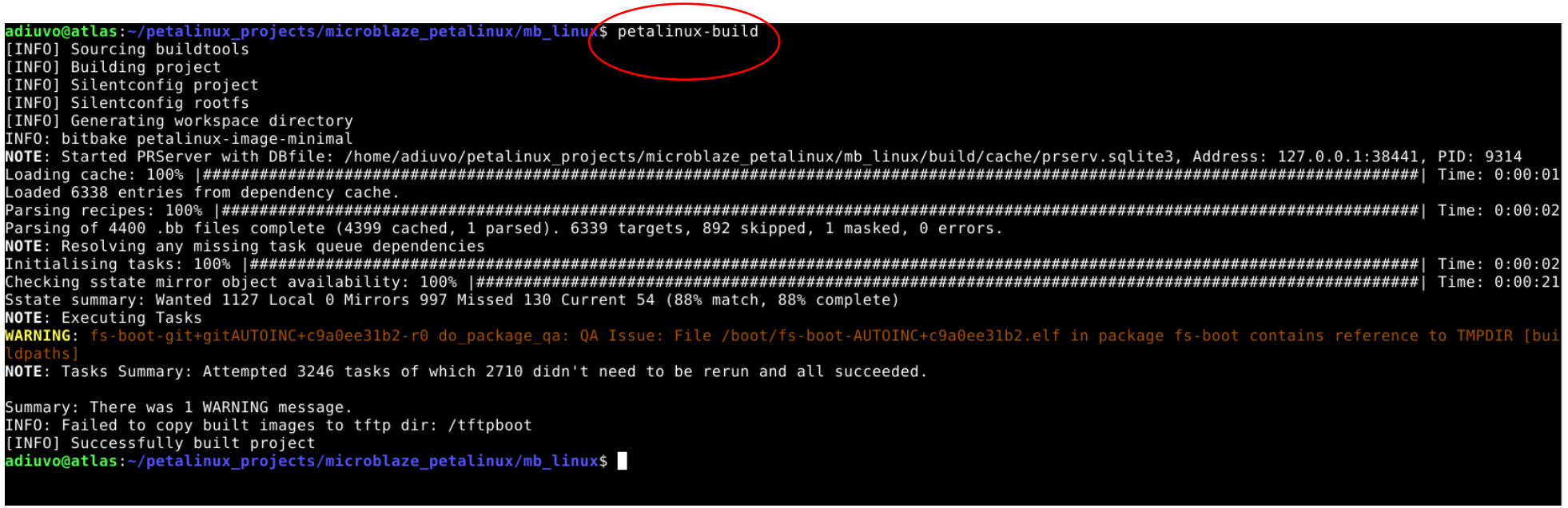
1. Add in the text below to enable the SPI Dev on device 0, Chip Select 0

Open + *system-user.dtsi
~/petalinux_projects/microblaze_petalinux...ec/meta-user/recipes-bsp/device-tree/files

```
/include/ "system-conf.dtsi"
/ {
};
        &axi_quad_spi_0 {
                status = "okay";
                spidev@0 {
                        compatible = "rohm,dh2228fv";
                        spi-max-frequency = <50000000>;
                        reg = <0>;
                };
        };
```

Lab: Embedded Linux

1. Build the system



Lab: Embedded Linux

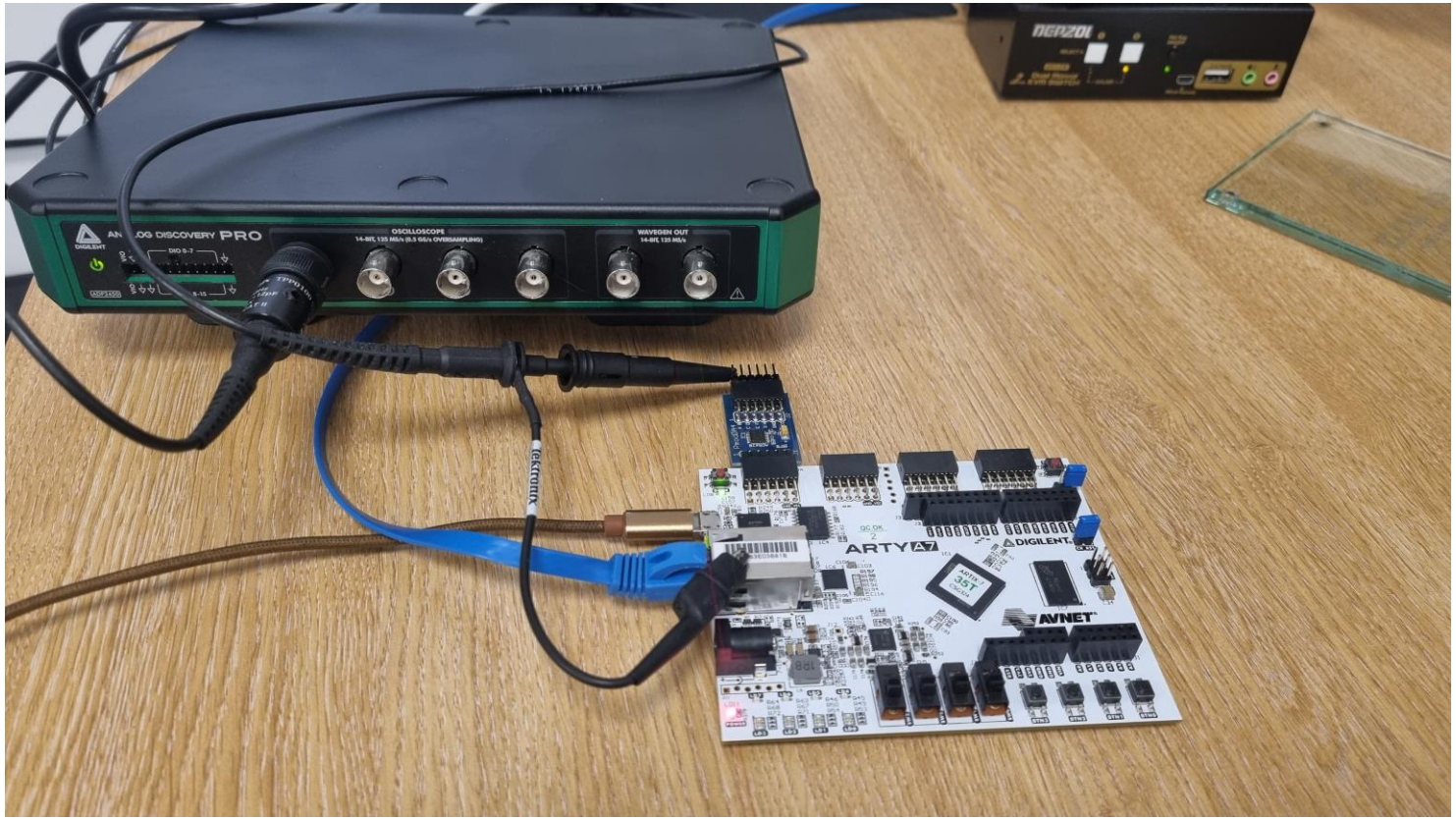
1. Connect the board over the USB Uart and Connect the Ethernet, etc
2. Download the FPGA over JTAG
3. Download the Kernel over JTAG

```
adiuvo@atlas:~/petalinux_projects/microblaze_petalinux/mb_linux$ petalinux-boot --jtag --fpga
[INFO] Sourcing buildtools
INFO: Use bitstream: "/home/adiuvo/petalinux_projects/microblaze_petalinux/mb_linux/images/linux/system.bit.
INFO: Please use --fpga --bitstream <BITSTREAM> to specify a bitstream if you want to use other bitstream.
INFO: Launching XSDB for file download and boot.
INFO: This may take a few minutes, depending on the size of your image.
rlwrap: warning: your $TERM is 'xterm-256color' but rlwrap couldn't find it in the terminfo database. Expect some problems.: Inappropriate ioctl for device
INFO: Configuring the FPGA...
INFO: Downloading bitstream: /home/adiuvo/petalinux_projects/microblaze_petalinux/mb_linux/images/linux/system.bit to the target.

adiuvo@atlas:~/petalinux_projects/microblaze_petalinux/mb_linux$ petalinux-boot --jtag --kernel
[INFO] Sourcing buildtools
INFO: Launching XSDB for file download and boot.
INFO: This may take a few minutes, depending on the size of your image.
rlwrap: warning: your $TERM is 'xterm-256color' but rlwrap couldn't find it in the terminfo database. Expect some problems.: Inappropriate ioctl for device
INFO: Downloading ELF file: /home/adiuvo/petalinux_projects/microblaze_petalinux/mb_linux/images/linux/u-boot.elf to the target.
INFO: Loading image: /home/adiuvo/petalinux_projects/microblaze_petalinux/mb_linux/images/linux/linux.bin.ub at 0x80000000
INFO: Loading image: /home/adiuvo/petalinux_projects/microblaze_petalinux/mb_linux/images/linux/system.dtb at 0x81e00000
INFO: Loading image: /home/adiuvo/petalinux_projects/microblaze_petalinux/mb_linux/images/linux/rootfs.cpio.gz.u-boot at 0x82e00000
INFO: Loading image: /home/adiuvo/petalinux_projects/microblaze_petalinux/mb_linux/images/linux/boot.scr at 0x8f200000
adiuvo@atlas:~/petalinux_projects/microblaze_petalinux/mb_linux$
```

Lab: Embedded Linux

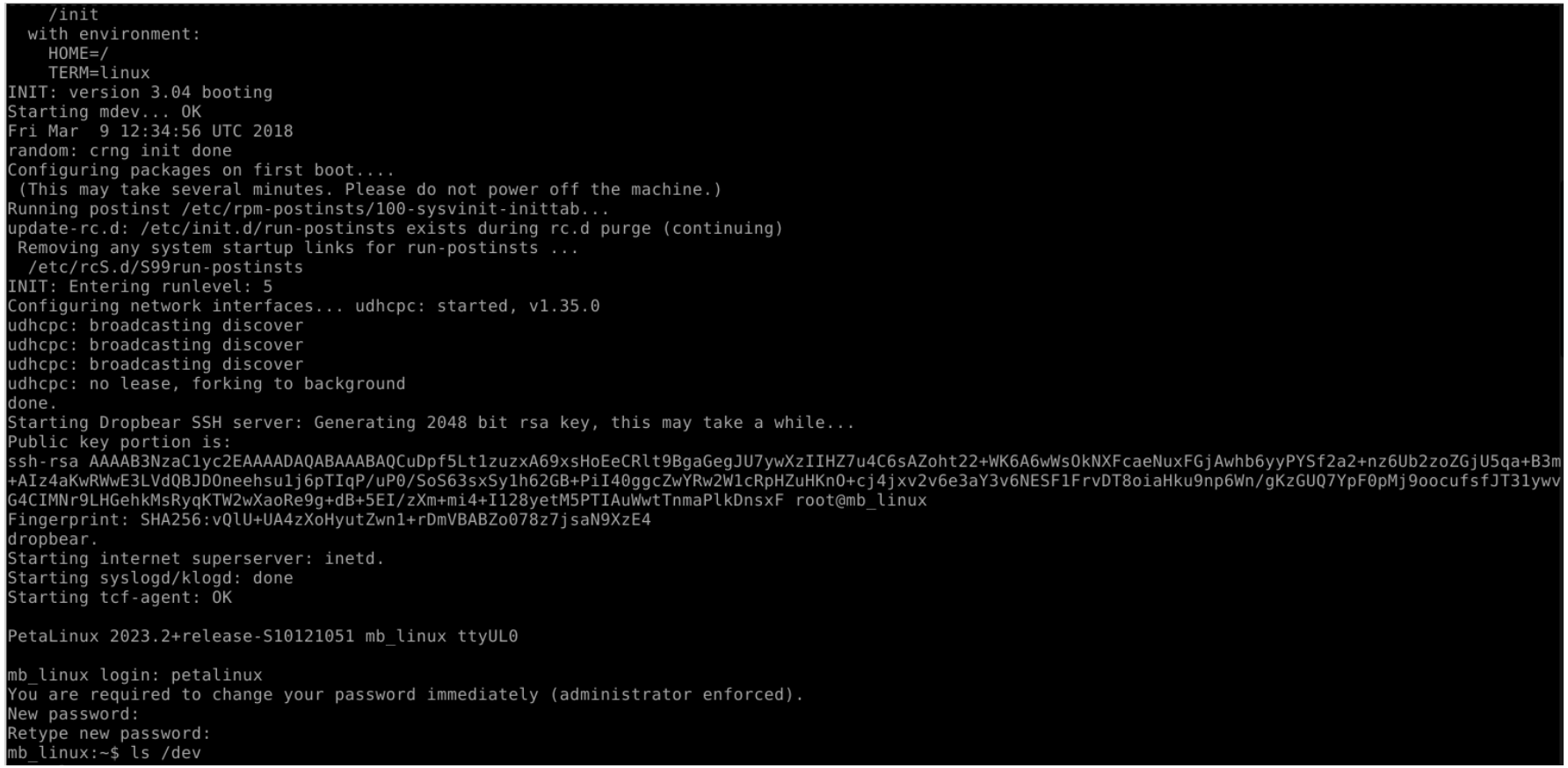
1. The configuration should be similar to as shown



Lab: Embedded Linux

1. In a terminal window set for 9600:N:1 wait for the Linux OS to boot and sign in

2. View the list of devices



Lab: Embedded Linux

1. You should observe spidev0.0 as present

```
mb_linux:~$ ls /dev
console      ptyc7        ptyp9        ptysb        ptyvd        ptyyf        ttya9        ttydb        ttyqd        ttytf        ttyx1
full         ptyc8        ptypa        ptysc        ptyve        ptyz0        ttyaa        ttydc        ttyqe        ttyu0        ttyx2
initctl      ptyc9        ptypb        ptysd        ptyvf        ptyz1        ttyab        ttydd        ttyqf        ttyu1        ttyx3
kmsg         ptyca        ptypc        ptyse        ptyw0        ptyz2        ttyac        ttyde        ttyr0        ttyu2        ttyx4
log          ptycb        ptypd        ptysf        ptyw1        ptyz3        ttyad        ttydf        ttyr1        ttyu3        ttyx5
mem          ptycc        ptype        ptyt0        ptyw2        ptyz4        ttyae        ttye0        ttyr2        ttyu4        ttyx6
mtab         ptycd        ptypf        ptyt1        ptyw3        ptyz5        ttyaf        ttye1        ttyr3        ttyu5        ttyx7
null         ptyce        ptyq0        ptyt2        ptyw4        ptyz6        ttyb0        ttye2        ttyr4        ttyu6        ttyx8
port         ptycf        ptyq1        ptyt3        ptyw5        ptyz7        ttyb1        ttye3        ttyr5        ttyu7        ttyx9
ptmx         ptyd0        ptyq2        ptyt4        ptyw6        ptyz8        ttyb2        ttye4        ttyr6        ttyu8        ttyxa
pts          ptyd1        ptyq3        ptyt5        ptyw7        ptyz9        ttyb3        ttye5        ttyr7        ttyu9        ttyxb
ptya0        ptyd2        ptyq4        ptyt6        ptyw8        ptyza        ttyb4        ttye6        ttyr8        ttyua        ttyxc
ptya1        ptyd3        ptyq5        ptyt7        ptyw9        ptyzb        ttyb5        ttye7        ttyr9        ttyub        ttyxd
ptya2        ptyd4        ptyq6        ptyt8        ptywa        ptyzc        ttyb6        ttye8        ttyra        ttyuc        ttyxe
ptya3        ptyd5        ptyq7        ptyt9        ptywb        ptyzd        ttyb7        ttye9        ttyrb        ttyud        ttyxf
ptya4        ptyd6        ptyq8        ptyta        ptywc        ptyze        ttyb8        ttyea        ttyrc        ttyue        ttyy0
ptya5        ptyd7        ptyq9        ptytb        ptywd        ptyzf        ttyb9        ttyeb        ttyrd        ttyuf        ttyy1
ptya6        ptyd8        ptyqa        ptytc        ptywe        ram0         ttyba        ttyec        ttyre        ttyv0        ttyy2
ptya7        ptyd9        ptyqb        ptytd        ptywf        ram1         ttybb        ttyed        ttyrf        ttyv1        ttyy3
ptya8        ptyda        ptyqc        ptyte        ptyx0        ram10        ttybc        ttyee        ttys0        ttyv2        ttyy4
ptya9        ptydb        ptyqd        ptytf        ptyx1        ram11        ttybd        ttyef        ttys1        ttyv3        ttyy5
ptyaa        ptydc        ptyqe        ptyu0        ptyx2        ram12        ttybe        ttyp0        ttys2        ttyv4        ttyy6
ptyab        ptydd        ptyqf        ptyu1        ptyx3        ram13        ttybf        ttyp1        ttys3        ttyv5        ttyy7
ptyac        ptyde        ptyr0        ptyu2        ptyx4        ram14        ttyc0        ttyp2        ttys4        ttyv6        ttyy8
ptyad        ptydf        ptyr1        ptyu3        ptyx5        ram15        ttyc1        ttyp3        ttys5        ttyv7        ttyy9
ptyae        ptye0        ptyr2        ptyu4        ptyx6        ram2         ttyc2        ttyp4        ttys6        ttyv8        ttyya
ptyaf        ptye1        ptyr3        ptyu5        ptyx7        ram3         ttyc3        ttyp5        ttys7        ttyv9        ttyyb
ptyb0        ptye2        ptyr4        ptyu6        ptyx8        ram4         ttyc4        ttyp6        ttys8        ttyva        ttyyc
ptyb1        ptye3        ptyr5        ptyu7        ptyx9        ram5         ttyc5        ttyp7        ttys9        ttyvb        ttyyd
ptyb2        ptye4        ptyr6        ptyu8        ptyxa        ram6         ttyc6        ttyp8        ttysa        ttyvc        ttyye
ptyb3        ptye5        ptyr7        ptyu9        ptyxb        ram7         ttyc7        ttyp9        ttysb        ttyvd        ttyyf
ptyb4        ptye6        ptyr8        ptyua        ptyxc        ram8         ttyc8        ttypa        ttysc        ttyve        ttyz0
ptyb5        ptye7        ptyr9        ptyub        ptyxd        ram9         ttyc9        ttypb        ttysd        ttyvf        ttyz1
ptyb6        ptye8        ptyra        ptyuc        ptyxe        random       ttyca        ttypc        ttyse        ttyw0        ttyz2
ptyb7        ptye9        ptyrb        ptyud        ptyxf        spidev0.0    ttycb        ttypd        ttysf        ttyw1        ttyz3
ptyb8        ptyea        ptyrc        ptyue        ptyy0        tty          ttycc        ttype        ttyt0        ttyw2        ttyz4
ptyb9        ptyeb        ptyrd        ptyuf        ptyy1        ttyS0        ttycd        ttypf        ttyt1        ttyw3        ttyz5
ptyba        ptyec        ptyre        ptyv0        ptyy2        ttyS1        ttyce        ttyq0        ttyt2        ttyw4        ttyz6
ptybb        ptyed        ptyrf        ptyv1        ptyy3        ttyS2        ttycf        ttyq1        ttyt3        ttyw5        ttyz7
ptybc        ptyee        ptys0        ptyv2        ptyy4        ttyS3        ttyd0        ttyq2        ttyt4        ttyw6        ttyz8
ptybd        ptyef        ptys1        ptyv3        ptyy5        ttyUL0       ttyd1        ttyq3        ttyt5        ttyw7        ttyz9
ptybe        ptyp0        ptys2        ptyv4        ptyy6        ttya0        ttyd2        ttyq4        ttyt6        ttyw8        ttyza
ptybf        ptyp1        ptys3        ptyv5        ptyy7        ttya1        ttyd3        ttyq5        ttyt7        ttyw9        ttyzb
ptyc0        ptyp2        ptys4        ptyv6        ptyy8        ttya2        ttyd4        ttyq6        ttyt8        ttywa        ttyzc
ptyc1        ptyp3        ptys5        ptyv7        ptyy9        ttya3        ttyd5        ttyq7        ttyt9        ttywb        ttyzd
ptyc2        ptyp4        ptys6        ptyv8        ptyya        ttya4        ttyd6        ttyq8        ttyta        ttywc        ttyze
ptyc3        ptyp5        ptys7        ptyv9        ptyyb        ttya5        ttyd7        ttyq9        ttytb        ttywd        ttyzf
```

Lab: Embedded Linux

1. Get the IP address of the board

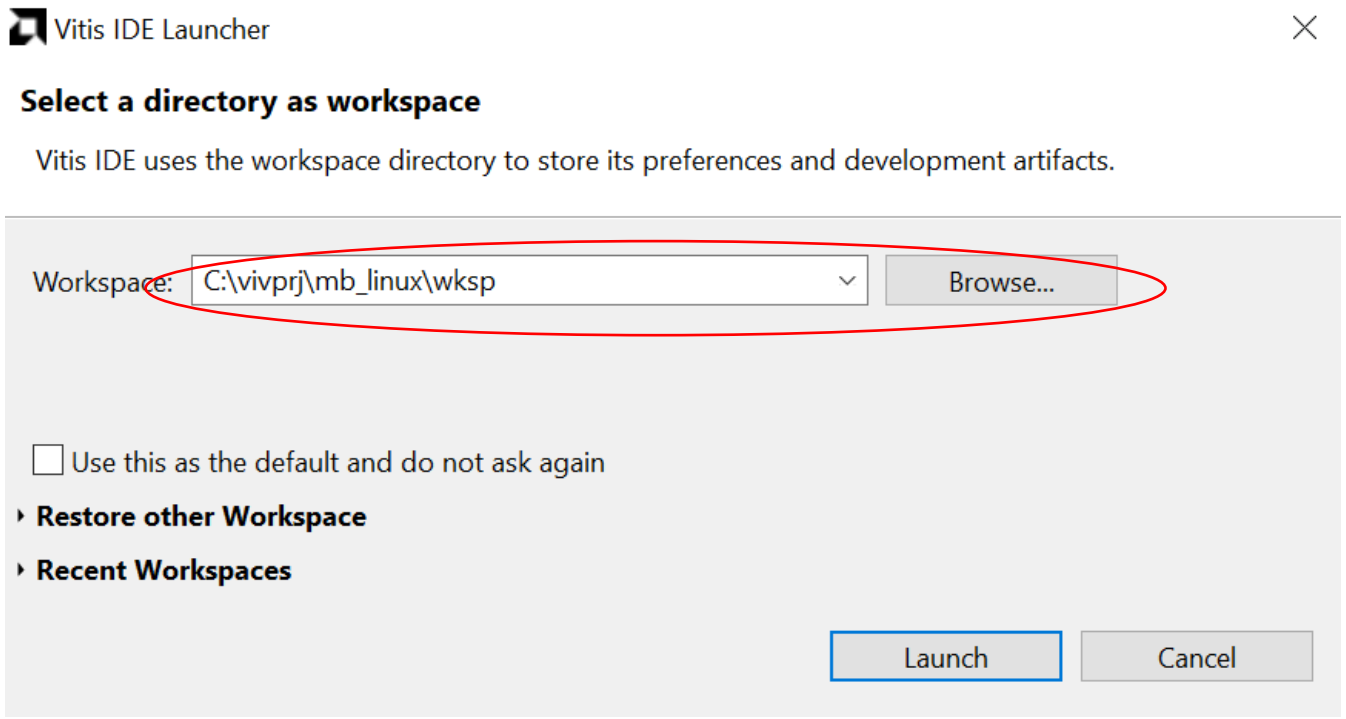
```
mb_linux:~$ ifconfig
eth0      Link encap:Ethernet  HWaddr 00:0A:35:00:84:79
          inet addr:10.10.30.13  Bcast:10.10.30.255  Mask:255.255.255.0
          UP BROADCAST RUNNING  MTU:1500  Metric:1
          RX packets:990 errors:0 dropped:607 overruns:0 frame:0
          TX packets:64 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:1066065 (1.0 MiB)  TX bytes:7468 (7.2 KiB)
          Interrupt:4 Memory:40e00000-40e0ffff

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

mb_linux:~$
```

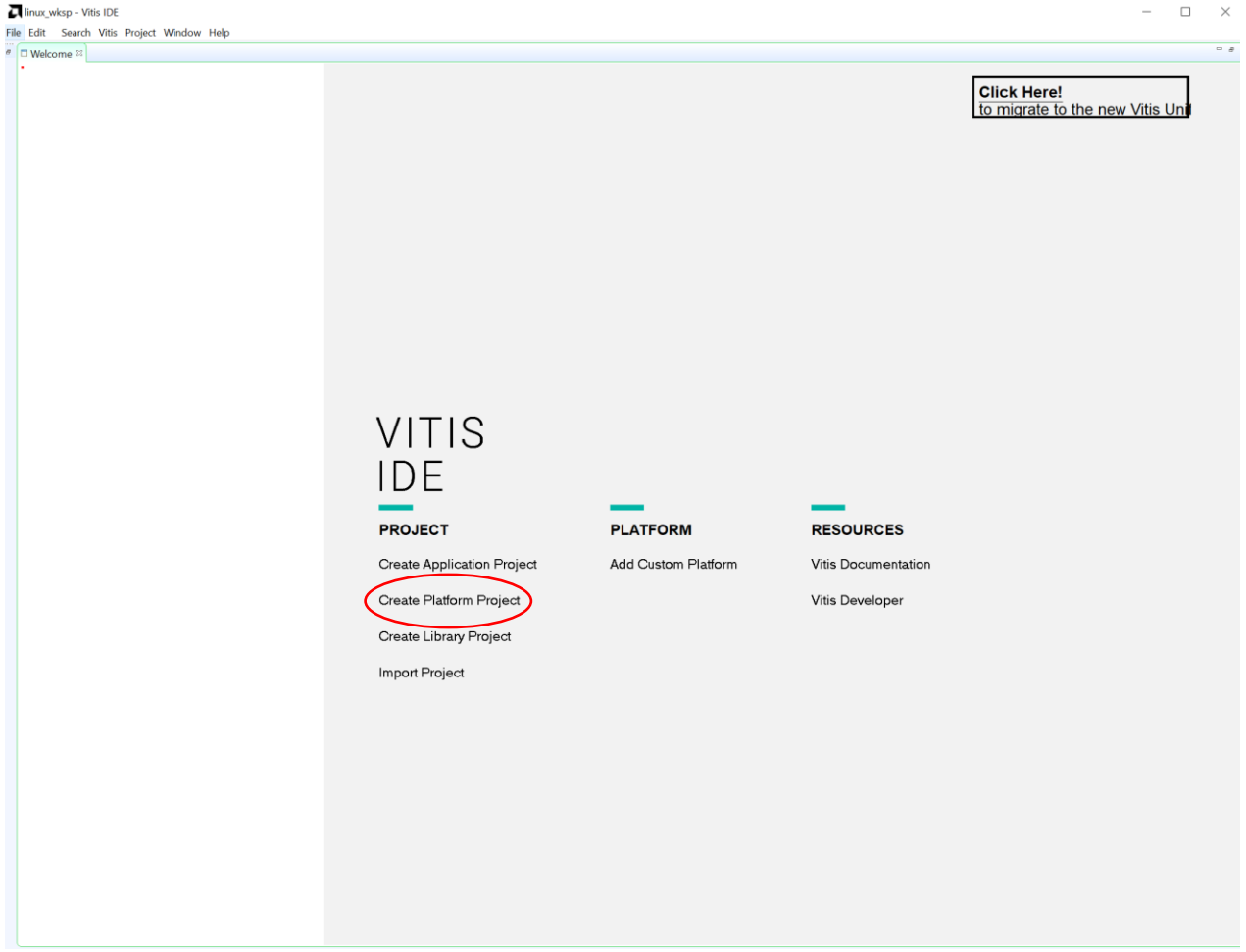
Lab: Embedded Linux

1. Open the AMD Vitis™ software and select the workspace you want to work with



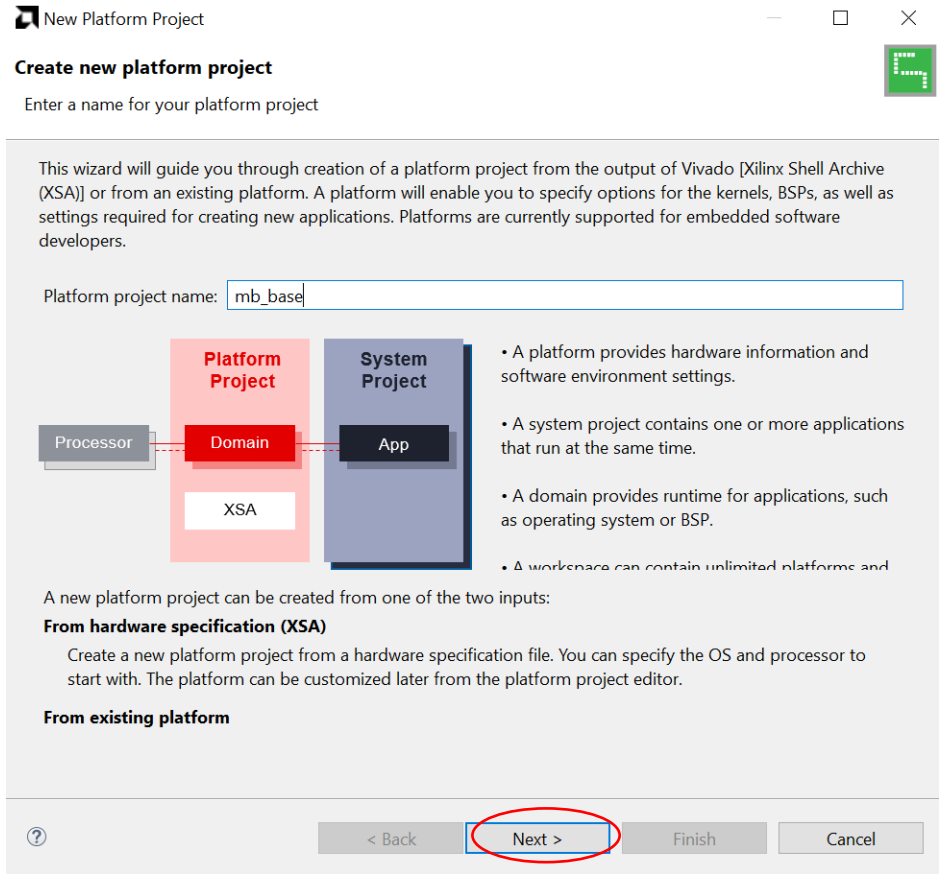
Lab: Embedded Linux

1. Create a Platform Project



Lab: Embedded Linux

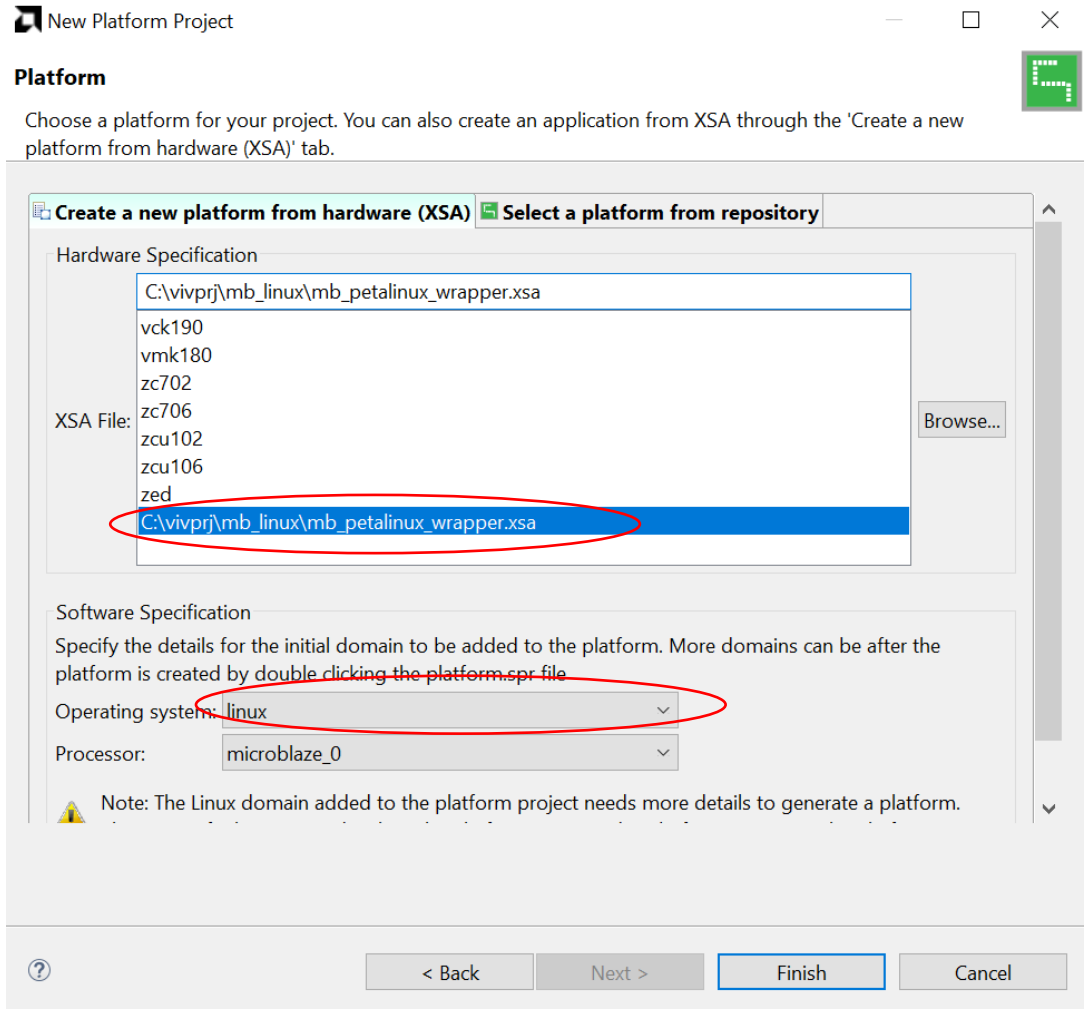
1. Click Next



Lab: Embedded Linux

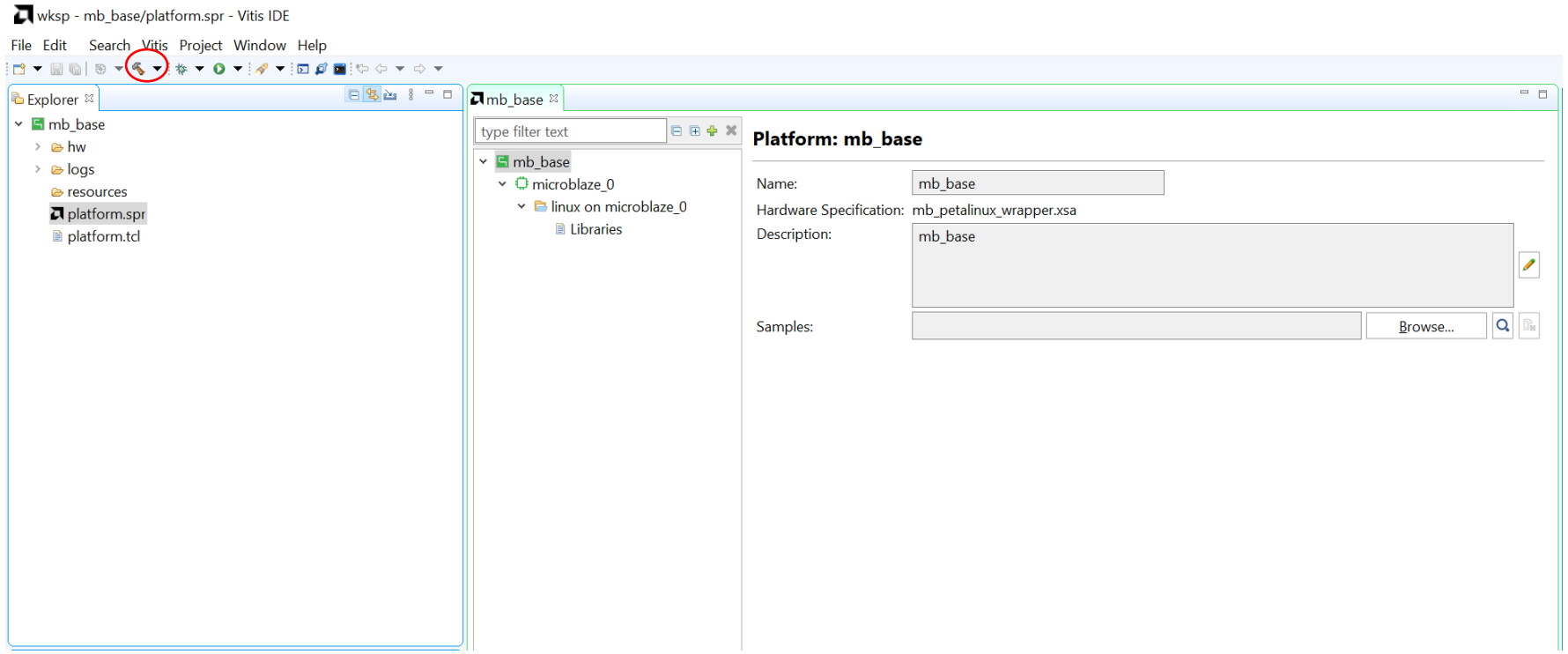
1. Select the XSA exported from the AMD Vivado™ software

2. Select the operating system as Linux



Lab: Embedded Linux

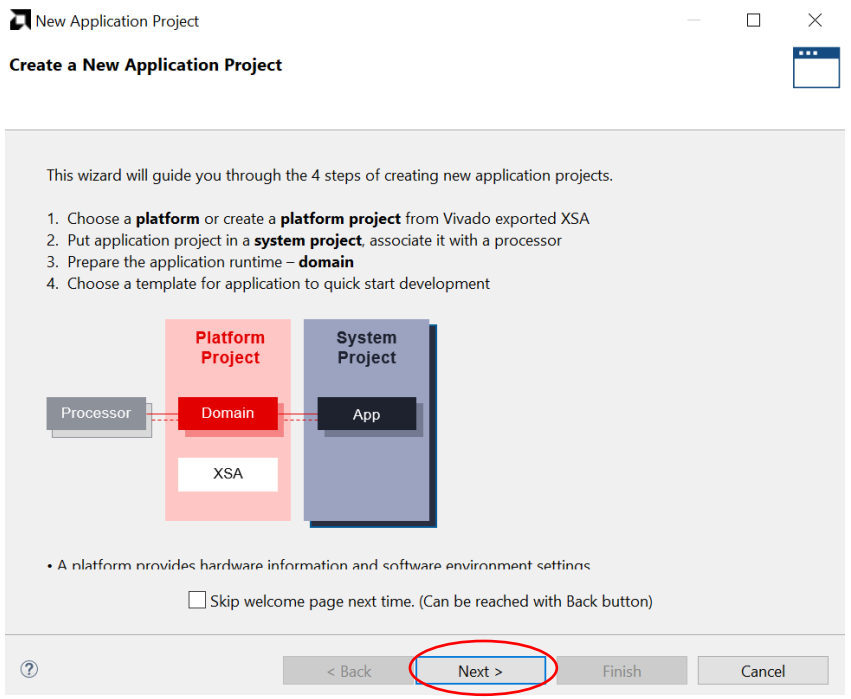
1. When the platform opens click on the hammer to compile it



Lab: Embedded Linux

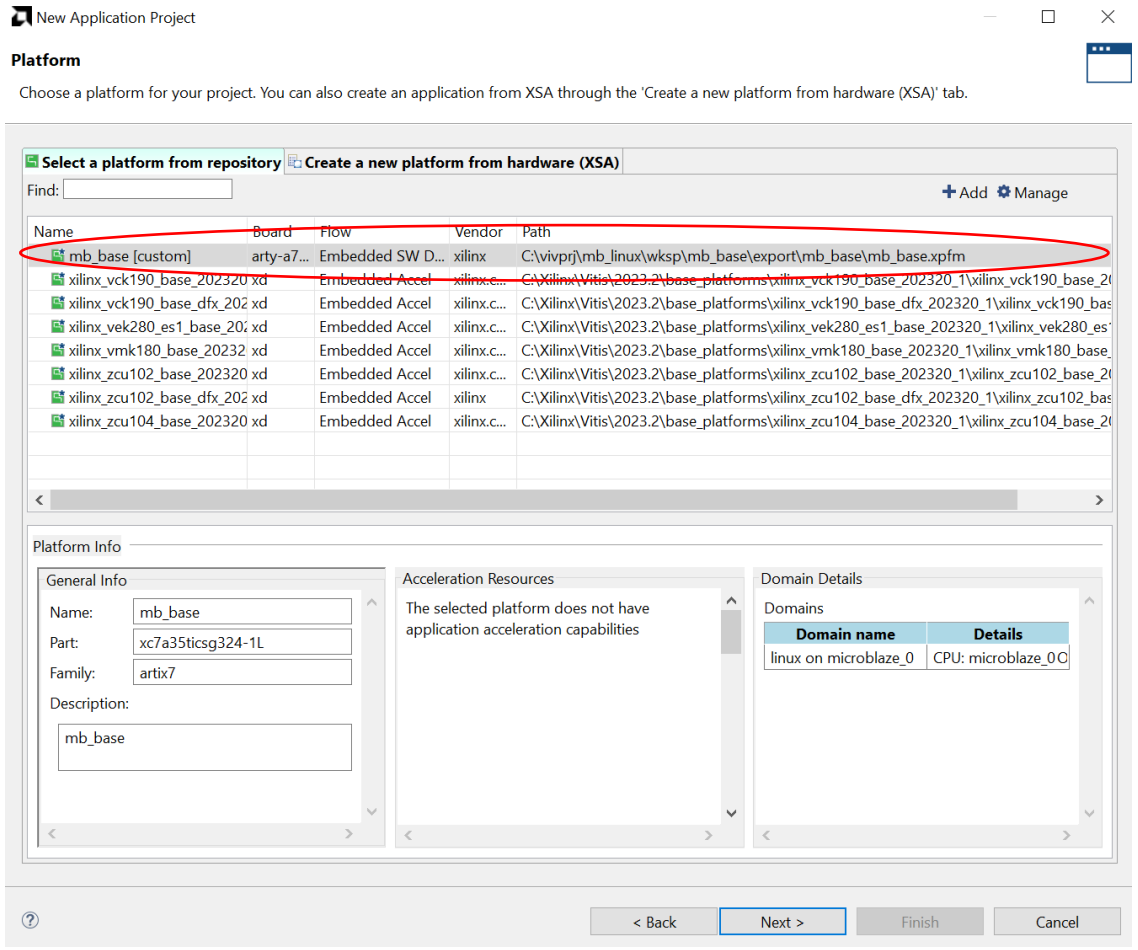
1. Create a new application project

2. Click Next



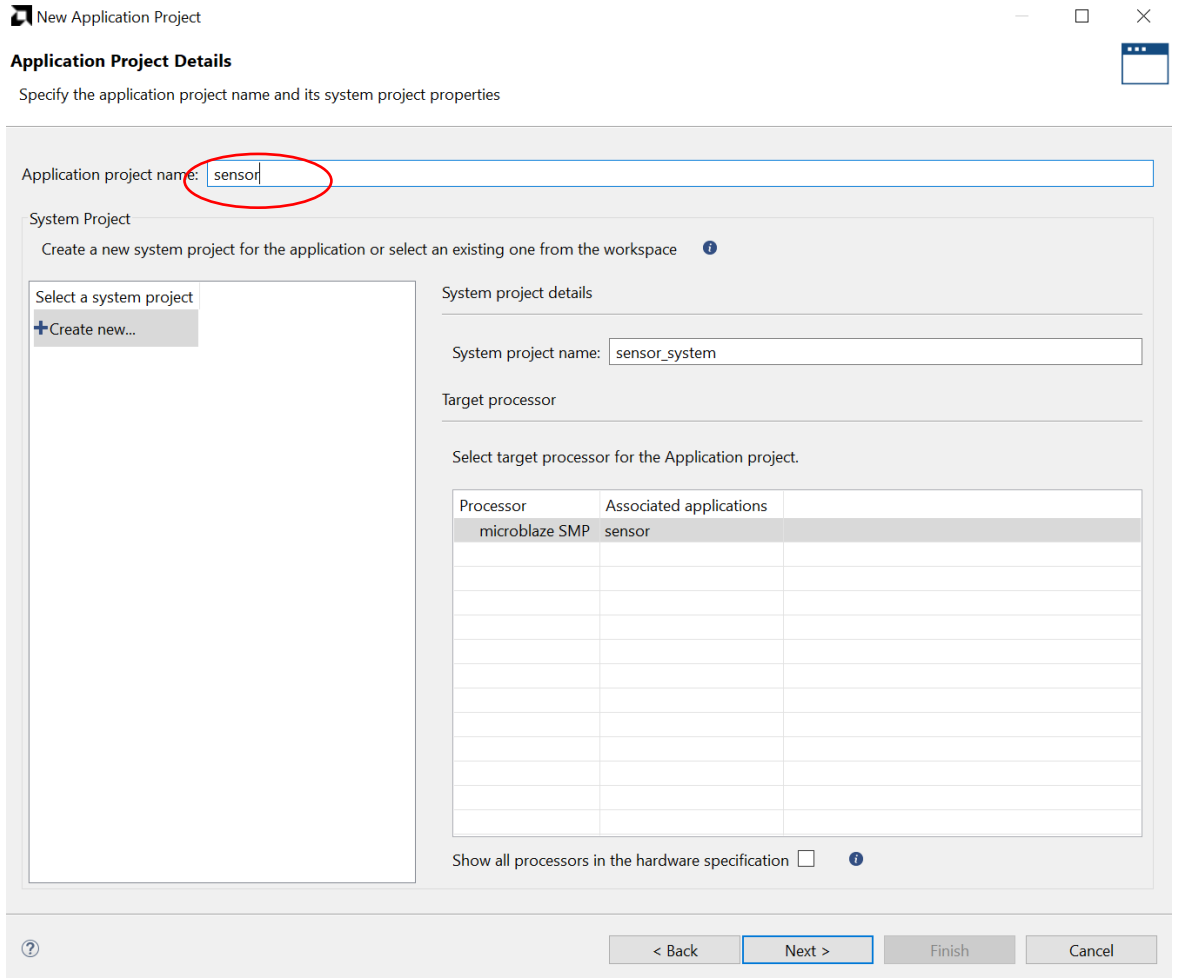
Lab: Embedded Linux

1. Select the platform we just created



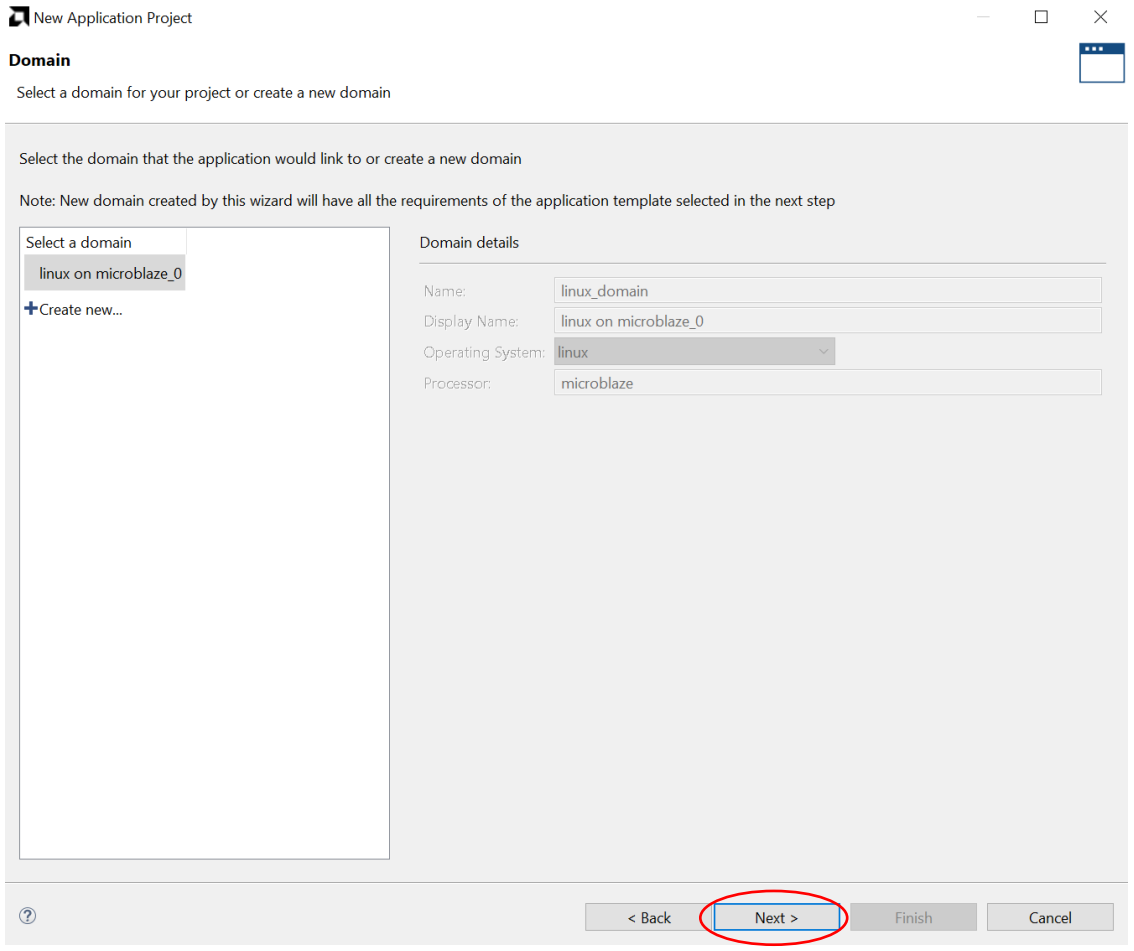
Lab: Embedded Linux

1. Name the project and click next



Lab: Embedded Linux

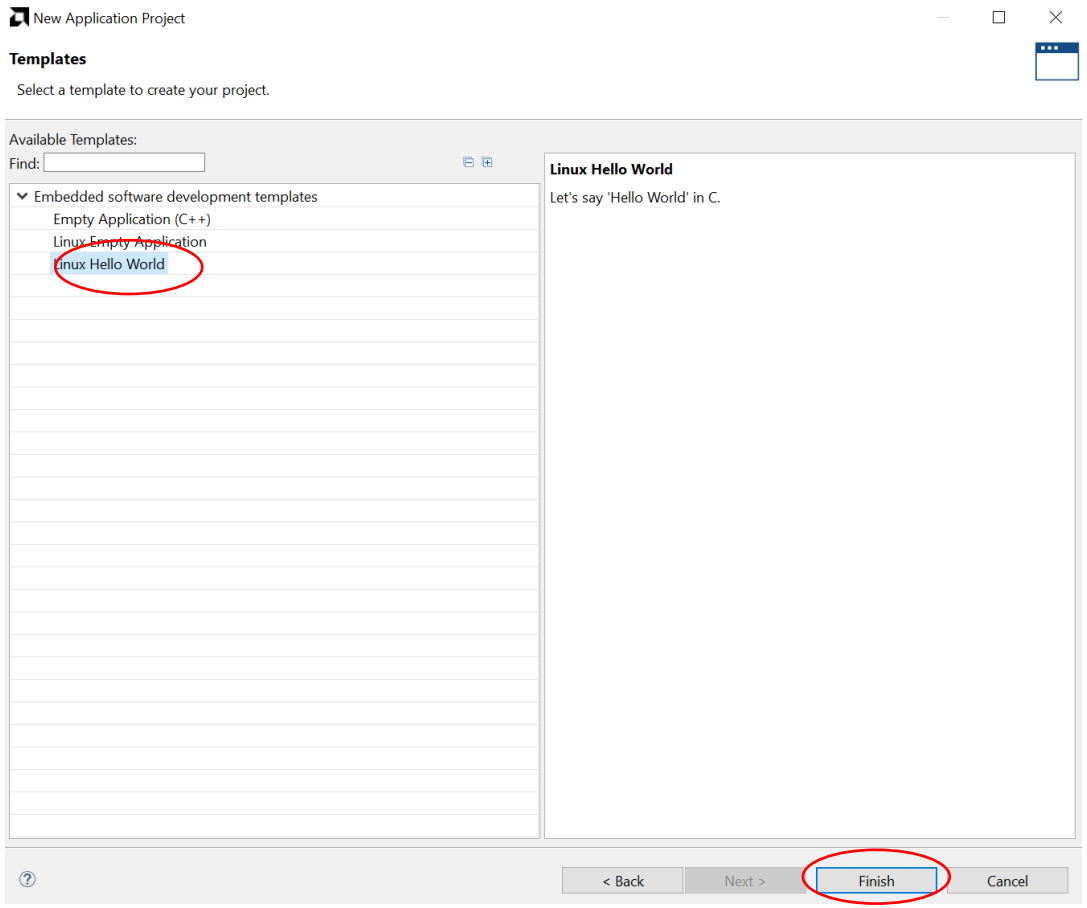
1. Click Next



Lab: Embedded Linux

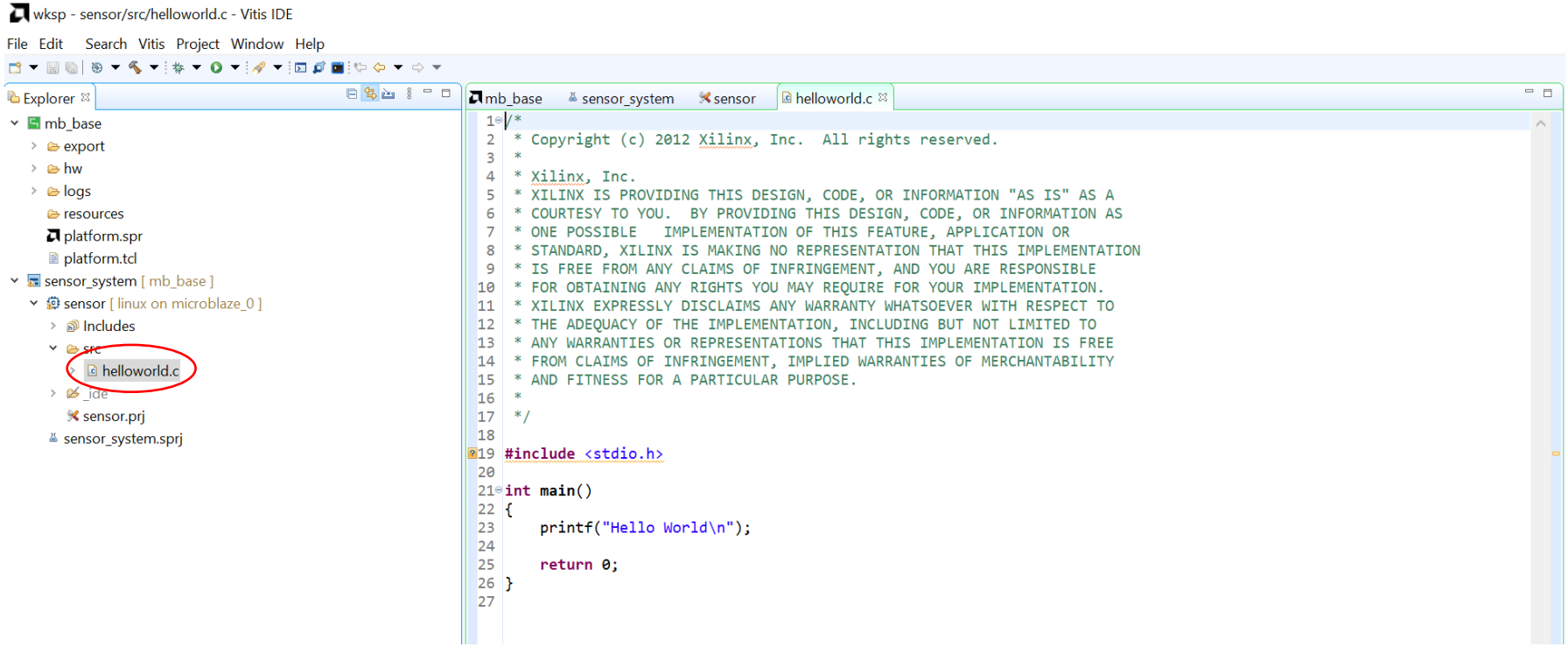
1. Select the Linux hello world

2. Click Next



Lab: Embedded Linux

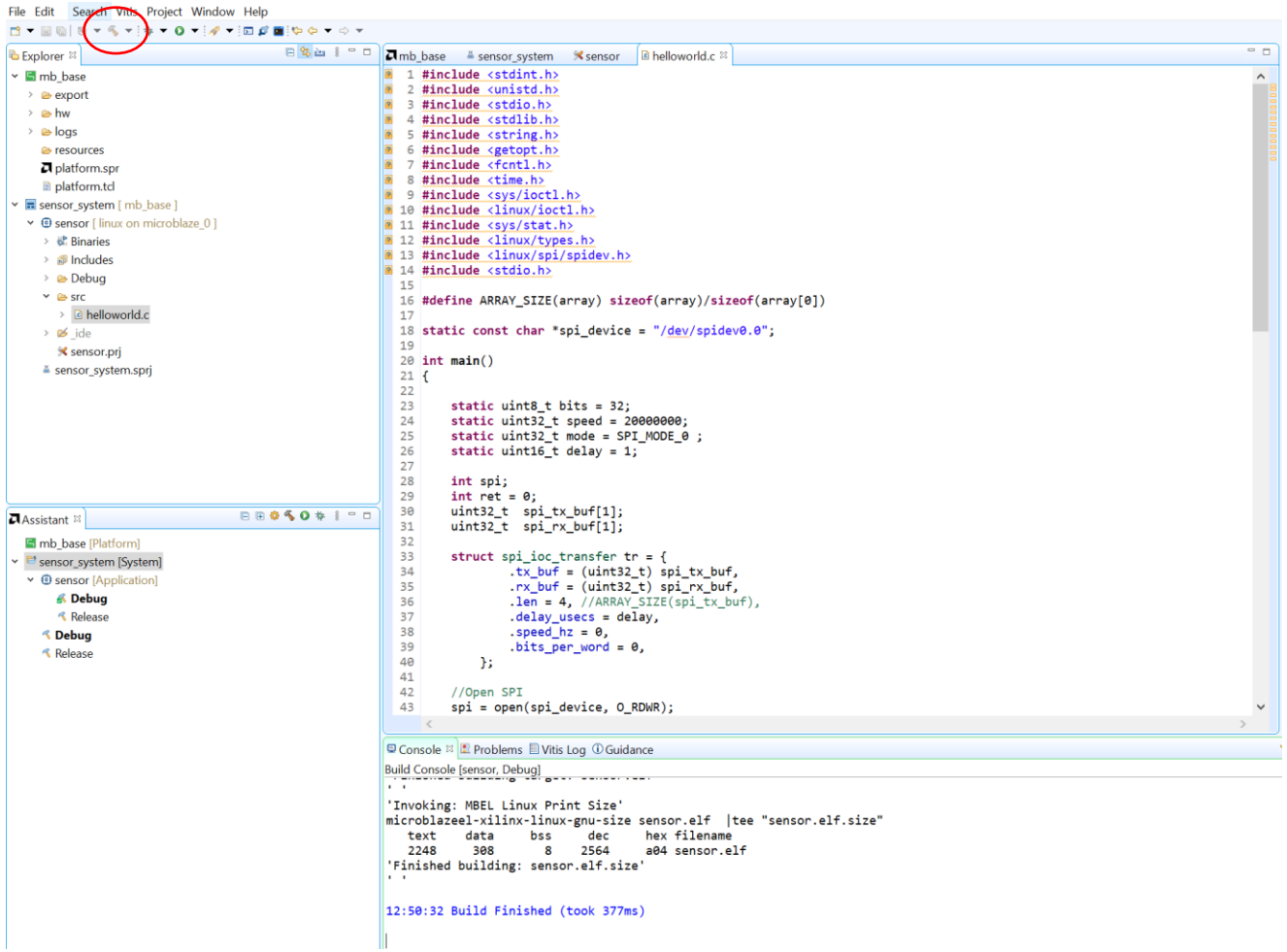
1. Open the helloworld.c source and delete the contents



Lab: Embedded Linux

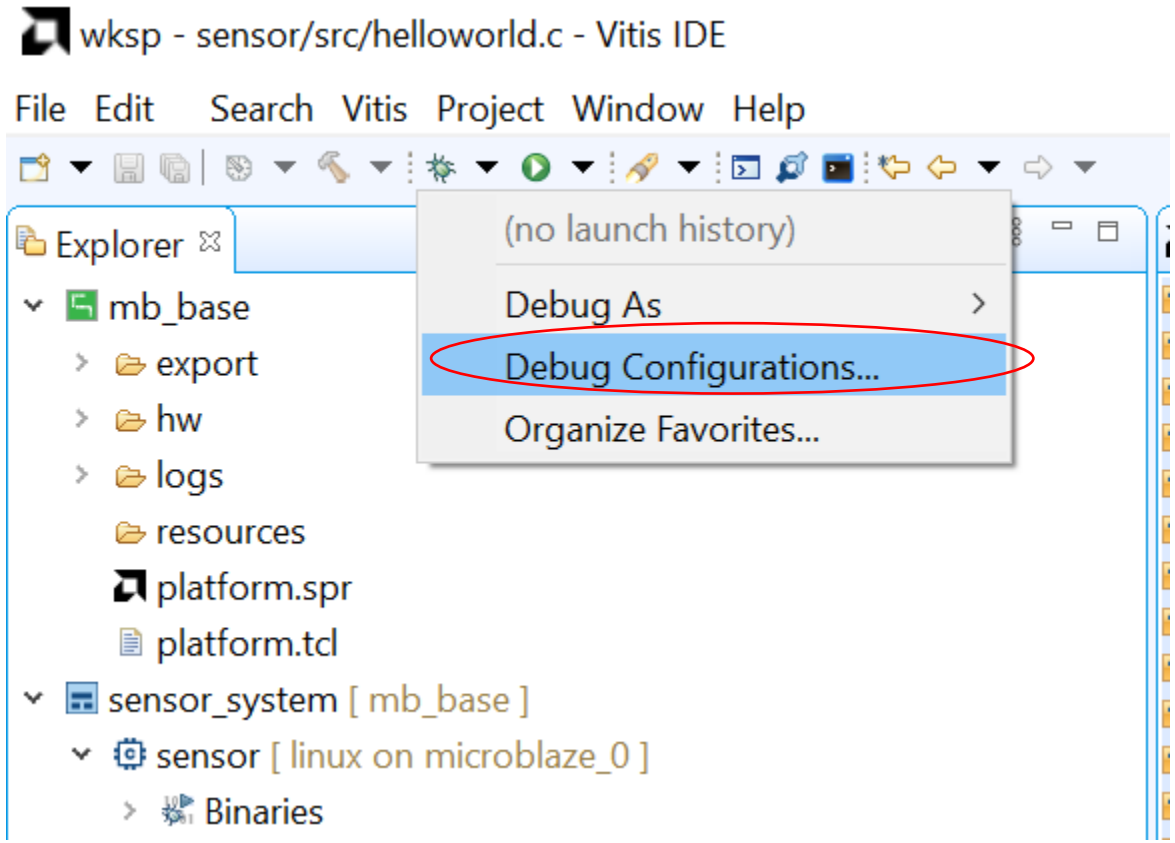
1. Copy in the source from the provided git repo

2. Click on the hammer to build the application



Lab: Embedded Linux

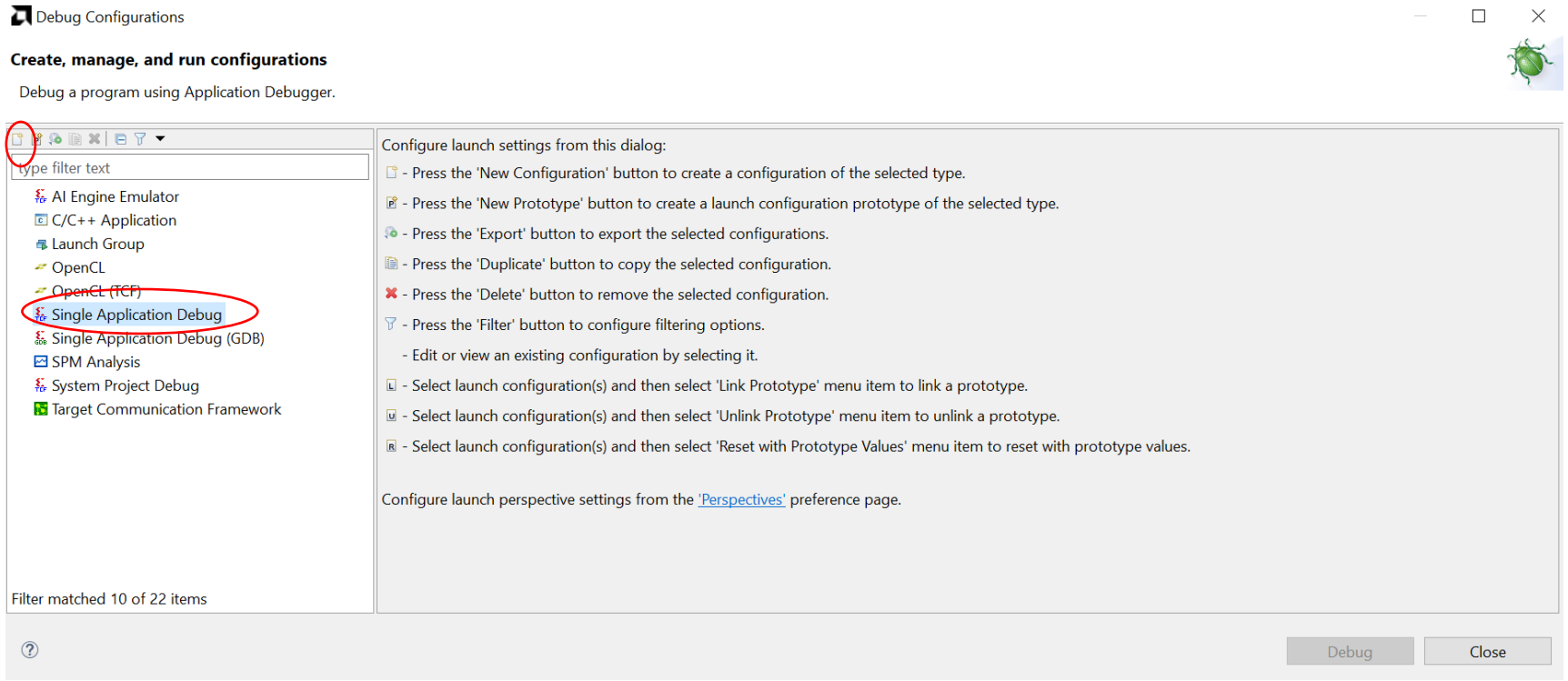
1. From the debug menu select Debug Configurations



Lab: Embedded Linux

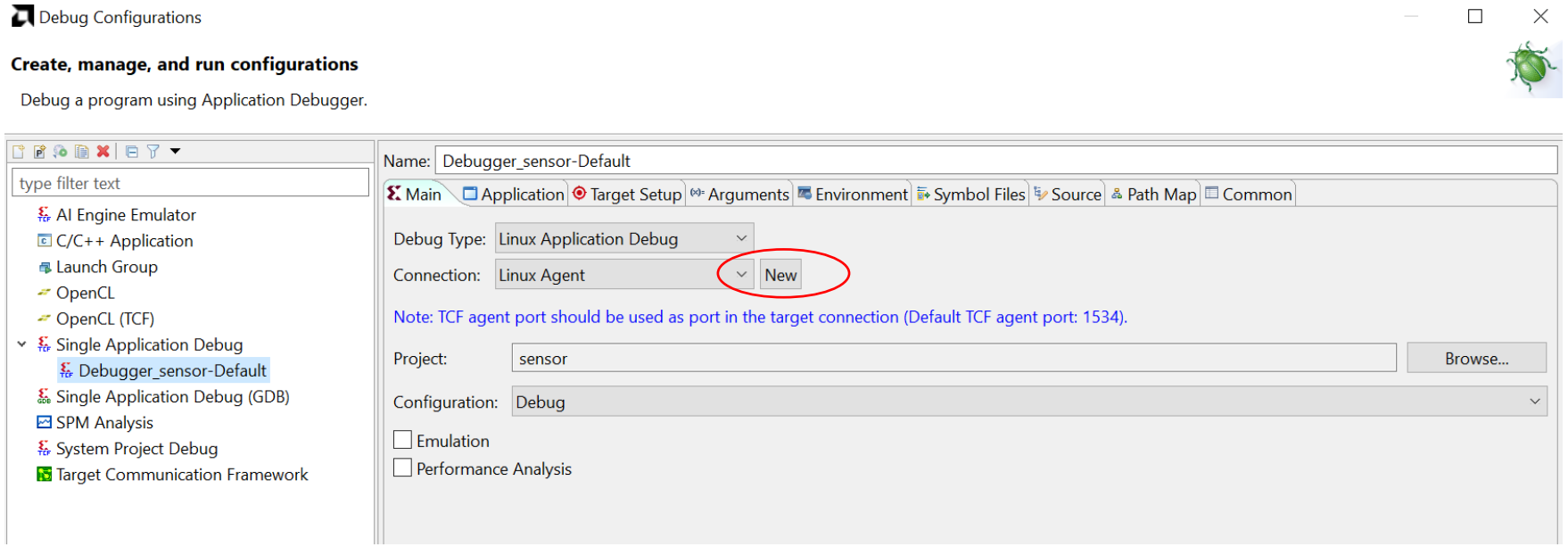
1. Select Single application debug

2. Click new



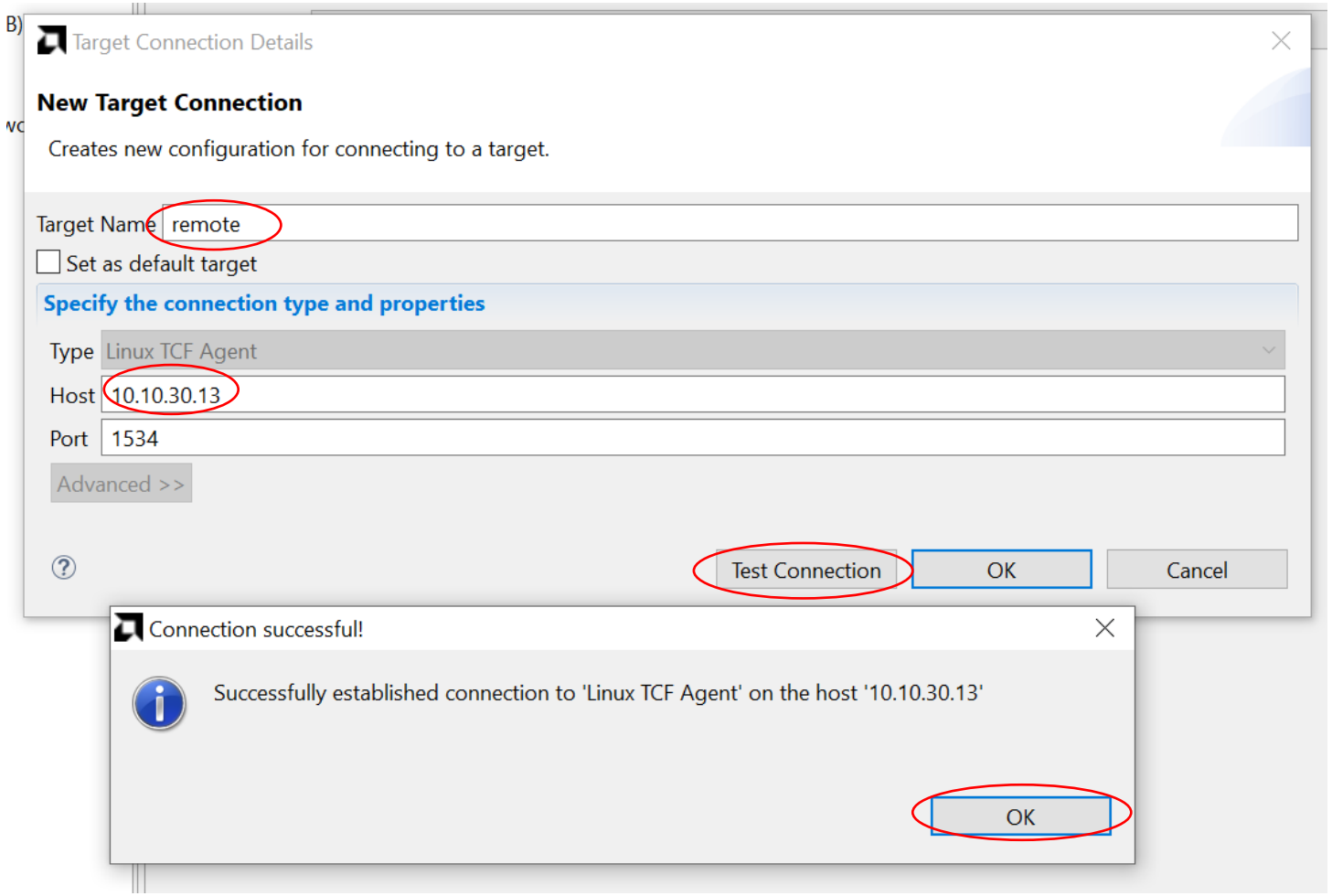
Lab: Embedded Linux

1. Click new on the connection type



Lab: Embedded Linux

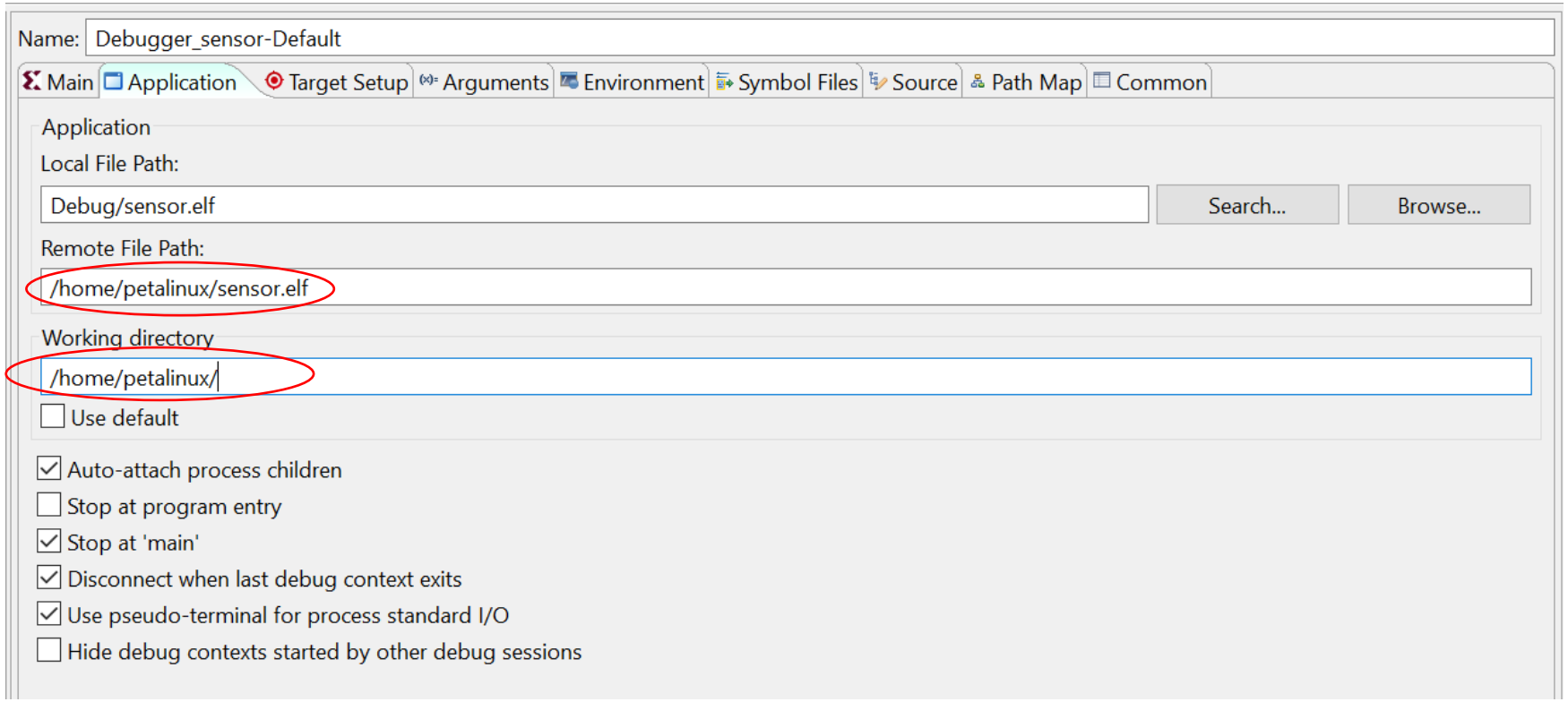
1. Enter a target name
2. Enter the board IP address
3. Click Test Connection
4. Click Ok



Lab: Embedded Linux

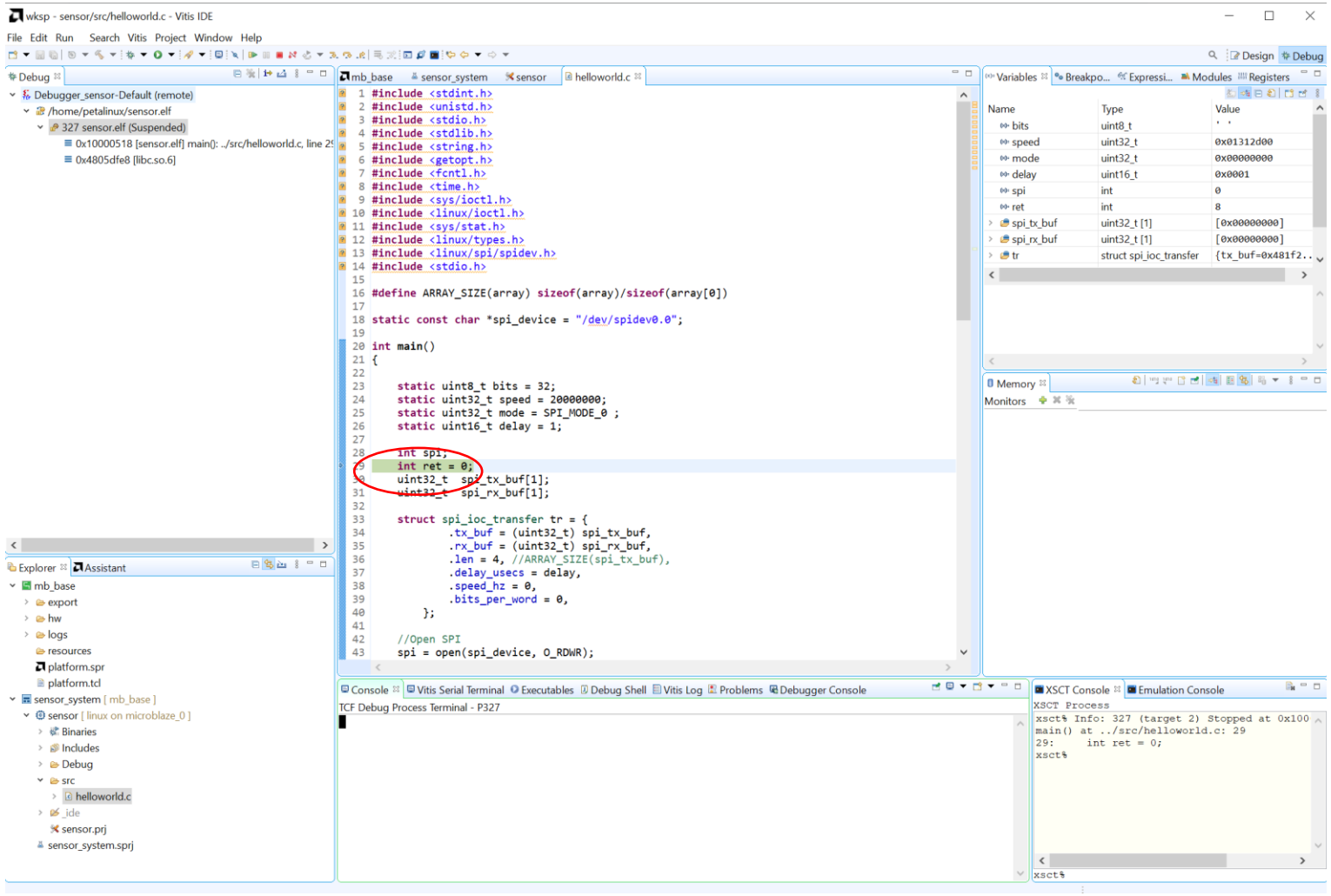
1. Change the remote file path and working directory to be /home/petalinux/

2. Click Debug



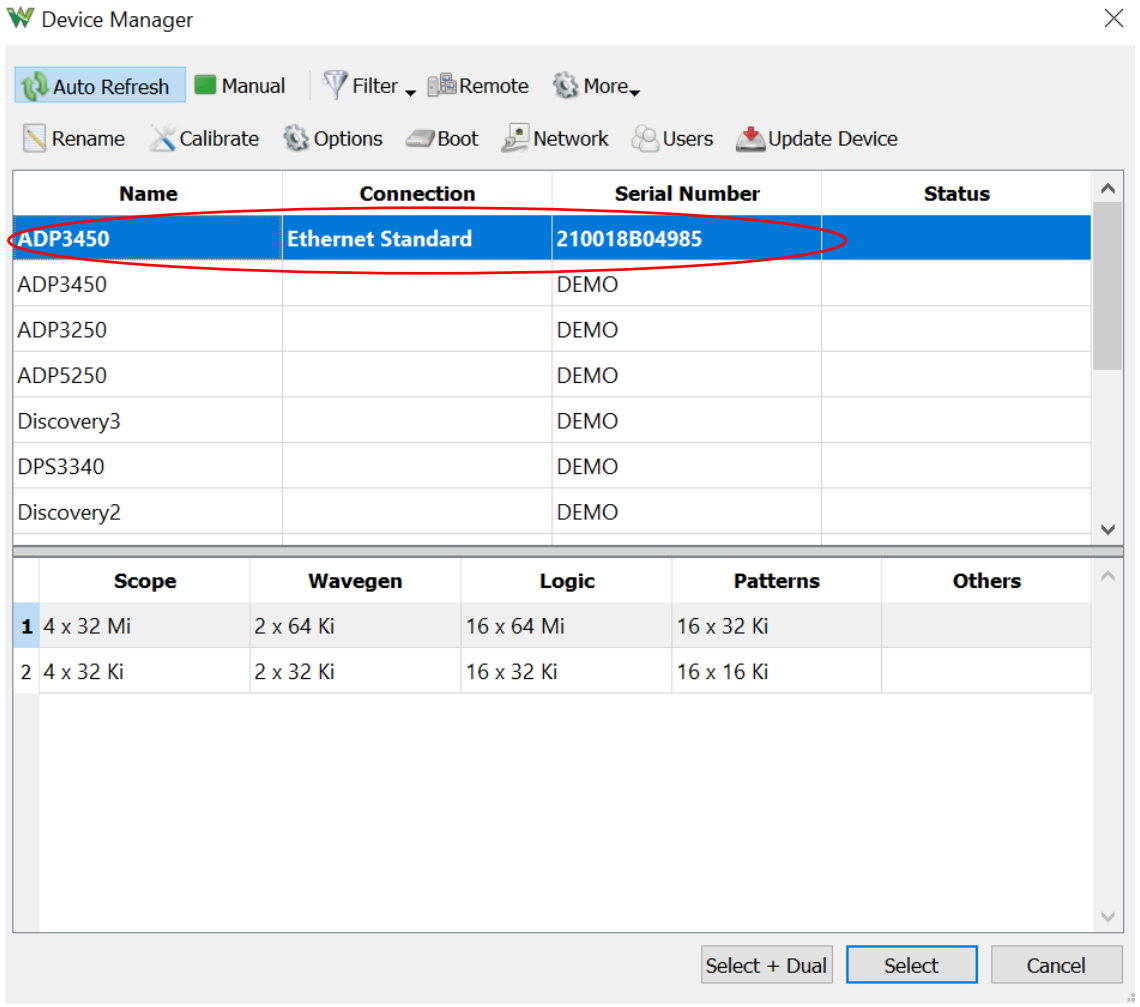
Lab: Embedded Linux

1. This will download the application on to the target board and pause for execution



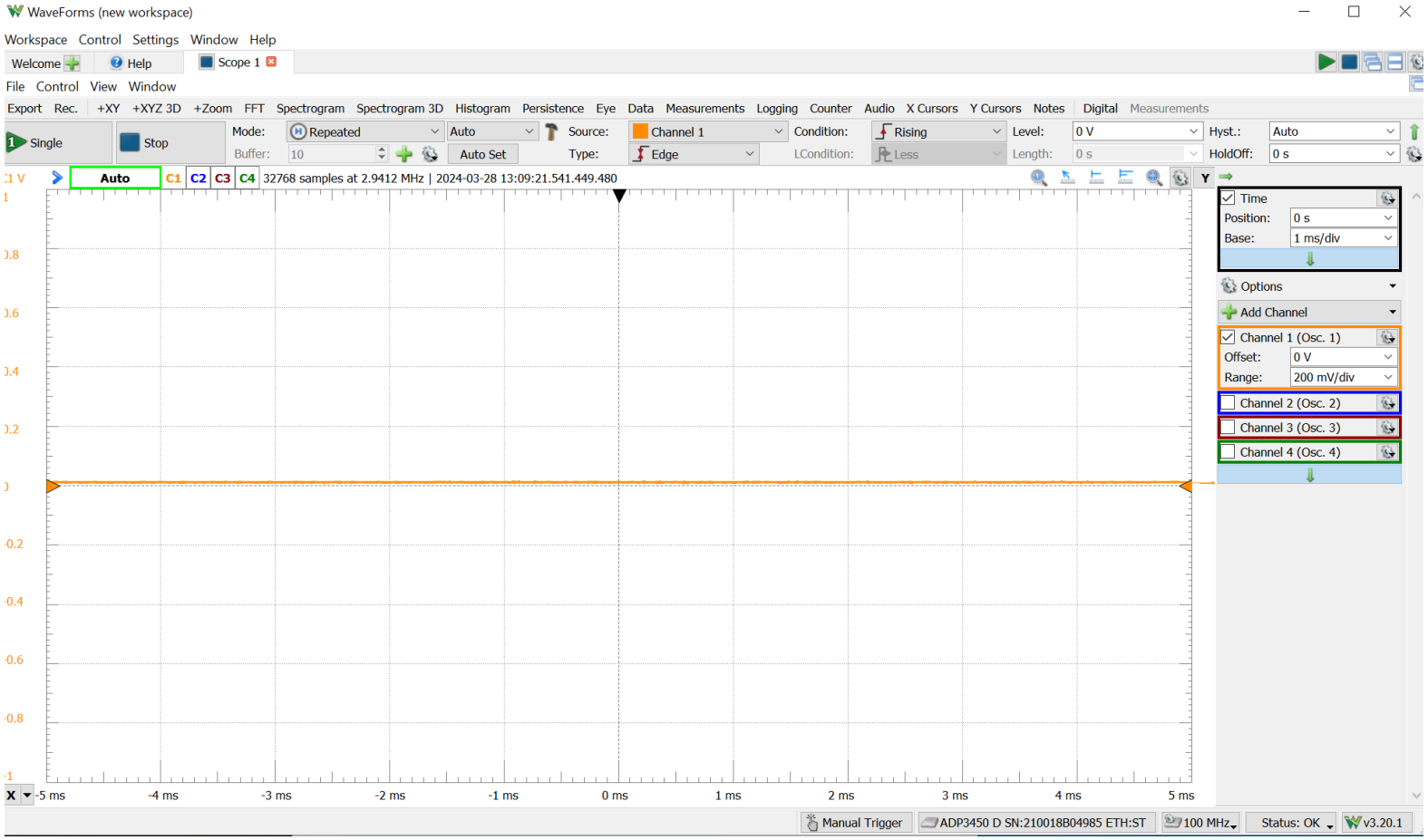
Lab: Embedded Linux

1. Open Waveforms and connect to the oscilloscope



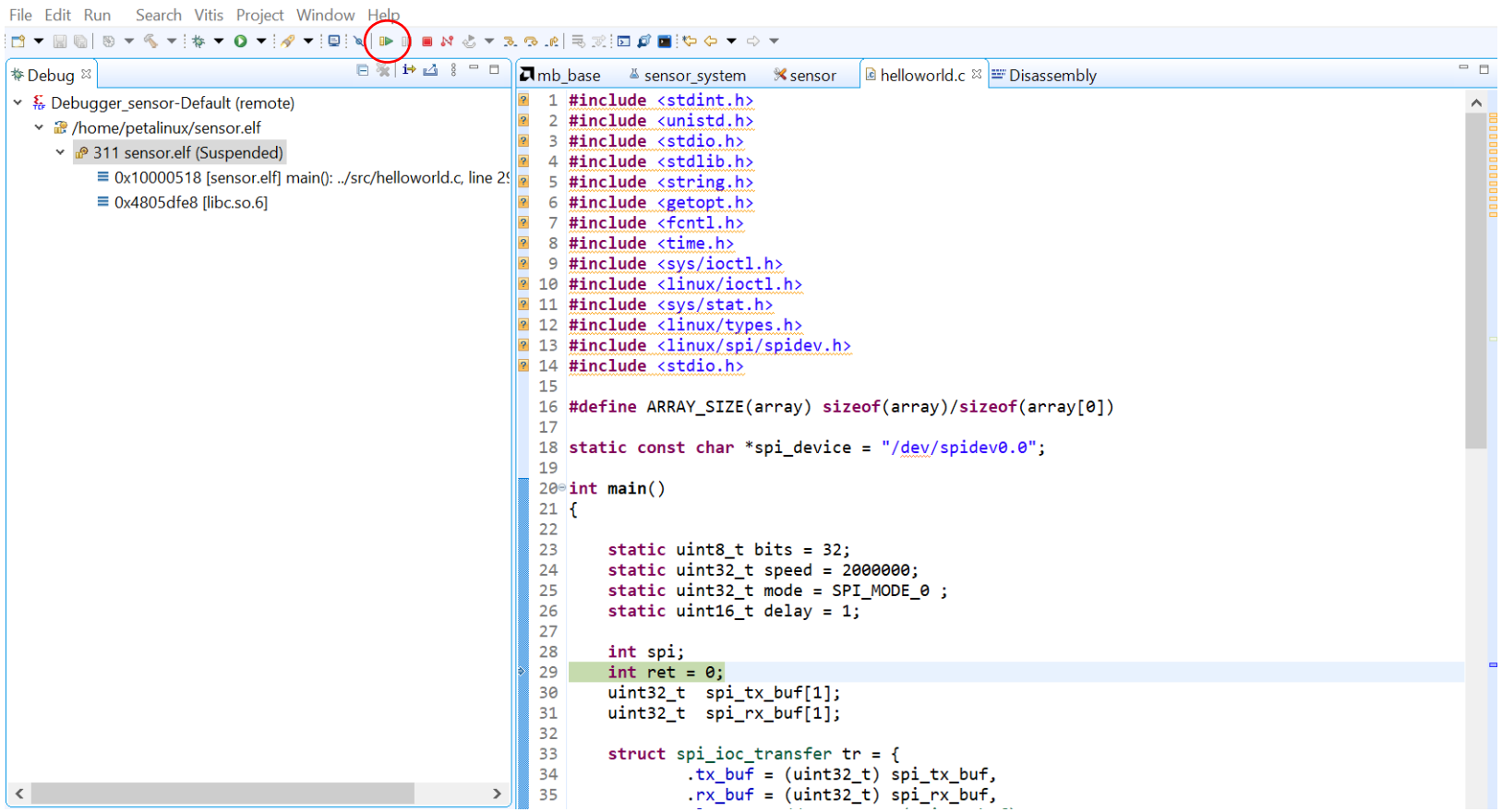
Lab: Embedded Linux

1. Open the scope view and run the scope



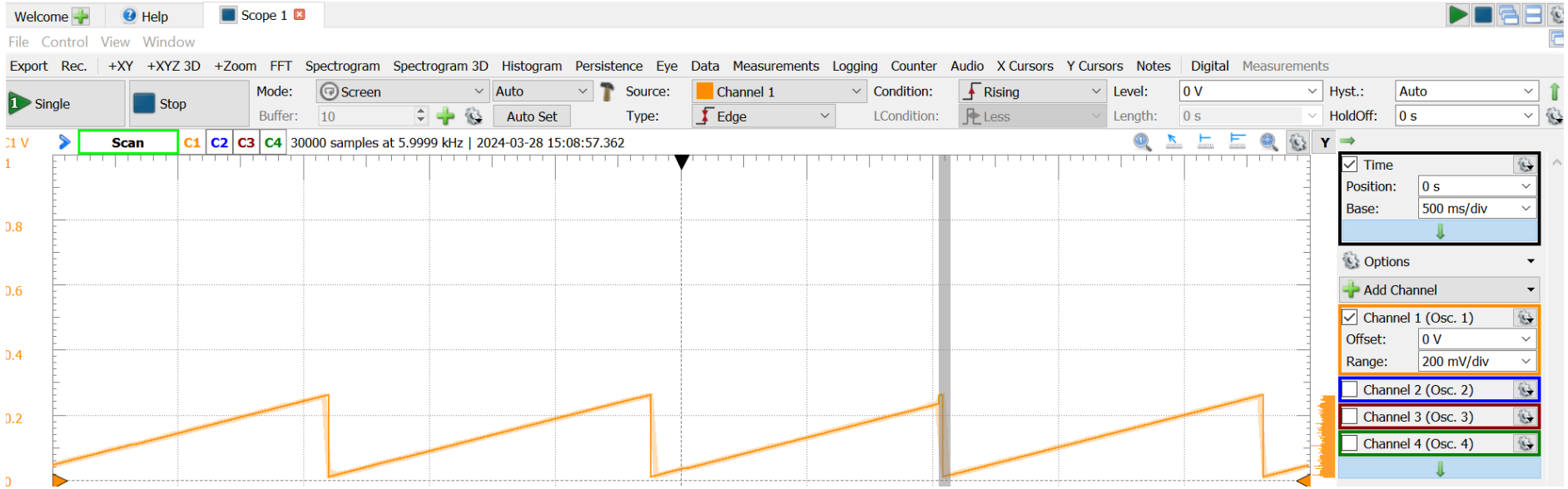
Lab: Embedded Linux

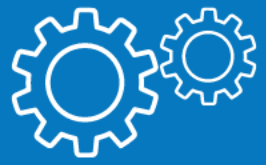
1. Click Run



Lab: Embedded Linux

1. Observe the output in the scope





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