TWR-K20D50M Quick Start Demo Lab Guide

Board configuration, software and development tools

Rev. 2

Most Up-to-date lab guide an source code are available at

www.freescale.com/twr-k20d50m

Contents

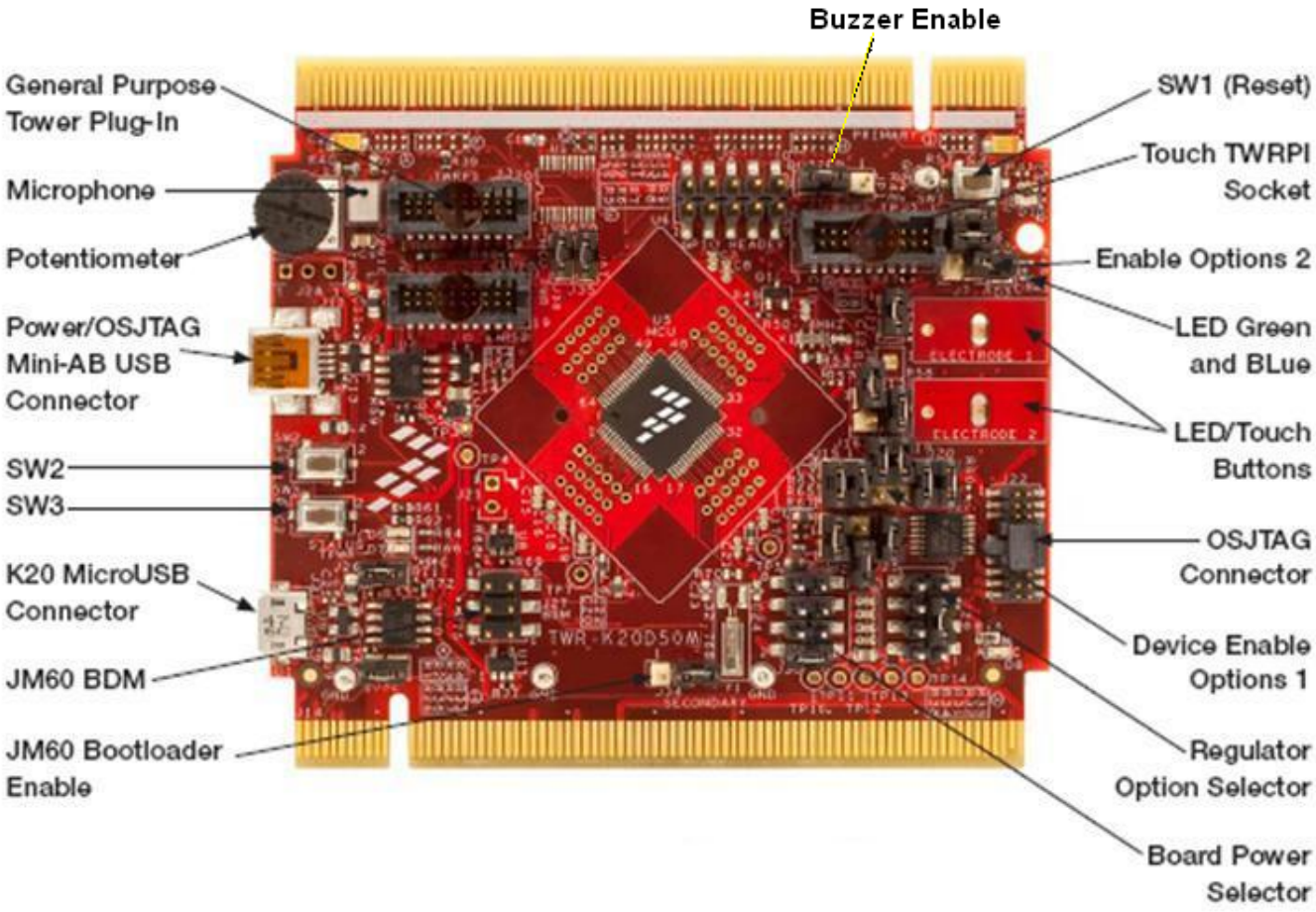
1 Purpose

This lab document will familiarize you with TWR-K20D50M board and development tools.

You will learn the full features of the TWR-K20D50M demos that are pre-programmed onto your Tower module. You will learn how to access the source code using development tools IAR 6.3 or the CodeWarrior 10.2

2 Getting known the board

Main components of the TWR-K20D50M are shown in following picture.



3 Download and Install Software and Tools

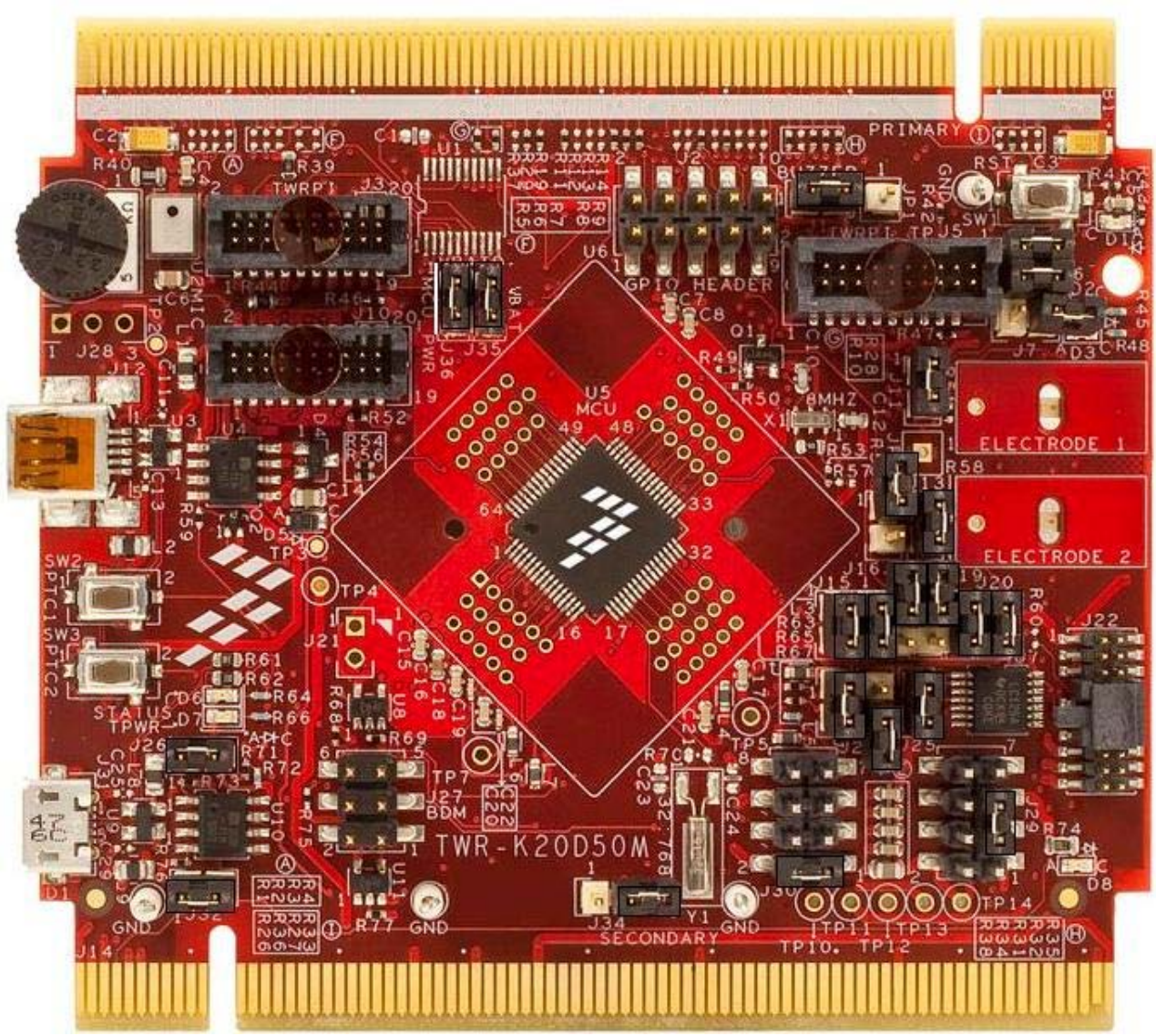
Get the installation software and documentation under “Jump Start Your Design” at www.freescale.com/TWR-K20D50M

Install the P&E Micro Kinetis Tower Toolkit to install the OSJTAG and USB-to-Serial drivers.
[pemicro_osbdm_osjtag_tower_toolkit.exe]

Note: Please follow instructions on section 12 before using of CW or IAR tools.

4 Configure Hardware

1) Make sure jumpers are set in default position as shown in following picture, for more details see TWR-K20D50M Jumper options



2) Connect one end of the USB cable to the PC and the other end to the Power/OSJTAG mini-B connector on the TWR-K20D50M module. Allow the PC to automatically configure the USB drivers if needed.

3) Allow the PC to automatically configure the OSJTAG drivers used for debugging and the serial-to-USB feature.

5 Run the Demos

TWRK20D50M Demo software

This code is pre-programmed in your TWRK20D50M, and shows some of the features of the K20 family and the TWRK20D50M board. Following table show how different modules are used in this application

Table 1 K20 Modules used on TWRK20 Demo software

Module	Function	Details
ADC	Reads 2 signals Potentiometer Microphone	12 bits mode Hardware triggered
PDB	Creates a sampling frequency of 8 kHz for the ADC converter	Continous mode at 8 Khz Triggers ADC0
DMA	Store microphone readings in a double buffer of 128 samples each	Interrupt when 128 samples are sampled and perform calculation of FFT, and filters.
DSP	Calculates FFT of 128 samples and magnitude of each harmonic	Uses CMSIS integrated library in IAR 6.3
I2C	Reads accelerometer, acceleration in each axes x, y, and z	K20 calculates tilt angle and fall detection based on axes acceleration.
PIT	CH0 Generates a 1 msec periodic interrupt CH1 Generates a 125 msec periodic interrupt	
GPIO	4 LED, 2 Push button	
HSCMP	Reads signal for IR receiver, and output is connected to UART0 receiver	DAC6 used as HSCMP minus input, IR receiver connected to HSCMP plus input,
MCG+OSC	Oscillator of 8MHz crystal, MCG creates a 50 MHz signal from 8MHz crystal with the PLL	
CMT	Create a 40KHz carrier frequency, and 600 Baud modulation signal for the IR transmitter.	
UART0	Receives signal from HSCMP(IR receiver) 600,8,n,1	Inverted reception
TSI	Configured to read 2 Electrodes	
RTC	A real time clock (seconds only) based on 32Khz Crystal	
JTAG	Interface of debugging and programming of the parts. Programmed through the OSJTAG	
UART1	User communication interface 38400,8,n,1	
FTM0	Generate buzzer frequency	

5.1 Buzzer Demo

Press reset button, the board will sound 3 tones.

Note: Different tests use the buzzer as feedback; you can disable the buzzer by removing jumper J1 (BUZZER).

5.2 Switch Demo

Press SW3, a tone is generated and red led glows
Press SW2, a tone is generated.

5.3 Touch Demo

Touch Electrode 2, a tone is generated and orange LED glows.
Touch Electrode 3, a tone is generated and yellow LED glows.

5.4 Accelerometer Demo

Tilt the board slowly back and forth to hear different tones depending on tilt angle.

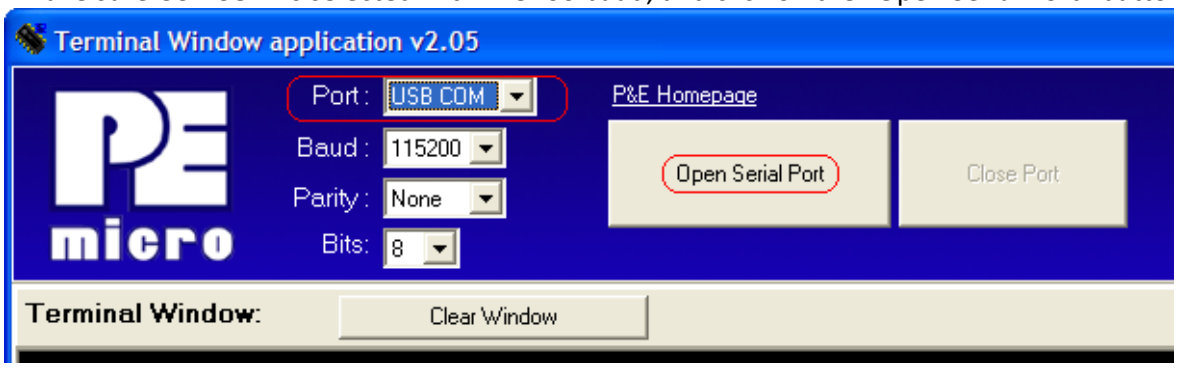
5.5 Microphone Demo

Whistle a tone for 1 or 2 seconds, the board will respond with a high tone.
Clap or snap near the microphone, the board will respond with a low tone

5.6 Terminal Demo

Open the P&E Terminal Utility by clicking on Start Menu->Programs->P&E OSBDM OSJTAG Virtual Serial Toolkit->Utilities->Terminal Utility.

Make sure USB COM is selected with 115200 baud, and click on the “Open Serial Port” button.



Press reset button.
The terminals will display a RESET message and prompt:

```
TWRK20D50M Demo Software Rev 1.4
```

In the terminal program, there will be a shell prompt after you hit the Enter key. Type "**help**" to see the list of commands.

5.6.1 Display command

Most of the commands included in this demo can be displayed with command "**disp**" and a number, as shown below.

```
K20_Demo >disp  N
```

Table 2 List of available options for "disp" command

Command		display	Description
disp 0	Cancel display	>	Abort current display and prompt for new command
disp 1	rtc	Rtc nnn	Shows RTC second counter
disp 2	Buttons	B nn	Show buttons/electrodes that are pressed
disp 3	leds	LEDs nn	Test 4 leds
disp 4	Accelerometer test	xy=[14]<-517, xz=[49]<-220, yz =[48]<-149	Show [magnitude] and <angle in degrees*10
Disp 5	IR test	IR port: Tx = 2, Rx= 0	Echoes the transmitted IR
Disp 6	ADC test	ADC POT = 1425	
Disp 7	FFT test	fft[0]8824,[1] 0,[2] 31,[3] 0,[4] 31,[5] 0,[6] 0,[7] 0 , [8] 0,	
Disp 8	DMA status	Status DMA 416, 0	

See following section for more details:

Note: some display modes are overwriting the terminal screen, when change to other display mode, just type the new command, even if it is not properly showed the command will be performed.

5.6.2 RTC Demo

Type command: K20_Demo >disp 1
Terminal will display seconds since last reset, and seconds elapsed since VBAT has been powered.

```
RTC 953  ;  elapsed time with Vbat  1955
```

5.6.3 ADC Demo (Potentiometer)

Type command: K20_Demo >disp 6

Terminal will display the value of the ADC connected to the potentiometer.

```
ADC  POT = 1425
```

5.6.4 LED Demo

Type command: K20_Demo >disp 3
Terminal will display a counter and the 4 leds will be turning on/off according to the counter.

```
LEDs n
```

5.6.5 Tilt detection / Accelerometer Demo

Buzzer beeps at different tones depending on how tilt is the board, and terminal display the angle and magnitude respect with gravity “g”

```
xy=[  3]<  0,  xz=[ 65]<  0,  yz =[ 65]<  0 ,
```

where:

[magnitude] relative magnitude
Angle in degrees*10 from -90.0 to 90.0 degrees

5.6.6 Infra Red port Demo (IR demo)

Terminal will display a counter and every time the counter increase, the number is transmitted by the IR port, if the IR signal is reflected the receiver will echo the same value. In case there is not reception the value displayed in reception is zero or the latest value received.

Note: you can use a piece of white paper to reflect the IR signal.

Jumper configuration

Jumper configuration for IR demo.
J9 ON (default OFF)

J7 ON (default OFF)
J4 OFF(default ON)

Note: remember to re-place jumpers at default configuration once this demo is completed.

Type command: K20_Demo >disp 5

IR port: Tx = 002, Rx= 000 ; IR signal is not being received,

IR port: Tx = 005, Rx= 005 ; IR signal being received.

5.6.7 FFT

Microphone is sampled at 8000Hz, every 128 samples a FFT is performed, the result of the FFT is used for tone detection, first harmonics of FFT are shown with following command

Type command: K20_Demo >disp 7
fft[1] 0,[2] 0,[3] 0,[4] 0,[5] 0,[6] 0,[7] 0,[8] 0,

where:
XX[n]
[n] number of harmonic.
XX magnitude of harmonic n.

Note: FFT is based on CMSIS library integrated in IAR embedded workbench, because of that this demo is only available with IAR.

6 Directory Structure

The directory structure for the TWRK20D50M demo code and other bare metal examples has three main folders—build, src and util. The build folder contains all development toolchain specific files. All of the source code files are in the src directory. The util folder includes compiler patches referenced in this document.

The source tree is broken up as follows:

- src\common\ - Common utilities such as compiler startup are provided in this directory
- src\cpu\ - CPU specific initialization and header files here
- src\drivers\ - Drivers for some of the various peripherals are provided here.
- src\platforms\ - Each supported platform has a header file that defines board specific information, such as the input clock frequency used for that board.
- src\projects\ - This directory holds all the individual example project source code
- src\semihosting\ - Utilities to handle native compiler support for printf and scanf

7 Toolchain Support

Currently the IAR 6.30 and CW10.2 tool chains are supported.

7.1 IAR Embedded Workbench

IAR workspace, project, linker, and support files are provided in kinetis-sc\build\iar. Each example has its own directory and within that directory is a workspace file (.eww) that will load the supported projects (usually one project for each supported hardware platform). Each project contains several configuration options that can be selected using a drop menu. The configuration support different link targets for different Kinetis memory configurations (e.g. RAM_16KB or FLASH_128KB_PFLASH).

7.2 CodeWarrior 10.2

CodeWarrior 10.2 project files can be found in the kinetis-sc\build\cw folder. Again, each example has its own directory.

8 Other Examples

There are many example projects that highlight the operation of different modules. The "hello_world" demo is the simplest example, and this project is the baseline used for developing other examples. The hello_world project will perform basic initialization for the board and then display the device configuration information on the terminal (default baud rate is 115200).

Each example includes a readme.txt file in the workspace or project directory that gives a description of what the project does and describes any configuration needed to use it.

9 Update OSJTAG

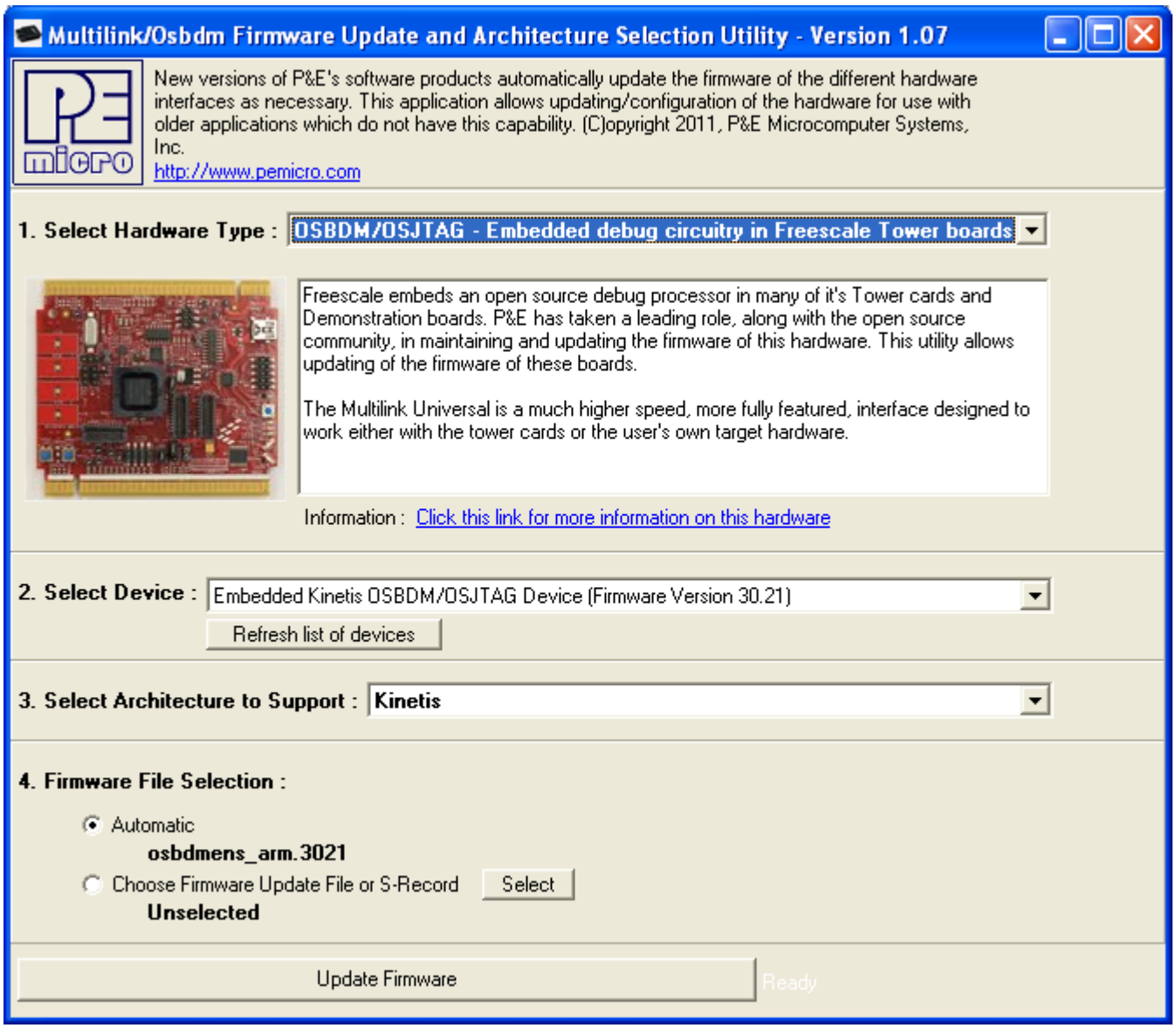
The TWR-K20D50M includes the OSJTAG circuit. By default all of the demo projects are setup to use OSJTAG to download and debug code. The OSJTAG circuit is also used as the primary serial communication port.

Open Source JTAG (also known as OSBDM on ColdFire tower boards) allows a user to program, debug, and get serial data from Kinetis devices via a USB cable. The firmware runs on a Freescale MCFS08JM60 on the underside of the Kinetis tower board. To ensure compatibility between the drivers, firmware, and terminal window, the latest versions of each need to be installed.

First download and install both of the latest **P&E Firmware Updates and Recovery** and **OSBDM Virtual Serial Toolkit** programs which can be found at http://www.pemicro.com/osbdm

Make sure your tower board is plugged in, and run the **P&E Firmware Updater Utility** to use the OSJTAG boot loader to upgrade to the latest OSJTAG version.

Under “Select Hardware Type” make sure OSBDM/OSJTAG is selected. It should automatically detect your board settings and fill out the rest of the fields automatically.



Click on “Update Firmware” to update the firmware. It will prompt you to disconnect the USB cord from your computer, and then short the JM60 boot loader jumper header. It is **J34**. Then re-connect the board to your computer.

The firmware will then be updated on your board. When it is finished, it will prompt you again to disconnect the USB cable, remove the jumper, and then re-connect the board again. OSJTAG is now updated.

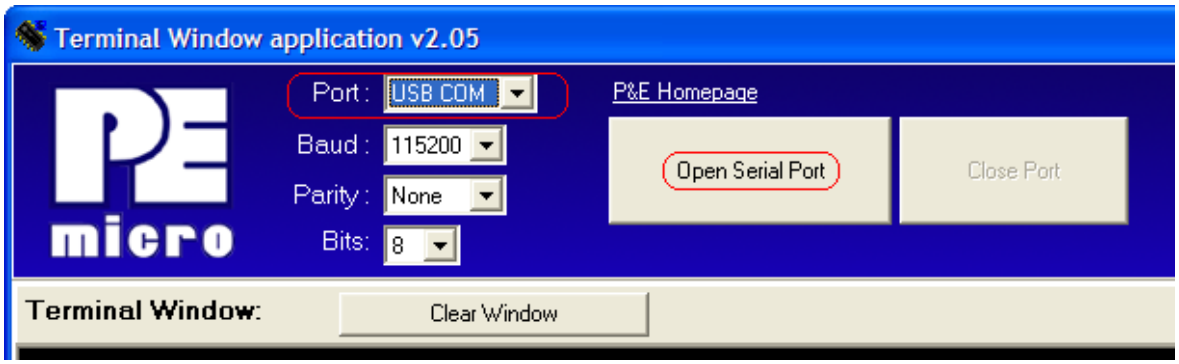
10 Configure Hardware

The hello world example can be run using a TWR-K20D50M stand-alone. No other tower boards/components are required for this example.

1) Note that the default jumper settings are in section TWR-K20D50M Jumper options. If you want to change back to the default settings after you are done running the demo.
2) Connect a mini-AB USB cable between the TWR board and the USB port on your computer.
3) Allow the PC to automatically configure the OSJTAG drivers used for debugging and the serial-to-USB feature.

11 Launch the Terminal

1) Open the P&E Terminal Utility by clicking on Start Menu->Programs->P&E Kinetis Tower Toolkit->Utilities->Terminal Utility
2) Make sure USB COM is selected with 115200 baud, and click on the “Open Serial Port” button.



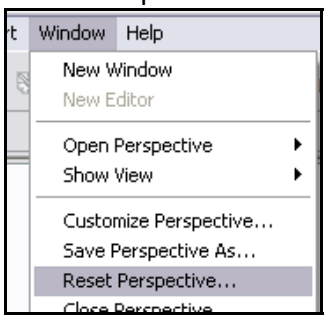
12 Development Software and Programming the Board

The following instructions describe how to build and flash the hello world demo using CodeWarrior MCU 10.2 or IAR 6.30.

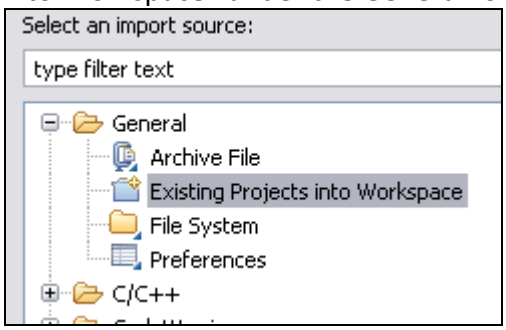
12.1 CodeWarrior for Microcontrollers v10.2

1) Follow the directions in Section 9 to update the OSJTAG firmware and drivers.
2) Install CodeWarrior for Microcontrollers 10.2.
3) Make sure you have CodeWarrior for Microcontrollers 10.2 or higher
4) Open CW10.2. At the welcome screen, **set the workspace to the "kinetis_50MHz_sc"** folder location. These projects use workspace relative paths, so in order for the project to find all files correctly the workspace must be set to the **kinetis_50MHz_sc** folder (the one that contains the build and src directories).

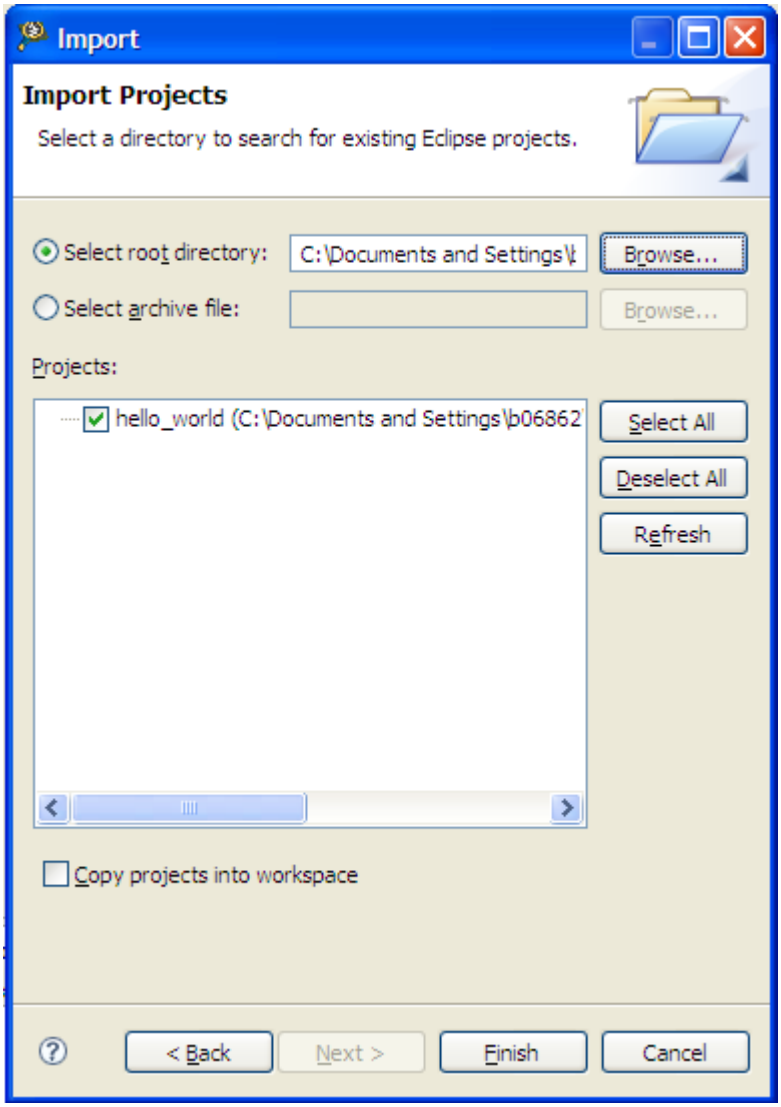
5) If you already have CW10 open, you can change the workspace by going to **File->Switch Workspace**
6) The first time you open CW10, you will be taken to the Welcome screen. Click on “Go To Workbench” in the lower left hand side.
7) The workbench view will open up. To ensure all the windows are properly set, go to Window-> Reset Perspective



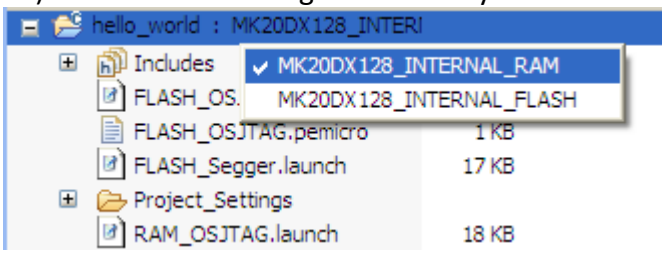
8) Click on **File->Import** in the menu bar. In the dialog box that comes up, select “Existing Projects into Workspace” under the General folder. Then click Next



9) On the next screen, select the “Select root directory:” option, and click on Browse
10) Navigate to the ..**\ kinetis_50MHz_sc\build\cw\hello_world** directory and hit OK.
11) Select the projects to import. Then select Finish.



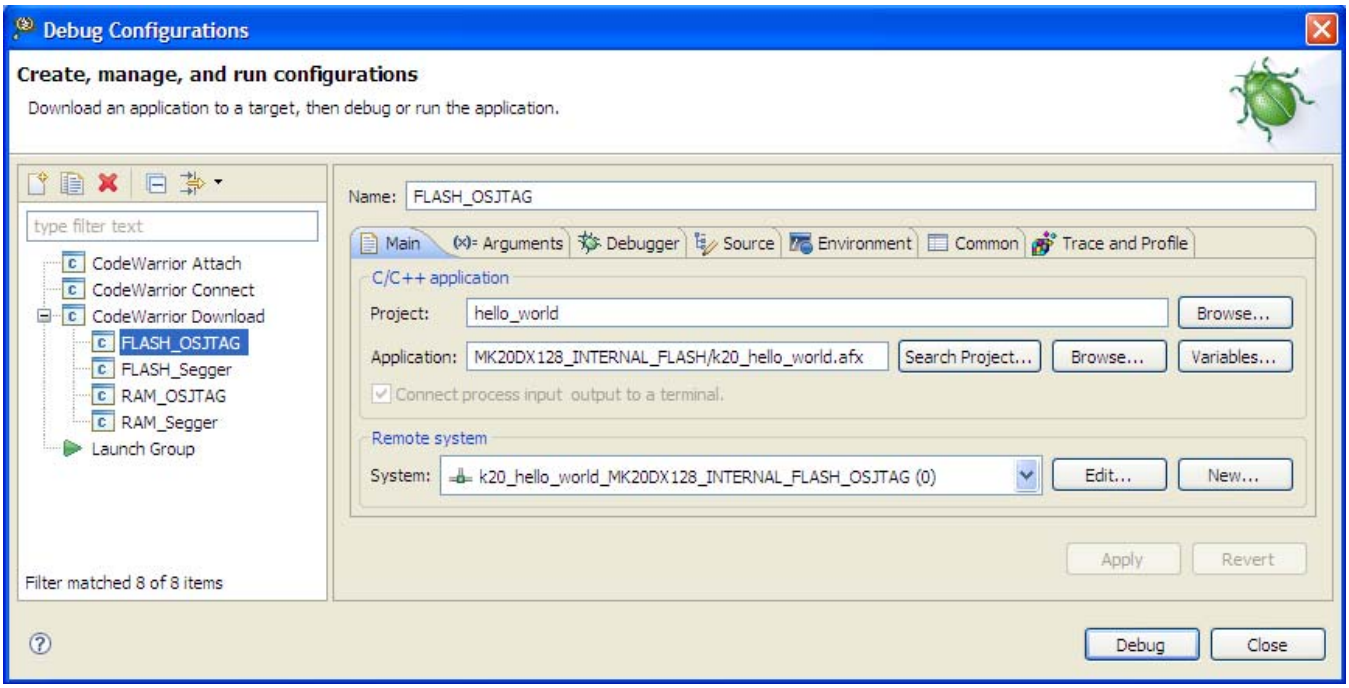
12)Select the link configuration that you would like to build.



13)Build the project by clicking on the Hammer icon in the toolbar 

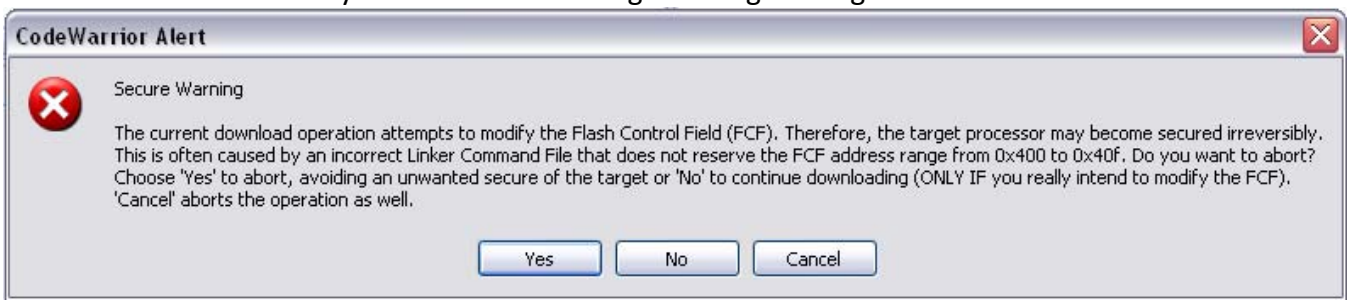
14)Click **Run->Debug Configurations…** in the menu bar, and select the debug configuration appropriate for the project, build configuration, and hardware connection you are using. For example, if you are building the hello_world project to run from the internal RAM and using

OSJTAG as your debugger, then you would select the **FLASH_OSJTAG** configuration. Then hit the debug button in the bottom of the window



15)If this is the first time you've used CW10.2 with your board, you may get a dialog box asking to update the OSJTAG firmware. Unplug your board, put a jumper on **J34 (JM60 BOOT)**, and plug the board back in. Hit "OK" on the dialog box, and the board OSJTAG firmware will update. When it is done, unplug the board, remove the jumper on **J34**, plug the board back in and hit "OK" again on the dialog box. If you do not have a spare jumper, you can temporarily use the one on J7.

16)The code will then be downloaded to the board and the debugger started. This may take a several moments. You may also see the following Warning message:



This is a check introduced with a CodeWarrior compiler patch. Hit **No** to continue flashing the part, as the sample code is configured to ensure the part remains unsecured.

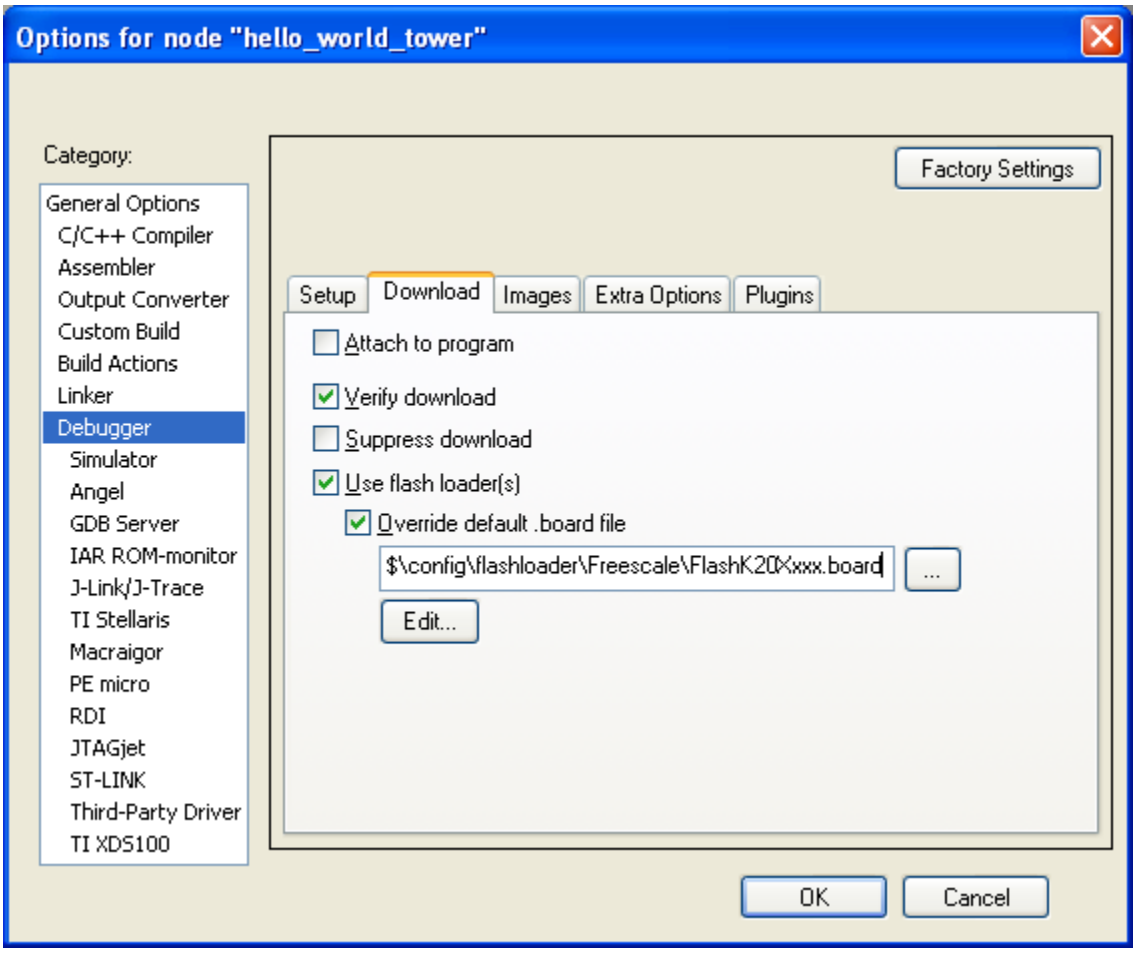
17)Once the code is done flashing, the code will pause at the start of the main() function.

18)Hit the run icon to continue the program execution. 

19)On the terminal you should see the hello world message.

12.2 IAR Embedded Workbench for ARM 6.30

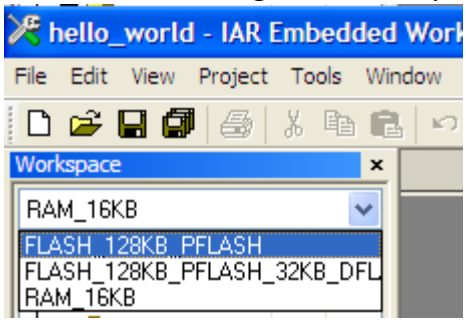
1) Follow the directions in Section 9 to update the OSJTAG firmware and drivers.
2) Install IAR for ARM v6.30 or higher.
3) Open the workspace at **..\kinetis-sc\build\iar\hello_world\hello_world.eww**
4) Configure flash loader
    a. Unzip **utils\iar_flash_p0_8kb_ram.zip**
    b. Place all of the files in this zip (except this readme file) in your IAR Systems\Embedded Workbench.6.0_x\arm\config\flashloader\Freescale folder
    c. Open your IAR workspace file and select a flash configuration for the project (you might have to create one if you don't have one already)
    d. In the project options select Debugger->Download



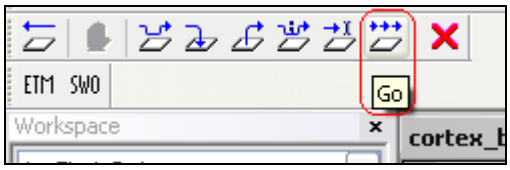
    e. Check the "Use flash loader(s)" box
    f. Check the "Override default .board file box"
    g. Provide the path to the FlashK20Xxxx.board file. Should be: $TOOLKIT_DIR$\config\flashloader\Freescale\FlashK20Xxxx.board

5) The project for the board is selected (hello_world_tower)

6) Select the link configuration that you want to build.



7) Compile the project by clicking the Make icon  (or right clicking on the project and select "Make").
8) After compilation completes, download the code to the board and start the debugger by pressing the "Download and Debug" button 
9) The code will download, and the debugger screen will come up and pause at the first instruction. Hit the "Go" button to start running.



20)On the terminal you should see the hello world message.

13 Creating New Projects

The kinetis-sc\build\iar\make_new_project.exe or kinetis-sc\build\cw\make_new_cw_project.exe files can be used to clone the hello_world project for the appropriate toolchain. The script will prompt you for a name to use for the new project, and then create copies of all needed files and folders.

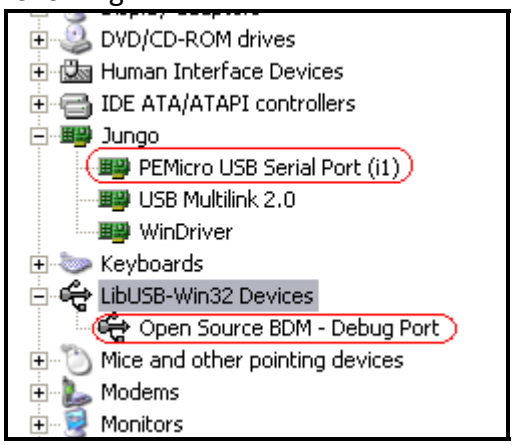
Note: kinetis_50MHz_sc\build\cw\make_new_cw_project.exe doesn't clone the src\hello_world folder. This must be manually created. The kinetis-sc\build\iar\make_new_project.exe doesn't need to create any additional folder.

14 OSJTAG

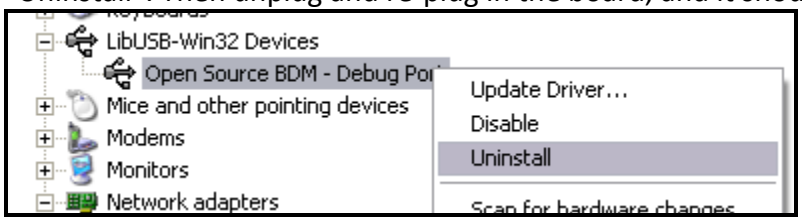
Open Source JTAG (also known as OSBDM on ColdFire tower boards) allows a user to program, debug, and get serial data from Kinetis devices via a USB cable. The firmware runs on a Freescale MCFS08JM60 on the underside of the Kinetis tower board.

The latest firmware and drivers can be found at http://pemicro.com/osbdm. See the **Installation and Operation** document on the P&E website for details on updating the firmware and drivers. If you are having trouble connecting, try updating to the latest drivers, virtual serial toolkit, and firmware located on that website.

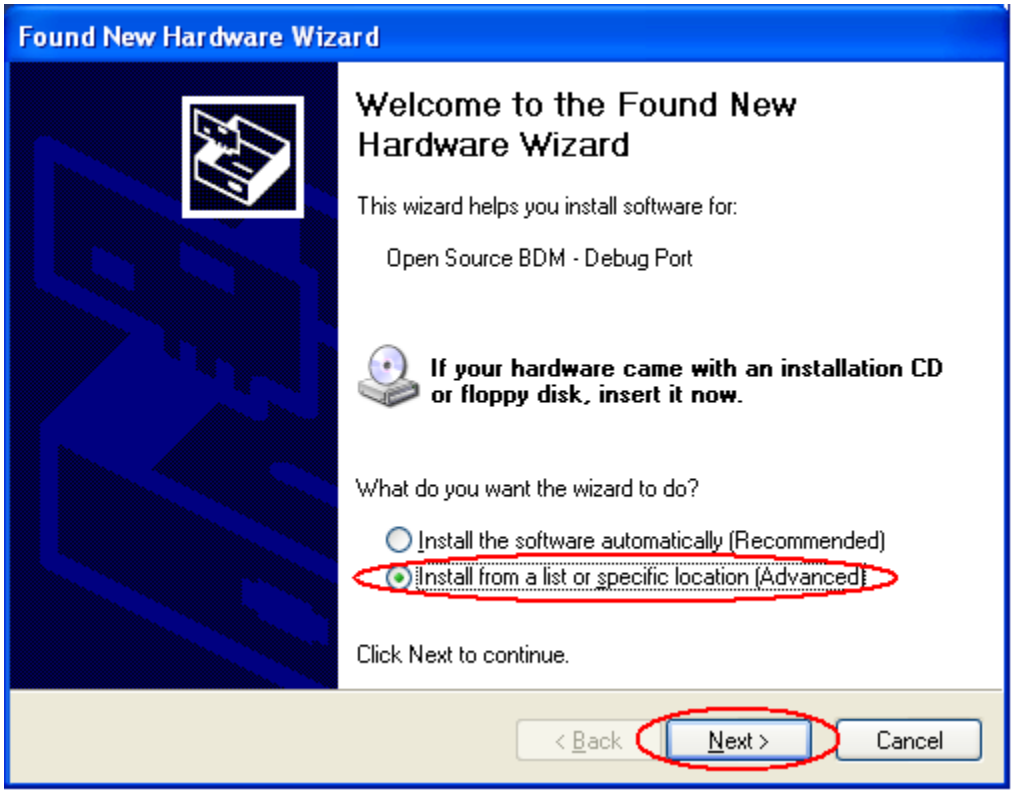
When the tower board is plugged in, it should enumerate as a composite device, with one driver for debugging, and the other as a serial port. If you go to the Device Manager you should see the following:

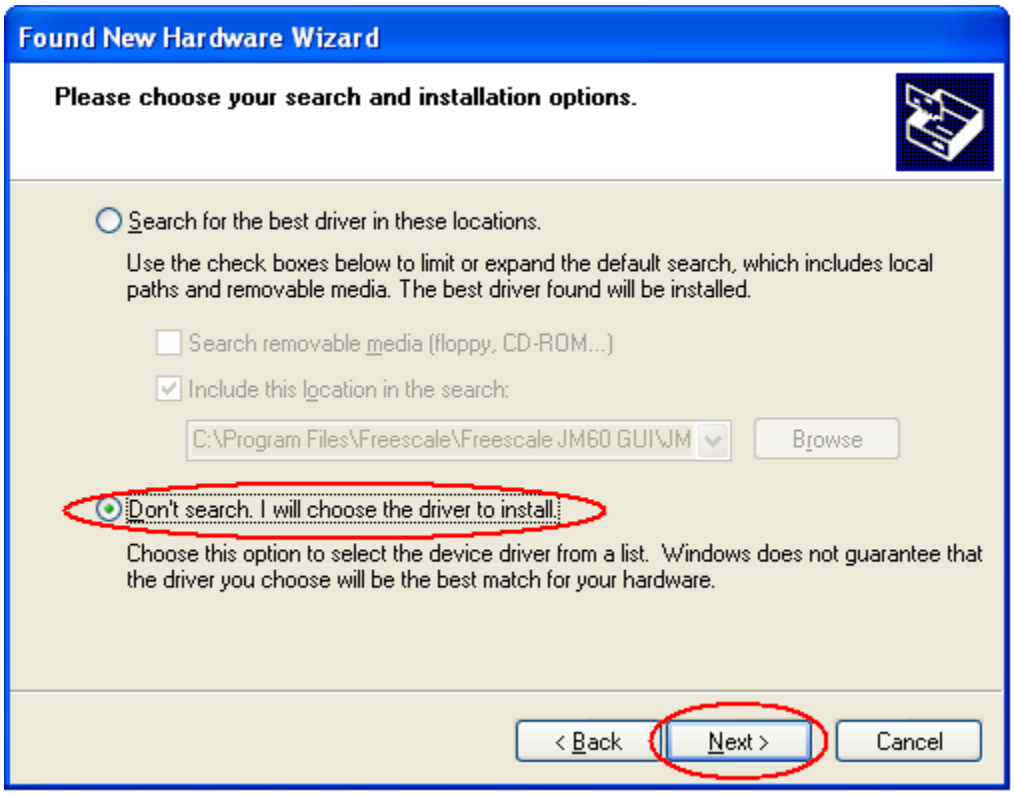


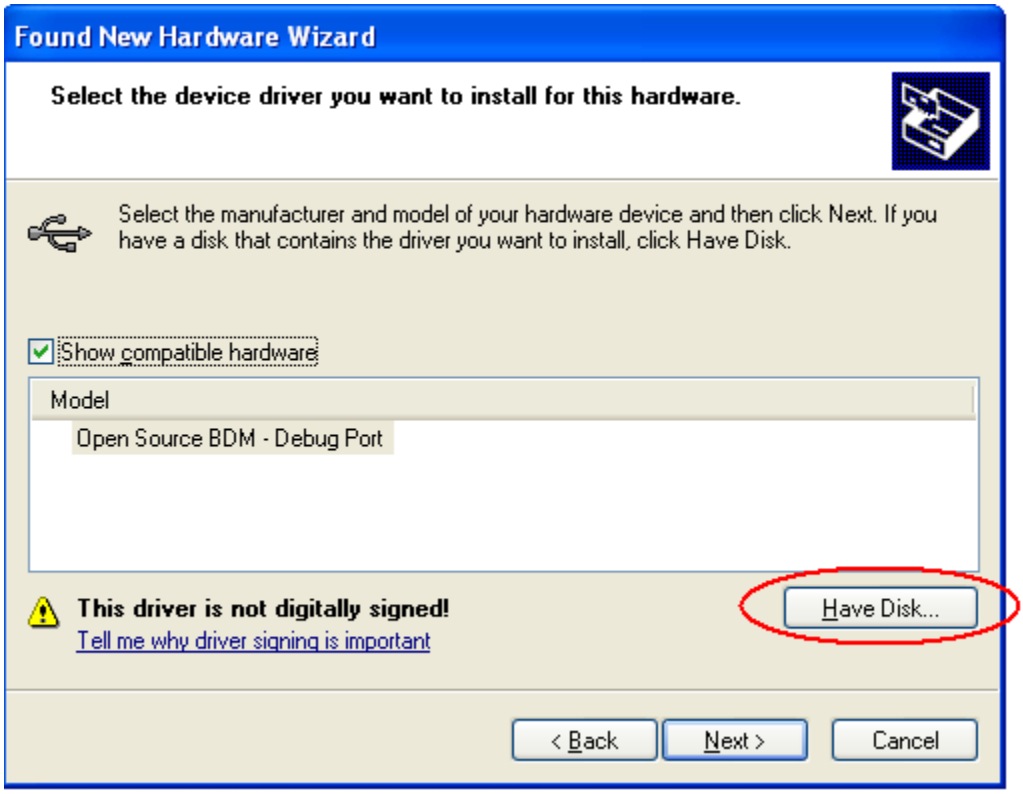
If you only see it enumerate as the Open Source BDM Debug Port, then your computer may automatically picking up an outdated driver. To fix this, right click on the OSBDM driver and select "Uninstall". Then unplug and re-plug in the board, and it should enumerate correctly.

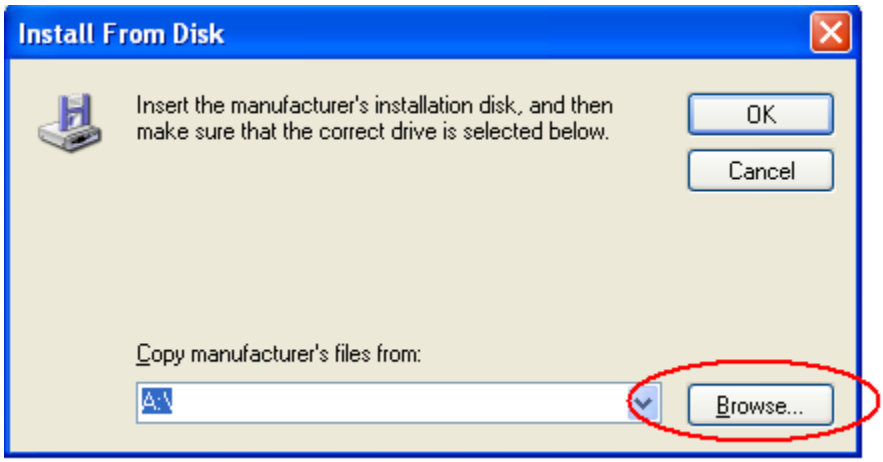


If there are still problems with enumerating correctly, you can also manually select the drivers.


Found New Hardware Wizard
Welcome to the Found New Hardware Wizard
This wizard helps you install software for:
Open Source BDM - Debug Port
If your hardware came with an installation CD or floppy disk, insert it now.
What do you want the wizard to do?
Install the software automatically (Recommended)
Install from a list or specific location (Advanced)
Click Next to continue.
< Back
Next >
Cancel


Found New Hardware Wizard
Please choose your search and installation options.
Search for the best driver in these locations.
Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.
Search removable media (floppy, CD-ROM...)
Include this location in the search:
C:\Program Files\Freescale\Freescale JM60 GUI\JM
Browse
Don't search. I will choose the driver to install.
Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.
< Back
Next >
Cancel





- For the Open Source BDM – Debug Port, use the driver at:
  C:\pemicro\kinetis_tower_toolkit\Drivers\osbdm\OSJTAG_Debug_Interface_libusb.inf

- For the PEMicro USB Serial Port (i1), use the driver at:
  C:\pemicro\kinetis_tower_toolkit\Drivers\osbdm\OSJTAG_Serial_Interface_windriver_version.inf

15

15 TWR-K20D50M Jumper options

The following is a list of all the jumper options. The default installed jumper settings are shown in bold.

Note: Default Configuration, Board powered by OSJTAG USB, RTC powered by PWR_MCU

Jumper	Jumper designator	Signal	Jumper Option
V_BRD	J25	V_BRD	**DEF: 1-2 VBRD to MCU_PWR**
	J23	VDDA_HDR	**DEF: 1-2 VDDA to MCU_PWR**
VBAT	J35	VBATD Enable VBAT	**DEF: 1-2**
	J36	VBATD Enable MCU_PWR	**DEF: 1-2**
P5V_TRG_USB	J24	P5V_TRG_USB	**DEF: open Disconnect target power of JTAG connector**
JM60 Bootloader	J34	JM60 BOOTLOAD EN	**open OSJTAG mode** 1-2 JM60 bootloader mode
VREG IN SELECTOR	J30	VREG IN SELECTOR	**DEF: 1-2 Regulator powered by OSJTAG USB** 5-6 K20 USB power the K20 Regulator 8-6 TWR-USB power up the K20 Regulator
BOARD POWER SELECTION	J29	BOARD POWER SELECTION	**DEF: 3-5 P3.3V_REG powers VBRD(MCU_PWR)** 7-5 1.8V powers VBRD(MCU & Interface circuit input power) 1-2 K20 3.3 Regulator Output powers VBRD(MCU_PWR)

Table 3 Connectors and Pin Usage

Module	Jumper Designator	name	Options	Signal
USB	J26	K20 USN ENA	DEF: 1-2	PTC9_EBI_AD6
	J32	K20 USB FLGA	DEF: 1-2	PTC8_EBI_AD7/SSI0_CLK
IRDA	J9	IRDAJ	open	PTD7_CMT_IRO
	J7	CMP0_IN0	open	PTC7_EBI_AD8/CMP0_IN1
Microphone	J16	Microphone Enable	DEF: 1-2	ADC0_DP3
Potentiometer	J15	Potentiometer Enable	DEF: 1-2	ADC0_DM3
Buzzer	J1	Buzzer Enable	DEF: 1-2	PTC4
Accelerometer	J19	SDA Accelerometer Enable	DEF: 1-2	PTB3_I2C0_SDA/ADC0_SE13/TSI0_CH8
	J20	SCL Accelerometer Enable	DEF: 1-2	PTB2_I2C0_SCL/ADC0_SE12/TSI0_CH7
	J18	ACCELEROMETER INT1	DEF: OPEN	PTB0/ADC0_SE8/TSI0_CH0
	J17	ACCELEROMETER INT2	DEF: OPEN	PTB1/ADC0_SE9/TSI0_CH6
GPIO Header	J2-1	SAI0_RX_FS	PTC10_EBI_AD5/SSI0_RX_FS	
	J2-2	SAI0_TX_FS	PTB19/SSI0_TX_FS/TSI0_CH12	
	J2-3	SAI0_RXD0	PTC5	
	J2-4	SAI0_TXD0	PTC1/UART_RTS/FTM0_CH0/TSI0_CH14	
	J2-5	SAI0_RXD1	PTC11_LLWU_SSI0_RXD1	
	J2-6	SAI0_TXD1	PTC0/SSI0_TXD/TSI0_CH13	
	J2-7	SAI0_RX_BCLK	PTC6	
	J2-8	SAI0_TX_BCLK	PTB18/SSI0_TX_BCLK/TSI0_CH11	
	J2-9	SAI0_MCLK	PTC8_EBI_AD7/SSI0_CLK	
	J2-10	GND	GND	
LEDs	J13	LED orange Enable	DEF: 1-2	PTC10
	J11	LED Yellow Enable	DEF: 1-2	PTC9
	J4	LED Green Enable	DEF: 1-2	PTC7
	J6	LED Blue	DEF: 1-2	PTC8

Module	Jumper Designator	name	Options	Signal
PTA12 - Header	J28	PTA12	1 MCU_PWR 2 PTA12 3 GND	This header can be used to power up an external circuit/sensor
Push Buttons	SW2	Pushbutton1	PTC1	PTC1/UART_RTS/FTM0_CH0/TSI0_CH14
	SW3	Pushbutton0	PTC2	PTC2/UART_CTS/FTM0_CH1/TSI0_CH15
TSI Electrodes	Elec1	Electrode1	TSI0_CH0	PTB0/ADC0_SE8/TSI0_CH0
	Elec2	Electrode2	TSI0_CH6	PTB1/ADC0_SE9/TSI0_CH6