



FPGA Development System User Manual

## **DUEPROLOGIC**

### **FPGA DEVELOPMENT SYSTEM User Manual**

The **DueProLogic (DPL)** and its integrated development and distinctive runtime environment has been specifically designed for Electrical Engineering students, hobbyists, and entrepreneurs prototyping/developing/running projects involving logic, with the added opportunity, of readily mating with a widely used microprocessor board, the Arduino Due, and other ARM Cortex compatibles . The combination of FPGA programmable logic and a microcontroller is unbeatable in an educational student learning setting and in many other projects where each can bring its strength.

The DPL FPGA development system provides a convenient, user-friendly work flow by connecting seamlessly with Altera's Quartus Prime software. The user will develop the code in the Quartus environment on a Windows Personal Computer. The programmable logic code is loaded into the FPGA using only the Quartus Programmer tool and a standard USB cable. The Active Host SDK provides a highly configurable bi-directional communications interface between Arduino and host. It connects transparently with the Active Transfer Library in the FPGA code. This Active Host/Active Transfer combination eliminates the complexity of designing a USB communication system. No scheduling USB transfers, USB driver interface or inf file changes are needed. The EPT FPGA development system is a unique combination of hardware and software.

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### 1 Introduction and General Description

The DPL gives learners the opportunity to have an appropriate hands-on approach when learning logic, exploring different iterations of schematic/code designs with simple uploads of the design, and the operation of those circuits with relatively easy runtime passing of project parameters and data, and an abundance of headers that can interface to external components, without having to spend inordinate amounts of time reading datasheets, designing the right combinations of gates on multi-gate chips, and building/revising/debugging/revising repeatedly... spaghetti bowls of wires and chips on multiple breadboards to connect to those same external components.

With the DPL's FPGA, projects can also more easily be attempted which rely on asynchronous, exceedingly fast, and even multiple separate concurrent logic structures operating in parallel which would have traditionally required a plethora of chip gates or multiple high speed microprocessors to implement parallel processes. Logic circuits are implemented within the FPGA at few-nanosecond gate speeds and highly parallel in operation, effectively a few hundred MHz; Microprocessors often rely on inherently slower single threaded program loops with interrupt servicing, which is typically much slower. Programmable logic is today's technology for logic learners and implementers, replacing discrete logic chips. The DPL allows the learner to be more productive and better focus on the underlying logic and integration with the non-logic aspects of non-trivial projects.

The Earth People Technology FPGA development system hardware consists of a High Speed (480 Mb/s) USB to parallel (8 bit) bus chip and an FPGA. The USB interface provides both Configuration of the FPGA and a High Speed transfer path. The software consists of the Active Host SDK for the PC. The firmware includes the Active Transfer Library which is used in the FPGA to provide advanced functions for control and data transfer to/from the Arduino.

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The DueProLogic FPGA Development System allows users to write HDL code (either Verilog or VHDL) that will implement any digital logic circuit. The user's HDL code is compiled and synthesized and packaged into a programming file. The programming file is programmed into the Configuration Flash using one channel of the USB to Serial chip, the FT232RL. The Active Host SDK contains a dll which maintains device connection, polling, writes and includes a unique receive mechanism that automatically transfers data from DPL when data is ready. It also alerts the user code when the dll has stored the transfer and the data is available to the software GUI (graphical user interface). Users do not need to interface with the USB Host Driver or any Windows drivers. They need only to include the Active Host dll in their projects. The Active Transfer Libraries must be included in the FPGA project to take advantage of the configurability of the Active Host SDK. All of the drivers, libraries, and project source code are available at [www.earthpeopletechnology.com](http://www.earthpeopletechnology.com).

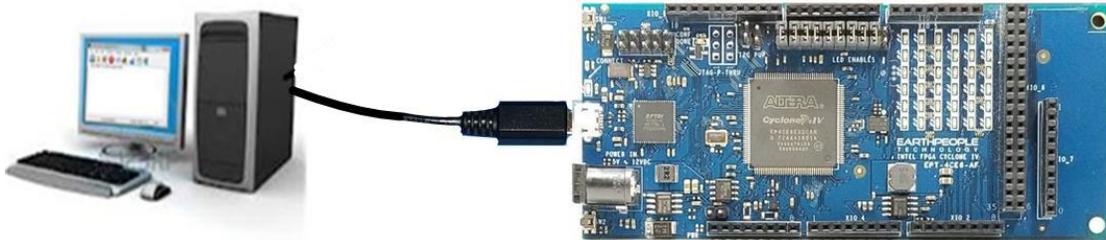
## ***1.1 Test Driving the Active Host Test Application***



The DueProLogic board comes pre-loaded with the EPT\_Platform\_Demo HDL project in the FPGA. This project allows the user to test out the functions of the Active Host API and the board hardware.

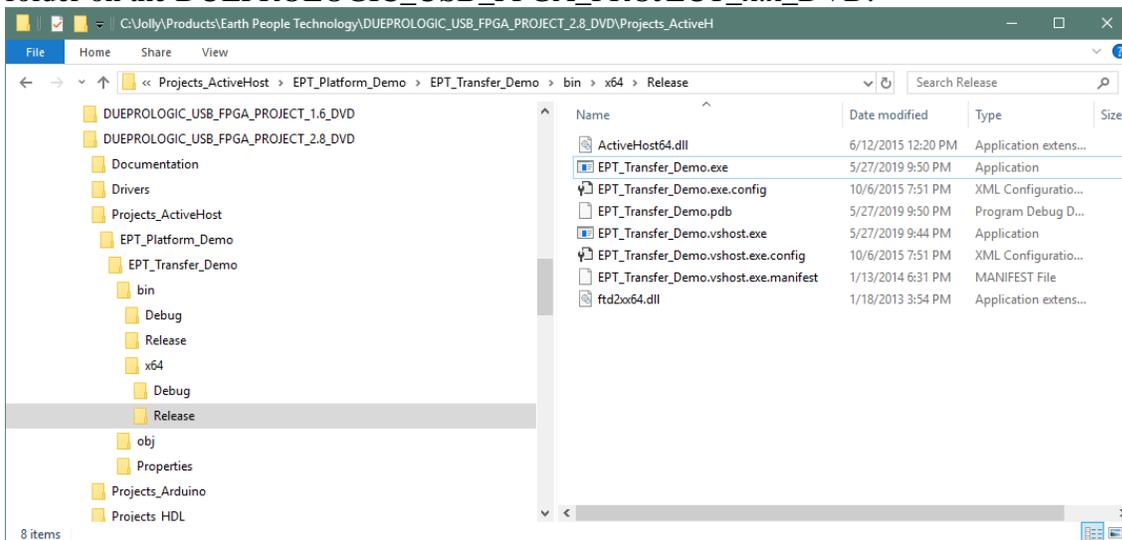
To test drive the application, connect the DPL to the Windows PC using a Micro B USB cable. Load the driver for the board. See the section “EPT Drivers” for instructions on loading the DPL driver. If the USB driver fails to load, the Windows OS will indicate that no driver was loaded for the device. In the case of the failed USB driver, try rebooting the PC and following the steps in the EPT Drivers section of this User Manual.

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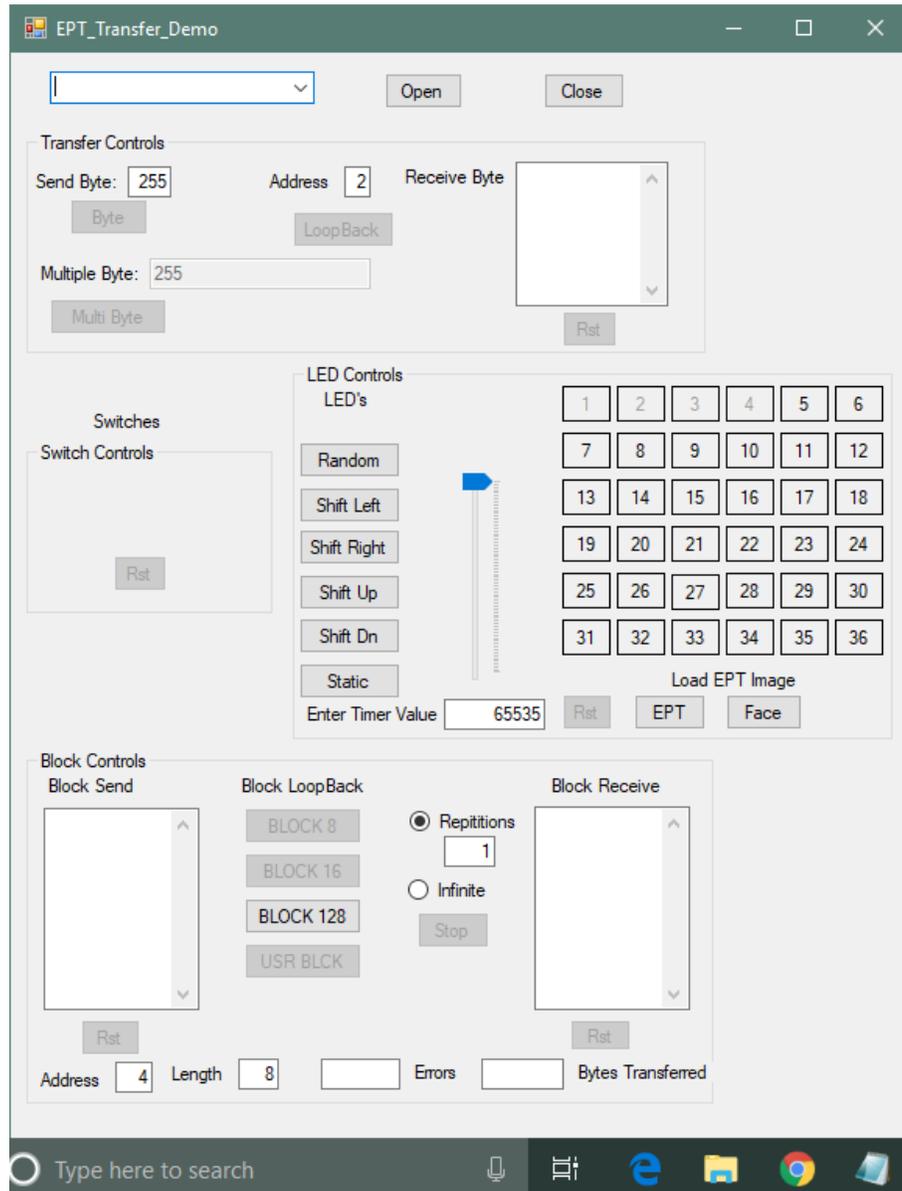
Next, open a Windows Explorer browser.

Browse to the  
Projects\_ActiveHost\EPT\_Platform\_Demo\EPT\_Transfer\_Demo\bin\X64\Release\  
folder on the DUEPROLOGIC\_USB\_FPGA\_PROJECT\_x.x\_DVD.



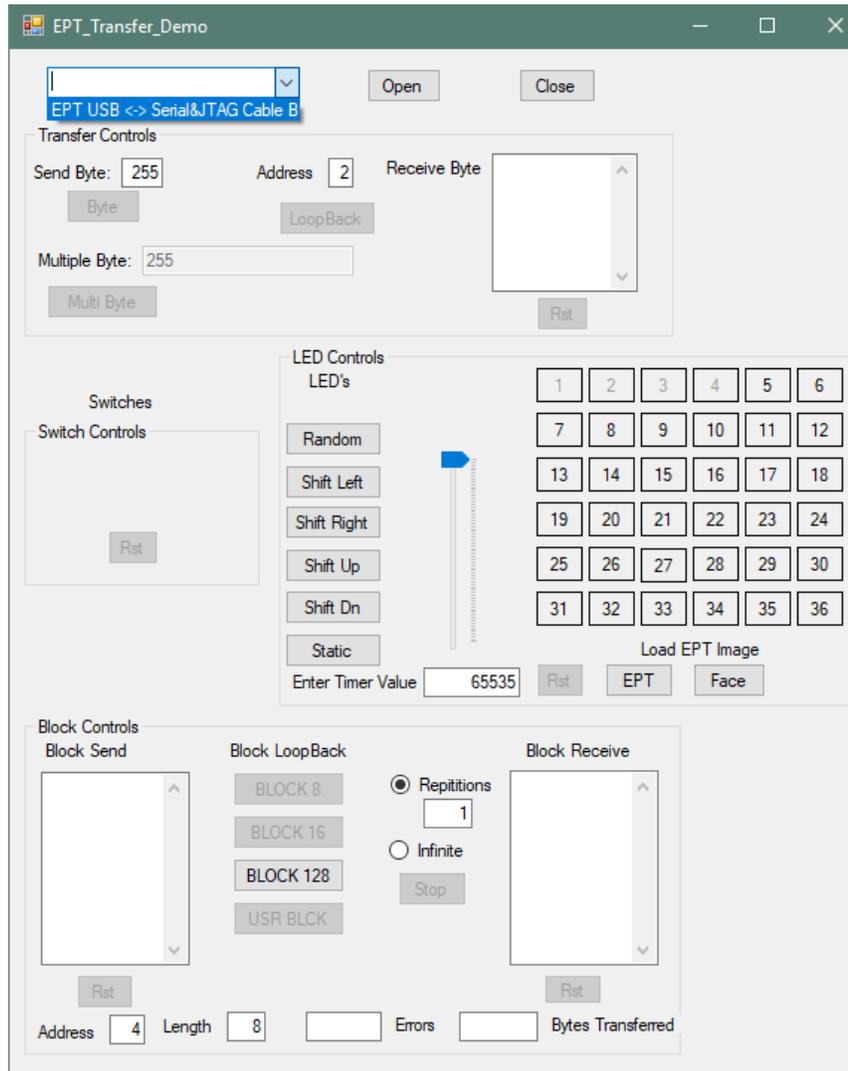
Double click on the EPT\_Transfer\_Demo.exe. The application should load with a Windows form.

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With the application loaded, select the FPGA board from the dropdown combo box and click on the “Open” button.

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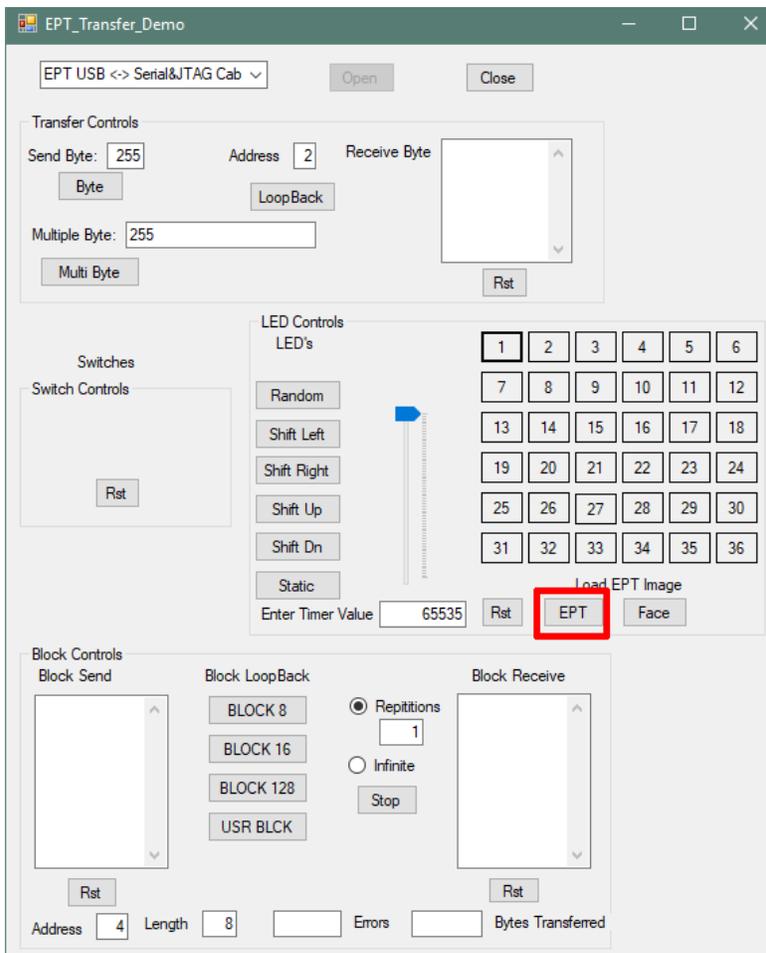
Leave the Address set at 2 for the Transfer Controls Group. And, leave the Address set at 4 for the Block Controls Group.

To exercise the Single Byte Transfer EndTerm, click the “LoopBack” button in the Transfer Controls group. Type in several numbers separated by a space and less 256 into the Multiple Byte textbox. Then hit the Multi Byte button. The numbers appear in the Receive Byte textbox.

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To exercise the Block Transfer EndTerm, click the “BLOCK 8”, “BLOCK 16” or “BLOCK 128” button in the Block Controls group. A pre-selected group of numbers appear in the Block Receive textbox.

Under LED Controls, press the “EPT” button under the “Load EPT Image”.



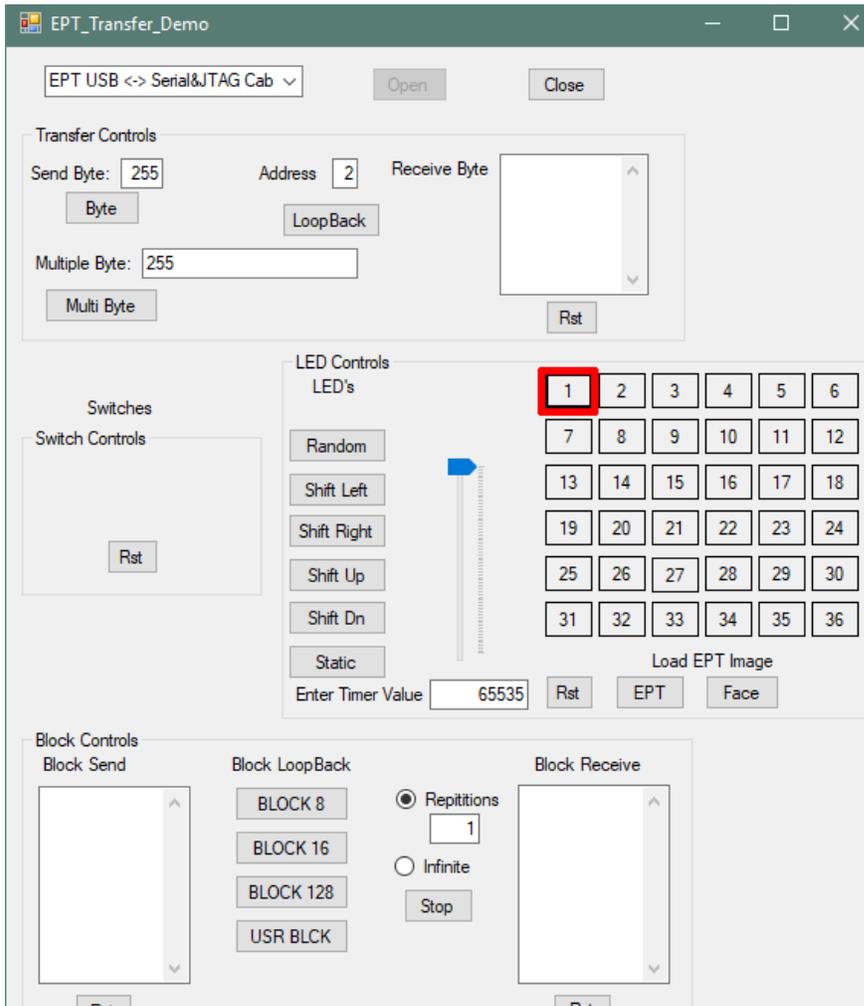
The characters “EPT” will be displayed on the 6x6 LED array. All the characters cannot be displayed at once, so the “Shift Left” or “Shift Right” button must be pressed to see all characters.

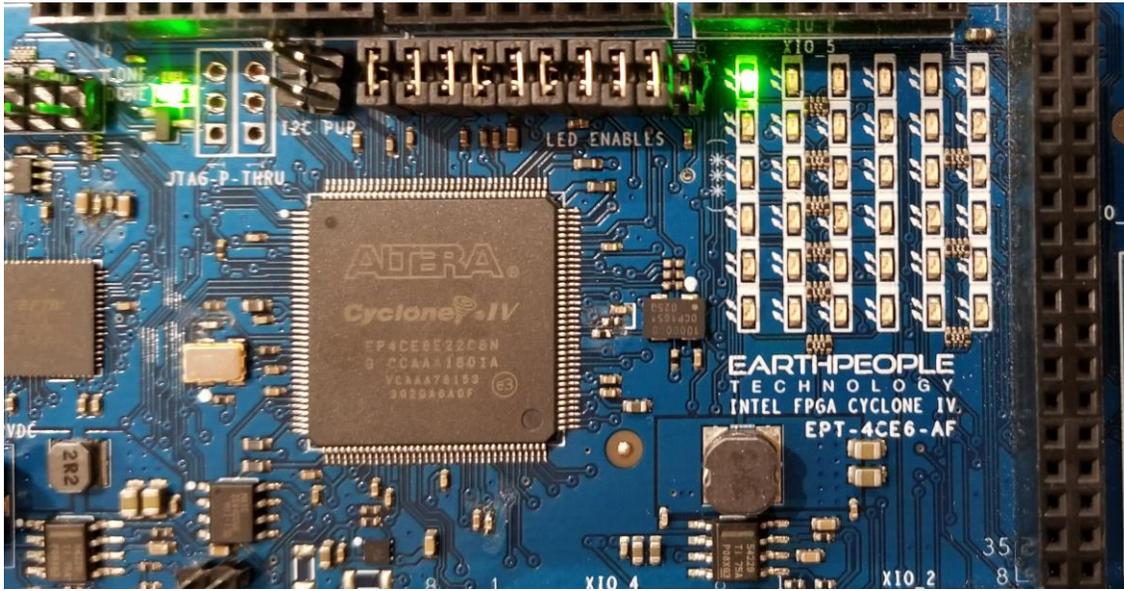
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Next press any of the numbered buttons in the “LED Controls” group. This will toggle the corresponding LED in the 6x6 LED Array. It performs this operation as a Block Write. So, an entire LED frame will be transferred to the DueProLogic each time a button is pressed.

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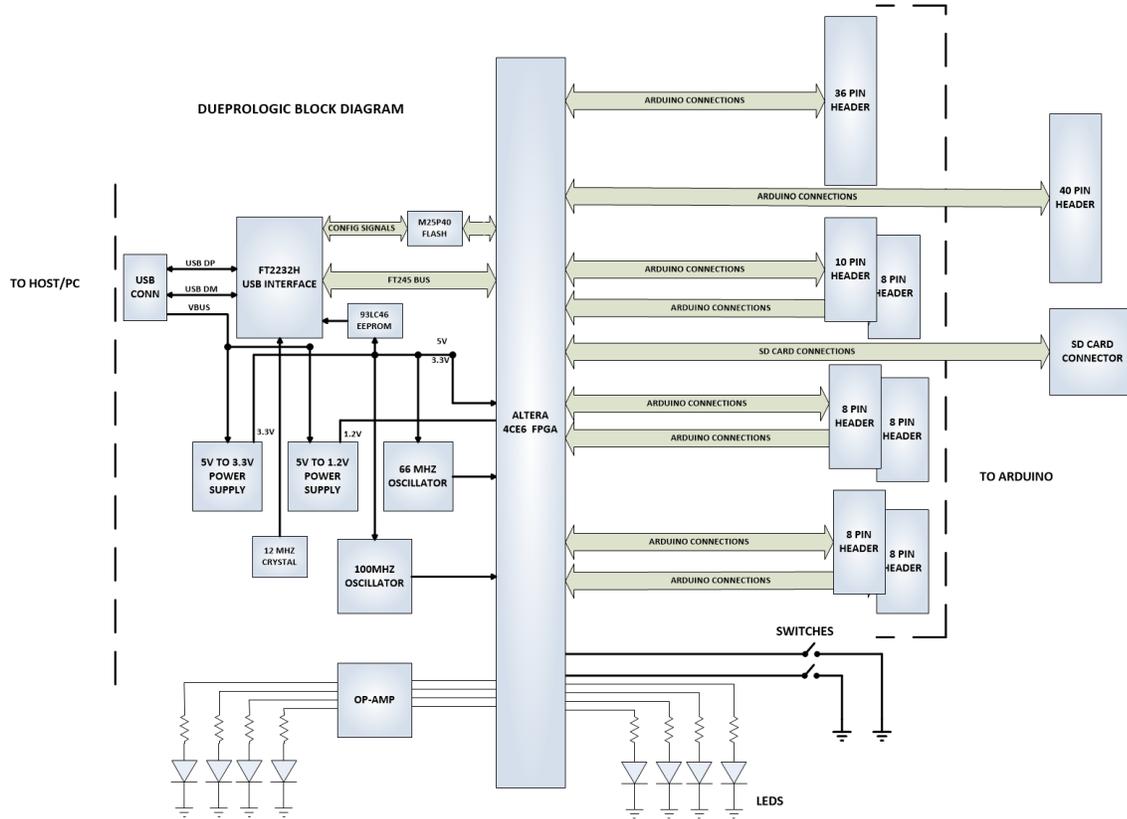
## 1.2 Hardware Description

The EPT-5M57-AP-U2 board is equipped with an Altera EP4CE6E22C8 FPGA; which is programmed using the Altera Quartus Prime software. The FPGA has 6672 Logic Elements and 276480 Total RAM Bits. An on board 66 MHz oscillator is used by the EPT Active Transfer Library to provide data transfer rates of up to 8 Mega Bytes per second. Fifty Four I/O's from the FPGA are attached to eight separate user connectors. I/O's. The user connectors are organized to fit the Due Arduino platform. There is a separate 40 pin dual row connector at the rear of the board arranged to mate with standard Bread boards. There are four green User LED's, four multicolored System LED's and two Push Buttons that are controllable by the user code. The hardware features are as follows.

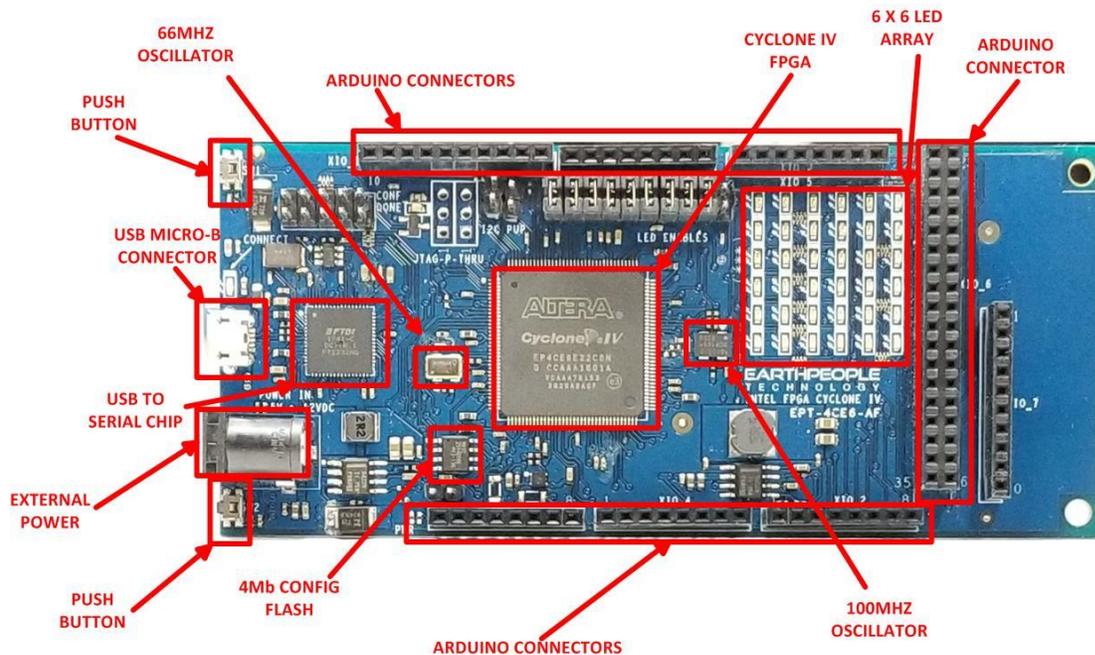
- Intel/Altera EP4CE6 FPGA with 6272 Logic Cells
- Dual Channel High Speed USB FT232H
- 66 MHz oscillator for driving USB data transfers and users code
- 100MHz oscillator for scaling up/down for users needs
- Standard SD Card interface for memory expansion
- 54 user Input/Outputs (+3.3V only)
- 36 Green LED Array accessible by the user
- Two PCB switches accessible by the user
- I/O connectors stack into the Arduino Due

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### EPT-4CE6-AF-D2



## DueProLogic Hardware

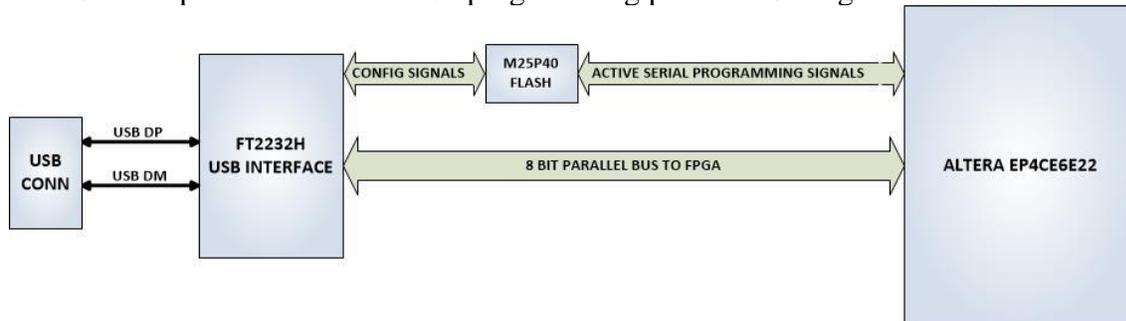


### 1.2.1 Inputs and Outputs

There are 54 Inputs/Outputs which are +3.3Volt only. Do not connect a 5Volt device to the DPL. The FPGA I/O's are organized as separate pins and connect to the Arduino connectors. Each I/O must be defined as input or output in the user code. Each pin of the Arduino connectors can behave as either input or output. Refer to the DueProLogic Data Sheet for exact pinout location.

## 1.2.2 FPGA Configuration

The EP4CE6 FPGA is configured for operation when the power is applied to the board. A dedicated Configuration Flash chip is included on the DueProLogic for the purpose of configuring the FPGA as power up. The DPL uses the second channel of the FT2232H chip as a dedicated Flash programming port. The Configuration Flash can be



programmed directly from Quartus Prime by using the EPT-Blaster driver. Follow the instructions in the “EPT Drivers” section of this manual.

## 1.2.3 FT2232H Dual Channel USB to Serial Chip

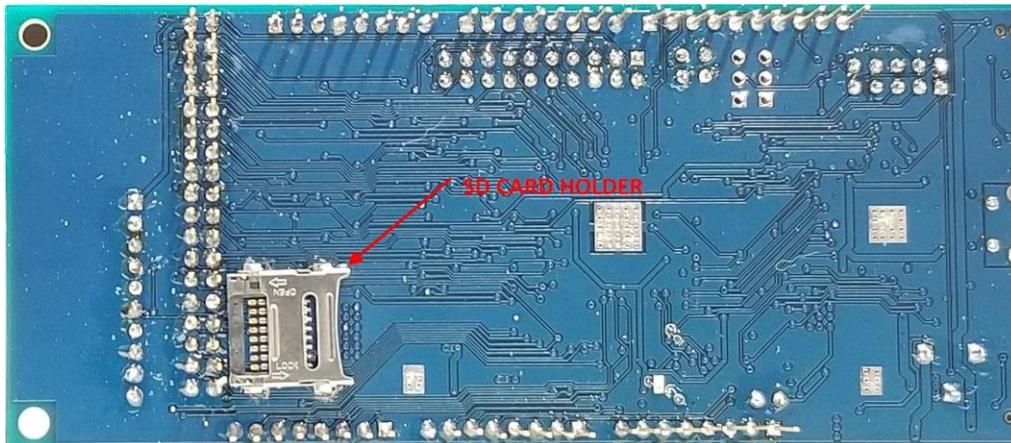
The DueProLogic contains an FTDI 2232H dual channel high speed (480 Mb/s) USB to FIFO (first in-first out) integrated circuit to interface between the Host PC and the FPGA. The FT2232H provides a means of data conversion from USB to serial/ parallel data and serial/parallel to USB for data being sent from the FPGA to the PC. Channel A is configured as a Flash Configuration bus and Channel B is configured as an 8 bit parallel bus. FPGA Programming commands are transmitted via the channel A interface. Channel B has one dual port 4Kbyte FIFO for transmission from Host PC to the FPGA, it also has one dual port 4Kbyte FIFO for receiving data from the FPGA to the Host PC.

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### 1.2.4 SD Card Interface

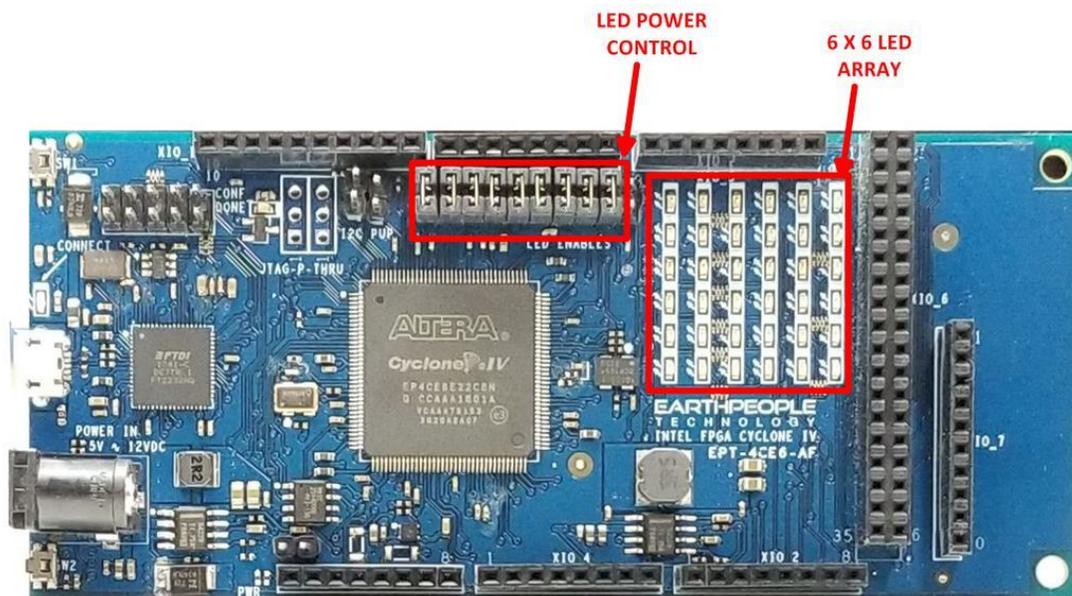
The DPL includes a standard SD Card Interface. The SD connector is on the bottom of the DPL. This interface allows the user to add expansion memory or the standard SD interface.



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### 1.2.5 LEDs

The DueProLogic includes a 6x6 Green LED array. Each LED is sinked to an individual pin on the FPGA. Each LED is current limited to 6mA. The total current consumed for all 36 LEDs is 216mAs. The FPGA can easily sink this current. So, individually sinking all 36 LEDs makes easy control for User Code. The DueProLogic also contains a method to turn on/off the LEDs in four unit blocks. A jumper is used to control the state of each LED block.



LED Power Control

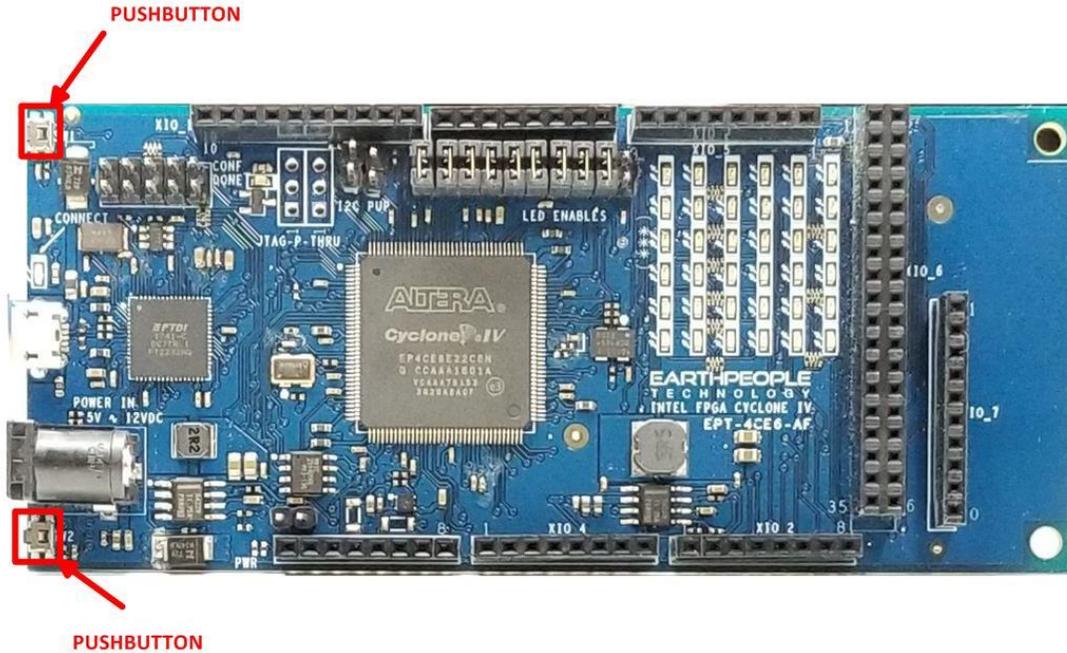
Connect LED

CONF DONE LED

### 1.2.6 Pushbuttons

The DueProLogic includes two pushbuttons that can be used in a way the user would like. They are both attached to separate debounce circuits. These pushbuttons were designed to use as little PCB are as possible. The switch is engaged by the plunger which is directed off the PCB.

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**1.2.7 Power Options**

There are two power options for the DueProLogic

- USB Micro B Connection to a PC (+5VDC)
- Barrel Connector (+5VDC to +12VDC)

The USB Micro B Connector is a the standard connector specified by the USB SIG.



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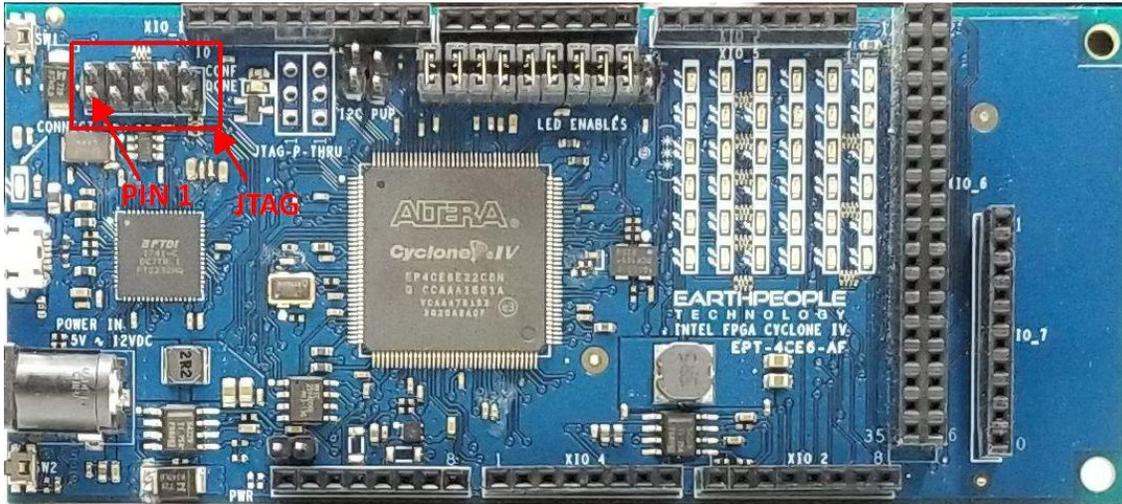
The Barrel Connector is located on the front of the board. It has 2.0mm inner diameter and 5.5mm outer diameter. The inner male connection is the positive connection and the outer connection is the ground. This connection can accept between +5VDC and +12VDC power. However, great care must be used when using this connection. This power is applied to several pins on the I/O headers. Consult the Data Sheet for these connections.



### 1.2.8 JTAG Header

The DueProLogic can be programmed by writing to the on board configuration flash or by directly accessing the FPGA JTAG connection. Connector J13 provides access to the FPGA JTAG connections. The pinout follows the USB Blaster arrangement which is standard on all Intel/Altera devices. Be sure to follow the pin 1 orientation. Connect an Intel/Altera compatible programmer to J13, and the FPGA can be programmed directly from Quartus Prime Lite.

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### **1.3 FPGA Active Host Development**

The DueProLogic comes complete with step by step instructions on building an entire communications system from FPGA to Windows Host. Using the EPT Active Host dll provides an easy to use programming interface. The tools required are the free Visual Studio IDE and the free Quartus Prime.

The DueProLogic also comes with instructions on how to build a communications systems between the Arduino Due and the DPL. The DVD included in the kit has all source files, compiled projects and user manuals to assist the user in using the software. In order to assemble a full communications system between the PC and the DPL, the following software items are required:

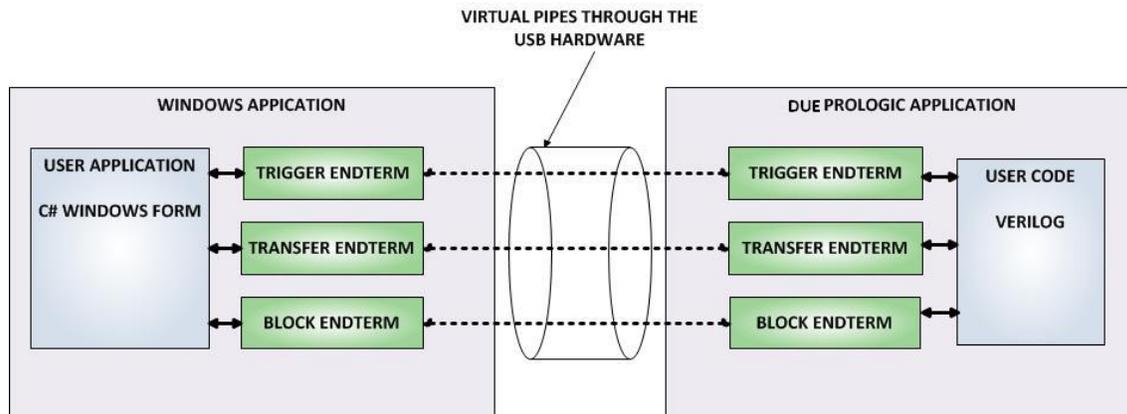
- Active Host dll – This library provides the communication mechanism on the PC
- Active Transfer library – This library is included and synthesized into the users code on the FPGA

These two software components provide a communication mechanism by talking to each other over an item called “EndTerms”. EndTerms is the name given to the virtual “pipes” provided by the above libraries. The next two sections provides a brief introduction to EndTerms. Following sections will provide greater detail on using EndTerms.

### **1.4 Active Host EndTerms**

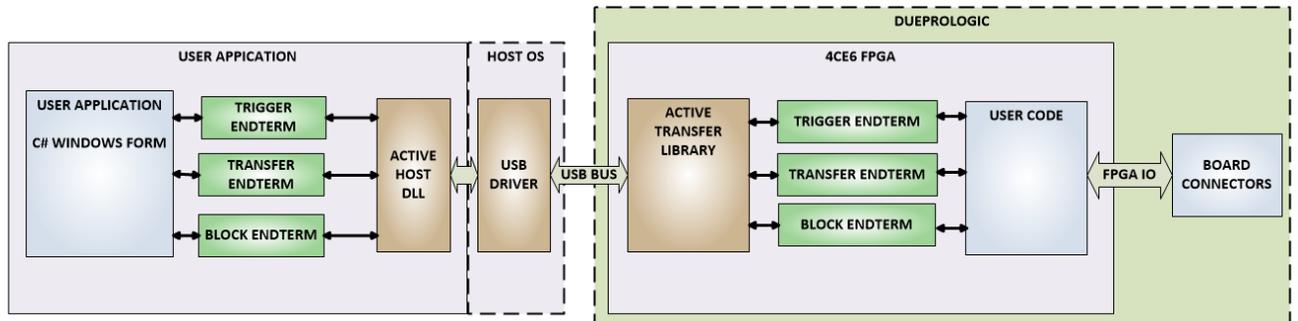
The Active Host SDK is provided as a dll which easily interfaces to application software written in C#, C++ or C. It runs on the PC and provides transparent connection

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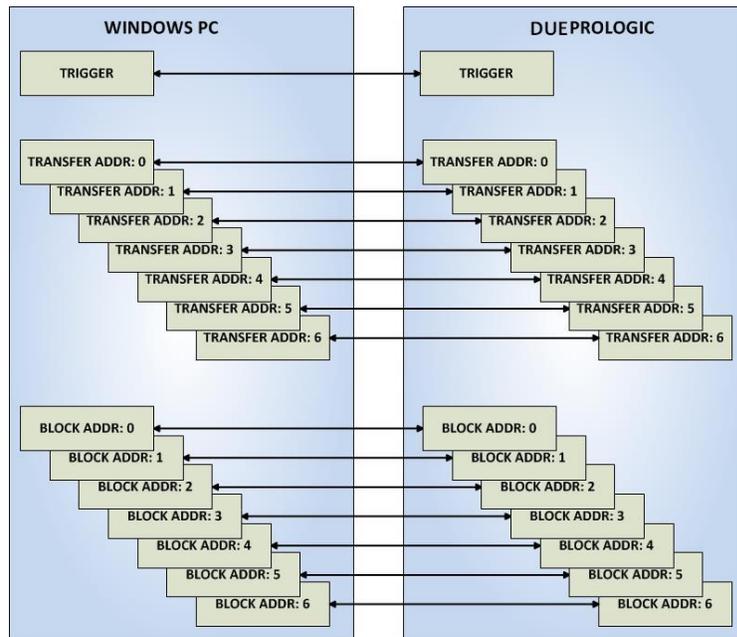
from PC/Windows application code through the USB driver to the user FPGA code. The user code connects to “Endterms” in the Active Host dll. These Host “Endterms” have complementary HDL “Endterms” in the Active Transfer Library. Users have seamless bi-directional communications at their disposal in the form of:

- Trigger Endterm
- Transfer Endterm
- Block Endterm



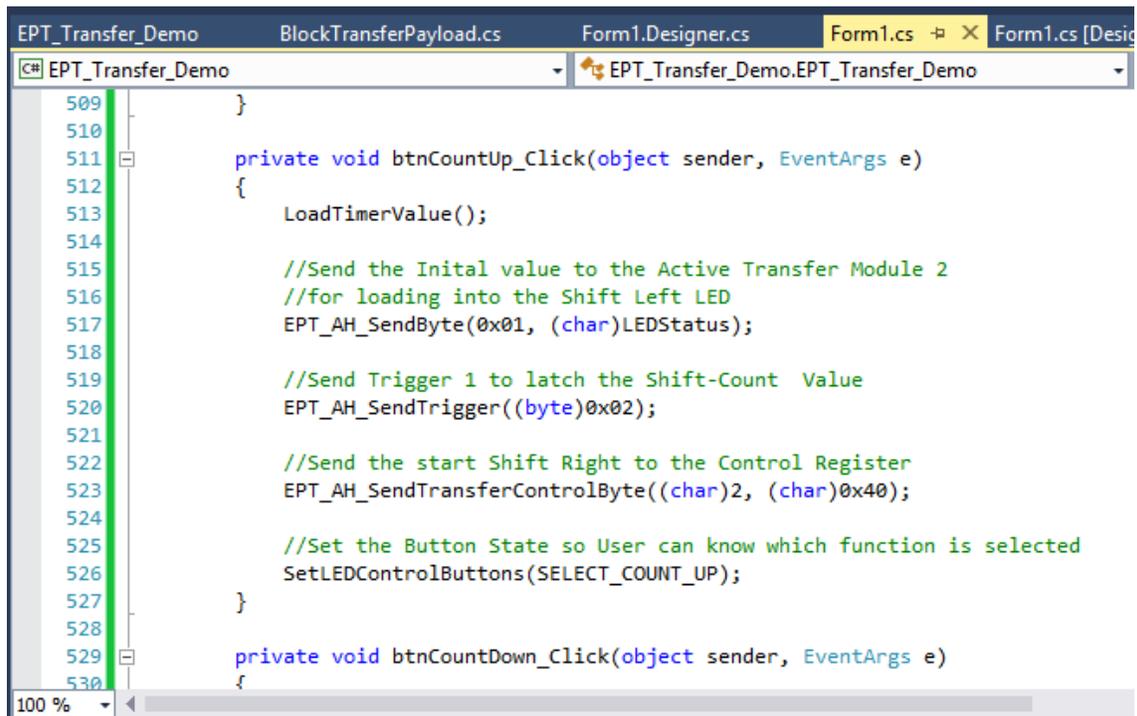
User code writes to the Endterms as function calls. Just include the address of the individual module (there are eight individually addressable modules of each Endterm).

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Immediately after writing to the selected Endterm, the value is received at the HDL Endterm in the FPGA.

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```
EPT_Transfer_Demo  BlockTransferPayload.cs  Form1.Designer.cs  Form1.cs  Form1.cs [Desig
C# EPT_Transfer_Demo  EPT_Transfer_Demo.EPT_Transfer_Demo
509     }
510
511     private void btnCountUp_Click(object sender, EventArgs e)
512     {
513         LoadTimerValue();
514
515         //Send the Initial value to the Active Transfer Module 2
516         //for loading into the Shift Left LED
517         EPT_AH_SendByte(0x01, (char)LEDStatus);
518
519         //Send Trigger 1 to latch the Shift-Count Value
520         EPT_AH_SendTrigger((byte)0x02);
521
522         //Send the start Shift Right to the Control Register
523         EPT_AH_SendTransferControlByte((char)2, (char)0x40);
524
525         //Set the Button State so User can know which function is selected
526         SetLEDControlButtons(SELECT_COUNT_UP);
527     }
528
529     private void btnCountDown_Click(object sender, EventArgs e)
530     {
```

The above is a code sample from a C# Windows Form. You can see functions that write a byte to the FPGA (EPT\_AH\_SendByte(0x01, (char)LEDStatus)) and write a trigger bit to the FPGA (EPT\_AH\_SendTrigger((byte)0x02)).

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```

953
954 */
955 active_trigger          ACTIVE_TRIGGER_INST
956 (
957     .uc_clk              (CLK_66),
958     .uc_reset            (RST),
959     .uc_in               (UC_IN),
960     .uc_out              (uc_out_m[ 0*22 +: 22 ]),
961
962     .trigger_to_host     (trigger_out),
963     .trigger_to_device   (trigger_in_byte)
964
965 );
966
967 active_transfer         ACTIVE_TRANSFER_INST_1
968 (
969     .uc_clk              (CLK_66),
970     .uc_reset            (RST),
971     .uc_in               (UC_IN),
972     .uc_out              (uc_out_m[ 1*22 +: 22 ]),
973
974     .start_transfer      (led_start_transfer),
975     .transfer_received    (led_transfer_in_received),
976
977     .transfer_busy       (),
978
979     .uc_addr             (3'h1),
980
981     .transfer_to_host    (led_host_transfer_byte),
982     .transfer_to_device  (led_device_transfer_byte)
983 );
  
```

The above code is the interface Verilog which resides in the FPGA. When the C# Windows form sends a byte or trigger, the signals in the FPGA code react and allow the user code to receive the byte and trigger and perform some function with the information. In the case of this example, the LEDs will change state.

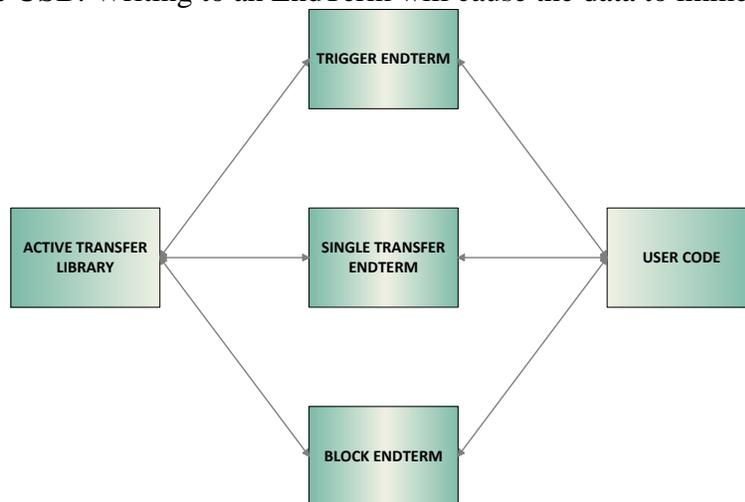
Receiving data from the FPGA is made simple by Active Host. Active Host transfers data from the FPGA as soon as it is available. It stores the transferred data into circular buffer. When the transfer is complete, Active Host invokes a callback function which is registered in the users application. This callback function provides a mechanism to transparently receive data from the FPGA. The user application does not need to schedule a read from the USB or call any blocking threads.

### 1.5 Active Transfer EndTerms

The Active Transfer Library is a portfolio of HDL modules that provides an easy to use yet powerful USB transfer mechanism. The user HDL code communicates with EndTerms in the form of modules. These EndTerm modules are commensurate with the Active Host EndTerms. There are three types of EndTerms in the Active Transfer Library:

- Trigger Endterm
- Transfer Endterm
- Block Endterm

They each have a simple interface that the user HDL code can use to send or receive data across the USB. Writing to an EndTerm will cause the data to immediately arrive



at the commensurate EndTerm in the Active Host/user application. The transfer through the USB is transparent. User HDL code doesn't need to set up Endpoints or respond to Host initiated data requests. The whole process is easy yet powerful.

## 2 EPT Drivers

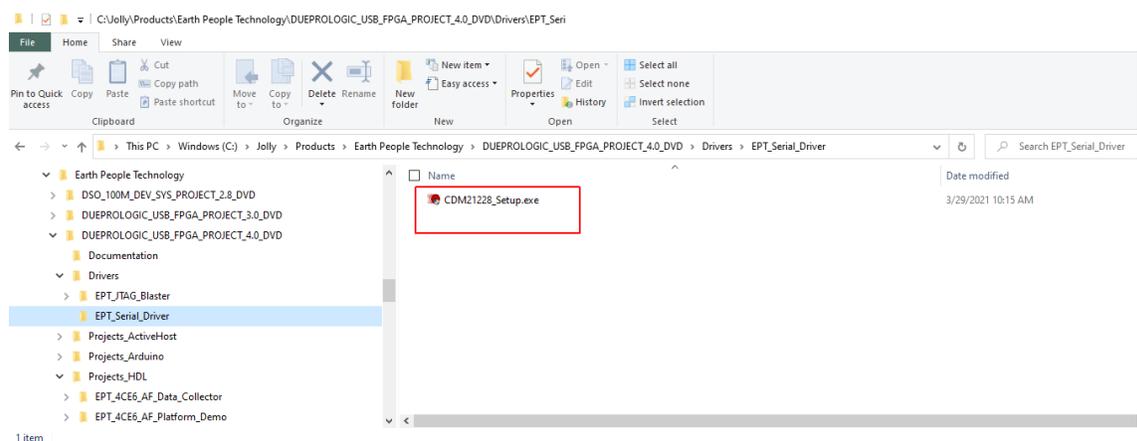
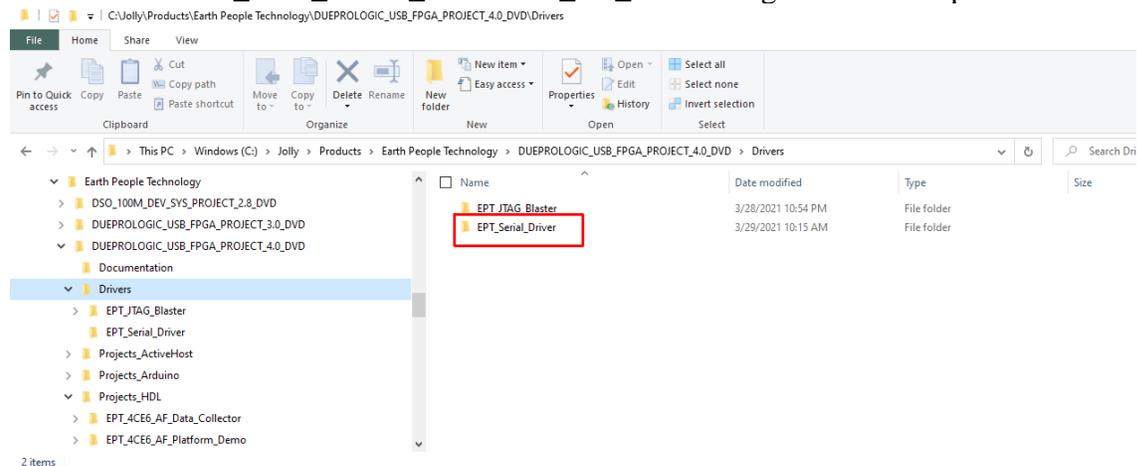
The DueProLogic Development system requires drivers for any interaction between PC and the board. The communication between the two consists of programming the FPGA and data transfer. In both cases, the USB Driver is required. This will allow Windows to recognize the USB Chip and setup a pathway for Windows to communicate with the USB hardware.

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### 2.1 USB Driver

The DueProLogic uses an FTDI FT2232H USB to Serial chip. This chip provides the USB interface to the PC and the serial/FIFO interface to the FPGA. The FT2232H requires the use of the FTDI USB driver. To install the driver onto your PC, use the EPT\_Serial\_Driver Folder. The installation of the FTDI 2.12.28 driver is easily accomplished by double clicking the CDM21228\_Setup.exe.

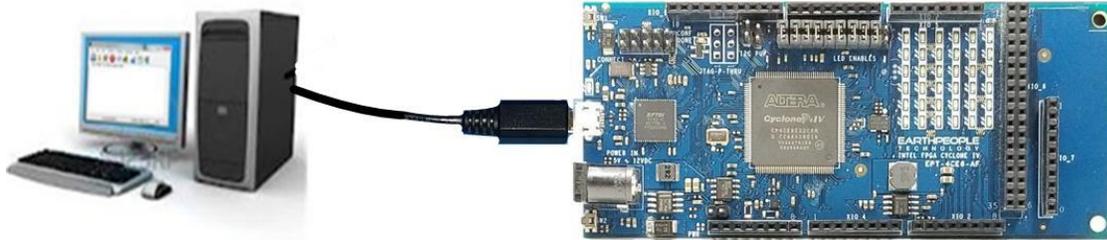
Locate the EPT\_Serial\_Driver folder in the Drivers folder of the DUEPROLOGIC\_USB\_FPGA\_PROJECT\_x.x\_DVD using Windows Explorer.



Double click on the \*.exe file and select the default settings when the software tool queries the user.

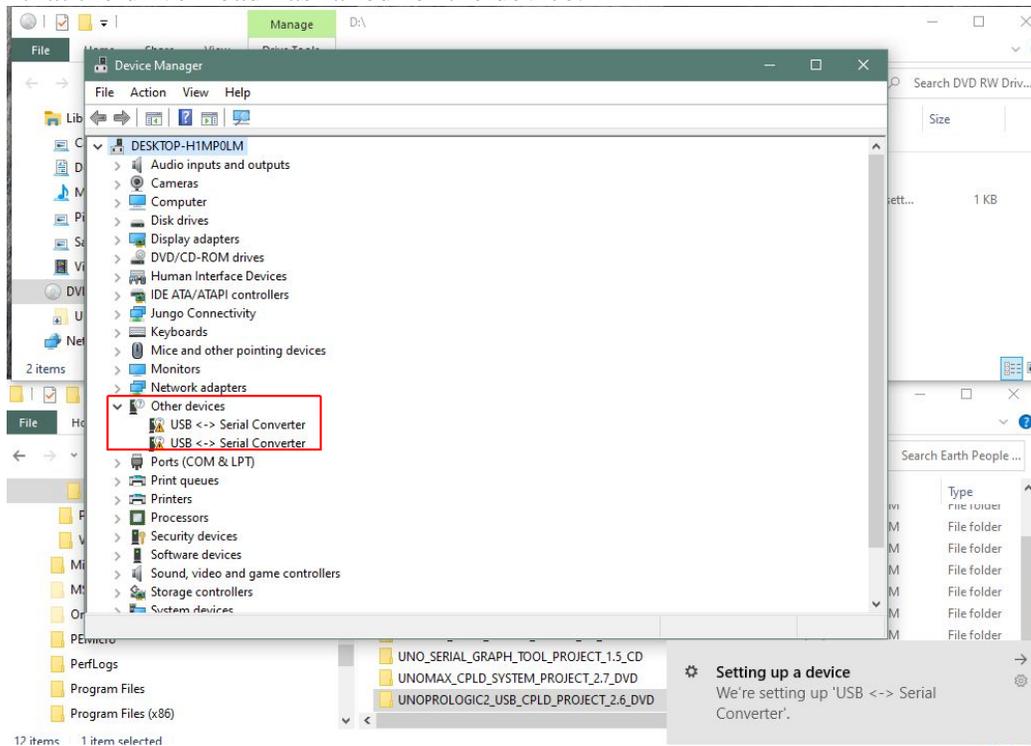
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Plug in the DueProLogic into an available USB port.



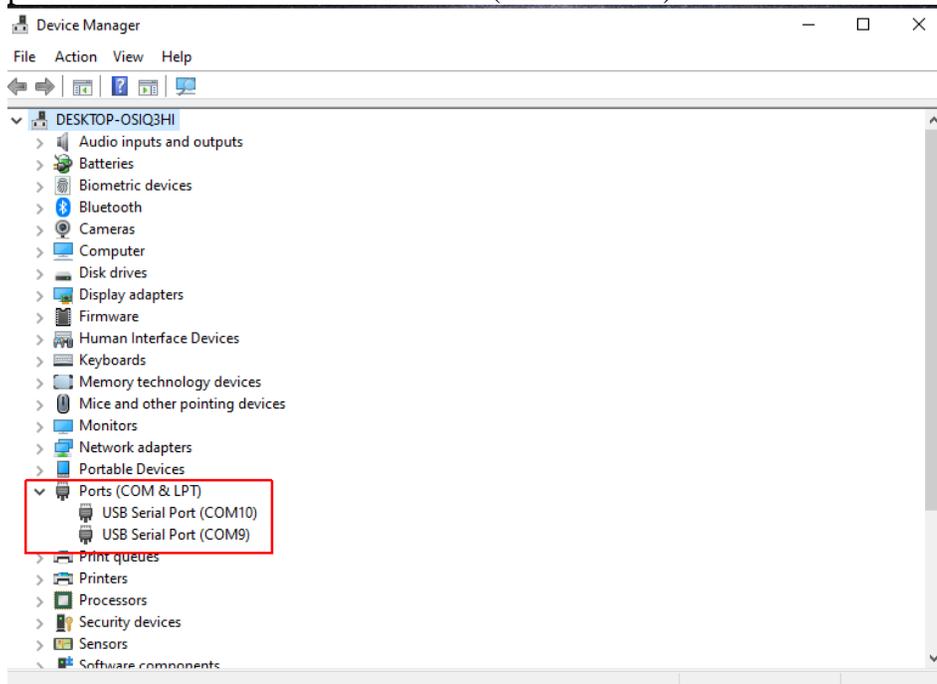
Windows will attempt to locate a driver for the USB device. Allow Windows to install the driver for the DueProLogic.

If Windows cannot load a driver for the DPL, a notification window will inform the user that the driver load has failed for the device.



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If the driver is successfully installed, Windows will inform the user. The user can check Device Manager to ensure the correct driver was installed for the DPL. The DPL will show up as two COM Ports under the “Ports (COM & LPT)” under the Device Manager.



When this is complete, the drivers are installed and the DueProLogic can be used for programming and USB data transfers.

### ***2.2 JTAG DLL Insert to Quartus Prime***

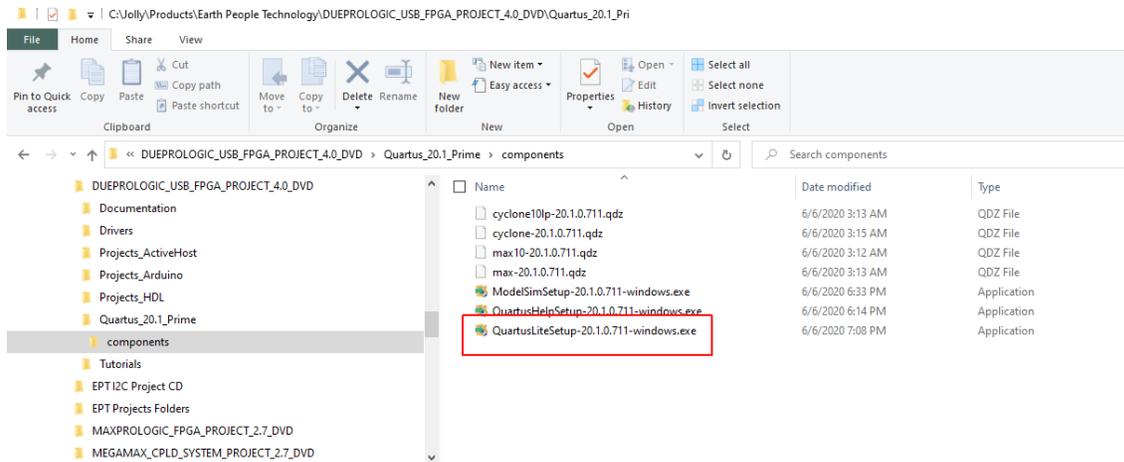
The JTAG DLL Insert to Quartus Prime allows the Programmer Tool under Quartus to recognize the DueProLogic. The DueProLogic can then be selected and perform programming of the FPGA. The file, `jtag_hw_mbftdi_blaster.dll` must be placed into the folder that hosts the `jtag_server` for Quartus. This dll is available for Windows 10 64-bit.

#### **2.2.1 Installing Quartus**

Locate the `Quartus_Prime` folder on the EPT FPGA Development System DVD.

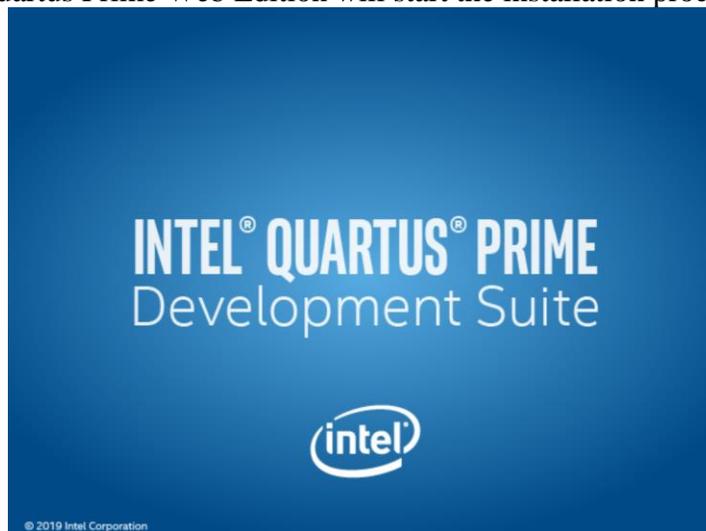


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If you don't have the EPT FPGA Development System DVD, you can download the Quartus Prime by following the directions in the Section Downloading Quartus.

If you don't need to download Quartus, double click on the QuartusLiteSetup-xxx.xxx.xxx-windows .exe (the xxx is the build number of the file, it is subject to change). The Quartus Prime Web Edition will start the installation process.



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When the install shield window pops up click “Yes” or if needed, enter the administrator password for the users PC. Click “Ok”

Next, skip the “Download Quartus” section. Go down to the “Quartus Installer” section to complete the Quartus installation.

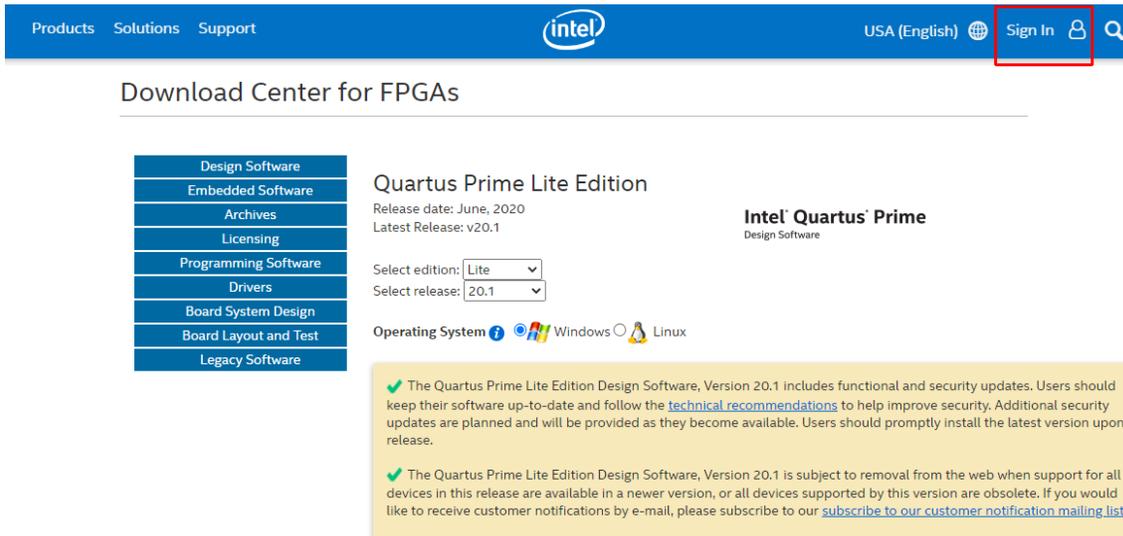
### 2.2.2 Downloading Quartus

The first thing to do in order build a project in Quartus is to download and install the application. You can find the latest version of Quartus at:

[Intel FPGA Quartus Prime Lite](https://www.intel.com/content/www/us/en/programmable/development-software/quartus-prime-lite-edition.html)

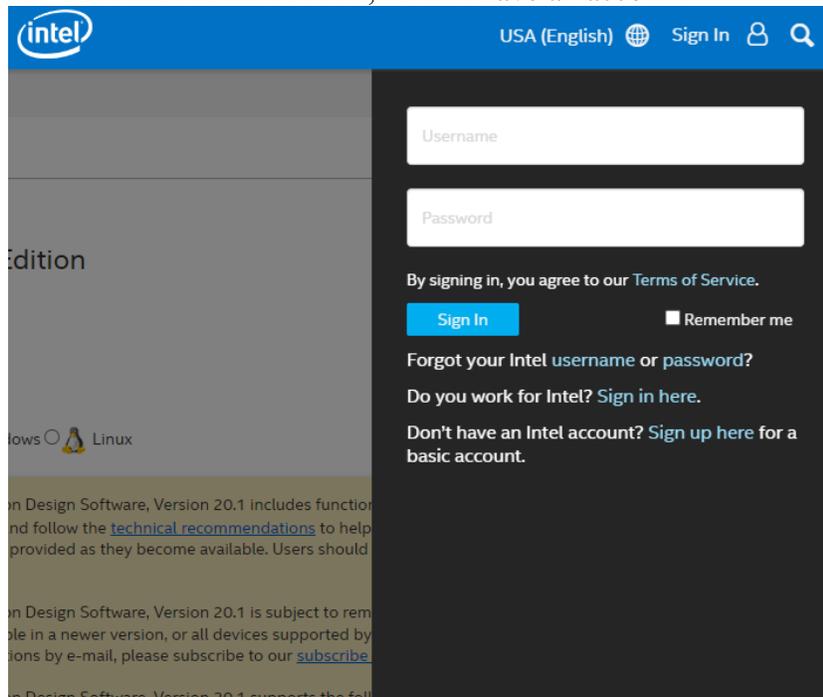
You will first need to apply for an account with Intel. Then use your login and password to access the download site. Click on the Download Windows Version.

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The screenshot shows the Intel website's navigation bar with 'Products', 'Solutions', and 'Support' on the left, the Intel logo in the center, and 'USA (English)', 'Sign In', and a search icon on the right. The 'Sign In' button is highlighted with a red box. Below the navigation bar, the page title is 'Download Center for FPGAs'. A sidebar on the left lists software categories: Design Software, Embedded Software, Archives, Licensing, Programming Software, Drivers, Board System Design, Board Layout and Test, and Legacy Software. The main content area is for 'Quartus Prime Lite Edition', showing release information (June 2020, v20.1), edition and release selection dropdowns, and operating system options (Windows, Linux). A yellow information box contains two green checkmarks and text regarding security updates and account notifications.

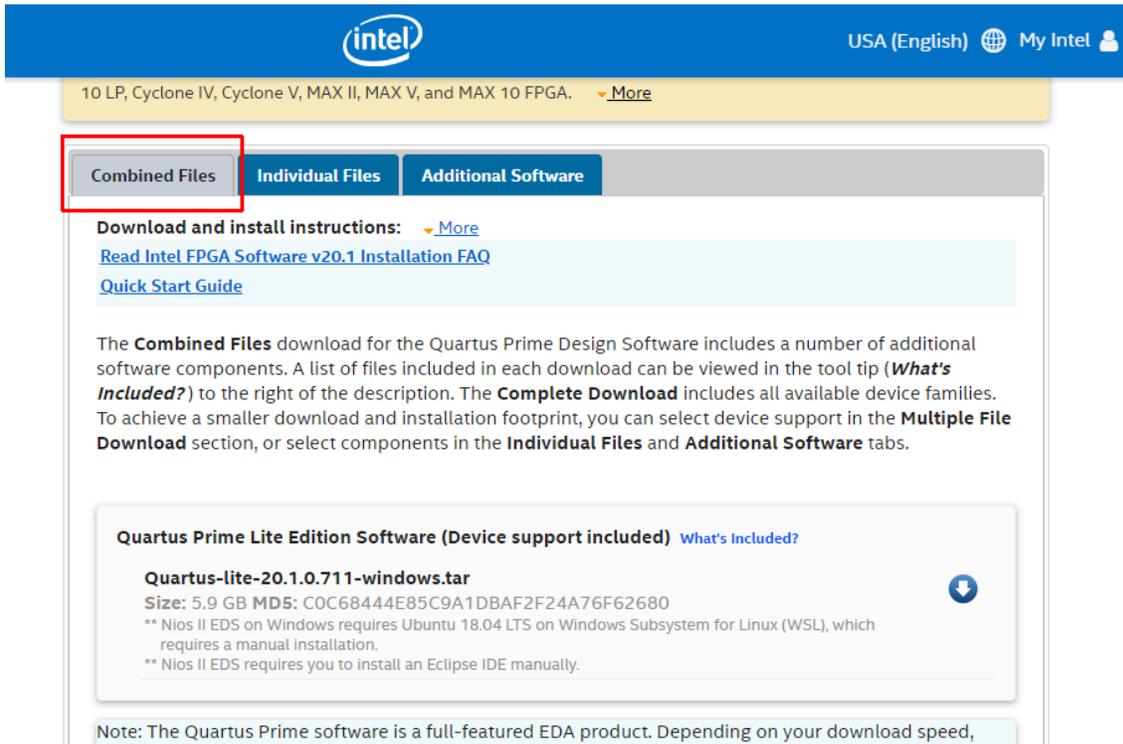
The next page will require you to sign into your “myAltera” account. If you do not have one, follow the directions under the box, “Don’t have an account?”



The screenshot shows the Intel website's login form. The navigation bar is visible at the top. The login form includes a 'Username' input field, a 'Password' input field, a 'Sign In' button, and a 'Remember me' checkbox. Below the form, there are links for 'Forgot your Intel username or password?', 'Do you work for Intel? Sign in here.', and 'Don't have an Intel account? Sign up here for a basic account.' The background of the page is dimmed, showing the same software information as the previous screenshot.

Once you have created your myAltera account, enter the User Name and Password. The next window will ask you to allow pop ups so that the file download can proceed.

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10 LP, Cyclone IV, Cyclone V, MAX II, MAX V, and MAX 10 FPGA. [More](#)

**Combined Files** Individual Files Additional Software

Download and install instructions: [More](#)  
[Read Intel FPGA Software v20.1 Installation FAQ](#)  
[Quick Start Guide](#)

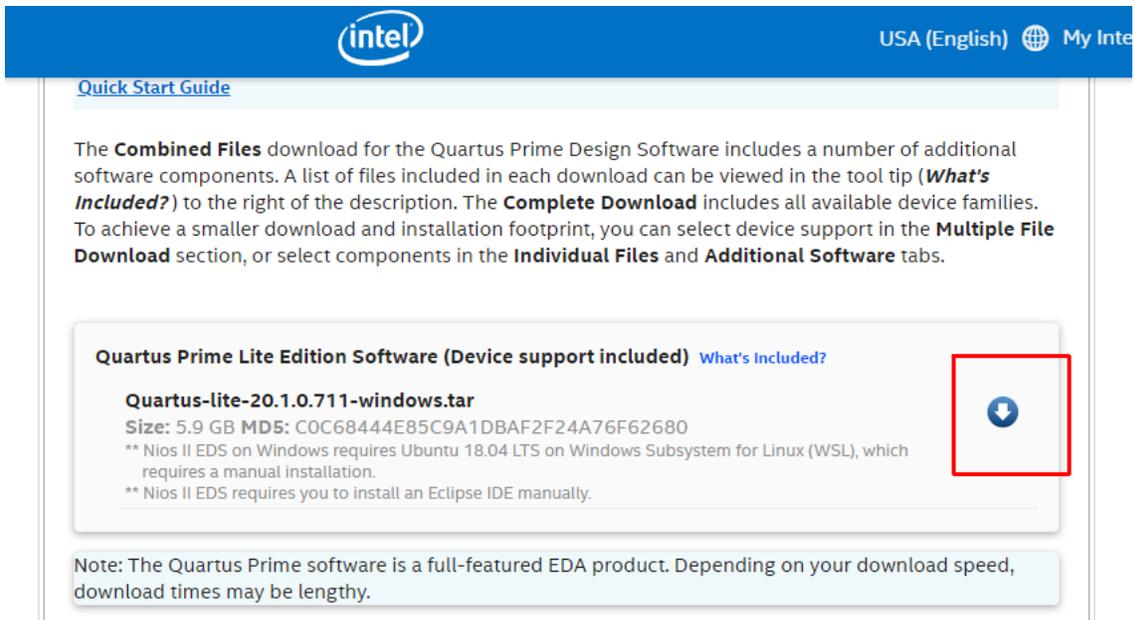
The **Combined Files** download for the Quartus Prime Design Software includes a number of additional software components. A list of files included in each download can be viewed in the tool tip (**What's Included?**) to the right of the description. The **Complete Download** includes all available device families. To achieve a smaller download and installation footprint, you can select device support in the **Multiple File Download** section, or select components in the **Individual Files** and **Additional Software** tabs.

**Quartus Prime Lite Edition Software (Device support included)** [What's Included?](#)

**Quartus-lite-20.1.0.711-windows.tar**   
Size: 5.9 GB MD5: COC68444E85C9A1DBAF2F24A76F62680  
\*\* Nios II EDS on Windows requires Ubuntu 18.04 LTS on Windows Subsystem for Linux (WSL), which requires a manual installation.  
\*\* Nios II EDS requires you to install an Eclipse IDE manually.

Note: The Quartus Prime software is a full-featured EDA product. Depending on your download speed,

Click on the download icon.



[Quick Start Guide](#)

The **Combined Files** download for the Quartus Prime Design Software includes a number of additional software components. A list of files included in each download can be viewed in the tool tip (**What's Included?**) to the right of the description. The **Complete Download** includes all available device families. To achieve a smaller download and installation footprint, you can select device support in the **Multiple File Download** section, or select components in the **Individual Files** and **Additional Software** tabs.

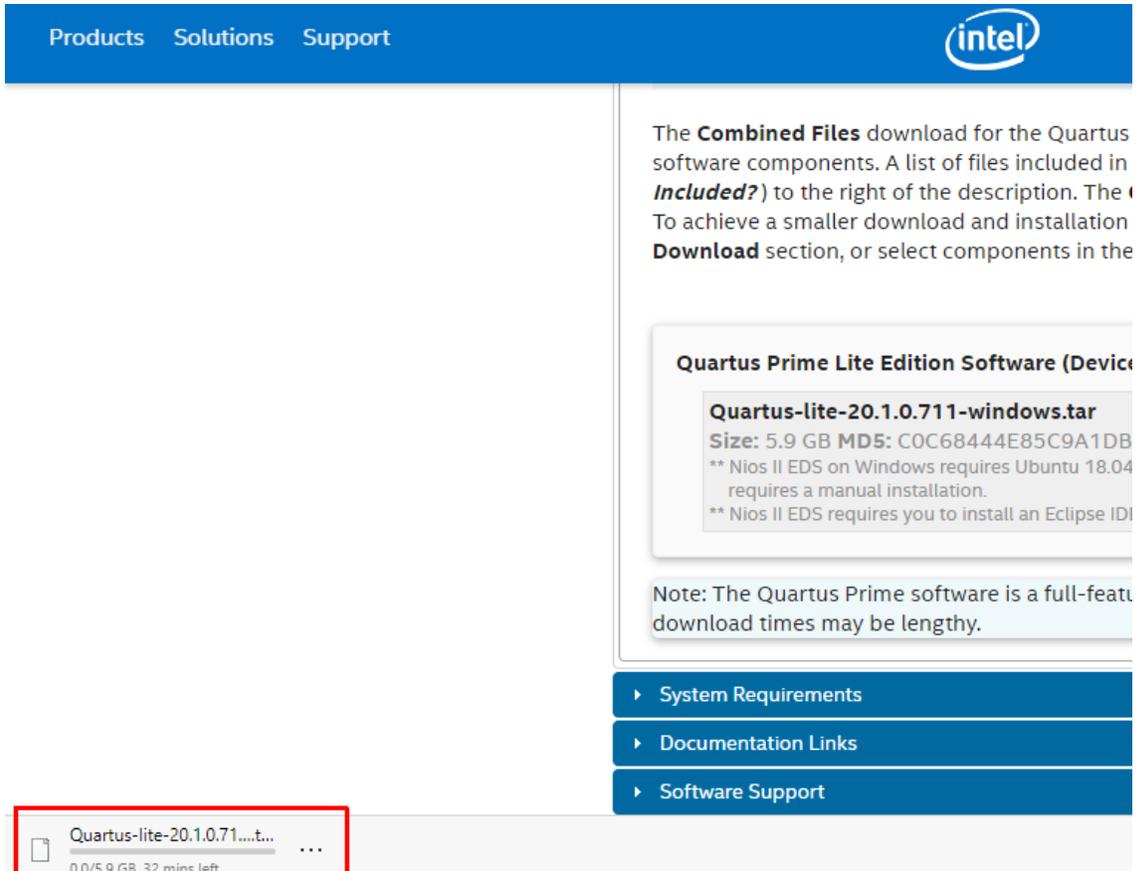
**Quartus Prime Lite Edition Software (Device support included)** [What's Included?](#)

**Quartus-lite-20.1.0.711-windows.tar**   
Size: 5.9 GB MD5: COC68444E85C9A1DBAF2F24A76F62680  
\*\* Nios II EDS on Windows requires Ubuntu 18.04 LTS on Windows Subsystem for Linux (WSL), which requires a manual installation.  
\*\* Nios II EDS requires you to install an Eclipse IDE manually.

Note: The Quartus Prime software is a full-featured EDA product. Depending on your download speed, download times may be lengthy.

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This will start the download.



The screenshot shows the Intel website's download page for Quartus Prime Lite Edition Software. The page has a blue header with 'Products Solutions Support' and the Intel logo. The main content area contains a description of the 'Combined Files' download, a list of included files, and a note about the software being a full-featured download. Below the main content are three blue buttons: 'System Requirements', 'Documentation Links', and 'Software Support'. At the bottom, a download progress bar is visible, showing the file name 'Quartus-lite-20.1.0.711...t...' and the progress '0.0/5.9 GB, 32 mins left'.

Products Solutions Support 

The **Combined Files** download for the Quartus software components. A list of files included in **Included?**) to the right of the description. The To achieve a smaller download and installation **Download** section, or select components in the

**Quartus Prime Lite Edition Software (Device**

**Quartus-lite-20.1.0.711-windows.tar**  
Size: 5.9 GB MD5: C0C68444E85C9A1DB  
\*\* Nios II EDS on Windows requires Ubuntu 18.04 requires a manual installation.  
\*\* Nios II EDS requires you to install an Eclipse IDE

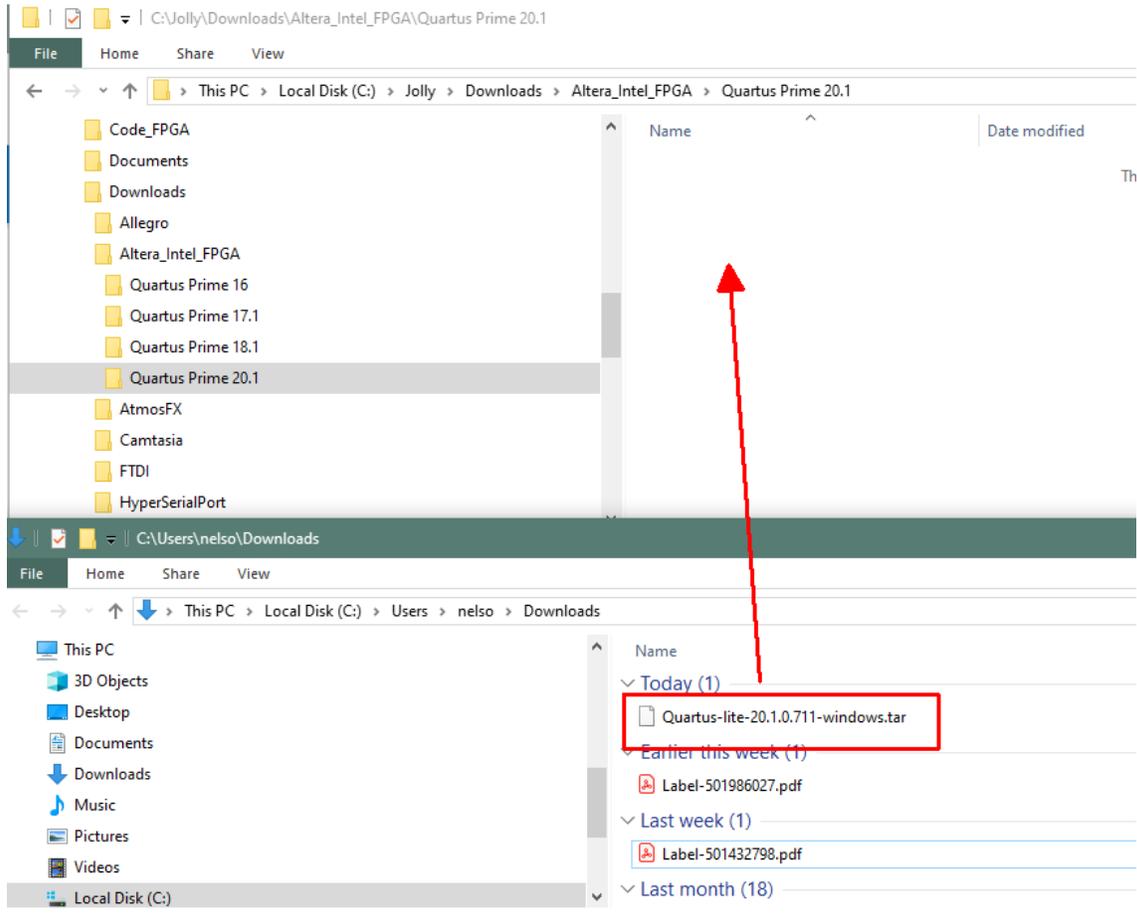
Note: The Quartus Prime software is a full-featured download times may be lengthy.

- ▶ System Requirements
- ▶ Documentation Links
- ▶ Software Support

Quartus-lite-20.1.0.711...t...  
0.0/5.9 GB, 32 mins left

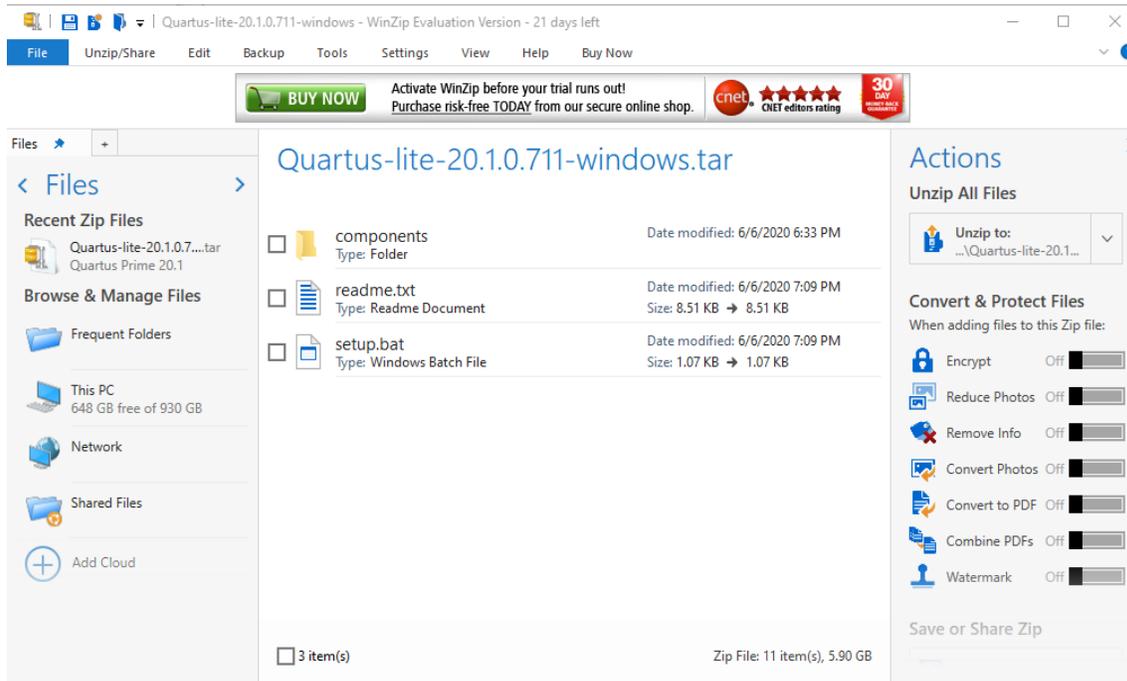
The file is 5.9 GB, so this could take a couple of hours depending on your internet connection. When download is complete, store the \*.tar file in a directory on your PC.

## FPGA Development System User Manual

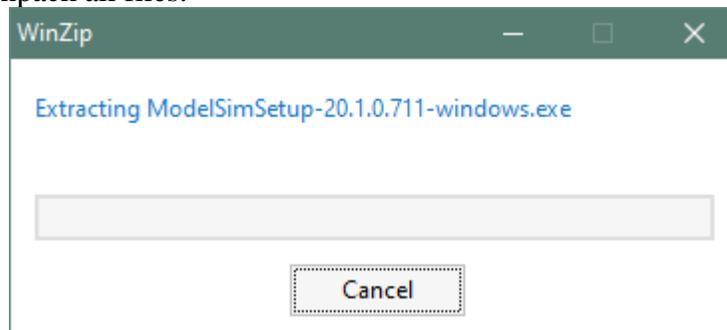


Use a tool such as WinZip to Extract the \*.tar file.

## FPGA Development System User Manual



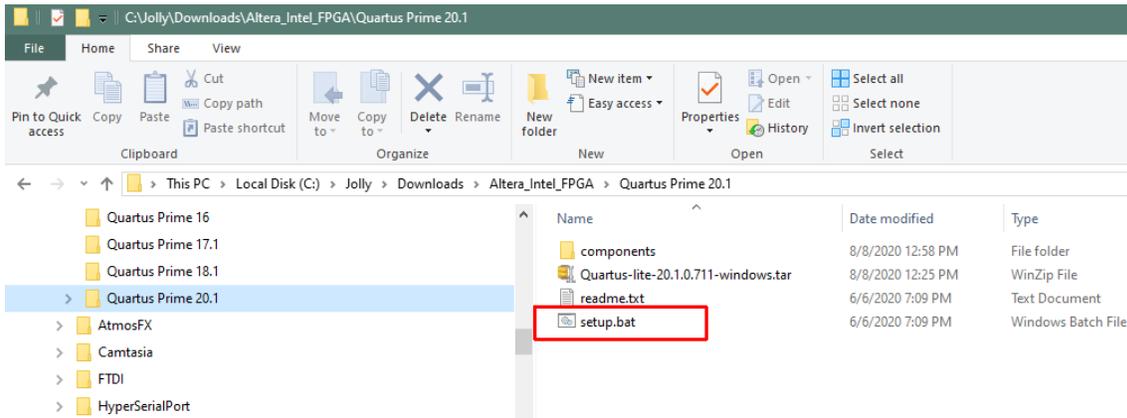
The tool will unpack all files.



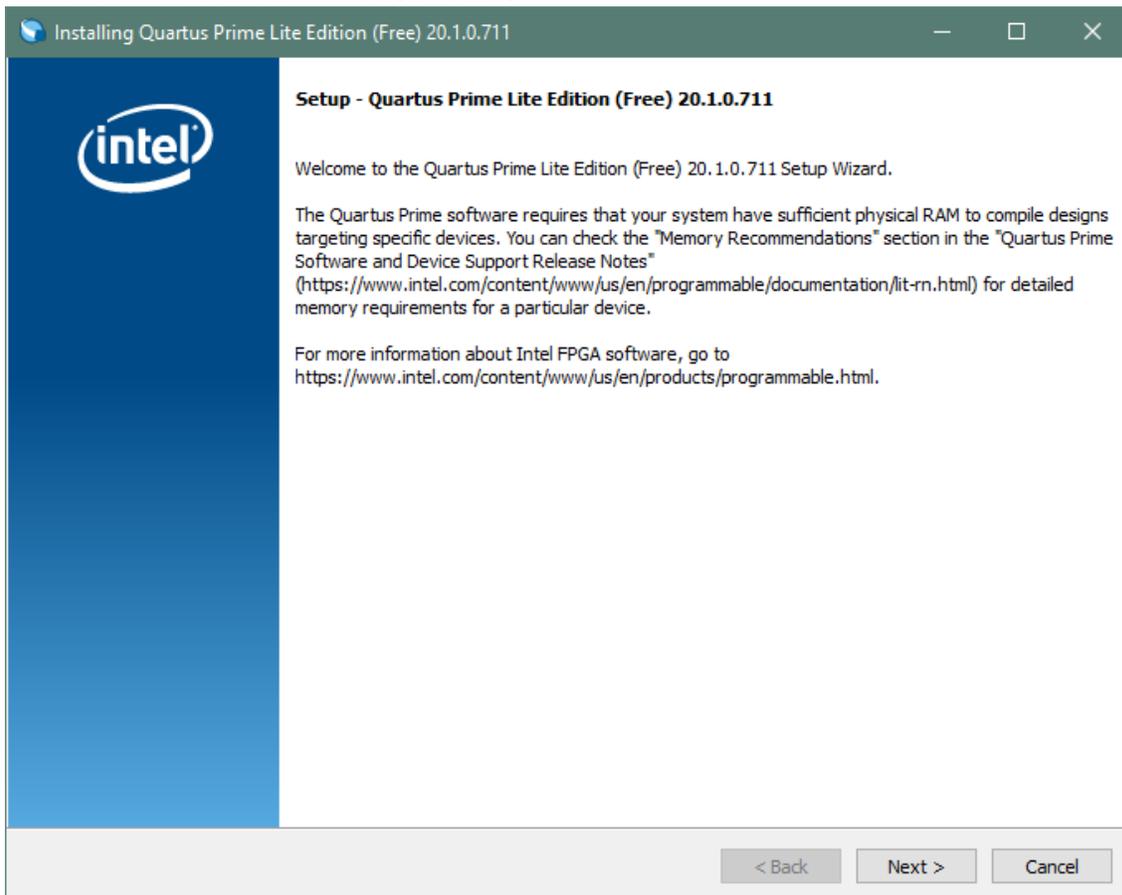
### 2.2.3 Quartus Installer

When the unpacking finishes from the previous section, double click the setup.bat file in the download folder.

## FPGA Development System User Manual

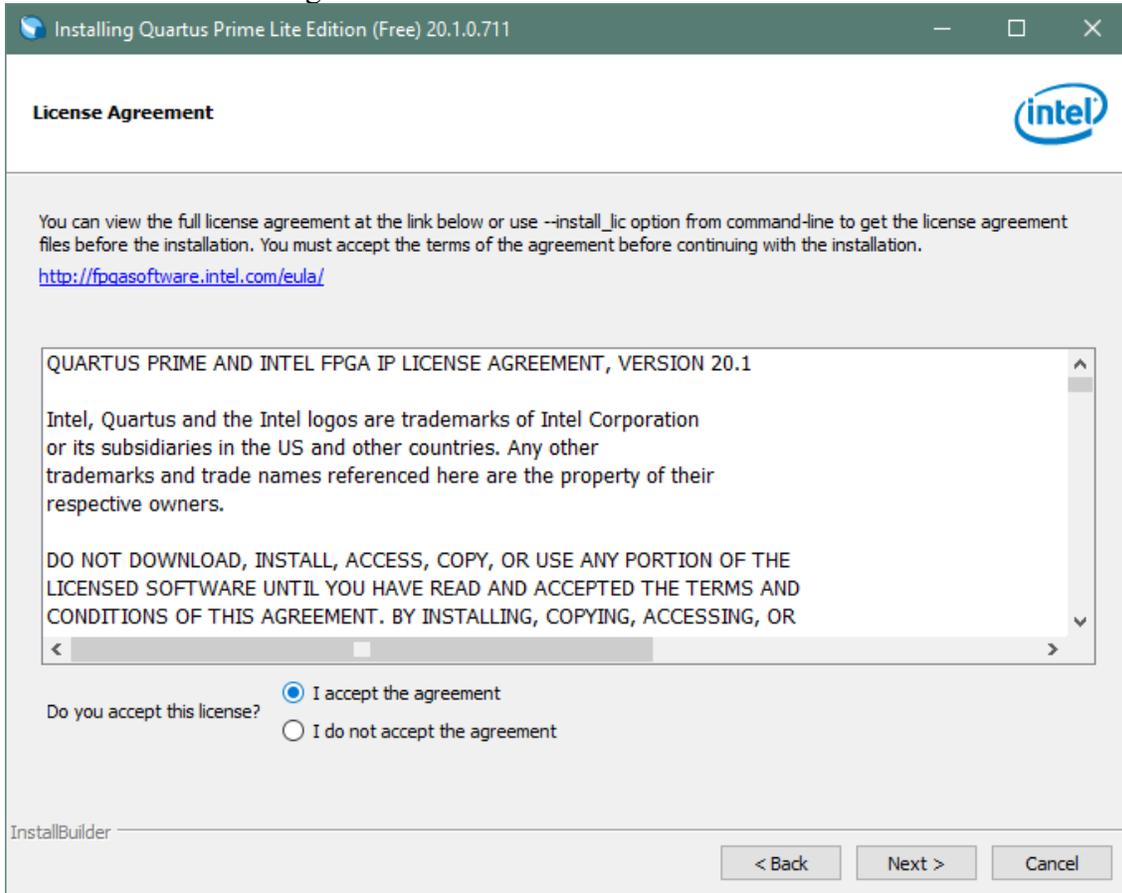


Click “Next” on the Introduction Window.



## FPGA Development System User Manual

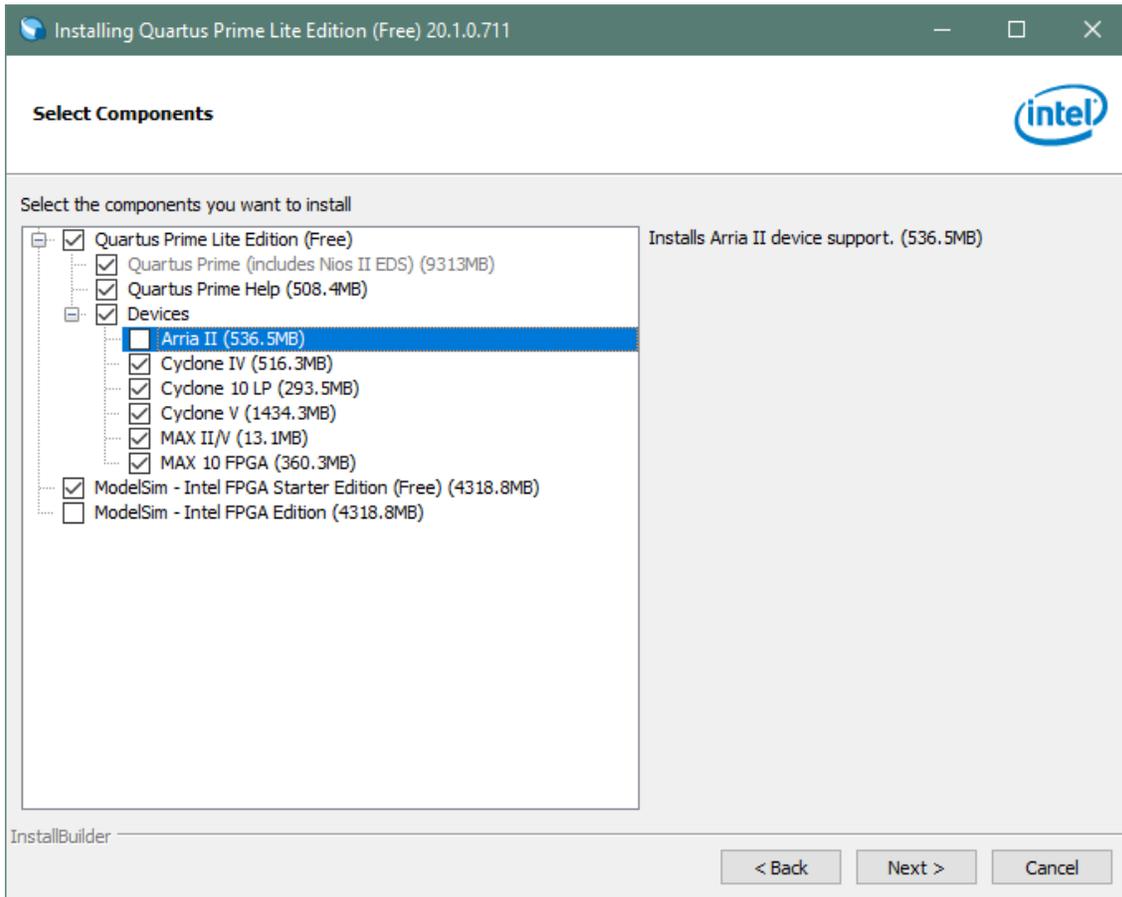
Click the checkbox to agree to the license terms. Then click “Next”.



Click “Next” and accept the defaults.

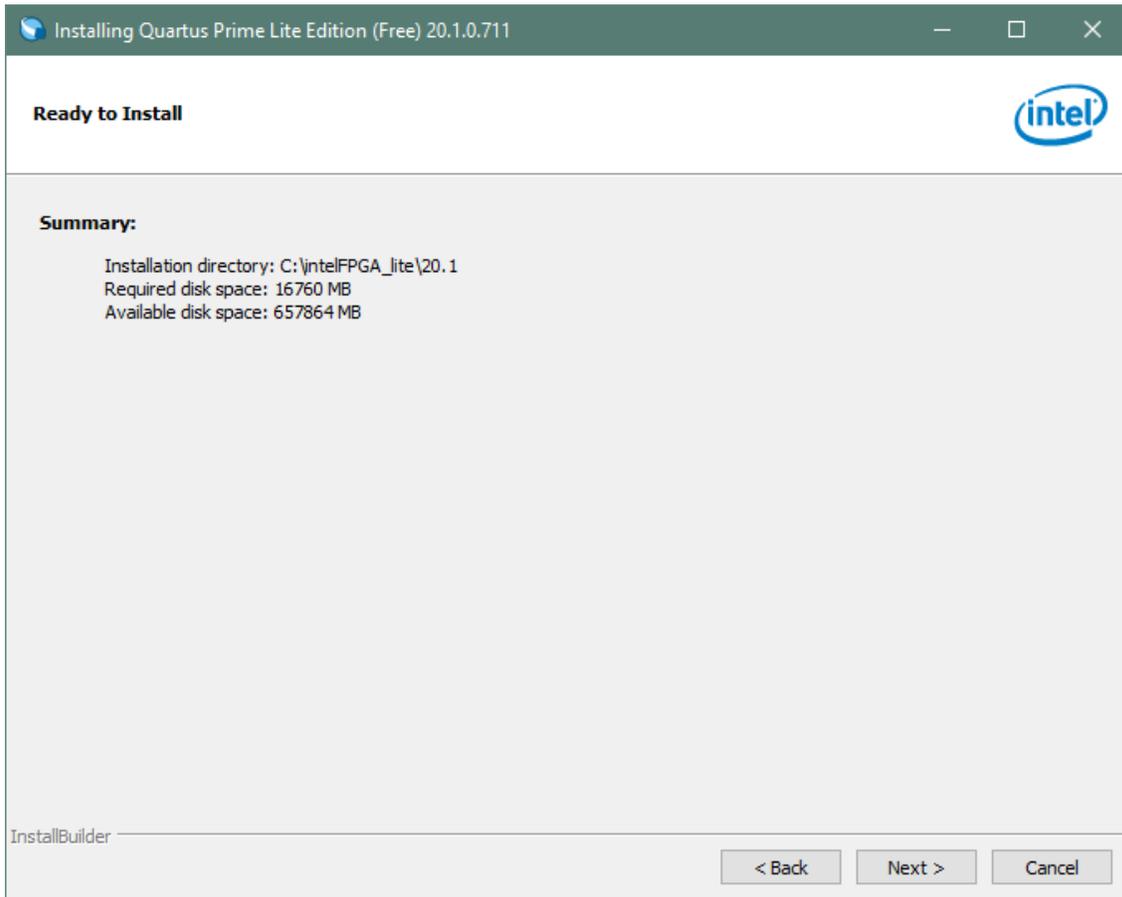
At the Select Products Window, de-select the Quartus Prime Subscription Edition by clicking on its check box so that the box is not checked. Then click on the check box by the Quartus Prime Web Edition (Free).

## FPGA Development System User Manual



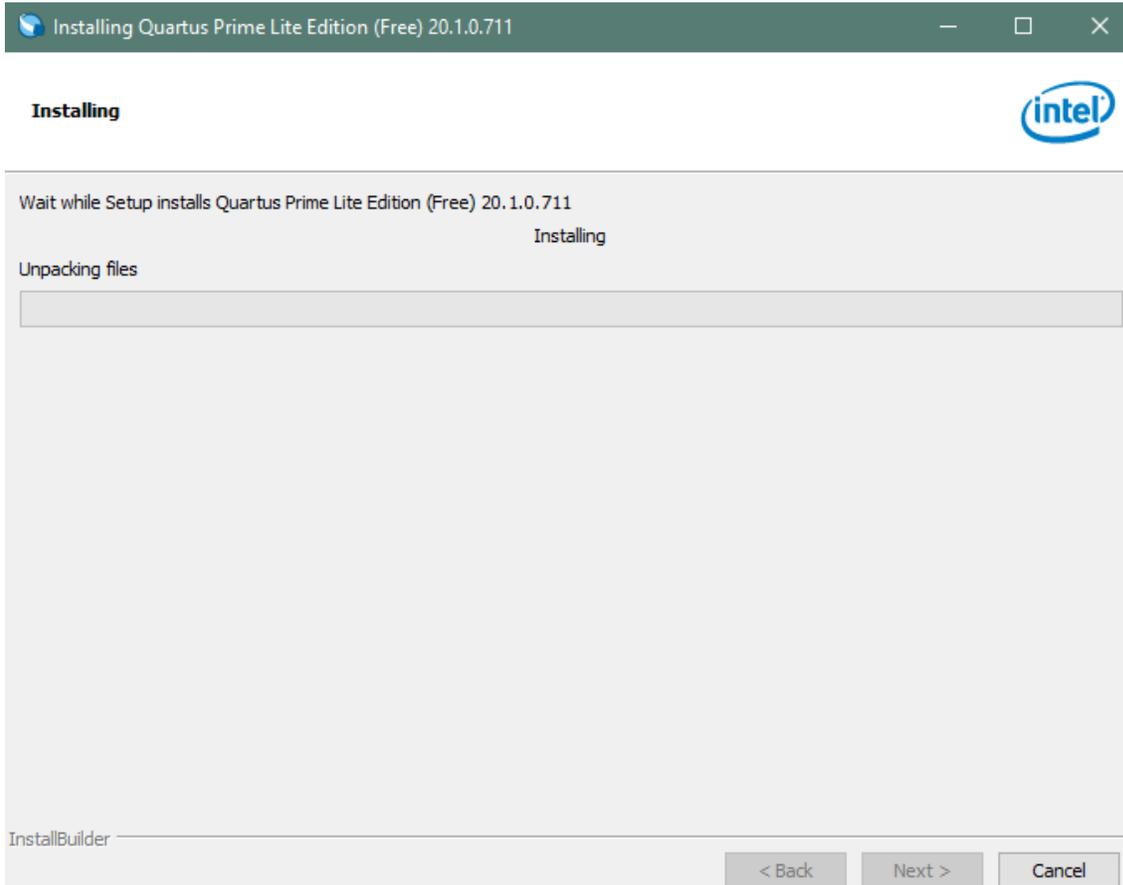
Click “Next” to accept the defaults

## FPGA Development System User Manual



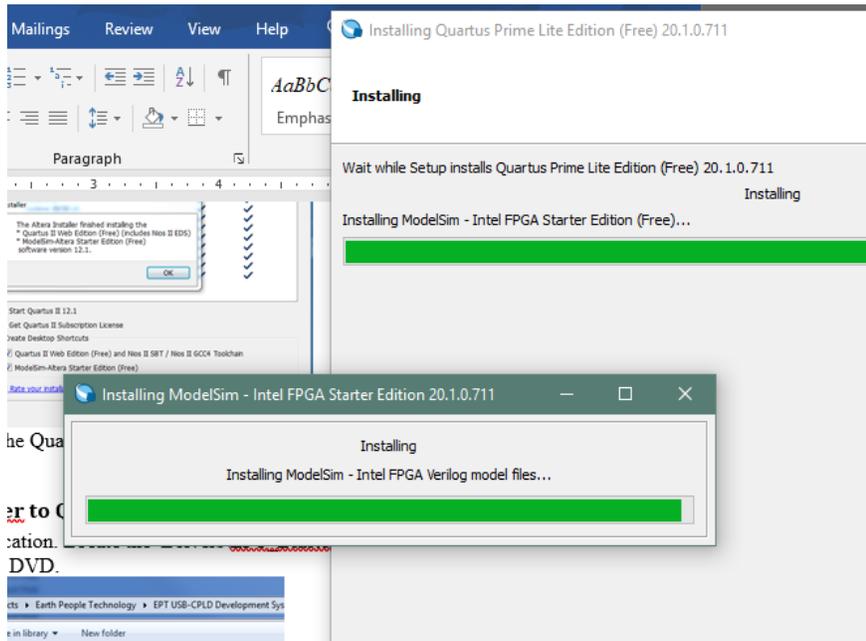
Click “Next” to accept the defaults

## FPGA Development System User Manual

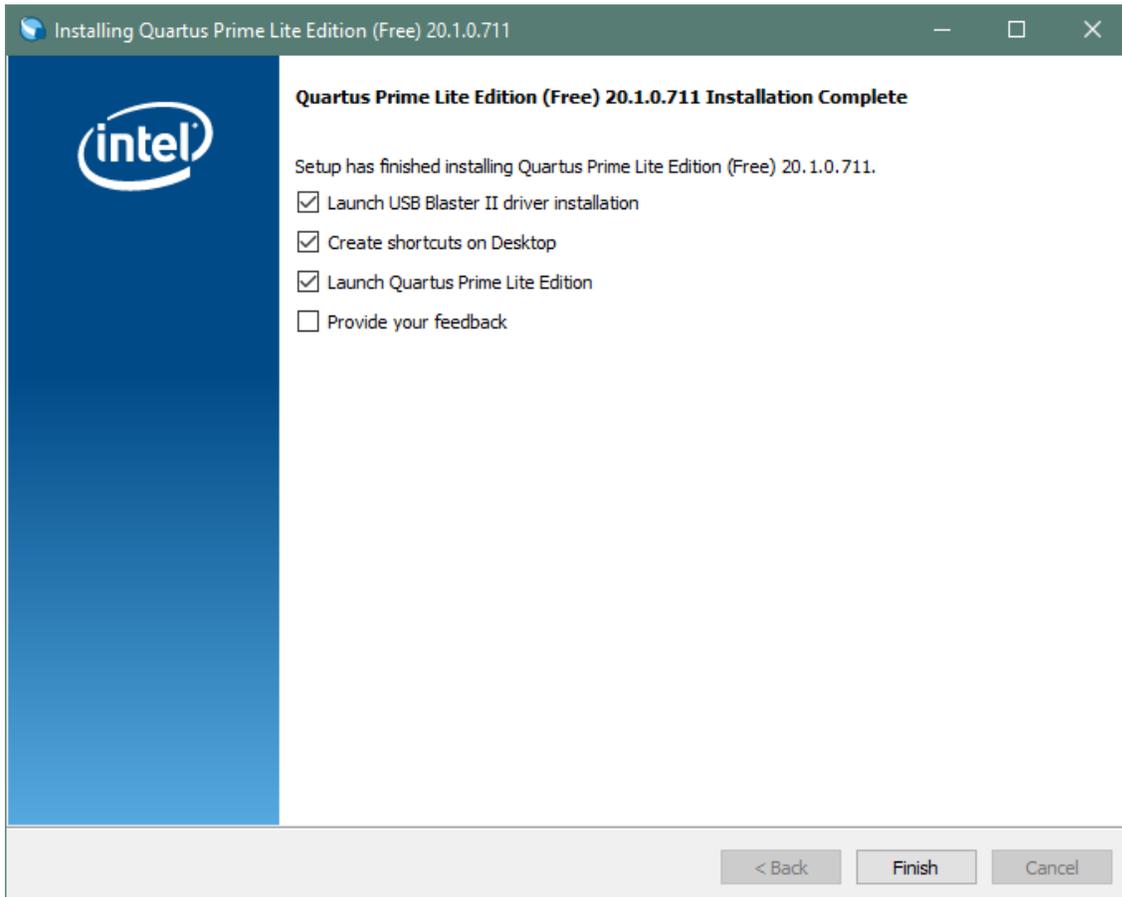


Wait for the installation to complete.

## FPGA Development System User Manual

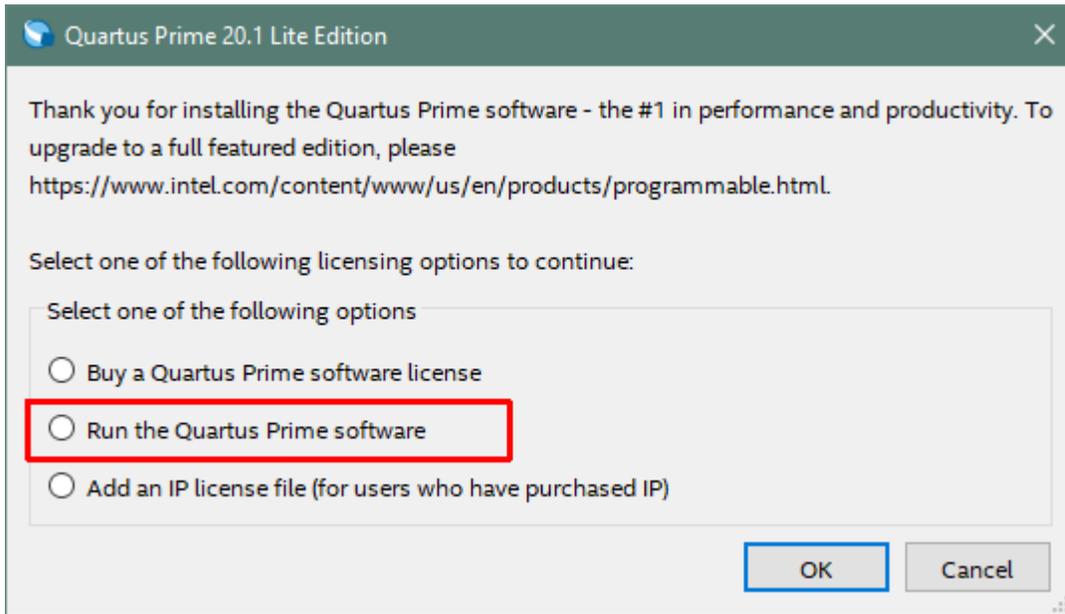


## FPGA Development System User Manual



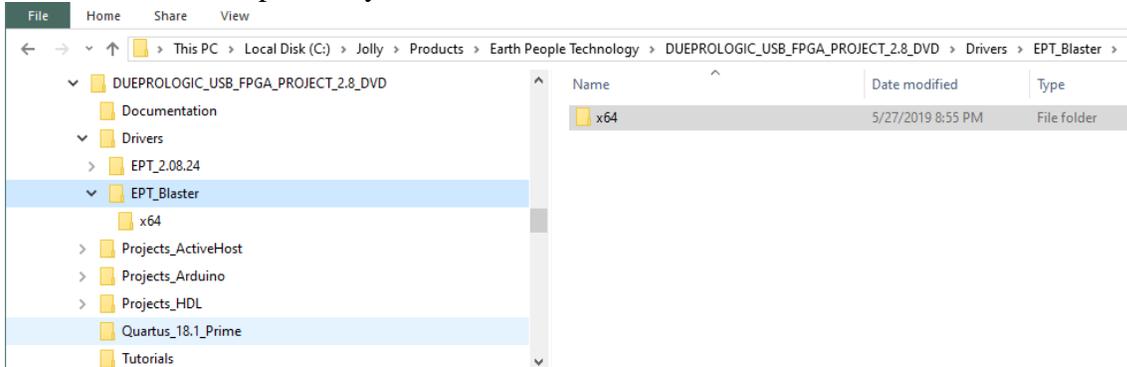
Click "Ok", then click "Finish". The Quartus Prime is now installed and ready to be used.

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### 2.2.4 Adding the EPT\_Blaster to Quartus Prime

Close out the Quartus Prime application. Locate the \Drivers\EPT\_Blaster folder on the EPT FPGA Development System DVD.

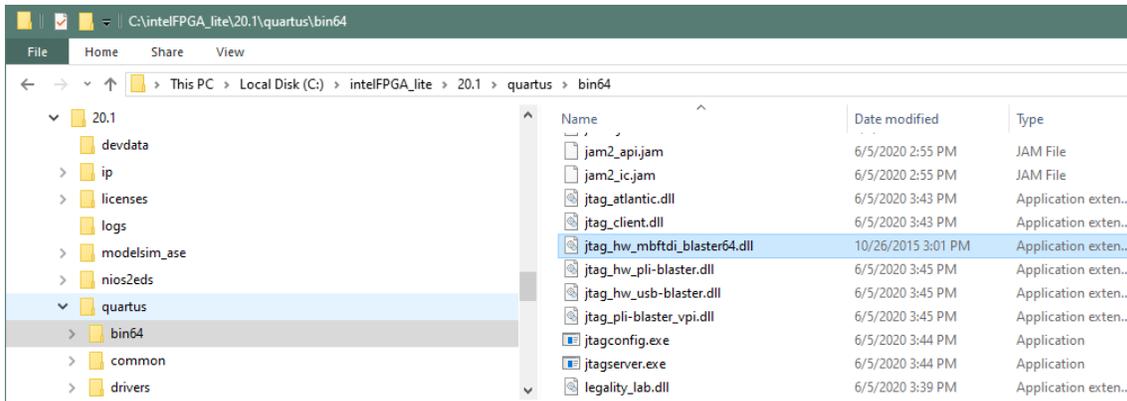


Follow these directions:

1. Open the C:\EPT FPGA Development System DVD\Drivers\EPT\_Blaster\x64 folder.
2. Select the file “jtag\_hw\_mbfldi\_blaster.dll” and copy it.
3. Browse over to C:\intelFPGA\_lite\xx.x\quartus\bin64.
4. Right click in the folder and select Paste

## FPGA Development System User Manual

5. Click Ok.
6. Open the Quartus Prime application.



The DLL is installed and the JTAG server should recognize it. Go to the section “Programming the FPGA” of this manual for testing of the programming. If the driver is not found in the Programmer Tool->Hardware Setup box, see the JTAG DLL Insert to Quartus Prime Troubleshooting Guide.

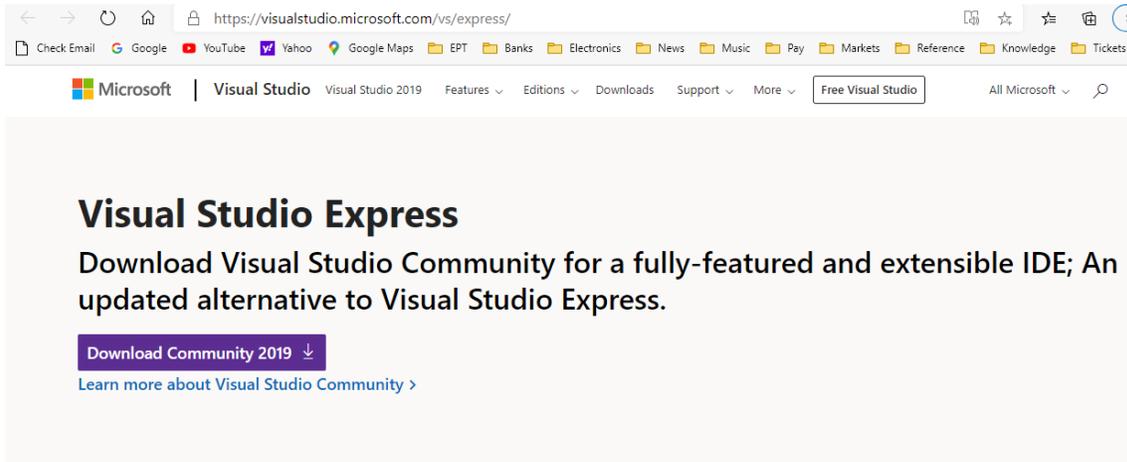
### ***2.3 Active Host Application DLL***

Download the latest version of Microsoft Visual C# Express environment from Microsoft. It’s a free download.

<https://visualstudio.microsoft.com/vs/express/>

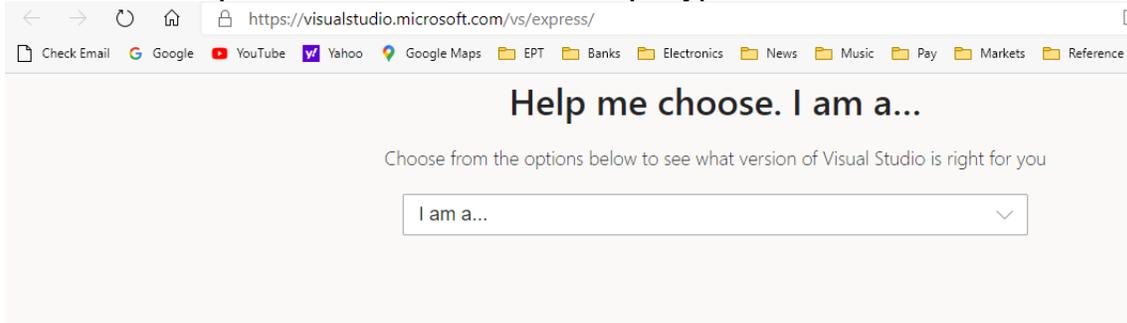
Go to the website and click on the “+” icon next to the Visual C# Express.

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A screenshot of a web browser showing the Visual Studio Express download page. The address bar shows the URL <https://visualstudio.microsoft.com/vs/express/>. The page features the Microsoft logo and navigation links for Visual Studio, Visual Studio 2019, Features, Editions, Downloads, Support, and More. A prominent heading reads "Visual Studio Express" followed by the text "Download Visual Studio Community for a fully-featured and extensible IDE; An updated alternative to Visual Studio Express." Below this is a purple button labeled "Download Community 2019" and a link "Learn more about Visual Studio Community".

Click on the “Express 20xx for Windows Desktop” hypertext.



A screenshot of the Visual Studio selection page. The address bar shows the URL <https://visualstudio.microsoft.com/vs/express/>. The page has a heading "Help me choose. I am a..." and a sub-heading "Choose from the options below to see what version of Visual Studio is right for you". Below this is a dropdown menu with the text "I am a..." and a downward arrow.

### Still want Visual Studio Express?

[Express 2017 for Windows Desktop](#)

Supports building managed and native desktop applications.\*

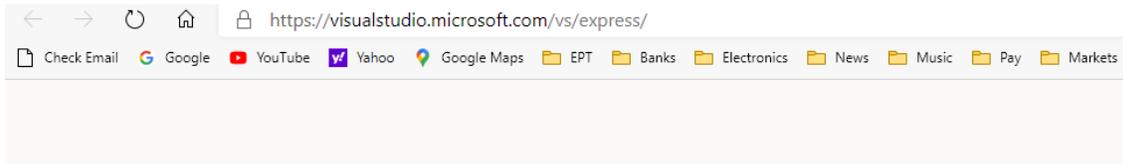
[Express 2015 for Windows Desktop](#)

Supports the creation of desktop applications for Windows.

The download manager file will download the “WDEpress.exe” file.



## FPGA Development System User Manual



### Still want Visual Studio Express?

#### [Express 2017 for Windows Desktop](#)

Supports building managed and native desktop applications.\*

#### [Express 2015 for Windows Desktop](#)

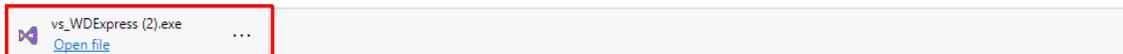
Supports the creation of desktop applications for Windows.

#### [Express 2015 for Web](#)

Create standards-based, responsive websites, web APIs, or real-time online experiences using ASP.NET.

#### [Express 2015 for Windows 10](#)

Provides the core tools for building compelling, innovative apps for Universal Windows Platform. Windows is required.



Right click on the WDEpress.exe.

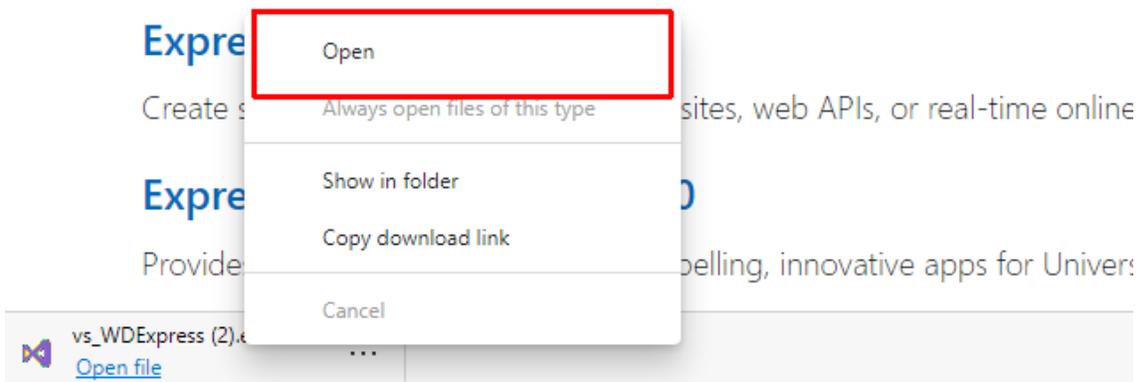
## Still want Visual Studio Express?

### [Express 2017 for Windows Desktop](#)

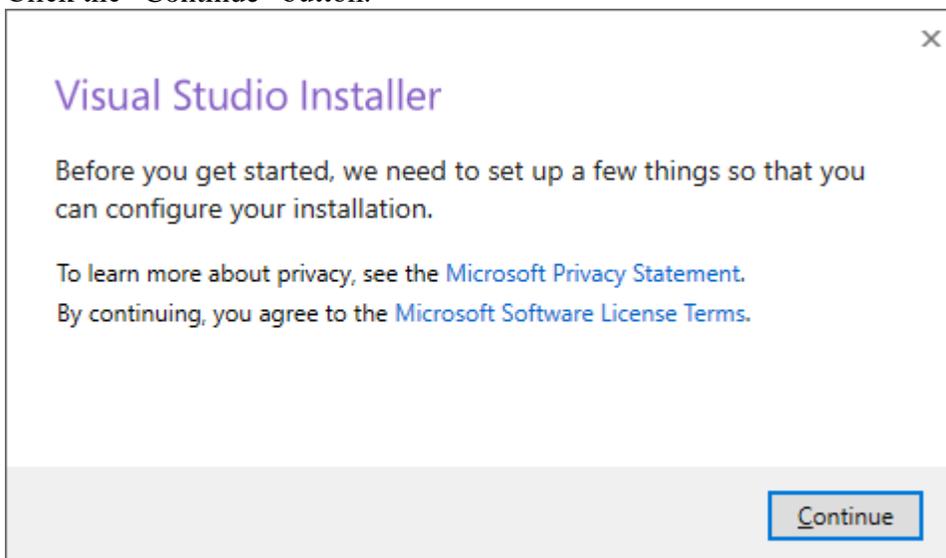
Supports building managed and native desktop applications.\*

### [Express 2015 for Windows Desktop](#)

Supports the creation of desktop applications for Windows.



Click the “Continue” button.

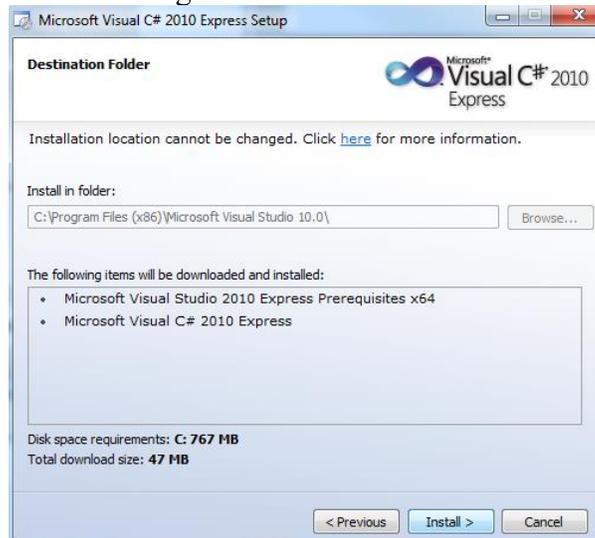


Next, follow the on screen windows and accept the default answers.

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Click “Next”, accept the license agreement. Click “Next”.



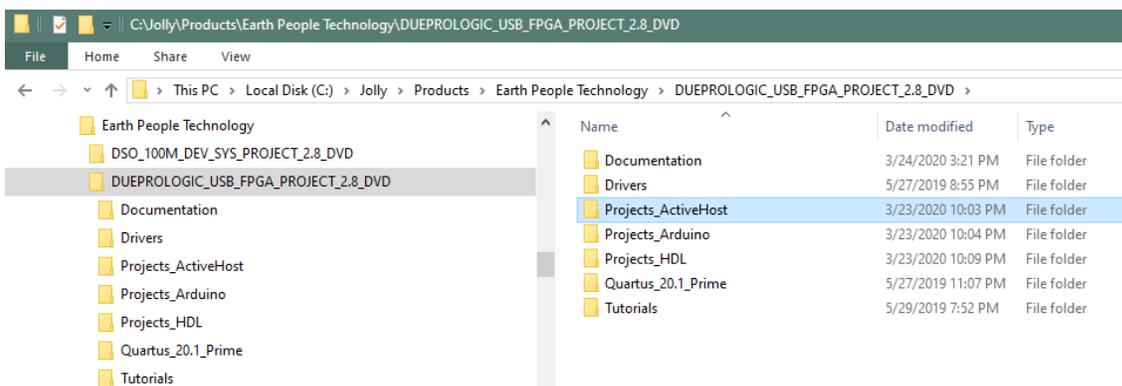
Visual C# 2010 Express will install. This may take up to twenty minutes depending on your internet connection.

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The installed successfully window will be displayed when Visual C# Express is ready to use.

The Active Host Application Software will allow the user to create a custom applications on the PC using the EndTerms to perform Triggers and Data Transfer to/from the DueProLogic. The methods and parameters of the Active Host library are explained in the Active Host Application section. Locate the \Projects\_ActiveHost folders on the EPT FPGA Development System DVD.

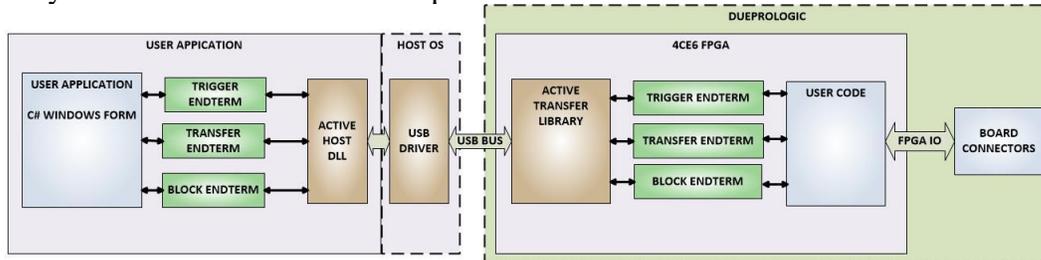


### 3 FPGA Active Transfer Library

The Active Transfer Library is an HDL library designed to transfer data to and from the DueProLogic via High Speed (480 MB/s) USB. It is a set of pre-compiled HDL files

## FPGA Development System User Manual

that the user will add to their project before building it. The description of what the library does and how to use its components are described in this manual.



### 3.1 EPT Active Transfer System Overview

The Active Transfer System components consist of the following:

- active\_transfer\_library.v
- ft\_245\_state\_machine.v
- endpoint\_registers.vqm
- active\_trigger.vqm
- active\_transfer.vqm
- active\_block.vqm

The Active\_Transfer\_Library provides the communication to the USB hardware. While separate Input and Output buses provide bi-directional communications with the plug in modules. See Figure 6 for an overview of the EPT Active\_Transfer system.

Figure 6 EPT Active Transfer Library Overview

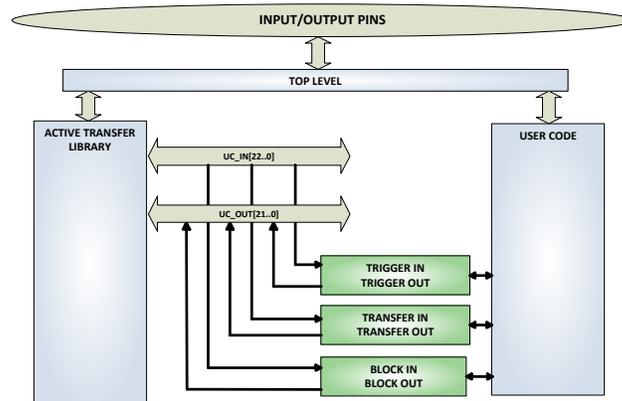


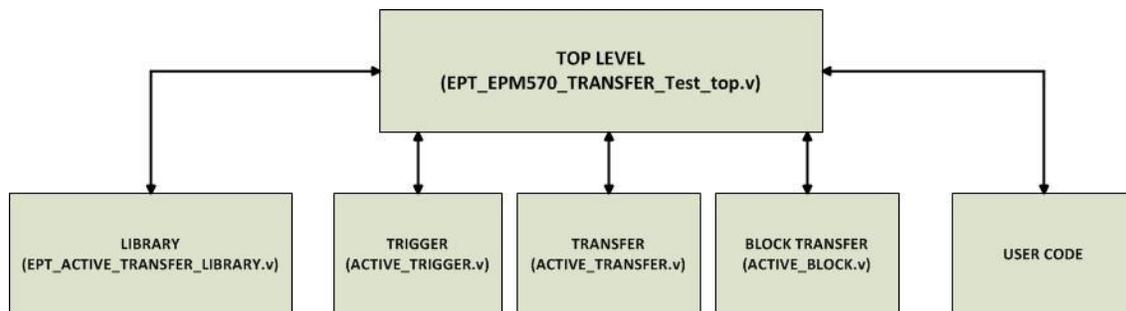
Figure 6 shows how the modules of the EPT Active Transfer Library attach to the overall user project. The EPT Active\_Transfer\_Library.vqm, Active\_Trigger.vqm, Active\_Transfer.vqm and Active\_Block.vqm modules are instantiated in the top level

## FPGA Development System User Manual

of the user project. The User\_Code module is also instantiated in the top level. The Active\_Transfer modules communicate with the User\_Code through module parameters. Each module is a bi-directional component that facilitates data transfer from PC to FPGA. The user code can send a transfer to the Host, and the Host can send a transfer to the user code. This provides significant control for both data transfers and signaling from the user code to PC. The Triggers are used to send momentary signals that can turn on (or off) functions in user code or PC. The Active Transfer is used to send a single byte. And the Active Block is used to send a block of data. The Active\_Transfer and Active\_Block modules have addressing built into them. This means the user can declare up to 8 individual instantiations of Active\_Transfer or Active\_Block, and send/receive data to each module separately.

### 3.2 Active Transfer Library

The Active Transfer Library contains the command, control, and data transfer mechanism that allows users to quickly build powerful communication schemes in the FPGA. Coupled with the Active Host application on the PC, this tools allows users to focus on creating programmable logic applications and not have to become distracted by USB Host drivers and timing issues. The Active Transfer Library is pre-compiled file that the user will include in the project files.





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```
#####  
//#  
//# Copyright   Earth People Technology Inc. 2021  
//#  
//#  
//# File Name:   EPT_4CE6_AF_D1_Top.v  
//# Author:     Earth People Technology  
//# Date:       March 14, 2021  
//# Revision:   A  
//#  
//# Development: EPT Platform Demonstration Project  
//# Application: Altera Cyclone IV FPGA  
//# Description: This file contains verilog code which will allow access  
//#               to Active Transfer Library.  
//#  
//#  
//#  
//#*****  
//#  
//# Revision History:  
//#   DATE       VERSION   DETAILS  
//#   3/14/21    1         Created  
//#  
//#  
//#  
#####
```



## FPGA Development System User Manual

```

//*****
//* Module Declaration
//*****

module EPT_4CE6_AF_D1_Top (

    input wire          CLK_66MHZ,
    input wire          RST,

    //UART COMMAND BUS
    output wire         UART_OUT, //To external
    input wire         UART_IN, //From external

    output wire [7:0]   XIO_1,    //XIO -- UB
    input wire  [5:0]   XIO_2,    //XIO -- UB
    output wire [5:0]   XIO_3,    //XIO -- UB
    input wire  [5:0]   XIO_4,    //XIO -- UB
    output wire [5:0]   XIO_5,    //XIO -- UB
    output wire [31:0]  XIO_6,    //XIO -- UB
    output wire [3:0]   XIO_7,    //XIO -- UB

    input wire         PB_SWITCH_1,
    input wire         PB_SWITCH_2

);
```

The interface from the library to the user code is two uni directional buses, UC\_IN[22:0] and UC\_OUT[20:0]. The UC\_IN[22:0] bus is an output bus (from the library, input bus to the Active Modules) that is used channel data, address, length and control information to the Active Modules. The UC\_OUT[21:0] bus is an input bus (to the library, output bus from the Active Modules) that is used to communicate data, address, length, and control information to the Active Modules.



## FPGA Development System User Manual

```
//-----  
// Instantiate the EPT Library  
//-----  
  
active_serial_library    ACTIVE_SERIAL_LIBRARY_INST  
(  
    .aa                (aa) ,  
    .UART_OUT          (UART_OUT) ,  
    .UART_IN           (uart_txd) ,  
  
    .UC_IN              (UC_IN) ,  
    .UC_OUT             (UC_OUT) ,  
  
    .STATE_OUT         (active_serial_state_out) ,  
    .TEST_OUT          (active_transfer_test_out)  
  
);
```

The UART signals are used to channel data, and control signals to the USB interface chip. These signals are connected directly to input and output pins of the FPGA.

### 3.2.1 Active Trigger EndTerm

The Active Trigger has eight individual self resetting, active high, signals. These signals are used to send a momentary turn on/off command to Host/User code. The Active Trigger is not addressable so the module will be instantiated only once in the top level.



## FPGA Development System User Manual

```
743 wire [22*3-1:0] uc_out_m;
744 eptWireOR # (.N(3)) wireOR (UC_OUT, uc_out_m);
745     active_trigger          ACTIVE_TRIGGER_INST
746 (
747     .uc_clk                 (CLK_66),
748     .uc_reset               (RST),
749     .uc_in                  (UC_IN),
750     .uc_out                 (uc_out_m[ 0*22 +: 22 ]),
751
752     .trigger_to_host        (trigger_to_host),
753     .trigger_to_device      (trigger_in_byte)
754
755 );
756
```

To send a trigger, decide which bit (or multiple bits) of the eight bits you want to send the trigger on. Then, set that bit (or bits) high. The Active Transfer Library will send a high on that trigger bit for one clock cycle (66 MHz), then reset itself to zero. The bit can stay high on the user code and does not need to be reset to zero. However, if the user sends another trigger using the trigger byte, then any bit that is set high will cause a trigger to occur on the Host side.

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```

277 //-----
278 // Detect Trigger Out to Host
279 //-----
280 always @(TRIGGER_OUT or trigger_in_reset or reset)
281 begin
282     if(!reset)
283         trigger_to_host = 8'h0;
284     else if (trigger_in_reset)
285         trigger_to_host = 8'h0;
286     else if (TRIGGER_OUT > 8'h0)
287         trigger_to_host = TRIGGER_OUT;
288 end
289
290 //-----
291 // Reset Trigger Out to Host
292 //-----
293 always @(posedge CLK_66 or negedge reset)
294 begin
295     if(!reset)
296     begin
297         trigger_in_reset <= 0;
298     end
299     else
300     begin
301         if (trigger_to_host > 0)
302             trigger_in_reset <= 1'b1;
303         else
304             trigger_in_reset <= 0;
305     end
306 end

```

So, care should be used if the user code uses byte masks to send triggers. It is best to set only the trigger bits needed for a given time when sending triggers.

The user code must be setup to receive triggers from the Host. This can be done by using an asynchronous always block. Whenever a change occurs on a particular trigger bit (or bits), a conditional branch can detect if the trigger bit is for that block of code. Then, execute some code based on that trigger.



## FPGA Development System User Manual

```
308 | //-----  
309 | // Detect Trigger In  
310 | //-----  
311 | always @(trigger_in_byte or trigger_in_reset or reset)  
312 | begin  
313 |     if(!reset)  
314 |     begin  
315 |         trigger_in_detect = 1'b0;  
316 |     end  
317 |     else if (trigger_in_reset)  
318 |     begin  
319 |         trigger_in_detect = 1'b0;  
320 |     end  
321 |     else if (trigger_in_byte > 8'h0)  
322 |     begin  
323 |         trigger_in_detect = 1'b1;  
324 |     end  
325 | end  
326 |  
327 | //-----  
328 | // Store the value of Trigger In  
329 | //-----  
330 | always @(posedge CLK_66 or negedge reset)  
331 | begin  
332 |     if(!reset)  
333 |     begin  
334 |         trigger_in_store <= 8'h0f;  
335 |         trigger_in_reg <= 1'b0;  
336 |         trigger_in_reset <= 1'b0;  
337 |     end  
338 |     else if (trigger_in_detect & !trigger_in_reg)  
339 |     begin  
340 |         if(trigger_in_byte != 0)  
341 |             trigger_in_store[7:0] <= trigger_in_byte[7:0];  
342 |             trigger_in_reg <= 1'b1;  
343 |     end  
344 |     else if (trigger_in_reg)  
345 |     begin  
346 |         trigger_in_reg <= 1'b0;  
347 |         trigger_in_reset <= 1'b1;  
348 |     end  
349 |     else if (!trigger_in_detect)  
350 |     begin  
351 |         trigger_in_reg <= 1'b0;  
352 |         trigger_in_reset <= 1'b0;  
353 |     end
```

### 3.2.2 Active Transfer EndTerm

The Active Transfer module is used to send or receive a byte to/from the Host. This is useful when the user's microcontroller needs to send a byte from a measurement to the Host for display or processing. The Active Transfer module is addressable, so up to eight individual modules can be instantiated and separately addressed.

```

757 active_transfer          ACTIVE_TRANSFER_INST
758 (
759     .uc_clk                (CLK_66),
760     .uc_reset              (reset),
761     .uc_in                 (UC_IN),
762     .uc_out                (uc_out_m[ 1*22 +: 22 ]),
763
764     .start_transfer        (transfer_out_reg),
765     .transfer_received     (transfer_in_received),
766
767     .uc_addr               (3'h2),
768
769     .transfer_to_host      (transfer_out_byte),
770     .transfer_to_device    (transfer_in_byte)
771 );
772
  
```

To send a byte to the Host, select the appropriate address that corresponds to an address on Host side. Place the byte in the “transfer\_to\_host” parameter, then strobe the “start\_transfer” bit. Setting the “start\_transfer” bit to high will send one byte from the “transfer\_to\_host” byte to the Host on the next clock high signal (66 MHz). The “start\_transfer” bit can stay high for the duration of the operation of the device, the Active Transfer module will not send another byte. In order to send another byte, the user must cycle the “start\_transfer” bit to low for a minimum of one clock cycle (66 MHz). After the “start\_transfer” bit has been cycled low, the rising edge of the bit will cause the byte on the “transfer\_to\_host” parameter to transfer to the host.

## FPGA Development System User Manual

```

181 //-----
182 // Transfer byte to Device
183 //-----
184 always @(TRANSFER_OUT_EN or reset)
185 begin
186     if(!reset)
187     begin
188         transfer_out_detect = 1'b0;
189     end
190     else
191     begin
192         if(transfer_to_device_reset)
193             transfer_out_detect = 1'b0;
194         else if(TRANSFER_OUT_EN)
195         begin
196             transfer_out_byte = TRANSFER_OUT_BYTE;
197             transfer_out_detect = 1'b1;
198         end
199     end
200 end
201
202 //-----
203 // Reset transfer_to_device_reset
204 //-----
205 always @(posedge CLK_66 or negedge reset)
206 begin
207     if (!reset)
208     begin
209         transfer_to_device_reset <= 1'b0;
210     end
211     else
212     begin
213         if(transfer_out_detect)
214             transfer_to_device_reset <= 1'b1;
215         else
216             transfer_to_device_reset <= 1'b0;
217     end
218 end

```

## FPGA Development System User Manual

To receive a byte, the Active Host will send a byte using it's dll. The user code must monitor the transfer\_received port. The transfer\_received port will assert high for one clock cycle (66 MHz) when a byte is ready for reading on the transfer\_to\_device port. User code should use an asynchronous always block to detect when the transfer\_received port is asserted. Upon assertion, the user code should read the byte from the transfer\_to\_device port into a local register.

```

220 //-----
221 // Transfer to Host
222 //-----
223 always @(posedge CLK_66 or negedge reset)
224 begin
225     if (!reset)
226     begin
227         transfer_out <= 1'b0;
228         transfer_out_reg <= 1'b0;
229         transfer_out_byte <= 8'h0;
230     end
231     else
232     begin
233         if(start_transfer_byte & !transfer_out)
234         begin
235             transfer_out_byte <= TRANSFER_HOST_BYTE;
236             transfer_out_reg <= 1'b1;
237             transfer_out <= 1'b1;
238         end
239         else if(start_transfer_byte & transfer_out)
240         begin
241             transfer_out_reg <= 1'b0;
242             transfer_out <= 1'b1;
243         end
244         else if(!start_transfer_byte & transfer_out)
245         begin
246             transfer_out_reg <= 1'b0;
247             transfer_out <= 1'b0;
248         end
249     end
250 end

```

### 3.2.3 Active Block EndTerm

The Active Block module is designed to transfer blocks of data between Host and User Code and vice versa. This allows buffers of data to be transferred with a minimal amount of code. The Active Block module is addressable, so up to eight individual

## FPGA Development System User Manual

modules can be instantiated and separately addressed. The length of the block to be transferred must also be specified in the uc\_length port.

```

811     active_block          BLOCK_TRANSFER_INST
812     (
813         .uc_clk           (CLK_66),
814         .uc_reset        (RST),
815         .uc_in            (UC_IN),
816         .uc_out           (uc_out_m[ 2*22 +: 22 ]),
817
818         .start_transfer  (block_out_reg),
819         .transfer_received (block_in_rcv),
820
821         .transfer_ready  (block_byte_ready),
822
823         .uc_addr          (3'h4),
824         .uc_length        (BLOCK_COUNT_8),
825
826         .transfer_to_host (block_out_byte),
827         .transfer_to_device (block_in_data),
828
829         .STATE_OUT        (block_state_out),
830         .TEST_BUS         (block_out_test_bus)
831     );
832
833

```

To send a block, it's best to have buffer filled in a previous transaction, Then assert the start\_transfer bit. This method is opposed to collecting and processing data bytes after the start\_transfer bit has been asserted and data is being sent to the Host.

Once the buffer to send is filled with the requisite amount of data, the address and buffer length should be written to the uc\_addr and uc\_length ports. Set the start\_transfer bit high, the user code should monitor the transfer\_ready port. At the rising edge of the transfer\_ready port, the byte at transfer\_to\_host port is transferred to the USB chip. Once this occurs, the user code should copy the next byte in the buffer to transfer\_to\_host port. On the next rising edge of transfer-ready, the byte at transfer\_to\_host will be transferred to the USB chip. This process continues until the number of bytes described by the uc\_length have been transferred into the USB chip.



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```
542 //-----  
543 // Registers to start Block Transfer Out  
544 //-----  
545 always @(posedge CLK_66 or negedge RST)  
546 begin  
547     if(!RST)  
548     begin  
549         block_out_reg <= 1'b0;  
550         start_block_transfer_reg <= 1'b0;  
551     end  
552     else  
553     begin  
554         if(start_block_transfer & !start_block_transfer_reg)  
555             start_block_transfer_reg <= 1'b1;  
556         else if(start_block_transfer_reg & !block_out_reg)  
557         begin  
558             block_out_reg <= 1'b1;  
559         end  
560         else if(block_out_counter >= BLOCK_COUNT_8)  
561         begin  
562             block_out_reg <= 1'b0;  
563             start_block_transfer_reg <= 1'b0;  
564         end  
565     end  
566 end  
567  
568 //-----  
569 // Data for Block Transfer Out  
570 //-----  
571 always @(posedge CLK_66 or negedge RST)  
572 begin  
573     if(!RST)  
574     begin  
575         block_out_counter <= 0;  
576     end  
577     else  
578     begin  
579         if(block_byte_ready)  
580         begin  
581             block_out_counter <= block_out_counter + 1'd1;  
582         end  
583         else if(block_out_counter >= BLOCK_COUNT_8 )  
584         begin  
585             block_out_counter <= 0;  
586         end  
587     end  
588 end
```

To receive a buffer from the Host, the user code should monitor the `transfer_received` port for assertion. When the bit is asserted, the next rising edge of `transfer_ready` will indicate that the byte at `transfer_to_device` is ready for the user code to read.

[Add code snippet showing Active Block Module bytes received by the user code]

### 3.3 Timing Diagram for Active Transfer EndTerms

The Active Transfer Library uses the 66 MHz clock to organize the transfers to Host and transfer to Device. The timing of the transfers depends on this clock and the specifications of the USB chip. Users should use the timing diagrams to ensure proper operation of user code in data transfer.

#### 3.3.1 Active Trigger EndTerm Timing

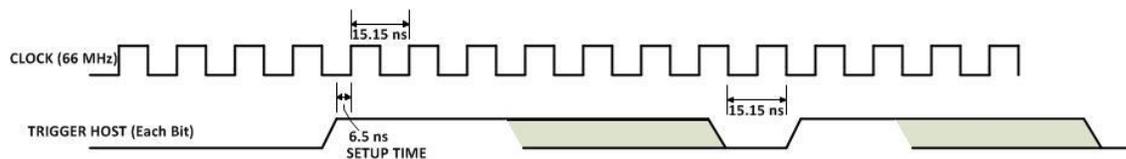


Figure xx Active Trigger to Host Timing

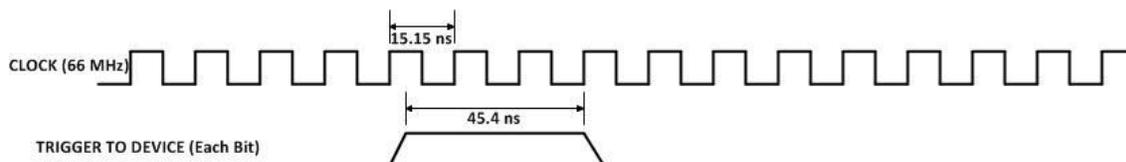


Figure xx Active Trigger to Device Timing

#### 3.3.2 Active Transfer EndTerm Timing

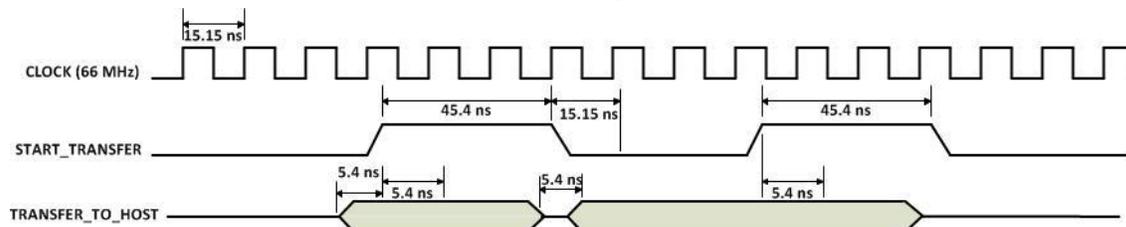


Figure xx Active Transfer To Host Timing

## FPGA Development System User Manual

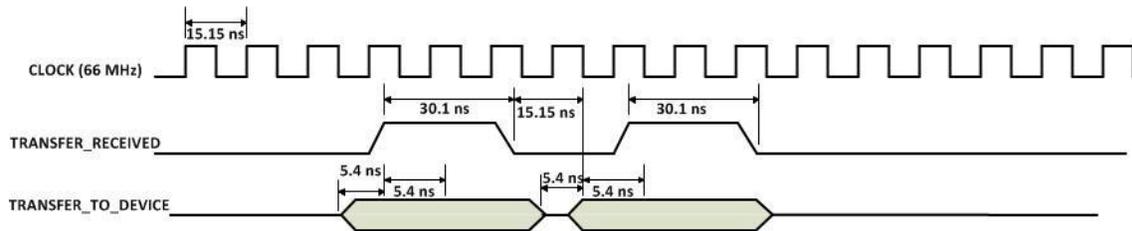


Figure xx Active Transfer To Device Timing

### 3.3.3 Active Block EndTerm Timing

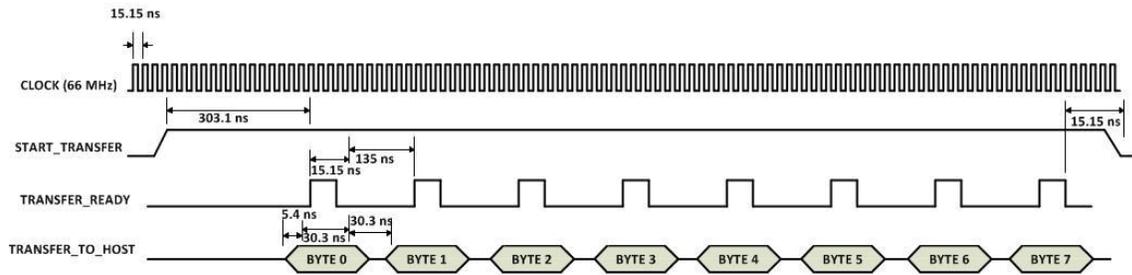


Figure xx Active Block To Host Timing

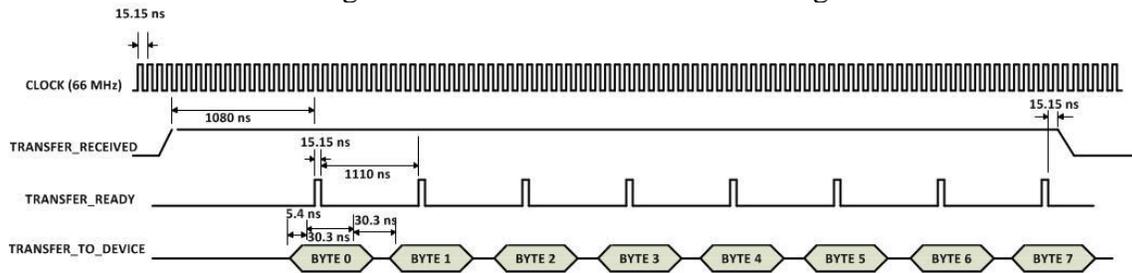
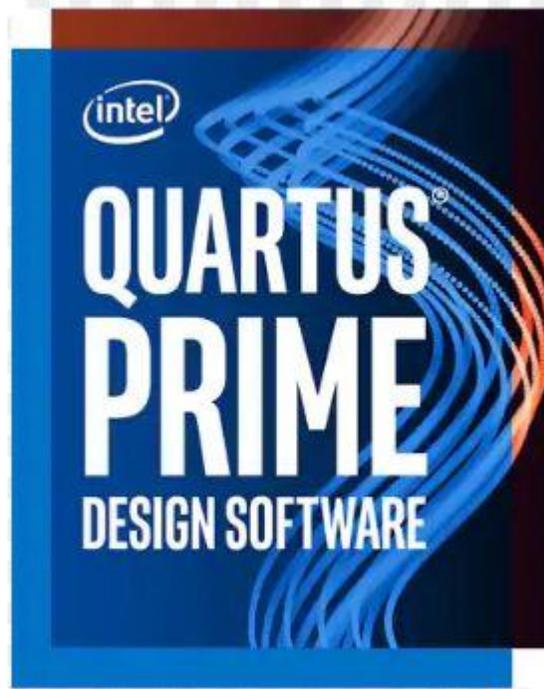


Figure xx Active Block To Device Timing

## 4 Compiling, Synthesizing, and Programming FPGA

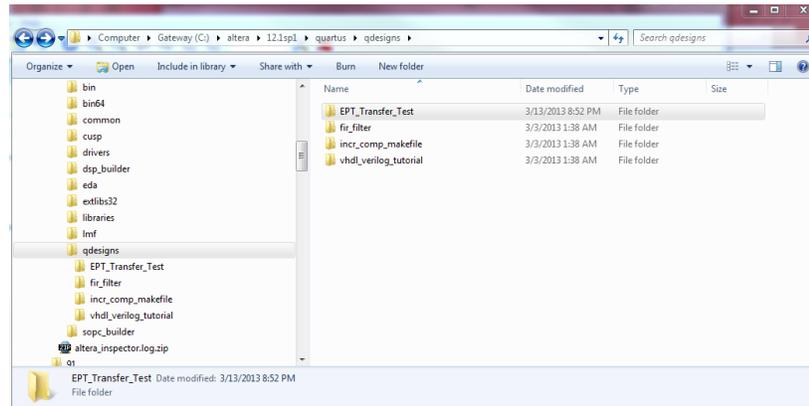


The FPGA on the EPT-4CE6-AF-D2 can be programmed with the Active Transfer Library and custom HDL code created by the user. Programming the FPGA requires the use of the Quartus Prime software and a standard USB cable. There are no extra parts to buy, just plug in the USB cable. Once the user HDL code is written according to the syntax rules of the language (Verilog and VHDL) it can be compiled and synthesized using the Quartus Prime software. This manual will not focus on HDL coding or proper coding techniques, instead it will use the example code to compile, synthesize and program the FPGA.

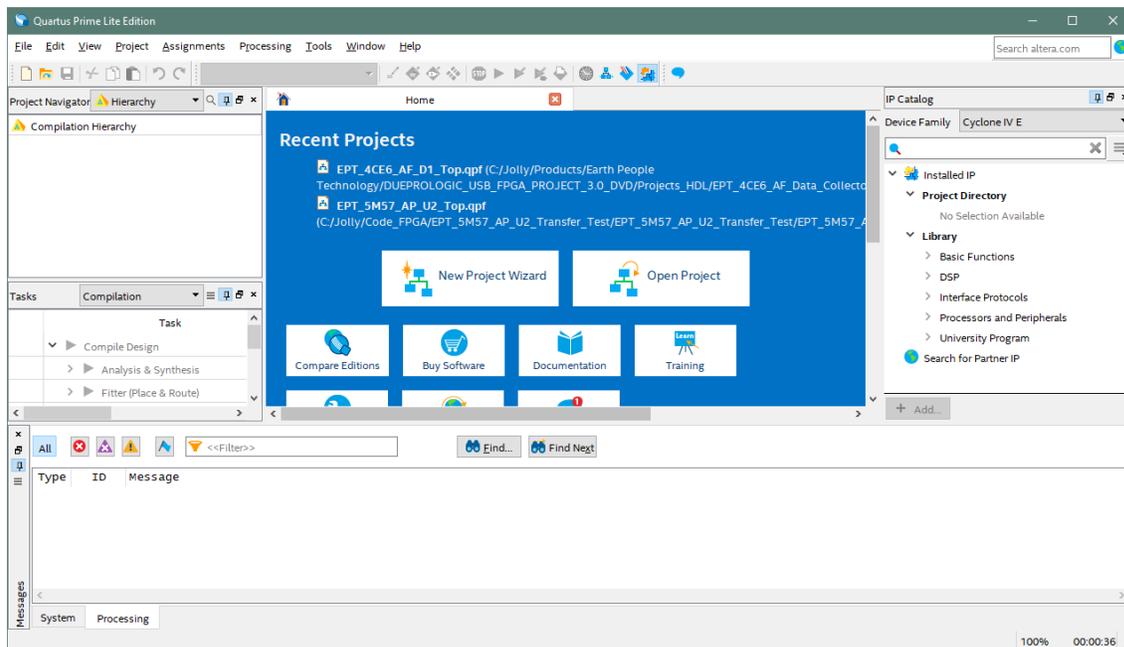
### ***4.1 Setting up the Project and Compiling***

Once the HDL code (Verilog or VHDL) is written and verified using a simulator, a project can be created using Quartus Prime. Writing the HDL code and simulating it will be covered in later sections. Bring up Quartus Prime, then use Windows Explorer to browse to C:\intel\FPGA\_lite\xxx.x\quartus\qdesignscreate a new directory called: “EPT\_4CE6\_AF\_Platform\_Demo”.

## FPGA Development System User Manual

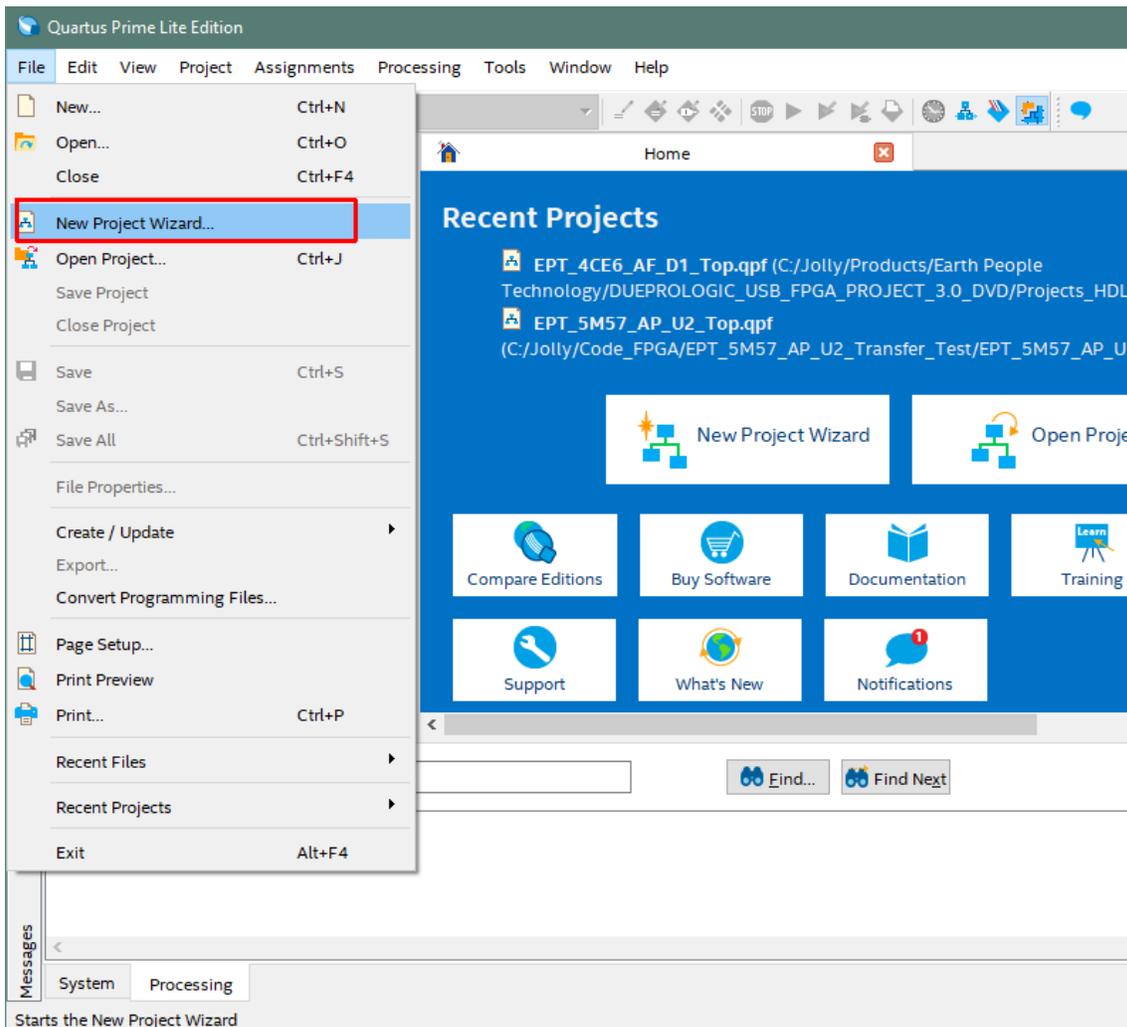


Open Quartus Prime by clicking on the icon .



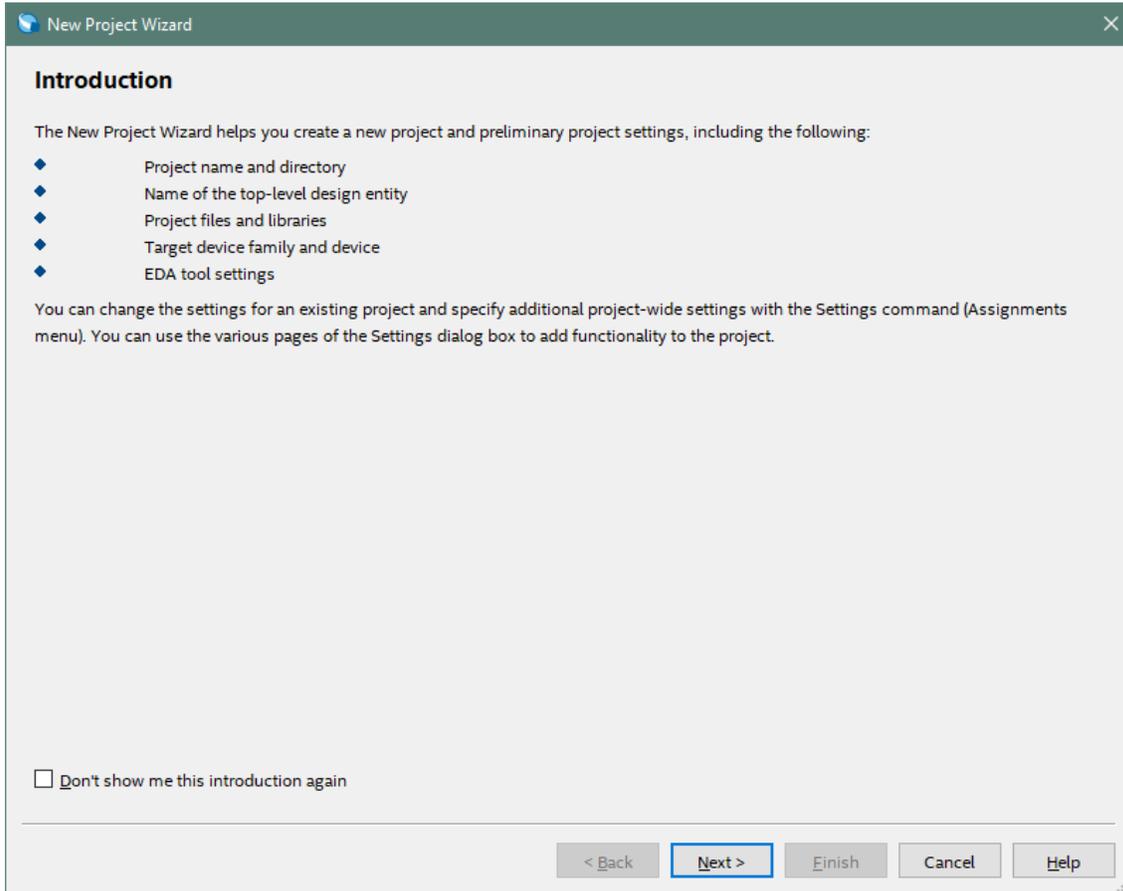
Under Quartus, Select File->New Project Wizard. The Wizard will walk you through setting up files and directories for your project.

## FPGA Development System User Manual

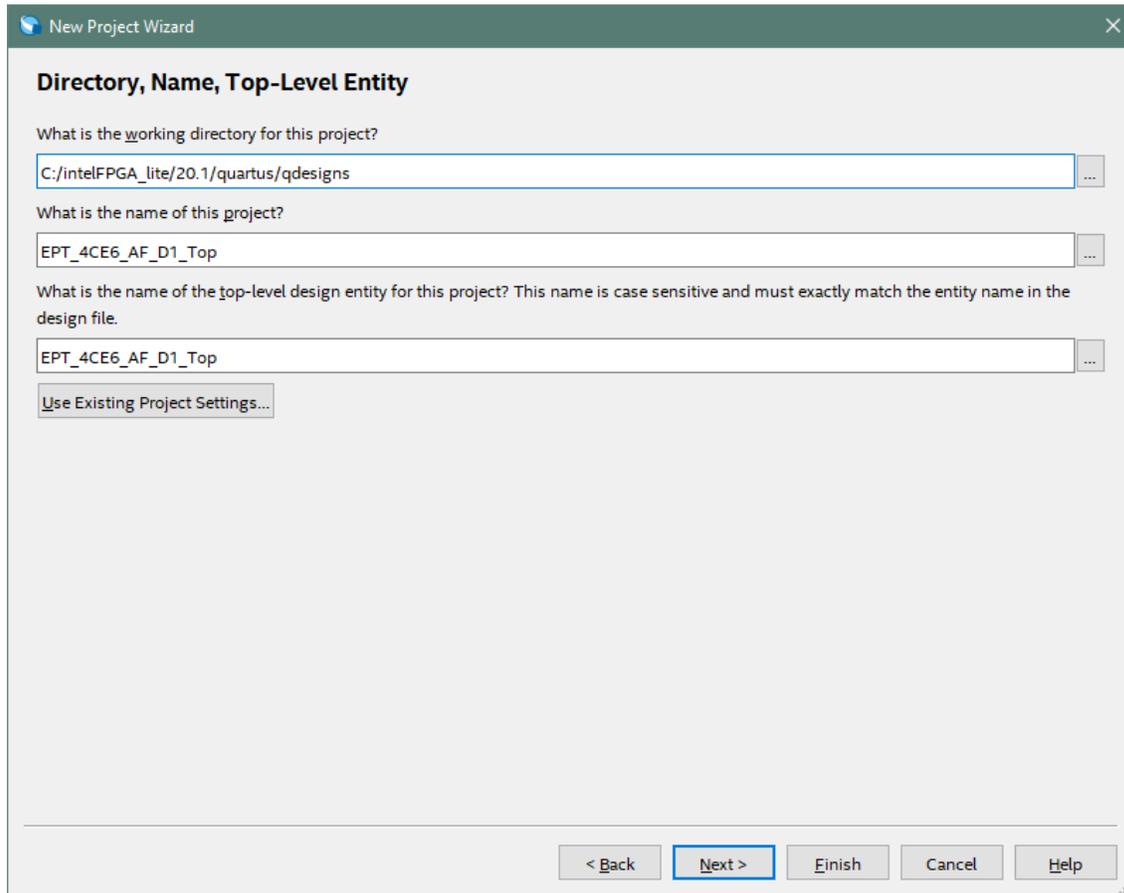


At the Top-Level Entity page, browse to the `c:/intelFPGA_Lite/xxx.x/quartus/qdesigns` directory to store your project. Type in a name for your project “EPT\_4CE6\_AF\_D1\_Top”.

## FPGA Development System User Manual



## FPGA Development System User Manual

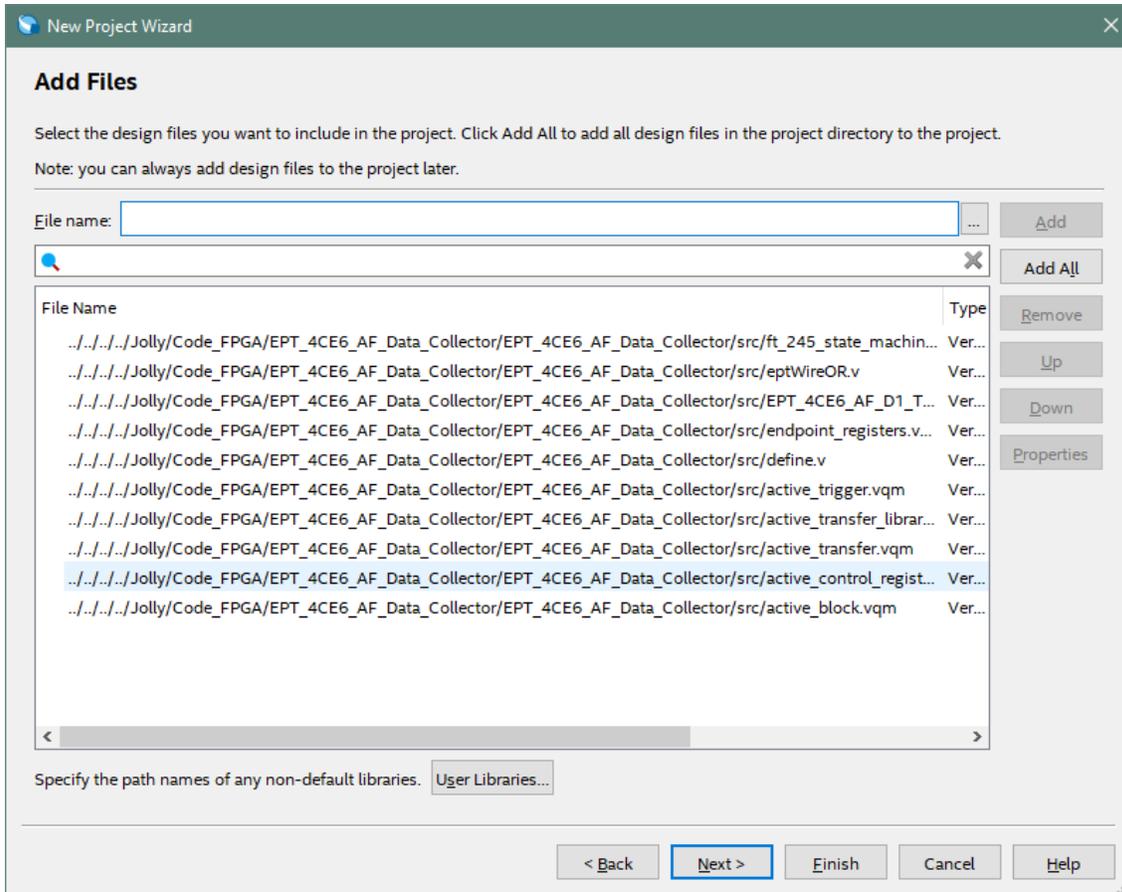


Select Next. At the Add Files window: Browse to the \\Projects\_HDL\EPT\_Transfer\_Demo \src folder of the EPT FPGA Development System DVD. Copy the files from the \src directory.

- Active\_block.vqm
- Active\_transfer.vqm
- Active\_trigger.vqm
- Active\_transfer\_library.v
- ft\_245\_state\_machine.v
- endpoint\_registers.vqm
- eptWireOr.v
- mem\_array.v
- read\_control\_logic.v
- write\_control\_logic.v

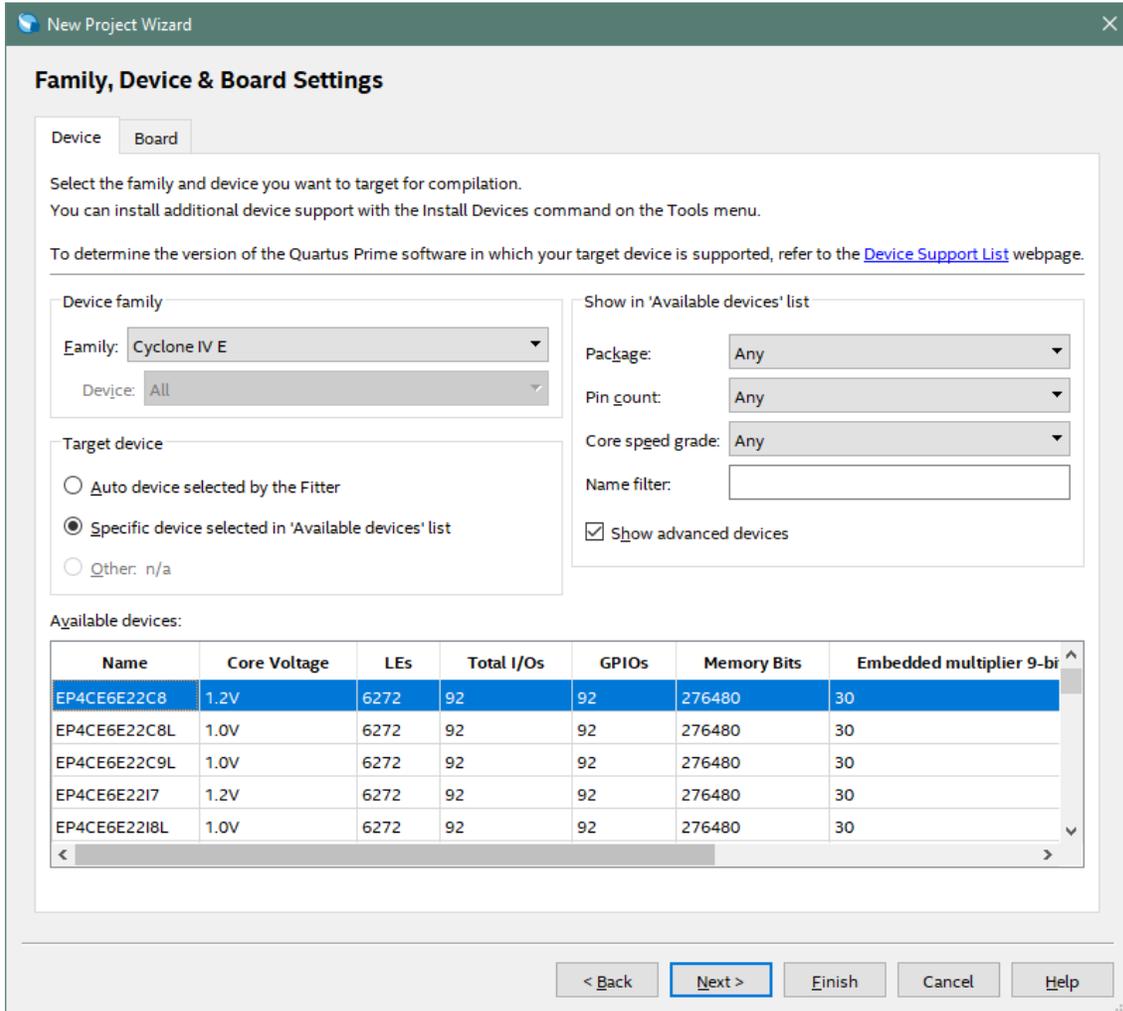
## FPGA Development System User Manual

- EPT\_4CE6\_AF\_D1\_Top.v



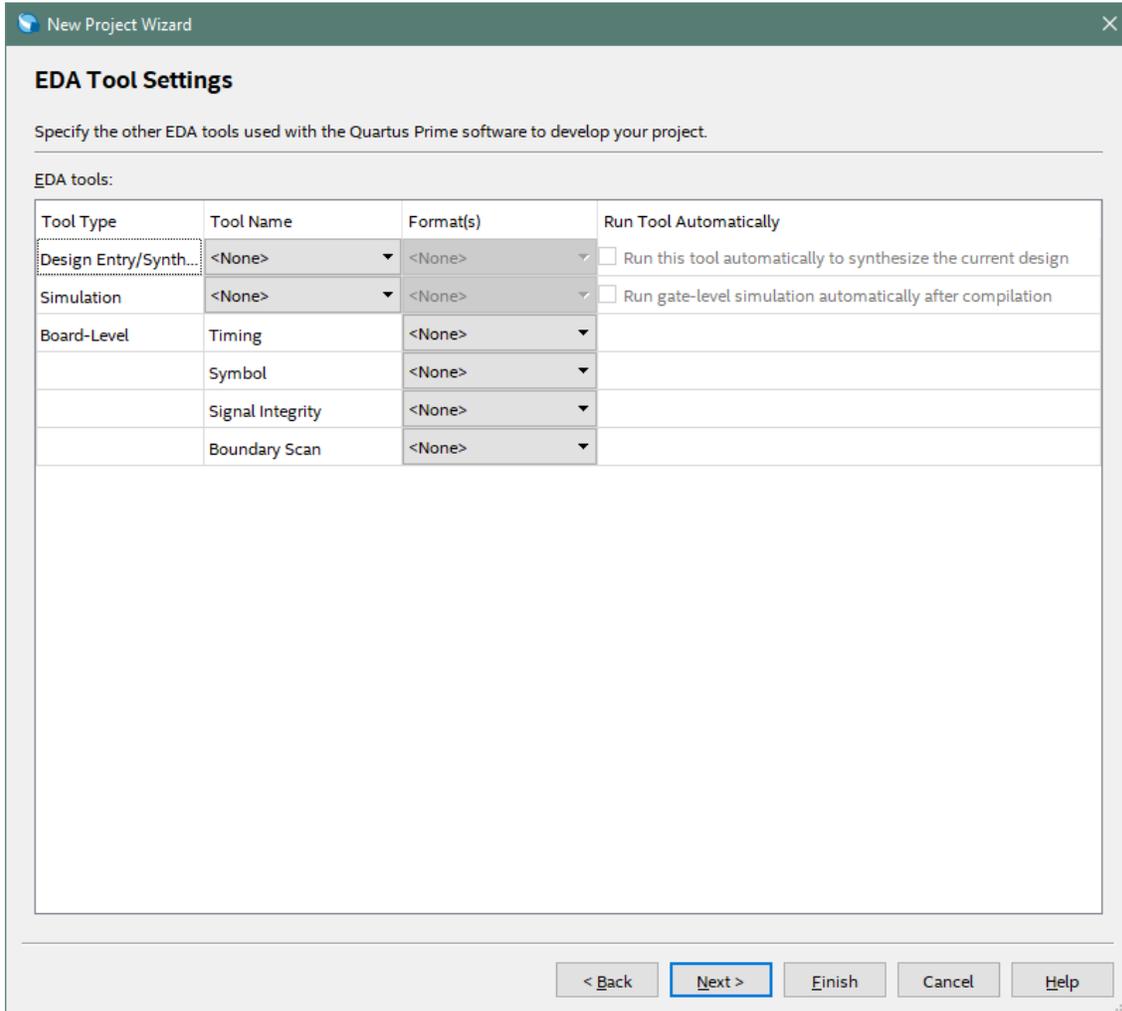
Select Next, at the Device Family group, select Cyclone IV for Family. In the Available Devices group, browse down to EP4CE6E22C8 for Name.

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Select Next, leave defaults for the EDA Tool Settings.

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**EDA Tool Settings**

Specify the other EDA tools used with the Quartus Prime software to develop your project.

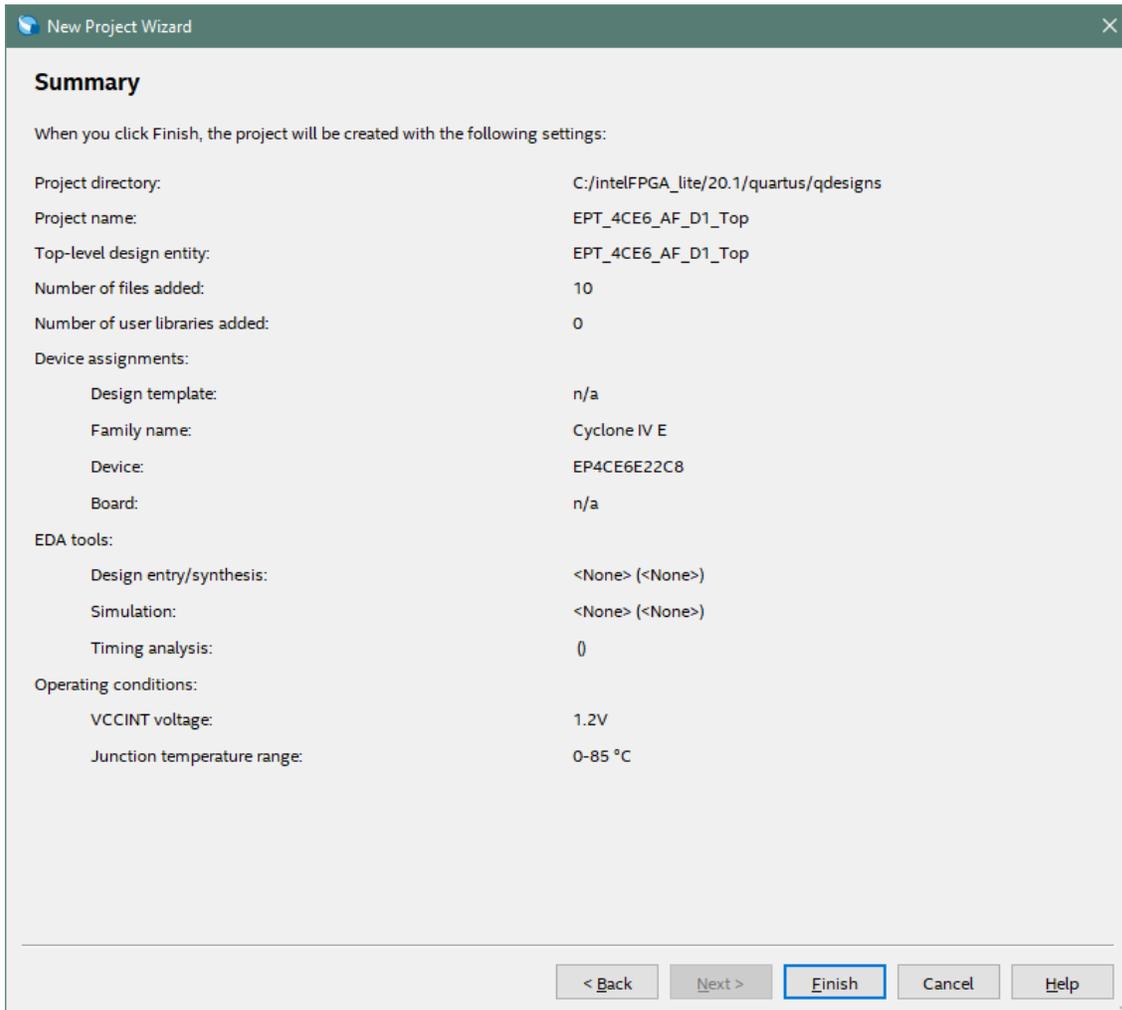
EDA tools:

Tool Type	Tool Name	Format(s)	Run Tool Automatically
Design Entry/Synth...	<None>	<None>	<input type="checkbox"/> Run this tool automatically to synthesize the current design
Simulation	<None>	<None>	<input type="checkbox"/> Run gate-level simulation automatically after compilation
Board-Level	Timing	<None>	
	Symbol	<None>	
	Signal Integrity	<None>	
	Boundary Scan	<None>	

< Back   **Next >**   Finish   Cancel   Help

Select Next, then select Finish. You are done with the project level selections.

## FPGA Development System User Manual

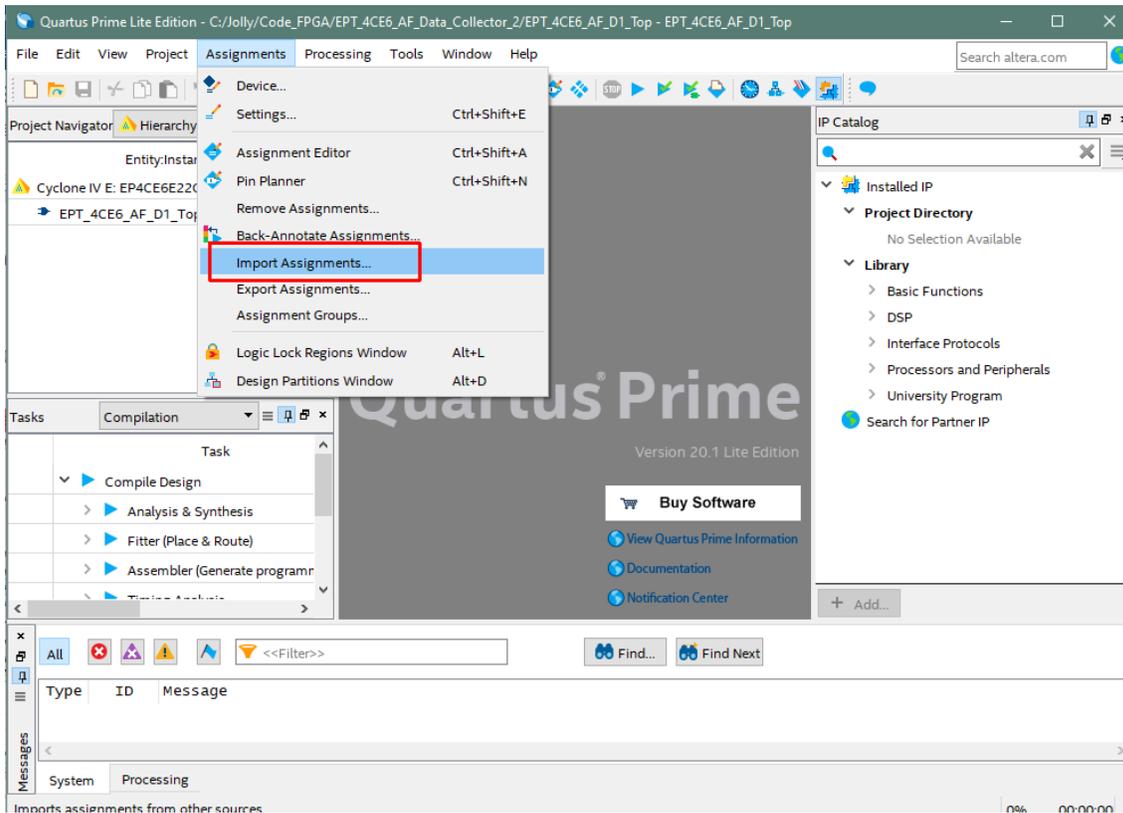


Next, we will select the pins and synthesize the project.

### 4.1.1 Selecting Pins and Synthesizing

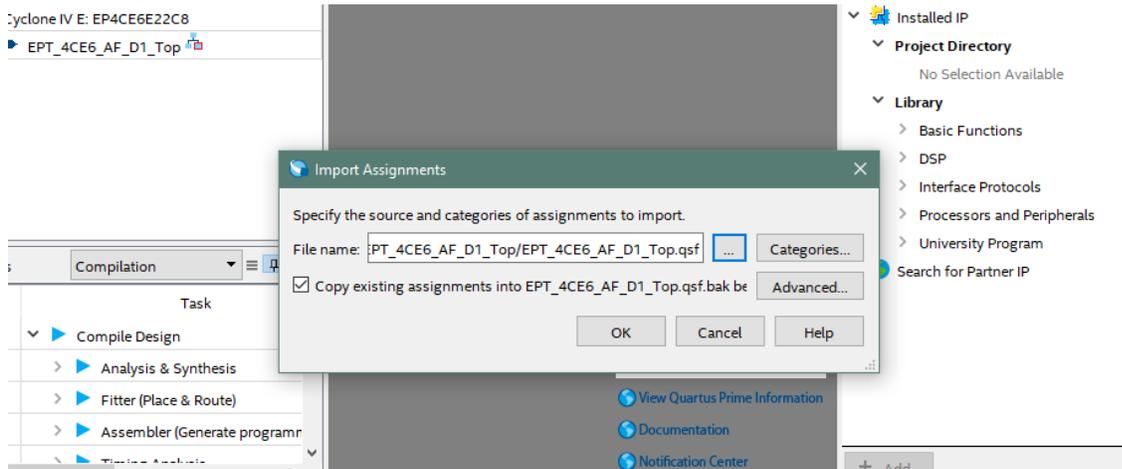
With the project created, we need to assign pins to the project. The signals defined in the top level file (in this case: EPT\_4CE6\_AF\_D1\_Top.v) will connect directly to pins on the FPGA. The Pin Planner Tool from Quartus Prime will add the pins and check to verify that our pin selections do not violate any restrictions of the device. In the case of this example we will import pin assignments that created at an earlier time. Under Assignments, Select Import Assignments.

## FPGA Development System User Manual

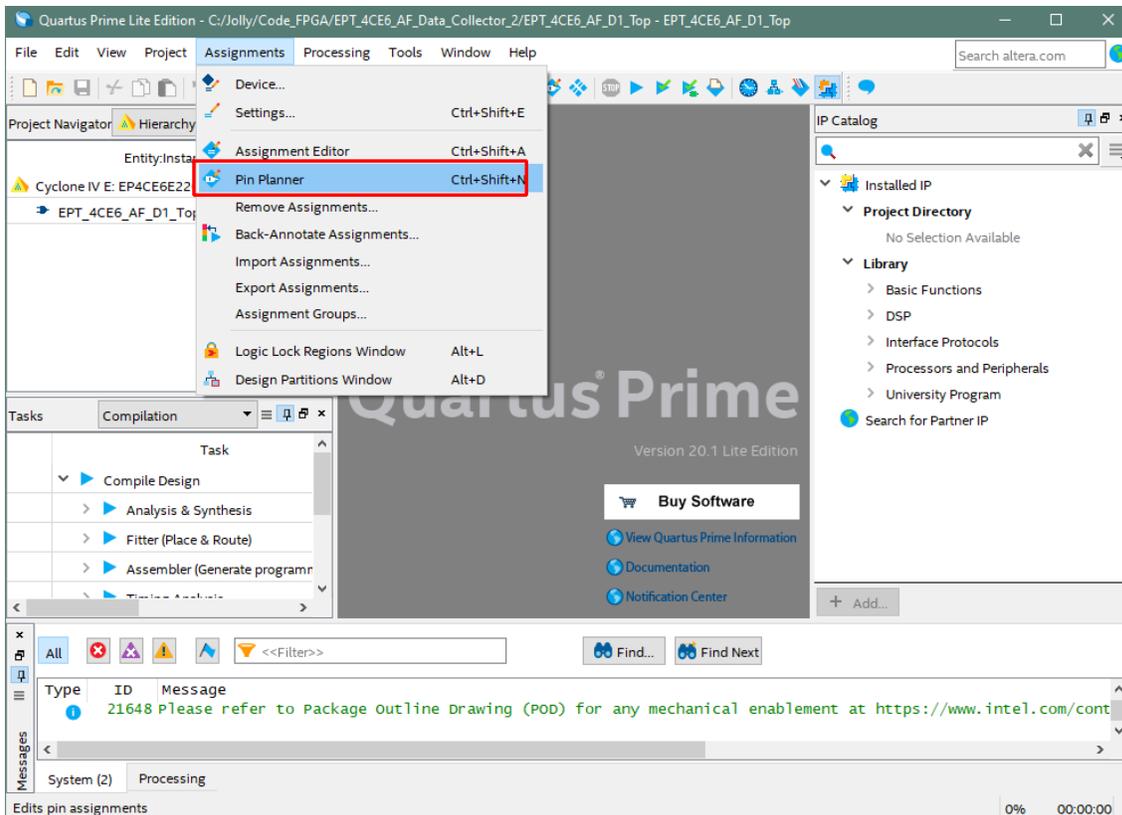


At the Import Assignment dialog box, Browse to the  
\\Projects\_HDL\EPT\_Transfer\_Demo \ EPT-4CE6-AF-D1\_TOP folder of the EPT  
FPGA Development System DVD. Select the “EPT-4CE6-AF-D1\_Top.qsf” file.

## FPGA Development System User Manual



Click Ok. Under Assignments, Select Pin Planner. Verify the pins have been imported correctly.

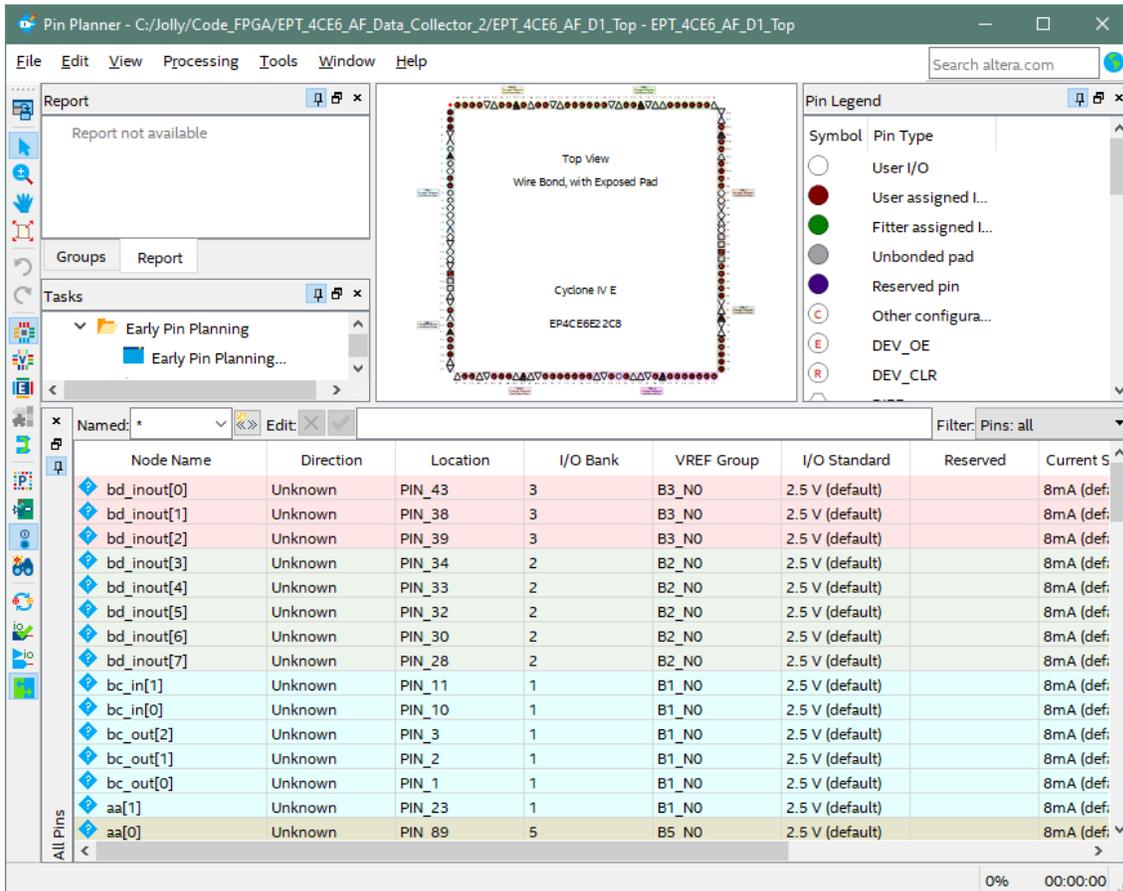




## FPGA Development System User Manual

The pin locations should not need to be changed for EPT USB FPGA Development System. However, if you need to change any pin location, just click on the “location” column for the particular node you wish to change. Then, select the new pin location from the drop down box.

## FPGA Development System User Manual

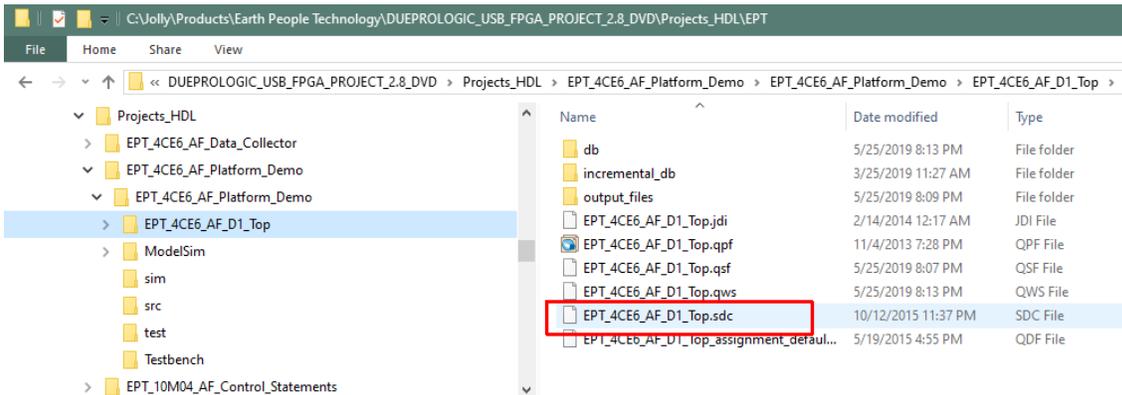


Exit the Pin Planner. Next, we need to add the Synopsys Design Constraint file. This file contains timing constraints which forces the built in tool called TimeQuest Timing Analyzer to analyze the path of the synthesized HDL code with setup and hold times of the internal registers. It takes note of any path that may be too long to appropriately meet the timing qualifications. For more information on TimeQuest Timing Analyzer, see

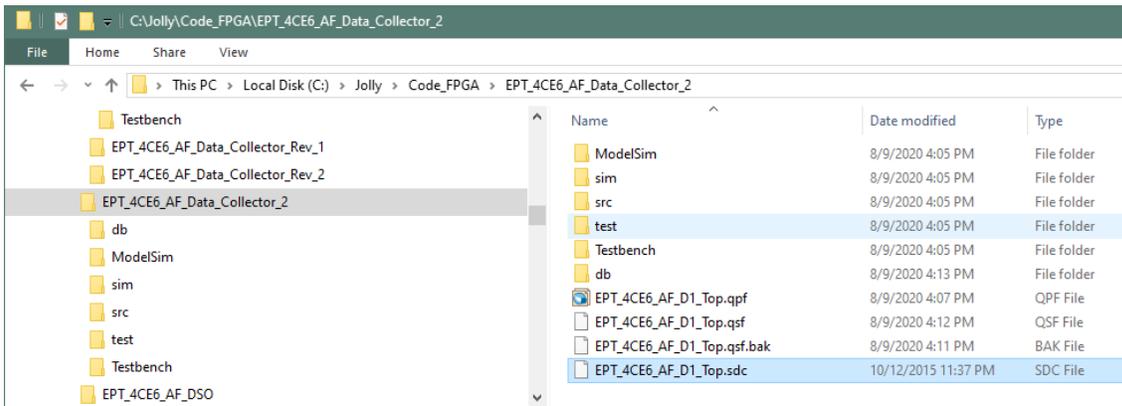
### [Quest Timing Analyzer Quick Start Guide](#)

Browse to the \Projects\_HDL\EPT\_Platform\_Demo \ EPT-4CE6-AF-D1\_TOP folder of the EPT FPGA Development System DVD. Select the “EPT-4CE6-AF-D1\_Top.sdc” file.

## FPGA Development System User Manual

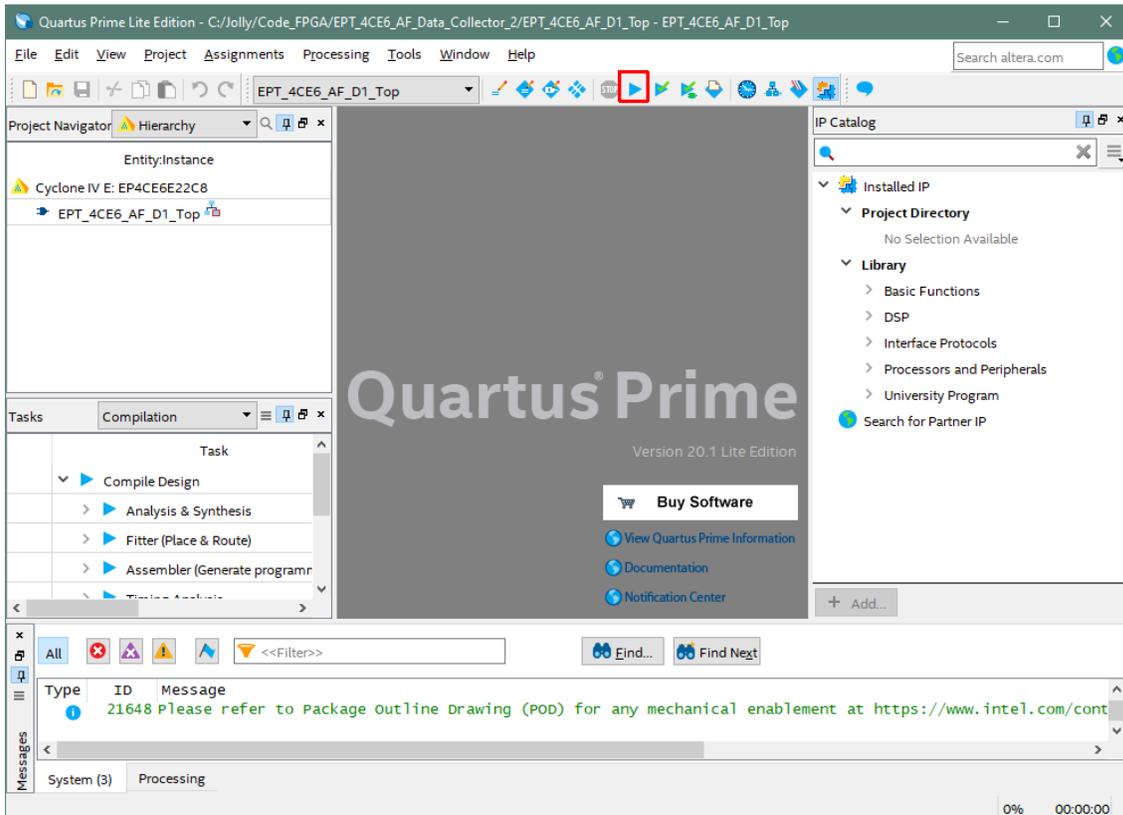


Copy the file and browse to c:\intelFPGA\_Lite\xxx\quartus\qdesigns\EPT\_Transfer\_Demo directory. Paste the file.



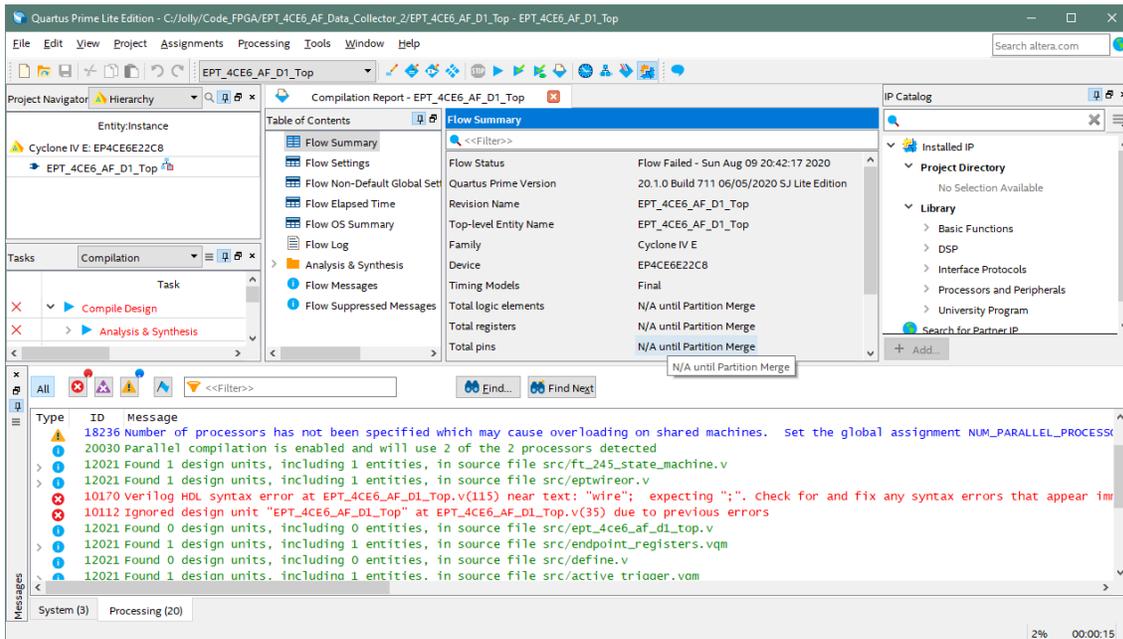
Select the Start Compilation button.

## FPGA Development System User Manual



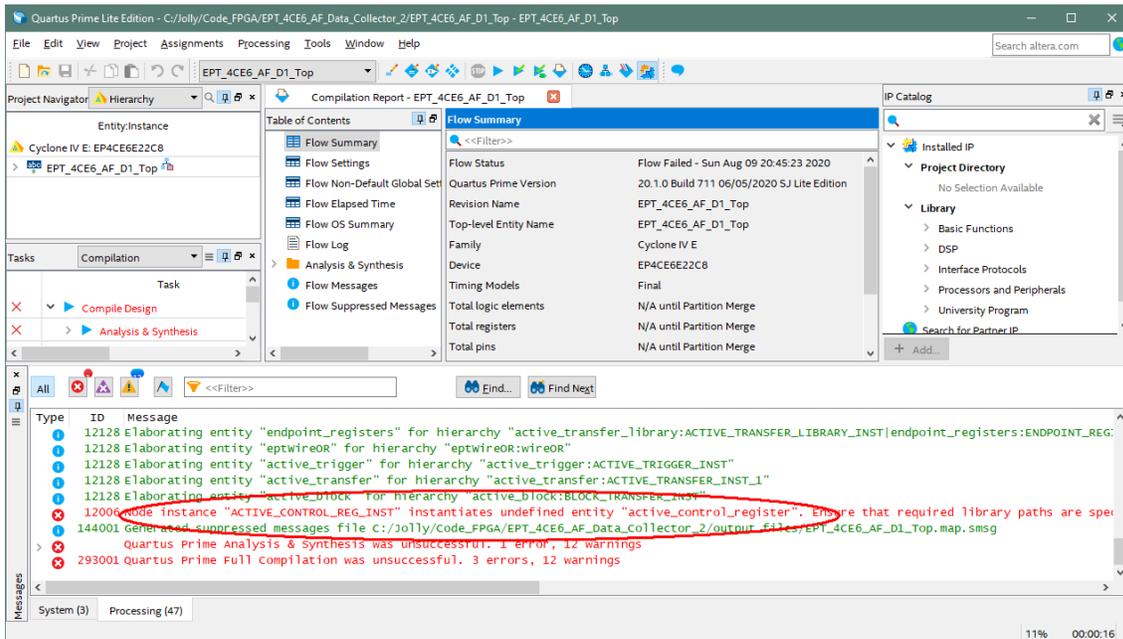
If you forget to include a file or some other error you should expect to see a screen similar to this:

## FPGA Development System User Manual



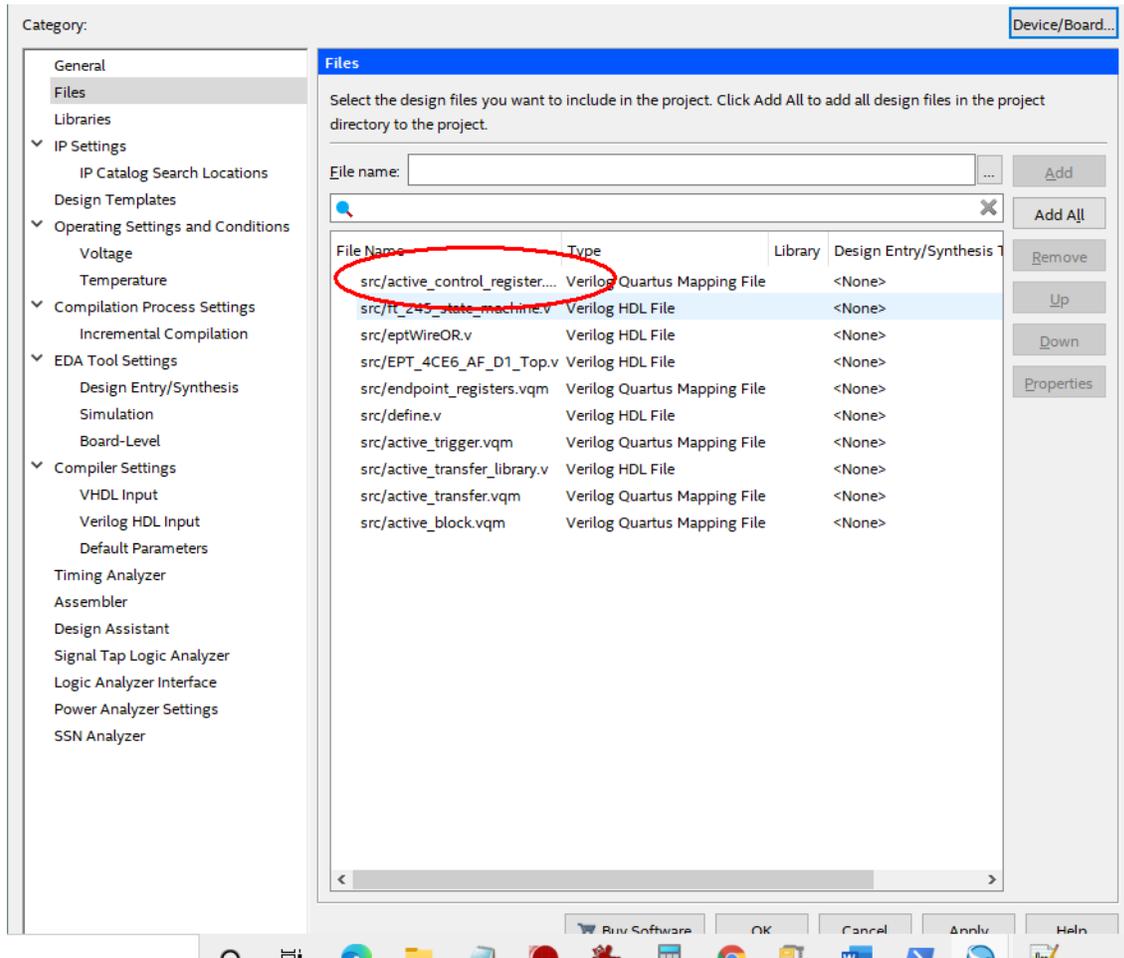
Click Ok, then select the “Error” tab to see the error.

## FPGA Development System User Manual



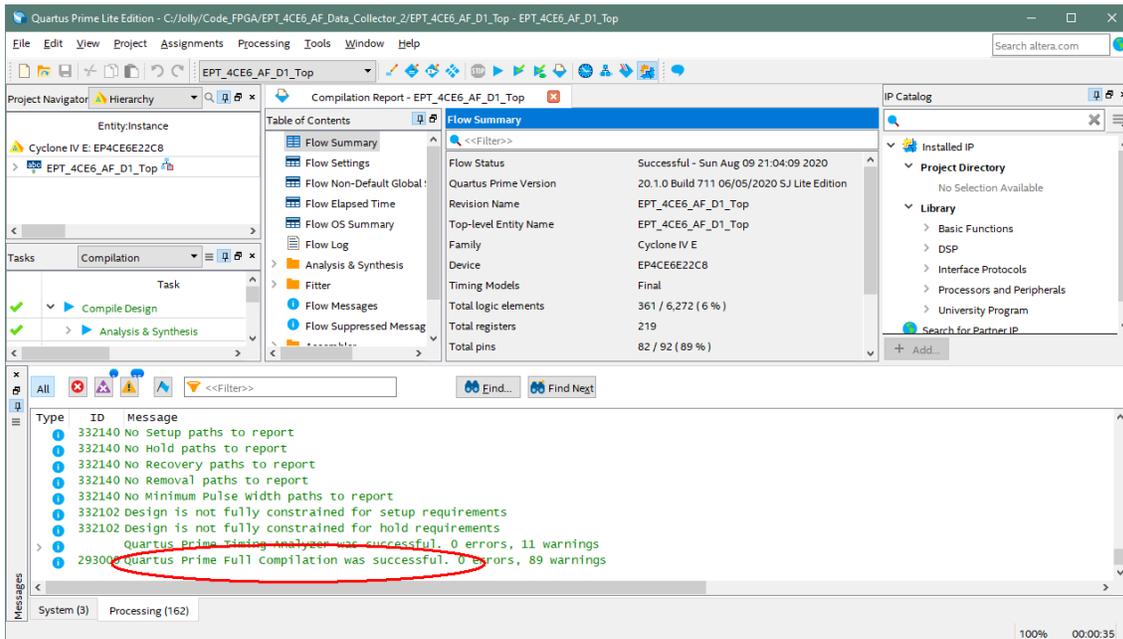
The error in this case is the missing file “active\_control\_register”. Click on the Assignment menu, then select Settings, then select Files. Add the “active\_control\_register.v” file from the database.

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Click Ok then re-run the Compile process. After successful completion, the screen should look like the following:

## FPGA Development System User Manual



At this point the project has been successfully compiled, synthesized and a programming file has been produced. See the next section on how to program the FPGA.

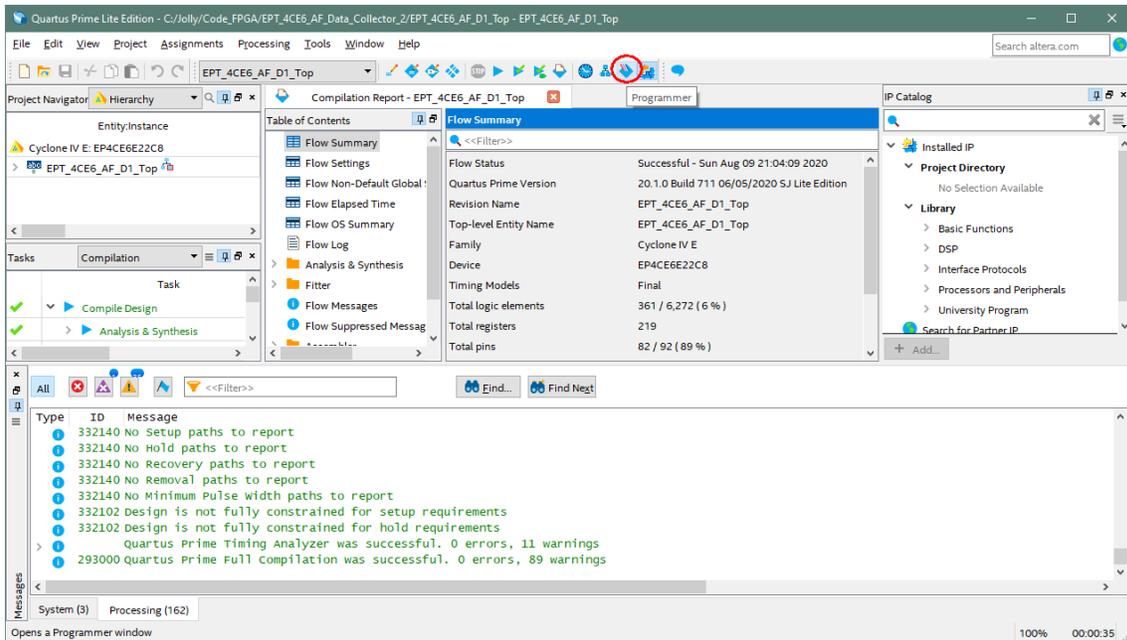
### 4.1.2 Configuring the FPGA

Configuring the FPGA is quick and easy. All that is required is a standard USB Micro B cable and the EPT\_Blaster Driver DLL. Connect the DueProLogic to the PC, open up Quartus Prime, open the programmer tool, and click the Start button. To program the DPL Configuration Flash, follow the steps to install the USB Driver and the JTAG Driver Insert for Quartus Prime.



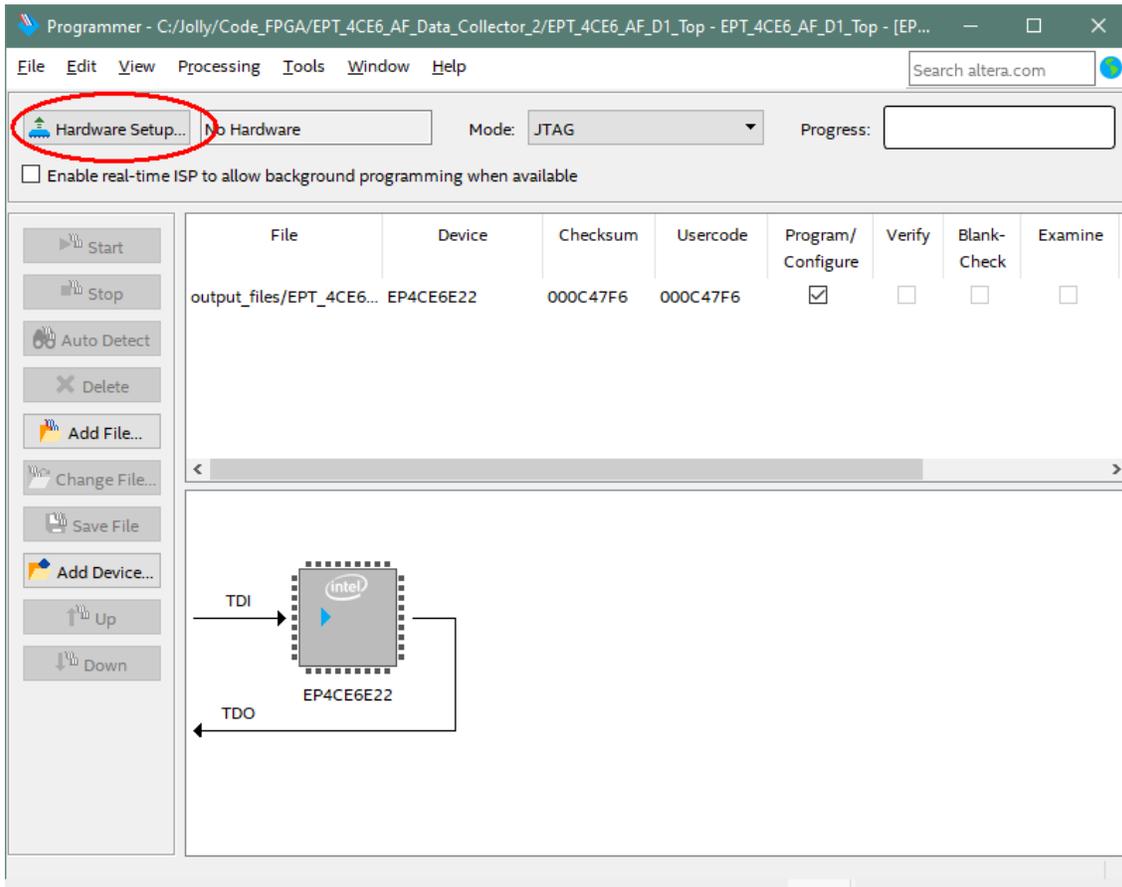
## FPGA Development System User Manual

If the project created in the previous sections is not open, open it. Click on the Programmer button.



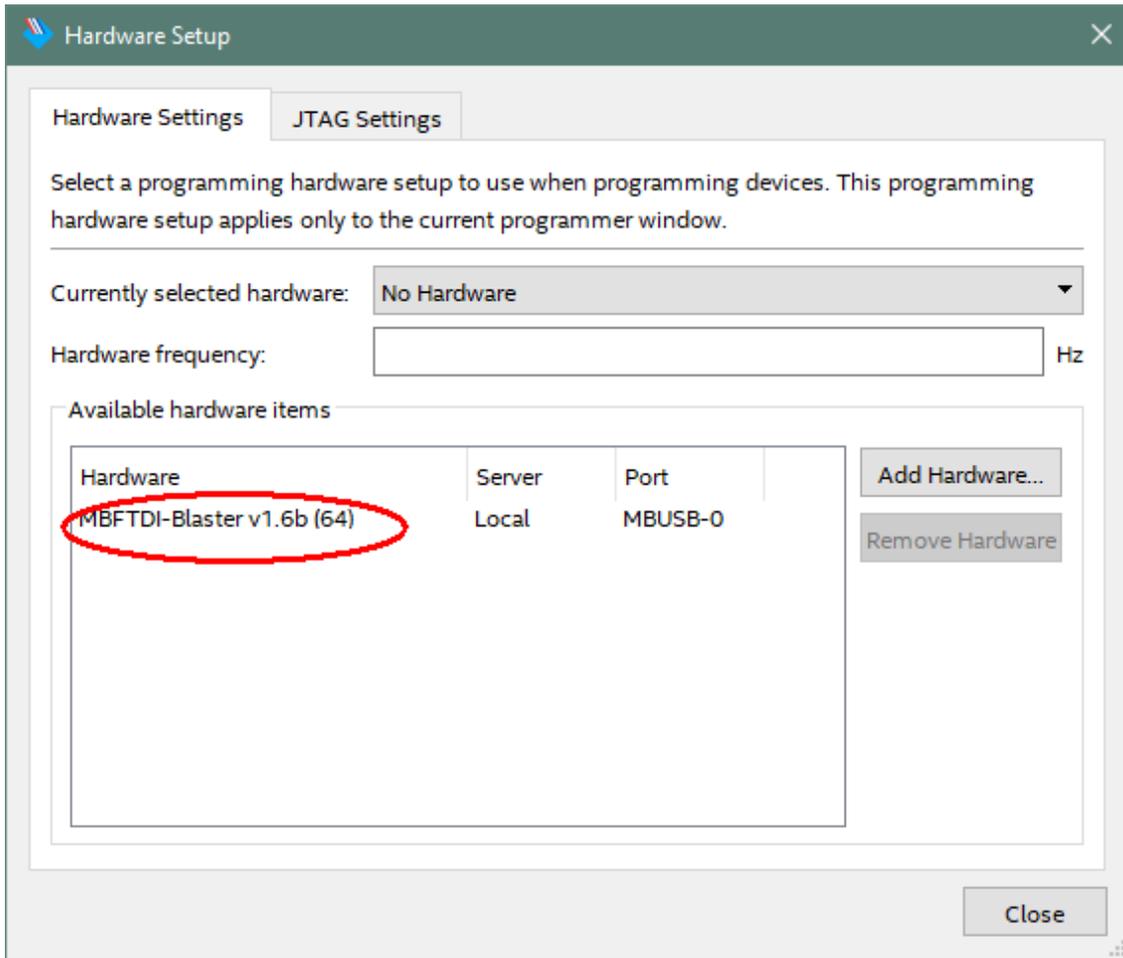
The Programmer Window will open up with the programming file selected. Click on the Hardware Setup button in the upper left corner.

## FPGA Development System User Manual



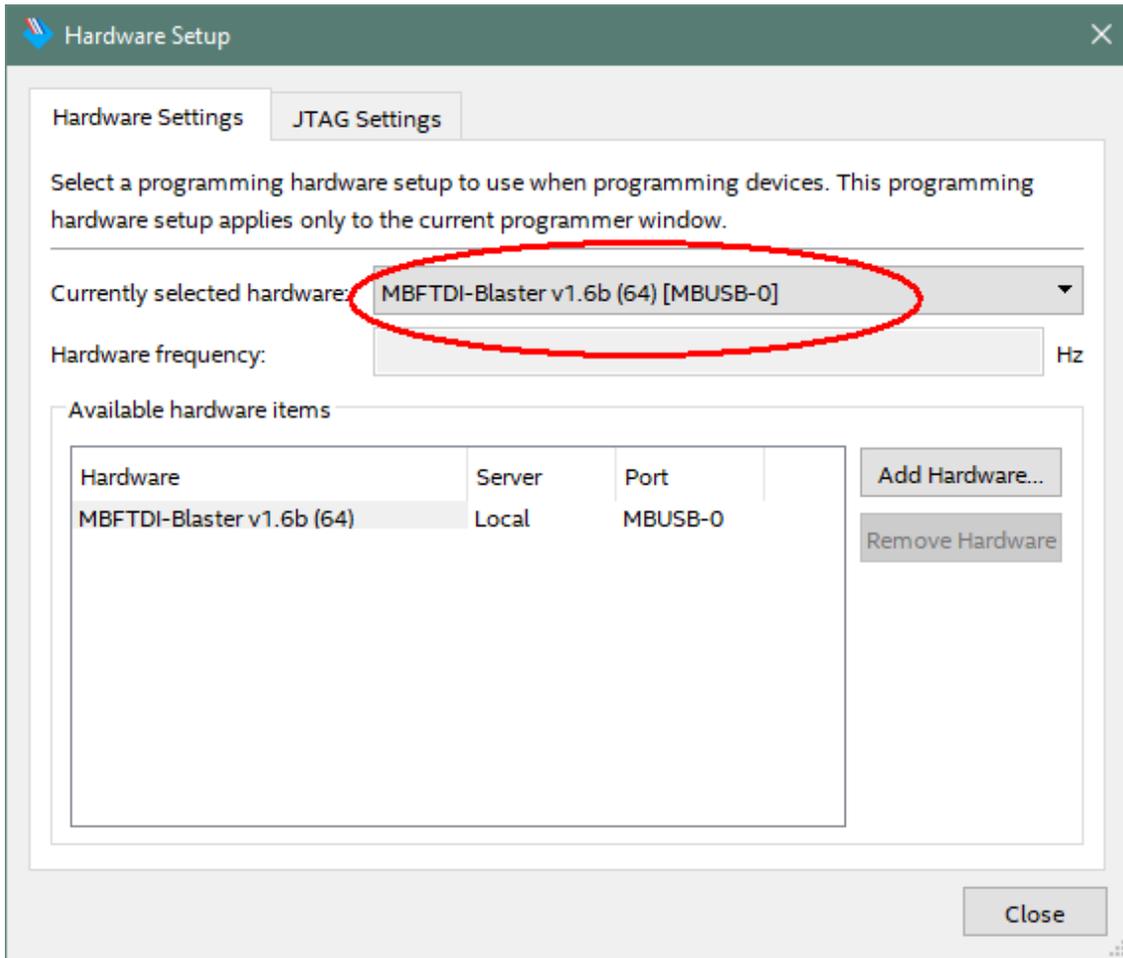
The Hardware Setup Window will open. In the “Available hardware items”, double click on “EPT-Blaster v1.6b”.

## FPGA Development System User Manual



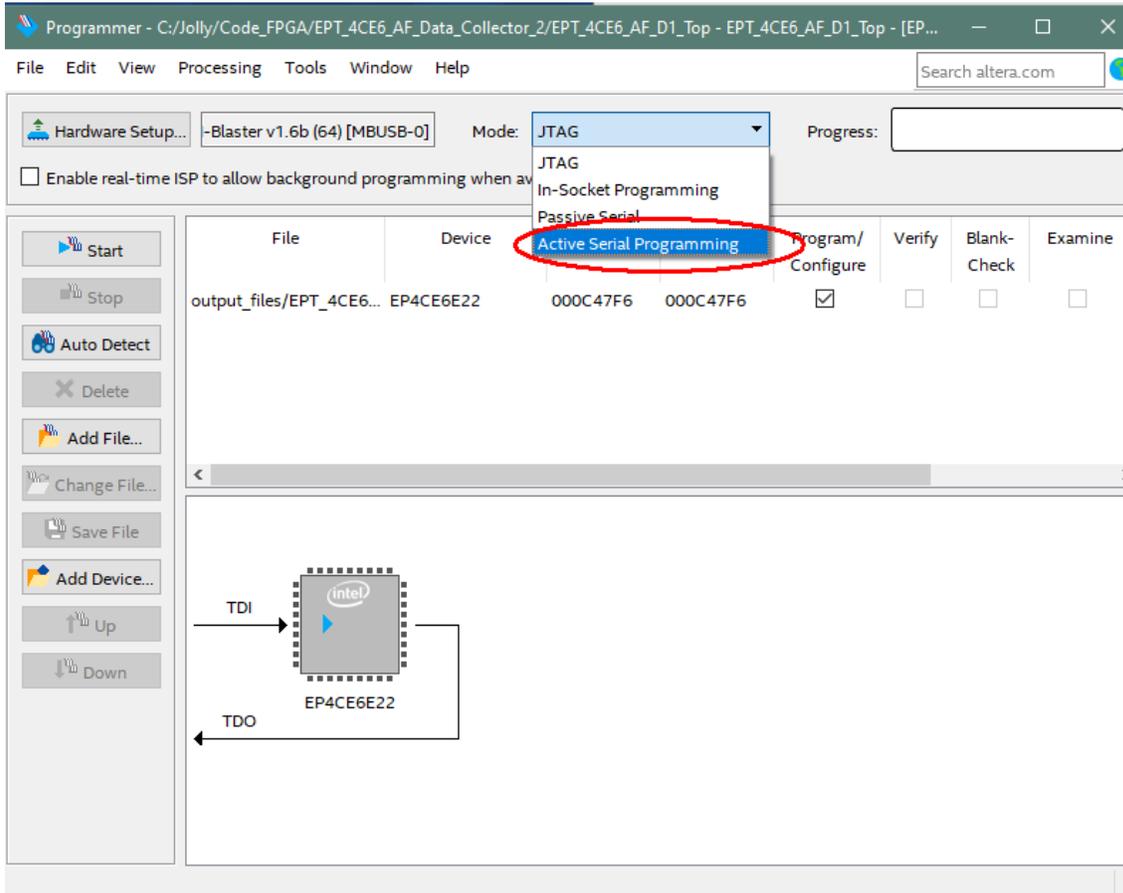
If you successfully double clicked, the “Currently selected hardware:” dropdown box will show the “EPT-Blaster v1.6b”.

## FPGA Development System User Manual



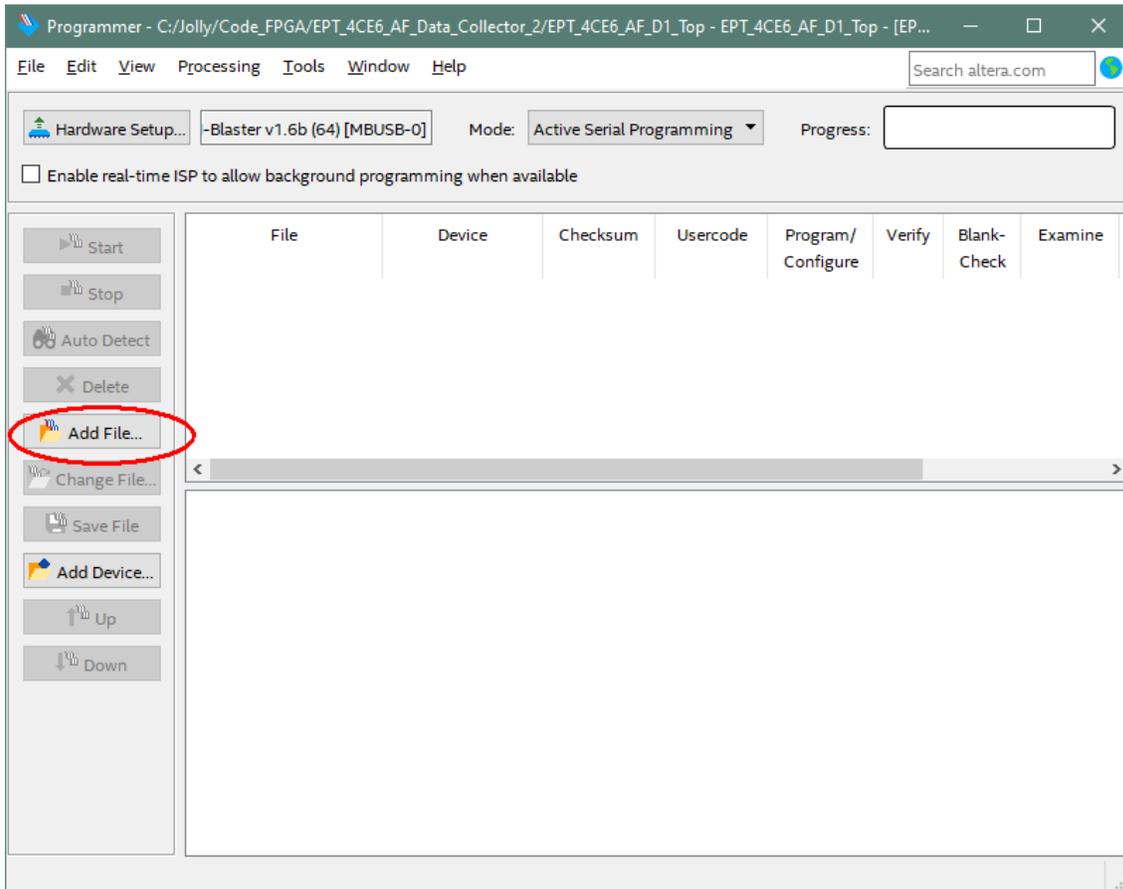
Click on the “Mode:” drop down box. Select the “Active Serial Programming” option.

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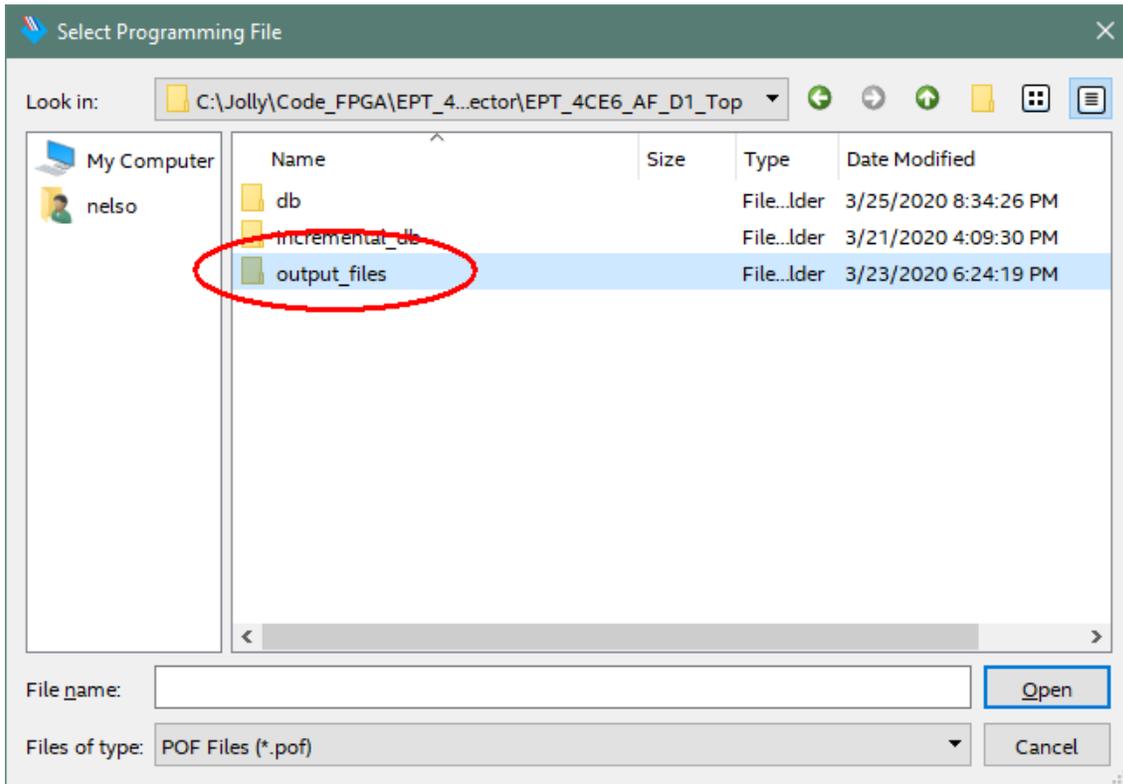


Click on the “Add File” button

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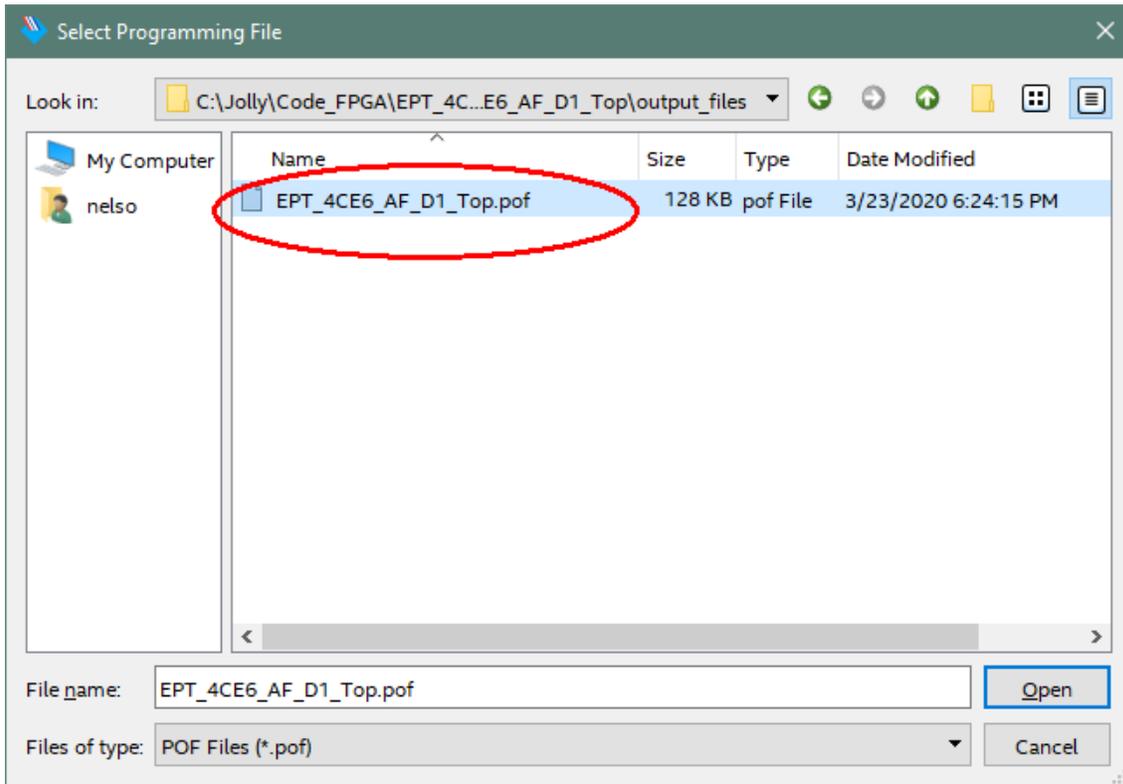


## FPGA Development System User Manual



At the Browse window, double click on the output files folder.

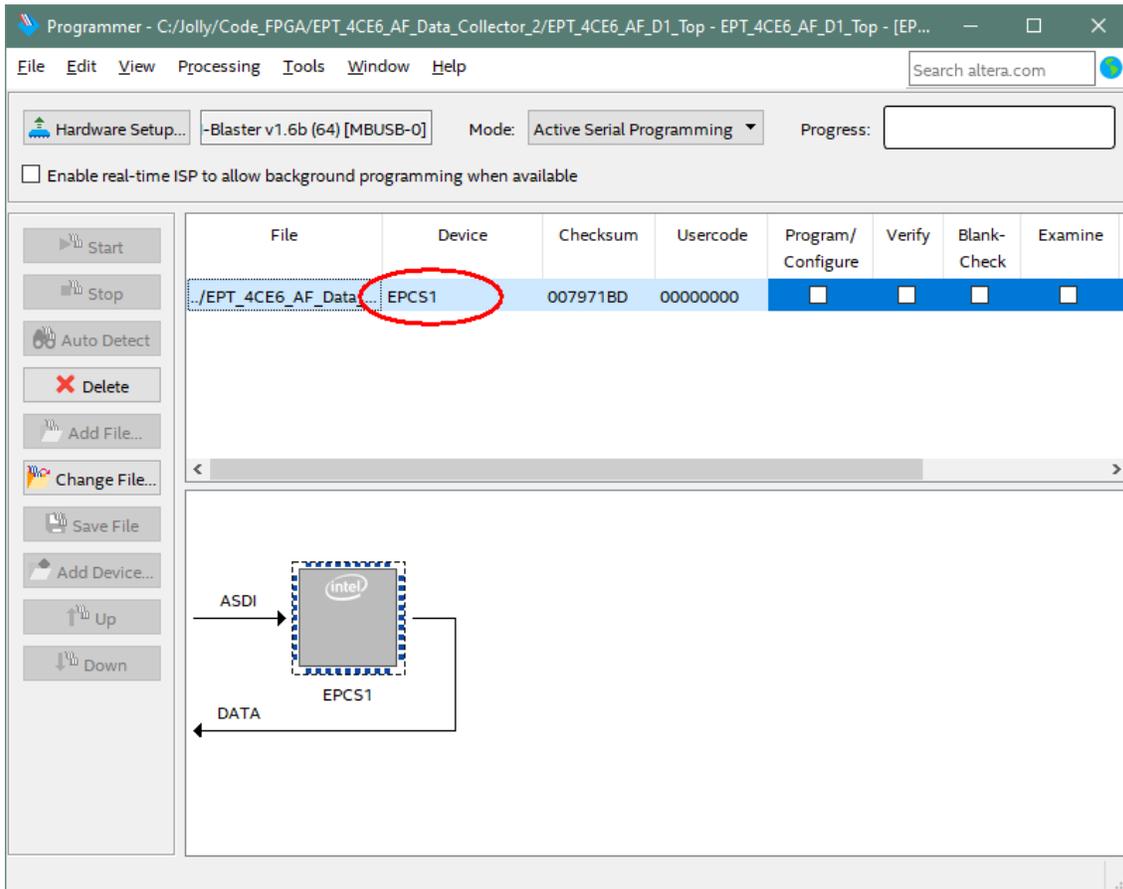
## FPGA Development System User Manual



Double click on the “EPT\_4CE6\_D1\_Top.pof” file. Click the Open button in the lower right corner.

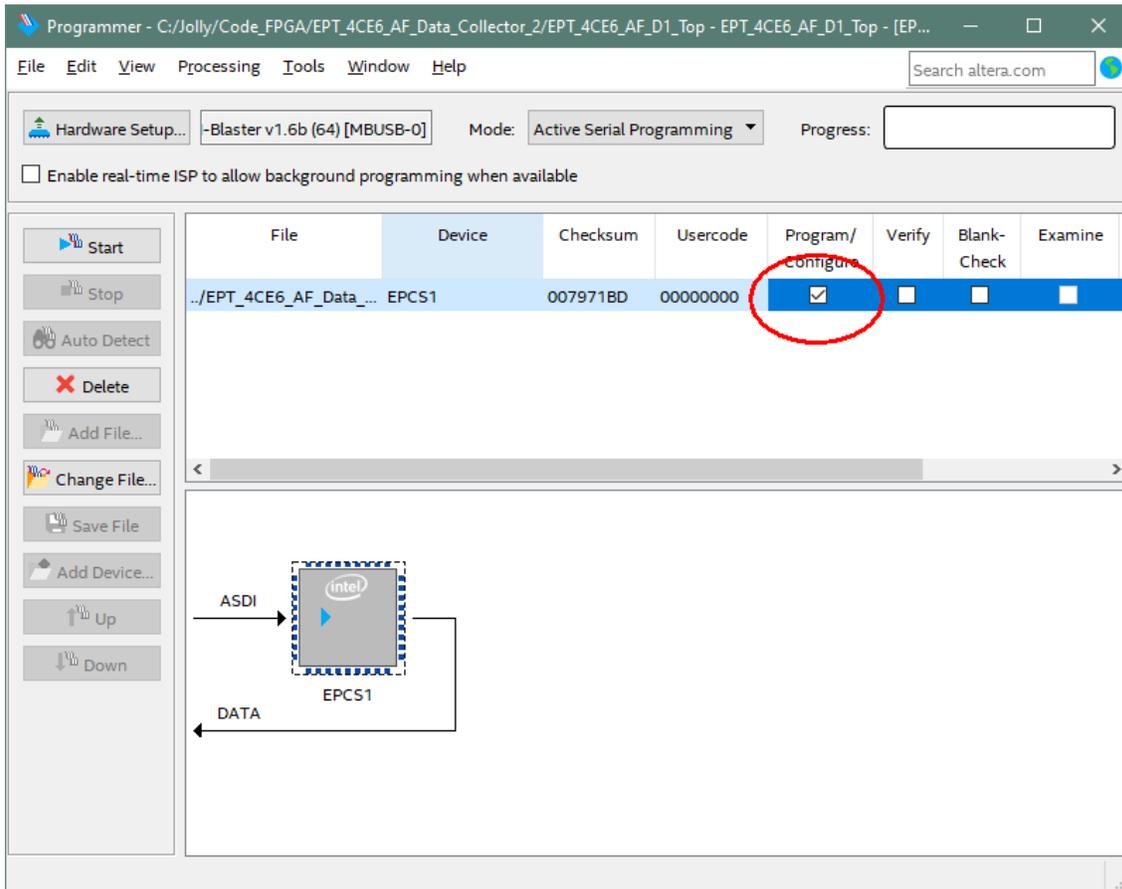
Select the EPCS1 under “Device”.

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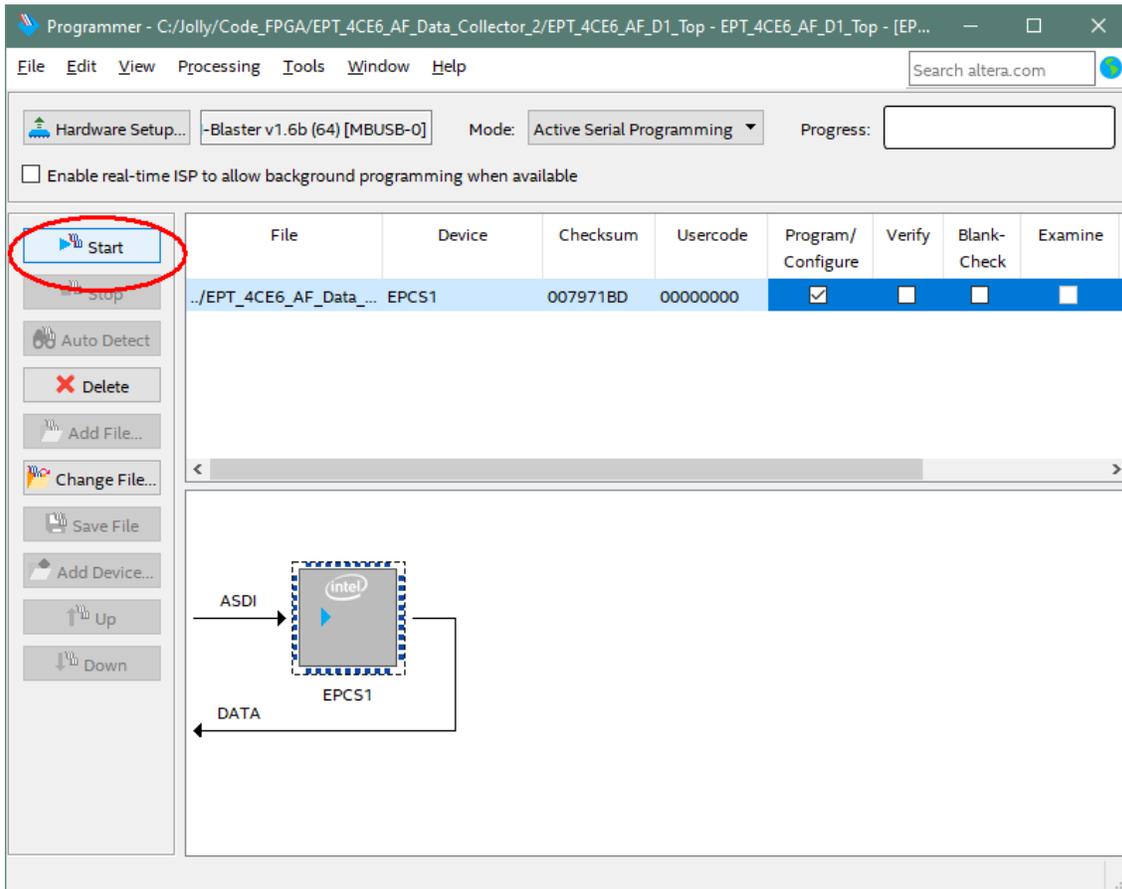
Next, select the checkbox under the “Program/Configure” of the Programmer Tool.

## FPGA Development System User Manual



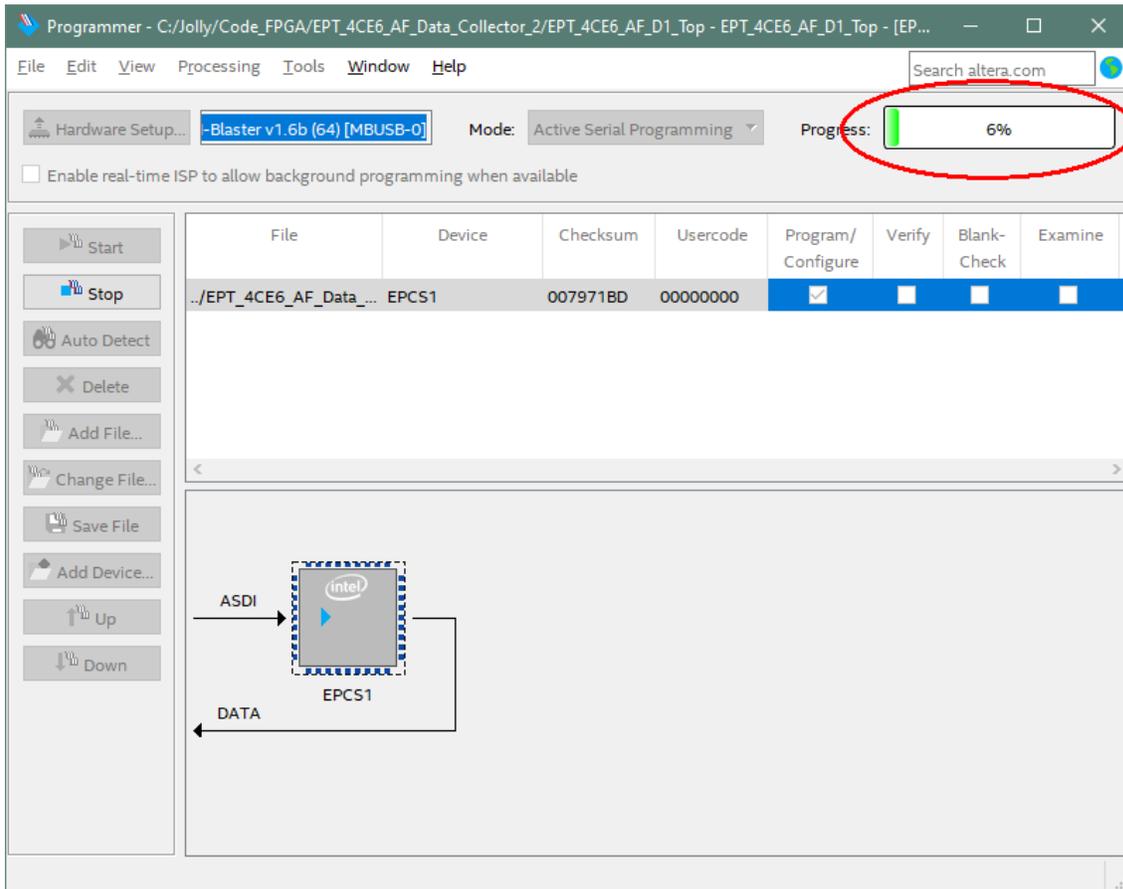
Click on the Start button to start programming the FPGA. The Progress bar will indicate the progress of programming.

## FPGA Development System User Manual



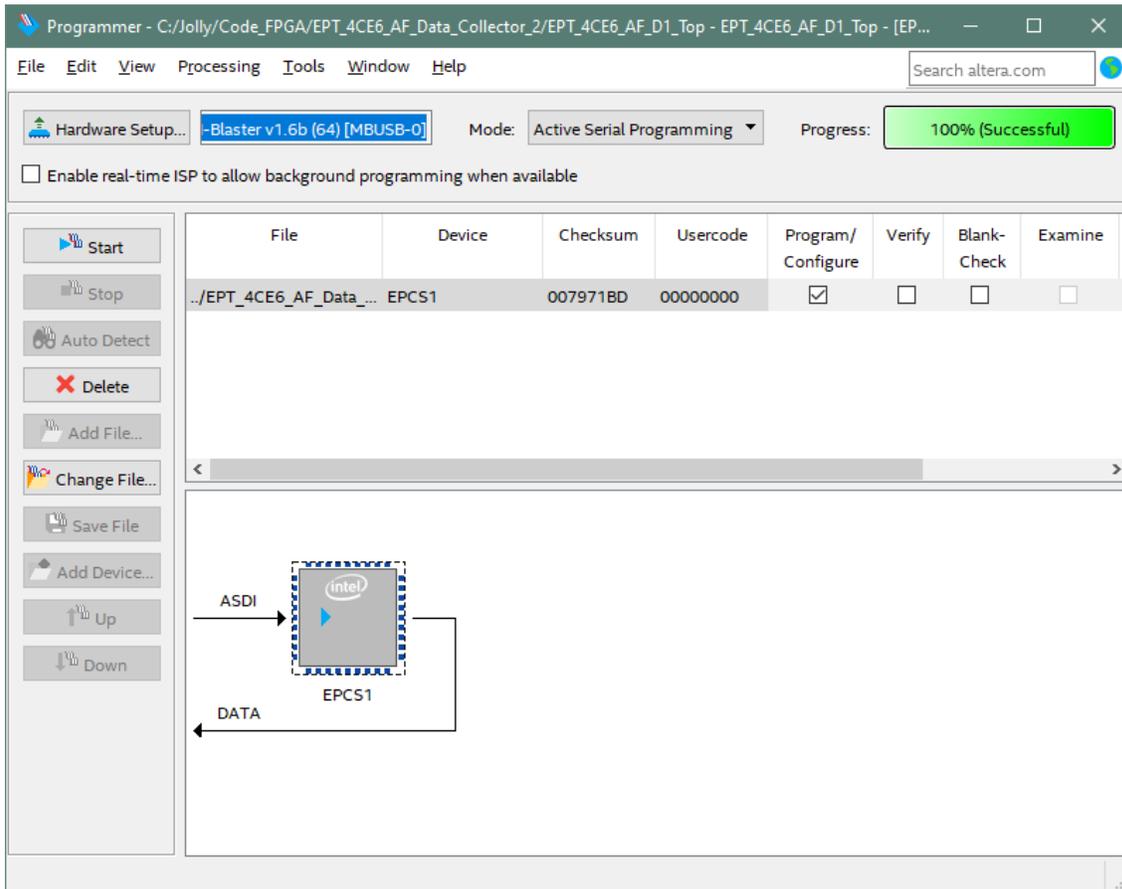
The programming of the DueProLogic will start and you can check the progress in the “Progress” Bar.

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When the programming is complete, the Progress bar will indicate success.

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At this point, the DueProLogic is programmed and ready for use. To test that the FPGA is properly programmed, bring up the Active Transfer Demo Tool. Click on one of the LED's and verify that the LED selected lights up. Press one of the switches on the board and ensure that the switch is captured on the Active Host Test Tool. Now you are ready to connect to the Arduino Due and write some code to transfer data between microcontroller and PC.

## 5 Active Host Application

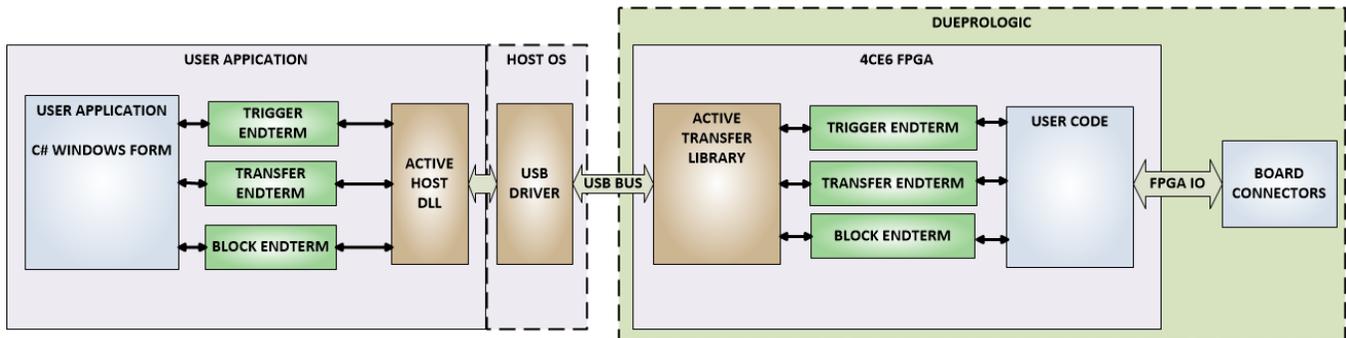
The Active Host SDK is provided as a dll which easily interfaces to application software written in C#, C++ or C. It runs on the PC and provides transparent connection from PC application code through the USB driver to the user FPGA code. The user code connects to "Endterms" in the Active Host dll. These host "Endterms" have

## FPGA Development System User Manual

complementary HDL “Endterms” in the Active Transfer Library. Users have seamless bi-directional communications at their disposal in the form of:

- Trigger Endterm
- Transfer Endterm
- Block Endterm

User code writes to the Endterms as function calls. Just include the address of the individual module (there are eight individually addressable modules of each Endterm). Immediately after writing to the selected Endterm, the value is received at the HDL Endterm in the FPGA. The Trigger Endterms are used as “switches”. The user code can set a Trigger bit in the FPGA and cause an event to occur. The Transfer Endterm sends one byte to the FPGA. The Block Endterm sends a block of bytes. By using one of the Active Host Endterms, the user can create a dynamic, bi-directional, and configurable data transfer design.



### 5.1 Trigger EndTerm

The Trigger EndTerm is a software component that provides a direct path from the users application to the commensurate Trigger EndTerm in the FPGA. The Trigger has eight bits and is intended to be used to provide a switch at the opposite EndTerm. They are fast acting and are not stored or buffered by memory. When the user code sets a Trigger, it is immediately passed through to the opposite EndTerm via the USB driver. When receiving Trigger, the user application is required to respond to a callback from the Active Host dll.

### 5.2 Transfer(Byte) EndTerm

The Transfer EndTerm is a software component that provides a direct path from the users application to the commensurate Transfer EndTerm in the FPGA. It is used to transfer a byte to and from the FPGA. Eight separate Transfer EndTerm modules can be instantiated in the FPGA. Each module is addressed by the user application. Sending a

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byte is easy, just use the function call with the address and byte value. The byte is immediately sent to the corresponding EndTerm in the FPGA. Receiving a byte is just as easy, a callback function is registered at initialization. When the FPGA transmits a byte using its EndTerm, the callback function is called in the user application. The user code must store this byte in order to use it. The incoming Transfers are stored in a circular buffer in memory. This allows the user code to fetch the transfers with out losing bytes.

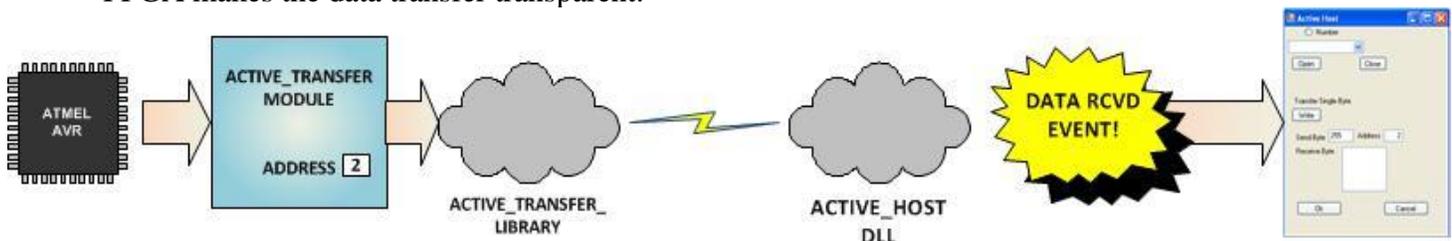
### 5.3 Block EndTerm

The Block EndTerm is a software component that provides a direct path from the users application to the commensurate Block EndTerm in the FPGA. The Block EndTerm is used to transfer a complete block to the FPGA. Block size is limited to 1 to 256 bytes. Eight separate Block EndTerm modules can be instantiated in the FPGA. Each module is addressed by the user application. Sending a block is easy, just use the function call with the address, block length, byte array. The block is buffered into a circular buffer in memory then transmitted via the USB bus to the Block EndTerm in the FPGA.

Receiving a block is just as easy, a callback function is registered at initialization. When the FPGA transmits a block using its EndTerm, the callback function is called in the user application. The incoming Transfers are stored in a circular buffer in memory. This allows the user code to fetch the transfers with out losing bytes.

### 5.4 Active Host DLL

The Active\_Host DLL is designed to transfer data from the FPGA when it becomes available. The data will be stored into local memory of the PC, and an event will be triggered to inform the user code that data is available from the addressed module of the FPGA. This method of automatically moving data from the user code Endterm in the FPGA makes the data transfer transparent.



The data seamlessly appears in Host PC memory from the Arduino. The user code will direct the data to a control such as a textbox on a Windows Form. The transparent receive transfer path is made possible by a Callback mechanism in the Active Host dll.



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The dll calls a registered callback function in the user code. The user code callback can be designed to generate any number of events to handle the received data.

The user application will access the FPGA by use of functions contained in the Active Host dll. The functions to access the FPGA are:

- EPT\_AH\_SendTrigger ()
- EPT\_AH\_SendByte ()
- EPT\_AH\_SendBlock ()
- EPT\_AH\_SendTransferControlByte()

### 5.4.1 Active Host Open Device

To use the library functions for data transfer and triggering, an Earth People Technology device must be opened. EPT Devices use the COM Port library of the Visual Studio to provide communications. The first function called when the Windows Form loads up is the <project\_name>\_Load(). This function is called automatically upon the completion of the Windows Form, so there is no need to do anything to call it. Once this function is called, it in turn calls the ComPortNames(). Use the function List Devices() to detect all EPT devices connected to the PC.

## FPGA Development System User Manual

```

1 reference
private void EPT_Transfer_Demo_Load(object sender, System.EventArgs e)
{
    //String buffer
    String PortText = "";

    //Index registers
    int Index = 0, EPTgroupNumber=0;

    // Call the List Devices function
    List<string> names = ComPortNames("0403", "6010");

    // Get a list of serial port names.
    string[] ports;
    ports = SerialPort.GetPortNames();

    if (names.Count > 0)
    {
        foreach (String port in ports)
        {
            //Compare port name with the found VID/PID
            //combinations. Add them to Matching port list
            //and comboDevList
            if (names.Contains(port))
            {
                MatchingComPortList[Index] = port;

                if (Index == 0)
                {
                    PortText = "EPT JTAG Blaster " + EPTgroupNumber;
                    Index++;
                }
                else
                {
                    PortText = "EPT Serial Communications " + EPTgroupNumber++;
                    Index++;
                }
                cmbDevList.Items.Add(PortText);
            }
        }
    }
    else
        MessageBox.Show("No EPT Devices found!");

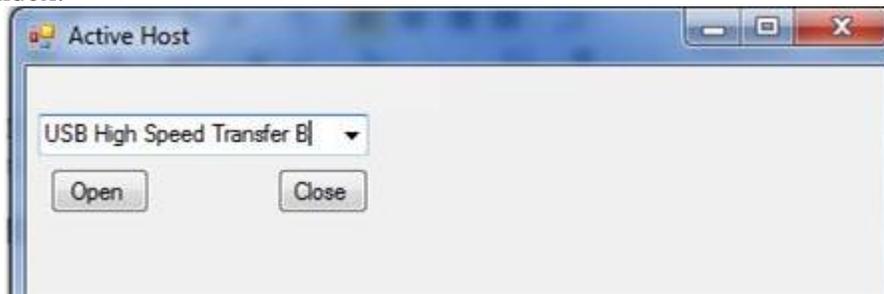
    SetButtonEnables_Close();
    //SetButtonEnables_Stop();
}

```

The ComPortNames() searches through all attached COM Ports and attempts to find the DueProLogic. Once it finds the DPL, a List is populated with each channel. The code in \*\_Load() function then adds the appropriate name to the COM Port channel and matches the COM Port number with the string in the list.

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The user will select the device from the drop down combo box. This can be seen when the Windows Form is opened and the cmbDevList combo box is populated with all the devices. The selected device will be stored as an index number in the variable device\_index.



In order to select the device, the user will click on the “Open” button which calls the OpenSerialPort1() function. The PortName is passed into the OpenSerialPort1 () function. If the function is successful, the device name is displayed in the label, labelDeviceCnt. Next, the device is made the active device the Open button is grayed out and the Close button is made active.

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```
1 reference
public bool OpenSerialPort1()
{
    try
    {
        //Set the serial port parameters
        serialPort_AH.PortName = PortName;
        serialPort_AH.BaudRate = Convert.ToInt32(BaudRate);
        serialPort_AH.Parity = (Parity)Enum.Parse(typeof(Parity), vParity);
        serialPort_AH.DataBits = Convert.ToInt16(DataBits);
        serialPort_AH.StopBits = (StopBits)Enum.Parse(typeof(StopBits), StopBits);
        serialPort_AH.Handshake = (Handshake)Enum.Parse(typeof(Handshake), pHandshake);

        if (!serialPort_AH.IsOpen)
        {
            serialPort_AH.Open();
            btnOpenDevice.Enabled = false;
            btnCloseDevice.Enabled = true;
            //textBox1.ReadOnly = false;
            return true;
        }
    }
    catch (Exception ex)
    {
        MessageBox.Show(ex.Message);
    }
    return false;
}
```

### 5.4.2 Active Host Data Received Function

The serialPort\_AH\_DataReceived function is activated and assigned to the serial port received event. It resides in the active\_transfer.cs file. This function will be called when the serial port receives bytes from the DueProLogic. The function must determine if the incoming transfer is:

- Trigger Byte
- Transfer Byte
- Block Transfer

## FPGA Development System User Manual

```

1 reference
private void serialPort_AH_DataReceived(object sender, System.IO.Ports.SerialDataReceivedEventArgs e)
{
    uint c, l;
    uint eptBytesToRead=0;

    if (serialPort_AH.BytesToRead < 2)
    {
        return;
    }
    int bytes = serialPort_AH.BytesToRead;
    int bytesStored = 0;
    byte[] buffer = new byte[bytes];
    serialPort_AH.Read(buffer, 0, bytes);

    //Check for incoming block
    c = (uint)buffer[0];
    c = c & 0xf8;
    if (c == 0xe0)
    {
        bytesStored = bytesStored + bytes;
        eptBytesToRead = (uint)buffer[1];
        byte[] blockBuffer = new byte[eptBytesToRead + 2];
        System.Buffer.BlockCopy(buffer, 0, blockBuffer, 0, bytes);
        while (bytesStored <= eptBytesToRead)
        {
            bytes = serialPort_AH.BytesToRead;
            buffer = new byte[bytes];
            serialPort_AH.Read(buffer, 0, bytes);

            System.Buffer.BlockCopy(buffer, 0, blockBuffer, bytesStored, buffer.Length);
            bytesStored = bytesStored + bytes;
        }

        this.Invoke(new MethodInvoker(delegate () { EPT_AH_Receive(blockBuffer); }));
    }
    else
    {
        //string WriteRcvChar = "";
        // WriteRcvChar = String.Format("{0}", (int)buffer[0]);
        this.Invoke(new MethodInvoker(delegate () { EPT_AH_Receive(buffer); }));
    }
}

```

Once the serialPort\_AH\_DataReceived() has stored all incoming bytes due to the transfer, it calls the EPT\_AH\_Receive(). This function will process the incoming transfer and populate the class:

- EPTReceiveDevice

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```

2 references
public void EPT_AH_Receive(byte[] receiveBytes)
{
    uint c, a, p, l, index;
    //Compare first byte to the incoming message code
    string s = String.Empty;
    foreach (byte b in receiveBytes)
    {
        s += String.Format("{0:x2}", (int)System.Convert.ToUInt32(b.ToString()));
        s += "\r\n";
    }
    //tbBlockRcv.AppendText(s);
    //this.Invoke(new MethodInvoker(delegate () { textBox1.AppendText(s); }));

    //Write the command into the EPTReceiveDevice
    c = (uint)receiveBytes[0];
    c = c & 0xf8;

    //Write the address into EPTReceiveDevice
    a = (uint)receiveBytes[0];
    a = a & 0x07;
    EPTReceiveDevice.Address = a;
    //Display Address to text box
    string r = String.Empty;
    r += String.Format("EPTReceiveDevice Address= {0:x2}", EPTReceiveDevice.Address);
    r += "\r\n";
    //this.Invoke(new MethodInvoker(delegate () { textBox1.AppendText(r); }));

    switch (c)
    {
        case 0xc8:
            //this.Invoke(new MethodInvoker(delegate () { textBox1.AppendText("Trigger Recieved\r\n"); }));
            EPTReceiveDevice.Command = TRIGGER_IN_COMMAND;
            break;
        case 0xd0:
            //this.Invoke(new MethodInvoker(delegate () { textBox1.AppendText("Transfer Byte Recieved\r\n"); }));
            EPTReceiveDevice.Command = TRANSFER_IN_COMMAND;
            break;
        case 0xe0:
            //this.Invoke(new MethodInvoker(delegate () { textBox1.AppendText("Block Recieved\r\n"); }));
            EPTReceiveDevice.Command = BLOCK_IN_COMMAND;

            l = (uint)receiveBytes[1];
            EPTReceiveDevice.Length = l;
            //Display Length to text box
            string n = String.Empty;
            n += String.Format("EPTReceiveDevice Length = {0:x2}", EPTReceiveDevice.Length);
            n += "\r\n";
            //this.Invoke(new MethodInvoker(delegate () { textBox1.AppendText(n); }));
    }
}

```

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```

        n += string.Format("EPTReceiveDevice Length = {0:x2}", EPTReceiveDevice.Length);
        n += "\r\n";

        EPTReceiveDevice.cBlockBuf = new byte[EPTReceiveDevice.Length];
        //this.Invoke(new MethodInvoker(delegate () { textBox1.AppendText(n); }));
        for (index = 2; index <= EPTReceiveDevice.Length+1; index++)
        {
            EPTReceiveDevice.cBlockBuf[index - 2] = receiveBytes[index];
        }
        //Once EPTReceiveDevice has been populated, call the Receive Parser function
        EPTParseReceive();
        return;
    //break;
    default:
        //this.textBox1.AppendText(text);
        break;
    }

    //Write the payload into EPTReceiveDevice
    p = (uint)receiveBytes[1];
    EPTReceiveDevice.Payload = p;
    //Display Payload to text box
    string q = String.Empty;
    q += String.Format("EPTReceiveDevice Payload = {0:x2}", EPTReceiveDevice.Payload);
    q += "\r\n";

    //this.Invoke(new MethodInvoker(delegate () { textBox1.AppendText(q); }));

    //Once EPTReceiveDevice has been populated, call the Receive Parser function
    EPTParseReceive();
}

//-----
// The Following Section of Visual Studio Code sends
// Triggers, Bytes and Block data to the EPT Device
//-----
5 references
private void EPT_AH_SendTrigger(byte trigger_value)
{
    PutBuff = new byte[1];

    // Load element 0 with the command.
    PutBuff[0] = (byte)(OUT_CONTROL_WORD + TRIGGER_OUT_COMMAND + 0x00);
    //Send byte to COM Port
    serialPort_AH.Write(PutBuff, 0, 1);
}

```

This object holds the command, address and payload for the transfer. Once the object is populated, the function calls the EPTParseReceive() function.

### 5.4.3 Active Host Triggers

The user application can send a trigger to the FPGA by using the EPT\_AH\_SendTrigger() function. First, open the EPT device to be used with openSerialPort1(). Call the function with the bit or bits to assert high on the trigger byte as the parameter. Then execute the function, the trigger bit or bits will momentarily assert high in the user code on the FPGA.



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```
private void btnTrigger1_Click(object sender, EventArgs e)
{
    EPT_AH_SendTrigger((char) 1);
}
```

To detect a trigger from the FPGA, the user application will set up functions in the `EPTParseReceive()` function. A switch statement is used to decode which event should be called to handle the incoming received data.

- TRIGGER\_IN
- TRANSFER\_IN
- BLOCK\_IN

```
private void EPTParseReceive(object sender, System.EventArgs e)
{
    switch (EPTReceiveData.Command)
    {
        case TRIGGER_OUT_COMMAND:
            TriggerOutReceive();
            break;
        case TRANSFER_OUT_COMMAND:
            TransferOutReceive();
            break;
        case BLOCK_OUT_COMMAND:
            BlockOutReceive();
            break;
        default:
            break;
    }
}
```

The event handler function for the TRIGGER\_IN's uses a switch statement to determine which trigger was asserted and what to do with it.

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```
public void Receive_Trigger_In(object sender, EventArgs e)
{
    switch (ept_data.Payload)
    {
        case 0x01:
            lLabelSwitch1.Text = "Switch 1\n Pressed";
            break;
        case 0x02:
            lLabelSwitch2.Text = "Switch 2\n Pressed";
            break;
        case 0x04:
            lLabelSwitch1.Text = "";
            lLabelSwitch2.Text = "";
            break;
    }
}
```

### 5.4.4 Active Host Byte Transfers

The Active Host Byte Transfer EndTerm is designed to send/receive one byte to/from the EPT Device. To send a byte to the Device, the appropriate address must be selected for the Transfer module in the FPGA. Up to eight modules can be instantiated in the user code on the FPGA. Each module has its own address.

```
private void btnWriteByte_Click(object sender, EventArgs e)
{
    int ibyte, address_to_device;
    ibyte = Convert.ToInt32(tbNumBytes.Text);
    address_to_device = Convert.ToInt32(tbAddress.Text);
    EPT_AH_SendByte(address_to_device, (char)ibyte);
}
```

Use the function EPT\_AH\_SendByte() to send a byte the selected module. Then add the address of the transfer module as the first parameter of the EPT\_AH\_SendByte() function. Enter the byte to be transferred in the second parameter. Then execute the function, the byte will appear in the ports of the Active Transfer module in the user code on the FPGA.

To transfer data from the FPGA Device, a polling technique is used. This polling technique is because the Bulk Transfer USB is a Host initiated bus. The Device will not transfer any bytes until the Host commands it to. If the Device has data to send to the Host in an asynchronous manner (meaning the Host did not command the Device to send data), the Host must periodically check the Device for data in it's transmit FIFO. If



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data exists, the Host will command the Device to send it's data. The received data is then stored into local memory and register bits are set that will indicate data has been received from a particular address.

To receive a byte transfer from the Active host, user code must subscribe to the event created when the incoming byte transfer has arrived. A switch statement is used to decode which event should be called to handle the incoming received data. The event handler function will check for any bytes read for that address.

```
private void EPTParseReceive(object sender, System.EventArgs e)
{
    switch (EPTReceiveData.Command)
    {
        case TRIGGER_OUT_COMMAND:
            TriggerOutReceive();
            break;
        case TRANSFER_OUT_COMMAND:
            TransferOutReceive();
            break;
        case BLOCK_OUT_COMMAND:
            BLockOutReceive();
            break;
        default:
            break;
    }
}
```

The EventHandler function EPTParseReceive() is called by the Read Callback function. The EPTParseReceive() function will examine the command of the incoming byte transfer and determine which receive function to call.

```
public void TransferOutReceive()
{
    string WriteRcvChar = "";
    WriteRcvChar = String.Format("{0}", (int)EPTReceiveData.Payload);
    tbDataBytes.AppendText(WriteRcvChar + ' ');
    tbAddress.Text = String.Format("{0:x2}", (uint)System.Convert.ToUInt32(EPTReceiveData.Address.ToString()))
}
```

For our example project, the TransferOutReceive() function writes the Transfer byte received to a text block. The receive callback method is complex, however, Earth People Technology has created several projects which implement callbacks. Any part of these sample projects can copied and pasted into a user's project.



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#### **5.4.5 Active Host Block Transfers**

The Active Host Block Transfer is designed to transfer blocks of data between Host and FPGA and vice versa through the Block EndTerm. This allows buffers of data to be transferred with a minimal amount of code. The Active Host Block module (in the User Code) is addressable, so up to eight individual modules can be instantiated and separately addressed. The length of the block to be transferred must also be specified. The Block EndTerm is limited to 1 to 256 bytes.

To send a block, first, open the EPT device to be used with `openSerialPort1()`, transfer module as the first parameter. Next, place the pointer to the buffer in the second parameter of `EPT_AH_SendBlock()`. Add the length of the buffer as the third parameter. Then execute the function, the entire buffer will be transferred to the USB chip. The data is available at the port of the Active Block module in the user code on the FPGA.



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```
public unsafe void BlockCompare(object data)
{
    int BlockAddress = (int)data;
    byte[] cBuf = new Byte[device[BlockAddress].Length];

    if ((device[BlockAddress].Repetitions > 0) &
        !device[BlockAddress].TransferPending & !BlockTransferStop)
    {
        device[BlockAddress].TransferPending = true;
        Buffer.BlockCopy(block_8_in_payload, 0, cBuf, 0,
            device[BlockAddress].Length);
        fixed (byte* pBuf = cBuf)
        {
            EPT_AH_SendBlock(device[BlockAddress].Address,
                (void*)pBuf, (uint)device[BlockAddress].Length);
        }
        Thread.Sleep(1);
        EPT_AH_SendTransferControlByte((char)2, (char)2);
        Thread.Sleep(1);
        EPT_AH_SendTrigger((char)128);
        Thread.Sleep(1);
        EPT_AH_SendTransferControlByte((char)2, (char)0);

        if (BlockTransferInfinite)
            device[BlockAddress].Repetitions = 1;
        else
            device[BlockAddress].Repetitions--;
    }
}
```

To receive a block transfer from the FPGA Device, a polling technique is used by the Active Host dll. This is because the Bulk Transfer USB is a Host initiated bus. The Device will not transfer any bytes until the Host commands it to. If the Device has data to send to the Host in an asynchronous manner (meaning the Host did not command the Device to send data), the Host must periodically check the Device for data in its transmit FIFO. If data exists, the Host will command the Device to send its data. The received data is then stored into local memory and register bits are set that will indicate data has been received from a particular address. The receive callback function is then called from the Active Host dll. This function start a thread to do something with the block data.

To receive a byte transfer from the callback function, user code must subscribe to the event created when the incoming byte transfer has arrived at the Read Callback function. The Read Callback must store the incoming transfer payload and module



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address in a local memory block. A switch statement is used to decode which event should be called to handle the incoming received data. The event handler function will check for any bytes read for that address.

```
private void EPTParseReceive(object sender, System.EventArgs e)
{
    switch (EPTReceiveData.Command)
    {
        case TRIGGER_OUT_COMMAND:
            TriggerOutReceive();
            break;
        case TRANSFER_OUT_COMMAND:
            TransferOutReceive();
            break;
        case BLOCK_OUT_COMMAND:
            BLockOutReceive();
            break;
        default:
            break;
    }
}
```

The EventHandler function EPTParseReceive() is called by the Read Callback function. The EPTParseReceive() function will examine the command of the incoming byte transfer and determine which receive function to call.



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```
public void Receive_Block_In(object sender, EventArgs e)
{
    device[ept_data.Address].TransferPending = false;
    Thread.Sleep(5);
    if (device[ept_data.Address].ContinuosCountTest == false)
    {
        Thread t = new Thread(new ParameterizedThreadStart(BlockCompare));
        t.Start(ept_data.Address);
    }
    if (device[ept_data.Address].Repititions == 0)
    {
        Thread u = new Thread(new ParameterizedThreadStart(Display_Block_In));
        u.Start(BlockCount);
    }
    else if (BlockTransferInfinite | device[ept_data.Address].ContinuosCountTest)
    {
        if ((BlockCount % 100) == 0)
        {
            Thread u = new Thread(new ParameterizedThreadStart(Display_Block_In));
            u.Start(BlockCount);
        }
    }
}
```

For our example project, the `Receive_Block_In()` function writes the Transfer block received to a text block. The receive callback method is complex, however, Earth People Technology has created several projects which implement callbacks. Any part of these sample projects can be copied and pasted into a user's project.

## 6 Assembling, Building, and Executing a .NET Project on the PC

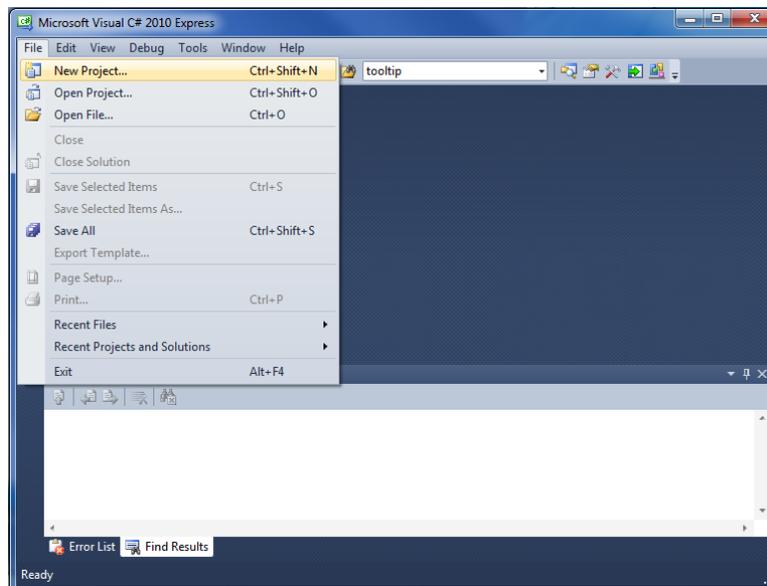
The Active Host Application DLL is used to build a custom standalone executable on the PC that can perform Triggers and Transfer data to/from the DueProLogic. A standalone project can range from a simple program to display and send data from the user to/from the Arduino Due. Or it can be more complex to include receiving data, processing it, and start or end a process on the Arduino. This section will outline the procedures to take an example project and Assemble it, Build it, and Execute it. This guide will focus on writing a Windows Forms application using the C# language for the Microsoft Visual Studio with .NET Framework. This is due to the idea that beginners can write effective Windows applications with the C# .NET Framework. They can focus on a subset of the language which is very similar to the C language. Anything that deviates from the subset of the C language, presented as in the Arduino

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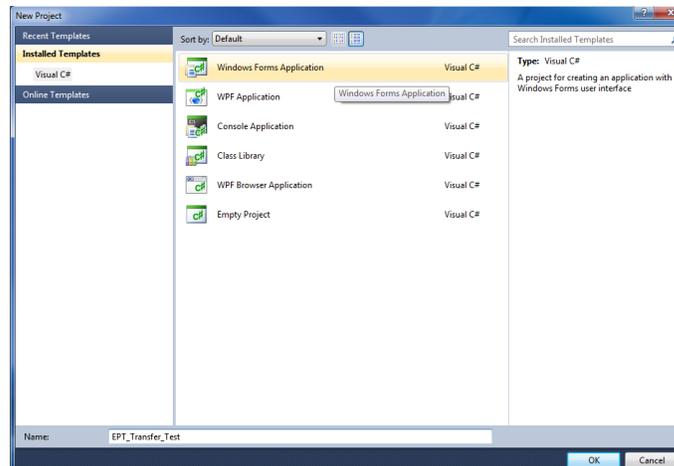
implication (such as events and controls), will be explained as the explanation progresses. Any language can be used with the Active Host Application DLL.

### 6.1 Creating a Project

Once the application is installed, open it up. Click on File->New Project.

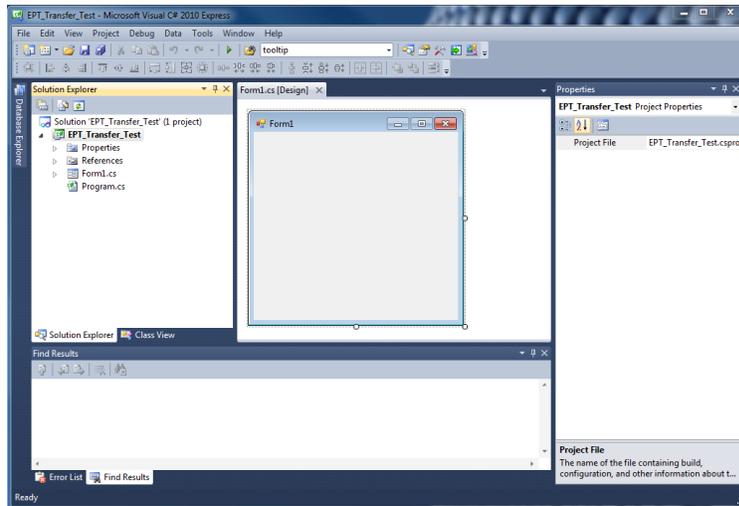


At the New Project window, select the Windows Forms Application. Then, at the Name: box, type in EPT\_Transfer\_Demo

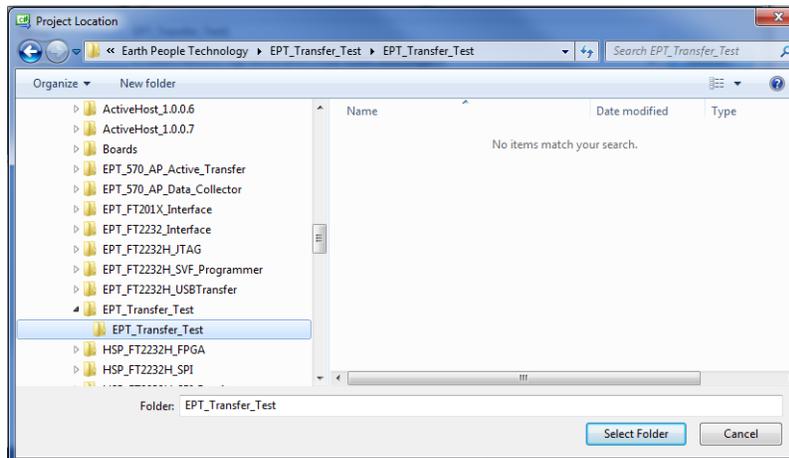


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The project creation is complete.



Save the project, go to File->Save as, browse to a folder to create EPT\_Transfer\_Demo folder. The default location is c:\Users\<<Users Name>\documents\visual studio 2010\Projects.



### 6.1.1 Setting up the C# Express Environment x64 bit

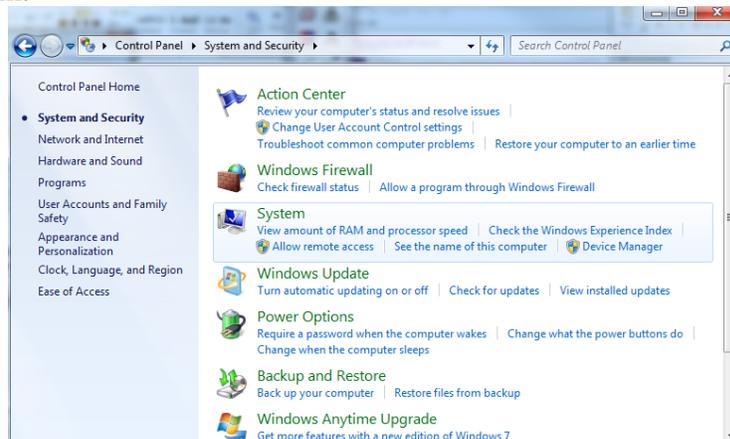
The project environment must be set up correctly in order to produce an application that runs correctly on the target platform. If your system supports 64 bit operation, perform the following steps. Otherwise if your system is 32 bit skip to the Section, Assembling Files into the Project. Visual C# Express defaults to 32 bit operation. If you are unsure

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if your system supports, you can check it by going to Start->Control Panel->System and Security->System

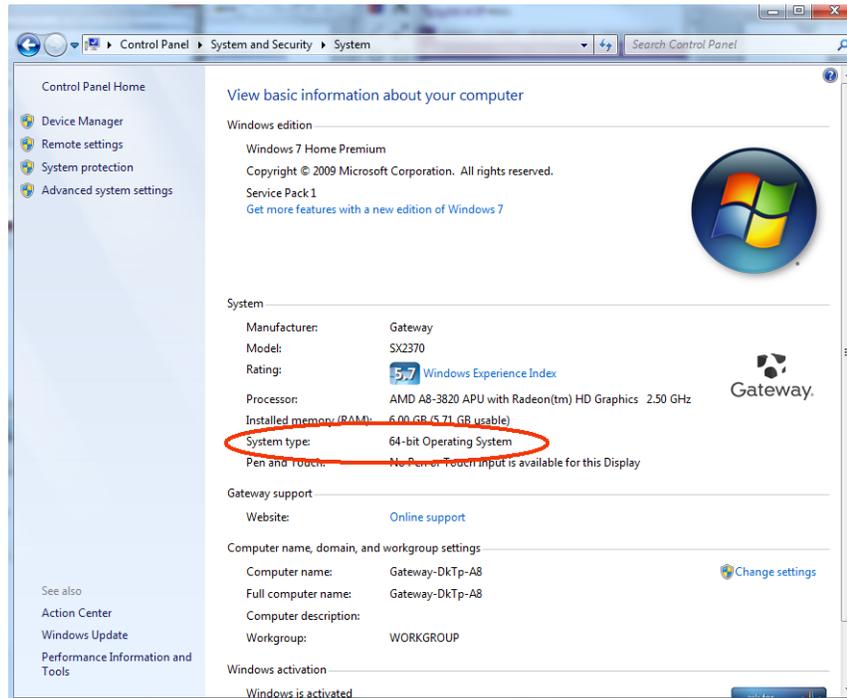


Click on System.

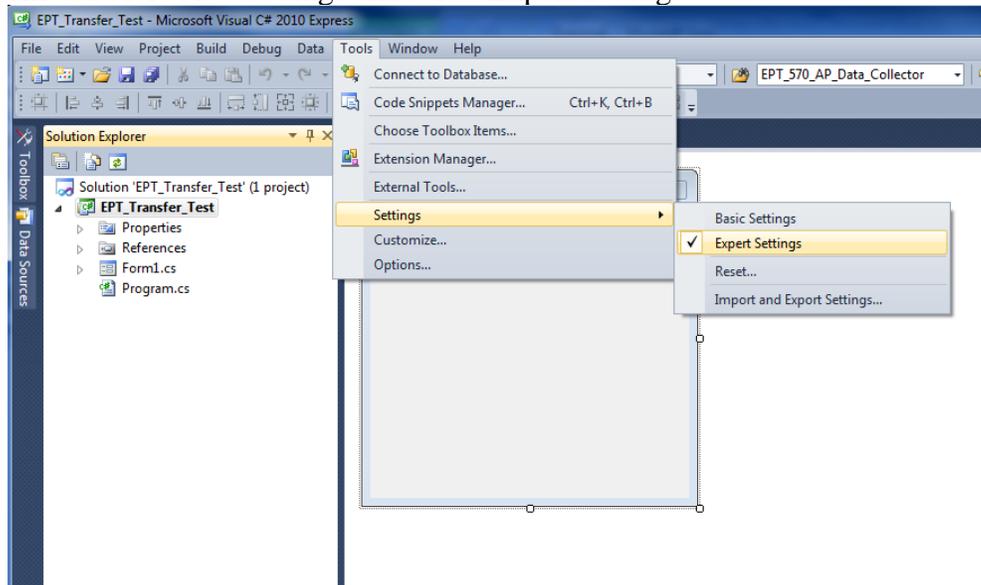


Check under System\System type:

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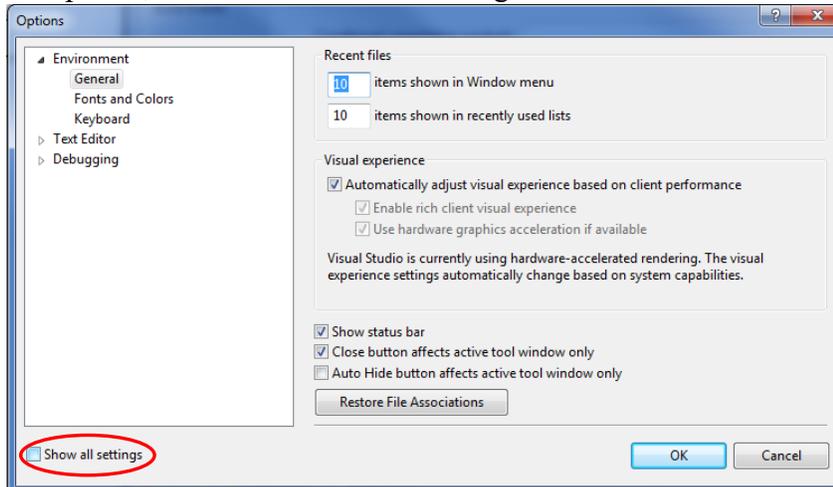


First, we need tell C# Express to produce 64 bit code if we are running on a x64 platform. Go to Tools->Settings and select Expert Settings

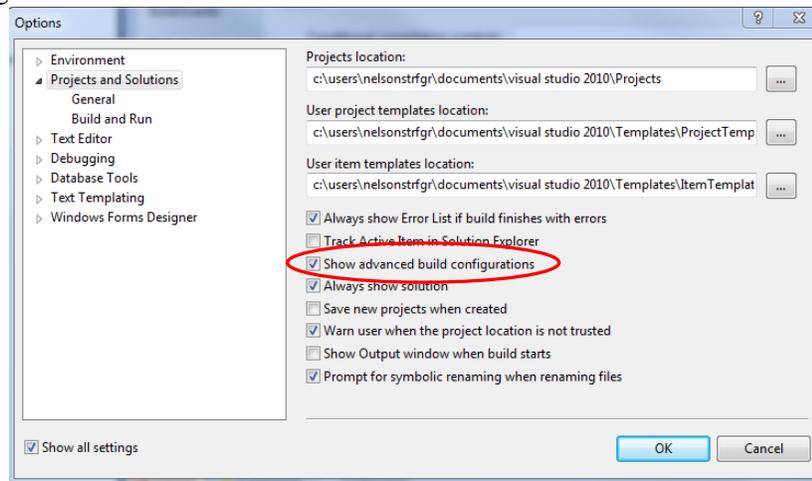


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Go to Tools->Options, locate the “Show all settings” check box. Check the box.

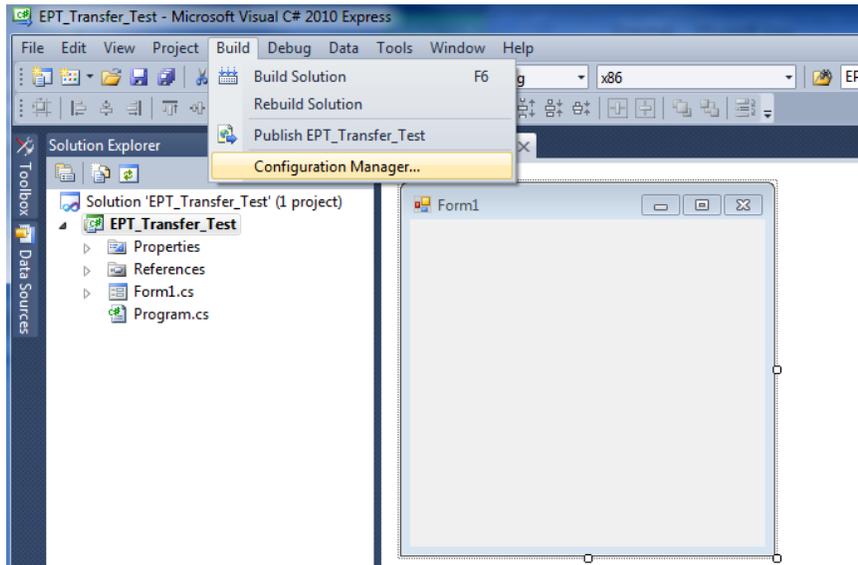


In the window on the left, go to “Projects and Solutions”. Locate the “Show advanced build configurations” check box. Check the box.

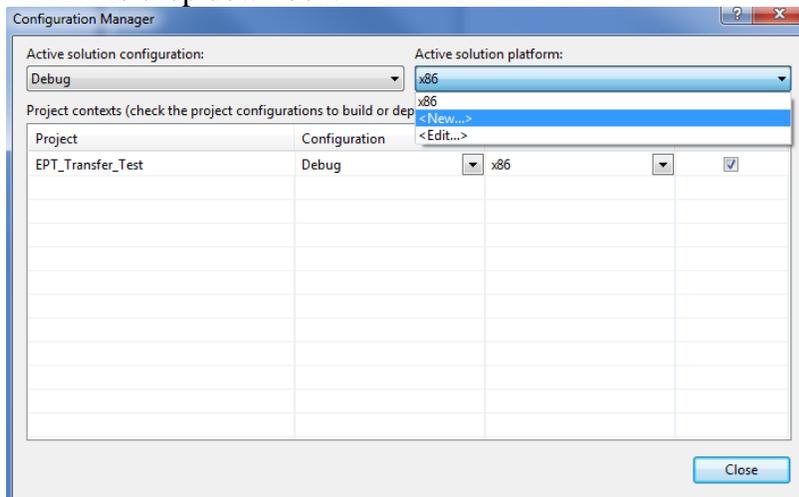


Go to Build->Configuration Manager.

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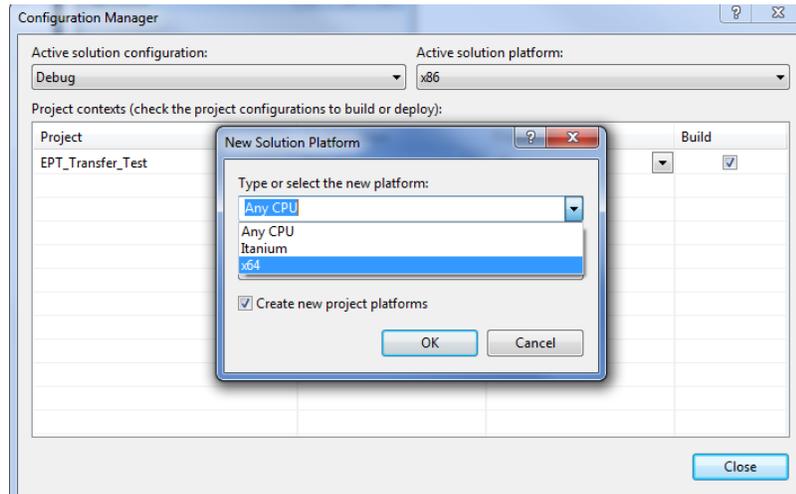


In the Configuration Manager window, locate the “Active solution platform:” label, select “New” from the drop down box.

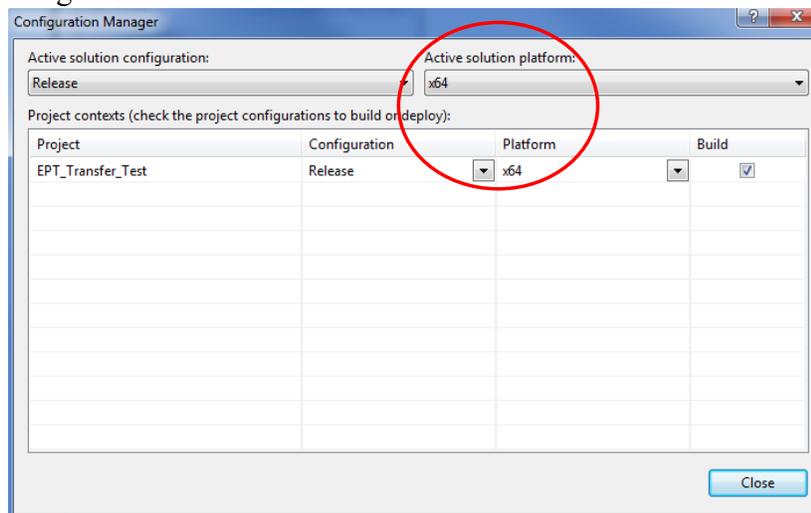


In the New Solution Platform window, click on the drop down box under “Type or select the new platform:”. Select “x64”.

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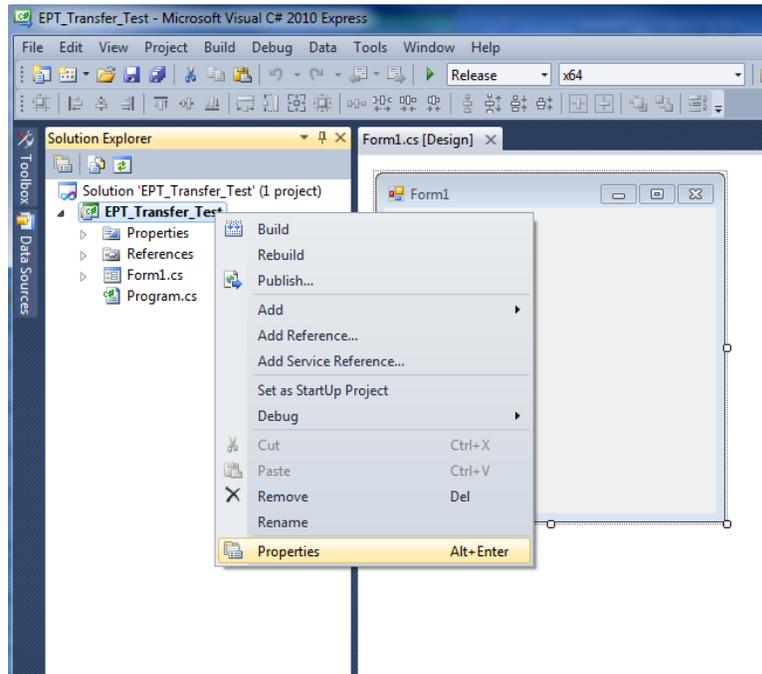


Click the Ok button. Verify that the “Active Solution Platform” and the “Platform” tab are both showing “x64”.

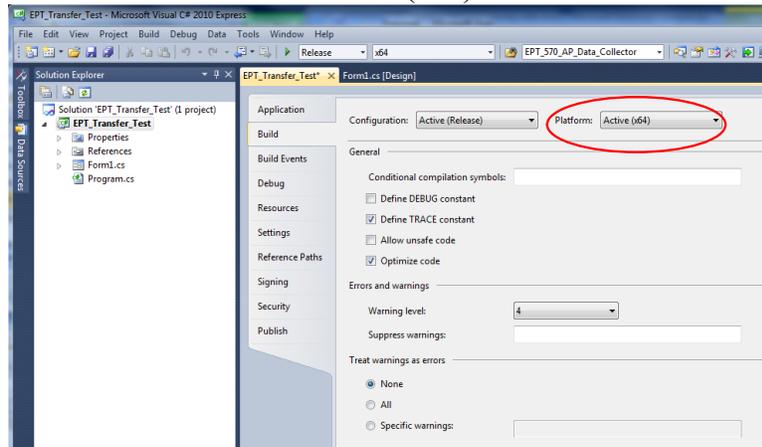


Also, select “Release” under “Active solution configuration”. Click Close. Then, using the Solution Explorer, you can right click on the project, select Properties and click on the Build tab on the right of the properties window.

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Verify that the “Platform:” label has “Active (x64)” selected from the drop down box.



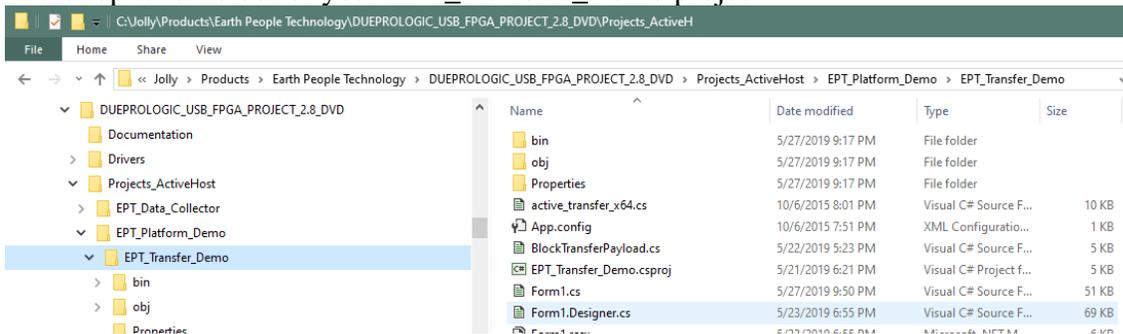
Click on the Save All button on the tool bar. The project environment is now setup and ready for the project files. Close the Project.



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### 6.2 Assembling Files into the Project

Locate the EPT FPGA Development System DVD installed on your PC. Browse to the EPT\_Platform\_Demo folder where the Project files, copy the \*.cs files, and install them in the top level folder of your EPT\_Platform\_Demo project.



#### 6.2.1 Changing Project Name

\*\*\*NOTE\*\*\*

If you named your project something other than EPT\_Platform\_Demo, you will have to make changes to the \*.cs files above. This is because Visual C# Express links the project files and program files together. These changes can be made by modifying the following:

1. Change namespace of Form1.cs to new project name.
2. Change class of Form1.cs to new project name.
3. Change constructor of Form1.cs to new project name.

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```
1  using System;
2  using System.Collections.Generic;
3  using System.ComponentModel;
4  using System.Data;
5  using System.Drawing;
6  using System.Linq;
7  using System.Text;
8  using System.Threading.Tasks;
9  using System.Windows.Forms;
10
11 namespace EPT_Platform_Demo
12 {
13     public partial class Form1 : Form
14     {
15         public Form1()
16         {
17             InitializeComponent();
18         }
19     }
20 }
21
```

4. Change EPT\_Transfer\_Demo\_Load of Form1.cs to new <project name>\_Load

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```

using System.Runtime.InteropServices;
using System.Diagnostics;

namespace EPT_Platform_Demo
{
    public partial class EPT_Platform_Demo : Form
    {
        public EPT_Platform_Demo()
        {
            InitializeComponent();
        }

        // Main object loader
        private void EPT_Transfer_Demo_Load(object sender, System.EventArgs e)
        {
            // Call the List Devices function
            ListDevices();
        }
    }
}

```

5. Change namespace of Form1.Designer.cs to new project name.
6. Change class of Form1.Designer.cs to new project name.

```

namespace EPT_Platform_Demo
{
    partial class EPT_Platform_Demo
    {
        /// <summary>
        /// Required designer variable.
        /// </summary>
        private System.ComponentModel.IContainer components = null;

        /// <summary>
        /// Clean up any resources being used.
        /// </summary>
        /// <param name="disposing">true if managed resources should be disposed;
        protected override void Dispose(bool disposing)
        {
            if (disposing && (components != null))
            {
                components.Dispose();
            }
            base.Dispose(disposing);
        }
    }
}

```

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7. Change the this.Name and this.Text in Form1Designer.cs to new project name.
8. Change this.Load in Form1Designer.cs to include new project name.

```

this.Controls.Add(this.btnOK);
this.Controls.Add(this.btnCloseDevice);
this.Controls.Add(this.btnOpenDevice);
this.Controls.Add(this.gbTransferControl);
this.Controls.Add(this.groupBox1);
this.Controls.Add(this.gbTriggerOut);
this.Name = "EPT Platform Demo";
this.Text = "EPT Platform Demo";
this.Load += new System.EventHandler(this.EPT_Platform_Demo_Load);
this.gbTriggerOut.ResumeLayout(false);
this.gbTriggerOut.PerformLayout();
this.gbTransferControl.ResumeLayout(false);
this.gbTransferControl.PerformLayout();
this.groupBox1.ResumeLayout(false);
this.groupBox1.PerformLayout();
this.LEDBox.ResumeLayout(false);
this.LEDBox.PerformLayout();
((System.ComponentModel.ISupportInitialize)(this.trkbrTimer)).EndInit();

```

9. Change namespace in Program.cs to new project name
10. Change Application.Run() in Program .cs to new projectname.

```

using System;
using System.Collections.Generic;
using System.Linq;
using System.Windows.Forms;

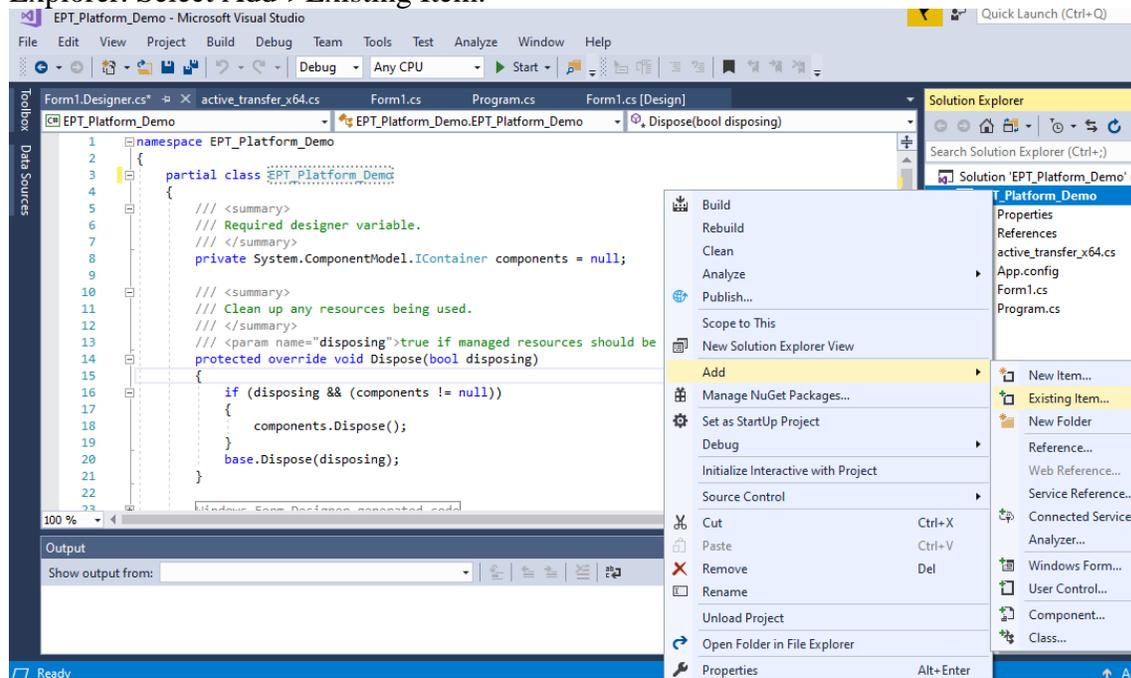
namespace EPT_Transfer_Demo
{
    static class Program
    {
        /// <summary>
        /// The main entry point for the application.
        /// </summary>
        [STAThread]
        static void Main()
        {
            Application.EnableVisualStyles();
            Application.SetCompatibleTextRenderingDefault(false);
            Application.Run(new EPT_Transfer_Demo());
        }
    }
}

```

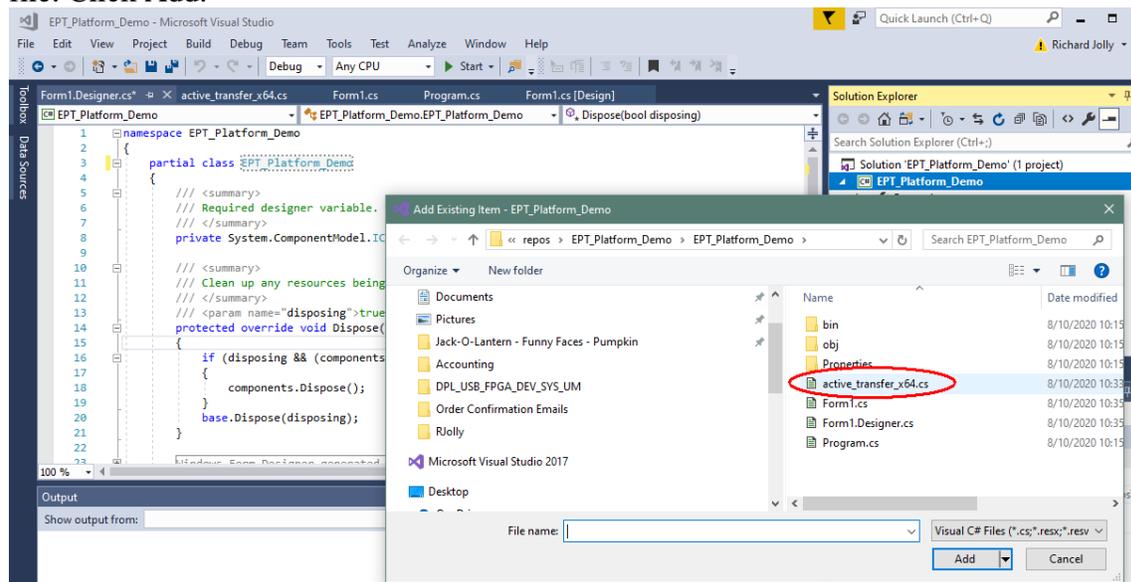
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### 6.2.2 Add Files to Project

Open the EPT\_Platform\_Demo project. Right click on the project in the Solutions Explorer. Select Add->Existing Item.

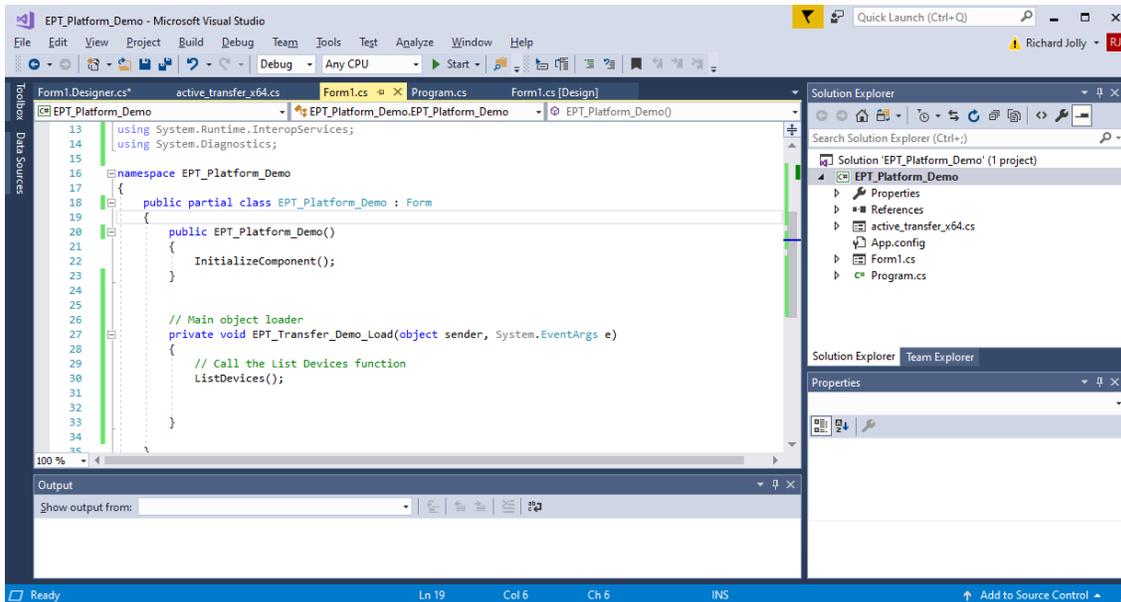


Browse to the EPT\_Platform\_Demo project folder and select the active\_transfer\_64.cs file. Click Add.



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In the C# Express Solution Explorer, you should be able to browse the files by clicking on them. There should be no errors noted in the Error List box.



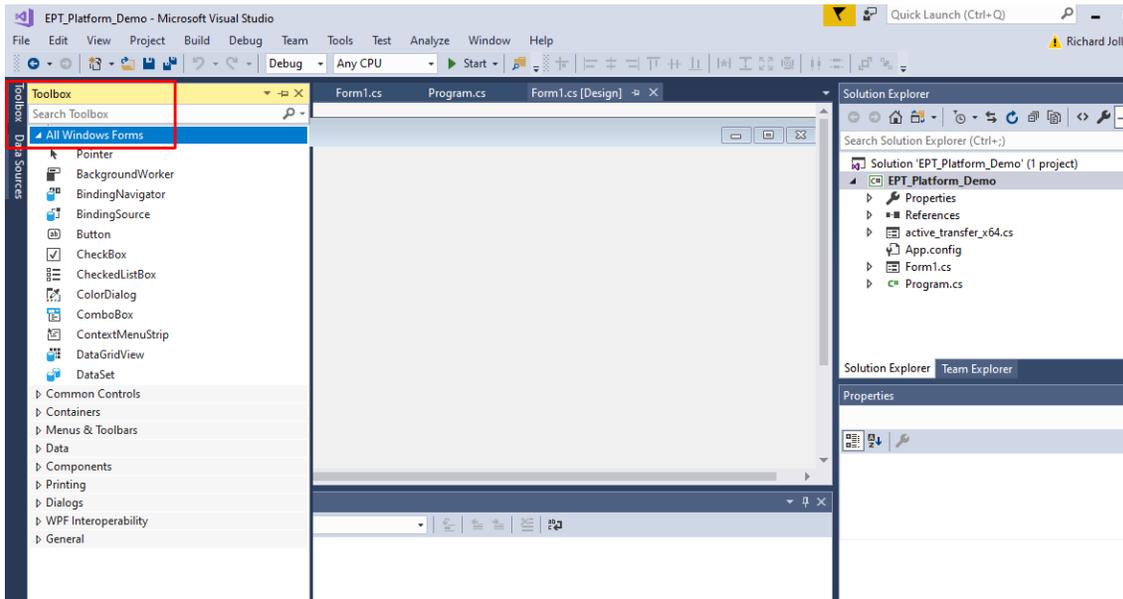
### 6.2.3 Adding Controls to the Project

Although, the C# language is very similar to C Code, there are a few major differences. The first is C# .NET environment is event based. A second is C# utilizes classes. This guide will keep the details of these items hidden to keep things simple. However, a brief introduction to events and classes will allow the beginner to create effective programs.

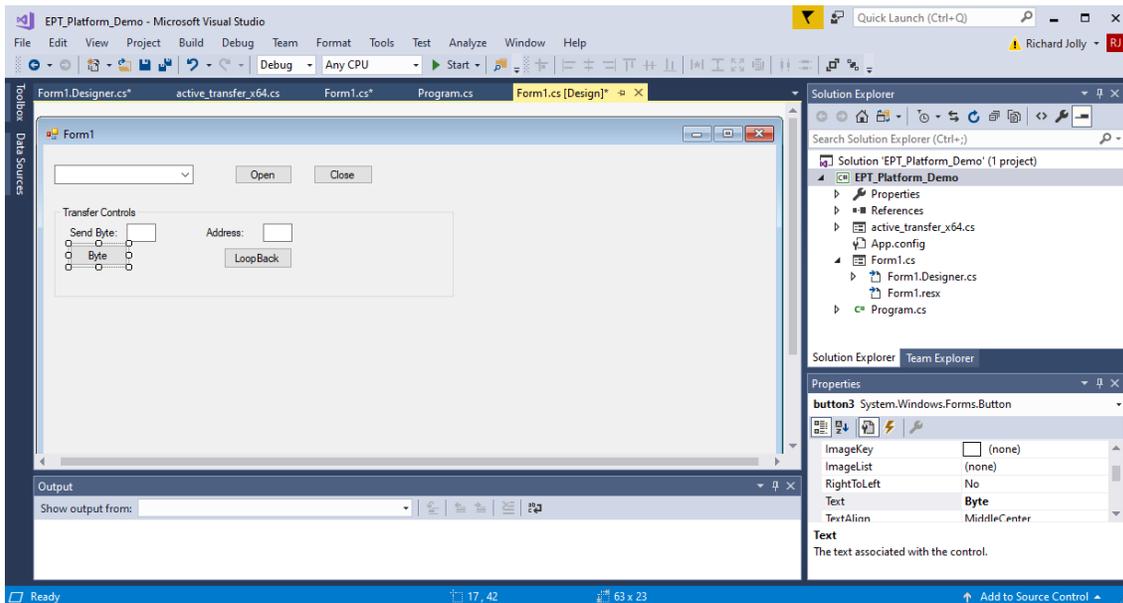
Event based programming means the software responds to events created by the user, a timer event, external events such as serial communication into PC, internal events such as the OS, or other events. The events we are concerned with for our example program are user events and the timer event. The user events occur when the user clicks on a button on the Windows Form or selects a radio button. We will add a button to our example program to show how the button adds an event to the Windows Form and a function that gets executed when the event occurs.

The easiest way to add a button to a form is to double click the Form1.cs in the Solution Explorer. Click on the  button to launch the Toolbox.

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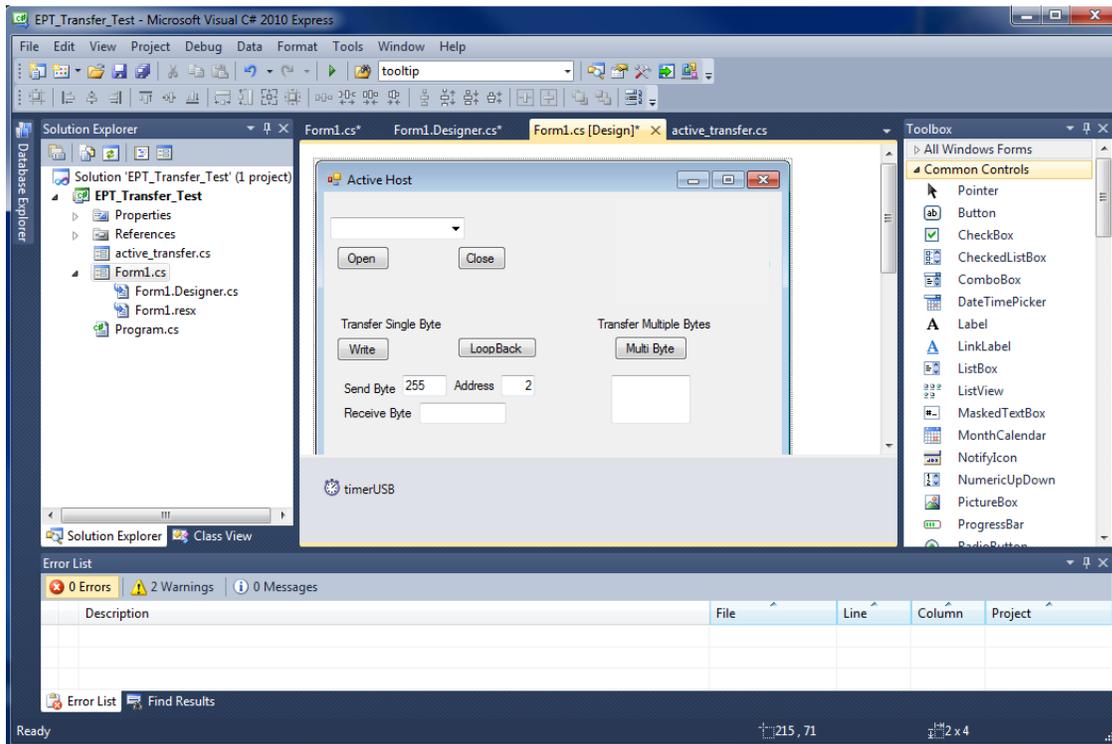


Locate the button on the Toolbox, grab and drag the button onto the Form1.cs [Design] and drop it near the top.



Go to the Properties box and locate the (Name) cell. Change the name to “btnOpenDevice”. Locate the Text cell, and change the name to Open.

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Double click on the Open button. The C# Explorer will automatically switch to the Form1.cs code view. The callback function will be inserted with the name of the button along with “\_click” appended to it. The parameter list includes (object sender, System.EventArgs e). These two additions are required for the callback function to initiate when the “click” event occurs.

Private void btnOpenDevice\_click(object sender, System.EventArgs e)

There is one more addition to the project files. Double click on the Form1.Designer.cs file in the Solution Explorer. Locate the following section of code.

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```
//  
// btnOpenDevice  
//  
this.btnOpenDevice.Location = new System.Drawing.Point(240, 13);  
this.btnOpenDevice.Name = "btnOpenDevice";  
this.btnOpenDevice.Size = new System.Drawing.Size(50, 23);  
this.btnOpenDevice.TabIndex = 2;  
this.btnOpenDevice.Text = "Open";  
this.btnOpenDevice.UseVisualStyleBackColor = true;  
this.btnOpenDevice.Click += new System.EventHandler(this.btnOpenDevice_Click);
```

This code sets up the button, size, placement, and text. It also declares the “System.EventHandler()”. This statement sets the click method (which is a member of the button class) of the btnOpenDevice button to call the EventHandler – btnOpenDevice\_Click. This is where the magic of the button click event happens.

```
private void btnOpenDevice_Click(object sender, EventArgs e)  
{  
    //Open the Device  
    OpenDevice();  
}  
  
private void btnCloseDevice_Click(object sender, EventArgs e)  
{  
    if (EPT_AH_CloseDeviceByIndex(device_index) != 0)  
    {  
        btnBlkCompare8.Enabled = false;  
        btnBlkCompare16.Enabled = false;  
        btnTrigger1.Enabled = false;  
        btnTrigger2.Enabled = false;  
        btnTrigger3.Enabled = false;  
        btnTrigger4.Enabled = false;  
        btnLEDReset.Enabled = false;  
    }  
    btnOpenDevice.Enabled = true;  
    btnCloseDevice.Enabled = false;  
}
```

When btnOpenDevice\_Click is called, it calls the function “OpenDevice()”. This function is defined in the dll and will connect to the device selected in the combo box. This is a quick view of how to create, add files, and add controls to a C# project. The user is encouraged to spend some time reviewing the online tutorial at

<http://www.homeandlearn.co.uk/csharp/csharp.html>

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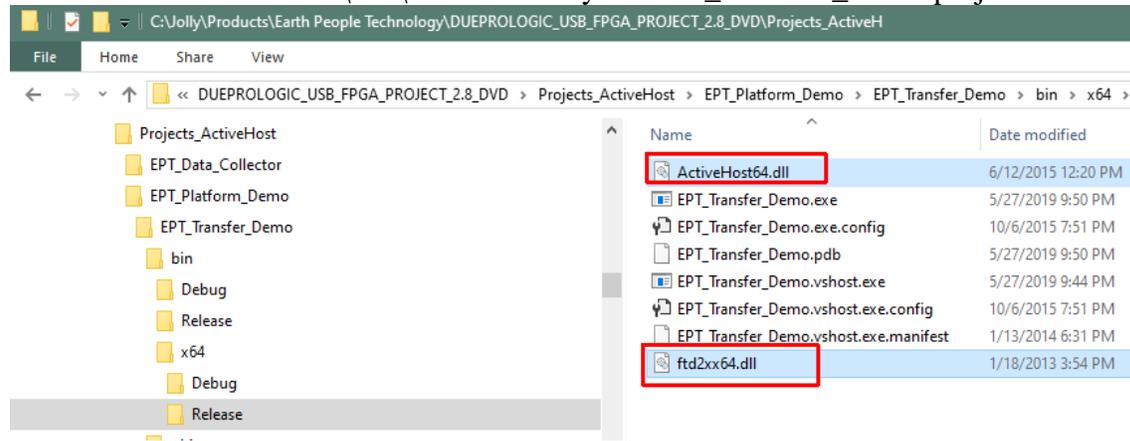
to become intimately familiar with Visual C# .NET programming. In the meantime, follow the examples from the Earth People Technology to perform some simple reads and writes to the EPT USB-FPGA Development System.

### 6.2.4 Adding the DLL's to the Project

Locate the EPT FPGA Development System DVD installed on your PC. Browse to the Projects\_ActiveHost folder. Open the Bin folder, copy the following files:

- ActiveHostXX.dll
- ftd2xxXX.dll

and install them in the bin\x64\x64 folder of your EPT\_Platform\_Demo project.

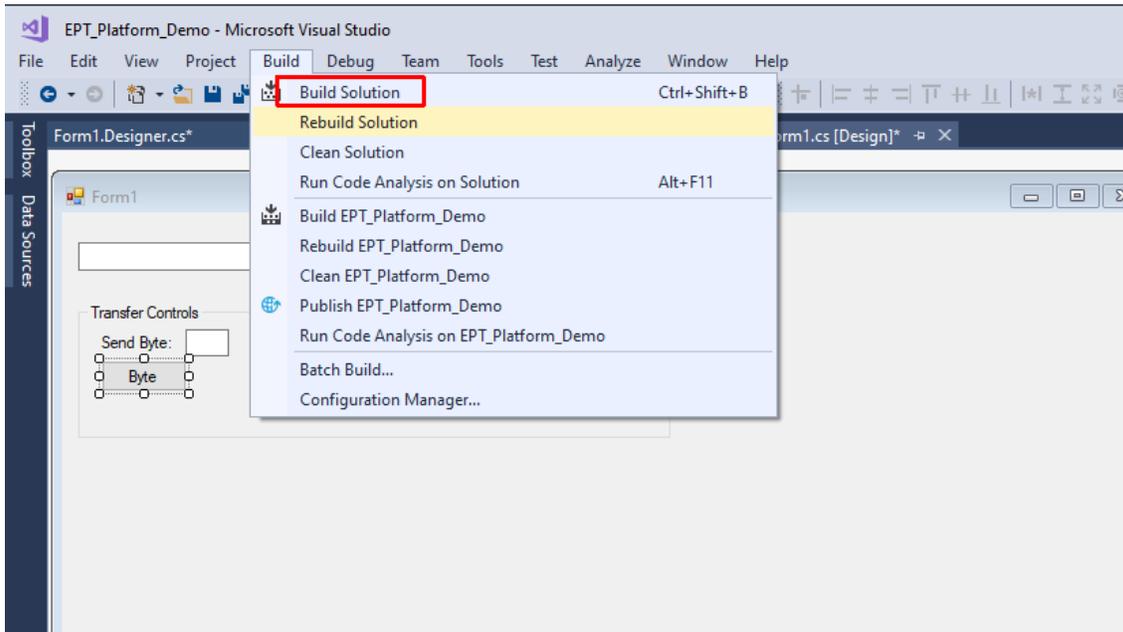


Save the project.

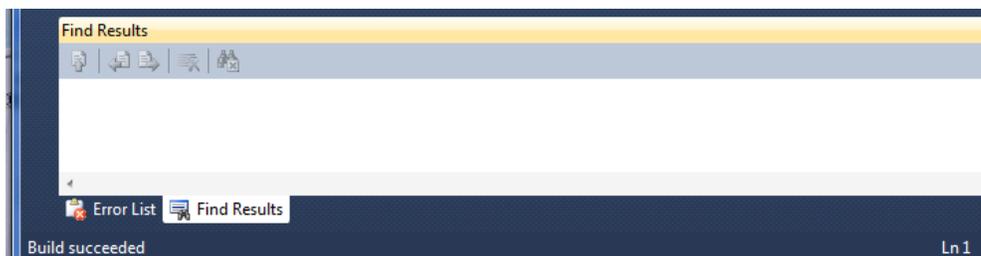
### 6.2.5 Building the Project

Building the EPT\_Platform\_Demo project will compile the code in the project and produce an executable file. To build the project, go to Debug->Build Solution.

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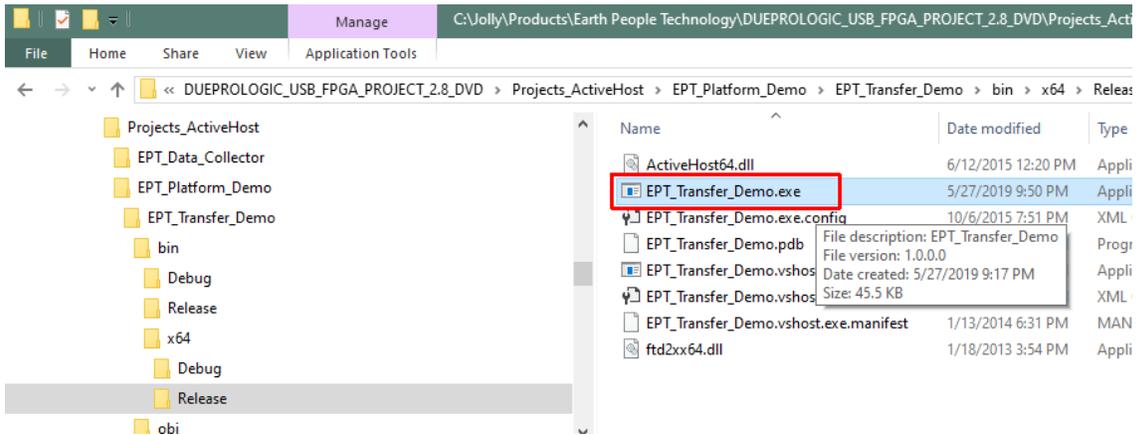
The C# Express compiler will start the building process. If there are no errors with code syntax, function usage, or linking, then the environment responds with “Build Succeeded”.



### 6.2.6 Testing the Project

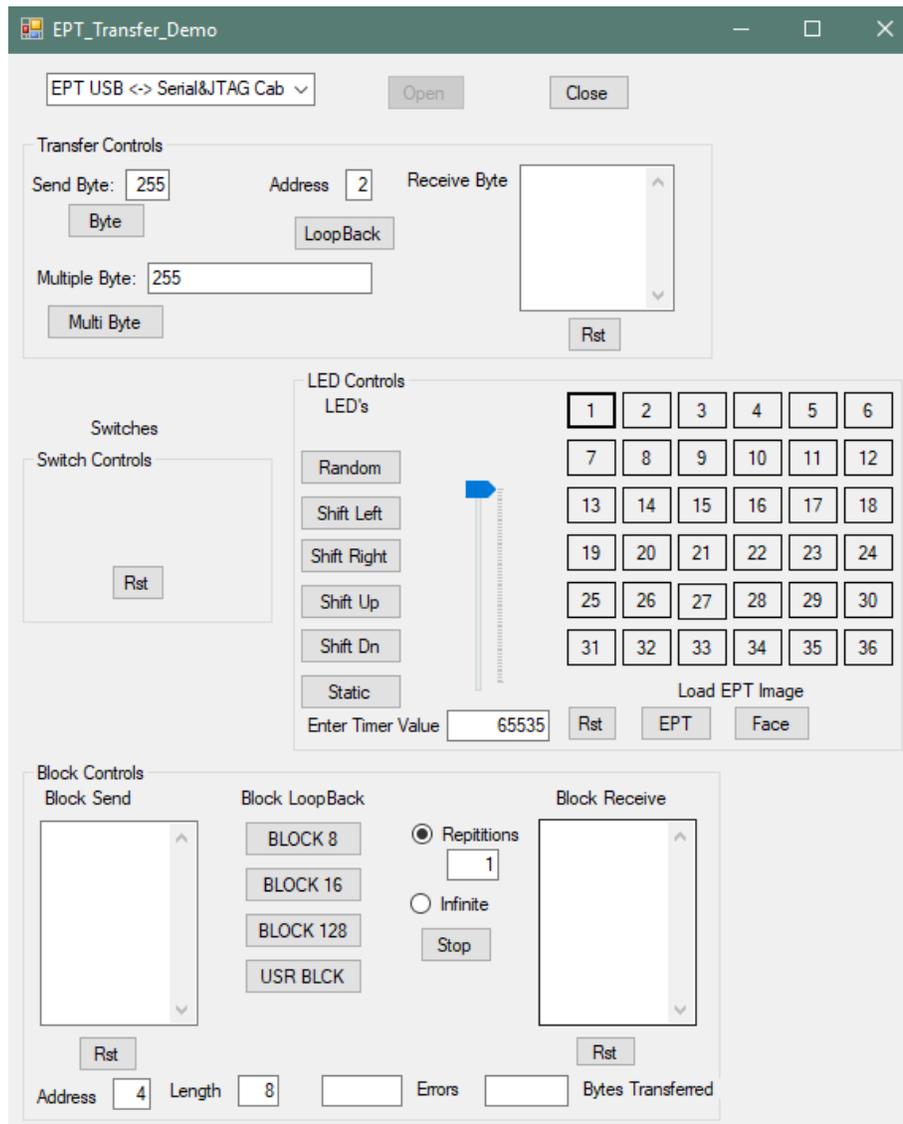
Once the project has been successfully built, it produces an \*.exe file. The file will be saved in the Release or Debug folders.

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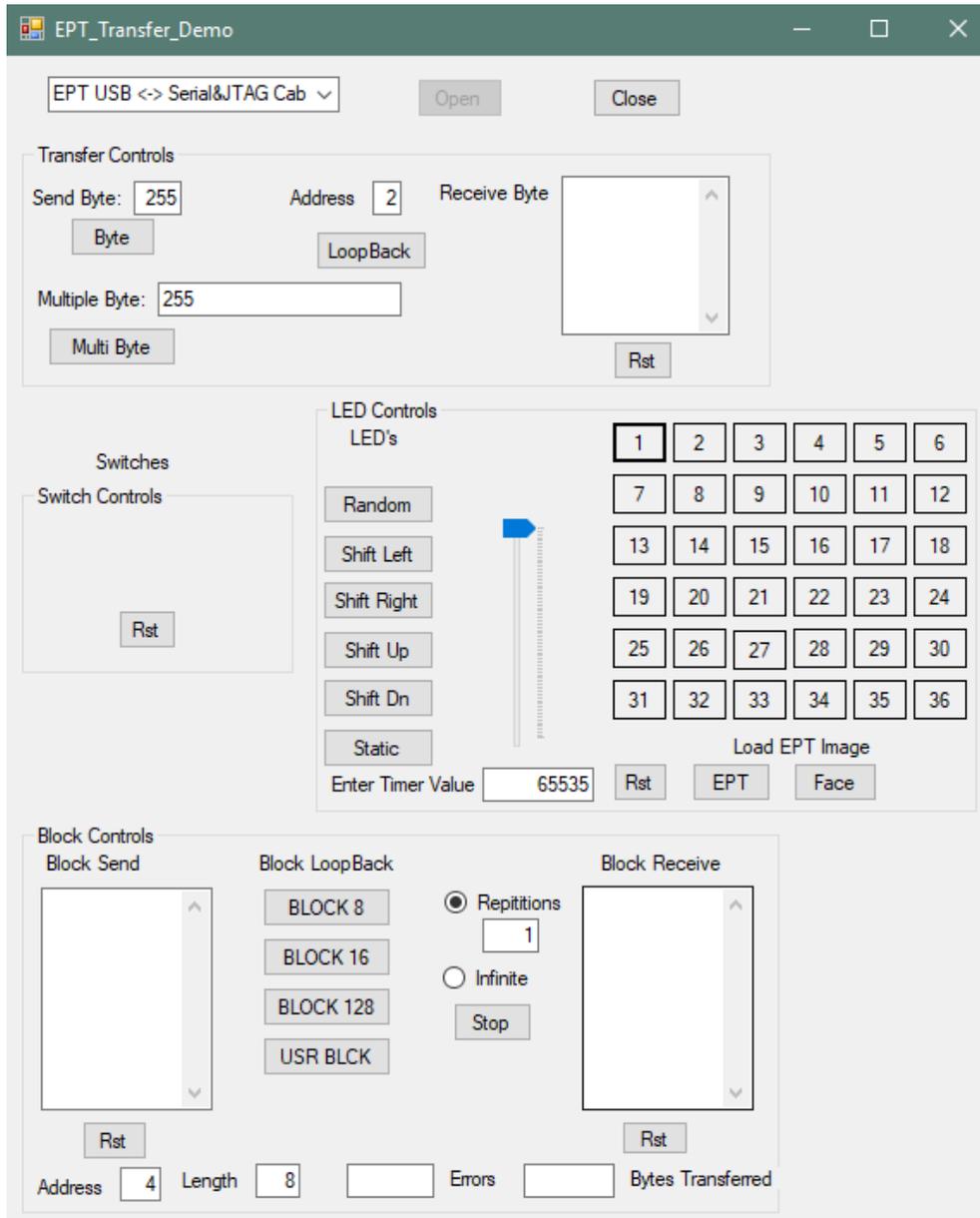
The EPT\_Platform\_Demo.exe file can now be tested using the DueProLogic board. To test the file, connect the DueProLogic to the Windows PC using Type A to Type Micro B USB cable. Make sure the driver for the board loads. If the USB driver fails to load, the Windows OS will indicate that no driver was loaded for the device. Go to the folder where the EPT\_Platform\_Demo.exe file resides, and double click on the file. The application should load with a Windows form.

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With the application loaded, select the USB-FPGA board from the dropdown combo box and click on the “Open” button.

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Click on one of the LED buttons in the middle of the window. The corresponding LED on the DueProLogic board should light up.

To exercise the Single Byte Transfer EndTerm, click the “LoopBack” button in the Transfer Controls group. Type in several numbers separated by a space and less 256



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into the Multiple Byte textbox. Then hit the Multi Byte button. The numbers appear in the Receive Byte textbox.