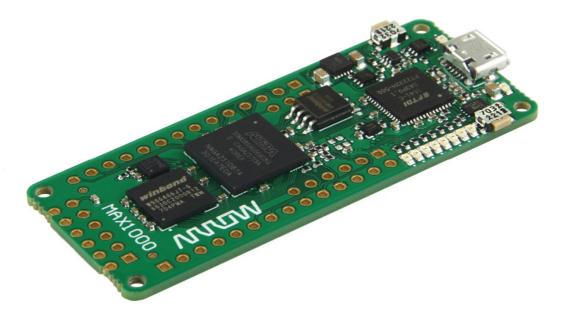
# MAX1000 User Guide



Please read the legal disclaimer at the end of this document.

**Revision 1.0** 

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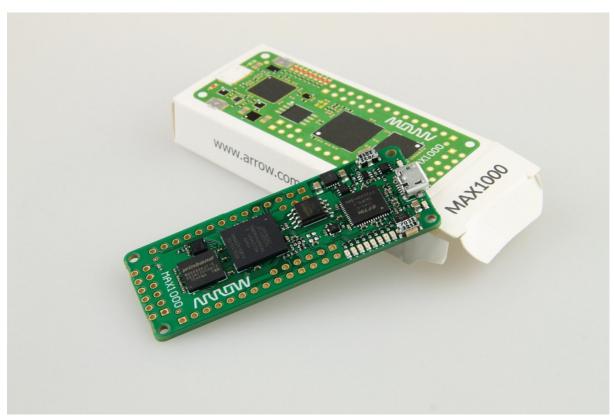
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### Chapter 1 - MAX1000 IoT / Maker Board

#### 1.1 About Arrow MAX1000 Board

The MAX1000 is a customizable IoT / Maker Board ready for evaluation, development and/or use in a product. It is built around the Intel MAX10 FPGA, which is the industry's first single chip, nonvolatile programmable logic device (PLDs) to integrate the optimal set of system components. Users can now leverage the power of tremendous re-configurability paired with a highperformance, low-power FPGA system. Providing internally stored dual images with selfconfiguration, comprehensive design protection features, integrated ADCs and hardware to implement the Nios II 32-bit microcontroller IP, MAX10 devices are ideal solution for system management, protocol bridging, communication control planes, industrial, automotive and consumer applications. The MAX1000 is equipped with an Arrow USB Blaster, SDRAM, flash memory, accelerometer sensor and PMOD/ADRUINO MKR connectors making it a fully featured plug and play solution without any additional costs.



The MAX1000 board contains all the tools needed to use the board in conjunction with a computer that runs a 64-bit Linux / Microsoft Windows 7 operating system or later.

#### 1.2 Useful Links

A set of useful links that can be used to get relevant information about the MAX1000 or the MAX10 FPGA.

- MAX1000 at Arrow Shop
- MAX1000 at Trenz Electronic Shop
- Intel MAX10 Webpage
- MAX1000 Wiki Page

#### 1.3 Getting Help

Here are the addresses where you can get help if you encounter any problems:

#### • Arrow Electronics

<u>In Person</u> Arrow EMEA + 49 (0) 6102 5030 0

Online https://arrow.com

#### • Trenz Electronic GmbH

https://www.trenz-electronic.de/en/



### Chapter 2 - Introduction to the MAX1000 Board

#### 2.1 Layout and Components

Figure 1 shows a top view of the board. It depicts the layout of the board and indicates the location of the various connectors and key components.

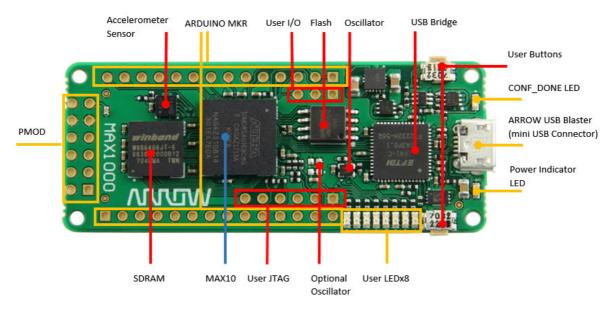


Figure 1 - MAX1000 Board (top view)

The following are available on the MAX1000 board:

- Intel MAX®10 10M08SAU169C8G device
- Arrow USB Blaster on-board for programming; JTAG Mode
- 64MBit SDRAM (16-bit data bus)
- 64Mbit Flash Memory
- One 12MHz MEMS Oscillator
- One optional MEMS Oscillator of preferred frequency
- Eight red user LEDs
- Two board indication LEDs
- Two user buttons
- One 3-axis accelerometer
- One 12-pin PMOD header
- One Arduino MKR header
- One User JTAG header
- One User I/O header



#### 2.2 Block Diagram

Figure 2 represents the block diagram of the board. All the connections are established through the MAX 10 FPGA device to provide maximum flexibility for users. Users can configure the FPGA to implement any system design.

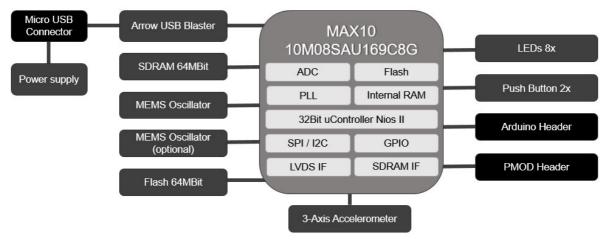


Figure 2 - MAX1000 Block Diagram

#### **FPGA Device**

• Available MAX10 Devices for the MAX1000

Resources	Device			
	10M02	10M04	10M08	10M16
Logic Elements (LE) (K)	2	4	8	16
M9K Memory (K)	108	189	378	549
User Flash (K)	96	1248	1376	2368
Internal Configuration Image	1	2	2	2
ADC	-	1	1	1
PLLs	2	2	2	4

#### Configuration and Debug

• On-board Arrow USB Blaster (mini-USB type B connector)

#### **Memory Devices**

- 64MBit to 128 MBit external flash memory
- 64MBit to 256 MBit external SDRAM memory



#### Headers

- PMOD Header
- Arduino MKR Header
- User JTAG Header
- User I/O Header

#### **Buttons and Indicators**

- 2 x side-buttons
- 8 x red user LEDs
- 2 x board indication LEDs

#### Sensors

• One 3-axis accelerometer

#### Power

- Recommended external supply voltage range: +5.0 V (nominal)
- Recommended I/O signal voltage range: 0/0 to +3.3 V



### Chapter 3 - Connections and Peripherals of the MAX1000 Board

#### 3.1 Board Status Elements

In addition to the 8 LEDs that the FPGA can control, there are 2 additional LEDs which can indicate the status of the board.



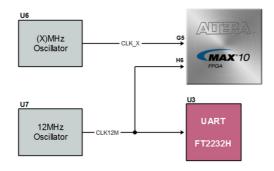
Figure 3 – Position of Indication LEDs

<b>Board Reference</b>	LED Name	Description
D1	3.3V	On when 3.3V power is active
D10	CONF_DONE	On when configuration data was loaded to MAX10 device without error

#### 3.2 Clock Circuitry

All the external clocks of the system can be seen in Figure 4. The default clock (CLK12M) is at 12 MHz and is connected and driving the FPGA's user logic and the Arrow USB Blaster. There is an optional slot of another clock (CLK\_X) to add another preferred clock source to the FPGA. Both clocks are driving PLL1/PLL3, which are able to drive the ADC clock.

For more information on clocks and PLLs of the MAX10, please refer to this <u>document</u>.



<b>Board Reference</b>	FPGA Pin No.	Description	I/O Standard
CLK12M	PIN_H6	12MHz clock input	3.3 V
CLK_X	PIN_G5	Optional clock input	3.3 V



#### 3.3 Peripherals Connected to the FPGA

#### 3.3.1 LEDs

There are eight red user-controllable LEDs connected to the FPGA. Each LED is driven directly and individually by the MAX10 FPGA; driving its associated pin to a high logic level for on or low logic level for off.

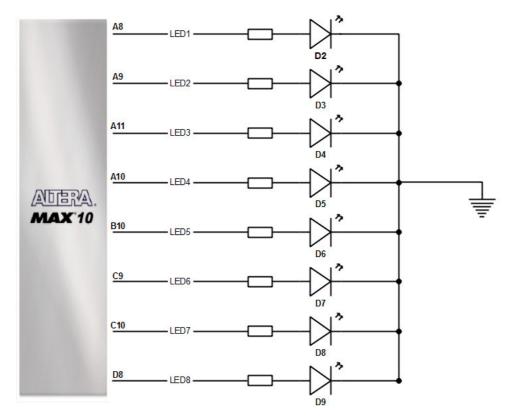


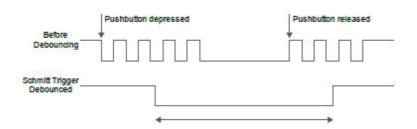
Figure 5 – LED Connections

<b>Board Reference</b>	FPGA Pin No.	I/O Standard
LED1	PIN_A8	3.3 V
LED2	PIN_A9	3.3 V
LED3	PIN_A11	3.3 V
LED4	PIN_A10	3.3 V
LED5	PIN_B10	3.3 V
LED6	PIN_C9	3.3 V
LED7	PIN_C10	3.3 V
LED8	PIN_D8	3.3 V

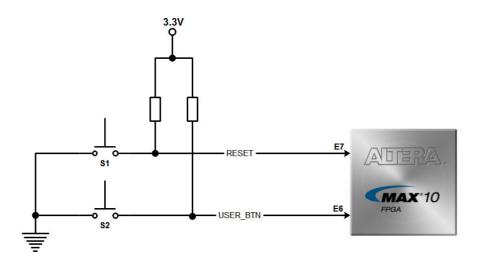


#### 3.3.2 Push Buttons

The board has two push buttons connected to the FPGA. MAX10 devices support Schmitt trigger input on all I/O pins. A Schmitt trigger feature introduces hysteresis to the input signal for improved noise immunity, especially for signal with slow edge rate and acts as switch debouncer. Push buttons drive their associated pins low logic level when pressed and high logic level when released.





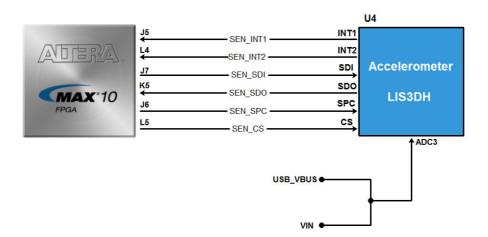




<b>Board Reference</b>	FPGA Pin No.	Description	I/O Standard
RESET	PIN_E7	Dual-function Pin: GPIO or nCONFIG	3.3 V Schmitt Triger
USER_BTN	PIN_E6	User button	3.3 V Schmitt Triger

#### 3.3.3 Accelerometer

The board comes with a digital accelerometer (LIS3DH), commonly known as the G-Sensor. This G-Sensor is a small, thin, ultra-low power consumption, 3-axis accelerometer with digital I2C/SPI serial interface, standard output. The LIS3DH has user-selectable full scales of +/-2g, +/-4g, +/-8g, +/-16g and it is capable of measuring accelerations with output data rates from 1 Hz to 5 kHz. The supplied power to the board (coming either from micro-USB connection or user Vin) can be monitored through the ADC channel 3 of the accelerometer.



#### Figure 8 – Accelerometer Connections

<b>Board Reference</b>	FPGA Pin No.	Description*	I/O Standard
SEN_INT1	PIN_J5	Interrupt 1	3.3 V
SEN_INT2	PIN_L4	Interrupt 2	3.3 V
SEN_SDI	PIN_J7	Data In (MOSI)	3.3 V
SEN_SDO	PIN_K5	Data Out (MISO)	3.3 V
SEN_SPC	PIN_J6	Clock	3.3 V
SEN_CS	PIN_L5	Chip Select	3.3 V

\*For SPI connection



#### 3.3.4 SDRAM Memory

The MAX1000 board supports 64 MBit (default version) or up to 256 MBit (customized version) SDRAM which can operate up to 166 MHz clock frequency. Below are the connections and pinning of the SDRAM used in the MAX1000.



Figure 9 – SDRAM Connections

<b>Board Reference</b>	FPGA Pin No.	Description	I/O Standard
A0	PIN_K6	SDRAM Address [0]	3.3 V
A1	PIN_M5	SDRAM Address [1]	3.3 V
A2	PIN_N5	SDRAM Address [2]	3.3 V
A3	PIN_J8	SDRAM Address [3]	3.3 V
A4	PIN_N10	SDRAM Address [4]	3.3 V
A5	PIN_M11	SDRAM Address [5]	3.3 V
A6	PIN_N9	SDRAM Address [6]	3.3 V
A7	PIN_L10	SDRAM Address [7]	3.3 V
A8	PIN_M13	SDRAM Address [8]	3.3 V
A9	PIN_N8	SDRAM Address [9]	3.3 V
A10	PIN_N4	SDRAM Address [10]	3.3 V
A11	PIN_M10	SDRAM Address [11]	3.3 V
A12	PIN_L11	SDRAM Address [12]	3.3 V
A13	PIN_M12	SDRAM Address [13]	3.3 V
BA0	PIN_N6	SDRAM Bank Address [0]	3.3 V
BA1	PIN_K8	SDRAM Bank Address [1]	3.3 V
CLK	PIN_M9	SDRAM Input Clock	3.3 V
СКЕ	PIN_M8	SDRAM Clock Enable	3.3 V
RAS	PIN_M7	SDRAM Row Address Strobe	3.3 V
CAS	PIN_N7	SDRAM Column Address Strobe	3.3 V
WE	PIN_K7	SDRAM Write Enable	3.3 V
CS	PIN_M4	SDRAM Chip Select	3.3 V



<b>Board Reference</b>	FPGA Pin No.	Description	I/O Standard
DQ0	PIN_D11	SDRAM Data[0]	3.3 V
DQ1	PIN_G10	SDRAM Data [1]	3.3 V
DQ2	PIN_F10	SDRAM Data [2]	3.3 V
DQ3	PIN_F9	SDRAM Data [3]	3.3 V
DQ4	PIN_E10	SDRAM Data [4]	3.3 V
DQ5	PIN_D9	SDRAM Data [5]	3.3 V
DQ6	PIN_G9	SDRAM Data [6]	3.3 V
DQ7	PIN_F8	SDRAM Data [7]	3.3 V
DQ8	PIN_F13	SDRAM Data [8]	3.3 V
DQ9	PIN_E12	SDRAM Data [9]	3.3 V
DQ10	PIN_E13	SDRAM Data [10]	3.3 V
DQ11	PIN_D12	SDRAM Data [11]	3.3 V
DQ12	PIN_C12	SDRAM Data [12]	3.3 V
DQ13	PIN_B12	SDRAM Data [13]	3.3 V
DQ14	PIN_B13	SDRAM Data [14]	3.3 V
DQ15	PIN_A12	SDRAM Data [15]	3.3 V
DQM0	PIN_E9	SDRAM Lower Data Mask	3.3 V
DQM1	PIN_F12	SDRAM Upper Data Mask	3.3 V

#### 3.3.5 Flash Memory

The MAX1000 board supports up to 128 MBit of serial flash memory that can be used for user data and programming non-volatile storage. Single SPI interface is supported that can reach up to 104 MHz SPI performance. Device offers unique advanced security features that could benefit greatly end node security applications.

			U	5
	B3	——— F CS ———	/CS	
	A3	F CLK	CLK	
	A2	F DI	100	Flash
	B2	F D0	101	
FPGA*10	C4	NSTATUS	103	W74M64
and the second	B9 ←	DEVCLRN	102	

Figure 10 – Flash Connections

<b>Board Reference</b>	FPGA Pin No.	Description	I/O Standard
F_CS	PIN_B3	Flash Chip Select	3.3 V
F_CLK	PIN_A3	Flash Clock Input	3.3 V
F_DI	PIN_A2	Flash Data Input Input (IO0)	3.3 V
F_DO	PIN_B2	Flash Data Input Output (IO1)	3.3 V
NSTATUS	PIN_C4	NSTATUS	3.3 V
DEVCLRN	PIN_B9	DEVLCLRN	3.3 V





#### 3.3.6 User I/O

The MAX1000 board has two pins that can be connected to the board and take analogue inputs. Those two pins are connected to the ADC block of the MAX10 and can measure up to 3.6V. This 12-bit SAR ADC can reach 1 MSPS and has single ended capabilities.

For more information on the ADCs of the MAX10, please refer to this document.

#### Note: If you use bank 1A for ADC, you cannot use the bank for GPIO.

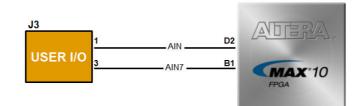


Figure 11 - User I/O Connections

<b>Board Reference</b>	FPGA Pin No.	Description
AIN	PIN_D2	Dedicated analogue input pin
AIN7	PIN_B1	Dual function pin

#### 3.3.7 Arduino MKR Connectors

The MAX1000 board offers connectivity to Arduino MKR compatible shields that could also alternatively be used as GPIOs. The MKR connectors offer up to 7 analogue inputs and 15 digital I/Os. There is also an option to use or not use the 4.7k Ohm pull-up resistor lines for communication interfaces.

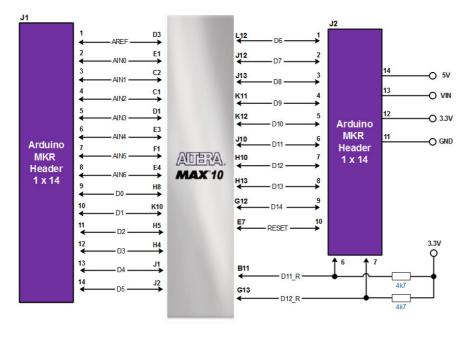
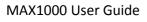


Figure 12 - Arduino MKR Header Connections





#### Note: If you use bank 1A for ADC, you cannot use the bank for GPIO (includes all AIN[0..7] pins)

Board Reference	FPGA Pin No.	Description	MKR Header/Pin	I/O Standard
AREF	PIN_D3	Analogue Reference	J1/1	N/A
AINO	PIN_E1	Analogue In Channel 8 of ADC or GPIO	J1 / 2	3.3 V
AIN1	PIN_C2	Analogue In Channel 2 of ADC or GPIO	J1/3	3.3 V
AIN2	PIN_C1	Analogue In Channel 5 of ADC or GPIO	J1 / 4	3.3 V
AIN3	PIN_D1	Analogue In Channel 1 of ADC or GPIO	J1/5	3.3 V
AIN4	PIN_E3	Analogue In Channel 3 of ADC or GPIO	J1/6	3.3 V
AIN5	PIN_F1	Analogue In Channel 7 of ADC or GPIO	J1 / 7	3.3 V
AIN6	PIN_E4	Analogue In Channel 4 of ADC or GPIO	J1/8	3.3 V
D0	PIN_H8	Digital In[0]	J1/9	3.3 V
D1	PIN_K10	Digital In[1]	J1 / 10	3.3 V
D2	PIN H5	Digital In[2]	J1 / 11	3.3 V
D3	PIN_H4	Digital In[3]	J1/12	3.3 V
D4	PIN_J1	Digital In[4]	J1 / 13	3.3 V
D5	PIN_J2	Digital In[5]	J1 / 14	3.3 V
D6	PIN_L12	Digital In[6]	J2 / 1	3.3 V
D7	PIN_J12	Digital In[7]	J2 / 2	3.3 V
D8	PIN_J13	Digital In[8]	J2/3	3.3 V
D9	PIN_K11	Digital In[9]	J2 / 4	3.3 V
D10	PIN_K12	Digital In[10]	J2 / 5	3.3 V
D11	PIN_J10	Digital In[11]	J2 / 6	3.3 V
D12	PIN_H10	Digital In[12]	J2 / 7	3.3 V
D13	PIN_H13	Digital In[13]	J2/8	3.3 V
D14	PIN_G12	Digital In[14]	J2/9	3.3 V
D11_R	PIN_B11	Digital In[11] with pull-up resistor	J2 / 6	3.3 V
D12_R	PIN_G13	Digital In[12] with pull-up resistor	J2 / 7	3.3 V
RESET	N/A	Connected to system reset of the board	J2 / 10	N/A
GND	N/A	Ground output to the connector	J2 / 11	N/A
3.3V	N/A	3.3V power to the connector	J2 / 12	N/A
VIN	N/A	User power into to the MAX1000	J2 / 13	N/A
5V	N/A	5V power to the connector	J2 / 14	N/A

\*Can only choose one, hence same name pinning



#### 3.3.8 PMOD Connector

The MAX1000 board offers connectivity to PMOD compatible connectors (2x6-pin or 1x12-pin), making it possible to add a big variety of sensors or ICs to the system. Below is the connection schematic and pinning information.

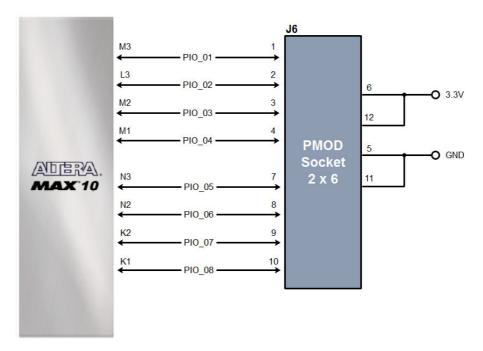


Figure 13 – PMOD Header Connections

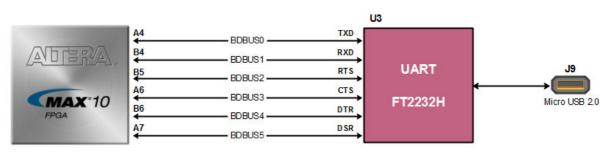
Board Reference	FPGA Pin No.	Description	I/O Standard
PIO_01	PIN_M3	PMOD Pin 1	3.3 V
PIO_02	PIN_L3	PMOD Pin 2	3.3 V
PIO_03	PIN_M2	PMOD Pin 3	3.3 V
PIO_04	PIN_M1	PMOD Pin 4	3.3 V
PIO_05	PIN_N3	PMOD Pin 5	3.3 V
PIO_06	PIN_N2	PMOD Pin 6	3.3 V
PIO_07	PIN_K2	PMOD Pin 7	3.3 V
PIO_08	PIN_K1	PMOD Pin 8	3.3 V
GND	N/A	Ground	N/A
3.3V	N/A	3.3 V Power to PMOD	3.3 V

#### 3.3.9 Communication and Configuration

The MAX1000 board uses a single chip to perform configuration of the device and USB to UART communications, having each described below.

#### 3.3.9.1 UART Communication

UART to USB communication supports USB 2.0 High Speed (up to 480 Mb/s) independently of other protocols used in the chip like JTAG. Below is the connection schematic and pinning information.



#### Figure 14 – UART Connections

<b>Board Reference</b>	FPGA Pin No.	Description	I/O Standard
BDBUS0	PIN_A4	Transmitter output of FT2232H (Tx)	3.3 V
BDBUS1	PIN_B4	Receiver input of FT2232H (Rx)	3.3 V
BDBUS2	PIN_B5	Ready To Send handshake output (RTS)	3.3 V
BDBUS3	PIN_A6	Clear To Send handshake input (CTS)	3.3 V
BDBUS4	PIN_B6	Data Transmit Ready (DTR)	3.3 V
BDBUS5	PIN_A7	Data Set Ready (DSR)	3.3 V

#### 3.3.9.2 JTAG Chain Configuration

There are two types of configuration methods supported by MAX1000:

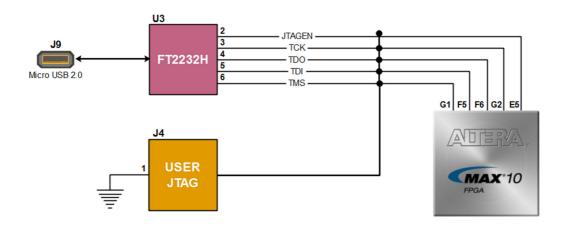
- 1. **JTAG Configuration:** configuration using JTAG ports. JTAG configuration scheme allows you to directly configure the device core through JTAG pins (TDI, TDO, TMS and TCK pins). The Quartus Prime software automatically generates a .sof that can be downloaded to the MAX10 with a download cable through the Quartus Prime Programmer.
- 2. Internal Configuration: configuration using internal flash. Before internal configuration, you need to program the configuration data .pof into the configuration flash memory (CFM) which provides non-volatile storage for the bit stream. The information is retained within CFM even if the MAX1000 is turned off. When the board is powered on, the configuration data in the CFM is automatically loaded into the MAX10 FPGA.



The FPGA device can be configured through JTAG interface on MAX1000, but the JTAG chain must form a closed loop, which allows Quartus Prime programmer to detect the FPGA device.

MAX1000 offers two ways of configuring your board.

- 1) Through the on-board Arrow USB Blaster
- 2) Pins for connecting user's preferred JTAG interface





<b>Board Reference</b>	FPGA Pin No.	Description	I/O Standard
JTAGEN	PIN_E5	Dual Function: JTAG Pin Sharing	3.3 V
ТСК	PIN_G2	Test Interface Clock	3.3 V
TDO	PIN_F6	Test Data Out	3.3 V
TDI	PIN_F5	Test Data In	3.3 V
TMS	PIN_G1	Test Mode Select	3.3 V

For detailed information about how to configure the MAX10 device, please refer to Chapter 6.

#### 3.3.10 Power Tree

The MAX1000 is powered by Enpirion's buck regulator, which provides high efficiency up to 1A with integrated magnetics, switches, control, and compensation. As seen from the diagram below, the board can be powered either by a micro-USB connection, or by user input voltage from the Arduino MKR header (takes precedence over the USB bus). All devices are powered by 3.3V voltage line and the 5V and 3.3V lines are fed back to the Arduino header to power that connection if needed.

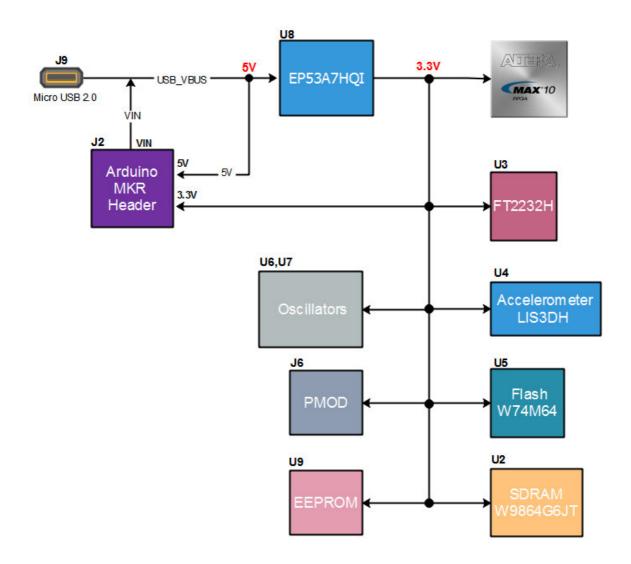


Figure 16 – Power Tree Connections

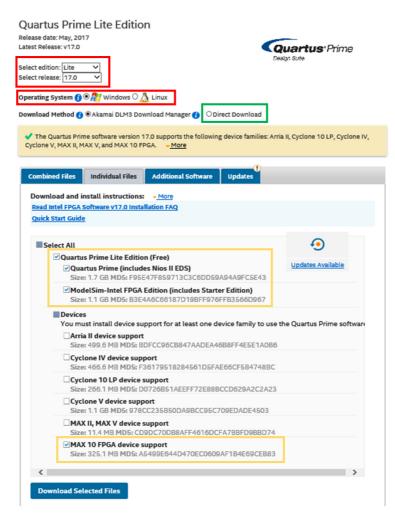


### Chapter 4 - Software and Driver Installation

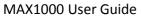
Firstly it is required to create your <u>myAltera Account</u> if you don't own one already. It is required to download the software. Below are guides for installing the software and drivers for Windows and Linux operating systems.

#### 4.1 Installing Quartus Prime Software (Windows)

- 4.1.1 Go to the Intel Download Centre: Link.
- 4.1.2 Select **Windows** as the operating system (highlighted in red).
- 4.1.3 Select Release **17.0**, or your preferred version (highlighted in red).
- 4.1.4 Select the following files from the "Individual Files" tab to be downloaded (highlighted in yellow):
  - Quartus Prime Lite Edition (Free)
  - ModelSim-Altera Edition (includes Starter Edition)
  - MAX10 FPGA device support



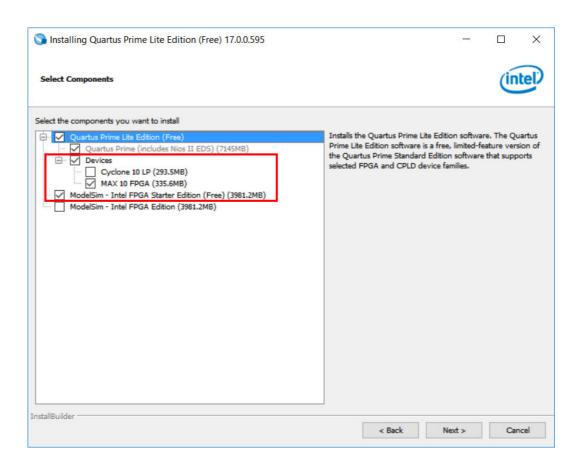
4.1.5 Click "Download Selected Files" to begin the download and save them in the same folder.





*Note:* In case of browser issues using Akamai DLM3 Manager, you can alternative download the above files using the "Direct Download" (highlighted in green).

- 4.1.6 After the download is finished, run the Quartus Prime installer.
- 4.1.7 When prompted to select the components, the installer will detect automatically the MAX10 device support and ModelSim packages when they are in the same folder. Make sure these components are selected:



4.1.9 Finish the installation of the Quartus Lite and proceeded to the next section to install Arrow USB Blaster to be able to connect to the MAX1000 board.

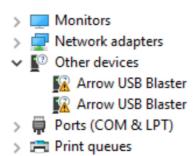
#### 4.2 Installing Arrow USB Blaster (Windows)

The MAX1000 board uses version 2 of the Arrow USB Blaster programming solution, that is an FTDI FT2232H Hi-Speed USB controller plus a programmer DLL. Since this FTDI USB controller is a very common standard device, usually no specific drivers are needed to make the MAX1000 work.

4.2.1 Download the appropriate version of Arrow USB Blaster for MAX1000 from Trenz Electronic Wiki page or alternatively this direct <u>link.</u>

Home Products <b>Download</b>	Company Services Jobs News Distributors
Download > Trenz_Electronic >	accessories > Drivers > Arrow_USB_Blaster
Digilent OHO-Elektronik	Arrow_USB_Blaster_1.9_MAX1000_Rev01_only Arrow_USB_Blaster_2.0_MAX1000_Rev02_only
SunDance	
Trenz_Electronic	
-corporate -obsolete_products Digital_IO PMOD	
Pinout TE-USB-Suite	
TE0140 series	

- 4.2.2 After downloading the file, run the installer to install the Arrow USB Blaster. The setup executable installs the programmer DLL and adds some keys to the registry of the PC.
- 4.2.3 After connecting the MAX1000 board to the PC, two unknown devices might appear in the "Other devices" section of device manager of the PC.





Windows usually automatically finds the appropriate drivers for these devices. After some time, the "Other devices" section should be empty. Instead, two USB Serial Converters should be listed in the section "USB Serial Bus controllers":

- > ኪ System devices
- Üniversal Serial Bus controllers
  - Generic USB Hub
  - Generic USB Hub
  - Intel(R) 8 Series/C220 Series USB EHCI #1 8C26
  - Intel(R) 8 Series/C220 Series USB EHCI #2 8C2D
  - Intel(R) USB 3.0 eXtensible Host Controller 1.0 (Microsoft)
  - USB Composite Device
  - USB Root Hub
  - USB Root Hub
  - USB Root Hub (xHCl)
  - USB Serial Converter A
  - USB Serial Converter B

Furthermore, a USB Serial Port should be listed in the "Ports (COM & LPT)" section.

- > 💻 Network adapters
- Ports (COM & LPT)
  - Intel(R) Active Management Technology SOL (COM3)
  - USB Serial Port (COM9)
- > 📇 Print queues

*Note: The number of the port will most probably be different from the one shown here.* 

In case Windows does not automatically find the appropriate drivers go to <u>http://www.ftdichip.com/Drivers/D2XX.htm</u> to download the setup executable to install the required drivers.

#### 4.3 Installing Quartus Prime Software (Linux)

- 4.3.1 Go to the Intel Download Centre: Link.
- 4.3.2 Select Linux as the operating system (highlighted in red).
- 4.3.3 Select Release **17.0**, or your preferred version (highlighted in red).
- 4.3.4 Select the following files to be downloaded from the "Individual Files" tab (highlighted in yellow):
  - Quartus Prime (Includes Nios II EDS)
  - ModelSim-Intel FPGA Edition (includes Starter Edition)
  - MAX10 FPGA device support

	ntel' Quartus' Prime
t edition: Lite v t release: 17.0 v	
ating System 👩 🔿 🎊 Windows 🔍 👌 Línux	
iload Method 🕜 🖳 Akamai DLM3 Download Manager 🍞 🧿 Direct Download	
The Quartus Prime software version 17.0 supports the following device families: Arria MAX II, MAX V, and MAX 10 FPGA. <u>More</u>	a II, Cyclone 10 LP, Cyclone IV, Cycl
ombined Files Individual Files Additional Software Updates	
Download and install instructions: <u>More</u> Read Intel FPGA Software v17.0 Installation FAQ	
Quick Start Guide	
Quartus Prime Lite Edition (Free)	•
Quartus Prime Lite Edition (Fee) Quartus Prime (includes Nios II EDS)	Updates Available
Size: 2.0 GB MD5: 454350830D780072396B5F0DED77E18B	0
ModelSim-Intel FPGA Edition (includes Starter Edition) Size: 1.1 GB MDS: 0BSF39AFFB777E90700C30F96DAB1A0C	0
** Require 32-bit libraries, see installation manual.	
Devices	
You must install device support for at least one device family to use the Qua	rtus Prime software.
You must install device support for at least one device family to use the Qua Arria II device support Size: 499.6 MB MD5: BDFCC96CB847AADEA46B8FF4E5E1A0B6	rtus Prime software.
Arria II device support Size: 499.6 MB MD5: BDFCC96CB847AADEA46B8FF4E5E1A0B6 Cyclone IV device support	rtus Prime software.
Arria II device support Size: 499.6 MB MD5: BDFCC96CB847AADEA46B8FF4E5E1A0B6 Cyclone IV device support Size: 466.6 MB MD5: F36179518284561D5FAE66CF5B4748BC	rtus Prime software.
Arria II device support Size: 499.6 MB MD5: BDFCC96CB847AADEA46B8FF4E5E1A0B6 Cyclone IV device support	rtus Prime software.
Arria II device support Size: 499.6 MB MD5: BDFCC96CB847AADEA46B8FF4E5E1A0B6 Cyclone IV device support Size: 466.6 MB MD5: F36179518284561D5FAE66CF5B4748BC Cyclone 10 LP device support	rtus Prime software.
Arria II device support Size: 499.6 MB MDS: BDFCC96CB847AADEA46B8FF4E5E1A0B6 Cyclone IV device support Size: 466.6 MB MDS: F36179518284561D5FAE66CF5B4748BC Cyclone 10 LP device support Size: 266.1 MB MD5: D0726B51AEEFF72E88BCCD629A2C2A23 Cyclone V device support	rtus Prime software.



4.3.5 Download the selected files and store them into the same folder.

For example, the Downloads folder under the home of the current user **~/Downloads:** Quartus Prime Lite edition: ~/Downloads/QuartusLiteSetup-17.0.0.595-linux.run ModelSim-Intel FPGA Edition: ~/Downloads/ModelSimSetup-17.0.0.595-linux.run MAX10 device support package for Quartus: ~/Downloads/max10-17.0.0.595.qdz

Run Intel Quartus installer. Open a terminal and navigate through the folder where the installers are downloaded:

\$ cd ~/Downloads

Make sure the installer has execution permissions. If you have a different version of Quartus Software, please match the name of the file:

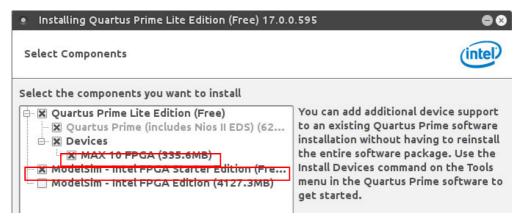
\$ chmod +x QuartusLiteSetup-17.0.0.595-linux.run

Run the installer:

- \$ ./QuartusLiteSetup-17.0.0.595-linux.run
- 4.3.6 Follow the steps through the installation assistant. When prompted the destination folder, you can choose a path within your home directory, so you don't need additional permissions:



4.3.7 The installer will detect automatically the MAX10 device support and ModelSim packages when they are located in the same folder. Make sure these components are selected:







4.3.8 Continue through the installation assistant until the process has finished. Now you can run Quartus Lite.

To connect with the MAX1000 board you need to install additional Arrow USB Blaster drivers as explained in the next section.

#### 4.4 Installing Arrow USB Blaster (Linux)

4.4.1 Download the Arrow USB Blaster Driver for Linux from Trenz Electronic Wiki page or alternatively this direct <u>link</u>.

Download > Trenz_Electronic >	accessories > Drivers > Arrow_USB_Blaster	> Arrow_USB_Blaster_1.9 > linux64
Digilent OHO-Elektronik SunDance Trenz Electronic	Files 51-usbblaster.rules Size 508 B / Modified 03.05.2017 - 04:37:00 README Size 1,65 KB / Modified 03.05.2017 - 04:37:00	]
-corporate -obsolete_products Digital_IO	arrow_usb_blaster.conf Size 323 B / Modified 03.05.2017 - 04:37:00	
PMOD Pinout	Size 169,63 KB / Modified 03.05.2017 - 04:37:00	

- 4.4.2 You can download the files in a temporal folder such as the Downloads folder under the home of the current user **~/Downloads:** 
  - Udev USB rules: ~/Downloads/**51-usbblaster.rules**
  - Default configuration file: ~/Downloads/arrow\_usb\_blaster.conf:
  - Plugin for Quartus Prime: ~/Downloads/libjtag\_hw\_arrow.so:

#### 4.4.3 Open a terminal and navigate through your Downloads folder:

- \$ cd ~/Downloads
- 4.4.4 Install udev USB rules:
  - \$ sudo cp 51-usbblaster.rules /etc/udev/rules.d/

#### 4.4.5 Make sure your linux user belongs to the plugdev group:

\$ sudo useradd -G plugdev <your linux username>

#### 4.4.6 Install default configuration file:

\$ sudo cp arrow\_usb\_blaster.conf /etc/

#### 4.4.7 Install the Quartus Prime plugin:

#### Use the directory quartus/linux64 under the installation path selected on step 4.3.6.

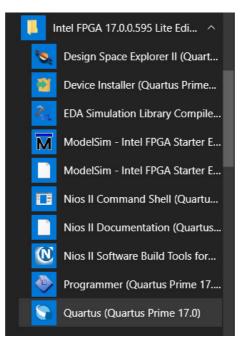
\$ cp libjtag\_hw\_arrow.so <Quartus Path>/quartus/linux64



### Chapter 5 - New Project with MAX1000

#### 5.1 Creating a new Blinky Project with MAX1000

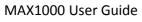
5.1.1 Launch Quartus Prime Lite Edition from the Start Menu.



5.1.2 In the Quartus Prime tool, create a new project: **File -> New Project Wizard.** 

The New Project Wizard walks you through the project settings, such as the name, directories, files, directories, device family and other settings. These settings can be changed later if needed.

New Proj	ect Wizard
Introdu	Iction
The New F	roject Wizard helps you create a new project and preliminary project settings, including the following:
•	Project name and directory Name of the top-level design entity Project files and libraries Target device family and device EDA tool settings
	nange the settings for an existing project and specify additional project-wide settings with the Settings command (Assignments menu). You can use the ses of the Settings dialog box to add functionality to the project.
Don't s	how me this introduction again
	< Back Next > Finish Cancel Help



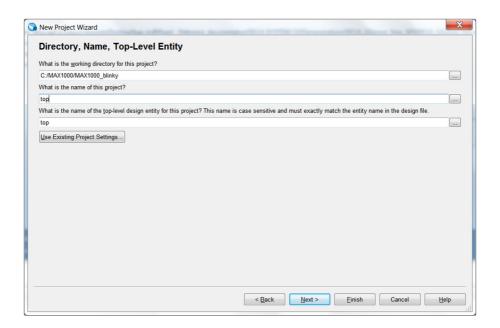


#### 5.1.3 Click "Next".

5.1.4 Browse in the project directory and choose a preferred location for the new project. Then create new folder named MAX1000\_blinky. This will be the folder containing all the project files.

New Project Wizard	two is not the other data and the lines in Figure 1	
Directory, Name, Top-Level Entity		
What is the working directory for this project?		
C:/MAX1000/MAX1000_blinky		
What is the name of this project?		
Vhat is the name of the top-level design entity for this p	roject? This name is case sensitive and must exactly match the entity name in the design file.	_
Jse Existing Project Settings		
	<back next=""> Einish Cancel He</back>	elp

5.1.5 Enter the project name: "top".



#### 5.1.6 Click "Next".





#### 5.1.7 Project Type

In this page you choose the Project Type. In this tutorial, a new project will be created, and thus the default settings of empty project should be selected.

New Project Wizard
Project Type
Select the type of project to create.
Empty project
Create new project by specifying project files and libraries, target device family and device, and EDA tool settings.
Project template
Create a project from an existing design template. You can choose from design templates installed with the Quartus Prime software, or download design templates from the Design Store.
< <u>Back</u> <u>Next</u> <u>Einish</u> Cancel <u>Help</u>

#### 5.1.8 Click "Next".

#### 5.1.9 Add Project Files

The Add File window will appear. For this tutorial, new design files will be created so no files will be added. For other designs, files could be added here.

ile name:		Add
R. Contraction of the second sec	×	Add All
File Name Type Library Design Entry/Synthesis Tool HDL Version		<u>R</u> emove
		<u>U</u> p
		Down
		Properties

#### 5.1.10 Click "Next".



#### 5.1.11 Select the Device Part Number of the MAX1000 Board

In the Family and Device Settings, use the pull down menu to select the family as MAX10. Then in the Name Filter enter **10M08SAU169C8G**.

Device Board Select the family and dev You can install additional	device support with the	Install De	vices command on			to the Day	ice Support List webpage.	
Device family	or the Quartus Prime s	oitware in v	which your target u		Available de		vice Support Cist webpage.	
Eamily: MAX 10 (DA/DF/DC/SA/SC)					c (	Any		•
Devices: All					t: [	Any		•
Target device			Core Sp	ed grade:	Any			
Auto device selecte			Name filter: 10M08SAU169C8G					
<ul> <li>Specific device sele</li> <li>Other: n/a</li> </ul>	ected in 'Available devic	es' list		Show	v advanced	devices		
Available devices:								
Name	Core Voltage	LEs	Total I/Os	GPIOs	Memo	ory Bits	Embedded multiplier 9-bit	elemen 🔺
10M08SAU169C8G	3.3V	8064	130	130	387072		48	
10M08SAU169C8GES	3.3V	8064	130	130	387072		48	+

Rather than entering the exact part number, the pull-down menus can be used to select the correct family, package, pin count, and speed grade. Quartus Prime will use these settings to compile the design, and also provide the programming file that you will use later to program the device.

5.1.12 Click "Next".

#### 5.1.13 EDA Tool Settings

In the EDA tool Settings window, disable any EDA tools, if there are any present. EDA tools are third party tools that work with Quartus Prime for design entry, simulation, verification and board-level timing. For this tutorial, no EDA software will be used, as only Quartus Prime will be used.

DA tools:				
Tool Type	Tool Name	Format(s)		Run Tool Automatically
Design Entry/Sy	<none></none>	▼ <none></none>	Ŧ	Run this tool automatically to synthesize the current design
Simulation	<none></none>	▼ <none></none>	Ŧ	Run gate-level simulation automatically after compilation
Board-Level	Timing	<none></none>	•	
	Symbol	<none></none>	-	
	Signal Integrity	<none></none>	•	
	Boundary Scan	<none></none>	~	



#### 5.1.14 Click "Next".

#### 5.1.15 Project Summary Page

This is the Summary Page that showing the settings Quartus Prime will use for this Project. Those settings can be changed if required at a later time.

Summan/								
Summary								
When you click Finish, the project will be created with the	e following settings:							
Project directory:	C:/MAX1000/MAX1000_blinky							
Project name: Top-level design entity: Number of files added:	top top 0							
							Number of user libraries added:	0
							Device assignments:	
Design template: Family name: Device:	n/a							
	MAX 10 (DA/DF/DC/SA/SC) 10M08SAU169C8G n/a							
							Board:	
EDA tools:								
Design entry/synthesis:	<none> (<none>)</none></none>							
Simulation:	<none> (<none>)</none></none>							
Timing analysis:	0							
Operating conditions:								
Core voltage:	3.3V							
Junction temperature range:	0-85 °C							
	< Back Next > Finish Cancel Help							

#### 5.1.16 Click "Finish".

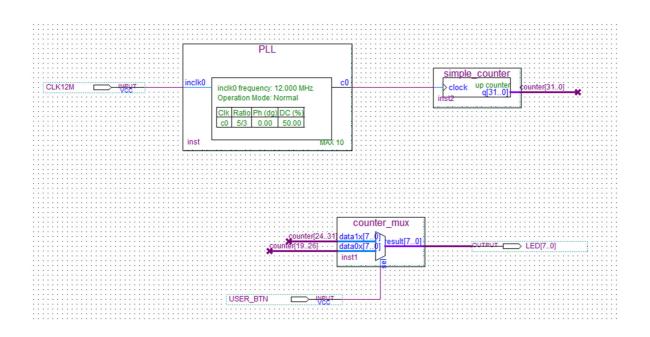


#### 5.2 Building a Blinky Project with MAX1000

**Overview**: In this section you will create the components to a design, make connections, set the pins and compile a project. The goal is to go through the design process of a simple blinky project, where the toggle speed of the LEDs could be controlled by one of the pushbuttons of the MAX1000.

#### 5.2.1 Block Diagram

The final system that will be built with the following steps will look as follows when complete:

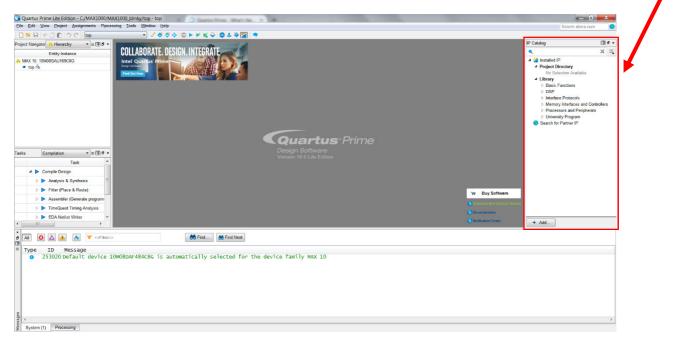


#### 5.2.2 Components of the Design

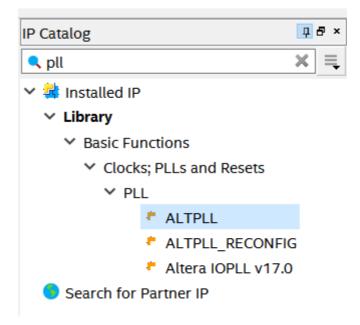
There are three components in the system: a PLL, a counter and a mux. The components, in the following steps, will be built separately and then connected together. A user push button on the board controls the mux. The mux in turn control which of the counter outputs (slow counting or fast counting) will be shown on the LEDs. There are different ways to create components, such as RTL or schematic. In this lab, schematics will be used. There are also different ways for entering schematics such as Qsys and IP Catalog. This lab will focus on the IP Catalog.

#### 5.2.3 Catalog IP

The IP Catalog allows you to create and modify design files with custom variations. The IP Catalog window is open by default when you open Quartus Prime. If it's not present, you can open it by going to the tab **Tool**  $\rightarrow$  **IP Catalog**.



5.2.3.1 In the Search bar of the IP Catalog, type "pll" and select **ALTPLL** which stands for Altera Phase Locked Loop.





### 5.2.3.2 Click "Add".

When the Save IP Variation window appears, enter the file name variation as PLL and select VHDL (Verilog can be used as well). Both Verilog and VHDL schematics will be created.

P variation file name:	ОК
C:/MAX1000/MAX1000_blinky/PLL	
IP variation file type	Cancel
VHDL	
C Verilog	

5.2.3.3 Click "OK".

### 5.2.4 Create and Configure the PLL

The next step is to configure the PLL component that we just named.

5.2.4.1 Enter the PLL reference clock frequency to match the clock input on the MAX1000 Board. Since we have a 12 MHz coming into the FPGA, the inclk input will be 12 MHz.

The setting should look like this:

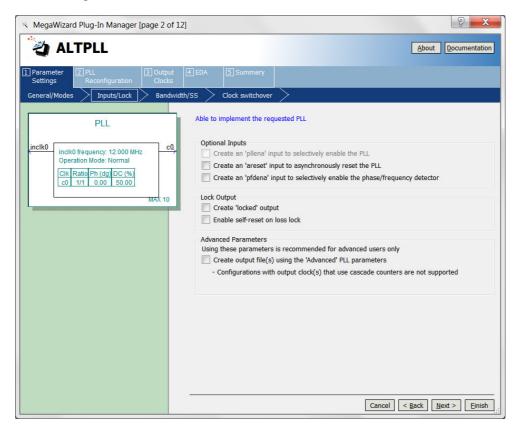
MegaWizard Plug-In Manager [page 1 of 12]	X 9
ALTPLL	About Documentation
I Parameter         I PLL         I Output         I EDA           Settings         Reconfiguration         Clocks         I	Summary
General/Modes $ ightarrow$ Inputs/Lock $ ightarrow$ Bandwidth/SS $ ightarrow$	Clock switchover
	Currently selected device family: MAX 10 -
PLL	Match project/default
inclk0 frequency: 12.000 MHz Operation Mode: Normal Citk Ratio Ph (dg) DC (%) col 1/1 0.00 50.00 MAX 10	Able to implement the requested PLL  General  Which device speed grade will you be using?  Use military temperature range devices only  What is the frequency of the inclk0 input?  Set up PLL in LVDS mode Data rate: Not Available  Mbps  PLL Type  Which PLL type will you be using?  Fast PLL  Operation Mode How will the PLL outputs be generated?  Use the feedback path inside the PLL  Operation Mode How will the PLL outputs be generated?  Use the feedback path inside the PLL  Operation Mode In normal mode In a normal mode In connect the forminic port (bidirectional) In connect the forminic port (bidirectional) In output for an external feedback (External Feedback Mode)  Which output clock will be compensated for?  Cancel < Back Next > Einish

5.2.4.2 Click "Next".



5.2.4.3 Simplify the PLL, by disabling areset and locked outputs.

The setting should look like this:



- 5.2.4.4 Click "Next".
- 5.2.4.5 Continue to select Next to go through the various options (e.g. Pages 3 to Pages 5), but leaving the default options as they are. The page numbers can be seen on the top of the window.
- 5.2.4.6 On page 6, (c0-Core/External Output Clock) select "Enter output clock frequency" and set the requested setting to 20 MHz, leave the rest as default. For simplification, there is one input to the PLL (12 MHz), and one output of the PLL (20 MHz)





The setting should look like this:

K MegaWizard Plug-In Manager [page 6 of 12	]		2 ×
altpll			About Documentation
I Parameter     I Pull     I Output       Settings     Reconfiguration     Clocks       Clk c0     clk c1     clk c2     clk c3	EDA     Summary     clk c4		
PLL inclk0 frequency: 12.000 MHz Operation Mode: Normal Clk Ratio Ph (dg) DC (%) c0 5/3 0.00 50.00 MAX 10	c0 - Core/External Output Able to implement the requested PLL ✓ Use this clock Clock Tap Settings ● Enter output clock frequency: ● Enter output clock parameters: Clock multiplication factor Clock division factor Clock phase shift	Requested Settings 20 MHz v 1 v 1 v 0.00 k deg v	Actual Settings 20.000000 5 3 0.00
	Clock duty cycle (%) Note: The displayed internal settings of the PLL is recommended for use by advanced users only	50.00 Solution	50.00 Vz • (MHz) 4 4 n •
		Per Clock Feasib C0 c1 c2	

5.2.4.7 Click "Next".

- 5.2.4.8 Click "Next" for pages 7 to 11, as default settings are to be used.
- 5.2.4.9 On page 12 there is a list of output files that will be generated. Since the design will be done in a schematic, you will need to select PLL.bsf checkbox. The .bsf file provides a symbol that can be used in the schematic design we will be creating later.

### The setting should look like this:

× MegaWizard Plug-In Manager [page 12 of 12	2]	କ୍ର <mark>×</mark>
altpll		About Documentation
1 Parameter         2 PLL         3 Output           Settings         Reconfiguration         Clocks	4 EDA 5 Sumi	mary
PLL inclk0 inclk0 frequency: 12.000 MHz Operation Mode: Normal	generated, and a gr files. The state of ea sessions.	u wish to generate. A gray checkmark indicates a file that is automatically een checkmark indicates an optional file. Click Finish to generate the selected ach checkbox is maintained in subsequent MegaWizard Plug-In Manager ug-In Manager creates the selected files in the following directory: 100_blinky\
Clk Ratio Ph (dg) DC (%) c0 5/3 0.00 50.00	File	Description
0 5/3 0.00 50.00	V PLL.vhd	Variation file
MAX 10	✓ PLL.ppf	PinPlanner ports PPF file
	PLL.inc	AHDL Include file
	PLL.cmp	VHDL component declaration file
	V PLL.bsf	Quartus Prime symbol file
	PLL_inst.vhd	Instantiation template file
		Cancel< <u>Back</u> <u>Next</u> > <u>Finish</u>

5.2.4.10 Click "Finish".

The PLL (1<sup>st</sup> component) will now be created.

5.2.4.11 If this is the first time that you are using this version of Quartus Prime, you might see a pop-up Window for Quartus Prime IP Files, that asks if the tool should add IP files automatically after generating them.

Quartus Prime IP I	Files		X	
When you create an Altera IP variation, a Quartus Prime IP File is generated. Quartus Prime IP Files are used to represent the Altera IP in your design. Do you want to add the Quartus Prime IP File to the project?				
C:\MAX1000\MAX	1000_blinky\PLL.qij	þ		
Automatically add	Quartus Prime IP F	iles to all projec	ts	
✓ Automatically add (Note: Turning on this You can change this s	option permanently	suppresses this		

5.2.4.12 Select "Automatically add Quartus Prime IP Files to all projects.

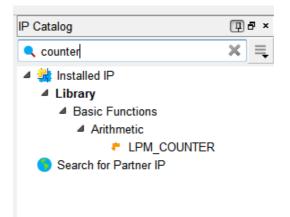


5.2.4.13 Click "Yes" to allow all of the IP to automatically be added to the project, and so that this message will not be seen for other designs.

### 5.2.5 Create and Configure the Counter

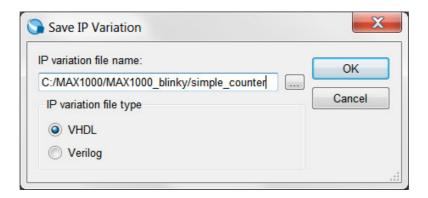
The next step is to create the counter which will drive the LEDs on the MAX1000 board.

5.2.5.1 To create this counter, select the IP Catalog and expand the **Basics** → **Arithmetic** and select the LPM\_COUNTER or type "counter" in the search field.



**Note:** LPM stands for Library of Parameterized Modules

- 5.2.5.2 Click "Add".
- 5.2.5.3 When the Save IP Variation pop up appears, enter "simple\_counter" and select VHDL as below:



5.2.5.4 Click "OK".



- 5.2.5.5 The next step is to increase the size of the counter to a number of bits large enough to divide down the clock so we can see the LEDs toggling.
- 5.2.5.6 Change this number to 32.
- 5.2.5.7 Let the counter to be Up only, so the LEDs will show the counters counting up.

The setting should look like this:

× MegaWizard Plug-	In Manager [page 1 of 5]	? ×
👌 LPM_	COUNTER	About Documentation
1 Parameter Settings		
General > Genera	l 2 > Optional Inputs >	
simple_counter ← clock up counter q[310]		evice family: MAX 10 -
	How wide should the 'q' output bus be? 32  What should the counter direction be?	bits
	<ul> <li>Up only</li> <li>Down only</li> <li>Create an 'updown' input port to allow me to do</li> </ul>	lo both (1 counts up; 0 counts down)
Resource Usage 32 lut + 32 reg	Q	ancel < <u>B</u> ack <u>N</u> ext > <u>Finish</u>

5.2.5.8 Select "Next" until reaching Page 5.

Select simple\_counter.bsf checkbox to generate a symbol for our schematic design.

### The screen should look like this now:

MegaWizard Plug-In Manager [page 5 of 5]			
LPM_COUNTER	About		
1 Parameter 2 EDA 3 Summary Settings			
Simple_counter clock up counter q[25.0]  generated, and a green check selected files. The state of eac Manager sessions.	enerate. A gray checkmark indicates a file that is automatically mark indicates an optional file. Click Finish to generate the ch checkbox is maintained in subsequent MegaWizard Plug-In ager creates the selected files in the following directory:		
File	Description		
Simple_counter.vhd	Variation file		
simple_counter.inc	AHDL Include file		
simple_counter.cmp	VHDL component declaration file		
✓ simple_counter.bsf	Quartus Prime symbol file		
simple_counter_inst.vhd	Instantiation template file		
Resource Usage			
	Cancel< BackNext >Einish		

5.2.5.9 Click "Finish".

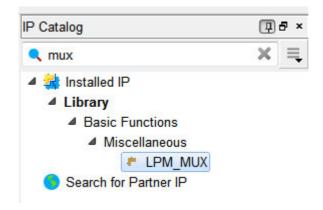
The counter is now created.



### 5.2.6 Create and Configure the Multiplexer

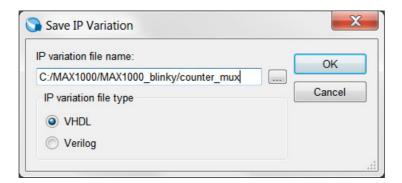
The next step is to create a mux component. This mux will be used along with a push button on the MAX1000 board to control the speed of the counter, where the counter outputs will be seen on the LEDs.

5.2.6.1 To create this mux, select IP Catalog and expand **Basic Functions** → **Miscellaneous** and select LPM\_MUX or type mux in the search field.



5.2.6.2 Click "Add".

5.2.6.3 In the Save IP Variation, enter the name of the counter\_mux and the file type to be VHDL.



5.2.6.4 Click "OK".

5.2.6.5 Select 2 data inputs and the width of the input and output buses to be 8 bits. The reason for 8 bits is that there are 8 LEDs to be toggled (showing count values).

The screen should look like this now:

🕺 MegaWizard Plug-In Ma	mager [page 1 of 3]	? ×
🍓 LPM_MU	X	About Documentation
1 Parameter Settings	3 Summary	
counter_mux data1x[70] data0x[70]	Currently selected devi	ice family: MAX 10 *
	How many 'data' inputs do you ' 2 How wide should the 'data' input and the 'result' output buses he? Do you want to pipeline the multiplexer? No Yes, I want an output latency of 1 Create an asynchronous Clear input Create a Clock Enable input	▼ clock cycles
Resource Usage 1 lpm_mux	Can	ncel < Back Next > Finish

- 5.2.6.6 Click "Next" until Page 3.
- 5.2.6.7 Select counter\_mux.bsf checkbox to generate a symbol for our schematic design.

The view of this now looks like:

Parameter       2 EDA       3 Summary         Settings       2 EDA       3 Summary         Image: Counter_mux data1x[7]       Image: Counter_mux data1x[7]       Turn on the files you wish to generate. A gray checkmark indicates a file that is automatically generated, and a green checkmark indicates an optional file. Click Finish to generate the selected files. The state of each checkbox is maintained in subsequent WegaWizard Plug-In Manager sessions.         The MegaWizard Plug-In Manager creates the selected files in the following directory: C:(MAX1000/MAX1000_blinky)         File       Description         Image: counter_mux.chd       Ariation file         Image: counter_mux.chd       Ariation template file         Image: counter_mux.in       Instantiation template file			About Documentation
Settings         Turn on the files you wish to generate. A gray checkmark indicates a file that is automatically generated, and a green checkmark indicates an optional file. Click Finish to generate the selected files. The state of each checkbox is maintained in subsequen MegaVizard Plug-In Manager creates the selected files in the following directory: C:\MAX1000(MAX1000_blink)         File       Description         counter_muxchid       Vaniation file         counter_muxchic       APID include file         counter_muxchic       Print of the selected file         file       Description         counter_muxchic       Vaniation file         counter_muxchic       Quartus Prime symbol file         counter_muxchin       Instantiation template file			
Settings         Turn on the files you wish to generate. A gray checkmark indicates a file that is automatically generated, and a green checkmark indicates an optional file. Click Finish to generate the selected files. The state of each checkbox is maintained in subsequen MegaVizard Plug-In Manager creates the selected files in the following directory: C:\MAX1000(MAX1000_blink)         File       Description         counter_muxchid       Vaniation file         counter_muxchic       APID include file         counter_muxchic       Print of the selected file         file       Description         counter_muxchic       Vaniation file         counter_muxchic       Quartus Prime symbol file         counter_muxchin       Instantiation template file	Parameter 2 EDA	3 Summary	
counter_mux         dataty/			
counter_mux       automatically generated, and a green checkmark indicates an optional file. Click Finish to generate the selected files. The state of each checkbox is maintained in subsequen MegaWizard Plug-In Manager sessions.         The MegaWizard Plug-In Manager reates the selected files in the following directory:         C:(MAX1000_MIX1000_Dlinky)         File       Description         Counter_mux/nd       Variation file         Counter_mux/nd       APROL Thread file         Counter_mux/nd       Instantiation template file			
counter_mux       automatically generated, and a green checkmark indicates an optional file. Click Finish to generate the selected files. The state of each checkbox is maintained in subsequen MegaWizard Plug-In Manager sessions.         The MegaWizard Plug-In Manager reates the selected files in the following directory:         C:(MAX1000_MIX1000_Dlinky)         File       Description         Counter_mux/nd       Variation file         Counter_mux/nd       APROL Thread file         Counter_mux/nd       Instantiation template file		Turn on the files you w	ish to generate. A grav checkmark indicates a file that is
The MegaWizard Plug-In Manager creates the selected files in the following directory: C:(MAX1000)(MAX1000_blinky) File Description Counter_mux.vhd Variation file Counter_mux.cmp VHDL component declaration file Counter_mux.bsf Quartus Prime symbol file Counter_mux_in Instantiation template file	counter_mux	automatically generate	d, and a green checkmark indicates an optional file. Click Finish
The MegaWizard Plug-In Manager creates the selected files in the following directory: C:(MAX1000)(MAX1000_blinky) File Description Counter_mux.vhd Variation file Counter_mux.cmp VHDL component declaration file Counter_mux.bsf Quartus Prime symbol file Counter_mux_in Instantiation template file	data1x[70] data0x[7.0] result[70]		
C:\MAX1000\MAX1000_blinky\ File Description Counter_mux-thd Vanation file Counter_mux-thd Vanation file Counter_mux-the Vanation file Counter_mux-the Vible Component declaration file Counter_mux-the Vible Component file Counter_mux-in Instantiation template file		5 5	5
File       Description         Counter_mux.vhd       Variation file         counter_mux.inc       AHDL Include file         counter_mux.cm       VHDL component declaration file         Counter_mux.cm       VHDL component declaration file         counter_mux.cm       VHDL component declaration file         counter_mux.cm       Quartus Prime symbol file         counter_mux_in       Instantiation template file			
Counter_muxchd Variation file     Counter_muxcinc AHDL Include file     counter_muxcbf VHDL component declaration file     Counter_muxcbf Quartus Prime symbol file     counter_mux_in Instantiation template file			
Counter_mux.inc AHDL Include file			· · · · · · · · · · · · · · · · · · ·
Counter_mux.cmp VHDL component declaration file Counter_mux.bsf Quartus Prime symbol file Counter_mux_in Instantiation template file			
Counter_mux_in Instantiation template file			
counter_mux_in Instantiation template file			
Resource Usage			instantiation template me
Resource Usage			

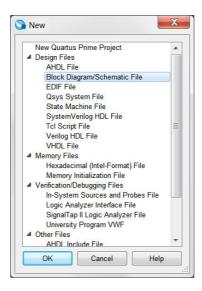
5.2.6.8 Click "Finish".



### 5.2.7 Adding the Components to the Schematic

The next step would be to connect all three components together.

5.2.7.1 To do so, select File menu, then select New and select Block Diagram/Schematic File.



5.2.7.2 Click "OK".

A new schematic will be created, where the components can be added.

5.2.7.3 Right click on the schematic page, and select **Insert**  $\rightarrow$  **Symbol**... as seen below.

Block1.bdf			8		
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	4	Cut Copy Paste	12	1	
	×	Delete Update Symbol or Block			
		Insert	•	S <u>v</u> mbol	
	۹ آ ل	Zoom <u>I</u> n Zoom <u>O</u> ut Zoom Eit in Window Fit Selection in Window	Ctrl+Space Ctrl+Shift+Space Ctrl+Alt+W Ctrl+Shift+W	Symbol as Block,	]



5.2.7.4 In the new window, expand "Project" and the three components that were created can now be seen.

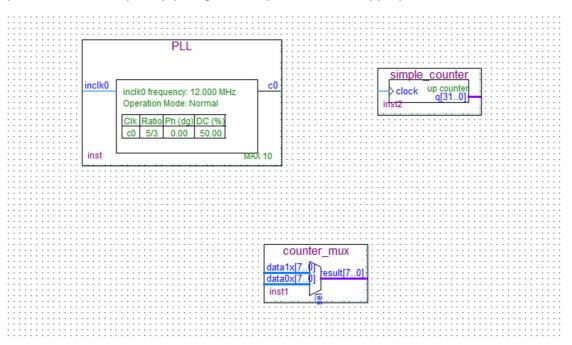
Libraries:	
🔺 🗁 Project	
PLL	
Counter_mux	
⊈ simple_counter	
D C:/altera_lite/16.0/quartus/librari	· · · · · · · · · · · · · · · · · · ·
4 III >	
Name:	
Repeat-insert mode	
Insert symbol as block	

5.2.7.5 Select "PLL".

5.2.7.6 Click "OK".

The PLL component can be added now by left clicking on the schematic page.

- 5.2.7.7 Just like in the steps from 5.7.2.3 to 5.2.7.6, do the same for counter\_mux and simple\_counter to add them to the schematic page. The order of adding the components does not matter, as the connections between them will happen in the following steps.
- 5.2.7.8 After adding three components, your schematic should look similar to the following. To place them similarly, simply drag the components to the appropriate locations.

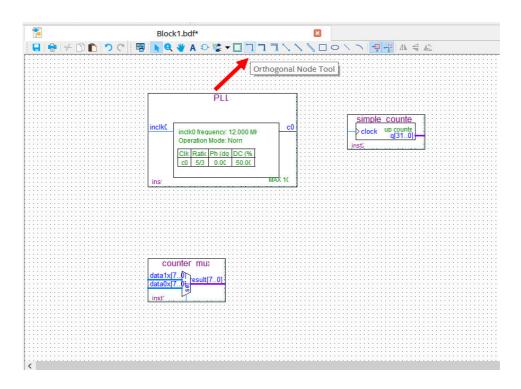




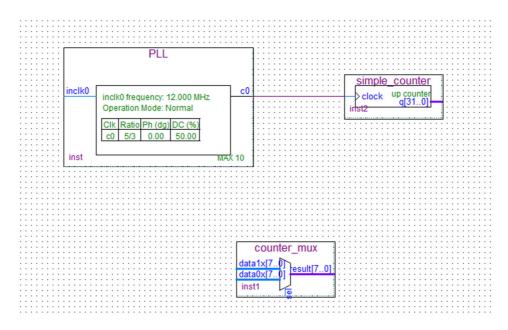
### 5.2.8 Connecting the Components

Next step is to make the proper connections between the three components we just added to the schematic.

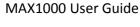
5.2.8.1 Select the **"Node Tool"**.



5.2.8.2 Connect the c0 of the PLL to the simple\_counter as shown below:



This will mean that a single signal (c0) is connected to the simple\_counter (clock).

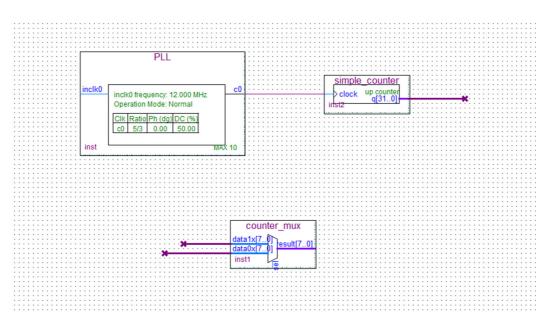


WUVIN

5.2.8.3 Select the "Bus Tool".

50		
<b>7</b>	Block1.bdf*	
	🕨 🔍 👋 A 🕀 👺 🗸 🗖 🦳 🦳	$\mathbf{X} = \mathbf{O} \times \mathbf{V} = \mathbf{W} \times \mathbf{W}$
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	PLL	
		· · · · · · · · · · · · · · · · · · ·
		simple counte
	clkC cl	
	inclk0 frequency: 12.000 MF	clock up counte [310]
	Operation Mode: Norn	431.0
		inst
	Clk Ratic Ph (dq DC (%	· · · · · · · · · · · · · · · · · · ·
	c0 5/3 0.0C 50.0C	
	ns MAX 1(	
	counter mu)	
d	ata1x[7]	
	ata1x[70] ata0x[70]	
•••••••••••••••••••••••••••••••••••••••		
	nst'	
	194	

5.2.8.4 Using the bus tool create a connection coming out of the simple\_counter and one connection for each of the inputs of the counter\_mux as show below.





5.2.8.5 Right click on the output bus of the simple counter that you just created and select "Properties".

Set the name of the bus to: counter[31..0]

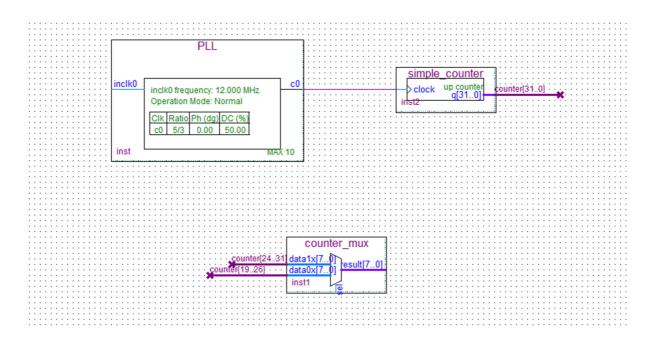
The view of the "Bus Properties" should look like this:

🔁 Bus Prop	berties X
General	Font Format
Name:	counter[310]
Hide	name in block design file.
	OK Cancel Help

5.2.8.6 Do the same for input buses of the mux:

Name the top bus input:	data1x[70] $\rightarrow$ counter[2431]
Name the bottom bus input:	data0x[70] → counter[1926]

Schematic should look like this:





5.2.8.7 Add inputs to the schematic

Click on the "Pin Tool" as show below and select "Input".

Block1.bdf*	×	
🗧 🖶 🗲 🗅 🌔 🤈 🦿 🐺 🔍 🖉 🖌 🕀 👺 🗣	$- \square \neg \neg \neg \neg \land \land \land \land \square$	
in in	Input	
	input	
out.	0	
	Output	
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L	Bidir	
· · · · · · · · · · · · · · · · · · ·		
		simple_counte
inclkC		
	inclk0 frequency: 12.000 MF	c0 clock up counter counter[31. ★
	Operation Mode: Norm	q 31.0
	Operation mode. North	inst
	Clk Ratic Ph (dq DC (%	
	CIK Rait FIT (UV DC (%	
	c0 5/3 0.00 50.00	
	20 Ni	
		AX 1(
inst	M	AA IL
1		
001	unter mw	
lytoteb	701 705 705	
counter[24.3 data1x	esult[70]	
data0x[	<u>/</u>	
inst	M	
	· · · · · · · · · · · · · · · · · · ·	

### 5.2.8.8 Add one input pin for inclk0 of the PLL. Add one input pin for sel of counter\_mux.

Your schematic should look like this:

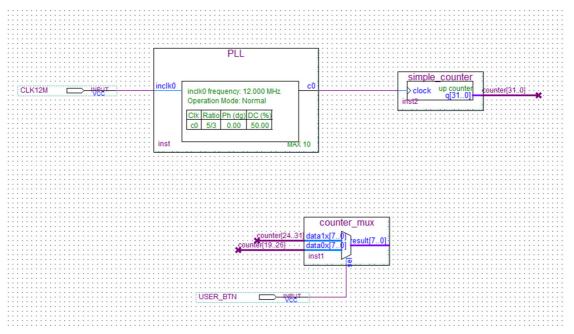
			_								
	1	PLL									
	1		- 1								
	1		- 1								
	1										
	1										
	1		- 1				simn	e counte	r		
			. 1				Junip				
	inclk0	c0	01					up counte	d 1	1.14.2.144	
pin_name1NELT		inclk0 frequency: 12.000 MHz	- 1				-> clock	up counte	l count	eri3101	
· · · · · · · · · · · · · · · · · · ·							r	up counte q[310			<b>— X</b> • • •
		Operation Mode: Normal					inst2		u		
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			-								
		Clk Ratio Ph (dg) DC (%)									
	1										
		c0 5/3 0.00 50.00	1								
		00 0/0 0.00 00.00	1								
	inst	MAX 10	1								
		110 0 1 0									
			• •								
			• •								
			• •								
			2.2								
				counte	er_mu	v i.					
				Jound	er_mu	^ i.					
		counter[2431] dat	ata	1x[70							
					esult	7 01					
		dat	atal	$0 \times [7]$	- Count						
		· · · · · · · · · · · · · · · · · · ·	nst	1 L	7						
			131	· ·	100						
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			• •								
		inin nomo?	• •								
		···· pin_name2 ·	• •								
		· · · ·	• •								
			• •								

5.2.8.9 Rename the pin\_name1 to **CLK12M** by double clicking its current name. This is going to be the clock signal coming into the FPGA.



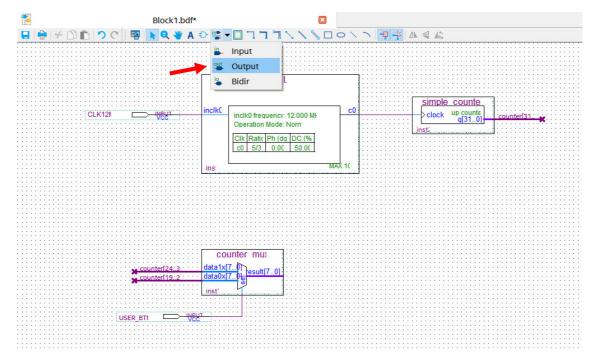
- 5.2.8.10 Rename the pin\_name2 to **USER\_BTN** by double clicking its current name. This is going to be the user button of the MAX1000 board to select the mux.
- 5.2.8.11 Using the "Node Tool" connect:
  - **CLK12M** → inclk0 (of the PLL component)
  - **USER\_BTN**  $\rightarrow$  sel (of the counter\_mux component)

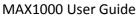
Your schematic should look like this now:



5.2.8.12 Add the outputs to the schematic

Click on the "Pin Tool" as before, but this time select "Output".







- 5.2.8.13 Add one output pin for the LEDs.
- 5.2.8.14 Rename the pin to **LED[7..0]**.
- 5.2.8.15 Using the **"Bus Tool"**, make the connection between counter\_mux component and output pin:

### result[7..0] $\rightarrow$ LED[7..0]

The final schematic should look like the following:

	1	PLL							
		I LL							
	1					simple	counter		
	inclk0		c0				up counter q[310]	· · · · · · · · · · · · · · · ·	
··· CLK12M	inc	Ik0 frequency: 12.000 MHz				> clock	up counter	counter[310]	
· · · · · · · · · · · · · · · · · · ·							q 310		<b></b>
		eration Mode: Normal				inst2			
		Ratio Ph (dg) DC (%)							
	c0	5/3 0.00 50.00							
		0.00 0.00 00.00							
	1 1								
	inst	MAX	(10						
				counter	mux -				
			· I · · ·						
		counter[24.3	1	-4.17 B					
		counter[243	u data	aix[/ሀ]ጊ					
		counter[1926]	dat	-0v17 bi	esuit / 0 !!			LED[7 0]	
		Counter[1920]	data	a0x[70]				· LED[70]	
		· · · · · · · · · · · · · · · · · · ·							
			ins	50 🖂					
				<u>ں</u>					
		USER BTN	_						
		VCC							

Looking at the schematic, even though the buses are not connected together by wires, the names of counter tell Quartus Prime to connect the signals together. Overall, the user button will toggle between displaying higher 8 bits of the counter and 8 lower bits of the counter. The signals of the counter that are not connected will not be used by Quartus Prime.

### 5.2.8.16 Save your design

Open the File Menu and select "Save". Save it as top.bdf

### 5.2.9 Analysis and Synthesis

The next step is to run Analysis and Synthesis to ensure that there is no errors in the design.

To run Analysis and synthesis open **Processing** → **Start** → **Analysis and Synthesis** 

or from clicking the button on the top toolbar as seen below:

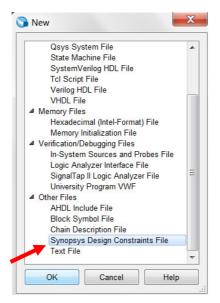
Quartus Prime Lite Edition - C:/MAX1000/M	AX1000_blinky/top - t	ор			
Eile Edit View Project Assignments Proce					
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Project Navigator 🔥 Hierarchy 🔹 🗐 🗗 🗙	÷	Compilation Report - top	🗙 🔁	top.bdf*	×
Entity:Instance	📒 🔒 🗲 🗅 🗈	🔿 ୯ 🛛 🖼 📲 🚺 🥱 🗶 🕯	D 📽 🕶 🗖 🤉 🤊 🔍		
A MAX 10: 10M08SAU169C8G					
D 🛃 top 🖄	CLK12M	nelk0	PLL incik0 frequency: 12.000 MHz Operation Mode: Normal Cik Ratio Ph (dg) DC (%) c0 5/3 0.00 50.00	c0 clock inst x 10	Counter up counter [31.0]

There should be no errors. If there are errors, they should be fixed before continuing and Analysis and Synthesis run again.

### 5.2.10 Adding Timing Constraints

Timing Constraints tell the Quartus what are the timing requirements for this design. Timing Constraints are required in every CPLD/FPGA design.

To add the timing constraints, select File  $\rightarrow$  New and under the "Other File" section, select "Synopsys Design Constraints File" and select "OK".



MAX1000 User Guide

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Type or copy the following lines into this new file:

#create input clock which is 12MHz
create\_clock -name CLK12M -period 83.333 [get\_ports {CLK12M}]

#derive PLL clocks derive\_pll\_clocks

#derive clock uncertainty
derive\_clock\_uncertainty

#set false path
set\_false\_path -from [get\_ports {USER\_BTN}]
set\_false\_path -from \* -to [get\_ports {LED\*}]

- 5.2.10.1 The first line "create\_clock" tells Quartus Prime that the clock, CLK12M is 83.333 ns (12 MHz). It also assigns the CLK12M to a pin (port) in the .sdc format.
- 5.2.10.2 The second line "derive\_pll\_clocks" tells the software to look if there are any PLLs, and if so, automatically derive the clock multiplication/division of the outputs of the PLL even if they are used internally within the CPLD/FPGA.
- 5.2.10.3 The third line "derive\_clock\_uncertainty" tells the software to automatically determine the internal clock uncertainty. No clock is ideal, and thus there will be some internal jitter within the FPGA associated with it.
- 5.2.10.4 The fourth and fifth line "set\_false\_path" tells the software to not do any timing optimization to the stated paths/pins. The I/Os of this design are trivial, so they can be ignored in the Timing Analysis.
- 5.2.10.5 Use File  $\rightarrow$  Save to save it as top.sdc.

5.2.10.6 Ensure that the file is added to the Project: Assignments → Settings and select "Timequest Timing Analyzer". The top.sdc should have been already added by default. If it is not, it will need to be added manually.

🖌 Settings - top		
Category:		Device/Board
General	TimeQuest Timing Analyzer	
Files Libraries	Specify TimeQuest Timing Analyzer options.	
✓ IP Settings IP Catalog Search Locations Design Templates	SDC files to include in the project	
Operating Settings and Conditions	File name:	Add
Voltage Temperature	<ul> <li>X</li> </ul>	Remove
Compilation Process Settings     Incremental Compilation	File Name Type top.sdc Synopsys Design Constraints File	Up
<ul> <li>EDA Tool Settings</li> <li>Design Entry/Synthesis</li> </ul>	top.sdc Synopsys Design Constraints File	Down
Simulation Board-Level Compiler Settings VHDL Input Verilog HDL Input		
Default Parameters TimeQuest Timing Analyzer Assembler Design Assistant	Enable Advanced I/O Timing     Report worst-case paths d	uring compilation
SignalTap II Logic Analyzer	Tcl Script File for customizing reports during compilation	
Logic Analyzer Interface PowerPlay Power Analyzer Setting	Tcl Script File name:	
SSN Analyzer	$\fbox$ Run default timing analysis before running custom script	
	Metastability analysis	
	Synchronizer identification: Auto	-
	Description:	
	Associates a Synopsys Design Constraint File (.sdc) with this project.	
<	Weight Buy Software OK Cancel Apply	Help

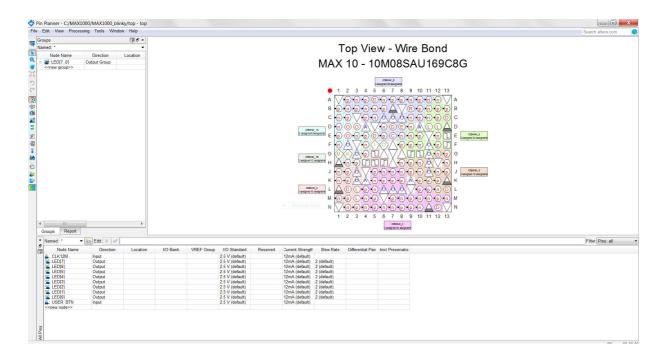


### 5.2.11 Pinning Assignments

Before the design can be downloaded to the FPGA, pin assignments that match the hardware on the board are needed. There are different ways to do this such as the Pin Planner, Assignment Editor, and text files.

The following steps will show one of these ways, the Pin Planner. Since there are only 10 pins that need to be assigned, the Pin Planner can be used. If many pins are needed, other ways can be used such as the Quartus Assignment Editor, or by importing constraints from a text file or spreadsheet.

### 5.2.11.1 Open the Pin Planner: Assignments $\rightarrow$ Pin Planner.



A new window will open as seen below:

5.2.11.2 To make pin assignments, select the CLK12M (node name) on the bottom portion and drag and drop it to pin H6 of the Top View of the FPGA or alternatively set the Location field of the CLK12M to **PIN\_H6**.



The window should now look like this:

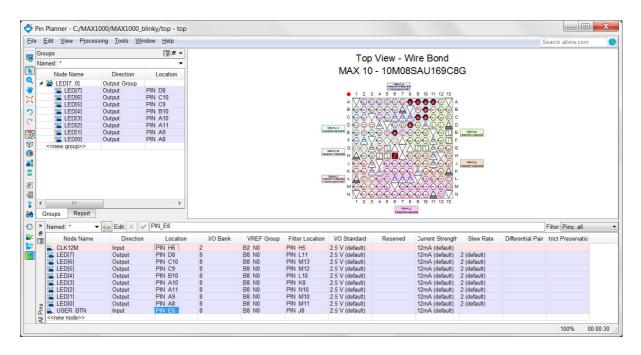
Four Alem Llocess	sing <u>T</u> ools <u>W</u> indo	w <u>H</u> elp								Sea	arch altera.com
Groups		🗊 🗗 🗙				Top	View - Wi	re Bond			
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Node Name	Direction	Location				MAX 10	- 10M085	AU169C8G	3		
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						^ <b>\∕ @ @</b>	000000	<u>● ● ● ● ● </u> ▲			
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					6						
< III		4			8			▲ ● ● ● ▲ K			
Groups Report		4									
Groups Report * Named: *	Kan Edit: X	PIN_H6								Fi	ilter:Pins; all
Groups Report × Named: * ▼	Edit: X V Direction	PIN_H6 Location	I/O Bank	VREF Group	Fitter Location					12000 2000	iter: Pins: all trict Preservatio
Groups Report  Named: *  Node Name  CLK12M	Direction		VO Bank 2	VREF Group B2 N0	Fitter Location PIN H5	K 0 0 A L 0 0 N 0 0 N 1 2 3 I/O Standard 2.5 V (default)		COOC A K     COOC A K	Slew Rate	12000 2000	
Groups Report  Named: *  Node Name  CLK12M  LED[7]	Direction Input Output	Location			Fitter Location PIN H5 PIN L11	K Q Q A L Q C N V Q C 1 2 3 1/O Standard 2.5 V (default) 2.5 V (default)			Slew Rate 2 (default)	12000 2000	
Groups Report  Named:  Named:  Node Name  CLK12M  LED[7]  LED[6]	Direction Input Output Output	Location			Fitter Location PIN H5 PIN L11 PIN M13	K Q Q A L Q C N 1 2 3 I/O Standard 2.5 V (default) 2.5 V (default)			Slew Rate 2 (default) 2 (default)	12000 2000	
Groups Report  Named: *  Node Name  CLK12M  CLED[7]  LED[5]	Direction Direction Unput Output Output Output Output	Location			Fitter Location PIN H5 PIN L11 PIN M13 PIN M12	K O O A K O O C N O C N O C 1 2 3 V/O Standard 2.5 V (default) 2.5 V (default) 2.5 V (default) 2.5 V (default)		Current Strength 12mA (default) 12mA (default) 12mA (default) 12mA (default) 12mA (default) 12mA (default) 12mA (default)	Slew Rate 2 (default) 2 (default) 2 (default)	12000 2000	
Groups Report Named * Node Name CLK12M LED[7] LED[6] LED[4]	Direction Input Output Output Output Output	Location			Fitter Location PIN H5 PIN L11 PIN M13 PIN M12 PIN L10	K 0 0 0 L 0 0 0 N 0 0 0 S 5 V (default) 2.5 V (default) 2.5 V (default) 2.5 V (default) 2.5 V (default) 2.5 V (default)		Q ⊕ O ⊕ K         K           Q ⊕ O ⊕ K         K           Q ⊕ O ⊕ K         K           Q ⊕ O ⊕ K         K           Q ⊕ O ⊕ K         K           Q ⊕ O ⊕ K         K           Q ⊕ O ⊕ K         K           Q ⊕ O ⊕ K         K           Q ⊕ O ⊕ K         K           Q ⊕ O ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ G ⊕ K         K           Q ⊕ K         K           Q ⊕ K         K           Q ⊕ K         K           Q ⊕ K         K           Q ⊕ K         K           Q ⊕ K         K           Q ⊕ K         K           Q ⊕ K         K     <	Slew Rate 2 (default) 2 (default) 2 (default) 2 (default)	12000 2000	
Groups Report Named: * ▼ Node Name LED(7) LED(6) LED(6) LED(6) LED(1) LED(1) LED(1) LED(1)	Direction Direction Unput Output Output Output Output Output Output	Location			Fitter Location PIN H5 PIN L11 PIN M12 PIN L10 PIN K8	K ○ ○ A     K ○ ○ A     K ○ ○ A     K ○ ○ A     K ○ ○ C     N ○ □ ○ C     N ○ □ ○ C     N ○ □ ○ C     N ○ □ ○ C     N ○ □ ○ C     N ○ □ ○ C     N ○ □ ○ C     N ○ □ ○ C     N ○ □ ○ C     N ○ □ ○ C     N ○ □ □ □ □ □     N ○ □ □ □ □ □ □     N ○ □ □ □ □     N ○ □ □ □ □     N ○ □ □ □ □     N □ □ □ □     N □ □ □ □     N □ □ □ □		Quere of the second s	Slew Rate 2 (default) 2 (default) 2 (default) 2 (default) 2 (default)	12000 2000	
Groups         Report           *         Node Name           *         •           *         •           *         •           *         •           *         •           *         •           •         •	Direction Input Output Output Output Output Output Output	Location			Fitter Location PIN H5 PIN L11 PIN M13 PIN L10 PIN L10 PIN K8 PIN N10	K ○ ○ A     K ○ ○ C     N     V     C     V     C     V     C     V     C     V     C     C     V     C     C     V     C     C     V     C     C     V     C     C     V     C    C		Q ⊕ Q ⊕ K         K           Q ⊕ Q ⊕ K         K           Q ⊕ Q ⊕ K         M           Q ⊕ Q ⊕	2 (default) 2 (default) 2 (default) 2 (default) 2 (default) 2 (default) 2 (default)	12000 2000	
Groups Report Named: * Node Name CLK12M	Direction Input Output Output Output Output Output Output Output	Location			Fitter Location PIN H5 PIN L11 PIN M12 PIN L10 PIN K8 PIN N10 PIN M10	I         O ⊂ C           N         O ⊂ C           Z         V (default)		Querent Strength           2mrent Strength           12mA (default)	2 (default) 2 (default) 2 (default) 2 (default) 2 (default) 2 (default) 2 (default) 2 (default)	12000 2000	
Groups         Report           *         Node Name           *         •           *         •           *         •           *         •           *         •           *         •           •         •	Direction Input Output Output Output Output Output Output	Location			Fitter Location PIN H5 PIN L11 PIN M13 PIN L10 PIN L10 PIN K8 PIN N10	K ○ ○ A     K ○ ○ C     N     V     C     V     C     V     C     V     C     V     C     C     V     C     C     V     C     C     V     C     C     V     C     C     V     C    C		Q ⊕ Q ⊕ K         K           Q ⊕ Q ⊕ K         K           Q ⊕ Q ⊕ K         M           Q ⊕ Q ⊕	2 (default) 2 (default) 2 (default) 2 (default) 2 (default) 2 (default) 2 (default) 2 (default)	12000 2000	

Note that the Location of the CLK12M is now set to Location PIN\_H6 (as seen in blue colour in the top view of the FPGA).

5.2.11.3 The other pins need to be assigned as well. Just like previously set all the pins to their appropriate locations using the table below, by either drag and drop or writing manually the location.

Node Name	Pin Location
LED[7]	PIN_D8
LED[6]	PIN_C10
LED[5]	PIN_C9
LED[4]	PIN_B10
LED[3]	PIN_A10
LED[2]	PIN_A11
LED[1]	PIN_A9
LED[0]	PIN_A8
USER_BTN	PIN_E6

5.2.11.4 Now the Pin Planner should look like this after assigning all the pin locations.

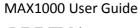


The specific pins are now selected, but the I/O standards now need to be set as well. The button, LEDS, and clock pins are the same I/O standard for MAX1000 since all banks and peripherals are powered by 3.3V. The USER\_BTN is a 3.3 V Schmitt Trigger, the LEDs and clock pins are 3.3-V LVTTL. These I/O standards can be set in the Pin Planner, by selecting the I/O Standard. Select the I/O standard either from the "All Pins" tab or the "Groups" tab, and change the 2.5V (default) to the specific I/O standard.

5.2.11.5	The Pin Planner should now look like this:
----------	--

Grou	ips					۱	₽ <i>8</i> ×		Ten V		Dond		
Nam	ned: *						•			iew - Wire			
	Node Name	Direction	Location	I/O Bank	VREF Group	I/O Standard	Current		MAX 10 -	10M08SA	U169C8G		
4.9	LED[70]	Output Group			That broop	3.3-V LVTTL	8mA (c						
	LEDI71		PIN D8	8	B8 N0	3.3-V LVIIL	8mA (c			CRUNK 6 Fastbracci in donate 1 Port 6 argun (1997)			
	LEDI61		PIN C10	8	B8 N0	3.3-V LVTTL	8mA (c			5 6 7 8 9			
	LEDI51		PIN C9	8	B8 N0	3.3-V LVTTL	8mA (c		A V @ 0 @	00000	🔁 🕣 🕢 🔺		
	LED[4]		PIN B10	8	B8 N0	3.3-V LVTTL	8mA (c		B (p (n) (p (n)				
	LED[3]		PIN A10	8	B8 N0	3.3-V LVTTL	8mA (c		c @ @ 76	AAAA	0000 c		
	LEDI21		PIN A11	8	B8 N0	3.3-V LVTTL	8mA (c		- n 0 0 0 0	VOODO			
	LED[1]		PIN A9	8	B8 N0	3.3-V LVTTL	8mA (c	District 1	EGOOG	00000	0 V 0 🗖 = 📖	inkje 102 autorate	
	SUL LEDIOI		PIN A8	8	B8 N0	3.3-V LVTTL	8mA (c					(compress)	
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Gr F F	Named: * Node Name CLK12M	Direction Input Output	Locatio PIN H6 PIN D8	2 8	B2 N0 B8 N0	PIN H6 PIN D8	3.3-V LVTTL 3.3-V LVTTL		Lurrent Strength BmA (default) BmA (default)	C C C C C C C C C C C C C C C C C C C	Q A Q Q H Q A Q Q J J B Q Q Q Q Q L Q Q Q Q Q M Q Q Q Q Q M N Q Q Q Q Q M N N 10 11 12 13	Filter: Pins: all	
Gr F	Named: * Node Name CLK12M UED[7] UED[6]	Direction Input Output Output	Locatio PIN H6 PIN D8 PIN C10	2 8 8	B2 N0 B8 N0 B8 N0	PIN H6 PIN D8 PIN C10	3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL		J GOAL J GOAL M GOAL N COAC 1 2 3 4	Slew Rate 2 (default)	Q A Q Q H Q A Q Q J J B Q Q Q Q Q L Q Q Q Q Q M Q Q Q Q Q M N Q Q Q Q Q M N N 10 11 12 13	Filter: Pins: all	
Gr F	Named: * Node Name CLK12M LED[7] LED[6] LED[5]	Direction Input Output Output Output	Locatio PIN H6 PIN D8 PIN C10 PIN C9	2 8 8 8	B2 N0 B8 N0 B8 N0 B8 N0 B8 N0	PIN H6 PIN D8 PIN C10 PIN C9	3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL		Jurrent Strength 8mA (default) 8mA (default) 8mA (default) 8mA (default)	Control Contro Control Control Control Control Control Control Control Control Co	Q A Q Q H Q A Q Q J J B Q Q Q Q Q L Q Q Q Q Q M Q Q Q Q Q M N Q Q Q Q Q M N N 10 11 12 13	Filter: Pins: all	2
Gr F	Named: * Node Name 	Direction Input Output Output Output Output	Locatio PIN H6 PIN D8 PIN C10 PIN C9 PIN B10	2 8 8 8 8	B2 N0 B8 N0 B8 N0 B8 N0 B8 N0 B8 N0	PIN H6 PIN D8 PIN C10 PIN C9 PIN B10	3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL		J         O         O         J           J         O         O         O         O           M         O         O         O         O         O           M         O	Control C	Q A Q Q H Q A Q Q J J B Q Q Q Q Q L Q Q Q Q Q M Q Q Q Q Q M N Q Q Q Q Q M N N 10 11 12 13	Filter: Pins: all	
Gr F F	Named: * Node Name LED[7] LED[6] LED[6] LED[5] LED[3]	Direction Input Output Output Output Output Output	PIN H6 PIN H6 PIN D8 PIN C10 PIN C9 PIN B10 PIN A10	2 8 8 8 8 8 8	B2 N0 B8 N0 B8 N0 B8 N0 B8 N0 B8 N0 B8 N0	PIN H6 PIN D8 PIN C10 PIN C9 PIN B10 PIN A10	3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL		J         Image: Constraint of the second secon	Control Contro Control Control Control Control Control Control Control Control Co	Q A Q Q H Q A Q Q J J B Q Q Q Q Q L Q Q Q Q Q M Q Q Q Q Q M N Q Q Q Q Q M N N 10 11 12 13	Filter: Pins: all	
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Gr × I ₽	Named: * Node Name CLK12M LED[7] LED[6] LED[5] LED[4] LED[3] LED[3] LED[3] LED[2] LED[1]	Direction Input Output Output Output Output Output Output Output	Locatio PIN H6 PIN D8 PIN C10 PIN C9 PIN B10 PIN A10 PIN A11 PIN A10	2 8 8 8 8 8 8 8 8 8	B2         N0           B8         N0	PIN H6 PIN D8 PIN C10 PIN C9 PIN B10 PIN A10 PIN A11 PIN A9	3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL 3.3-V LVTTL		Image: Second	Comparison of the second	Q A Q Q H Q A Q Q J J B Q Q Q Q Q L Q Q Q Q Q M Q Q Q Q Q M N Q Q Q Q Q M N N 10 11 12 13	Filter: Pins: all	
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5.2.11.6 Close the Pin Planner. The settings are automatically saved.



### 5.2.12 Compiling the Design

5.2.12.1 First, make sure that the operating conditions of the device are set correctly.

Open Settings  $\rightarrow$  Operating Settings and Conditions  $\rightarrow$  Voltage and set VCCA voltage to "3.3V" and press "Apply" and "OK".

			L
General	Voltage		
Files Libraries	Select the operating volta	ge conditions.	
✓ IP Settings	Name:	Setting:	
IP Catalog Search Locations	VCCA voltage	3.3V	
Design Templates	VCCIO voltage	Configurable through pin assignments	
<ul> <li>Operating Settings and Conditions</li> <li>Voltage</li> </ul>			
Temperature			
<ul> <li>Compilation Process Settings Incremental Compilation</li> </ul>			
✓ EDA Tool Settings			
Design Entry/Synthesis			
Simulation			
Board-Level			
✓ Compiler Settings			
VHDL Input			

5.2.12.2 You can also set the default I/O Standard which can eliminate some design warning and save you time from setting the standard for some pins manually.

Open Assignments  $\rightarrow$  Device  $\rightarrow$  Device and Pin Options  $\rightarrow$  Voltage and set Default I/O Standard to "3.3-V LVTTL" and press "OK" to all the windows.

General	Voltage		
Configuration Programming Files	Specify voltage options fo	or the device.	
Jnused Pins	Default I/O standard:	3.3-V LVTTL	
Dual-Purpose Pins Capacitive Loading	VCCIO I/O bank1 voltage:	n/a in MAX 10 use Pin Planner to adjust VCCIO voltage	
Board Trace Model	VCCIO I/O bank2 voltage:	n/a in MAX 10 use Pin Planner to adjust VCCIO voltage	
/O Timing	Core voltage: 1.2V		
/oltage			
Pin Placement			
Error Detection CRC			
CVP Settings			

5.2.12.3 The next step is to compile and complete the design. This step will verify that there are no errors, create internal databases, and create programming files that will be used in the next steps.

To compile the design, select **Processing**  $\rightarrow$  **Start Compilation** or through the button as show below:

Quartus Prime Lite Edition - C:/MAX1000/MA	X1000 blinky/top - top						
File Edit View Project Assignments Processing Tools Window Help							
🗋 🛅 🖶   🗲 🗂 💼   🄈 🦿 🤀 top	- < < < < < < < < < < < < < < < < < < <						
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MAX 10: 10M08SAU169C8G							
PLL:inst (							
counter_mux:inst1							
F simple_counter.inst2	PLL inclk0 inclk0 frequency 12.000 MHz 00 inclk0 frequency 12						

If there are errors, they will need to be resolved and re-compiled before the design can be programmed to the board. When Compiling finishes and there are no errors, there will be a message at the bottom of the window that states: Full Compilation was successful and a 100% indication along with the compile time in the right bottom corner.

### 5.2.13 Reading the Compilation Report

Eile Edit View Project Assignments Proce	sand Toola Window Helb			Search altera.com
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roject Navigator 🔥 Hierarchy 🔹 🗐 🗗 🛪	Compilation Report - top		top.sdc 💌	IP Catalog 🗊 🖉
Entity:Instance	Table of Contents	Flow Summary		<ul> <li>X</li> </ul>
MAV 10 1000624 P PL Int School (1) P PL Int PL Int School (1) P PL Int PL I	Im Brow Summary:     Im Frow Standard Global Settings     Im Frow Standard Global Settings     Im Frow Elacystar Time     Im Ora Of Sammary     Frow Log     For Vog     Im Standard Schulters     Im From Standard	Flow Status Quartus Prine Version Revision Name Top-lavel Enthy Name Family Device Tradial Journey Total and Galactic Angle Total inguisters Total inguisters T	Successful - True Jul 11 12 35 35 2017 16 0 B Build 211 04/27/2016 31 Like Edition Top MAX 10 10M085AJL/68CBG Final 11.8,064 (< 1% ) 21.8,064 (< 1% ) 22.1,8,064 (< 1% ) 22.1,8,064 (< 1% ) 0 0 / 130 (0% ) 0 / 48 (0% ) 1 / 1 (0% ) 0 / 1 (0% )	A Second P     Project Directory     Projectory     Projectory
	> 😽 Find	Find Next		
<ul> <li>332146 Worst-case setup</li> <li>332146 Worst-case hold</li> <li>332140 No Recovery path</li> <li>332140 No Removal paths</li> <li>332140 No Removal paths</li> <li>332146 Worst-case minin</li> <li>332101 Design is fully</li> <li>33210 Design is fully</li> <li>Quartus Prime Ti</li> </ul>	Jncertainty. Please refer to report o slack is 48.548 slack is 0.241 is to report	sful. 0 errors, 1 warning	ck uncertainties.	

After successfully compiling the design, a Compilation Report should appear as shown above:

This report is very useful with a lot of information about the design. Last message state that the design was fully constrained, Timing Analysis and compilation successful, but there is more to it:

- In the Flow Summary, it can be seen how many logic elements the whole design took, along with total PLLs, registers, pins, etc.
- In Analysis and Synthesis, more detailed information about the resources used can be seen in Resource Usage Summary, as well how many LEs were used for each component in Resource Utilization by Entity.
- In the Fitter, more detailed information about the pins and their banks can be seen. For example if we used the RESET\_BTN (PIN\_E7), we could have issues since it is configured as a secondary function, which can be seen in Fitter → Resource Section → Dual Purpose and Dedicated Pins, which would require to disable in the settings.
- TimeQuest Timing Analyzer shows various timing information concerning the design, as well as if the design has met the timing requirements. In this case timing requirements were met, but in other cases that requirements might not be met, could be solved by going over the information provided in the reports inside this folder. Most notable reports in this folder are: the maximum frequency the design can achieve, setup and hold slack, unconstrained paths in case they were missed, etc.

### Chapter 6 - Configuring the MAX1000

After successfully compiling your project, there should new files generated. In case of MAX10 devices, two type of files are generated due to the architecture of the device, .sof and .pof. In other device architectures, only the .sof file is generated automatically.

### Note: Difference between .pof and .sof files

**sof**: is for the direct volatile configuration, which programs the FPGA fabric directly (SRAM cells). Configuration is lost on power off.

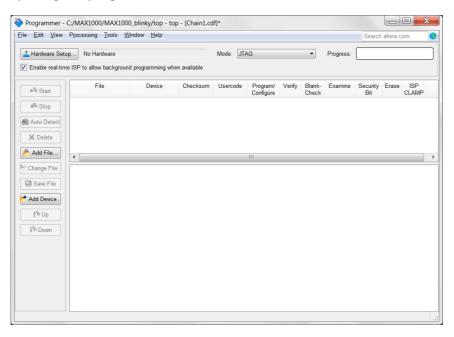
**pof**: is for non-volatile programming, which program the either an external configuration devices or in MAX10 case, itself as it is a non-volatile FPGA.

### 6.1 Configure the FPGA in JTAG Mode

6.1.1 Open the Quartus Prime Programmer from **Tools** → **Programmer** or double-click on Program Device (Open Programmer) from the Tasks pane. Since the MAX1000 is not connected yet, the Programmer should show a blank configuration.

	rvavigato	or 🔥 Hierarchy		]≡ @ ₽	
		Entity:Instance			
		M08SAU169C8G			
D BDF	top 눱				1
• 1	H				•
Tasks		Compilation	•	]≡ @ ₽	×
		Tas	k		
	▷ ▶ 0	Compile Design			
<ul> <li>Image: A second s</li></ul>		dit Settings			
~	📑 E	ait Settings			
			oon Pro	arammer	4
•		Program Device (O	pen Pro	grammer	)
•			pen Pro	grammer	)
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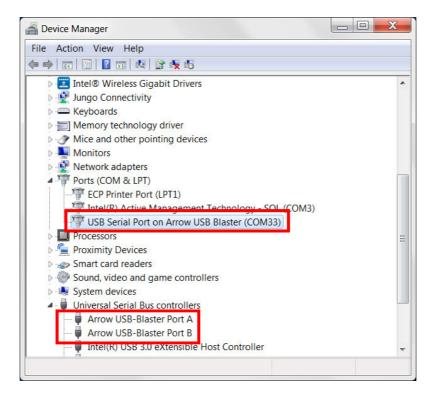
6.1.2 After opening the program this should be the view of the new window:



6.1.3 Connect your MAX1000 board to your PC using a USB cable. The Arrow USB Blaster driver software should already be installed, if not please refer to Chapter 4.2 (Windows based operating system) or 4.4 (Linux based operating system) for installing the drivers.

After plugging in the MAX1000, the green LED should also light up indicating power on, along with a brief flash of the red LED CONF\_DONE.

In the Window's Device Manager should display the following entries that are highlighted in red.





6.1.4 In the Programmer window, click Hardware Setup and double-click the ARROW-USB-BLASTER entry in the Hardware Settings tab (you should only be able to see this Arrow USB Blaster if MAX1000 is connected to the PC). The "Currently selected hardware" dropdown should now show ARROW-USB-BLASTER [USB-0]. Depending on your PC, the USB port number may vary.

Select a programming lardware setup applie				vices. This programming
Currently selected har	dware: [	Arrow-USB-Bla	ster [USB0]	
Available hardware it	tems			
Hardware		Server	Port	Add Hardware
Arrow-USB-Blaster		Local	USB0	Remove Hardware

### 6.1.5 Click "Close".

6.1.6 The Programmer window should now have a Hardware Setup such as:

<u>File Edit View Proc</u>	cessing <u>T</u> ools <u>W</u> indow <u>H</u> elp					Search altera.com
🛓 Hardware Setup	Arrow-USB-Blaster [USB0]	Mode:	JTAG	•	Progress:	
Enable real-time ISP	to allow background programming	when avai	lable			

6.1.7 Click "Auto Detect" on the left side of the Programme window and make sure the Mode is JTAG.

Ardware Setup	Arrow-USB-Blaster	IUSB01		Mode: JTA	NG.		•	Progress:			
Enable real-time ISF			ien available	mode.	10			r togicos.	L		
▶ <sup>N</sup> b Start	File	Device	Checksum	Usercode	Program/ Configure	Verify	Blank- Check	Examine	Security Bit	Erase	ISP CLAMF
🕪 Stop											
Auto Detect											
X Delete											
Add File											
Change File.											
Save File											
Add Device											
1 <sup>™</sup> b Up											
<sup>1</sup> <sup>™</sup> Down											



6.1.8 Select your device and click OK. In this case its "10M08SA"

ound devices with shared JTAG ID fo	or device 1. Please select your device
10M08SA	
10M08SAES	
10M08SC	
	15

6.1.9 To choose the programming file, you can either click "Add File.." on the right side of the Programmer window (highlighted in red) or double-click <none> below the File tab (highlighted in green).

Ph Start Configure Check Bit CLA	<u>E</u> dit <u>V</u> iew	Processing Tool	s <u>W</u> indow <u>H</u> elp							Search	altera.c	om
▶ Start       Configure       Check       Bit       CLA         ■ Stop       10M08SA       00000000 <none>       Image: Check       Bit       CLA         Auto Detect       X       Delete       Image: Check       Image: Check</none>				hen available	Mode: JT/	AG		•	Progress:			
Auto Detect  Add File Add File Add Device TDI ADDITEXAN III ADDITEXAN III IIII IIII IIIIIIIIIIIIIIIIIIIIII	▶ <sup>™</sup> Start	File	Device	Checksum	Usercode		Verify		Examine		Erase	ISP CLAM
K Delete Add File Add Device 1 <sup>th</sup> Up 10M08SA	Stop	<none></none>	10M08SA	00000000	<none></none>							
Add File hange File. Save File dd Device 1 <sup>th</sup> Up 10M08SA	Auto Detect											
hange File. VSave File vdd Device 1 <sup>th</sup> Up 10M08SA	Colete											
hange File. Save File Md Device 1 <sup>th</sup> Up 10M08SA	Add File											
Add Device	hange File.											
Add Device TDI ADDERA	Save File											
10M08SA	dd Device	AVE										
10M08SA	1 <sup>11</sup> Up	<b>_</b>										
	P Down	100										
		+										

6.1.10 In either case, navigate to: <project\_directory>/output\_files/ in your compilation directory. Select and open the top.sof file.

ok in:	MAX1000\MAX1000_blinky\output_file	5	- 0 0 0 📑 🗉 🛛
Ny Computer	Name	Size Type	Date Modified
a dkolosov	L greybox_tmp	File Folder	04/07/2017 10:53:31
	top.pof	314 KB pof File	11/07/2017 12:35:28
	top.sof	711 KB sof File	11/07/2017 12:35:28
le name: top.sof			Open

### 6.1.11 Click "Open".

6.1.12 The Programmer window should look like this now:

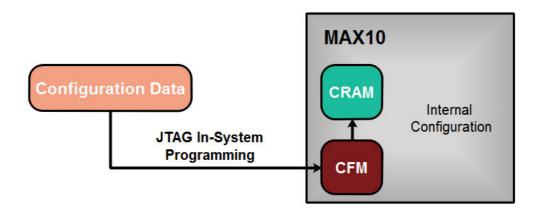
e <u>E</u> dit <u>V</u> iew	Processing Tools	<u>W</u> indow <u>H</u> elp					S	earch altera	.com	6
Hardware Setu	p Arrow-USB-Blast e ISP to allow backgrou		Mode: JTAG en available		•	Progre	ss:			
▶ <sup>™</sup> Start	File	Device	Checksum	Usercode	Program/ Configure	Verify	Blank- Check	Examine	Security Bit	Era
Auto Detect	output_files/top.sof	10M08SAU169	00086CF1	00086CF1						
Add File	•			Ш						4
Add Device										

6.1.13 Make sure the Program/Configure checkbox is checked (highlighted in red above) and click "Start" (highlighted in green above) to program the MAX1000. You should see the CONF\_DONE LED toggle briefly to indicate that the configuration is complete and the Progress bar should reach 100% (Successful). The design is now programmed to the FPGA.

*Note:* that turning off and then on the FPGA will result into losing its configuration.

### 6.2 Internal Configuration

The configuration data to be written to CFM will be part of the programmer object file (.pof). This configuration data is automatically loaded from the CFM into the MAX10 device when the board is powered up.



6.2.1 Going back to step 6.1.10, instead of choosing the .sof file, choose the .pof file.

.ook in: 🛛 📙 C:\	MAX1000\MAX1000_blinky\output_files	3	🔄 🗘 🗘 🗘 🚺
鷆 My Computer	Name	Size Type	Date Modified
k dkolosov	L greybox_tmp	File Fo	lder 04/07/2017 10:53:31
	top.pof	314 KB pof File	e 11/07/2017 12:35:28
	top.sof	711 KB sof File	11/07/2017 12:35:28
ile name: top.pof			Open

### 6.2.2 Click "Open".

### 6.2.3 The window should look like this:

	-	<u>V</u> indow <u>H</u> elp							Gearch	altera.c	om
Hardware Setu	<u>·</u>			Mode: JTA	AG		•	Progress:			
Enable real-tim	e ISP to allow backgroun					1		1		1	
▶ <sup>™</sup> Start	File	Device	Checksum	Usercode	Program/ Configure	Verify	Blank- Check	Examine	Security Bit	Erase	ISP CLAMP
■ <sup>3</sup> Stop	output_files/top.pof CFM0	10M08SAU169	026601C6	00086CF1							
Auto Detect	UFM										
X Delete											
Add File									_		
hange File.	•			111							
Save File											
Add Device											
1 <sup>™</sup> Up	10M08SAU										
<b>I</b> ™ Down	TDO										

Select all the checkboxes under the Program/Configure for CFMO and UFM (highlighted in red above).

6.2.4 Click "Start" to configure MAX10. The programming could take a while.

6.2.5 When the programming is finished, the MAX1000 should be able to keep its configuration data even after powered off.

### 6.3 Testing the Design

Does not matter which way the MAX1000 was configured, the results should be the same for both methods, with the only difference being if configuration is retained after power off.

On the board by default, the LEDS should now toggle in a slow counting sequence.

Push and hold the USER\_BTN to see that the LEDs will now toggle in a very fast counting sequence. USER\_BTN is on the side of the LEDs.

Releasing the USER\_BTN, will make the LEDs toggle at a slower rate as before.

### Chapter 7 - Common Issues and Fixes

- 1) **Issue:** In some rare cases when using Windows 10 operating system, the programmer DLL is not properly loaded/unloaded, causing the Quartus Programmer to not detect the Arrow USB Blaster.
  - **Solution:** Restart the Altera JTAG Server using the Services application of Windows.

Services						
File Action View	Help					
	à 📑   🛛 📷   🕨 🔲 II IÞ					
Services (Local)	Services (Local)					
	Altera JTAG Server	Name	Description	Status	Startup Type	Log On As
		ActiveX Installer (AxInstS	SV) Provides Us		Manual	Local System
	Stop the service Pause the service	Adobe Acrobat Update	Serv Adobe Acro	Running	Automatic	Local System
	Restart the service	Adobe Flash Player Update This service AeXAgentSrvHost Provides th			Manual	Local System
					Manual	Local System
		AllJoyn Router Service	Routes AllJo		Manual (Trig	Local Service
		Altera JTAG Server		Running	Automatic	Local System
				Running	Automatic	Local System
		AltirisAgentProvide	Start		Manual	Local System
		App Readiness	Stop		Manual	Local System
		Application Identity	Pause	Running	Manual (Trig	Local Service
		Application Inform	Resume		Manual (Trig	Local System
		Application Layer G	Restart		Manual	Local Service
		Application Manag		Running	Manual	Local System
		AppX Deployment	All Tasks >		Manual	Local System
			Refresh	Running	Automatic (D	Local System
		🔍 Auto Time Zone Up			Disabled	Local Service
		Avaya Quality of Se	Properties	Running	Automatic	Local System
		Background Intellig	Help	Running	Automatic (D	Local System
		Background Tasks I		Running	Automatic	Local System
		Base Filtering Engine	The Base Fil	Running	Automatic	Local Service
		BitLocker Drive Encryption		Running	Manual (Trig	Local System
	1	🖾 Block Level Backup Engi	ne The WBENG		Manual	Local System





### Chapter 8 - Appendix

### 7.1 Revision History

Version	Change Log	Date of Change
V1.0	Initial Version	11/07/2017

### 7.2 Legal Disclaimer

### ARROW ELECTRONICS

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