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**FAKULTI KEJURUTERAAN ELEKTRIK
UNIVERSITI TEKNOLOGI MALAYSIA
KAMPUS SKUDAI
JOHOR**

**SKEL 3742
VLSI SYSTEM DESIGN LAB**

STUDENT PACK – ALTERA DE2 TUTORIAL

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Introduction:

A Field-Programmable Gate Array (FPGA) is a type of Complex Programming Logic Device (CPLD) that consists of transistors and input/output ports that can be programmed. The first step in designing a digital device such as a graphic accelerator or video enhancer is to create a prototype of the design on the FPGA and tested. Once the final design is approved, it is sent to be manufactured as an Application Specific Integrated Circuit (ASIC) chip. Any digital design can be coded in Hardware Description Language (HDL) such as Verilog and VHDL or drawn using a schematic file and synthesized and used to configure the FPGA to function as the digital device.

In this tutorial, we will learn how to design a hardware block using schematic and download it onto an FPGA. We will be using the Quartus II software and the Altera DE2 Development Board as shown in Fig. 1.

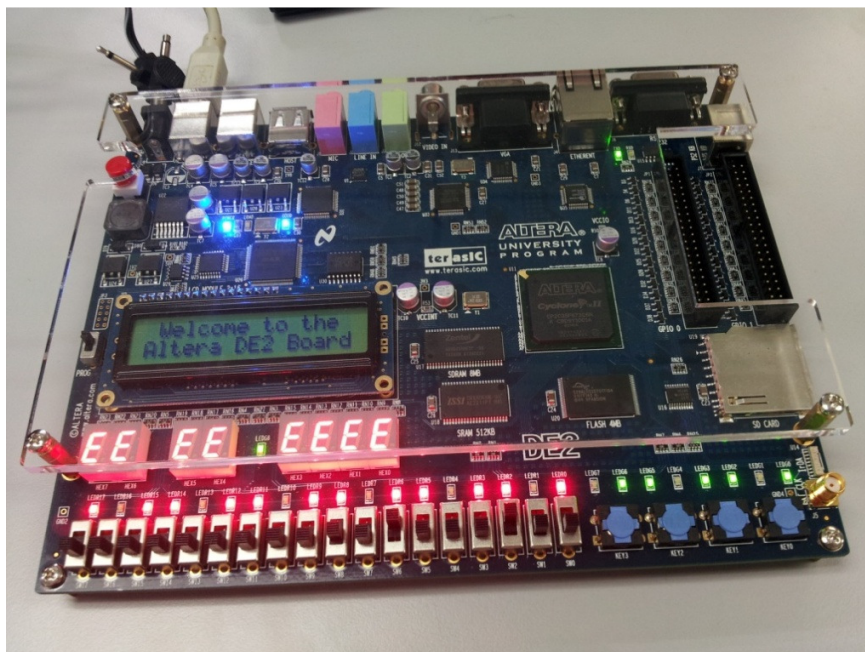


Fig. 1: Altera DE2 Development Board

As an example, we will design a simple decimal counter that counts from 0 to 9. This counter needs two inputs called 'Enable' and 'Count' and shows the count values as output on LEDs as well as a 7-segment display unit on the FPGA board. Fig. 2 shows the functional block diagram of the counter circuit.

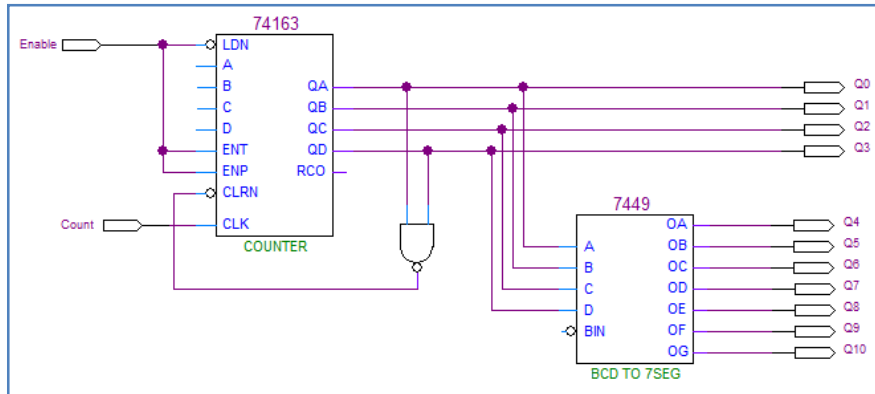


Fig. 2: Functional Block Diagram of a Decimal Counter

In a common digital circuit the input port 'Enable' is connected to Vcc and 'Count' is connected to a clock signal generator such as the 555 timer chip. However, in this initial design, we connect both input ports to switches on the FPGA board so that we can control the circuit manually. Output ports Q0 – Q3 will be connected to LEDs to display the count value in binary whereas output ports Q4 – Q10 will be connected to a 7-segment display on the FPGA board to display count value in decimal number.

1. Open the Quartus II Design software. Create a new project by choosing File > New Project Wizard and then click 'Next'. Click on the Browse button to select the 'working directory'. Create a new folder (preferably in C: or in C:/altera folder) and name it 'Tuto'. Click 'Select Folder' and then select a name for your project (such as 'Lab 01' as shown in Fig. 3).

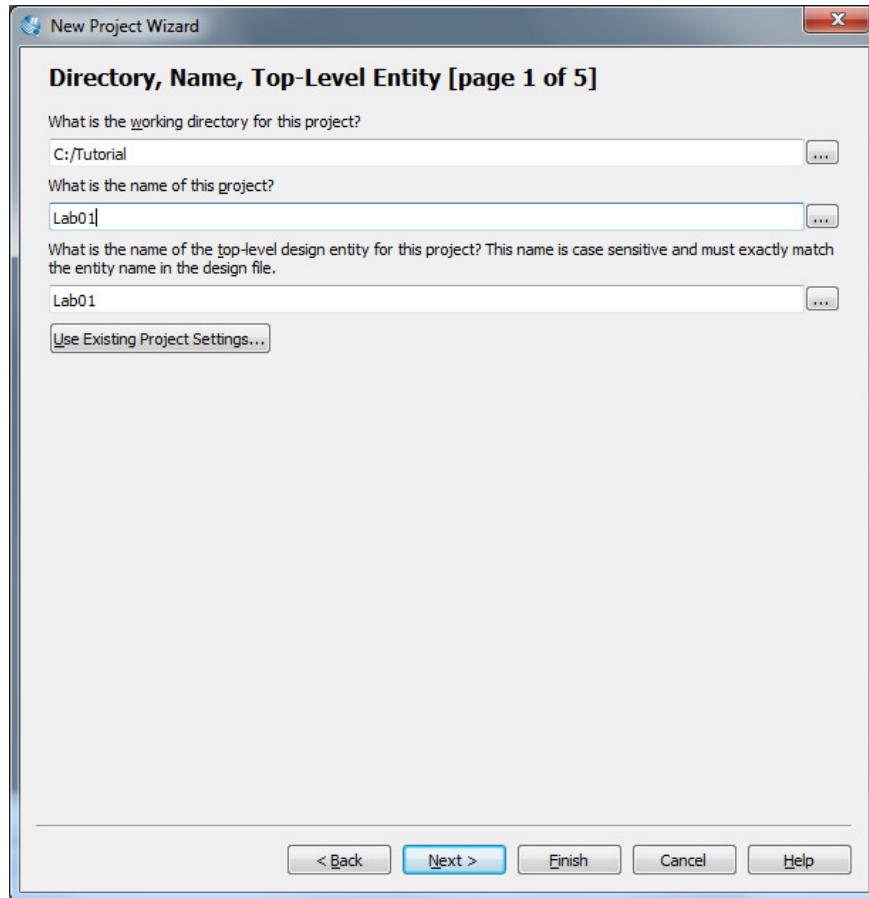


Fig. 3: 'New Project Wizard' window

Hint:

- Make sure the project directory does not have any blank spaces (such as 'C:/Documents and Settings/User/Desktop/My First Tutorial'). This would cause Compilation Error.
- Create a new folder for each project because the Quartus software will generate many files when you compile your project and do not re-use same folder for other Quartus projects.
- The name of your project ('Lab01') also must not have any blank spaces in it and your top-level module must have the same name (save your Verilog code as 'Lab01.v'). Quartus is case-sensitive so use same case for both project name and Verilog file name.

2. Click 'Next' and 'Next' again to reach the 'Family and Device Settings' page and select the following settings. (See Fig. 4) This is the device specification for the Altera DE2 Development Kit that we will use in this lab.

Family:	Cyclone II
Package:	FBGA
Pin Count:	672
Speed Grade:	6

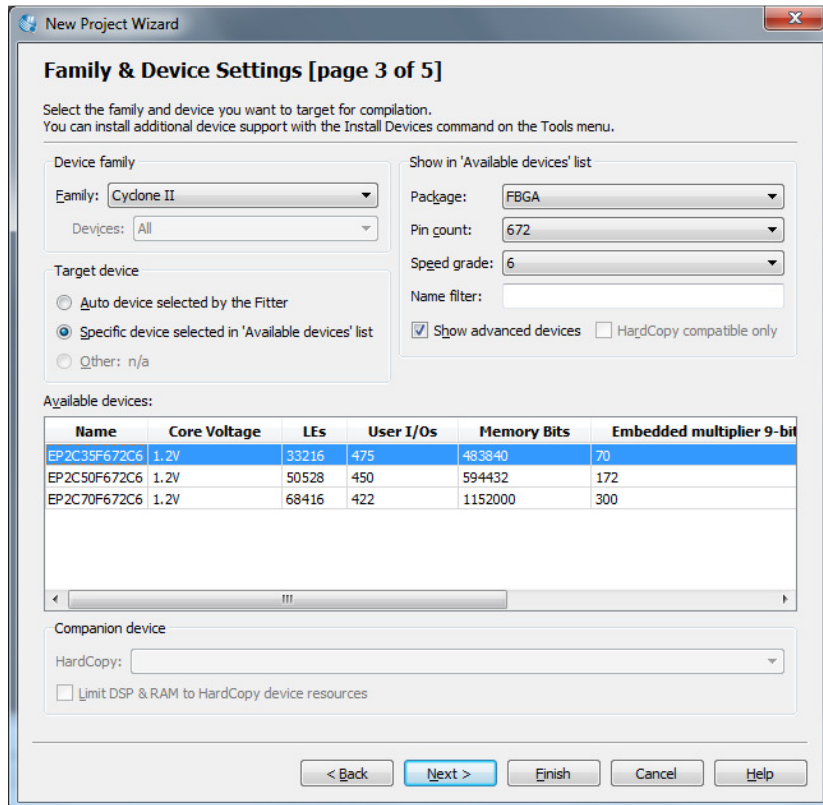


Fig. 4: 'Family & Device Settings'

3. Click 'Next' then 'Next' then 'Finish'.
4. Click File > New > Block Diagram/Schematic File (Fig. 5).

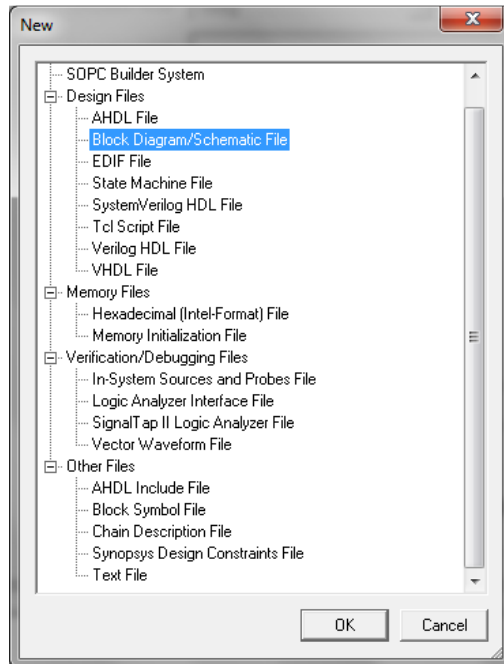



Fig. 5: New Block Diagram/Schematic File

5. Select components to be added to the schematic file as shown in Fig. 6. Components can be added using one of the following method:

- Double click anywhere on the schematic file
- Click Edit >> Insert Symbol
- Click on the () icon in the side-menu bar

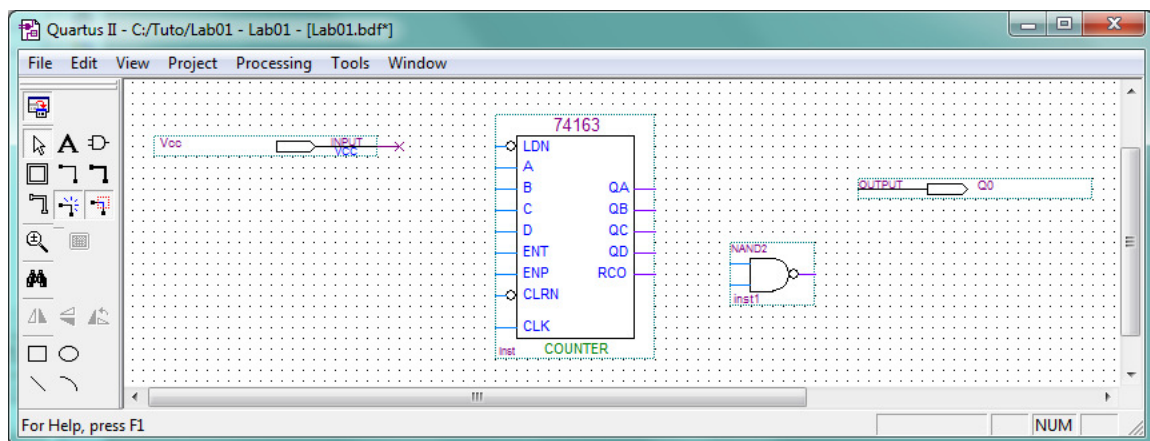


Fig. 6: Adding components to the schematic file

- Draw the schematic design of a mod-9 counter module as shown in Fig. 7. This counter counts from 0 to 9 and resets to 0.

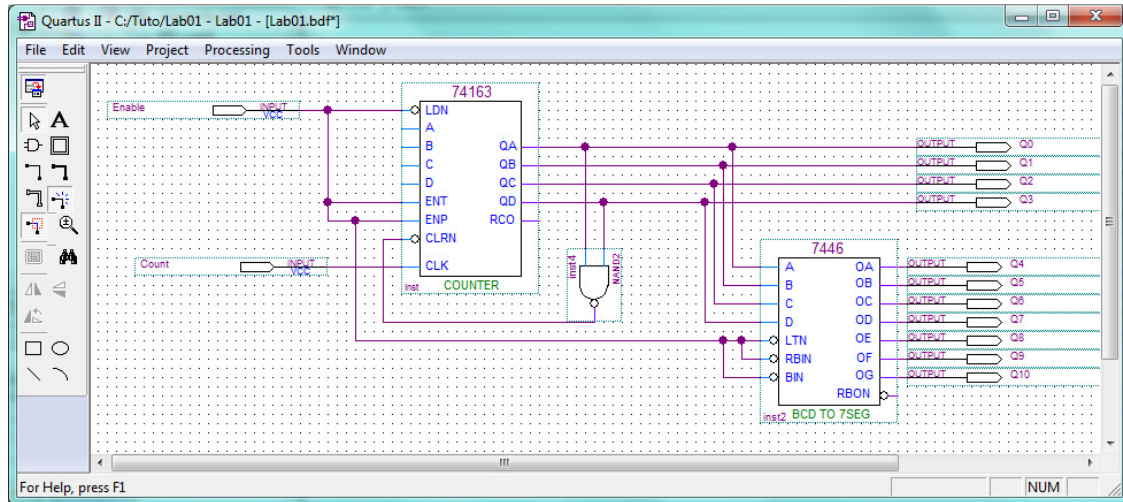



Fig. 7: Schematic File design of a Decimal Counter

- Once the schematic file is designed, synthesize the circuit:

- Click Processing >> Start Compilation
- Press Ctrl + L or
- Click the compilation icon ()

To confirm that the schematic design is connected correctly, click Tools >> Netlist Viewer >> RTL Viewer and confirm that your RTL design is same as shown in Fig. 8.

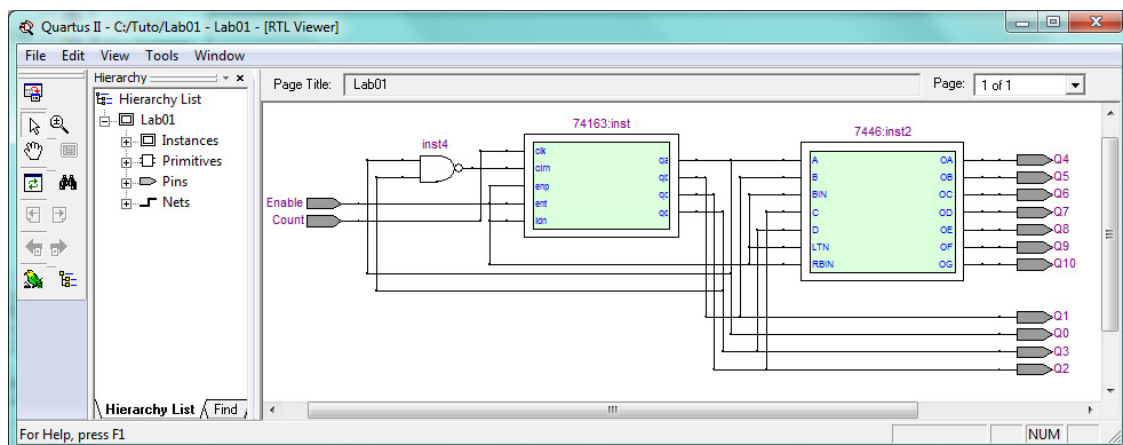


Fig. 8: RTL Netlist of Decimal Counter

- Next, click File >> New >> Vector Waveform File and right-click on the input/output port column. Click on the 'Node Finder' and click 'List All'. Select the input and output ports and

add them to the waveform file, click 'Ok'. Provide suitable input values for 'Enable' and 'Count' input ports as shown in Fig. 9. Perform the Timing Simulation by clicking the () icon.

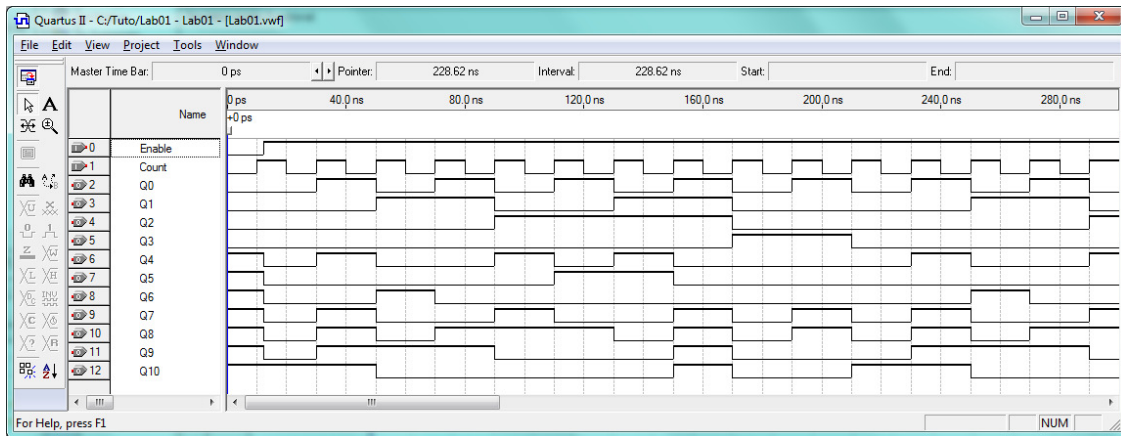


Fig. 9: Waveform Simulation

- The next step is to download the design to the DE2 FPGA board. The Enable input port will be connected to a switch and the Count input port will be connected to a push button on the DE2 FPGA board as shown in Fig. 8. To do that a few configurations must be done.

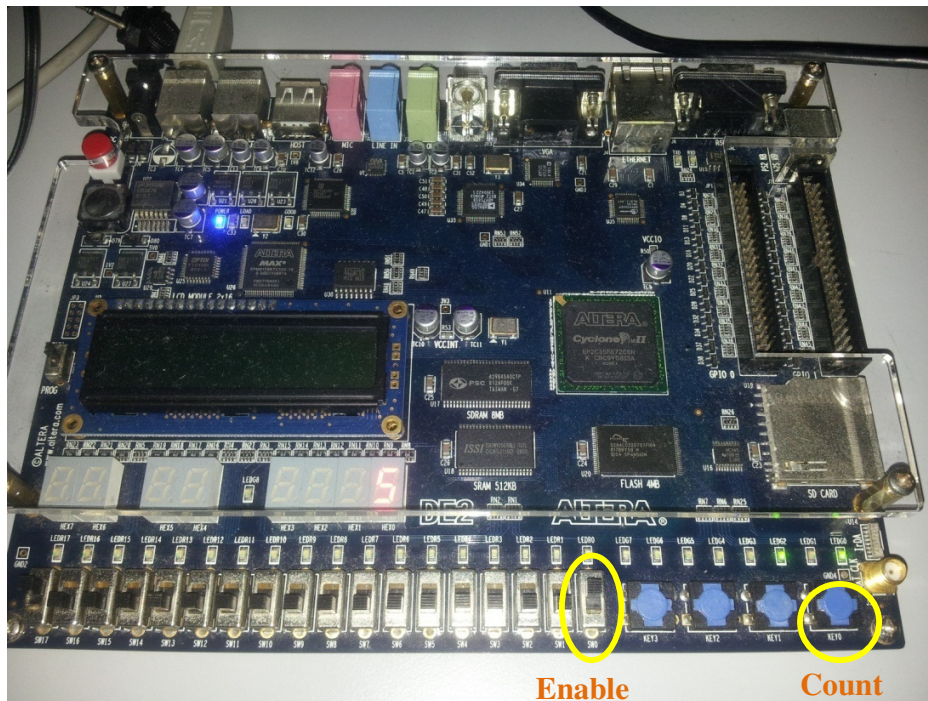


Fig. 8: Altera DE2 Development Board

- In the Quartus II main window, click on Assignments > Device. Click the 'Device and Pins Options...' button. In the 'Category' window, click on the 'Unused Pins' and change settings for 'Reserve all unused pins' to 'As input tri-stated' (See Fig. 9).

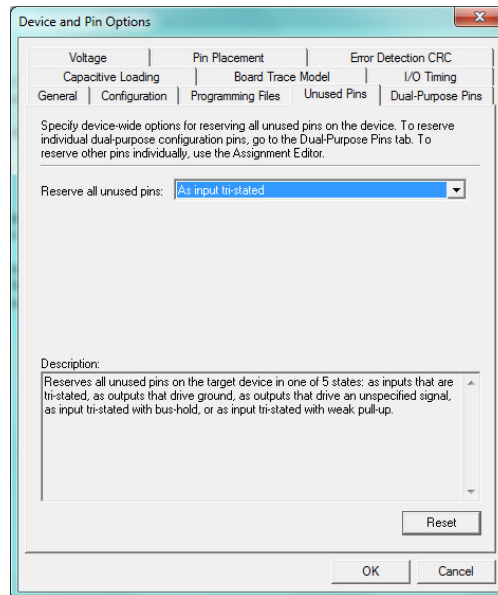


Fig. 9: Settings for Unused Pins

- Next, click on Assignments > Pin Planner (See Fig. 10). If the pin list at the bottom of the window is not visible, click View > All Pins List.

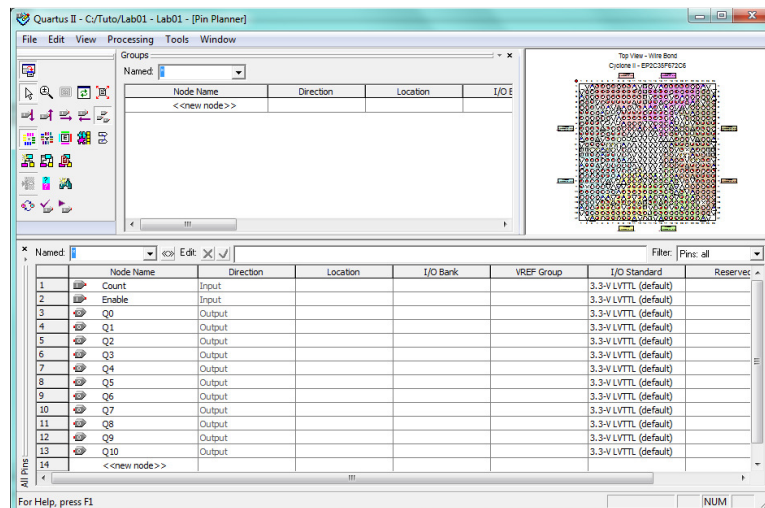



Fig. 10: Pin Planner

12. Change the Pin Location for each input and output port as shown in Fig. 11. Click on the Location cell of each port and type the appropriate pin name.

	Node Name	Direction	Location	I/O Bank
1	Count	Input	PIN_G26	5
2	Enable	Input	PIN_N25	5
3	Q0	Output	PIN_AE22	7
4	Q1	Output	PIN_AF22	7
5	Q2	Output	PIN_W19	7
6	Q3	Output	PIN_V18	7
7	Q4	Output	PIN_AF10	8
8	Q5	Output	PIN_AB12	8
9	Q6	Output	PIN_AC12	8
10	Q7	Output	PIN_AD11	8
11	Q8	Output	PIN_AE11	8
12	Q9	Output	PIN_V14	8
13	Q10	Output	PIN_V13	8
14	<<new node>>			

Fig. 11: Settings for Pins

13. Connect the Altera DE2 Development Kit to the computer using the USB Blaster cable and switch it on. Initially all the 7-segment displays and LEDs will light up as depicted in Fig. 1.
14. Compile the Quartus project called Lab01 and click on the programmer icon () or click Tools > Programmer from the top menu bar. When the programmer window opens, make sure that the USB-Blaster is detected or click on Hardware Setup to select it. If there is any previous file in the program window, select it and click 'Delete'. Click on 'Add File...' button and select *Lab01.sof*. Make sure the 'Program/Configure' option is checked (✓) and click the 'Start' button.

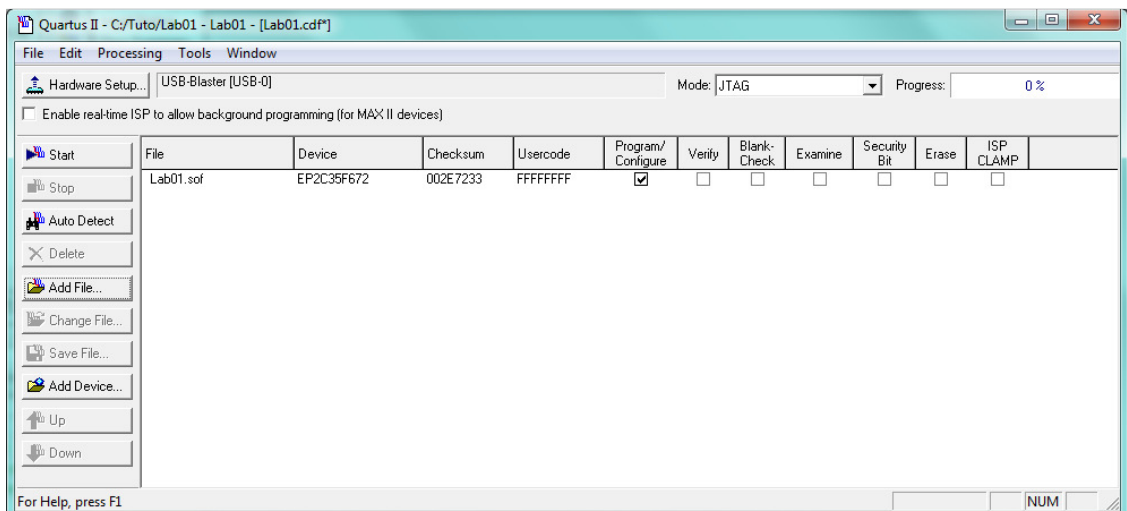


Fig. 11: Programmer Window

15. Once the program is running, Key [0] will act as reset button, while SW[17] will copy input from SW[7:0] to counter when high and start counting down when SW[17] is low. Counter counts up in decimal radix from '0' up to '9' and resets to '0'.

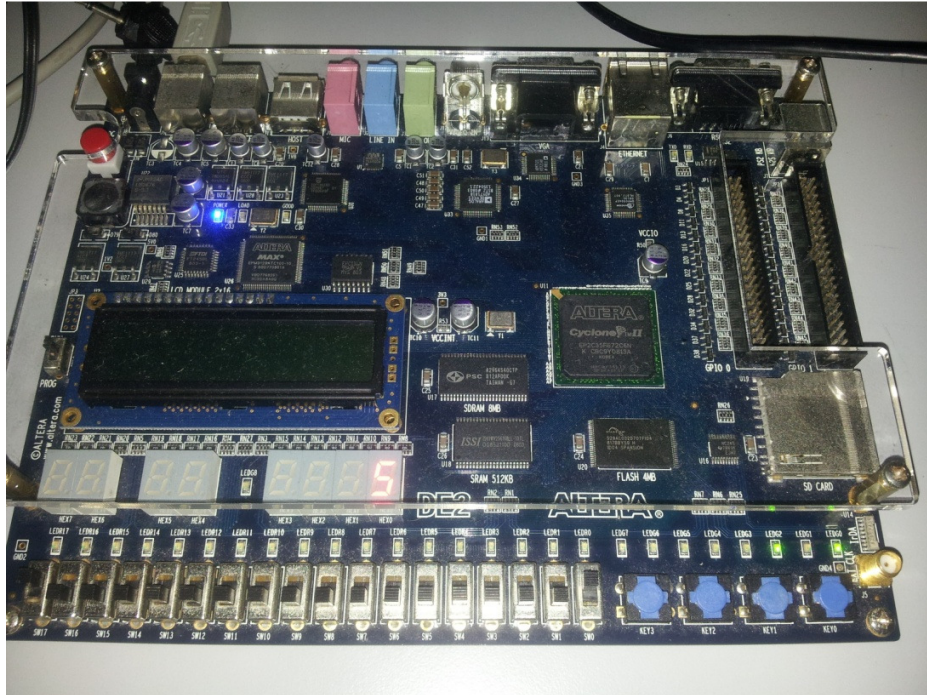


Fig. 12: Program Lab01 running on Altera DE2 FPGA Board

Signal Name	FPGA Pin No.	Description
SW[0]	PIN_N25	Toggle Switch[0]
SW[1]	PIN_N26	Toggle Switch[1]
SW[2]	PIN_P25	Toggle Switch[2]
SW[3]	PIN_AE14	Toggle Switch[3]
SW[4]	PIN_AF14	Toggle Switch[4]
SW[5]	PIN_AD13	Toggle Switch[5]
SW[6]	PIN_AC13	Toggle Switch[6]
SW[7]	PIN_C13	Toggle Switch[7]
SW[8]	PIN_B13	Toggle Switch[8]
SW[9]	PIN_A13	Toggle Switch[9]
SW[10]	PIN_N1	Toggle Switch[10]
SW[11]	PIN_P1	Toggle Switch[11]
SW[12]	PIN_P2	Toggle Switch[12]
SW[13]	PIN_T7	Toggle Switch[13]
SW[14]	PIN_U3	Toggle Switch[14]
SW[15]	PIN_U4	Toggle Switch[15]
SW[16]	PIN_V1	Toggle Switch[16]
SW[17]	PIN_V2	Toggle Switch[17]
Signal Name	FPGA Pin No.	Description
DRAM_ADDR[0]	PIN_T6	SDRAM Address[0]
DRAM_ADDR[1]	PIN_V4	SDRAM Address[1]
DRAM_ADDR[2]	PIN_V3	SDRAM Address[2]
DRAM_ADDR[3]	PIN_W2	SDRAM Address[3]
DRAM_ADDR[4]	PIN_W1	SDRAM Address[4]
DRAM_ADDR[5]	PIN_U6	SDRAM Address[5]
DRAM_ADDR[6]	PIN_U7	SDRAM Address[6]
DRAM_ADDR[7]	PIN_U5	SDRAM Address[7]
DRAM_ADDR[8]	PIN_W4	SDRAM Address[8]
DRAM_ADDR[9]	PIN_W3	SDRAM Address[9]
DRAM_ADDR[10]	PIN_Y1	SDRAM Address[10]
DRAM_ADDR[11]	PIN_V5	SDRAM Address[11]
DRAM_DQ[0]	PIN_V6	SDRAM Data[0]
DRAM_DQ[1]	PIN_AA2	SDRAM Data[1]
DRAM_DQ[2]	PIN_AA1	SDRAM Data[2]
DRAM_DQ[3]	PIN_Y3	SDRAM Data[3]
DRAM_DQ[4]	PIN_Y4	SDRAM Data[4]
DRAM_DQ[5]	PIN_R8	SDRAM Data[5]
DRAM_DQ[6]	PIN_T8	SDRAM Data[6]
DRAM_DQ[7]	PIN_V7	SDRAM Data[7]
DRAM_DQ[8]	PIN_W6	SDRAM Data[8]
DRAM_DQ[9]	PIN_AB2	SDRAM Data[9]
DRAM_DQ[10]	PIN_AB1	SDRAM Data[10]
DRAM_DQ[11]	PIN_AA4	SDRAM Data[11]
DRAM_DQ[12]	PIN_AA3	SDRAM Data[12]
DRAM_DQ[13]	PIN_AC2	SDRAM Data[13]
DRAM_DQ[14]	PIN_AC1	SDRAM Data[14]
DRAM_DQ[15]	PIN_AA5	SDRAM Data[15]
DRAM_BA_0	PIN_AE2	SDRAM Bank Address[0]
DRAM_BA_1	PIN_AE3	SDRAM Bank Address[1]
DRAM_LDQM	PIN_AD2	SDRAM Low-byte Data Mask
DRAM_UDQM	PIN_Y5	SDRAM High-byte Data Mask
DRAM_RAS_N	PIN_AB4	SDRAM Row Address Strobe
DRAM_CAS_N	PIN_AB3	SDRAM Column Address Strobe
DRAM_CKE	PIN_AA6	SDRAM Clock Enable
DRAM_CLK	PIN_AA7	SDRAM Clock
DRAM_WE_N	PIN_AD3	SDRAM Write Enable
DRAM_CS_N	PIN_AC3	SDRAM Chip Select
Signal Name	FPGA Pin No.	Description
FL_ADDR[0]	PIN_AC18	FLASH Address[0]
FL_ADDR[1]	PIN_AB18	FLASH Address[1]
FL_ADDR[2]	PIN_AE19	FLASH Address[2]
FL_ADDR[3]	PIN_AF19	FLASH Address[3]
FL_ADDR[4]	PIN_AE18	FLASH Address[4]

Altera DE2 Board Pin Table

FL_ADDR[5]	PIN_AF18	FLASH Address[5]
FL_ADDR[6]	PIN_Y16	FLASH Address[6]
FL_ADDR[7]	PIN_AA16	FLASH Address[7]
FL_ADDR[8]	PIN_AD17	FLASH Address[8]
FL_ADDR[9]	PIN_AC17	FLASH Address[9]
FL_ADDR[10]	PIN_AE17	FLASH Address[10]
FL_ADDR[11]	PIN_AF17	FLASH Address[11]
FL_ADDR[12]	PIN_W16	FLASH Address[12]
FL_ADDR[13]	PIN_W15	FLASH Address[13]
FL_ADDR[14]	PIN_AC16	FLASH Address[14]
FL_ADDR[15]	PIN_AD16	FLASH Address[15]
FL_ADDR[16]	PIN_AE16	FLASH Address[16]
FL_ADDR[17]	PIN_AC15	FLASH Address[17]
FL_ADDR[18]	PIN_AB15	FLASH Address[18]
FL_ADDR[19]	PIN_AA15	FLASH Address[19]
FL_ADDR[20]	PIN_Y15	FLASH Address[20]
FL_ADDR[21]	PIN_Y14	FLASH Address[21]
FL_DQ[0]	PIN_AD19	FLASH Data[0]
FL_DQ[1]	PIN_AC19	FLASH Data[1]
FL_DQ[2]	PIN_AF20	FLASH Data[2]
FL_DQ[3]	PIN_AE20	FLASH Data[3]
FL_DQ[4]	PIN_AB20	FLASH Data[4]
FL_DQ[5]	PIN_AC20	FLASH Data[5]
FL_DQ[6]	PIN_AF21	FLASH Data[6]
FL_DQ[7]	PIN_AE21	FLASH Data[7]
FL_CE_N	PIN_V17	FLASH Chip Enable
FL_OE_N	PIN_W17	FLASH Output Enable
FL_RST_N	PIN_AA18	FLASH Reset
FL_WE_N	PIN_AA17	FLASH Write Enable
Signal Name	FPGA Pin No.	Description
SRAM_ADDR[0]	PIN_AE4	SRAM Address[0]
SRAM_ADDR[1]	PIN_AF4	SRAM Address[1]
SRAM_ADDR[2]	PIN_AC5	SRAM Address[2]
SRAM_ADDR[3]	PIN_AC6	SRAM Address[3]
SRAM_ADDR[4]	PIN_AD4	SRAM Address[4]
SRAM_ADDR[5]	PIN_AD5	SRAM Address[5]
SRAM_ADDR[6]	PIN_AE5	SRAM Address[6]
SRAM_ADDR[7]	PIN_AF5	SRAM Address[7]
SRAM_ADDR[8]	PIN_AD6	SRAM Address[8]
SRAM_ADDR[9]	PIN_AD7	SRAM Address[9]
SRAM_ADDR[10]	PIN_V10	SRAM Address[10]
SRAM_ADDR[11]	PIN_V9	SRAM Address[11]
SRAM_ADDR[12]	PIN_AC7	SRAM Address[12]
SRAM_ADDR[13]	PIN_W8	SRAM Address[13]
SRAM_ADDR[14]	PIN_W10	SRAM Address[14]
SRAM_ADDR[15]	PIN_Y10	SRAM Address[15]
SRAM_ADDR[16]	PIN_AB8	SRAM Address[16]
SRAM_ADDR[17]	PIN_AC8	SRAM Address[17]
SRAM_DQ[0]	PIN_AD8	SRAM Data[0]
SRAM_DQ[1]	PIN_AE6	SRAM Data[1]
SRAM_DQ[2]	PIN_AF6	SRAM Data[2]
SRAM_DQ[3]	PIN_AA9	SRAM Data[3]
SRAM_DQ[4]	PIN_AA10	SRAM Data[4]
SRAM_DQ[5]	PIN_AB10	SRAM Data[5]
SRAM_DQ[6]	PIN_AA11	SRAM Data[6]
SRAM_DQ[7]	PIN_Y11	SRAM Data[7]
SRAM_DQ[8]	PIN_AE7	SRAM Data[8]
SRAM_DQ[9]	PIN_AF7	SRAM Data[9]
SRAM_DQ[10]	PIN_AE8	SRAM Data[10]
SRAM_DQ[11]	PIN_AF8	SRAM Data[11]
SRAM_DQ[12]	PIN_W11	SRAM Data[12]
SRAM_DQ[13]	PIN_W12	SRAM Data[13]
SRAM_DQ[14]	PIN_AC9	SRAM Data[14]
SRAM_DQ[15]	PIN_AC10	SRAM Data[15]

Altera DE2 Board Pin Table

SRAM_WE_N	PIN_AE10	SRAM Write Enable
SRAM_OE_N	PIN_AD10	SRAM Output Enable
SRAM_UB_N	PIN_AF9	SRAM High-byte Data Mask
SRAM_LB_N	PIN_AE9	SRAM Low-byte Data Mask
SRAM_CE_N	PIN_AC11	SRAM Chip Enable
Signal Name	FPGA Pin No.	Description
OTG_ADDR[0]	PIN_K7	ISP1362 Address[0]
OTG_ADDR[1]	PIN_F2	ISP1362 Address[1]
OTG_DATA[0]	PIN_F4	ISP1362 Data[0]
OTG_DATA[1]	PIN_D2	ISP1362 Data[1]
OTG_DATA[2]	PIN_D1	ISP1362 Data[2]
OTG_DATA[3]	PIN_F7	ISP1362 Data[3]
OTG_DATA[4]	PIN_J5	ISP1362 Data[4]
OTG_DATA[5]	PIN_J8	ISP1362 Data[5]
OTG_DATA[6]	PIN_J7	ISP1362 Data[6]
OTG_DATA[7]	PIN_H6	ISP1362 Data[7]
OTG_DATA[8]	PIN_E2	ISP1362 Data[8]
OTG_DATA[9]	PIN_E1	ISP1362 Data[9]
OTG_DATA[10]	PIN_K6	ISP1362 Data[10]
OTG_DATA[11]	PIN_K5	ISP1362 Data[11]
OTG_DATA[12]	PIN_G4	ISP1362 Data[12]
OTG_DATA[13]	PIN_G3	ISP1362 Data[13]
OTG_DATA[14]	PIN_J6	ISP1362 Data[14]
OTG_DATA[15]	PIN_K8	ISP1362 Data[15]
OTG_CS_N	PIN_F1	ISP1362 Chip Select
OTG_RD_N	PIN_G2	ISP1362 Read
OTG_WR_N	PIN_G1	ISP1362 Write
OTG_RST_N	PIN_G5	ISP1362 Reset
OTG_INT0	PIN_B3	ISP1362 Interrupt 0
OTG_INT1	PIN_C3	ISP1362 Interrupt 1
OTG_DACK0_N	PIN_C2	ISP1362 DMA Acknowledge 0
OTG_DACK1_N	PIN_B2	ISP1362 DMA Acknowledge 1
OTG_DREQ0	PIN_F6	ISP1362 DMA Request 0
OTG_DREQ1	PIN_E5	ISP1362 DMA Request 1
OTG_FSPEED	PIN_F3	USB Full Speed, 0 = Enable, Z = Disable
OTG_LSPEED	PIN_G6	USB Low Speed, 0 = Enable, Z = Disable
Signal Name	FPGA Pin No.	Description
LCD_DATA[0]	PIN_J1	LCD Data[0]
LCD_DATA[1]	PIN_J2	LCD Data[1]
LCD_DATA[2]	PIN_H1	LCD Data[2]
LCD_DATA[3]	PIN_H2	LCD Data[3]
LCD_DATA[4]	PIN_J4	LCD Data[4]
LCD_DATA[5]	PIN_J3	LCD Data[5]
LCD_DATA[6]	PIN_H4	LCD Data[6]
LCD_DATA[7]	PIN_H3	LCD Data[7]
LCD_RW	PIN_K4	LCD Read/Write Select, 0 = Write, 1 = Read
LCD_EN	PIN_K3	LCD Enable
LCD_RS	PIN_K1	LCD Command/Data Select, 0 = Command, 1 = Data
LCD_ON	PIN_L4	LCD Power ON/OFF
LCD_BLON	PIN_K2	LCD Back Light ON/OFF
Signal Name	FPGA Pin No.	Description
SD_DAT	PIN_AD24	SD Card Data
SD_DAT3	PIN_AC23	SD Card Data 3
SD_CMD	PIN_Y21	SD Card Command Signal
SD_CLK	PIN_AD25	SD Card Clock
Signal Name	FPGA Pin No.	Description
TDI	PIN_B14	CPLD -> FPGA (Data in)
TCS	PIN_A14	CPLD -> FPGA (CS)
TCK	PIN_D14	CPLD -> FPGA (Clock)
TDO	PIN_F14	FPGA -> CPLD (Data out)
Signal Name	FPGA Pin No.	Description
IRDA_TXD	PIN_AE24	IRDA Transmitter
IRDA_RXD	PIN_AE25	IRDA Receiver
Signal Name	FPGA Pin No.	Description

Altera DE2 Board Pin Table

HEX0[0]	PIN_AF10	Seven Segment Digit 0[0]
HEX0[1]	PIN_AB12	Seven Segment Digit 0[1]
HEX0[2]	PIN_AC12	Seven Segment Digit 0[2]
HEX0[3]	PIN_AD11	Seven Segment Digit 0[3]
HEX0[4]	PIN_AE11	Seven Segment Digit 0[4]
HEX0[5]	PIN_V14	Seven Segment Digit 0[5]
HEX0[6]	PIN_V13	Seven Segment Digit 0[6]
HEX1[0]	PIN_V20	Seven Segment Digit 1[0]
HEX1[1]	PIN_V21	Seven Segment Digit 1[1]
HEX1[2]	PIN_W21	Seven Segment Digit 1[2]
HEX1[3]	PIN_Y22	Seven Segment Digit 1[3]
HEX1[4]	PIN_AA24	Seven Segment Digit 1[4]
HEX1[5]	PIN_AA23	Seven Segment Digit 1[5]
HEX1[6]	PIN_AB24	Seven Segment Digit 1[6]
HEX2[0]	PIN_AB23	Seven Segment Digit 2[0]
HEX2[1]	PIN_V22	Seven Segment Digit 2[1]
HEX2[2]	PIN_AC25	Seven Segment Digit 2[2]
HEX2[3]	PIN_AC26	Seven Segment Digit 2[3]
HEX2[4]	PIN_AB26	Seven Segment Digit 2[4]
HEX2[5]	PIN_AB25	Seven Segment Digit 2[5]
HEX2[6]	PIN_Y24	Seven Segment Digit 2[6]
HEX3[0]	PIN_Y23	Seven Segment Digit 3[0]
HEX3[1]	PIN_AA25	Seven Segment Digit 3[1]
HEX3[2]	PIN_AA26	Seven Segment Digit 3[2]
HEX3[3]	PIN_Y26	Seven Segment Digit 3[3]
HEX3[4]	PIN_Y25	Seven Segment Digit 3[4]
HEX3[5]	PIN_U22	Seven Segment Digit 3[5]
HEX3[6]	PIN_W24	Seven Segment Digit 3[6]
HEX4[0]	PIN_U9	Seven Segment Digit 4[0]
HEX4[1]	PIN_U1	Seven Segment Digit 4[1]
HEX4[2]	PIN_U2	Seven Segment Digit 4[2]
HEX4[3]	PIN_T4	Seven Segment Digit 4[3]
HEX4[4]	PIN_R7	Seven Segment Digit 4[4]
HEX4[5]	PIN_R6	Seven Segment Digit 4[5]
HEX4[6]	PIN_T3	Seven Segment Digit 4[6]
HEX5[0]	PIN_T2	Seven Segment Digit 5[0]
HEX5[1]	PIN_P6	Seven Segment Digit 5[1]
HEX5[2]	PIN_P7	Seven Segment Digit 5[2]
HEX5[3]	PIN_T9	Seven Segment Digit 5[3]
HEX5[4]	PIN_R5	Seven Segment Digit 5[4]
HEX5[5]	PIN_R4	Seven Segment Digit 5[5]
HEX5[6]	PIN_R3	Seven Segment Digit 5[6]
HEX6[0]	PIN_R2	Seven Segment Digit 6[0]
HEX6[1]	PIN_P4	Seven Segment Digit 6[1]
HEX6[2]	PIN_P3	Seven Segment Digit 6[2]
HEX6[3]	PIN_M2	Seven Segment Digit 6[3]
HEX6[4]	PIN_M3	Seven Segment Digit 6[4]
HEX6[5]	PIN_M5	Seven Segment Digit 6[5]
HEX6[6]	PIN_M4	Seven Segment Digit 6[6]
HEX7[0]	PIN_L3	Seven Segment Digit 7[0]
HEX7[1]	PIN_L2	Seven Segment Digit 7[1]
HEX7[2]	PIN_L9	Seven Segment Digit 7[2]
HEX7[3]	PIN_L6	Seven Segment Digit 7[3]
HEX7[4]	PIN_L7	Seven Segment Digit 7[4]
HEX7[5]	PIN_P9	Seven Segment Digit 7[5]
HEX7[6]	PIN_N9	Seven Segment Digit 7[6]
Signal Name	FPGA Pin No.	Description
KEY[0]	PIN_G26	Pushbutton[0]
KEY[1]	PIN_N23	Pushbutton[1]
KEY[2]	PIN_P23	Pushbutton[2]
KEY[3]	PIN_W26	Pushbutton[3]
Signal Name	FPGA Pin No.	Description
LEDR[0]	PIN_AE23	LED Red[0]
LEDR[1]	PIN_AF23	LED Red[1]

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LEDR[2]	PIN_AB21	LED Red[2]
LEDR[3]	PIN_AC22	LED Red[3]
LEDR[4]	PIN_AD22	LED Red[4]
LEDR[5]	PIN_AD23	LED Red[5]
LEDR[6]	PIN_AD21	LED Red[6]
LEDR[7]	PIN_AC21	LED Red[7]
LEDR[8]	PIN_AA14	LED Red[8]
LEDR[9]	PIN_Y13	LED Red[9]
LEDR[10]	PIN_AA13	LED Red[10]
LEDR[11]	PIN_AC14	LED Red[11]
LEDR[12]	PIN_AD15	LED Red[12]
LEDR[13]	PIN_AE15	LED Red[13]
LEDR[14]	PIN_AF13	LED Red[14]
LEDR[15]	PIN_AE13	LED Red[15]
LEDR[16]	PIN_AE12	LED Red[16]
LEDR[17]	PIN_AD12	LED Red[17]
LEDG[0]	PIN_AE22	LED Green[0]
LEDG[1]	PIN_AF22	LED Green[1]
LEDG[2]	PIN_W19	LED Green[2]
LEDG[3]	PIN_V18	LED Green[3]
LEDG[4]	PIN_U18	LED Green[4]
LEDG[5]	PIN_U17	LED Green[5]
LEDG[6]	PIN_AA20	LED Green[6]
LEDG[7]	PIN_Y18	LED Green[7]
LEDG[8]	PIN_Y12	LED Green[8]
Signal Name	FPGA Pin No.	Description
CLOCK_27	PIN_D13	On Board 27 MHz
CLOCK_50	PIN_N2	On Board 50 MHz
EXT_CLOCK	PIN_P26	External Clock
Signal Name	FPGA Pin No.	Description
UART_RXD	PIN_C25	UART Receiver
UART_TXD	PIN_B25	UART Transmitter
Signal Name	FPGA Pin No.	Description
PS2_CLK	PIN_D26	PS2 Data
PS2_DAT	PIN_C24	PS2 Clock
Signal Name	FPGA Pin No.	Description
I2C_SCLK	PIN_A6	I2C Data
I2C_SDAT	PIN_B6	I2C Clock
Signal Name	FPGA Pin No.	Description
TD_DATA[0]	PIN_J9	TV Decoder Data[0]
TD_DATA[1]	PIN_E8	TV Decoder Data[1]
TD_DATA[2]	PIN_H8	TV Decoder Data[2]
TD_DATA[3]	PIN_H10	TV Decoder Data[3]
TD_DATA[4]	PIN_G9	TV Decoder Data[4]
TD_DATA[5]	PIN_F9	TV Decoder Data[5]
TD_DATA[6]	PIN_D7	TV Decoder Data[6]
TD_DATA[7]	PIN_C7	TV Decoder Data[7]
TD_HS	PIN_D5	TV Decoder H_SYNC
TD_VS	PIN_K9	TV Decoder V_SYNC
TD_RESET	PIN_C4	TV Decoder Reset
Signal Name	FPGA Pin No.	Description
VGA_R[0]	PIN_C8	VGA Red[0]
VGA_R[1]	PIN_F10	VGA Red[1]
VGA_R[2]	PIN_G10	VGA Red[2]
VGA_R[3]	PIN_D9	VGA Red[3]
VGA_R[4]	PIN_C9	VGA Red[4]
VGA_R[5]	PIN_A8	VGA Red[5]
VGA_R[6]	PIN_H11	VGA Red[6]
VGA_R[7]	PIN_H12	VGA Red[7]
VGA_R[8]	PIN_F11	VGA Red[8]
VGA_R[9]	PIN_E10	VGA Red[9]
VGA_G[0]	PIN_B9	VGA Green[0]
VGA_G[1]	PIN_A9	VGA Green[1]
VGA_G[2]	PIN_C10	VGA Green[2]

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VGA_G[3]	PIN_D10	VGA Green[3]
VGA_G[4]	PIN_B10	VGA Green[4]
VGA_G[5]	PIN_A10	VGA Green[5]
VGA_G[6]	PIN_G11	VGA Green[6]
VGA_G[7]	PIN_D11	VGA Green[7]
VGA_G[8]	PIN_E12	VGA Green[8]
VGA_G[9]	PIN_D12	VGA Green[9]
VGA_B[0]	PIN_J13	VGA Blue[0]
VGA_B[1]	PIN_J14	VGA Blue[1]
VGA_B[2]	PIN_F12	VGA Blue[2]
VGA_B[3]	PIN_G12	VGA Blue[3]
VGA_B[4]	PIN_J10	VGA Blue[4]
VGA_B[5]	PIN_J11	VGA Blue[5]
VGA_B[6]	PIN_C11	VGA Blue[6]
VGA_B[7]	PIN_B11	VGA Blue[7]
VGA_B[8]	PIN_C12	VGA Blue[8]
VGA_B[9]	PIN_B12	VGA Blue[9]
VGA_CLK	PIN_B8	VGA Clock
VGA_BLANK	PIN_D6	VGA BLANK
VGA_HS	PIN_A7	VGA H_SYNC
VGA_VS	PIN_D8	VGA V_SYNC
VGA_SYNC	PIN_B7	VGA SYNC
Signal Name	FPGA Pin No.	Description
AUD_ADCLRCK	PIN_C5	Audio CODEC ADC LR Clock
AUD_ADCDATA	PIN_B5	Audio CODEC ADC Data
AUD_DACLK	PIN_C6	Audio CODEC DAC LR Clock
AUD_DACDATA	PIN_A4	Audio CODEC DAC Data
AUD_XCK	PIN_A5	Audio CODEC Chip Clock
AUD_BCLK	PIN_B4	Audio CODEC Bit-Stream Clock
Signal Name	FPGA Pin No.	Description
ENET_DATA[0]	PIN_D17	DM9000A DATA[0]
ENET_DATA[1]	PIN_C17	DM9000A DATA[1]
ENET_DATA[2]	PIN_B18	DM9000A DATA[2]
ENET_DATA[3]	PIN_A18	DM9000A DATA[3]
ENET_DATA[4]	PIN_B17	DM9000A DATA[4]
ENET_DATA[5]	PIN_A17	DM9000A DATA[5]
ENET_DATA[6]	PIN_B16	DM9000A DATA[6]
ENET_DATA[7]	PIN_B15	DM9000A DATA[7]
ENET_DATA[8]	PIN_B20	DM9000A DATA[8]
ENET_DATA[9]	PIN_A20	DM9000A DATA[9]
ENET_DATA[10]	PIN_C19	DM9000A DATA[10]
ENET_DATA[11]	PIN_D19	DM9000A DATA[11]
ENET_DATA[12]	PIN_B19	DM9000A DATA[12]
ENET_DATA[13]	PIN_A19	DM9000A DATA[13]
ENET_DATA[14]	PIN_E18	DM9000A DATA[14]
ENET_DATA[15]	PIN_D18	DM9000A DATA[15]
ENET_CLK	PIN_B24	DM9000A Clock 25 MHz
ENET_CMD	PIN_A21	DM9000A Command/Data Select, 0 = Command, 1 = Data
ENET_CS_N	PIN_A23	DM9000A Chip Select
ENET_INT	PIN_B21	DM9000A Interrupt
ENET_RD_N	PIN_A22	DM9000A Read
ENET_WR_N	PIN_B22	DM9000A Write
ENET_RST_N	PIN_B23	DM9000A Reset
Signal Name	FPGA Pin No.	Description
GPIO_0[0]	PIN_D25	GPIO Connection 0[0]
GPIO_0[1]	PIN_J22	GPIO Connection 0[1]
GPIO_0[2]	PIN_E26	GPIO Connection 0[2]
GPIO_0[3]	PIN_E25	GPIO Connection 0[3]
GPIO_0[4]	PIN_F24	GPIO Connection 0[4]
GPIO_0[5]	PIN_F23	GPIO Connection 0[5]
GPIO_0[6]	PIN_J21	GPIO Connection 0[6]
GPIO_0[7]	PIN_J20	GPIO Connection 0[7]
GPIO_0[8]	PIN_F25	GPIO Connection 0[8]
GPIO_0[9]	PIN_F26	GPIO Connection 0[9]

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GPIO_0[10]	PIN_N18	GPIO Connection 0[10]
GPIO_0[11]	PIN_P18	GPIO Connection 0[11]
GPIO_0[12]	PIN_G23	GPIO Connection 0[12]
GPIO_0[13]	PIN_G24	GPIO Connection 0[13]
GPIO_0[14]	PIN_K22	GPIO Connection 0[14]
GPIO_0[15]	PIN_G25	GPIO Connection 0[15]
GPIO_0[16]	PIN_H23	GPIO Connection 0[16]
GPIO_0[17]	PIN_H24	GPIO Connection 0[17]
GPIO_0[18]	PIN_J23	GPIO Connection 0[18]
GPIO_0[19]	PIN_J24	GPIO Connection 0[19]
GPIO_0[20]	PIN_H25	GPIO Connection 0[20]
GPIO_0[21]	PIN_H26	GPIO Connection 0[21]
GPIO_0[22]	PIN_H19	GPIO Connection 0[22]
GPIO_0[23]	PIN_K18	GPIO Connection 0[23]
GPIO_0[24]	PIN_K19	GPIO Connection 0[24]
GPIO_0[25]	PIN_K21	GPIO Connection 0[25]
GPIO_0[26]	PIN_K23	GPIO Connection 0[26]
GPIO_0[27]	PIN_K24	GPIO Connection 0[27]
GPIO_0[28]	PIN_L21	GPIO Connection 0[28]
GPIO_0[29]	PIN_L20	GPIO Connection 0[29]
GPIO_0[30]	PIN_J25	GPIO Connection 0[30]
GPIO_0[31]	PIN_J26	GPIO Connection 0[31]
GPIO_0[32]	PIN_L23	GPIO Connection 0[32]
GPIO_0[33]	PIN_L24	GPIO Connection 0[33]
GPIO_0[34]	PIN_L25	GPIO Connection 0[34]
GPIO_0[35]	PIN_L19	GPIO Connection 0[35]
GPIO_1[0]	PIN_K25	GPIO Connection 1[0]
GPIO_1[1]	PIN_K26	GPIO Connection 1[1]
GPIO_1[2]	PIN_M22	GPIO Connection 1[2]
GPIO_1[3]	PIN_M23	GPIO Connection 1[3]
GPIO_1[4]	PIN_M19	GPIO Connection 1[4]
GPIO_1[5]	PIN_M20	GPIO Connection 1[5]
GPIO_1[6]	PIN_N20	GPIO Connection 1[6]
GPIO_1[7]	PIN_M21	GPIO Connection 1[7]
GPIO_1[8]	PIN_M24	GPIO Connection 1[8]
GPIO_1[9]	PIN_M25	GPIO Connection 1[9]
GPIO_1[10]	PIN_N24	GPIO Connection 1[10]
GPIO_1[11]	PIN_P24	GPIO Connection 1[11]
GPIO_1[12]	PIN_R25	GPIO Connection 1[12]
GPIO_1[13]	PIN_R24	GPIO Connection 1[13]
GPIO_1[14]	PIN_R20	GPIO Connection 1[14]
GPIO_1[15]	PIN_T22	GPIO Connection 1[15]
GPIO_1[16]	PIN_T23	GPIO Connection 1[16]
GPIO_1[17]	PIN_T24	GPIO Connection 1[17]
GPIO_1[18]	PIN_T25	GPIO Connection 1[18]
GPIO_1[19]	PIN_T18	GPIO Connection 1[19]
GPIO_1[20]	PIN_T21	GPIO Connection 1[20]
GPIO_1[21]	PIN_T20	GPIO Connection 1[21]
GPIO_1[22]	PIN_U26	GPIO Connection 1[22]
GPIO_1[23]	PIN_U25	GPIO Connection 1[23]
GPIO_1[24]	PIN_U23	GPIO Connection 1[24]
GPIO_1[25]	PIN_U24	GPIO Connection 1[25]
GPIO_1[26]	PIN_R19	GPIO Connection 1[26]
GPIO_1[27]	PIN_T19	GPIO Connection 1[27]
GPIO_1[28]	PIN_U20	GPIO Connection 1[28]
GPIO_1[29]	PIN_U21	GPIO Connection 1[29]
GPIO_1[30]	PIN_V26	GPIO Connection 1[30]
GPIO_1[31]	PIN_V25	GPIO Connection 1[31]
GPIO_1[32]	PIN_V24	GPIO Connection 1[32]
GPIO_1[33]	PIN_V23	GPIO Connection 1[33]
GPIO_1[34]	PIN_W25	GPIO Connection 1[34]
GPIO_1[35]	PIN_W23	GPIO Connection 1[35]