EDGE Artix 7 FPGA Development Board Demonstration Manual

Overview

This package of demonstration projects can be used to illustrate the features of the EDGE FPGA development platform. Each chapter of this document will provide a brief overview for a basic demonstration of some of the EDGE Board components and capabilities. In each chapter, there are details of the hardware required, version of Xilinx tools required, included support files and instructions to perform the demonstrations.

The *edge_artix7_codes* zipped folder contains this manual and directories for each chapter. In each chapter directory there are source files, compiled bit files, and documentation files for any additional hardware used. All projects were developed in Vivado Design Suite

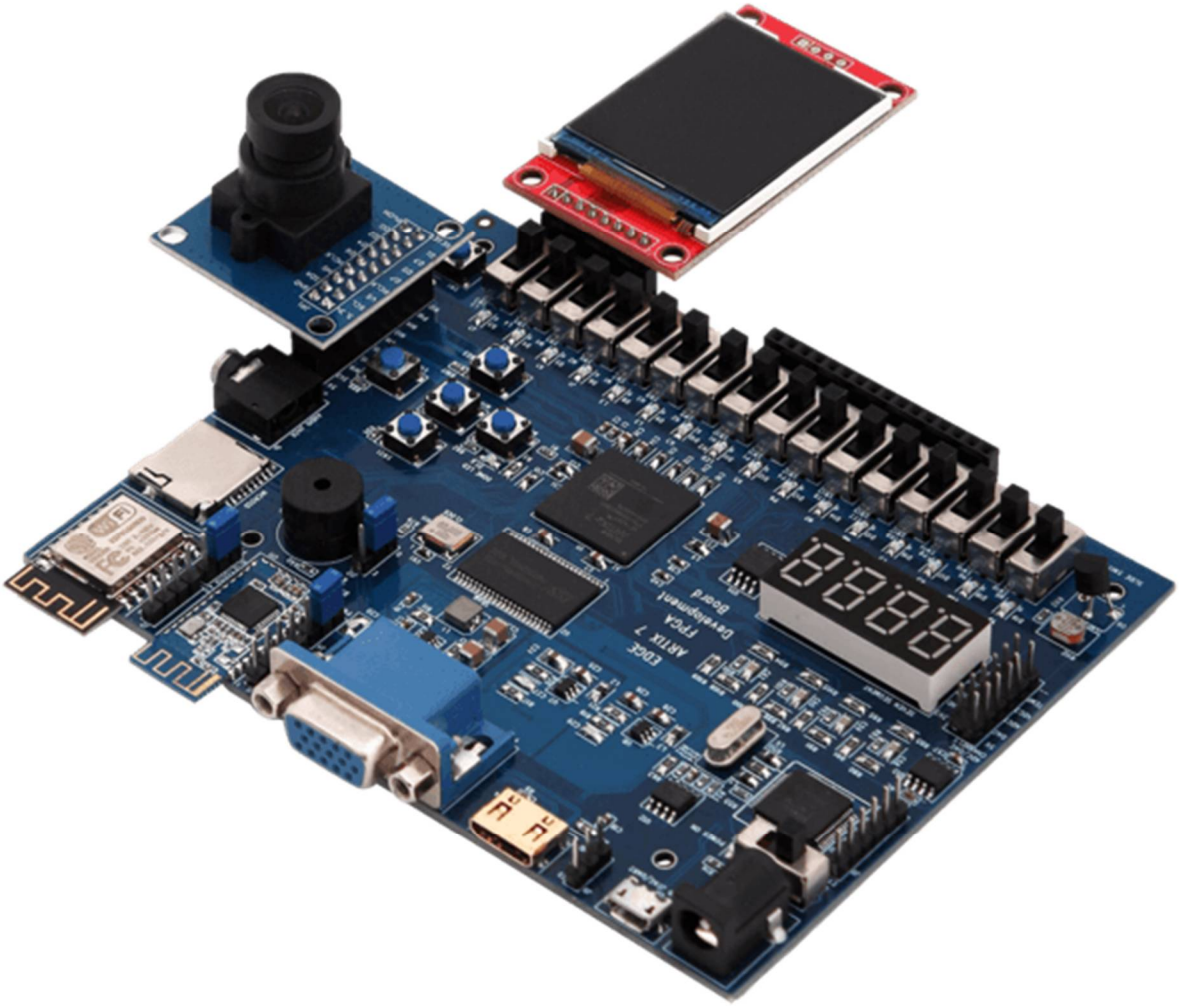


Table of Contents

Setting up and programming the EDGE Artix 7 Board

In every chapter, the board will need to be setup and programmed. This section describes how to accomplish this.

Hardware Required:

- EDGE Artix 7 FPGA Development board

- USB A to micro B cable

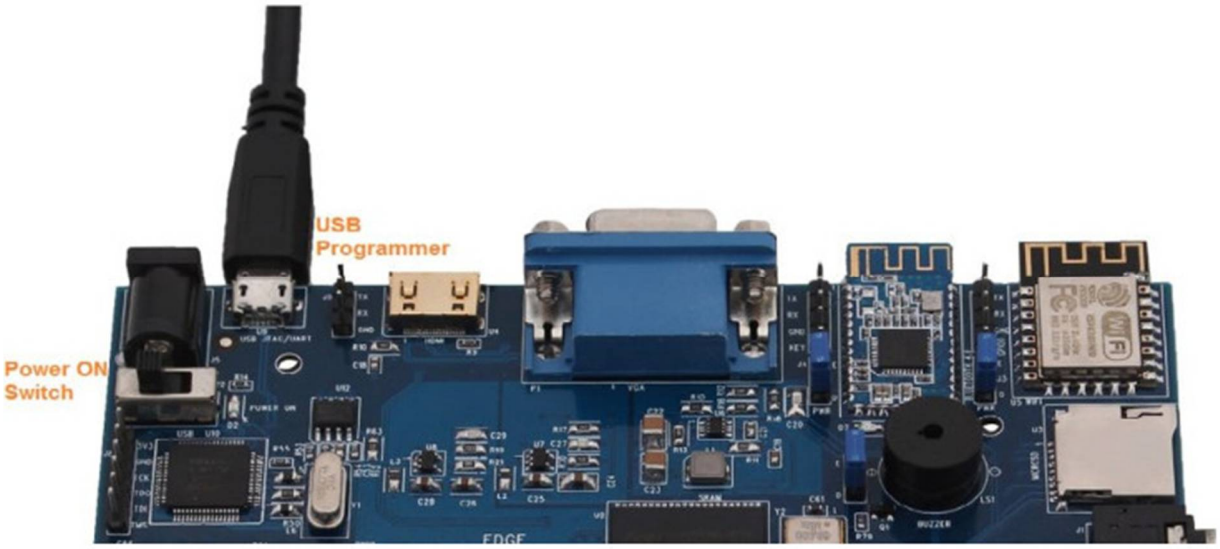
Software Required:

- Vivado Design Suite 2018.1 or latest

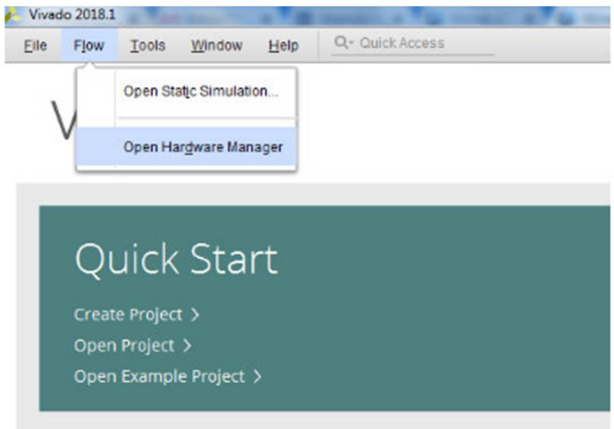
Instructions:

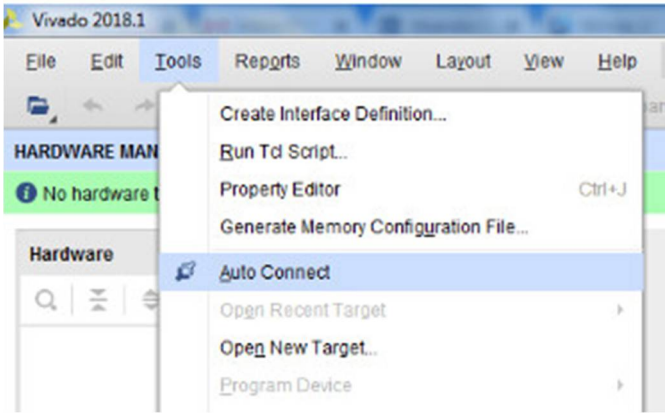
1. Connect the USB A to USB Micro B cable to the USB port (U9) on the EDGE Artix 7 Board above the power switch

2. Change the power switch position from Ext to USB on the EDGE Board to Power ON.

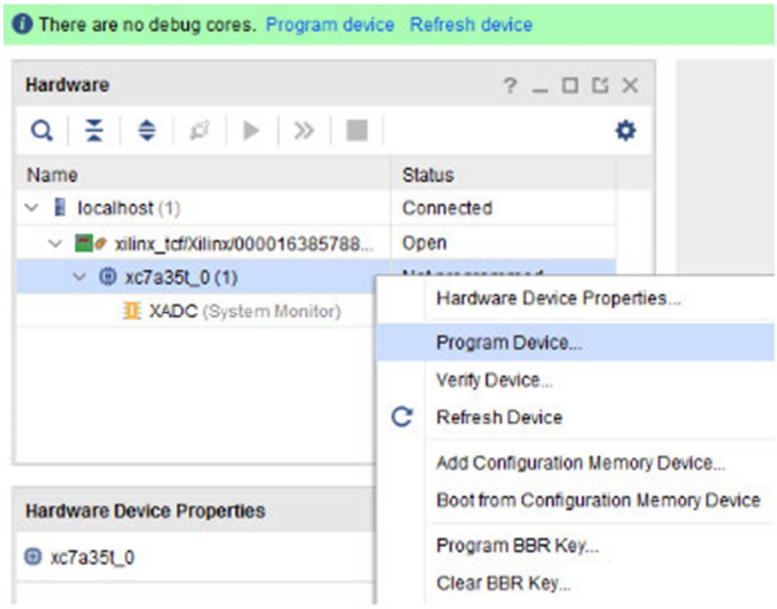


Open **Vivado Design Suite** and Select "**Hardware Manager** -> **Open Target** -> **Auto Connect**"

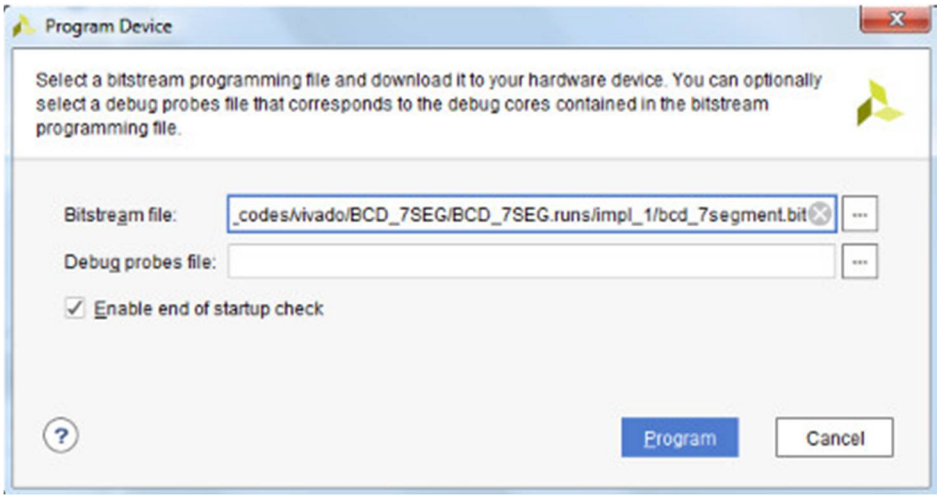




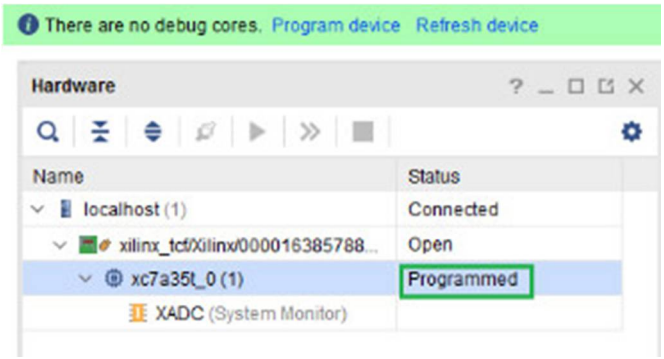
If the device is detected successfully, then select "**Program Device**" by right click on the target device "**xc7a35t_0**" as shown below



Browse the Bit file need to be downloaded to the Artix 7 FPGA and click **Program**.



Once the Program Succeeds, **Done LED D1** light up on EDGE Artix 7 FPGA kit.



Chapter 1: Switch LED Demo

This is a simple demo that changes the status of the user LEDs (D3-D19) when user change SPDT switch state from low to High.

Additional Hardware Required:

None

Software Platforms:

- Vivado Design Suite 2018.1 or latest

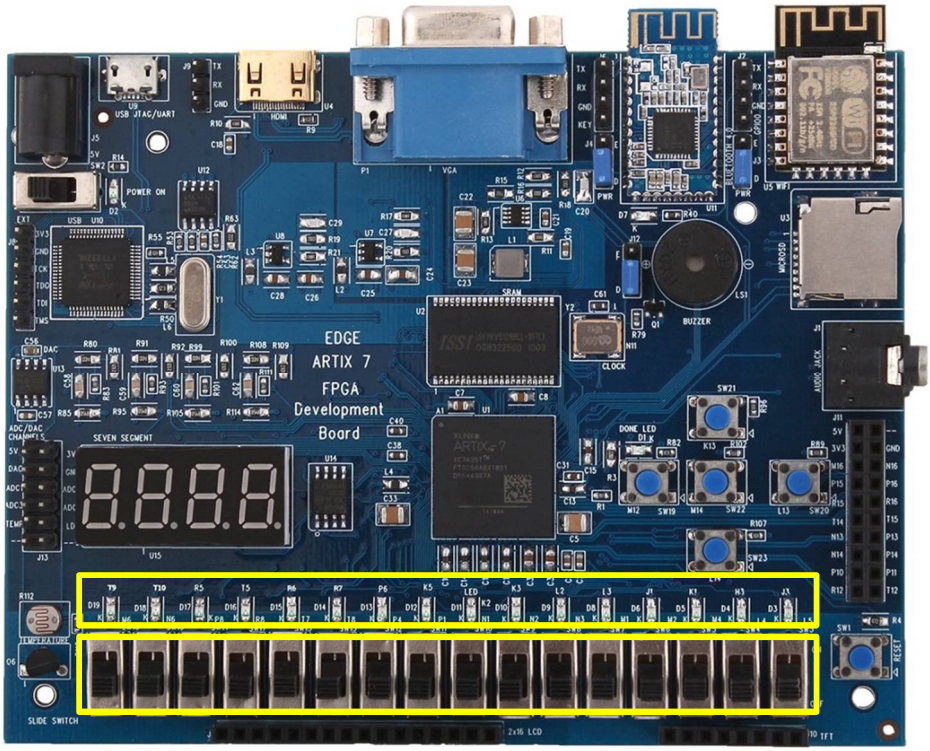
Supplied Files:

- Vivado project files

Instructions:

1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

The LEDs (D3 – D19) will light, when the SPDT Switches change their state from LOW to High.



Chapter 2: BCD to 7 Segment Demo

This is a simple demo that displays 4 bit Switch BCD state in 7 Segment Display.

Additional Hardware Required:

- none

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

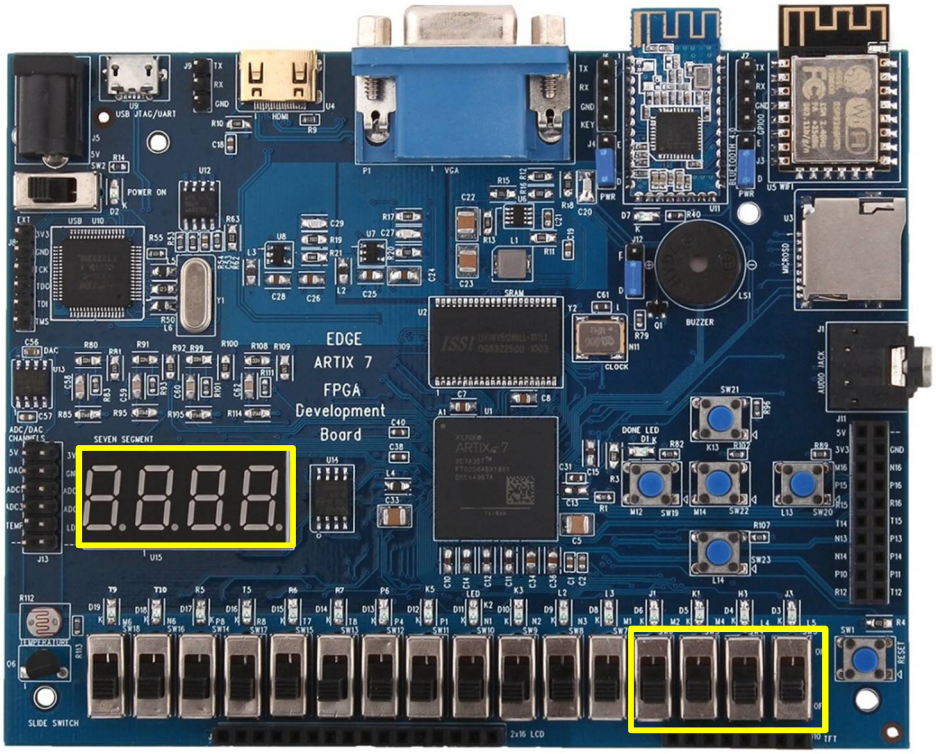
- Vivado project files

Instructions:

1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

SPDT Switch SW3, SW4, SW5, SW6 is assigned for input of 4 bit BCD value.

When the Switch State is changed from 0000 to 1001 state corresponding decimal value is displayed on the seven segment displays from 0 to 9.



Chapter 3: Seven Segment Display counter demo

This is a simple demo that displays decimal Counter on 7 Segment Display.

Additional Hardware Required:

- none

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

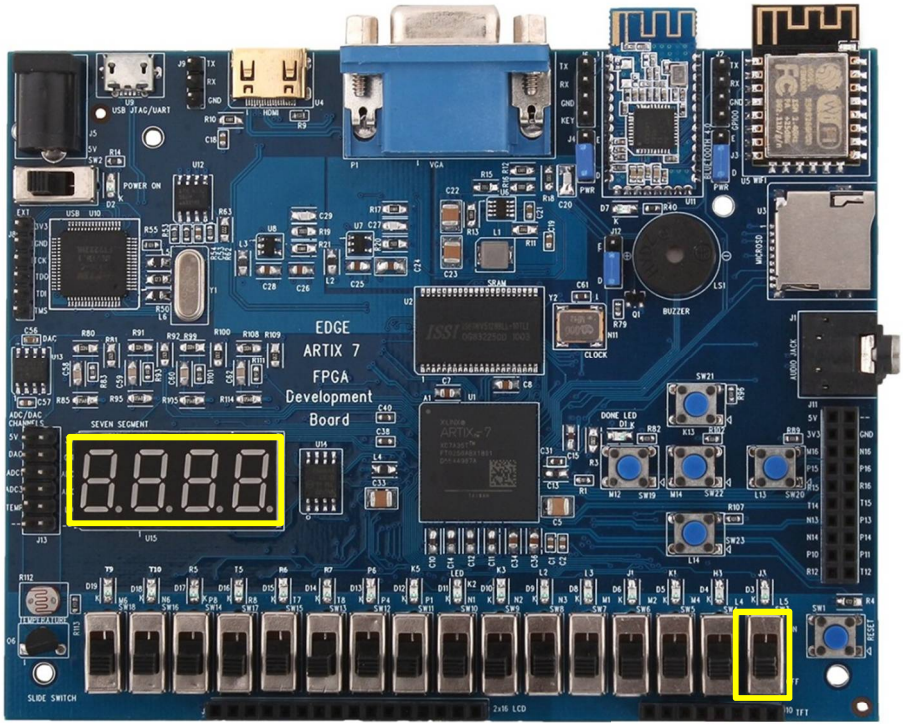
- Vivado project files

Instructions:

1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

Decimal counter counts from 0 to 9999. The counter increments at the interval of 1 sec and repeat the sequence.

Reset switch sw3 is used to reset the counter to 0.



Chapter 4: Push Button Demo

This is a simple demo display the Push button state on LEDs.

Additional Hardware Required:

None

Software Platforms:

- Vivado Design Suite 2018.1 or latest

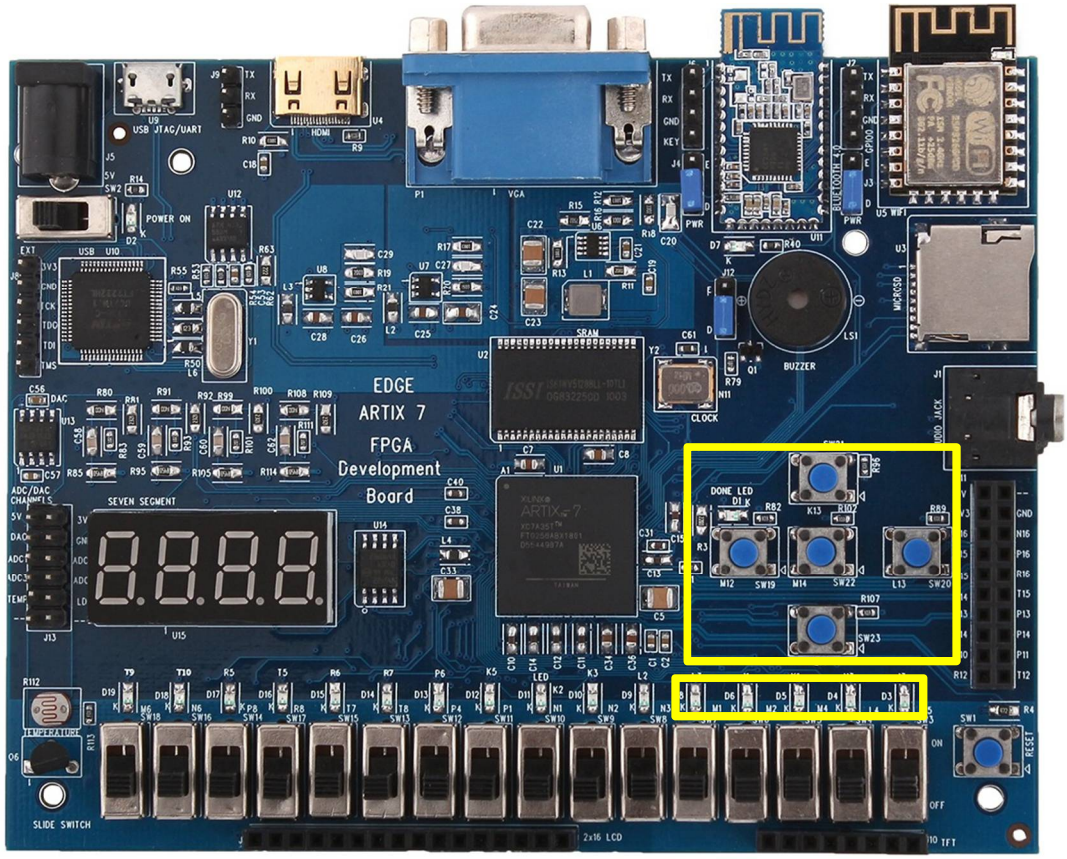
Supplied Files:

- Vivado project files

Instructions:

1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

Each of 5 Push Button states is directly assigned to LEDs. When the user press Push Button corresponding LED turn ON. Push Button switch SW19, SW20, SW21, SW22 and SW23 are assigned in this demonstration with respective of LED D3, D4, D5, D6, and D7.



Chapter 5: Buzzer Demo

This is a simple demo produce sound at piezo Buzzer at regular interval.

Additional Hardware Required:

To enable Buzzer, Jumper needs to be placed at Enable position at J6

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

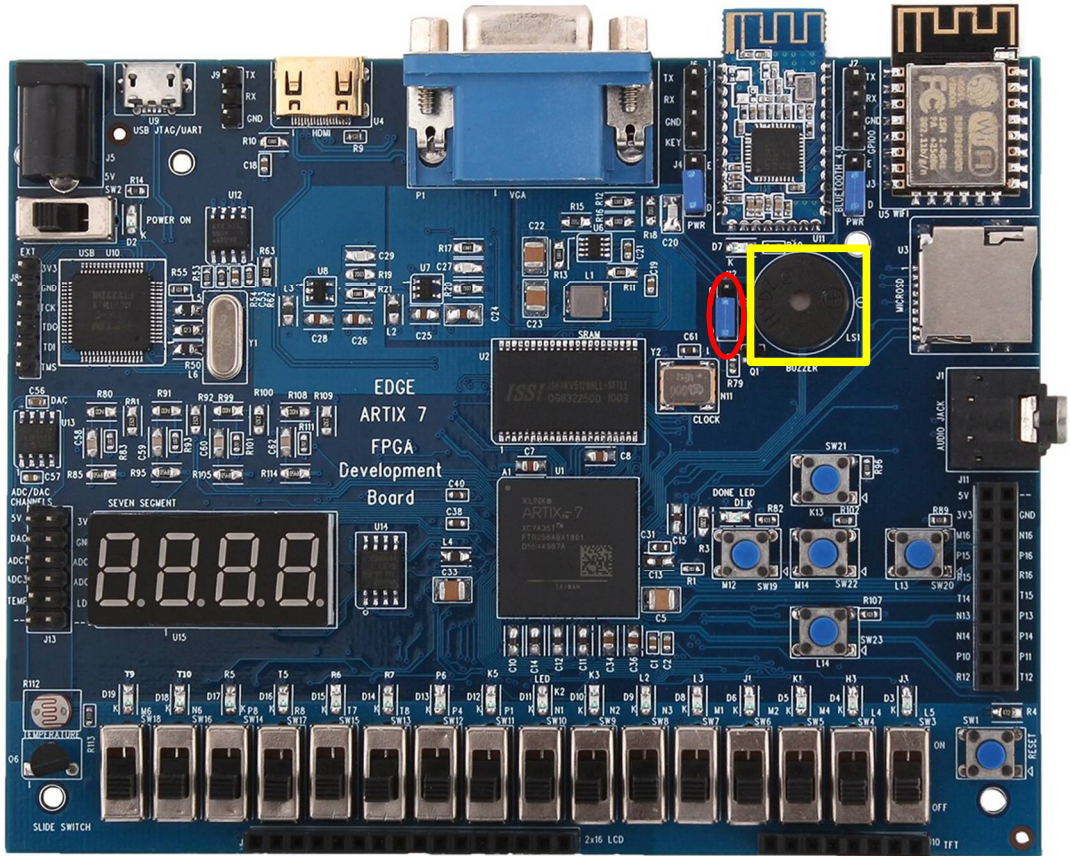
- Vivado project files

Instructions:

1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

PWM pulse of 2 sec is generated and supplied to buzzer.

5v Piezo buzzer produce beep sound at the interval of 2 sec.



Chapter 6: 2x16 LCD Demo

This is a simple demo for displaying characters in the 2x16 LCD.

Additional Hardware Required:

Connect 2x16 LCD display at J7 Header

Software Platforms:

- Vivado Design Suite 2018.1

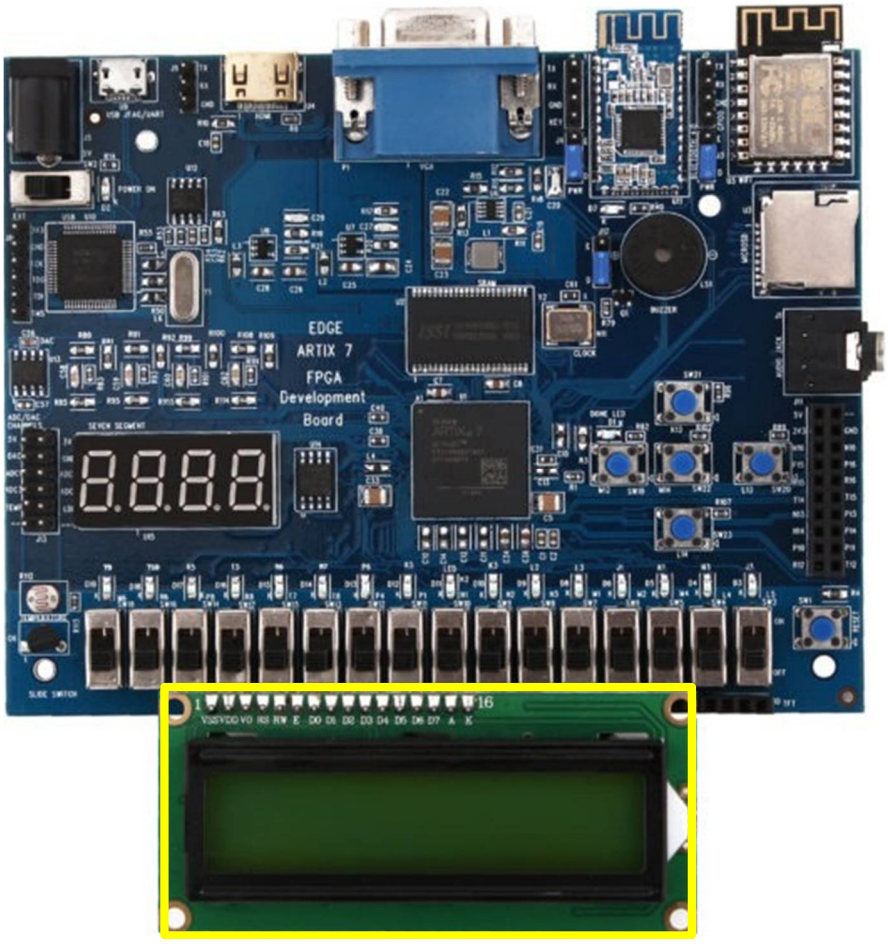
Supplied Files:

- Vivado project files

Instructions:

1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

2x16 LCD displays the following characters **123456789ABCDEF** in the second row.



Chapter 7: Temperature Sensor and LDR (ADC) Demo

This demo reads the temperature and light intensity value through XADC and displays it on LCD.

Additional Hardware Required:

Connect 2x16 LCD display at J7 Header.

External Temperature Sensor LM35 Input is available at the 9th pin of ADC Connector. To Connect Temperature sensor with XADC, Place a jumper between 7th and 9th pin of J13 Connector.

LDR input is available at the 10th pin of ADC Connector. To Connect LDR sensor with XADC, Place a jumper between 8th and 10th pin of ADC Connector.

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

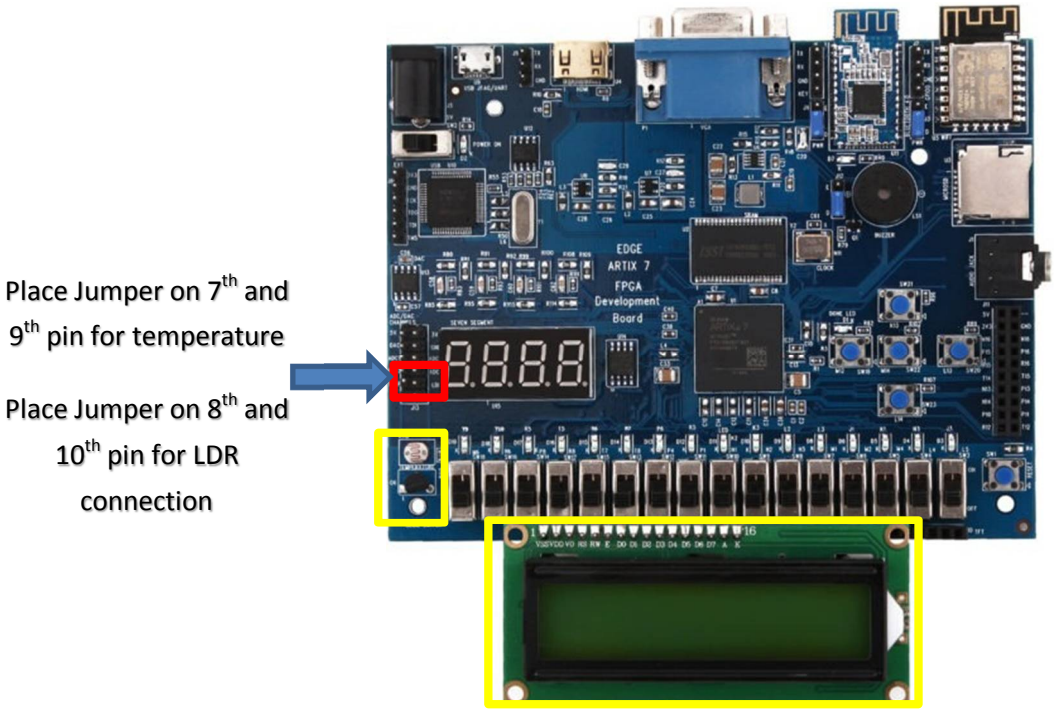
- Vivado project files

Instructions:

1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

Temperature input at channel 7 of XADC is converted to 16 bit digital output. LDR input at channel 15 of XADC is converted to 16 bit digital output.

Both temperature sensor and LDR outputs are displayed in 2x16 LCD. By placing finger over the top of Temperature sensor or LDR, Variation can be easily verified on LCD.



Chapter 8: UART Demo

This demo transmit the ASCII data through UART at 9600 baud Rate.

Additional Hardware Required:

-none

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

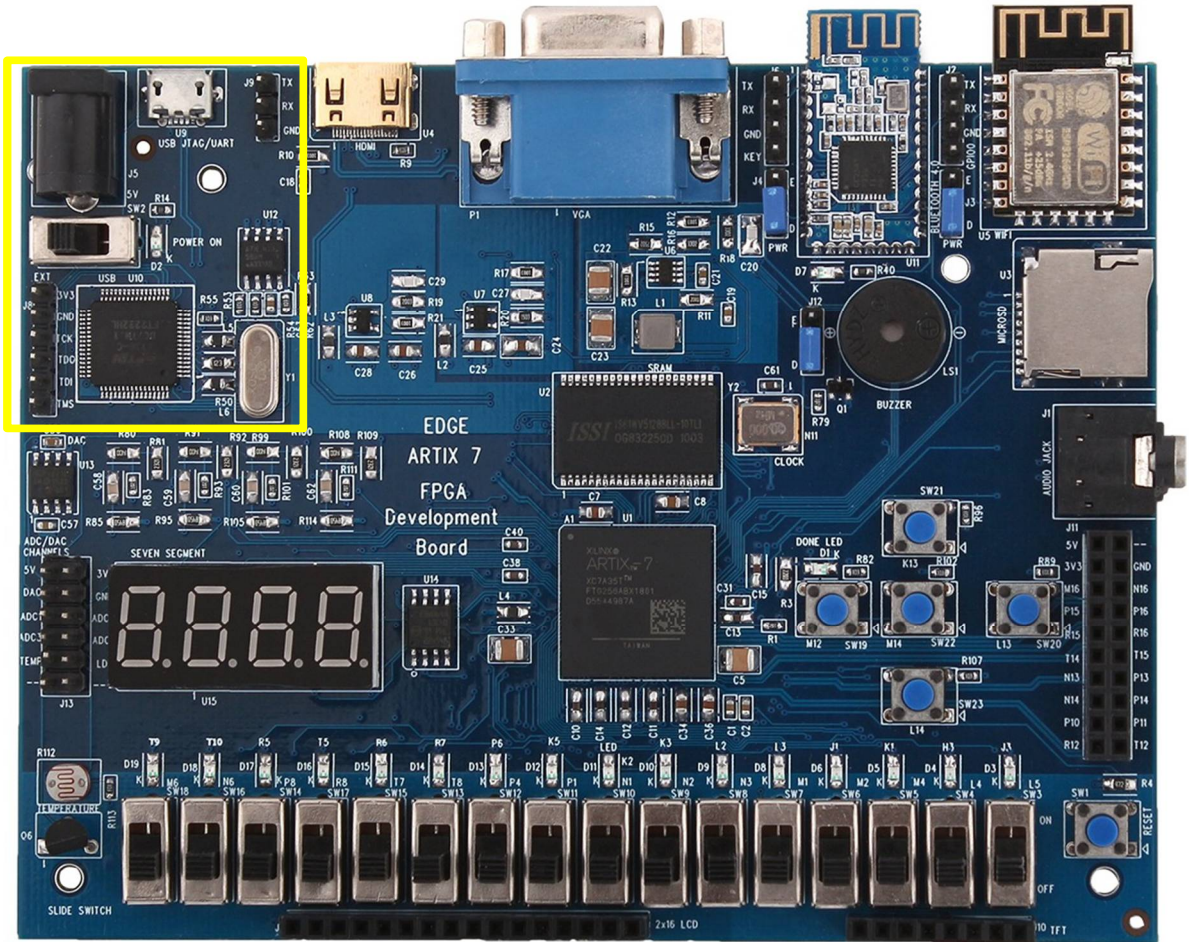
- Vivado project files

Instructions:

1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

UART interface is transmitting at the max baud rate of 3 M Baud.

We are transmitting ASCII data Hello World at 9600 Baud rate.



Chapter 9: DAC Demo

This demo output the sine wave generated from DAC IC

Additional Hardware Required:

Connect DSO probe at 19th and 20th pin of J3 connector to view the Analog output.

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

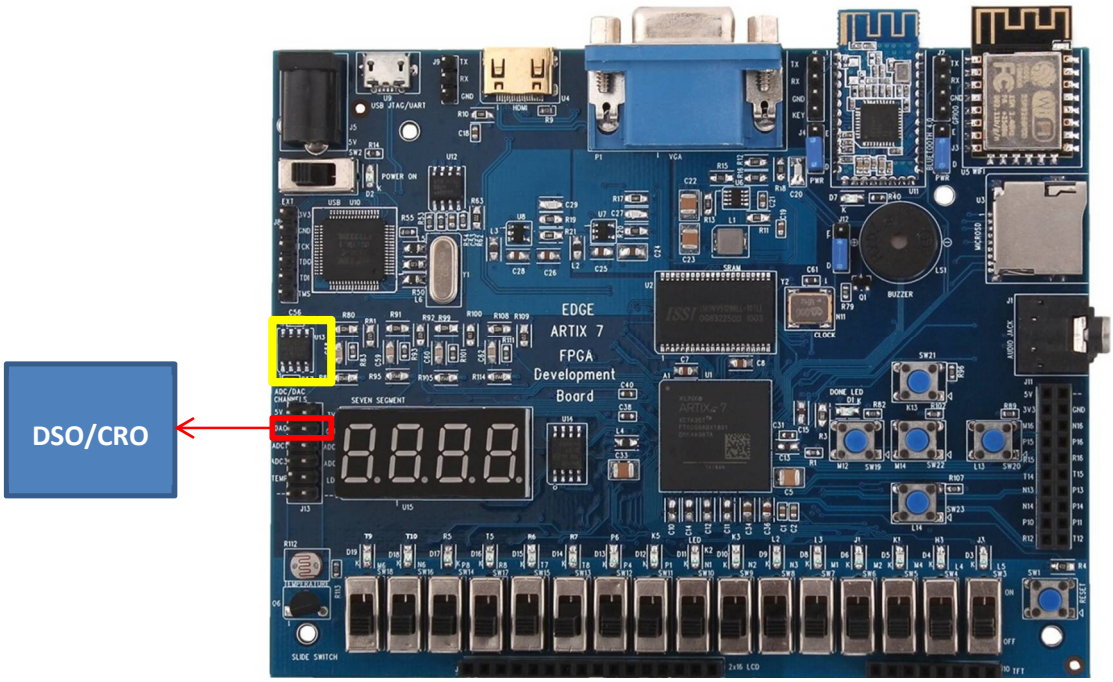
- Vivado project files

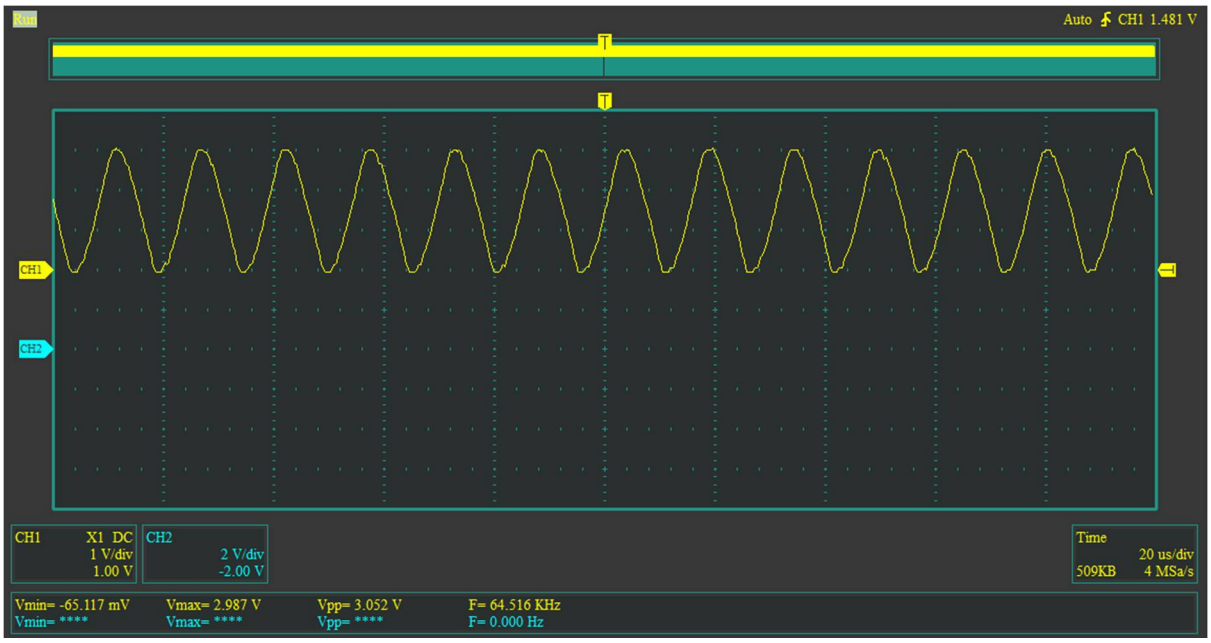
Instructions:

1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

MCP4921 SPI DAC IC converts 12 bit digital discrete sign Values to continuous analog sine wave Output at the connector J13.

Connect DSO at 19th and 20th pin of J3 connector to view the Analog output.




Run
Auto CH1 1.481 V
CH1
CH2
CH1 X1 DC
1 V/div
1.00 V
CH2
2 V/div
-2.00 V
Time
20 us/div
509KB 4 MSa/s
Vmin= -65.117 mV
Vmax= 2.987 V
Vpp= 3.052 V
F= 64.516 KHz
Vmin= ****
Vmax= ****
Vpp= ****
F= 0.000 Hz

Chapter 10: HDMI /DVI-D Demo

This demo displays a 480p colour screen using DVI-D / HDMI Monitor.

Additional Hardware Required:

Connect HDMI cable at the U4 Connector and connect the other end to HMDI monitor

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

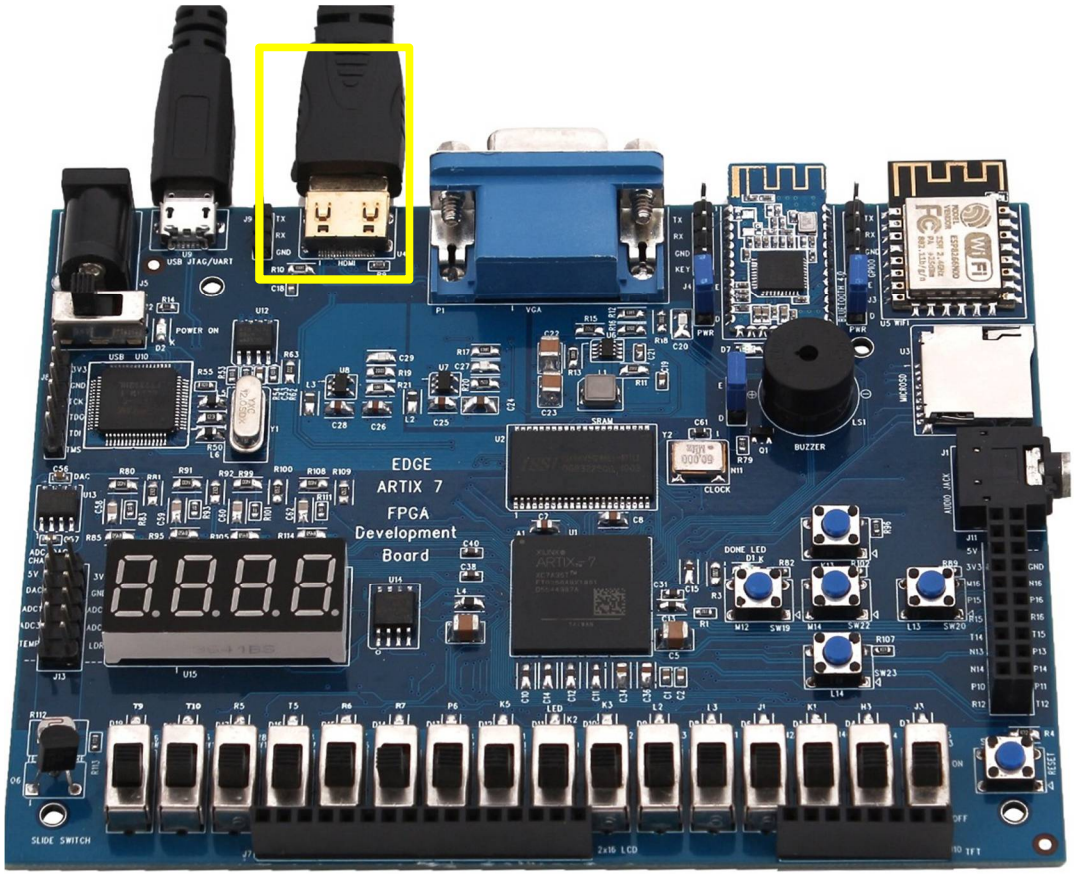
- Vivado project files

Instructions:

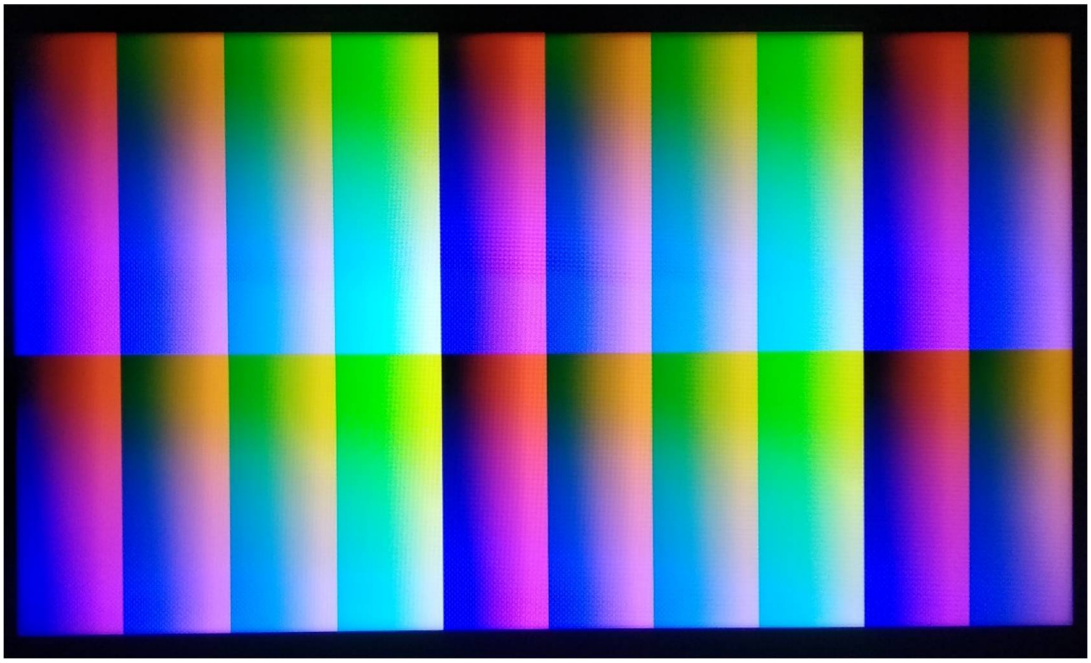
1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

HDMI port work with 640*480 frame which is actually sent as an 800*525 frame.

It specifies a 25MHz minimum pixel clock. It has three 4 bit primary colours such as red, green, blue



Display of HDMI monitor:



Chapter 11: CMOS Camera / VGA Demo

This demo displays the OV7670 CMOS Camera sensor output in the VGA Monitor as a video frames.

Additional Hardware Required:

To interface OV7670 CMOS Camera with EDGE Board, **Leave pin1 and pin2 of J5 unconnected**. Connect pin3 of expansion connector to pin1 of CMOS Camera.

Connect VGA Monitor to the connector P1

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

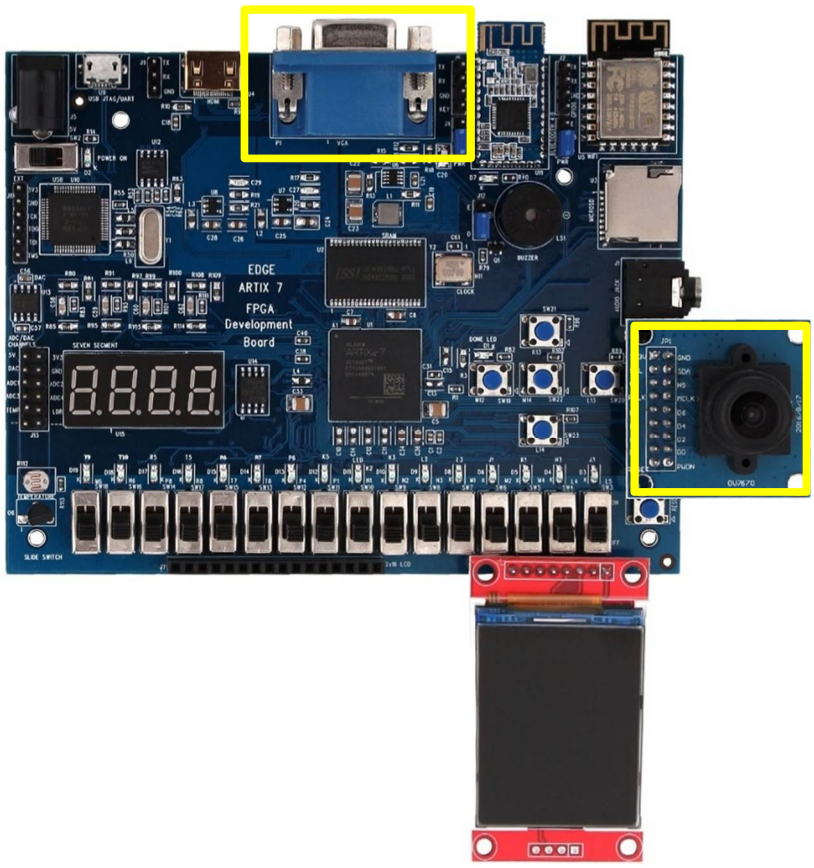
- Vivado project files

Instructions:

1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

Video frames captures through OV7670 Camera module is 320*240.

Data is stored in BRAM present on Artix 7 FPGA as frame buffer before displaying in the VGA monitor.



Chapter 12a: SPI TFT Display – colour band Demo

This demo displays the colour on the SPI TFT Display.

Additional Hardware Required:

Connect SPI TFT to the connector J10

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

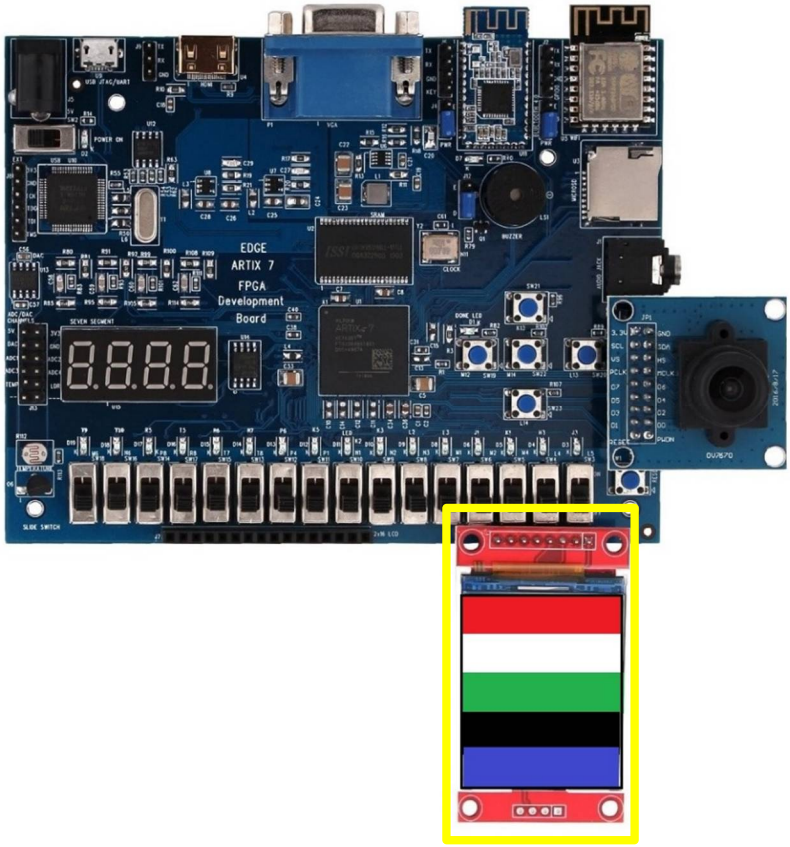
- Vivado project file

Instructions:

Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

1.8 inch SPI TFT Display the pixel area of 128x160.

Colour band data is sent to TFT Display through SPI Protocol.



Chapter 12b: SPI TFT Display - colour image Demo

The demo displays 128x160 pixel image on the SPI TFT Display.

Additional Hardware Required:

Connect SPI TFT to the connector J10

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

- Vivado project file

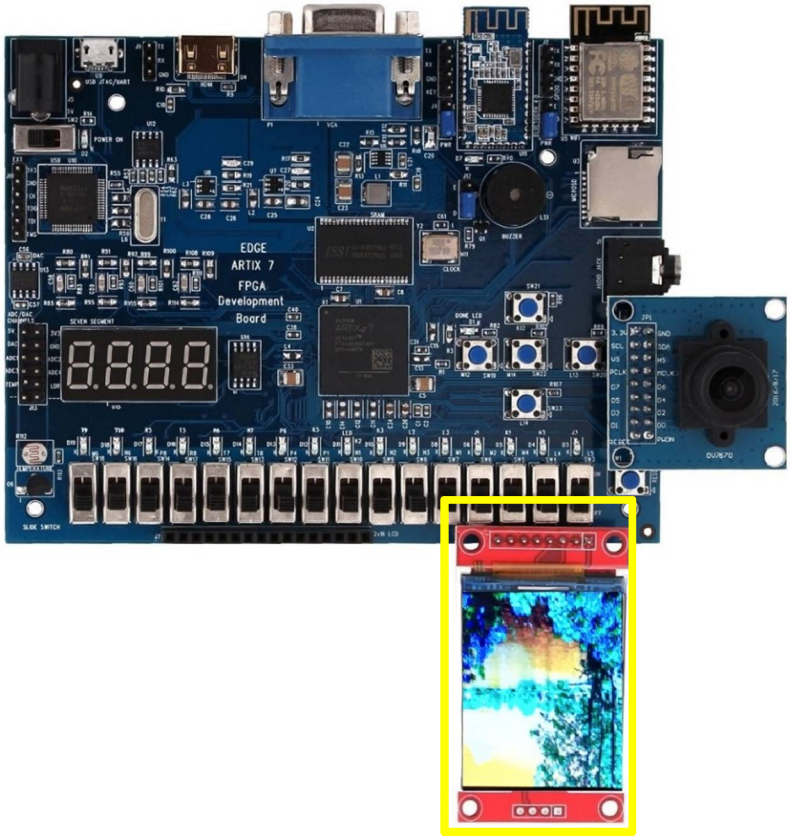
Instructions:

Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

1.8 inch SPI TFT Display the pixel area of 128x160.

The image converted into image.coe file for storing the image in FPGA BRAM

Through SPI Protocol image is transferred from BRAM to SPI TFT display as shown below.



Chapter 13: Bluetooth Demo

In this demo, FPGA LEDs are controlled through Bluetooth interface.

Additional Hardware Required:

To enable power supply to the Bluetooth modem place jumper at Enable and centre pin of J4.

D19 LED ON/OFF at every 1 sec delay to represent Bluetooth is ready to pair.

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

- Vivado Project file

Instructions:

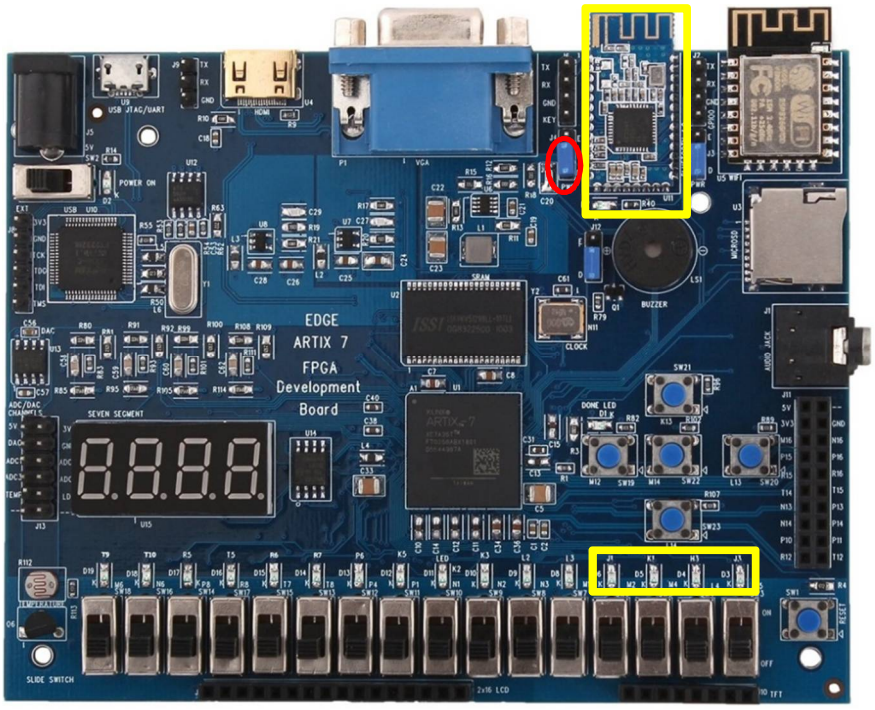
1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

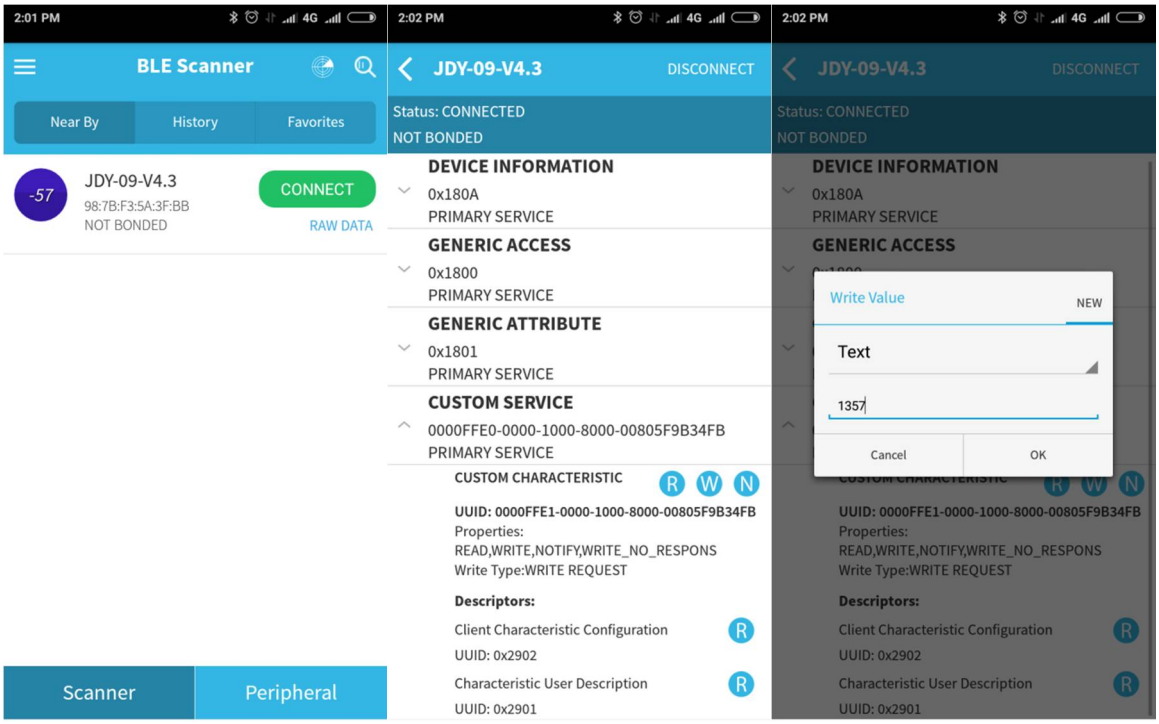
We are going to control On-board LEDs through Bluetooth via Android Phone App.

Install BLE Scanner App from play store. Pair with Bluetooth device on FPGA kit. D7 LED glow continuously once paired with Bluetooth.

Under Custom Services, select **W** option to send some data through Bluetooth. EDGE Board LEDs D2, D3, D4 and D5 are turned **ON** sending 1, 3, 5, and 7 respectively through Bluetooth.

Those LEDs are turned **OFF** by sending 2, 4, 6, and 8 through Bluetooth.




2:01 PM
BLE Scanner
Near By
History
Favorites
-57
JDY-09-V4.3
98:7B:F3:5A:3F:BB
NOT BONDED
CONNECT
RAW DATA
Scanner
Peripheral
2:02 PM
JDY-09-V4.3
DISCONNECT
Status: CONNECTED
NOT BONDED
DEVICE INFORMATION
0x180A
PRIMARY SERVICE
GENERIC ACCESS
0x1800
PRIMARY SERVICE
GENERIC ATTRIBUTE
0x1801
PRIMARY SERVICE
CUSTOM SERVICE
0000FFE0-0000-1000-8000-00805F9B34FB
PRIMARY SERVICE
CUSTOM CHARACTERISTIC
R W N
UUID: 0000FFE1-0000-1000-8000-00805F9B34FB
Properties:
READ,WRITE,NOTIFY,WRITE_NO_RESPONS
Write Type:WRITE REQUEST
Descriptors:
Client Characteristic Configuration
R
UUID: 0x2902
Characteristic User Description
R
UUID: 0x2901
2:02 PM
JDY-09-V4.3
DISCONNECT
Status: CONNECTED
NOT BONDED
DEVICE INFORMATION
0x180A
PRIMARY SERVICE
GENERIC ACCESS
Write Value
NEW
Text
1357
Cancel
OK
UUID: 0000FFE1-0000-1000-8000-00805F9B34FB
Properties:
READ,WRITE,NOTIFY,WRITE_NO_RESPONS
Write Type:WRITE REQUEST
Descriptors:
Client Characteristic Configuration
R
UUID: 0x2902
Characteristic User Description
R
UUID: 0x2901

Chapter 14: Wi-Fi Demo

In this demo, Temperature and LDR data is sent to cloud through Wi-Fi Interface.

Additional Hardware Required:

To enable power to the WiFi device, Place jumper at E and centre pin of J3.

Connect 2x16 LCD display at J7 Header.

External Temperature Sensor LM35 Input is available at the 9th pin of ADC Connector. To Connect Temperature sensor with XADC, Place a jumper between 7th and 9th pin of J13 Connector.

LDR input is available at the 10th pin of ADC Connector. To Connect LDR sensor with XADC, Place a jumper between 8th and 10th pin of ADC Connector.

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

- Vivado Design Suite

Instructions:

1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

Monitoring Temperature data through IoT

Transmitting Temperature and light level data through WiFi involves communication with cloud server using IP Address. We used an open source data logger website thingspeak.com to reduce the implementation cost. It provides a free user space for creating the data channels. Each channel will be having 8 fields to write the various data and it automatically plots the given data in a graphical representation.

We have to program for ESP8266-12F to send the required AT commands and to establish a connection between the system and thingspeak server.

Once we created our channel for entering the data into cloud, the channel will be allocated with one API key. So we have to write the API key before writing the actual data, then the data will be stored and displayed in the required channel.

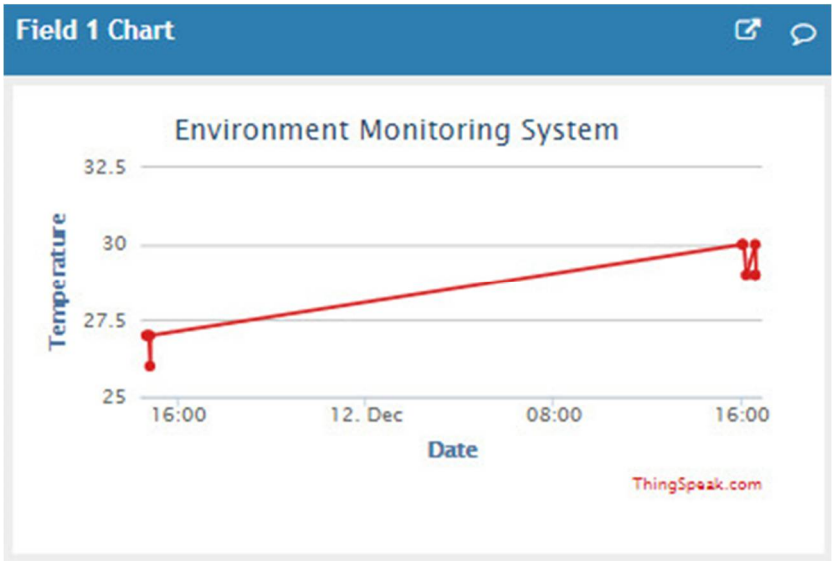
We have created two thingspeak channel that includes field 1 for Temperature Reading and field 2 for light level reading. The actual data obtained from the sensor will be first stored in a script and then the thingspeak server will automatically plots the data retrieving from the field.

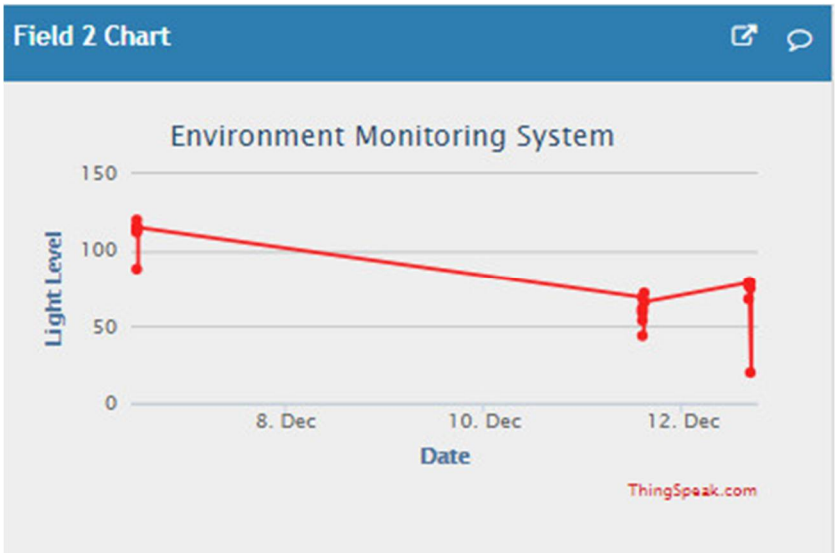
To access the data from personal computing devices such Laptop, Tablet and Mobile Phone channel ID is required. Channel ID will be provided by Thingspeak.com when you create new

channel. These channel ID can be changed to private or public depending on the application requirement.

Example Channel ID Will be like

https://thingspeak.com/channels/384072





Procedure to check the IoT Demo Code

Step 1: To start using ThingSpeak, you must create a new MathWorks account.

https://thingspeak.com/users/sign_up

Step 2: Login and setting up new channel to collect and display temperature data.

https://www.mathworks.com/help/thingspeak/collect-data-in-a-new-channel.html

New channel created can be available to the public or private based on settings selected.

Step 3: Establishing connection between ESP12F WiFi modem and Thingspeak cloud. We have send the following AT commands.

AT+RST

Reset the WiFi Module to Default State

AT+CWJAP="WIFINAME","Password"

Set the home/office Wifi User Id and Password to connect ESP module to the internet

AT+CIPSTART="TCP","184.106.153.149",80

Connecting to TCT IP Address of Thingspeak.com

AT+CIPSEND=49

Sending total lengh of the data to transmitted to server.

GET /update?api_key=XXXXXXXXXXXXXXXX&field1=000

Set your API key received when creating new channel. Field 1 represent temperature value and Field 2 represent light intensity value.

AT+CLOSE

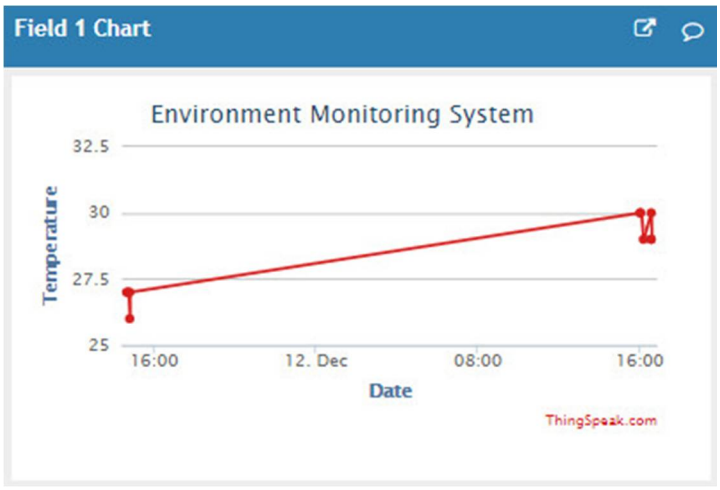
Close the communication with server.

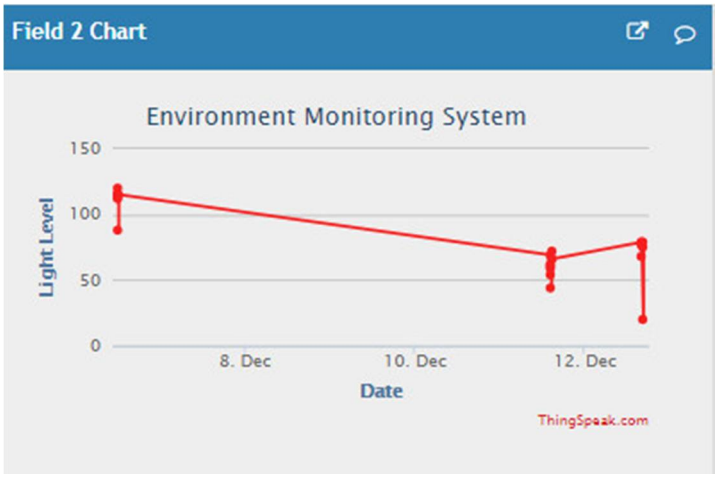
Step 4: After updating IoT project file with WiFi user id, password and API key. Regenerate the project and download the bit file to FPGA.

Note: WiFi user id and password length may vary. We need to update the array length based on it.

Step5: Monitoring the data through channel id.

https://thingspeak.com/channels/384072

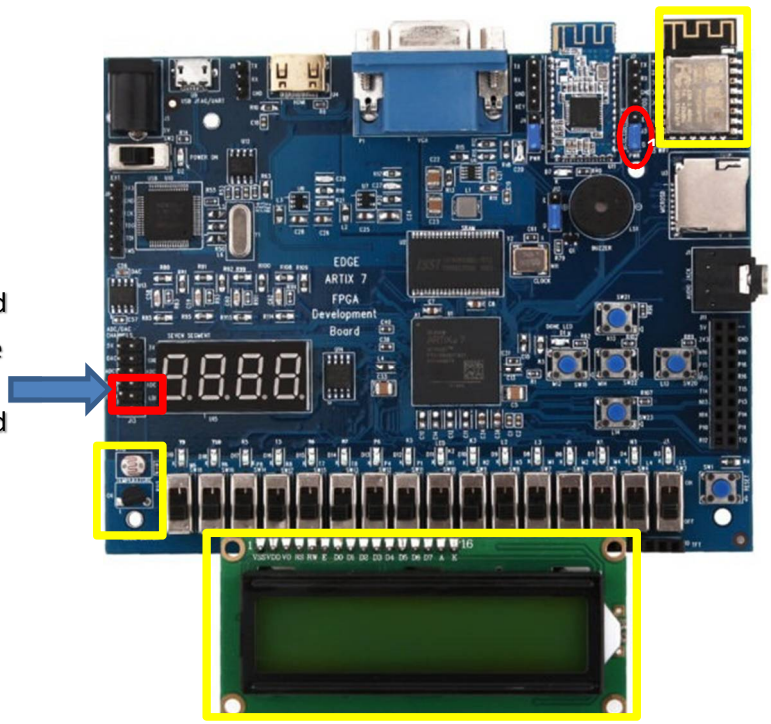




With API key and channel id, we can also monitor the output in Android / IOS App.

Place Jumper on 7th and 9th pin for temperature

Place Jumper on 8th and 10th pin for LDR connection



Chapter 15: Audio Demo

This demo generates 2-voice music box that plays J.S. Bach's Invention at audio connector

Additional Hardware Required:

Connect head phone jack or speaker to the stereo Audio Connector

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

- Vivado Project file

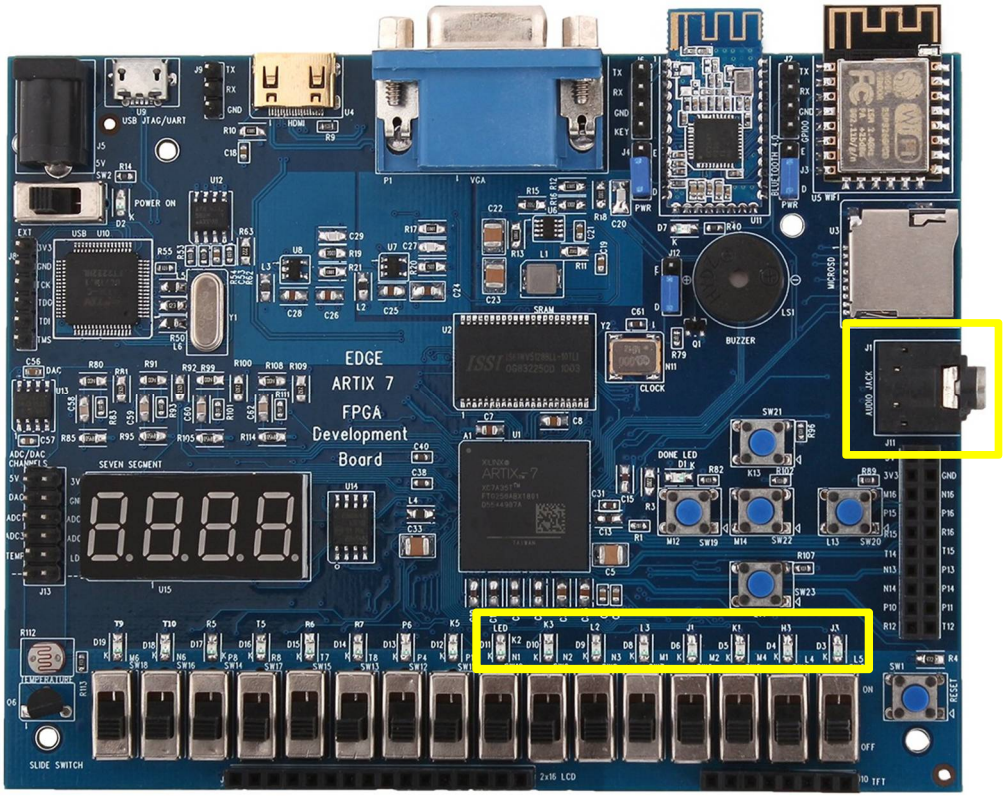
Instructions:

1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

Stereo Audio tempo is displayed on the LEDs.

Music is held in a BRAM-based ROM, as are the tone frequencies (well-tempered scale), and output waveform. Output is 12-bit PWM at 48 KHz on each of the two audio outputs. This music conveniently has only two voices and one is played on each channel (left or right).

The music is repeating again and again.



Chapter 16a: SRAM basic Demo

In this demo, write and read operation has done through the SRAM

Additional Hardware Required:

none

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

- Vivado Project file

Instructions:

The EDGE Board includes 512 KB of Static Random-Access Memory (SRAM). This memory has a standard, easy to use parallel interface with 19 address signals, 8 bi-directional data signals, and 3 control signals.

sw - It is 8 bits wide and used as data or address input.

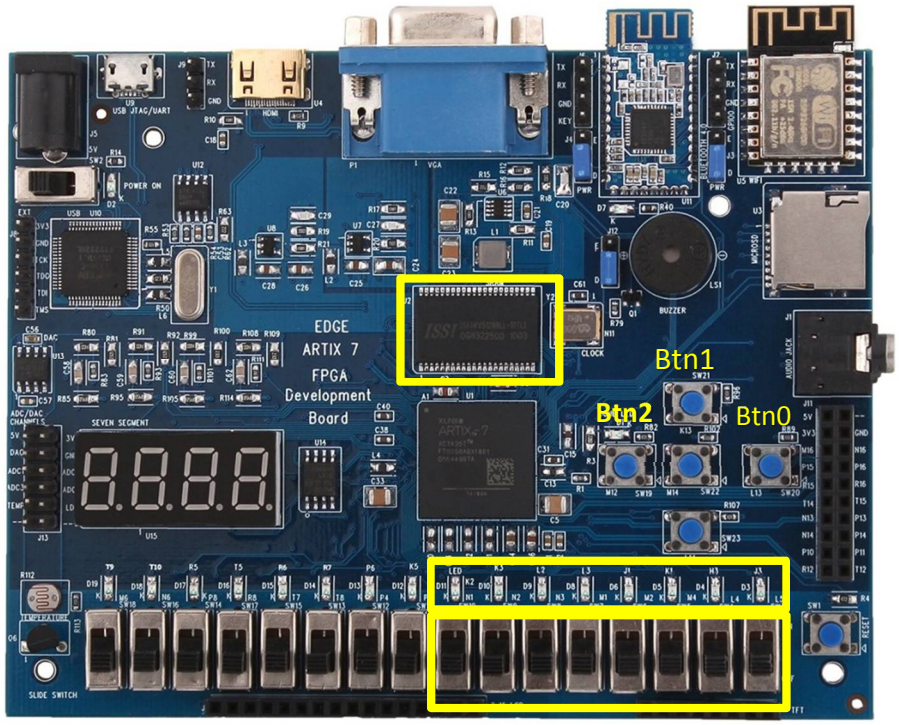
led - It is 8 bits wide and used to display the retrieved data.

btn(0)- When it is asserted, the current value of sw is loaded to a data register.

btn(1)- When it is asserted, the controller uses the value of sw as a memory address and perform the write operation

btn(2)- When it is asserted, the controller uses the value of sw as a memory address and perform the read operation and read out is send to 8 bit LEDs

During a write operation, we first specify the data value and load it to the internal register and then specify the address and initiate the write operation. During a read operation, we specify the address and initiate the read operation. The retrieved data is displayed in eight discrete LEDs.


EDGE
ARTIX 7
FPGA
Development
Board
Btn1
Btn2
Btn0

Chapter 16b: SRAM to VGA Demo

In this demo, Send an image via Serial to FPGA, store it in SRAM Memory and show it

Additional Hardware Required:

none

Software Platforms:

- Vivado Design Suite 2018.1 or latest

-Any MATLAB version

Supplied Files:

- Vivado Project file

-Matlab file

Instructions:

The EDGE Board includes 512 KB of Static Random-Access Memory (SRAM). The goal of this project is to read a raw image on a SRAM and to display it on a VGA monitor.

Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

Make the SW18(RESET switch) high.

Open the Im_Serial.m in MATLAB and set the COM port detected in device manager.

Run the MATLAB script

Now the image pixel data is sent to FPGA over the UART.

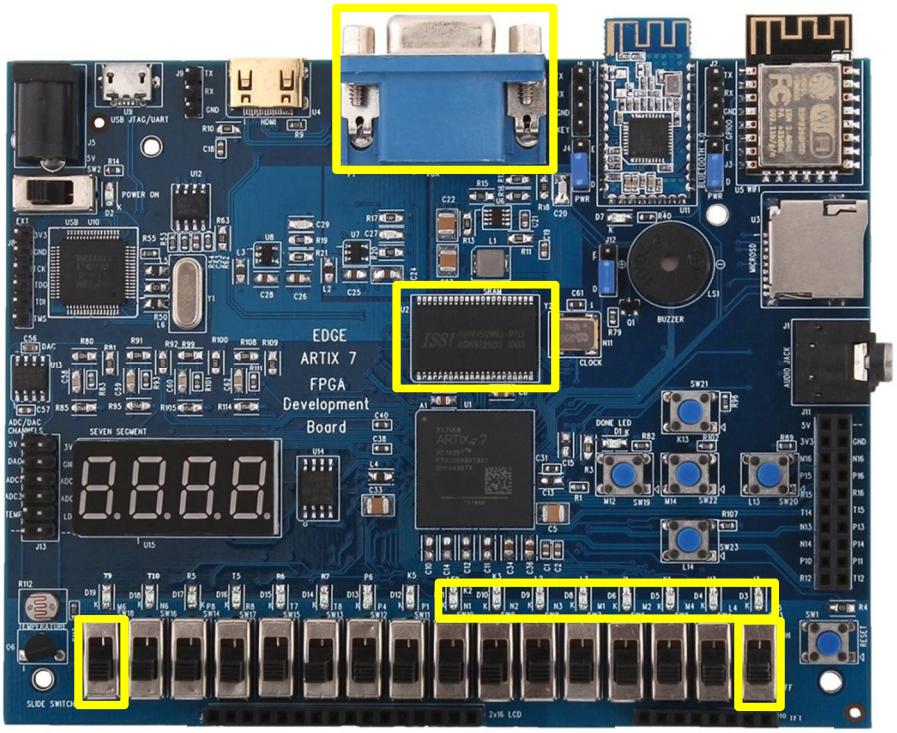
FPGA receives 8 bit serial data and write it to SRAM. Serial data is also sent to LED.

Once the blinking of LED coming to end, on the switch SW3

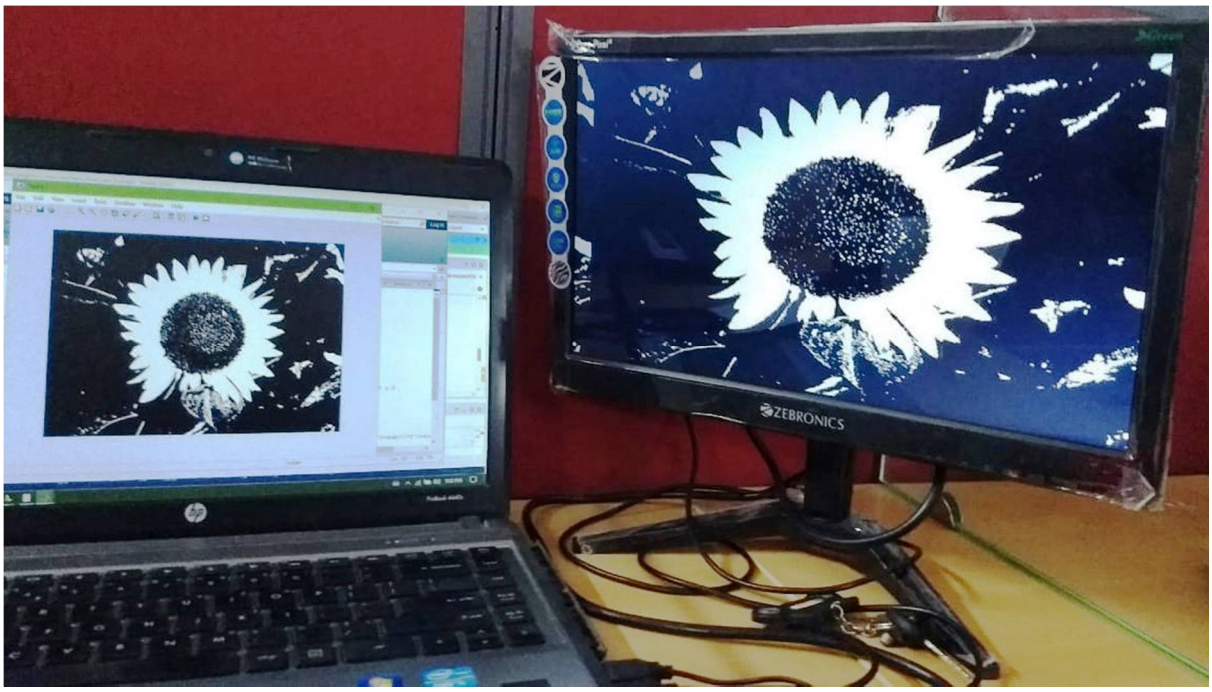
The written data are read from the SRAM and displaying on the display through VGA port.

Im_Serial.m

```
1 -     clear all;close all;clc;
2 -     delete(instrfind({'port'},{'COM4'}));
3       %I = imread('Untitled-1.jpg');
4 -     I = imread('sunflower.jpg');
5 -     Ib = im2bw(I);
6 -     Ib = imresize(Ib, [480 640]);
7 -     imshow(Ib);
8 -     PS=serial('COM4');
```



SW18 SW3


ZEBRONICS

Chapter 17: SD Card/VGA Demo

The demo is to read a raw image of SD card and display it on a screen through a VGA port

Additional Hardware Required:

Insert the microSD card into the microSD port

Software Platforms:

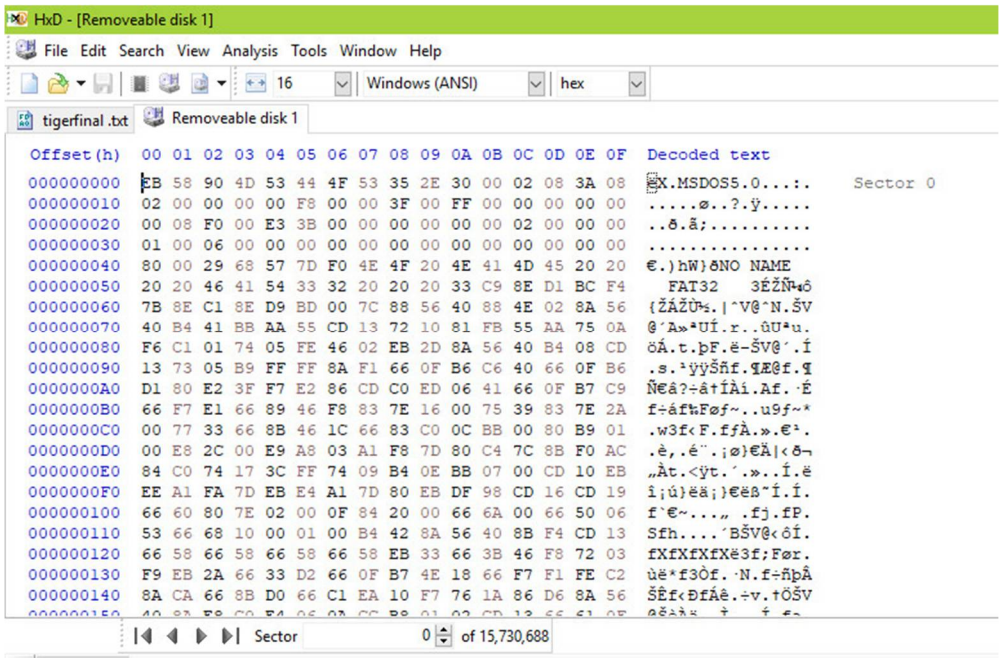
- Vivado Design Suite 2018.1 or latest

Supplied Files:

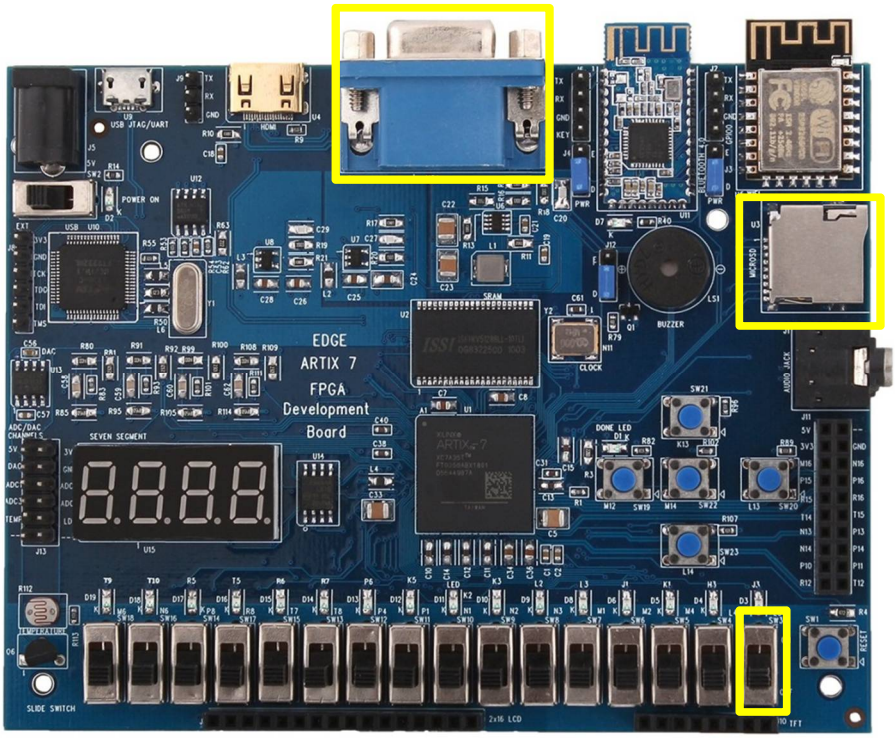
- Vivado Project file

Instructions:

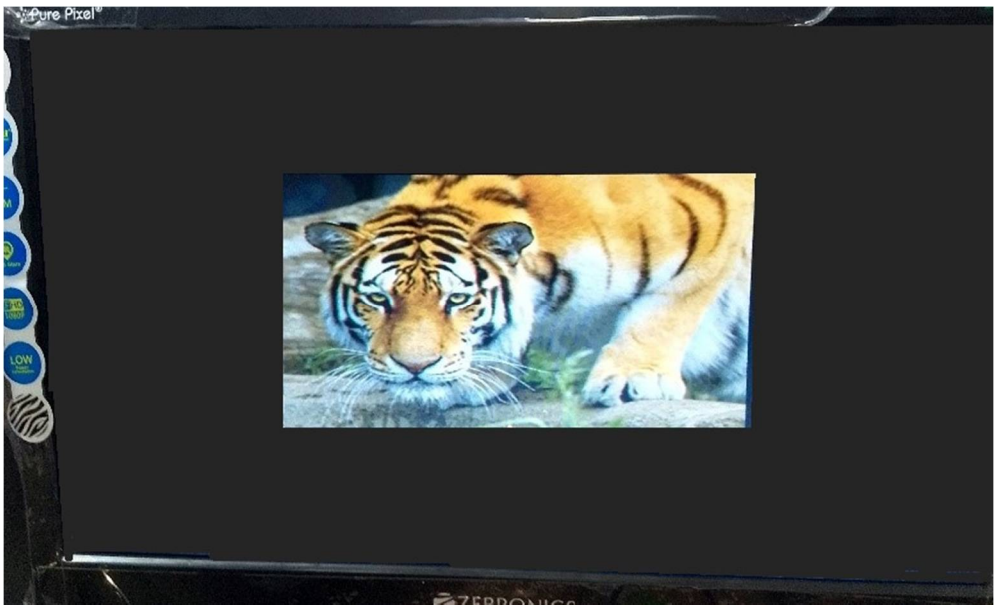
1. Setup and program the board as described in the “Setting up and programming the EDGE Board” Section
2. The goal of this project is to read a raw image on a SD Card and to display it on a screen through a VGA port.
3. The image format on the SD Card has to be 320*240, with 24 bits per pixel coded in RGB.
4. A test image is provided in the file tiger.txt. Copy the raw image data to the SD card.
5. It is possible to do it by using **HxD software** as shown below. Open the HxD software with admin permission.
6. Go to tools and open the disk. In this, you have to select removable disk under physical disk and deselect the **Open as Read only option**. Paste the given test image file to the removable disk from the first sector.



6. Change the value of the offset in the first process of the file FSM.vhd, if you are using your own image. The offset is the first sector of the image.
7. Insert the SD card into the board. The card detect LED will be on.
8. Make the reset switch high. The given 24 bit RGB image display it on a screen through VGA port.



Output Image Displaying on the VGA Monitor



Chapter 18: Image processing Demo

This demo displays the OV7670 CMOS Camera sensor output in the VGA Monitor as a video frames.

Additional Hardware Required:

Connect VGA Monitor to the connector P1

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

- Vivado project files

Instructions:

Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

The image converted into flower.coe file for storing the image in FPGA BRAM

According to the switch input shown below, the system process the image and display the result on a VGA monitor.

SWITCH INPUT	IMAGE OUTPUT
0000	RGB image to Gray scale image
0001	Increase brightness
0010	Decrease brightness
0011	colour inversion
0111	original image
1000	average blurring
1001	sobel edge detection
1010	edge detection
1011	motion blurring xy
1100	emboss
1101	sharpen
1110	motion blur x
1111	Gaussian Blur

0000-Gray scale Image

0001-Increase brightness

0010-decrease brightness

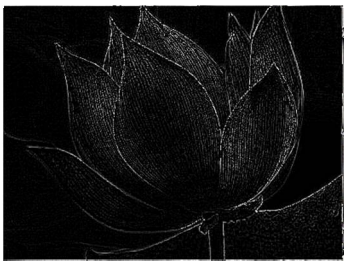
0011-Colour inversion

0111-Original image

1000-Average Blurring

1001-Sobel Edge Detection

1010- Edge Detection

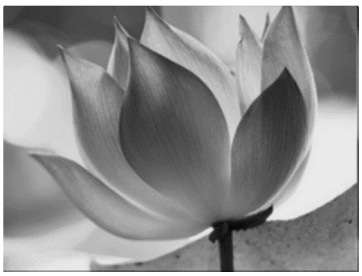


1011- Motion Blurring xy

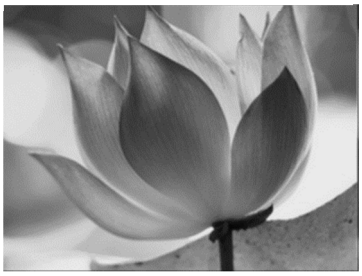
1100-Emboss

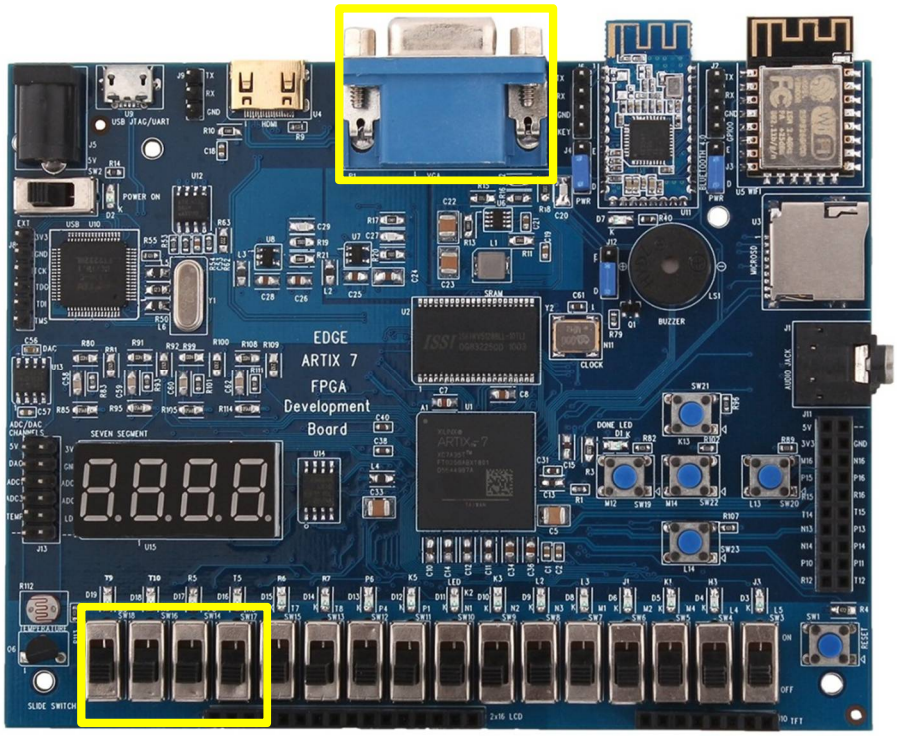
1101-Sharpen

1110- Motion Blurring x



1111- Gaussian blurr




EDGE
ARTIX 7
FPGA
Development
Board
SEVEN SEGMENT
SLIDE SWITCH
2x16 LCD
TFT
BUZZER
CLOCK
SRAM
DONE LED
RESET
POWER ON
USB JTAG/UART
HDMI
ADC/DAC CHANNELS

Chapter 19: Real-Time Edge Detection-Video processing Demo

Unstable version: This demo is unstable, no guarantee for its working

This demo displays the Edge Detection output in the VGA Monitor from OV7670 CMOS Camera sensor.

Additional Hardware Required:

To interface OV7670 CMOS Camera with EDGE Board, **Leave pin1 and pin2 of J5 unconnected**. Connect pin3 of expansion connector to pin1 of CMOS Camera.

Connect VGA Monitor to the connector P1

Software Platforms:

- Vivado Design Suite 2018.1 or latest

Supplied Files:

- Vivado project files

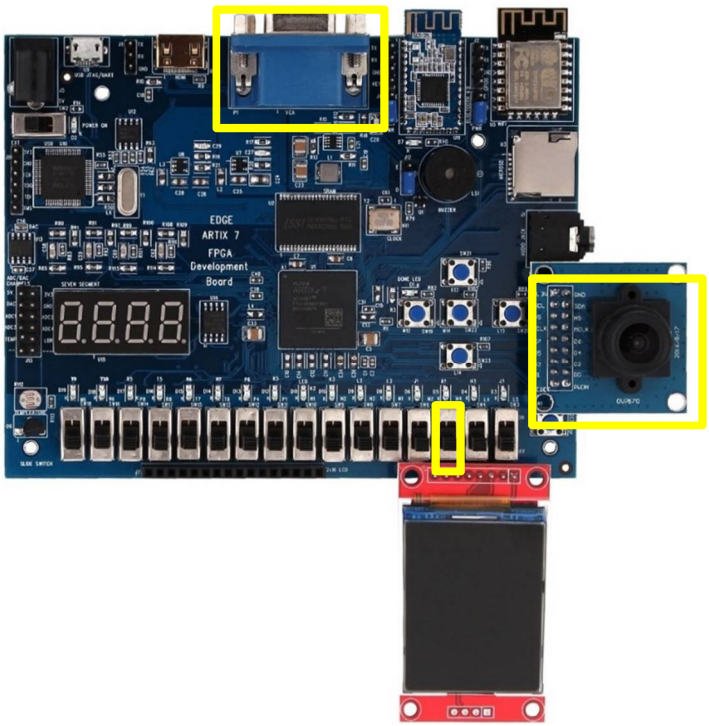
Instructions:

Setup and program the board as described in the “Setting up and programming the EDGE Board” Section

The system takes the images from a CMOS camera, process them in order to emphasize edges of the objects and then display the result on a VGA monitor.

Data is stored in BRAM present on Artix 7 FPGA as frame buffer before displaying in the VGA monitor.

Initially normal camera output displays. To see the real time Edge detection output, turn on switch SW5.


EDGE
ARTIX 7
FPGA
Development
Board


Pure Pixel
ZEBRONICS