DCT and IDCT Implementation in FPGA

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Objective

The Objective of the Project is implement the Discrete Cosine Transform and Inverse Discrete IDCT in FPGA. We used icoboard FPGA along with Arduino Mega for recieving and sending the values of siganl. We have used Butterfly algorithm to implement the DCT and IDCT in FPGA.

- All the Codes and the Report available in the following github link.
- Link: https://github.com/shiva1393/shiva

Requirements

Hardware Requirements

- Icoboard
- SDCARD with raspbian OS
- Arduino
- Raspberry
- Breadboard
- Jumperwires

Software Requirements

- Icoprog
- yosys
- arachne-pnr
- icostrom tools

Link for install softwares

- https://github.com/gadepall/EE5811/blob/master/icoboard_fpga/ gvv_hemanth_icoboard.pdf

Theory

- In this project we did 4-point DCT-II followed by IDCT.
- Formula for DCT-II

$$X_k = \sum_{n=0}^{N-1} x_n * cos[(\frac{\pi}{N}) * (n + \frac{1}{2})k] \quad k = 0...N-1 \qquad (1)$$

- Formula for IDCT:

$$x_n = \frac{1}{2} * [\frac{1}{2} * X0 + \sum_{k=1}^{N-1} X_k * cos[(\frac{\pi}{N}(n + \frac{1}{2}]] \quad n = 0...N-1 \qquad (2)$$

Implmentation of Butterfly Algorithm For DCT

- Computations For DCT

$$X(0) = [A(0) + A(1)] \cdot a(2)$$
$$X(1) = B(0) \cdot a(1) + B(1) \cdot a(3)$$
$$X(2) = [A(0) - A(1)] \cdot a(2)$$
$$X(3) = B(0) \cdot a(3) - B(1) \cdot a(1)$$

$$A(0) = x(0) + x(3),$$
$$A(1) = x(1) + x(2),$$
$$B(0) = x(0) - x(3), \text{and}$$
$$B(1) = x(1) - x(2)$$

Figure: Computation for 4-point DCT

- Where a(2) $=1/\sqrt{2}, a(1) = cos(\pi/8)$, a(3) = cos ($3\pi/8$)

Algorithm Steps

- **Communication between Arduino to Icoboard FPGA**
- **Implementation of DCT and IDCT in Verilog-HDL**
- **Post processing in Arduino**

Implementaion Algorithm continued

- **Communication between Arduino to Icoboard FPGA**

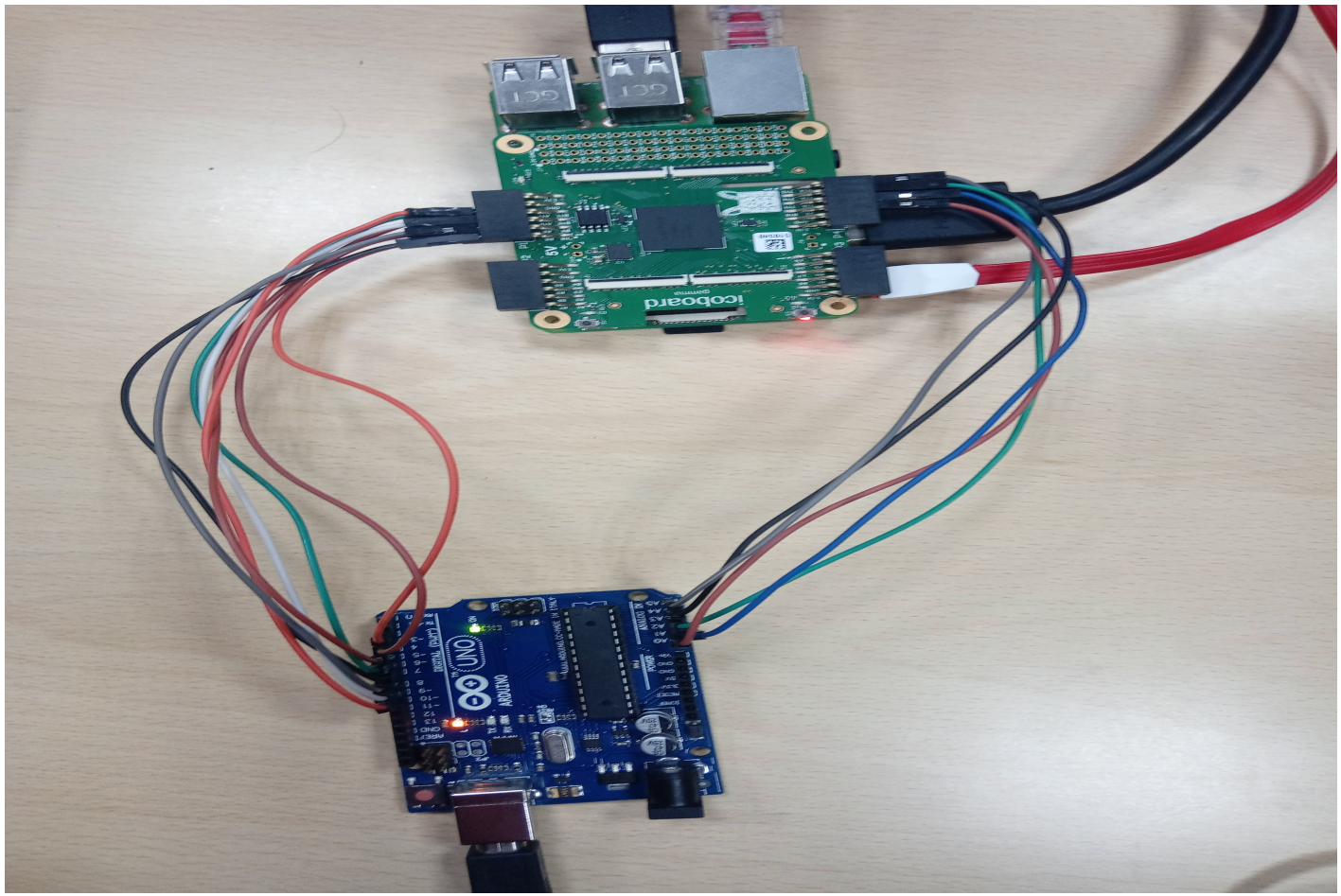

Figure: Arduino-Rasberry Pi connection

Implementaion Algorithm continued

- Used Physical Constraints File (PCF) to connect the input and output pins which are used in DCT Verilog Program
- **DCT and IDCT in Verilog**

Implementaion Algorithm continued

- **Post processing in Arduino**

System setup

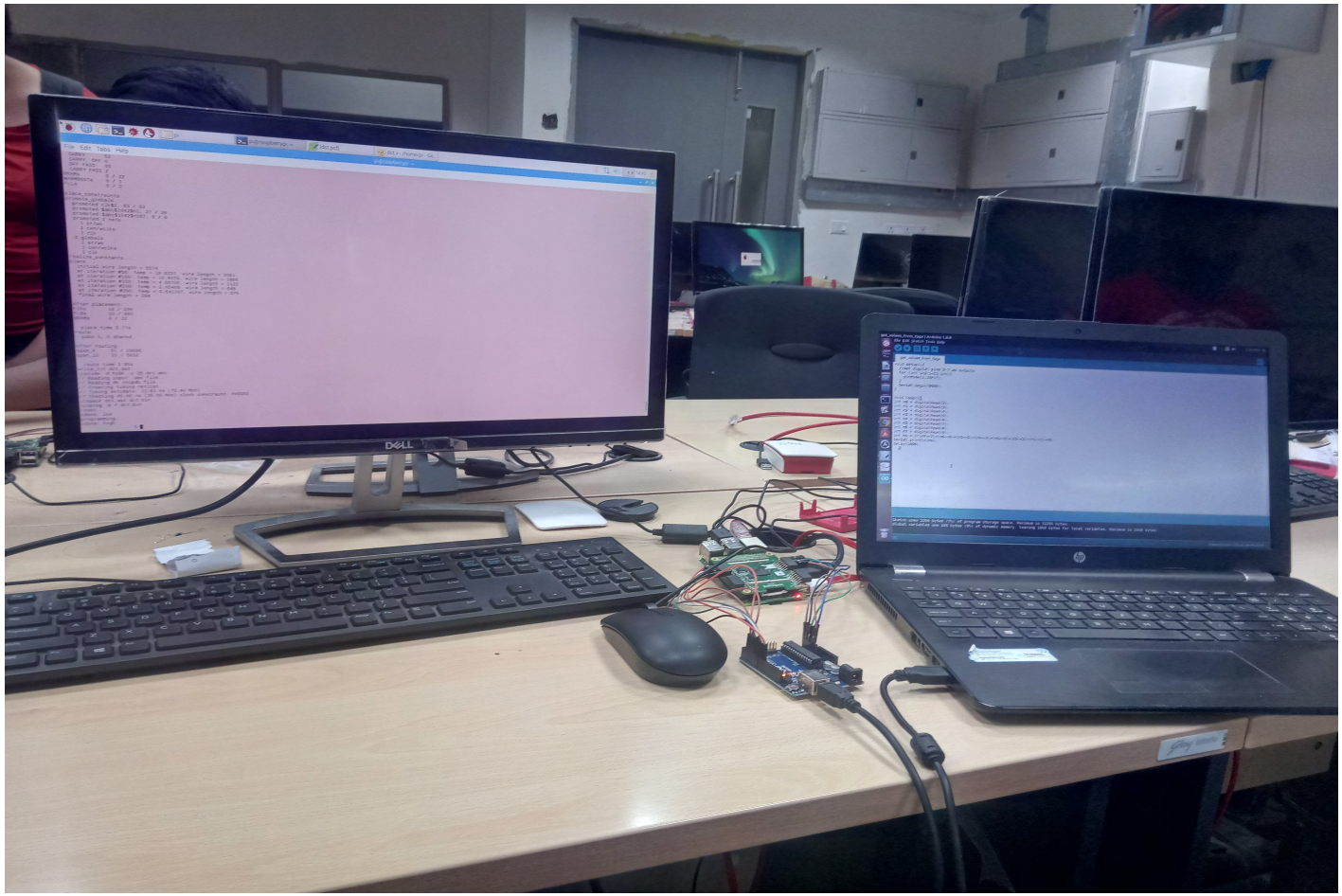

Figure: System set-up

Results