EE214
ADC Interface with FPGA

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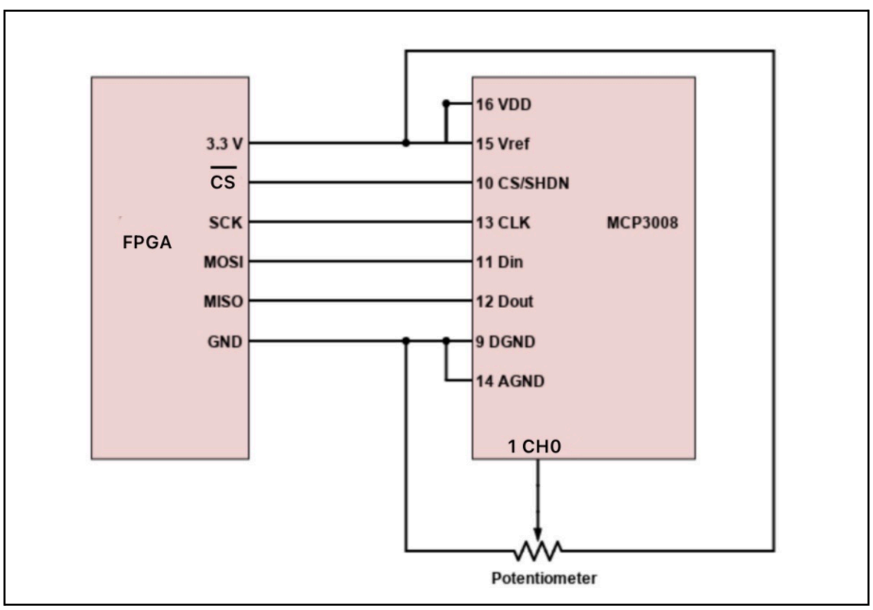
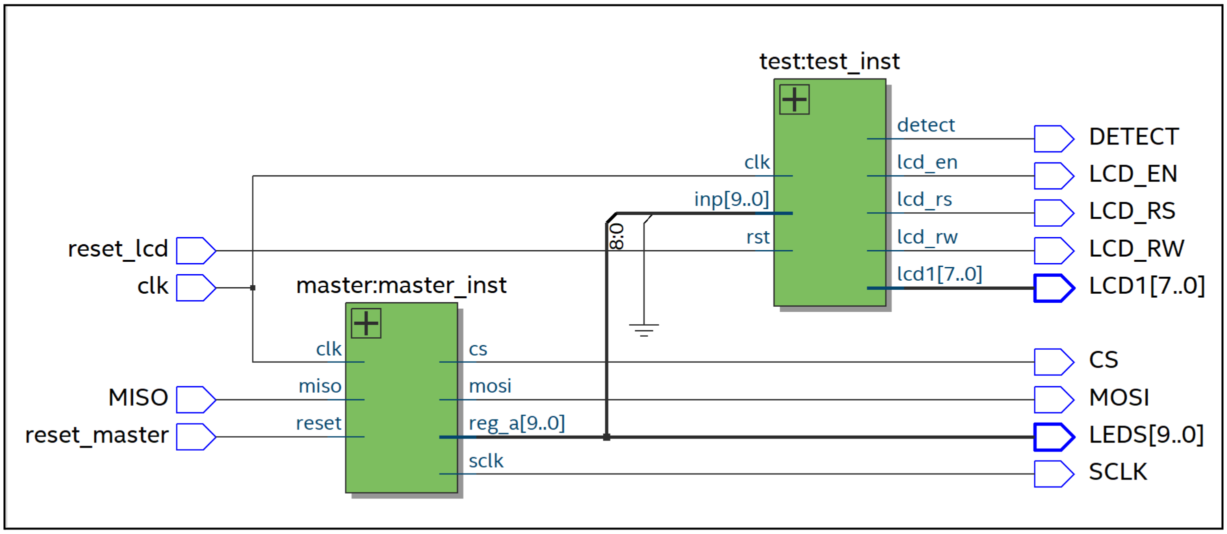
Project Overview

This project aims to utilize a master module previously implemented in VHDL to facilitate communication between these components, demonstrating the ability to send and receive data through SPI (Serial Peripheral Interface). The system architecture is designed to process an analog input voltage of 2V, convert it to a digital format using the ADC, display the digital value on LEDs and an LCD.

Block diagrams

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LCD_RW
LCD1[7..0]
reset_lcd
clk
8:0
master:master_inst
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miso
reset
cs
mosi
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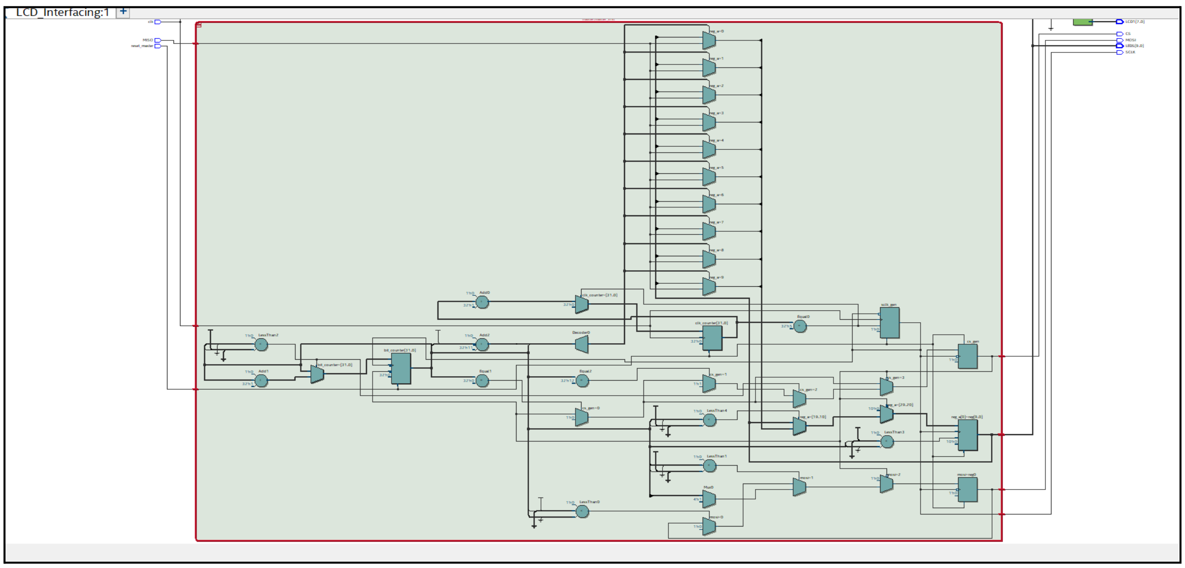
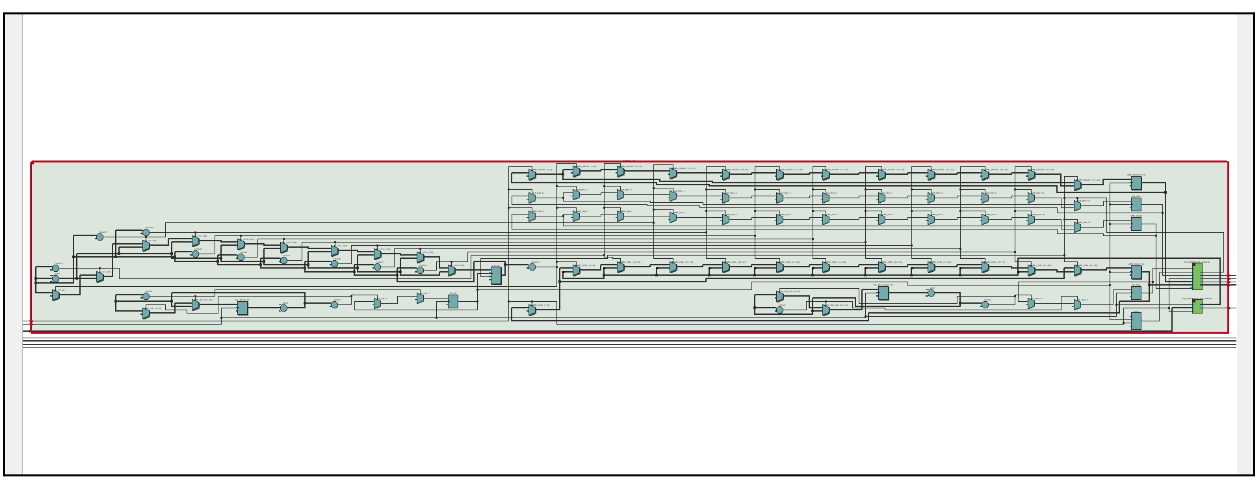
sclk
MISO
reset_master
CS
MOSI
LEDS[9..0]
SCLK


LCD_Interfacing:1



System Architecture

ADC to LCD Interface (part 2(a))

The system architecture includes the following components:

- **ADC Interface (master.vhdl):** Configures the ADC by sending the bits "11000" to the MCP3008 to activate CH0 which would then receive the analog input voltage. It reads the 10-bit digital output from the ADC and stores it in a register (reg_a).
- **LED Display Logic:** Displays the 10-bit digital value on the LEDs for initial verification of the SPI functionality.
- **LCD Controller (lcd_controller.vhdl):** Responsible for displaying the digital value stored in reg_a on the LCD. The controller is initialized and operates through a finite state machine.

Implementation Details

ADC Configuration

- The ADC is configured using specific command bits transmitted via SPI, following the MCP3008 datasheet specifications. The analog input voltage is adjusted to 2V using a potentiometer, and a multimeter is used to ensure proper voltage scaling.

SPI Data Transmission

- The SPI protocol is implemented in the master module, which communicates with the ADC. The 10-bit digital output from the ADC is stored in reg_a, which is subsequently displayed on the LEDs and the LCD upon a reset signal.

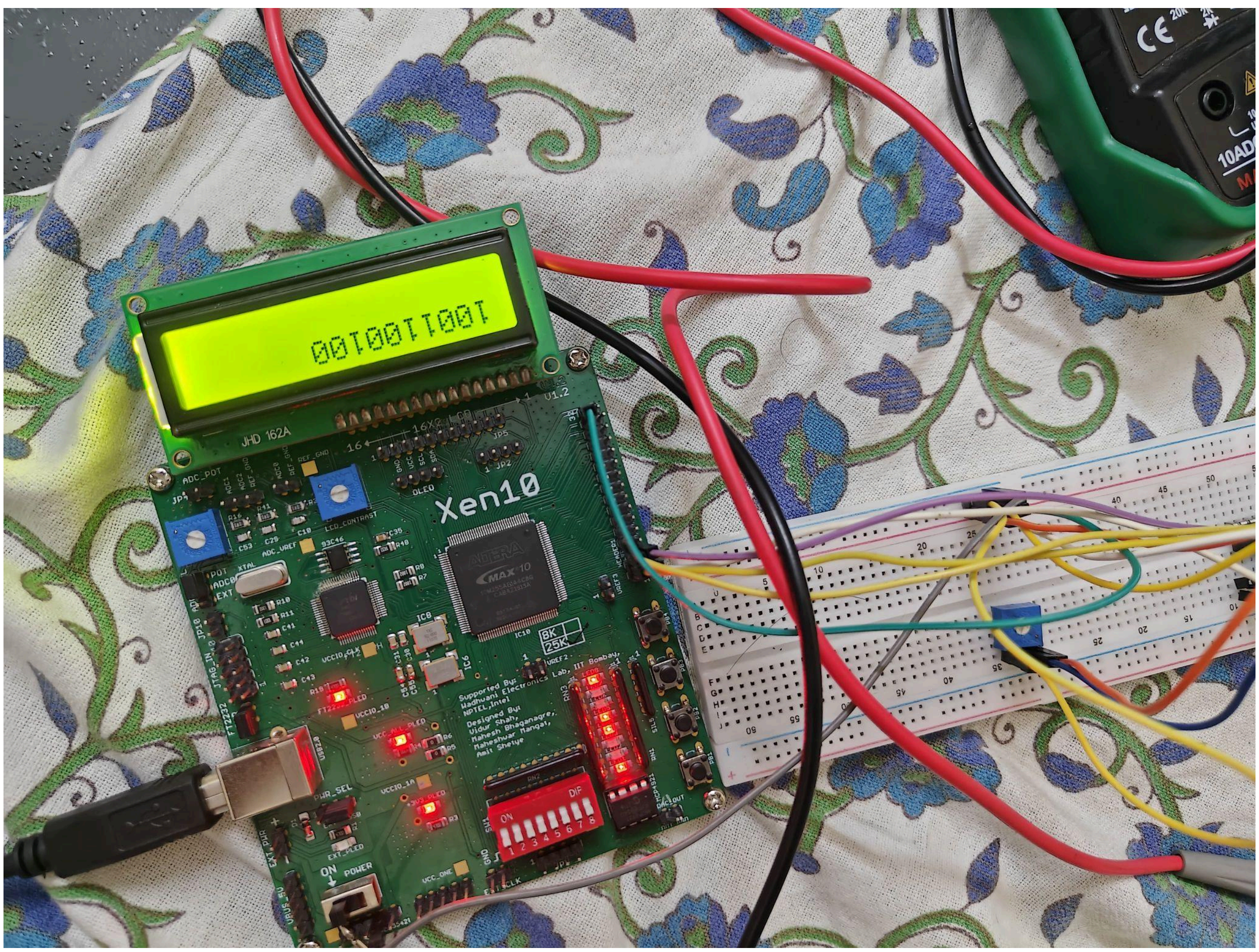
Reset Mechanism

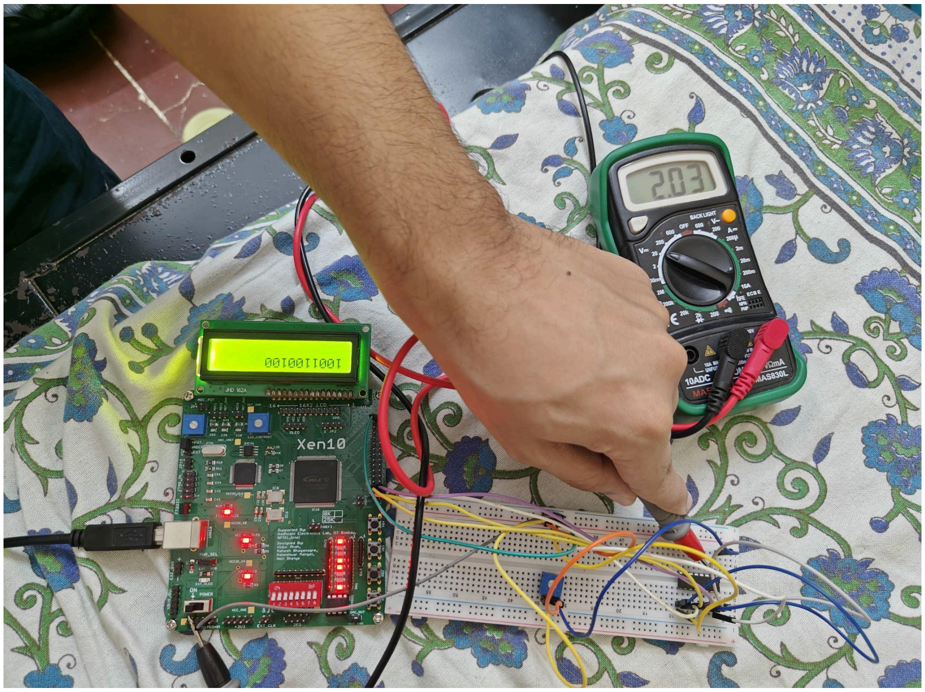
- A push button is utilized to reset the LCD, allowing for the display of the latest 10-bit value stored in reg_a. The separate reset signals for the SPI master and the LCD ensure independent operation and smooth data flow.

Simulation Results

ADC Output to LED and LCD

Simulation results show the successful transmission of the 10-bit digital data from the ADC to the FPGA. The digital value is accurately displayed on the LEDs for verification, and upon pressing the reset button, the same value is displayed on the LCD.





Observation

During testing, the multimeter displayed a voltage of 2.02V, while the LCD indicated a value of 1.97V. This discrepancy arises from the inherent limitations in the ADC resolution and the analog signal conversion process. The digital value retrieved from the ADC was 1001100100 (binary), which corresponds to a decimal value of 620. This value was then calculated using the formula:

$$Voltage\ =\ (\frac{ADC\ Value}{1023})\times Vref\ =\ (\frac{620}{1023})\times 3.3\approx 1.97V$$

The observed difference between the multimeter and LCD readings can be attributed to several factors, including:

1. **ADC Resolution**: The MCP5008 ADC has a resolution of 10 bits, meaning it can represent values from 0 to 1023. The limited resolution can introduce quantization errors, resulting in slight variations between the actual input voltage and the calculated output voltage.
2. **Reference Voltage Variation**: Any deviation in the reference voltage (3.3V) due to power supply fluctuations or measurement inaccuracies can affect the output voltage calculation.

3. **Measurement Errors**: Both the multimeter and the ADC may have inherent measurement errors, which can contribute to the discrepancies in the readings.

Work Distribution

- **Varun**: Responsible for writing the VHDL code for the SPI interface, ADC configuration, and LCD display. His work included implementing the master module and integrating the necessary components.
- **Tanisha**: Focused on preparing the final report, compiling the project details, results, and observations. Additionally, handled all the hardware connections, including setting up the breadboard for the project.
- **Testing and Simulation**: The testing and simulation of the implemented system were conducted together. We verified the functionality of the system, ensuring that the data transmission was accurate and the outputs were displayed correctly on both the LEDs and the LCD.

Conclusion

This project successfully demonstrates the integration of an FPGA with an ADC and LCD using VHDL. The design meets the task requirements by effectively transmitting digital data through SPI, displaying results on both LEDs and an LCD, and converting the digital output back to an analog signal for verification. The implementation showcases the practical applications of digital circuits in interfacing with real-world components, providing a comprehensive understanding of system synthesis in FPGA-based projects.