Using a Temperature Sensor to control a PWM Fan

Maxwell Hammond, Jonathan Nguyen,
David Pattison, Ryan Paye

ECE 4710 Winter 2023
Oakland University

Table of Contents

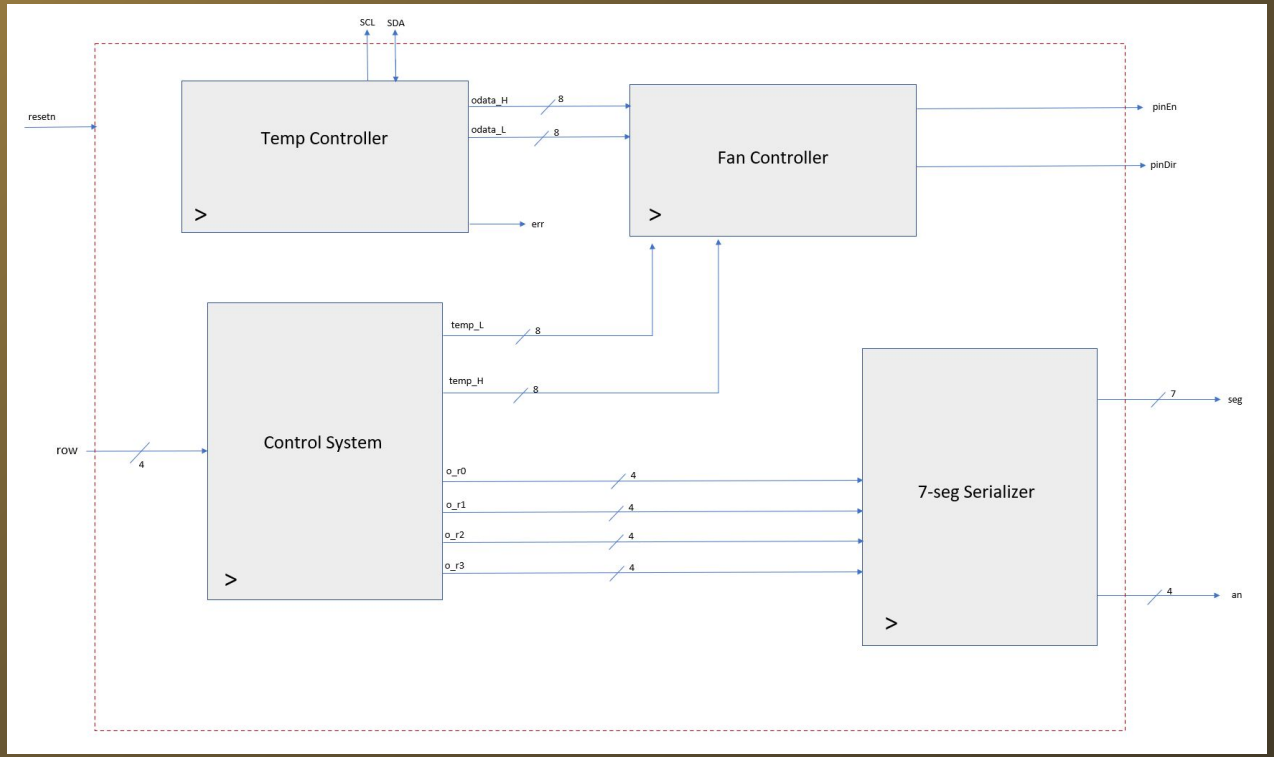
Introduction + Objectives

Project Objectives

- Goal: Using the FPGA on-board temperature sensor, take the output data and display it while using it to toggle an external motor
- Objectives:
  - Implementing 7-segment display to display current sensor data as well as programmed high/low limits
  - Implementing an external keypad in order to change limit trigger points
  - Successfully code a PWM system that can run an external motor to run a fan on/off when the sensor detects the current temperature is higher, lower, or in between set limits

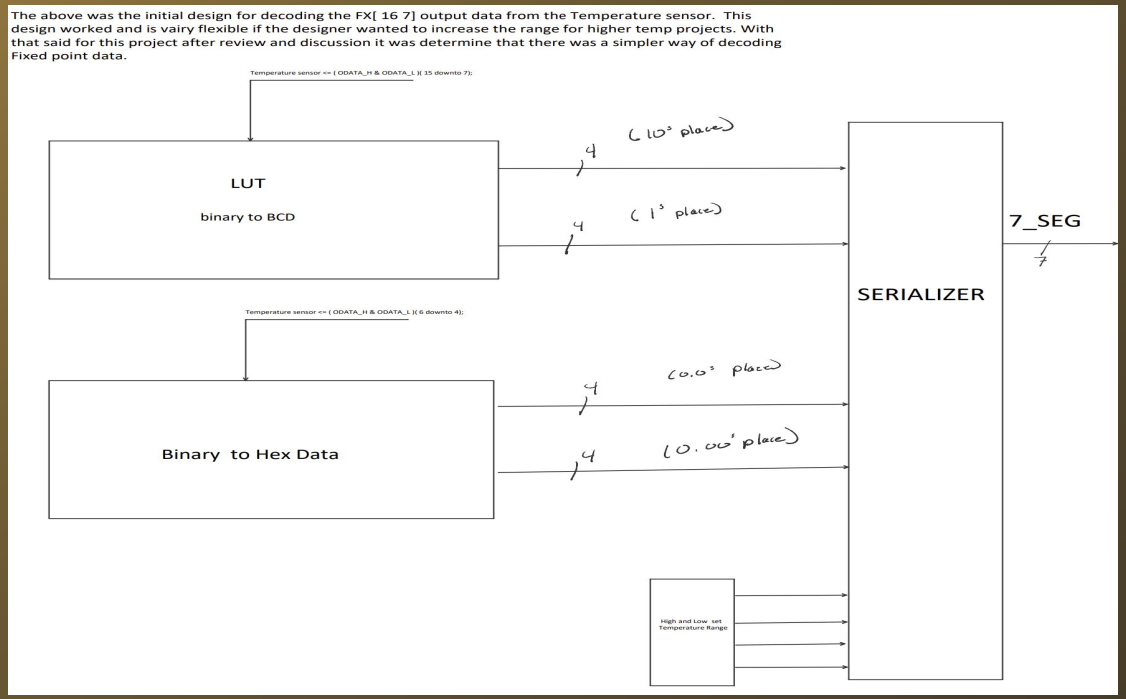
Overall Circuit Design

Final Circuit Design



Final Circuit Design

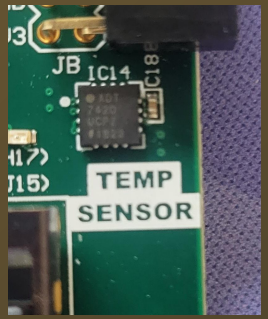
The above was the initial design for decoding the FX[16 7] output data from the Temperature sensor. This design worked and is vairy flexible if the designer wanted to increase the range for higher temp projects. With that said for this project after review and discussion it was determine that there was a simpler way of decoding Fixed point data.

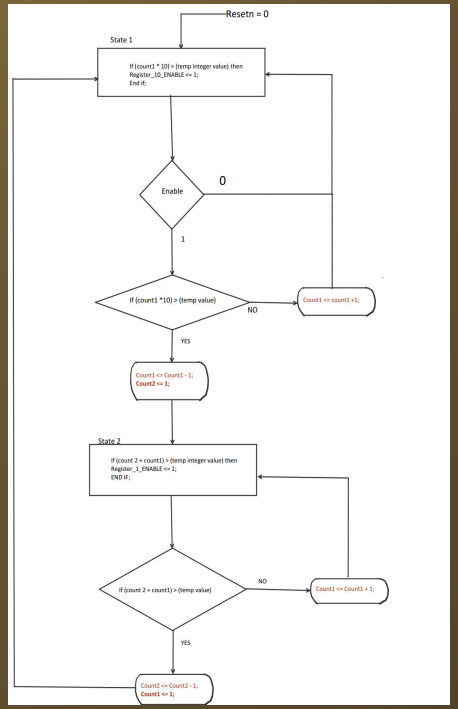


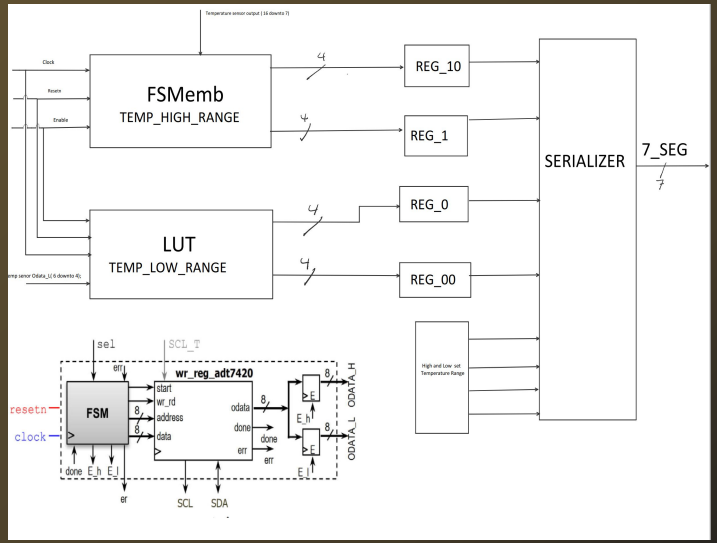
Circuit Components

Temperature Sensor

- ADT 7420 Temp. Sensor (on-board sensor of FPGA)
- Outputs data in [16 7] fixed format
- Two registers for full output data
  - Temp_H and Temp_L (8-bits per register)
- Design constraints:
  - Output data range is 00-99
  - Data is considered unsigned
- Main goal is displaying output data on 7-seg displays and driving the motor

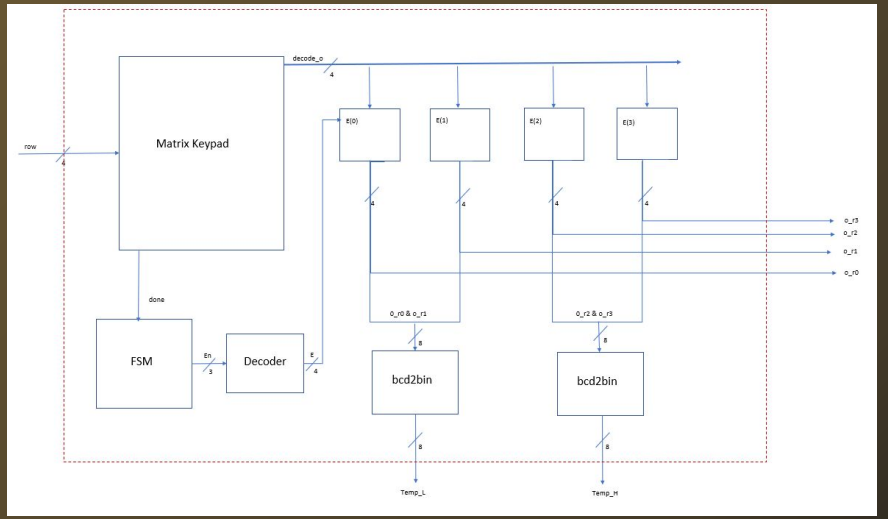




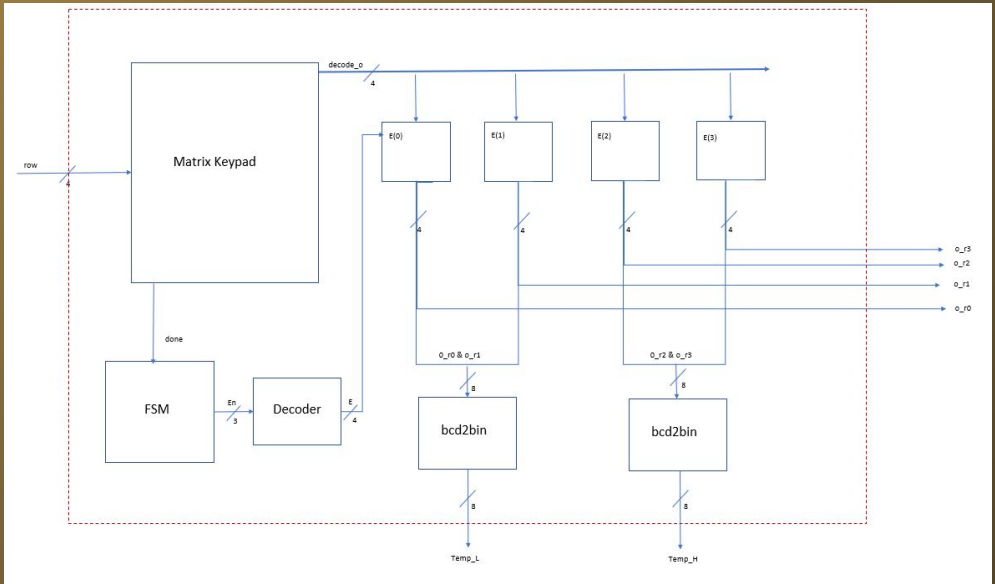


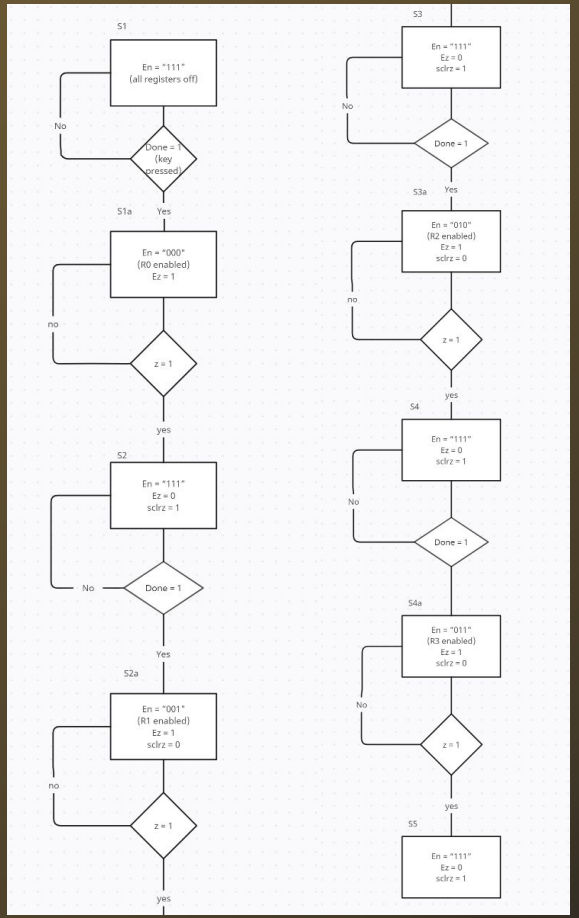
External Keypad

- Digilent PmodKYPD (external device) designed for use with FPGA
- Professor Llamocca's Matrix Keypad component
- Uses a ring counter circuit to cycle through keypad when scanning for key presses
- Keypad sends data (converted from key to BCD) to registers to be stored for reference for 7-segment display
- BCD value is also put through LUTs to convert to binary for motor control



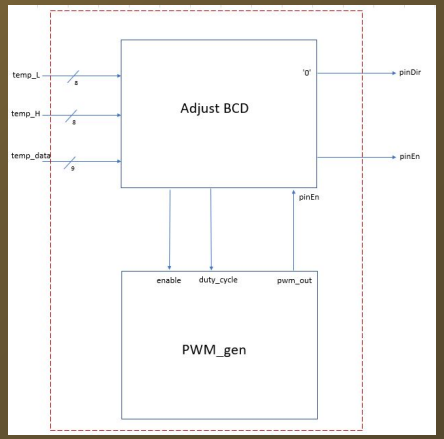
ASM Diagram for Keypad Control Circuit

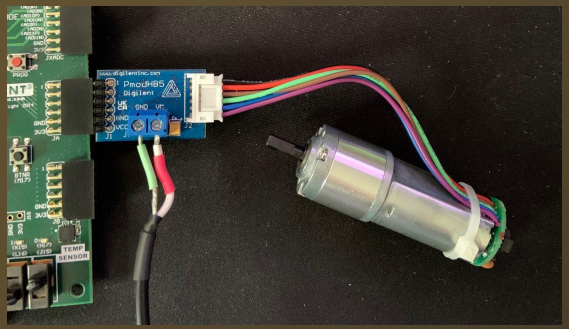


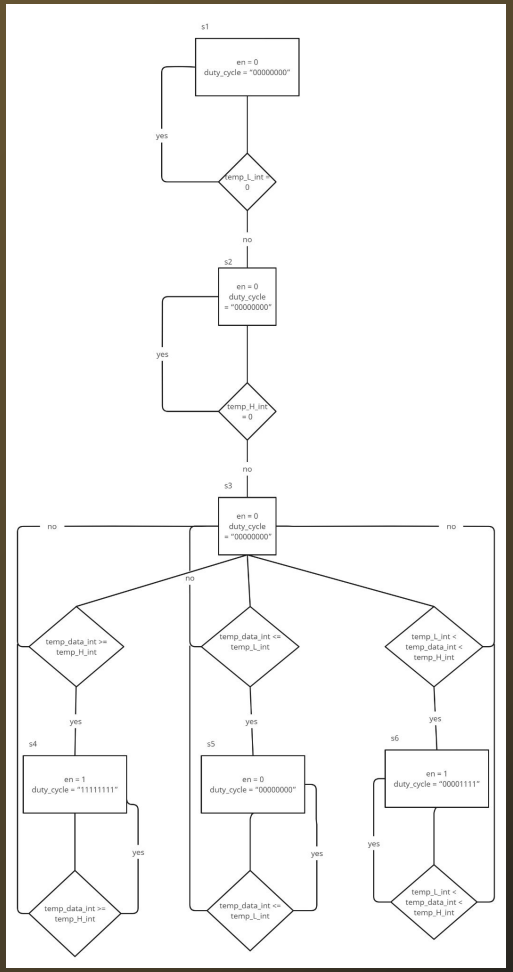


External Motor + Fan

- External motor from Digilent
- Paired with an H-bridge for ease of use
- Controlled by a pulse-width modulation (PWM) circuit
- Designed to power motor on/off when temp sensor detects current temperature is within designated limits
- Temperature is above high threshold: Duty Cycle = 100%
- Temperature is below low threshold: Duty Cycle = 0%
- Temperature is within high and low threshold: Duty Cycle ~ 50%

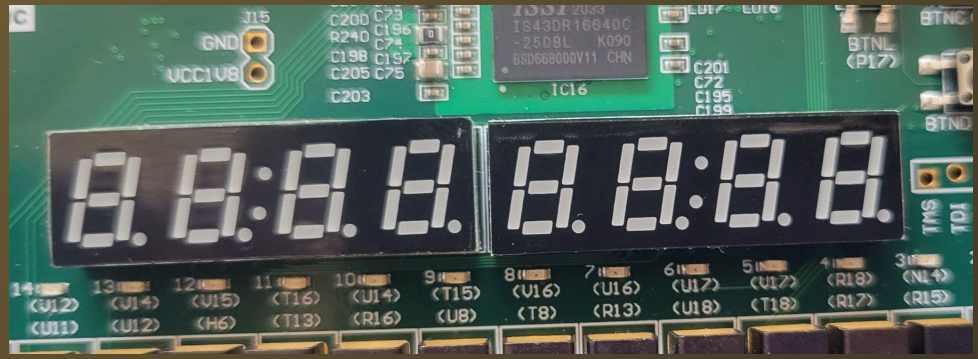






7-Segment Display

- FPGA on-board 7-segment display
- Goal was to use as many displays as possible
  - 2x for lo-limits
  - 2x for hi-limits
  - 4x for actual reading
- Left-most four displays are for temperature limits based from keypad inputs while rightmost four displays are set for actual current sensor readings
- Standard given code was used, just slightly modified to use all eight displays



Final Summary

Ending Results and Conclusions

- Successfully programmed a circuit that could read data from the sensor, display the data on the 7-segment displays, and toggle a PWM-controlled motor
  - Met majority, if not all, basic objectives
  - Motor control is working as intended with regards to hi-limit settings
  - Keypad inputs are being recorded properly

- Improvements to be considered:
  - Improving timing latency of keypad presses
  - Improve display precision
  - Fine-tune motor control system
  - Possibly using a larger capacity 7-segment display