Jeide, Matthew Date 1/14/2025 Period 2

W2B: DE Project 2.2.5 Fireplace Control

Read the introduction in each section carefully.

INTRODUCTION

A local company that installs fireplace units hired you to redesign the fireplace control circuit for their latest residential gas fireplace. The fireplace burner is equipped with four thermal sensors that output a logic 1 whenever a flame is present. These sensors are connected to the fireplace control circuit, which outputs a 1 to the emergency cutoff valve to keep the gas flowing (a 0 will turn the gas off).

The original design of the fireplace control circuit was quite simple. For the gas valve to remain on, all four sensors needed to output a logic 1. During field testing it was discovered that variations in gas pressure and

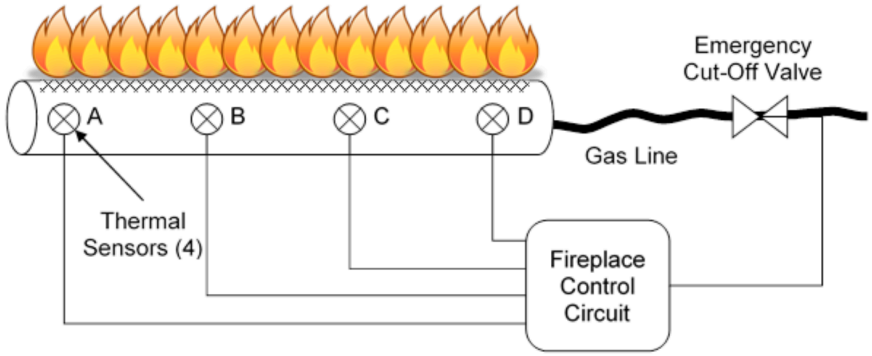

Figure 1. Fireplace Control

humidity cause the thermal sensors to occasionally output a logic 0 even when a flame is present. This caused frequent unnecessary shut downs and constant customer dissatisfaction.

For the redesign, the designers determined that the emergency cutoff value should **remain open** as long as three of the four sensors indicate that a flame is present.

Additionally, the designers have asked you to add a second output indicator to the control circuit. This indicator will output a logic 1 when the four sensors do not all agree (not all on or not all off). This indicator will be used by the service technician to diagnose whether a faulty sensor exists.

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Equipment

- Computer with Circuit Design Software (CDS)
- Breadboarding Hardware or Digital MiniSystem
- **Integrated Circuits (NAND:74LS00 and NOR: 74LS02)**
- 22-gauge solid wire
- Multipurpose Wire Stripper

Procedure

Presentation: Review Combinational Logic Design Process.

https://docs.google.com/presentation/d/13X0XTMRrSi3EB46U8bFPVcuksg4dBCLj6kvPyOU2yEM/edit?usp=sharing

Design a combinational logic circuit that meets the detailed design specifications.

Additionally:

- The circuit that controls the emergency cutoff valve must be implemented using only 74LS00 two-input **NAND gates**.
- The circuit for the possible faulty sensor indicator must be implemented using only 74LS02 two-input **NOR gates**.
- The **Karnaugh mapping** technique must be used to obtain the simplified logic expression for both outputs.

K-Mapping Design Sketch

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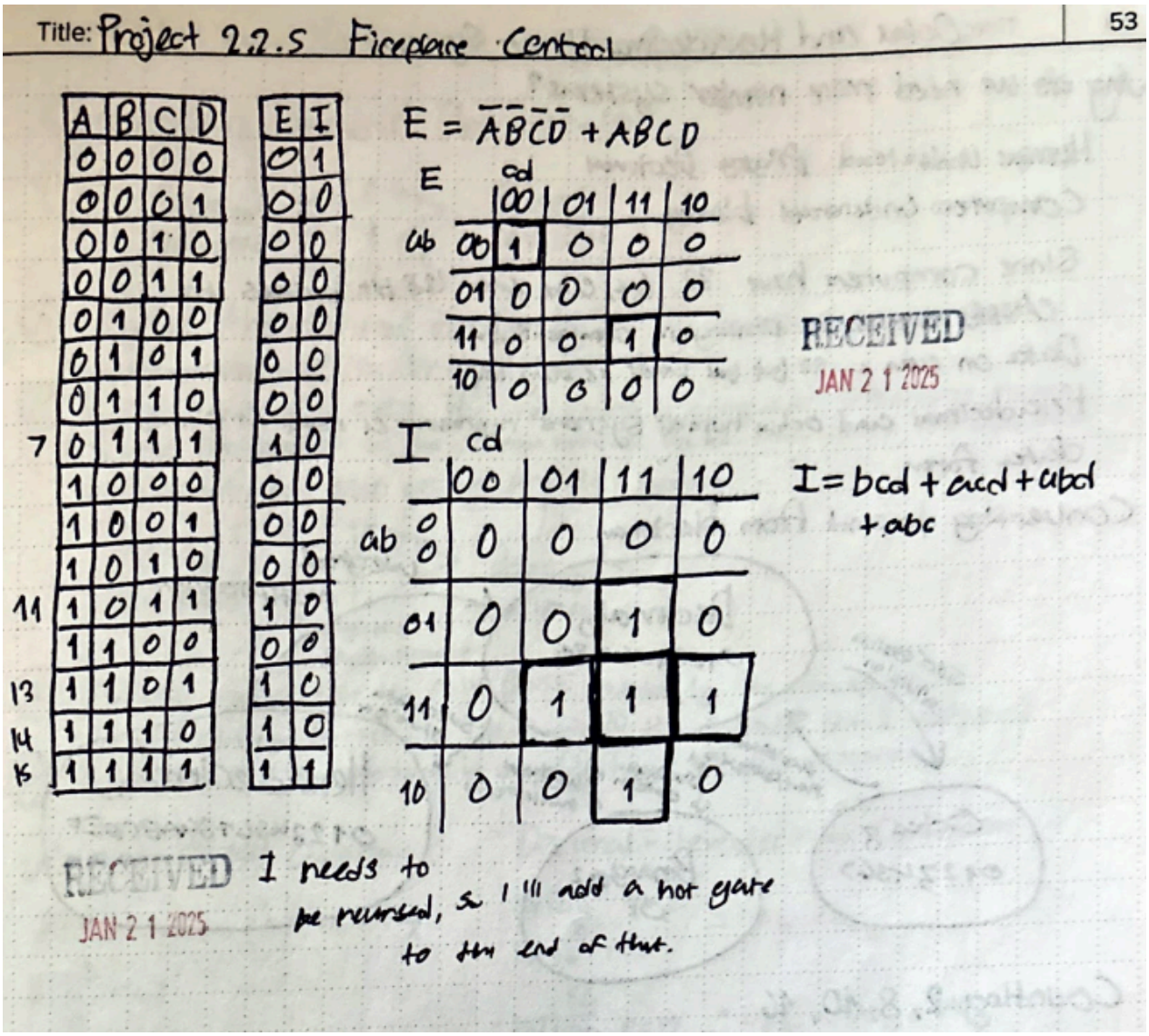

Multisim Design for the Fireplace Problem-EMERGENCY CUT OFF VALVE

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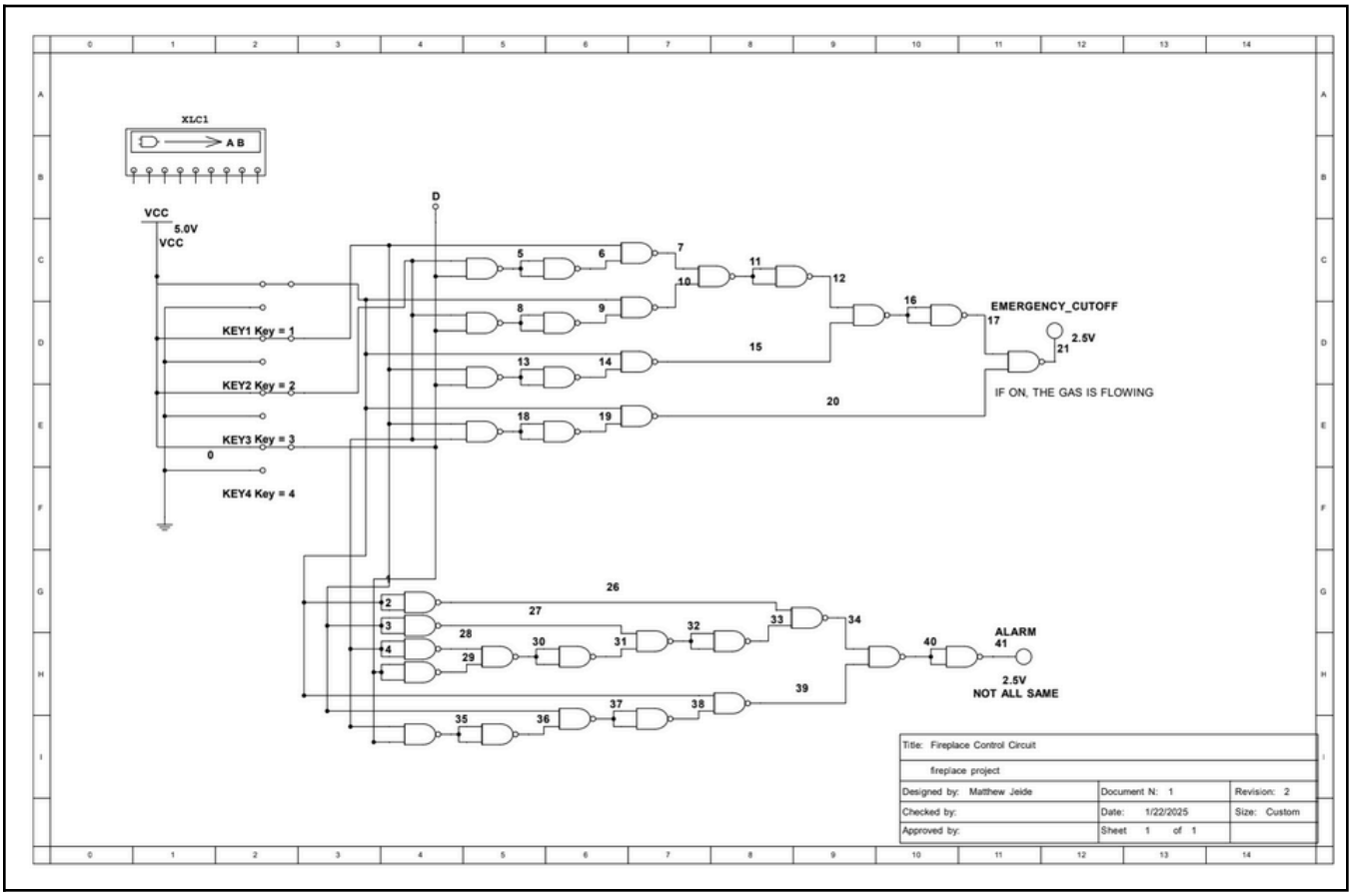

Multisim Design for the Fireplace Problem-FAULTY SENSOR INDICATOR

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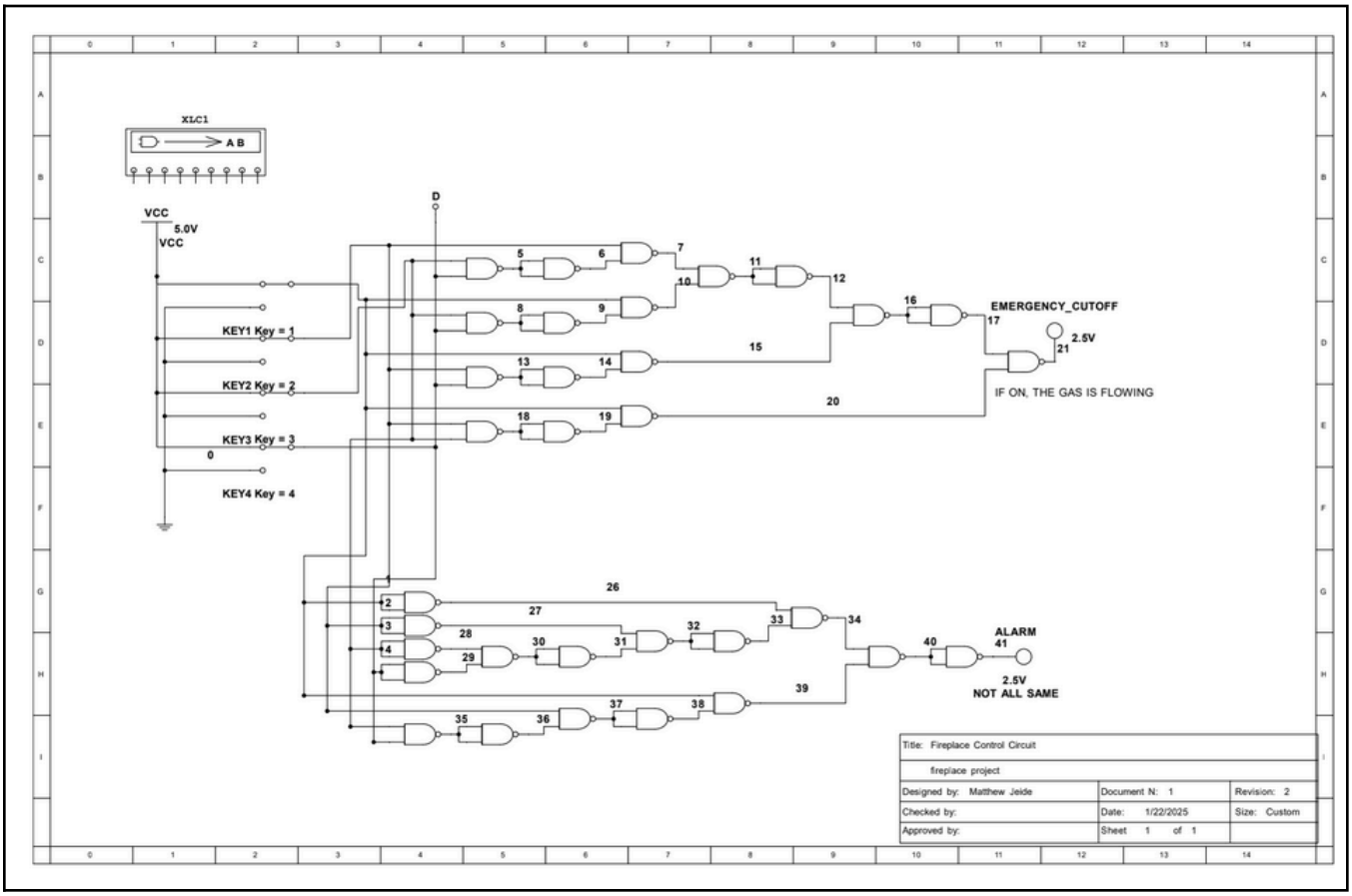

Simulate

Using the Circuit Design Software (CDS), enter and test your *Fireplace Control Circuit* design. Use switches for the inputs ***A, B, C,*** and ***D*** and a probe or LED circuit for the two outputs. Verify that the circuit is working as designed. If it is not, review your design work and circuit implementation to identify your mistake. Make any necessary corrections and retest. Be sure to document all changes in your engineering notebook.

Multisim **Simulation Video** for the Fireplace Problem
Fireplace Control Circuit Multisim Video.mp4

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Prototype

Using a Digital Logic Board (DLB) or Digital MiniSystem (DMS), build and test your *Fireplace Control Circuit* design. Verify that the circuit is working as designed. If it is not, ***you should not change your design***. You know that your design functions because you simulated it. If your circuit isn't working correctly, you must have built something incorrectly. Review your circuit implementation to identify your mistakes, make the necessary corrections, and retest. Be sure to document all changes in your engineering notebook.

E-Portfolio published link with Video of the Fireplace Breadboard Design
https://sites.google.com/riversideunified.org/matthewjeide/projects/de-2024-2025/fireplace-control-circuit

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Conclusion

Writing prompt requirement 250 words.

I approached this project systematically to ensure a robust solution. The initial step involved analyzing the problem and defining the requirements/design criteria. For the emergency cutoff valve, it was determined that the gas should remain on if at least 3 of the 4 sensors detect a flame. Using the Karnaugh Mapping (k-map) technique, I simplified the logic expression for this requirement. Similarly, for the faulty sensor indicator circuit, I identified that the output should be 1 when the sensors do not all agree (not all on or all off), then derived its logic expression through another k-map. With simplified expressions in hand, we created preliminary schematics using the specified components (two-input NAND gates (74LS00) and two-input NOR gates (74LS02) for the faulty sensor indicator. These were implemented in Multisim to simulate the design. Inputs A, B, C, and D were represented with switches, and outputs were tested using LEDs/probes. Simulation results confirmed the circuit's accuracy. Next, the design was prototyped on a breadboard using a MyDAQ with 22-gauge solid wires and the required integrated circuits. Despite correct simulation results, initial errors in physical wiring caused malfunction, but troubleshooting ensured the final circuit worked as expected. Final documentation included truth tables, K-maps, schematics, and digital photographs/videos of the breadboard setup. This process demonstrated the value of iterative design and testing, ensuring a functional, reproducible solution and a very padded out conclusion paragraph.