VIETNAM NATIONAL UNIVERSITY HO CHI MINH CITY
HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY
FACULTY OF APPLIED SCIENCE

Electrical Electronic Circuits (CO2037)

Assignment Report

Computer Hardware Design

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Class: CC02

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Contents

1 Requirement engineering:

1.1 General description:

The fire alarm system is designed to detect smoke and fire early to minimize potential damages and risks

Key features:

- Detect smoke or heat that may indicate the presence of fire
- Trigger audible (buzzer) and visual (LED) alarms to warn residents.

Purpose:

- Ensures early warning to evacuate people safely.
- Help minimize fire damage by early detection and response.

Applications:

- In residential building.
- In commercial properties (e.g, offices, malls).
- In industrial facilities.
- In public spaces.

1.2 Specification:

In some fire detectors, there is only smoke detection, so when someone smokes, it will activate the system and make it run incorrectly. But, in this fire detector system, it is equipped with a temperature sensor, which helps the system determine the presence of a flame exactly.

Additionally, the system also supplies power to other devices, such as automatic sprinkler, alarm or light ..., allowing these devices to operate in coordination with the system.

2 Conceptual design:

2.1 Conceptual functionality:

- Detection phase: the system uses the change in intensity of infrared light and thermistor to detect fire and smoke.
- Processing phase: the IC LM358 processes sensor signals and triggers alarms when thresholds are exceeded.
- Notification phase: the system activates a buzzer, three LEDs to signal fire detection in the area.
- Power source: Operates on a stable power supply of 5V.

2.2 Principle of operation:

The smoke detection system operates based on IR-T and IR-R signal transmission and reception. When smoke passes through the space between the infrared emitter and receiver, it reduces the infrared intensity. This change in intensity will trigger a fire alarm signal. Additionally, high temperatures during a fire will activate a thermal resistor, which also triggers an alarm. The combination of smoke and temperature detection ensures that fires without smoke can also be detected and controlled.

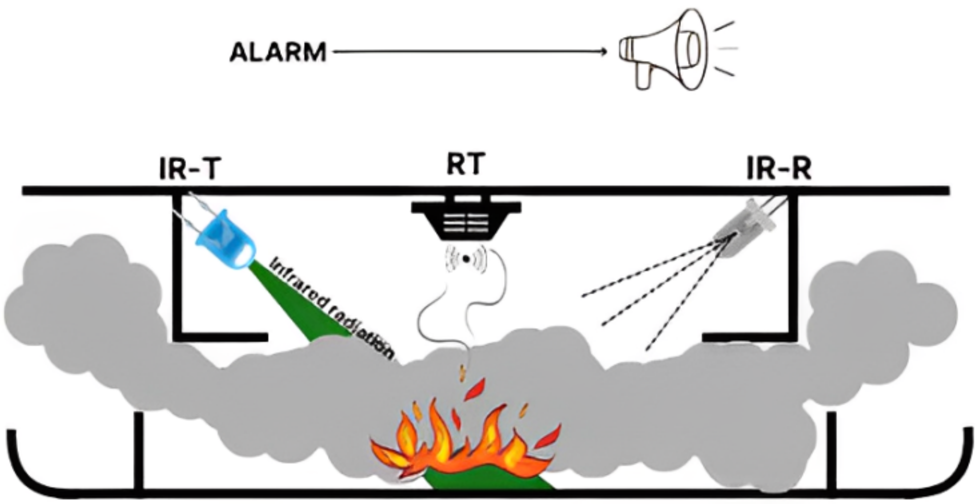


Figure 1: The main idea of a fire detector system

2.3 List of components:

Component type	Label	Valuation
Resistors	R4, R3, R8, R13, R11	$36.5\Omega, 37\Omega, 3k\Omega, 187.5, 6.5\Omega$
	R2, R9, R12, R10, R15, R5	$35.4\Omega, 3k\Omega, 187.5\Omega, 6.5\Omega$
	R15, R5	$20\Omega, 50k\Omega$
	RV1, RV2, RT1	$10\text{k}\Omega, 10k\Omega, 10k\Omega$
Capacitors	C1, C3, C6	100µF
	C2	100nF
	C4, C5, C7	10µF
Diodes (1N4007)	D1, D2, D3	Forward voltage: $>$1.1V Peak reverse voltage: 1000V
Transistors NPN	Q1, Q3	Output current (I_C): 20mA Output current (I_B): 2mA Output voltage ($V_{CE(sat)}$): 0.5V
Transistors PNP	Q2	Output current (I_C): 1A Output current (I_B): 100mA Output current (V_{BE}): 1.25V
IC OP-AMP (LM358)	U1B, U1A	Input voltage: 5V Output voltage: 1.5V Output current: 10mA
Speaker	Buzzer	Input voltage: 1.5V Square wave: 10cm
Fixed voltage regulator (7805)	U2	Input voltage: 12V - 2A Input current: 2A Output voltage: 5V Output current: 5mA - 1A
DC input connector	CON1	Supply: 12V

2.4 Block diagram:

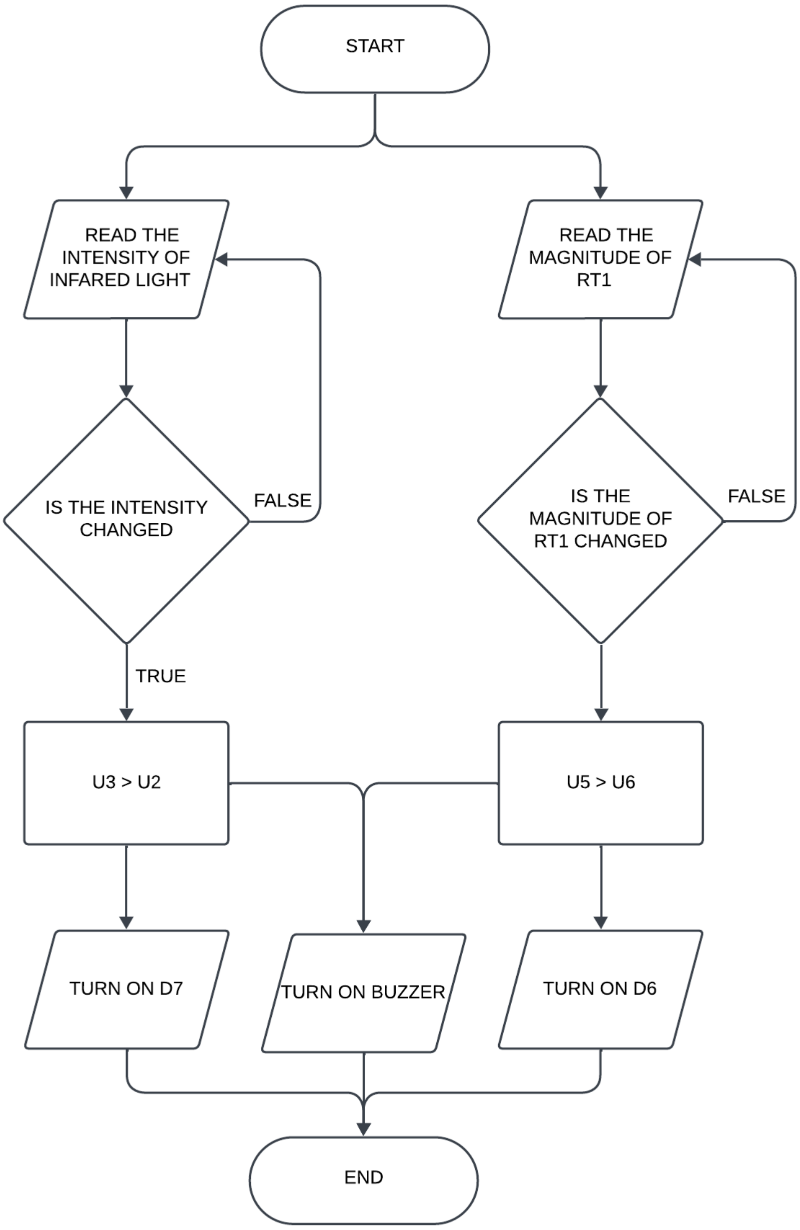


Figure 2: How the system can detect smoke & fire

3 Schemetic design and validation:

3.1 Schematic diagram

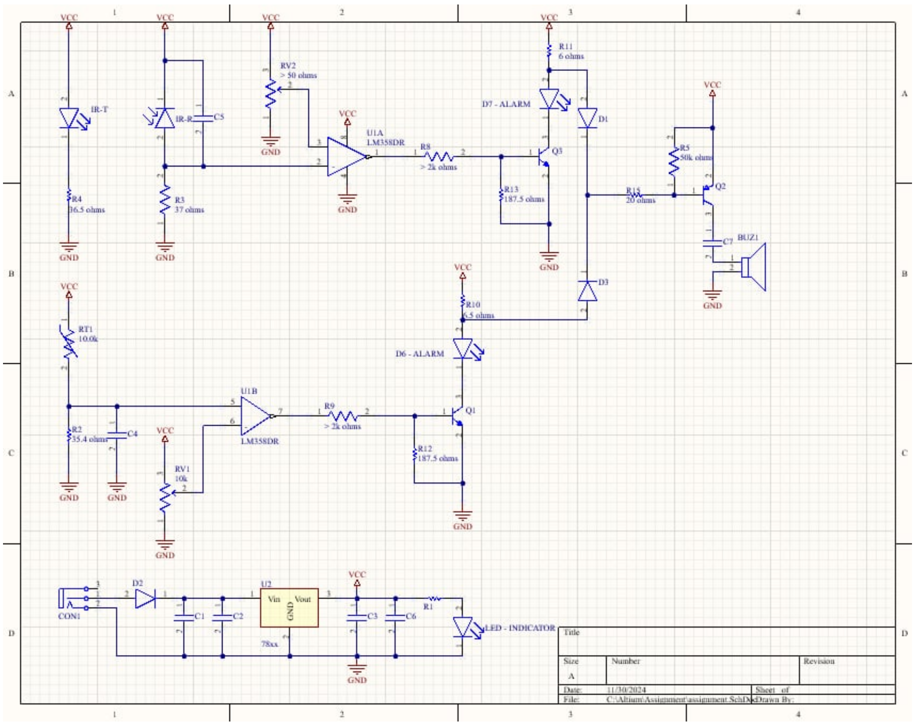


Figure 3: Schematic design of the system

3.2 Calculation:

3.2.1 Source part:

$$CON1 \xrightarrow{supply} V = 12V, I = 2A \xrightarrow{IC\ 7805} V = 5V, I = 5mA \to 1A$$

3.2.2 Detection smoke part:

$$I_{source} = 100mA \xrightarrow{supply} V_{IR-R} = 1.3V \to R_{R3} = \frac{5-1.3}{100} = 37\Omega$$

* Select the magnitude of RV2, therefore, we assume that is smoke.

$$V_{source} = 5V \xrightarrow{IR-R} V_2 = 5 - 1.3 = 3.7V \to LM358$$

* So we choose $R_{RV2} > 50\Omega \to V_3 > 3.54V$ because $V_3 > V_2$ when there is smoking and $V_3 < V_2$ it's no smoking.

$$\to V_{R8} = 1.5V, I_{R8} = 10mA$$

*Transistor Q3:
If there is smoke, we need the transistor in saturation mode

$$\to I_C = 20mA, I_B = 2mA \to V_{CE} = 0.5V$$

$$I_{R13} = 10 - 2 = 8mA$$

$$R_{R13} = \frac{1.5}{8} = 187.5\Omega$$

* We have: $V_{CE} = V_{CC} - I_C \cdot R_{R11} - V_{LED} = 0.5 = 5 - 350 \cdot R_{R11} - 2.2 \to R_{R11} = 6.5\Omega$

$\rightarrow I_E = 20 + 2 = 22mA$
$So, I_{down} = 350 - 20 = 330mA$

3.2.3 Speaker part:

* Transistor Q2: because the current of I_{R5} very small.So we don't need to consider $\Rightarrow I_B = 100mA$
If there is smoke, we need the transistor in saturation mode
$\rightarrow I_C = 1A, I_B = 100mA \rightarrow V_{BE} = 1.25V, V_{CE} = 500mV$
Thus $V_B > V_{BE} \Leftrightarrow I_B \cdot R_{R15} > V_{BE} \Leftrightarrow 100 \cdot R_{R15} > 1.25 \Leftrightarrow R_{R15} > 12.5\Omega$
$\rightarrow$ So we choose $R_{R15} = 20\Omega$
When we don't have signal $I_B = 100nA \Rightarrow 100nA = \frac{5}{R_{R5}} \Rightarrow R_{R5} = 50k\Omega$

We have: $V_{BE} = V_B - V_E \Leftrightarrow 1.25 = (\frac{100}{1000} \cdot 20) - V_E \Leftrightarrow V_E = 0.75$

Then: $V_{CE} = V_C - V_E \Leftrightarrow \frac{500}{1000} = V_C - 0.75 \Leftrightarrow V_C = 1.25V$
Therefore, the buzzer can be turned on.

3.2.4 Detection fire part:

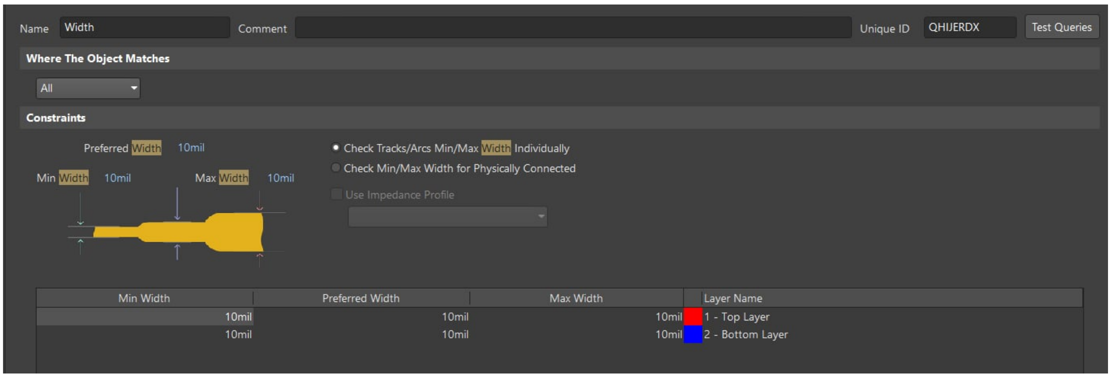
We set R_{RV1} equal $R_{RV2} > 50\Omega$, $I_{RV2} = I_{RT1} = 100mA$. Normally, $t = 25°C \rightarrow R_{RT1} = 10k\Omega$, when it's hotter then R descreases $\rightarrow U$ decreases. So $U_{after\ RT1}$ increases, then V_5 is bigger than V_6.

Formula: $R_T = R_{25°C} \times e^{K \cdot (\frac{1}{T_T} - \frac{1}{T_{25°C}})}(1)$
Assume $R_{RV1} = 50\Omega\ (min) \rightarrow V_{RV1} = 3.54V$
So, $V_{RT1} \geq 5 - 3.54 = 1.46V \rightarrow V_{RT1} = 1.46V$
Beside that, $5 - V_{RT1} = 1.46 \Leftrightarrow 5 - 100 \cdot R_{RT1} = 1.46 \Rightarrow R_{RT1} = 35.4\Omega$

(1)$\Rightarrow 35.4 = 10 \times e^{3380 \cdot (\frac{1}{x} - \frac{1}{297})} \Rightarrow x = 587.17K \Rightarrow t = 316°C$
$\rightarrow R_{R2} = \frac{5=1.46}{100} = 35.4\Omega$
R_{R9}, R_{R10}, R_{R12} are the same component of detection smoke part.

4 PCB design:

4.1 Design rule:



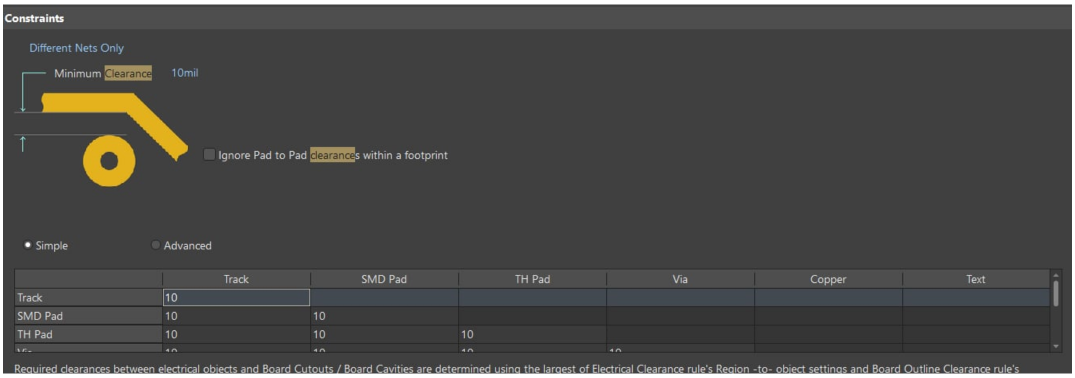


Figure 4: Design rule of the circuit

* With the simple circuit, we just use 10mil width for all because of some reasons following:

- Electrical isolation: provides sufficient space to prevent short circuits or electrical interference between traces and pads.
- Prevent arcing: reduces the risk of electrical arcing by maintaining adequate space between high-voltage components.
- Thermal management: allows heat to dissipate effectively, preventing overheating and ensuring thermal stability.
- Solder bridge prevention: minimizes the risk of solder bridges during assembly by maintaining proper between pads.
- Signal integrity: helps maintain clean signal transmission by preventing noise.
- Reliability: Enhances overall circuit reliability by reducing thee chances of short circuits, noise, or thermal issues.

4.2 Design PCB:

4.2.1 Model of PCB:

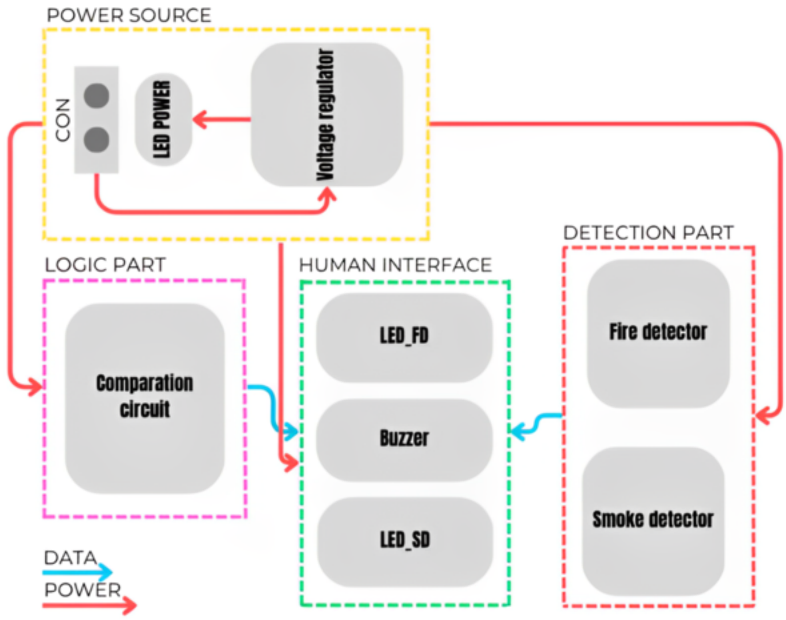


Figure 5: Model of the PCB

- I decided to place the ”Fire detector” before the ”Smoke detector” to prevent a fire from damaging other components before the ”Fire detector” detects it. Besides that, a buzzer and two alarm lights were placed together in one section for easier management, and an LED in source power was used to indicate that power had been supplied. Additionally, I had many capacities to reduce noise in the circuit.

4.2.2 Initialize in Altium

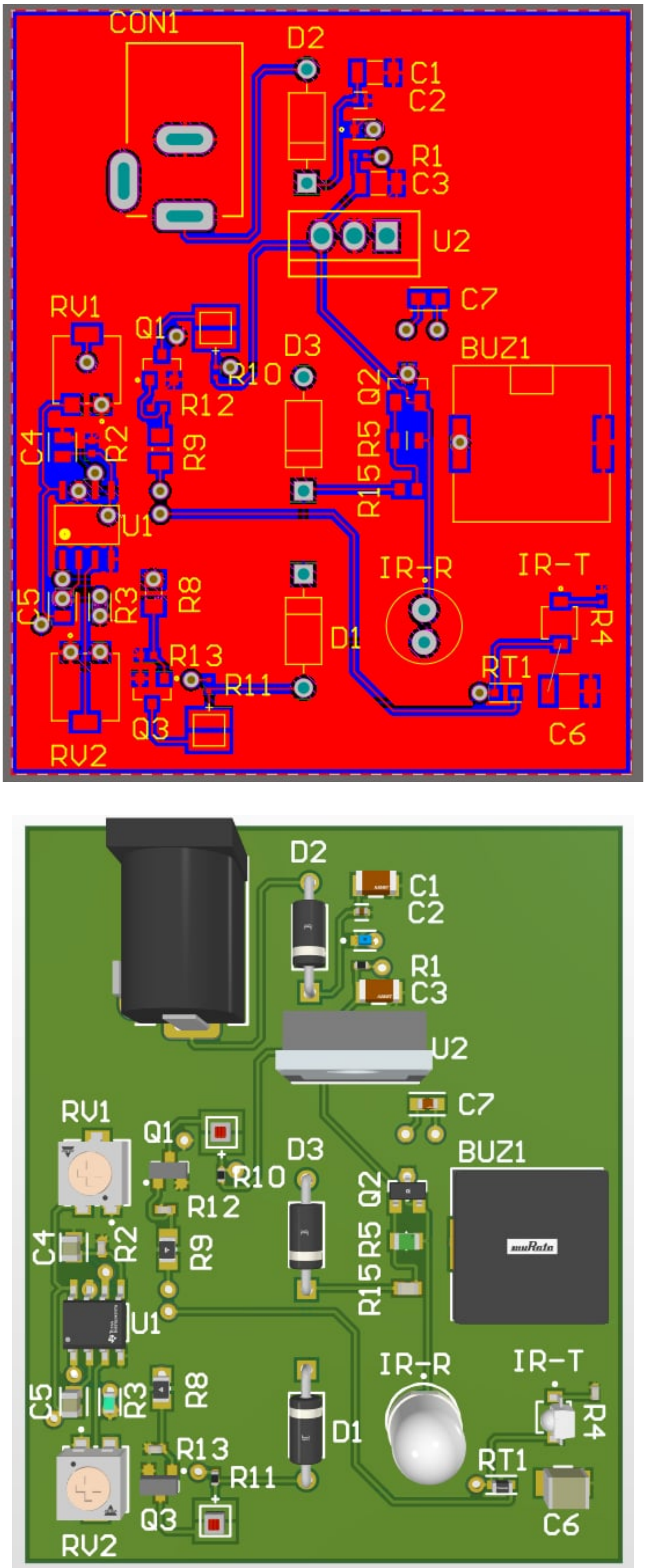


Figure 6: PCB design of the circuit