CONSTRUCTING FIRE ALARM SYSTEM BY USING ALTERA DE2-115 FPGA

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ABSTRACT: The project is carried out to design a circuit to detect the presence of fire by monitoring the atmospheric changes. The goal of this project is to notify occupants to evacuate in the event of fire. In the experiments, the responses of the two detectors, act as control panels of this system, were measured when exposed to high temperature and light. The circuit produced in the project used the principled of analog circuit and digital circuit, which is mod 6 synchronous up counter, while the hardware implementation in this project are the integrated circuit, Field-Programmable Gate Array (FPGA), LM35 as temperature sensor, and Light Dependent Resistor (LDR) as light sensor. The result from this project is useful to be implemented at home and industrial as it act as catalyst in saving lives and injuries, furthermore to avoid losses and death.

KEYWORDS: *fire, temperature, light, sensor, analog, digital*

1.0 INTRODUCTION

A fire alarm system is a device that notify people about the event of fire occurred. It may issue a signal to a fire alarm control panel as part of fire alarm system, especially in commercial security devices or may issue a local audible or visual alarm in the household (Jinghong et al. (2012)). It is mostly designed to fulfill the protection of life, and protection of properties and assets. In the last two decades, the life- safety aspect of fire protection has become one of the major factors in safety.

In general, fire alarm system is classified as automatic, manually activated, or both. Automatic fire alarm system is able to notify people to evacuate in the event of fire or other emergency, to summon emergency services, and to prepare the structure, and associated systems to control the spread of fire.his document contains the guidelines extended abstract preparation.

2.0 MATERIAL AND COMPONENT

A. Altera DE2-115 FPGA Board (FPGA Cyclone II EP4CE115F29C7)

The system uses DE2 development FPGA board of Altera as the hardware platform. A field-programmable gate array (FPGA) is an integrated circuit (IC) that can be programmed in the field after manufacture. The temperature and light sensored by the sensor components will transmit inputs to this integrated circuit and light up the LED embedded in the board to indicate that it receives input.

B. Light Dependent Resistor (LDR)

Light Dependent Resistor is a resistor which has a resistance that varies depending of the light intensity. A component that used in circuits where it is necessary to detect the presence or the level of light.

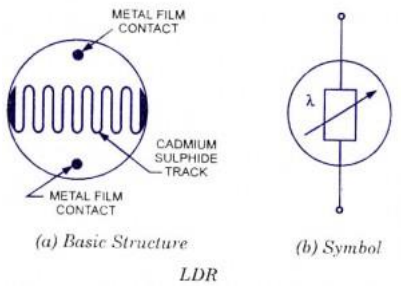

Fig. 1. Light Dependent Resistor (LDR)

C. LM35

The LM35 is one kind of commonly used temperature sensor that can be used to measure temperature with an electrical output comparative to the temperature (in °C). The LM35 has an output voltage that is proportional to the Celsius temperature. The scale factor is 01V/°C. The operating voltage range of this LM35 ranges from -55° to +150°C and it has low-self heating.

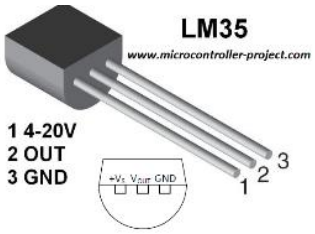

Fig. 2. LM35

3.0 PROJECT DESCRIPTION

The fire alarm system is mainly using the sensors as inputs, block diagram in Altera DE2 board as the digital circuitry and also buzzer as output. The procedure and procees to develop the prototype was followed instruction given in Arefin A. (2012).

In this project, the DC source connected to 5V and ground from Altera DE2 board to the circuit. The temperature sensor (LM35) and light sensor (LDR) are connected in a breadboard. Both sensor are connected to Altera DE2 board by using GPIO. According to Jaeger (1997) and Carter (2003), when the circuit received the signal from input sensor, it will produce an output. The output is connected to the buzzer in a breadboard by using GPIO from Altera DE2 board. The LEDs, switch A and switch B mentioned in the project are also provided in the Altera DE2 board.

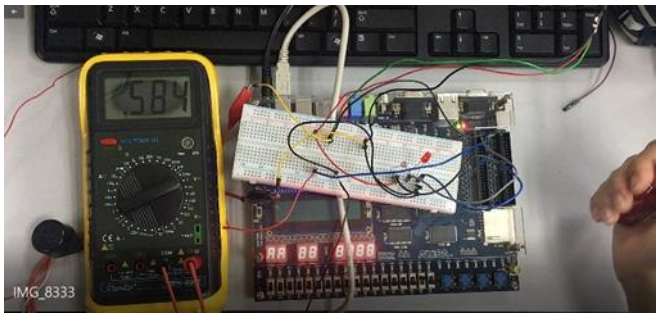

Fig. 3. Circuit connected by using breadboard and Altera DE2 Board

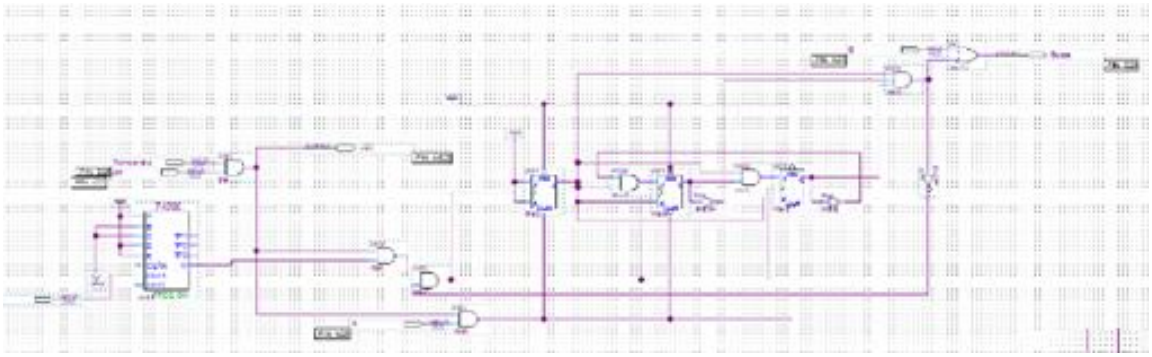

Fig. 4. Circuit for Fire Alarm System

A. Input Control Gate

In order to make the fire alarm system work, the temperature sensor and light sensor must detect the input, which is when there is fire occur, the temperature in surrounding will increase and the light intensity in surrounding will also increase (Razavi (2000)). Therefore, when the AND gate (Input Control) detect the input from both sensor, it will immediately light up the LED in Altera DE2 board and the output is as input for other gate like Clock Control and Clear Control.

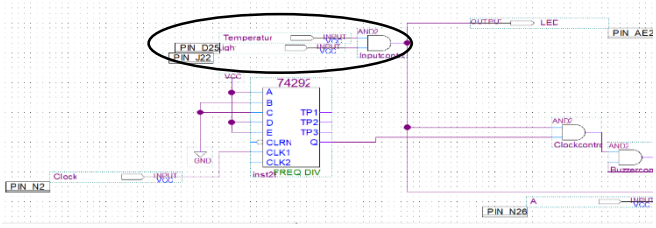

Fig. 5. Input Control Gate

B. Clock Control Gate

Once the output from Input Control gate is detected, one of the input for Clock Control gate will be HIGH and the other input is depended on the Clock. The frequency divider had divide the input clock as 0.671s per bit. Therefore, the Clock Control gate will be HIGH in every 0.671s and its output will become one of the input for Buzzer Control gate. The importance of Clock Control gate is to make sure that when the Clock Control gate do not receive any input from Input Control gate, it will not allow any clock to activate the counter. If there are no Clock Control gate and clock is directly enter the counter, then the buzzer will buzzes without any detection from input sensor after the circuit is being activate for 3.36s.

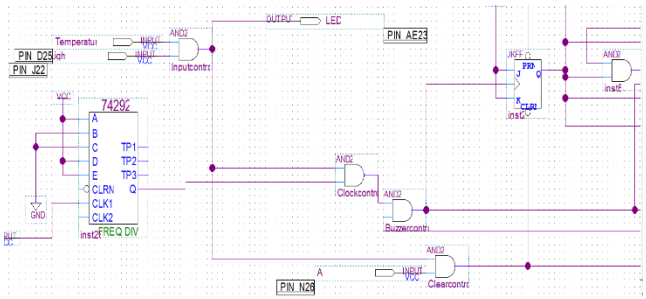

Fig. 6. Clock Control Gate

C. Mod 6 Synchronous Up Counter

When the clock is activated, the counter starts to count from 0 until 6 to get the output. In order

design MOD 6 synchronous up counter, 3 JK flip-flops is used. JK flip-flops are in toggle state when both inputs are HIGH, and this means the outputs are switched subsequently between 1 and 0, and this allows the counter to begin counting from 0 to in binary, which is 000 until 101. Once all three flip-flops reach 101, it will activate the Time Control gate.

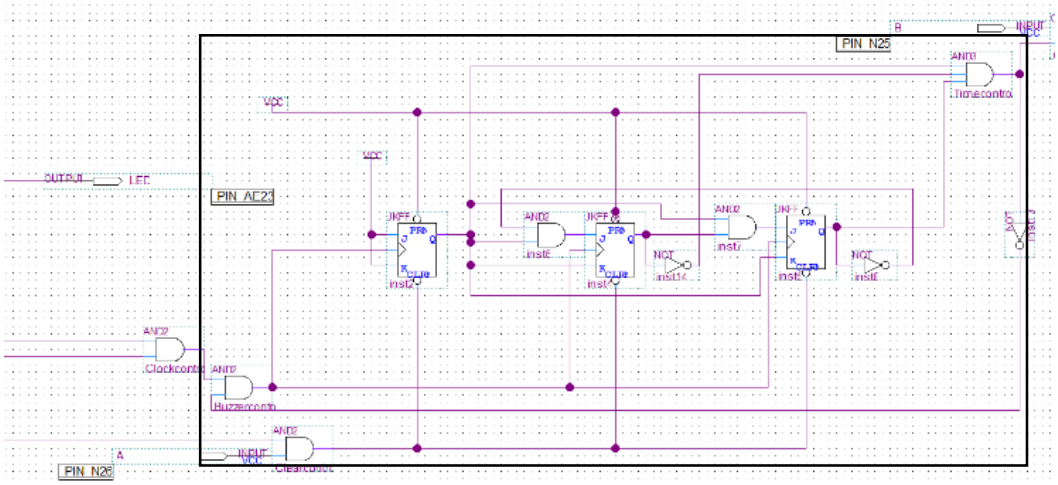

Fig. 7. Mod 6 Synchronous Up Counter

By using the next state table, the inputs to the J and K pins using the next state diagram needs to be determined. Hence, we need to construct excitation tables for all the output to determine the inputs of JK flip flops. The data were obtained from a simplified JK excitation table.

Table 1. Simplified Exitation Table

Output Transition		**Flip-Flop Input**	
Q	Q^+	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Table 2. Flip-Flop Tansition Table

Present State			**Next State**			**Flip-Flop Inputs For State Transition**					
Q_2	Q_1	Q_0	Q_2^+	Q_1^+	Q_0^+	J_2	K_2	J_1	K_1	J_0	K_0
0	0	0	0	0	1	0	X	0	X	1	X
0	0	1	0	1	0	0	X	1	X	X	1
0	1	0	0	1	1	0	X	X	0	1	X
0	1	1	1	0	0	1	X	X	1	X	1
1	0	0	1	0	1	X	0	0	X	1	X
1	0	1	0	0	0	X	1	0	X	X	1

D. Output Control Gate

The buzzer will buzzes when the input sensor is detected and when the circuit is being run for 3.36s, the output for the Time Control gate is HIGH and the Output Control is HIGH. The buzzer will also buzzes when the input B is turned on manually. Input B will always be LOW unless it is turned on manually.

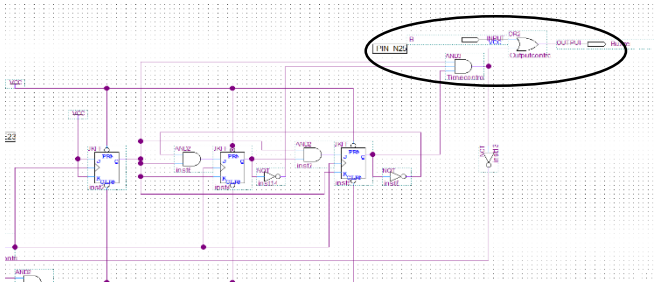

Fig. 8. Output Control Gate

Table 3. Truth Table for Output Control Gate

B	Time Control	Buzzer
0	0	0
0	1	1
1	0	1
1	1	1

4.0 DISCUSSION

The fire alarm system is designed as the fire alarm will rings when the sensor detects the input after 3s. The 3s were chosen as the fire starts to spread. This is because in there are some small fire in real life that fire can be extinguished it in 3s.

Next, the fire alarm system is designed as the fire alarm will ring again in 3s when manually turn off the fire alarm and turn it on back immediately after that. This is due to the reason that the user feels that the fire alarm is annoying when he thought that the fire is already extinguished. The function of the Clear Control gate is used to alert the users that the fire have not extinguished. Besides, the users can turn off the fire alarm manually when they know that there are something on fire. They will make sure that there are no fire before the fire alarm is turned on again with similar approach introduced in Liu (2011).

The reason why both temperature sensor (LM35) and light sensor (LDR) are used instead of just temperature sensor (LM35) is because sometimes the temperature in surrounding is very hot, the users cook in the kitchen or smoke in the room. Fire alarm will ring if there is only temperature sensor as the only sensor. It will be annoying if the users need to turn off the fire alarm when they cook or smoke. This is slightly different methods as discussed in He et al. (2007) where his method is more on the disturbed temperature senses in the environment.

Then, add OR gate in the Output Control gate is because in real life, there will be emergency case where we needed to turn on the fire alarm as emergency alarm or turn on the alarm during fire drill. If there is fire but the temperature is not high enough, the OR gate will enable the fire alarm to ring when turn it on manually.

5.0 CONCLUSION

In conclusion, the objectives of this project conducted are achieved as the desired output are gain. The atmospheric changes tested on the circuit are detected by the system designed, specifically by the temperature sensor and the light sensor.

When the inputs is transmitted, the output produced which are buzzer buzzed and the LED lighted up. Initially, the main objectives of this project is to design an automated fire alarm system by using Altera DE2 FPGA board with the circuit designed via Altera Quartus II software.

It is designed to notify users about the event of fire occur at home. This system is advantageous to users as it is mostly designed to fulfill the protection of life, and protection of properties and assets. The implementation of this project is based on our daily life particularly from the security aspect.

6.0 ACKNOWLEDGEMENT

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7.0 REFERENCES

Arefin A. (2012). Design & Implementation Of Fire Alarm Circuit. Bachelor Dissertation. Northern University Bangladesh

Carter B. (2003). The Integrated Circuit Package, In *Op Amps For Everyone*, 4th Ed., Newnes

He M. K., Zhang P. Z. & Li Y. L. (2007). Application of Distributed Temperature Sensing Technology for Power Equipment Monitoring, *Electrical Equipment, 8(10), 30-32*

Jaeger R. C. (1997). *Microelectronic Circuit Design*, 4th Ed., McGraw Hill

Jinghong L., Xiaohui Z. & Lu W. (2012). The Design and Implementation of Fire Smoke Detection System Based on FPGA, *Chinese Control and Decision Conference (CCDC)*

Liu J., Ma L. & Yang J. (2011). Methods and Techniques of Temperature Measurement. *International Conference on Electrical and Control Engineering*

Razavi B. (2000). *Design of Analog CMOS Integrated Circuit*, First Ed., McGraw Hill