King Abdulaziz University

Faculty of Computing & Information Technology
Computer Science Department

Digital Logic Design

CPCS-211
Final Project Report
(First Term 2022)

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Student Number : [illegible]
Project Title : *Smart Air Conditioner*

	Max. Marks	Obtained Marks
1. Report	15	
2. Circuit	5	
Total Score	20	

Topics

1. Introduction
2. Digital Circuits
3. Analog Vs Digital Circuits
4. Types of Digital Circuits
    - 4.1 Combinational Circuits
    - 4.2 Sequential Circuits
    - 4.3 Difference between Combinational and Sequential Circuits
5. Description of the main idea in your project :
    - 5.1 What do you want to design?
    - 5.2 The most common device that will be used in your project.
6. Design Steps
    - 6.1 The idea of the circuit:
    - 6.2 Different cases:
7. Circuit layout
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1. Introduction

In this report we will summarize general concepts about circuits and their different types and how each one is used. Then, we will describe how to build a smart air conditioner using the Cedar Logic Simulator Program.

2. Digital Circuits

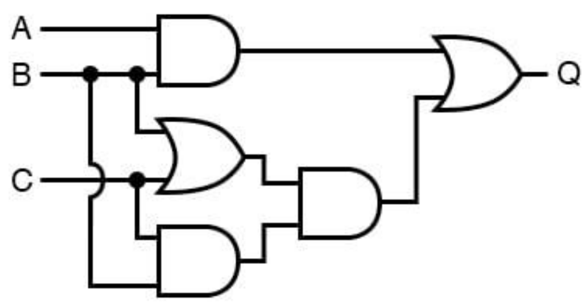

Figure 1: Simple Digital Circuit

A digital circuit is an electronic circuit that has two discrete voltage levels, each representing one of two states (on/off, true/false, working/not working, and so on). It uses voltages between two logic levels, Logic Low and Logic High, to operate. The '0' represents the range of voltages that correspond to Logic Low. Similarly, the voltage range corresponding to Logic High is represented with '1'. Digital circuits are often called switching circuit, because the voltage levels are assumed to be switching from one value to another instantaneously, that is, the transition time is assumed to be zero.

Digital systems are used extensively in computation and data processing because of its high accuracy and precision. it also used in control systems, communications and measurement. Some of the more familiar digital systems include digital computers and calculators, Digital Thermometer, digital audio and video equipment, and the telephone system—the world's largest digital system.

3. Analog Vs Digital Circuit

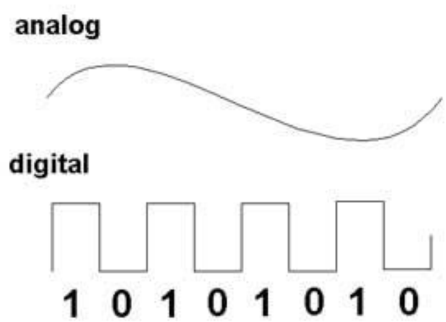

Figure 2: Analog Vs Digital Circuit

Circuits	Analog	Digital
Definition	The analog signal of some constantly changing signal is required by the analog electronic circuit. It can be used to convert a signal from one format to another, such as a digital signal.	The digital circuit is a circuit where the signal is one of two discrete levels. Each level is represented as one of two states (for instance, 0 or 1).
Functionality & Uses	Used to transmit and process the information like sound, light from an environment to generate continuous variable signals. • Sensors • Amplifiers	Used to transmit the power signal to the different parts of the electronic device through various gates. • Automatic glass doors • Countdown timer
Differences	Analog has more than 2 states.	Digital has two states.
	Designing is difficult & less flexible.	Designing is easy & very flexible.
	Information can not be lost.	Information can be lost.
	Analog circuits are less expensive.	Digital circuits are more expensive.

Table 1: Analog Vs Digital Circuit

4. Types of Digital Circuits

There are two types of digital circuits, one that depends only on the current inputs and has no memory of previous states, which is called a combinational circuit. And the other type depends on both the inputs and the memory of previous states, this type is called a sequential circuit.

4.1 Combinational Circuits

- Construction :

  Input variables, logic gates, and output variables make up a combinational circuit.

- Functionality :

  Combinational circuits are made up of logic gates like (AND, OR, NOT, NAND and NOR). Binary values are used in these circuits. The output of a combinational circuit are solely determined by the inputs.

- Uses :

  Examples of combinational circuits: Adder, Subtractor, Converter, and Encoder/Decoder.

4.2 Sequential Circuits

- Construction :

  The sequential circuit is made up of a memory and a combinational circuit.

- Functionality :

  Sequential circuit generates an output based on the current and previous input. That is, sequential circuits have memory elements capable of storing binary information. That binary information defines the state of the sequential circuit at that time.

- Uses :

  Examples of Sequential circuits: Flip flops, Counters, Clocks and Shift registers.

4.3 Difference between Combinational and Sequential Circuit

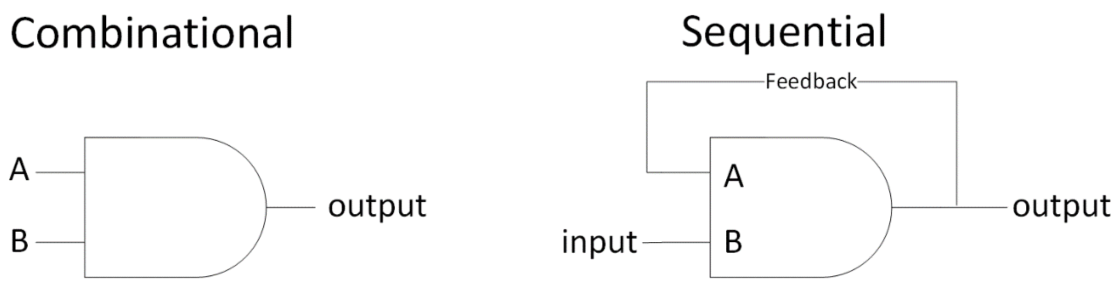

Figure 3: Combinational Vs Sequential Circuit

Combinational	Sequential
Output depends on inputs only.	Output depends on inputs and memory.
Made using basic gates.	Made using gates with a feedback functionality.
Faster and Easy to design.	Slower and Difficult to design.
Used in basic arithmetic operations.	Used to store data using the flip flop function.

Table 2: Combinational Vs Sequential Circuit

5 Description of the main idea in your project :

5.1 What do I want to design?

My project is a smart air conditioner (A/C). The device maintains normal room temperature by means of temperature sensors. It is operated automatically if there is movement or by means of a timer provided that the control device is open. After that, the temperature is tested. If it is high, the air conditioner will be turned on, and if it is low, it will be turned off.

5.2 The most common device that will be used in your project.

Flip Flops

- Functionality :

  Flip Flops are electronic sequential circuits that are configured to cope with and store binary data. When a pulse is triggered by rising or falling, flip flops store the previous state and modify the present state, making them suitable as data storage elements.

- Types:
  - Set-Reset (SR) flip-flop or Latch.
  - JK flip-flop.
  - Data or delay (D) flip flop.
  - Toggle (T) flip flop.

- Applications :
  - Counters
  - Registers
  - Frequency Divider circuits
  - Data transfer

- Uses :

  The main real-life uses of flip flops are counter displays in banks, token counters, and microwave oven timers since counter circuits solely act on the flipflop function and count value based on the number of flip flops used. They are also used in weighing machine, vending machine, fuel pump, etc.

6 Design Steps

6.1 The idea of the circuit:

Designing a smart air conditioner is a very useful idea for maintaining the normal temperature and reducing electricity consumption by turning on the A/C at a specific time or in the event of movement. It can also be controlled and turned off by the remote when the person wants. In this case, the power button and temperature sensors are activated, and the temperature sensors control the A/C.

6.2 Different cases:

- When the remote control is on and the motion sensor or timer is on or both, then the power button is on.
- When the remote control is off regardless of the state of the motion sensor and timer, then the power button is off.
- When the state of the power button is on and the temperature is high, then the A/C is turned on.
- When the state of the power button is on and the temperature is low, then the A/C is turned off.
- When the state of the power button is off regardless of the temperature, the A/C is turned off.

- **Input & output of my system :**

  - Motion Sensor = M
  - Timer = Ti
  - Remote Control = C
  - Temperature Sensor = T = Set = Reset
    - To avoid the situation where the temperature is high and low at the same time.
  - Power Button = D , It is a output from function (M + Ti) *C and input to D-flip flop

  - A/C Turned On = Q
  - A/C Turned Off = Q'
  - x = Don't Care Cases

- **Input :**
  - M
  - Ti
  - C
  - T
  - D

- **Output :**
  - D
  - Q
  - Q'

- **Truth table :**

INPUT					OUTPUT		
Motion	**Timer**	**Control**	**Set T**	**Reset T**	**D**	**Q**	**Q'**
0	0	0	0	0	x	0	1
0	0	0	1	1	0	0	1
0	0	1	0	0	x	0	1
0	0	1	1	1	0	0	1
0	1	0	0	0	x	0	1
0	1	0	1	1	0	0	1
0	1	1	0	0	x	0	1
0	1	1	1	1	1	1	0
1	0	0	0	0	x	0	1
1	0	0	1	1	0	0	1
1	0	1	0	0	x	0	1
1	0	1	1	1	1	1	0
1	1	0	0	0	x	0	1
1	1	0	1	1	0	0	1
1	1	1	0	0	x	0	1
1	1	1	1	1	1	1	0

Table 3: Truth table

- **State table :**

Present state Q	Inputs		Next state Q
	D	**T**	
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

Table 4: State table

- **State diagram :**

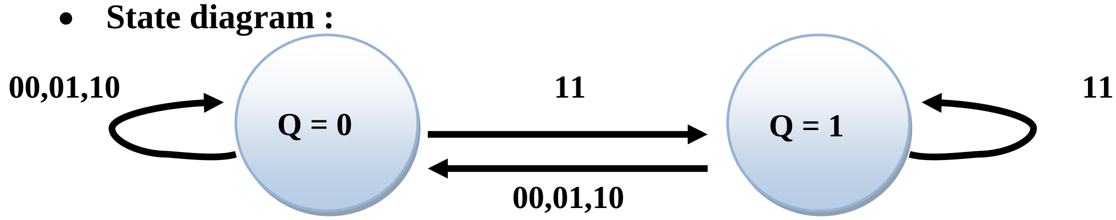

Diagram 1: State diagram

- **K-map & Boolean functions :**

D	M Ti				
C T		**00**	**01**	**11**	**10**
	00	0	0	0	0
	01	0	0	0	0
	11	0	1	1	1
	10	0	x	x	x

Table 5: K-map for D

✳ **Boolean function for D :**

D = Ti*C + M*C

Q	M Ti				
C T		**00**	**01**	**11**	**10**
	00	0	0	0	0
	01	0	0	0	0
	11	0	1	1	1
	10	0	0	0	0

Table 6: K-map for Q

✳ **Boolean function for Q :**

Q = Ti*C*T + M*C*T

Q'	M Ti				
C T		**00**	**01**	**11**	**10**
	00	1	1	1	1
	01	1	1	1	1
	11	1	0	0	0
	10	1	1	1	1

Table 7: K-map for Q'

✳ **Boolean function for Q' :**

Q' = M'*Ti' + C' + T'

7 Circuit Layout

Circuit of Smart Air Condition:

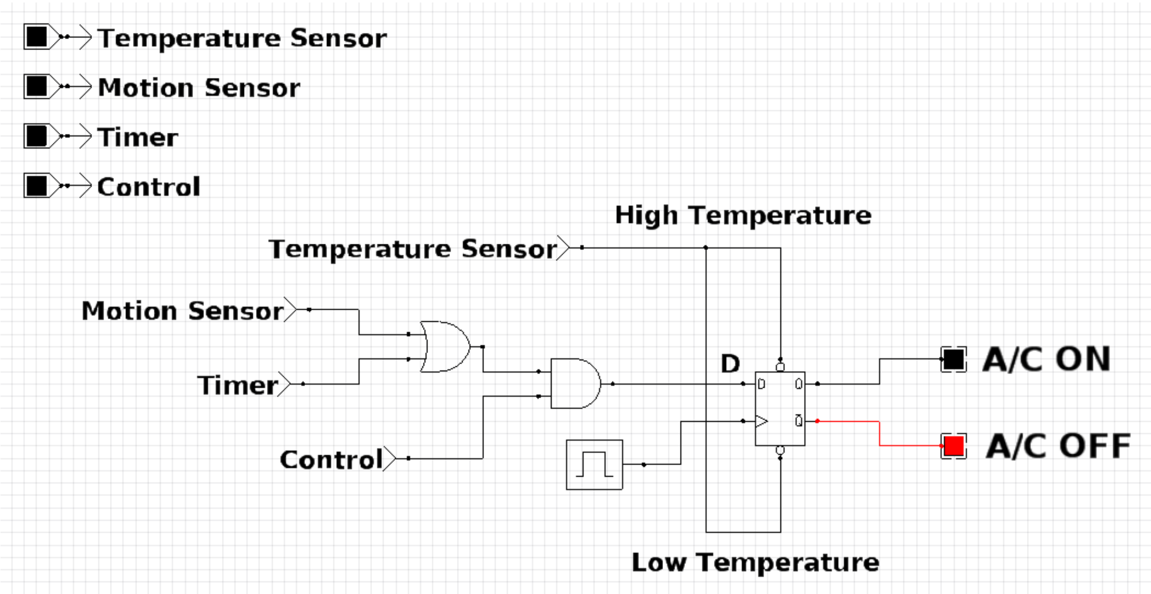

Figure 4: Circuit of Smart Air Condition

Power button is on and the temperature is high case:

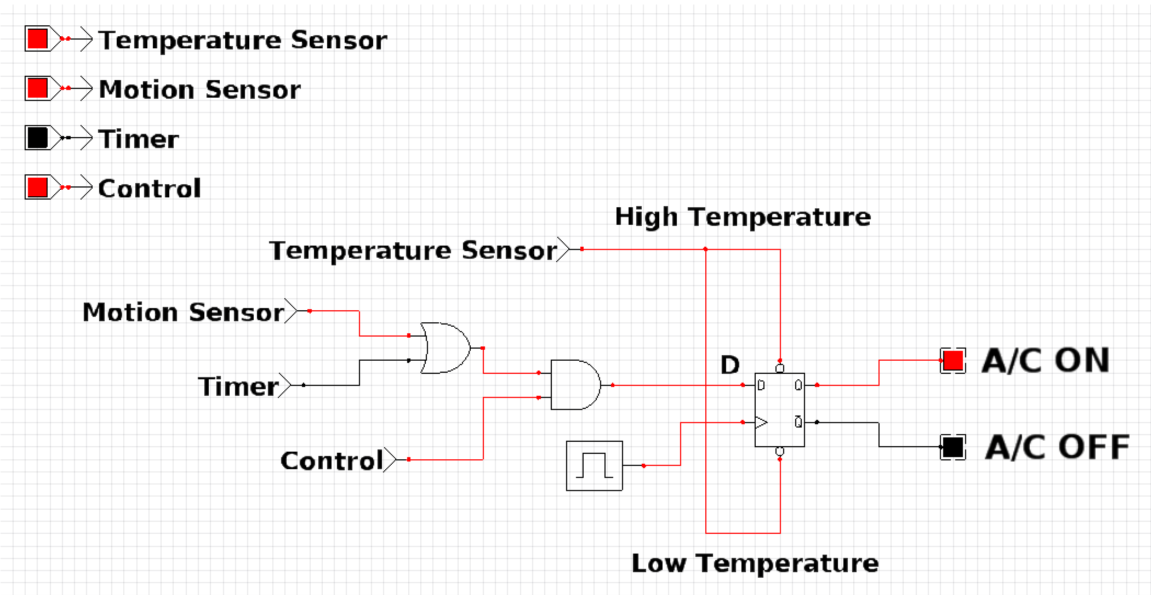

Figure 5: Circuit of Case 1

Power button is on and the temperature is low case:

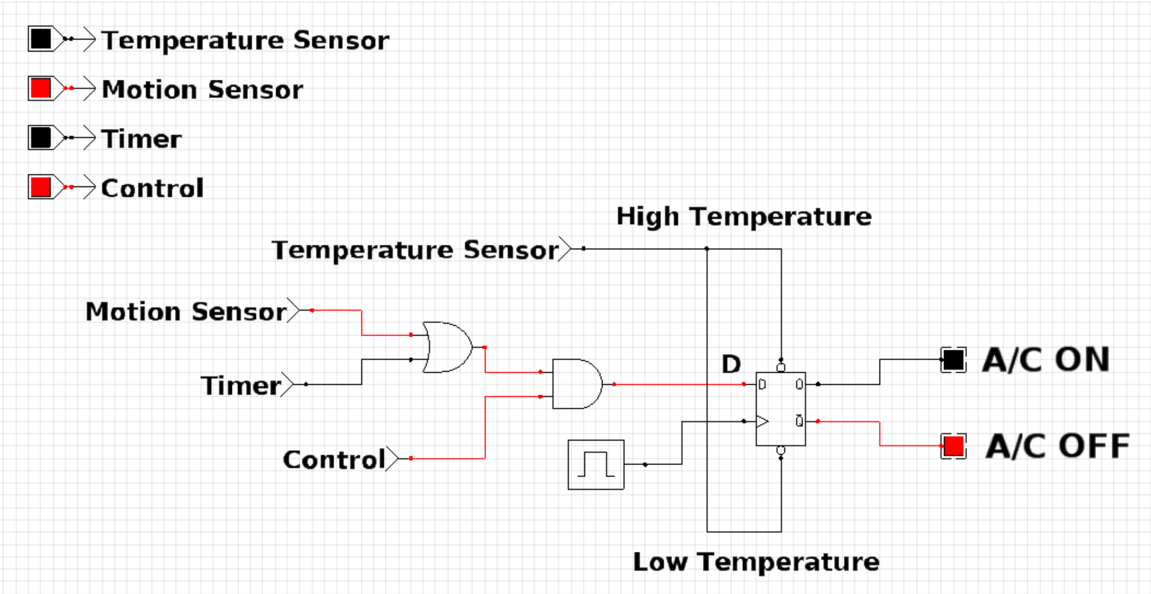

Figure 6: Circuit of Case 2

Power button is off and the temperature is high case:

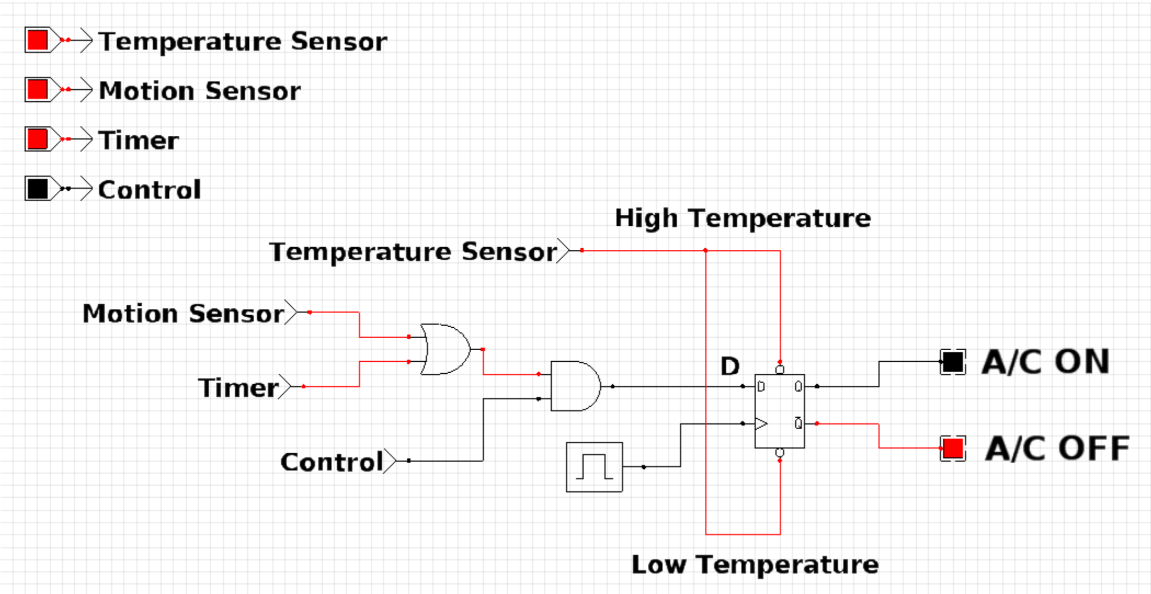

Figure 7: Circuit of Case 3

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