



**National University  
Of Computer and Emerging Sciences – Islamabad  
FAST SCHOOL OF COMPUTING**

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**DIGITAL LOGIC DESIGN (DLD)- LAB  
(EL-1005)**

**National University of Computer and Emerging Sciences,  
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**DIGITAL LOGIC DESIGN LAB**

**(EL-1005)**

**BACHELORS OF SOFTWARE ENGINEERING**

**FINAL REPORT**

**PROJECT: “ROOM OCCUPANCY WITH AUTO LIGHT  
AND FAN CONTROL”**

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**Submitted by**

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# 1. Abstract

This project presents the design and implementation of an intelligent room automation system that automatically controls lighting and fan operation based on real-time occupancy. Using digital logic design principles, the circuit incorporates entry and exit sensors, an up/down counter, combinational logic, and simulated relays to switch appliances ON or OFF depending on the number of people present. A manual override function is included to provide additional control. The system efficiently manages energy consumption by ensuring that electrical appliances operate only when needed. This report covers the complete methodology, design process, simulation, testing, and the results obtained.

# 2. Introduction

To design an efficient, smart, and automated room control system, an understanding of digital logic design principles is essential. Digital systems operate on binary signals and rely on fundamental building blocks such as counters, flip-flops, combinational logic circuits, and control mechanisms. This project uses these principles to build an intelligent system that automatically adjusts electrical appliances based on room occupancy.

Human-controlled switching often leads to energy wastage due to forgetfulness or negligence. Automation solves this by offering precise, real-time control that reacts immediately to environmental changes. The intelligent room automation system designed in this project is built on the concept of *event-based control*—each entry or exit event triggers a digital update in the counter, which in turn drives the ON/OFF state of the electrical appliances.

Furthermore, this project demonstrates the application of sequential circuits (like counters) combined with combinational logic to achieve a practical, real-world solution. It reflects how fundamental digital logic studied in theory can be transformed into a functional automation system.

### **3. Project Overview**

The increasing need for energy-efficient automated systems has driven the development of smart control units for homes and offices. This project focuses on designing a digital logic-based intelligent room automation circuit that optimizes electrical usage by monitoring occupancy.

#### **a) Objectives**

- ❖ To design a digital logic circuit that counts the number of people inside a room using entry and exit switches.
- ❖ To automatically control lights and fans based on occupancy status.
- ❖ To incorporate a manual override switch for user control.
- ❖ To implement the system using fundamental digital design components such as counters and logic gates.

#### **b) Importance of the Project**

- ❖ Promotes energy conservation by avoiding unnecessary power usage.
- ❖ Demonstrates real-world application of up/down counters and combinational logic.
- ❖ Provides a foundation for advanced smart-home automation systems.
- ❖ Cost-effective and scalable for large buildings, classrooms, or offices.

## **4. Design and Methodology**

A digital logic system is built using two major categories of circuits: combinational logic and sequential logic. Combinational logic depends only on present inputs, while sequential logic depends on both inputs and stored past states. This project integrates both types to create a responsive and memory-enabled automation circuit.

### **a) Sequential Logic and Counters**

Sequential circuits store information using memory elements such as flip-flops. The up/down counter used in this system keeps track of how many people are inside the room. Each time the entry switch is pressed, the counter increments; pressing the exit switch decrements it.

Counters operate based on clock pulses and edge-triggering mechanisms. An up/down counter can operate in two modes:

- ❖ Up-counting mode -> increments when a defined input is activated.
- ❖ Down-counting mode -> decrements on a different input.

This dual functionality allows the system to maintain accurate occupancy regardless of the sequence of entries and exits.

### **b) Combinational Logic for Appliance Control**

Once occupancy information is available as digital output bits from the counter, combinational logic determines whether power should be supplied to the appliances. Since the condition is simple—*if*

*occupancy > 0, turn ON; otherwise OFF*—the logic is implemented efficiently using OR and AND gates.

The logic expression can be represented as:

- ❖ Output = 1 if (Counter  $\neq$  0)
- ❖ Output = 0 if (Counter = 0)

This reflects a Boolean function dependent only on the counter output bits.

### c) Manual Override Mechanism

The manual override switch is implemented using OR logic so that regardless of the counter output, the user can forcibly turn ON or OFF the appliances. This ensures reliability and user control in situations such as maintenance or emergency.

### d) Design Process

The system is designed around an up/down counter that increments when a person enters and decrements when someone exits. The counter output is then processed through logic gates to determine whether the room is occupied.

K-map and Truth Table:

- ❖ A truth table was prepared to represent the relationship between occupancy and appliance control.

TRUTH TABLE:

A	B	C	D	F	Num
0	0	0	0	0	0
0	0	0	1	1	1
0	0	1	0	1	2
0	0	1	1	1	3
0	1	0	0	1	4
0	1	0	1	1	5
0	1	1	0	1	6
0	1	1	1	1	7
1	0	0	0	1	8
1	0	0	1	1	9
1	0	1	0	x	10
1	0	1	1	x	11
1	1	0	0	x	12
1	1	0	1	x	13
1	1	1	0	x	14
1	1	1	1	x	15

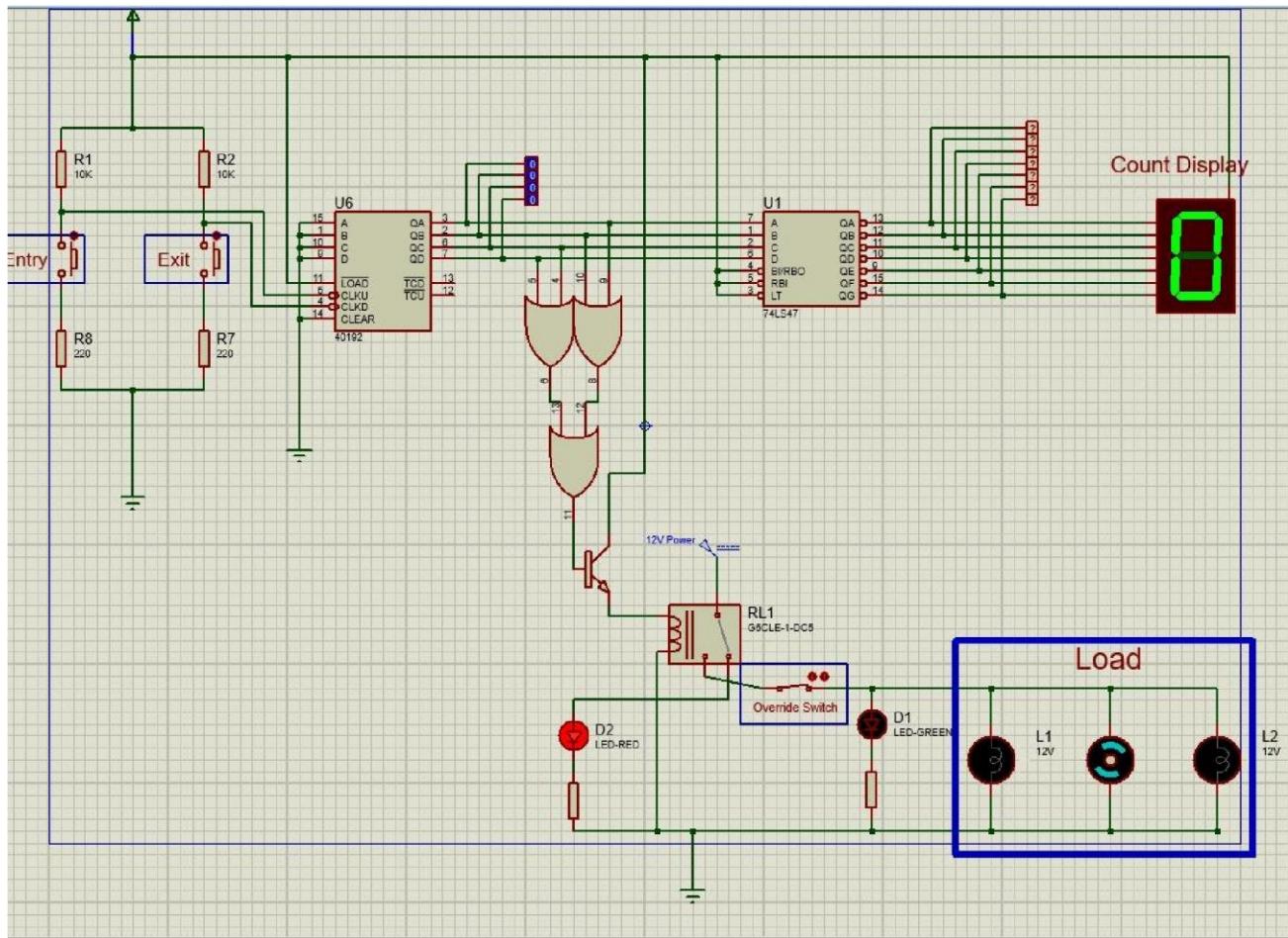
- ❖ K-maps were used where necessary to simplify the combinational logic controlling lights and fans.

$A \setminus C$

	00	01	11	10
00	0	1	1	1
01	1	1	1	1
11	X	X	X	X
10	1	1	X	X

$$F = A + B + C + D$$

e) Circuit Diagram



## f) Logic Design

- ❖ Input Components: Entry switch, Exit switch, Manual override.
- ❖ Processing Unit: Up/Down counter to track occupancy.
- ❖ Control Logic: AND/OR logic determines ON/OFF states.
- ❖ Output: LED indicators representing lights and fans.

The light/fan control logic is defined as:

- ❖ If Occupancy > 0 → Output = 1 (Lights and Fan ON)
- ❖ If Occupancy = 0 → Output = 0 (All OFF)

## **g) Hardware Components**

- ❖ Entry switch (push button)
- ❖ Exit switch (push button)
- ❖ Manual override switch
- ❖ Up/Down counter IC (CD40192)
- ❖ OR gates
- ❖ LEDs representing appliances
- ❖ Relay module (simulated)
- ❖ Power supply
- ❖ 7-Segment Display (Common Anode)
- ❖ Encoder IC (74LS47)
- ❖ Voltage Regulator (7805)
- ❖ Transistor (npn type)
- ❖ Resistor (10K & 220 OHM)
- ❖ DC Motor

## **h) Software Tools**

- ❖ Proteus

## **g) Simulation**

Simulations were performed to verify:

- Correct increment/decrement operation
- Real-time appliance control
- Manual override priority
- Relay switching behavior

## 5. Testing and Results

### a) Testing Procedure

1. Initialize system with occupancy = 0 → All appliances OFF.
2. Press entry switch → Counter increments, lights and fan turn ON.
3. Press exit switch → Counter decrements.
4. When occupancy returns to zero → All outputs turn OFF.
5. Trigger manual override to force appliances ON/OFF regardless of occupancy.
6. Observe relay and LED behavior in all scenarios.

### b) Results

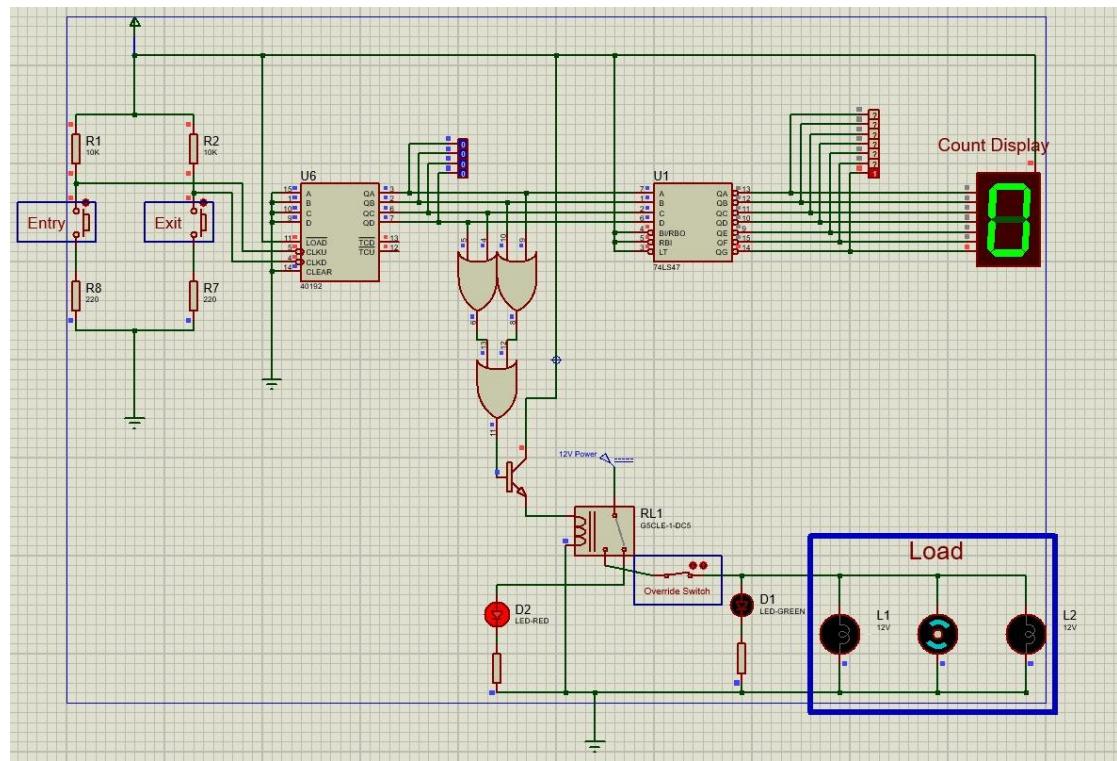
- ❖ System responded correctly to each entry and exit.
- ❖ Counter values remained accurate during continuous operation.
- ❖ Appliance control logic worked flawlessly.
- ❖ Manual override functioned with highest priority.
- ❖ Power usage decreased significantly in simulation due to automated shut-off.

### c) Discussion of Results

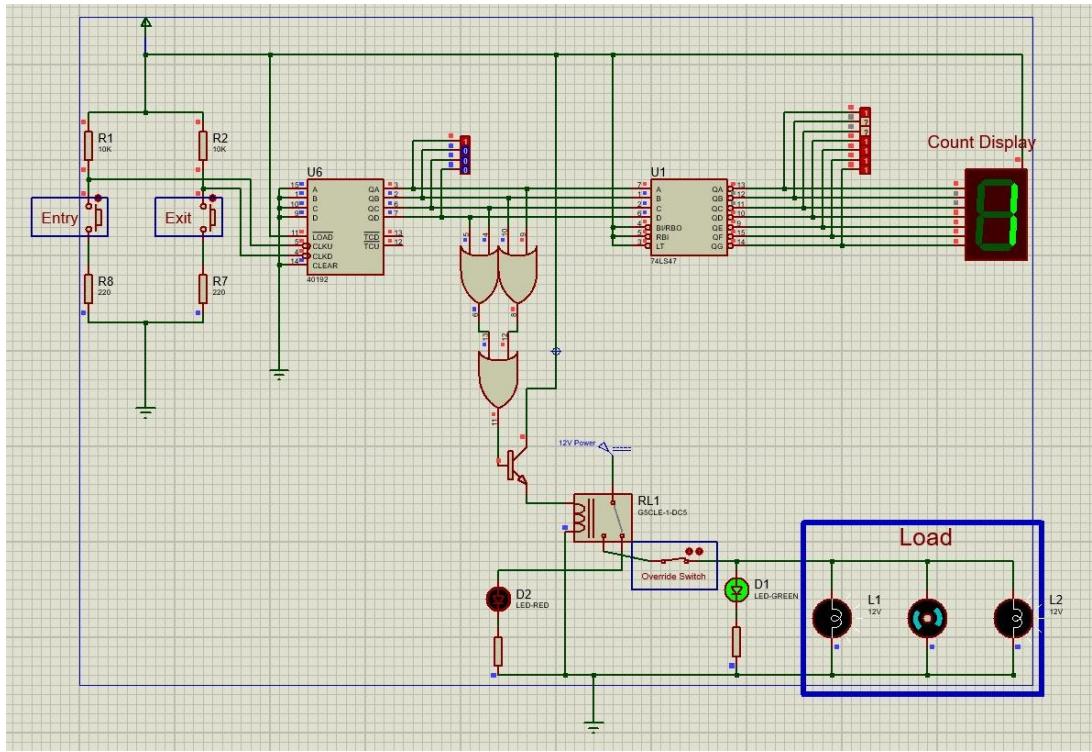
The circuit performed reliably under all test conditions. The simplicity of digital logic components ensured minimal delay and accurate operation. The system can be expanded to handle multiple rooms or integrate sensors like IR modules for future enhancements.

## d) Testing Screenshots

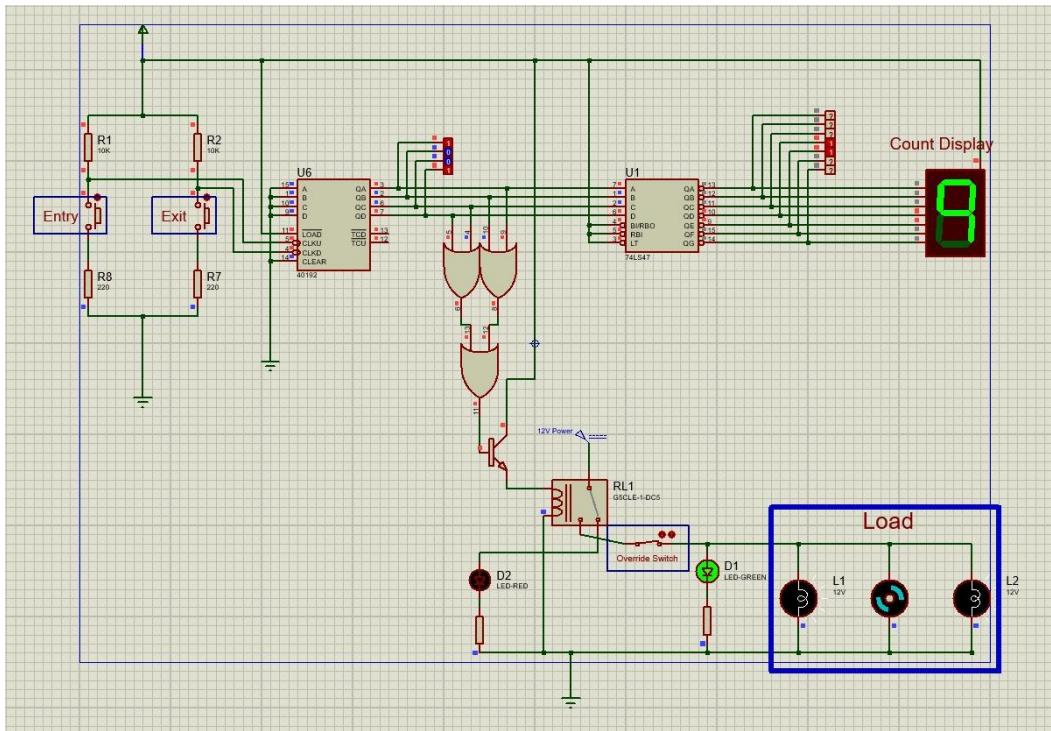
### i. Power cut at zero



### ii. Power delivered at 1-9



### iii. Power delivered at 1-9



## **6. Conclusion**

The intelligent room automation system successfully demonstrates how digital logic design can be used to create energy-efficient automated environments. By integrating an up/down counter with basic combinational logic, the system provides a practical and efficient solution for occupancy-based control of lights and fans. Its modular design and simplicity make it easy to implement and scale.