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# DESIGN AND IMPLEMENTATION OF A SPECTATOR COUNTING SYSTEM

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## ABSTRACT

A **Spectator Counter** is a device used to count the number of people traversing a certain passage or entrance over a period of time. The device is often used at the entrance of buildings, Amusement parks or stadia so that the total number of people entering and leaving them can be electronically counted and recorded. The aim of this Paper therefore is to present the 'Design and Implementation of a Spectator Counter' for safety, accurate generation of revenue and to prevent overcrowding public places. This device is unique because it offers a relatively accurate means of managing capacity and controlled by software, which can be modified at any time the system demands a change. Here, the system has one (1) Service Barrier or Gate modeled and simulated using a PIC 16F877 Microcontroller as the major component and a Micro-C programming language as the software.

Two active infrared sensor systems are used to detect spectators one after the other coming toward the entrance of any public place. From the sensing system a signal conditioning circuit is used in order to get a suitable and desirable output signal that the microcontroller could recognize, process and display the real number of Spectators inside the amusement Park on the seven segment display screen.

In conclusion, this counting system can be easily adapted by any electric gate and any form of control which requires the use of sensors. They can be employed in organizations such as, the public car parks, residential parking lots, examination halls etc where no form of security measure is a priority.
It is recommended that the design be modified by incorporating an Exit Barrier to accurately determine space availability.

  

**Keywords:** Counter, Microcontroller, Spectators, Sensors, Gate Barrier.

## 1.0 INTRODUCTION

Sometimes it is difficult for invigilators to control the students entering the examination hall and to determine the student attendance accurately so as to avoid exceeding the hall capacity. Also the number of Spectators entering an Amusement Park, stadium etc may be difficult to determine (Liu, 2014). A precise system that can count and display the number of students in the examination halls or spectators entering stadia etc at a given instance would prevent crowd disturbances, helps in determining revenue generation for the stadium per game, and the effects of national television broadcasts (Borland, 1992). It also ensures safety, intelligence-information gathering and order within the confines and vicinity of those public places. In this work, a system was designed and implemented based on a microcontroller (Said, 2014) that displays and stores the number of spectators entering the amusement Park. Two active infrared sensor systems are used to detect spectators one after the other coming toward the entrance of the Park. Active infrared sensors are used because they are not influenced by external temperature and light conditions as they have their own radiation source, they are unobtrusive, easy to install, and can cover a field of view (Iske, 2004)

## 2.0 METHODOLOGY

This device is controlled by a program which can be modified at any time the system demands a change. The system has one (1) Service Barrier or Gate modeled and simulated using a PIC 16F877 Microcontroller as the major component and a Micro-C programming language as the software. The design is divided into two (2) basic ections namely, Hardware and Software.

### 2.1 Hardware Design Consideration

This section consists of the Sensors, CPU, Display, Gate Control and the Power Supply Units.

  

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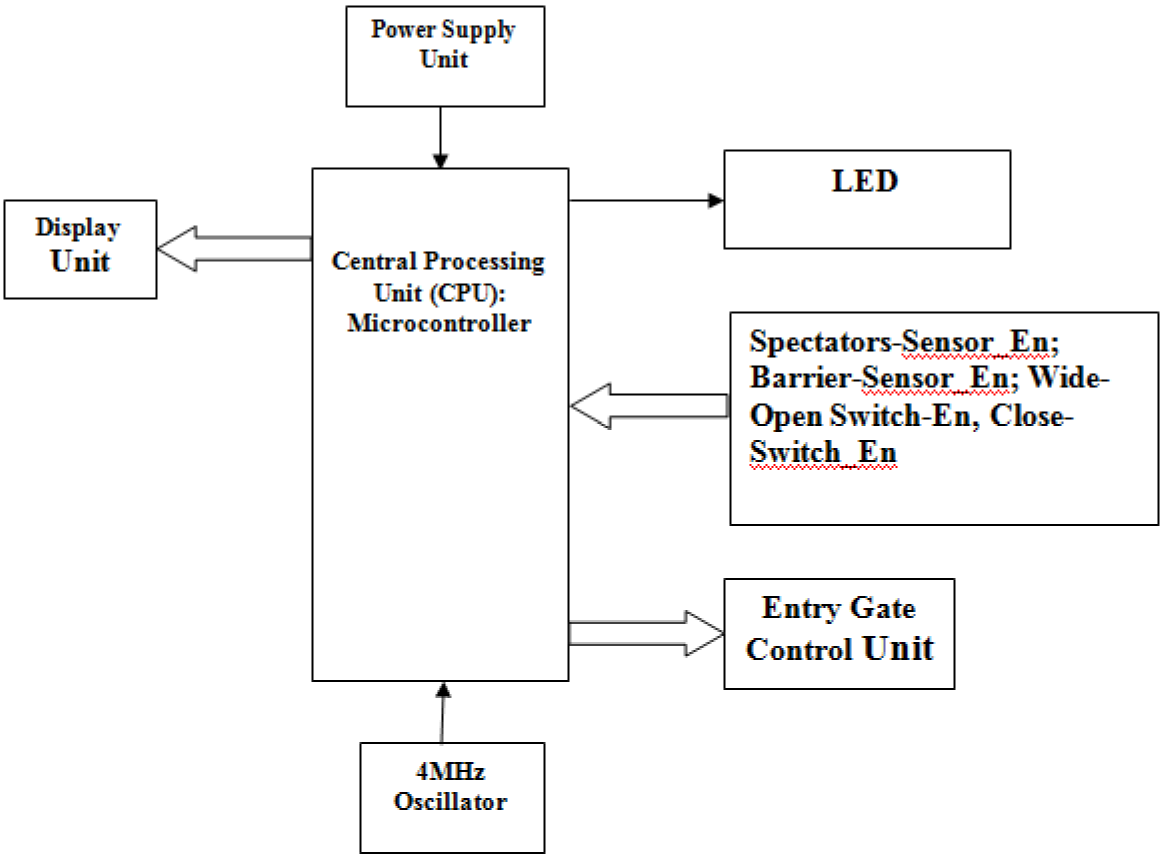


**Figure 1: Block Diagram of the Students Counter**

**Sensor Unit** (see Figure 3a & 3b)

The outputs from the sensors unit are part of the trigger circuitry and are connected to the ADC input of the microcontroller. It detects the presence of a spectator when approaching the barriers. In this design, Infra-Red LED (IR-LED) and Phototransistor circuits are used as sensors. Two (2) conditions are considered:

**(1) When the light rays from the IR LEDs are directed at the Phototransistors (i.e $Q_1$, $Q_2$):** The output voltages of $Q_1$, and $Q_2$ are low (approximately 0V).

**(2) When the light rays from IR LEDs are intercepted by any passing Spectator.**
The output voltages of $Q_1$, and $Q_2$ are high (approximately 5V).

  

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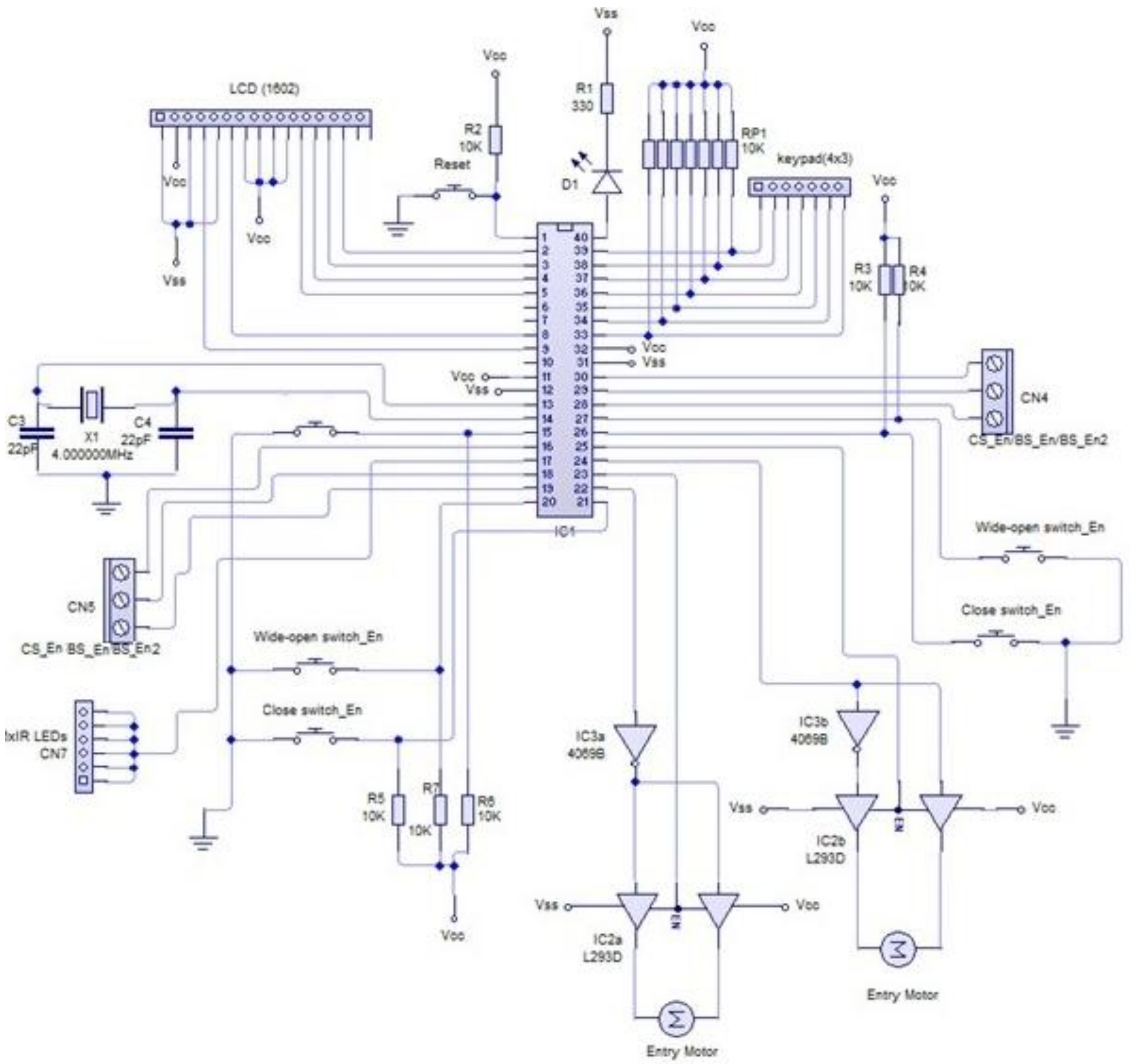


**Figure 2: Circuit Diagram of the Spectators' Counter**

  

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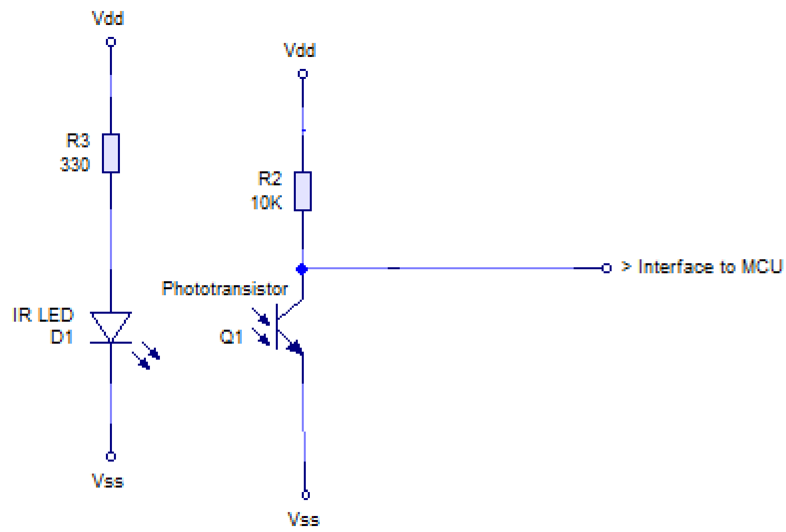


**Figure 3a: Sensor Unit (Spectators Entry Sensor)**

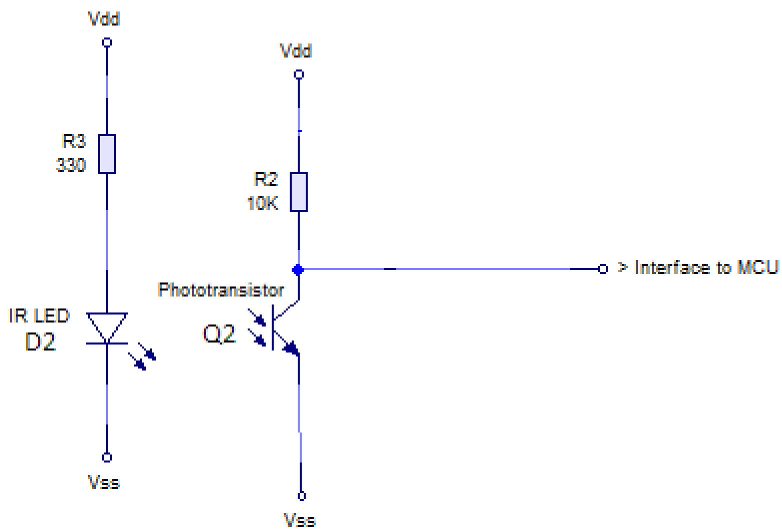


**Figure 3b: Sensor Unit (Spectators Entry Barrier Sensor)**

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**CPU Unit**

A low-cost Microcontroller and a PIC 16F877A type 8-bit Microcontroller was chosen. It contains a flash program memory which can easily be programmed using a suitable programmer device. This makes the development and testing an easy and a relatively quick task.

**Display Unit**

The display unit consists of the Liquid Crystal Display (LCD-1602). This can display sixteen (16) characters on a line and has two rows and uses a 7-segment configuration to form the decimal characters 0 through 9 and sometimes the hexadecimal characters. The output of the Counter cannot be fed directly to the 7-segment display; it needs a driver (see Appendix B for the LCD datasheet). The unit sends signals to the driver each time a spectator crosses the gate. Figure 4 shows the LCD Connector unit used.

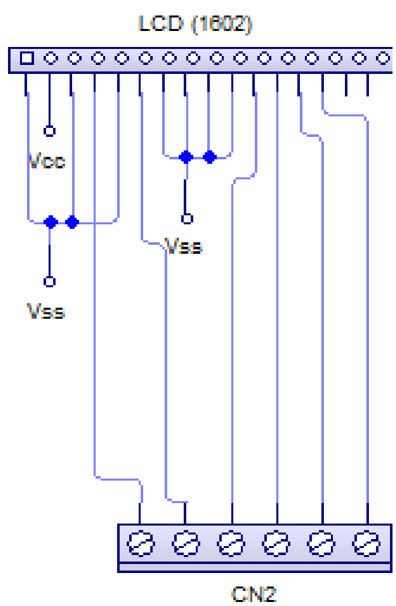


**Figure 4: LCD Connector unit**

**Gate Control Unit (see Figure 2)**

The gate control circuit is used at the entrance gate. The D.C. motor is used to control the opening and closing of gate. The electric motor used is one that has the ability to rotate in both directions simply by reversing the polarity. The L293D used is a quadruple high-current half-H driver.

  

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**Table 1: Motor Direction for different Input Conditions**

| Motor Direction | Input 1 | Input 2 |
|---|---|---|
| Stop | Low | Low |
| Clockwise | High | Low |
| Anti-Clockwise | Low | High |
| Stop | High | High |

**Power Supply Unit**

A microprocessor based system design has to be powered with a well regulated power supply. A transient on the power line could send the microprocessor wandering, resulting in system failure. The PIC 16F877 microcontroller used operates on a voltage ($V_{DD}$) = 5V. As a result, the power supply unit designed is 5Vd.c (see Figure 5).

The LED turns ON when the system is switched ON.

**Power Supply Requirements:**

Power must be kept at maximum of 500mW and an output Voltage of 5V.
Hence,
The maximum current ($I_{max}$) $= \frac{Power}{Voltage} = \frac{0.5}{5} = 100mA\ or\ 0.1$A

$$= Resistor's\ value\ (R_1) = \frac{Voltage\ Drop}{Maximum\ Current}$$

$$= \frac{9-5}{0.1} = 40\Omega$$

The smoothing Capacitor, $C_1$ is obtained from;

$$C_1 = \frac{I_{dc}}{4f(V_m - V_{dc}}$$

$$C_1 = \frac{0.1}{4\times 50(9-5)}$$

$$C_1 = 125\mu F$$

It should be noted that C2 could be of any value to improve the performance of the regulator. Therefore, C2 is taking to be 10µF. The regulator (7805) regulator used maintains a 5V DC supply voltage to the system. The 9V battery incorporated is for power back-up in case of power failure.

  

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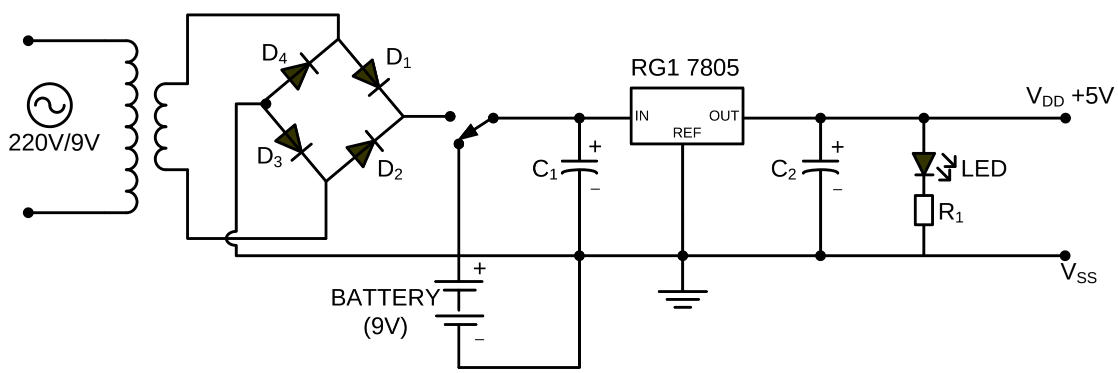


**Figure 5: Power Supply Unit**

### 2.2 Software Development Procedure

The software was designed using the following steps:

**1. Algorithm**

1. Start
2. Configurations
3. Check if Hall is full
   - I. If full: update the LCD as FULL and go back to step 3
   - II. Else Display the number of Spectators in the Hall
4. A Spectator detected by Spectators -Sensor_En (CS_En)
   - I. If detected:
     - i. open the Entry Barrier
     - ii. Restrict the barrier from over open by Wide-Open_switch_En
5. While a Spectators is not under the barrier (by Barrier-Sensor_En), Go to Step 7
6. Step 8
   - I. Increment Spectators Counter
   - II. Close Entry Barrier
   - III. When it is full closed, stop the barrier dc motor
7. Go to Step 3
8. While the Spectator is not under the barrier, Go to Step 5
9. Step 5
   - I. Increment Spectators Counter
   - II. Close Entry Barrier
   - III. When the is full closed, stop the barrier dc motor
10. Go to Step 3
11. END

**3. Program Code (Main Program (Micro-C Language)**

```
#define Spectator_sensor_En PORTD.F7
#define Barrier_Sensor_En PORTD.F6
#define Spectator_Entry_En PORTC.F6
#define Spectator_Entry_DIR PORTC.F5
#define wide_Open_switch_En PORTD.F4
#define close_switch_En PORTC.F7
```

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```
#define FULL 10
#define Enable 1
#define Disable 0
#define is ==
unsigned int Spectator_counter = 10;
char Spectator_counter_str[5];
char safe_close;
void entry_();
void exit();
void main()
{
TRISA = 0;
TRISE = 0;
TRISC = 0x8B;
TRISD = 0xF7;
TRISB = 0x0F;
Lcd_Custom_Config(&PORTA,1,2,3,4,&PORTE,1,2,0);
Lcd_Custom_Cmd(Lcd_CURSOR_OFF);
// Turn off cursor
 while(1)
 {

 if (Spectators_counter == FULL)
   {
    Lcd_Custom_Out(1, 1, "The Spectator Counter is FULL"); // Print text at LCD
    //exit();    //go to exit barrier
   }
 else {
   //cd_Custom_Cmd(Lcd_Clear);
    intToStr(Spectator_counter, Spectator_counter_str); // convert Spectator_counter to string
    Lcd_Custom_Out(1, 1, Spectator_counter_str); // Print text at LCD
    }
 if (Spectator_sensor_En == 1) // Spectator present at the barrier
  {
 do
  {
   Spectator_Entry_En= Enable;    //open the barrier
   Spectator_Entry_DIR = Enable;
   } while(wide_Open_switch_En == 0);    // stop Dc Spectator while wide_switch is enabled

   Spectator_Entry_En= Disable;    //open the barrier
   Spectator_Entry_DIR = Disable;
   }

 if ((Barrier_Sensor_En))
   {
   do
   {
   Spectator_Entry_En= Enable;    //open the barrier
   Spectator_Entry_DIR = 0;
   }  while (close_switch_En == 0);
  Spectator_Entry_En=  0;      //open the barrier
   Spectator_Entry_DIR = 0;
     Spectator_counter++;
     //if(Spectator_counter >= 10) call display full
   }
  }
  }
 void exit()
 {
 while (1)
```

  

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```
 {
  Spectator_Entry_En= Disable;    //open the
barrier
  Spectator_Entry_DIR = Disable;
  }
 // else
 //entry();
  Spectatort_Entry_En=  0;        //open  the
barrier
  Spectator_Entry_DIR = 0;
    Spectator_counter--;
   }
   }
   }
```

**3.0 TESTING AND RESULTS**

When the system is powered, the LCD is reset to zero (0) to show that the Amusement Park is empty. Two (2) IR TX – RX pairs are arranged either side of the Entry barrier/gate. They are used to identify the entry of Spectators into the Park. When a Spectator approaches the barrier/gate, the IR signal gets intercepted and the microcontroller opens the barrier by rotating the D.C. motor.

The wide open switch connected to the barrier prevents it from opening beyond its limits. The second IR TX – RX pair prevents the barrier from closing until the Spectator has left it. Whenever any Spectator interrupts the light beams of the sensor units, the voltage at the output of the sensor goes HIGH. The circuit resets to a LOW voltage level when the interrupt is removed. The truth table of the sensors is shown in Table 2.

The microcontroller then increments the value of the counter and displays it on the LCD. If the count reaches ‘10’, i.e. if the Park is completely filled up, the microcontroller will display “Spectators Counter is Full” on LCD (see Table 3).

However, if any Spectator tries to enter the Park, the barrier will not be opened since there is no more free space for him/her.

**Table 2: Truth Table of the Voltage Levels of the Sensors Unit**

| Spectators’ **Sensor Test** | **Result (V)** |
|---|---|
| **Without Object** | **0** |
| **With Object** | **5** |
| **Object Removed** | **0** |

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**Table 3: Results of the Test Strategy of the Spectators Counter at the Entrance Barrie/Gate**

| Spectators Arrival at the Entrance Barrier/Gate | | | | | | |
|---|---|---|---|---|---|---|
| **Spectators Sensor** | **Barrier Sensor 1** | **Wide Open Switch** | **Spectators Sensor** | **Barrier Sensor 1** | **Close Switch** | **LCD Display (Counter)** |
| ON | ON | ON | OFF | OFF | ON | Increment (1) |
| ON | ON | ON | OFF | OFF | ON | Increment (2) |
| ON | ON | ON | OFF | OFF | ON | Increment (3) |
| ON | ON | ON | OFF | OFF | ON | Increment (4) |
| ON | ON | ON | OFF | OFF | ON | Increment (5) |
| ON | ON | ON | OFF | OFF | ON | Increment (6) |
| ON | ON | ON | OFF | OFF | ON | Increment (7) |
| ON | ON | ON | OFF | OFF | ON | Increment (8) |
| ON | ON | ON | OFF | OFF | ON | Increment (9) |
| ON | ON | ON | OFF | OFF | ON | Increment(10)<br>Hall is Full |
| OFF | OFF | OFF | OFF | OFF | OFF | Park is Full |

## 4.0 CONCLUSION AND RECOMMENDATIONS

This Paper models and implements a microcontroller-based Spectators Counter. Although the automated Counter is modeled for an Amusement Park, it can it can be easily adopted by any electric gate and any form of control which requires the use of sensors. They can be employed in organizations such as, the public car Parks, residential parking lots, automobile termini, examination Halls etc where no form of security measure is a priority.

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The design is a Sensor-based system where the sensors serve as transducers for Spectators detection while the programming language used (i.e Micro-C) is fundamental to software design, based on the system requirements, specifications, and planned operation of the system.

It is recommended that the model be modified by incorporating an Exit Barrier to accuratelt determine space availability.

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