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Design of Automatic Mass Gathering Restriction Door to Limit the Number of People Presents In the Same Building During Pandemics

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Abstract
People in most countries around the world spend upward of 80 percent of their time indoors inside homes, apartment buildings, schools, and offices. With the threat of pandemic such as COVID-19 looming over every interaction, those indoor spaces (where the virus spreads more easily) can seem loaded with hidden threats. The pandemic may be the stressor that pushes many buildings to adopt healthy practices, and those benefits could linger long after the outbreak fades. One of the most important solutions is to limit number of people to be physically present in a building. This research presents the design of automatic mass gathering restriction door by using digital bidirectional visitor counter (DBVC). The DBVC is a reliable circuit that takes over the task of counting number of persons / visitors in the building (room) very accurately and denies access to people when the number of visitors exceeds the approved limit of the building.

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I. INTRODUCTION

A pandemic is an epidemic of an infectious disease that has spread across a larger region, for instance multiple continents or worldwide, affecting a substantial number of individuals. Wide spread epidemic diseases with a stable number of infected individuals such as recurrences of seasonal influenza are generally excluded as they occur simultaneously in large region of the globe rather than being spread worldwide.

Throughout the human history, there have been a number of pandemics of diseases such as smallpox. The most fatal pandemic in recorded history was the Black Death also known as the Plague which killed an estimated 75 – 200 million people in the 14th century (ABC, News, 2008 and BBC, News, 2001). The term had not been used then but was later used for epidemics, including 1918 influenza pandemic, more commonly known Spanish flu (H1N1 virus, 1989, Rosewald, 202 and WHO, 2010).

The most recent pandemic include the HIV/AIDS pandemic, (Roychoudhury, et al., 2020) the 2009 H1N1 pandemic and COVID-19 pandemic. Almost all these diseases still circulated among humans though their impact is far less.

In response to the COVID-19 pandemic recently 194 members states of the World Health Organization (WHO) began negotiations on an International Treaty on pandemic prevention preparedness and Response with a requirement to submit a draft of this treaty to the 77th World Health Assembly during it 2024 convention. This is expected to set a rules for dealing with pandemic by the international community (WHO, 2021 and Cumming-Bruce, 2021).

Pandemic prevention comprises activities such as anticipatory research and development of therapies and vaccines as well as monitoring the pathogens and diseases outbreak which may have pandemic potentials (Williams, 2022).

Collaboration, in response to the COVID-19 pandemic WHO established a pandemic Hub in September 2021 in Berlin aiming to address weaknesses around the world in how countries detect, monitor and manage public health threats. The Hub initiatives include using artificial intelligence to analyses more than 35,000 data feeds for indications of emerging health treats as well as improving facilities and coordination between academic institutions and WHO member's countries (Morgan and Pebody, 2022).

Detection, in May 2023, WHO launched the international pathogens surveillance network (IPSN) (hosted by the pandemic Hub) aiming to detecting and response to disease threats before they become epidemic and pandemic and to optimize routine disease surveillance. The network provides a platform to connect countries improving systems for collecting and analyzing samples of potentially harmful pathogens.

Therapies and vaccine, the coalition for epidemic preparedness innovations (CEPI) is developing a program to condense new vaccine development timeline to 100 days a third of the time it took to develop a COVID-19 vaccine. CEPI aims to reduce global epidemic and pandemic risk by developing vaccines against known pathogens as well as enabling rapid response to disease (Bill and Melinda, 2023 and Delivering pandemic vaccine in 100 days, 2022). In the US National Institute of Allergy and Infectious Diseases (NIAID) has developed a pandemic preparedness plan which focus on identifying viruses of concern and developing diagnostics and therapies (including prototypes vaccine) to combat them (NIAID, 2023).

Pandemic management, the key part of managing an infection diseases outbreak is trying to decreases the epidemic peak known as flattening the curve (Anderson et al., 2020 and Stawicki et al., 2020). A broad group of non-pharmaceutical intervention may be taken to manage the outbreak (Stawicki et al., 2020). In a flu pandemic, the these action may include personal preventive measures such as hand hygiene, wearing of face marks and self-quarantine, community measures aimed at social distancing such as closing schools and cancelling mass gathering, community engagement to encourage acceptance and participation in such interventions and environmental measures such as cleaning the surface (CDCP, 2017).

Another strategy, suppression requires more extreme long term non pharmaceutical interventions to reverse the pandemic by reducing the number the basic reproduction number to less than 1. The suppression strategy, which includes stringent population-wide social distancing, home isolation of cases and household quarantine was undertaken by China during the COVID-19 pandemic where entire cities were placed under lockdown, such strategy may carry with it considerable social and economic cost (NPIS, 2020). This door is main to support social distancing by limiting the number of people that have access to the building to half it capacity or any number.

Automatic sliding doors are suitable for a wide variety of building types, from offices and residential buildings to retails environments and transit centers. They are compact, durable, power saving and can be enhanced with a variety of security and safety options, including burglary prevention, emergency egress and fire proofing features.

Specification

Opening, closing and stop are controlled by a radio controller or line controller. If meet obstacles during closing it will automatically opened and close in 10 seconds. The main difference between ordinary automatic door and the one we designed is that, the door has ability to count the number of people that goes in and those the comes out and it will allow only the number of people require to go in.

II. Experimental Procedure

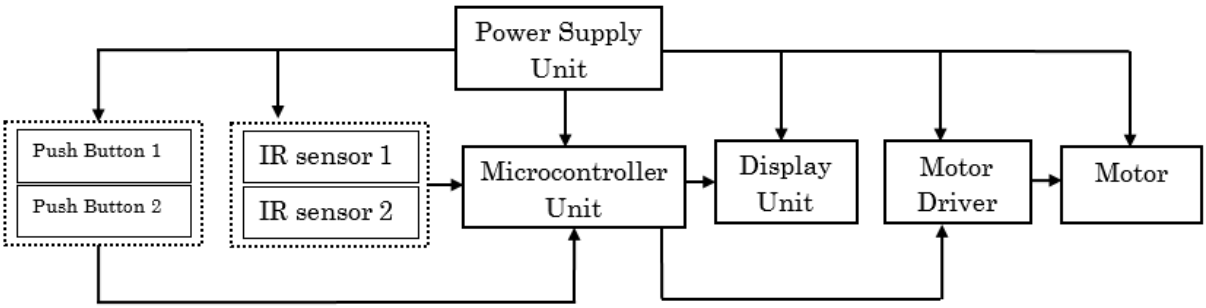

Figure 1.0 block diagram of automatic mass gathering restriction door, system.

1.1 The function of each block above is as stated below

- **The Power Supply Unit**: Power Supply Unit: supply a stable or fixed DC signal to the different section of the design (microcontroller, LCD display, IR transceiver, and buzzer)
- **The Microcontroller Unit**: is an electronic device that accepts process and executes data based on its internal programming. It was used in this project because of its versatility and durability.
- **IR Sensors Unit**: these are used in this project to detect the presence of human and sends signal to the microcontroller.
- **Push Buttons Unit**: these are used in to initialize the microcontroller to project to detect the presence of human and sends signal to the microcontroller.

- **Motor Driver Unit:** Motor Driver is an important part of the project as it is responsible for driving the motor of the door either to open or close the door.
- **Display Unit**: 16 x 2 LCD is used to display ASCII character. LCDs have become a cheap and easy way to get text display for embedded system. The Common displays are set up as 16 to 20 characters by 1 to 4 lines.

1.2 **DESIGN ANALYSIS**

Introduction

This stage presented design procedure of the individual units of the circuit. Consideration is given to component manufacturer's specification after which circuit analysis tools were used to determine components values. Special symbols were used for representing electronics components connected together using lines representing conductors of negligible resistance to form a circuit diagram. The schematic diagram will however use to implement the circuit.

1.3 **Power Supply Unit**

It is basically consisted the following elements, transformer, rectifier, filter and regulator circuits. The most convenient and economic source of power is the domestic AC supply and the ability of the power supply to convert alternating voltage (usually $230v\ r.m.s$) to DC voltage (usually smaller in value) is called rectification and is accomplished with the help of a rectifier and voltage regulator circuit. These elements put together constitute DC power supply.

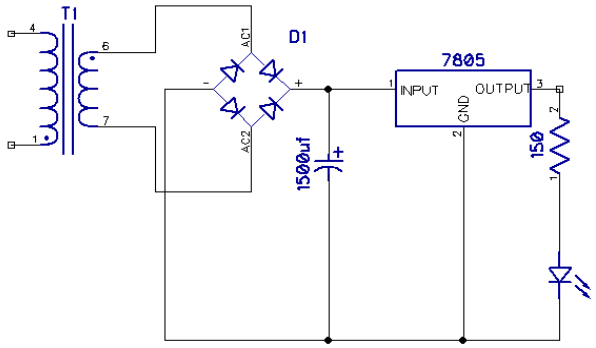

Figure 1.2 power supply circuit diagram

1.4 **Selection of Transformer**

The voltage requirement for the over speed detector using microcontroller ATMEGA328P-PU is 5 Volt DC. Therefore, 230V/9V 50Hz step down transformer was selected to power the circuit.

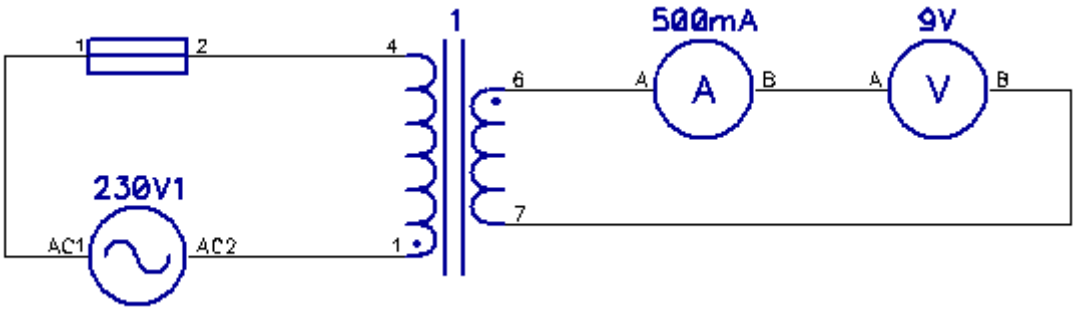

Figure 3.2 transformer circuit diagrams

2.1 **The Transformer Specification:**

Input Voltage= 230 VAC
Output Voltage (V_s) = 9 VAC
Current Rating (I_{rms}) = 500 mA
Frequency = 50Hz
The maximum voltage of the transformer is given by

$$V_{max} = V_s \times \sqrt{2} \qquad (2.1)$$

Where V_s is the voltage of the secondary winding of the transformer
Therefore,

$$V_{max} = 9 \times \sqrt{2} = 12.72$$

I_{max} is determined as follows

$$I_{max} = \sqrt{2} \times I_{rms} \quad (2.2)$$

Where I_{rms} is the root mean square current
Therefore,

$$I_{max} = \sqrt{2} \times 500 \times 10^{-3} = 707mA$$

However, the average DC value current can be determined from the equation below

$$I_{dc} = \frac{2I_{max}}{\pi} \quad (2.3)$$

Therefore,

$$I_{dc} = \frac{2 \times 707 \times 10^{-3}}{\pi} = 450mA$$

Similarly the Dc output voltage of the transformer is given by

$$V_{dc} = \frac{2V_{max}}{\pi} \quad (2.4)$$

Therefore, from equation 2.4

$$V_{dc} = \frac{2 \times 12.72}{\pi} = 8.10V$$

However, load resistance is given by

$$R_L = \frac{V_{dc}}{I_{dc}} \quad (2.5)$$

Therefore,

$$R_L = \frac{8.10}{0.45} = 18\Omega \quad (2.6)$$

2.2 **Rectifier Diode's Selection**

Bridge rectifying arrangement was employed here in order to get full cycle wave shape. Peak inverse voltage (PIV) and forward current are the two major parameters to be considered when a diode is employed for rectification purpose.
The output of a bridge rectifier circuit is given by

$$V_{rec} = V_{max} - 2V_f \quad (2.7)$$

Where,
V_{rec} Is the rectifier voltage and V_f is forward drop of a diode (about 0.7V for silicon diode)
From equation 3.7

$$V_{rec} = 12.73 - 2 \times 0.7 = 11.33V$$

For full wave bridge rectifying circuit, peak inverse voltage (PIV) is giving by

$$PIV = V_{max} + V_f \quad (2.8)$$

Where V_f is forward drop of a diode (about 0.7V for silicon diode)
Therefore, from equation 2.7

$$PIV = 12.73 + 0.7 = 12.08V$$

It is usually considered safer to select a diode that has reverse break action voltage of at least 50% greater than the expected PIV
From the above fact, the cheapest available rectifier KBP310 having a PIV of 50V was chosen for rectification.

2.3 **Filter Capacitor**

The simplest way to eliminate ripples in power supply unit is used to shunt a capacitor across the output of rectifier so as to pass to ground harmonic contents.
The details of the shunted capacitor is given by

$$C = \frac{V_{av}}{\Delta V f_p R_l} \quad (2.9)$$

Where f_p is peak frequency (i.e twice supply frequency)
And f_p= 2f = 2 x 50 = 100Hz
ΔV= differential voltage
$\Delta V = V_{av} - V_{min}$=16.25 - 7.5=8.75v
Therefore,

$$C = \frac{16.25}{8.75 \times 100 \times 18} = 0.001032 = 1032\mu f$$

However, the nearest standard value of 1500µf 16V capacitor is selected for the filtration action.

2.4 **Voltage Regulator**

Voltage regulator is fabricated into the form of an integrated circuit which is capable of providing a nearly constant DC output voltage. In this project work, positive 5V regulator (LM7805) was used to provide +5V DC voltage to the circuit and to improve stability of the circuit. The selected voltage regulator has the following electrical specifications.

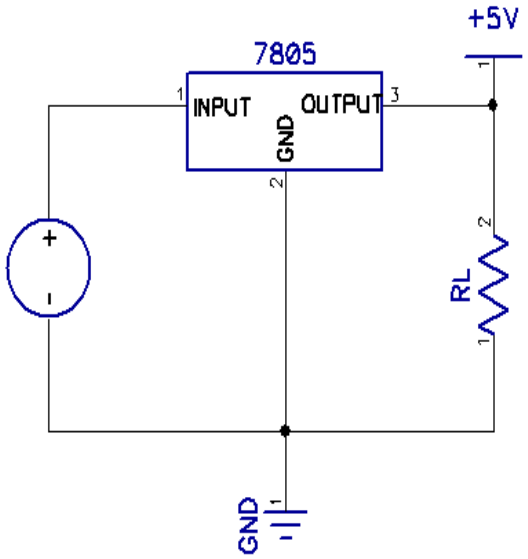

Figure 2.1 voltage regulator circuit

From the data sheet of voltage regulators, LM7805 has the following specifications;
Minimum input voltage (V_{min}) = 7.0V
Maximum input (V_{max}) = 25.0V
Therefore, the average DC voltage is given by

$$V_{av} = \frac{V_{max} + V_{min}}{2} \qquad (2.11)$$

Where V_{max} and V_{min} are the maximum and minimum voltage of the regulator.
Using equation 3.9 above

$$V_{av} = \frac{25 + 7.0}{2} = 16.0V$$

2.5 **Indicating Unit**

This comprises of an LED which is used as a means of indicating a powered circuit. However when an LED is powered by a voltage source greater than 2V there is need to connect a resistor in series with the diode so as to limit the amount of current flowing in such a diode.

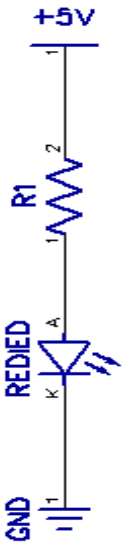

Figure 2.2 Power indicator circuit

The value of series resistor is given by

$$R1 = \frac{V_{in} - V_{led}}{I_{led}} \qquad (2.12)$$

Where,
LED colour = Red
LED size = 5mm
V_{led} Is forward voltage = 2.0V
I_{led} Is forward current =20mA
From equation 3.10

$$R1 = \frac{5-2}{20\times10^{-3}} = 150\Omega$$

3.1 **Microcontroller Stage**

An ATmega328 is a microcontroller chip found on Arduino Uno boards. ATmega328 microcontrollers are from the 8-bit AVR microcontroller family. The creators of the AVR give no definitive answer as to what the term "AVR" stands for. However, it **is** commonly accepted that AVR stands for Alf and Vegard's RISC processor. Note that the use of "AVR" in this article generally refers to the 8-bit RISC line of Atmel AVR Microcontrollers. Microcontrollers can take inputs from the device they controlling and retain control by sending the device signals to different parts of the device. ATmega 328 has 1KB Electrically Erasable Programmable Read Only Memory (EEPROM). This property shows if the electric supply supplied to the micro-controller is removed, even then it can store the data and can provide results after providing it with the electric supply. Moreover, ATmega-328 has 2KB Static Random Access Memory (SRAM).

ATmega 328 has several different features which make it the most popular device in today's market. These features consist of advanced RISC architecture, good performance, low power consumption, real timer counter having separate oscillator, 6 PWM pins, programmable Serial USART, programming lock for software security, throughput up to 20 MIPS etc. It operates ranging from 3.3V to 5.5V but normally we use 5V as a standard.

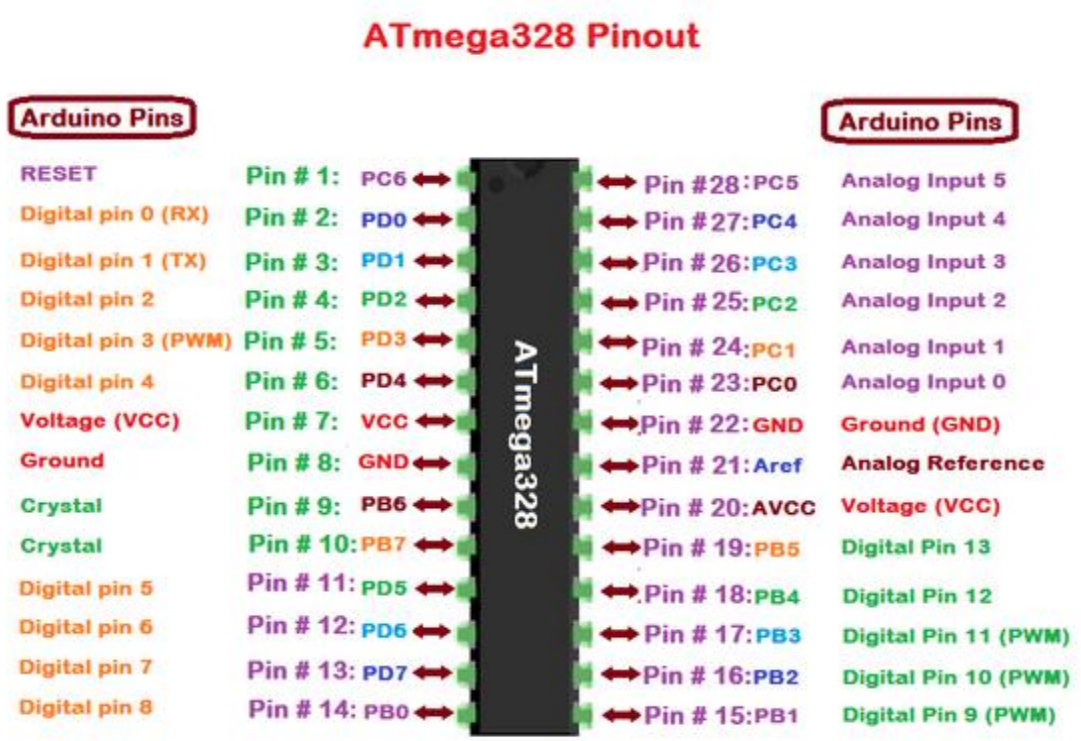

Figure 3.1 Pictorial Diagram of AT mega 328-PU

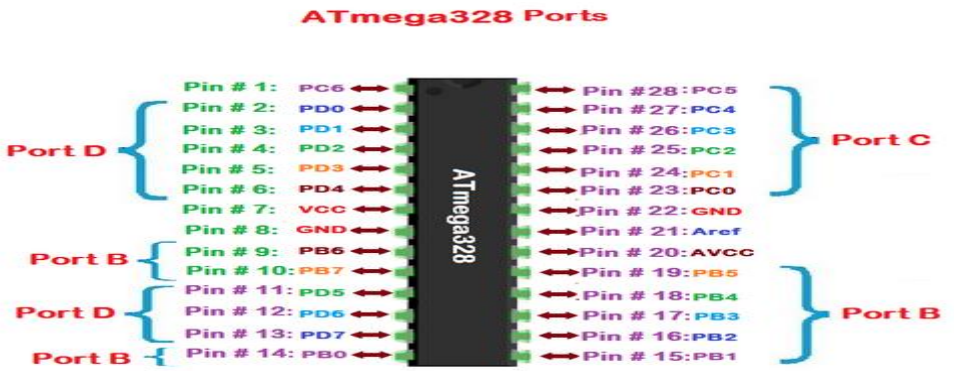

Figure 3.2 ATmega Port Division Diagram

Features:

- ✓ Atmega328 has 28 pins in total.
- ✓ It has 3 Ports in total which are named as Port B, Port C and Port D.
- ✓ Port C is an analogue Port and it has six pins in total. So, in simple words, ATmega328 has 6 analogue pins.
- ✓ Port B and Port D are digital ports and have 7 pins each.
- ✓ So, in total ATmega328 have 14 digital pins.
- ✓ It also supports Serial Communications, we can perform serial communication via Pin # 2 (RX) and Pin # 3 (TX).
- ✓ It also supports SPI Protocol.
- ✓ It needs a crystal oscillator for generating the frequency. You can use crystal oscillator ranging from 4MHz to 40 MHz
- ✓ Arduino UNO board uses 16MHz crystal oscillator.

3.2 **Display Stage (LCD 16x2)**

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

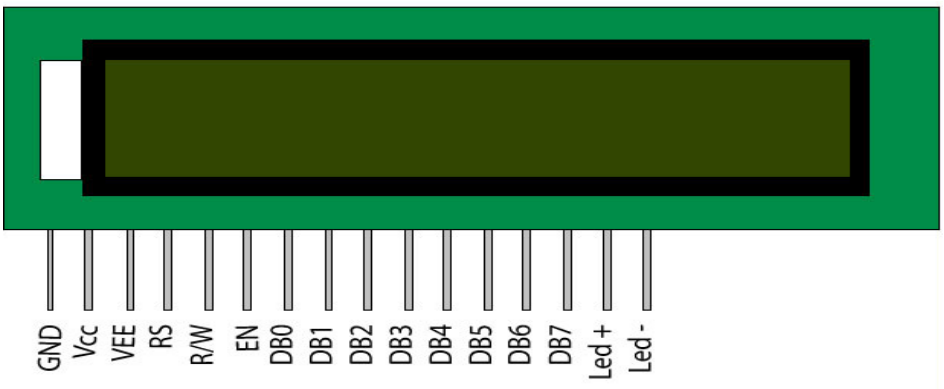

Figure 3.3 Pin diagram of LCD
http://circuitdigest.com/microcontroller-projects/automatic-door-opener-project

Pin Description:

Table 3.1 pin description of LCD

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

3.3 **Infrared Transceiver Module**

This Infrared obstacle/object detection sensor is super easy to use. It comes with on board potentiometer to adjust the sensitivity. The output is digital signal so it is easy to interface with any microcontroller such as Arduino/Genuino UNO, Mega, Leonardo, Zero, even the Raspberry Pi or Raspberry Pi Zero. And of course it is also compatible with all other controller boards out there including CIKU, CT-UNO, CT-ARM, etc. This Infrared sensor offers simple, user friendly and fast obstacle detection via infrared reflection, it is non contact detection. As it is based on light reflection, the detection does vary with different surface. And any infrared source might also interfere the detection

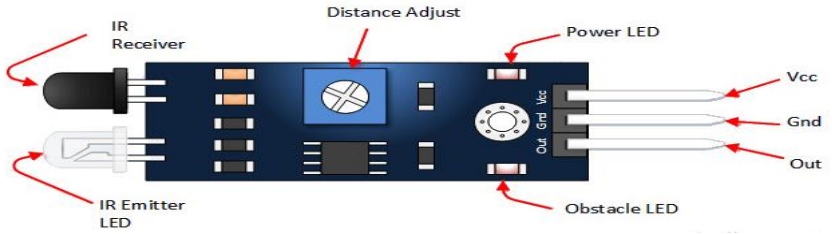

Figure 3.4 pictorial diagram of IR module
http://circuitdigest.com/microcontroller-projects/automatic-door-opener-project

It comes in a pair of Infrared emitter and receiver at the front of module, whenever there is object blocking the infrared source, it reflects the infrared and the receiver get it and the signal go through a comparator circuit on board. And depending on the threshold that being adjusted, it will output logic LOW at output pin and the green LED will light up to indicate the detection. Turning the on board potentiometer clock wise will increase the sensitivity and further increase the detection range. Compatible with 5V or 3.3V power input.

3.4 **Features:**

- Input Power: 3.3V or 5VDC.
- 3 pin interface which are OUT, GND and VCC:
- OUT is digital output pin from sensor module.
- GND is where you connect to your controller ground, or 0V.
- VCC is the +ve supply, connect to either +3.3V or +5V.
- Two LED indicators, one (Red) as power indicator, another (green) as object detection indicator.
- Obstacle detection range: 2cm to 10cm
- Adjustable sensitivity with on board potentiometer, this translates to adjustable detection range.
- Detection angle: 35 degree
- Small size makes it easy to assembly.
- Single bit output.

- Compatible with all types of microcontrollers.
- Dimension: 3.1cm x 1.5cm

3.5 **Motor Driver IC (L293D)**

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction**.** L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC. Dual H-bridge Motor Driver integrated circuit (IC). The motor draws a much higher current. Connecting directly will result in not working motor and destroying the microcontroller due to high currents. Drivers are not used only for motors. They are used for any device that usually draws more than 50-100 mA. L293D IC generally comes as a standard 16-pin DIP (dual-in line package). This motor driver IC can simultaneously control two small motors in either direction; forward and reverse with just 4 microcontroller pins (if you do not use enable pins).

Specifications

- Supply Voltage Range 4.5V to 36V.
- 600-mA Output current capability per driver.
- Separate Input-logic supply.
- It can drive small DC-geared motors, bipolar stepper motor.
- Pulsed Current 1.2-A per Driver.
- Thermal Shutdown.
- Internal ESD Protection.
- High-Noise-Immunity Inputs.

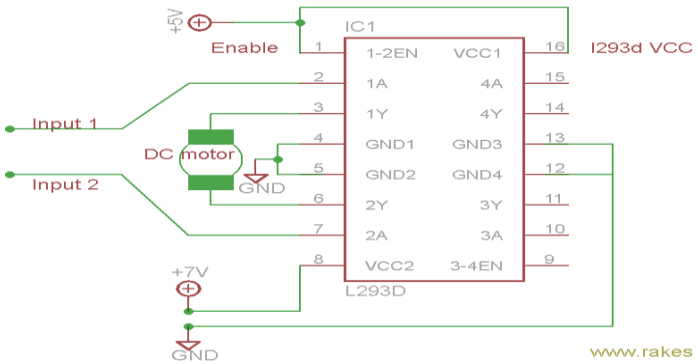

Figure 3.4 motor driver circuits

3.6 Pin No**.**

- **1 - Enable 1-2**: when this is HIGH the left part of the IC will work and when it is low the left part won't work.
- **2 - INPUT 1**: when this pin is HIGH the current will flow though output 1
- 3 - **OUTPUT 1**: this pin should be connected to one of the terminal of motor
- **4,5 – GND**: ground pins
- **6 - OUTPUT 2**: this pin should be connected to one of the terminal of motor
- **7 - INPUT 2**: when this pin is HIGH the current will flow though output 2
- **8 - VCC2**: this is the voltage which will be supplied to the motor.
- **16 - VCC1**: this is the power source to the IC. So, this pin should be supplied with 5 V
- **15 - INPUT 4**: when this pin is HIGH the current will flow though output 4
- **14 - OUTPUT 4**: this pin should be connected to one of the terminal of motor
- **13,12 - GND**: ground pins
- **11 - OUTPUT 3**: this pin should be connected to one of the terminal of motor
- **10 - INPUT 3**: when this pin is HIGH the current will flow though output 3
- **9 - Enable 3-4**: when this is HIGH the right part of the IC will work and when it is low the right part won't work.

L293D Logic: Let's consider a Motor connected on left side output pins (pin 3,6). For rotating the motor in clockwise direction the input pins has to be provided with Logic 1 and Logic 0.

• **Pin 2** = Logic 1 and **Pin 7** = Logic 0 **|** Clockwise Direction

• **Pin 2** = Logic 0 and **Pin 7** = Logic 1 **|** Anticlockwise Direction

• **Pin 2** = Logic 0 and **Pin 7** = Logic 0 **|** Idle [No rotation]
• **Pin 2** = Logic 1 and **Pin 7** = Logic 1 **|** Idle [No rotation]

3.7 **DC Motor**

DC motor is one type of motor that uses the DC current to convert electrical energy into mechanical energy. When the electric current passes through a coil in a magnetic field, a magnetic force will be generated, this produces a torque in the DC motor.

3.8 M**otor Specifications**

- Standard 130 Type DC motor
- Operating Voltage: 4.5V to 9V
- Recommended/Rated Voltage: 6V
- Current at No load: 70mA (max)
- No-load Speed: 9000 rpm
- Loaded current: 250mA (approx)
- Rated Load: 10g*cm
- Motor Size: 27.5mm x 20mm x 15mm
- Weight: 17 gram

3.8 **Conclusion**

This door access control with bidirectional counter can be implemented by using a simple microcontroller and IR technologies. This research is will be very helpful in public buildings such as banks, offices, schools and colleges. "automatic mass gathering restriction door" as the name specifies that it controls the task of counting the number of individuals and automatically grant access to building when the numbers of people require in the building is less than they require but once the number of people require has been archived it automatically deny access to the building with accuracy.

3.9 **Recommendations**

Based on this study, the following recommendations have been made:
Entire system should be incorporated with auxiliary power supply source e.g. solar power system, thus, this guarantees constant supply of power to the main circuit, in order in increase the reliability of the entire system.
It is also possible to add a GSM modem to this project for knowing the status of the equipment and to control it accordingly through an SMS to perform the remote operations as well.
Emergency exit for the building using this door should be provided in case of any malfunctioning of the system.

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