PBL PROJECT REPORT ON

MOTION DETECTING STREET LAMP WITH GAS DETECTING SMART STREET SYSTEM

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UNDER THE GUIDANCE OF

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IN PARTIAL FULFILLMENT OF

S. E (ELECTRONICS & TELECOMMUNICATION)

DEGREE OF SAVITRIBAI PHULE PUNE UNIVERSITY

MAY/JUNE 2021

DEPARTMENT OF ELECTRONICS & TELECOMMUNICATION ENGINEERING

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ACKNOWLEDGEMENT

First and foremost we would like to thank our principal **Dr. Pramod Patil (sir)** for giving us such a great opportunity to explore such a wonderful project due to which we came across many new learnings and acquired a great deal of knowledge.

Secondly, we are extremely grateful to our external guide and our PBL guide **Mrs. Priti Shende (ma'am)**, for their invaluable advice and continuous support. Their immense knowledge and plentiful experience have encouraged us throughout the project.

Now, we would also like to thank our Head of the Department, **Dr. Bhavna Ambudkar (ma'am)**, for her technical support and our co-guides **Mrs. Nilakshee Rajule (ma'am)**, and **Dr. Jyoti Gangane (ma'am)**, and all the other teaching and non-teaching staffs for their continuous support to our project. It is due to their kind help and support that made our project a successful one.

Finally, we would like to express our gratitude to our parents without whose tremendous understanding and encouragement in the past few years it would have been impossible for us to complete the project and team-mates whose support and guidance helped and encouraged us to complete our project within the limited time frame.

Thank You…

CONTENTS

ABSTRACT

Now-a-days the amount of power consumed by lighting and streets share a major energy demand. During night all street lights will be on in conventional energy street lighting system. To overcome from this issue, a proper energy saving method and light control to be implemented. The proposed work is to have controls like to switch OFF light during no vehicle movements in street and automatically switch it ON when vehicle arrives. In this work LED lights are used for street arrangements, the Photodiodes and IR sensors are used to sense vehicle movement from the proposed method the overall energy being utilized nowadays for lighting can be minimized.

This project can be used to detect gas leaks and also smoke. Smoke detector circuit which not only sense the smoke in the air but also reads and displays the level of smoke in the air in PPM. The circuit triggers the alert system when smoke or gas leakage is detected. This MQ5 gas sensor is sensible to LPG, alcohol, methane etc. Methane, iso-butane, propane, LNG and cigarette smoke. It detects the presence of a dangerous LPG leak in a car or in a service station, storage tank environment. The sensor has excellent sensitivity combined with a quick response time. If it senses gas leakage from the storage the output goes low.

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADC: Analog to Digital Converter
CO: Carbon Monoxide
CONT.: Count
DC: Direct Current
ESP: Electronic Stability Control
IAES: Institute of Agriculture and Environmental Science
IC: Integrated Circuit
IEEE: Institute of Electrical and Electronics Engineers
IOT: Internet of Things
IR: Infrared Radiation
LDR: Light Dependent Resistor
LED: Light Emitting Diode
LPG: Liquefied Petroleum Gases
LNG: Liquefied Natural Gas
MAX: Maximum
MIN: Minimum
NI: National Instruments
NTC: Negative Temperature Coefficient
OPAMP: Operational Amplifier
PPM: Parts Per Million
PTC: Positive Temperature Coefficient
RAM: Random Access Memory
ROM: Read Only Memory
RTEICT: Recent Trends in Electronics, Information & Communication Technology
UART: Universal Asynchronous Receiver-Transmitter

CHAPTER 1 INTRODUCTION

1.1 Introduction

This paper shows the design to detect the vehicle movement on roadways to switch ON just a block of road lights in front of it, and to turn OFF the trailing lights to save energy. It also consists of gas and smoke detection system. During night each one of the lights on the expressway stay ON for the vehicles, yet loss of power is experienced when there is no vehicle movement. This proposed framework satisfactorily works for energy saving. This is accomplished by detecting a vehicle moving towards the street and turns ON a block of street lamps in front of the vehicle. As the vehicle moves forward by, the trailing lamps turn OFF on its own. By doing this, a considerable amount of power is saved.

Nowadays, security has been affected by different types of matters. Gas leakage and fire incidents are considered among them. At present, there are many undesirable accidents from gas leakage and fire incidents. One way to prevent accidents involving gas leakage and fire incident detection is to affix a gas leakage and fire incident detection device at adequate places. Indeed, when the gas leakage or fire incident occurs, then the temperature can be increased naturally. Gas leakage and detection of gas leakages and harmful gases in and around industries and can be effectively handled by using sensors and automation using IoT. Here we developed a basic model for detection of harmful gases and measurement of harmful gases on a self-calibrated ppm scale

1.2 Problem Statement

How to deal with the energy being consumed by street lights that glows overnight and dangerous accidents that occur due to gas and smoke leakages on roads?

1.3 AIM AND OBJECTIVES

Aim: The main aim of a new smart street lighting system is to control energy efficient LED street lights to turn on only when needed and smartly detect smoke leakages on street.

Objectives:

- To reduce consumption of electricity by street lamps
- To efficiently use the resources of our planet
- To alert officials regarding any gas leakages on streets
- To make our life more comfortable and eco friendly

CHAPTER 2: LITERATURE SURVEY

PAPER 1:

Title: Automatic Street Light Control by Detecting Vehicle Movement
Author: Yashaswini N, Raghu N, Yashaswini S, Prathib Kumar G
Publication: IEEE
Year of Publication: 2018
"This paper presents the design of a smart street light that glows on detection of vehicle movement. When vehicle movement is detected then the lights are switched ON while as when no movement is detected, the lights remain switched OFF. LED lights are used for street arrangement, the Photo diodes and IR sensors are used to sense vehicle movements. The control signals of sensors are being fed to microcontroller 8051."

PAPER 2:

Title: Smart Power Consumption Street Light That Glows On Detecting Vehicle Moment Utilizing The Solar Power –An Energy Saving Approach
Author: Mihir Ranjan Acharya, Madhusmita Priyardahni, S K Sabir, Udaya Kumar Sahoo
Publication: IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
Year of Publication: 2015
"This project is all about to control the electric power consumptions Street Lights and eliminating manpower. The project is designed to detect vehicle movement on street to switch ON only a block of street lights ahead of it (vehicle), and to switch OFF the trailing lights to save energy. During night all the lights on the street remains ON for the vehicles, but lots of energy is wasted when there is no vehicle movement. For auto power consumption when there is no vehicle on the Street Light this includes controlling a circuit of street lights with NE555P, specific IR Sensors & Light Dependent Resistor (LDR) is a type of sensor which actually does this work and senses the light as our eyes does. As soon as the sunlight comes, visible to our eyes it automatically switches OFF lights .Total process operation in Solar Power."

PAPER 3:

Title: Toxic gas detection and monitoring utilizing internet of things
Author: Chalasani Srinivas_Mohan Kumar Chandol
Publication: Research Gate
Year of Publication: 2017
"Harmful gas leakage accidents are the main reason for workers death in industries which work mainly using chemicals. Gas leakage can be easily detected and controlled by using latest trends in information technology by applying internet of things. This project intended to avoid industrial accidents and to monitor harmful gases and to intimate alert message to safety control board of industry using Arduino Uno R3 and internet of things. Ardunio Uno R3 board is used as central microcontroller which is connected with sensor. Such as temperature, gas sensor, alcohol sensor which can continuously monitor respective environmental parameters. Hence this device may be used as multi gases detection apparatus more over the rate of response is high. An alarm is produced instantly if the level of the gases goes above the normal level means indication through the internet specific receiver section. Data received by sensor is stored in internet which can be used for further processing and it can be analyzed for improving safety regulations. This model can be future extended for providing better living environment for people in and around industries with a pollution controlled environment"

PAPER 4:

Title: Comparison of ESP programming platform.

Author: Filip Rak, Józef Wiora

Publication: IAES Computer Science and Technologies

Year of Publication: 2021

"The growing popularity of ESP boards has led to the development of several programming platforms. They allow users to develop applications for ESP modules in different programming languages, such as C++, C, Lux, Micro Python, or using AT Commands. Each of them is very specific and has different advantages. The programming style, efficiency, speed of execution, level of advancement, or memory usage will differ from one language to another. Users mostly base their choice depending on their programming skills and goals of the planned projects. The aim of this work is to determine, which language is the best suitable for a particular user for a particular type of project. We have described and compared the mentioned languages. We have prepared test tasks to indicate quantified values. There is no common rule because each of the languages is intended for a different kind of user. While one of the languages is slower but simpler in usage for a beginner, the other one requires broad knowledge but offers availability to develop very complex applications."

PAPER 5:

Title: IOT based Air Quality Monitoring System using MQ135 and MQ7 with Machine Learning Analysis.

Author: Kinnera Bharath Kumar Sai, Somula Rama Subbareddy, Ashish Kumar Luhach

Publication: Scalable Computing: Practice and Experience

Year of Publication: 2019

"This paper deals with measuring the Air Quality using MQ135 sensor along with Carbon Monoxide CO using MQ7 sensor. Measuring Air Quality is an important element for bringing awareness to take care of the future generations and for a healthier life. Based on this, Government of India has already taken certain measures to ban Single Stroke and Two Stroke Engine based motorcycles which are emitting high pollution. We are trying to implement a system using IoT platforms like Things speak or Cayenne in order to bring awareness to every individual about the harm we are doing to our environment. Already, New Delhi is remarked as the most pollution city in the world recording Air Quality above 300 PPM. We have used easiest platform like Things speak and set the dashboard to public such that everyone can come to know the Air Quality at the location where the system is installed. Machine Learning analysis brings us a lot of depth in understanding the information that we obtained from the data. Moreover, we are proving a reducement of the cost of components versus the state of the art."

Paper	Technology/Methodology Used	Advantages	Limitations
[1]	**Microcontroller 8051**	The implemented model is a less cost, pragmatic, eco-friendly and the most secure approach to save energy.	The initial investment cost and erection may be the disadvantage.

[2]	**Utilizes solar power**	Complete elimination of manpower Reduced energy costs Reduced maintenance costs Higher community satisfaction Higher security aspects Fast payback	Initial costs can be more.
[3]	**Arduino Uno R3 board is used as central microcontroller**	In this work a clever framework for toxic gas and radiation discovery checking cautioning has been created to defeat the drawback looked in more established techniques by utilizing Wi-Fi module and web of things.	Complicated model.
[4]	**ESP**	It brings information for new users about efficiency and also allows the comparison of the particular language. The users of the microcontrollers can be categorized by their knowledge and their developing experience. It is also easy to get started working with these languages, which is desired by beginner users.	This platform is desired for users who want to create more complex applications but during conducting the benchmarks we also got unpredictable working and crashes. The users should stay aware and use LFS for official releases of the applications.

[5]	**IOT based Air Quality Monitoring System using MQ135 and MQ7 with Machine Learning Analysis**	This project can be used both for indoor as well as outdoor. In this IoT project, one can monitor the pollution level from anywhere using a computer or a mobile	The problem with MQ135 sensor is that specifically it cannot tell the Carbon Monoxide or Carbon Dioxide level in the atmosphere.

CHAPTER 3. SYSTEM SPECIFICATION & BLOCK DIAGRAM

2.1 Block Diagram

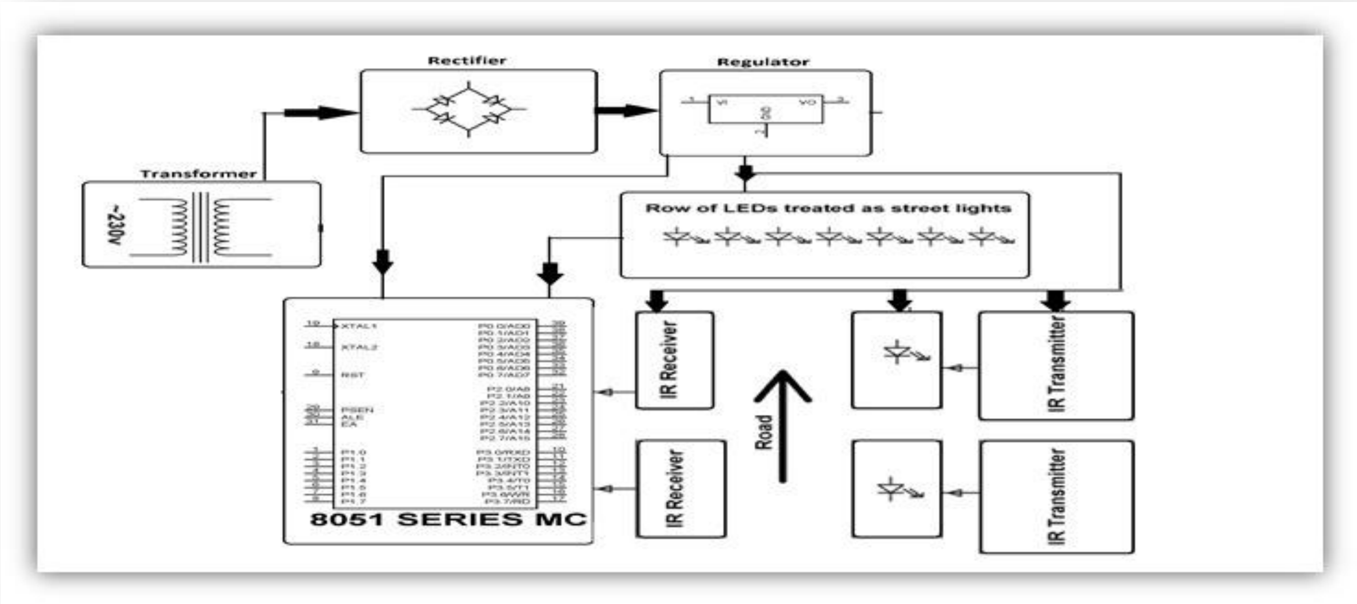

Fig 1 Block Diagram of ‘Motion Detecting Street Lights’.

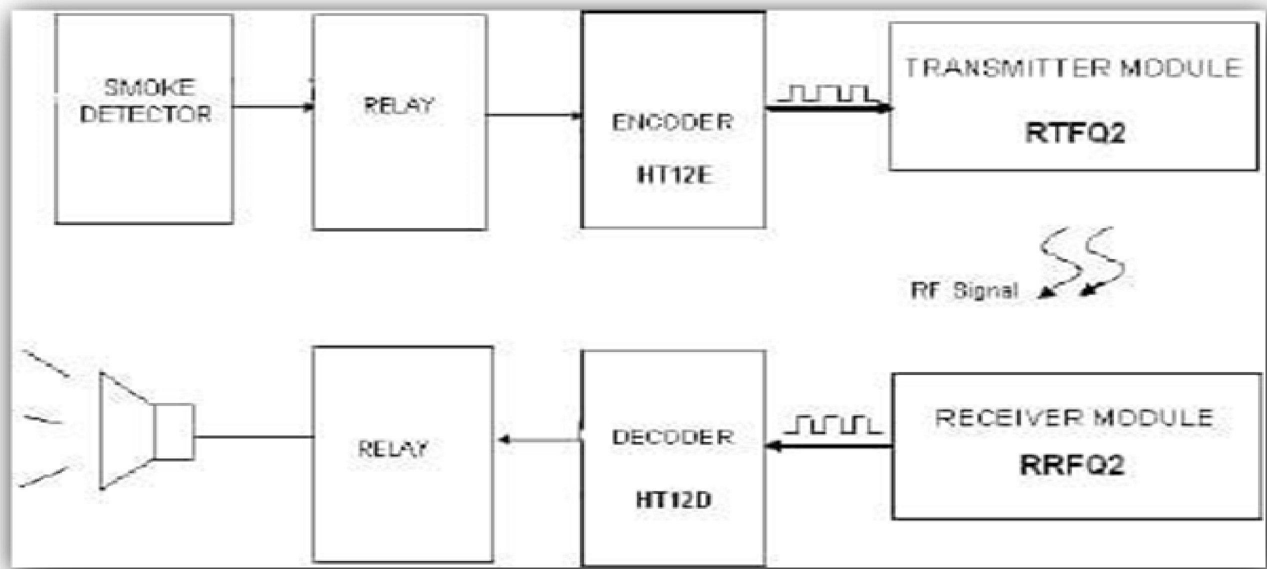

Fig 2 Block Diagram of ‘Gas and Smoke Detector System’

2.1SYSTEM SPECIFICATION

MOTION DETECTING STREET LIGHTS:

In this work, the LED lights are used for street arrangement, the Photo diodes and IR sensors are used to sense vehicle moments. The infrared diodes are set on side of the street and photodiodes are set on the opposite side of the street straight forwardly confronting IR diodes. The control signals of sensors have been fed to microcontroller 8051.

GAS AND SMOKE DETECTOR SYSTEM:

- **MICROCONTROLLER:** It is the heart of the project. It is used to control the LED and Buzzer when LPG leakage occurs. The input/ output ports of the microcontroller are used for this purpose.
- **MQ-6 LPG SENSOR:** This sensor is used to sense the leakage of LPG. In normal conditions the output of this sensor is 'high' and it goes 'low', when the LPG is sensed.
- **Buzzer:** The leakage of the LPG is indicated by using the buzzer. It is 12 V DC operated buzzer.
- **LED:** The leakage of the LPG is indicated by using the LED. It is 1.2 V DC operated LED

CHAPTER 4: CIRCUIT DIAGRAM AND KEY COMPONENTS

4.1 Circuit Diagram

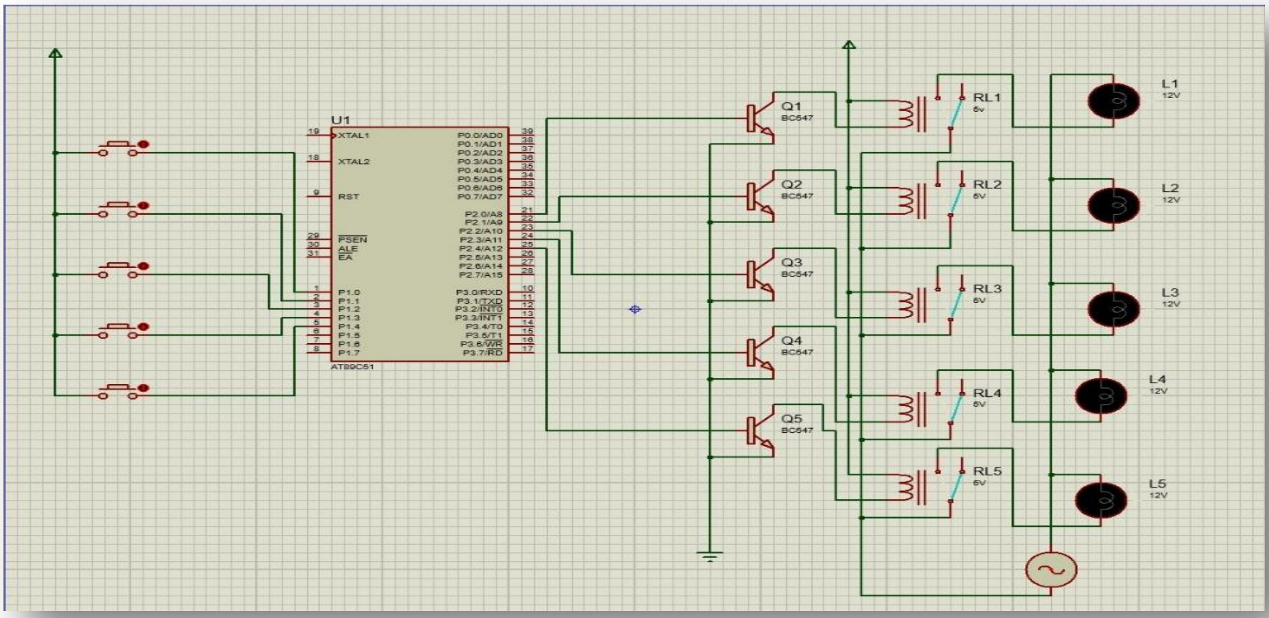

Fig 3.1: Circuit Diagram of ‘Motion Detecting Street Lights’ using 8051 Microcontroller implemented on Proteus 8 Professional software.

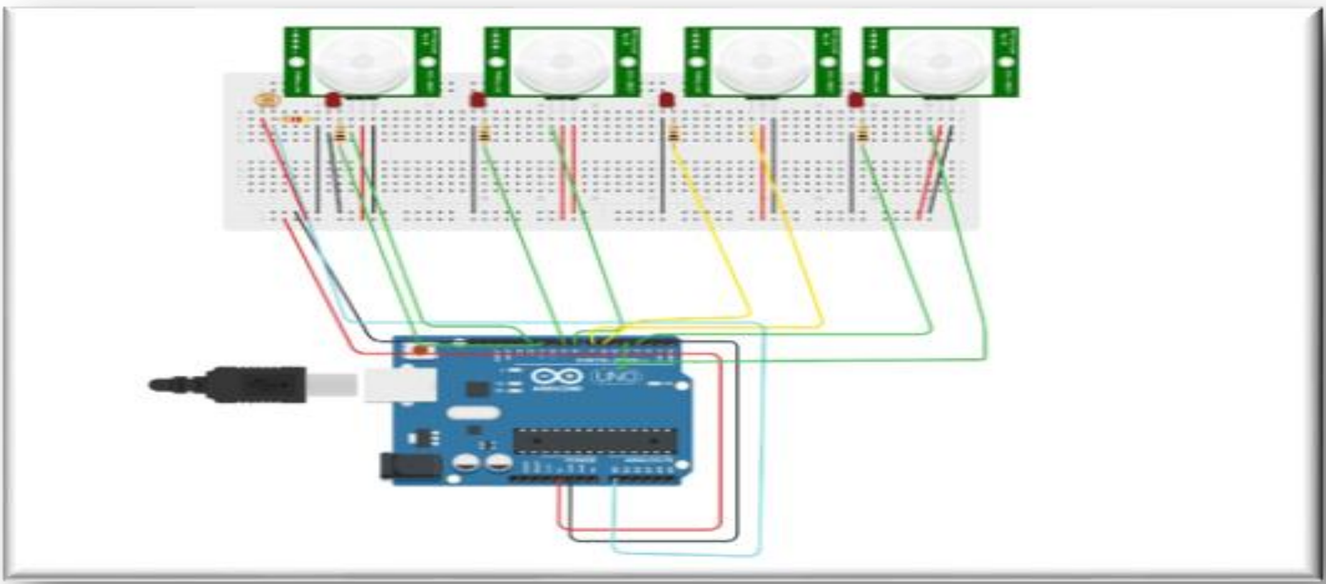

Fig 3.2: Circuit Diagram of ‘Motion Detecting Street Lights’ using Arduino Uno R3 implemented on Tinkercad.

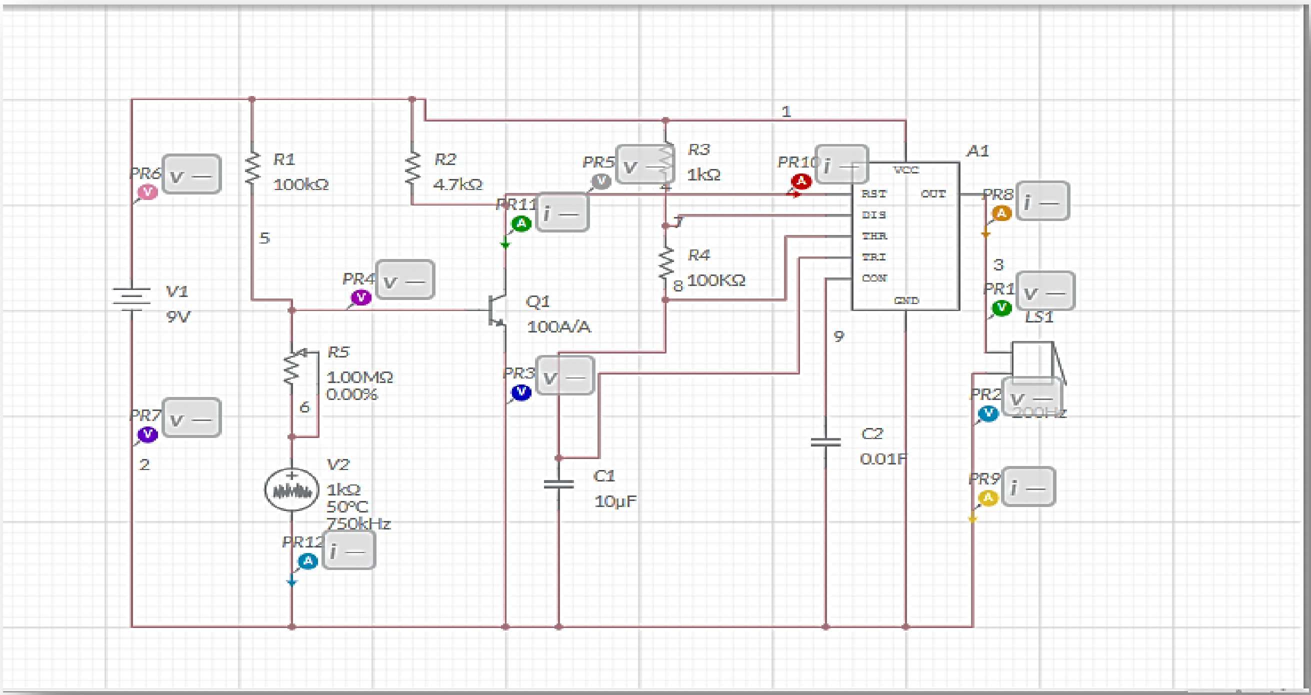

Fig 4.1: Circuit Diagram of ‘Gas and Smoke Detector System’ using Timer IC555 implemented on NI Online Multisim software

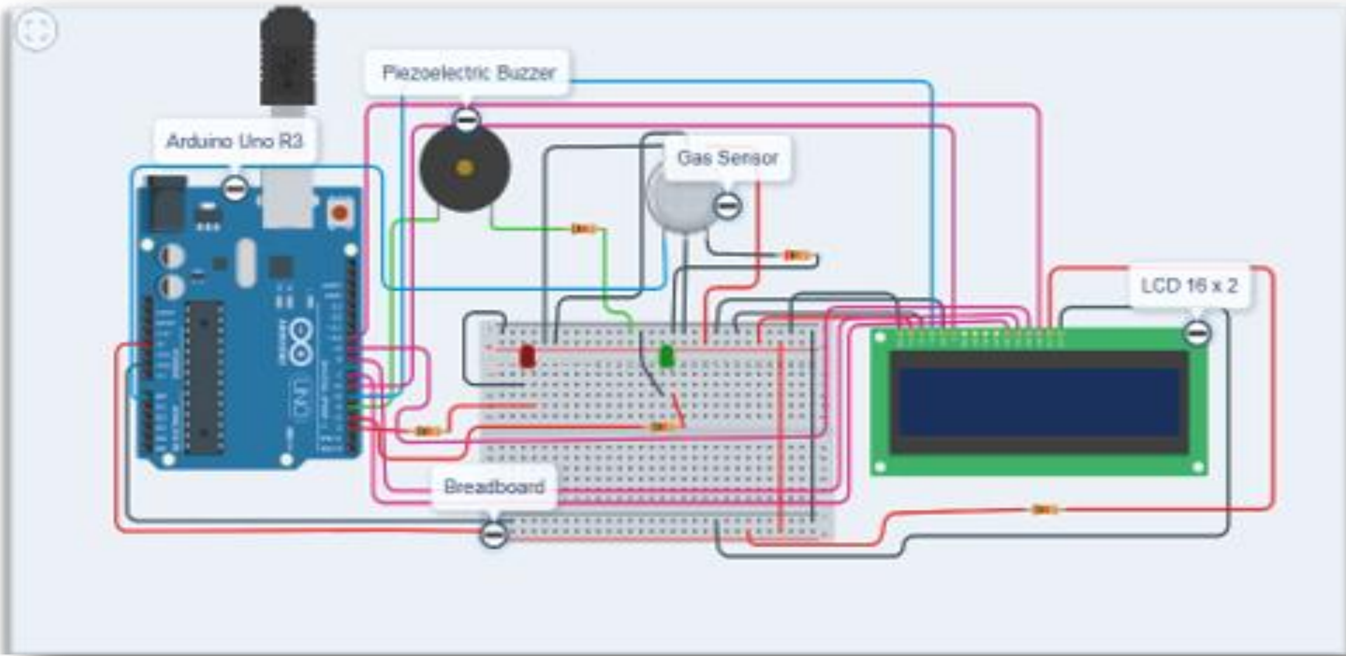

Fig 4.2: Circuit Diagram of ‘Gas and Smoke Detector System’ using Arduino UNO R3 implemented on Tinkercad.

4.2: Key Components:

Arduino UNO R3:

a. Board: UNO
b. Operating voltage:5 volts
c. Usable pins:A0 to A5
d. Max resolution:10 bits
e. Time taken to read the data:100 microseconds (0.0001 s)
f. Minimum reading rate:10,000 times a second

8051 Microcontroller:

a. 4KB bytes on-chip program memory (ROM)
b. 128 bytes on-chip data memory (RAM)
c. Four register banks
d. 128 user defined software flags
e. 8-bit bidirectional data bus
f. 16-bit unidirectional data bus
g. 32 general purpose registers each of 8 bit
h. 16 bit Timers (usually 2, but may have more or less)
i. Three internal and two external Interrupts
j. Four 8-bit ports, (short model have two 8-bit ports)
k. 16-bit program counter and data pointer
l. 8051 may also have a number of special features such as UARTs, ADC, Op-amp, etc.

Piezoelectric buzzer:

a. Minimum Operating Voltage: 4.2v
b. Rated Current (A): 0.02
c. Insulation Resistance (MΩ): 100
d. Mass (g): 25
e. Operating Voltage Range (V): 5-8
f. Operating Temperature Range (°c): -20-60
g. Rated Voltage (V): 24

LCD 16x2:

a. No. Of pins: 16
b. The operating voltage of this LCD is 4.7V-5.3V
c. It includes two rows where each row can produce 16-characters.
d. The utilization of current is 1mA with no backlight
e. Every character can be built with a 5×8 pixel box
f. The alphanumeric LCDs alphabets & numbers
g. Is display can work on two modes like 4-bit & 8-bit
h. These are obtainable in Blue & Green Backlight

PIR Motion Sensor:

a. Input Voltage: Dc4.5V-20V
b. Static Current: <50uA

c. Output Signal: 0V/3V (Output high when motion detected)
d. Sensing Range: 7 meters (120 degree cone)
e. Delay time: 8s-200s (adjustable)
f. Operating Temperature: -15°C — +70°C
g. Dimensions: 24mm*32mm*25mm (Height with lens)
h. Weight: 6.6g

Timer 555 IC:

a. 555 Timer IC one of the most well-known and most utilized ICs ever.
b. This IC mainly used as a time delay, oscillator, and flip-flop element in different applications and projects.
c. The 555 timer IC has three different operating modes, these are astable modes, bistable modes, and monostable modes.
d. So, this IC output pin can produce rectangular pulses having a specific frequency.

Thermistor:

a. The thermistor is one type of variable resistor whose resistance change according to the change in temperature.
b. There are two types of temperature available one is the negative temperature coefficient (NTC) and another one is the positive temperature coefficient (PTC).
c. In this project, we will use the 10K negative temperature coefficient (NTC) thermistor.
d. Whose, resistance is increase when the temperature is decreased and resistance is decreased when the temperature is increasing.

MQ-6 Gas Sensor:

a. Operating Voltage is: +5V
b. Can be used to detect: LPG or Butane gas
c. Analog output voltage: 0V to 5V
d. Digital Output Voltage: 0V or 5V (TTL Logic)
e. Preheat duration: 20 seconds
f. No. Of pins: 4

Photo Resistor:

a. Max power dissipation: 200mW
b. Max voltage @ 0 lux: 200V
c. Peak wavelength: 600nm
d. Min resistance @ 10lux: 1.8kΩ
e. Max resistance @ 10lux: 4.5kΩ
f. Typ. Resistance @ 100lux: 0.7kΩ
g. Dark resistance after 1 sec: 0.03MΩ
h. Dark resistance after 5 sec: 0.25MΩ

Transistor (NPN) (BC547):

a. BC547 is an NPN Bipolar Junction Transistor.
b. This is normally used as a switch and amplifier.
c. In this circuit, the transistor is used as a switch.
d. The smaller amount of current applied at the base, it can control the larger amount of currents at the

collector and emitter.

LED (red):

a. Length: 5mm LED with a red lens.
b. Forward voltage: 2.0V rated
c. Forward current: 20mA.
d. Forward drop: 1.8-2.2VDC
e. Suggested using current: 16-18mA.
f. Luminous Intensity: 150-200mcd.

LED (green):

a. This is a very basic 5mm LED with a green lens.
b. Forward voltage: 2.0V rated
c. Forward current: 20mA.
d. Forward drop: 1.8-2.2VDC
e. Suggested using current: 16-18mA.
f. Luminous Intensity: 150-200mcd.

Resistor:

a. Have a worst case error of 0.1% - translating to a typical temperature error of 0.05 Celsius.
b. The resistors also change their resistance very little with temperature

Relay:

a. Contact current Max: 2A
b. Coil Voltage VDC Nom: 6V
c. Contact Voltage DC Nom: 60V
d. Coil Current: 33.3mA
e. Coil Resistance: 180Ω
f. Contact Configuration: SPDT
g. Coil Power Cont.: 200mW
h. Coil Type: DC
i. Relay Mounting: 10.1mm
j. External Width: 12mm
k. External Depth; 7.4mm

CHAPTER 5: SIMULATION SETUP AND EXPECTED OUTCOME

MOTION DETECTING STREET LIGHTS:

For circuit using Arduino UNO3, we did the simulation on **Tinkercad**

For circuit using Microcontroller 8052, we did the simulation on **Proteus 8 Professional** Software used:

Circuit Design – Proteus 8 Professional

Programming – Keil uVision

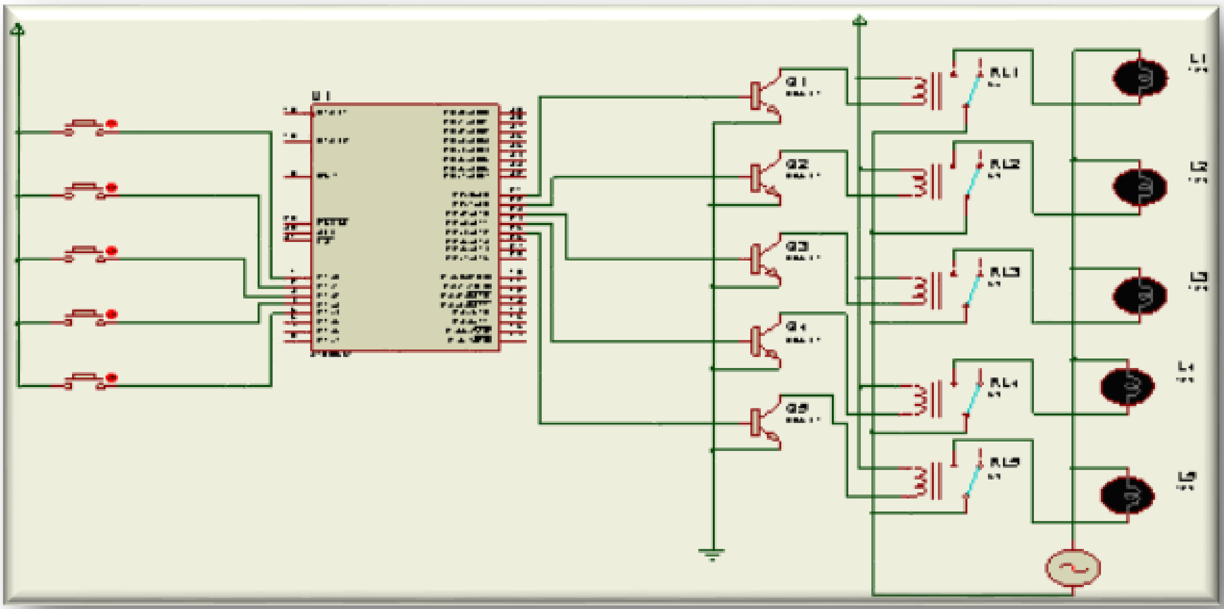

Fig 5.1: Simulation of 'Motion Detecting Street Lights' using 8051 Microcontroller on Proteus 8 Professional software.

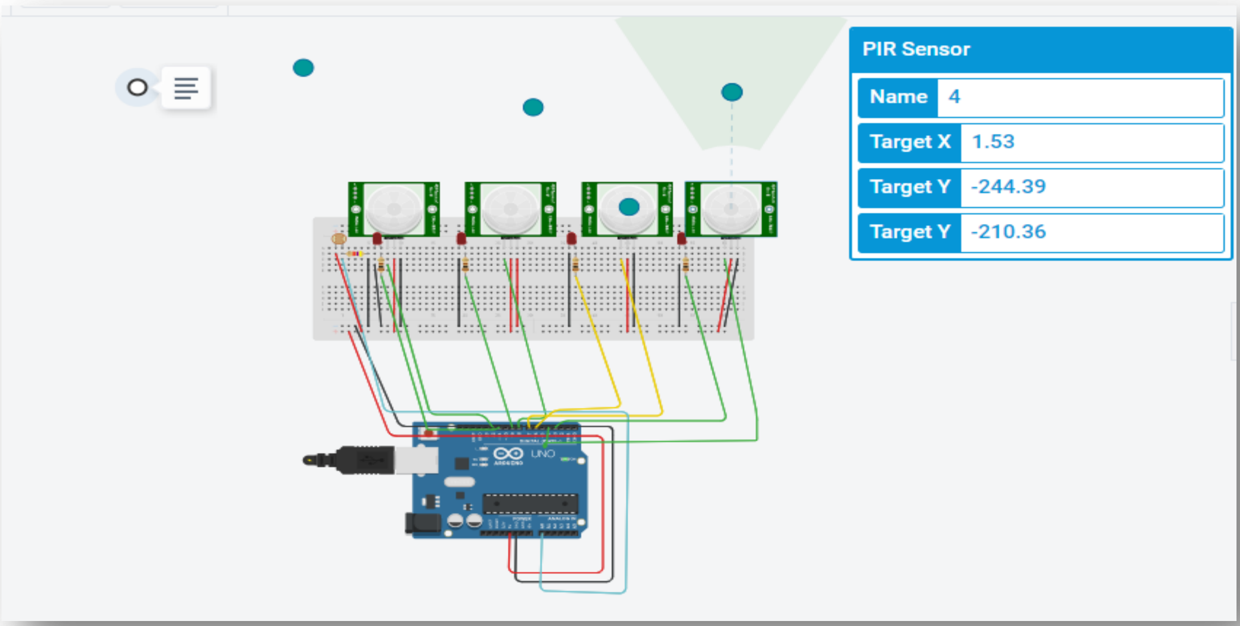

Fig. 5.2: Simulation of 'Motion Detecting Street Lights' using Arduino UNO R3 on tinkercad.

GAS AND SMOKE DETECTOR SYSTEM:

For circuit using Arduino UNO3, we did simulation on Tinkercad.
For circuit using Timer 555 IC, we did simulation on NI Online Multisim.

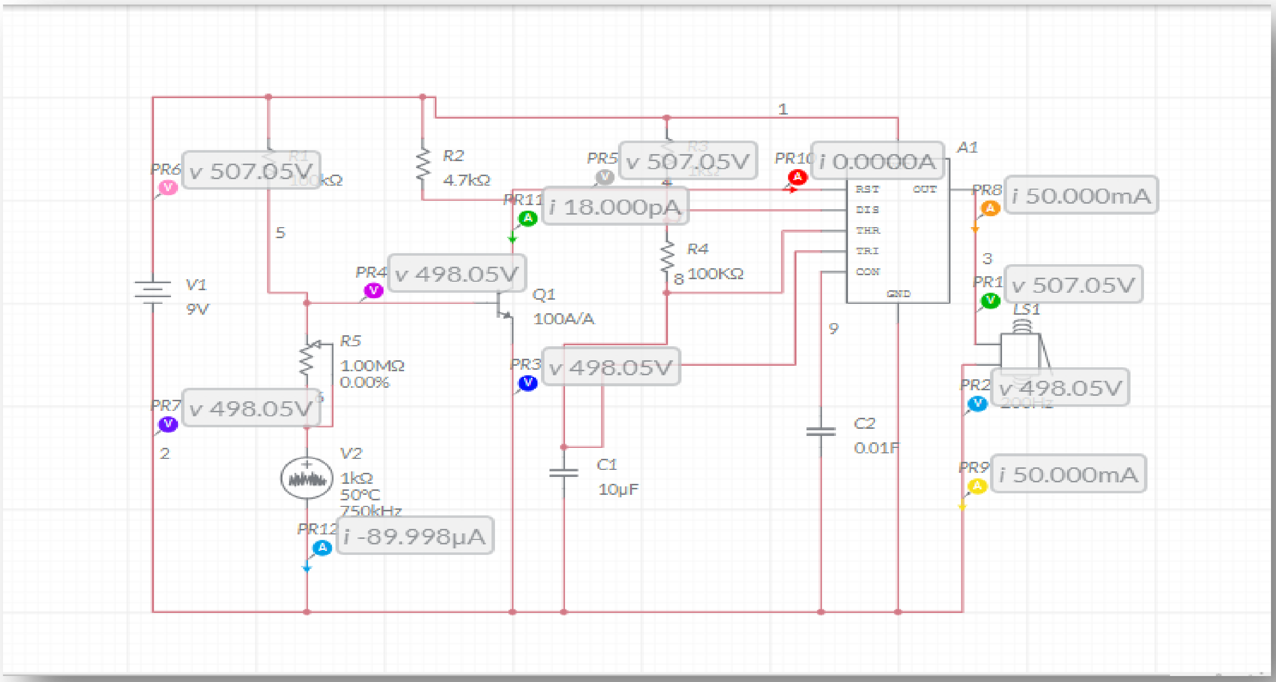

Fig 6.1: Output of ‘Motion Detecting Street Lights’ using 8051 Microcontroller on NI Online Multisim software

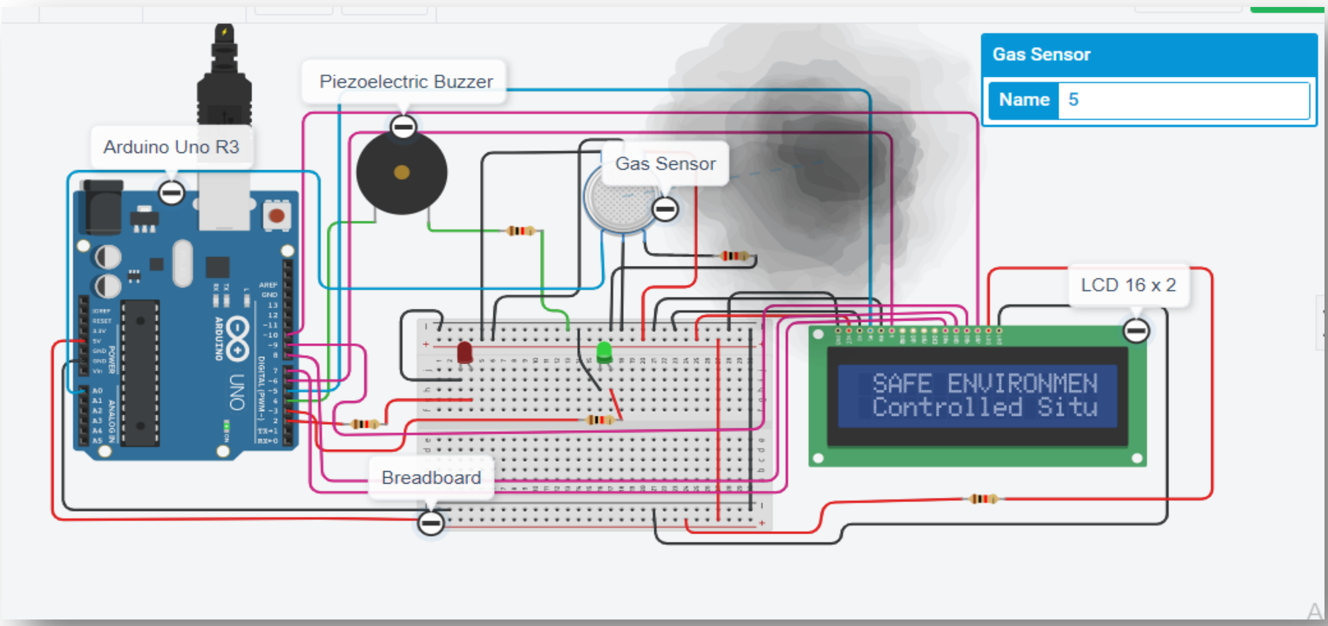

Fig 6.2: Output of ‘Motion Detecting Street Lights’ using Arduino UNO R3 on Tinkercad.

EXPECTED OUTPUT

In the above simulation done, we expected the LEDs to get switched ON when a vehicle movement is detected and to get switched OFF when the vehicle is out of the vicinity of the street lights. In the gas and smoke detector system, we expected the buzzer to start working as soon as gas or smoke leak is detected. As shown in the above figures, both of the circuits worked perfectly and gave the desired output.

CHAPTER 6: ADVANTAGES AND LIMITATIONS

Advantages:

- More lifespan.
- Cost effective.
- Less energy consumption.
- Hazard prevention.
- Pollution control.
- Healthy and safe environment.

Limitations:

- The automatic street light system requires a higher initial investment in comparison to conventional street lights.
- Risk of theft of the automatic street light system is relatively higher since they are non-wired & are much expensive.

CHAPTER 7: CONCLUSION AND FUTURE SCOPE

Conclusion:

In this paper, we have proposed a model that includes a 'Motion Detecting Street Lights' and 'Gas and Smoke Detector system' together. In this project, we have aimed to reduce cost as well as energy that is required for normal street lights to glow overnight. Street Lighting installations focused on open distributed control systems could be easily adapted to the growing number of Smart City initiatives currently underway, allowing for more flexibility. The initial cost and construction may be limitations, but with bulk development of a device, the overall cost of construction may be reduced further due to advances in technology and innovation, and the development cost may be reduced further. The design could be used for a variety of uses, such as lighting. Also, we have aimed in reducing the number of hazards that occur on the road due to gas and smoke leakages. In this work a clever framework for toxic gas and radiation discovery checking cautioning has been created to defeat the drawback looked in more established techniques. Consequently the utilization of serial correspondence makes the framework with Arduino controller and IoT. The IoT door associate remote sensor connects with the web, guarantee the operation of the gas and smoke observing framework. It utilized just constrained sensor.

Future Scope:

Keeping in view the long term benefits and the initial cost would never be a problem as the investment return time is very less. The project has scope in various other applications like for providing lighting in industries, campuses, office and parking lots of huge shopping malls. This can also be used for surveillance in corporate campuses and industries. Despite its limitations, MQ-6 gas sensors are widely used in home electronics projects with Arduino. Major future scope could be including a Automatic Shut-off device which will turn off the gas supply whenever it will detect any gas leakage. This system can be implemented in Industries, Hotels and wherever the LPG cylinders are used.

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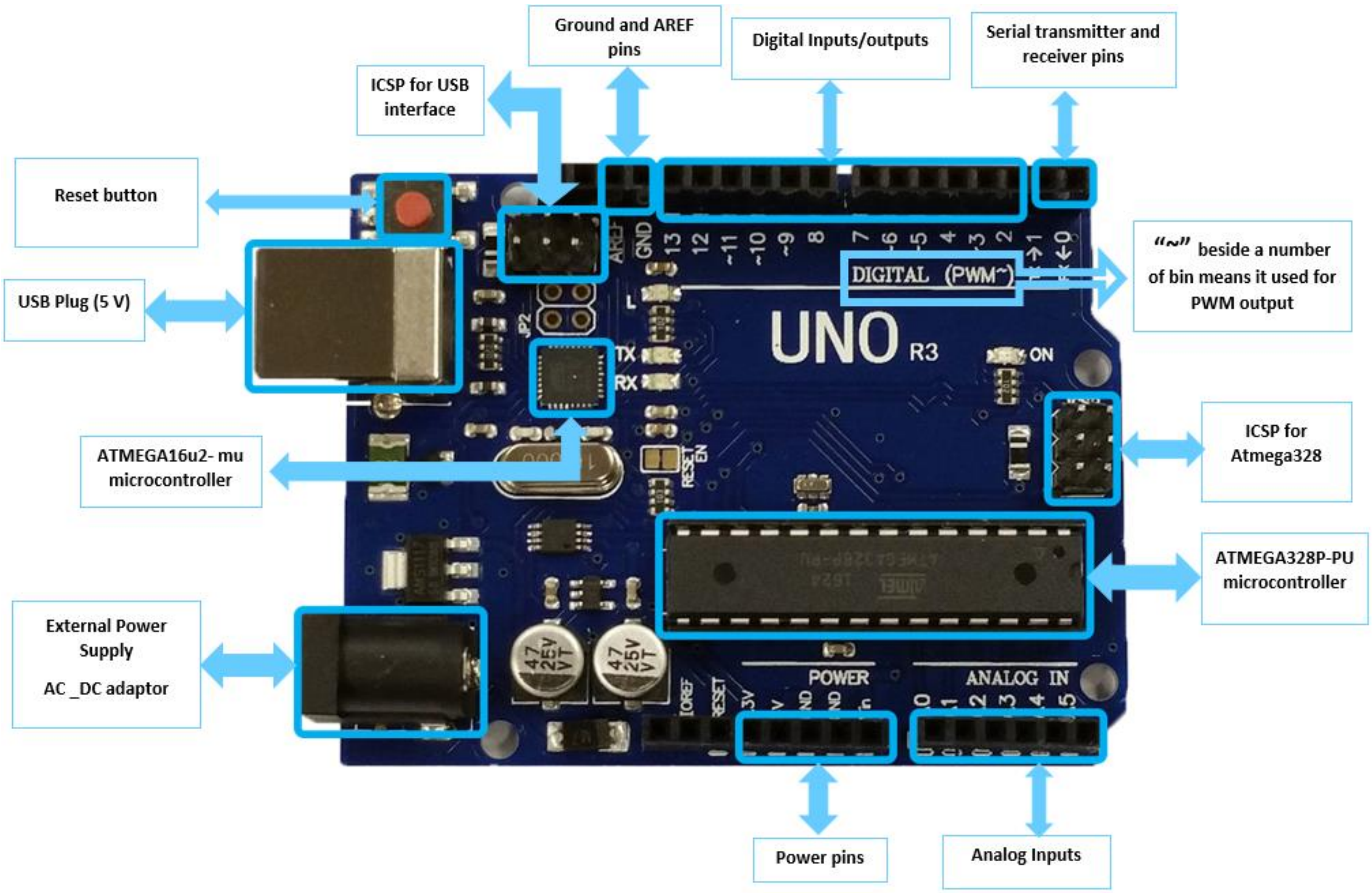
Arduino Uno R3



INTRODUCTION

Arduino is used for building different types of electronic circuits easily using of both a physical programmable circuit board usually microcontroller and piece of code running on computer with USB connection between the computer and Arduino.

Programming language used in Arduino is just a simplified version of C++ that can easily replace thousands of wires with words.

ARDUINO UNO-R3 PHYSICAL COMPONENTS

ATMEGA328P-PU microcontroller

The most important element in Arduino Uno R3 is ATMEGA328P-PU is an 8-bit Microcontroller with flash memory reach to 32k bytes. It's features as follow:

• High Performance, Low Power AVR

• Advanced RISC Architecture

- 131 Powerful Instructions – Most Single Clock Cycle Execution
- 32 x 8 General Purpose Working Registers
- Up to 20 MIPS Throughput at 20 MHz
- On-chip 2-cycle Multiplier

• High Endurance Non-volatile Memory Segments

- 4/8/16/32K Bytes of In-System Self-Programmable Flash program memory
- 256/512/512/1K Bytes EEPROM
- 512/1K/1K/2K Bytes Internal SRAM
- Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
- Data retention: 20 years at 85°C/100 years at 25°C
- Optional Boot Code Section with Independent Lock Bits
- In-System Programming by On-chip Boot Program
- True Read-While-Write Operation
- Programming Lock for Software Security

• Peripheral Features

- Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
- One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
- Real Time Counter with Separate Oscillator
- Six PWM Channels
- 8-channel 10-bit ADC in TQFP and QFN/MLF package
- Temperature Measurement
- 6-channel 10-bit ADC in PDIP Package
- Temperature Measurement
- Programmable Serial USART

- Master/Slave SPI Serial Interface
- Byte-oriented 2-wire Serial Interface (Philips I2 C compatible)
- Programmable Watchdog Timer with Separate On-chip Oscillator
- On-chip Analog Comparator
- Interrupt and Wake-up on Pin Change

• Special Microcontroller Features

- Power-on Reset and Programmable Brown-out Detection
- Internal Calibrated Oscillator
- External and Internal Interrupt Sources
- Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby

• I/O and Packages

- 23 Programmable I/O Lines
- 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF

• Operating Voltage:

- 1.8 - 5.5V

• Temperature Range:

- -40°C to 85°C

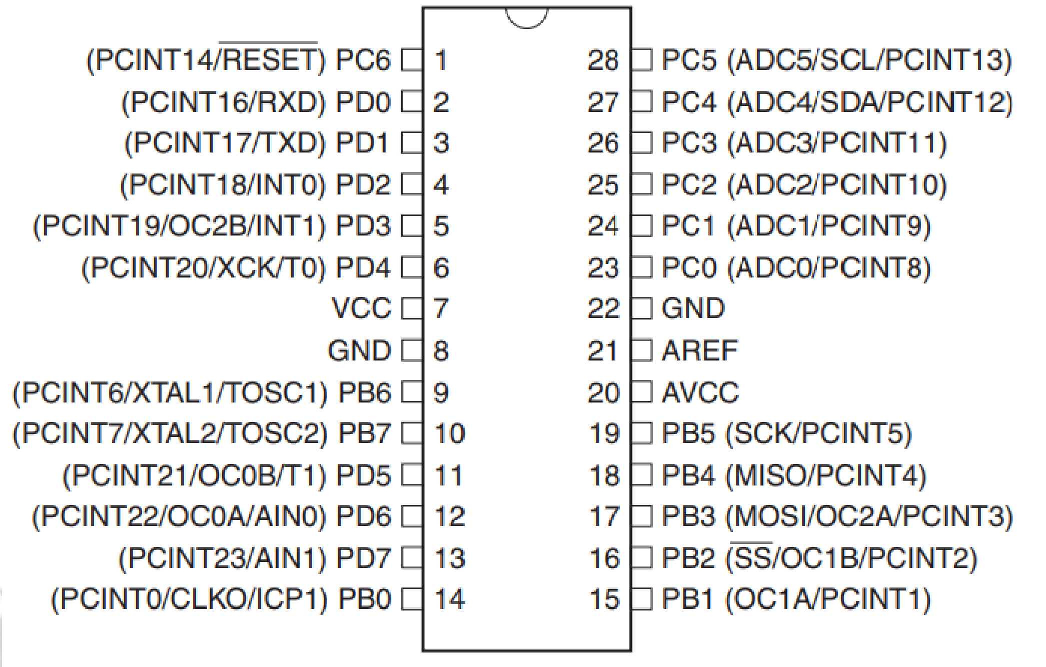
• Speed Grade:

- 0 - 4 MHz@1.8 - 5.5V, 0 - 10 MHz@2.7 - 5.5.V, 0 - 20 MHz @ 4.5 - 5.5V

• Power Consumption at 1 MHz, 1.8V, 25°C

- Active Mode: 0.2 mA
- Power-down Mode: 0.1 µA
- Power-save Mode: 0.75 µA (Including 32 kHz RTC)

- Pin configuration



ATMEGA16u2- mu microcontroller

Is a 8-bit microcontroller used as USB driver in Arduino uno R3 it's features as follow:

- High Performance, Low Power AVR

- Advanced RISC Architecture
  - 125 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16 MHz

- Non-volatile Program and Data Memories
  - 8K/16K/32K Bytes of In-System Self-Programmable Flash
  - 512/512/1024 EEPROM
  - 512/512/1024 Internal SRAM
  - Write/Erase Cycles: 10,000 Flash/ 100,000 EEPROM
  - Data retention: 20 years at 85˚C/ 100 years at 25˚C

- Optional Boot Code Section with Independent Lock Bits
- In-System Programming by on-chip Boot Program hardware-activated after reset
- Programming Lock for Software Security

• USB 2.0 Full-speed Device Module with Interrupt on Transfer Completion

- Complies fully with Universal Serial Bus Specification REV 2.0
- 48 MHz PLL for Full-speed Bus Operation: data transfer rates at 12 Mbit/s
- Fully independent 176 bytes USB DPRAM for endpoint memory allocation
- Endpoint 0 for Control Transfers: from 8 up to 64-bytes
- 4 Programmable Endpoints:
  - IN or Out Directions
  - Bulk, Interrupt and Isochronous Transfers
  - Programmable maximum packet size from 8 to 64 bytes
  - Programmable single or double buffer
- Suspend/Resume Interrupts
- Microcontroller reset on USB Bus Reset without detach
- USB Bus Disconnection on Microcontroller Request

• Peripheral Features

- One 8-bit Timer/Counters with Separate Prescaler and Compare Mode (two 8-bit PWM channels)
- One 16-bit Timer/Counter with Separate Prescaler, Compare and Capture Mode(three 8-bit PWM channels)
- USART with SPI master only mode and hardware flow control (RTS/CTS)
- Master/Slave SPI Serial Interface
- Programmable Watchdog Timer with Separate On-chip Oscillator
- On-chip Analog Comparator
- Interrupt and Wake-up on Pin Change

• On Chip Debug Interface (debug WIRE)

• Special Microcontroller Features

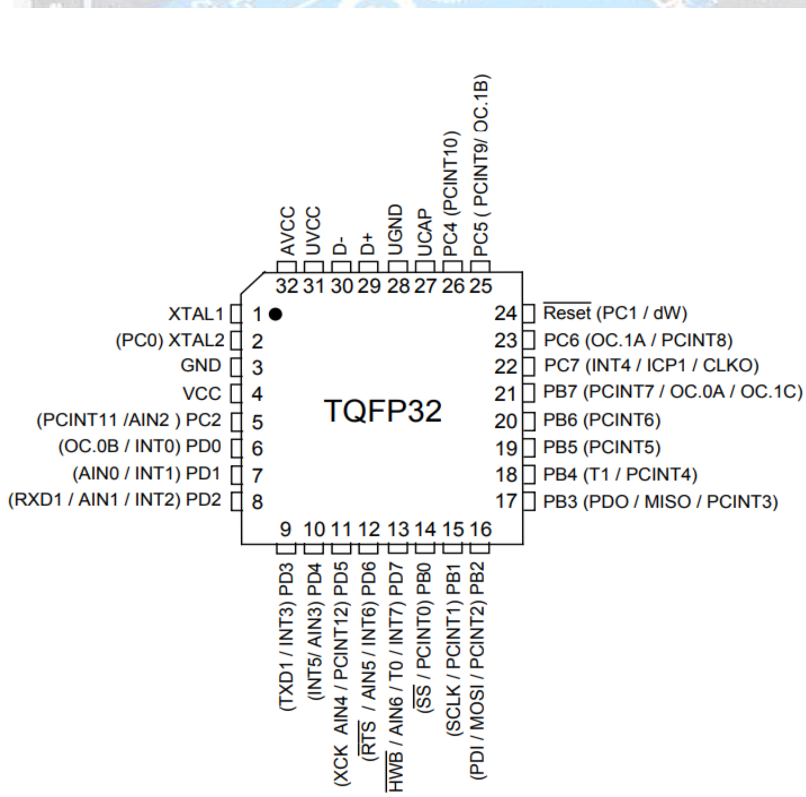
- Power-On Reset and Programmable Brown-out Detection
- Internal Calibrated Oscillator
- External and Internal Interrupt Sources
- Five Sleep Modes: Idle, Power-save, Power-down, Standby, and Extended Standby

• I/O and Packages

- 22 Programmable I/O Lines
- QFN32 (5x5mm) / TQFP32 packages

- Operating Voltages
    - 2.7 - 5.5V
- Operating temperature
    - Industrial (-40°C to +85°C)
- Maximum Frequency
    - 8 MHz at 2.7V - Industrial range
    - 16 MHz at 4.5V - Industrial range

- Pin configuration



OTHER ARDUINO UNO R3 PARTS

Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode (), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 k Ohms. In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

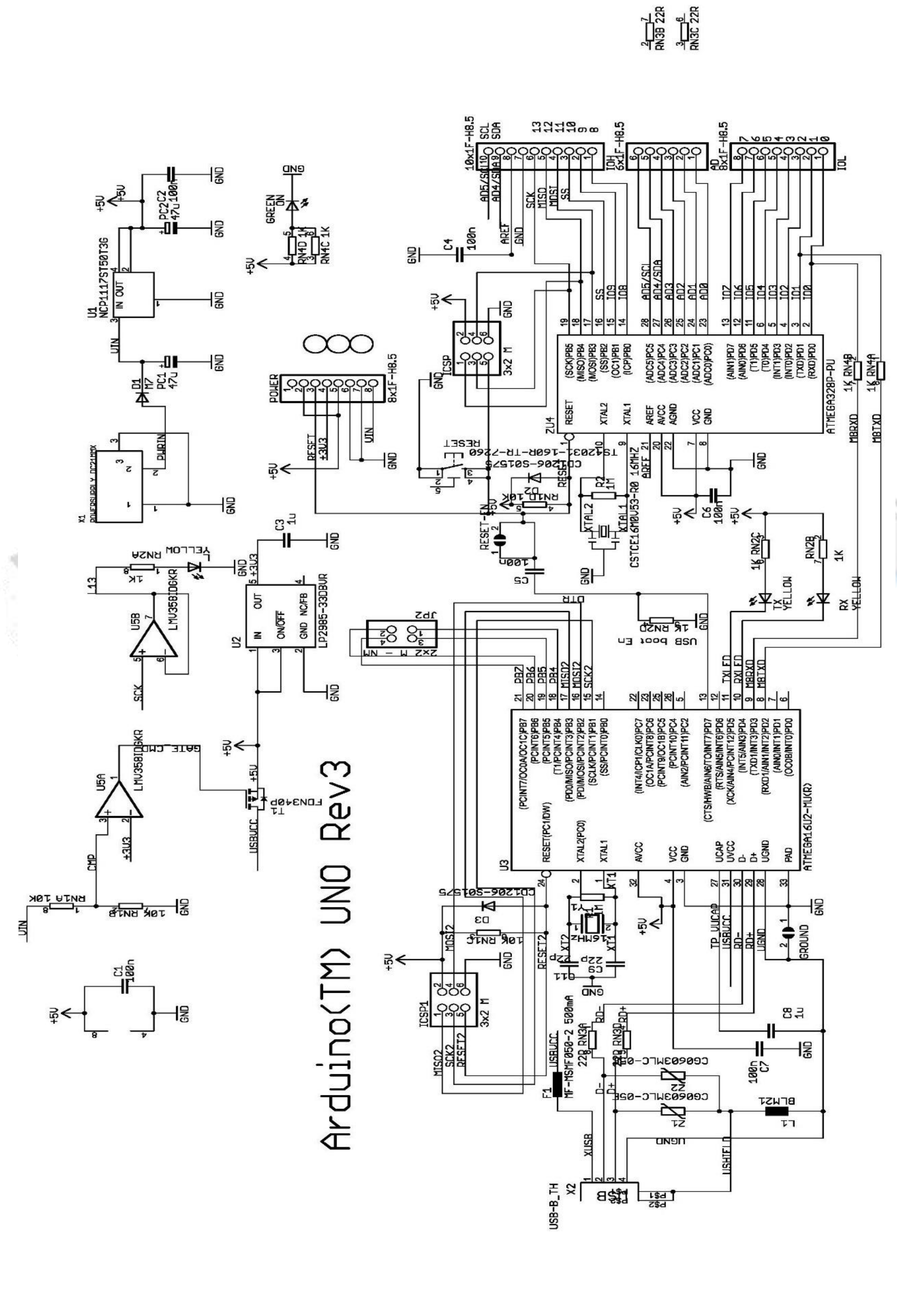
The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e.1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

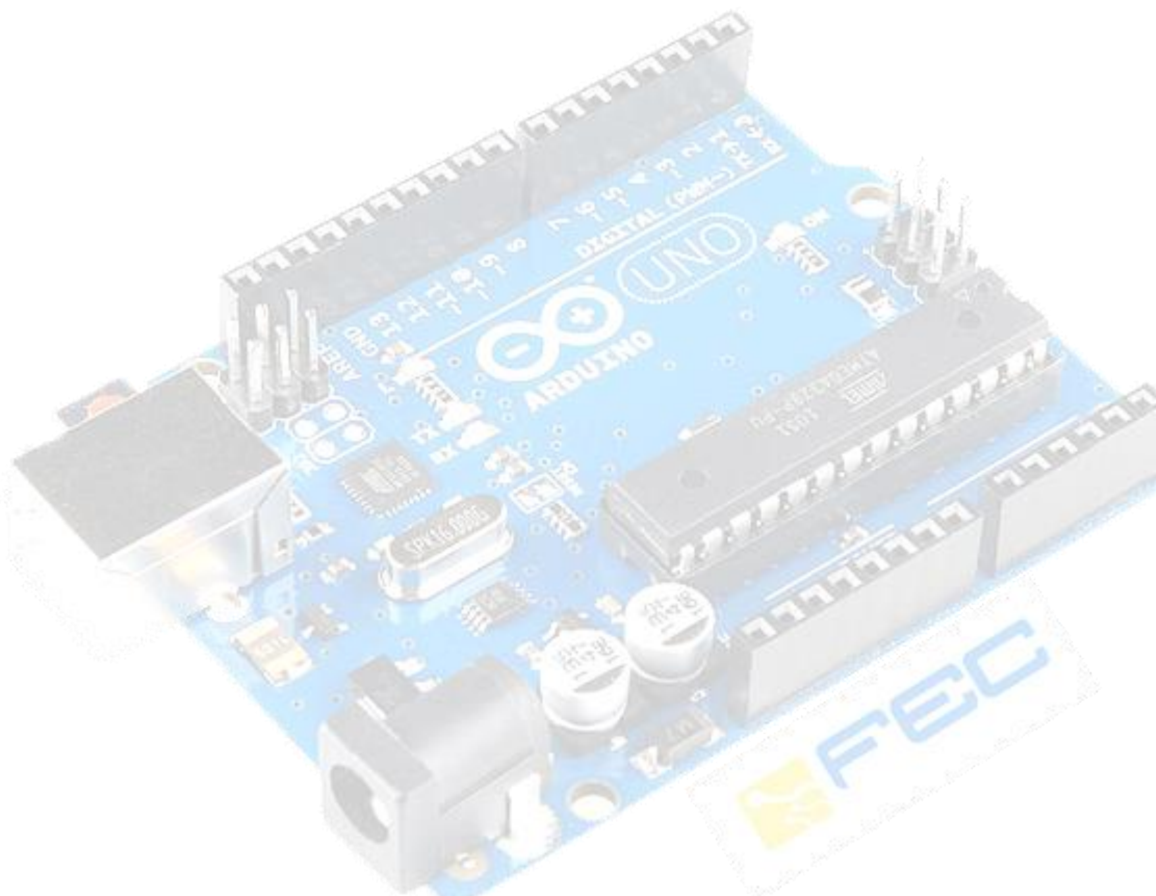
- TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

There are a couple of other pins on the board:

- AREF: Reference voltage for the analog inputs. Used with analogReference().
- Reset: Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

ARDUINO UNO R3 SCHEMATIC DIAGRAM




UNO
ARDUINO

ALDEC 8051 IP Core Data Sheet

Overview

The 8051 core is the HDL model of the Intel™ 8-bit 8051 micro controller. The model is fully compatible with the Intel 8051 standard.

Features

- Opcode and Cycle Equivalent to Intel standard 8051
- Support for Intel Hex file format
- Up to 4K Bytes Internal Program Memory (ROM)
- Up to 128 Bytes Internal Data Memory (RAM)
- Up to 64K Bytes External Program Memory address space
- Up to 64K Bytes External Data Memory address space
- Up to 128 Special Function Registers (SFR)
- 32 bi-directional and individually addressable I/O Lines
- Two 16-bit timer/counters
- Full Duplex UART (Serial Port)
- 6-Source/5-Vector Interrupt Structure with Two Priority Levels

Pinout

Table 1: **Core Signal Pinout**

Name	Direction	Polarity	Description
CLK 1)	Input	-	Clock input
EA 2)	Input	Low	External Access
RST 2)	Input	High	Synchronous reset
ALE 2)	Output	High	Address Latch Enable
PSEN 2)	Output	Low	Program Store Enable
P0[7:0] 3)	Bidirectional	-	Port P0
P1[7:0] 3)	Bidirectional	-	Port P1
P2[7:0] 3)	Bidirectional	-	Port P2
P3[7:0] 3)	Bidirectional	-	Port P3

Notes:

1) XTAL1 and XTAL2 original device pins were replaced with one CLK (clock) input signal. The clock frequency value has no limitations during the functional simulation.
2) EA, RST, ALE and PSEN signals behave exactly the same as the original device and are compatible with the Intel 8051 standard.
3) In the synthesizable model, each bidirectional pin is defined in the core interface as two separated VHDL ports. Optionally, using the Aldec VHDL/Verilog Interface, it can be merged to one bidirectional VHDL port. The behavioral model has bidirectional ports.

Block Diagram

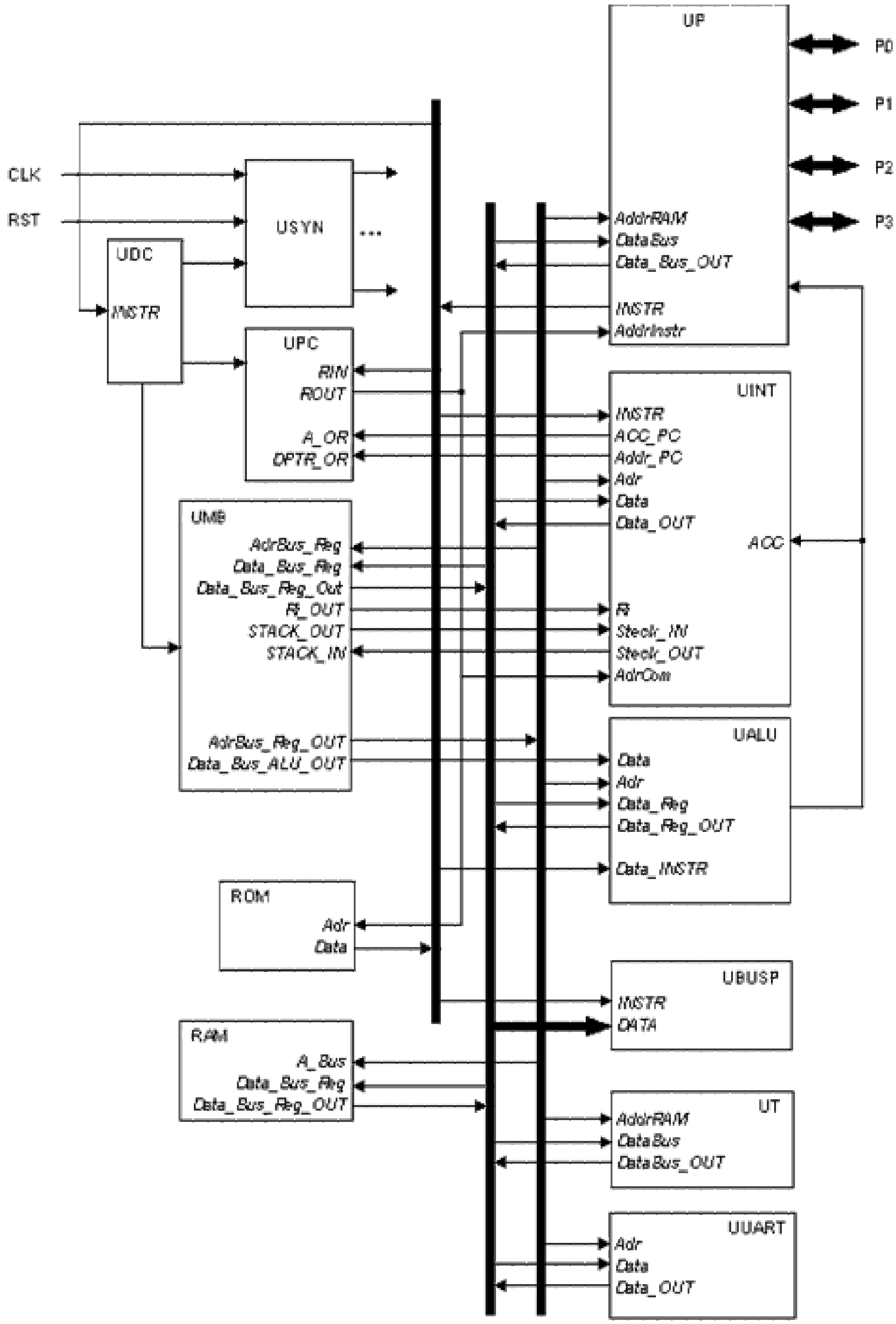


Figure 1: Core Structure

Deliverables

Available at No Cost:

- Verilog and/or VHDL Simulation Model (Encrypted for Aldec simulator only)
- Data Sheet
- Application Notes

Available Upon ordering:

- VHDL/Verilog source code
- Internal program memory
- ROM Generator tool
- RAM memory
- Technology-dependent EDIF and VHDL/Verilog netlists
- Aldec 8051 VHDL/Verilog Interface
- Verification Test Bench source code
- RTL Source compilation and simulation scripts
- Synthesis scripts
- Integration Manual
- User-Guide

Ordering Information

Aldec, Inc.

2260 Corporate Circle

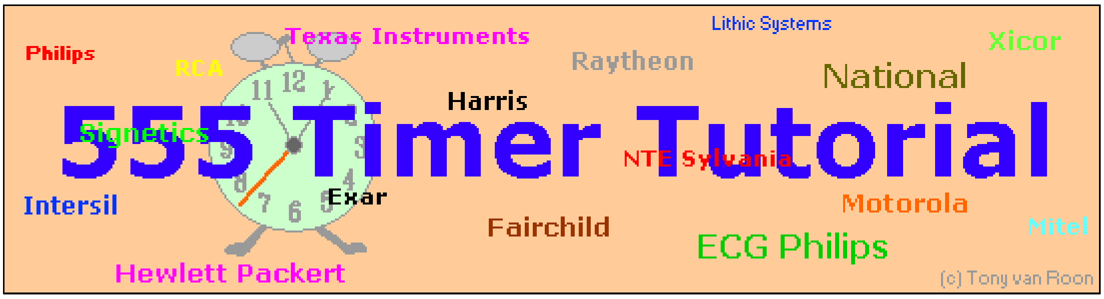
Henderson, NV 89074

Tel: 702-990-4400

Fax: 702-990-4414

Email: ipcores@aldec.com

http://www.aldec.com



© by Tony van Roon

The 555 timer IC was first introduced arround 1971 by the Signetics Corporation as the SE555/NE555 and was called "**The IC Time Machine**" and was also the very first and only commercial timer ic available. It provided circuit designers and hobby tinkerers with a relatively cheap, stable, and user-friendly integrated circuit for both monostable and astable applications. Since this device was first made commercially available, a myrad of novel and unique circuits have been developed and presented in several trade, professional, and hobby publications. The past ten years some manufacturers stopped making these timers because of competition or other reasons. Yet other companies, like NTE (a subdivision of Philips) picked up where some left off.

This primer is about this fantastic timer which is after 30 years still very popular and used in many schematics. Although these days the CMOS version of this IC, like the Motorola MC1455, is mostly used, the regular type is still available, however there have been many improvements and variations in the circuitry. But all types are pin-for-pin plug compatible. Myself, every time I see this 555 timer used in advanced and high-tech electronic circuits, I'm amazed. It is just incredible.

In this tutorial I will show you what exactly the 555 timer is and how to properly use it by itself or in combination with other solid state devices without the requirement of an engineering degree. This timer uses a maze of transistors, diodes and resistors and for this complex reason I will use a more simplified (but accurate) block diagram to explain the internal organizations of the 555. So, lets start slowly and build it up from there.

Manufacturer	Type Number
ECG Philips	ECG955M
Exar	XR-555
Fairchild	NE555
Harris	HA555
Intersil	SE555/NE555
Lithic Systems	LC555
Motorola	MC1455/MC1555
National	LM1455/LM555C
NTE Sylvania	NTE955M
Raytheon	RM555/RC555
RCA	CA555/CA555C
Texas Instruments	SN52555/SN72555

(c) Tony van Roon

Table 1.

The first type-number, in Table 1 on the left, represents the type which was/is preferred for military applications which have somewhat improved electrical and thermal characteristics over their commercial counterparts, but also a bit more expensive, and usually metal-can or ceramic casing. This is analogous to the 5400/7400 series convention for TTL integrated circuits.

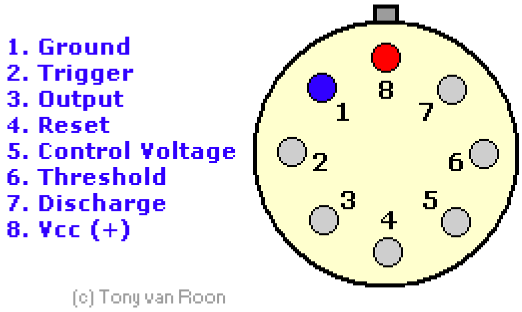


fig. 1. 8-pin T package

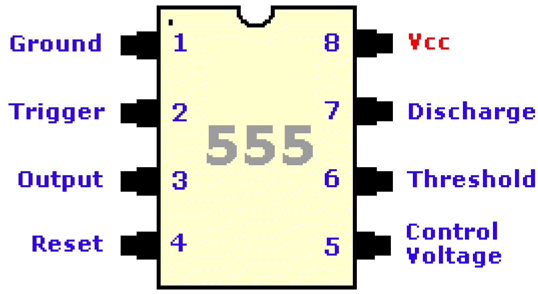


fig. 2. 8-pin V package

The 555, in fig. 1 and fig. 2 above, come in two packages, either the round metal-can called the 'T' package or the more familiar 8-pin DIP 'V' package. About 20-years ago the metal-can type was pretty much the standard (SE/NE types). The 556 timer is a dual 555 version and comes in a 14-pin DIP package, the 558 is a quad version with four 555's also in a 14 pin DIP case.

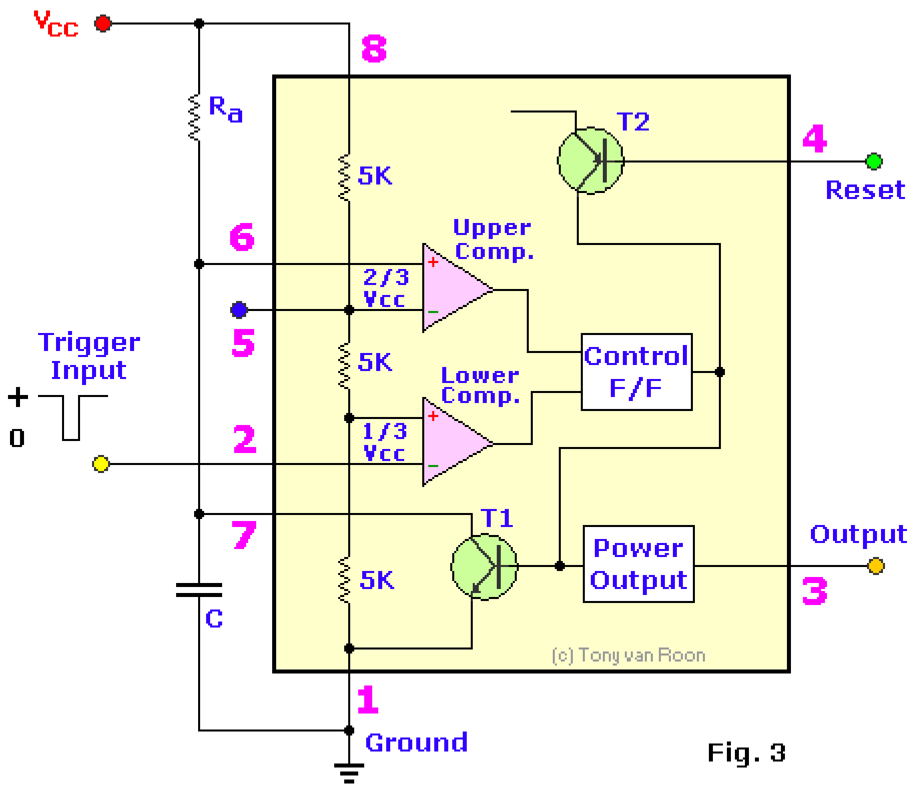
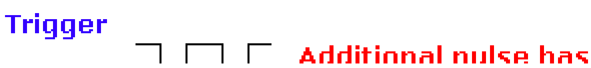


Fig. 3

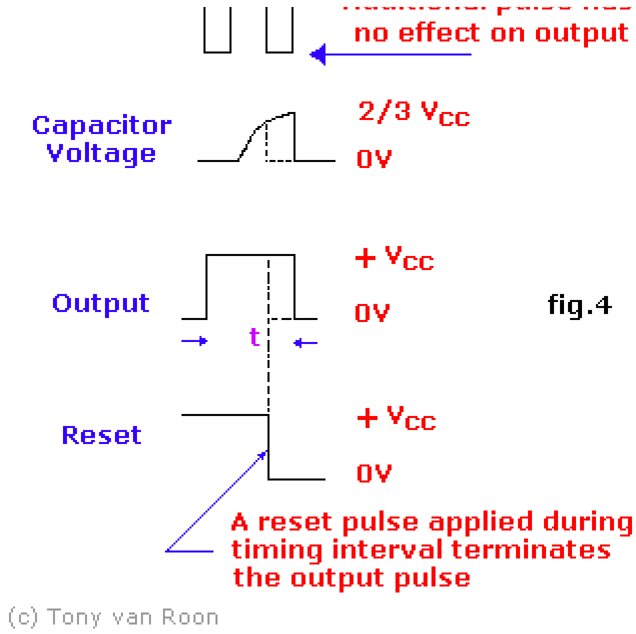
Inside the 555 timer, at fig. 3, are the equivalent of over 20 transistors, 15 resistors, and 2 diodes, depending of the manufacturer. The equivalent circuit, in block diagram, providing the functions of control, triggering, level sensing or comparison, discharge, and power output. Some of the more attractive features of the 555 timer are: Supply voltage between 4.5 and 18 volt, supply current 3 to 6 mA, and a Rise/Fall time of 100 nSec. It can also withstand quite a bit of abuse.

*The Threshold current determine the maximum value of Ra + Rb. For 15 volt operation the maximum total resistance for **R** (Ra +Rb) is 20 Mega-ohm.*

The supply current, when the output is 'high', is typically 1 milli-amp (mA) or less. The initial monostable timing accuracy is typically within 1% of its calculated value, and exhibits negligble (0.1%/V) drift with supply voltage. Thus longterm supply variations can be ignored, and the temperature variation is only 50ppm/°C (0.005%/°C).



All IC timers rely upon an external capacitor to determine the off-on time



intervals of the output pulses. As you recall from your study of basic electronics, it takes a finite period of time for a capacitor (C) to charge or discharge through a resistor (R). Those times are clearly defined and can be calculated given the values of resistance and capacitance. The basic RC charging circuit is shown in fig. 4. Assume that the capacitor is initially discharged. When the switch is closed, the capacitor begins to charge through the resistor. The voltage across the capacitor rises from zero up to the value of the applied DC voltage. The charge curve for the circuit is shown in fig. 6. The time that it takes for the capacitor to charge to 63.7% of the applied voltage is known as the time constant (t). That time can be calculated with the simple expression:

$$\mathbf{t = R \ X \ C}$$

Assume a resistor value of 1 MegaOhm and a capacitor value of 1uF (micro-Farad). The time constant in that case is:

$$\mathbf{t = 1{,}000{,}000 \ X \ 0.000001 = 1 \ second}$$

Assume further that the applied voltage is 6 volts. That means that it will take one time constant for the voltage across the capacitor to reach 63.2% of the applied voltage. Therefore, the capacitor charges to approximately 3.8 volts in one second.

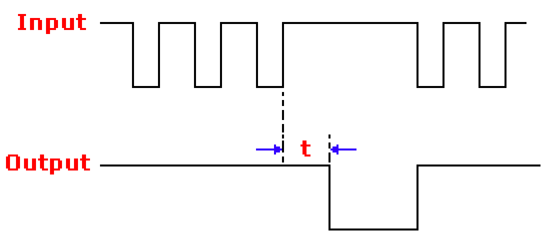
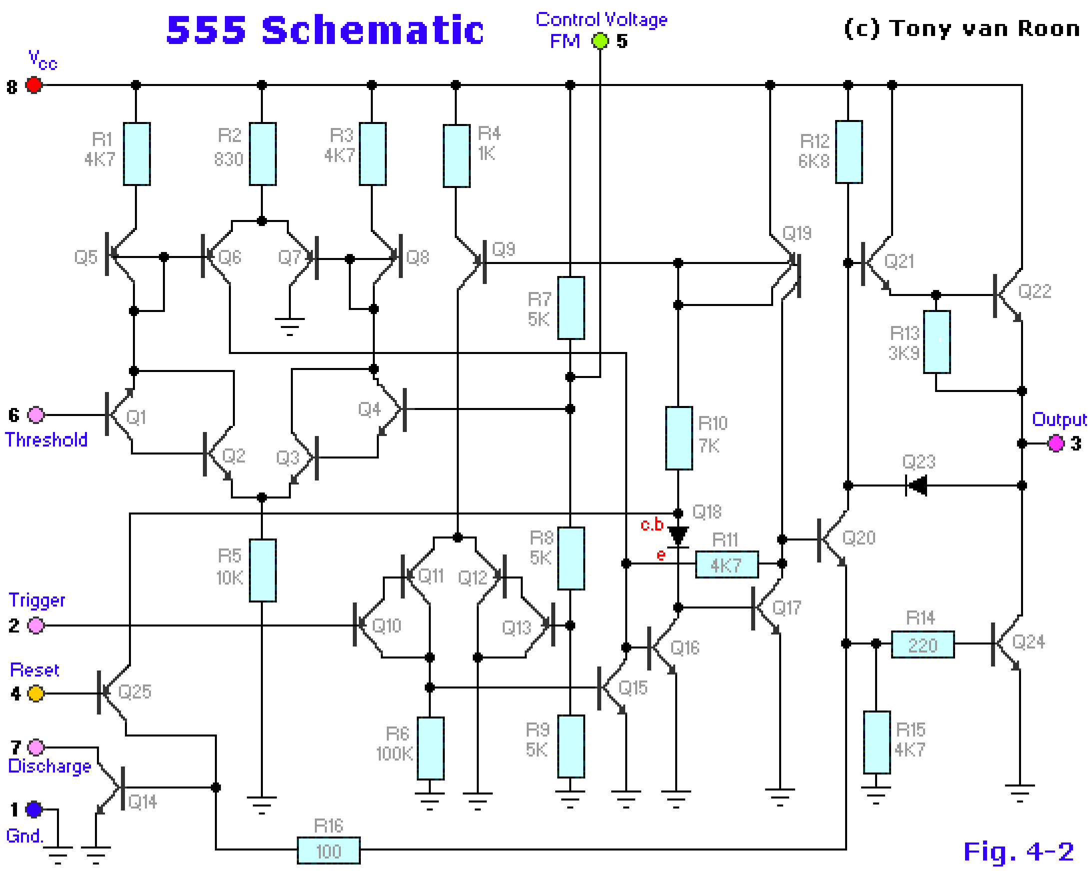


Fig. 4-1

Fig. 4-1, Change in the input pulse frequency allows completion of the timing cycle. As a general rule, the monostable 'ON' time is set approximately 1/3 longer than the expected time between triggering pulses. Such a circuit is also known as a 'Missing Pulse Detector'.

Looking at the curve in fig. 6. you can see that it takes approximately 5 complete time constants for the capacitor to charge to amost the applied voltage. It would take about 5 seconds for the voltage on the capacitor to rise to approximately the full 6-volts.



Definition of Pin Functions:

Refer to the internal 555 schematic of Fig. 4-2

Pin 1 (Ground): The ground (or common) pin is the most-negative supply potential of the device, which is normally connected to circuit common when operated from positive supply voltages.

Pin 2 (Trigger): This pin is the input to the lower comparator and is used to set the latch, which in turn causes the output to go high. This is the beginning of the timing sequence in monostable operation. Triggering is accomplished by taking the pin from above to below a voltage level of 1/3 V+ (or, in general, one-half the voltage appearing at pin 5). The action of the trigger input is level-sensitive, allowing slow rate-of-change waveforms, as well as pulses, to be used as trigger sources.
One precaution that should be observed with the trigger input signal is that it must not remain lower than 1/3 V+ for a period of time *longer* than the timing cycle. If this is allowed to happen, the timer will retrigger itself upon termination of the first output pulse. Thus, when the timer is driven in the monostable mode with input pulses longer than the desired output pulse width, the input trigger should effectively be shortened by differentiation.
The minimum-allowable pulse width for triggering is somewhat dependent upon pulse level, but in general if it is greater than the 1uS (micro-Second), triggering will be reliable.
A second precaution with respect to the trigger input concerns storage time in the lower comparator. This portion of the circuit can exhibit normal turn-off delays of several microseconds after triggering; that is, the latch can still have a trigger input for this period of time *after* the trigger pulse. In practice, this means the minimum monostable output pulse width should be in the order of 10uS to prevent possible double triggering due to this effect.

The voltage range that can safely be applied to the trigger pin is between V+ and ground. A dc current, termed the *trigger* current, must also flow from this terminal into the external circuit. This current is typically 500nA (nano-amp) and will define the upper limit of resistance allowable from pin 2 to ground. For an astable configuration operating at V+ = 5 volts, this resistance is 3 Mega-ohm; it can be greater for higher V+ levels.

Pin 3 (Output): The output of the 555 comes from a high-current totem-pole stage made up of transistors Q20 - Q24. Transistors Q21 and Q22 provide drive for source-type loads, and their Darlington connection provides a high-state output voltage about 1.7 volts less than the V+ supply level used. Transistor Q24 provides current-sinking capability for low-state loads referred to V+ (such as typical TTL inputs). Transistor Q24 has a low saturation voltage, which allows it to interface directly, with good noise margin, when driving current-sinking logic. Exact output saturation levels vary markedly with supply voltage, however, for both high and low states. At a V+ of 5 volts, for instance, the low state Vce(sat) is typically 0.25 volts at 5 mA. Operating at 15 volts, however, it can sink 100mA if an output-low voltage level of 2 volts is allowable (power dissipation should be considered in such a case, of course). High-state level is typically 3.3 volts at V+ = 5 volts; 13.3 volts at V+ = 15 volts. Both the rise and fall times of the output waveform are quite fast, typical switching times being 100nS.
The state of the output pin will always reflect the inverse of the logic state of the latch, and this fact may be seen by examining Fig. 3. Since the latch itself is not directly accessible, this relationship may be best explained in terms of latch-input trigger conditions. To trigger the output to a high condition, the trigger input is momentarily taken from a higher to a lower level. [see "Pin 2 - Trigger"]. This causes the latch to be set and the output to go high. Actuation of the lower comparator is the only manner in which the output can be placed in the high state. The output can be returned to a low state by causing the threshold to go from a lower to a higher level [see "Pin 6 - Threshold"], which resets the latch. The output can also be made to go low by taking the reset to a low state near ground [see "Pin 4 - Reset"].

Pin 4 (Reset): This pin is also used to reset the latch and return the ouput to a low state. The reset voltage threshold level is 0.7 volt, and a sink current of 0.1mA from this pin is required to reset the device. These levels are relatively independent of operating V+ level; thus the reset input is TTL compatible for any supply voltage.
The reset input is an overriding function; that is, it will force the output to a low state regardless of the state of either of the other inputs. It may thus be used to terminate an output pulse prematurely, to gate oscillations from "on" to "off", etc. Delay time from reset to output is typically on the order of 0.5 uS, and the minumum reset pulse width is 0.5 uS. Neither of these figures is guaranteed, however, and *may vary* from one manufacturer to another. When not used, it is recommended that the reset input be tied to V+ to avoid any possibility of false resetting.

Pin 5 (Control Voltage): This pin allows direct access to the 2/3 V+ voltage-divider point, the reference level for the upper comparator. It also allows indirect access to the lower comparator, as there is a 2:1 divider (R8 - R9) from this point to the lower-comparator reference input, Q13. Use of this terminal is the option of the user, but it does allow extreme flexibility by permitting modification of the timing period, resetting of the comparator, etc.
When the 555 timer is used in a voltage-controlled mode, its voltage-controlled operation ranges from about 1 volt less than V+ down to within 2 volts of ground (although this is not guaranteed). Voltages can be safely applied outside these limits, but they should be confined within the limits of V+ and ground for reliability.
In the event the control-voltage pin is not used, it is recommended that it be bypassed with a capacitor of about 0.01uF (10nF) for immunity to noise, since it is a comparator input.

Pin 6 (Threshold): Pin 6 is one input to the upper comparator (the other being pin 5) and is used to reset the latch, which causes the output to go low.

Resetting via this terminal is accomplished by taking the terminal from below to above a voltage level of 2/3 V+ (the normal voltage on pin 5). The action of the threshold pin is level sensitive, allowing slow rate-of-change waveforms.
The voltage range that can safely be applied to the threshold pin is between V+ and ground. A dc current, termed the *threshold* current, must also flow into this terminal from the external circuit. This current is typically 100nA, and will define the upper limit of total resistance allowable from pin 6 to V+. For either timing configuration operating at V+ = 5 volts, this resistance is 16 Mega-ohm.

Pin 7 (Discharge): This pin is the open collector of an npn transistor (Q14), the emitter of which goes to ground. The conduction state of this transistor is identical in timing to that of the output stage. It is "on" (low resistance to ground) when the output is low and "off" (high resistance to ground) when the output is high.
In both the monostable and astable time modes, this transistor switch is used to clamp the appropriate nodes of the timing network to ground. Saturation voltage is typically below 100mV (milli-Volt) for currents of 5 mA or less, and off-state leakage is about 20nA (these parameters are not specified by all manufacturers, however).
Maximum collector current is internally limited by design, thereby removing restrictions on capacitor size due to peak pulse-current discharge. In certain applications, this open collector output can be used as an auxiliary output terminal, with current-sinking capability similar to the output (pin 3).

Pin 8 (V +): The V+ pin (also referred to as Vcc) is the positive supply voltage terminal of the 555 timer IC. Supply-voltage operating range for the 555 is +4.5 volts (minimum) to +16 volts (maximum), and it is specified for operation between +5 volts and + 15 volts. The device will operate essentially the same over this range of voltages without change in timing period. Actually, the most significant operational difference is the output drive capability, which increases for both current and voltage range as the supply voltage is increased. Sensitivity of time interval to supply voltage change is low, typically 0.1% per volt.

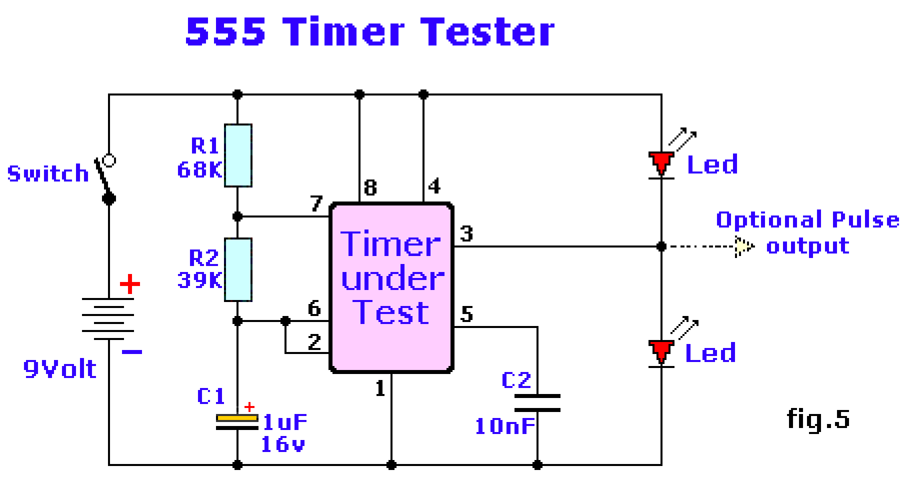
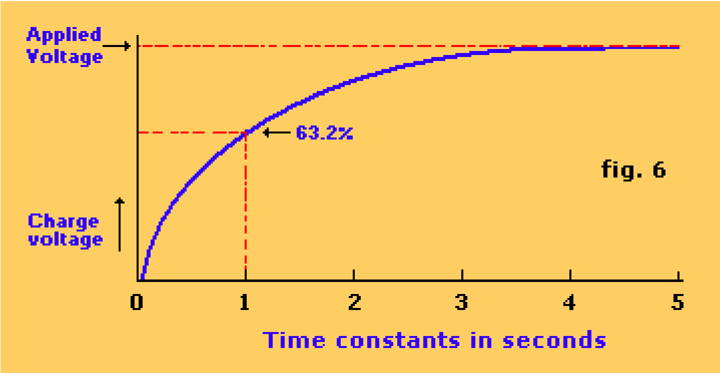
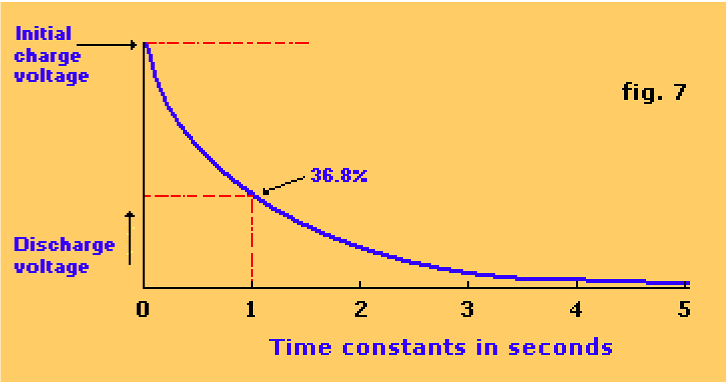


fig.5

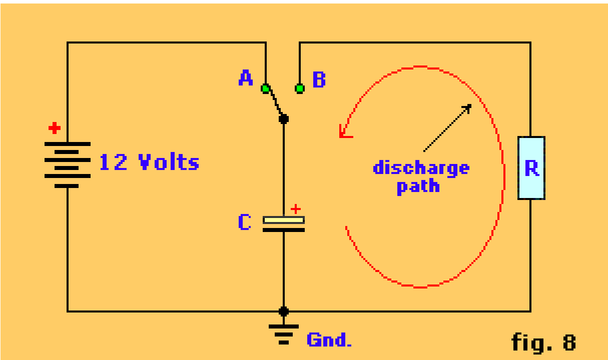
Try the simple 555 testing-circuit of Fig. 5. to get you going, and test all your 555 timer ic's. I build several for friends and family. I bring my own tester to ham-fests and what not to instantly do a check and see if they are oscillating. Or use as a trouble shooter in 555 based circuits. This tester will quickly tell you if the timer is functional or not. Although not foolproof, it will tell if the 555 is shorted or oscillating. If both Led's are flashing the timer is most likely in good working order. If one or both Led's are either off or on solid the timer is defective. Simple huh?



The capacitor slows down as it charges, and in actual fact never reaches the full supply voltage. That being the case, the maximum charge it receives in the timing circuit (66.6% of the supply voltage) is a little over the charge received after a time constant (63.2%).



The capacitor slows down as it discharges, and never quite reaches the ground potential. That means the minimum voltage it operates at must be greater than zero. Timing circuit is 63.2% of the supply voltage.



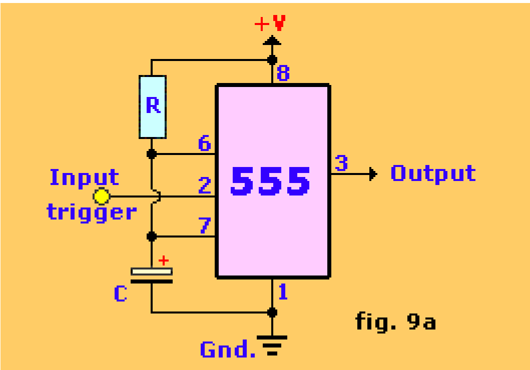
The discharge of a capacitor also takes time and we can shorten the amount of time by decreasing resistance (R) to the flow of current.

Operating Modes: The 555 timer has two basic operational modes: one shot and astable. In the one-shot mode, the 555 acts like a monostable multivibrator. A monostable is said to have a single stable state--that is the off state. Whenever it is triggered by an input pulse, the monostable switches to its temporary state. It remains in that state for a period of time determined by an RC network. It then returns to its stable state. In other words, the monostable circuit generates a single pulse of a fixed time duration each time it receives and input trigger pulse. Thus the name one-shot. One-shot multivibrators are used for turning some circuit or external component on or off for a specific length of time. It is also used to generate delays. When multiple one-shots are cascaded, a variety of sequential timing pulses can be generated. Those pulses will allow you to time and sequence a number of related operations.

The other basic operational mode of the 555 is as and astable multivibrator. An astable multivibrator is simply and oscillator. The astable multivibrator generates a continuous stream of rectangular off-on pulses that switch between two voltage levels. The frequency of the pulses and their duty cycle are dependent upon the RC network values.

One-Shot Operation: Fig. 4 shows the basic circuit of the 555 connected as a monostable multivibrator. An external RC network is connected between the supply voltage and ground. The junction of the resistor and capacitor is connected to the threshold input which is the input to the upper comparator. The internal discharge transistor is also connected to the junction of the resistor and the capacitor. An input trigger pulse is applied to the trigger input, which is the input to the lower comparator.

With that circuit configuration, the control flip-flop is initially reset. Therefore, the output voltage is near zero volts. The signal from the control flip-flop causes T1 to conduct and act as a short circuit across the external capacitor. For that reason, the capacitor cannot charge. During that time, the input to the upper comparator is near zero volts causing the comparator output to keep the control flip-flop reset.



Notice how the monostable continues to output its pulse regardless of the inputs swing back up. That is because the output is only triggered by the input pulse, the output actually depends on the capacitor charge.

Monostable Mode:

The 555 in fig. 9a is shown here in it's utmost basic mode of operation; as a triggered monostable. One immediate observation is the extreme simplicity of this circuit. Only two components to make up a timer, a capacitor and a resistor. And for noise immunity maybe a capacitor on pin 5. Due to the internal latching mechanism of the 555, the timer will always time-out once triggered, regardless of any subsequent noise (such as bounce) on the input trigger (pin 2). This is a great asset in interfacing the 555 with noisy sources. Just in case you don't know what *'bounce'* is: bounce is a type of fast, short term noise caused by a switch, relay, etc. and then picked up by the input pin.
The trigger input is initially high (about 1/3 of +V). When a negative-going trigger pulse is applied to the trigger input (see fig. 9a), the threshold on the lower comparator is exceeded. The lower comparator, therefore, sets the flip-flop. That causes T1 to cut off, acting as an open circuit. The setting of the flip-flop also causes a positive-going output level which is the beginning of the output timing pulse.

The capacitor now begins to charge through the external resistor. As soon as the charge on the capacitor equal 2/3 of the supply voltage, the upper comparator triggers and resets the control flip-flop. That terminates the output pulse which switches back to zero. At this time, T1 again conducts thereby discharging the capacitor. If a negative-going pulse is applied to the reset input while the output pulse is high, it will be terminated immediately as that pulse will reset the flip-flop.

Whenever a trigger pulse is applied to the input, the 555 will generate its single-duration output pulse. Depending upon the values of external resistance and capacitance used, the output timing pulse may be adjusted from approximately one millisecond to as high as on hundred seconds. For time intervals less than approximately 1-millisecond, it is recommended that standard logic one-shots designed for narrow pulses be used instead of a 555 timer. IC timers are normally used where long output pulses are required. In this applicaton, the duration of the output pulse in seconds is approximately equal to:

$$T = 1.1 \text{ x } R \text{ x } C \text{ (in seconds)}$$

The output pulse width is defined by the above formula and with relatively few restrictions, timing components R(t) and C(t) can have a wide range of values. There is actually no theoretical upper limit on T (output pulse width), only practical ones. The lower limit is 10uS. You may consider the range of T to be 10uS to infinity, bounded only by R and C limits. Special R(t) and C (t) techniques allow for timing periods of days, weeks, and even months if so desired.
However, a reasonable lower limit for R(t) is in the order of about 10Kilo ohm, mainly from the standpoint of power economy. (Although R(t) can be lower that 10K without harm, there is no need for this from the standpoint of achieving a short pulse width.) A practical minimum for C(t) is about 95pF; below this the stray effects of capacitance become noticeable, limiting accuracy and predictability. Since it is obvious that the product of these two minimums yields a T that is less the 10uS, there is much flexibility in the selection of R(t) and C(t). Usually C(t) is selected first to minimize size (and expense); then R(t) is chosen.

The upper limit for R(t) is in the order of about 15 Mega ohm but should be less than this if all the accuracy of which the 555 is capacle is to be achieved. The absolute upper limit of R(t) is determined by the threshold current plus the discharge leakage when the operating voltage is +5 volt. For example, with a threshold plus leakage current of 120nA, this gives a maximum value of 14M for R(t) (very optimistic value). Also, if the C(t) leakage current is such that the sum of the threshold current and the leakage current is in excess of 120 nA the circuit will never time-out because the upper threshold voltage will not be reached. Therefore, it is good practice to select a value for R(t) so that, with a voltage drop of 1/3 V+ across it, the value should be 100 times more, if practical.
So, it should be obvious that the real limit to be placed on C(t) is its leakage, not it's capacitance value, since larger-value capacitors have higher leakages as a fact of life. Low-leakage types, like tantalum or NPO, are available and preferred for long timing periods. Sometimes input trigger source conditions can exist that will necessitate some type of signal conditioning to ensure compatibility with the triggering requirements of the 555. This can be achieved by adding another capacitor, one or two resistors and a small signal diode to the input to form a pulse differentiator to shorten the input trigger pulse to a width less than 10uS (in general, less than T). Their values and criterion are not critical; the main one is that the width of the resulting differentiated pulse (after C) should be *less* than the desired output pulse for the period of time it is below the 1/3 V+ trigger level.

There are several different types of 555 timers. The LM555 from National is the most common one these days, in my opinion. The Exar XR-L555 timer is a micropower version of the standard 555 offering a direct, pin-for-pin (also called plug-compatible) substitute device with an advantage of a lower power operation. It is capable of operation of a wider range of possitive supply voltage from as low as 2.7volt minimum up to 18 volts maximum. At a supply voltage of +5V, the L555 will typically dissipate of about 900 microwatts, making it ideally suitable for battery operated circuits. The internal schematic of the L555 is very much similar to the standard 555 but with additional features like 'current spiking' filtering, lower output drive capability, higher nodal impedances, and better noise reduction system.

Intersil's ICM7555 model is a low-power, general purpose CMOS design version of the standard

555, also with a direct pin-for-pin compatibility with the regular 555. It's advantages are very low timing/bias currents, low power-dissipation operation and an even wider voltage supply range of as low as 2.0 volts to 18 volts. At 5 volts the 7555 will dissipate about 400 microwatts, making it also very suitable for battery operation. The internal schematic of the 7555 (not shown) is however totally different from the normal 555 version because of the different design process with cmos technology. It has much higher input impedances than the standard bipolar transistors used. The cmos version removes essentially any timing component restraints related to timer bias currents, allowing resistances as high as practical to be used.
This very versatile version should be considered where a wide range of timing is desired, as well as low power operation and low current sync'ing appears to be important in the particular design.
A couple years after Intersil, Texas Instruments came on the market with another cmos variation called the LINCMOS (LINear CMOS) or Turbo 555. In general, different manufacturers for the cmos 555's reduced the current from 10mA to 100µA while the supply voltage minimum was reduced to about 2 volts, making it an ideal type for 3v applications. The cmos version is the choice for battery powered circuits. However, the negative side for the cmos 555's is the reduced output current, both for sync and source, but this problem can be solved by adding a amplifier transistor on the output if so required. For comparison, the regular 555 can easily deliver a 200mA output versus 5 to 50mA for the 7555. On the workbench the regular 555 reached a limited output frequency of 180Khz while the 7555 easily surpassed the 1.1Mhz mark and the TLC555 stopped at about 2.4Mhz. Components used were 1% Resistors and low-leakage capacitors, supply voltage used was 10volt.

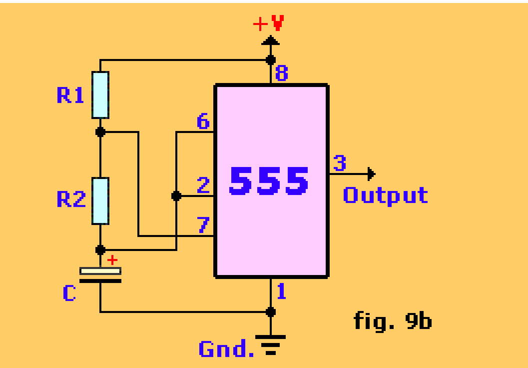


fig. 9b

Astable operation: Figure 9b shows the 555 connected as an astable multivibrator. Both the trigger and threshold inputs (pins 2 and 6) to the two comparators are connected together and to the external capacitor. The capacitor charges toward the supply voltage through the two resistors, R1 and R2. The discharge pin (7) connected to the internal transistor is connected to the junction of those two resistors.

When power is first applied to the circuit, the capacitor will be uncharged, therefore, both the trigger and threshold inputs will be near zero volts (see Fig. 10). The lower comparator sets the control flip-flop causing the output to switch high. That also turns off transistor T1. That allows the capacitor to begin charging through R1 and R2. As soon as the charge on the capacitor reaches 2/3 of the supply voltage, the upper comparator will trigger causing the flip-flop to reset. That causes the output to switch low. Transistor T1 also conducts. The effect of T1 conducting causes resistor R2 to be connected across the external capacitor. Resistor R2 is effectively connected to ground through internal transistor T1. The result of that is that the capacitor now begins to discharge through R2.

The only difference between the single 555, dual 556, and quad 558 (both 14-pin types), is the common power rail. For the rest everything remains the same as the single version, 8-pin 555.

As soon as the voltage across the capacitor reaches 1/3 of the supply voltage, the lower comparator is triggered. That again causes the control flip-flop to set and the output to go high. Transistor T1 cuts off and again the capacitor begins to charge. That cycle continues to repeat with the capacitor alternately charging and discharging, as the

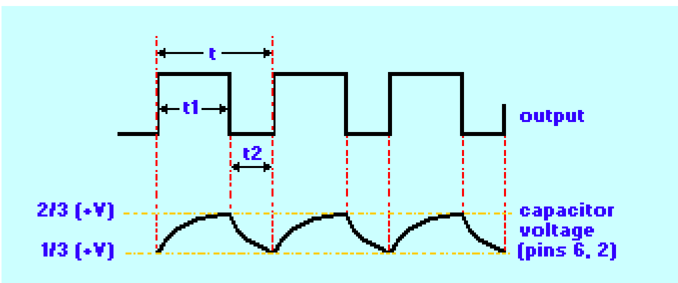


Fig. 10

comparators cause the flip-flop to be repeatedly set and reset. The resulting output is a continuous stream of rectangular pulses.

The frequency of operation of the astable circuit is dependent upon the values of R1, R2, and C. The frequency can be calculated with the formula:

$$f = 1/(.693 \times C \times (R1 + 2 \times R2))$$

The Frequency f is in Hz, R1 and R2 are in ohms, and C is in farads.
The time duration between pulses is known as the 'period', and usually designated with a 't'. The pulse is on for t1 seconds, then off for t2 seconds. The total period (t) is t1 + t2 (see fig. 10).
That time interval is related to the frequency by the familiar relationship:

$$f = 1/t$$

or

$$t = 1/f$$

The time intervals for the on and off portions of the ouput depend upon the values of R1 and R2. The ratio of the time duration when the ouput pulse is high to the total period is known as the duty-cycle. The duty-cycle can be calculated with the formula:

$$D = t1/t = (R1 + R2) / (R1 + 2R2)$$

You can calculate t1 and t2 times with the formulas below:

$$t1 = .693(R1+R2)C$$
$$t2 = .693 \times R2 \times C$$

The 555, when connected as shown in Fig. 9b, can produce duty-cycles in the range of approximately 55 to 95%. A duty-cycle of 80% means that the ouput pulse is on or high for 80% of the total period. The duty-cycle can be adjusted by varying the values of R1 and R2.

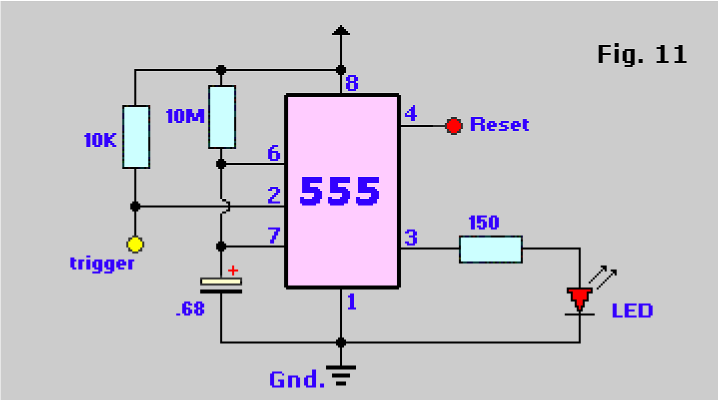
Applications:

There are literally thousands of different ways that the 555 can be used in electronic circuits. In almost every case, however, the basic circuit is either a one-shot or an astable.
The application usually requires a specific pulse time duration, operation frequency, and duty-cycle. Additional components may have to be connected to the 555 to interface the device to external circuits or devices.
In the remainder of this experiment, you will build both the one-shot and astable circuits and learn about some of the different kinds of applications that can be implemented. Furthermore, the last page of this document contains 555 examples which you can build and experiment with.

Required Parts:

In addition to a breadboard and a DC powersupply with a voltage in the 5 to 12 volt range, you will need the following components: 555 timer, LED, 2-inch /8 ohm loudspeaker, 150-ohm 1/4 watt resistor, two 10K ohm 1/4 resistors, two 1-Mega ohm 1/2 watt resistors, 10 Mega ohm 1/4 watt resistor, 0.1 uF capacitor, and a 0.68uF capacitor. All parts are available from Radio Shack or Tandy.

Experimental steps:



This circuit is resetable by grounding pin 4, so be sure to have an extra wire at pin 4 ready to test that feature.

1. **On your breadboard, wire the one-shot circuit as shown in figure 11.**

2. **Apply power to the circuit. If you have a standard 5 volt logic supply, use it for convenience. You may use any voltage between 5 and 15 volts with a 555 timer. You can also run the circuit from battery power. A standard 9-volt battery will work perfectly.
With the power connected, note the status of the LED:
is it on or off? ________________**

3. **Connect a short piece of hook-up wire to the trigger input line on pin 2. Momentarily, touch that wire to ground. Remove it quickly. That will create a pulse at the trigger input.
Note and record the state of LED: _____________________**

4. **Continue to observe the LED and note any change in the output state after a period of time. What is the state? ______________**

5. **When you trigger the one-shot, time the duration of the output pulse with a stopwatch or the seconds hand on your watch. To do that, the instant that you trigger the one-shot by touching the wire to ground, immediately start your stopwatch or make note of the seconds hand on your watch. Trigger the one-shot and time the ouput pulse. Write in the approximate value of the pulse-duration: ______________________**

6. **Using the values of external resistor and capacitor values in Fig. 11 and the time interval formula for a one-shot, calculate the output-pulse dura
What is your value? _____________________**

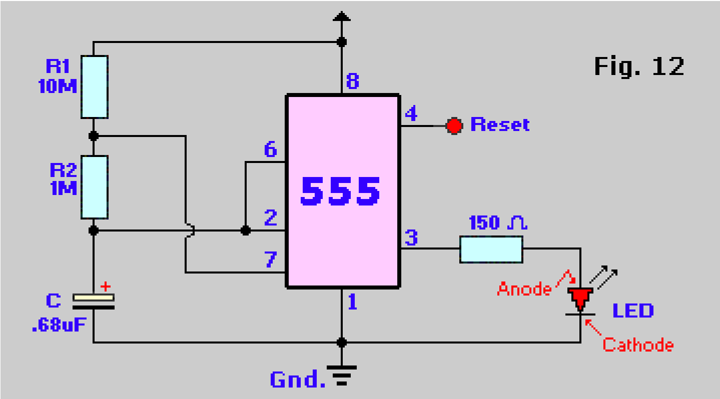
7. **Compare your calculated and timed values of output pulses. Explain any discrepencies between your calculated and measured values.
Answer: ____**

8. **Connect a short piece of hook-up wire to pin 4. You will use that as a reset.**

9. **Trigger the one-shot as indicated previously. Then immediately thouch the reset wire from pin 4 to ground. Note the LED result: _____________**

10. **With a DC voltmeter, measure the output voltage at pin 3 during the one shot's off and on states. What are your values?
OFF: __________ volts ON: ___________ volts.**

11. **Replace the 10 MegOhm resistor with a 1 MegOhm resostor and repeat steps 5 and 6. Record your timed and calculated results:
Timed: ________ seconds Calculated: _________seconds**



If you want to get fancy, after you've completed the experiment you can replace the resistors with potentiometers to build a variable function generator and play with that to learn more.

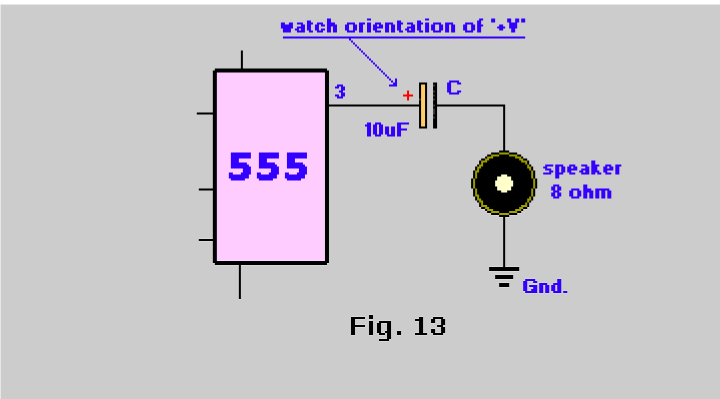
12. Next you will experiment with astable circuits. First, rewire the circuit it appears as shown in Fig. 12.

13. Apply power to the circuit and observe the LED. What is happening?
    Answer: ____

14. Replace the 10 MegOhm resistor with a 1 MegOhm resistor. Again observe the LED. Is the frequency higher or lower? _________________

15. Using the forumla given in the tutorial, calculate the oscillation frequenc using R1 as 10 MegOhm, and again with R1 as 1 MegOhm, and again with R1 as 10 MegOhm. R2 is 1 MegOhm in both cases. Record your freq's:
    f = _____________ Hz (R1 = 10 MegOhm)
    f = _____________ Hz (R1 = 1 MegOhm)

16. Calculate the period, t1 and t2, and the duty-cycle for each resistor value
    10 MegOhm: t = ___________ t1 = ____________ t2 = ____________
    1 MegOhm: t = ___________ t1 = ____________ t2= ____________



Monitoring the timer with a speaker can be amusing if you switch capacitors or resistors to make an organ.

17. Rewire the circuit making R1 and R2 10,000 ohms and C equal to 0.1uF. Use the same circuit in Fig. 12. But, replace the LED and its resistor wi a speaker and capacitor as shown in Fig. 13.

18. Apply power to the circuit and note the result: ______________________

19. Calculate the frequency of the circuit: f = ____________________ Hz

20. If you have an oscilloscope, monitor the output voltage on pin 3. Disconnect the speaker and note the output. Also, observe the capacitor charge and discharge at pin 6 or 2: ______________________________

Review of steps 1 through 20:

The circuit you built for those steps was a one-shot multi-vibrator. The circuit is similar to that described in the tutorial. The trigger input is held high with a 10,000 ohm resistor. When you bring pin 2 low, by touching the wire to ground, the one-shot is fired. The LED installed at the output of the 555 is used to monitor the output pulse. The LED goes on when the one-shot is triggered.

The component values selected for the circuit are large, so as to generate a long output pulse. That allows you to measure the pulse duration with a stop watch. Once the one-shot is triggered, the output LED stays on until the capacitor charges to 2/3 of the supply voltage. That triggers the upper comparator and causes the internal control flip-flop to reset, turning off the pulse and discharging the capacitor. The one-shot will remain in that state until it is triggered again.

Timing the pulse should have produced an output duration of approximately 7.5 seconds.

Calculating the output time interval using the formula given previously, you found the pulse duration to be:

$$t = 1.1 \times .68 \times 10^{-6} \times 10^{7} = 7.48 \text{ seconds}$$

You may have notice some difference between the calculated and actual measured values. The differences probably result from inaccuracies in your timing. Further, component tolerances may be such that the actual values are different from the marked values.

In **steps 8 and 9** you demonstrated the reset function. As you saw, you could terminate the output pulse before the timing cycle is completed by touching pin 4 to ground. That instantly resets the flip-flop and shuts off the output pulse.

In **step 10**, you measured the output voltage. When off, the output is only a fraction of a volt. For all practical purposes it is zero. When triggered, the 555 generates a 3.5 volt pulse with a 5-volt supply. If you used another value of supply voltage, you would probably have discovered that the output during the pulse is about 1.5 volt less than the supply voltage.

In **step11**, you lowered the resistor value to 1 Megohm. As you noticed, that greatly shortens the output pulse duration. The LED only stayed on for a brief time; so brief in fact that you probably couldn't time it accurately. The calculated duration of the output pulse is 0.748 seconds.

The circuit you built for **steps 12 - 20** was an astable multi-vibrator. The astable circuit is an oscillator whose frequency is dependent upon the R1, R2, and C values. In **step 13**, you should have found that the LED flashed off and on slowly.

The oscillation frequency is 0.176 Hz. That gives a period of:

$$t = 1/f = 1/.176 = 5.66 \text{ seconds}$$

Since R1 is larger than R2, the LED will be **on** for a little over 5 seconds and it will stay **off** for only 0.5 seconds. That translates to a duty-cycle of:

$$D = t1/t = 5.18/5.66 = .915 \text{ or } 91.5\%$$

In **step 14**, you replaced the 10 MegOhm resistor with a 1 MegOhm resistor making both R1 and R2 equal. The new frequency is 0.706 Hz, much higher than in **step 13**. That translates to a period of 1.41 seconds. Calculating the t1 and t2 times, you see that the LED is on for 0.942 second and off for 0.467 second. That represents a duty-cycle of:

$$D = 0.942/1.41 = 0.67 \text{ or } 67\%$$

In **step 17**, you made R1 = R2 = 10,000 ohm (10K) and C = 0.1uF. That increased the frequency to 480Hz. The result should have been a loud tone in the speaker.
If you had used an oscilloscope, you saw the output to be a distorted rectangular wave of about 2 volts peak-to-peak. That distortion is caused by the speaker load. Removing it makes the waveform nice and square and the voltage rises to about 5 volts peak-to-peak. The capacitor waveform is a combination of the classical charge and discharge curves given earlier.
The time is useful in computer, function generators, clocks, music synthesizers, games, flashing lights, printers, scanners and the list goes on and on.

Example Circuits:

I have placed a couple of 555 circuit examples below for your convenience. Play with different component values and use the formulas mentioned earlier to calculate your results. Things to remember: For proper monostable operation with the 555 timer, the negative-going trigger pulse width should be kept short compared tot he desired output pulse width. Values for the external timeing resistor and capacitor can either be determined from the previous formulas. However, you should stay within the ranges of resistances shown earlier to avoid the use of large value electrolytic capacitors, since they tend to be leaky. Otherwise, tantalum or mylar types should be used. (For noise immunity on most timer circuits I recommend a 0.01uF (10nF) ceramic capacitor between pin 5 and ground.) In all circuit diagrams below I used the LM555CN timer IC from National, but the NE555 and others should not give you any problems

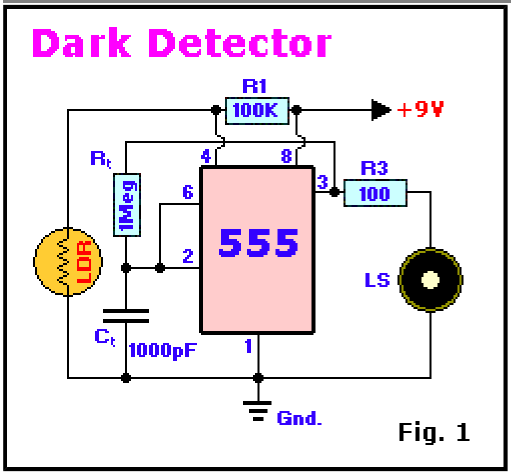


Fig. 1

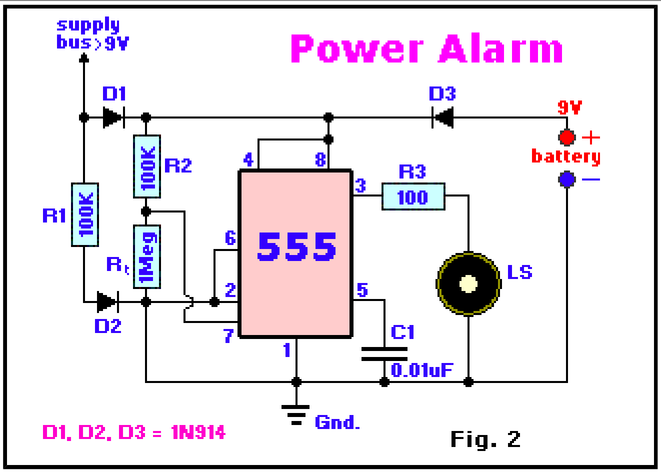


Fig. 2

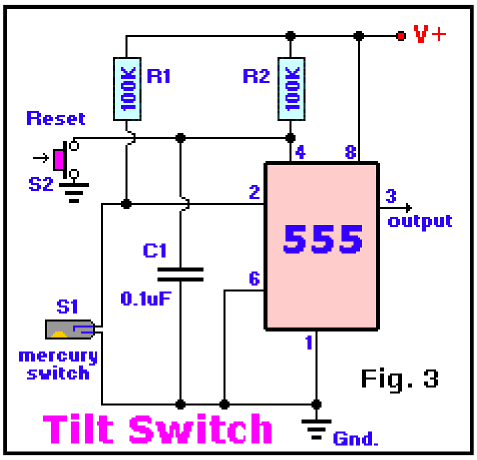


Fig. 3

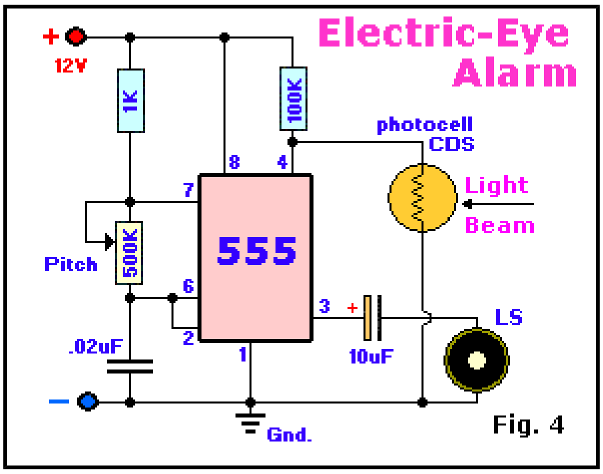
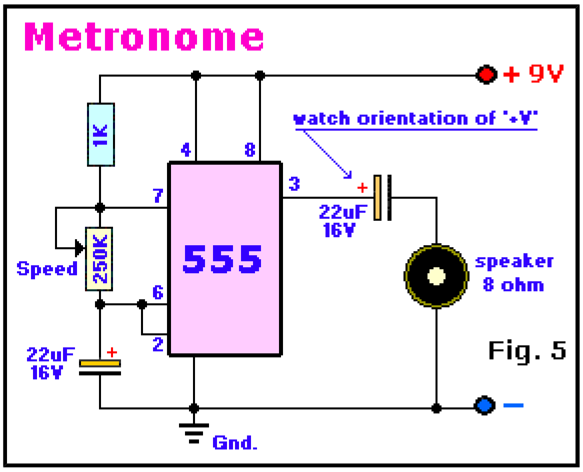
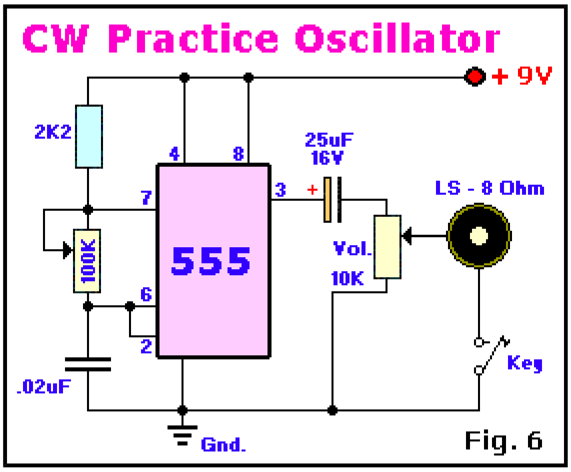
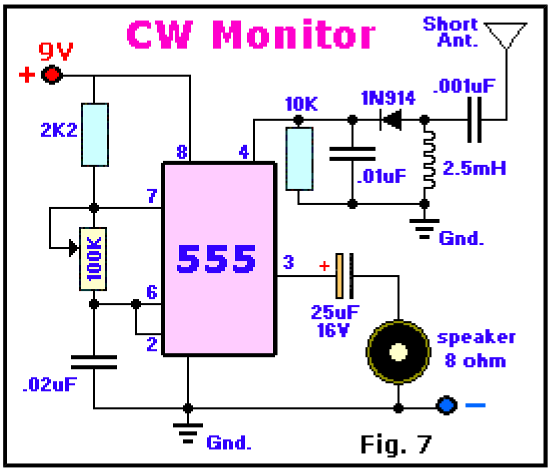
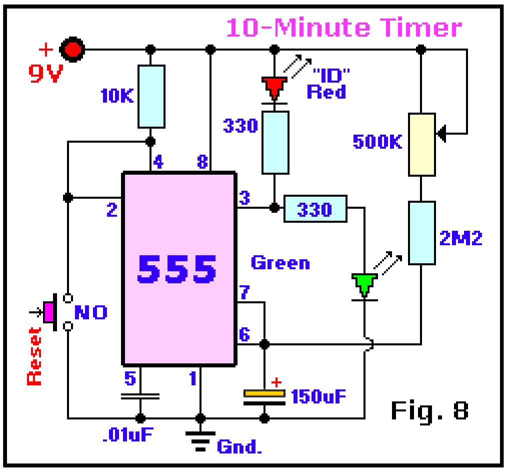


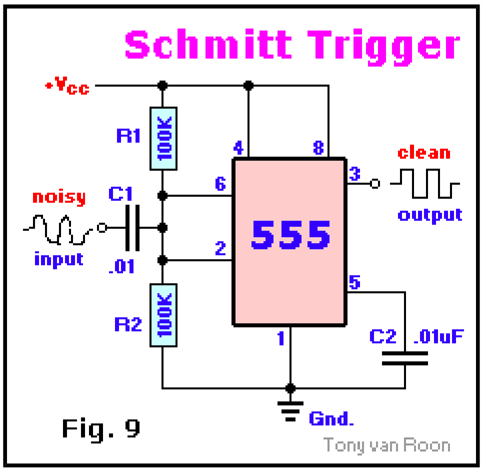
Fig. 4

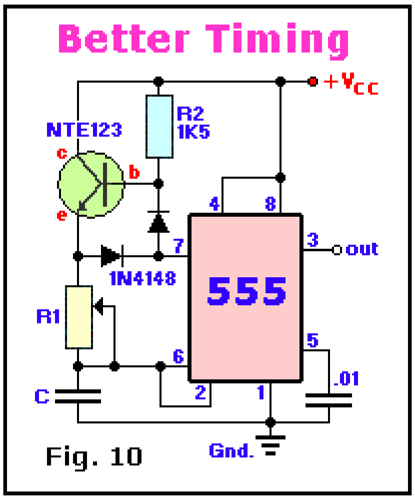












Circuits 1 to 10:

Play with different indicating devices such as bells, horns, lights, relays, or whatever (if possible). Try different types of LDR's. If for any reason you get false triggering, connect a ceramic 0.01uF (=10nF) capacitor between pin 5 (555) and ground. Keeping the basic rules of the 555 timer, try different values for Ct and Rt (or the C & R over pins 2, 6 & 7) Replace Rt with a 1 megohm potentiometer if you wish. Make notes of the values used and use the formulas to calculate timing. Verify your calculations with your timing.

Fig. 1, Dark Detector: It will sound an alarm if it gets too dark all over sudden. For example, this circuit could be used to notify when a lamp (or bulb) burns out. The detector used is a regular cadmium-sulphide Light Dependent Resistor or ***LDR***, for short, to sense the absense of light and to operate a small speaker. The LDR enables the alarm when light falls below a certain level.

Fig. 2, Power Alarm: This circuit can be used as a audible 'Power-out Alarm'. It uses the 555 timer as an oscillator biased off by the presence of line-based DC voltage. When the line voltage fails, the bias is removed, and the tone will be heard in the speaker. R1 and C1 provide the DC bias that charges capacitor Ct to over 2/3 voltage, thereby holding the timer output low (as you learned previously). Diode D1 provides DC bias to the timer-supply pin and, optionally, charges a rechargeable 9-volt battery across D2. And when the line power fails, DC is furnished to the timer through D2.

Fig. 3 Tilt Switch: Actually really a alarm circuit, it shows how to use a 555 timer and a small glass-encapsulated mercury switch to indicate 'tilt'.
The switch is mounted in its normal 'open' position, which allows the timer output to stay low, as established by C1 on startup. When S1 is disturbed, causing its contacts to be bridged by the mercury blob, the 555 latch is set to a high output level where it will stay even if the switch is returned to its starting position. The high output can be used to enable an alarm of the visual or the audible type. Switch S2 will silent the alarm and reset the latch. C1 is a ceramic 0.1uF (=100 nano-Farad) capacitor.

Fig. 4, Electric Eye Alarm: The Electric-Eye Alarm is actually a simular circuit like the Dark Detector of Fig. 1. The same type of LDR is used. The pitch for the speaker can be set with the 500 kilo-ohm potentiometer. Watch for the orientation of the positive (+) of the 10uF capacitor. The '+' goes to pin 3.

Fig. 5, Metronome: A Metronome is a device used in the music industry. It indicates the ritme by a 'toc-toc' sound which speed can be adjusted with the 250K potentiometer. Very handy if you learning to play music and need to keep the correct ritme up.

Fig. 6, CW Practice Oscillator: CW stands for *'Contineous Wave'* or Morse-Code. You can practice the morse-code with this circuit. The 100K potmeter is for the 'pitch' and the 10K for the speaker volume. The "Key" is a morse code key.

Fig. 7, CW Monitor: This circuit monitors the morse code 'on-air' via the tuning circuit hookup to pin 4 and the short wire antenna. The 100K potmeter controls the tone-pitch.

Fig. 8, Ten-Minute Timer: Can be used as a time-out warning for Ham Radio. The Federal Communications Commission (FCC) requires the ham radio operator to identify his station by giving his call-sign at least every 10 minutes. This can be a problem, especially during lengthy conversations when it is difficult to keep track of time. The 555 is used as a one-shot so that a visual warning indicator becomes active after 10-minutes. To begin the cycle, the reset switch is pressed which causes the *'Green'* led to light up. After 10 minutes, set by the 500K potentiometer R1, the *'Red'* led will light to warn the operator that he must indentify.

Fig. 9, Schmitt Trigger: A very simple, but effective circuit. It cleans up any noisy input signal in a nice, clean and square output signal. In radio control (R/C) it will clean up noisy servo signals caused by rf interference by long servo leads. As long as R1 equals R2, the 555 will automatically be biased for any supply voltage in the 5 to 16 volt range. (Advanced Electronics: It should be noted that there is a 180-degree phase shift.) This circuit also lends itself to condition 60-Hz sine-wave reference signal taken from a 6.3 volt AC transformer before driving a series of binary or divide-by-N counters. The major advantage is that, unlike a conventional multivibrator type of squarer which devides the input frequency by 2, this method simply squeares the 60-Hz sine wave reference signal without division.

Fig. 10, Better Timing: Better and more stable timing output is created with the addition of a transistor and a diode to the R-C timing network. The frequency can be varied over a wide range while maintaining a constant 50% duty-cycle. When the output is **high**, the transistor is biased into saturation by R2 so that the charging current passes through the transistor and R1 to C. When the output goes **low**, the discharge transistor (pin 7) cuts off the transistor and discharges the capacitor through R1 and the diode. The high & low periods are equal. The value of the capacitor (C) and the resistor (R1 or potmeter) is not given. It is a mere example of how to do it and the values are pending on the type of application, so choose your own values. The diode can be any small signal diode like the NTE519, 1N4148, 1N914 or 1N3063, but a high conductance Germanium or Schottky type for the diode will minimize the diode voltage drops in the transistor and diode. However, the transistor should have a high beta so that R2 can be large and still cause the transistor to saturate. The transistor can be a TUN (europe), NTE123, 2N3569 and most others.

The following circuits are examples of how a 555 timer IC assist in combination with another **I**ntegrated **C**ircuit. Again, don't be afraid to experiment. Unless you circumvent the min and max parameters of the 555, it is very hard to destroy. Just have fun and learn something doing it.

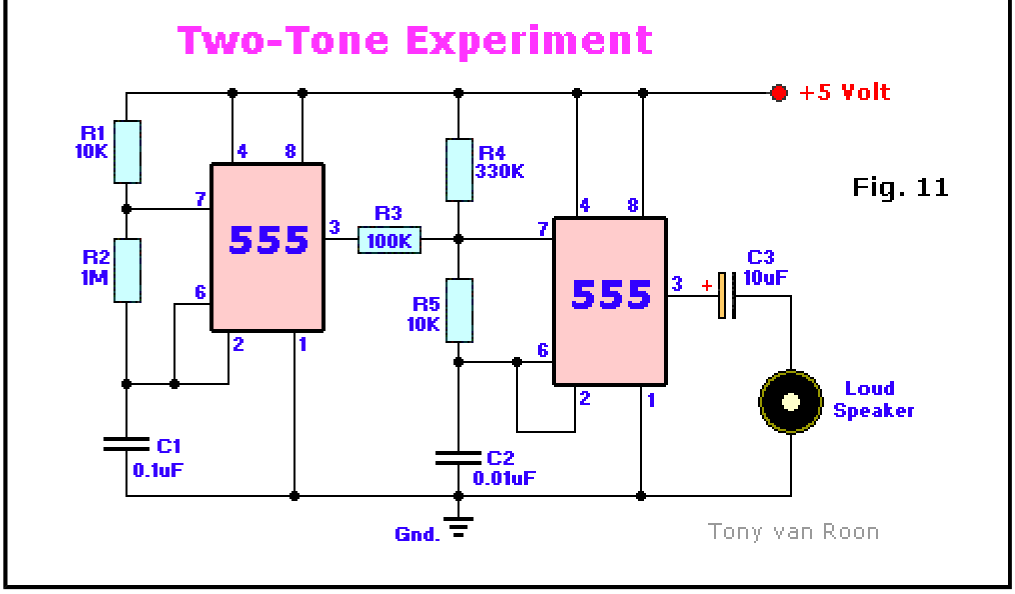


Fig. 11

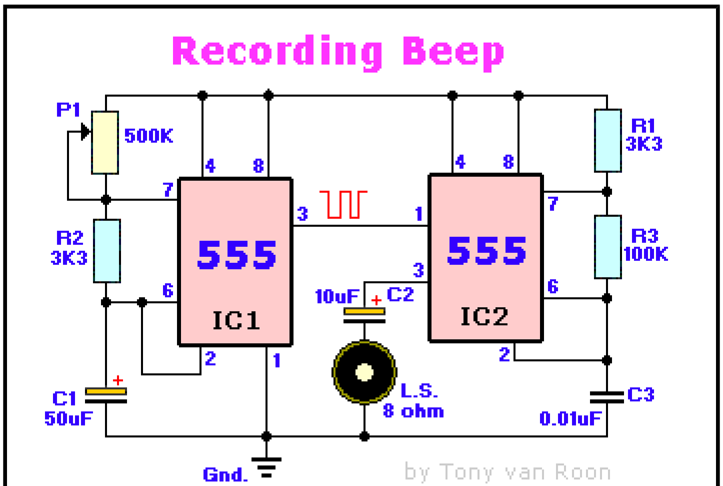
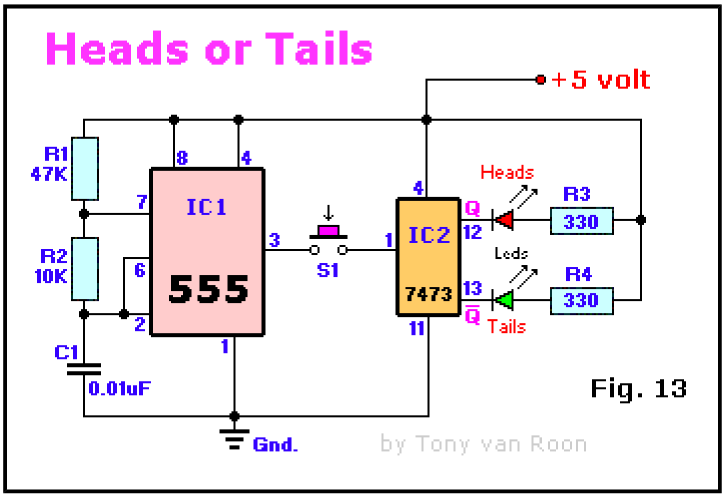
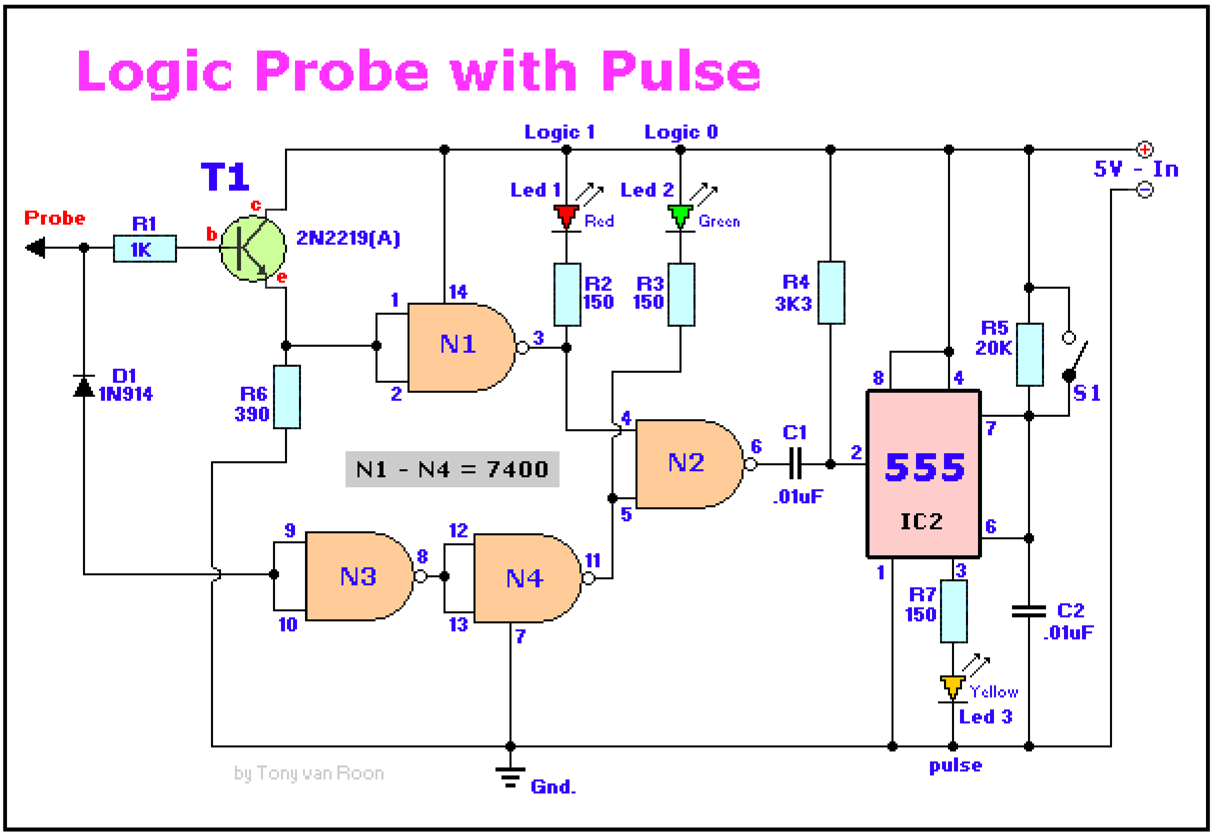
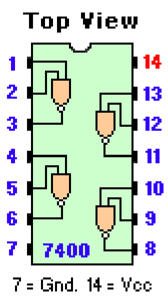


Fig. 12







Circuits 11 to 14:

Play with different indicating devices such as bells, horns, lights, relays, or whatever (if possible). Try different types of LDR's. If for any reason you get false triggering, connect a ceramic 0.01uF (=10nF) capacitor between pin 5 (555) and ground. In all circuit diagrams below I used the LM555CN timer IC from National. Keeping notes is an important aspect of the learning process.

Fig. 11, Two-Tones: The purpose of this experiment is to wire two 555 timers together to create a 2-note tone. If you wish, you can use the dual 556 timer ic.

Fig. 12, Recording Beep: This circuit is used to keep recording of telephone conversations legal. As you may know, doing otherwise without consent of the other party is illegal. The output of IC1 is fed to the 2nd 555's pin 3 and made audible via C2 and the speaker. Any 8-ohm speaker will do.

Fig. 13, Coin Toss: Electronic 'Heads-or-tails' coin toss circuit. Basically a **Yes** or **No** decision maker when you can't make up your mind yourself. The 555 is wired as a Astable Oscillator, driving in turn, via pin 3, the [7473](7473) flip-flop. When you press S1 it randomly selects the 'Heads' or 'Tails' led. The leds flashrate is about 2Khz (kilo-Hertz), which is much faster than your eyes can follow, so initially it appears that both leds are 'ON'. As soon as the switch is released only one led will be lit.

Fig. 14, Logic Probe: Provides you with three visible indicators; "Logic 1" (+, red led), "Logic 0" (-, green led), and "Pulse" (yellow led). Good for TTL and CMOS. The yellow or 'pulse' led comes on for approximately 200 mSec to indicate a pulse without regards to its width. This feature enables one to observe a short-duration pulse that would otherwise not be seen on the logic 1 and 0 led's. A small switch (subminiature slide or momentary push) across the 20K resistor can be used to keep this "pulse" led on permanently after a pulse occurs.
In operation, for a logic 0 input signal, both the '0' led and the pulse led will come 'ON', but the 'pulse' led will go off after 200 mSec. The logic levels are detected via resistor R1 (1K), then amplified by T1 (NPN, Si-AF Preamplifier/Driver), and selected by the 7400 IC for what they are. Diode D1 is a small signal diode to protect the **7400** and the leds from excessive inverse voltages during capacitor discharge.
For a logic '1' input, only the logic '1' led (red) will be 'ON'. With the switch closed, the circuit will indicate whether a negative-going or positive-going pulse has occurred. If the pulse is positive-going, both the '0' and 'pulse' led's will be on. If the pulse is negative-going, the '1' and 'pulse' led's will be on.

INPUTS			OUTPUTS	
Pin 4 (LOW)	Pin 6 (HIGH)	Pin 2 (LOW)	National LM555H	Signetics NE555V
⊔	0	1	Resets ∫	Resets ∫
⊔	1	1	0	0
⊔	0	0	⊔	⊔
⊔	1	0	0	⊔
1	⊓	1	Resets	Resets
1	⊓	0	⊔	1
0	⊓	1	0	0
0	⊓	0	0	0
1	0	⊔	sets ∫	sets ∫
1	1	⊔	0	⊓
0	0	⊔	0	0
0	1	⊔	0	0

Pin 2 = Trigger, Pin 4 = Reset, Pin 6 = Threshold
Pin 2, 4, and 6 are 'active'

Table 2.

Check the listing in Table 2. It shows some variations in the 555 manufacturing process by two different manufacturers, National Semiconductor and Signetics Corporation. Since there are other manufacturers then those two I suggest when you build a circuit to stick with the particular 555 model they specify in the schematic.
Unless you know what you're doing ofcourse... [grin].

The absolute maximum ratings (in free air) for NE/SA/SE types are:

```
                     Vcc, supply voltage: 18V
Input voltage (CONT, RESET, THRES, TRIG): Vcc
                          Output current: 225mA (approx)
          Operating free-air temp. range: NE555..........   0°C - 70°C
                                          SA555.......... -40°C - 85°C
                                          SE555, SE555C... -55°C - 125°C
               Storage temperature range: -65°C - 150°C
Case temperature for 60sec. (FK package): 260°C
```

Suggested Reading:

1. 555 Timer IC Circuits. Forrest M. Mims III, Engineer's Mini Notebook. Radio Shack Cat. No: 62-5010. "Create & experiment with pulse generators, oscillators, and time delays."

2. IC Timer Cookbook. Walter G. Jung. Published by Howard W. Sams & Co., Inc. ISBN: 0-672-21932-8. "A reference 'must' for hobby, technicians, and engineers."

3. The 555 Timer Applications Sourcebook. Howard M. Berlin. Published by Sams Inc. ISBN: 0-672-21538-1. "Learn how to connect the 555, perform 17 simple experiments."

Docs updated, September 29, 2000

Flammable Gas Sensor

（Model：MQ-5）

Manual

Version: 1.5

Valid from: 2018-04-1

Zhengzhou Winsen Electronics Technology Co., Ltd

Statement

Thanks for purchasing our product. In order to let customers use it better and reduce the faults caused by misuse, please read the manual carefully and operate it correctly in accordance with the instructions. If users disobey the terms or remove, disassemble, change the components inside of the sensor, we shall not be responsible for the loss.

The specific such as color, appearance, sizes &etc, please in kind prevail.

We are devoting ourselves to products development and technical innovation, so we reserve the right to improve the products without notice. Please confirm it is the valid version before using this manual. At the same time, users’ comments on optimized using way are welcome.

Please keep the manual properly, in order to get help if you have questions during the usage in the future.

Zhengzhou Winsen Electronics Technology CO., LTD

MQ-5 Semiconductor Sensor for Flammable Gas

Profile

Sensitive material of MQ-5 gas sensor is SnO_2, which with lower conductivity in clean air. When the target flammable gas exist, the sensor's conductivity gets higher along with the gas concentration rising. Users can convert the change of conductivity to correspond output signal of gas concentration through a simple circuit.

MQ-5 gas sensor has high sensitivity to butane, propane, methane and can detect methane and propane at the same time. It also can detect kinds of flammable gases, especially LPG(propane). It is a kind of low–cost sensor for many applications.

Features

It has good sensitivity to flammable gas (especially propane) in wide range, and has advantages such as long lifespan, low cost and simple drive circuit &etc.

Main Applications

It is widely used in domestic gas leakage alarm, industrial flammable gas alarm and portable gas detector.

Technical Parameters Stable.1

Model			MQ-5
Sensor Type			Semiconductor
Standard Encapsulation			Bakelite, Metal cap
Target Gas			LPG, CH_4
Detection range			300～10000ppm（CH_4,C_3H_8）
Standard Circuit Conditions	Loop Voltage	V_c	≤24V DC
	Heater Voltage	V_H	5.0V±0.1V AC or DC
	Load Resistance	R_L	Adjustable
Sensor character under standard test conditions	Heater Resistance	R_H	26Ω±3Ω (room temp.)
	Heater consumption	P_H	≤950mW
	Sensitivity	S	Rs(in air)/Rs(in 2000ppm C_3H_8)≥5
	Output Voltage	Vs	2.5V～4.0V (in 2000ppm C_3H_8)
	Concentration Slope	α	≤0.6($R_{3000ppm}$/$R_{1000ppm}$ C_3H_8)
Standard test conditions	Tem. Humidity		20℃±2℃；55%±5%RH
	Standard test circuit		Vc:5.0V±0.1V V_H:5.0V±0.1V
	Preheat time		Not less than 48 hours
	O2 content		21%（not less than 18%） O2 concentration effects initial value, sensitivity and repeatability.
Lifespan			10 years

NOTE: Output voltage (Vs) is V_{RL} in test environment.

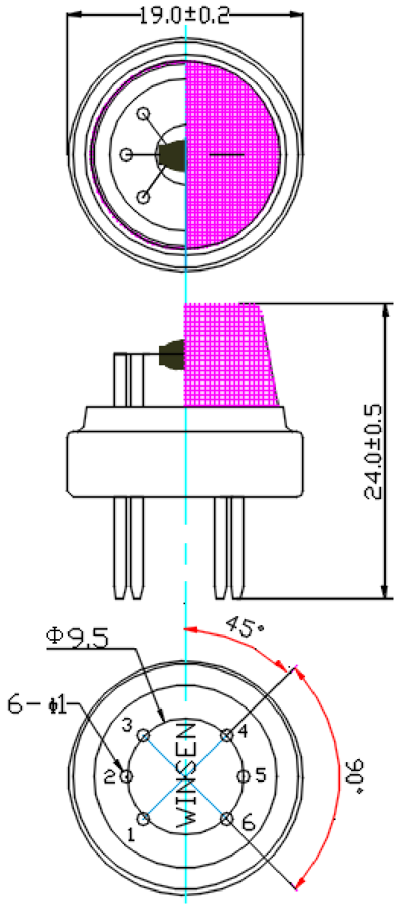


Fig1.Sensor Structure

Unit: mm Tolerance:±0.1mm

Basic Circuit

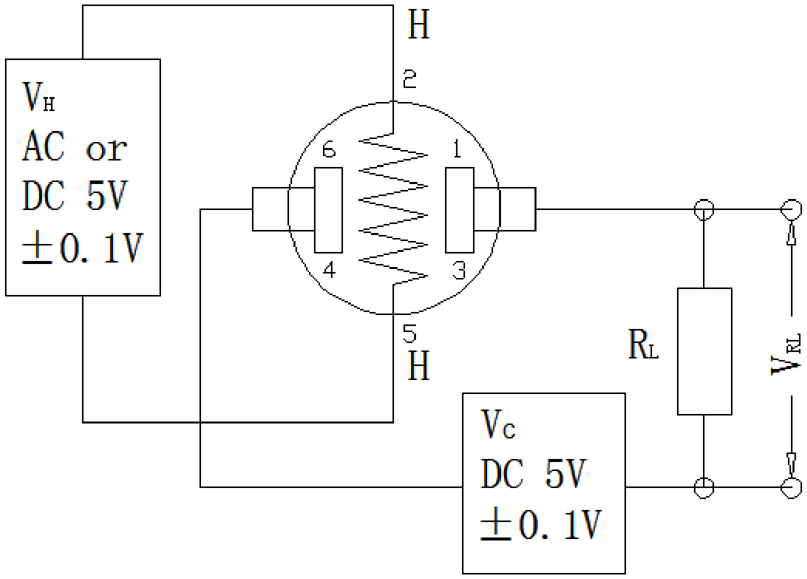


Fig2. MQ-5 Test Circuit

Instructions: The above fig is the basic test circuit of MQ-5.The sensor re r

Fig1.Sensor Structure

voltage (V_H) and circuit voltage (V_C). V_H is used to supply standard workir **Unit: mm** d

it can adopt DC or AC power, while V_{RL} is the voltage of load resistance R_L which is in series with sensor. Vc supplies the detect voltage to load resistance R_L and it should adopt DC power.

Description of Sensor Characters

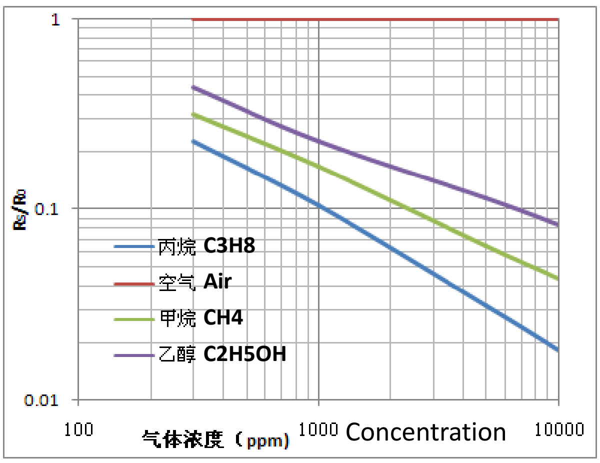


Fig3.Typical Sensitivity Curve

The ordinate is resistance ratio of the sensor (Rs/R_0), the abscissa is concentration of gases. Rs means resistance in target gas with different concentration, R_0 means resistance of sensor in clean air. All tests are finished under standard test conditions.

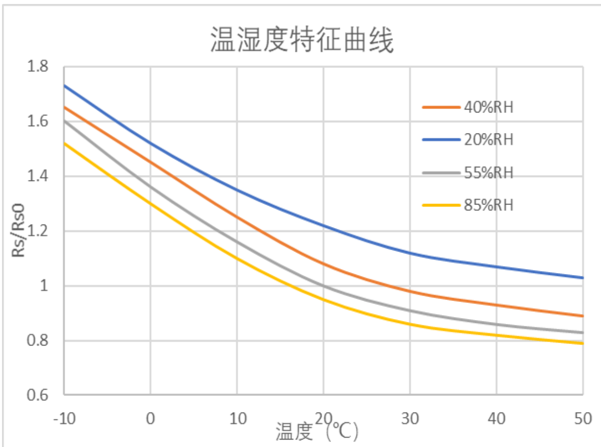


Fig4.Typical temperature/humidity characteristics

The ordinate is resistance ratio of the sensor (Rs/Rso).Rs means resistance of sensor in 2000ppm propane (C_3H_8) under different tem. and humidity. Rso means resistance of the sensor in 2000ppm propane under 20℃/55%RH.

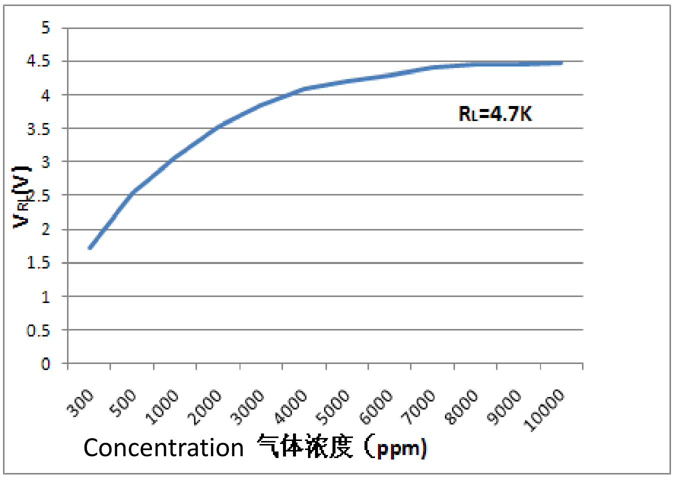


Fig5.Sensitity Curve

Fig5 shows the V_{RL} in propane with different concentration. The resistance load R_L is 4.7 KΩ and the test is finished in standard test conditions.

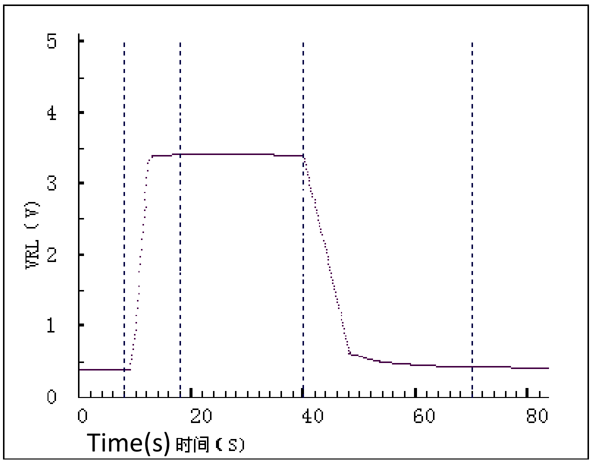


Fig6.Responce and Resume

Fig5 shows the changing of V_{RL} in the process of putting the sensor into target gas and removing it out.

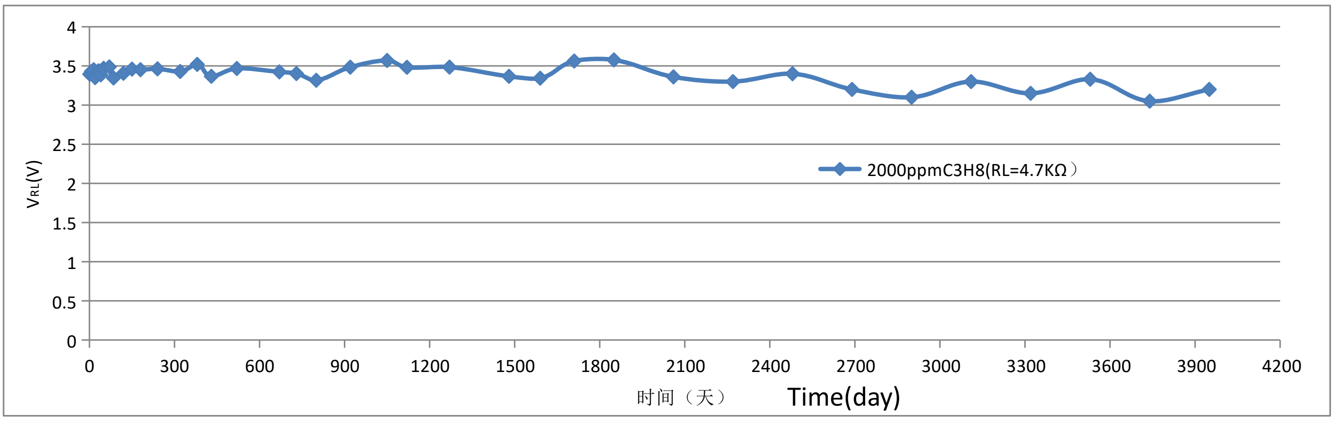


Fig7.long-term Stability

Test is finished in standard test conditions, the abscissa is observing time and the ordinate is V_{RL}.

Cautions

1 .Following conditions must be prohibited

1.1 Exposed to organic silicon steam

Sensing material will lose sensitivity and never recover if the sensor absorbs organic silicon steam. Sensors must avoid exposing to silicon bond, fixature, silicon latex, putty or plastic contain silicon environment.

1.2 High Corrosive gas

If the sensors are exposed to high concentration corrosive gas (such as H_2S, SO_X, Cl_2, HCl etc.), it will not only result in corrosion of sensors structure, also it cause sincere sensitivity attenuation.

1.3 Alkali, Alkali metals salt, halogen pollution

The sensors performance will be changed badly if sensors be sprayed polluted by alkali metals salt especially brine, or be exposed to halogen such as fluorine.

1.4 Touch water

Sensitivity of the sensors will be reduced when spattered or dipped in water.

1.5 Freezing

Do avoid icing on sensor's surface, otherwise sensing material will be broken and lost sensitivity.

1.6 Applied higher voltage

Applied voltage on sensor should not be higher than stipulated value, even if the sensor is not physically damaged or broken, it causes down-line or heater damaged, and bring on sensors' sensitivity characteristic changed badly.

1.7 Voltage on wrong pins

For 6 pins sensor, Pin 2&5 is heating electrodes, Pin (1,3)/(4,6) are testing electrodes (Pin 1 connects with Pin 3, while Pin 4 connects with Pin 6).If apply voltage on Pin 1&3 or 4&6, it will make lead broken; and no signal putout if apply on pins 2&4.

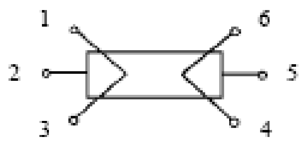


Fig8. Lead sketch

2 .Following conditions must be avoided

2.1 Water Condensation

Indoor conditions, slight water condensation will influence sensors' performance lightly. However, if water condensation on sensors surface and keep a certain period, sensors' sensitive will be decreased.

2.2 Used in high gas concentration

No matter the sensor is electrified or not, if it is placed in high gas concentration for long time, sensors characteristic will be affected. If lighter gas sprays the sensor, it will cause extremely damage.

2.3 Long time storage

The sensors resistance will drift reversibly if it's stored for long time without electrify, this drift is related with storage conditions. Sensors should be stored in airproof bag without volatile silicon compound. For the sensors with long time storage but no electrify, they need long galvanical aging time for stability before using. The suggested aging time as follow:

Stable2.

Storage Time	**Suggested aging time**
Less than one month	No less than 48 hours
1 ~ 6 months	No less than 72 hours
More than six months	No less than 168 hours

2.4 Long time exposed to adverse environment

No matter the sensors electrified or not, if exposed to adverse environment for long time, such as high humidity, high temperature, or high pollution etc., it will influence the sensors' performance badly.

2.5 Vibration

Continual vibration will result in sensors down-lead response then break. In transportation or assembling line, pneumatic screwdriver/ultrasonic welding machine can lead this vibration.

2.6 Concussion

If sensors meet strong concussion, it may lead its lead wire disconnected.

2.7 Usage Conditions

2.7.1For sensor, handmade welding is optimal way. The welding conditions as follow:

- Soldering flux: Rosin soldering flux contains least chlorine

- homothermal soldering iron
- Temperature： 250℃
- Time：less than 3 seconds

2.7.1If users choose wave-soldering, the following conditions should be obeyed:

- Soldering flux: Rosin soldering flux contains least chlorine
- Speed: 1-2 Meter/ Minute
- Warm-up temperature：100±20℃
- Welding temperature：250±10℃
- One time pass wave crest welding machine

If disobey the above using terms, sensors sensitivity will be reduced.

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E-mail: sales@winsensor.com
Website: www.winsen-sensor.com

Photoelectric Motion Sensor

PIR-045

CE

Features

- Specific component from Japan
- Saving power, High sensitivity, Easy installation
- Compatible with any light source: Tungsten lamp, Light tube, LED light
- Multi-Function switchablel ; OFF delay, Standby brightness, Day/Night functions 3 main settings combination
- 2 years warranty

Applications

- Motion detection
- Suitable location: Parking lot, Basement, Staircase, Front door, Porch, Garage, Public toilet

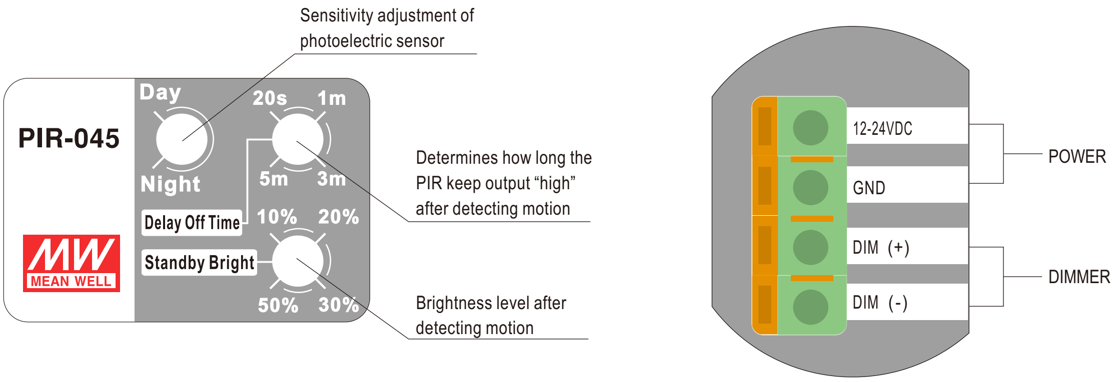
Description

PIR-045 is a photoelectric motion sensor with DC input. when PIR-045 deters movement of human, it will provide a 10VDC signal. The signal can be transmitted to a 0~10V or 1~10V dimmble led power supply so as to switch and control multiple lighting units simultaneously.

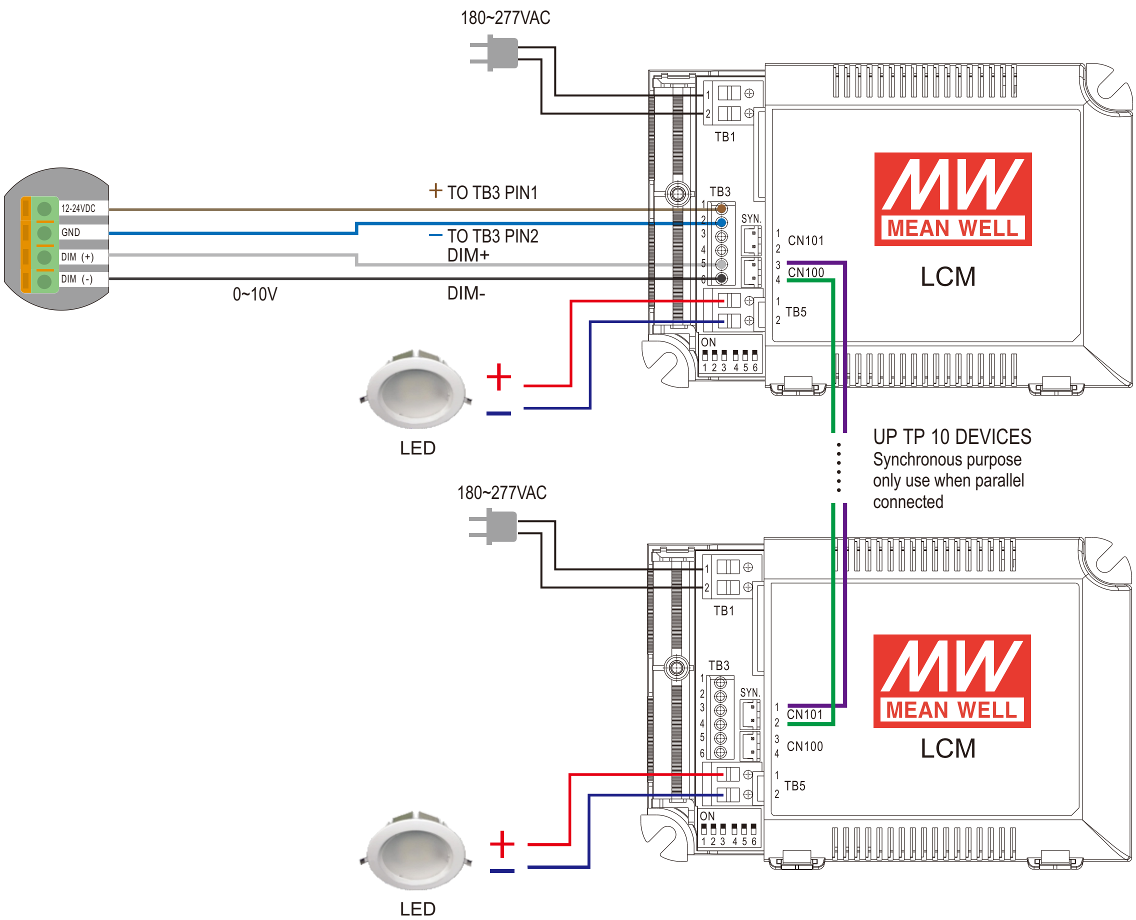
SPECIFICATION

MODEL		PIR-045
OUTPUT	SENSING DISTANCE	≦6M
	SENSING ANGLE	<120°
	OPERATING VOLTAGE	DC12~24V
	CURRENT CONSUMPTION	≦18mA
	OUTPUT DIM VOLTAGE	High=10V ; Low=1V / 2V / 3V / 5V selected by standby bright
FUNCTION	WORKING PURPOSE	Day / Night
	STANDBY BRIGHT	10%, 20%, 30%, 50%
	DELAY OFF TIME	20s, 1 min, 3min, 5min
	DIMMING MODE	gradually ON and OFF
ENVIRONMENT	OPERATING TEMPERATURE	-10 ~ +40℃
	OPERATING HUMIDITY	35 ~ 85% RH non-condensing
OTHERS	MATERIAL	PC
	DIMENSION	60*71.3mm (D*H)
	PACKING	78g; 160pcs/13.6Kg

FUNCTION

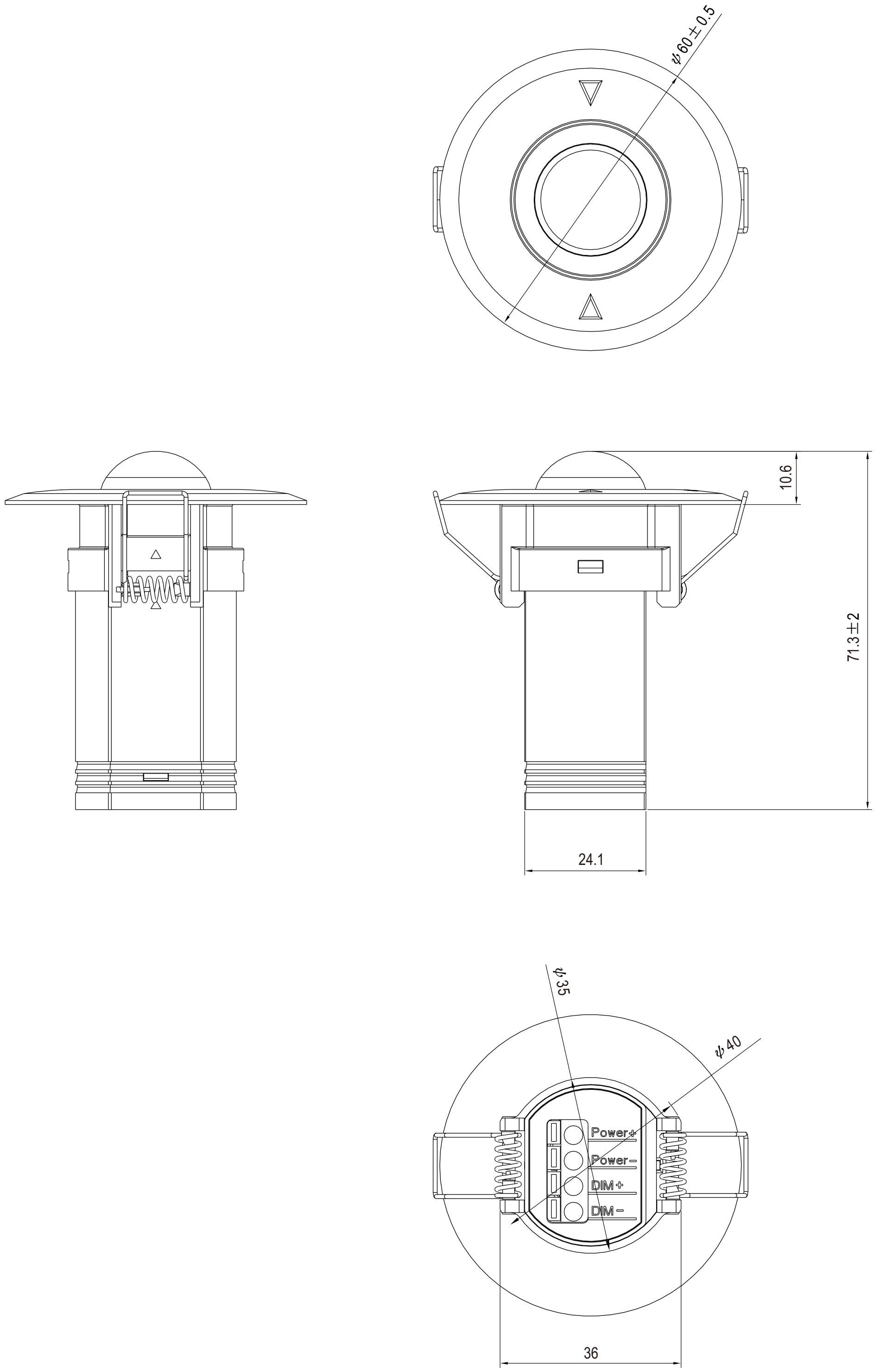


CONNECTION

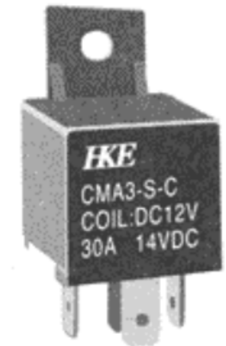


■ Mechanical Specification

Unit:mm



CMA3 Relay



CMA3 Relay

1.COIL DATA

1-1.Nominal Voltage	6 VDC to 24 VDC
1-2.Coil Resistance	Refer to Table 1
1-3.Operate Voltage	Refer to Table 1
1-4.Release Voltage	Refer to Table 1
1-5.Nominal Power Consumption	1.6 W

2.CONTACT DATA

2-1.Contact Arrangement	1 Form C , 1 Form A
2-2.Contact Material	$AgSnO_2$
2-3.Contact Rating	30A 14VDC Resistive (1 Form C) 40A 14VDC Resistive (1 Form A)
2-4.Max. Switching Voltage	75VDC
2-5.Max. Switching Current	40A
2-6.Max. Switching Power	420W (1 Form C) 560W (1 Form A)

2-7.Max. Load Current (12VDC Load Voltage)

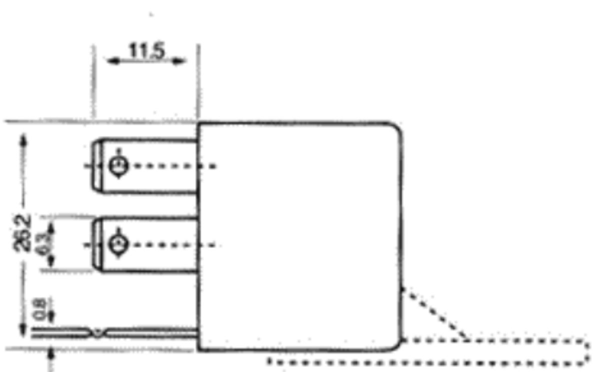
Load	Form A	Form C	
		NO	NC
Max.Carry Current	40A	40A	30A
Max.Make Current	100A	100A	30A
Max.Break Current	40A	40A	30A

2-8.Contact Resistance (Initial)		50 m¦¸ at 6VDC 1A
2-9.Life Expectancy	Electrical	100,000 operations at nominal load
	Mechanical	10,000,000 operations

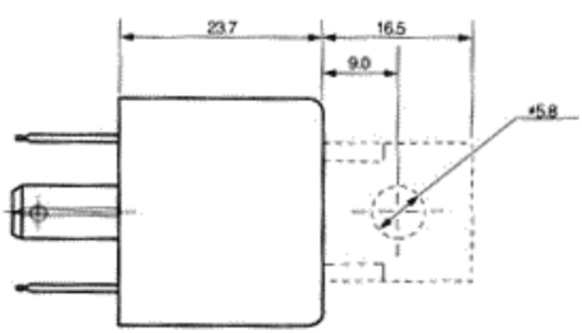
3.GENERAL DATA

3-1.Insulation Resistance	Min.100M¦¸ at 500 VDC
3-2.Dielectric Strength	550VAC , 1min between open contacts 750VAC , 1min between contacts and coil
3-3.Operate Time	Max. 10ms
3-4.Release Time	Max. 10ms
3-5.Temperature Range	-40 to +85 ¡æ
3-6.Shock Resistance	10G
3-7.Vibration Resistance	10 - 55 Hz , Amplitude 1.5mm
3-8.Weight	30 gr.

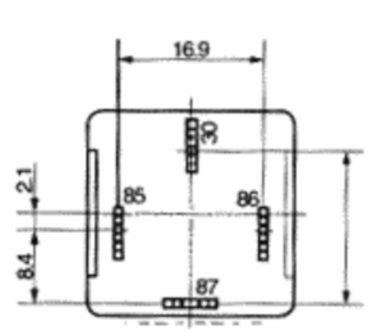
4.DIMENSIONS (in mm)

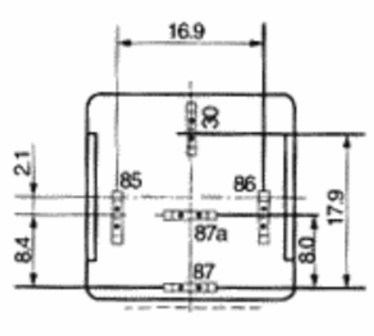


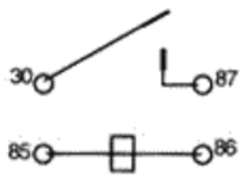
1 Form A

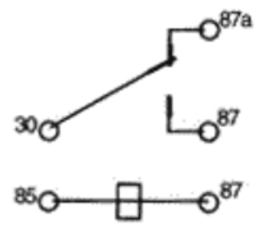


1 Form C









¡¡

5.ORDERING CODE

CMA3	DC6V	A	¡¡
			CONTACT ARRANGEMENT **A**: 1 FORM A **C**:1 FORM C
			NOMINAL VOLTAGE: DC6V , DC12V , DC24V
			TYPE

6.COIL DATA CHART

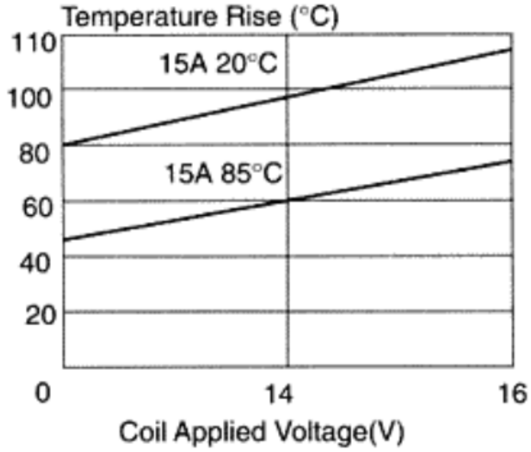
at 20¡æ

ORDERING CODE	COIL NOMINAL VDC	COIL RESISTANCE ¦¸ +/- 10%	OPERATE VOLTAGE VDC	RELEASE VOLTAGE VDC	COIL NOMINAL mW
CMA3-S DC6V	6	22	4.2	0.6	1.6
CMA3-S DC12V	12	85	8.4	1.2	
CMA3-S DC24V	24	350	16.8	2.4	

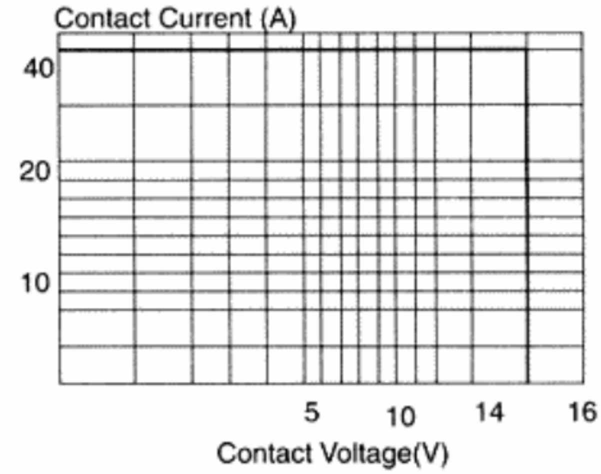
Table 1

7.CMA3 CHARACTERISTIC DATA

Temperature Rise



MAXIMUM SWITCHING POWER



CMA3 Relay

CMA3 Relay

1.COIL DATA

1-1.Nominal Voltage	6 VDC to 24 VDC
1-2.Coil Resistance	Refer to Table 1
1-3.Operate Voltage	Refer to Table 1
1-4.Release Voltage	Refer to Table 1
1-5.Nominal Power Consumption	1.6 W

2.CONTACT DATA

2-1.Contact Arrangement	1 Form C , 1 Form A
2-2.Contact Material	$AgSnO_2$
2-3.Contact Rating	30A 14VDC Resistive (1 Form C) 40A 14VDC Resistive (1 Form A)
2-4.Max. Switching Voltage	75VDC
2-5.Max. Switching Current	40A
2-6.Max. Switching Power	420W (1 Form C) 560W (1 Form A)

2-7.Max. Load Current (12VDC Load Voltage)

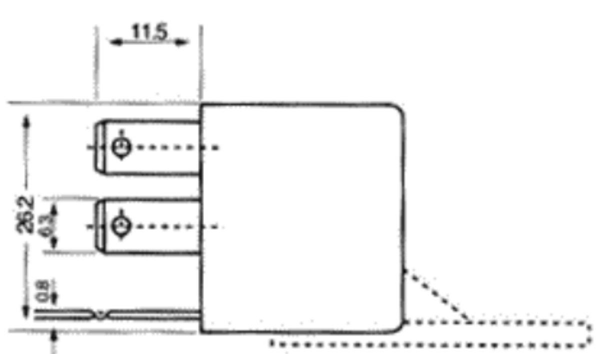
Load	Form A	Form C	
		NO	NC
Max.Carry Current	40A	40A	30A
Max.Make Current	100A	100A	30A
Max.Break Current	40A	40A	30A

2-8.Contact Resistance (Initial)		50 m¦¸ at 6VDC 1A
2-9.Life Expectancy	Electrical	100,000 operations at nominal load
	Mechanical	10,000,000 operations

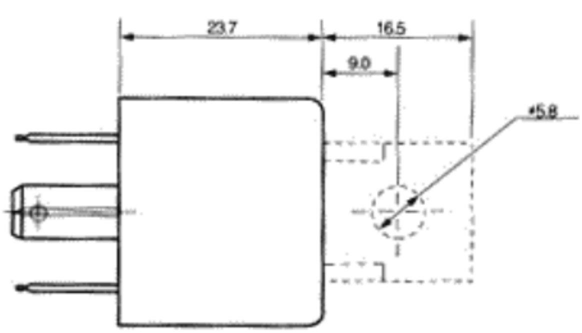
3.GENERAL DATA

3-1.Insulation Resistance	Min.100M¦¸ at 500 VDC
3-2.Dielectric Strength	550VAC , 1min between open contacts 750VAC , 1min between contacts and coil
3-3.Operate Time	Max. 10ms
3-4.Release Time	Max. 10ms
3-5.Temperature Range	-40 to +85 ¡æ
3-6.Shock Resistance	10G
3-7.Vibration Resistance	10 - 55 Hz , Amplitude 1.5mm
3-8.Weight	30 gr.

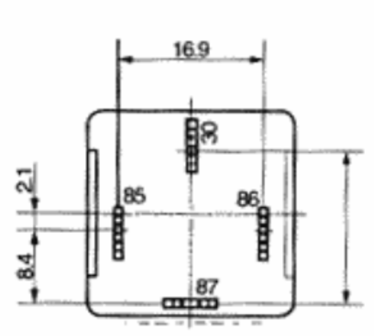
4.DIMENSIONS (in mm)

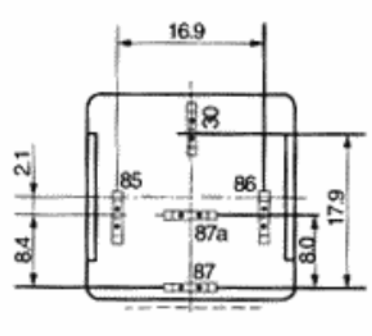


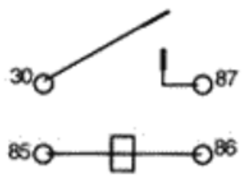
1 Form A



1 Form C







¡¡

5.ORDERING CODE

CMA3 **DC6V** **A** ¡¡

CONTACT ARRANGEMENT
A: 1 FORM A **C**:1 FORM C

NOMINAL VOLTAGE:
DC6V , DC12V , DC24V

TYPE

6.COIL DATA CHART

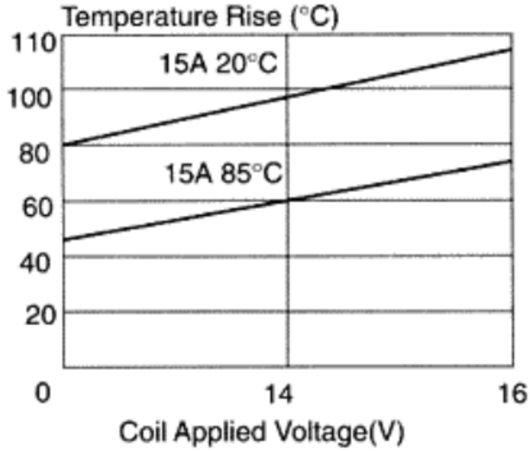
at 20¡æ

ORDERING CODE	COIL NOMINAL VDC	COIL RESISTANCE ¦¸ +/- 10%	OPERATE VOLTAGE VDC	RELEASE VOLTAGE VDC	COIL NOMINAL mW
CMA3-S DC6V	6	22	4.2	0.6	1.6
CMA3-S DC12V	12	85	8.4	1.2	
CMA3-S DC24V	24	350	16.8	2.4	

Table 1

7.CMA3 CHARACTERISTIC DATA

Temperature Rise



MAXIMUM SWITCHING POWER