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PROJECT REPORT:

"Radar detector module using Arduino"

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PREAMBLE

Radar is an object detection system. It uses Microwaves to determine the range, altitude, or speed of objects. The radar can transmit radio waves or microwaves which bounce off any object in their path. So, we can easily determine any object in the radar range. Arduino is a single-board microcontroller to make electronics more discipline. The radar system has different performance specifications and also it comes in a variety of size.

Auth. Nguyen Van Anh Tuan

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Chapter 1

Introduction

1.1 PRELIMINARY INTRODUCTION

1.1.1 The reason why to choose project

With the passion for aviation as well as passion for technology and equipment related to it, I decided to choose an aviation-related project in this project. Fortunately, my project this time is on the topic of embedded programming. So, I choose a project named "NDB radar detector module using Arduino". In this project, I will rely on the NDB radar to make a small scale NDB radar detector model. So, to get started in this project, we need to know what NDB radar is and how it works.

Recognize the continuous development of aviation technology. I want to add my own knowledge about how a radar system works and a bit of creative idea for this device that came along during I make this project. And that's why I choose this project for myself.

Block diagram

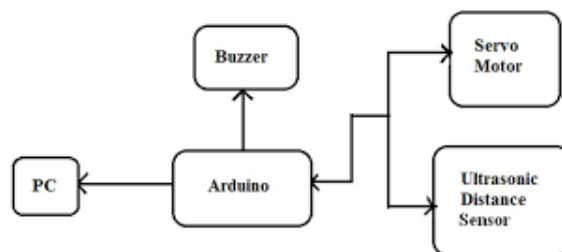


Figure 1.1: Block diagram for radar model

You may ask how the processing application works here. It's very simple, the Ultrasonic sensor collects the object information with the help of Arduino and passes it to processing application, there is a simple Graphics application implemented which mimic a radar screen.

1.1.2 Target Research

The short term goal of this topic is with the desire to learn and supplement the knowledge that in the course of research. With the long term goal, i want to perform the topic in the best way i can. As well as improve the errors of myself. And also, i want to additional the knowledge i haven't learned at my school.

1.1.3 Object and position research

- **Object Research:** The object that i study is the sensor system installed on the air traffic control station or installed on robots that detect objects and avoid them.
- **Position Research:** My reserach is based on the application of radar to detect missing vehicles or to apply air traffic control as call as "Primary Surveillance Radar".

1.1.4 Method of research

- **Observation Method:** By observing directly at air traffic control and also via movies or aviation videos on internet.
- **Method of analysis:** Looking for some similar projects that have been made available online, from the detailed data of those projects, i draw some methods and experience for my project. Avoid mistakes in my project.

1.1.5 Structure Project

My article is divided into three main sessions, summarized as follow:

- In the first chapter, i will focus on brief introduce my project, presenting some of the research content on the topic of the method of conducting research that gives practical results during the project research process.

- The second chapter, is an introduction about some of basic project implementation theories, to present related project i'm working on it.
- Chapter three is the chapter where i introduce the main content of my project, presenting a basic article of project and how it works, accompany it with some examples.
- The next chapter is the construction and circuit design on Kicad Altium software and the implementation of hardware construction.
- And the final chapter is the final section where i draw some conclusion during project implementation, as well as point out my own strengths weaknesses in the course of my project.

1.2 BASIC THEORY

1.2.1 Some research related to the project

Some research ideas related to my project:

- The function contained in some robots, helps robots scan the terrain and detect objects to avoid.
- Radar in the Air traffic control tower named "Primary Surveillance Radar"

1.2.2 Theory concepts related to research issues

- **PSR(Primary Surveillance Radar)**: A Surveillance radar system which uses reflected radio signals.
- **US(Ultrasonic Sensor)**: As the name indicates, ultrasonic sensors measure distance by using ultrasonic waves.
- **PWM(Pulse-Width Modulation)**: is a method of reducing the average power delivered by an electrical signal, by effectively chopping it up into discrete parts.
- **RAM(Random-Access Memory)**: is a form of computer memory that can be read and changed in any order, typically used to store working data and machine code.
- **CPU(Central Processing Unit)**: also called a central processor or main processor, is the electronic circuitry within a computer that executes instruction that make up a computer program.

1.2.3 Components Required

1. For power: Micro USB-B
2. For radar model:
 - (a) Arduino UNO
 - (b) Servo motor
 - (c) Ultrasonic Sensor HRF-04
 - (d) Buzzer
 - (e) LCD 16x02
 - (f) LED (green, red)
 - (g) Test board

1.2.4 Component Description

1.2.4.1 Arduino Uno

1. Introduction about Arduino UNO

Arduino UNO is a microcontroller board developed by Arduino.cc which is open-source electronics platform mainly based on AVR microcontroller ATmega328.

First Arduino project was started in Interaction Design Institute Ivrea in 2003 by David Cuartielles and Massimo Banzi with the intention of providing a cheap and flexible way to students and professional for controlling a number of devices in the real world.

The current version of Arduino UNO comes with USB interface, 6 analog input pins, 14 I/O(input/output) digital ports that are used to connect with external electronic circuit. Out of 14 I/O ports, 6 pins can be used for PWM output.

It allows the designers to control and sense the external electronic devices in the real world.

Apart from USB, battery or AC to DC adopter can also be used to power the board.

There are many versions of Uno board available. However, Arduino Uno V3 and Arduino Uno are the most official versions that come with ATmega328 8-bit AVR Atmel microcontroller where RAM memory is 32KB.

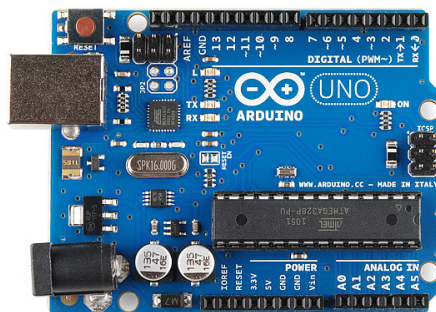


Figure 1.2: Arduino Uno board

2. Features

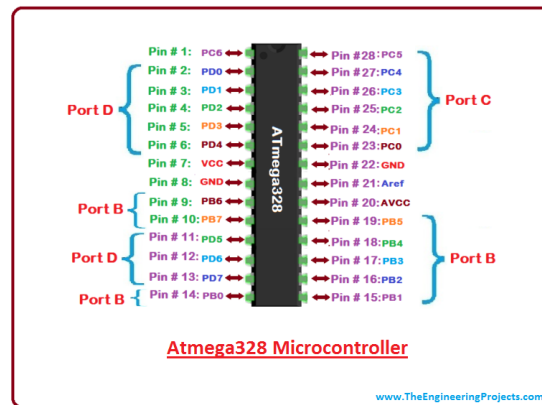


Figure 1.3: ATmega328 Microcontroller

- Comes with USB interface.
- USB port is added on the board to develop serial communication with the computer
- ATmega328 microcontroller is placed on the board that comes with a number of features like timers, counters, interrupts, PWM, CPU, I/O pins and based on a 16MHz clock that helps in producing more frequency and number of instruction per cycle.
- It's an open-source platform where anyone can modify and optimize the board based on the number of instructions and task they want to achieve.
- Come with a built-in regulation feature which keeps the voltage under control when the device is connected to the external device.
- There are 14 pins I/O digital and 6 analog pins in the board that allows the external connection with any circuit with the board. These pins provide the flexibility and ease of use to the external devices that can be connected through these pins.
- 6 analog pins are marked as A0 to A5 and come with a resolution of 10bits. These pins measure from 0V to 5V, however, they can be configured to the high range using analogReference() function and AREF pin.
- 13KB of flash memory is used to store the number of instructions in the form of code.

- Only 5V is required to turn the board on, which can be achieved directly using USB port or external adopter, however, it can support external power source up to 12V which can be regulated and limit to 5V or 3.3V based on the requirement of the project.

3. Pinout

Arduino Uno is based on AVR microcontroller call ATmega328. This controller comes with 2KB RAM, 32KB of flash memory, 1KB of EEPROM. Arduino board comes with 14 digital pins and 6 analog pins.

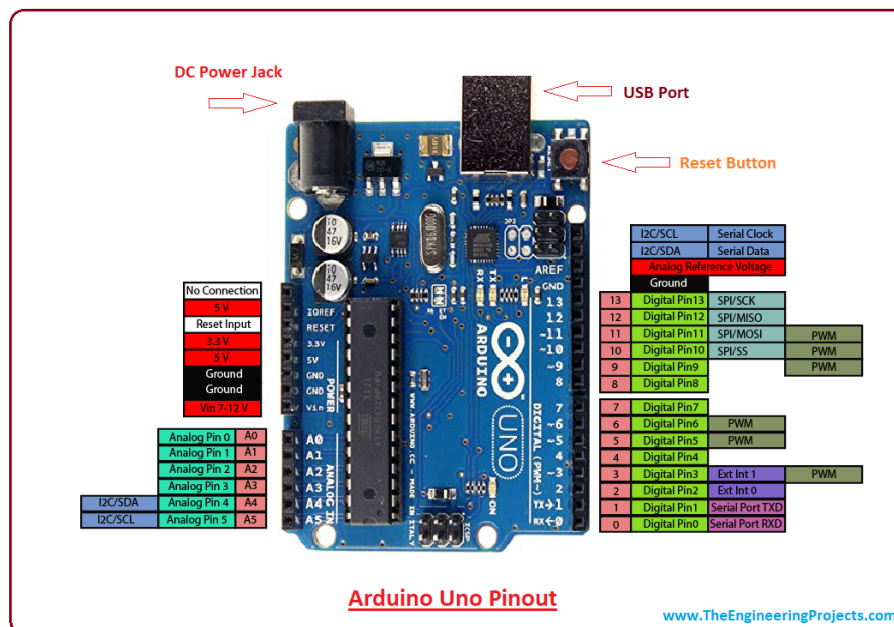


Figure 1.4: Arduino Uno Pinout

4. Pin Description

LED: comes with build-in LED which is connected through pin 13. Providing HIGH value to the pin will turn it ON and LOW will turn it OFF.

Vin: input voltage provided to the Arduino Uno board. It's different than 5V supplied through the USB port. This pin is

used to supply voltage. If a voltage is provided through power jack, it can be accessed through this pin.

5V: comes with the ability to provide voltage regulation. 5V pin is used to provide output regulated voltage. The board is powered up using the 3 ways: USB, Vin pin of the board or DC power jack.

GND: ground pins. More than one ground pins are provided on the board which can be used as per requirement.

Reset: this is incorporated on the board which resets the program running on the board. Instead of physical reset on the board, IDE comes with a feature of resetting the board through programming.

IOREF: this pin very useful for providing voltage reference to the board. A shield is used to read the voltage across this pin which then select the proper power source.

PWM: is provided by 3,5,6,9,10; 11 pins. These pins are configured to provided 8-bit output PWM.

SPI: It is known as Serial Peripheral Interface. 4 pins 10(SS), 11(MOSI), 12(MISO), 13(SCK) provide SPI communication with the help of SPI library.

AREF: called Analog Reference. This pin is used for providing a reference voltage to the analog inputs.

TWI: called Two-tire Interface. TWI communication is accessed through Wire Library. A4 and A5 pins are used for this purpose.

Serial Communication: is carried out through 2 pins call pin 0(Rx) and pin 1(Tx). Rx pin is used to receive data while Tx pin is used to transmit data.

External Interrupts: Pin 2 and 3 are used for providing external interrupts. An interrupt is called by providing LOW or changing value.

5. Communication and Programming

Arduino Uno comes with an ability of interfacing with other Arduino boards, microcontrollers and computer. The ATmega328 placed on board provides serial communication using pins like Rx and Tx.

Arduino Uno is programmed using Arduino Software which is a cross-platform application call IDE(Integrated Development Environment) written in Java. The AVR microcontroller ATmega328 laid out on the base comes with built-in bootloader that sets you free from using a separate burner to upload the program on the board.

6. Application

Arduino Uno comes with a wide range of Applications. A larger number of people are using Arduino boards for developing sensors and instruments that are used in scientific research. Following are some main applications of the board:

- »Embedded System
- »Security and Defense System
- »Digital Electronics and Robotics
- »Parking Lot Counter
- »Weighing Machines
- »Traffic Light Count Down Timer
- »Medical Instrument
- »Emergency Light for Railways
- »Home Automation
- »Industrial Automation

There are a lot of other microcontrollers available in the market that are more powerful and cheap as compared to Arduino board.

Actually, Arduino comes with a big community that is developing and sharing the knowledge with a wide range of audience. Quick support is available pertaining to technical aspects of any electronic project.

1.2.4.2 Servo Motor

1. Introduction

Servo Motors(or servos) are self-contained electric devices that rotate or push parts of machine with great precision. Servos are found in many places, from toys to home electronics to cars and airplanes. If you have a radio-controlled model car, airplanes, or helicopter, you are using at least a few servos. By rotating a shaft connected to the engine throttle, a servo

regulates the speed of a fuel-powered car or aircraft.

Servo also appear behind the scene in devices we use every day. Electronic device such as DVD players use servos to extend or retract the disc trays.



Figure 1.5: Assortment of Servos

2. How does a servo work?

The simple of a servo among the features that make them so reliable. The heart of a servo is a small direct current (DC) motor, similar to what you might find in an cheap toy. These motors run on electricity from a battery and spin at high RPM(Rotations per minute) but put out very low **torque**(a twisting force used to do work you apply torque when you open a bottle).

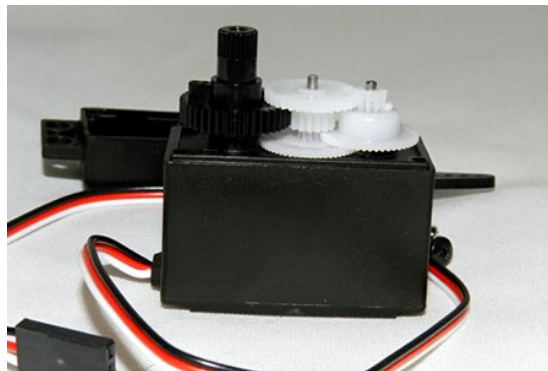


Figure 1.6: The Gears in a Typical Standard-size servo

In high-power servo, the plastic gears are replaced by metal ones for strength. The motor is usually more powerful than in a low-power servo and the overall output torque can be as much as 20 times higher than a cheaper plastic one. Better quality is more expensive, and high-output servos can cost two or three times as much as standard ones.

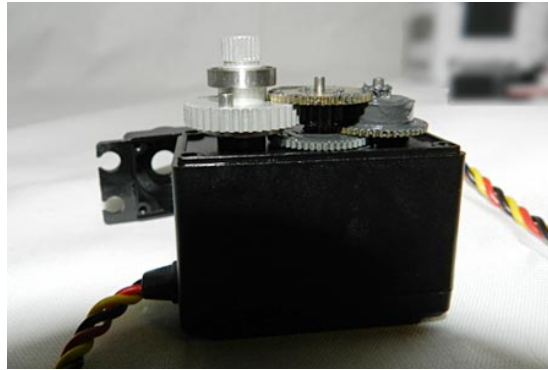


Figure 1.7: The gears in a Typical High-power servo

With a small DC motor, you apply power from a battery, and the motor spins. Unlike a simple DC motor, however, a servo's spinning motor shaft is slowed way down with gears. A positional sensor on the final gear is connected to a small circuit board. The sensor tells this circuit board how far the servo output shaft has rotated. The electronic input signal from the computer or the radio in a remote-controlled vehicle also feeds into that circuit board. The electronics on the circuit board decode the signals to determine how far the user wants the servo to rotate. Then compares the desired position to the actual position and decides which direction to rotate the shaft so it gets to the desired position.

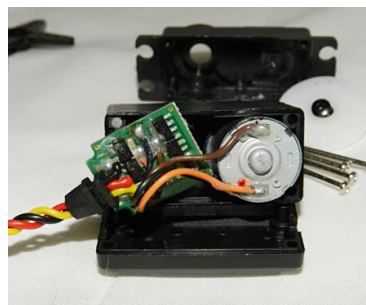


Figure 1.8: The circuit board and DC motor in a high-power servo

3. Types of servo motors

Servos come in many sizes and in 3 basic types:

- **Positional rotation servo:** This is the most common type of servo motor. The output shaft rotates in about half of a circle, or 180 degrees. It has physical stops placed in the gear mechanism to prevent turning beyond these limits to protect the rotational sensor. These common servos are found in radio-controlled cars, aircraft, toys, robots and many applications.
- **Continuous rotation servo:** This is quite similar to the common positional rotation servo motor, except it can turn in either direction indefinitely. The control signal, rather than setting the static position of the servo, is interpreted as the direction and speed of rotation. The range of possible commands causes the servo to rotate clockwise or counterclockwise as desired, at varying speed, depending on the command signal. You might use a servo of this type on a radar dish if you mounted one on a robot. Or you could use one as a drive motor on a mobile robot.
- **Linear servo:** This is also like the positional rotation servo motor described above, but with additional gears(usually a **rack and pinion** mechanism) to change the output from circular to back-and-forth. These servos are not easy to find, but you can sometimes find them at hobby stores where they are used as actuators in larger model airplanes.

4. Selecting a servo motor



Figure 1.9: Micro Servo 90

Micro servo motor 90(SG90) is tiny and lightweight with high output power. This servo can rotate approximately 180 degrees (90 in each direction), it works just like the standard kinds but smaller. We can use any servo code, hardware or library to control this servo. It good for beginners who want to make stuff move without building a motor controller with feedback and gear box, especially since it will fit in small places.

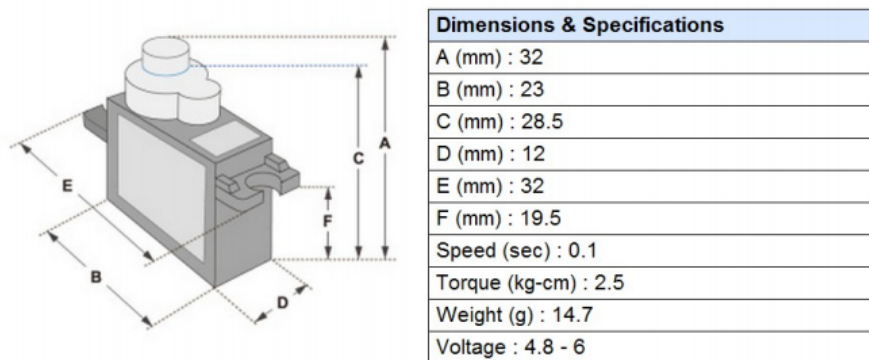


Figure 1.10: Section of SG90

Block Diagram of SG90

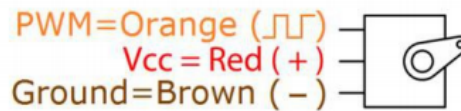


Figure 1.11: SG90 datasheet

5. Controlling a servo motor

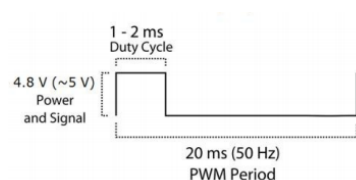


Figure 1.12: PWN Period

Servo take commands from a series of pulse sent from the computer or radio. A pulse is a transition from low voltage to

high voltage which stays high for a short time, and then returns to low. In battery devices such as servos, "low" is considered be ground or 0V and "high" is the battery voltage. Servos tend to work in a range of 4.5 to 6 volts, so they are extremely hobbyist computer-friendly.

1.2.4.3 HC-SR04 (Ultrasonic Sensor)

1. Introduction

An Ultrasonic Sensor is an electronic device that measures the distance of target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (the sound that human can hear).

Transmitter and Receiver are two main parts of the sensor where former converts an electrical signal to ultrasonic waves while later converts that ultrasonic signal back to electrical signals.

Following table shows the main features of this ultrasonic sensor

Parameter	Value
Main Parts	Transmitter and Receiver
Operating Voltage	5V
Operating Frequency	4MHz
Detection Range	2cm to 400cm
Measuring Angle	30 degrees
Resolution	3mm
Operating Current	< 15mA
Sensor Dimensions	45mm x 20mm x 15mm

Table 1.1: Feature of HC-SR04

In order to calculate the distance between the sensor and the object, the sensor measures the time it takes between the emission the sound by the transmitter to its contact with the receiver. The formula for this calculation:

$$D = 1/2 * T * C$$

Where:

- D: the distance

- T: the time
- C: the speed of sound 343 meter/second

2. HC-SR04 Pinout and Description

HC-SR04 contain 4 pins in total.

No.	Pin name	Pin Description
1	VCC	The power supply pin of the sensor that mainly operates at 5V DC
2	TRIG Pin	It plays a vital role to initialize measurement for sending ultrasonic waves. It should be kept high for 10us for triggering the measurement
3	ECHO Pin	This pin remains high for short period based on the time taken by the ultrasonic waves to bounce back to the receiving end
4	Ground	This pin is connected to ground

Table 1.2: Pinout of HC-SR04

This figure below here is labelled these HC-SR04 Pinout for better visualization:



Figure 1.13: HC-SR04 Pinout

3. How does it work?

The **HC-SR04 Ultrasonic Sensor(US)** is an ultrasonic transducer that comes with 4 pin interface named as Vcc, Trigger, Echo, and Ground. It is very useful for accurate

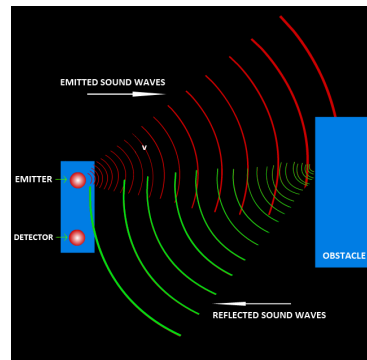


Figure 1.14: Ultrasonic sensor diagram

distance measurement of the target object and mainly works on the sound waves.

As we connect the module to 5V and initialize the input pin, it starts transmitting the sound waves which then travel through the air and hit the required object. These waves hit and bounce back from the object and then collected by the receiver of the module.

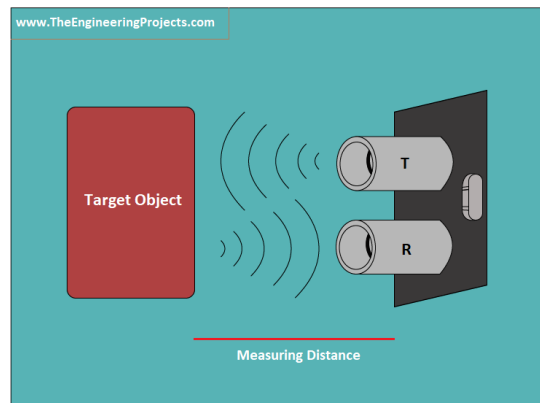


Figure 1.15: Principle of wave transmission

Distance is directly proportional to the time these waves require to come back at the receiving end. The more the time taken, more the distance will be.

The waves will be generating if the Trig pin is kept high for $10\mu\text{s}$. These waves will travel at the speed of sound, creating 8 cycle sonic burst that will be collected in the Echo pin.

The Echo pin remains turned on for the time these waves take to travel and bounce back to the receiving end. This sensor is

mainly incorporated with Arduino to measure the required distance.

Following the formula is used to calculate the distance of the object.

$$S = (V * t)/2$$

Where S is the required distance, V is the speed of sound and t is the time sound waves take to come back after hitting the object. We need to divide the value by 2 because time will be double as the waves travel and bounce back from the initial point. Dividing it by 2 will give the actual distance of the target object.

4. Application

HC-SR04 comes with a wide range of applications mainly targeting distance and direction measurement. Following are the major applications it can be used for:

- »Speed and direction measurement
- »Wireless charging
- »Humidifiers
- »Medical ultrasonography
- »Burglar alarms
- »Embedded system
- »Depth measurement
- »Non-destructive testing

1.2.4.4 LCD 16x02

1. Introduction

Liquid crystal displays are normally used in different embedded projects due to their low cost, easy access and flexibility to be programmed.

Almost each and every electronic device we daily see it like in your mobile, calculator and some other devices.

There is a type of liquid display that has sixteen column and two rows so it is known as 16 x 02 LCD modules.

LCD also available in different arrangements like (8x1), (10x2), (16x1), but the (16x2) liquid crystal is normally used in embedded projects.

In this liquid crystal display, there are thirty-two characters and each of them consists of 5x8 pixels.

So we can say that character consists of forty pixels or dots and total pixels in this liquid crystal display can be fined as (32x40) or 1280 pixels.

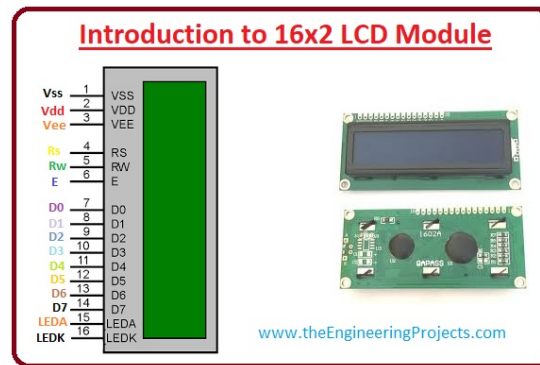


Figure 1.16: LCD 16x2 Module

2. Pinout Description

Pin No:	Pin Name:	Parameter
Pin 1	Ground	Connect the ground
Pin 2	+5 Volts	At this pinout plus five volts are applied to on the LCD
Pin 3	VE	Select the contract of the display
Pin 4	Register	This pinout is used to MCU controller connected led to a shift from command to data mode
Pin 5	Read and Write	Reading and Writing data
Pin 6	Enable	Linked with the MCU to toggle among zero and one
Pin 7	Data pin 0	The pinout from 0 to 7 are data pinouts and these are linked with the MCU for transmission of data. This module can also operate on the 4-bit mode by working on 1,2 and 3 pinouts and others are free
Pin 8	Data pin 1	
Pin 9	Data pin 2	
Pin 10	Data pin 3	
Pin 11	Data pin 4	
Pin 12	Data pin 5	
Pin 13	Data pin 6	
Pin 14	Data pin 7	
Pin 15	Led Positive	This pinout for turn backlight of LED into positive
Pin 16	Led Negative	Backlight liquid crystal display pinout negative terminal

Table 1.3: Pinout Description