# OBJECT LOCATOR USING RF MODULE

Project Report submitted in partial fulfillment of the Degree of

Bachelor of Technology

In

**ELECTRONICS AND COMMUNICATION ENGINEERING**

Under the supervision of

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# CERTIFICATE

This is to certify that the work titled "**Object Locator using RF Module**" submitted by "**Navneet kaur Maan(111067), Vikas Sangwan(111074), Udit Jindal(111087)**" in the partial fulfilment of the degree of Bachelor of Technology (ECE) of Jaypee University of Information Technology, Waknaghat has been carried out under my supervision. This work has not yet been submitted partially or wholly to any other university or institution for the award of this or any other degree or diploma.

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# ABSTRACT

This project proposes designing a system which will help locate some of the most important objects which are of daily use or are supposed to be used in an emergency and are easily misplaced.
Often there are things like a box of medicines or other daily use things like car keys, iron, hardware toolbox or a book which tend to be misplaced or forget where they are. In case of medicines it can be a really sensitive and crucial emergency. In case of objects like car keys or toolboxes it may lead to wastage of time in trying to find them. Things that are small in size may be very difficult to find if they falls in small unreachable corners like in the cavity besides bed. This project will help reduce the search time and search area by a very large factor. The system will use tags and reader to do the job of locating the objects and notify the user where they are.

# OBJECTIVES

‘Object Locator’ consists of one or more tags that responds to a readers over a wireless interface. The main function of ‘Object Locator’ is to enable tagged items or persons to automatically state their identity to the reader wirelessly.

- To find keys, handbag, laptop, wallet, books and remote controls easily.
- To find your luggage easily on the luggage belt after a flight.
- To avoid forgetting your phone in a restaurant.
- To reduce loss and theft.
- To avoid theft of essentials like credit cards, passport etc.
- To track kids in a crowded environment.
- To ensure pets do not go far away.

# Chapter 1: INTRODUCTION

Object Locator is a system of identification which uses radio frequency to communicate. The basic components of the system are the tag and reader. Tag is the device used to identify the object which is to be tracked. The device that identifies the tag and reads the information stored on it is called reader.

It is a technology to record the presence of an object using radio signals. It is the wireless use of electromagnetic fields to transfer data, for the purposes of automatically identifying and tracking tags attached to objects. The tags contain electronically stored information. Some tags are powered by electromagnetic induction from magnetic fields produced near the reader while some types collect energy from the interrogating radio waves and act as a passive transponder.

It is a non-contact and automatic identification technology to identify, track, sort and detect a variety of objects including people, vehicles, goods and assets without the need for direct contact or line of sight contact. RFID technology can track the movements of objects through a network of radio enabled scanning devices over a distance of several meters.

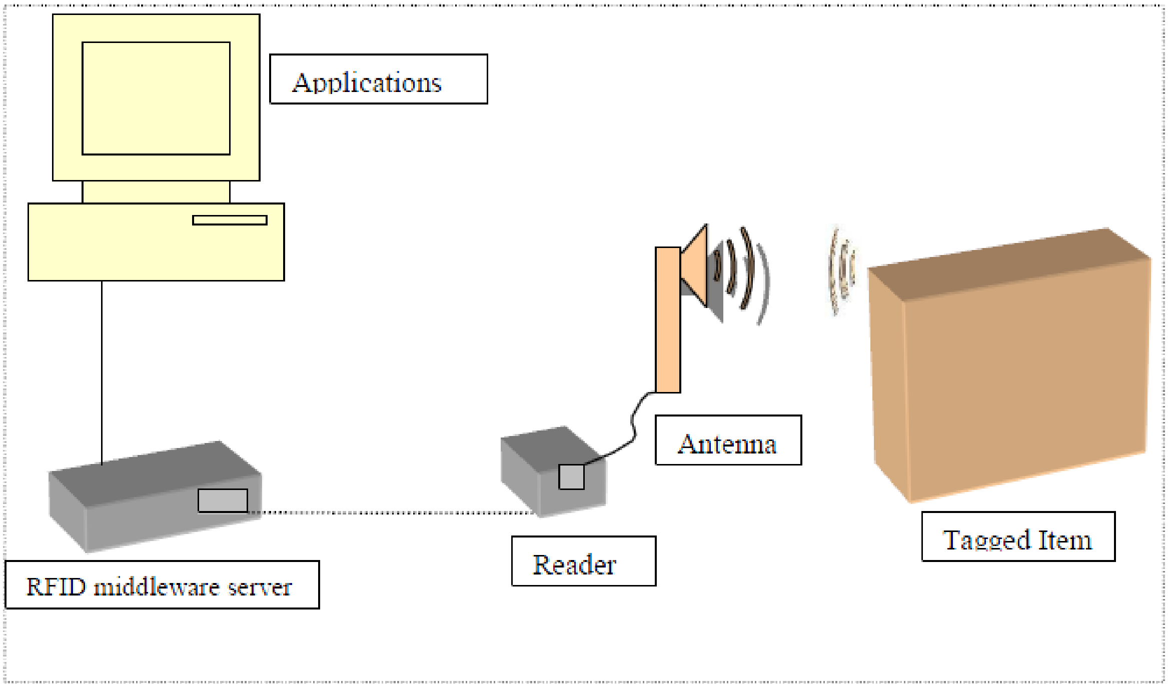



**Figure 1: RF System**

## Radio Frequency:

- The radio frequency can be defined as any frequency within electromagnetic spectrum associated with radio wave propagation.
- Radio frequency is in the range of about 3 kilohertz to about 300,000 megahertz.
- Many wireless technologies are based on RF field propagation.

**Table 1: Radio frequency range**

| Title | Frequencies | Wave length | Applications |
|---|---|---|---|
| Very low frequency | 9KHz -30KHz | 33 km - 10 km | Ear |
| Low frequency | 30KHz -300KHz | 10 km - 1 km | |
| Medium frequency | 300KHz-3MHz | 1 km - 100 m | |
| High frequency | 3MHz-30MHz | 100 m - 10 m | |
| Very high frequency | 30MHz-300MHz | 10 m - 1 m | FM, TV |
| Ultra high frequency | 300MHz-3GHz | 1 m - 100 mm | Mobile |
| Super high frequency | 3GHz-30GHz | 100 mm - 10 mm | Satellite TV |
| Extra high frequency | 30GHz-300GHz | 10 mm - 1 mm | Microwave |

RF systems can also be distinguished by frequency range.

- Low-frequency (30 KHz to 300 KHz): These systems have short reading ranges and lower system costs. These are mostly applicable in security access, tracking assets. These capable of penetrating ocean depths to approximately 20km.
- Medium- frequency (300 KHz to 3 MHz): These systems have medium reading range and used for identifying and tracking nearby objects.
- High-frequency (3 MHz to 30 MHz): These systems have very long reading ranges and used for car tracking and automated toll collection applications.

## (1.1) System components

## TAGS:

Tags are the devices attached to the items or material that the reader system is intended to track. The tags may be placed directly on individual items such as in the case of consumer goods or on shipping containers or pallets that hold multiple items. Tags come in all sorts of shapes and sizes.

The primary function of the tag is to transmit data to reader system. Tags generally contain three basic parts. These include:

- The electronic integrated circuit.
- A miniature antenna.
- A substrate to the integrated circuit and the antenna together and to the inventory item.

Tags are categorized as active or passive:

**Active tags** are powered by an internal battery and can be rewritten or modified. An active tag's memory size varies according to application requirements. Normally these systems operate with up to 1MB of memory.

**Passive tags** (Also called Read-only tags) operate without any external power source and use the electromagnetic field emitted by the reader. Passive tags are much lighter than active tags, less expensive. These tags have shorter read ranges than active tags and require a higher-powered reader.

## READERS:

The reader is a device that creates an electromagnetic signal, which is transmitted to the tags through one or more antennas. It is used to recognize the presence of nearby tags. A reader transmits radio frequency energy via antenna. An antenna in the nearby tag picks up this energy, and the tag then converts it to electric energy which is used to power the semiconductor chip attached to the tag antenna, which stores the tag identity in case of passive tag. The tag then matches the information received with its own. If the information matches the tag responds to it accordingly, otherwise it does not respond. A reader comprises a system called event management. When a reader reads a tag, it is said as observation. An observation that differs from the previous observation is called an event. The analysis of observations is called event filtering. Event manager defines what kinds of observations are considered events and decide which events are to be put in the report or to the external application. Under normal operation, the reader is continuously transmitting the electromagnetic signal in search of one or more tags.

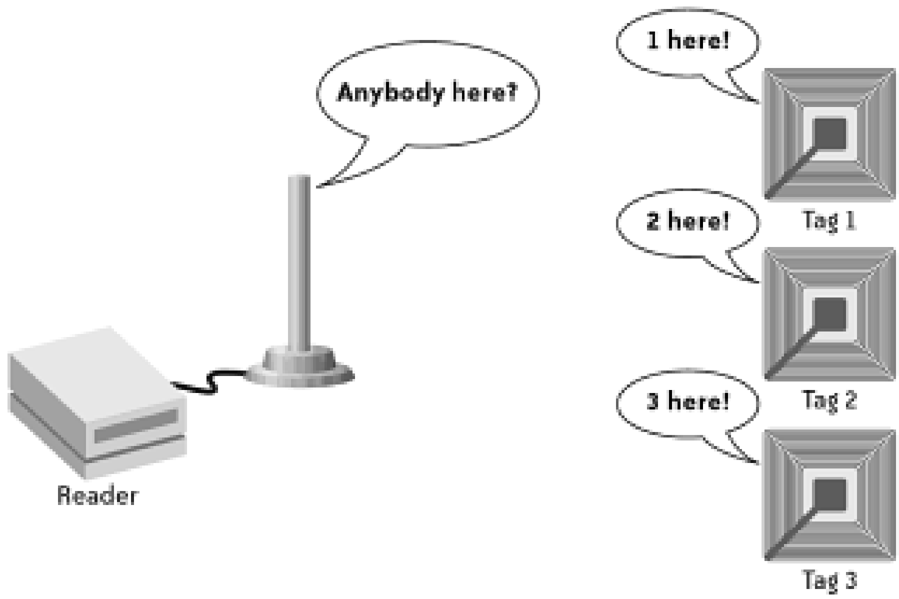



**Figure 2: Communication between Tags and Readers**

## ANTENNAS:

The function of the antenna is to transmit and receive electromagnetic signals between the tags and the reader. The effective electromagnetic field that the antenna transmits is in interrogation zone. That is, the antenna creates a three-dimensional space that is used to communicate with the tags. In order to obtain successful communication, the tags must be within range of the antenna or in the interrogation zone.

## (1.2) Advantages of RFID over other Technologies

They are many technologies to identify objects other than RFID. The barcode is the most commonly used computer readable technology, but the reader has some limitations. Most important is the source should exactly face the reader with no obstacle in between the laser and the bar code. Magnetic strips on credit cards, also must line up correctly with the readers. RFID tags provide a mechanism for identifying an item at a distance and able to track numerous objects at a time. One cannot add information to a barcode after it is printed, whereas some type of RFID tags can be written and rewritten many times. Some other benefits of RFID are:

- Alignment is not necessary: While scanning an RFID tag it does not require line of sight. This is convenient where you line up huge amount of goods that are to be traced.
- High inventory speeds: Numerous amounts of assets can be scanned at the same time. As a result time factor for manual counting can be cut down.
- Variety of form factors: As previously mentioned RFID tags and readers are available in variety of range both in size and frequency. Data rewritable: Some type of tags can be written and rewritten many times. This makes data change simpler.

- Large operating and communication range.
- Read and write capability of the transponder memory.
- High data capacity (user memory).
- High data security.
- Data encryption/authentication capability.
- Multiple tag read capability with anti-collision.
- Durability and reliability.
- Reusability of the transponder.
- A tag can store large amounts of data additionally to a unique identifier.
- As no line-of-sight is required, tag placement is less constrained.
- Tag detection not requiring human intervention reduces employment costs and eliminates human errors from data collection.

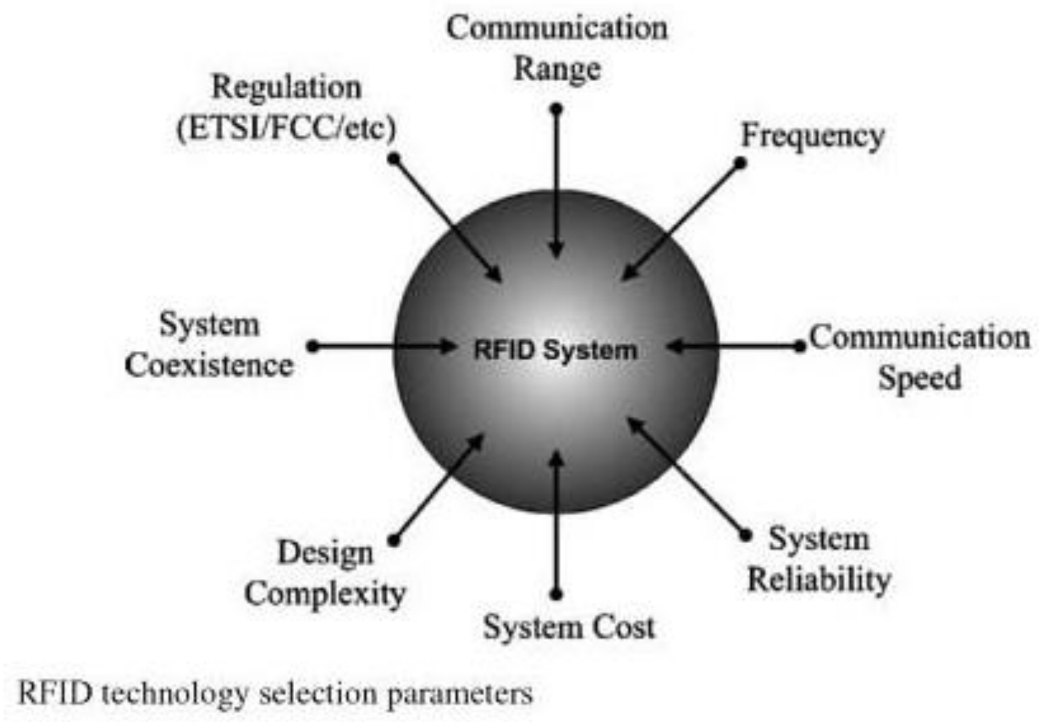



**Figure 3: RFID technology selection parameters**

# Chapter 2: TAGS

A tag is a microchip combined with an antenna in a compact package, the packaging is structured to allow the tag to be attached to an object to be tracked. The tags can be made in incredible array of shapes, sizes and capabilities. This will include describing the difference, advantages and disadvantages of different types of tags that are commercially available.

Tags differ in the following ways:

- Power sources.
- Frequencies.
- Writing capabilities.
- Tag components.
- Tag generations.
- Tag costs.

**Power sources:**

This is one of the main differences in the tags. Passive tags obtain all of their energy by radio waves transmitted from the reader. Active tags use on-board battery to power communications, a processor, memory and sensors. These tags have extremely long read range and perform some functions in the absence of a reader. Semi-passive tag is not only capable of supplying power for itself but also able to initiate communication with other tags without the reader. The read range is longer for semi-passive tags because the passive communications can use all of the power provided by the reader.

**Tag frequencies:**

Tags primarily operate at either high frequency (HF) or ultra-high frequency (UHF). The operating frequency is the electromagnetic frequency the tag uses to communicate or to obtain power. The electromagnetic spectrum in the range in which RF system typically operates is usually broken up into low frequency, high frequency, ultra-high frequency and microwave. Because RF systems broadcast electromagnetic waves, they are regulated as radio devices. RF systems must not interfere with other, protected applications, such as emergency service radios or television transmissions.

**Table 2: Radio frequency ranges**

| Name | Frequency range |
|---|---|
| LF | 30-300khz |
| HF | 3-30Mhz |
| UHF | 300Mhz-3Ghz |
| Microwave | >3Ghz |

**Table 3: Read range by frequency**

| Frequency | Typical max. read range for tags | Applications |
|---|---|---|
| LF | 50cm | Pet identification and close reads of items with high water content. |
| HF | 3m | Building access control |
| UHF | 9m | Boxes and pallets |
| Microwave | >10m | Vehicle identification of all sorts. |

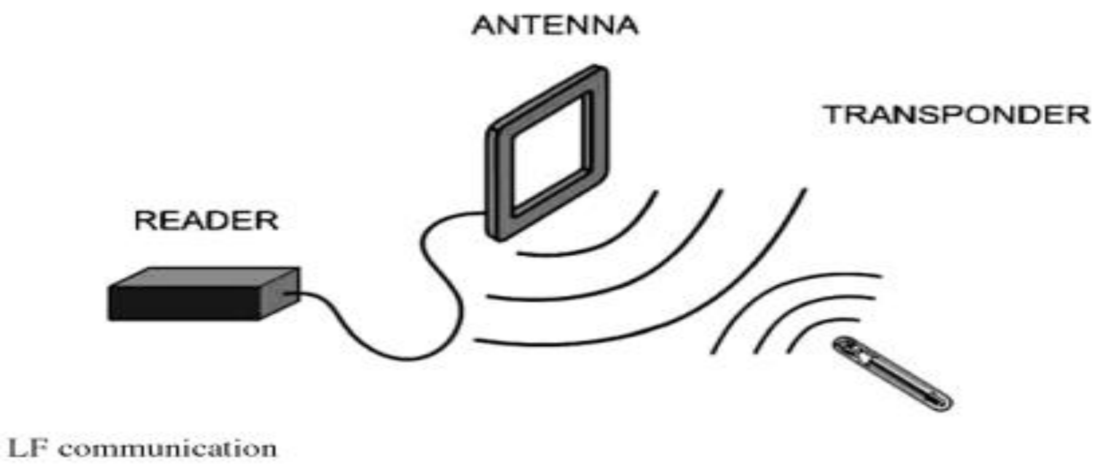



**Figure 4: LF Communication**

## (2.1) Tag components

The packaging material and the substrate on the tag is a significant issue as some devices to be tracked are radio frequency absorbing while others are radio frequency reflecting. The RF reflecting characteristic of metals can prevent the tag antenna from absorbing sufficient RF energy to be powered by deflecting the RF wave.

**Writing capabilities:**

When the tag enters the interrogation zone. The Reader communicates with the tags using radio frequency. The data exchanged between the reader and the tags can be ASCII, hex characters, or decimal characters. The data that is stored in the tag is dependent on the tag's writing capability.

The three general types of writing capabilities are:

- Read only.
- Write once ,read many
- Read/write.

The writing capability of tags used in Object locator is Read/Write. The Data stored in the tag is basically the configuration of the decoder in the tag. If the tag decoder is configured in the way transmission is done by the reader, the tag simply responds. The configuration in tag can be changed manually as many times as desired.

## (2.2) Tag generations

Passive, active and semi-passive tags all contain a minimum of:

- Integrated circuitry or chip.
- An antenna.
- A substrate or tag housing.

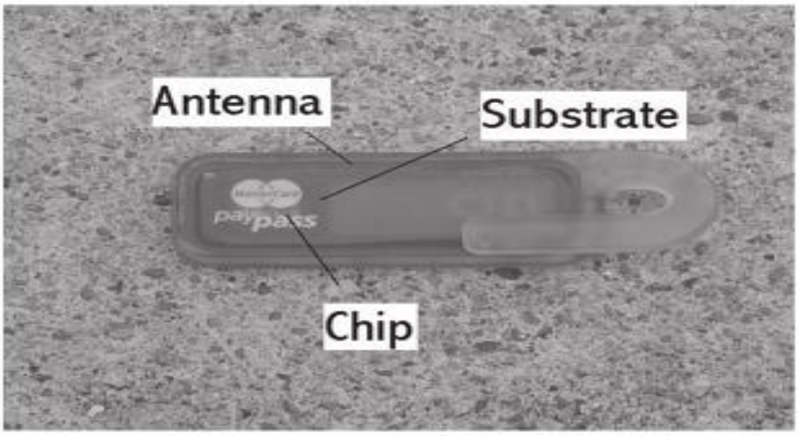



**Figure 5: Tag**

**i) Tag substrate or tag housing:**

The tag substrate performs two functions:

- On the front surface, it provides a surface or housing for the tag components.
- On the back surface, it can provide means for attaching the adhesive or tape for positioning the tag to the item. A variety of materials can be used for tag substrate.

**ii) Tag antennas:**

Not to be confused with the system reader antenna, the tag antenna is an integral component on the actual RFID tag. The tag antenna is used to both receive and send radio frequency waves. In the case of passive tags, the tag antenna receives the radio frequency energy and passes the energy on to the tag's integrated circuitry. The integrated circuitry's response to the radio frequency energy is then transmitted back out through the tag's antenna. The configuration of the tag's antenna is dependent on what type of frequency is used by the tag. HF tag antennas will most likely be shaped like coils, UHF antennas will be more linear in shape.

A significant antenna issue revolves around the potential placement of the tag on the intended object. The effectiveness of the antenna may depend on how it is oriented with respect to the product, which in turn is dependent on how it is positioned with respect to the reader's antenna. To address this issue, some RFID tags contain multiple antennas or antennas that have different branches. All these attempts are aimed at increasing the RFID system's ability to obtain more reliable communication.

**iii) Tag integrated circuitry:**

The tag integrated circuit or chip is that part of the tag that contains the data that is transmitted. It also contains the logic to decode the RF signal from the reader and code the data recorded on the chip for subsequent transmission by the tag's antenna. Passive tags commonly have the capability to transmit ninety-six bits of data. Active tags on the other hand are limited only by the other system components integrated with the RFID tag.

## (2.3) Table 4: RF technology comparison

| | Passive | Active | Semi-passive |
|---|---|---|---|
| Power source | External electromagnetic antenna field | On-board battery | On-board battery for internal circuitry External electromagnetic field for transmission |
| Range | Measured in feet | Up to thousands of feet | Measured in feet |
| Size | Smaller | Larger | Larger |
| Data storage | Less | More | More |
| Cost | Less | More | More |

# Chapter 3: READERS

A reader, also known as an interrogator, is a device that provides the connection between the tag data and the enterprise system software that needs the information. The reader communicates with tags that are within its field of operation, performing any number of tasks including simple continuous inventorying, filtering (searching for tags that meet certain criteria), writing (or encoding) to selected tag, etc.

The reader uses an attached antenna to transmit/capture data from tags. It then passes the data to a computer for processing. Just like tags, there are many different sizes and types of readers. Readers can be affixed in a stationary position in a store or factory, or integrated into a mobile device such as a portable, handheld scanner. Readers can also be embedded in electronic equipment or devices, and in vehicles.

## (3.1) Reader Antennas

Readers and reader antennas work together to read tags. Reader antennas convert electrical current into electromagnetic waves that are then radiated into space where they can be received by a tag antenna and converted back to electrical current. Just like tag antennas, there is a large variety of reader antennas and optimal antenna selection varies according to the solution's specific application and environment.

The two most common antenna types are linear- and circular-polarized antennas. Antennas that radiate linear electric fields have long ranges, and high levels of power that enables their signals to penetrate through different materials to read tags. Linear antennas are sensitive to tag orientation; depending on the tag angle or placement, linear antennas can have a difficult time reading tags. Conversely, antennas that radiate circular fields are less sensitive to orientation, but are not able to deliver as much power as linear antennas.

Signaling between the reader and the tag is done in several different incompatible ways, depending on the frequency band used by the tag. Tags operating on LF and HF bands are, in terms of radio wavelength, very close to the reader antenna because they are only a small percentage of a wavelength away. In this near field region, the tag is closely coupled electrically with the transmitter in the reader. The tag can modulate the field produced by the reader by changing the electrical loading the tag represents. By switching between lower and higher relative loads, the tag produces a change that the reader can detect. At UHF and higher frequencies, the tag is more than one radio wavelength away from the reader, requiring a different approach.

Choice of antenna is also determined by the distance between the reader and the tags that it needs to read. This distance is called read range. Reader antennas operate in either a "near-field" (short range) or "far-field" (long range). In near-field applications, the read range is less than 30 cm and the antenna uses magnetic coupling so the reader and tag can transfer power. In near-field systems, the readability of the tags is not affected by the presence of dielectrics such as water and metal in the field.

In far-field applications, the range between the tag and reader is greater than 30 cm and can be up to several tens of meters. Far-field antennas utilize electromagnetic coupling and dielectrics can weaken communication between the reader and tags.

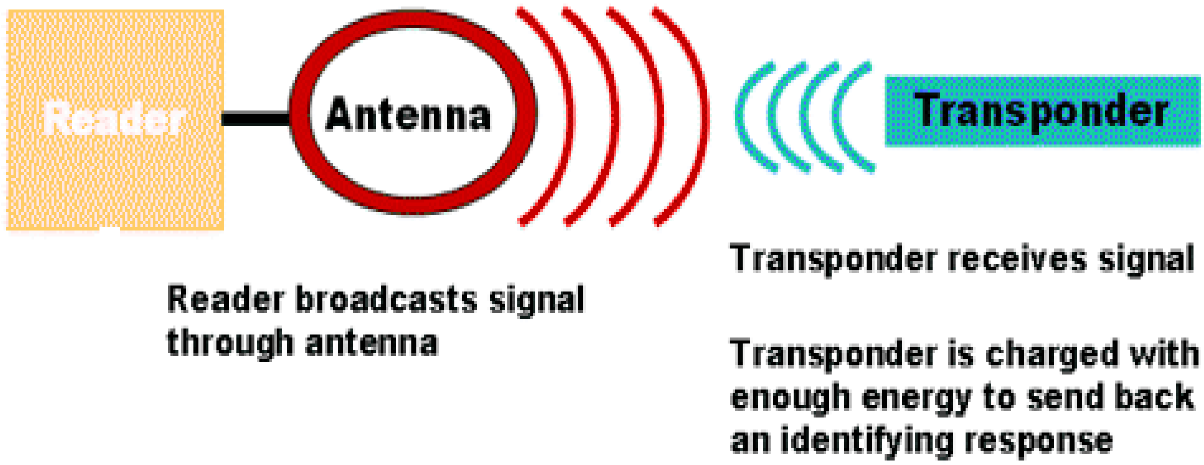



**Figure 6: RF working**

# Chapter 4: PHYSICAL PRINCIPLES OF RF SYSTEM

## (4.1) Magnetic Field

*Magnetic Field Strength H*

Every moving charge (electrons in wires or in a vacuum), i.e. flow of current, is associated with a magnetic field. The intensity of the magnetic field can be demonstrated experimentally by the forces acting on a magnetic needle (compass) or a second electric current. The magnitude of the magnetic field is described by the magnetic field strength H regardless of the material properties of the space.

In the general form we can say that: the contour integral of magnetic field strength along a closed curve is equal to the sum of the current strengths of the currents within it.

$$\sum I = \oint \vec{H} \cdot \vec{\mathrm{d}}s$$

We can use this formula to calculate the field strength *H* for different types of conductor. In a straight conductor the field strength *H* along a circular flux line at a distance r is constant.

The following is true:

$$H = \frac{1}{2\pi r}$$

The total number of lines of magnetic flux that pass through the inside of a cylindrical coil, for example, is denoted by magnetic flux .Magnetic flux density B is a further variable related to area A. Magnetic flux is expressed as:

$$\Phi = B \cdot A$$

The material relationship between flux density B and field strength H is expressed by the material equation:

$$B = \mu_0 \mu_r H = \mu H$$

$$\mu_0 = 4\pi \times 10^{-6} \ \mathrm{V\,s/A\,m}$$

The constant is the magnetic field constant which describes the permeability (=magnetic conductivity) of a vacuum.

**Inductance L**

A magnetic field, and thus a magnetic flux, will be generated around a conductor of any shape. This will be particularly intense if the conductor is in the form of a loop (coil). Normally, there is not one conduction loop, but N loops of the same area A, through which the same current I flows. Each of the conduction loops contributes the same proportion to the total flux $\psi$.

$$\Psi = \sum_{N} \Phi_N = N \cdot \Phi = N \cdot \mu \cdot H \cdot A$$

The ratio of the interlinked flux $\psi$ that arises in an area enclosed by current I, to the current in the conductor that encloses it (conductor loop) is denoted by inductance L:

$$L = \frac{\Psi}{I} = \frac{N \cdot \Phi}{I} = \frac{N \cdot \mu \cdot H \cdot A}{I}$$

Inductance is one of the characteristic variables of conductor loops (coils). The inductance of a conductor loop (coil) depends totally upon the material properties (permeability) of the space that the flux flows through and the geometry of the layout.

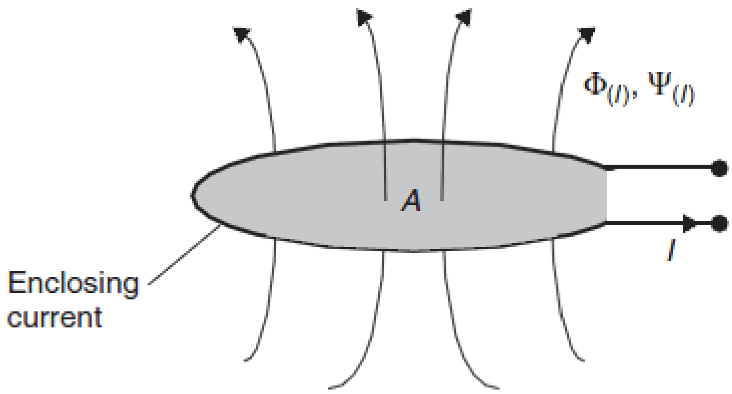



**Figure 7: Definition of inductance L**

**Mutual Inductance M**

The mutual inductance $M21$ of conductor loop 2 in relation to conductor loop 1 is defined as the ratio of the partial flux $\psi 21$ enclosed by conductor loop 2, to the current $I1$ in conductor loop 1

$$M_{21} = \frac{\Psi_{21}(I_1)}{I_1} = \oint_{A2} \frac{B_2(I_1)}{I_1} \cdot dA_2$$

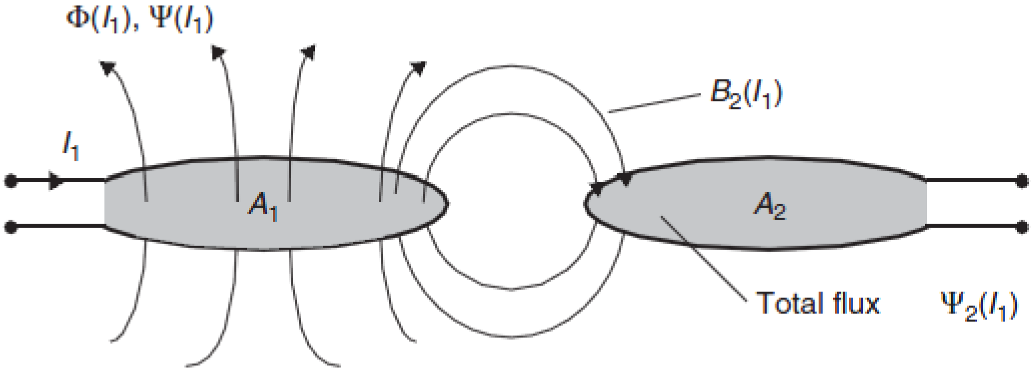



**Figure 8: Definition of mutual inductance**

**Faraday's Law**

Any change to the magnetic flux generates electric field strength *E*i. This characteristic of the magnetic field is described by *Faraday's law*.

It is described as:

$$u_i = \oint E_i \cdot ds = -\frac{d\Psi(t)}{dt}$$

$$u_i = N \cdot d\Psi/dt$$

## (4.2) Electromagnetic waves

A time varying magnetic field in space induces an electric field with closed field lines. The electric field surrounds the magnetic field and itself varies over time. Due to the variation of the electric rotational field over time, a magnetic field with closed field lines occurs in space (rotational field). It surrounds the electric field and itself varies over time, thus generating another electric field. Electromagnetic waves are energy transported through space in the form of periodic disturbances of electric and magnetic fields. All electromagnetic waves travel through space at the same speed, c = $2.99792458 \times 10^8$ m/s, commonly known as the speed of light. An electromagnetic wave is characterized by a frequency and a wavelength. These two quantities are related to the speed of light by the equation, speed of light = frequency x wavelength.

The frequency (and hence, the wavelength) of an electromagnetic wave depends on its source. There is a wide range of frequency encountered in our physical world, ranging from the low frequency of the electric waves generated by the power transmission lines to the very high frequency of the gamma rays originating from the atomic nuclei.

Due to the mutual dependence of the time-varying fields there is a chain effect of electric and magnetic fields in space. Radiation can only occur given a finite propagation speed (c ≈ 300 000 km/s; speed of light) for the electromagnetic field, which prevents a change in the voltage at the antenna from being followed immediately by the field in the vicinity of the change. Even at the alternating voltage's zero crossover, the field lines remaining in space from the previous half-wave cannot end at the antenna, but close into themselves, forming eddies. The eddies in the opposite direction that occur in the next half-wave propel the existing eddies, and thus the energy stored in this field, away from the emitter at the speed of light c. The magnetic field is interlinked with the varying electrical field that propagates at the same time. When a certain distance is reached, the fields are released from the emitter, and this point represents the beginning of electromagnetic radiation. At high frequency, that is small wavelengths, the radiation generated is particularly effective, because the separation takes place in the direct vicinity of the emitter, where high field strengths still exist.

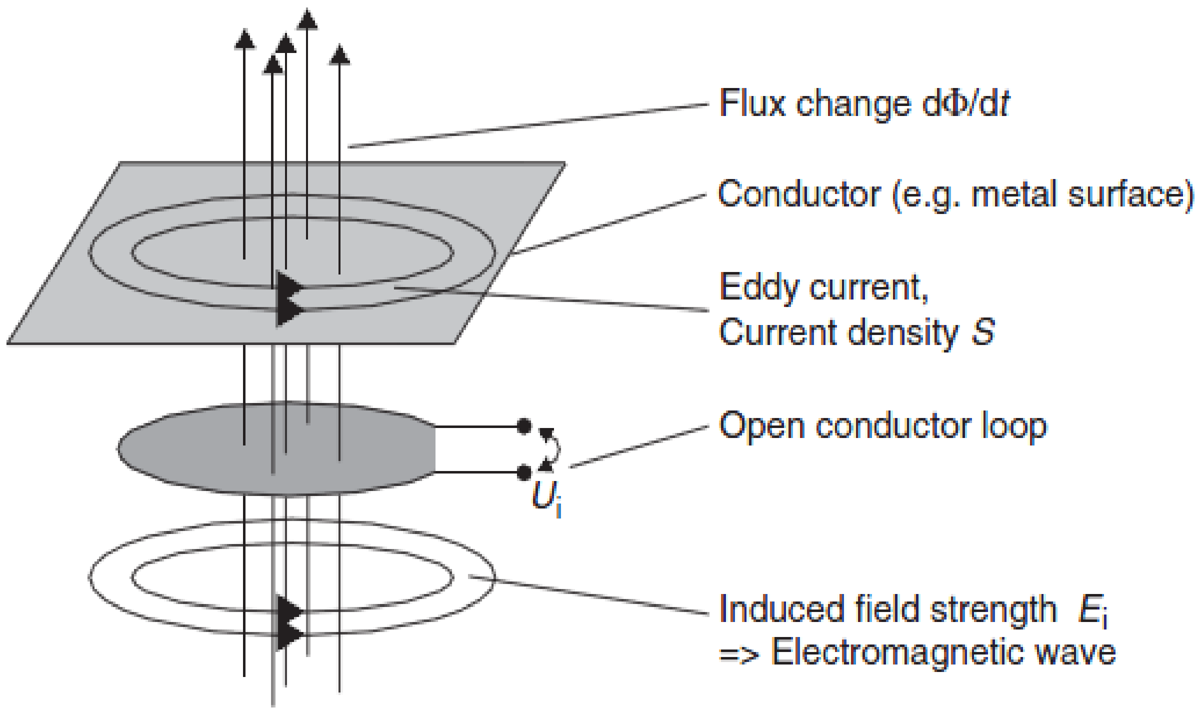



**Figure 9: Induced electric field strength E in different materials**

# Chapter 5: RF MODULE

## (5.1) Introduction

An RF Module is a small electronic circuit which is used to receive, transmit or transceive radio waves on one of a number of carrier frequencies. An RF module is a functional integration of semiconductor devices. The corresponding frequency range varies between 30 kHz & 300 GHz. In this RF system, the digital data is represented as variations in the amplitude of carrier wave. This kind of modulation is known as Amplitude Shift Keying (ASK). Wireless transmission can be done by using 433MHz or 315MHz ASK RF Transmitter and Receiver modules. In these modules digital data is represented by different amplitudes of the carrier wave, hence this modulation is known as Amplitude Shift Keying (ASK). Radio Frequency (RF) transmission is more strong and reliable than Infrared (IR) transmission due to following reasons:

- Radio Frequency signals can travel longer distances than Infrared.
- Only line of sight communication is possible through Infrared while radio frequency signals can be transmitted even when there is obstacles.
- Infrared signals will get interfered by other IR sources but signals on one frequency band in RF will not interfered by other frequency RF signals.
- RF transmission is more strong and reliable than IR transmission. RF communication uses a specific frequency unlike IR signals which are affected by other IR emitting sources.

This RF module comprises of an RF Transmitter and an RF Receiver. There are two ways to transmit data normally:

1. **Parallel:**

When we want to transmit data in parallel we need parallel number of links for wireless or number of wire for wired communication depend upon how many bit you want to transmit at a time. For example 8 bit, 16 bit, 32bit

2. **Series:**

In series transmission only one channel is required for wireless transmission or one wire for wire communication. In serial transmission one by one bit is transmitted through channel or wire.

The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps - 10Kbps.The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter.

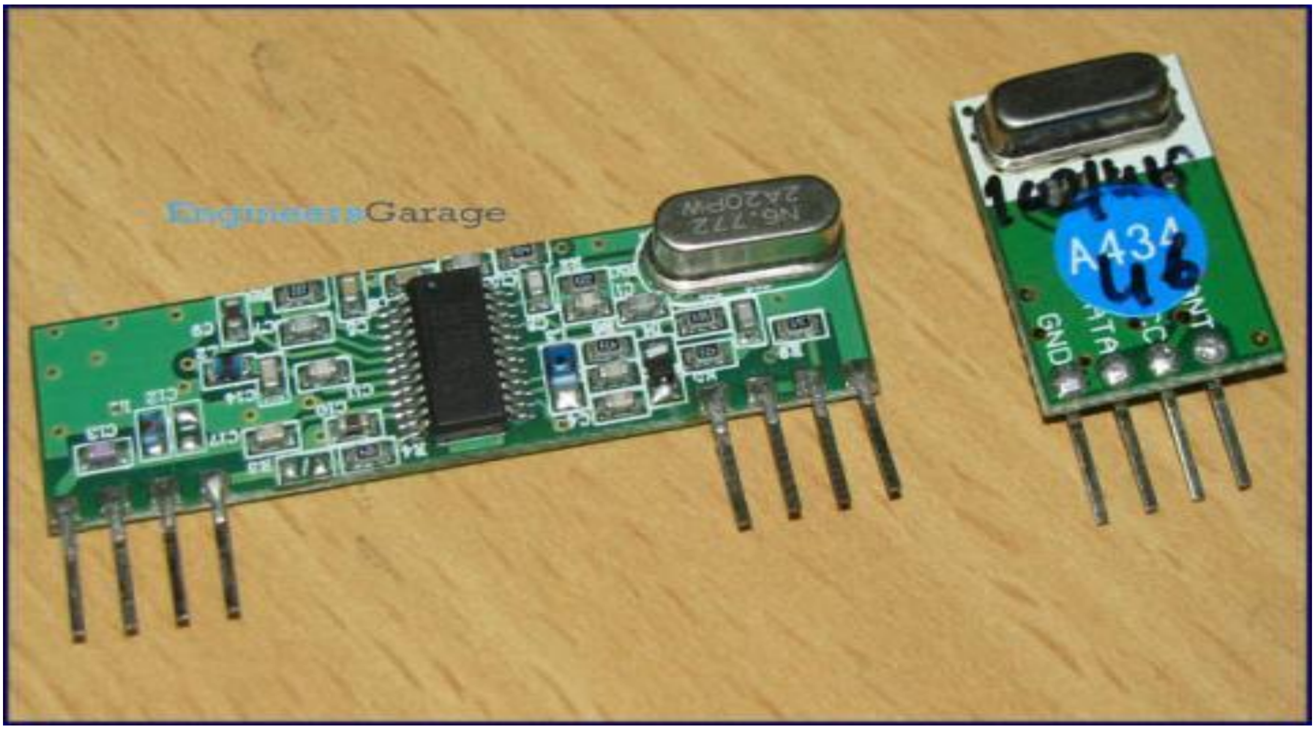



**Figure 10: TX RX**

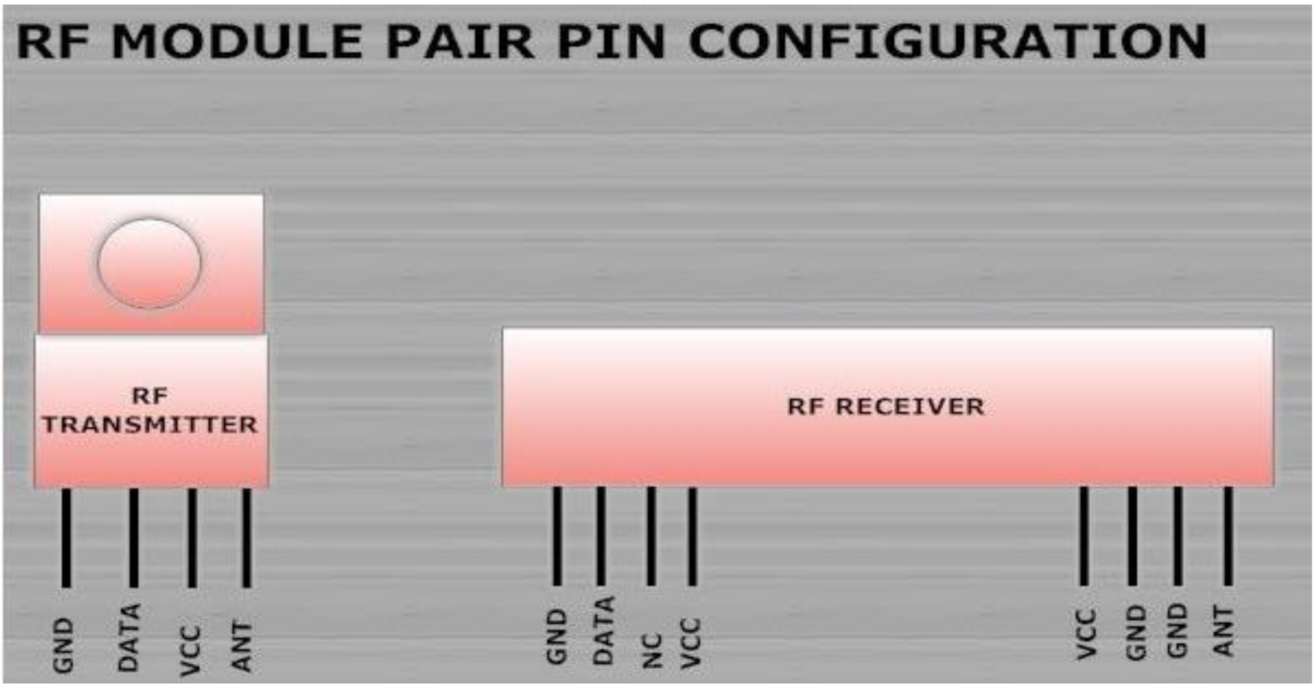



**Figure 11: RF module pin configuration**

**Pin Description:**

**Table 5: RF Transmitter**

| Pin No | Function | Name |
|---|---|---|
| 1 | Ground (0V) | Ground |
| 2 | Serial data input pin | Data |
| 3 | Supply voltage; 5V | Vcc |
| 4 | Antenna output pin | ANT |

**Table 6: RF Receiver**

| Pin No | Function | Name |
|---|---|---|
| 1 | Ground (0V) | Ground |
| 2 | Serial data output pin | Data |
| 3 | Linear output pin; not connected | NC |
| 4 | Supply voltage; 5V | Vcc |
| 5 | Supply voltage; 5V | Vcc |
| 6 | Ground (0V) | Ground |
| 7 | Ground (0V) | Ground |
| 8 | Antenna input pin | ANT |

**Features:**

- Range in open space(Standard Conditions) : 100 Meters
- RX Receiver Frequency : 433 MHz
- RX Typical Sensitivity : 105 Dbm
- RX Supply Current : 3.5 mA
- RX IF Frequency : 1MHz
- Low Power Consumption
- Easy For Application
- RX Operating Voltage : 5V
- TX Frequency Range : 433.92 MHz
- TX Supply Voltage : 3V ~ 6V
- TX Out Put Power : 4 ~ 12 Dbm

Receiver module specification:

- Operation voltage: DC5V
- Static Current: 4MA
- Receiver frequency: 433.92MHZ; 315 MHz
- Sensitivity： －105DB
- Dimension：30*14*7mm
- External Antenna：32CM signal wire spiral

Transmitter Module Specification:

- Operating voltage :3-12V
- Operating frequency: 433.92MHz; 315Mhz
- Standby current: 0mA
- Operating current :20-28mA
- Transmission distance :> Output Power: 16dBm (40mW)
- Transfer rate: <10Kbps
- Operating Temperature: -10 ℃ ~ +70 ℃
- Size: 19 × 19 × 8mm

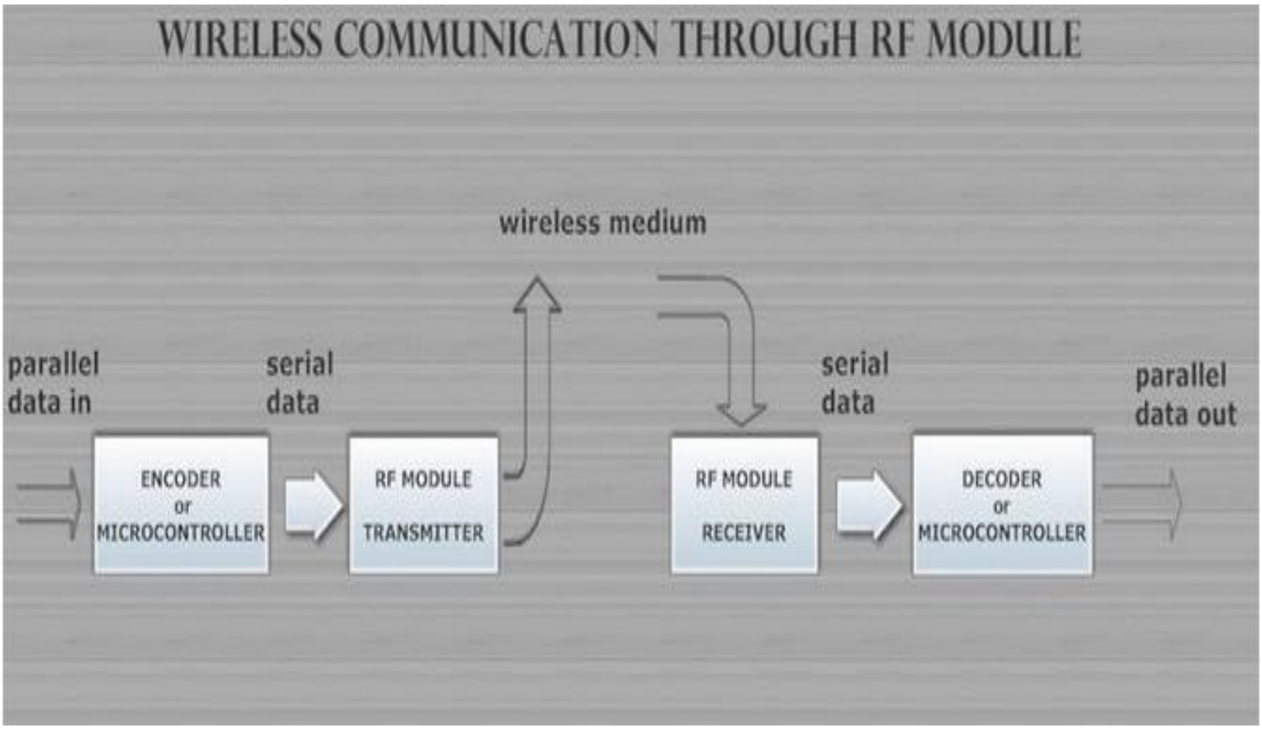



**Figure 12: Wireless communication through RF module**

## (5.2) Modulation technique used in RF module

**Amplitude shift keying:**

Amplitude-shift keying (ASK) is a form of amplitude modulation that represents digital data as variations in the amplitude of a carrier wave. In an ASK system, the binary symbol 1 is represented by transmitting a fixed-amplitude carrier wave and fixed frequency for a bit duration of T seconds. If the signal value is 1 then the carrier signal will be transmitted; otherwise, a signal value of 0 will be transmitted.

Any digital modulation scheme uses a finite number of distinct signals to represent digital data. ASK uses a finite number of amplitudes, each assigned a unique pattern of binary digits. Usually, each amplitude encodes an equal number of bits. Each pattern of bits forms the symbol that is represented by the particular amplitude. The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the amplitude of the received signal and maps it back to the symbol it represents, thus recovering the original data. Frequency and phase of the carrier are kept constant.

Like AM, ASK is also linear and sensitive to atmospheric noise, distortions, propagation conditions on different routes in PSTN, etc. Both ASK modulation and demodulation processes are relatively inexpensive. The ASK technique is also commonly used to transmit digital data over optical fiber. For LED transmitters, binary 1 is represented by a short pulse of light and binary 0 by the absence of light. Laser transmitters normally have a fixed "bias" current that causes the device to emit a low light level. This low level represents binary 0, while a higher-amplitude light wave represents binary 1. The simplest and most common form of ASK operates as a switch, using the presence of a carrier wave to indicate a binary one and its absence to indicate a binary zero. This type of modulation is called on-off keying (OOK), and is used at radio frequencies to transmit Morse code (referred to as continuous wave operation),

More sophisticated encoding schemes have been developed which represent data in groups using additional amplitude levels. For instance, a four-level encoding scheme can represent two bits with each shift in amplitude; an eight-level scheme can represent three bits; and so on. These forms of amplitude-shift keying require a high signal-to-noise ratio for their recovery, as by their nature much of the signal is transmitted at reduced power.

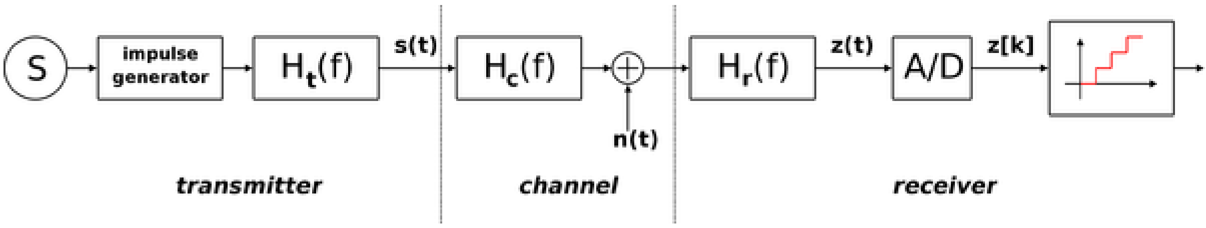



**Figure 13: ASK diagram**

ASK system can be divided into three blocks. The first one represents the transmitter, the second one is a linear model of the effects of the channel, and the third one shows the structure of the receiver. The following notation is used:

- $ht_{(f)}$ is the carrier signal for the transmission
- $hc_{(f)}$ is the impulse response of the channel
- $n_{(t)}$ is the noise introduced by the channel
- $hr_{(f)}$ is the filter at the receiver
- $L$ is the number of levels that are used for transmission
- $T_s$ is the time between the generation of two symbols

Different symbols are represented with different voltages. If the maximum allowed value for the voltage is A, then all the possible values are in the range [−A, A] and they are given by:

$$v_i = \frac{2A}{L-1} i - A; \quad i = 0, 1, \ldots, L-1$$

The difference between one voltage and the other is:

$$\Delta = \frac{2A}{L-1}$$

**(5.2.a) Advantages of Amplitude-shift keying (ASK):**

The main advantage of ASK modulation is generation of ASK is very much easy. Both ASK modulation and demodulation processes are relatively inexpensive. The ASK technique is also commonly used to transmit digital data over optical fiber. There are many other advantages of ASK, Such as Amplitude-shift keying transmitters are very simple and transmitter current is lower than FSK. One important advantage of ASK is it need lees bandwidth than FSK.

### (5.2.b) Disadvantages of Amplitude-shift keying (ASK):

ASK is linear and sensitive to atmospheric noise, distortion, propagation condition on different routes in PSTN. It requires excessive bandwidth and is therefore a waste of power.

## (5.3) Factors affecting RF module performance:

The performance of an RF module will depend on a number of factors:

- By increasing the transmitter power, a larger communication distance will be achieved. However, this will also result in a higher electrical power drain on the transmitter device, which will cause shorter operating life for battery powered devices. Also, using a higher transmit power will make the system more prone to interference with other RF devices, and may in fact possibly cause the device to become illegal depending on the jurisdiction.
- Increasing the receiver sensitivity will also increase the effective communication range, but will also potentially cause malfunction due to interference with other RF devices.
- The performance of the overall system may be improved by using matched antennas at each end of the communication link, such as those described earlier.
- The system is normally measured in an open-air line of sight configuration without any interference, but frequently there will be obstacles such as walls, floors, iron construction to absorb the radio wave signals, then the effective operational distance will in most practical instances is less than specified.
- The labelled remote distance of any particular system is normally measured in an open-air line of sight configuration without any interference, but often there will be obstacles such as walls, floors, iron construction to absorb the radio wave signals, so the effective operational distance will in most practical instances be less than specified.

# Chapter 6: ENCODER/DECODER

The RF module is often used along with a pair of encoder/decoder. The encoder is used for encoding parallel data for transmission feed while reception is decoded by a decoder.

## (6.1) HT12E

The HT12E is a $2^{12}$ series encoder IC (Integrated Circuit). They are capable of Encoding 12 bit of information which consists of N address bits and 12-N data bits. It converts 12 bit parallel data in to serial output which can be transmitted through a RF transmitter. These 12 bit parallel data is divided in to 8 address bits and 4 data bits. By using these address pins we can provide 8 bit security code for data transmission and multiple receivers may be addressed using the same transmitter.

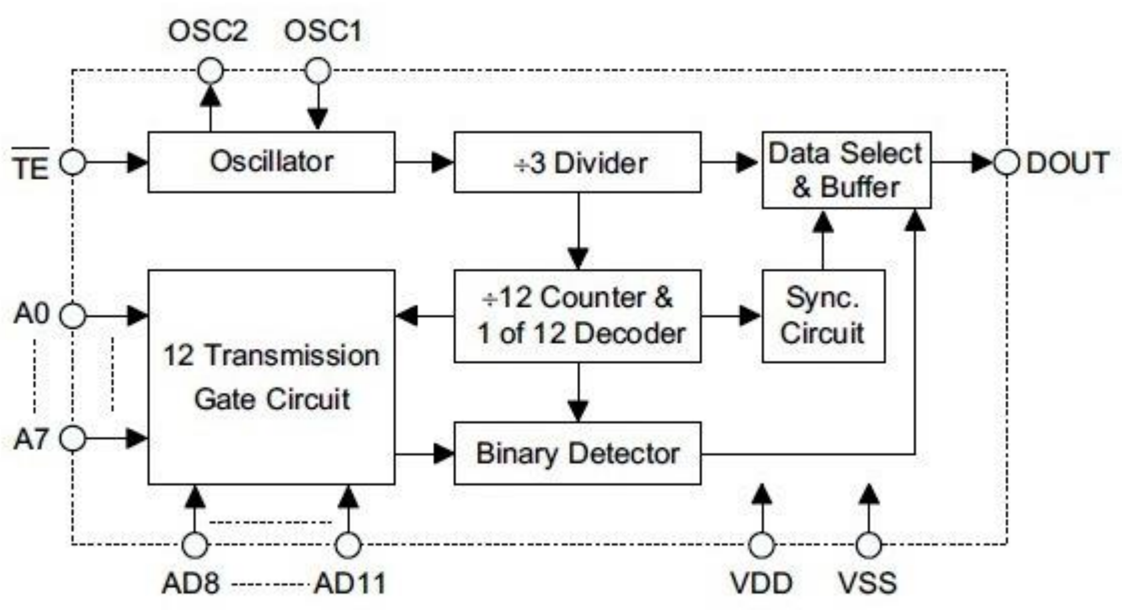



**Figure 14: HT12E – Block Diagram**

**Features:**

- 18 PIN DIP(dual inline package)
- Operating Voltage : 2.4V ~ 12V
- Low Power and High Noise Immunity
- CMOS Technology
- Low Standby Current (0.1µA at 5V VDD)
- Built-in Oscillator needs only 5% Resistance

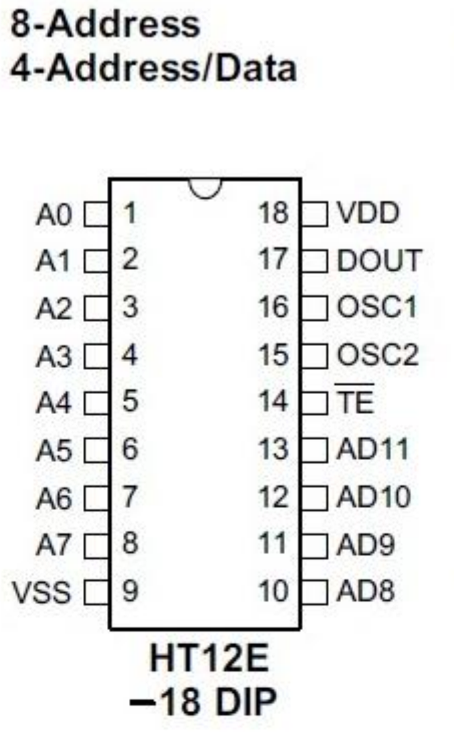



**Figure 15: H12E-Pin Diagram**

- VDD and VSS are power supply pins which are used to connect positive and negative of the power supply respectively.
- OSC1 and OSC2 are used to connect external resistance for the internal oscillator. OSC1 is the oscillator input pin and OSC2 is the oscillator output pin.

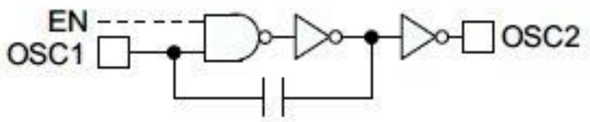



**Figure 16: Oscillator of HT12E**

- TE is used for enabling the transmission and is an active low input.
- A0 – A7 are the input address pins. By using these pins we can provide a security code for the data. These pins can be connected to VSS or left open.
- D8 – D11 are the input data pins. These pins can be connected to VSS or may left open for sending LOW and HIGH respectively.
- DOUT – It is the serial data output of the encoder and can be connected to a RF transmitter.

**(6.1.a) Working**

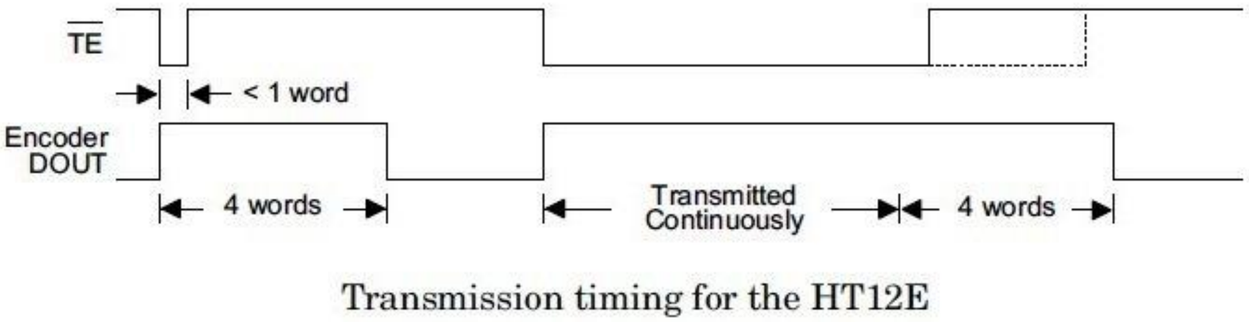



**Figure 17: Transmission timing for the HT12E**

The HT12E $2^{12}$ series encoder starts a 4 word transmission cycle upon receiving transmission enable signal on TE input. This output cycle will repeat as long as the transmission is enabled. When the transmission enable (TE) signal switches to HIGH, the encoder output completes the current cycle and stops. The encoder will be in the Standby mode when the transmission is disabled.

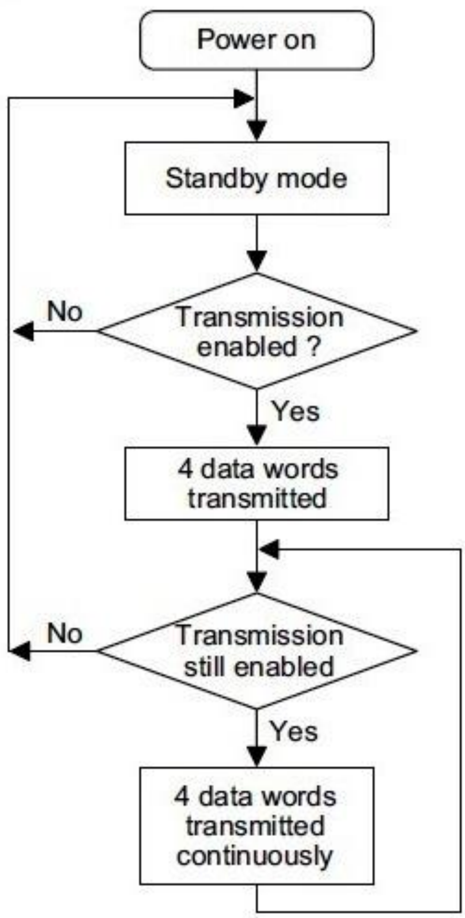



**Figure 18: Working Flowchart of HT12E**

## (6.2)HT12D

HT12D is a $2^{12}$ series decoder IC (Integrated Circuit). It converts serial data to its input (received through RF receiver) to 12 bit parallel data. These 12 bit parallel data is divided in to 8 address bits and 4 data bits. Using 8 address bits we can provide 8 bit security code for 4 bit data and can be used to address multiple receivers by using the same transmitter.

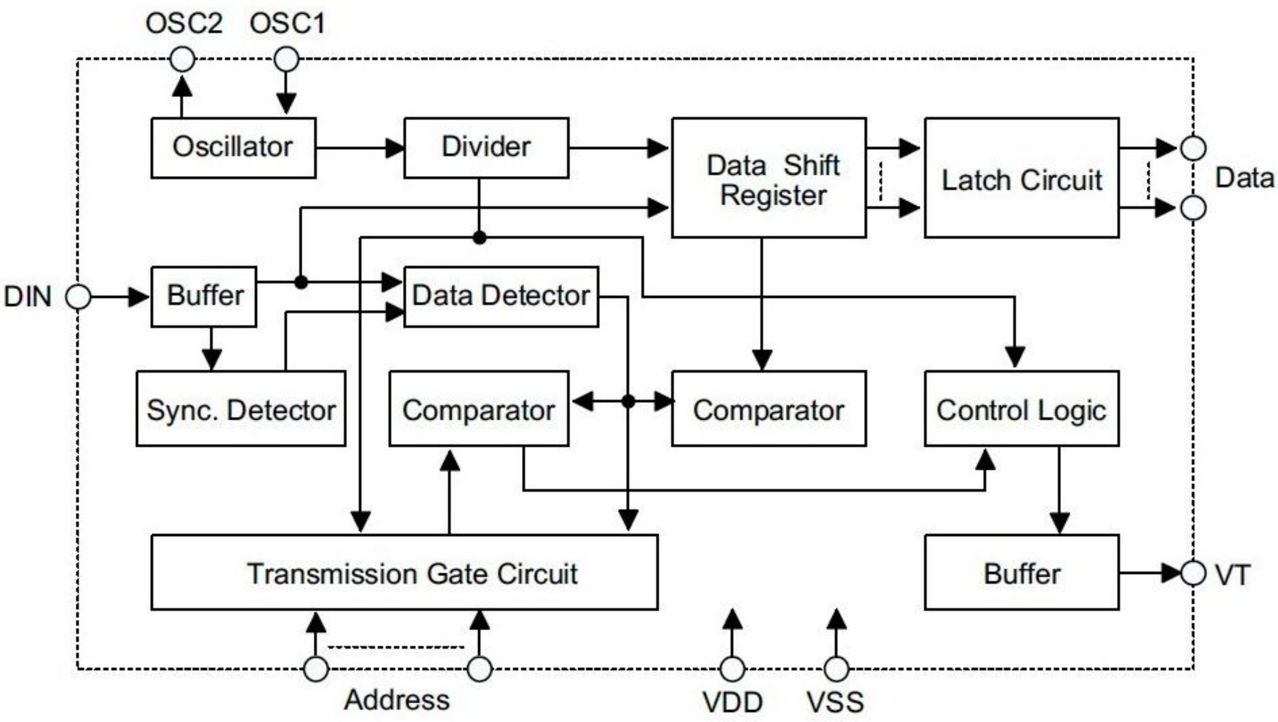



**Figure 19: HT12D - Block Diagram**

**Features:**

- 18 PIN DIP
- Operating Voltage : 2.4V ~ 12.0V
- Low Power and High Noise Immunity
- CMOS Technology
- Low Stand by Current
- Capable of Decoding 12 bits of Information
- 8 ~ 12 Address Pins and 0 ~ 4 Data Pins
- Received Data are checked 2 times, Built in Oscillator needs only 5% resistor
- VT goes high during a valid transmission

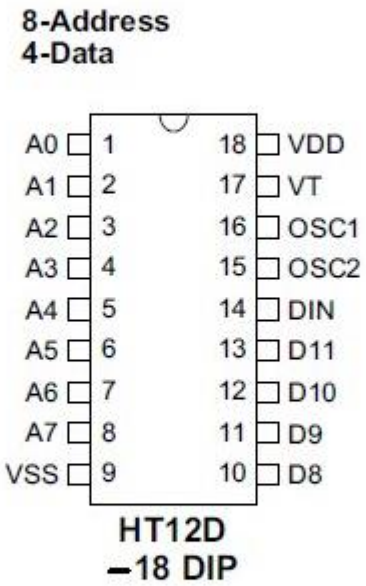



**Figure 20: H12D – Pin diagram**

- VDD and VSS are used to provide power to the IC, Positive and Negative of the power supply respectively. As I said earlier its operating voltage can be in the range 2.4V to 12V
- OSC1 and OSC2 are used to connect external resistor for internal oscillator of HT12D. OSC1 is the oscillator input pin and OSC2 is the oscillator output pin as shown in the figure below.

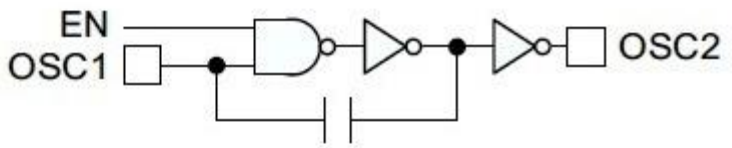



**Figure 21: Oscillator of HT12D**

- A0 – A7 are the address input pins. Status of these pins should match with status of address pin in HT12E (used in transmitter) to receive the data. These pins can be connected to VSS or left open.
- DIN is the serial data input pin and can be connected to a RF receiver output.
- D8 – D11 are the data output pins. Status of these pins can be VSS or VDD depending upon the received serial data through pin DIN.
- VT stands for Valid Transmission. This output pin will be HIGH when valid data is available at D8 – D11 data output pins.

**(6.2.a) Working**

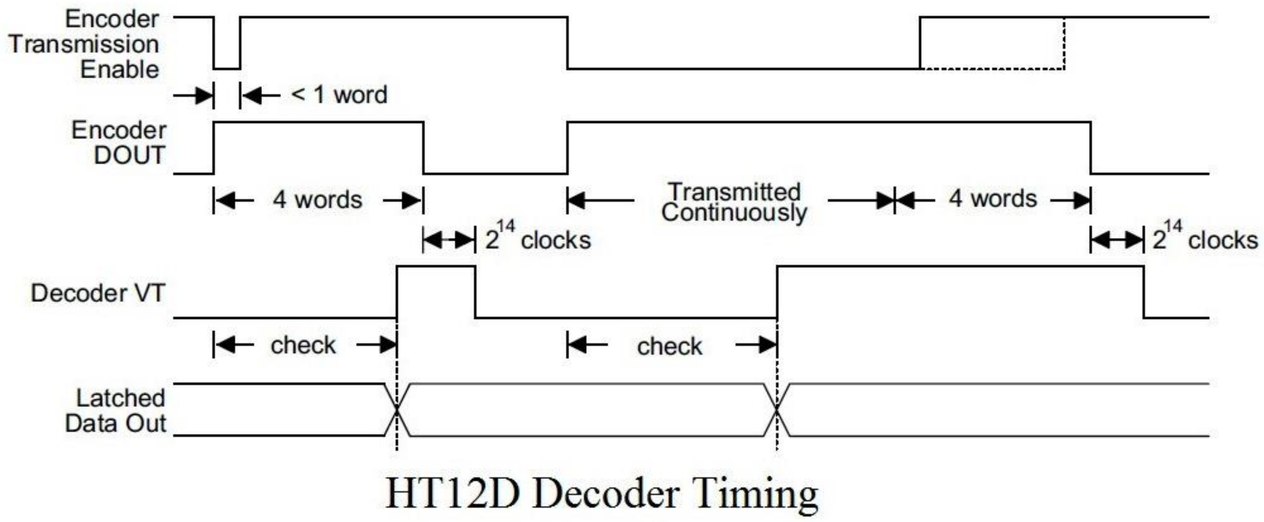



**Figure 22: HT12D Decoder Timing**

HT12D decoder will be in standby mode initially i.e. oscillator is disabled and a HIGH on DIN pin activates the oscillator. Thus the oscillator will be active when the decoder receives data transmitted by an encoder. The device starts decoding the input address and data. The decoder matches the received address three times continuously with the local address given to pin A0 – A7. If all matches, data bits are decoded and output pins D8 – D11 are activated. This valid data is indicated by making the pin VT (Valid Transmission) HIGH. This will continue till the address code becomes incorrect or no signal is received.

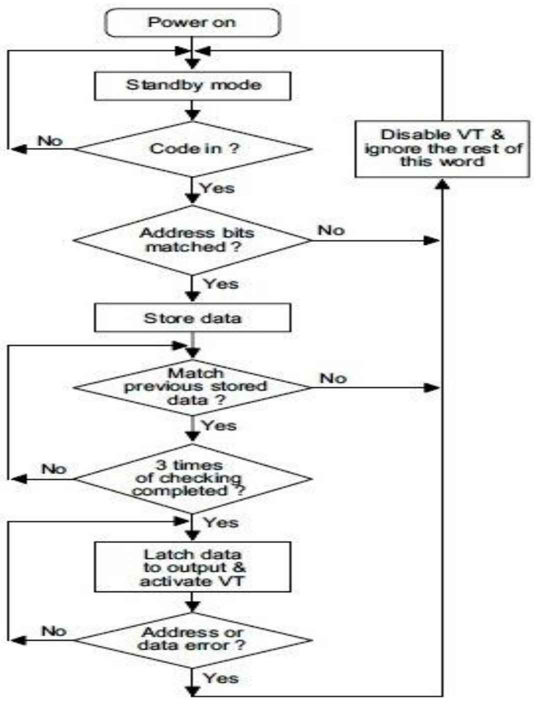



**Figure 23: HT12D Decoder working Flowchart**

**(6.3)CIRCUIT IMPLEMENTION**

(6.3.a) Assembling transmitter with Encoder HT12E:

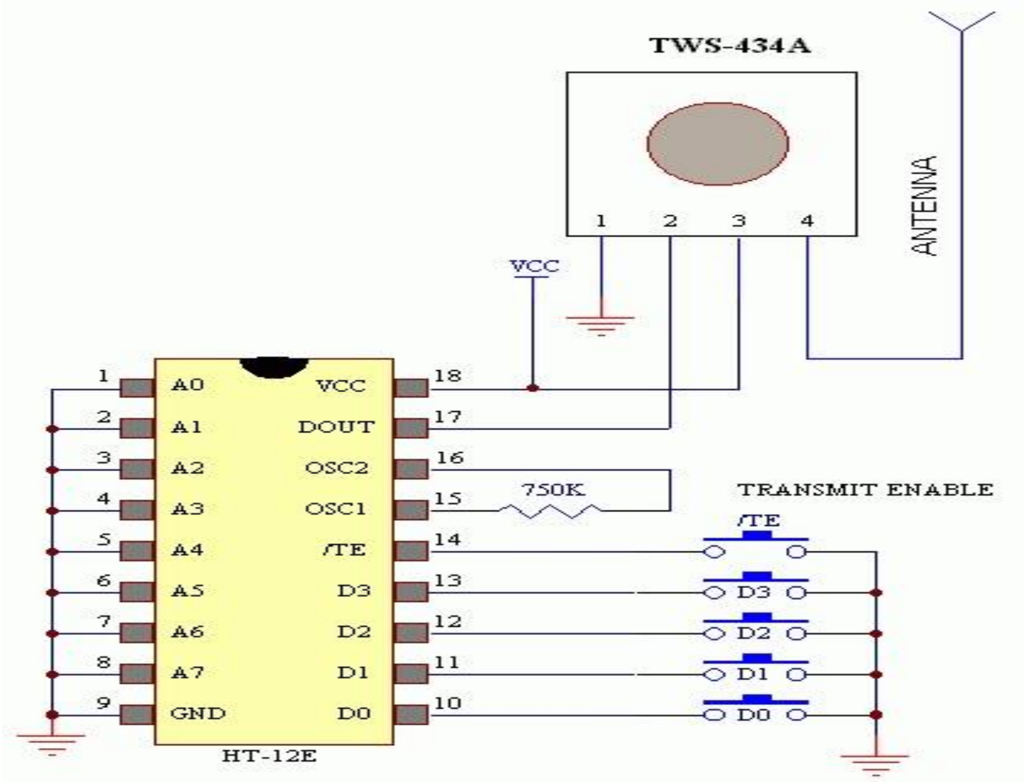
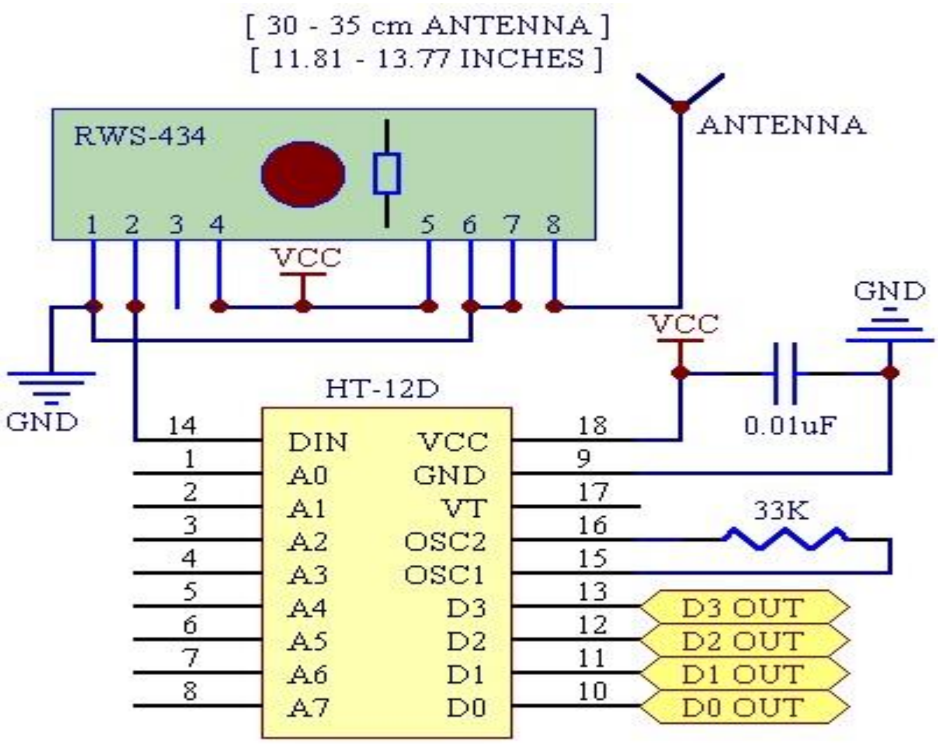



**Figure 24: Assembling Transmitter with encoder HT12E**

(6.3.b) Assembling receiver with Decoder HT12D:




**F**

**Figure 25: Assembling receiver with Decoder HT12D**

# Chapter 7: ARDUINO UNO

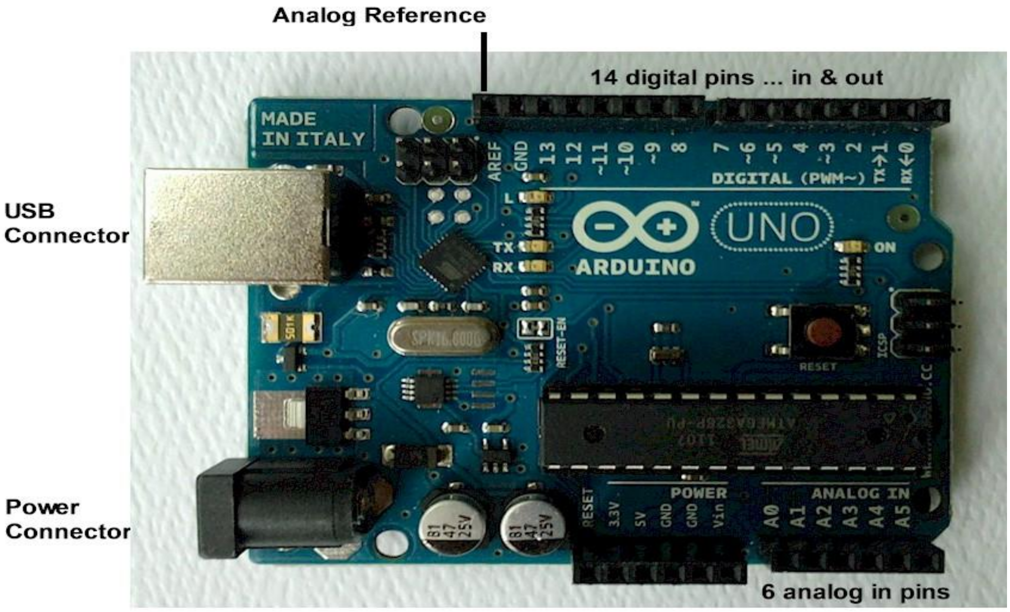



**Figure 26: Arduino Uno**

## (7.1)Overview

The Arduino Uno is a microcontroller board based on the ATmega32. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

### (7.1.a)Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

## (7.2)Specifications

| | |
|---|---|
| Microcontroller | ATmega328 |
| Operating Voltage | 5V |
| Input Voltage (recommended) | 7-12V |
| Input Voltage (limits) | 6-20V |
| Digital I/O Pins | 14 (of which 6 provide PWM output) |
| Analog Input Pins | 6 |
| DC Current per I/O Pin | 40 mA |
| DC Current for 3.3V Pin | 50 mA |
| Flash Memory | 32 KB (ATmega328) of which 0.5 KB used by bootloader |
| SRAM | 2 KB (ATmega328) |
| EEPROM | 1 KB (ATmega328) |
| Clock Speed | 16 MHz |
| Length | 68.6 mm |
| Width | 53.4 mm |
| Weight | 25 g |

**(7.2.a)Power**

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The power pins are as follows:

- VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V.This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or

the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

- 3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND. Ground pins.
- IOREF. This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

**(7.2.b)Memory**

The ATmega328 has 32 KB (with 0.5 KB used for the boot loader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

**(7.2.c)USB Overcurrent Protection**

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

## (7.3)Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), anddigitalRead() 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 kOhms. 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. See the attachInterrupt() function for details.
- 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.

## (7.4)Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A Software Serial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library.

# Chapter 8: LCD INTERFACING

16×2 character LCD display is a very basic LCD module. 16×2 means it can display 2 rows of 16 characters (columns). Its other variants such as 16×1, 16×4 etc are also available. These LCDs are usually made using HD44870 compatible controllers. The interface between this LCD and Arduino can be 8 bit or 4 bit and the difference between them is in how the data or commands are send to LCD. In the 8 bit mode, 8 bit data and commands are send through the data lines DB0 – DB7 and data strobe is given through E input of the LCD. But 4 bit mode uses only 4 data lines. In this 8 bit data and commands are splitted into 2 parts (4 bits each) and are sent sequentially through data lines DB4 – DB7 with its own data strobe through E input. The idea of 4 bit communication is introduced to save pins of the controller. You may think that 4 bit mode will be slower than 8 bit. But the speed difference is only minimal. As LCDs are slow speed devices, the tiny speed difference between these modes is not significant. Just remember that Arduino Uno is operating at high speed in the range of 16MHz and we are viewing LCD with our eyes. Due to Persistence of Vision of our eyes we will not even feel the speed difference.

The LCDs have a parallel interface, meaning that the microcontroller has to manipulate several interface pins at once to control the display. The interface consists of the following pins:

- A register select (RS) pin that controls where in the LCD's memory you're writing data to. You can select either the data register, which holds what goes on the screen, or an instruction register, which is where the LCD's controller looks for instructions on what to do next.
- A Read/Write (R/W) pin that selects reading mode or writing mode
- An Enable pin that enables writing to the registers
- 8 data pins (D0 -D7). The states of these pins (high or low) are the bits that you're writing to a register when you write, or the values you're reading when you read.
- A display contrast pin (Vo)
- power supply pins (+5V and Gnd)
- LED Backlight (Bklt+ and BKlt-) pins that you can use to power the LCD, control the display contrast, and turn on and off the LED backlight, respectively.

The process of controlling the display involves putting the data that form the image of what you want to display into the data registers, then putting instructions in the instruction register. The Liquid Crystal Library simplifies this for you so you don't need to know the low-level instructions.

The Hitachi-compatible LCDs can be controlled in two modes: 4-bit or 8-bit. The 4-bit mode requires seven I/O pins from the Arduino, while the 8-bit mode requires 11 pins. For displaying text on the screen, you can do most everything in 4-bit mode, so example shows how to control a 2x16 LCD in 4-bit mode.


**Figure 27: Liquid Crystal Display**

## (8.1) Circuit

Before wiring the LCD screen to your Arduino we suggest to solder a pin header strip to all the pins connector of the LCD screen, as you can see in the image above.

To wire your LCD screen to your Arduino, connect the following pins:

- LCD RS pin to digital pin 12
- LCD Enable pin to digital pin 11
- LCD D4 pin to digital pin 5
- LCD D5 pin to digital pin 4
- LCD D6 pin to digital pin 3
- LCD D7 pin to digital pin 2

Additionally, wire a 10K pot to +5V and GND, with its wiper (output) to LCD screens VO pin (pin3). This is required to adjust the screen contrast.

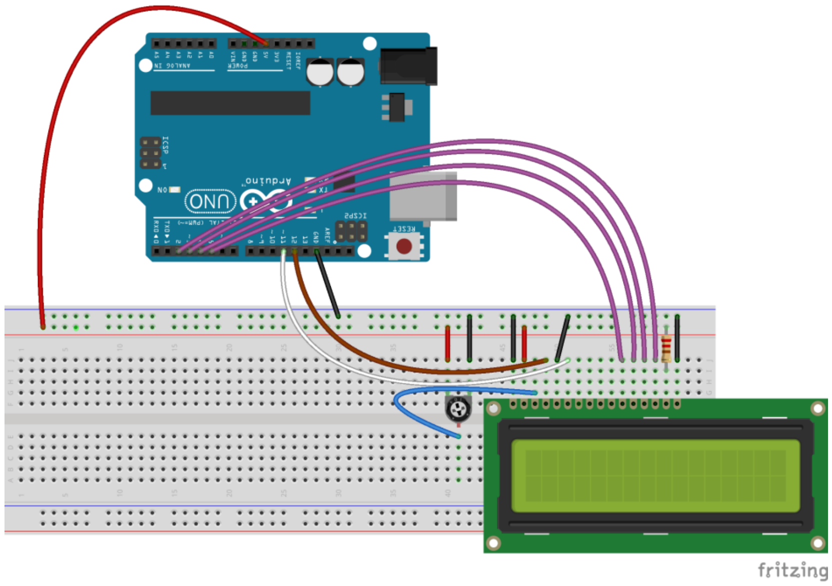



**Figure 28: Interfacing LCD with Arduino**

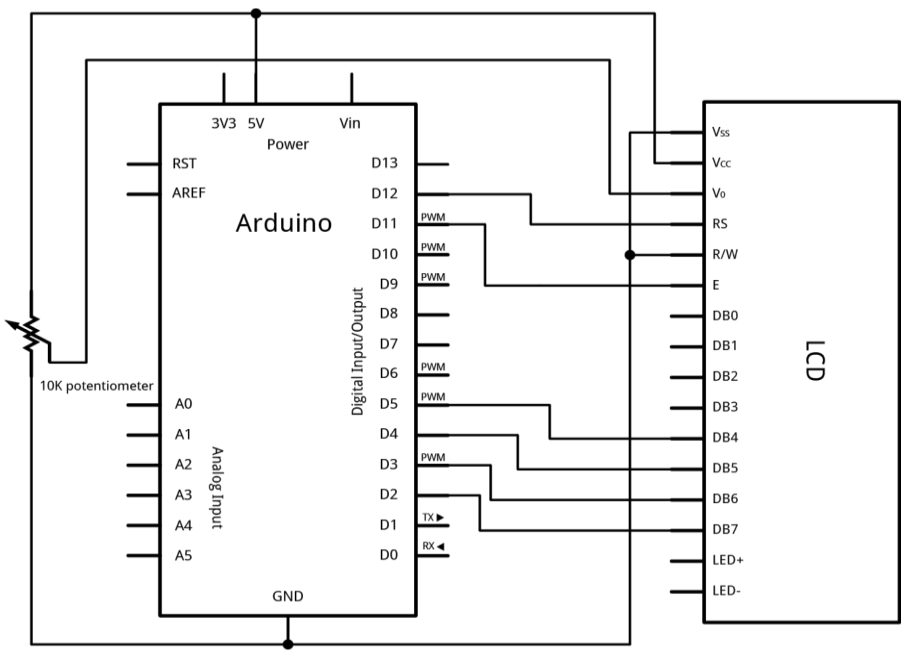



**Figure 29: LCD Interfacing with Arduino Board**

## (8.2) General Programming Commands for LCD

### Arduino LiquidCrystal Library

Arduino LiquidCrystal library enables us to interface LCDs having Hitachi HD44780 or compatible controllers with Arduino Boards. This library can work either in 8-bit or 4-bit mode depending upon how we initialize LCD connections.

**LiquidCrystal()**

This function is used to initialize connections of LCDs. It creates a variable of type LiquidCrystal. By proper initialization of connections, we can control LCD either in 8-bit or 4-bit mode.

Syntax :

```
LiquidCrystal(RS, EN, D4, D5, D6, D7)                        // 4-bit mode
LiquidCrystal(RS, RW, EN, D4, D5, D6, D7)                    // 4-bit mode
LiquidCrystal(RS, EN, D0, D1, D2, D3, D4, D5, D6, D7)        // 8-bit mode
LiquidCrystal(RS, RW, EN, D0, D1, D2, D3, D4, D5, D6, D7)    // 8-bit mode
```

Description

- RS indicates the Arduino pin number to which LCD RS (Register Select) is connected.
- EN indicates the Arduino pin number to which LCD EN (Enable) is connected.
- RW indicates the Arduino pin number to which LCD RW (Read / Write) is connected
- D0 – D8 indicates Arduino pin numbers to which LCD data pins are connected.

Note 1**:** D0 – D3 pins are optional, if omitted the LCD will be controlled in 4-bit mode.

Note 2**:** RW pin is also optional. RW pin is used to indicate Read or Write operation is to be performed. Since LCD is an output device, we usually write data to it, so RW pin can be tied to ground instead of connecting it to Arduino.

Example :

LiquidCrystal lcd(12, 11, 10, 5, 4, 3, 2);

Where *lcd* is the variable.

**begin()**

This function initializes the interface to LCD display and it also sets the size (columns and rows) of the display. It should be called before any other LCD library functions. The parameters of this function will be the dimensions of the display, that is the number of rows and columns.

Syntax :

lcd.begin(columns,rows);

Where,

*lcd* is a variable of type LiquidCrystal used while defining LCD connections

*columns* is the number of columns that the display has

*rows* is the number of rows that the display has

**clear()**

This function clears the LCD display and sets the cursor to upper left corner.

Syntax :

lcd.clear();

**home()**

Sets the cursor to upper left corner.

Syntax :

lcd.home();

**setCursor()**

This function will set the position of the LCD cursor. That means the location in which the subsequent data is displayed on the screen. In this function we can specify in which column and row we want to display our data. Note that the numbering of columns and rows are starting from 0.

Syntax :

lcd.setCursor(column, row);

**write()**

Writes a character to LCD display and returns the number of bytes written.

Syntax

lcd.write(Data);

Where *Data* is the character to be written to LCD.

**print()**

Writes text to LCD display and returns the number of bytes written.

Syntax :

lcd.print(Data);

lcd.print(Data, Base);

Where,

*Data* is the text to be printed. It can be char, byte, int, long or string.

*Base* is an optional parameter which can be used while printing numbers. It can be BIN (for binary), DEC (for decimal), OCT (for octal) and HEX (for hexadecimal).

**cursor()**

This function displays the cursor (underscore) on the LCD display at a position in which next character will be written.

Syntax :

lcd.cursor();

**noCursor()**

This function hides the LCD cursor.

Syntax :

lcd.noCursor();

**blink()**

This function displays blinking cursor on LCD display. This is useful in some cases where user input is required.

Syntax :

lcd.blink();

**noBlink()**

This function turns off the blinking cursor.

Syntax :

lcd.noBlink();

noDisplay()

This function turns off the LCD display without lossing the contents in the LCD.

Syntax :

lcd.noDisplay()

**display()**

Turns on the LCD when it is in off state by noDisplay().

Syntax :

lcd.display();

**scrollDisplayLeft()**

Scrolls the contents of LCD display left by one position.

Syntax :

lcd.scrollDisplayLeft();

scrollDisplayRight()

Scrolls the contents of LCD display right by one position.

Syntax :

lcd.scrollDisplayRight();

**autoscroll()**

This function turns on the automatic scrolling of LCD contents. If the current text direction is Left to Right (default), the display scrolls to left and if the current text direction is Right to Left, the display scrolls to right. You can change the current text direction using functions leftToRight() and rightToLeft() as described below.

Syntax :

lcd.autoscroll();

**noAutoscroll()**

Turns off the automatic scrolling of the LCD set by autoscroll().

Syntax :

lcd.noAutoscroll();

**leftToRight()**

Calling this function sets the direction of text written to the LCD as Left to Right (default). This implies that the subsequent characters written to LCD will go from Left to Right without affecting previously written characters.

Syntax :

lcd.leftToRight();

**rightToLeft()**

Calling this function sets the direction of text written to the LCD as Right to Left. This implies that the subsequent characters written to LCD will go from Right to Left without affecting previously written characters.

Syntax :

lcd.rightToLeft();

**createChar()**

This function creates a custom character for use on the LCD. Each character is created using 5×8 pixel matrix. We need to define it as a byte array. We can create up to 8 custom characters.

Syntax :

```
lcd.createChar(Number, Data);
```

Where,

*Number* is the reference number of custom character to be created, it ranges from 0 to 7.

*Data* is byte array indicates character's pixel data.

Example :

```
byte smiley[8] = {
  B00000,
  B10001,
  B00000,
  B00000,
  B10001,
  B01110, B00000,
};
void setup() {
  lcd.createChar(0, smiley);
  lcd.begin(16, 2);
  lcd.write(byte(0));
}
```

Note: You should typecast custom characters as byte as shown above if it is not in a variable.

## (8.3)ICULN2803

IC ULN2803 consists of octal high voltage, high current darlington transistor arrays. The eight NPN Darlington connected transistors in this family of arrays are ideally suited for interfacing between low logic level digital circuitry (such as TTL, CMOS or PMOS/NMOS) and the higher current/voltage requirements of lamps, relays, printer hammers or other similar loads for a broad range of computer, industrial, and consumer applications.

**Features**

- Eight Darlingtons with Common Emitter.
- Open–collector outputs.
- Free wheeling clamp diodes for transient suppression.
- Output Current to 500 mA.

- Output Voltage to 50 V.
- Inputs pinned opposite outputs to simplify board layout.

**(8.3.a) Pinout**

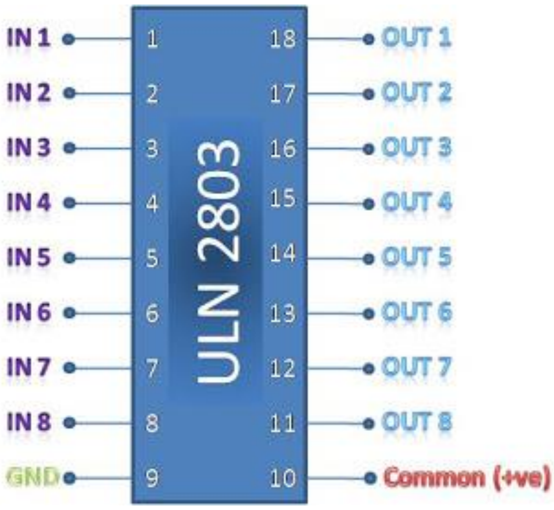



**Figure 30: Pinout of ULN2803**

**(8.3.b) Working**

The ULN 2803 IC consists of eight NPN Darlington connected transistors (often called a Darlington pair). Darlington pair consists of two bipolar transistors such that the current amplified by the first is amplified further by the second to get a high current gain β or $h_{FE}$. The figure shown below is one of the eight Darlington pairs of ULN 2803 IC.

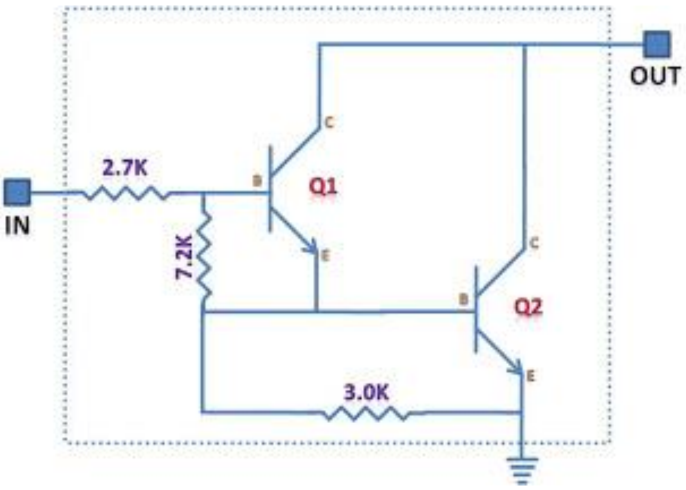



**Figure 31: Darlington pair of ULN2803 IC**

Now 2 cases arise:-

Case 1: When IN is 0 volts.

Q1 and Q2 both will not conduct as there is no base current provided to them. Thus, nothing will appear at the output (OUT).

Case 2: When IN is 5 volts.

Input current will increase and both transistors Q1 and Q2 will begin to conduct. Now, input current of Q2 is combination of input current and emitter current of Q1, so Q2 will conduct more than Q1 resulting in higher current gain which is very much required to meet the higher current requirements of devices like motors, relays etc. Output current flows through Q2 providing a path (sink) to ground for the external circuit that the output is applied to. Thus, when a 5V input is applied to any of the input pins (1 to 8), output voltage at corresponding output pin (11 to 18) drops down to zero providing GND for the external circuit. Thus, the external circuit gets grounded at one end while it is provided $+V_{cc}$ at its other end. So, the circuit gets completed and starts operating.

## (8.4) IC 7404

The 7404 IC contains six independent gates each of which performs the logic INVERT function. The operating voltage is 5V, high-level input voltage is 2V, and low-level input is 0.8V.

**Pin layout**

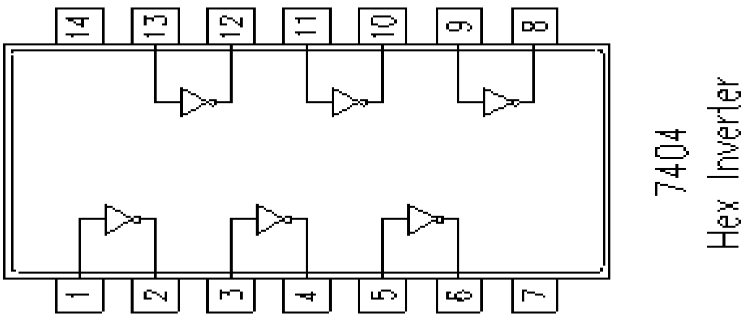



**Figure 32: Pin layout of IC 7404**

**Table 7: Pin description:**

| Pin Number | Description |
|---|---|
| 1 | A Input Gate 1 |
| 2 | Y Output Gate 1 |
| 3 | A Input Gate 2 |
| 4 | Y Output Gate 2 |
| 5 | A Input Gate 3 |

| | |
|---|---|
| 6 | Y Output Gate 3 |
| 7 | Ground |
| 8 | Y Output Gate 4 |
| 9 | A Input Gate 4 |
| 10 | Y Output Gate 5 |
| 11 | A Input Gate 5 |
| 12 | Y Output Gate 6 |
| 13 | A Input Gate 6 |
| 14 | Positive Supply |

**Features:**

- Six Hex Inverters in a 14-Pin DIP Package
- Outputs Directly Interface to CMOS, NMOS and TTL
- Large Operating Voltage Range
- Wide Operating Conditions

**Absolute Maximum Ratings:**

| | |
|---|---|
| Supply Voltage | 7V |
| Input Voltage | 5.5V |
| Operating Free Air Temperature | $0^{o}C$ to $+70^{O}c$ |
| Storage Temperature Range | $-65^{o}C$ to $+150^{o}C$ |

**Table 8: Operating Conditions:**

| Symbol | Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Vcc | Supply Votage | 4.75 | 5 | 5.25 | V |
| Vih | HIGH Level Input Voltage | 2 | | | V |
| Vil | LOW Level Input Voltage | | | 0.8 | V |
| Ioh | HIGH Level Output Current | | | -0.4 | mA |
| Iol | LOW Level Output Current | | | 16 | mA |
| Ta | Free Air Operating Temperature | 0 | | 70 | ℃ |

**Table 9: Electrical characteristics:**

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Vi | Input Clamp Voltage | Vcc=Min,Ii=-12mA | | | -1.5 | V |
| Voh | HIGH Level Output Voltage | Vcc=Min,Ioh=MAX,Vil=MAX | 2.4 | 3.4 | | V |
| Vol | LOW Level Output Voltage | Vcc=Min,Iol=MAX,Vih=MAX | | 0.2 | 0.4 | V |
| Ii | Input Current@MAX Input Voltage | Vcc=Max,Vi=5.5V | | | 1 | mA |
| Iih | HIGH Level Input Current | Vcc=Max,Vi=2.4V | | | 40 | µA |
| Iil | LOW Level Input Current | Vcc=Max,Vi=0.4V | | | -1.6 | mA |
| Ios | Short Circuit Output Current | Vcc=Max | -18 | | -55 | mA |
| Icch | Supply Current with Outputs HIGH | Vcc=Max | | 4 | 8 | mA |
| Iccl | Supply Current with Outputs LOW | Vcc=Max | | 12 | 22 | mA |

## (8.5) IC7805

7805 is a voltage regulator integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The voltage regulator IC maintains the output voltage at a constant value. The xx in 78xx indicates the fixed output voltage it is designed to provide. 7805 provides +5V regulated power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels.

**Pin diagram:**

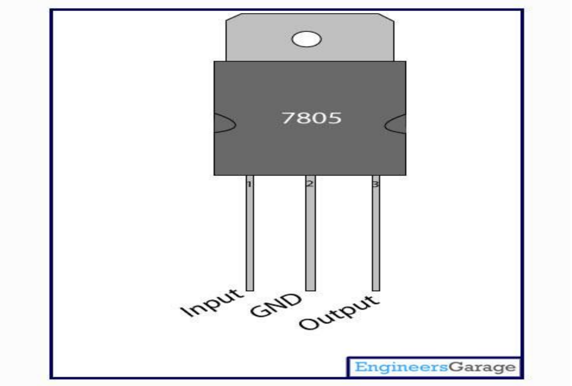


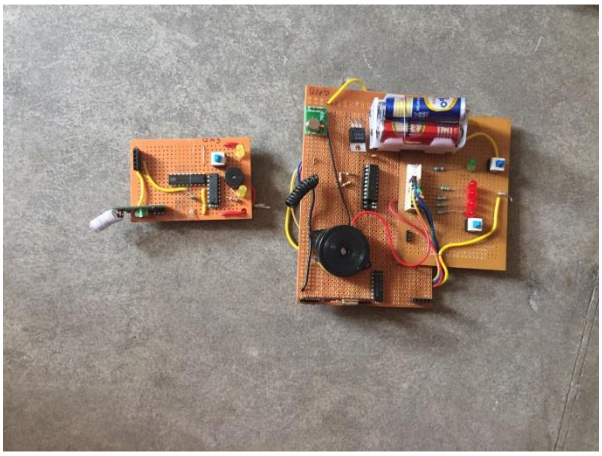

**Figure 33: Pinout of IC 7805**

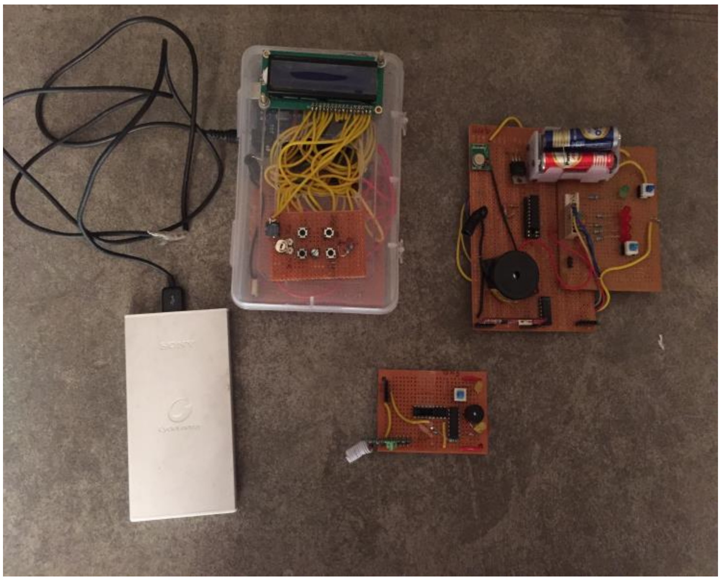
**Table 10: Pin Description:**

| Pin No | Function | Name |
|---|---|---|
| 1 | Input voltage (5V-18V) | Input |
| 2 | Ground (0V) | Ground |
| 3 | Regulated output; 5V (4.8V-5.2V) | Output |

# CONCLUSION AND FUTURE SCOPE

This project is very useful and reduces the effort spent in searching objects which are needed in an emergency or get misplaced frequently. Though this is targeted towards home users, it can be extended to commercial environments for tracking material. It can be used in warehouses of the logistics thus reducing the time to search each parcel individually. It can also be used to avoid theft of important items as in case of theft alarm after a certain range will alert. The size of the reader and tags can be significantly be reduced by using integrated circuit printing.





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