

# **MECHATRONICS AND ROBOTICS**

**Wireless Communication**

**LECT- 15:-**

**Bluetooth**

# Wireless Communication

## Bluetooth

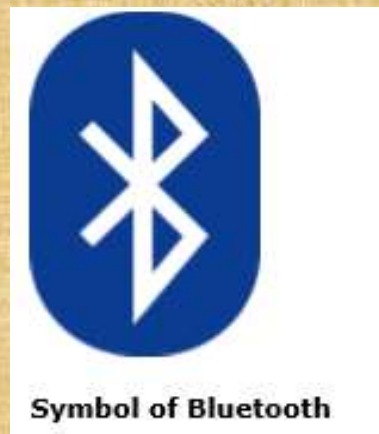


# MECHATRONICS AND ROBOTICS

## SECTION 2

### TOPIC:- Wireless communication

Bluetooth features, working, interfacing and programming with Arduino



# Wireless communication?

- Wireless communication is the transfer of information between two or more points that are not connected by an electrical conductor.
- The most common wireless technology use radio.
- The different types of wireless communication mainly include IR wireless communication, satellite communication, broadcast radio, microwave radio, Bluetooth, Zigbee etc.
- In wireless communication, information can be transmitted through air without requiring any cable or wires, by using Electromagnetic waves like RF, IR, satellite etc.
- Wireless communication technology refers to variety of wireless communication devices and technologies ranging from smart phone to computers, tabs, laptops, Bluetooth technology, printers.



# Wireless communication?

- Now a day, We're all use wireless communication, even if we don't always realize it.
- For example - Radio receivers and television sets pick up programs beamed in radio waves hundreds (possibly even thousands) of km/miles through the air.
- Cordless telephones use similar technologies to carry calls from a handset to a base station somewhere in your home.
- If you use Wi-Fi (wireless Internet), your computer sends and receives a steady stream of Internet data to and from a router that's probably wired directly to the Net.
- All these technologies involve sending information back and forth not along copper cables but in radio waves buzzing invisibly through the air.

# Bluetooth- What is it?



# What is Bluetooth?

- Bluetooth is a way to send or receive data between two different devices.
- Bluetooth is a similar radio-wave technology, but it's mainly designed for communicating over short distances less than about 10m or 30ft.
- Bluetooth is a short-range wireless communication technology that allows devices such as mobile phones, computers, and peripherals to transmit data or voice wirelessly over a short distance.
- Bluetooth is a wireless technology standard used for exchanging data between fixed and mobile devices over short distances using short-wavelength UHF radio waves in the industrial, scientific and medical radio bands, from 2.400 to 2.485 GHz, and building personal area networks (PANs).

# What is Bluetooth?

- Typically, you might use it to download photos from a camera to a PC, to hook up a wireless mouse to a laptop, to link a hands-free headset to your cellphone so you can talk and drive safely at the same time, and so on.
- It allows multiple devices to connect, interact, and sync without needing to set up complex networks and passwords.
- **Bluetooth** is everywhere these days, from mobile phones to laptops, and even car stereos also.



# Bluetooth features

1. Bluetooth technology eliminates the need for numerous and inconvenient cable attachments .
2. This technology enable users to automatically and easily connect a wide range of computing and telecommunication devices.
3. Bluetooth makes wireless communication and networking between devices in small localized area.
4. Signal can be transmitted through wall and briefcases, thus eliminating the need for line-of-sight.
5. The key **features** of **Bluetooth** technology are robustness, low power, and low cost.
6. Bluetooth has a range of around 10 meters and data transfer rate of 3 Mbps.

# Bluetooth features

- 1) Typical -80dBm sensitivity
- 2) Up to +4dBm RF transmit power
- 3) Low Power 1.8V Operation ,1.8 to 3.6V I
- 4) UART interface with programmable baud rate
- 5) With integrated antenna
- 6) Default Baud rate: 38400, Data bits:8, Stop bit:1,Parity:No parity, Data control: has Supported baud rate: 9600,19200,38400,57600,115200,230400,460800.

# Bluetooth features

- 1) Bluetooth technology uses radio waves to communicate between devices. Most of these radio waves have a range of 15-50 feet.
- 2) Bluetooth uses a low-power signal with a maximum range of 50 feet with sufficient speed to enable transmission of data.
- 3) The pairing process identifies and connects any two devices to each other. It also prevents interference from other non-paired Bluetooth devices in the area.
- 4) It uses maximum power only when it is required, thus preserving battery life.

# Bluetooth Specification

- Bluetooth is a global specification for a small form-factor, low-cost radio solution providing links between mobile computers, mobile phones, and other portable handheld devices, as well as connectivity to the Internet.
- The Institute of Electrical and Electronics Engineers (IEEE) has given the IEEE 802.15 standard. Its main strength is its ability to simultaneously handle both data and voice transmissions.
- A mobile computer equipped with Bluetooth technology, for example, could link to a similarly equipped mobile phone to connect to the Internet. Multiple Bluetooth units form a Wireless Personal Area Network(WPAN) , called and up to seven client devices



# Bluetooth specification

- A Bluetooth WPAN is capable of supporting an asynchronous data link with each client and synchronous voice links with up to three client devices.
- It provides a range of up to 10m at a transmit power of 1 m watt. The range can be extended to 100m if the transmit power is increased to 100 m watt.

# Working of Bluetooth Technology

- A Bluetooth module is a short range device of around 10 meters which provides both sound and data transmission.
- The Bluetooth transmits and receives at a frequency band of 2.4 GHz which is globally available.
- The Bluetooth device uses a IEEE 802 standards wherein the connections can be point-to-point or point-to-multipoint.
- The data transfer rate is 3mbps and the maximum range of a Bluetooth device can be 10-100 meters.
- The default baud rate is 38400 and other supported baud rates are 9600,19200,57600,115200,230400 and 460800.

# Working of Bluetooth Technology

- Bluetooth can connect up to 8 devices simultaneously.
- It uses the **spread spectrum technology** in which each device uses different frequency band and hence the devices do not transmit at same time.
- When the two devices come in range with each other , the transmission takes place between them

# What is spread spectrum?

- Suppose you're talking to a friend on a walkie-talkie , but there are other people using the same frequency and your conversation keeps getting interrupted. What can you do?

**Solution :**

- you both change to a different frequency (band) and resume your conversation there. And you can keep on switching band until you find a place where you can happily talk without interruption.
- In theory, you could use the same technique for covert communication: if you were talking over the radio and someone was eavesdropping, you could give a code-word to your friend and hastily switch to another, pre-arranged frequency band where the eavesdropper wouldn't find you (although they'd most likely still pick up your signal sooner or later).



# What is spread spectrum?

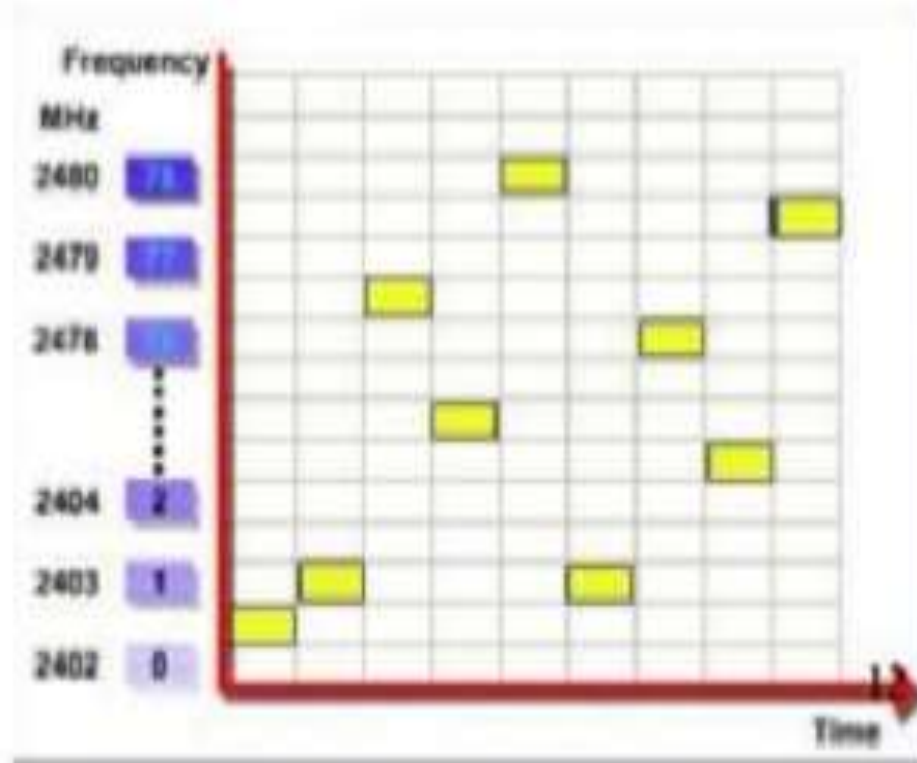
- Radios are clever electronic gadgets, so why can't they do this neat trick for themselves? Why can't they simply switch to another frequency automatically to prevent interference and eavesdropping? This is the basic idea behind a technique called **frequency hopping spread spectrum (FHSS)**, where signals are rapidly and randomly switched across a wide range of different frequencies to improve the security and reliability of wireless communication.

# How data travel?

## Frequency hopping spread-spectrum(FHSS)

➤NOTE

It's also define  
bluetooth data  
transmitting  
security



# How data travel?

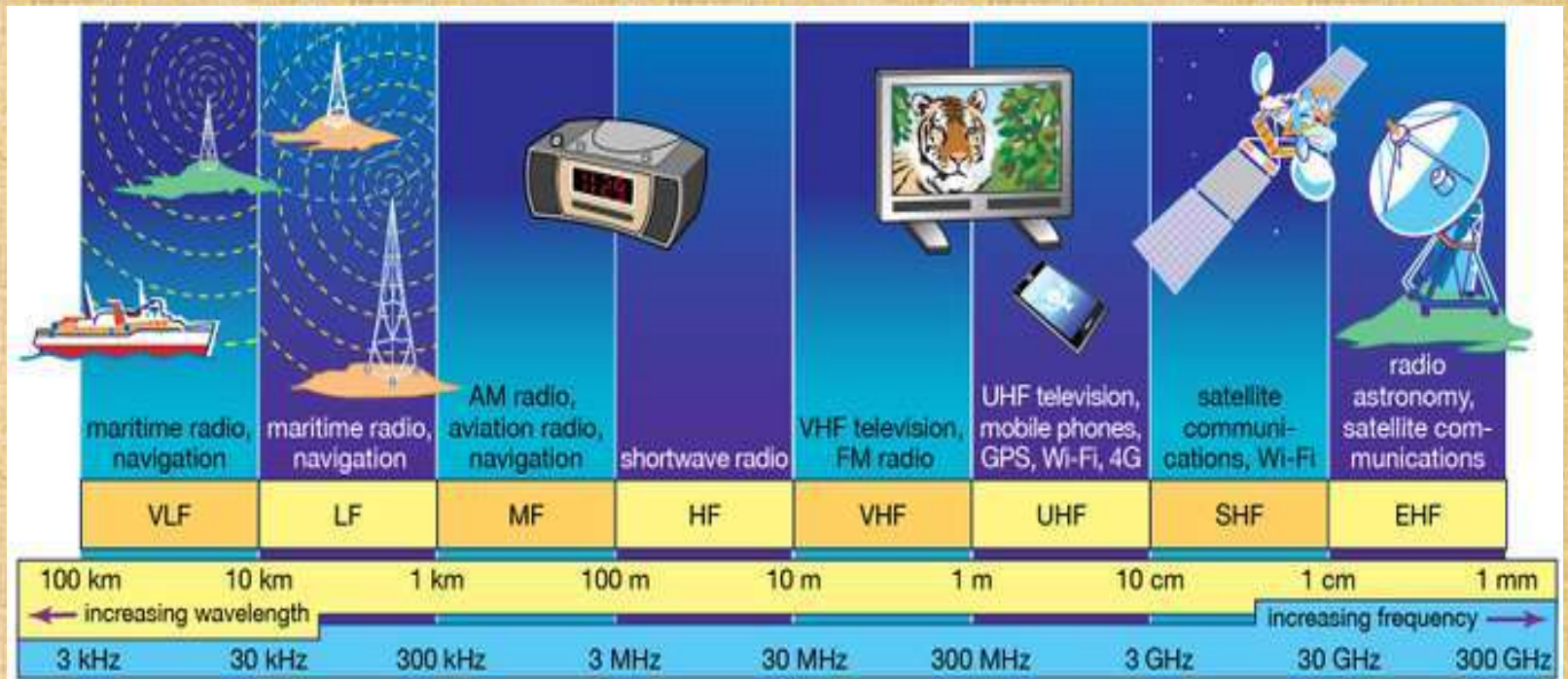
## Frequency hopping spread-spectrum(FHSS)

- Frequency hopping spread-spectrum(FHSS) is a method of transmitting radio signal by rapidly switching a carriers signals among many frequency channels. Transmitted data are divided into packets and each packets is transmitted on one of the **79 Bluetooth channels**.
- Frequency hopping spread-spectrum(FHSS) is defined in the 2.4 GHz band and operates in around 79 frequencies ranging from 2.402 GHz to 2.480 GHz . Every frequency is modulated with channel width of 1 MHz and rate defined as 1 Mbps.



# How does Bluetooth work?

- Bluetooth technology is a combination of software and hardware . On the hardware side , chip containing the Bluetooth radio. That send and receive signal at a specific ISM radio frequency 2.4 GHz.
- The software interprets incoming Bluetooth signals and sends them to other devices , so that it can read and understand.





# How does Bluetooth work?

- Bluetooth sends and receives radio waves in a band of 79 different frequencies (**channels**) centered on 2.45 GHz, set apart from radio, [television](#), and cell phones, and reserved for use by industrial, scientific, and medical gadgets. Don't worry: you're not going to interfere with someone's life-support machine by using Bluetooth in your home, because the low power of your transmitters won't carry your signals that far!
- Bluetooth's short-range transmitters are one of its biggest plus points. They use virtually no power and, because they don't travel far, are theoretically more secure than wireless networks that operate over longer ranges, such as Wi-Fi. (In practice, there are some security concerns.)

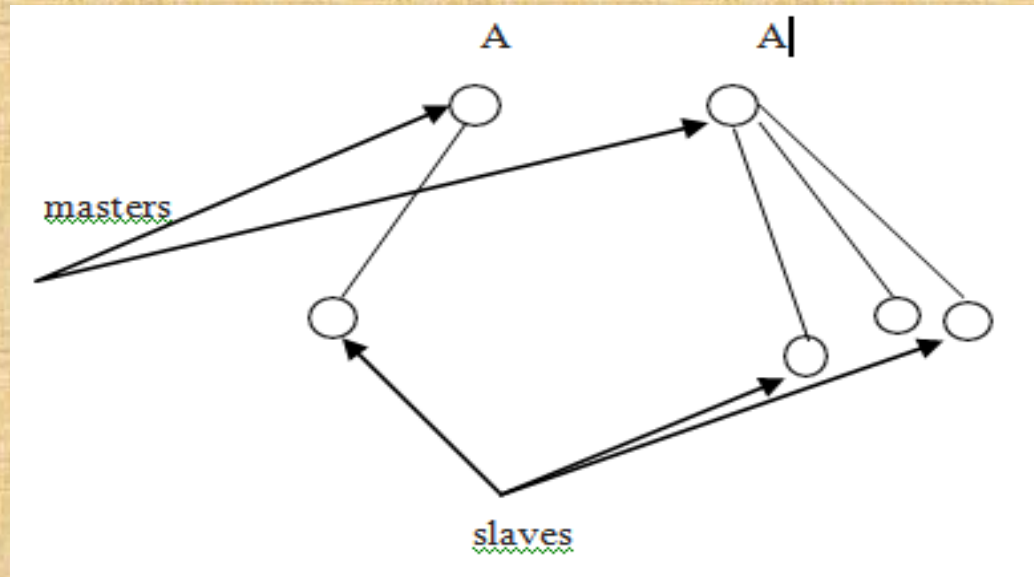
# How does Bluetooth work?

- Bluetooth devices automatically detect and connect to one another and up to eight of them can communicate at any one time. They don't interfere with one another because each pair of devices uses a different one of the 79 available channels.
- If two devices want to talk, they pick a channel randomly and, if that's already taken, randomly switch to one of the others (a technique known as spread-spectrum frequency hopping).
- To minimize the risks of interference from other electrical appliances (and also to improve security), pairs of devices constantly shift the frequency they're using—thousands of times a second.

# How does Bluetooth work?

- When a group of two or more Bluetooth devices are sharing information together, they form a kind of ad-hoc, mini computer network called a piconet. Other devices can join or leave an existing piconet at any time.
- One device (known as the master) acts as the overall controller of the network, while the others (known as slaves) obey its instructions. Two or more separate piconets can also join up and share information forming what's called a scatternet.

# Bluetooth Network Topology





# Bluetooth Network Topology

- There are three types of connections in Bluetooth: single slave ,multi slave or scatter net.
- Multiple Bluetooth devices form a piconet network that is a wireless personal area network.
- A piconet consists of one hub device along with seven client devices. In order to transmit or receive information with the client it should be in active mode.
- Only seven clients can be active at a time. In a scatter net , the two piconets are not synchronized (in terms of time and frequency). Each of them operates in its own frequency band, multiple piconets can work simultaneously using frequency division multiplexing.

# Security

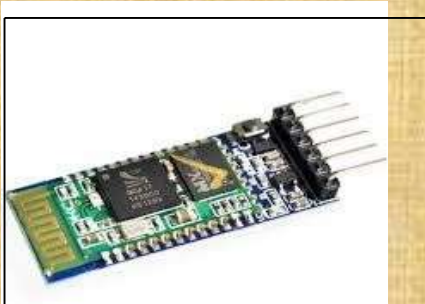
By default most of the devices operate in an unprotected environment. The link established between two devices in order to exchange information with each other there should provide authentication, this is achieved using encryption keys. This key is known as PIN code, both the devices should have the same PIN code. By default the PIN provided is “0000” or “1234”. After these PIN codes are entered, the two devices are paired and hence now they can exchange information with each other.

# Bluetooth module - HC- 05

- Here we discuss wireless communication using HC-05 Bluetooth module, Bluetooth network topology and interfacing Bluetooth with Arduino.
- Bluetooth is a wireless technology standard used for exchanging data between fixed and mobile devices over short distances using short-wavelength UHF radio waves in the industrial, scientific and medical radio bands, from 2.400 to 2.485 GHz, and building personal area networks (PANs).
- Bluetooth is a type of wireless communication used to transmit voice and data at high speed using radio waves.
- It is used for short range radio communication between many different types of devices.

# HC-05 Bluetooth Module

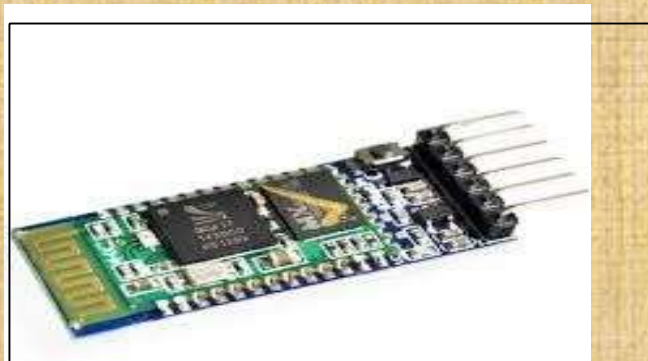
- Its main strength is its ability to simultaneously handle both data and voice transmissions.
- There are several ways for wireless communication such as NRF, ZigBee, Wi-Fi, and Bluetooth.
- Bluetooth protocol; an affordable communication method in PAN network, with a maximum data rate of 1Mb/S, working in a nominal range of 100 meters using 2.4 G frequency is a common way of wireless communicating.





# HC-05 Bluetooth Module

- HC05 module is a Bluetooth module using serial communication, mostly used in electronics applications.
- HC05 Bluetooth module important specifications:
  - 1) Working voltage: 3.6V – 5V
  - 2) Internal antenna: Yes
  - 3) Automatic connection to the last device: Yes



# HC-05 Bluetooth Module

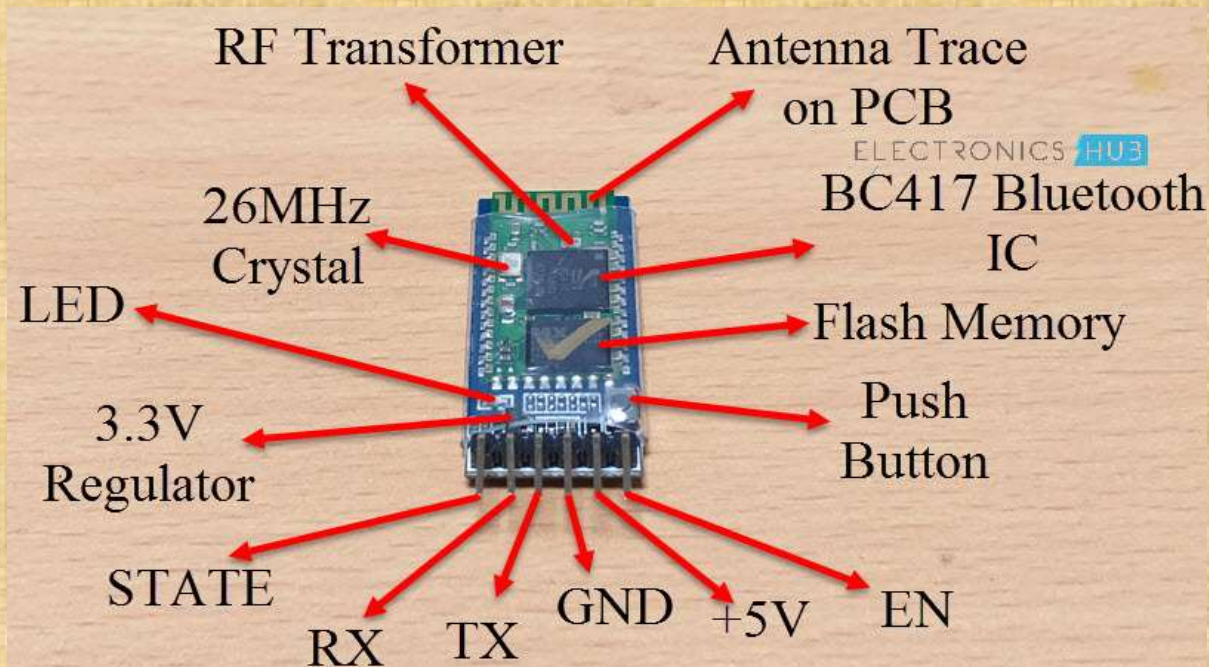
Here we will learn about HC-05 Bluetooth Module, how to interface this Bluetooth Module with Arduino and how the HC-05 Bluetooth Module can be used for controlling the Arduino Board over Wireless Communication (Bluetooth).



# Pins of HC-05 Bluetooth Module

**Pins of HC-05 Bluetooth Module:** The HC-05 Module supports for UART, USB as well as SPI communication and depending on the application, necessary pins can be used. In our case, the board uses the UART communication.

➤ Coming to the pins of the Bluetooth Module, generally, four pins are sufficient for successfully enabling a wireless communication link but the modules produced now-a-days come with six pins namely: VCC, GND, TX, RX, EN and STATE.





# Pins of HC-05 Bluetooth Module

## Pin Description

**State:** can be connected to the Arduino Input in order to know the state of the connection. Paired or disconnected.

**Rx:** Receive Pin of the module. It is recommended to use a voltage divider.

**Tx:** Can be connected directly to the Arduino Rx Pin

**GND:** connected to GND pin of Arduino

**5v:** This breakout board has a internal 3.3v regulator on board.

**EN:** Enables or Disables the module. It is Rarely Used.



# Interfacing with Arduino

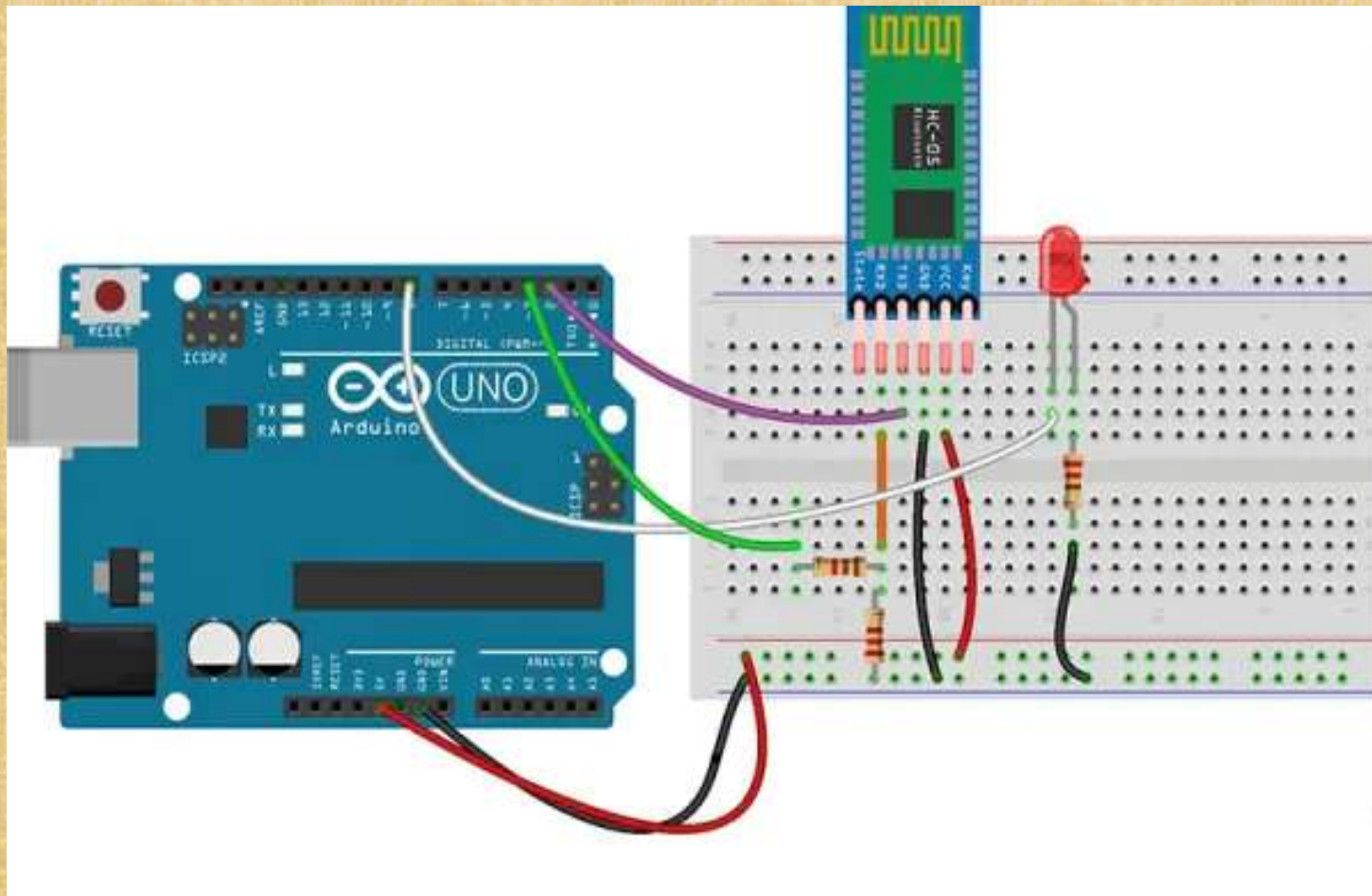
## **Sending Data to Arduino via Bluetooth :**

HC05 module has an internal 3.3v regulator and that is why you can connect it to 5v voltage. But we strongly recommend 3.3V voltage, since the logic of HC05 serial communication pins is 3.3V. Supplying 5V to the module can cause damage to the module.

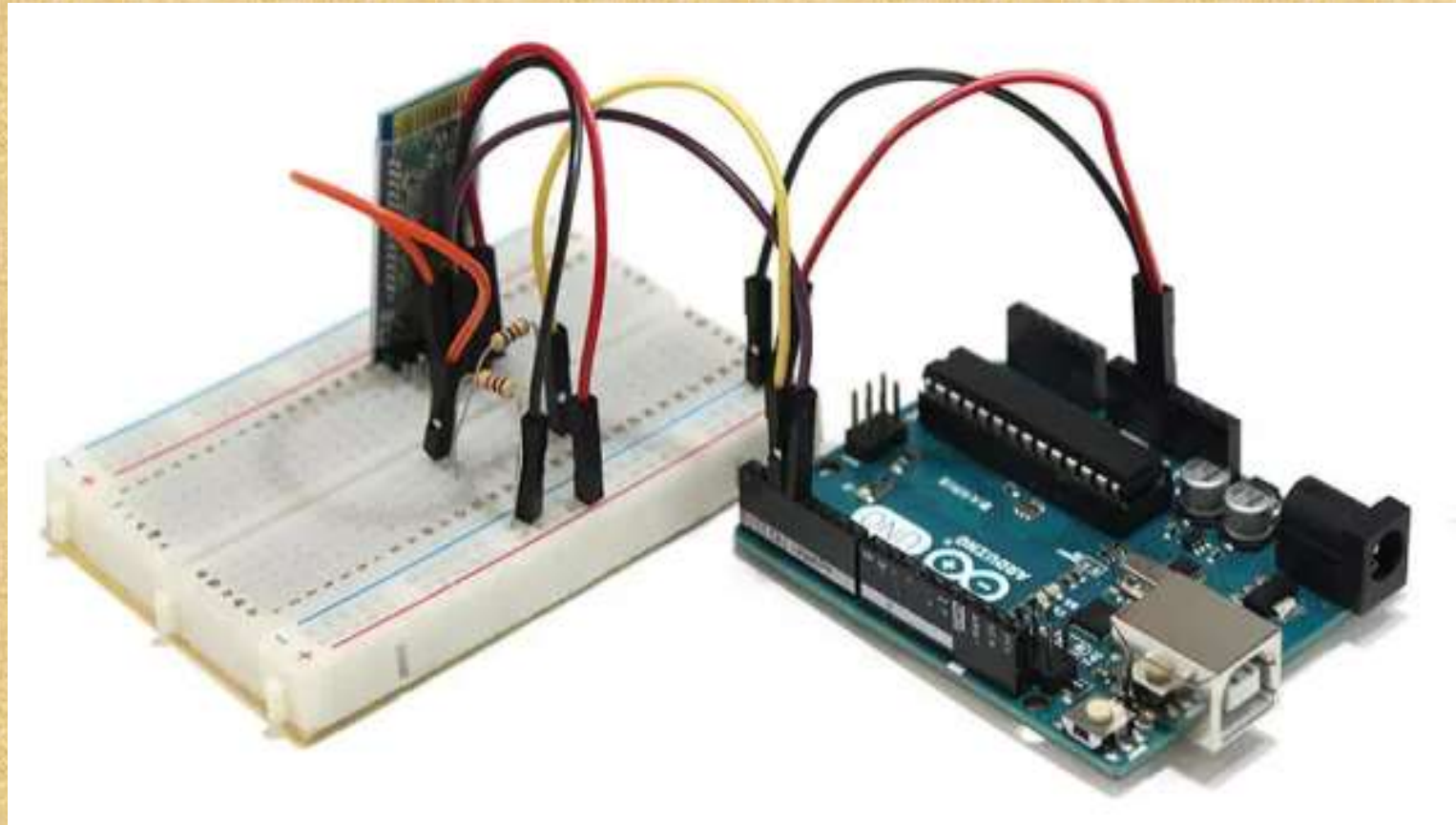
In order to prevent the module from damages and make it work properly, you should use a resistance division circuit (5v to 3.3v ) between Arduino TX pin and module RX pin.

When master and slave are connected, blue and red LEDs on the board blink every 2seconds. If they aren't connected, only blue one blinks every 2 seconds.

# Interfacing with Arduino



# Interfacing with Arduino





# Interfacing with Arduino

## Example :

- Here, we will transmit data from Smartphone via Bluetooth to the Arduino Uno and display it on Serial Monitor of PC.
- Download and install a Bluetooth terminal application on your phone and use it to connect to the HC-05 Bluetooth module.
- Data is sent from the Smartphone using the Bluetooth terminal application.
- Communication name is HC05, the password is 1234 or 0000 and the transfer baud rate is 9600 by default.



# ARDUINO CODE

## Bluetooth module

```
#include <SoftwareSerial.h>
SoftwareSerial BTserial(8,9);
//char rec = "";
void setup() {
  Serial.begin(9600);
  BTserial.begin(9600);
}
void loop() {
  if(BTserial.available()) {
    String rec = BTserial.readString();
    Serial.print(rec);
    Serial.println();
  }
}
```

# Advantages of Bluetooth device

- 1) Ease of use.
- 2) No LOS (Line of sight) required for data transfer.
- 3) Less power consumption makes its usage very practical.
- 4) 2.4 GHz radio frequency ensures world wide operability.
- 5) The data rate is high i.e around 3Mbps.

# Advantages of Wireless Communications

- 1) Any information can be conveyed or transmitted quickly and with a high speed.
- 2) The Internet can be accessed from anywhere and at anytime without the need to carry cables or wires and it improves easy access and productivity.
- 3) Helpful for Doctors, workers and other professionals working in remote areas as they can be in touch with the medical centers through wireless communication.
- 4) Emergency situations can be alerted through wireless communication. The affected regions can be provided support with the help of these alerts through wireless communication.
- 5) Wireless networks cost less for installation and maintenance.

# Disadvantages of Wireless Communications

- 1) A Hacker can easily capture the wireless signals that spread through the air.
- 2) It is very important to secure the wireless network so that the information cannot be exploited by unauthorized users, and this also increases the risk of losing data or information.



# Applications

1. Handheld device, music players, other electronic systems.
2. Wireless communication of devices like keyboard, mouse, printer , etc.
3. Wireless internet access using Bluetooth Dongle.
4. In medical field like
  - BLP -for blood pressure measurement.
  - HTP - for medical temperature measurement devices.
  - GLP -for blood glucose monitors.
  - CGMP -Continuous Glucose Monitor Profile
5. In sports field like
  - HRP –for devices which measure heart rate
  - LNP-Location and Navigation Profile
  - RSCP- Running Speed and Cadence Profile
  - WSP-Weight Scale Profile
6. Short range data transfer

**THANKS**