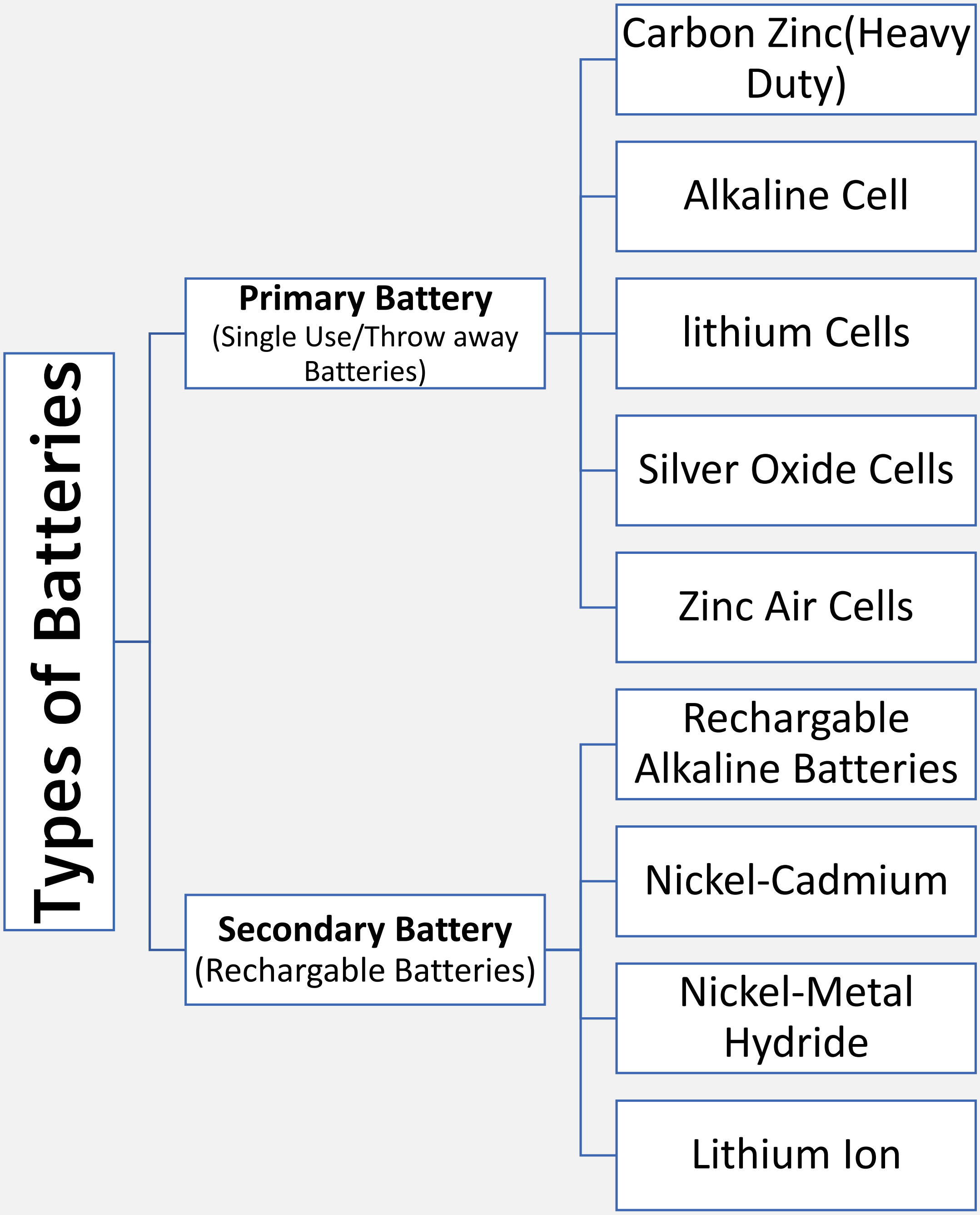
Power, Control & Communication Systems

Mars Task#2 Project-A

Om Kinage

EC22B111

Battery Classification:

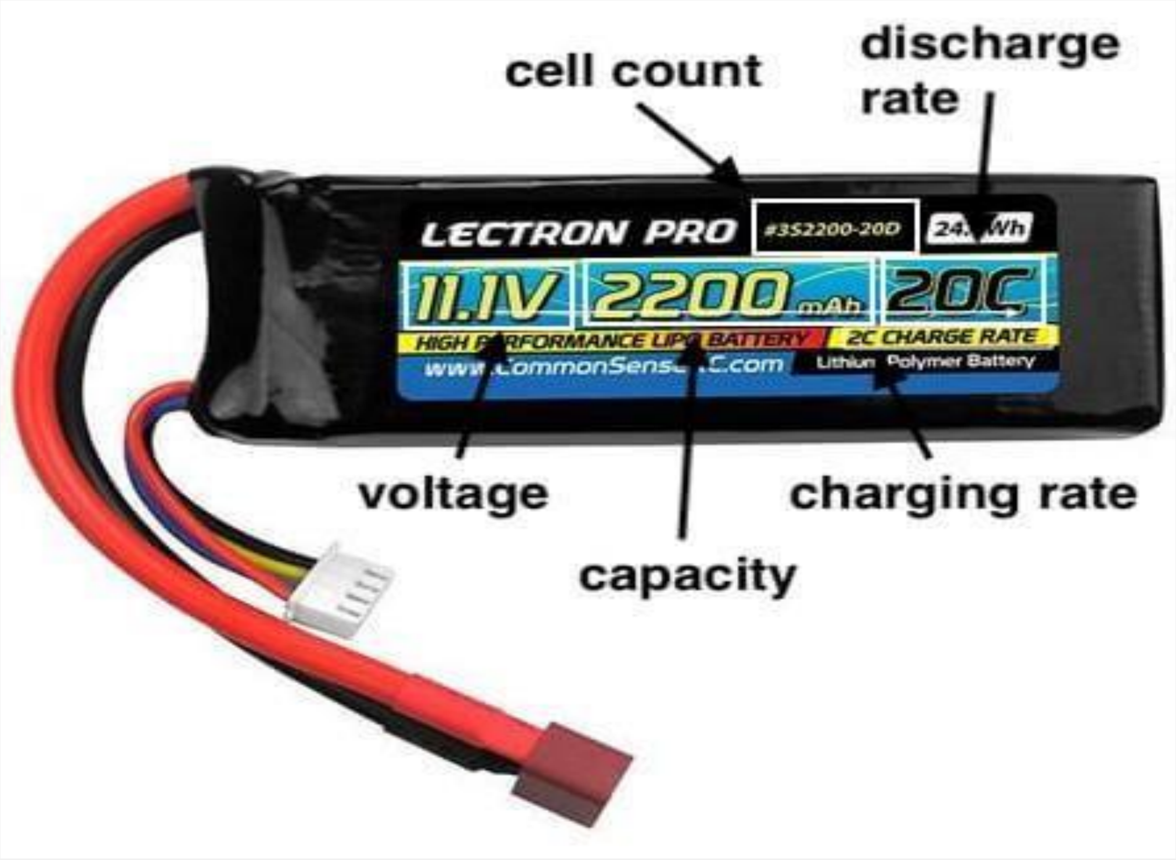


LIPO Battery:

A LiPo battery, short for Lithium Polymer battery, is a type of rechargeable battery commonly used in various electronic devices, including drones, remote-controlled vehicles, smartphones, and portable electronics. LiPo batteries have gained popularity due to their high energy density, lightweight design, and ability to deliver high discharge rates.

Important aspects for LiPo batteries being famous for RC vehicles, drones, etc. is that it is high energy density means we can store more energy in smaller and lighter package, similarly batteries are lightweight and compact. They provide high discharge rates and have higher normal voltage than other rechargeable batteries.

Reading the LiPo Battery:



Connecting Wires:

1. Balance Connector:
   (The White Cable head in above diagram)
   The balance connector is a multi-pin connector typically found on LiPo batteries. It is used to balance the charge levels of individual cells within the battery pack. The balance connector connects to a balance charger, which ensures that each cell is charged or discharged to the same voltage, improving the overall performance and longevity of the battery pack.

2. Power Connector:
   (The Red Cable head in above diagram)
   The power connector, also known as the main connector or discharge connector, is used to connect the LiPo battery to the device or equipment that requires power. There are various types of power connectors used with LiPo batteries, including popular ones like XT60, XT90, EC3, and Deans connectors. The choice of power connector depends on the specific requirements and compatibility with the device or system being powered by the battery.

Precautions:

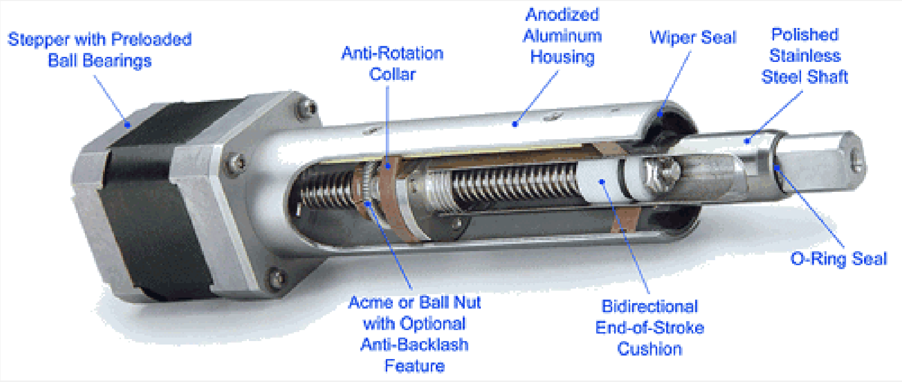
1. Avoid overcharging and excess discharging, maintain threshold up and below.
2. Store batteries in fireproof container and avoid high temp & exposure to sunlight.
3. Don’t puncture or damage battery that can lead to chemical leakage.
4. Ensure proper balance in charging and discharging for a multi-cell LiPo battery.

ACTUATORS:

Actuators are devices or components that convert input signals or energy into physical motion or force. They are used to control or manipulate mechanical systems or processes. Actuators play a crucial role in various industries, including robotics, automotive, aerospace, manufacturing, and many others.

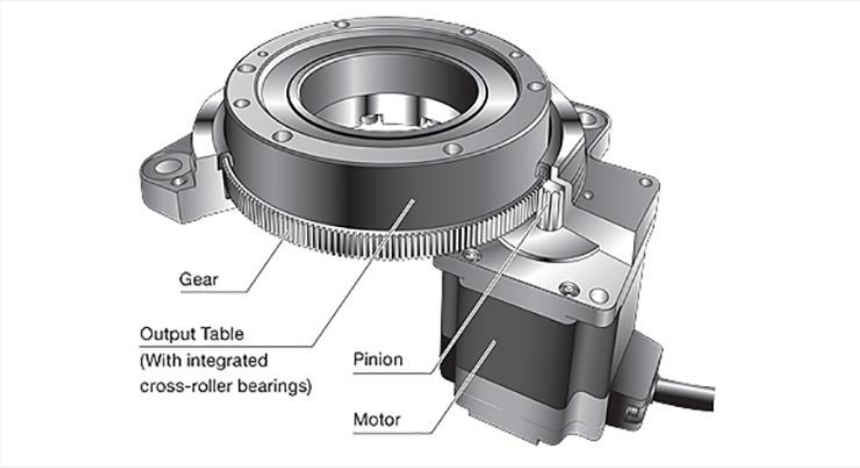
Types of actuators:

1. Linear Actuator:



It's is an actuator that generates linear or straight-line motion. It converts rotational motion into linear motion, typically through a threaded rod or screw mechanism.

2. Rotary Actuator:



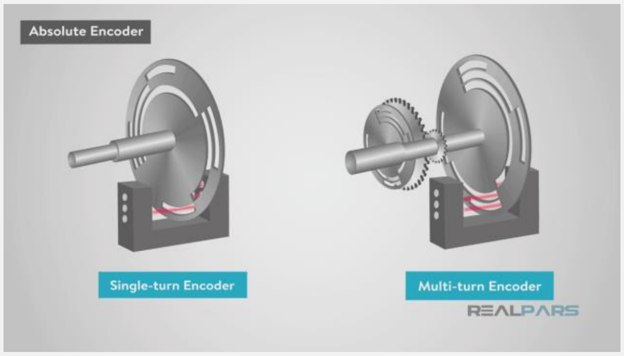
It's an actuator that generates rotation motion. It converts input signals or energy into rotary movement, allowing for control or manipulation of mechanism.

ROTARY ENCODERS:

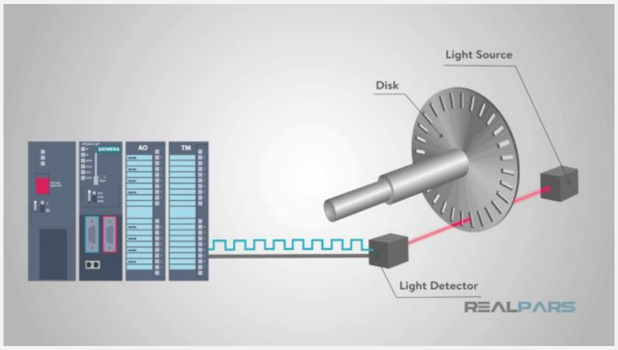
It is a device used to measure the rotational position, speed, and direction of a motor shaft. Rotary encoders typically consist of a disc or wheel attached to the motor shaft, with patterns or slots etched on it. Sensors (such as optical or magnetic) are used to detect these patterns as the disc rotates, generating electrical signals that are then processed to determine the motor's position and motion parameters.

1. Absolute Encoder:

An absolute encoder provides the exact position of the motor shaft at any given time. It assigns a unique digital code to each position, allowing the motor control system to know the absolute position without requiring any additional tracking. Absolute encoders can be either single-turn or multi-turn. Single-turn encoders provide position information within one full revolution of the motor shaft, while multi-turn encoders can track multiple revolutions.



Absolute Encoder



Incremental Encoder

2. Incremental Encoder:

An incremental encoder produces pulses as the motor shaft rotates. It generates two signals, commonly referred to as A and B channels, which have phase differences that help determine both position and direction. By counting the pulses, the motor control system can track the position and speed of the motor shaft. However, an incremental encoder does not provide absolute position information.

Printed Circuit Boards (PCBs):

PCB stands for Printed Circuit Board. It is a flat board made of non-conductive material (typically fiberglass or composite epoxy) on which electronic components are mounted and interconnected. PCBs are used to provide mechanical support and electrical connections for electronic circuits.

Manufacturing:

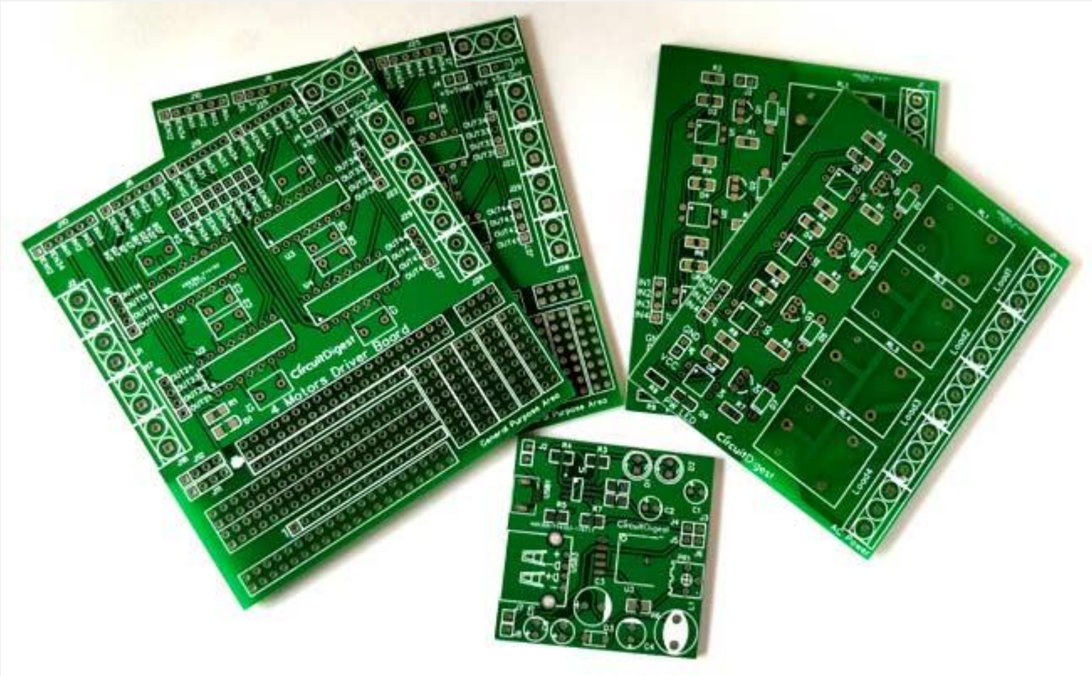
1) Slices of fiberglass are stacked together and treated with resin that makes them stick to each other eventually forming one solid slab.
2) Layers of copper are applied on both sides and coated in a chemical called photoresist.
3) After this a required patter of connections that is supposed to be present on the board is placed on top and the whole system is exposed to UV light.
4) The board is then washed which washes the uncovered areas leaving desired tracks of copper.
5) These tracks serve as base to how the PCB will actually look after a few more steps (including more additional copper and more washing).
6) The above same process is done in layers to form multiple parallel but not overlapping designed circuits of copper.

Devices that can be mounted on PCB

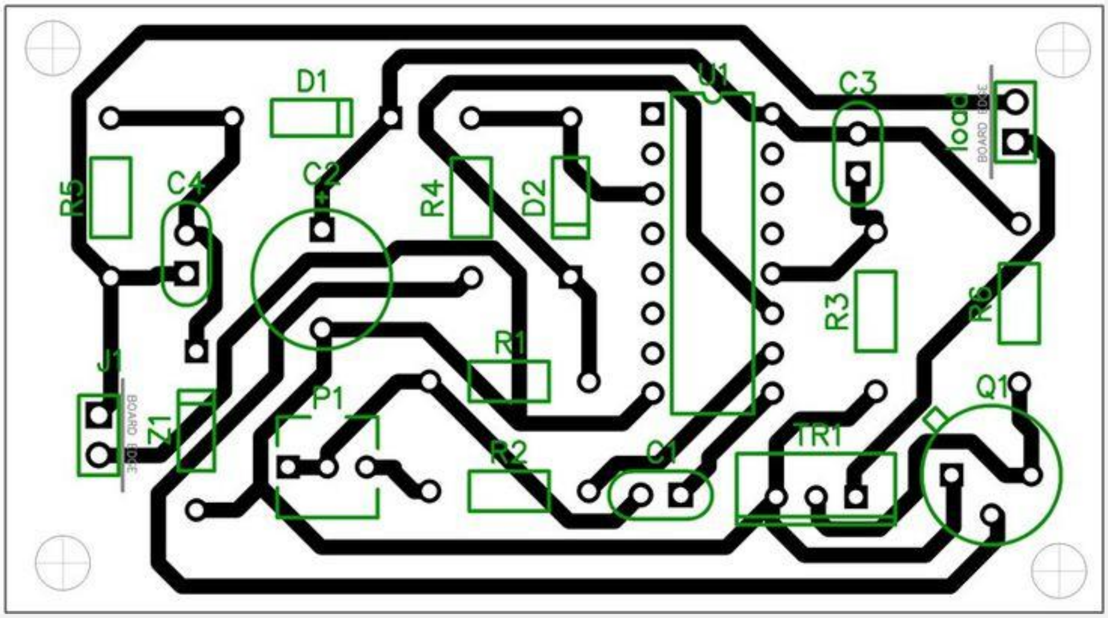
ICs	Resistors	Capaciotrs	Inductors	Diodes	Relays	Transistors	Connectors	Sensors	LEDs

There are still a lot many devices that can be mounted on a PCB and after all these are mounted according to a design, a Motherboard is formed.

Actual PCB:



Simple PCB Circuit Diagram



Radio Frequency (RF):

It is any of the electromagnetic wave frequencies that lie in the range staring from 3kHz to 300GHz. Using antennas, transmitters and receivers, a RF field can be created which than then be used for various types of wireless broadcasting and communications.

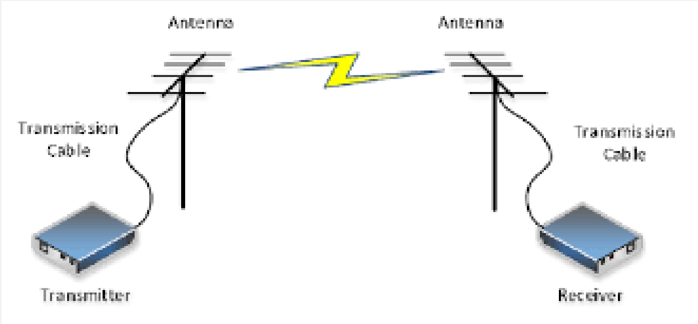
The following table depicts 8 bands in RF spectrum, showing frequency and bandwidth ranges.

RF Bands:

Designation	Abbreviation	Frequencies	Free-space wavelengths
Very Low Frequency	VLF	9 kHz to 30 kHz	33 km to 10 km
Low Frequency	LF	30 kHz to 300 kHz	10 km to 1 km
Medium Frequency	MF	300 kHz to 3 MHz	1 km to 100 m
High Frequency	HF	3 MHz to 30 MHz	100 m to 10 m
Very High Frequency	VHF	30 MHz to 300 MHz	10 m to 1 m
Ultra High Frequency	UHF	300 MHz to 3 GHz	1 m to 100 mm
Super High Frequency	SHF	3 GHz to 30 GHz	100 mm to 10 mm
Extremely High Frequency	EHF	30 GHz to 300 GHz	10 mm to 1 mm

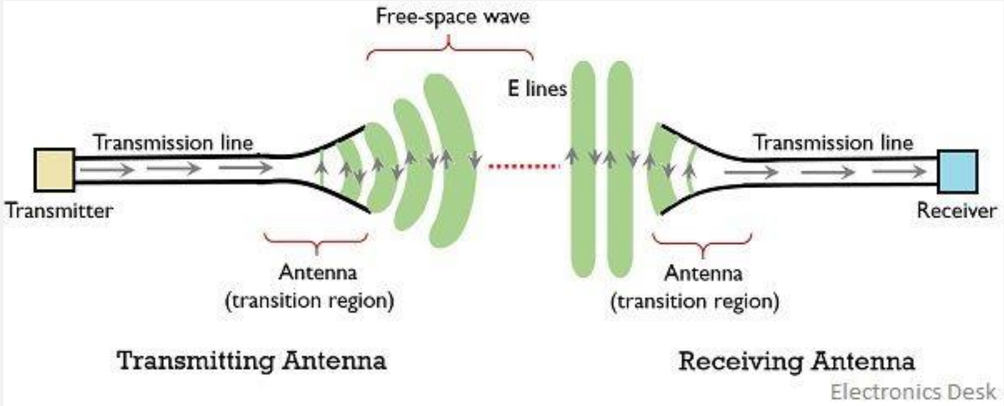
Antennas:

Antennas receive and electromagnetic waves and convert it into electrical signal or receive electrical signal and convert it into electromagnetic wave.



When an antenna is used for transmitting, the electrical current flowing through it generates electromagnetic waves that propagate outward. The shape and design of the antenna determine the direction and pattern of the transmitted waves.

When an antenna is used for receiving, it captures incoming electromagnetic waves from the environment. The waves induce an electrical current in the antenna, which can be amplified and processed by a receiver circuit. The antenna's design and size are optimized to efficiently convert the received electromagnetic energy into electrical signals.



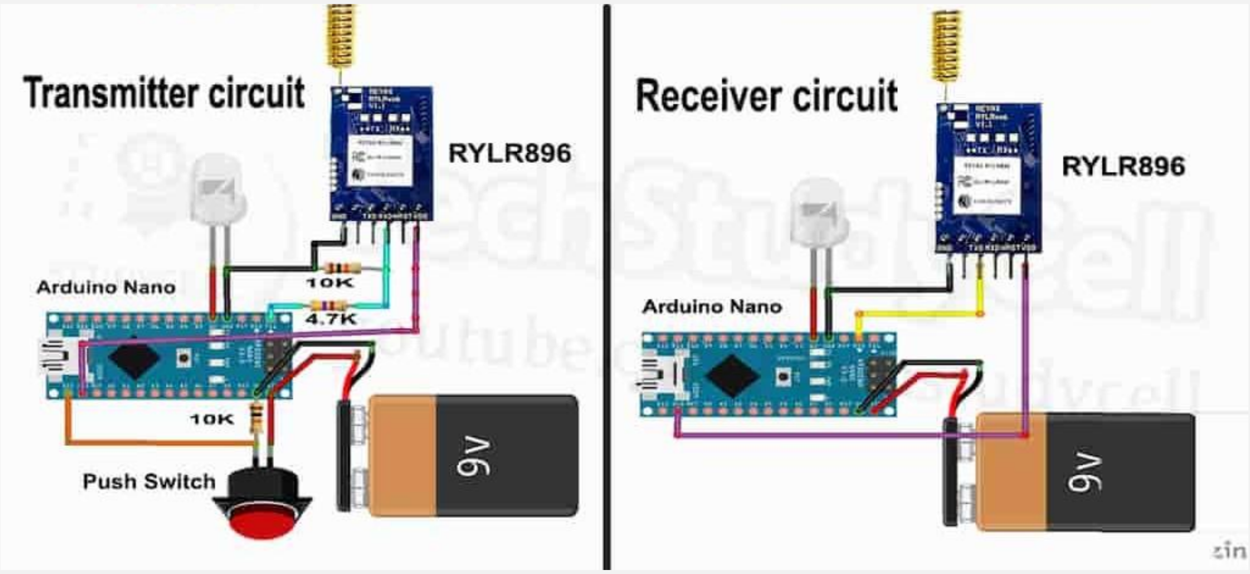
LoRa Module:

A LoRa (Long Range) module is a wireless communication device that utilizes the LoRa modulation technique to enable long-range, low-power communication between devices.

LoRa technology is designed for applications that require long-range communication with low data rates, reliable data transmission and low power consumption. It also offers a cost-effective solution for wireless communication.

LoRa module

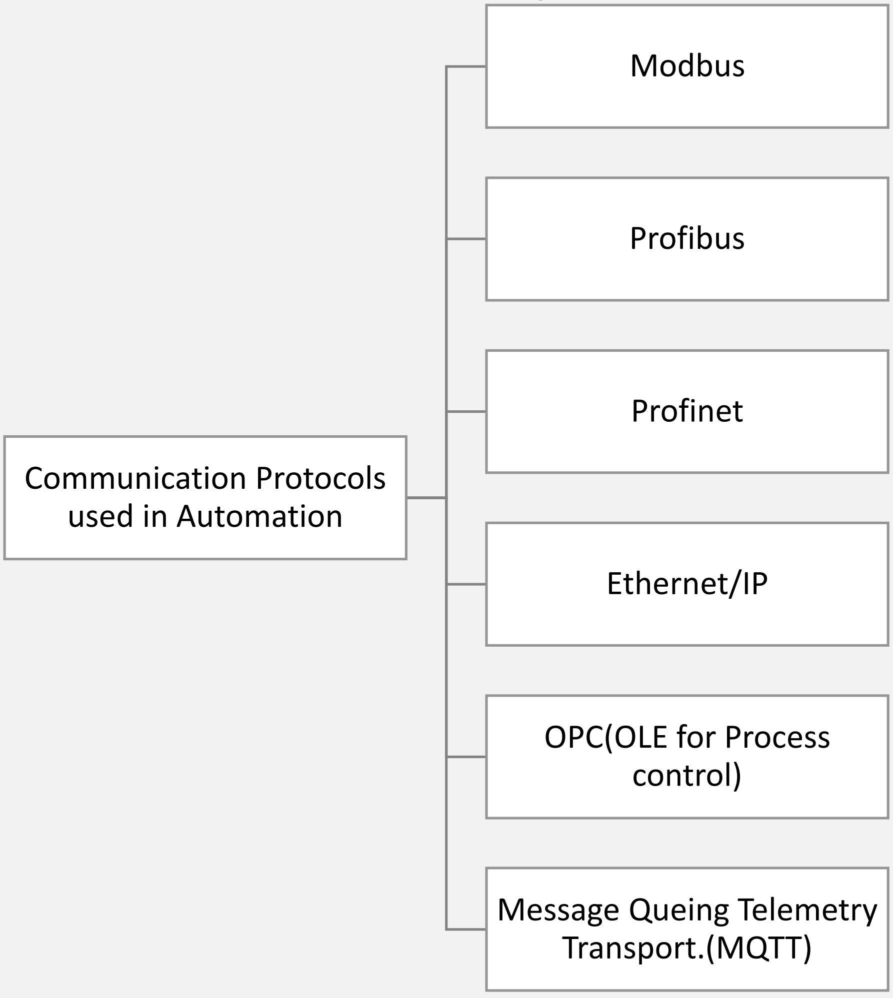
Transmitter & receiver LoRa circuit with Arduino:



Basics of Communication Protocols in Automation:

In automation, there are several basic communication protocols used to facilitate communication between different devices and systems. These protocols allow devices to exchange data, commands, and status information, enabling automation and control processes.

Protocol specifies the requirements or format that different devices on industrial network must confirm to during communication. These devices then use these protocols to form a well-structured message.



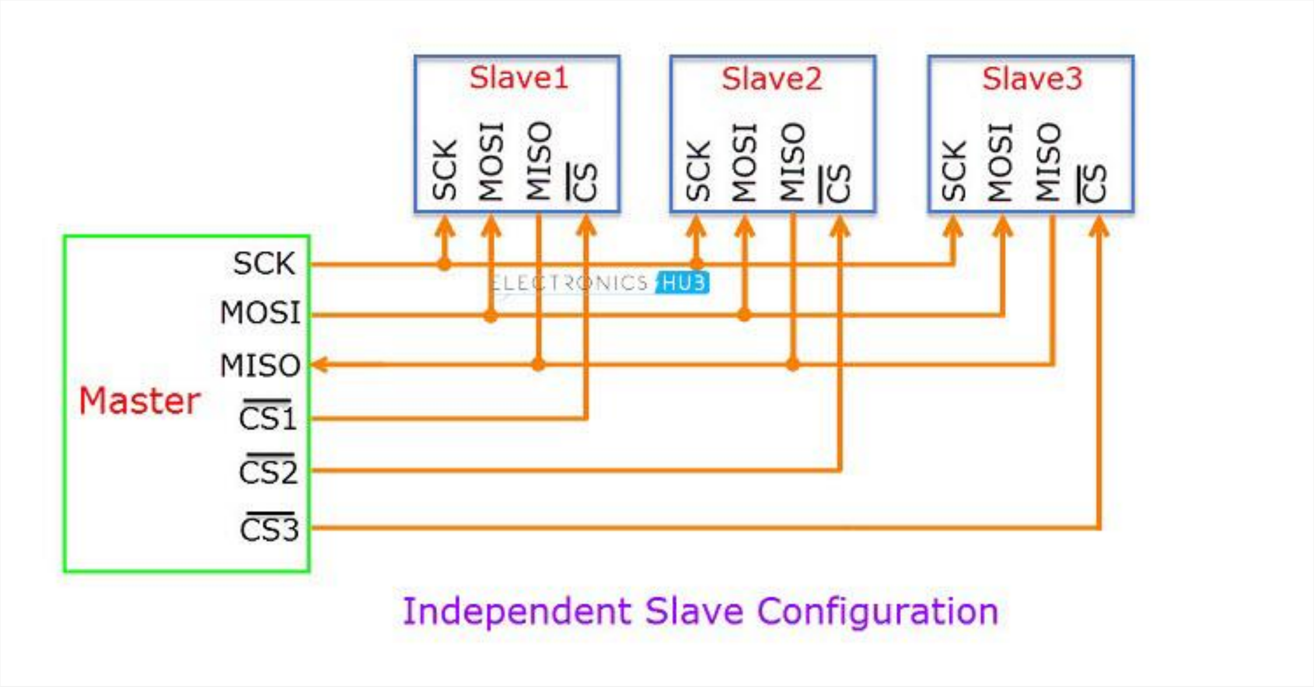
Serial Peripheral Interface (SPI) Communication:

SPI communication is a synchronous type of communication protocol that is all the devices that are communicating with each other have the same clock pulse/signal. It works up to 8 Megabits per second speed and even more than that.

It consists of master and slave configuration. This master and slave can talk to each other are transmitting and receiving data at the same time. This master can be connected to multiple slaves, and is connected to them with 4 connection lines:

MoSi (Master In Slave Out), MiSo (Master Out Slave In), Clock signal and the Chip select line.

Master-Slave Connections



Modes of SPI

SPI Mode	CPOL	CPHA	Clock Polarity in Idle State	Clock Phase Used to Sample and/or Shift the Data
0	0	0	Logic low	Data sampled on rising edge and shifted out on the falling edge
1	0	1	Logic low	Data sampled on the falling edge and shifted out on the rising edge
2	1	1	Logic high	Data sampled on the falling edge and shifted out on the rising edge
3	1	0	Logic high	Data sampled on the rising edge and shifted out on the falling edge

These modes are defined by the polarity and phase of the clock signal

1. Mode 0 (CPOL = 0, CPHA = 0):

- Clock Polarity (CPOL): 0 (clock idle state is low)
- Clock Phase (CPHA): 0 (data is sampled on the leading edge of the clock)
- Data is sampled on the leading edge (rising edge) of the clock, and data is propagated on the trailing edge (falling edge) of the clock.
- The clock line is initially low (idle state), and data is transmitted on the transition from low to high.
- This mode is commonly used in many SPI devices as the default mode.

2. Mode 1 (CPOL = 0, CPHA = 1):

- Clock Polarity (CPOL): 0 (clock idle state is low)
- Clock Phase (CPHA): 1 (data is sampled on the trailing edge of the clock)
- Data is sampled on the trailing edge (falling edge) of the clock, and data is propagated on the leading edge (rising edge) of the clock.
- The clock line is initially low (idle state), and data is transmitted on the transition from low to high.
- This mode is also commonly used in SPI devices.

3. Mode 2 (CPOL = 1, CPHA = 0):

- Clock Polarity (CPOL): 1 (clock idle state is high)
- Clock Phase (CPHA): 0 (data is sampled on the leading edge of the clock)
- Data is sampled on the leading edge (falling edge) of the clock, and data is propagated on the trailing edge (rising edge) of the clock.
- The clock line is initially high (idle state), and data is transmitted on the transition from high to low.
- This mode is less commonly used but can be found in some SPI devices.

4. Mode 3 (CPOL = 1, CPHA = 1):

- Clock Polarity (CPOL): 1 (clock idle state is high)
- Clock Phase (CPHA): 1 (data is sampled on the trailing edge of the clock)
- Data is sampled on the trailing edge (rising edge) of the clock, and data is propagated on the leading edge (falling edge) of the clock.
- The clock line is initially high (idle state), and data is transmitted on the transition from high to low.
- This mode is less commonly used but can be found in some SPI devices.