Department of Electronics & Communication Engg.

Course : ARM Microcontroller & ES-15EC62. . **Sem.: 6th (2017-18)**

Course Coordinator:

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Sensors and Actuators

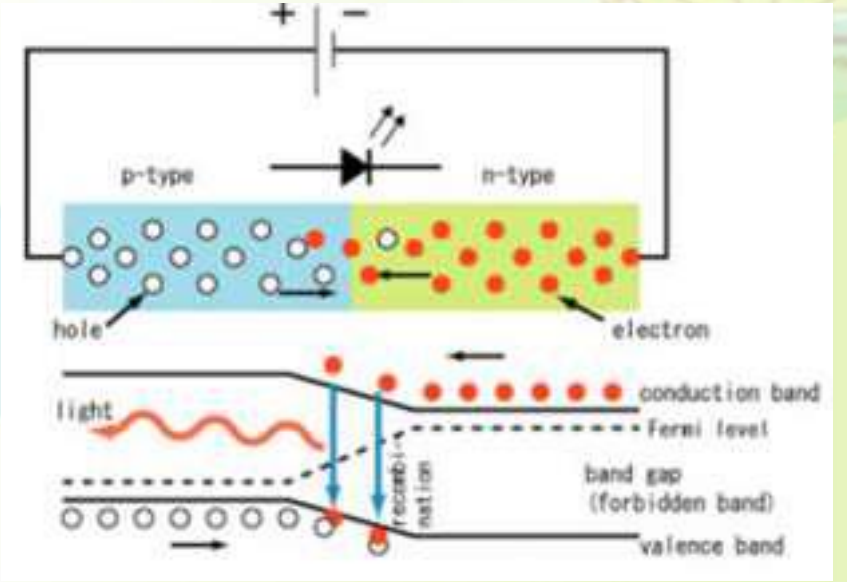
- A **sensor is a transducer device that converts energy from one form to another** for any measurement or control purpose.
- The changes in system environment or variables are detected by the sensors connected to the input port of the embedded system.
- **Actuator is a form of transducer device (mechanical or electrical) which** converts signals to corresponding physical action (motion). Actuator acts as an output device.
- If the embedded system is designed for any controlling purpose, the system will produce some changes in the controlling variable to bring the controlled variable to the desired value.
- It is achieved through an actuator connected to the output port of the embedded system.
- If the embedded system is designed for monitoring purpose only, then there is no need for including an actuator in the system.
- For example, take the case of an ECG machine. It is designed to monitor the heart beat status of a patient and it cannot impose a control over the patient's heart beat and its order. The sensors used here are the different electrode sets connected to the body of the patient. The variations are captured and presented to the user (may be a doctor) through a visual display or some printed chart.

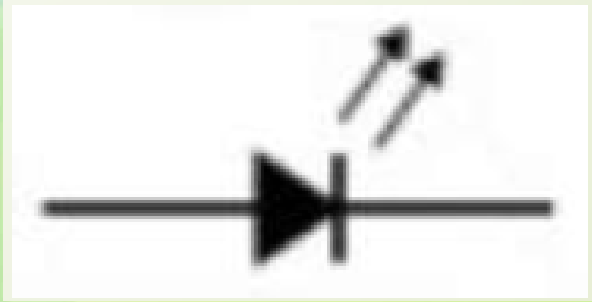
I/O Subsystem

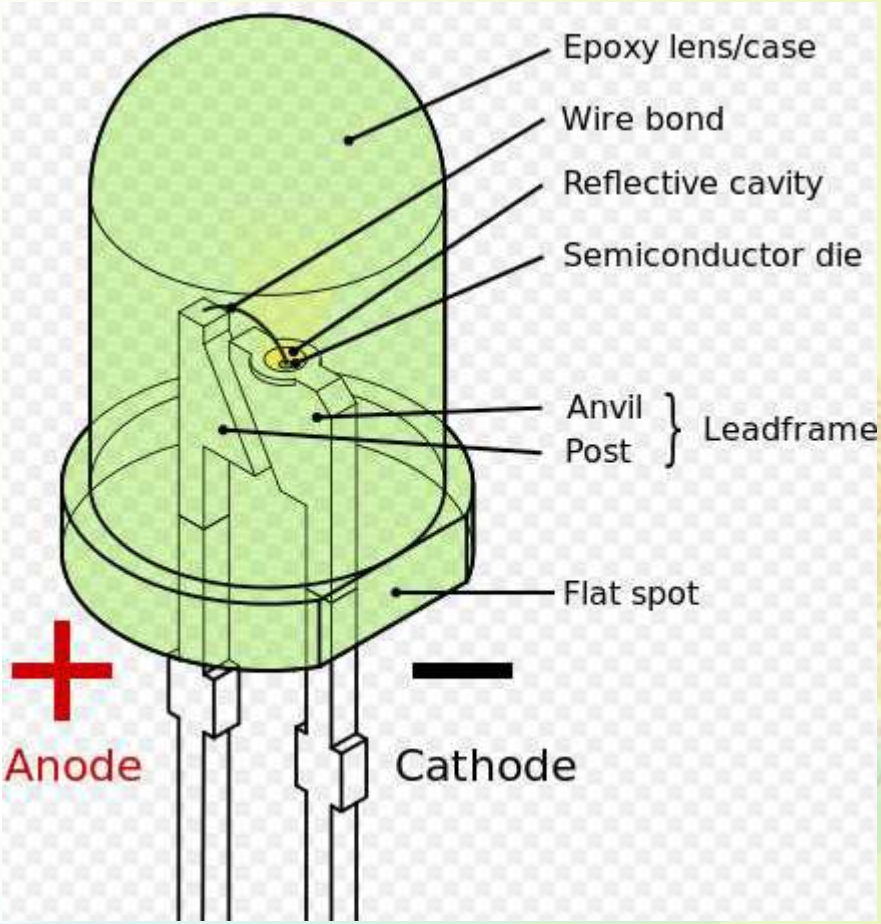
- **The I/O subsystem of the embedded system facilitates the interaction of the** embedded system with the external world.
- The interaction happens through the sensors and actuators connected to the input and output ports respectively of the embedded system.
- The **sensors may not be directly interfaced to the input ports, instead they may be** interfaced through signal conditioning and translating systems like ADC, opto-couplers, etc.
- Light Emitting Diode (LED)
- 7-Segment LED Display
- Optocoupler
- Stepper Motor
- Relay
- Piezo Buzzer
- Push Button Switch
- Keyboard
- Programmable Peripheral Interface (PPI)

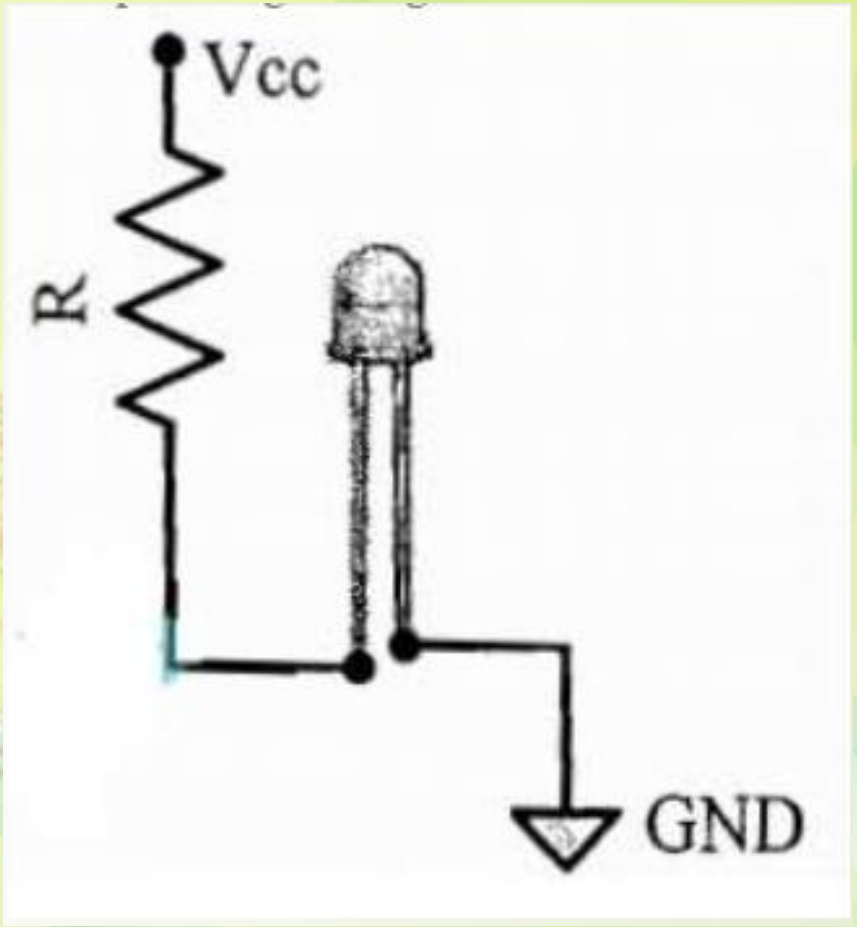
Light Emitting Diode (LED)

- **LED is an important output device for visual indication in any embedded** system. LED can be used as an indicator for the status of various signals or situations. Typical examples are indicating the presence of power conditions like ‘Device ON’, ‘Battery low’ or ‘Charging of battery’ for a battery operated handheld embedded devices.
- LED is a **p-n junction diode and it contains an anode and a cathode. For** proper functioning of the LED, the anode of it should be connected to +ve terminal of the supply voltage and cathode to the –ve terminal of the supply voltage. The current flowing through the LED must be limited to a value below the maximum current that it can conduct. A resistor is used in series between the power supply and the LED to limit the current through the LED.







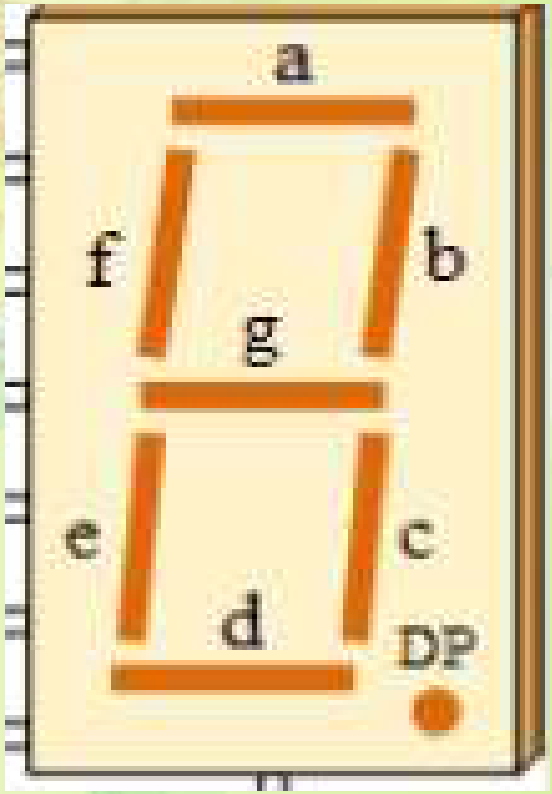


$$R = (V - VLED) \;/\; I$$

Figure. LED Interfacing

7- Segment LED Display

- The **7-segment LED display is an output device for displaying** alphanumeric characters. It contains 8 light-emitting diode (LED) segments arranged in a special form. Out of the 8 LED segments, 7 are used for displaying alphanumeric characters and 1 is used for representing ‘decimal point’ in decimal number display.
- The LED segments are named A to G and the decimal point LED segment is named as DP.



 The 7-segment LED displays are available in two different configurations, namely; Common Anode and Common Cathode. In the common anode configuration, the anodes of the 8 segments are connected commonly whereas in the common cathode configuration, the 8 LED segments share a common cathode line.

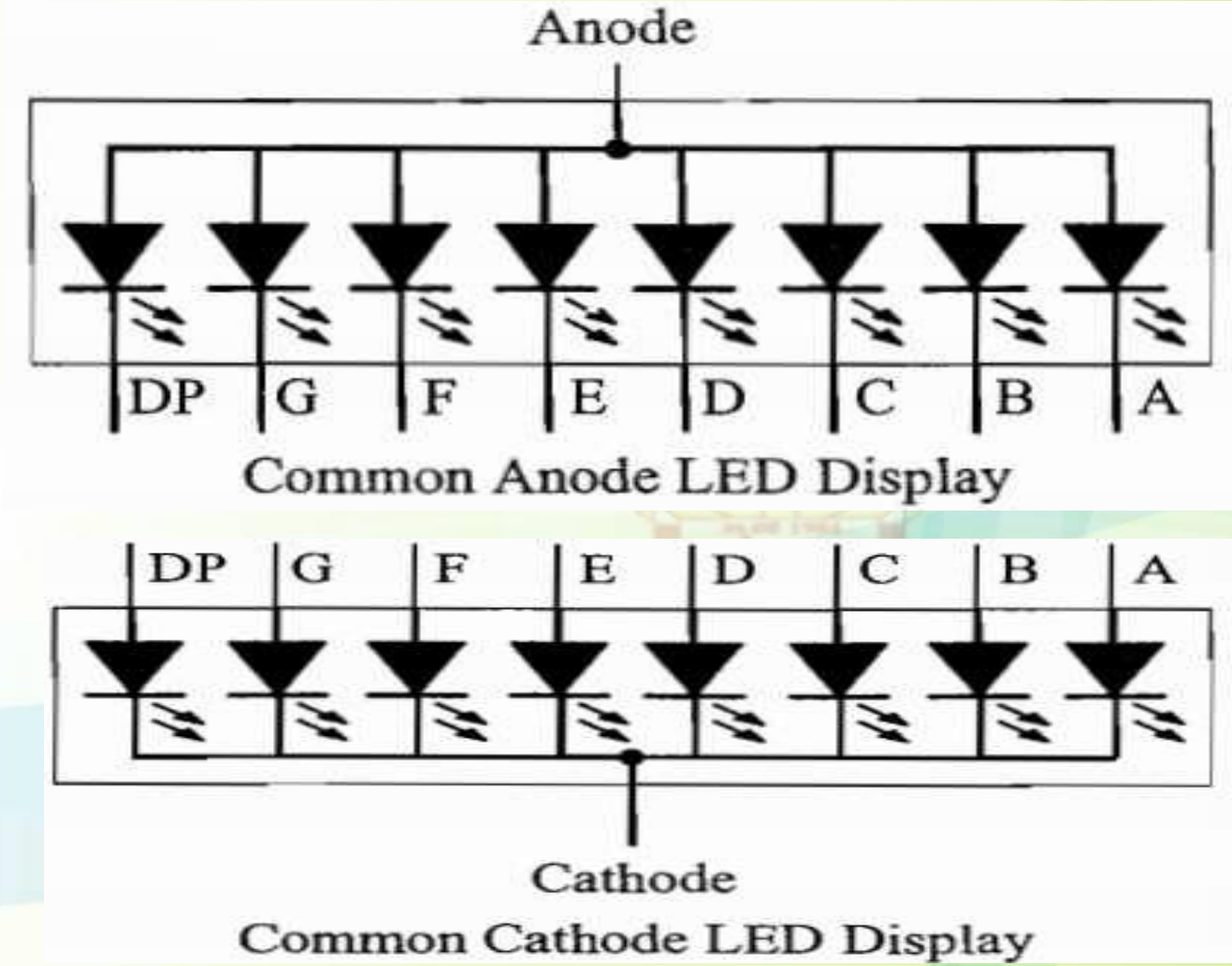
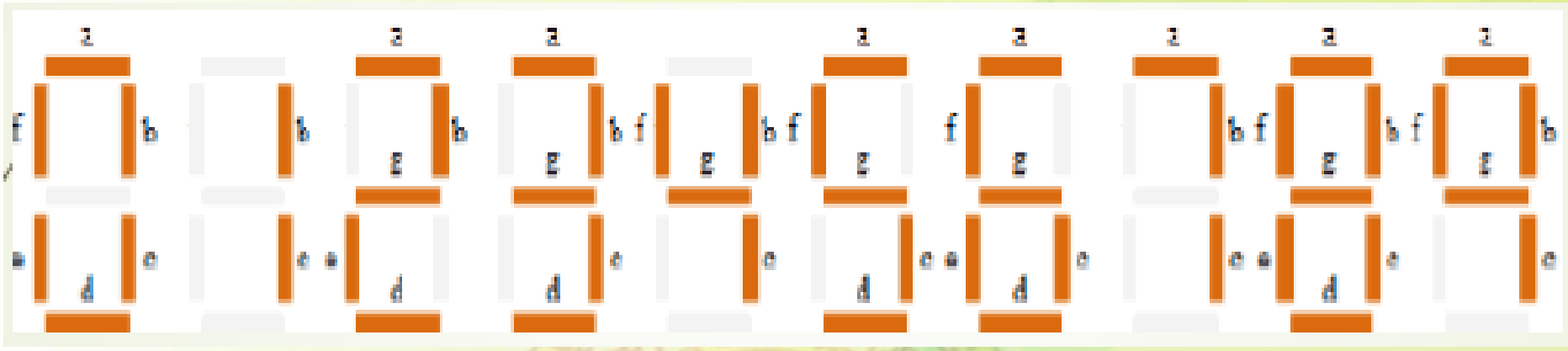
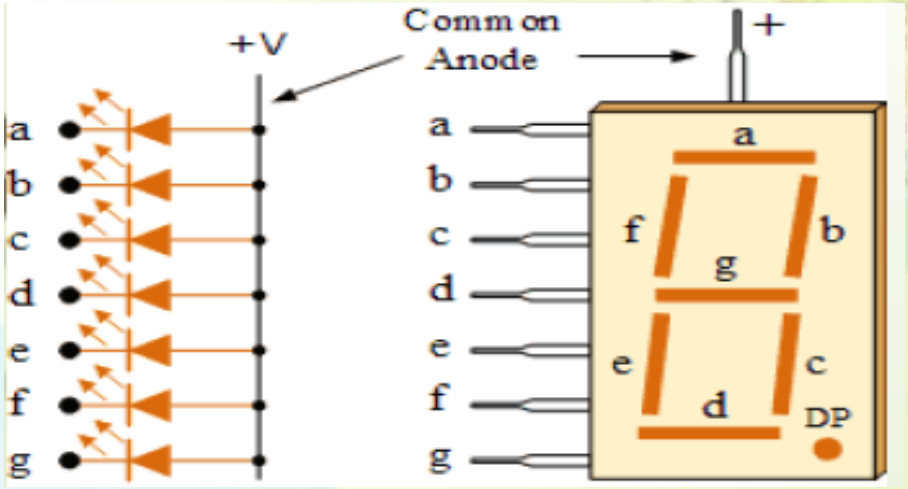
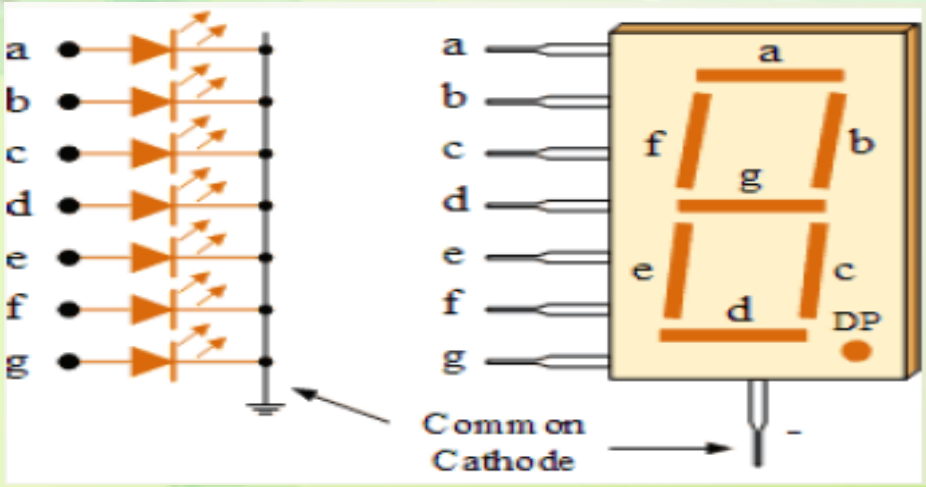


Figure: Common anode and cathode configurations of a 7-segment LED Display

- 7-segment LED display is a popular choice for low cost embedded applications like, Public telephone call monitoring devices, point of sale terminals, etc.







Opto-coupler

- Optocoupler is a solid state device to isolate two parts of a circuit.
- Optocoupler combines an LED and a photo-transistor in a single housing (package). Figure illustrates the functioning of an opto-coupler device.
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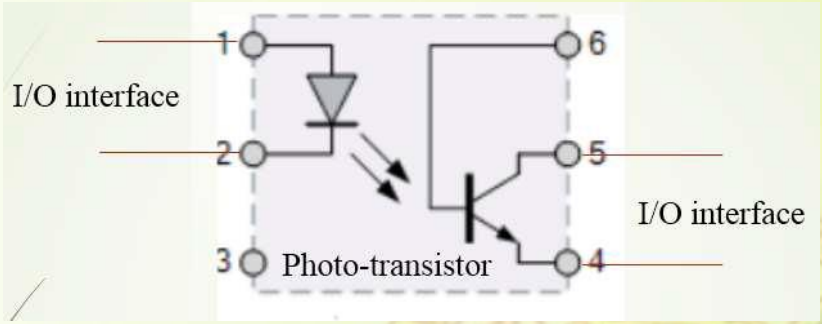


Figure. An optocoupler device

- In electronic circuits, an optocoupler is used for suppressing interference in data communication, circuit isolation, high voltage separation, simultaneous separation and signal intensification, etc.
- Optocouplers can be used in either input circuits or in output circuits.
- Figure illustrates the usage of optocoupler in input circuit and output circuit of an embedded system with a microcontroller as the system core.

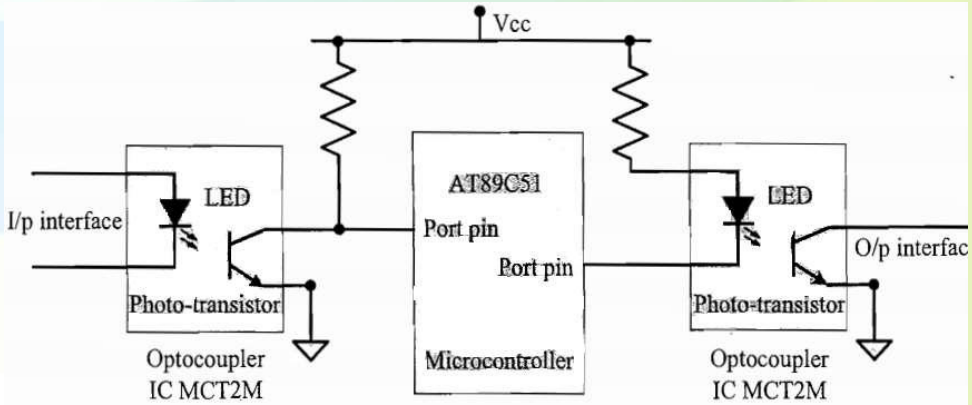
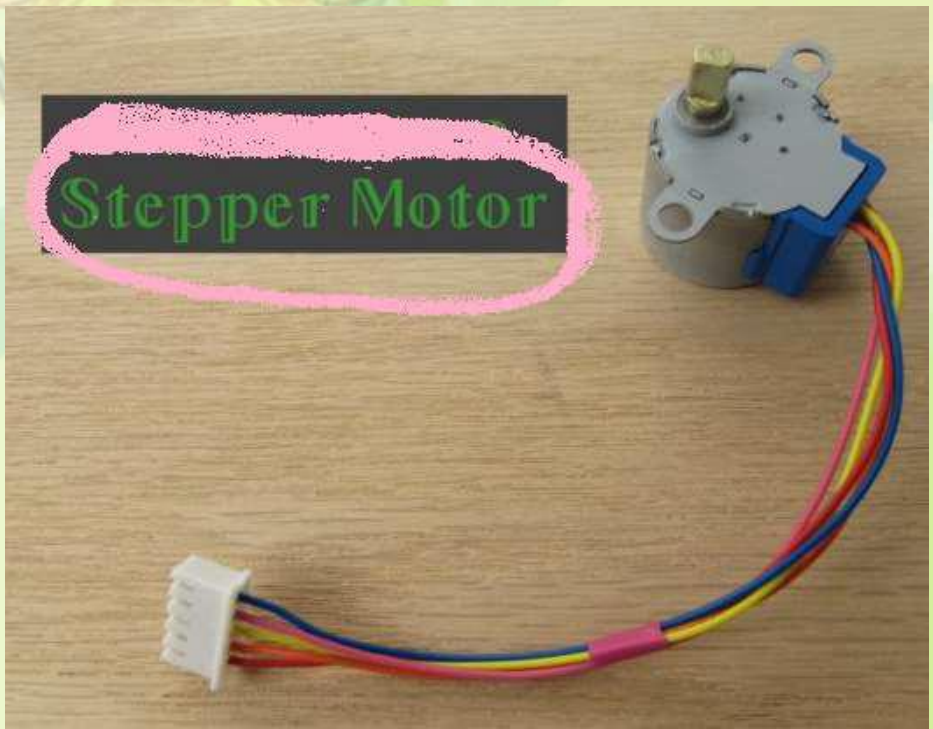


Figure. Optocoupler in Input and Output Circuit

Stepper Motor

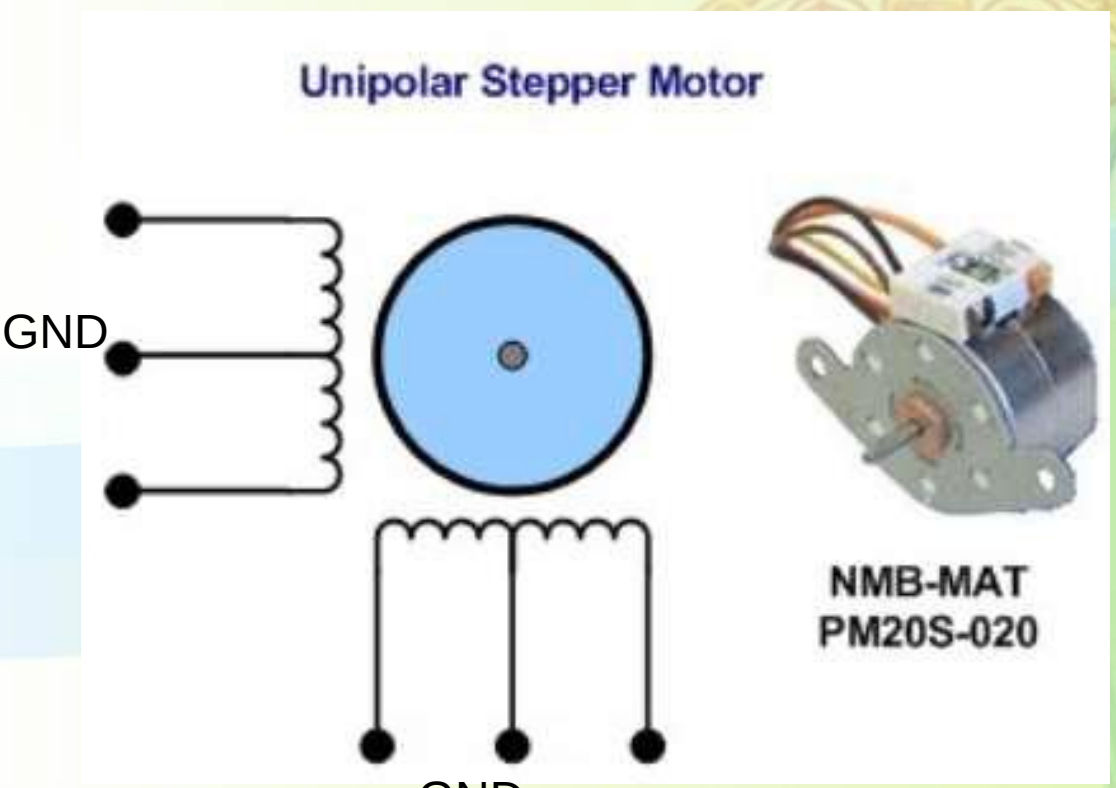
- A stepper motor is an **electro-mechanical device which generates discrete** displacement (motion) in response to dc electrical signals.
- It **differs from the normal dc motor in its operation.**
- The dc motor produces continuous rotation on applying dc voltage whereas a stepper motor produces discrete rotation in response to the dc voltage applied to it.
- Stepper motors are widely used in industrial embedded applications, consumer electronic products and robotics control systems.
- The paper feed mechanism of a printer/fax makes use of stepper motors for its functioning.
- Based on the coil winding arrangements, a two-phase stepper motor is classified into two. They are:

  1.Unipolar 2.Bipolar



Unipolar

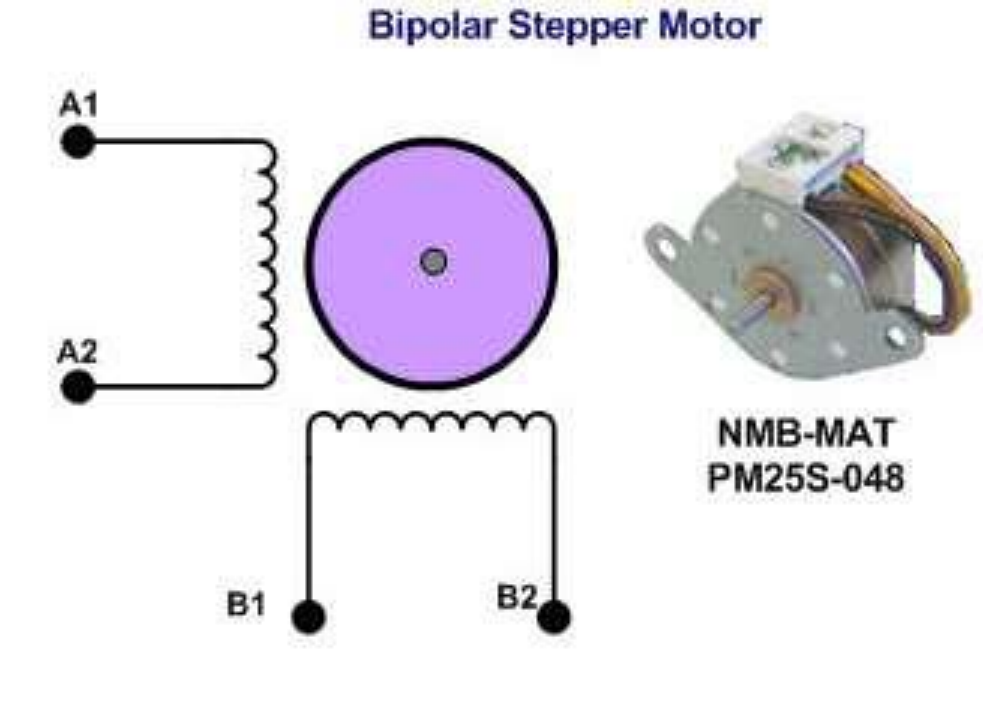
- A unipolar stepper motor contains two windings per phase.
- The direction of rotation (clockwise or anticlockwise) of a stepper motor is controlled by changing the direction of current flow.
- Current in one direction flows through one coil and in the opposite direction flows through the other coil.
- It is easy to shift the direction of rotation by just switching the terminals to which the coils are connected.
- Figure illustrates the working of a two-phase unipolar stepper motor.



2-Phase unipolar stepper motor

Bipolar

- A bipolar stepper motor contains single winding per phase.
- For reversing the motor rotation the current flow through the windings is reversed dynamically.
- It requires complex circuitry for current flow reversal.
- There is one disadvantage of unipolar motors. The torque generated by them is quite less. This is because the current is flowing only through the half the winding. Hence they are used in low torque applications.
- On the other hand, bipolar stepper motors are a **little complex to wire as we have to use a current reversing H bridge driver IC like an L293D. But** the advantage is that the **current will flow through the full coil. The resulting torque** generated by the motor is larger as compared to a uni-polar motor.



- The stepping of stepper motor can be implemented in different ways by changing the sequence of activation of the stator windings. The different stepping modes supported by stepper motor are explained below.
- **Full Step: In the step mode both the phases are energized** simultaneously. The coils A, B, C and D are energized in the following order:

Step	Coil A	Coil B	Coil C	Coil D
1	H	H	L	L
2	L	H	H	L
3	L	L	H	H
4	H	L	L	H

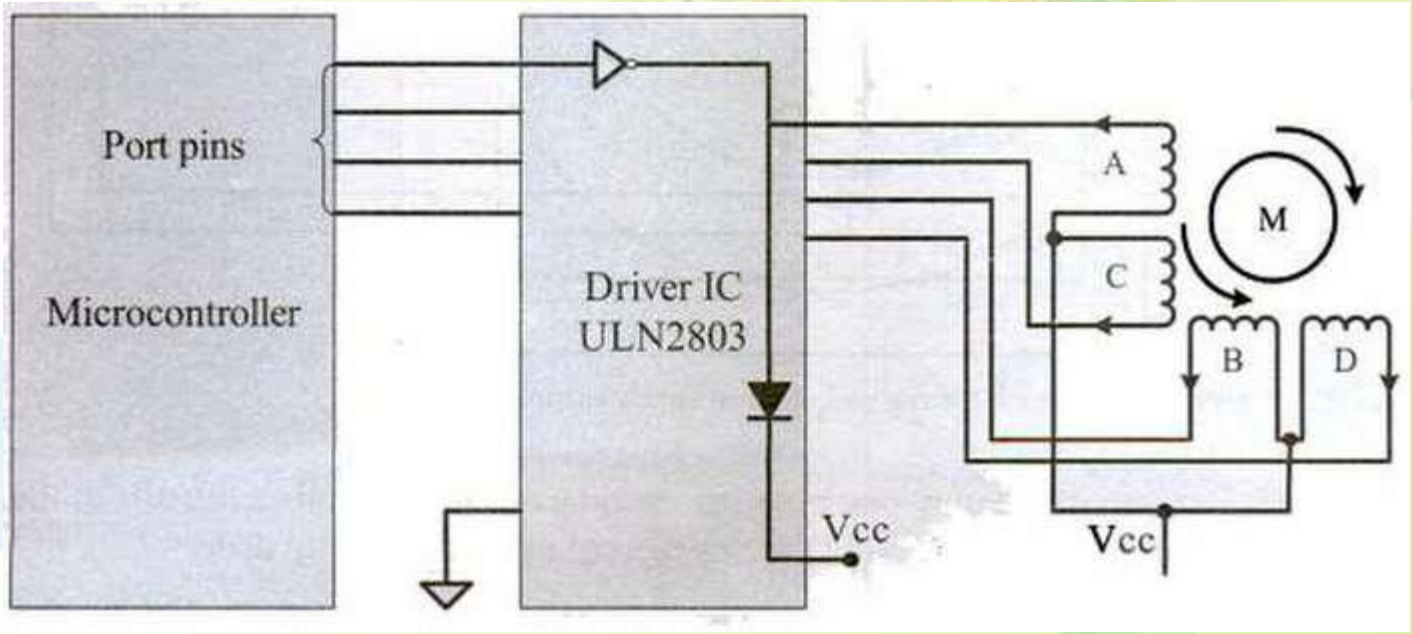
- It should be noted that out of the two windings, only one winding of a phase is energized at a time.
- **Wave Step: In the wave step mode only one phase is energized at** a time and each coils of the phase is energies alternatively. The coils A, B, C and D are energized in the following order:

Step	Coil A	Coil B	Coil C	Coil D
1	H	L	L	L
2	L	H	L	L
3	L	L	H	L
4	L	L	L	H

 Half Step : It uses the combination of wave and full step. It has the highest torque and stability. The coil energizing sequence for half step is given below.

Step	Coil A	Coil B	Coil C	Coil D
1	H	L	L	L
2	H	H	L	L
3	L	H	L	L
4	L	H	H	L
5	L	L	H	L
6	L	L	H	H
7	L	L	L	H
8	H	L	L	H

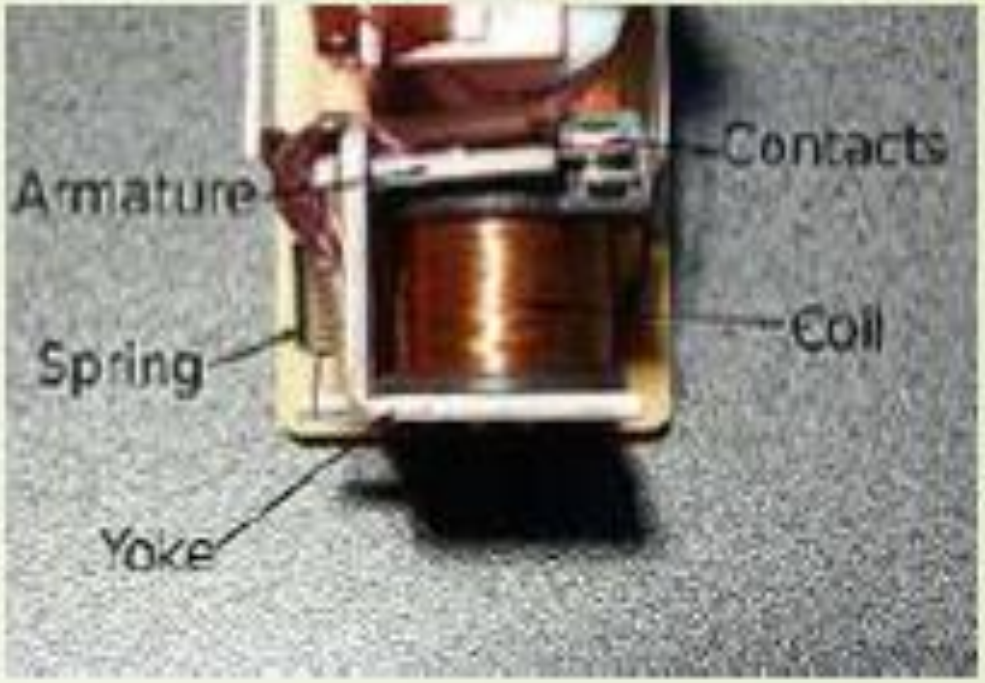
- The rotation of the stepper motor can be reversed by reversing the order in which the coil is energized.
- Two-phase unipolar stepper motors are the popular choice for embedded applications.
- The current requirement for stepper motor is little high and hence them port pins of a microcontroller/processor may not be able to drive them directly.
- Also the supply voltage required to operate stepper motor varies normally in the range 5V to 24 V.
- Depending on the current and voltage requirements, special driving circuits are required to interface the stepper motor with microcontroller/processors.
- The following circuit diagram illustrates the interfacing of a stepper motor through a driver circuit connected to the port pins of a microcontroller/processor.



Interfacing of stepper motor through driver circuit

Relay

- Relay is an **electro-mechanical device. In embedded application, the ‘Relay’ unit** acts as **dynamic path selectors for signals and power.**
- The ‘Relay’ unit contains **a relay coil made up of insulated wire on a metal core and a** metal armature with one or more contacts.
- ‘Relay’ works on electromagnetic principle. When a voltage is applied to the relay coil, current flows through the coil, which in turn generates **a magnetic field.**
- The magnetic field attracts **the armature core and moves the contact point. The** movement of the contact point changes the power/signal flow path.
- ‘Relays’ are available in different configurations. Figure given below illustrates the widely used relay configurations for embedded applications.



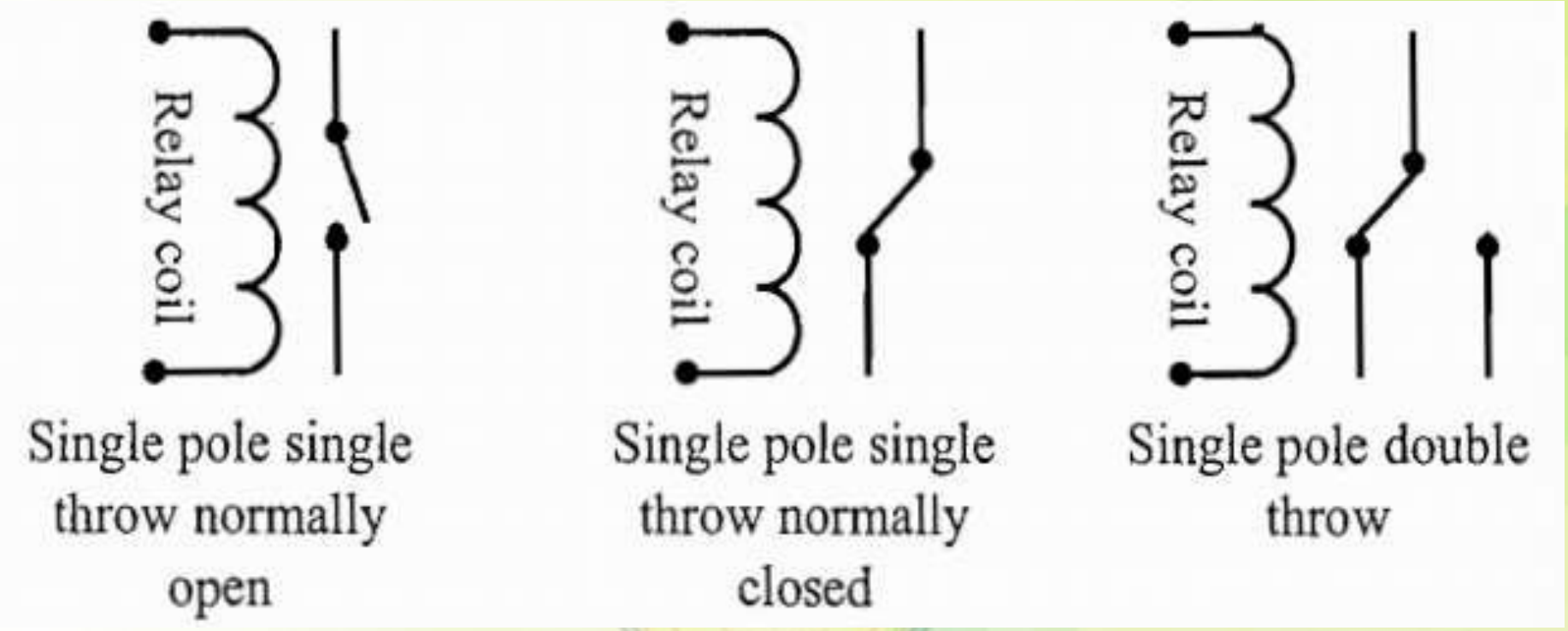


Figure Relay Configurations

- The **Single Pole Single Throw configuration has only one path for information flow.** The path is either open or closed in normal condition. For normally **Open Single** Pole Single Throw relay, the circuit is normally open and it becomes closed when the relay is energized. For normally **closed Single Pole Single Throw configuration, the** circuit is normally closed and it becomes open when the relay is energized. For **Single Pole Double Throw Relay, there are two paths for information flow and they** are selected by energizing or de-energizing the relay.

Queries ...?