Lecture -5

8255 PROGRAMMABLE PERIPHERAL INTERFACE (PPI)

References

- Chapter – 11
  - The Intel Microprocessors
    - Barry B Brey

- Chapter – 10 [Digital Interfacing]
  - Microprocessors and Interfacing
    - Douglas V Hall

Programmable Peripheral Interface-8255

- The 8255A is a general purpose programmable I/O device designed to transfer the data from I/O to interrupt I/O under certain conditions as required. It can be used with almost any microprocessor. Very popular, low cost, interfacing component.
- It consists of three 8-bit bidirectional I/O ports (24I/O lines) which can be configured as per the requirement.

Ports of 8255A

8255A has three ports, i.e., PORT A, PORT B, and PORT C.

- **Port A** contains one 8-bit output latch/buffer and one 8-bit input buffer.
- **Port B** is similar to PORT A.
- **Port C** can be split into two parts, i.e. PORT C lower (PC0-PC3) and PORT C upper (PC7-PC4) by the control word.

These three ports are further divided into two groups, i.e. Group A includes PORT A and upper PORT C. Group B includes PORT B and lower PORT C. These two groups can be programmed in three different modes, i.e. the first mode is named as mode 0, the second mode is named as Mode 1 and the third mode is named as Mode 2.

Operating Modes

8255A has three different operating modes −

Mode 0 − In this mode, Port A and B is used as two 8-bit ports and Port C as two 4-bit ports. Each port can be programmed in either input mode or output mode where outputs are latched and inputs are not latched. Ports do not have interrupt capability.

Mode 1 − In this mode, Port A and B is used as 8-bit I/O ports. They can be configured as either input or output ports. Each port uses three lines from port C as handshake signals. Inputs and outputs are latched.

Operating Modes

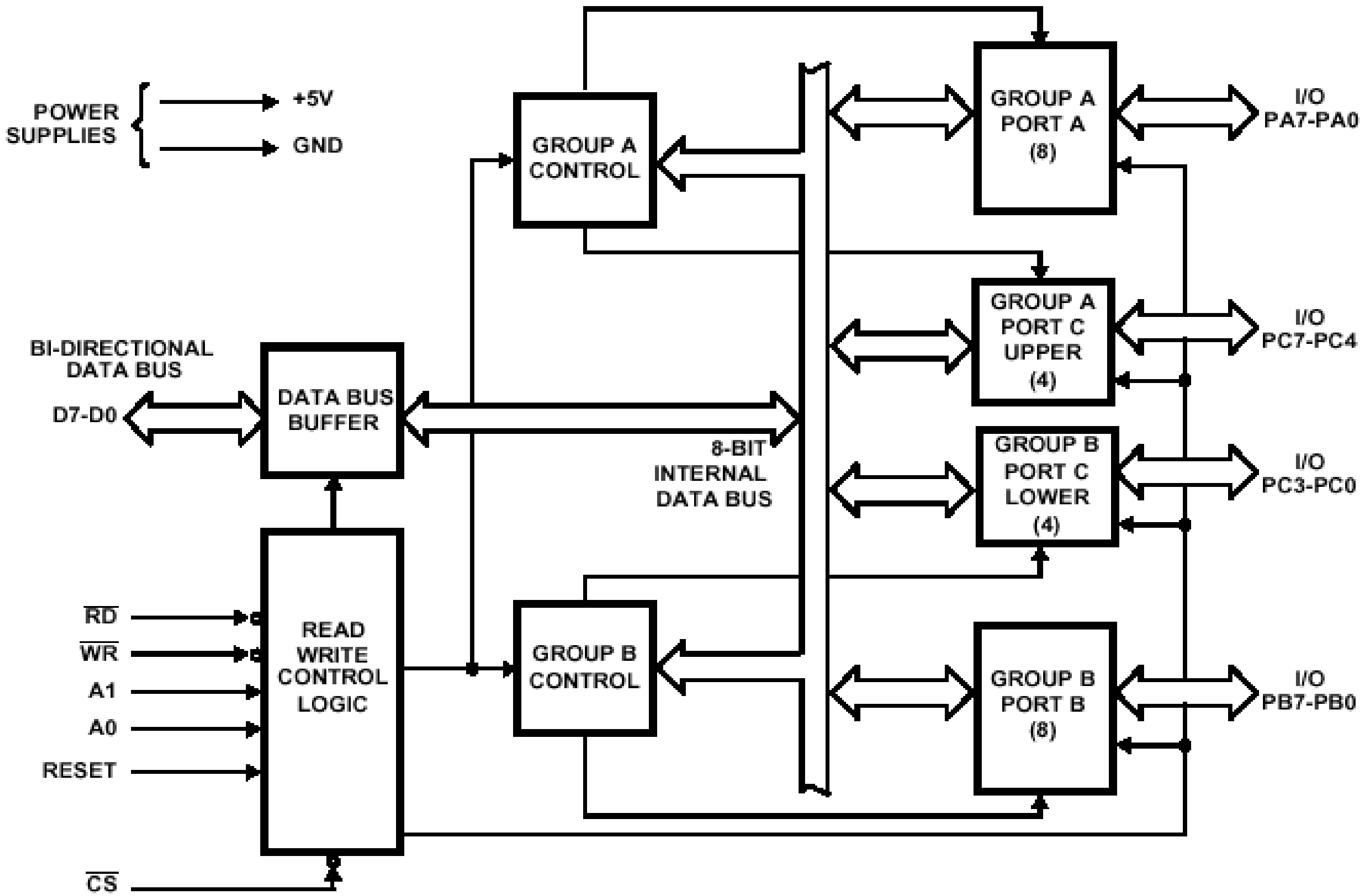
Mode 2 – In this mode, Port A can be configured as the bidirectional port and Port B either in Mode 0 or Mode 1. Port A uses five signals from Port C as handshake signals for data transfer. The remaining three signals from Port C can be used either as simple I/O or as handshake for port B.

Features of 8255A

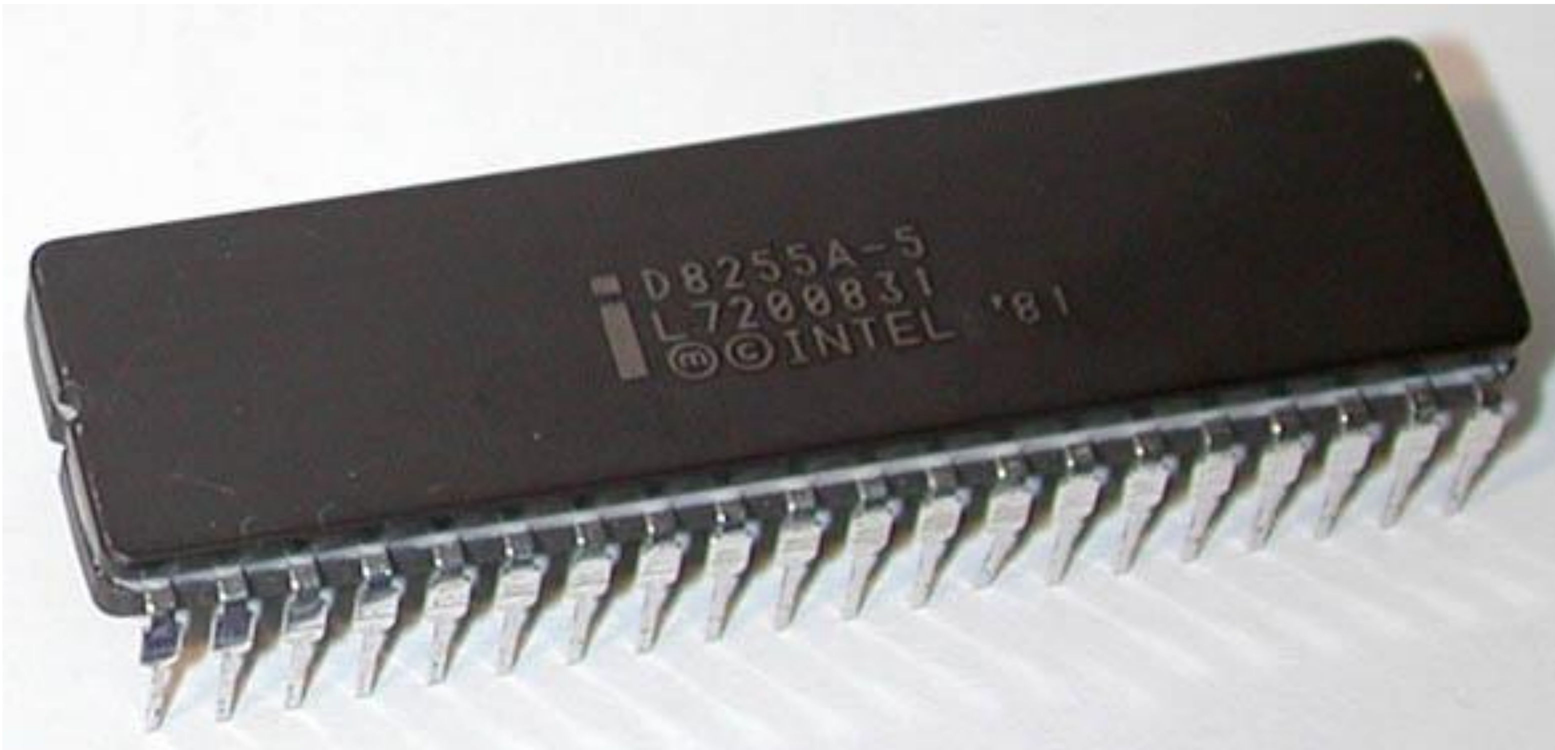
The prominent features of 8255A are as follows −

- It consists of 3 8-bit IO ports i.e. PA, PB, and PC.
- Address/data bus must be externally demux'd.
- It is TTL compatible.
- It has improved DC driving capability.

8255 Architecture



8255 IC

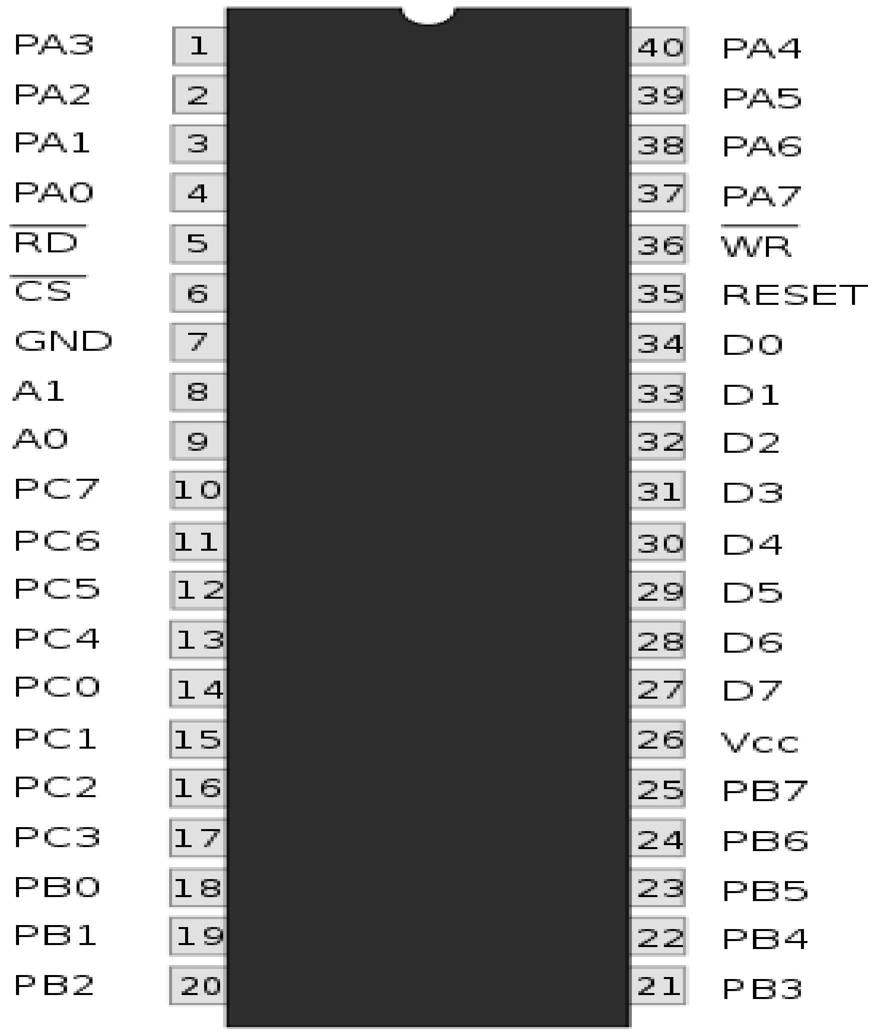


8255 IC

8255 IC

8255 IC

Pin Diagram of 8255



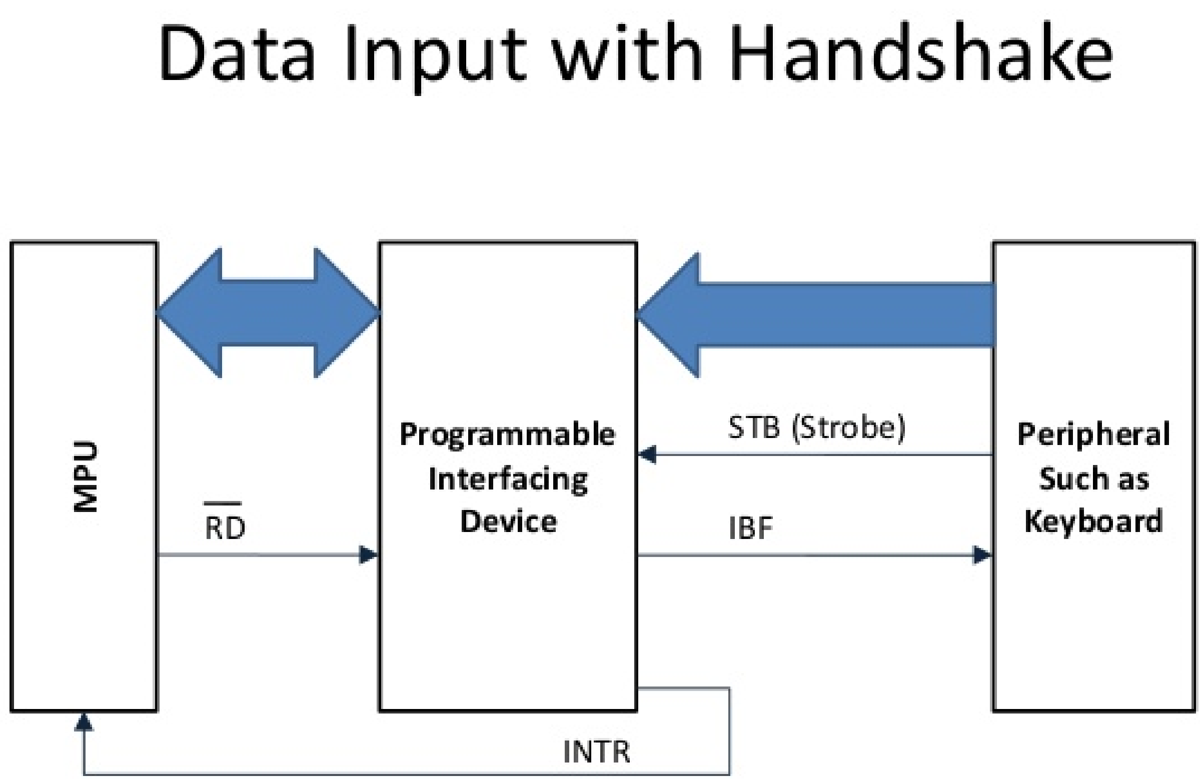
Basic Description of 8255

- 24 pins are divided into 3 ports:
  - Port A (PA0-PA7)
  - Port B (PB0-PB7)
  - Port C (PC0-PC7)
- 8 Data pins (D0-D7)
- Reset - Input
- CS - Input
- RD - Input
- WR - Output
- A0 - Input
- A1 - Input

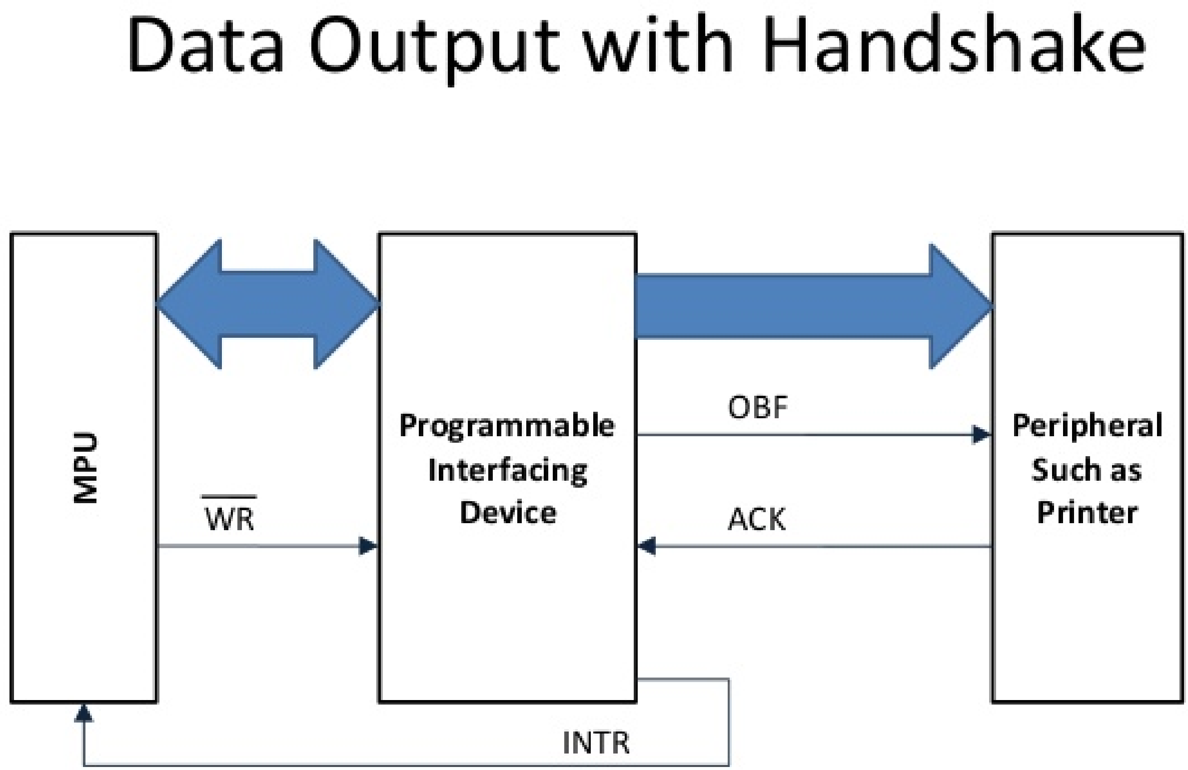
Basic Description of 8255

A_1	A_0	*Function*
0	0	Port A
0	1	Port B
1	0	Port C
1	1	Command Register

8255 Data Input Handshake



8255 Data Output Handshake



Interfacing a Microprocessor to Keyboard

When you press a key on your computer, you are activating a switch. There are many different ways of making these switches. An overview of the construction and operation of some of the most common types. They are:

- Mechanical key switches
- Membrane key switches

Mechanical key switches

In mechanical-switch keys, two pieces of metal are pushed together when you press the key. The actual switch elements are often made of a phosphor-bronze alloy with gold platting on the contact areas. The key switch usually contains a spring to return the key to the non-pressed position and perhaps a small piece of foam to help damp out bouncing.

Some mechanical key switches now consist of a molded silicon dome with a small piece of conductive rubber foam short two trace on the printed-circuit board to produce the key pressed signal.

Mechanical key switches

Mechanical switches are relatively inexpensive but they have several disadvantages.

- First, they suffer from contact bounce. A pressed key may make and break contact several times before it makes solid contact.
- Second, the contacts may become oxidized or dirty with age so they no longer make a dependable connection.
- Higher- quality mechanical switches typically have a rated life time of about 1 million keystrokes. The silicone dome type typically last 25 million keystrokes.

Mechanical key switches

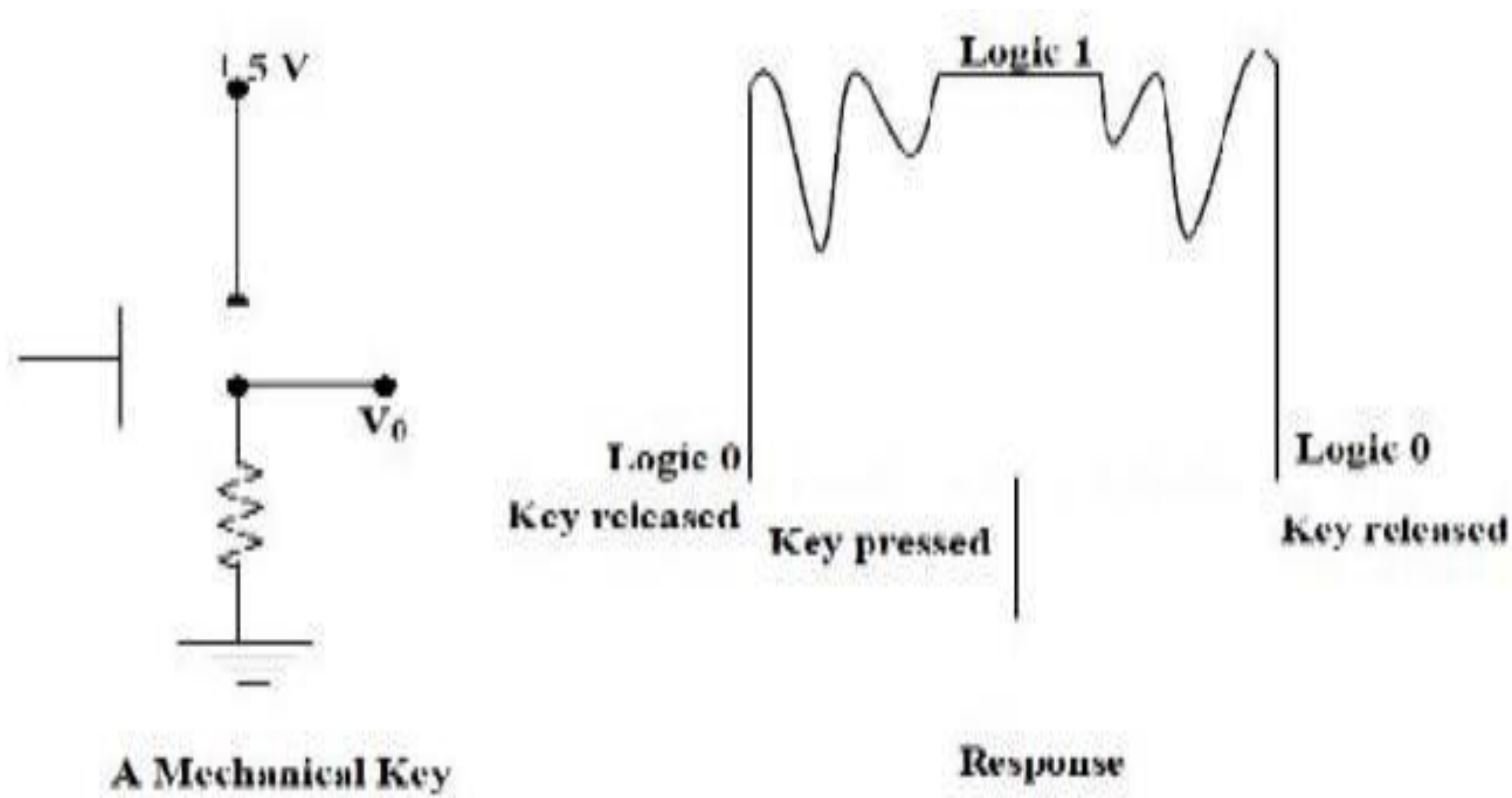


Fig .5.1 Mechanical key and its response to key press

Membrane key switches

These switches are really a special type of mechanical switches. They consist of a three-layer plastic or rubber sandwich.

The top layer has a conductive line of silver ink running under each key position. The bottom layer has a conductive line of silver ink running under each column of keys.

The key board interfaced is a matrix keyboard. This key board is designed with a particular rows and columns. These rows and columns are connected to the microcontroller through its ports of the micro controller 8051. We normally use 8*8 matrix key board. So only two ports of 8051 can be easily connected to the rows and columns of the key board.

Membrane key switches

Whenever a key is pressed, a row and a column gets shorted through that pressed key and all the other keys are left open. When a key is pressed only a bit in the port goes high which indicates microcontroller that the key is pressed. By this high on the bit key in the corresponding column is identified.

Once we are sure that one of key in the key board is pressed next our aim is to identify that key. To do this we firstly check for particular row and then we check the corresponding column the key board.

To check the row of the pressed key in the keyboard, one of the row is made high by making one of bit in the output port of 8051 high . This is done until the row is found out.

Once we get the row next out job is to find out the column of the pressed key. The column is detected by contents in the input ports with the help of a counter. The content of the input port is rotated with carry until the carry bit is set.

The contents of the counter is then compared and displayed in the display. This display is designed using a seven segment display and a BCD to seven segment decoder IC 7447. The BCD equivalent number of counter is sent through output part of 8051 displays the number of pressed key.

Membrane key switches

Fig 5.2 Interfacing Keyboard to 8051 Microcontroller

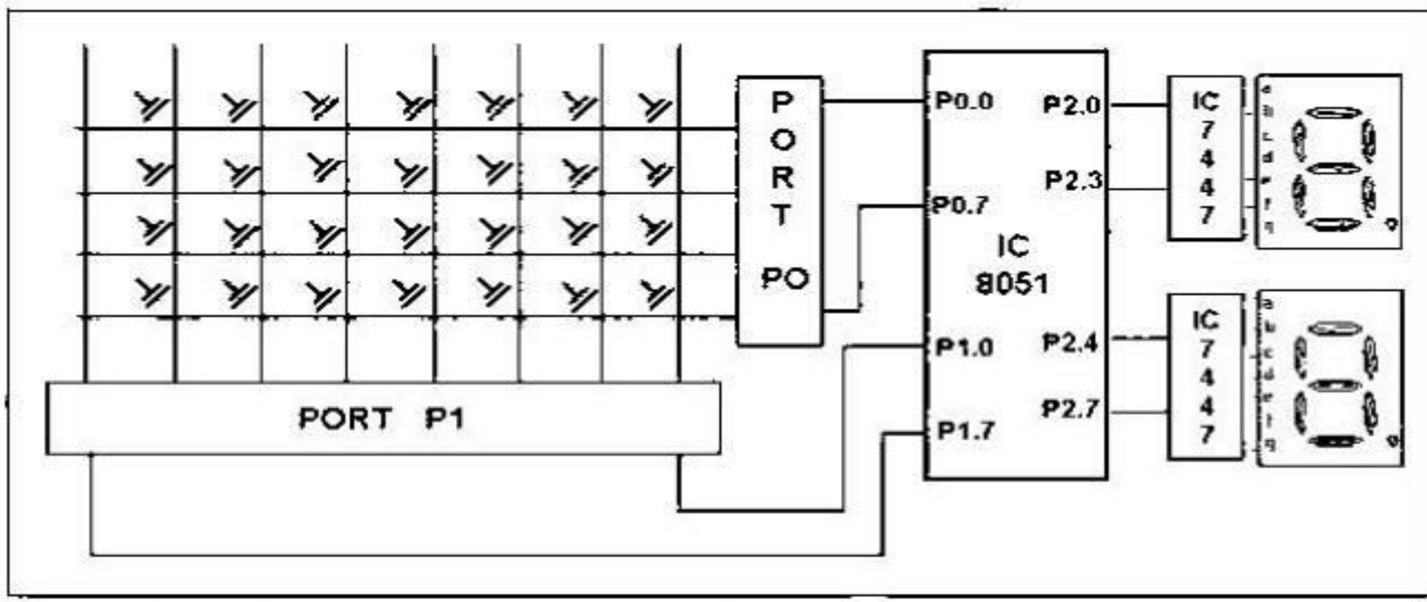


Fig. 5.3 Interfacing To Alphanumeric Displays

Membrane key switches

To give directions or data values to users, many microprocessor-controlled instruments and machines need to display letters of the alphabet and numbers. In systems where a large amount of data needs to be displayed a CRT is used to display the data. In system where only a small amount of data needs to be displayed, simple digit-type displays are often used.

- There are several technologies used to make these digit-oriented displays but we are discussing only the two major types.
- These are light emitting diodes (LED) and liquid-crystal displays (LCD).

LCD displays use very low power, so they are often used in portable, battery-powered instruments. They do not emit their own light, they simply change the reflection of available light. Therefore, for an instrument that is to be used in low-light conditions, you have to include a light source for LCDs or use LEDs which emit their own light.

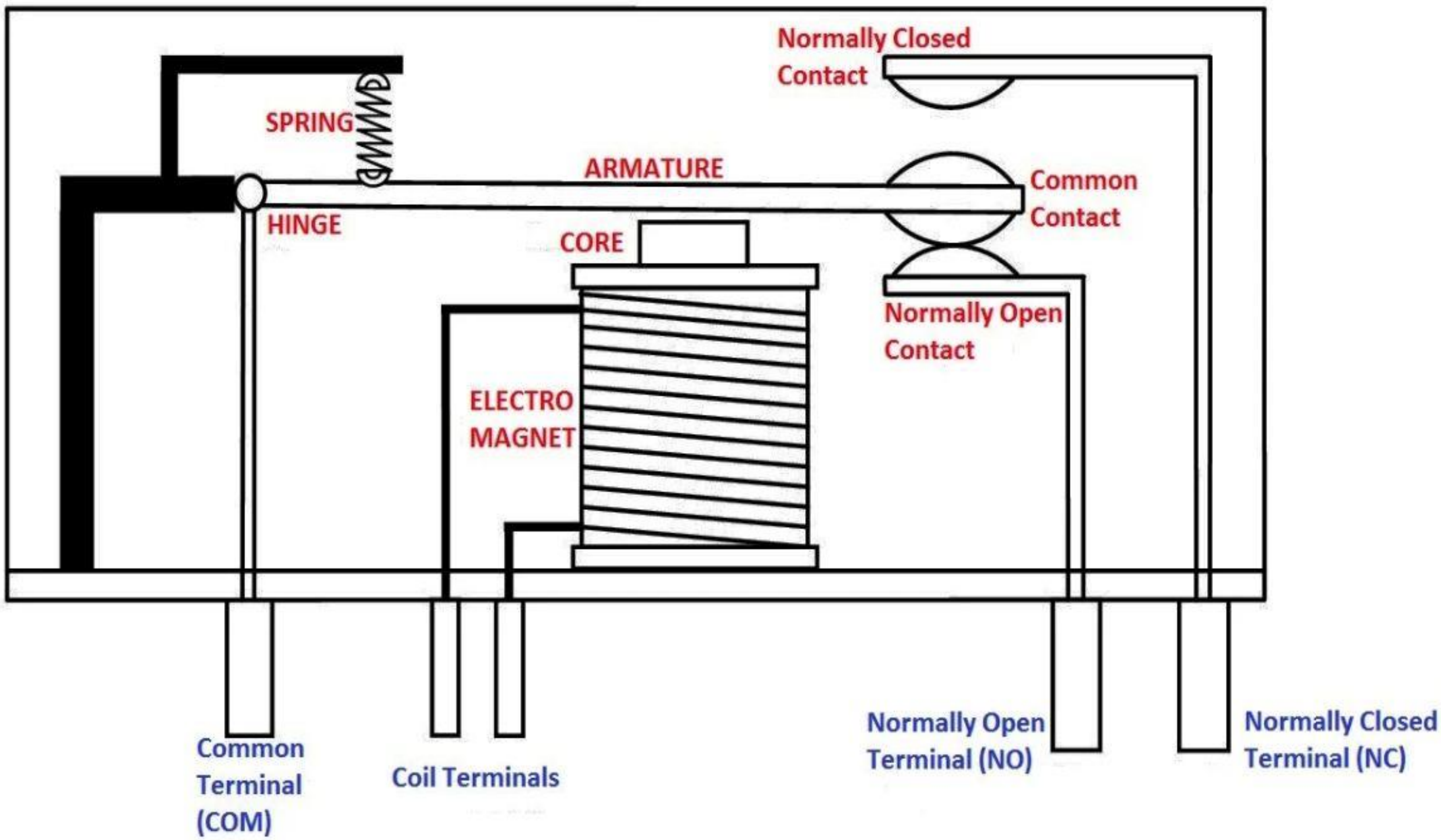
Relay Interface

A relay is an electromagnetic switch which is used to switch High Voltage/Current using Low power circuits. Relay isolates low power circuits from high power circuits. It is activated by energizing a coil wounded on a soft iron core. A relay should not be directly connected to a microcontroller, it needs a driving circuit.

A relay should not be connected directly to a microcontroller due to following reasons.

- Microcontroller can source or sink is 25mA while a relay needs about 50 – 100mA current.
- A relay is activated by energizing its coil. Microcontroller may stop working by the negative voltages produced in the relay due to its back emf.

Relay Interface



Stepper Motor Interface

A stepper motor is a device that translates electrical pulses into mechanical movement in steps of fixed step angle.

- The stepper motor rotates in steps in response to the applied signals.
- It is mainly used for position control.
- It is used in disk drives, dot matrix printers, plotters and robotics and process control circuits.

Structure

Stepper motors have a permanent magnet called rotor (also called the shaft) surrounded by a stator. The most common stepper motors have four stator windings that are paired with a center-tap. This type of stepper motor is commonly referred to as a four-phase or unipolar stepper motor. The center tap allows a change of current direction in each of two coils when a winding is grounded, thereby resulting in a polarity change of the stator.

Stepper Motor Interface

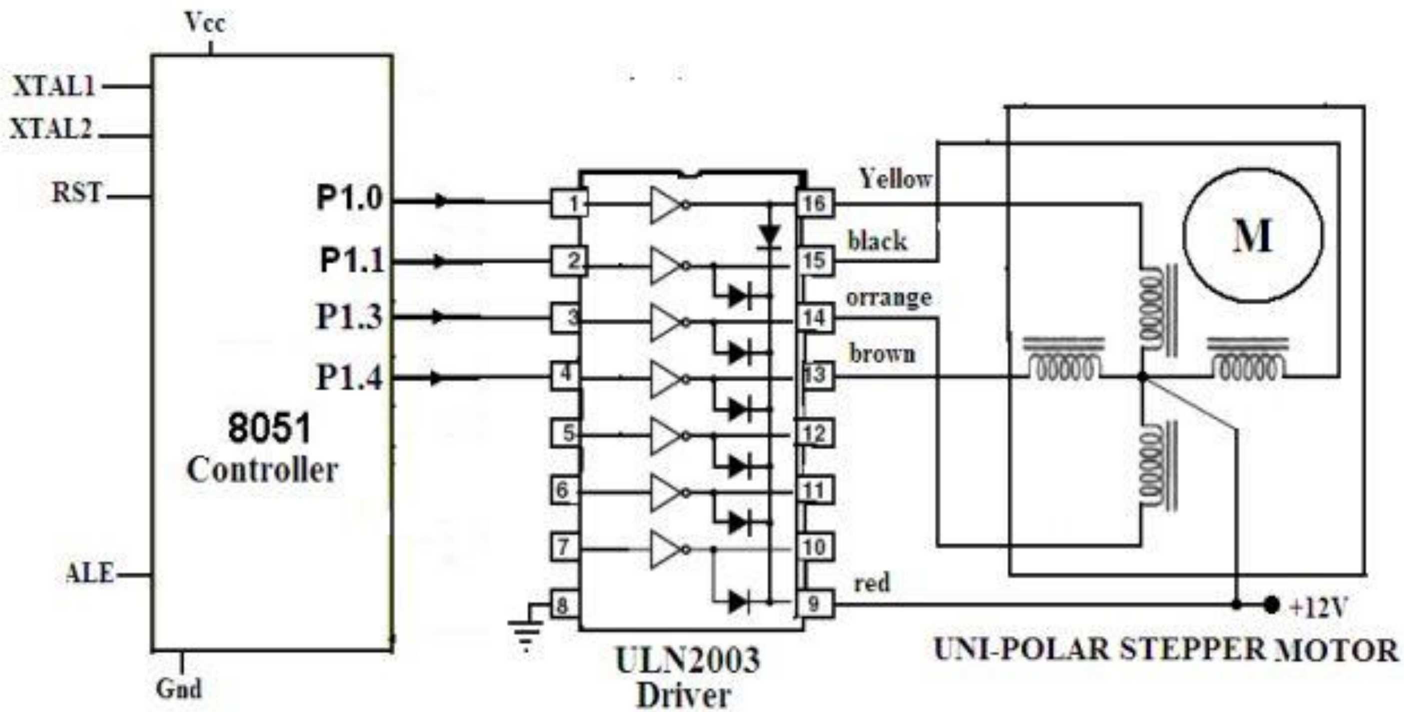
Interfacing

Even a small stepper motor require a current of 400 mA for its operation. But the ports of the microcontroller cannot source this much amount of current. If such a motor is directly connected to the microprocessor/microcontroller ports, the motor may draw large current from the ports and damage it. So a suitable driver circuit is used with the microprocessor/microcontroller to operate the motor.

Motor Driver Circuit (ULN2003)

Stepper motor driver circuits are available readily in the form of ICs. ULN2003 is one such driver IC which is a High-Voltage High-Current Darlington transistor array and can give a current of 500mA.This current is sufficient to drive a small stepper motor. Internally, it has protection diodes used to protect the motor from damage due to back emf and large eddy currents. So, this ULN2003 is used as a driver to interface the stepper motor to the microcontroller.

Stepper Motor interface- Schematic Diagram



Incremental Encoder

An incremental encoder is a linear or rotary electromechanical device that has two output signals, A and B, which issue pulses when the device is moved. Together, the A and B signals indicate both the occurrence of and direction of movement. Many incremental encoders have an additional output signal, typically designated index or Z, which indicates the encoder is located at a particular reference position. Also, some encoders provide a status output (typically designated alarm) that indicates internal fault conditions such as a bearing failure or sensor malfunction.

Incremental Encoder

Unlike an absolute encoder, an incremental encoder does not indicate absolute position;[note 1] it only reports changes in position[3] and, for each reported position change, the direction of movement. Consequently, to determine absolute position at any particular moment, it is necessary to send the encoder signals to an incremental encoder interface, which in turn will "track" and report the encoder's absolute position.

Incremental encoders report position changes nearly instantaneously, which allows them to monitor the movements of high speed mechanisms in near real-time. Because of this, incremental encoders are commonly used in applications that require precise measurement and control of position and velocity.

Incremental Encoder

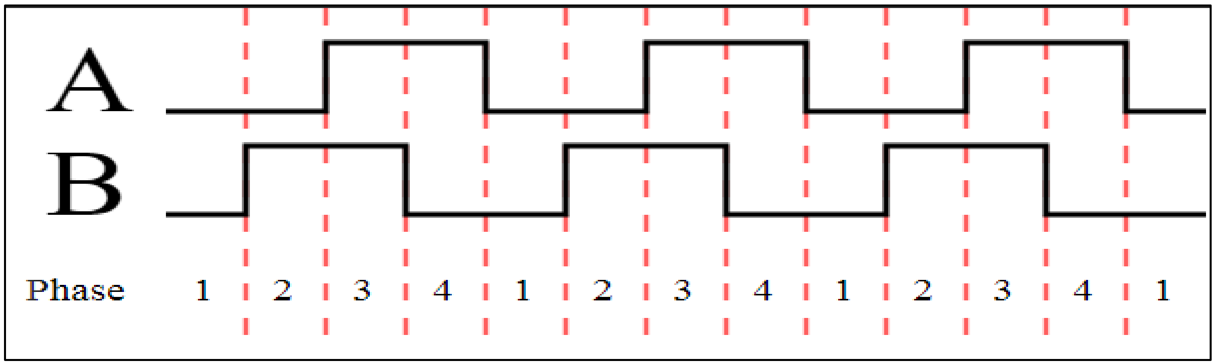
Quadrature outputs

An incremental encoder employs a quadrature encoder to generate its A and B output signals. The pulses emitted from the A and B outputs are quadrature-encoded, meaning that when the incremental encoder is moving at a constant velocity, the duty cycle of each pulse is 50% (i.e., the waveform is a square wave) and there is a 90 degree phase difference between A and B.

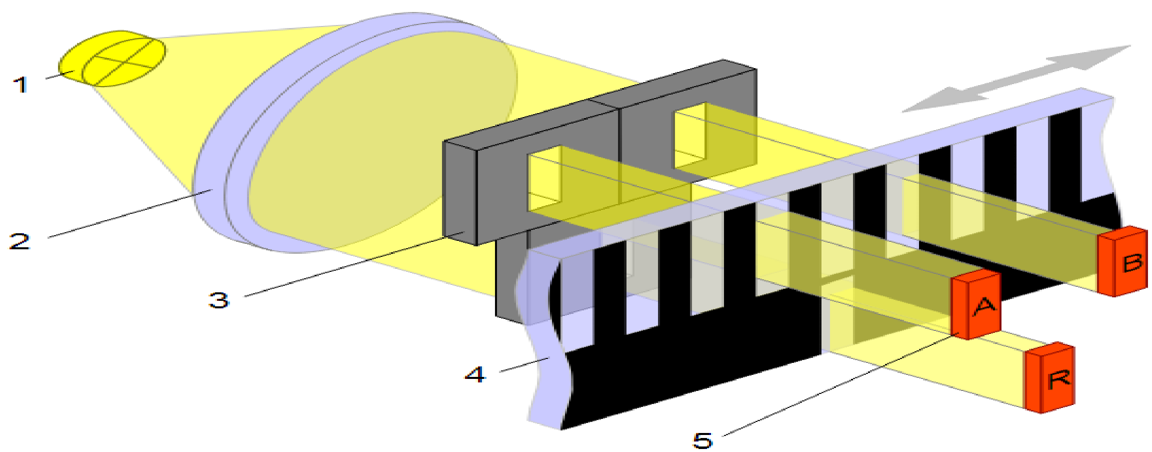
At any particular time, the phase difference between the A and B signals will be positive or negative depending on the encoder's direction of movement. In the case of a rotary encoder, the phase difference is +90° for clockwise rotation and −90° for counter-clockwise rotation, or vice versa, depending on the device design.

The frequency of the pulses on the A or B output is directly proportional to the encoder's velocity (rate of position change); higher frequencies indicate rapid movement, whereas lower frequencies indicate slower speeds. Static, unchanging signals are output on A and B when the encoder is motionless. In the case of a rotary encoder, the frequency indicates the speed of the encoder's shaft rotation, and in linear encoders the frequency indicates the speed of linear traversal.

Incremental Encoder

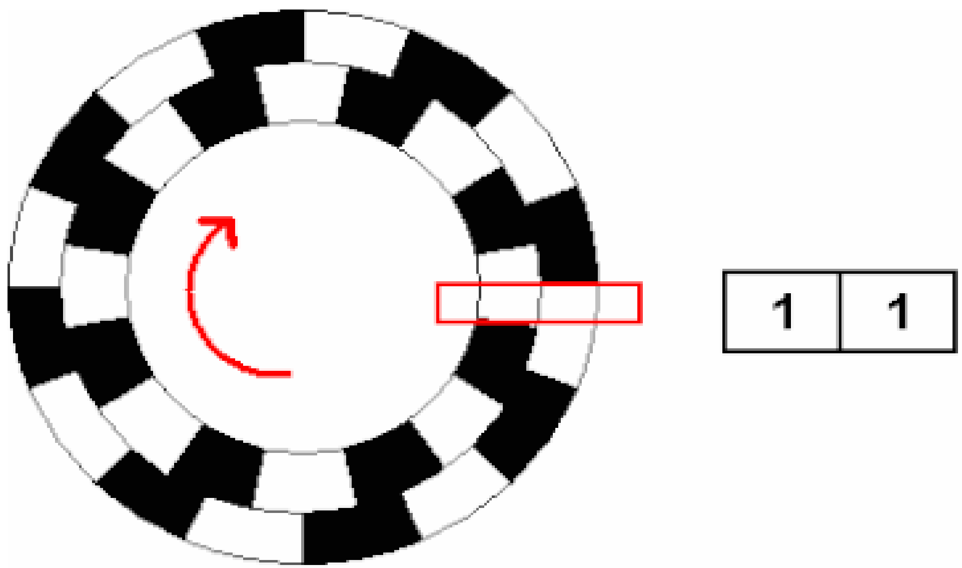


Two square waves in quadrature. The direction of motion is indicated by the sign of the A-B phase difference which, in this case, is negative because A trails B.



Linear encoder; the R signal indicates the encoder is located at its reference position

Incremental Encoder



Rotary encoder, with corresponding A/B signal states shown on the right

Optical Shaft Encoder

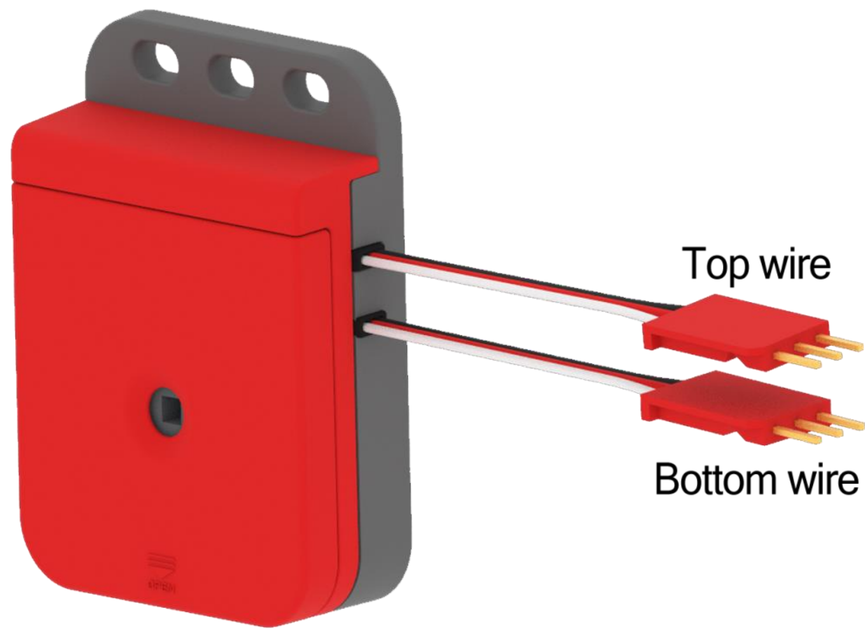
The Optical Shaft Encoder is a digital sensor which measures the rotation of a shaft using an internal encoder disk. The Optical Shaft Encoder's housing has three slotted mounting holes to allow easy mounting to the robot's structure.

The housing also has a removable cover which allows for cleaning and inspection of the internal encoder disk. In the center of the housing is the central hub of the encoder disk. This hub allows for a square shaft to be inserted through it and as the shaft rotates, it rotates the internal encoder disk.

The Optical Shaft Encoder is one of the 3-Wire series of sensors. From the side of the sensor's housing there are two 3-wire cables. The "Top" cable is the cable closest to the housing's mounting hole and the "Bottom" cable is the one closest to the center encoder hub.

Optical Shaft Encoder

This 3-Wire sensor is compatible with the V5 Robot Brain or the Cortex. The sensor's cables can be extended using 3-Wire Extension Cables.



Optical Shaft Encoder

In order for the Optical Shaft Encoder to be functional with the V5 Brain, both the sensor cables need to be fully inserted into a V5 Brain 3-Wire Ports. To measure a clockwise rotation of a shaft as a positive/forward direction the “Top” cable needs to be plugged into a 3-Wire port and the “Bottom” cable needs to be plugged into the next higher consecutive 3-Wire port. Note: only specific pairs of ports will work (AB, CD, EF, and GH).

For example, the “Top” cable on the sensor could be plugged into 3-Wire port A, and then the “Bottom” cable will need to be plugged into the 3-wire port B. The sensor will work if these cables are reversed, however a clockwise rotation will be measured as a negative/reverse direction.

Optical Shaft Encoder

Optical Shaft Encoder

3-Wire Ports

THANK YOU