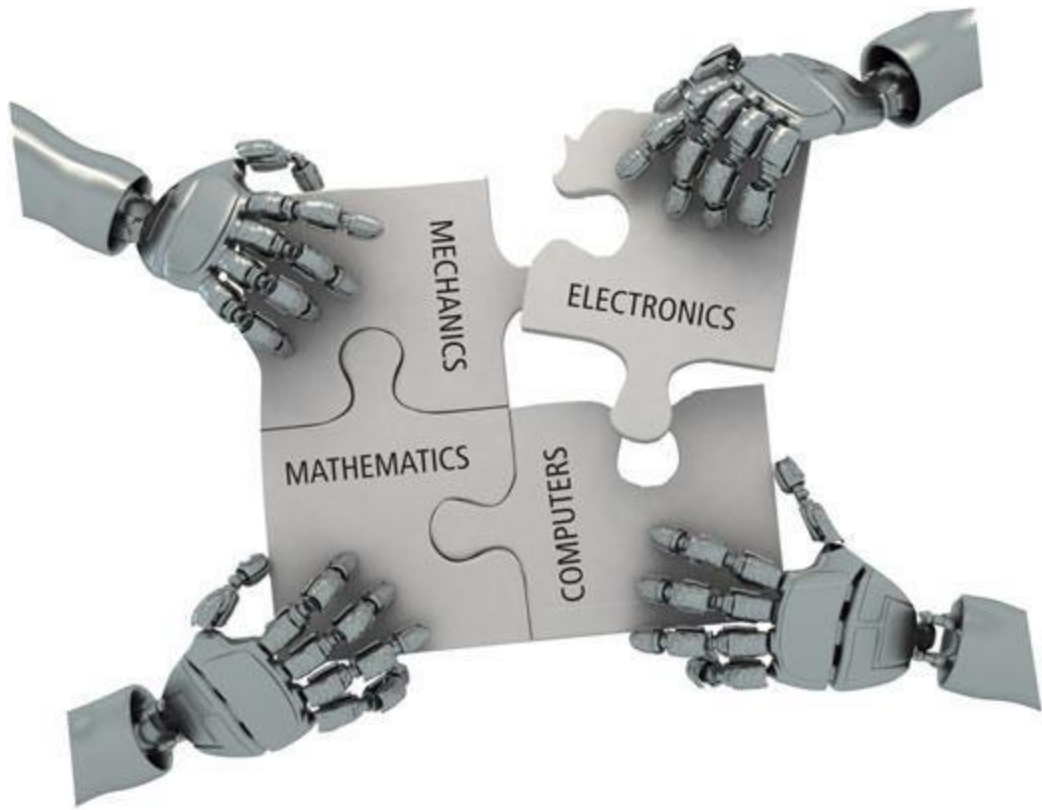# JAIPUR INSTITUTE OF TECHNOLOGY- GROUP OF INSTITUTIONS JAIPUR

MECHATRONICS LABORATORY

III B.TECH (Mechanical): V SEMESTER

DEPARTMENT OF MECHANICAL ENGINEERING

Lab Important Instructions:

1. Lab reports must be submitted immediately at the end of the lab session. Late submission will not be entertained on any account.

2. Flowcharts must be drawn neatly.

3. All observations and programs should be hand written neatly using a pen. Answers written using pencil will not be evaluated.

4. Avoid attaching printouts.

5. Individual reports must be submitted for all the lab experiments.

6. Plagiarism will be treated very seriously.

7. Use of hand phones and gadgets inside the lab is strictly prohibited.

Ex. No:		
Date :	**Introduction To Mechatronics**	**Page No.**

OBJECTIVE:

At the end of the lab session, students will have the knowledge of definition and elements of mechatronics system, apply the principles of mechatronics and automation for the development of productive and efficient manufacturing systems, the hydraulic and pneumatic systems employed in manufacturing, and learn the CNC technology as applications of mechatronics in manufacturing automation.

What is Mechatronics?

Mechatronics is a concept of Japanese origin (1970's) and can be defined as the application of electronics and computer technology to control the motions of mechanical systems
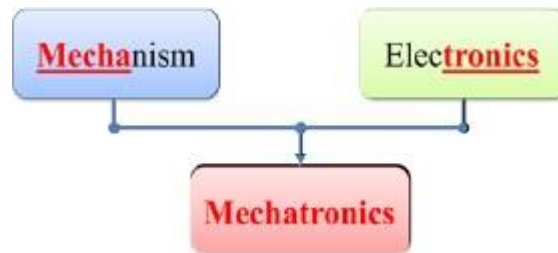

Fig Definition of Mechatronics

It is a multidisciplinary approach to product and manufacturing system design Fig It involves application of electrical, mechanical, control and computer engineering to develop products, processes and systems with greater flexibility, ease in redesign and ability of reprogramming. It concurrently includes all these disciplines.
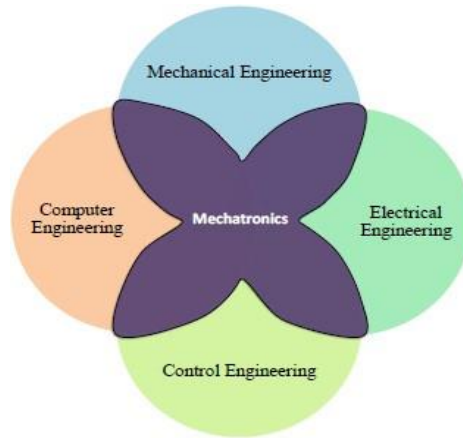
Fig Mechatronics a multi-disciplinary approach

Mechatronics can also be termed as replacement of mechanics with electronics or enhance mechanics with electronics. For example, in modern automobiles, mechanical fuel injection systems are now replaced with electronic fuel injection systems. This replacement made the automobiles more efficient and less pollutant. With the help of microelectronics and sensor technology, mechatronics systems are providing high levels of precision and reliability. It is now possible to move (in x – y plane) the work table of a modern production machine tool in a step of 0.0001 mm. By employment of reprogrammable microcontrollers/microcomputers, it is now easy to add new functions and capabilities to a product or a system. Today's domestic washing machines are "intelligent" and four-wheel passenger automobiles are equipped with safety installations such as air-bags, parking (proximity) sensors, anti- theft electronic keys etc.

MECHATRONICS SYSTEM

A system can be thought of as a box or a bounded whole which has input and output elements, and a set of relationships between these elements. Figure 1.1.4 shows a typical spring system. It has 'force' as an input which produces an 'extension'. The input and output of this system follows the Hooke's law $F = -kx$, where F is force in N, x is distance in m and k is stiffness of the spring.
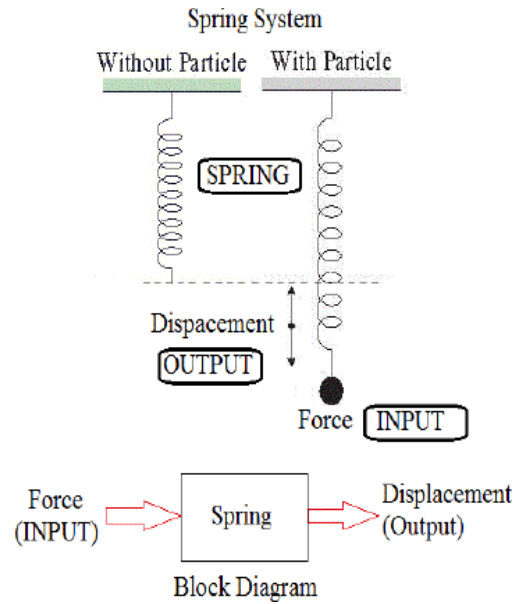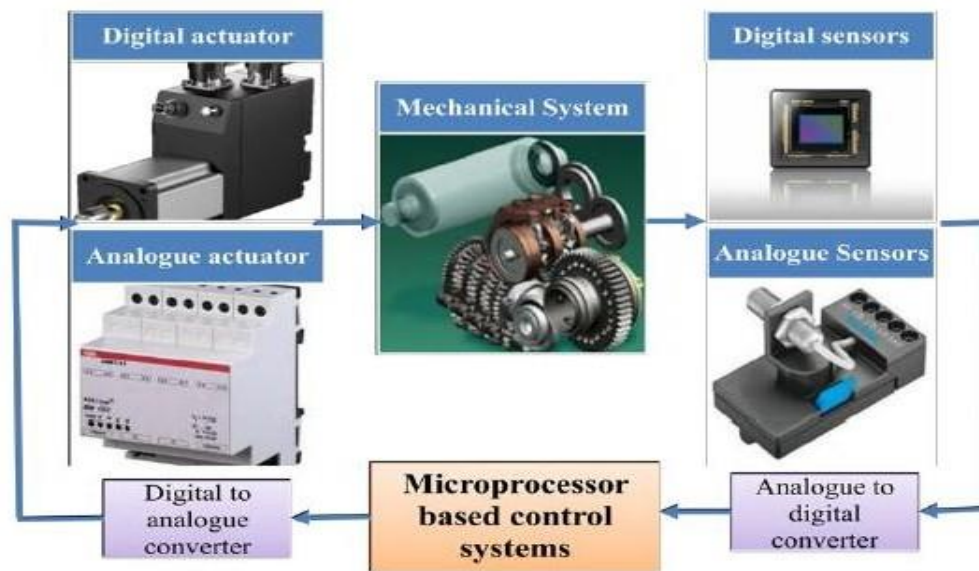
Fig A spring force system

Fig Constituents of a mechatronics system

A Mechatronics system integrates various technologies involving sensors, measurement systems, drives, actuation systems, microprocessor systems and software engineering. Figure 1.1.5 shows the basic elements of a mechatronics system. Consider the example of a simple spring-mass system as shown in figure
To replace the mechanics of this mechanical system with an equivalent mechatronics based system, we need to have the basic controlling

element, a

microprocessor. Microprocessor processes or utilizes the information gathered from the sensor system and generates the signals of appropriate level and suitable kind (current or voltage) which will be used to actuate the required actuator viz. a hydraulic piston-cylinder device for extension of piston rod in this case. The microprocessor is programmed on the basis of the principle of Hooks' Law. The schematic of microprocessor based equivalent spring mass system is shown in figure 1.1.6.
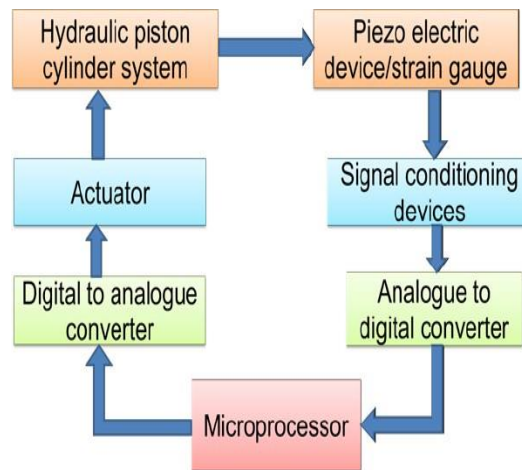

Fig Microprocessor based equivalent spring mass system

The input to the system is a force which can be sensed by suitable electro-mechanical sensors viz. piezo-electric device or strain gauges. These sensors generate either digital signals (0 or 1) or analogue signals (milli-volts or milli-amperes). These signals are then converted into right form and are attenuated to a right level which can properly be used by the microprocessor to take generate the actuation signals. Various electronics based auxiliary devices viz. Analogue-to-Digital Converter (ADC), Digital-to-Analogue Converter (DAC), Op-amps, Modulators, Linearization circuits, etc. are used to condition the signals which are either received by the microprocessor from the sensors or are sent to the actuators from the microprocessor. This mechatronics based spring-mass system has the input signals in the digital form which are received from the ADC and Piezo-electric sensor. The digital actuation signals generated by the microprocessors are converted into appropriate analogues signals. These analogue signals operate the hydraulic pump and control valves to achieve the desired displacement of the piston-rod.

APPLICATIONS

Mechatronics has a variety of applications as products and systems in the area of 'manufacturing automation'. Some of these applications are as follows:

1. Computer numerical control (CNC) machines
2. Tool monitoring systems
3. Advanced manufacturing systems
   a. Flexible manufacturing system (FMS)
   b. Computer integrated manufacturing (CIM)
4. Industrial robots
5. Automatic inspection systems: machine vision systems
6. Automatic packaging systems

COMPUTER NUMERICAL CONTROL (CNC) MACHINES

CNC machine is the best and basic example of application of Mechatronics in manufacturing automation. Efficient operation of conventional machine tools such as Lathes, milling machines, drilling machine is dependent on operator skill and training. Also a lot of time is consumed in work part setting, tool setting and controlling the process parameters viz. feed, speed, depth of cut. Thus conventional machining is slow and expensive to meet the challenges of frequently changing product/part shape and size.

Computer numerical control (CNC) machines are now widely used in small to large scale industries. CNC machine tools are integral part of Computer Aided Manufacturing (CAM) or Computer Integrated Manufacturing (CIM) system. CNC means operating a machine tool by a series of coded instructions consisting of numbers, letters of the alphabets, and symbols which the machine control unit (MCU) can understand.

These instructions are converted into electrical pulses of current which the machine's motors and controls follow to carry out machining operations on a work piece. Numbers, letters, and symbols are the coded instructions which refer to specific distances, positions, functions or motions which the machine tool can understand.
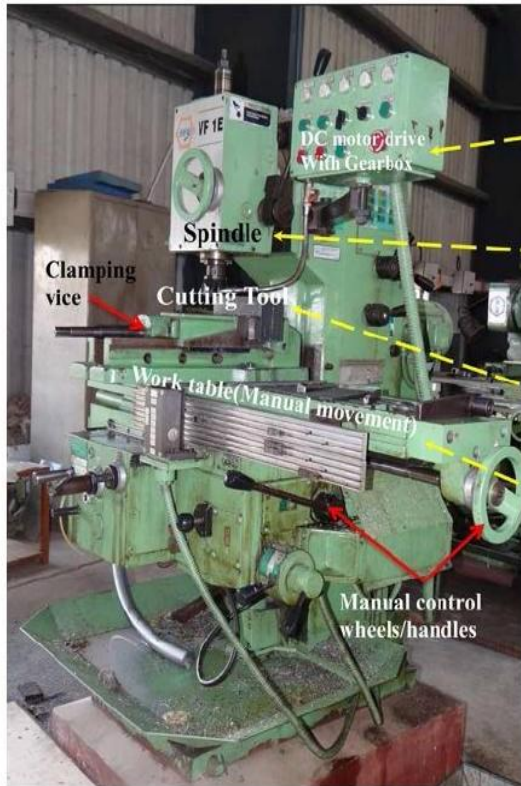
Fig Comparison between a conventional machine tool and a CNC machine tool

CNC automatically guides the axial movements of machine tools with the help of computers. The auxiliary operations such as coolant on-off, tool change, door open- close are automated with the help of micro-controllers. Figure 1.2.1 shows the fundamental differences between a conventional and a CNC machine tool. Manual operation of table and spindle movements is automated by using a CNC controllers and servo motors. The spindle speed and work feed can precisely be controlled and maintained at programmed level by the controller. The controller has self diagnostics facility which regularly alarms the operator in case of any safety norm violation viz. door open during machining, tool wear/breakage etc. Modern machine tools are now equipped with friction-less drives such as re-circulating ball screw drives, Linear motors etc. The detail study of various elements of such a Mechatronics based system is the primary aim of this course and these are described at length in the next modules.

Objective:

At the end of the lab session, students will have the knowledge on how to write an assembly language program to add, subtract, the given data stored at two consecutive locations using 8085 microprocessor.

Question 1: Write an assembly language program to add, the given data stored at two consecutive locations using 8085 microprocessor.

Program:

Address	Mnemonics	Operand	Opcode	Remarks
4000	LXI	H, 3000H	21	Load H-L pair with address 5000H.
4001			00	Lower-order of 5000H.
4002			50	Higher-order of 5000H.
4003	MOV	A, M	7E	Move the 1st operand from memory to reg. A.
4004	INX	H	23	Increment H-L pair.
4005	MOV	B, M	46	Move the 2nd operand from memory to reg. B.
4006	ADD	B	80	Add B with A.
4007	INX	H	23	Increment H-L pair.
4008	MOV	M, A	77	Move the result from reg. A to memory.
4009	HLT		76	Halt.

Question 2: Write an assembly language program to subtract, the given data stored at two consecutive locations using 8085 microprocessor.

Program:

Address	Mnemonics	Operand	Opcode	Remarks
4000	LXI	H, 3000H	21	Load H-L pair with address 5000H.
4001			00	Lower-order of 5000H.
4002			50	Higher-order of 5000H.
4003	MOV	A, M	7E	Move the 1st operand from memory to reg. A.
4004	INX	H	23	Increment H-L pair.

Address	Mnemonics	Operand	Opcode	Remarks
4005	MOV	B, M	46	Move the 2nd operand from memory to reg. B.
4006	SUB	B	90	Subtract B from A.
4007	INX	H	23	Increment H-L pair.
4008	MOV	M, A	77	Move the result from reg. A to memory.
4009	HLT		76	Halt.

Question 3: Write an assembly language program to find the largest of two given data using 8085 microprocessor.

Program:

Address	Mnemonics	Operand	Opcode	Remarks
4000	LXI	H, 3000H	21	Load H-L pair with address 5000H.
4001			00	Lower-order of 5000H.
4002			30	Higher-order of 5000H.
4003	MOV	A, M	7E	Move the 1st operand from memory to reg. A.
4004	INX	H	23	Increment H-L pair.
4005	MOV	B, M	46	Move the 2nd operand from memory to reg. B.
4006	CMP	B	B8	Compare B with A.
4007	JNC	200BH	D2	Jump to address 400BH if there is no carry.
4008			0B	Lower-order of 400BH.
4009			20	Higher-order of 400BH.
400A	MOV	A, B	78	Move largest from reg. B to reg. A.
400B	INX	H	23	Increment H-L pair.
400C	MOV	M, A	77	Move the result from reg. A to memory.
400D	HLT		76	Halt.

Question 4: Write an assembly language program to find the smallest of two given data using 8085 microprocessor.

Program:

Address	Mnemonics	Operand	Opcode	Remarks
4000	LXI	H, 3000H	21	Load H-L pair with address 5000H.
4001			00	Lower-order of 5000H.

4002			50	Higher-order of 5000H.
4003	MOV	A, M	7E	Move the 1st operand from memory to reg. A.
4004	INX	H	23	Increment H-L pair.
4005	MOV	B, M	46	Move the 2nd operand from memory to reg. B.
4006	CMP	B	B8	Compare B with A.
4007	JC	200BH	DA	Jump to address 400BH if there is no carry.
4008			0B	Lower-order of 400BH.
4009			20	Higher-order of 400BH.
400A	MOV	A, B	78	Move smallest from reg. B to reg. A.
400B	INX	H	23	Increment H-L pair.
400C	MOV	M, A	77	Move the result from reg. A to memory.
400D	HLT		76	Halt.

REPORT EVALUATION

S.no	Description	Weightage	Marks Awarded
1	Program	40	
2	Execution	30	
3	Results	10	
4	Viva-voce	20	
Total		100	

Ex. No:		
Date :	**Stepper Motor Interface**	**Page No.**

Objective:

At the end of the lab session, students will have the knowledge how to execute a program using micro controller kit to run a stepper motor at different angles, run in forward and reverse directions alternatively.

Apparatus Required

- 8051 Micro controller kit.
- Key broad.
- Stepper motor.

Procedure:

- Switch on the micro controller
- Engage the control DIP switch
- Feed the opcode to the micro controller kit through the keyboard.
- Execute the program using the GO command.
- The output of the program is verified from the stepper motor rotation.

Question 1: For the following write a program to run a stepper motor in clockwise direction

Program:

MEMORY ADDRESS	OBJECT CODES	MNEMONICS
4100	7C	MOV R4. #FF
4101	FF	
4102	90	START: MOV DPTR, # LOOK UP
4103	41	
4104	14	
4105	78	MOV R0, #04

4106	04	
4107	E0	JO: MOVX A, @DPTR
4108	C0	PUSH DPH
4109	83	
410A	C0	PUSH DPL
410B	82	
410C	90	MOV DPTR, #FFCOH
410D	FF	
410E	C0	
410F	F0	MOVX @DPTR, A
4110	DC	DJNZ R4, CALL
4111	06	
4112	80	HLT: SJMP HLT
4113	FE	
4114	09	LOOK UP: DB 09H, 05H, 06H, 0AH
4115	05	
4116	06	
4117	0A	
4118	7A	CALL: MOV R2, #03
4119	03	
411A	79	DLY2: MOV R1, #FFH
411B	FF	
411C	7B	DLY1: MOV R1, #FFH
411D	FF	
411E	DB	DLY: DJNZ R3, DLY
411F	FE	
4120	D9	DJNZ R1, DLY1
4121	FA	

MEMORY ADDRESS	OBJECT CODES	MNEMONICS
4122	DA	DJNZ R2, DLY2
4123	F6	
4124	D0	POP DPL
4125	82	
4126	D0	POP DPH
4127	83	
4128	A3	INC DPTR
4129	D8	DJNZ R0, JO
412A	DC	
412B	80	SJMP START
412C	D5	
412D		END

Question 2: For the following write a program to run a stepper motor in anticlockwise direction

Program:

MEMORY ADDRESS	OBJECT CODES	MNEMONICS
4100	7C	MOV R4. #FF
4101	FF	
4102	90	START: MOV DPTR, # LOOK UP
4103	41	
4104	14	
4105	78	MOV R0, #04
4106	04	
4107	E0	JO: MOVX A, @DPTR

4108	C0	PUSH DPH
4109	83	
410A	C0	PUSH DPL
410B	82	
410C	90	MOV DPTR, #FFCOH
410D	FF	
410E	C0	
410F	F0	MOVX @DPTR, A
4110	DC	DJNZ R4, CALL
4111	06	
4112	80	HLT: SJMP HLT
4113	FE	
4114	0A	LOOK UP: DB 0AH, 06H, 05H, 09H
4115	06	
4116	05	
4117	09	
4118	7A	CALL: MOV R2, #03
4119	03	
411A	79	DLY2: MOV R1, #FFH
411B	FF	
411C	7B	DLY1: MOV R1, #FFH

411D	FF	
411E	DB	DLY: DJNZ R3, DLY
411F	FE	
4120	D9	DJNZ R1, DLY1
4121	FA	
4122	DA	DJNZ R2, DLY2
4123	F6	
4124	D0	POP DPL
4125	82	
4126	D0	POP DPH
4127	83	
4128	A3	INC DPTR
4129	D8	DJNZ R0, JO
412A	DC	
412B	80	SJMP START
412C	D5	
412D		END

Question 3: For the following write a program to run a stepper motor in 360° clockwise direction

MEMORY ADDRESS	OBJECT CODES	MNEMONICS
4101	C8	
4114	09	LOOK UP: DB 09H, 05H, 06H, 0AH
4115	05	
4116	06	
4117	0A	

Question 4: For the following write a program to run a stepper motor in 360° anticlockwise direction

MEMORY ADDRESS	OBJECT CODES	MNEMONICS
4101	C8	
4114	0A	LOOK UP: DB 09H, 05H, 06H, 0AH
4115	06	
4116	05	
4117	09	

Question 5: For the following write a program to run a stepper motor in 270° clockwise direction

MEMORY ADDRESS	OBJECT CODES	MNEMONICS
4101	96	
4114	09	LOOK UP: DB 09H, 05H, 06H, 0AH
4115	05	
4116	06	
4117	0A	

Question 6: For the following write a program to run a stepper motor in 270° anticlockwise direction

MEMORY ADDRESS	OBJECT CODES	MNEMONICS
4101	96	
4114	0A	LOOK UP: DB 09H, 05H, 06H, 0AH

MEMORY ADDRESS	OBJECT CODES	MNEMONICS
4115	06	
4116	05	
4117	09	

Question 7: For the following write a program to run a stepper motor in 180° clockwise direction

MEMORY ADDRESS	OBJECT CODES	MNEMONICS
4101	64	
4114	09	LOOK UP: DB 09H, 05H, 06H, 0AH
4115	05	
4116	06	
4117	0A	

Question 8: For the following write a program to run a stepper motor in 180° anticlockwise direction

MEMORY ADDRESS	OBJECT CODES	MNEMONICS
4101	32	
4114	0A	LOOK UP: DB 09H, 05H, 06H, 0AH
4115	06	
4116	05	
4117	09	

Question 9: For the following write a program to run a stepper motor in 90° clockwise direction

MEMORY ADDRESS	OBJECT CODES	MNEMONICS
4101	32	
4114	09	LOOK UP: DB 09H, 05H, 06H, 0AH
4115	05	
4116	06	
4117	0A	

Question 10: For the following write a program to run a stepper motor in 90° anticlockwise direction

MEMORY ADDRESS	OBJECT CODES	MNEMONICS
4101	64	

		LOOK UP: DB 09H, 05H, 06H, 0AH
4114	0A	
4115	06	
4116	05	
4117	09	

REPORT EVALUATION

S.no	Description	Weightage	Mark Awarded
1	Procedure	15	
2	Circuit diagram	25	
3	Experimental Results	20	
4	Analysis	20	
5	Viva-voce	20	
Total		**100**	

Ex. No:		
Date :	**Speed Control of DC Motor**	**Page No.**

Objective:

At the end of the lab session, students will have the knowledge how to control the speed of the DC motor using PID controller.

Question 1 : For the following tabulate the measured error values and graphically represent it.

Apparatus Required

- PID controller
- Stepper motor
- DC motor speed control trainer

Procedure:

- Switch on the PID controller and DC motor speed control trainer
- Press INC key twice in PID controller
- Use INC,DEC, BACK and ENTER key to type the maximum range, set point, Kp,Ki, Kd values.
- Note down the process variable and controller output values as shown in LCD
- Reset the controller and reset the same procedure for various set points Kp,Ki, and Kd values.

Tabulation:

S.No	Time (secs)	K_p	K_i	K_d	SET RANGE	MAX RANGE	C_v	P_v	ERROR= (SET VALUE – P_v VALUE)

Where,

- K_p – Proportional gain value

- K_i- Integral Time

- K_d – Derivative Time

- C_v- Control Voltage or Control output

- P_v – Process Variable.

Graph:

   Set point Vs Error

REPORT EVALUATION

S.no	Description	Weightage	Mark Awarded
1	Readings	10	
2	Calculation	30	
3	Graph	10	
4	Experimental Results	10	
5	Analysis	20	
6	Viva-voce	20	
Total		100	

Ex. No:		
Date :	**Study Of Various Types Of Transducers**	**Page No.**

Objective:

At the end of the lab session, students will have the acquaintance on transducers, and its types.

Transducer

"An element when subjected to some physical change experiences a related change or an element which converts a specified measurand into a usable output by using a transduction principle", "A device that converts a signal from one form of energy to another form". A large number of devices transform values of physical variables into equivalent electrical signals. Such devices are called transducers and have been mentioned frequently in the preceding sections of this chapter. Some of the more widely used transducers and their principles of operation are discussed.

Types

- Variable-Resistance Transducer
- Differential Transformer
- Capacitive Transducers
- Piezoelectric Transducers
- Photoelectric Effects
- Photovoltaic Cells
- Photoconductive Transducers
- Ionization Transducers
- Hall-Effect Transducers
- Digital Displacement Transducers

The Variable-Resistance Transducer

The variable-resistance transducer is a very common device which may be constructed in the form of a moving contact on a slide-wire or a moving contact that moves through an angular displacement on a solid conductor like a piece of graphite. The device may also be called a *resistance potentiometer* or *rheostat* and is available commercially in many sizes, designs, and ranges. Costs can range from a

few cents for a simple potentiometer used as a volume control in a radio circuit to hundreds of dollars for a Precision device used for accurate laboratory work. The variable-resistance transducer fundamentally is a device for converting either linear or angular displacement into an electric signal; however, through mechanical methods it is possible to convert force and pressure to a displacement so that the device may also be useful in force and pressure measurements.
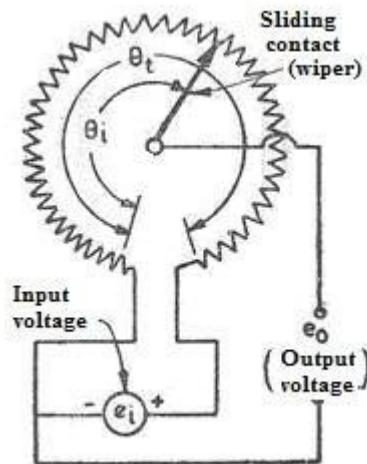
Fig Schematic Diagram of Variable-Resistance Transducer

The Differential Transformer (LVDT)

A schematic diagram of the differential transformer is shown in Fig. 2. Three coils are placed in a linear arrangement as shown with a magnetic core which may move freely inside the coils. The construction of the device is indicated in Fig. 3. An alternating input voltage is impressed in the center coil, and the output voltage from the two end coils depends on the magnetic coupling between the core and the coils. This coupling, in turn, is dependent on the position of the core. Thus, the output voltage of the device is an indication of the displacement of the core. As long as the core remains near the center of the coil arrangement, the output is very nearly linear, as indicated in Fig. 4.The linear range of commercial differential transformers is clearly specified, and the devices are seldom operated outside this range. When operating in the line arrange, the device is called a *linear variable differential transformer* (LVDT).
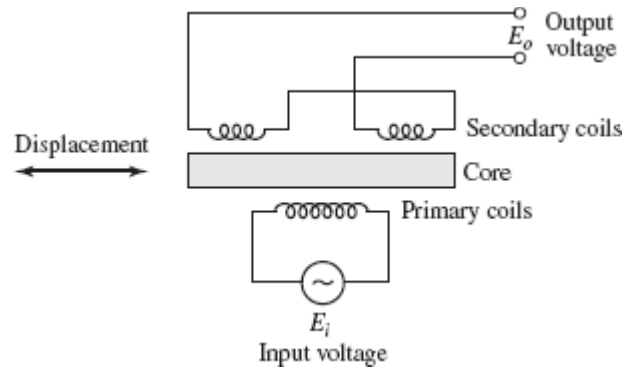
Figure 2. Schematic Diagram of a Differential transformer
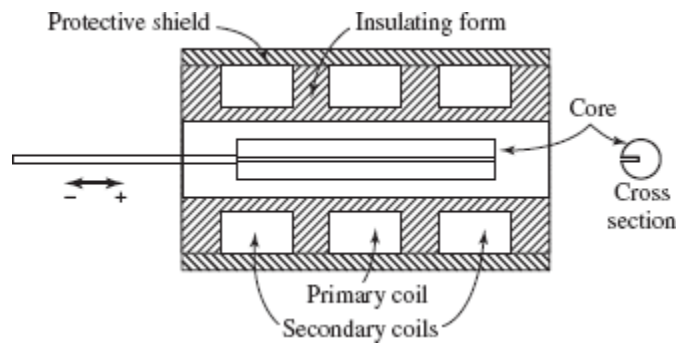
Figure 3. Construction of a Commercial linear variable Differential transformer
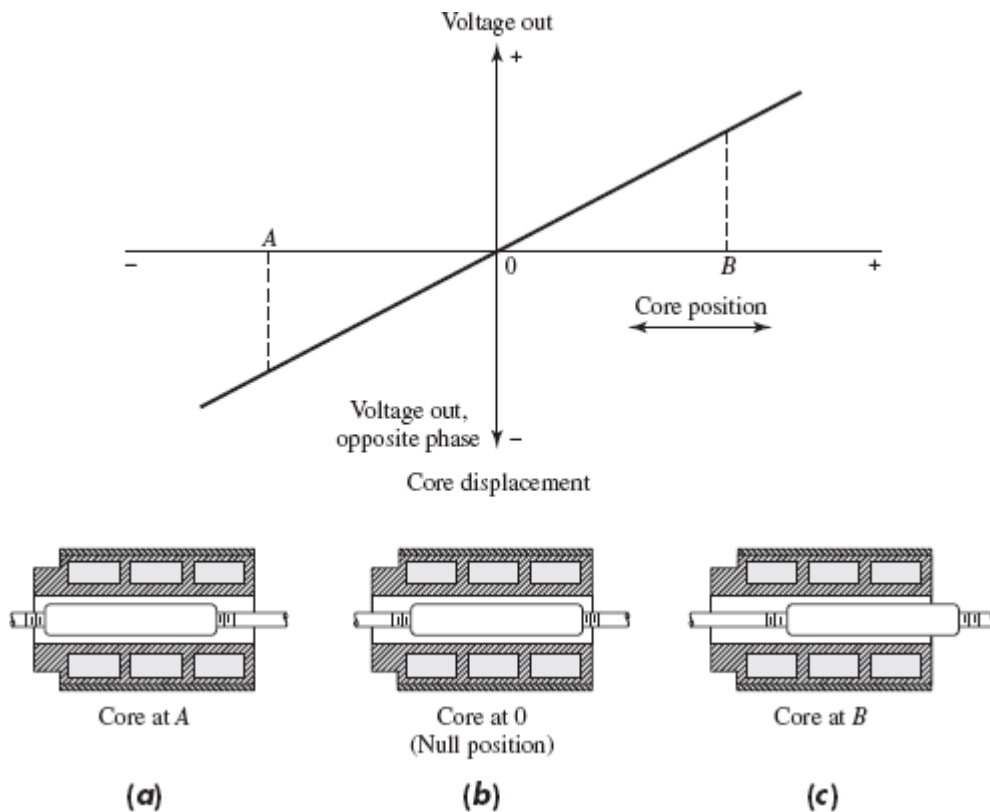
Figure 4. Output Characteristic of a LVDT

The frequency response of LVDTs is primarily limited by the inertia characteristics of the device. In general, the frequency of the applied voltage should be 10 times the desired frequency response. Commercial LVDTs are available in a broad range of sizes and are widely used for displacement measurements in a variety of applications. Force and pressure measurements may also be made after a mechanical conversion.

Capacitive Transducers

Consider the capacitive transducer shown in Fig. 4.52. The capacitance (in picofarads) of this arrangement is given by

$$C = 0.225\epsilon\frac{A}{d}$$

Where d = distance between the plates, in or cm
A = overlapping area, in² or cm²
ε = dielectric constant (ε= 1 for air; ε= 3 for plastics)

The constant 0.225 is 0.0885 when the area is in square centimeters and the separation distance is in centimeters. This plate arrangement may be used to measure a change in the distance d through a change in capacitance. A change in capacitance may also be registered through a change in the overlapping area. A resulting from a relative movement of the plates in a lateral direction or a change in the dielectric constant of the material between the plates. The capacitance may be measured with bridge circuits. The output impedance of a capacitor is given by

$$Z = \frac{1}{2\pi f C}$$

Where Z =   impedance, Ω
       f =   frequency, Hz
       C =   capacitance, F

In general, the output impedance of a capacitive transducer is high; this fact may call for careful design of the output circuitry to avoid loading.
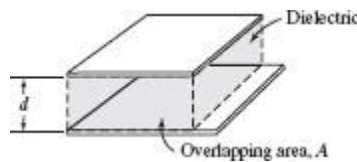
Figure.5. Schematic of a capacitive Transducer
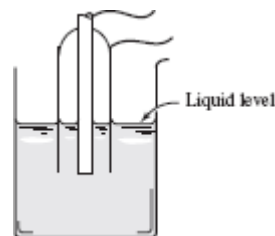
Figure.6. Use of capacitive transducer for liquid level measurement

The capacitive transducer may be used for displacement measurements through a variation of either the spacing distance d or the plate area. It is commonly used for liquid-level measurements, as indicated in Fig. .6. Two electrodes are arranged as shown, and the dielectric constant varies between the electrodes according to the liquid level. Thus, the capacitance between the electrodes is a direct indication of the liquid level. A charge amplifier may be used to increase the signal level before transmission to readout circuits.

Piezoelectric Transducers

Consider the arrangement shown in Fig.7.Apiezoelectric crystal is placed between two plate electrodes. When a force is applied to the plates, a stress will be produced in the crystal and a corresponding deformation. With certain crystals this deformation will produce a potential difference at the surface of the crystal, and the effect is called the *piezoelectric effect*. The induced charge on the crystal is proportional to the impressed force and is given by

$$Q = dF$$

Where,

Q is in coulombs
F is in newtons
proportionality constant d is called the *piezoelectric constant*.

The output voltage of the crystal is given by
$$E = gtp$$

Where

t is the crystal thickness in meters
p is the impressed pressure in newtons per square meter
g is the voltage sensitivity

$$g = \frac{d}{\epsilon}$$
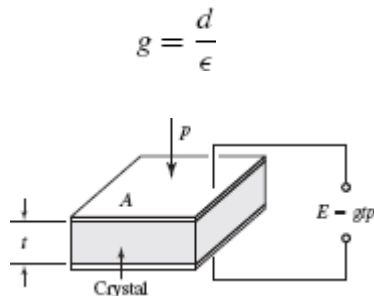
Figure.7.The Piezoelectric effect

The voltage output depends on the direction in which the crystal slab is cut in respect to the crystal axes. Piezoelectric crystals are used as pressure transducers for dynamic measurements.

Photoelectric Effects

A photoelectric transducer converts a light beam into a usable electric signal. Consider the circuit shown in Fig. 8. Light strikes the photo emissive cathode and releases electrons, which are attracted toward the anode, thereby producing an electric current in the external circuit. The cathode and anode are enclosed in a glass

or quartz envelope, which is either evacuated or filled with an inert gas. The photoelectric sensitivity is defined by

$$I = S\Phi$$

Where

I = photoelectric current

Φ = illumination of the cathode

S = sensitivity
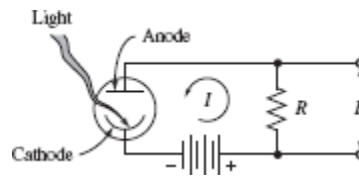
Figure 8.The Photoelectric effect

The sensitivity is usually expressed in units of amperes per watt or amperes per lumen. Photoelectric-tube response to different wavelengths of light is influenced by two factors: (1) the transmission characteristics of the glass-tube envelope and (2) the photo emissive characteristics of the cathode material. Photo emissive materials are available which will respond to light over a range of 0.2 to 0.8 μm. Most glasses transmit light in the upper portion of this range, but many do not transmit below about 0.4 μm. Photoelectric tubes are quite useful for measurement of light intensity. In expensive devices can be utilized for counting purposes through periodic interruption of a light source.

Photoconductive Transducers

The principle of the photoconductive transducer is shown in Fig. 9. A voltage is impressed on the semiconductor material as shown. When light strikes the semiconductor material, there is a decrease in the resistance, thereby producing an increase in the current indicated by the meter. A variety of substances are used for photo conductive materials, and a rather detailed discussion of the pertinent literature on the subject .Photoconductive transducers enjoy a wide range of applications and are useful for measurement of radiation at all wavelengths. It must be noted, however, that extreme experimental difficulties may be encountered when operating with long-wavelength radiation. The responsivity Rvof a detector is defined as

$$R_v = \frac{\text{rms output voltage}}{\text{rms power incident upon the detector}}$$

The *noise-equivalent power* (NEP) is defined as the minimum-radiation input that will produce a S/N ratio of unity. The detectivity D is defined as

$$D = \frac{R_v}{\text{rms noise-voltage output of cell}}$$

rms noise-voltage output of cell

The detectivity is the reciprocal of NEP. A normalized detectivity $D*$ is defined as

$$D^* = (A \, \Delta f)^{1/2} D$$

Where A is the area of the detector and f is a noise-equivalent bandwidth. The units of $D*$ are usually cm · Hz1/2/W, and the term is used in describing the performanceof detectors so that the particular surface area and bandwidth will not affect the results. The lead-sulfide cell is very widely used for detection of thermal radiation int he wavelength band of 1 to 3 μm. By cooling the detector more favorable response at higher wavelengths can be achieved up to about 4 or 5 μm. For measurements at longer wavelengths the indium-antimonide detector is preferred, but it has a lower detectivity than lead sulfide.
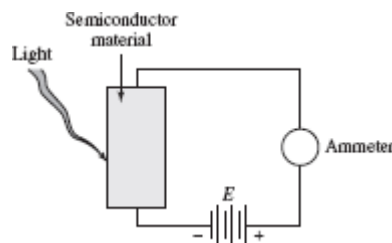
Figure 9. Schematic of a photoconductive transducer

Photovoltaic Cells

The photovoltaic-cell principle is illustrated in Fig. 10. The sandwich construction consists of a metal base plate, a semiconductor material, and a thin transparent metallic layer. This transparent layer may be in the form of a sprayed, conductinglacquer. When light strikes the barrier between the transparent metal layer and the semiconductor material, a voltage is generated. The output of the device is strongly dependent on the load resistance R. The open-circuit voltage approximates a logarithmic function, but more linear behavior may be approximated by decreasing the load resistance. Perhaps the most widely used application of the photovoltaic cell is the light exposuremeter in photographic work.

The logarithmic behavior of the cell is a decided advantage in such applications because of its sensitivity over a broad range of light intensities.
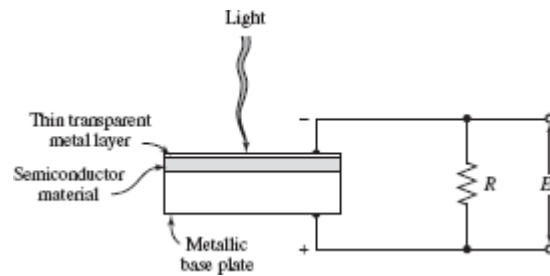
Figure 10 Schematic diagram of a Photovoltaic cell.

Ionization Transducers

A schematic of the ionization transducer is shown in Fig. 11. The tube contains a gas at low pressure while the RF generator impresses a field on this gas. As a result of the RF field, a glow discharge is created in the gas, and the two electrodes 1 and 2 detect a potential difference in the gas plasma. The potential difference is dependent on the electrode spacing and the capacitive coupling between the RF plates and the gas. When the tube is located at the central position between the plates, the potentials on the electrodes are the same; but when the tube is displaced from this central position, a DC potential difference will be created. Thus, the ionization transducer is a useful device for measuring displacement.
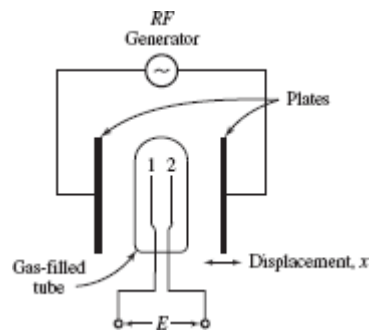
Figure.11 Schematic diagram of an ionization-displacement transducer

Hall-Effect Transducers

The principle of the Hall Effect is indicated in Fig. 4.63. A semiconductor plate of thickness t is connected as shown so that an external current I passes through the material. When a magnetic field is impressed on a plate in a direction perpendicular

to the surface of the plate, there will be potential EH generated as shown. This potential is called the Hall voltage and is given by

$$E_H = K_H \frac{IB}{t}$$

Where,

       I is in amperes

       B is in gauss

       t is in centimeters.

The proportionality constant is called the *Hall coefficient* and has the units of volt-centimeters per ampere gauss.
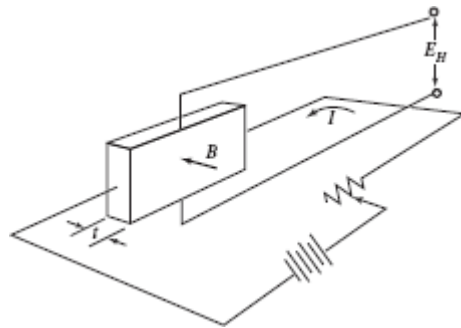
Figure.12The Hall Effect

Digital Displacement Transducers

      A digital displacement transducer can be used for both angular and linear measurements. In Fig. 13 an angular measurement device is shown. As the wheel rotates, light from the source is alternately transmitted and stopped, thereby submitting a digital signal to the photo detector. The signal is then amplified and sent to a counter. The number of counts is proportional to angular displacement. The frequency of the signal is proportional to angular velocity. Sensitivity of the device may be improved by increasing the number of cutouts. A linear transducer which operates on a reflection principle is shown in Fig. 14.Small reflecting strips are installed on the motion device. Light from the source is then alternately reflected and absorbed with linear motion, thereby presenting a digital signal to the photo detector. Readout is the same as with the angular instrument. Calibration with a known displacement standard must be performed.
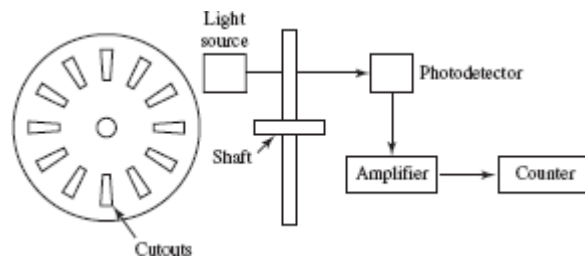
Figure13. Digital transducer for Angular Displacement
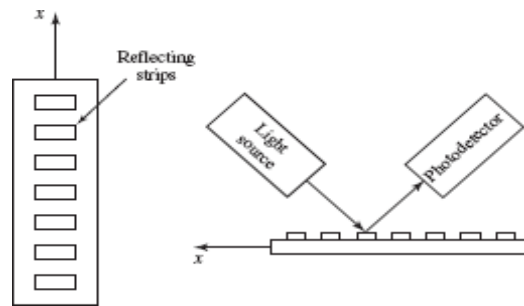
Figure14. Digital transducer for Linear Displacement

Objective

At the end of the lab session, students will have the knowledge of hydraulic, pneumatic and electro pneumatic circuits, and various graphical symbols used and to draw the circuit for various purposes.

Hydraulic circuit:

A hydraulic circuit is defined as the graphical representation of the hydraulic components in a hydraulically operated machine.

Components:
Hydraulic power pack:

Pump, drive motor, mechanical couplings, oil reservoir, strainers, filter, coolers.

Hydraulic control elements:

Directional control valves, pressure control valves, flow control valves, electrical control valves.

Power drive units or actuators:

Hydraulic cylinders and motors.

System accessories:

Fluid conductors, accumulators, boosters, pressure and temperature gauges, filters.

Factors to be considered:

- Safety of Operation
- Meet functional requirements
- Efficiency of Operation

Linear circuits:
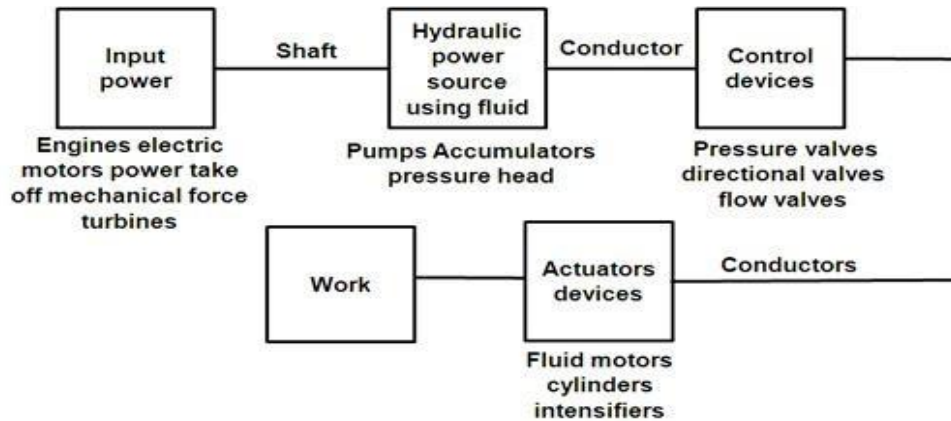
Fig
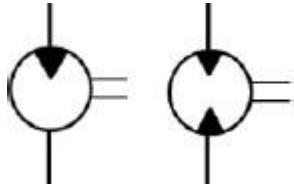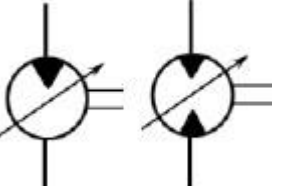
Symbols for ports

Port	Letter system	Number system
Pressure port	P	1
Working port	A	4
Working port	B	2
Exhaust port	R	5
Exhaust port	S	3
Pilot port	Z	14
Pilot port	Y	12
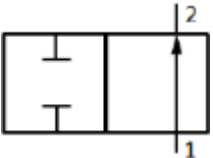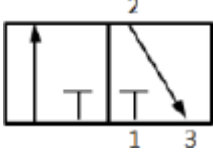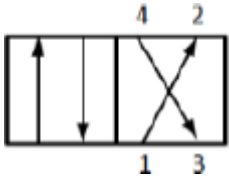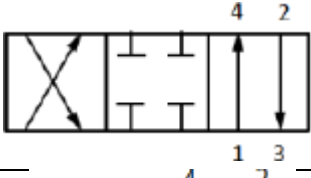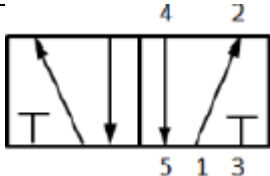
Graphical symbols of hydraulic elements and equipments

Rotary Actuators

SYMBOL	DESIGNATION	EXPLANATION
	Hydraulic pump	One direction and two direction of rotation with constant displacement volume
		One direction and two direction of rotation with variable displacement
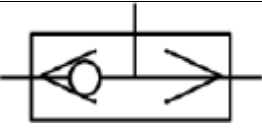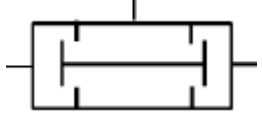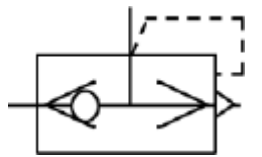
SYMBOL	DESIGNATION	EXPLANATION
	Hydraulic motor	One direction and two direction of rotation with constant displacement volume
		One direction and two direction of rotation with variable displacement

Direct Control Valve
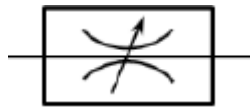
SYMBOL	DESIGNATION	EXPLANATION
	2/2 way valve	Two closed ports in the closed neutral position and flow during actuated position
	3/2 way valve	In the first position flow takes place to the cylinder In the second position flow takes out of the cylinder to the exhaust (Single acting cylinder)
	4/2 way valve	For double acting cylinder all the ports are open
	4/3 way valve	Two open positions and one closed neutral position
	5/2 way valve	Two open positions with two exhaust ports

Non Return Valves
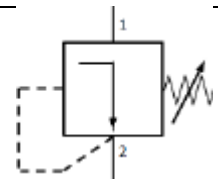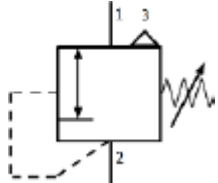
SYMBOL	DESIGNATION	EXPLANATION
	Check valve	Allows flow in one direction and blocks flow
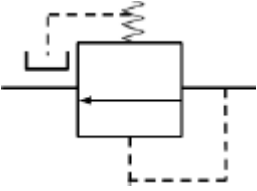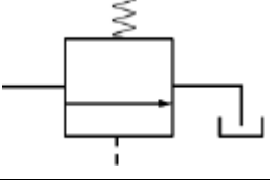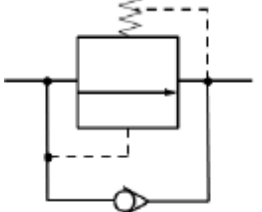
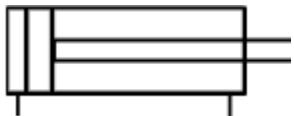|		in other direction
	Spring loaded check valve	In the first position flow takes place to the cylinder In the second position flow takes out of the cylinder to the exhaust (Single acting cylinder)
	Shuttle/ OR valve	When any one of the input is given the output is produced
	AND valve	Only when both the inputs are given output is produced
	Quick exhaust valve	For quick exhaust of air to cause rapid extension/ retraction of cylinder

Flow Control Valves

SYMBOL	DESIGNATION	EXPLANATION
	Flow control valve	To allow controlled flow
	Flow control valve with one way adjustment	To allow controlled flow in one direction and free flow in other

Pressure Control Valves

SYMBOL	DESIGNATION	EXPLANATION
	Pressure relieving valve	Non relieving type
		Relieving type with overload being vented out

SYMBOL	DESIGNATION	EXPLANATION
	Pressure reducing valve	Maintains the reduced pressure at specified location in hydraulic system
	Unloading valve	Allows pump to build pressure to an adjustable pressure setting and then allow it to be discharged to tank
	Counter balance valve	Controls the movement of vertical hydraulic cylinder and prevents its descend due to external load weight

Actuators

SYMBOL	DESIGNATION	EXPLANATION
	Single acting cylinder	Spring loaded cylinder with retraction taking place by spring force
	Double acting cylinder	Both extension and retraction by pneumatic/hydraulic force

Control of a single acting hydraulic cylinder

Circuit:

The circuit of a two-position, three way, manually operated, spring offset directional control valve is given. This circuit can be used to control the operation of single-acting cylinder. This circuit has a reservoir, a pump, a pressure relief valve, a 3/1 DC valve, and a single-acting cylinder

Two Position Two Way Manually Actuated Spring Offset DCV
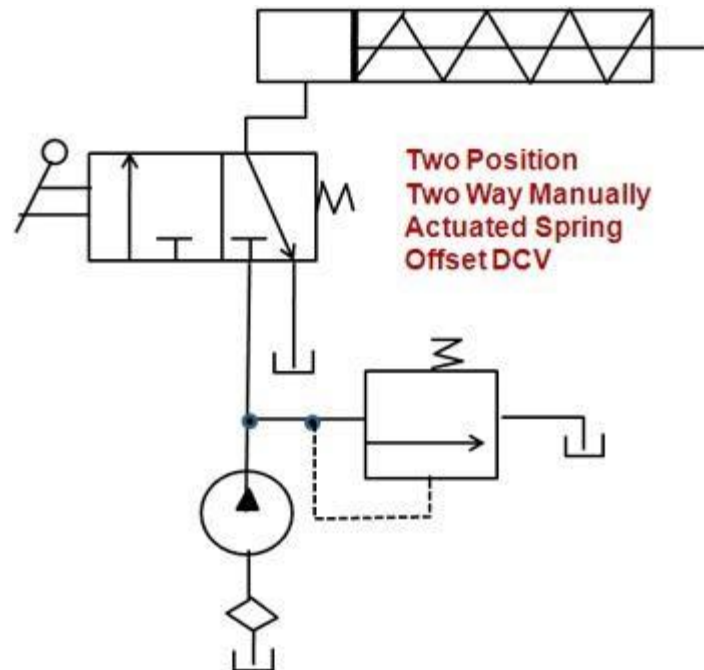
Operation:

Extension: When the 3/2 DC valve is manually shifted to the left mode (ie., left envelope flow path configuration), the oil flows from the pump to blind end of cylinder. This pump flow extends the cylinder. Once full extension is over, the 3/2 DC valve is shifted to the right envelope.

Retraction: When the 3/2 DC valve is shifted to the right mode, the pump flow is diverted to the tank via the pressure relief valve. Now the spring in the cylinder retracts the piston to send the oil back to the tank.

Control of a double acting hydraulic cylinder

Circuit:

The circuit of a three-position, four way, manually operated directional control valve and a double-acting cylinder.

Three Position Four Way Manually Actuated Spring Centered DCV
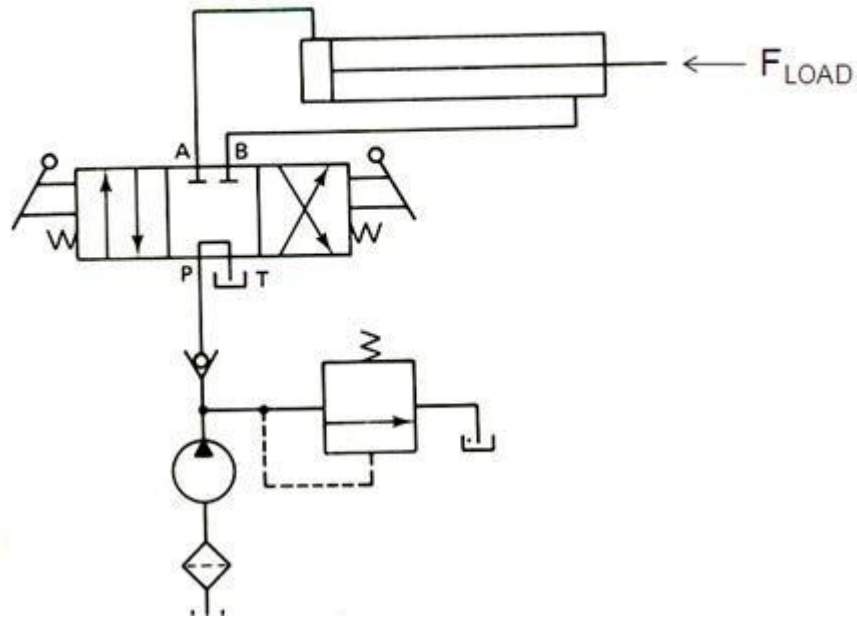
Operation:

Extension: When the 4/3 DC valve is manually shifted to the left mode (ie. left envelope flow path configuration), oil from the pump flows to the blind end of cylinder. As oil flows from port P through port A, the cylinder, is extended against the load force F_{load}. At the same time, the oil in the rod side of the cylinder flows back freely to the tank (via the 4/3 valve from port B through port T).

Retraction: At the end of the extension stroke, the 4/3 DC valve is manually shifted to the right envelope. When DCV is shifted to the right mode, the oil from the pump flows to the rod end of the cylinder. As oil flows from port P through port B, the cylinder is retracted. At the same time, oil in the blank end flows back freely to the tank (via the flow path from port A to port T).

Cylinder locking: When the 4/3 DCV is shifted to the centre position (ie. spring centered position in tandem design), the pump flow completely goes to tank and hence the cylinder is hydraulically locked.

Hydraulic cylinder for drilling machine

Circuit:

The below figure illustrates the circuit that can be used to produce a rapid extension of the cylinder (drill spindle) in the drilling machine application. This circuit uses a 4/3 DCV (open centered position) and a double acting cylinder.
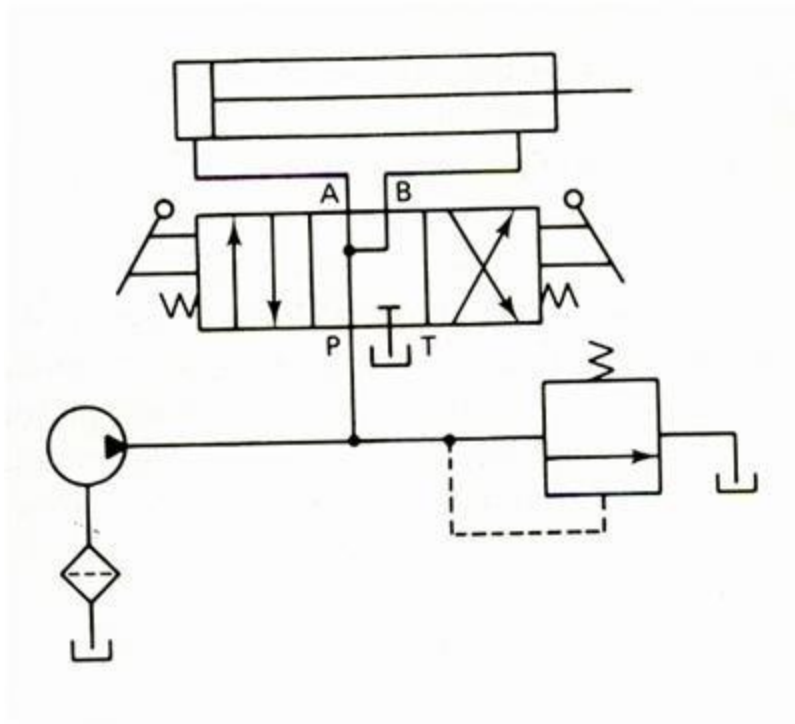
Operation:

Left mode: When the 4/3 DCV is shifted to the left envelope flow path configuration, the cylinder extends in the same manner as that of a regular double-acting cylinder.
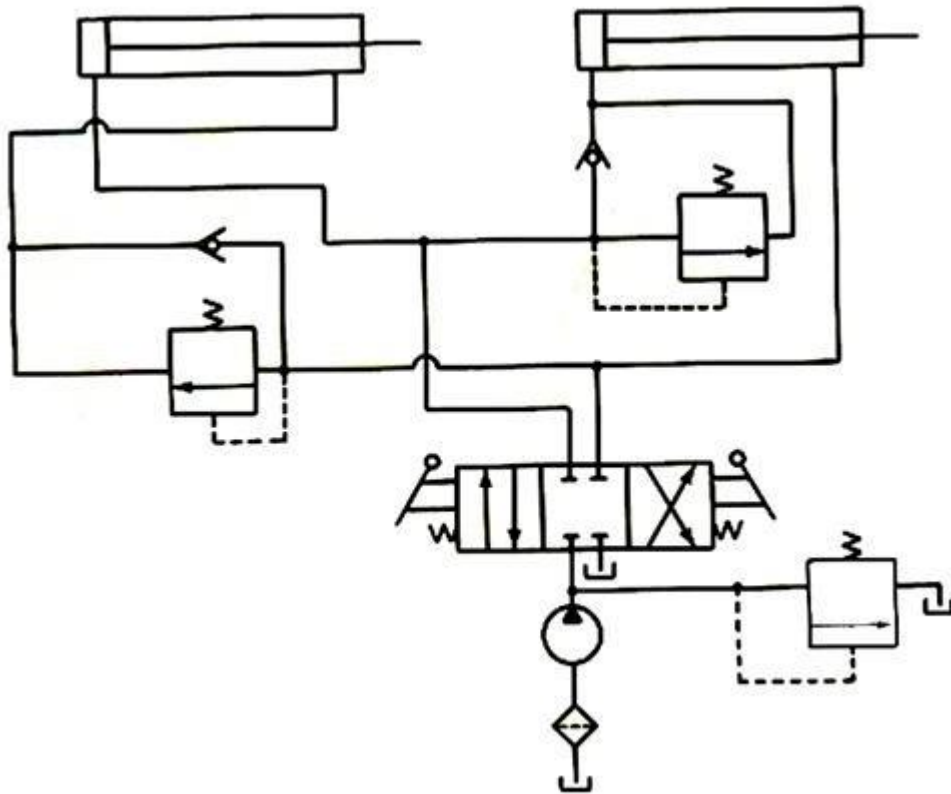
Right mode: When the 4/3 DCV is shifted to the right envelope flow path configuration, the cylinder retracts in the same manner as that of a regular double-acting cylinder.

Spring-Centered position: When the 4/3 DCV is shifted to the spring centered position, the oil from the rod end regenerates with the pump flow entering to the blank end. This effectively increases pump flow to the blank end of the cylinder. Thus the Spring-Centered position gives rapid extension of the cylinder (drill spindle).

Hydraulic cylinder sequence circuit (for clamping and punching operations)

Circuit:

      The below figure illustrates the circuit uses two sequence valves to control the sequence of operations of two double-acting cylinder. This circuit has a manually operated, spring centered 4/3 DCV, two sequencing valves, two check valves, and a pressure relief valve. Take the cylinder-1 is used to clamp the work piece and cylinder-2 is to perform punching, and the sequence of operation as clamping first and punching second.
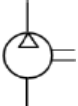

Operation:

      Left mode: When the 4/3 DCV is shifted manually to the left envelope flow path configuration, the cylinder-1 extends completely and the work piece is clamped. Once the cylinder-1 reaches its end of the stroke, pressure is increased and sequence valve 1 opens and the oil starts to flow into the cylinder-2. Now the cylinder-2 extends to drive a spindle to do punching operation in the work piece.

      Right mode: When the 4/3 DCV is shifted to the right mode, the cylinder-2 retracts. Once the cylinder-2 retracts completely, the sequence valve 2 opens and the oil starts to flow into the cylinder-1. It causes the cylinder-1 to retract and hence the unclamping of work piece is achieved.
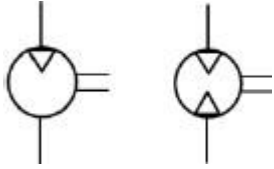
Spring-Centered position: When the 4/3 DCV is shifted to the spring centered position, the oil drains back to the tank through the pressure relief valve. Thus during the spring-centered position, both cylinders are hydraulically locked.
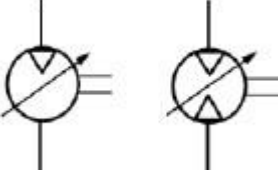
Pneumatics circuits

Pneumatic circuit is defined as the graphic representation of the pneumatic components in a pneumatically operated machine.
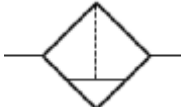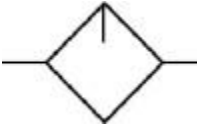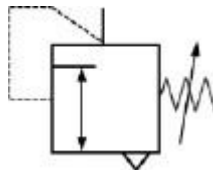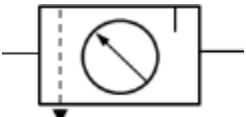
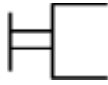| SYMBOL	DESIGNATION	EXPLANATION
⊙—	Main air supply	Supply of air from main
◁—	Exhaust air	Supply of air from exhaust
↑	Air Bleed	Bleeding of air
—┼—	Air pipes connected	Two pipes are connected
┼─⟩	Air pipes not connected	Two pipes are not connected
	Air compressor	One direction of rotation only with constant displacement volume
	Air receiver	Compressed air from the compressor is stored and diverted to the system when required

Rotary Actuators

SYMBOL	DESIGNATION	EXPLANATION
	Pneumatic motor	One direction and two direction of rotation with constant displacement volume
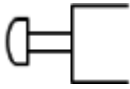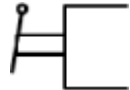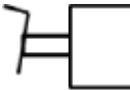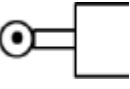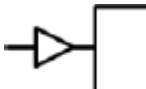
		One direction and two direction of rotation with variable displacement

Service Units

SYMBOL	DESIGNATION	EXPLANATION
	Air filter	This device is a combination of filter and water separator
	Dryer	For drying the air
	Lubricator	For lubrication of connected devices, small amount of oil is added to the air flowing through this device
	Regulator	To regulate the air pressure
	FRL unit	Combined filter, regulator and lubricator system

Direction control valve actuation methods

SYMBOL	DESIGNATION	EXPLANATION
	General manual actuation	Manual operation of DCV

	Push button actuation	
	Lever actuation	
	Detent lever actuation	
	Foot pedal actuation	Mechanical actuation of DCV
	Roller lever actuation	
	Idle return roller actuation	
	Spring actuation	
	Direct pneumatic actuation	Pneumatic actuation of DCV

Single-acting cylinder with three-port valve

In a single-acting cylinder compressed air is used to push a piston out, and a spring to push it in again. When compressed air is supplied to the cylinder, the piston rod extends (called the outstroke). When the air supply is switched off, the internal spring returns the piston rod to its retracted position (the instroke). The movement of a single-acting cylinder is normally controlled by a three-port valve - a type of simple switch which governs the flow of air. In the diagram below, a unidirectional-flow control valve is used to slow the speed of the piston on the outstroke. The instroke will be full speed. Press play to see how this works.
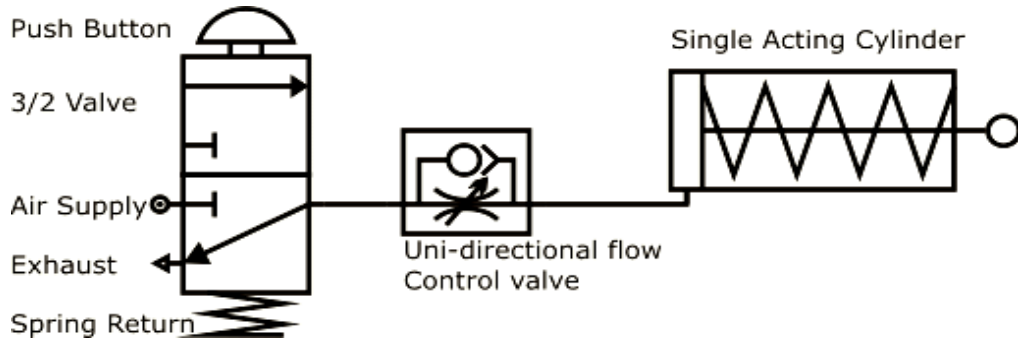
Figure 3/2 push button spring return valve and single acting cylinder

Double-acting cylinder with five-port valve
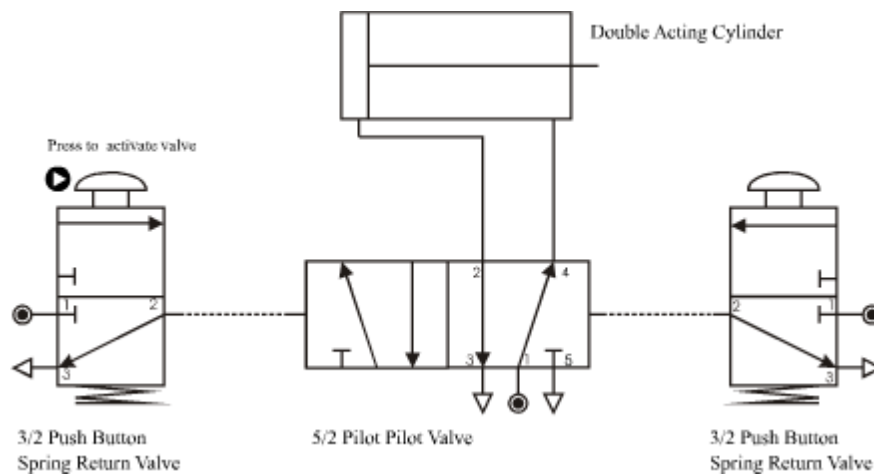
Pilot signals flow from the 3/2s to the sides of the 5/2 when the 3/2 is activated. These yellow pilot signals pushes the spool inside the 5/2 and let's work air flow up to the double-acting cylinder, a pilot signal from the left makes a work air signal come out the top left port of the 5/2, similarly for the right. The work air is shown as red circles entering the double-acting cylinder. As the cylinder rod moves positive it pushes the air inside the front half of the double acting cylinder out an exhaust port on the 5/2, shown as blue circles. It is this exhaust air that can be used to control the speed of a cylinder.
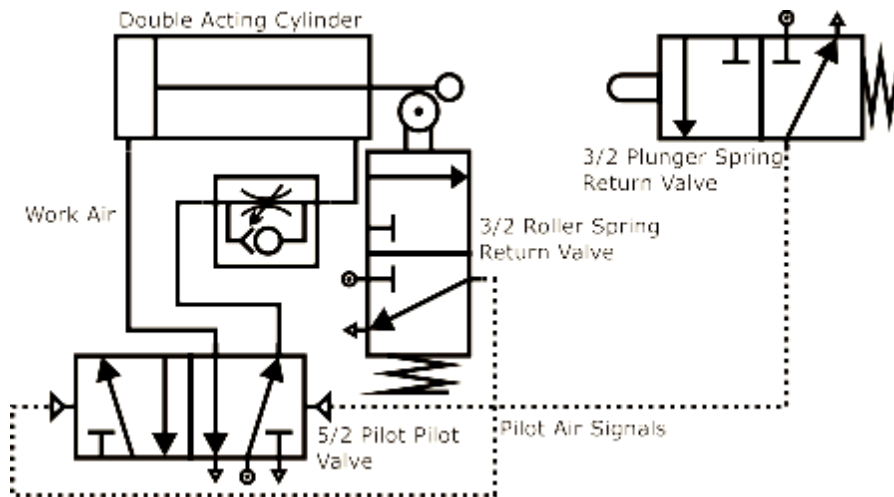
Figure 5/2 Pilot valve and double acting cylinder

When the piston on the double-acting cylinder is retracted (completes the in stroke), the piston activates the roller control, allowing air to pass through the 3/2 roller spring return valve. The air output from the three-port valve activates the left side of the 5/2 pilot valve (these are connected by the dashed line), releasing air at the top left of the 5/2 and causing the piston to outstroke. Air in front of the piston rod is pushed out the rod. This exhaust air can be used to control the speed of the outstroke by the unidirectional-flow control valve.

When the piston is fully extended, it operates the plunger, causing the 3/2 plunger spring return valve to send out a signal. The air released by the 3/2 plunger spring return valve activates the right side of the 5/2 pilot valve (these are connected by the dashed line). This signal causes air to be released from the top right of the 5/2 causing the piston to retract, or go negative. When the piston on the double acting cylinder is retracted (completes the in stroke), the piston operates the roller-trip control and the cycle is then repeated.

Electro Pneumatic Circuit

Electro Pneumatic control integrates pneumatic and electrical technologies, is more widely used for large applications.

In Electro Pneumatics, the signal medium is the electrical signal either AC or DC source is used. Working medium is compressed air. Operating voltages from around 12 V to 220 Volts are often used.

The final control valve is activated by solenoid actuation. The resetting of the valve is either by spring [single Solenoid] or using another solenoid [Double solenoid Valve].

Control of Electro Pneumatic system is carried out either using combination of Relays and Contactors or with the help of Programmable Logic Controllers [PLC].

In Electro pneumatic controls, mainly three important steps are involved:

- Signal input devices -Signal generation such as switches and contactor, Various types of contact and proximity sensors

- Signal Processing – Use of combination of Contactors of Relay or using Programmable Logic Controllers

- Signal Out puts – Out puts obtained after processing are used for activation of solenoids, indicators or audible alarms

Seven Basic Electrical Devices

- Manually actuated push button switches

- Limit switches

- Pressure switches

- Solenoids

- Relays

- Timers

- Temperature switches

Other devices used in electro pneumatics are

- Proximity sensors

- Electric counters

Electro-Pneumatic control system:
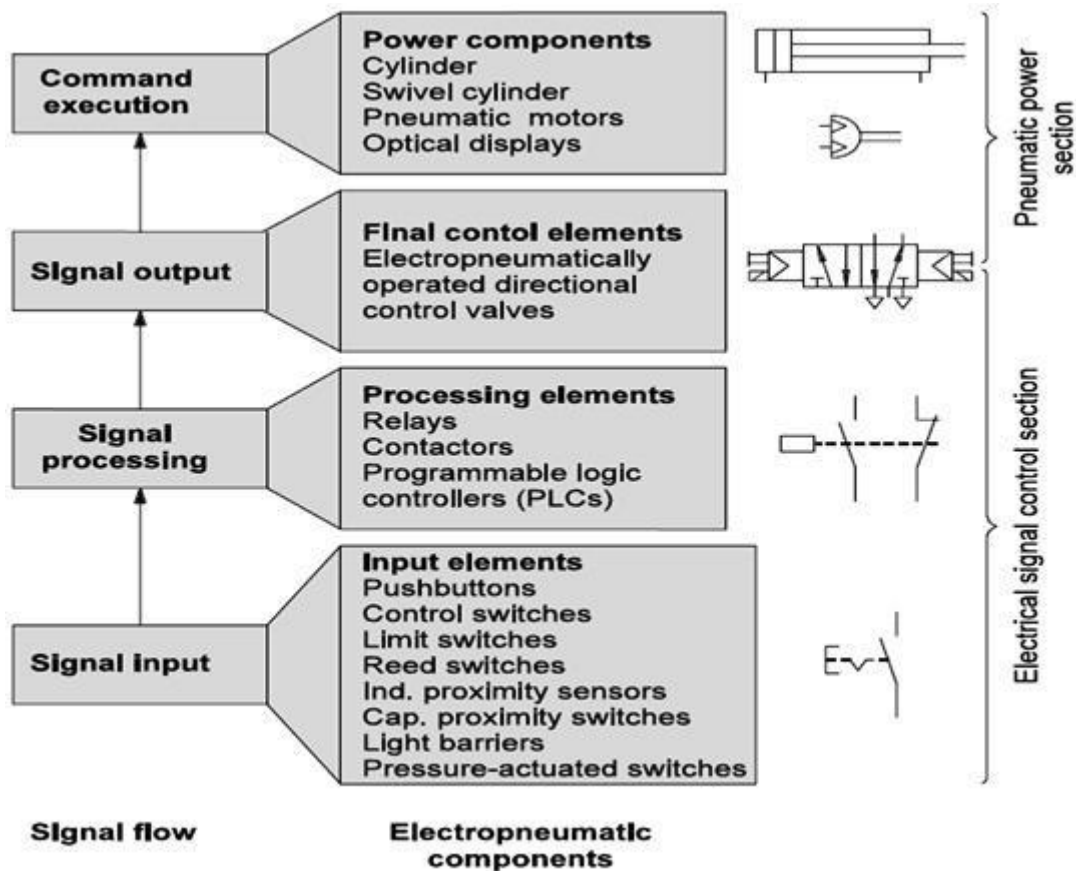
Figure Operation of Electro-pneumatic

Push button

A push button is a switch used to close or open an electric control circuit. They are primarily used for starting and stopping of operation of machinery. They also provide manual override when the emergency arises. Push button switches are actuated by pushing the actuator into the housing. This causes set of contacts to open or close.

The contact of the push buttons, distinguished according to their functions,

- Normally open (NO) type
- Normally closed (NC) type
- Change over (CO) type.

The cross section of various types of push buttons in the normal and actuated positions and their symbols are given in the Figure 1.1 In the NO type, the contacts

are open in the normal position, inhibiting the energy flow through them. But in the actuated position, the contacts are closed, permitting the energy flow through them. In the NC type, the contacts are closed in the normal position, permitting the energy flow through them. And, the contacts are open in the actuated position, inhibiting the energy flow through them. A changeover contact is a combination of NO and NC contacts.
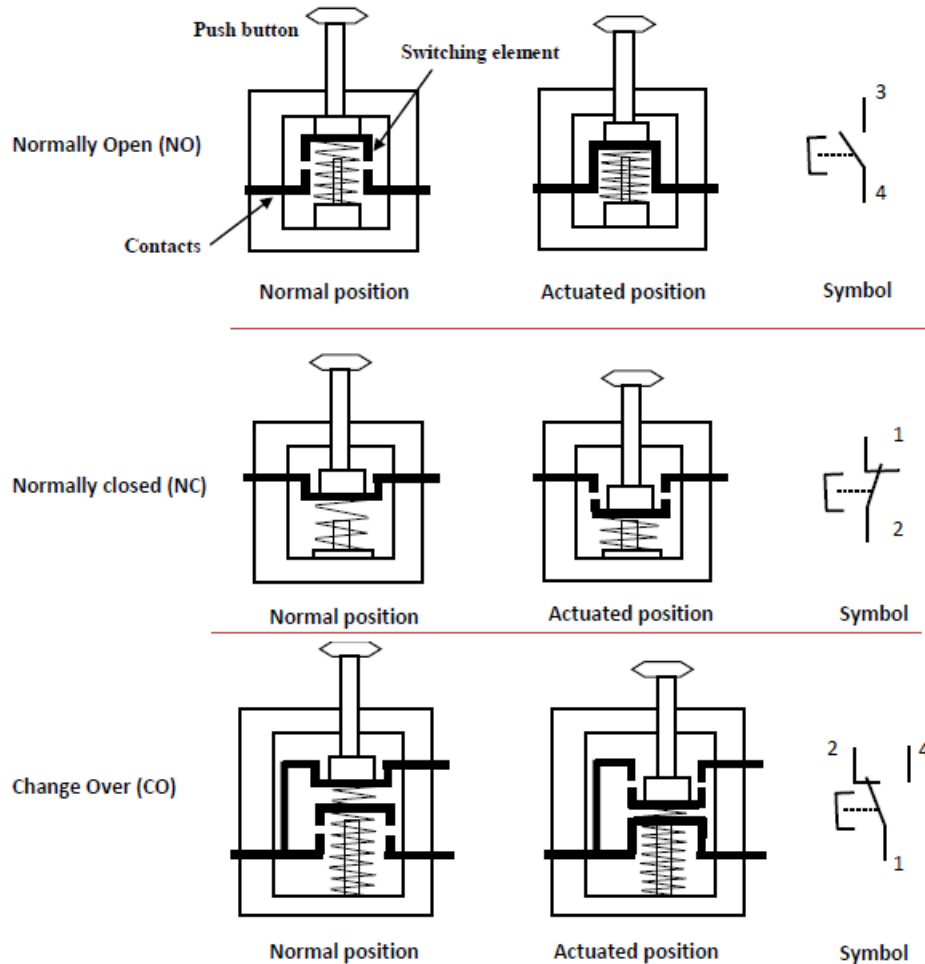
Figure Push button

Limit switches

Any switch that is actuated due to the position of a fluid power component (usually a piston rod or hydraulic motor shaft or the position of load is termed as limit switch. The actuation of a limit switch provides an electrical signal that causes an appropriate system response. Limit switches perform the same function as push button switches. Push buttons are manually actuated whereas limit switches are mechanically actuated.

There are two types classification of Limit switches depending upon method of actuations of contacts

- Lever actuated contacts

- Spring loaded contacts

In lever type limit switches, the contacts are operated slowly. In spring type limit switches, the contacts are operated rapidly. Figure 1.2 shows a simplified cross sectional view of a limit switch and its symbol.
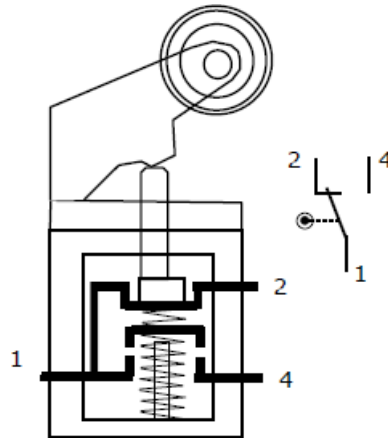
Figure 1.2: Cross sectional view of a limit switch

Pressure switches

A pressure switch is a pneumatic-electric signal converter. Pressure switches are used to sense a change in pressure, and opens or closes an electrical switch when a predetermined pressure is reached.

Bellow or diaphragm is used to sense the change of pressure. Bellows or Diaphragm is used to expand or contract in response to increase or decrease of pressure.

Figure shows a diaphragm type of pressure switch. When the pressure is applied at the inlet and when the pre-set pressure is reached, the diaphragm expands and pushes the spring loaded plunger to make/break contact.
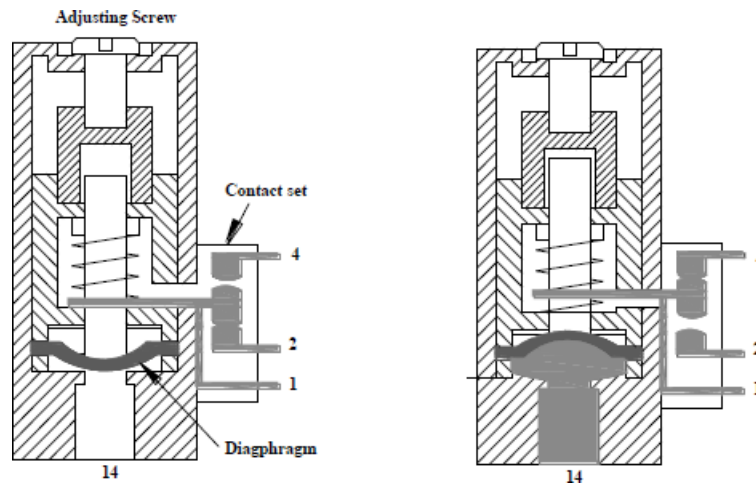
Figure Cross sectional view of a pressure switch

Solenoids

Electrically actuated directional control valves form the interface between the two parts of an electro-pneumatic control. The most important tasks of electrically actuated DCVs include.

- Switching supply air on or off

- Extension and retraction of cylinder drives

Electrically actuated directional control valves are switched with the aid of solenoids. They can be divided into two groups:

- Spring return valves only remain in the actuated position as long as current flows through the solenoid

- Double solenoid valves retain the last switched position even when no current flows through the solenoid.

In the initial position, all solenoids of an electrically actuated DCVs are de-energized and the solenoids are inactive.

A double valve has no clear initial position, as it does not have a return spring. The possible voltage levels for solenoids are 12 V DC, 12V AC, 12 V 50/60 Hz, 24V 50/60 Hz, 110/120V 50/60 Hz, 220/230V 50/60 Hz.

a) 3/2 Way single solenoid valve, spring return.
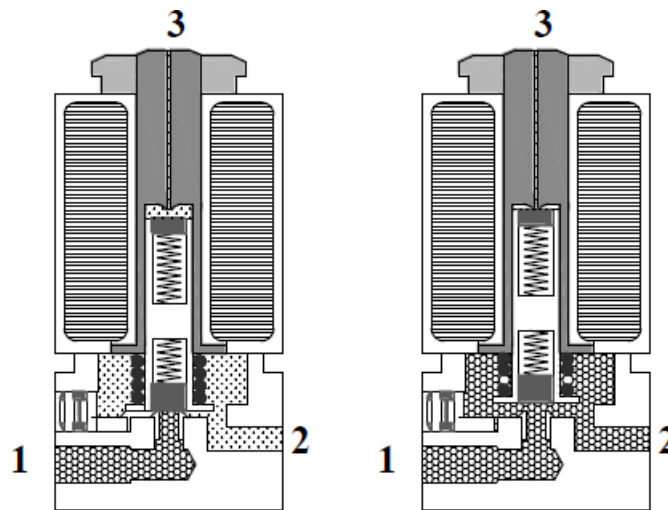
Figure Cross sectional view of a 3/2 single solenoid valve

The cross sectional view of 3/2 way single solenoid valve in the normal and actuated positions are shown in Figure In the normal position, port 1 is blocked and port 2 is connected to port 3 via back slot (details shown in the circle) When the rated voltage is applied to coil, armature is pulled towards the centre of the coil and in the process the armatures is lifted away from the valve seat. The compressed air now flows from port 1 to port 2, and ports 3 is blocked. When the voltage to the coil is removed, the valve returns to the normal position. Figure 1.5 shows 2/2 solenoid operated valve
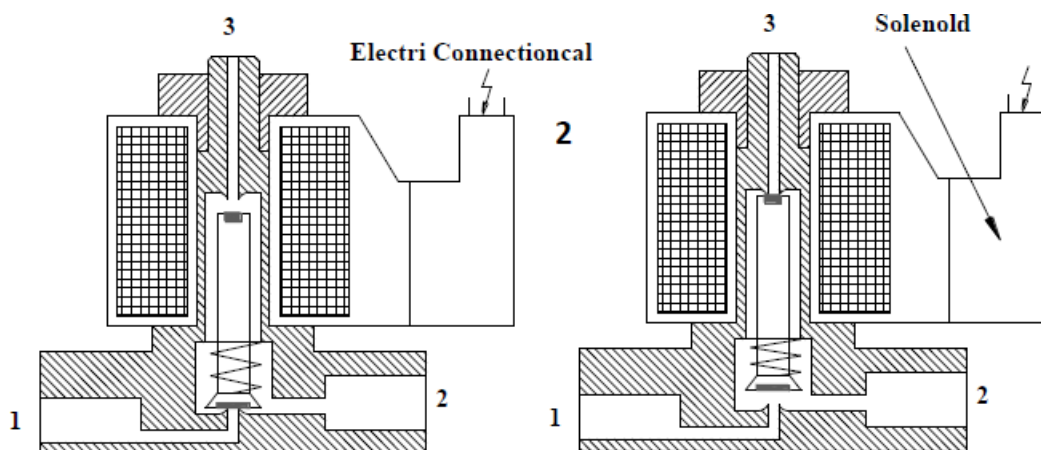
Figure 2/2 solenoid operated valve

Various symbols solenoid valves

Symbol	Details
	3/2 way Single solenoid valve (spring return)
	3/2 way pilot operated single solenoid valve(spring return)
	5/2 way single solenoid Valve (spring return)
	5/2 way double solenoid valve.
	5/2 way piloted operated double solenoid valve.

Relays

A relay is an electro magnetically actuated switch. It is a simple electrical device used for signal processing. Relays are designed to withstand heavy power surges and harsh environment conditions.

When a voltage is applied to the solenoid coil, an electromagnet field results. This causes the armature to be attracted to the coil core. The armature actuates the relay contacts, either closing or opening them, depending on the design.

A return spring returns the armature to its initial position when the current to the coil is interrupted. Cross sectional view of a relay is shown in Figure 1.8

A large number of control contacts can be incorporated in relays in contrast to the case of a push button station. Relays are usually designated as K1, K2, and K3 etc. Relays also possess interlocking capability that is an important safety feature in control circuits. Interlocking avoids simultaneous switching of certain coils.
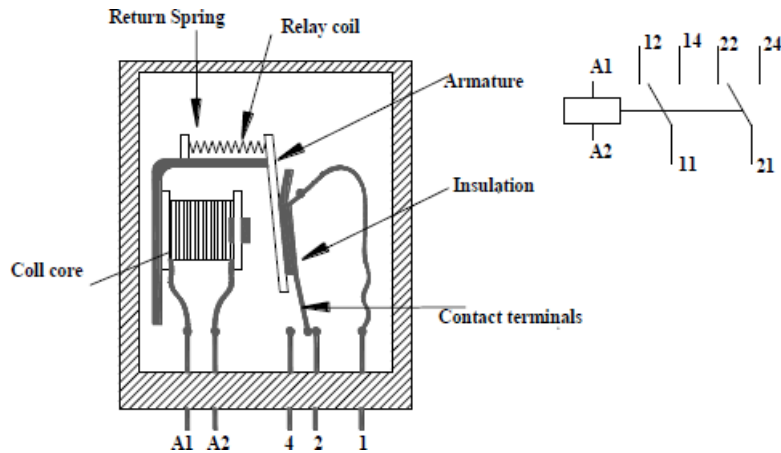
Figure Cross sectional view of a relay

Temperature Switch

Temperature switches automatically senses a change in temperature and opens or closes an electrical switch when a predetermined temperature is reached. This switch can be wired either normally open or normally closed.

Temperature switches can be used to protect a fluid power system from serious damage when a component such as a pump or strainer or cooler begins to malfunction.

Reed Proximity switches

Reed switches are magnetically actuated proximity switches. Reed switches are similar to relays, except a permanent magnet is used instead of a wire coil. Schematic diagram of reed switch is shown in Figure 1.1.

The reed switches comprise two ferromagnetic reeds placed with a gap in between and hermetically sealed in a glass tube. The glass tube is filled with inert gas to prevent the activation of the contacts. The surfaces of the reed contacts are plated with rhodium or iridium.

Whole unit is encapsulated in epoxy resin to prevent mechanical damage to the switch. They are also provided with LED indicator to show its switching status. When the magnet is away the switch is open, but when the magnet is brought near the switch is closed.

The reed switch is operated by the magnetic field of an energized coil or a permanent magnet which induces north (N) and south (S) poles on the reeds. The reed contacts are closed by this magnetic attractive force.

When the magnetic field is removed, the reed elasticity causes the contacts to open the circuit. The transfer type reed switch is normally ON, due to mechanical bias of the common (COM) lead, which is between the normally closed (N.C) reed contact and the normally open (N.O) reed contacts.

When an external magnetic field is induced, the N.C blade is not affected because it is non-magnetic but the COM lead is attracted by the N.O lead and moves. When the magnetic field is removed, COM lead again moves to the N.C lead by mechanical.
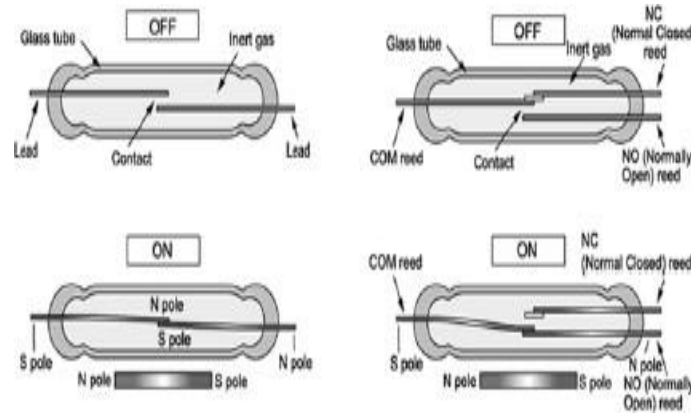
Figure 1.10: Construction features of reed switch

The two wire reed switch consists of two reeds. One of reed is connected to positive terminal of electric supply and other is connected to signal output. The three wire reed wire consists of three reed contacts.

One is connected to positive terminal of electric supply. Second one is connected to negative terminal of the electric supply and third one is connected to the signal output. Symbol of the three wire reed switch and two wire reed switch is shown in Figure 1.11
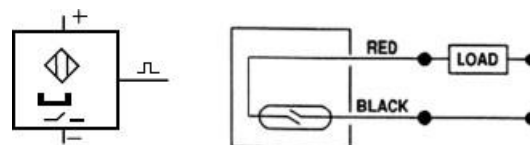
Figure 1.11: Symbol of 3 wire and 2 wire reed switch

Electronic sensors

Inductive, Optical and capacitive proximity switches are electronic sensors. They normally have three electrical contacts. One contact for supply voltage , other for ground and third for output signal.

In these sensors, no movable contact is switched. Instead, the output is either electrically connected to supply voltage or to ground. There are two types of electronic sensors with regard to the polarity of output voltage.

Positive switching sensors: In this output voltage is zero if no part is detected in the proximity. The approach of a work piece or machine part leads to switch over of the output, applying the supply voltage.

Negative switching sensors: In this the supply voltage are applied to the output if no part is detected in the proximity. The approach of a work piece or machine part leads to switch over of the output, switching the output voltage to 0 volts.

a) Inductive sensors

Inductive sensor use currents induced by magnetic field to detect the nearby metal objects. The inductive sensor uses a coil or inductor to generate a high frequency magnetic field as shown in Figure 1.12.

If there is a metal object near the changing magnetic field, current will flow in the object. This resulting current flow sets up a new magnetic field that opposes the original magnetic field. The net effect is that it changes the inductance of the coil in the inductive sensor.

By measuring the inductance the sensor can determine when a metal have been brought nearby. These sensors will detect any metals, when detecting multiple types of metal multiple sensors is used.

In addition to metals, graphite also can be sensed. It is important to note that these work by setting up a high frequency field. If a target nears the field will induce eddy currents. These currents consume power because of resistance, so energy is in the field is lost, and the signal amplitude decreases. The detector examines filed magnitude to determine when is has decreased enough to switch.
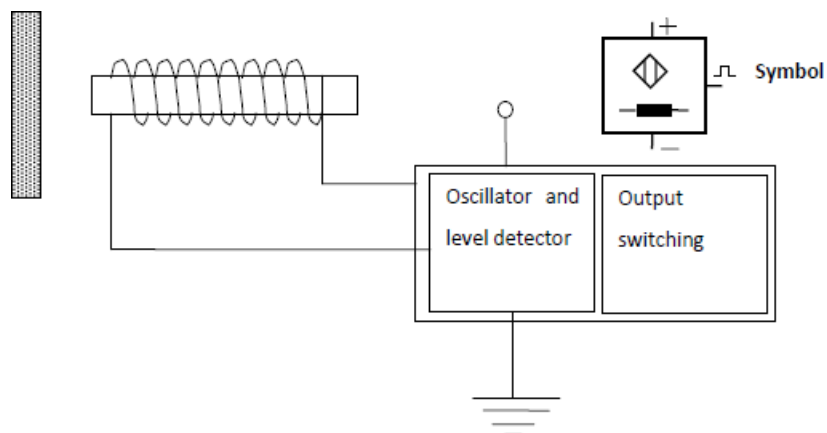
Figure Inductive sensor

Electro pneumatics circuits for single actuator

Control of single cylinders using electro pneumatics

Forward stroke: The circuit is closed when push button PB closes. A magnetic field is produced in the coil Y. The armature in the coil opens the passage for the compressed air. The compressed air flows from 1 to 2 of the 3/2 DCV to cylinder, which travels to the final forward position.

Position when cylinder is extended   Position when cylinder is retracted

Figure Direct control of single acting cylinder

Return stroke: When the push button PB is released, the circuit is interrupted. The magnetic field at coil Y collapses, the 3/2 way valve switches back to its original position as shown in Figure 1.27. The compressed air in the cylinder then exhausts through port 3 of the DCV and the cylinder travel to the final rear position.

Indirect control of single acting cylinder

Forward stroke: The circuit is closed when push button PB closes. Closing of Push button PB energizes a relay K1. The coil Y is energized via normally open contact K1 (indirect energizing).

A magnetic field is produced in armature of the coil Y opens the passage for the compressed air. The compressed air flows from 1 to 2 of the 3/2 DCV to cylinder, which travels to the final forward position.
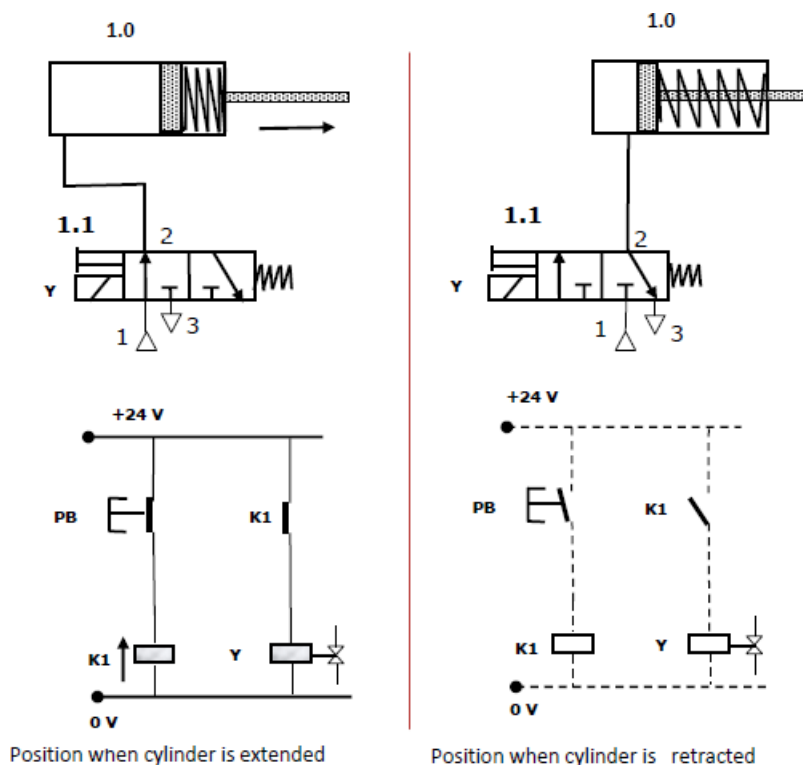
Figure Indirect control of single acting cylinder

Return stroke: When the push button PB is released, the circuit is interrupted. Opening of Push button PB de-energises a relay K1. The magnetic field at coil Y is collapses due to the opening of contact K1 the 3/2 way valve switches back to its original position as shown in Figure 1.28. The compressed air in the cylinder then exhausts through port 3 of the DCV and the cylinder travel to the final rear position.

Direct control of double acting cylinder

Forward stroke: The double acting cylinder is controlled by 5/2 way valve. When the pushbutton PB is pressed, coil Y is energised and the directional control valve is activated by compressed air via pilot control. The piston travels to the final forward position.

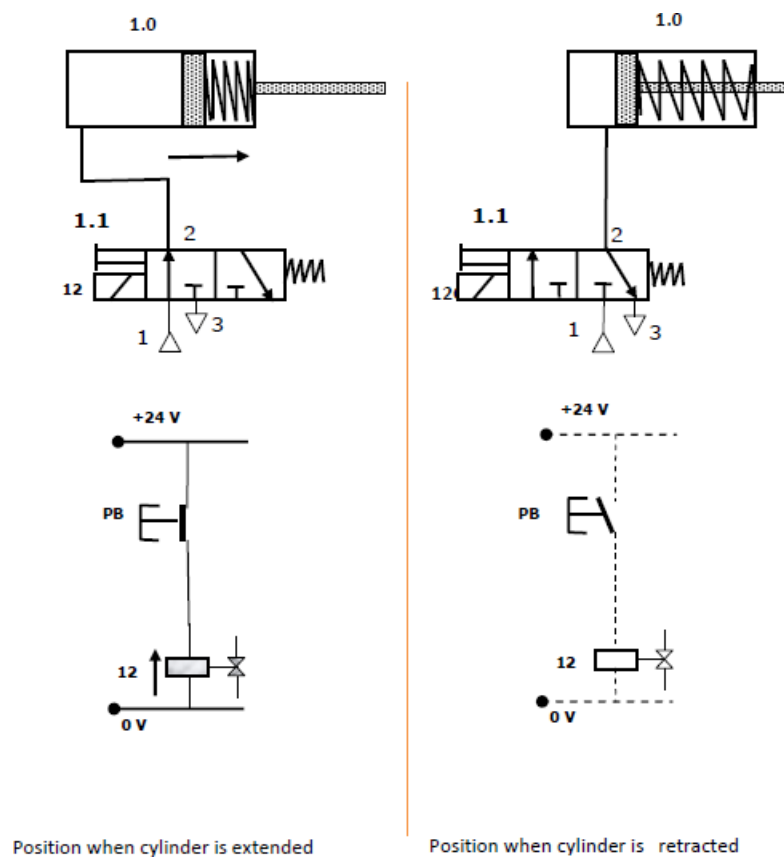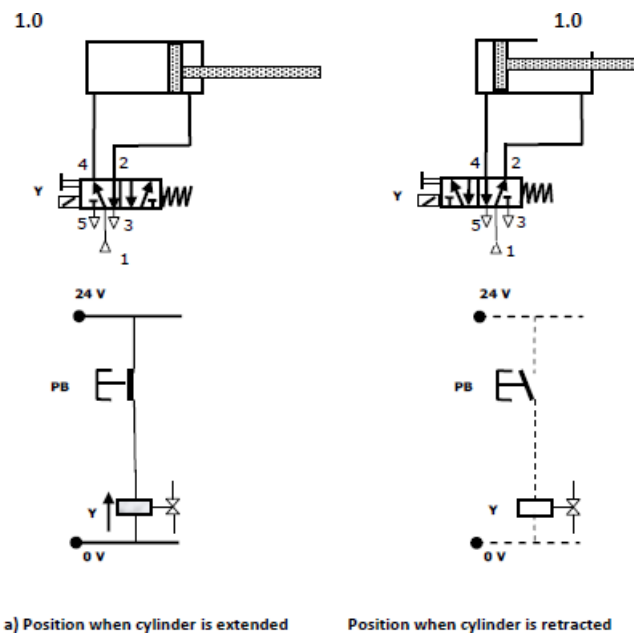a) Position when cylinder is extended   Position when cylinder is retracted

Figure Direct control of double acting cylinder

Return stroke: When the push button PB is released, the circuit is interrupted. The magnetic field at coil Y collapses, the return spring of 5/2 becomes active and the 5/2 way valve switches back to its original position as shown in Figure 1.29. The compressed air in the cylinder then exhausts through port 5 of the 5/2 DCV and the cylinder travel to the final rear position.

Ex. No:		
	Simulation Of Hydraulic, Pneumatic, Electro Pneumatic Circuit Using Fluidsim Software	**Page No.**
Date :		

Objective:

　　At the end of the lab session, students will have the knowledge to design and simulate a hydraulic, Pneumatic, Electro Pneumatic circuit by using fluidsim software.

Question 1: Draw a circuit for the operation of single acting cylinder using DCV in Hydraulic Trainer Kit

Apparatus Required

- HYDROSIM Software
- Single Acting Cylinder
- Flow Control Valve
- 3/2 Solenoid DCV
- Pump

Procedure:

- Draw the circuit in HYDROSIM software and check the connections.
- The various components are connected as per circuit.
- Block the valve openings if necessary.
- Check the leakage and correct it.
- Open the valve and operate the cylinder.

Circuit Diagram
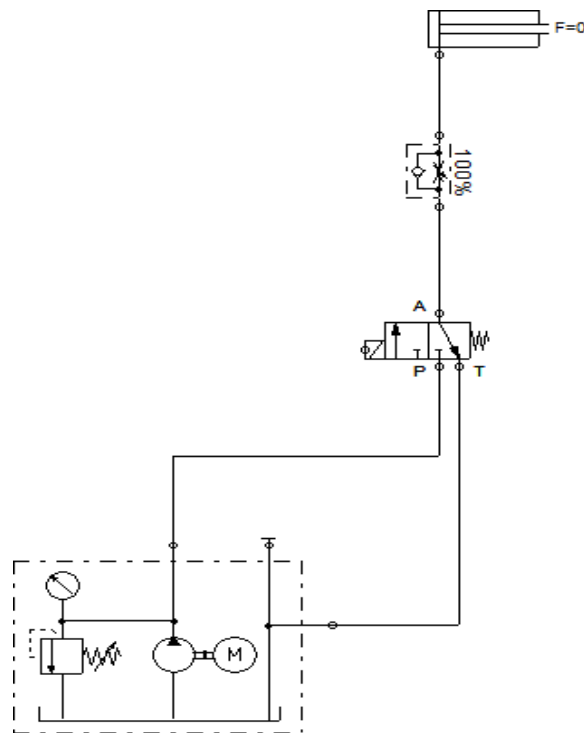
Question 2: Draw a circuit for the operation of double acting cylinder using DCV in Hydraulic Trainer Kit.

Apparatus Required

- HYDROSIM Software
- Double Acting Cylinder
- Flow Control Valve
- 4/2 Hand Levered valve
- Pump

Procedure:

- Draw the circuit in HYDROSIM software and check the connections.
- The various components are connected as per circuit.
- Block the valve openings if necessary.
- Check the leakage and correct it.
- Open the valve and operate the cylinder.

Circuit Diagram
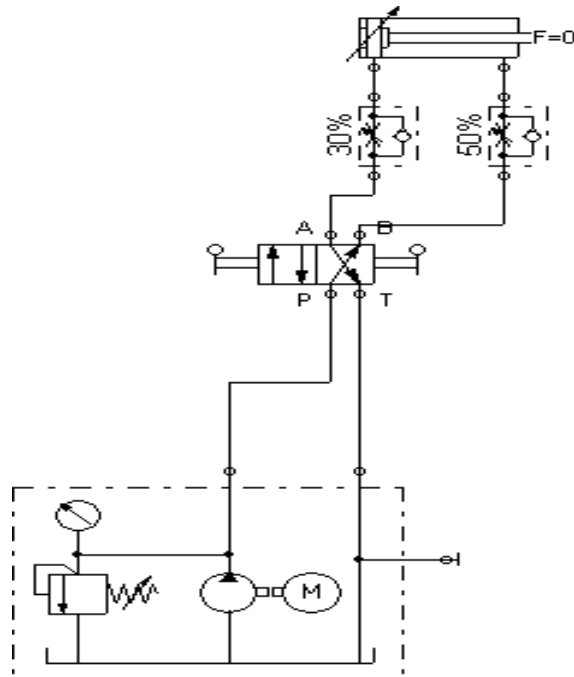
Question 3: Draw a circuit for the operation of two pneumatic cylinders simultaneously with synchronized movement using HYDROSIM software.

Apparatus Required

- HYDROSIM Software
- Double Acting Cylinder
- 4/3-way hand-lever valve with shutoff position
- Pump

Procedure:

- Draw the circuit in HYDROSIM software and check the connections.
- The various components are connected as per circuit.
- Block the valve openings if necessary.
- Check the leakage and correct it.
- Open the valve and operate the cylinder.

Circuit Diagram
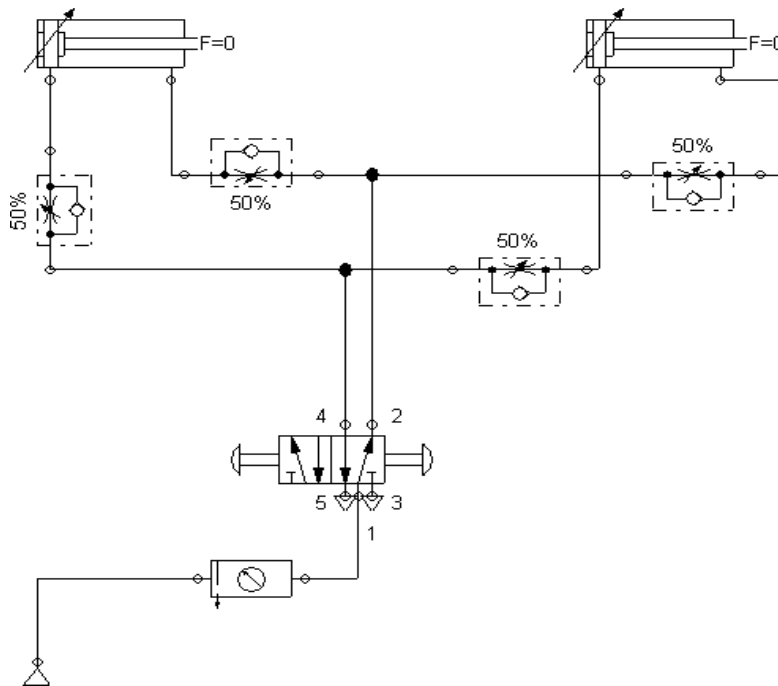
Question 4: Draw a circuit for the operation of double acting Cylinders in regenerative circuit using HYDROSIM software.

Apparatus Required

- HYDROSIM Software
- Double Acting Cylinder
- 4/3-way solenoid valve with floating position
- Pump

Procedure:

- Draw the circuit in HYDROSIM software and check the connections.
- The various components are connected as per circuit.
- Block the valve openings if necessary.
- Check the leakage and correct it.
- Open the valve and operate the cylinder.

Circuit Diagram
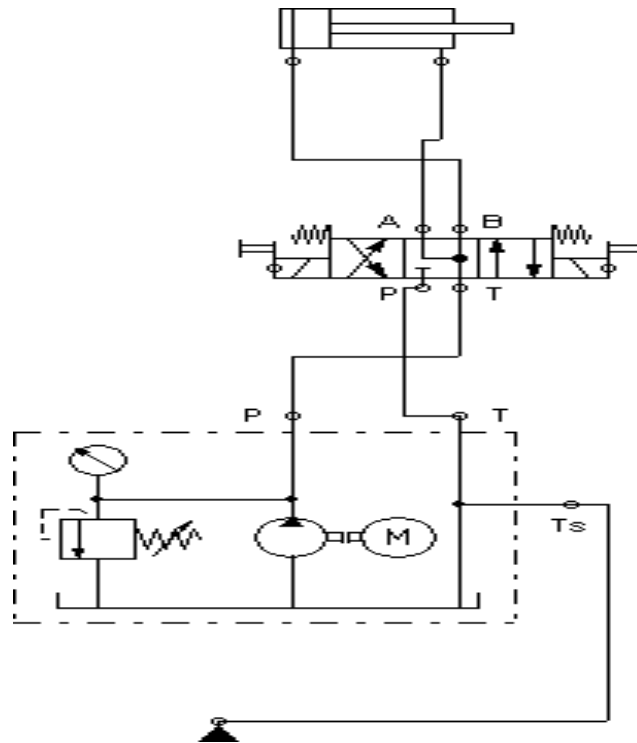
Question 5: Draw a circuit for the operation of double acting Cylinders in A+A- B+B-
using HYDROSIM software.

Apparatus Required

- HYDROSIM Software
- Double Acting Cylinder
- 3/2-way idle return roller valve, normally closed
- Pump

Procedure:

- Draw the circuit in HYDROSIM software and check the connections.
- The various components are connected as per circuit.
- Block the valve openings if necessary.
- Check the leakage and correct it.
- Open the valve and operate the cylinder.

Circuit Diagram
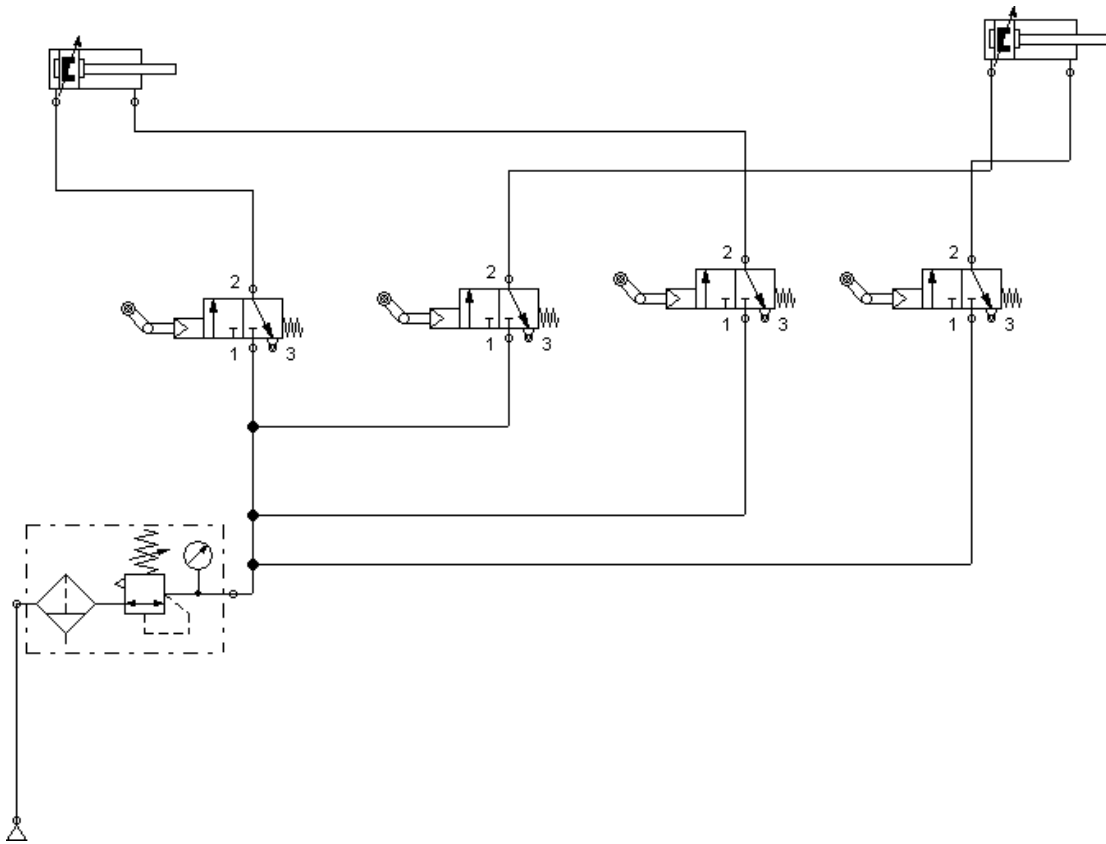
Question 6: Draw a circuit for the operation single acting cylinder using the Directional Control Valve (DCV) in Pneumatic Trainer Kit.

Apparatus Required

- FLUIDSIM Software
- Single Acting Cylinder
- 3/2 Hand Levered Spring Return DCV
- FRL Unit

Procedure:

- Draw the circuit in FLUIDSIM software and check the connections.
- Connect the FRL unit to the main air supply.
- The various components are connected as per circuit.
- Block the valve openings if necessary.

- Check the leakage of air supply and correct it.
- Open the valve and operate the cylinder.

Circuit Diagram
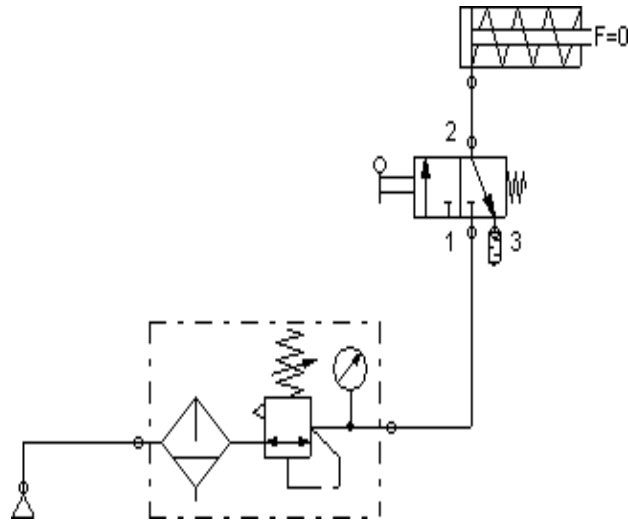
Question 7: Draw a circuit for the operation of double acting cylinder using the Directional Control Valve (DCV) in Pneumatic Trainer Kit

Apparatus required:

- FLUIDSIM Software
- Double Acting Cylinder
- 4/2 Hand Levered Spring Return DCV
- FRL Unit

Procedure:

- Draw the circuit in FLUIDSIM software and check the connections.
- Connect the FRL unit to the main air supply.
- The various components are connected as per circuit.
- Block the valve openings if necessary.
- Check the leakage of air supply and correct it.
- Open the valve and operate the cylinder.

Circuit Diagram
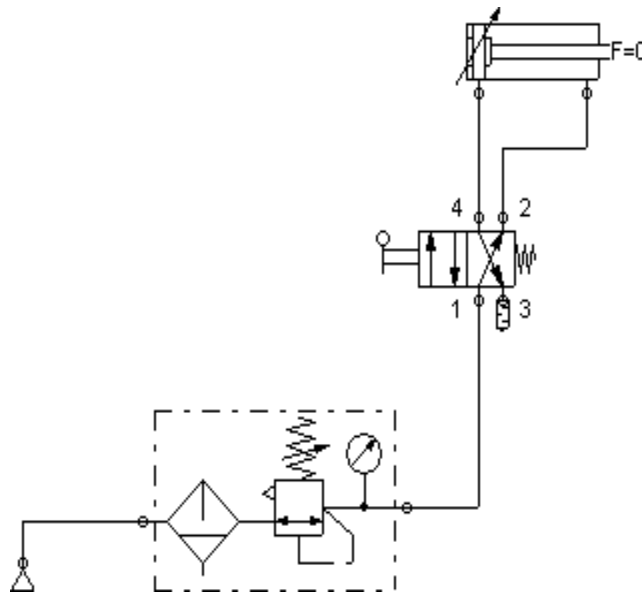
Question 8: Draw a circuit for the operation to control the speed of double acting cylinder using Metering In valve circuit in Pneumatic Trainer Kit.

Apparatus required:

- FLUIDSIM Software
- Double Acting Cylinder
- Flow control valve
- 4/2 Hand Levered Spring Return DCV
- FRL Unit

Procedure:

- Draw the circuit in FLUIDSIM software and check the connections.
- Connect the FRL unit to the main air supply.
- The various components are connected as per circuit.
- Block the valve openings if necessary.
- Check the leakage of air supply and correct it.

- Open the valve and operate the cylinder.

Circuit Diagram
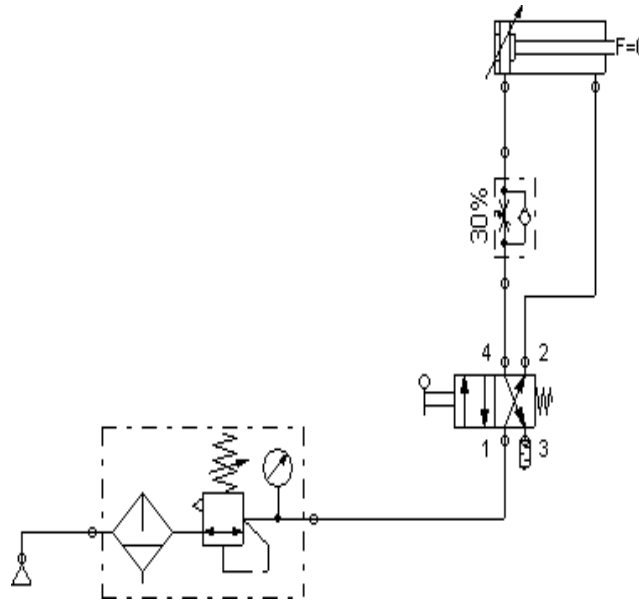
Question 9: Draw a circuit for the operation to control the speed of double acting cylinder using Metering Out valve circuit in Pneumatic Trainer Kit.

Apparatus required:

- FLUIDSIM Software
- Double Acting Cylinder
- Flow control valve
- 4/2 Hand Levered Spring Return DCV
- FRL Unit

Procedure:

- Draw the circuit in FLUIDSIM software and check the connections.
- Connect the FRL unit to the main air supply.
- The various components are connected as per circuit.
- Block the valve openings if necessary.
- Check the leakage of air supply and correct it.
- Open the valve and operate the cylinder.

Circuit Diagram
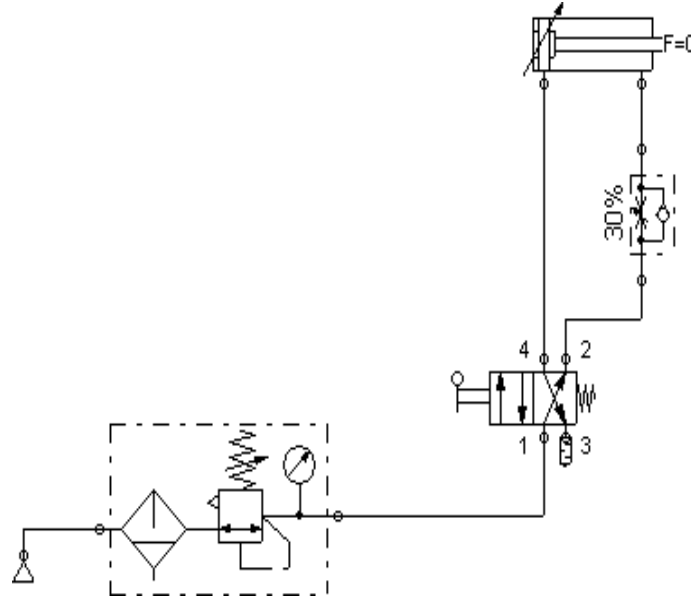
Question 10: Draw a circuit for the operation of single acting cylinder using AND logic circuit in Pneumatic Trainer Kit

Apparatus required:

- FLUIDSIM Software
- Single Acting Cylinder
- 3/2-way valve with selection switch or striking button
- Two pressure valve
- FRL Unit

Procedure:

- Draw the circuit in FLUIDSIM software and check the connections.
- Connect the FRL unit to the main air supply.
- The various components are connected as per circuit.
- Block the valve openings if necessary.
- Check the leakage of air supply and correct it.
- Open the valve and operate the cylinder.

Circuit Diagram
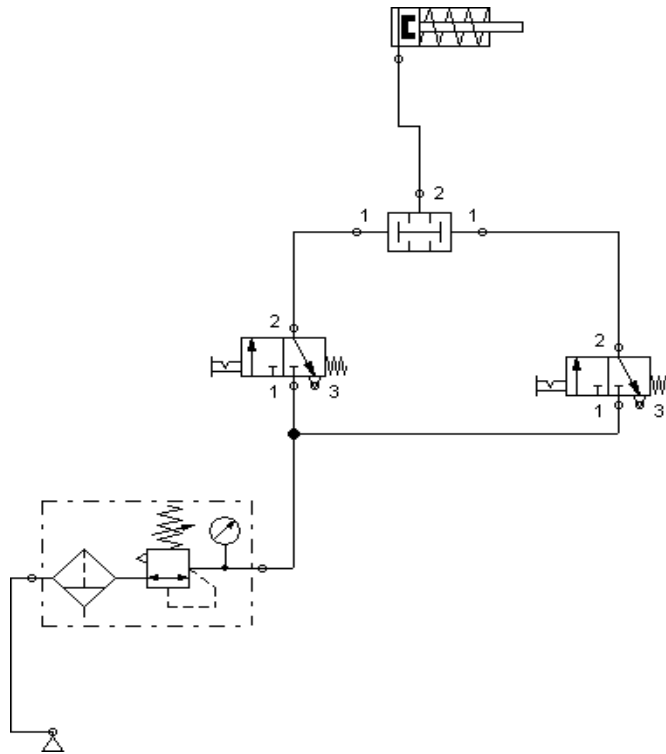
Question 11: Draw a circuit for the operation of single acting cylinder using AND logic circuit in Pneumatic Trainer Kit

Apparatus required:

- FLUIDSIM Software
- Single Acting Cylinder
- 3/2-way valve with selection switch or striking button
- Shuttle valve
- FRL Unit

Procedure:

- Draw the circuit in FLUIDSIM software and check the connections.
- Connect the FRL unit to the main air supply.
- The various components are connected as per circuit.
- Block the valve openings if necessary.
- Check the leakage of air supply and correct it.
- Open the valve and operate the cylinder.

Circuit Diagram
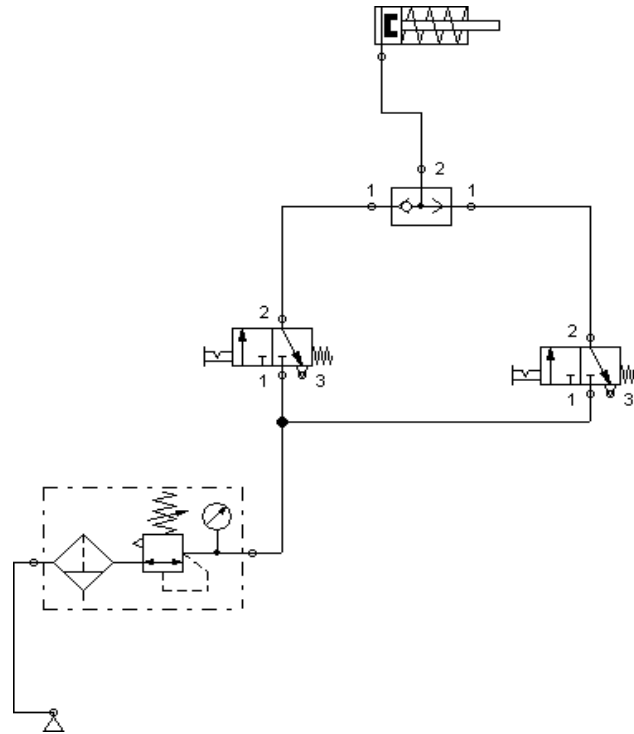
Question 12: Draw a circuit for the Operation of single acting cylinder using single Solenoid valve in Electro Pneumatic Trainer Kit

Apparatus required:

- FLUIDSIM Software
- Single Acting Cylinder
- Input / Output Relay Box
- 3/2 Solenoid Operated Spring Return Valve
- FRL Unit

Procedure

- Draw the circuit in FLUIDSIM software and check the connections.
- Connect the FRL unit to the main air supply.
- The various components are connected as per circuit.
- Block the valve openings if necessary.
- Check the leakage of air supply and correct it.

- Open the valve and operate the cylinder.

Circuit Diagram

Electro pneumatic Circuit Diagram
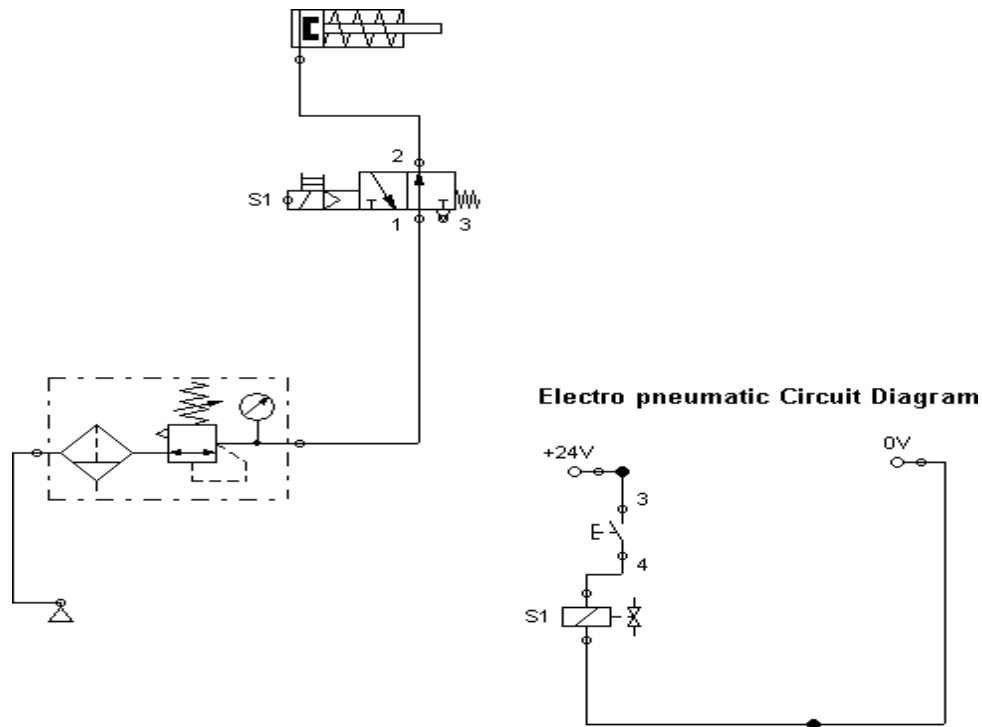
Question 13: Draw a circuit for the Operation of double acting cylinder using single Solenoid valve in Electro Pneumatic Trainer Kit

Apparatus required

- FLUIDSIM Software
- Double Acting Cylinder
- Input / Output Relay Box
- 4/2 Solenoid Operated Valve
- FRL Unit

Procedure

- Draw the circuit in FLUIDSIM software and check the connections.
- Connect the FRL unit to the main air supply.
- The various components are connected as per circuit.
- Block the valve openings if necessary.

- Check the leakage of air supply and correct it.
- Open the valve and operate the cylinder.

Circuit Diagram

Electro pneumatic Circuit Diagram
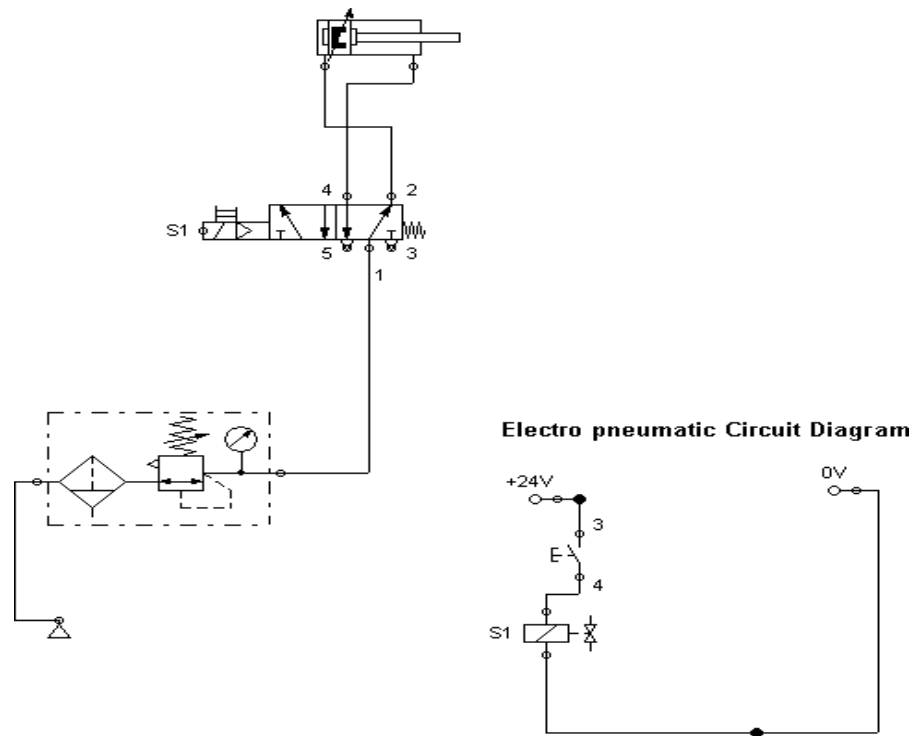
Question 14: Draw a circuit for the Operation of double acting cylinder using the double solenoid valve in Electro Pneumatic Trainer Kit

Apparatus required

- FLUIDSIM Software
- Double Acting Cylinder
- Input / Output Relay Box
- 4/2 Solenoid Operated Valve
- FRL Unit

Procedure

- Draw the circuit in FLUIDSIM software and check the connections.
- Connect the FRL unit to the main air supply.
- The various components are connected as per circuit.
- Block the valve openings if necessary.
- Check the leakage of air supply and correct it.

- Open the valve and operate the cylinder.

Circuit Diagram

Electro pneumatic Circuit Diagram

REPORT EVALUATION

S.no	Description	Weightage	Mark Awarded
1	Procedure	15	
2	Circuit diagram	25	
3	Experimental Results	20	
4	Analysis	20	
5	Viva-voce	20	
Total		**100**	

Ex. No:		
Date :	**Study Of PLC And Its Applications**	**Page No.**

Objective:

At the end of the lab session, students will have the acquaintance of history of PLC, operations, symbols, basic components, and selection and various applications.

HISTORY OF PLC

Over time control system engineering has evolved greatly. In the past manual control was the only the form of control. More recently electrical control based on relays were used. These relays allow switching of power without a mechanical switch.PLC or a programmable logic controller is used to check and control a system using digital inputs which can be programmed for automation. The growth of PLC started in 1970s.The PLCs have become a major component of factory mainly because of the advantages they offer like

- Cost effective control for complete system
- Flexible and reusable
- Computational abilities
- Analytical power and decision making

"The programmable logic controller is defined as a digital electronic device that uses a programmable memory to store instructions and to implement functions such as logic, sequencing, timing, counting and arithmetic words to control machines and processes "

PLCs are available in different designs or formats which vary in the type of their inputs and outputs and the software used for programming. A Programmable Logic Controller, PLC, or Programmable Controller is an electronic device used for Automation of industrial processes, such as control of machinery on factory assembly lines. A programmable controller is a digitally operating electronic apparatus which uses a programmable memory for the internal storage of instructions for implementing specific functions, such as logic, sequencing, timing, counting and arithmetic, to control various machines or processes through digital or analog input/output devices. Unlike general purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibrations and impacts. Programs to control machine operation are typically stored in battery backed

or non volatile memory. A PLC is an example of a real time system since output results are produced in response to input conditions within a bounded time, otherwise unintended operation results.

Operation of PLC

Checking the Input status

PLC takes a look at each input to determine whether it is on or off condition.

Execution of the Program

Executes a program by one instruction at a time. If the first input is on then it should turn on the first output. Since it is already known, it should be able to decide whether the first output should be turned on based on the state of the first input. It will store the execution results for use later during the next step.

Updating the output status

In the end PLC updates the status of the outputs based on which inputs are on during the first step and the results of executing your program during the second step.
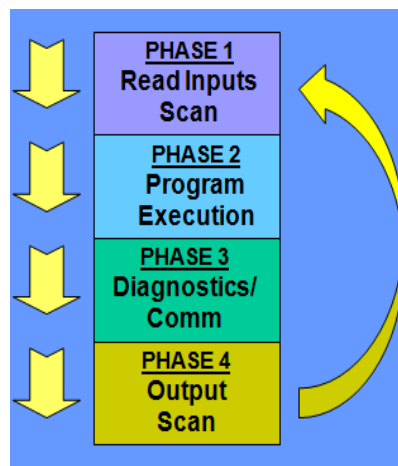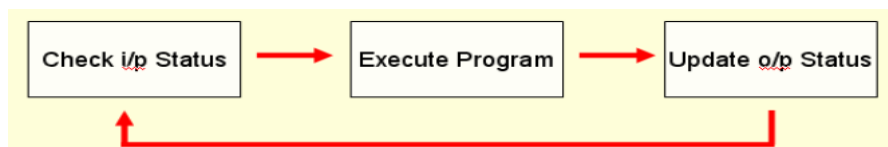
PLC Program:

Programming Languages

- Ladder logic
- Fbd logic (functional block diagram)
- Stl logic(statement list)

Meanings of symbols used in PLC Program:
] [

This instruction is called as "examine on" or "normally opened" as input functions or storage bits. If the corresponding memory bit is a "1" then the respective 'rung' will continuously be executed and the corresponding outputs will be energized. Rung is one of the multiple horizontal programming lines in a ladder logic diagram.

NOTE: Other factors may also affect rung simultaneously.

If the corresponding bit is "0" then the rung will not be executed continuously and outputs will be de-energized. If this instruction is used as input bit, its status should be according to the status of the real world input devices connected to the input table by identical addresses.

Addressing Sample: I: 3/1

This indicates address of a sample. I indicates input image table, 3 indicates slot no. 3 of input port and 1 indicates bit three of 3rd slot of input port.
]/[

This instruction is called "examine off" or "normally closed" as input functions or storage bits. If the corresponding memory bit is a "1" then the respective 'rung' will continuously be executed and the corresponding outputs will be energized.

NOTE: Other factors may also affect this rung simultaneously.

If the corresponding bit is "0" this instruction will not allow rung continuously and outputs will be energized. If used as input bit, its status should correspond to the status of the real world input devices tied to the input table by identical addresses.

OTE ⍰ ⍰( ) ⍰ ⍰

This is called as 'output energize'. This instruction sets the specified bit when rung continuity is achieved. Under normal operating conditions, if the set

bit corresponds to an output device, output device will be energized when rung goes true.

Addressing Example O: 3/1

      O -- Output image table

      3 -- Slot three

      1 -- Bit one of slot three

OTL ⬜ ⬜-(L)-

      This is called as 'output latch'. This instruction functions similar to output energize except that once a bit is set with OTL, it is latched on. Once an OTL bit has been set ON (1 on the memory) it will remain ON even if the rung condition goes false. The bit must be reset.

(U)

      This is called as 'output unlatch'. This is used to unlatch (reset) a latched bit. Its address must be same as latched one.

Timer

      This is also called as "TON". Figure 3.3.3 shows the schematic of a Timer. It is used to turn an output ON or OFF after the timer has been ON for preset time interval. This output instruction begins timing when rung goes true. It waits the specified amount of time (As specified in Preset), keeps track of accumulated intervals which have occurred (ACCUM), and sets DN (Done) bit when ACCUM time equals preset time.

      As long as rung condition remains true, Timer adjusts its accumulated value to each evaluation until it reaches the preset value. The accumulated value is reset when rung condition go false, regardless of whether timer has timed out. " TIME BASE" is an amount of time after which accumulator increases its value by 1.
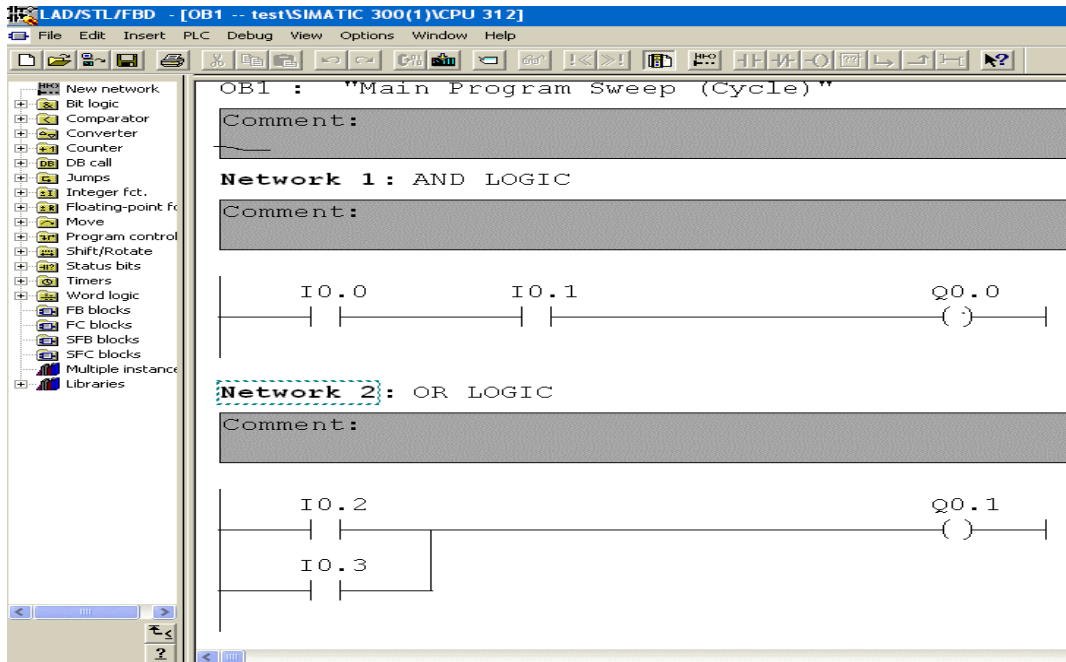
Fig Ladder logic

Fig FBD Logic (Functional Block Diagram)

```
LAD/STL/FBD - [OB1 -- test\SIMATIC 300(1)\CPU 312]
File  Edit  Insert  PLC  Debug  View  Options  Window  Help

New network
FB blocks
FC blocks
SFB blocks
SFC blocks
Multiple instance
Libraries

OB1 :   "Main Program Sweep (Cycle)"
Comment:


Network 1: AND LOGIC
Comment:


     A    I     0.0
     A    I     0.1
     =    Q     0.0


Network 2: OR LOGIC
Comment:


     O    I     0.2
     O    I     0.3
     =    Q     0.1
```
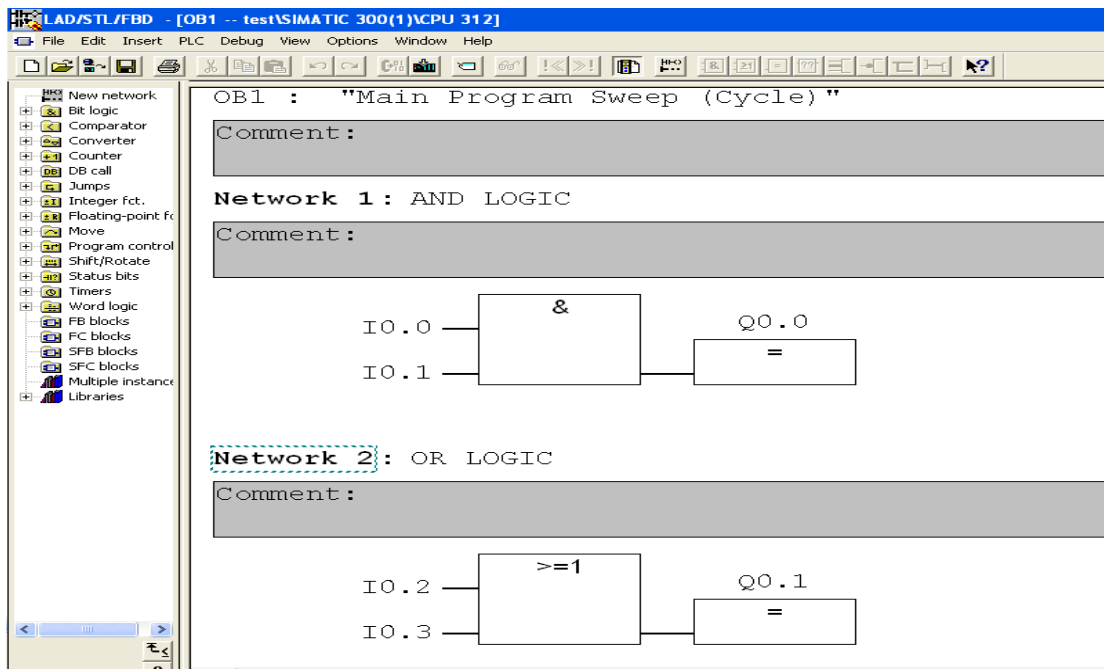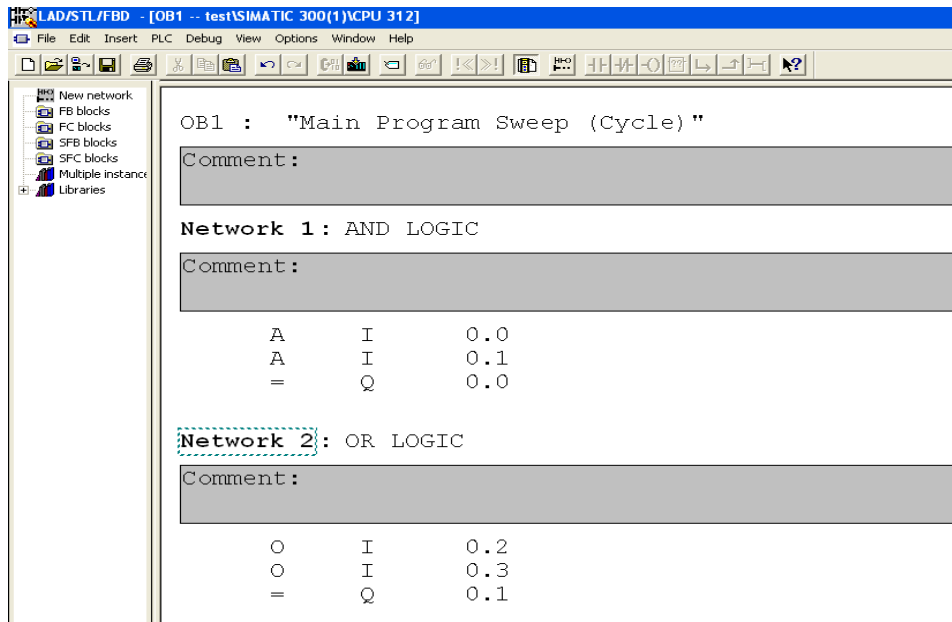
Fig STL Logic (Statement List)

PLC Program is a Logic that is executed by the CPU. This logic can be written in the form of Ladder diagram, Instruction List, Sequential Function Charts, Structured text or Functional block diagram. These are the languages used for writing logic as per IEC standard. The program is then downloaded to the PLC. This is usually done by temporarily connecting the PC or HHT to the PLC. Once the program is downloaded to the CPU, it is usually not necessary for the PC to remain connected.
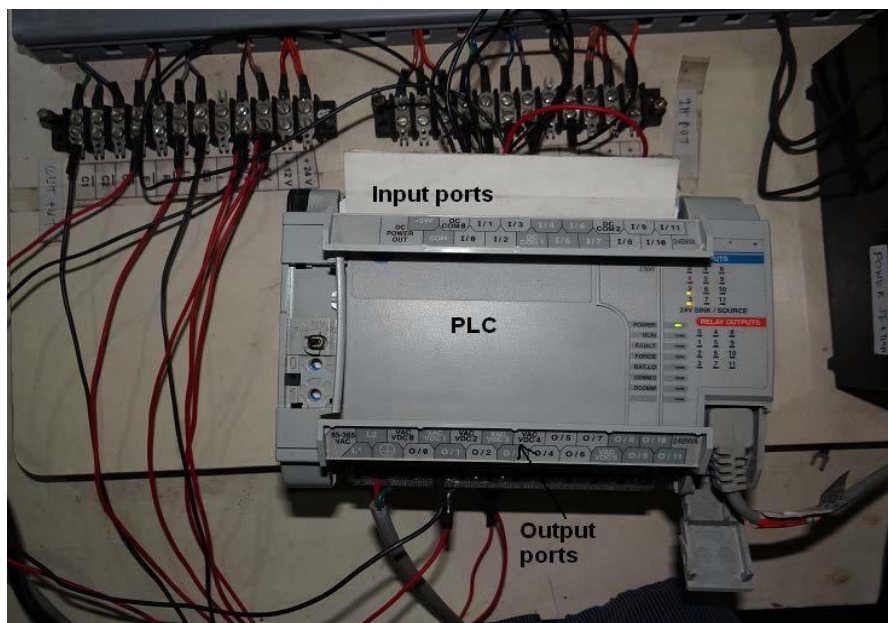
Fig PLC used in Industry

Basic Components of PLC:

- CPU and Memory module
- Power supply
- Input and output module
- Programming device
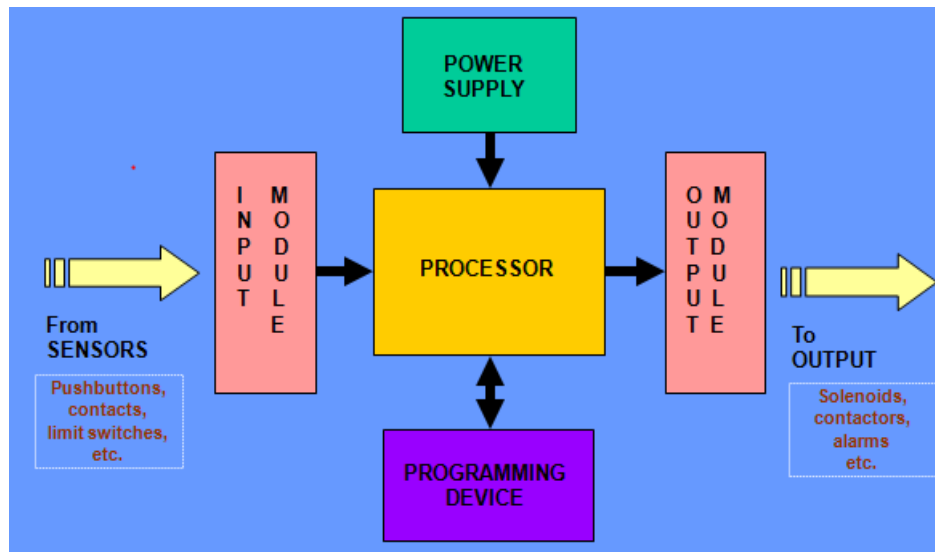
CPU and Memory Module:

This is the device where PLC program is stored and processed. The size and type of CPU determines the programming functions available, size of the application logic available, amount of memory supported, and processing speed.

Power Supply:

The power supply provides power for the PLC system. It provides internal DC current to operate the processor logic circuitry and input/output assemblies. This can be built into the PLC or an external unit. Common voltage levels required by the PLC are 24Vdc, 120Vac, 220Vac.

Input and Output Module:

Inputs carry signals from the field (process) to the controller. Various types of inputs can be switches, pressure sensors, transmitters etc. The field devices to whom PLC sends the results of logical operations is the output devices. These are the actuators that adjust or control the process, motors, lights, relays, pumps, etc.

Many types of inputs and outputs can be connected to a PLC and they can be categorized mainly as analog and digital. Digital inputs and outputs operate on discrete or binary change i.e. on/off, open/ . Analog inputs and outputs change continuously with reference to time.

Programming Device:

Used to enter the desired program that will determine the sequence of operation and control of process equipment or driven machine.
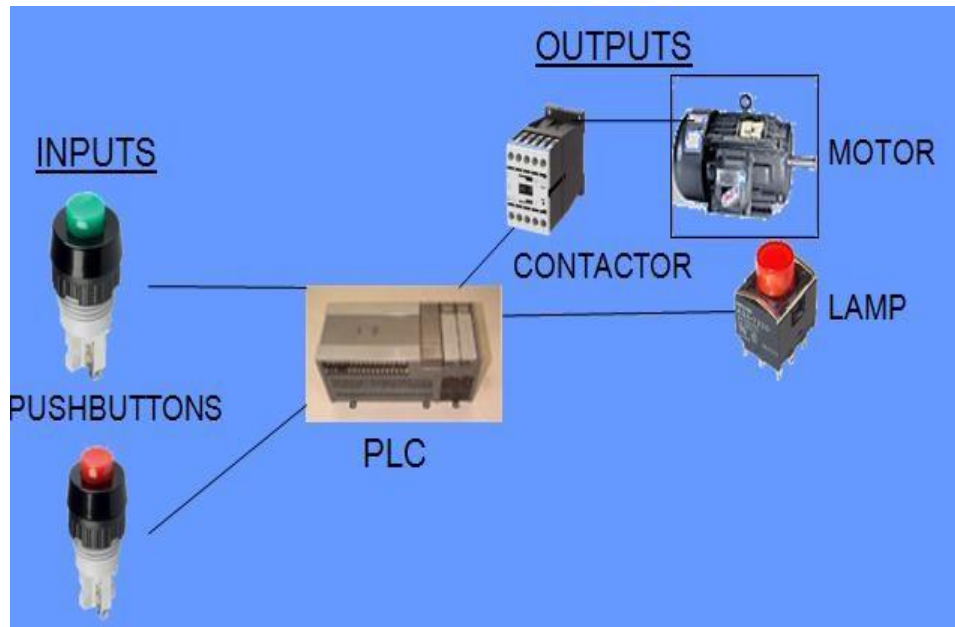
Selecting a PLC

- Number of logical inputs and outputs.
- Memory
- Number of special I/O modules
- Scan Time
- Communications
- Software

Classification of PLC

Programmable Logic Controllers can be classified in accordance with the number of I/Os which the PLC can handle. The different types of PLCs, thus exists due to this classification are as follows:

- Unitary PLC
- Modular PLC
- Rack Style PLC

Unitary PLC

The Unitary PLC is typically the smallest & least expensive. It contains every feature of a basic system in one box. They are attached to the machine being controlled. It would be used in a small machine or fixed application such as overhead door controls or a standalone parts inspection system. They are not expandable so the application is limited to on-board I/O. There are, however, some very powerful units available with built in GSM, colour screens, & web servers. Most have 1 or 2 analog I/O channels as well as a high speed input and pulse train output for motion control as shown in fig.

Modular PLC

The Modular PLCs start with a processor with a few or no on-board I/O. These use a range of modules that slot together to build up a system. The basic modules are the power supply, the main module is the CPU, the input module and the output module. Other modules such as A/D converters may be added. The main advantage is that the number of input and output terminals can be expanded to cope with changes to the hardware system. Modular PLCs are used in applications where a higher I/O count is needed or when using specialty modules such as quadrature encoders, thermocouple inputs, etc. They are also useful in small applications that have "upgrades" available to the end user. Systems can be expanded (within certain limits) without adding additional rack space

Rack Style PLC

      Rack style PLCs are a larger type of PLC that is a collection of I/O cards that are linked together and stored in a rack. A rack I/O can handle thousands of inputs and outputs. Rack style PLCs is usually more expensive, expandable, and powerful than unitary or modular PLCs. This is a similar concept to the modular design but the modules are on standard cards that slot into a standard rack inside a cabinet. The rack provides a power and communication backplane that greatly increases the communication rate between the processor and the modules as well as allowing some specialty modules to communicate with each other without the processor. In some brands, multiple processors can be in the same rack and share the inputs. Racks also allow for redundant processors for critical systems such as waste water pumps or fire control systems. The types of modules available for rack systems are far more extensive than modular systems. The number of available I/O points is also much higher in the rack systems. Available I/O points are around 1000 for some modular PLCs versus over 100,000 for the same brand of rack system as shown in fig.
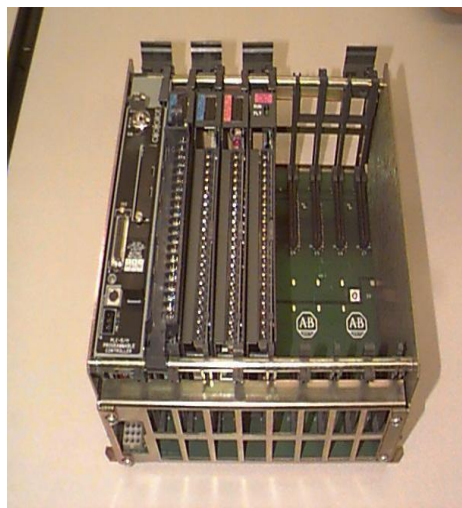
APPLICATIONS

PLC can also be used in automated sorting of objects in industries based on the physical properties like weight, shape, color, etc of the objects.

Considering weight, for example, the objects to be sorted are sensed by a weight sensor like piezoelectric sensors. They are then diverted to the respective storage area. PLCs are used in a wide range of applications which may range from automation of manufacturing processes in a factory to providing safety solutions.

PLCs are used in industrial departments like
- Chemical industry,
- Automobile industry,
- Steel industry and
- Electricity industry
- Glass industry.
- Manufacturing / Machining
- Food / Beverage
- Metals
- Power
- Mining

In making of a float glass, PLC itself cannot finish some controlling tasks because of the complexity of the control system and processing of huge data. For the production of glass, we make use of bus technology to construct the control mode of a PLC with a distributed control system. This control system deals with analog controlling and data recording; The PLC is also used for digital quality control and position control.

Applications of PLC in Cement Industry

Along with the best quality raw materials, the accurate data regarding process variables, especially during mixing processes within the kiln, ensures that the output provided should be of the best possible quality. Nowadays a DCS with bus technology is used in the production and management industry. By using this existing DCS control system, the PLC is in user mode of SCADA. This mode comprises PLC and configuration software. This SCADA mode comprises the PLC and host computer. The host computer consists of slave and master station. The PLC is used for controlling the ball milling, shaft kiln and Kiln of coal.

The programmable logic controller is used not only for industrial purpose but also in civil applications such as washing machine, elevators working and traffic signals control.

In large process plants PLCs are being increasingly used for automatic start up and shutdown of critical equipments. A PLC ensures that equipment cannot be started unless all the permissive conditions for safe start have been established. It also monitors the conditions necessary for safe running of the equipment and trip the equipment whenever any abnormality in the system is detected. The PLC can be programmed to function as an energy management system for boiler control for maximum efficiency and safety. In the burner management system it can be used to control the process of purging, pilot light off, flame safety checks, main burner light off and valve switching for changeover of fuels.

BOOELAN OPERATORS

AND			OR			NAND			NOR		
INPUT		OUTPUT	INPUT		OUTPUT	INPUT		OUTPUT	INPUT		OUTPUT
A	B		A	B		A	B		A	B	
0	0	0	0	0	0	0	0	1	0	0	1
1	0	0	1	0	1	1	0	1	1	0	0
0	1	0	0	1	1	0	1	1	0	1	0
1	1	1	1	1	1	1	1	0	1	1	0

XOR			NOT	
INPUT		OUTPUT	INPUT	OUTPUT
A	B			
0	0	0	0	1
1	0	1	1	0
0	1	1		
1	1	0		

Control of Cylinders Using PLC

Objective:

At the end of the lab session, students will have the knowledge how to draw a circuit diagram and simulate for the cylinders using PLC.

Question 1: Design a circuit diagram and simulate for actuation of single acting cylinder with on delay timer using PLC

Apparatus required:

- Compressor
- FRL Unit
- 3/2 Solenoid Operated DCV
- Single Acting Cylinder
- PLC
- Versa Pro Software

Procedure

- Draw the circuit diagram
- Provide +24V and – 24V from PLC trainer to panel
- Open the versa pro software in desktop
- Interface PLC with PC using RS232 cable
- Write a ladder diagram
- Output of PLC (Q1) is direct connecting to input o f solenoid coil
- Following the opening procedure of versa pro software
- Check the ladder diagram
- Connect the air supply to FRL unit
- Run the PLC
- Sometimes delay the cylinder should be activated

Circuit Diagram

LADDER DIAGRAM

Question 2 : Design a circuit diagram and simulate for actuation of single acting cylinder with OFF delay timer using PLC

Apparatus Required

- Compressor
- FRL Unit
- 3/2 Solenoid Operated DCV
- Single Acting Cylinder
- PLC
- Versa Pro Software

Procedure

- Draw the circuit diagram.
- Provide +24V and –24V from PLC trainer to panel.
- Open the versa pro software in desktop.
- Interface PLC with PC using RS232 cable.
- Write a ladder diagram.
- Output of PLC (Q1) is direct connecting to input of solenoid coil.
- Following the opening procedure of versa pro software.
- Check the ladder diagram.
- Connect the air supply to FRL unit.
- Run the PLC.
- Sometimes delay the cylinder should be activated.

Circuit Diagram

Question 3: Design a circuit diagram and simulate for control of double acting cylinder with up counter using PLC
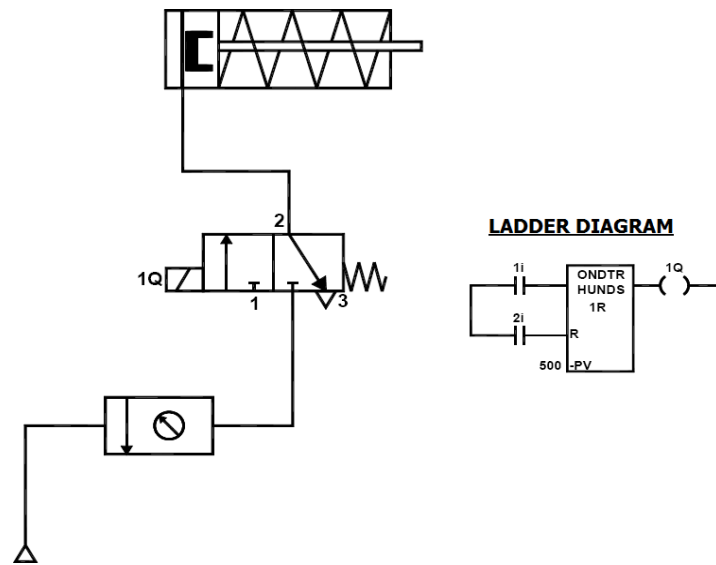
Apparatus required

- Compressor
- FRL Unit
- 5/2 Solenoid Operated DCV
- Single Acting Cylinder
- PLC
- Versa Pro Software

Procedure

- Draw the circuit diagram
- Provide +24V and −24V from PLC trainer to panel
- Open the versa pro software in desktop
- Interface PLC with PC using RS232 cable
- Write a ladder diagram
- Output of PLC (Q1) is direct connecting to input of solenoid coil
- Following the opening procedure of versa pro software
- Check the ladder diagram
- Connect the air supply to FRL unit
- Run the PLC

Circuit Diagram

LADDER DIAGRAM

Question 4: Design a circuit diagram and simulate for control of double acting cylinder with DOWN counter using PLC
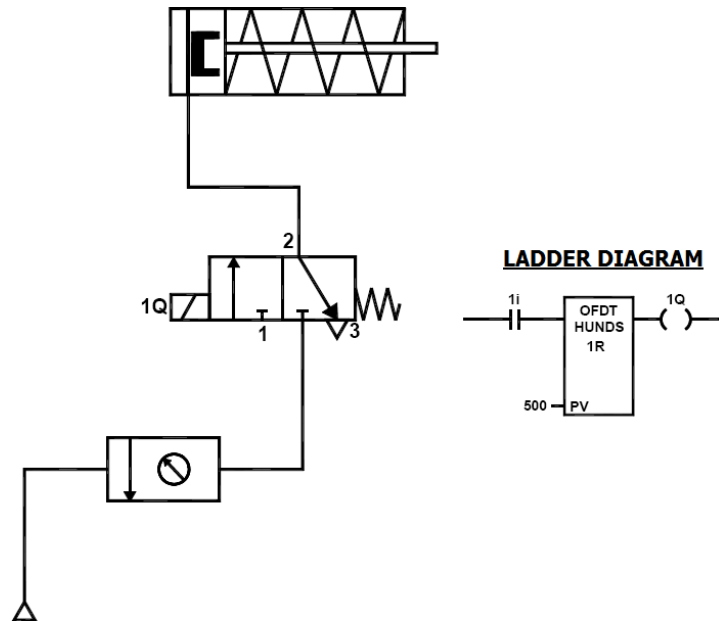
Apparatus required

- Compressor
- FRL Unit
- 5/2 Solenoid Operated DCV
- Single Acting Cylinder
- PLC
- Versa Pro Software

Procedure

- Draw the circuit diagram
- Provide +24V and –24V from PLC trainer to panel
- Open the versa pro software in desktop
- Interface PLC with PC using RS232 cable
- Write a ladder diagram
- Output of PLC (Q1) is direct connecting to input of solenoid coil
- Following the opening procedure of versa pro software
- Check the ladder diagram
- Connect the air supply to FRL unit
- Run the PLC

Circuit Diagram

LADDER DIAGRAM

Question 5: Design a circuit diagram and simulate the single acting cylinder with AND logic using PLC
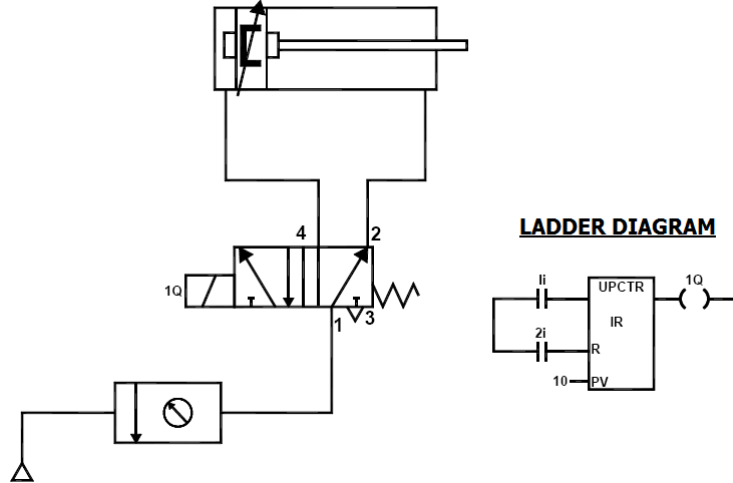
Apparatus required:

- Compressor
- FRL Unit
- 3/2 Solenoid Operated DCV
- Single Acting Cylinder
- PLC
- Versa Pro Software.

Procedure:
- Draw the circuit diagram.
- Provide +24V and –24V from PLC trainer to panel.
- Open the versa pro software in desktop.
- Interface PLC with PC using RS232 cable.
- Write a ladder diagram.
- Output of PLC (Q1) is direct connecting to input of solenoid coil.
- Following the opening procedure of versa pro software.
- Check the ladder diagram.
- Connect the air supply to FRL unit.
- Run the PLC.
- When two inputs (1i, 2i) are high, the output is high.

Circuit Diagram

LADDER DIAGRAM

Question 6: Design a circuit diagram and simulate the single acting cylinder with NOT logic using PLC
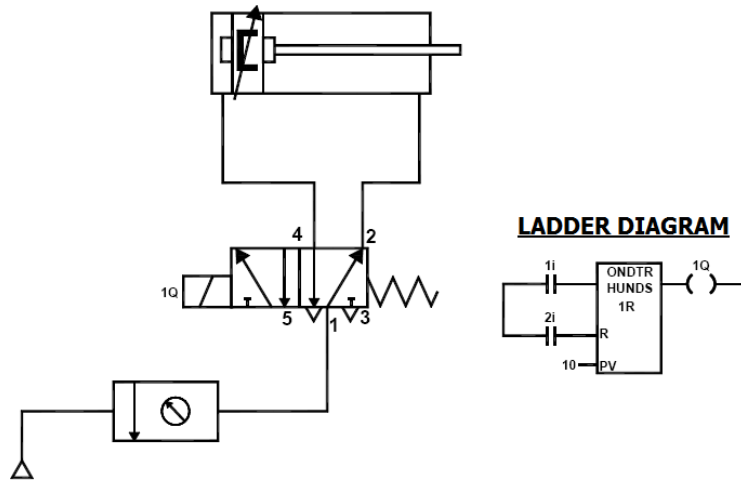
APPARATUS REQUIRED:

- Compressor
- FRL Unit
- 3/2 Solenoid Operated DCV
- Single Acting Cylinder
- PLC
- Versa Pro Software

Procedure:

- Draw the circuit diagram.
- Provide +24V and –24V from PLC trainer to panel.
- Open the versa pro software in desktop.
- Interface PLC with PC using RS232 cable.
- Write a ladder diagram.
- Output of PLC (Q1) is direct connecting to input of solenoid coil.
- Following the opening procedure of versa pro software.
- Check the ladder diagram.
- Connect the air supply to FRL unit.
- Run the PLC.

- When two inputs (1i, 2i) are high, the output is high.

Circuit Diagram

Ladder Diagram

Question 7: Design a circuit diagram and simulate the single acting cylinder with NOR logic using PLC
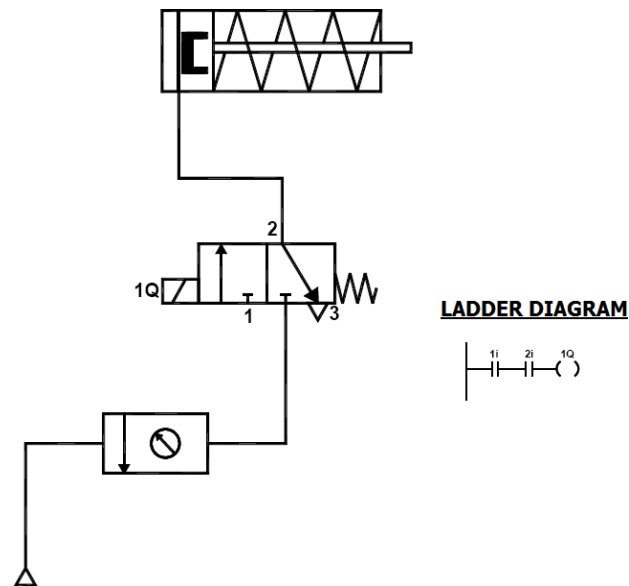
APPARATUS REQUIRED:

- Compressor
- FRL Unit
- 3/2 Solenoid Operated DCV
- Single Acting Cylinder
- PLC
- Versa Pro Software

Procedure:

- Draw the circuit diagram.
- Provide +24V and –24V from PLC trainer to panel.
- Open the versa pro software in desktop.
- Interface PLC with PC using RS232 cable.

- Write a ladder diagram.
- Output of PLC (Q1) is direct connecting to input of solenoid coil.
- Following the opening procedure of versa pro software.
- Check the ladder diagram.
- Connect the air supply to FRL unit.
- Run the PLC.
- When two inputs (1i, 2i) are high, the output is high.

Circuit Diagram

Ladder Diagram
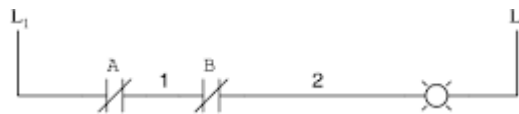
Question 5: Design a circuit diagram and simulate the single acting cylinder with NAND logic using PLC
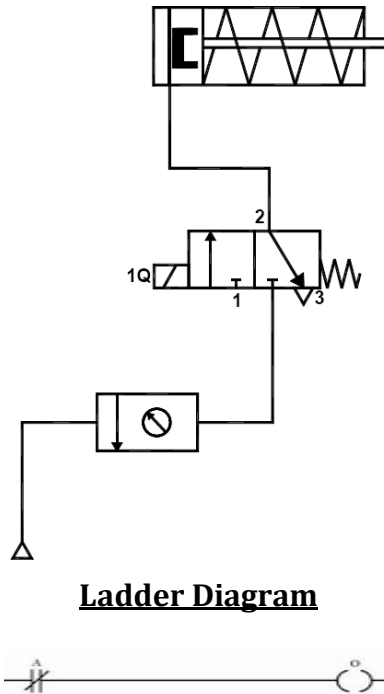
APPARATUS REQUIRED:

- Compressor
- FRL Unit
- 3/2 Solenoid Operated DCV
- Single Acting Cylinder
- PLC
- Versa Pro Software

Procedure:

- Draw the circuit diagram.
- Provide +24V and –24V from PLC trainer to panel.
- Open the versa pro software in desktop.
- Interface PLC with PC using RS232 cable.
- Write a ladder diagram.
- Output of PLC (Q1) is direct connecting to input of solenoid coil.
- Following the opening procedure of versa pro software.
- Check the ladder diagram.
- Connect the air supply to FRL unit.
- Run the PLC.
- When two inputs (1i, 2i) are high, the output is high.
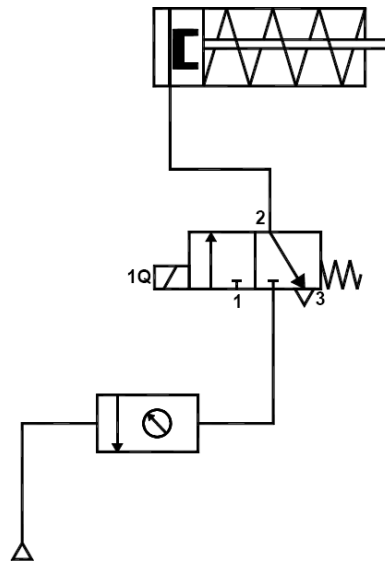
Circuit Diagram

Ladder Diagram

REPORT EVALUATION

S.no	Description	Weightage	Mark Awarded
1	Circuit diagram	20	
2	Ladder diagram	20	
3	Program	20	
4	Execution	15	
5	Actuation	15	
6	Viva-voce	10	
Total		**100**	

Ex. No:	Study Of Image Processing Technique	Page No.
Date :		

Objective:

At the end of the lab session, students will have the information's on image, digital image, and the processing techniques.

Image

An image may be defined as a two dimensional function f(x,y), where 'x' and 'y' are spatial coordinates, and the amplitude of 'f' at any pair of coordinates x,y is called intensity or gray level of the image at that point.

Digital Image

'x', 'y' and the amplitude 'f' are all finite and discrete quantities means then the image is called as digital image.

Digital Image Processing

The field of digital image processing refers to processing of digital images by a digital computer. Each object has finite number of pixels or pels or image elements or picture elements.

Image resolution

Image resolution is defined as the number of pixels that can be accommodated in a unit area. Image resolution depends on number of values for N and number of bits used in a gray level (m). If N and 'm' is high, then the resolution will be more.

Hue

Hue is an attribute associated with the dominant wavelength in a mixture of light waves. Thus hue represents dominant color as perceived by an observer eg., red, yellow.

Saturation

It refers to relative purity or the amount of white light mixed with the hue. The pure spectrum colors are fully saturated (RGB).Color such as pink and lavender are less saturated. ie., The degree of saturation being inversely proportional to the amount of white light added. Hue and saturation taken together are called chromoticity.

Image Histogram

An image histogram is a type of histogram that acts as a graphical representation of the tonal distribution in a digital image. It plots the number of pixels for each tonal value.

Horizontal axis → tonal variations

Vertical axis → represents the number of pixels in that particular tone.

The left side of the horizontal axis represents the black and dark areas, the middle represents medium grey and the right hand side represents light and pure white areas. The Vertical axis represents the size of the area that is captured in each one of these zones.

The histogram for the very dark image will have the majority of its data points on the left side and centre of the graph.

The histogram for the very bright image with few dark areas is shadows will have most of its data points on the right side and the centre of the graphs.

Fig 1.1, image histogram

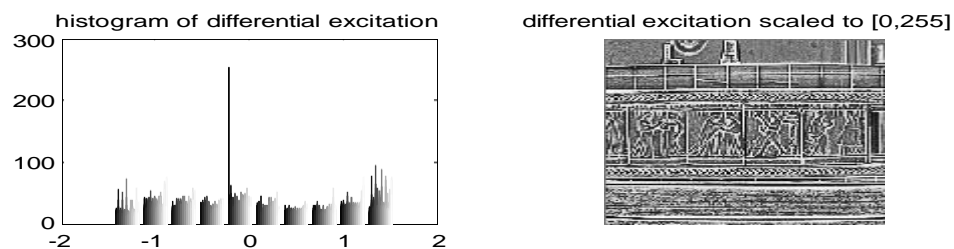**FFT Transform**

Typically, 2-D-Fourier transform (2-D-FT) is used as the representation of complex SAR images. However, the energy of the coefficients of 2-D FT on the complex SAR image distributes in the whole frequency domain. Generally, the frequency signals are divided into real and imaginary parts, and quantized with Lloyd-Max quantizer However, the compression ratios of the frequency domain

compression algorithms are almost limited in 10.4:1o r 9.8:1, which are not very high. Wavelet transform can locally analyze time and frequency in multiscale and shows very strong decorrelation ability. As it is particularly suitable for non-stationary signal processing, wavelet transform has been applied to complex SAR image compression currently; most compression algorithms of complex SAR image adopt the traditional wavelet transform.

However, for the complex SAR images, which are rich in edges and texture, traditional wavelet transform does not show efficient representation. proposed an algorithm which extracted edges of SAR image with wedge let transform and encoded the edges and texture separately. used 2-D oriented wavelet transform for remote sensing compression.

The SAR images used in are not complex SAR images. To the best of our knowledge, directional wavelet transform has not be applied to the compression of complex SAR images. Directional wavelet transform achieves the direction extraction while keeping the property of multiscale analysis of discrete wavelet transform (DWT). Directional wavelet transform can be divided into two classes: frequency-domain transform and spatial-domain transform.

The frequency-domain directional wavelet transform, such as contour let which continuously performs directional filter on the high-frequency sub bands of wavelet transform, gives an efficient representation of the edges at the cost of high redundancy. The spatial-domain directional wavelet, such as directional lifting wavelet transform (DLWT), employs direction prediction for wavelet decomposition, which adapts the wavelet transform direction to the image edges. DLWT integrates spatial direction prediction into the wavelet transform lifting framework, provides an efficient representation of edges along multiple directions of images, and thus reduces the energy of high-frequency bands and achieves more energy clustering.

As the real parts and imaginary parts of complex SAR image as well as the real image of fast FT (FFT) are rich in edges, two complex SAR image coding schemes using DLWT are proposed. Fourier Transform (FT) with its fast algorithms (FFT) is an important tool for analysis and processing of many natural signals. FT has certain limitations to characterise many natural signals, which are non-stationary (e.g. speech).

Wavelet compression system consists of several components:**1)** filters and algorithms for performing wavelet decomposition and reconstruction, 2) a bit allocation strategy, and **3)** quantizers. In order to minimize algorithm complexity and to reduce susceptibility to channel errors, the quantizer output is not encoded with an entropy or arithmetic coder. Side information concerning normalization and bit allocation can be coded in only a few bits for an entire image.

The wavelet transform is a relatively new technique for decomposition of a data set with orthogonal (ornonorthogonal) basis functions and is becoming widely used in image compression. The orthogonal wavelet decomposition provides a multi resolution representation of a signal over an orthonormal basis. It offers several advantages for SAR data compression:

1. The decomposition of an image into a representation selective both in frequency and spatial orientation allows allocation of quantization bits to "important" components.
2. Algorithms for performing a wavelet decomposition and reconstruction are recursive, computationally efficient, and easily implemented in hardware. The computation of a wavelet transform, as described by Mallat, has a computational burden on the order of &V' . Fast wavelet transform algorithms can reduce the computational burden **to** log -4-
3. The decomposition of an image into a pyramid of detail images results in a set of coefficients that have reduced dynamic range compared to the original image. This is particularly important for compression of SAR imagery due to its very large dynamic range.
4. A wavelet multiscale decomposition of an image is convenient for progressive image transmission. A coarse resolution image can be selected from a sensor or database, and then a) browsed at coarse resolution for data quality, data validation, correct location, etc.and or processed by algorithms which require only coarse resolution input data, or b) a subset of the image can be transmitted and displayed at the finest available resolution.
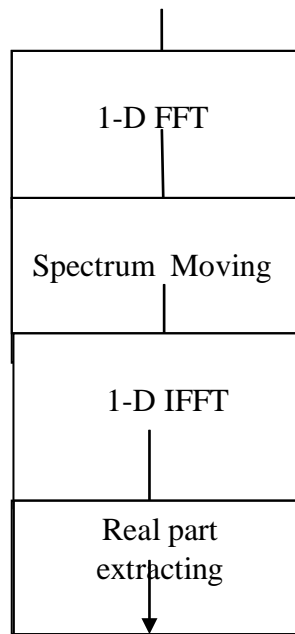
Complex SAR Image

1-D FFT
Spectrum Moving
1-D IFFT
Real part extracting

Fig 1.2, FFT Program

SAR Image

Synthetic aperture radar (SAR), which is an all-time, all-weather microwave imaging system, is an important tool for achieving information in the application field of microwave remote sensing. With synthetic aperture radar (SAR) developing along the directions of high resolution, multi polarization, multiband, and multimode, the quantity of SAR image data rises steadily. Data compression technology is an effective way to alleviate the pressure of transmission and storage on SAR system.

Complex SAR Image

The complex SAR image, which consists of amplitude and phase, is the first-level image data of the SAR system. The phase information fidelity in complex SAR image is crucial to some special applications, such as interferometry and moving target detection. Therefore, complex SAR image compression requires not only reasonable amplitude fidelity but also high phase information accuracy, which is different from the ordinary optical image compression.

Furthermore, compared with optical images, complex SAR images exhibit significantly higher dynamic range and less spatial correlation. Thus, common optical image compression algorithms are not suitable for the compression of complex SAR images. Efficient representation is important to the compression of complex SAR images.

Reconstructions of the compressed detected imagery were of good to excellent quality at data rates as low as *0.25* bpp (compression ratio of **32** : 1 when compared to an uncompressed data rate of 8 bpp). Visual impressions of the imagery were much better than the SNR's implied. SNR's for compressed SAR imagery are lower than those reported for optical imagery because the high spatial frequency speckle of SAR imagery does not get accurately reconstructed during the compression process.

However, accurate reconstruction of speckle is of virtually no importance to human interpretation of SAR imagery. Complex data rates are expressed as bits per real or imaginary element (bpe), which corresponds to twice the data rate of detected data since each pixel consists of two elements. Even when complex data rates are reported in bits per element, the quality of the reconstructed complex images is poorer than that of the reconstructed detected images; both shadows and objects are less well defined in the complex compressed imagery. Reasonable

looking images were obtained at data rates as low as 0.5-1 bpe or 1-2 bpp. On the other hand, since complex imagery is commonly represented with a two-byte integer for each real and imaginary part, a compressed data rate of 1 bpp (0.5 bpe) corresponds to a 32:1 compression ratio for complex data.

The first scheme directly encodes real parts and imaginary parts of complex SAR images using the CCSDS algorithm which replaces DWT by DLWT. The second scheme first converts a complex image into a real image using FFT, and then encodes the real image in the CCSDS coding algorithm which also replaces DWT by DLWT.

Compared with the original CCSDS image coding schemes using DWT, the proposed two coding schemes show significant performance gain not only in amplitude peak signal-to-noise ratio (PSNR) but also in mean phase error (MPE). the best in terms of PSNR and structure similarity (SSIM)]. However, the coding algorithm based on DLWT achieves better rate-distortion performance than that of DWT. It is because the rate-distortion performance of coding algorithm is determined not only by the number of significant coefficients, but also by the position distribution of significant coefficients, i.e., the clustering capability of significant coefficients.b the coding bits of significant coefficients with CCSDS algorithm with K-term nonlinear approximation gets less PSNR and SSIM than DWT, DLWT coefficients need less actual coding bits for the same number of significant coefficients than DWT.

Therefore, at the same bit rate, we can encode more coefficients with DLWT than DWT, and then DLWT may outperform DWT in terms of rate-distortion performance eventually. DLWT consuming less coding bits is due to the better clustering capability.

In the first approach the complex image data is converted to a real data format using a FFT scheme without neglecting any phase information. Shifting the frequency spectrum by the half bandwidth to positive frequencies, one obtains a negative spectrum equal to zero. After applying the inverse Fourier transform, the resulting complex signal can be represented by its real part without loss of any information, since real and imaginary part of the signal are mutual Hilbert transforms.

The sampling rate are doubled, but because of only using the real part of the converted signal the data amount is not raised. The particular advantage of this transformation is, that the wavelet decomposition and compression schemes can be applied as usual to ordinary intensity data. The reconstructed complex image data is received by undoing the FIT transformation scheme in reverse order.

In the second approach the complex image data is divided into magnitude and phase, applying two different compression techniques to both parts. The magnitude of the complex image data has the same properties as intensity SAR data and can be

compressed, using the discrete wavelet transform and a compression scheme described below.

The phase of the data is uniformly distributed and highly decorrelated, so that a nearly lossless compression technique has to be used. In this paper a vector quantizer was chosen for that. The codebook of the vector quantizer is trained, using a typical image area of a similar image. In both schemes a block adaptive Max quantizer was used with a fixed **5** bit quantization, either for the magnitudes of the image data in our first approach or for the real part of the converted complex image data in our second approach.

Additionally, a vector quantizer is used on the Max-quantized data, grouping neighbouring image pixels to specific vectors. The phase of the image data in the second approach is always quantized by a vector quantizer without utilization of a block adaptive Max quantizer. The complex SAR data set, we used for both compression methods, was taken in X-Band by the experimental SAR of DLR during a mission in 1996 and shows a part of Mount Etna.

For each approach two numerical examples **are** given with different compression ratios Both proposed schemes lead to good visual image quality as where only one compression example of each approach is depicted. The histograms of the reconstructed image magnitudes are also maintained with respect to their originals.

The image quality parameters SNR and PSNR as well as the mean phase error (MPE) and phase standard deviation (PSD) for all the four examples are listed in the first table with their resulting compression ratio. Additionally, the second approach is extended to multi polarization mode. The magnitudes of four polarization channels are separately quantized using a block adaptive Max quantizer with a fixed 5 bit quantization as well. The low-pass component of the final wavelet decomposition was linearly quantized with maximum quantization.