USN 1 C R 1 4 M E 0 5 7 **10ME73**

Seventh Semester B.E. Degree Examination, Dec.2017/Jan.2018
Hydraulics & Pneumatics

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. 2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

PART – A

1 a. With a neat block diagram, explain the structure of hydraulic power system. **(06 Marks)**

b. A gear pump has a 75 mm outside diameter, a 50 mm inside diameter and a 25 mm width. If the volumetric efficiency is 90% at rated pressure, what is the corresponding actual flow rate? The pump speed is 1000 rpm. **(04 Marks)**

c. A pump has a displacement volume of 100 cm^3. It delivers 0.0015 m^3/s at 1000 rpm and 70 bars. If the prime mover input torque is 120 N.m. Determine

(i) What is the overall efficiency of the pump?

(ii) What is the theoretical torque required to operate the pump? **(06 Marks)**

d. What are the advantages of hydraulic system? **(04 Marks)**

2 a. A pump supplies oil at 75.8 litres/min to a 50.8 mm diameter double-acting hydraulic cylinder. If the load is 4448 N (extending and retracting) and the rod diameter is 25.4 mm, find

(i) The hydraulic pressure during the extending stroke.

(ii) The piston velocity during the extending stroke.

(iii) The cylinder power during the extending stroke.

(iv) The hydraulic pressure during the retraction stroke.

(v) The piston velocity during the retraction stroke.

(vi) The cylinder power during the retraction stroke. **(09 Marks)**

b. Explain with a neat sketch a Gear Pump. **(05 Marks)**

c. A hydraulic motor has a displacement of 164 cm^3 and operates with a pressure of 70 bars and a speed of 2000 rpm. If the actual flow rate consumed by the motor is 0.006 m^3/s and the actual torque delivered by the motor is 170 NM, find

(i) Volumetric efficiency.

(ii) Mechanical efficiency.

(iii) Overall efficiency.

(iv) The actual kW delivered by the motor. **(06 Marks)**

3 a. Explain with neat sketch of $\frac{3}{2}$ Poppet valve with symbolic representation. **(08 Marks)**

b. Explain with neat sketch of pilot operated pressure Relief valve. **(07 Marks)**

c. Explain with a neat sketch the working of shuttle valve with symbolic representation. **(05 Marks)**

4 a. Explain with a neat circuit diagram, the working of double pump hydraulic system. **(10 Marks)**

b. Explain with a neat circuit diagram, the counter balance valve application. **(10 Marks)**

PART – B

5 a. Write any five desirable properties of a hydraulic fluid. (05 Marks)
b. Explain three basic types of filtering methods used in hydraulic system. (06 Marks)
c. Explain static seals and dynamic seals with examples. (05 Marks)
d. Identify the most common causes of hydraulic system break down. (04 Marks)

6 a. State five disadvantages of using air instead of hydraulic oil. (05 Marks)
b. Explain with schematic sketch of FRL unit with ANSI symbol. (09 Marks)
c. Explain the characteristics of compressed air. (06 Marks)

7 a. Explain with a neat circuit diagram, the working of two step speed control system. (10 Marks)
b. Explain the pressure dependent control of circuit with a $5/2$ double pilot operated DCV, two $3/2$ spring return and double acting cylinder. (10 Marks)

8 a. Write a brief note on SPST-NO, SPST-NC, DPST-NO/NC, DPDT-NO/NC and LS-NO with symbol of these switches. (10 Marks)
b. Explain with neat sketch of circuit of sequencing of two pneumatic cylinder that can be done by using Solenoids, limit switches and valves. (10 Marks)

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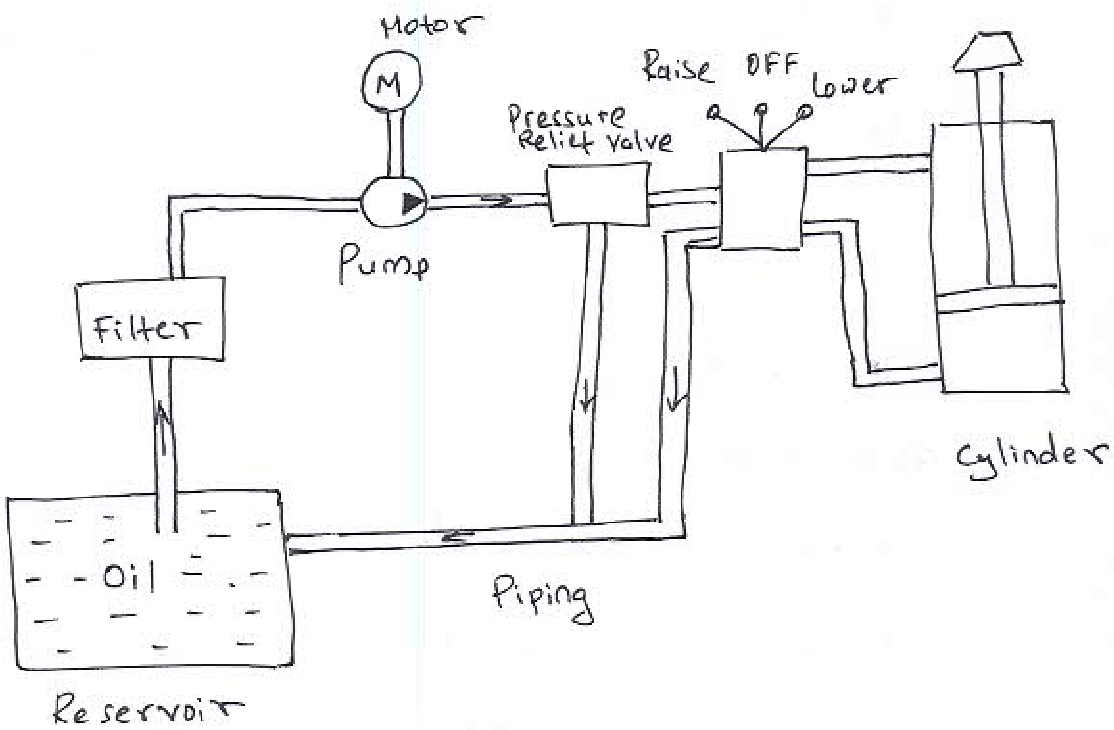
Hydraulics & Pneumatics

Dec 2017/ Jan 2018

Part A

Q. 1. a.



There are six basic components required in a hydraulic systems.

1. * tank (reservoir) to hold the hydraulic Oil

2. A pump to force the oil through the system

3. An electric motor or other power sources to drive the pump.

4. Valves to control oil direction, pressure and flow rate.

5. An actuator to convert the pressure of the oil into mechanical force or torque to do useful works.

6. Piping which carries oil from one location to another.

b. A gear pump:

Given data:

Outside dia. = 75 mm

Inside dia = 50 mm

width = 25 mm

Volumetric efficiency = η_v = 90%

Speed of pump = N = 1000 rpm

The volume displacement is

$$V_D = \frac{\pi}{4}\left[0.075^2 - 0.050^2\right] 0.025$$

$$= 0.0000614 \ m^3/rev$$

Since 1 L = 0.001 m^3, V_D = 0.0614 L

Now, $Q_A = \eta_v \times Q_T$

$= \eta_v V_D \times N$

$= 0.9 \times 0.0000614 \times 1000$

$= 0.0553 \ m^3/min$

Since $1 \ L = 0.001 \ m^3$

$Q_A = 55.3 \ Lpm$

c. A pump

Given data:

Displacement volume $= V_D = 100 \ cm^3$

Actual flow rate, $Q_A = 0.0015 \ m^3/s$

Speed, $N = 1000 rpm$

Pressure, $p = 70$ bars

Input torque, $T_A = 120 \ N.m$

To find i) Overall efficiency, η_o

ii) Theoretical torque, T_T

$$V_D = 100 \ cm^3/rev \times \left(\frac{1 m}{100 \ cm}\right)^3 = 0.000100 \ m^3/rev$$

We have

$$Q_T = V_D \times N = (0.000100 \ m^3/rev)\left(\frac{1000}{60} \ rev/s\right)$$
$$= 0.00167 \ m^3/s$$

Next solve for the volumetric efficiency

$$\eta_v = \frac{Q_A}{Q_T} = \frac{0.0015}{0.00167} = 0.898 = 89.8\%.$$

Then solve for mechanical efficiency

$$\eta_m = \frac{pQ_T}{T_A N}$$

$$= \frac{70 \times 10^5 \times 0.00167}{120 \times 1000 \times \frac{2\pi}{60}}$$

$$\eta_m = \frac{11690}{12570} = 0.930 = 93.0\%.$$

$$\eta_o = \eta_v \times \eta_m = 0.898 \times 0.930 = 0.835$$

$$\therefore \eta_o = 83.5\%$$

b. $T_T = T_A \times \eta_m = 120 \times 0.93 = \underline{\underline{112 \text{ N.m}}}$

Thus, due to mechanical losses within the pump, 120 N.m, of torque are required to drive the pump instead of 112 N.m.

d. Advantages of hydraulic system:

1. Ease of and accuracy of control
2. Multiplication of force
3. Constant force or torque
4. Simplicity, Safety, economy

Q 2. a. Given data

$Q_A = 75.8\ LPM = \frac{75.8 \times 0.001}{60} = 1.263\times10^{-3}\ m^3/s$

$A_p = \frac{\pi}{4} \times d_a^2 = \frac{\pi}{4} \times (50.8\times10^{-3})^2 = 2.026\times10^{-3}\ m^2$

$A_r = \frac{\pi}{4} \times d_a^2 = \frac{\pi}{4} (25.4\times10^{-3})^2 = 5.067\times10^{-4}\ m^2$

Extending & retracting load = 4448 N

a. $P_{ext} = \frac{F_{ext}}{A_p} = \frac{4448}{2.026\times10^{-3}} = 21.95$ bar

b. $V_{ex} = \frac{Q_{in}}{A_P} = \frac{1.263\times10^{-3}}{2.026\times10^{-3}} = 0.623\ m/s$

c. Power $= V_{ext} \times F = 0.623 \times 4448 = 2772.8$ W

d. $P_{ret} = \frac{F_{ret}}{A_p - A_r} = \frac{4448}{(2.026 \times 10^{-3} - 5.067 \times 10^{-4})}$

$= 29.33$ bar

e. $V_{ret} = \frac{Q_{in}}{A_p - A_r} = \frac{1.263 \times 10^{-3}}{1.5193 \times 10^{-3}}$

$= 0.8321$ m/s

f. $P_{ret} = V_{ret} \times F_{ret}$

$= 0.8321 \times 4448$

$P = 3701.18$ W

2.b. Gear pump

A Gear pump develops flow by carrying fluid between the teeth of two meshing gears. One of the gears is connected to a drive shaft connected to the prime mover. The second gear is driven as it meshes with the driver gear. Oil chambers are formed between the gear teeth, the pump housing and the side wear plates. The suction side is where teeth come out of mesh, and it is here that the volume expands. bringing about a reduction in pressure to below atmospheric pressure. Fluid is pushed into this void by atmospheric pressure because the oil supply tank is vented to the atmosphere. The discharge side is where teeth go into mesh, and it is here that the volume decreases between mating teeth since the pump has a positive internal seal against leakage the oil is positively ejected into the outlet port.

Volumetric displacement can be represented by

$$V_D = \frac{\pi}{4} \left(D_o^2 - D_i^2 \right) L$$

Theoretical flow rate

$$Q_T = V_D \times N$$

c. Hydraulic motor:

Given: $V_D = 164 \text{ cm}^3$

$p = 70 \times 10^5 \text{ N/m}^2$

$N = 2000 \text{ rpm}$

$Q_A = 0.006 \text{ m}^3/\text{s}$

$T_A = 170 \text{ N.m}$

Now,

a. To find volumetric efficiency we first calculate theoratical flow rate

$$Q_T = V_D \times N = 0.000164 \times \frac{2000}{60} = 0.00547 \text{ m}^3/\text{s}$$

$$\eta_v = \frac{Q_T}{Q_A} = \frac{0.00547}{0.006} = 0.912 = 91.2\%$$

b. To find η_m,

$$T_T = \frac{V_D \times p}{2\pi} = \frac{0.000164 \times 70 \times 10^5}{2\pi} = 182.8 \text{ N.m}$$

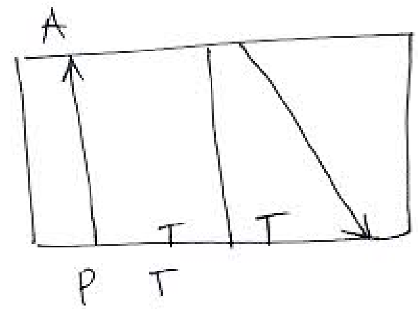
$$\eta_m = \frac{T_A}{T_T} = \frac{170}{182.8} = 0.930 = 93.0\%$$

c. $\eta_o = \eta_v \times \eta_m = 0.912 \times 0.930 = 0.848 = 84.8\%$

d. Actual torque $= T_A \times N = 170 \times 2000 \times \frac{2\pi}{60} = 35.6 \text{ kW}$

3.a. 3/2 Poppet Valve

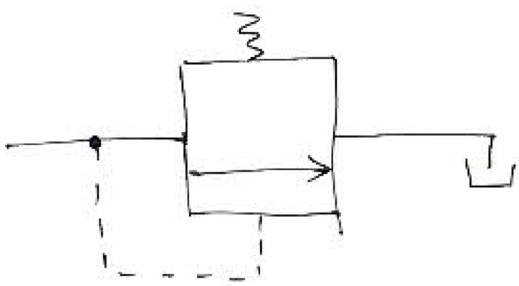
Graphical Symbol



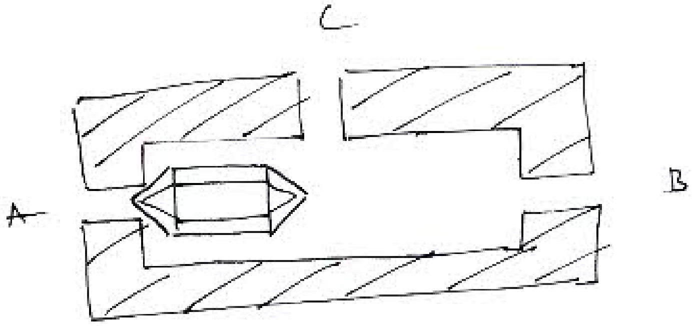
3.b. Pilot Operated pressure relief valve:

A pilot operated pressure relief valve is also called as Compound pressure valve, which operates in two stages. The pilot Stage is located in the upper valve body and contains a pressure limiting poppet held against a Seat by an adjustable Spring. The lower body contains the port connections. Diversion of the full pump flow is acomplished by the balanced piston in the lower body.

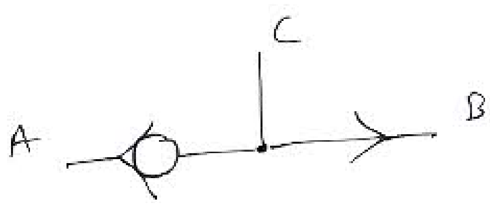
Graphical Symbol



3.c. <u>Shuttle Valve</u>



Construction diagram

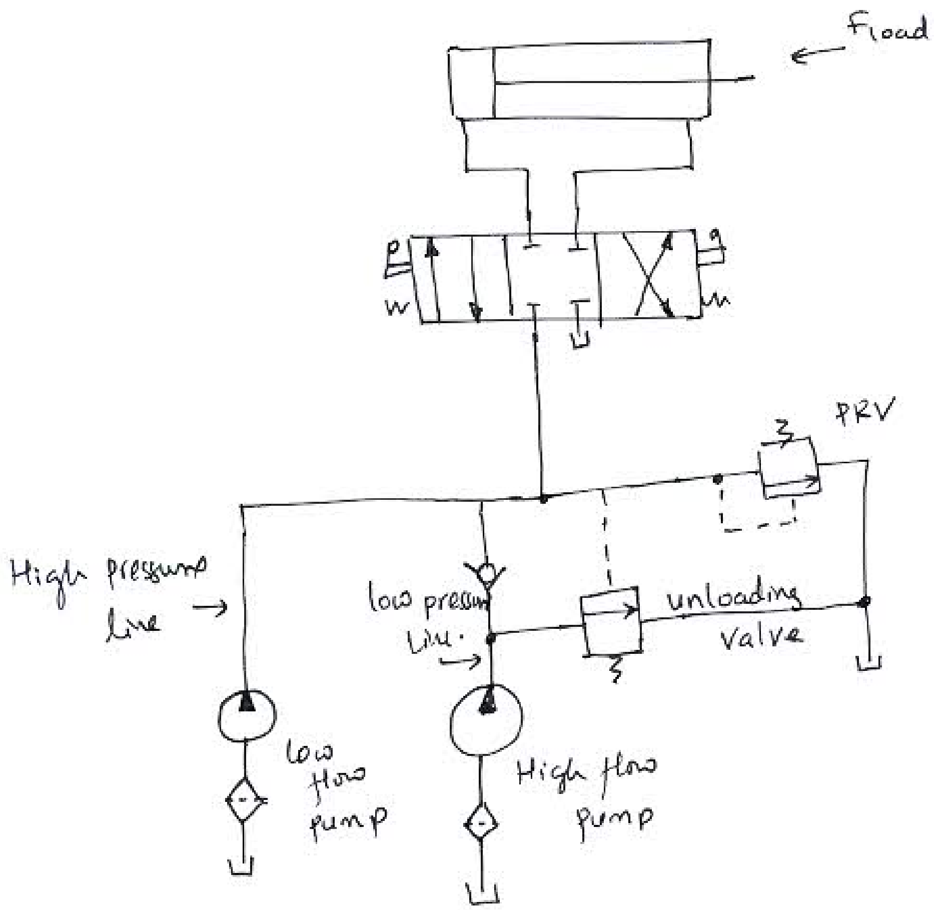


The shuttle valve is an automatic type of directional control valve with three-ways and two position characteristics. This is based on three port body with a moving valving element in the form of

Spool or shuttle or a ball.

A shuttle valve is also known as double check valve. It is primarily a pneumatic device and is rarely found in hydraulic circuits. A Shuttle valve allows either of two pressurized inlets. which ever is greater from two sources. The higher pressure inlet moves the shuttle to a position where it blocks the other inlets. . ..

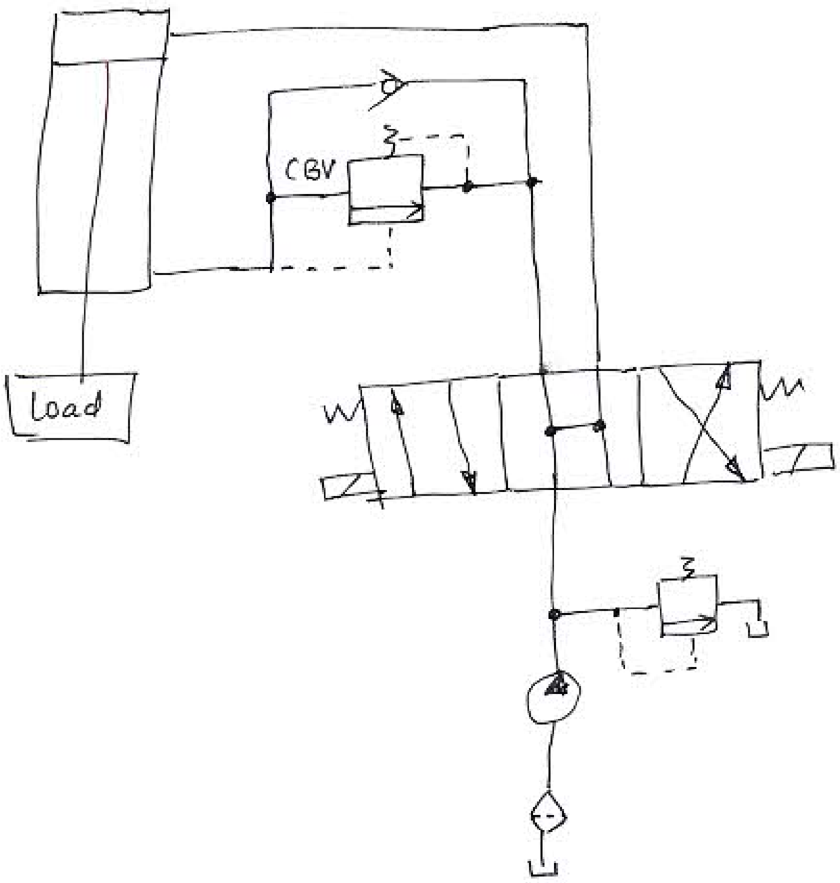
4. a. Double pump hydraulic System:



Double pump circuit uses a high-pressure, low flow pump in conjuction with a low-pressure, high flow pump. A typical application is a sheet metal punch press in which the hydraulic ram (cylinder) must extend rapidly over a great distance with the very low pressure but high flow-rate requirements. This rapid extension of the cylinder occurs under no external load as the punching tool approaches the sheet metal strip to be punched. However, during the short motion portion when the punching operation occurs, the pressure requirements are high due to the punching load. During the punching ~~load~~ operation the cylinder travel is small and thus the flow rate requirements are low.

The circuit shown eliminates the necessity of having a very expensive high-pressure high flow pump.

4.6. Counter balance valve applications.



Counter balance valve or back pressure valve is used to keep a vertically mounted hydraulic cylinder in the upward position while the pump is idling. The counter balance valve (CBV) is set to open at somewhat above the pressure required to prevent the vertical cylinder from descending due to the weight of its load. This permits the cylinder to be forced downward when pressure is applied on the top. The open centre directional control valve unloads the pump. The DCV is a solenoid-actuated, spring-centered valve with an open-center flow path configuration.

Part B

5. a. There are six desirable properties of a hydraulic fluid.

1. Viscosity
2. Viscosity index
3. Demulsibility
4. Oxidation stability
5. Lubricity or lubricative value
6. Rust and corrosion preventive quality.

5.6. There basic types of filtering methods:

1. Mechanical. This type of normally contains a metal or cloth screen or a series of metals disks separated by this spacers. Mechanical type filters are capable of removing only relatively coarse particles from the fluid.

2. Absorbent. This type of filters are porous and permeable materials such as papers, wood pulp, diatomaceous earth, cloth, cellulose, and asbestos. Paper filters are normally impregnated with a resin to provide added strength.

3. Adsorbent: Adsorption is a surface phenomenon, and refers to the tendency of particles to cling to the surface of the filter. Thus the capacity of such filter depends on the amount of surface area available. Adsorbent materials used include activated clay and chemically treated papers.

5.c. Static Seals

Static Seals are used between mating parts ~~to~~ that do not move relative to each other. These seals are compressed between two rigidly connected parts. They represent a relatively simple and non wearing joint. which should be ~~to~~ trouble free if properly assembled.

Dynamic seals are assembled between mating parts that move relative to each other. hence dynamic seals are subject to wear because one of the mating parts rubs against the seal.

Seal configurations generally used

1. O- rings
2. Compression packings
3. Piston cup packings
4. piston rings
5. wiper rings

5. d. i Common causes of hydraulic system breakdown.

1. Noisy pump
2. Low or ~~eratic~~ erratic pressure
3. No pressure
4. Actuator fails to move
5. Slow or erratic motion of actuator
6. overheating of hydraulic fluid.

6. Five disadvantages of using air instead of hydraulic oil.

1. Relative low accuracy because of change in volume due to compression of the air.

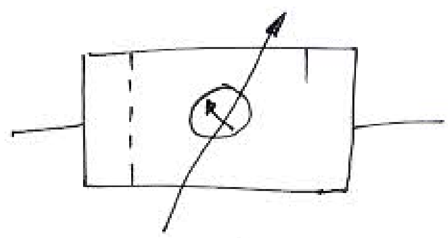
2 It cannot be adopted for large load applications

3. The medium should be processed before use to ensure absence of water and dust, otherwise the components gets rusted and efficiency of the system gets affected.

4. uniform speed of the actuators cannot be achieved, because of uneven motion of the pistons

5. Difficult to achieve constant force & torque

6. b. FRL unit



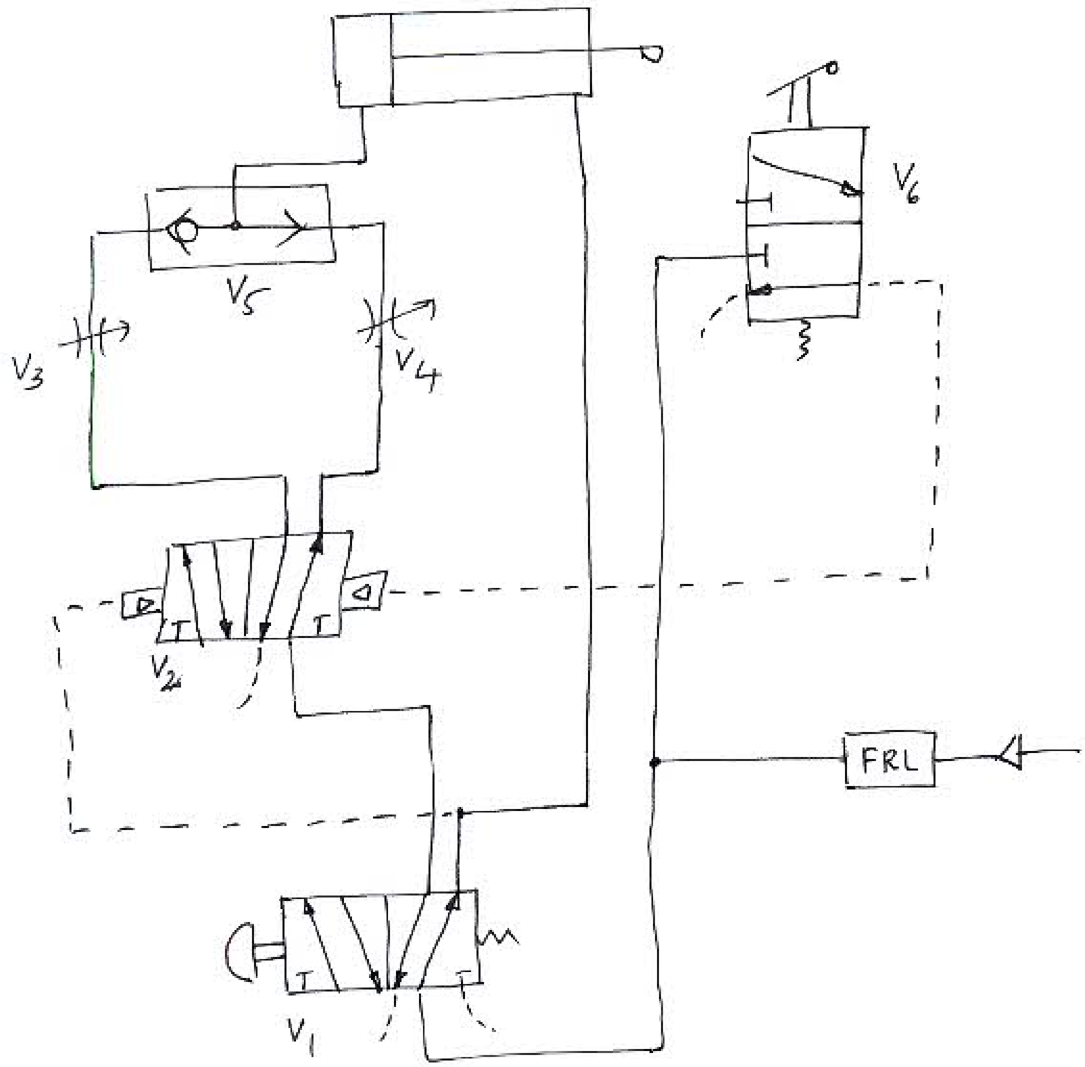
FRL ANSI Symbol

6. c. Characteristics of compressed air

1. Availability
2. Transportation
3. Storage
4. Temperature
5. Cleanliness
6. Overload safety

7. a. Two step speed control system.

A two-step speed control system

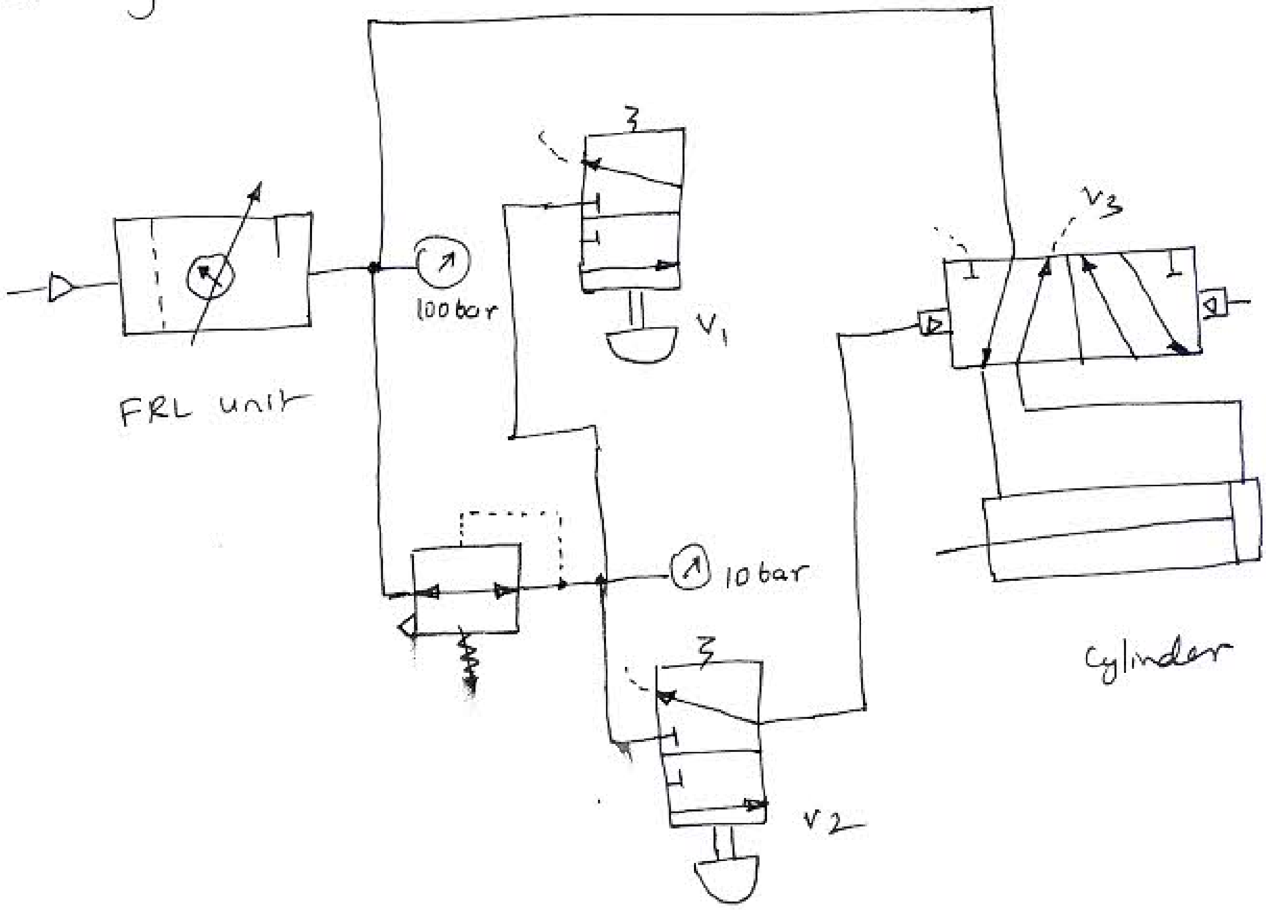


The operation is as follows, assuming that flow control valve V_3 is adjusted to allow a greater flow rate than valve V_4. Initially, the cylinder is fully retracted. When push-button valve V_1 is actuated airflow goes through valves V_2, V_3

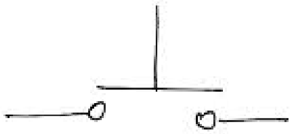
and the shuttle valve V_5 to extend the cylinder at high speed. When the piston rod cam actuates valve V_6, valve V_2 shifts. The flow is therefore diverted to valve V_4. and through the shuttle valve. However due to the low flow setting of valve V_4. The extension speed of the cylinder is reduced. After the cylinder has fully extended, valve V_1 is released by the operator to cause retraction of the cylinder.

7.6. Pressure dependent control of circuit

A double acting cylinder can be remotely operated through the use of an air pilot-actuated DCV. Push button valves V_1 and V_2 are used to direct air flow at low pressure to actuate the air piloted DCV, which directs air at high pressure ~~Such as 100 PS~~ to the cylinder. Thus operating personnel can use low-pressure. push button valves to remotely control the operation of a cylinder that requires high pressure air for performing its intended function. When V_1 is actuated and V_2 is in spring offset mode, the cylinder extends. Deactivating V_1 and then actuating V_2 retracts the cylinder.

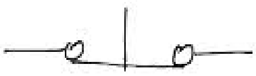


8. a. SPST – NO



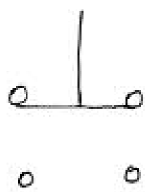
Single pole single throw
Normaly open

b. SPST – NC



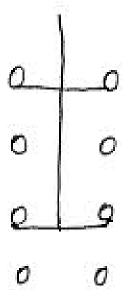
Single pole single throw
Normaly closed

c. DPST – NO/NC



Double pole single through
normaly open / Normaly close

d. DPDT – NO/NC

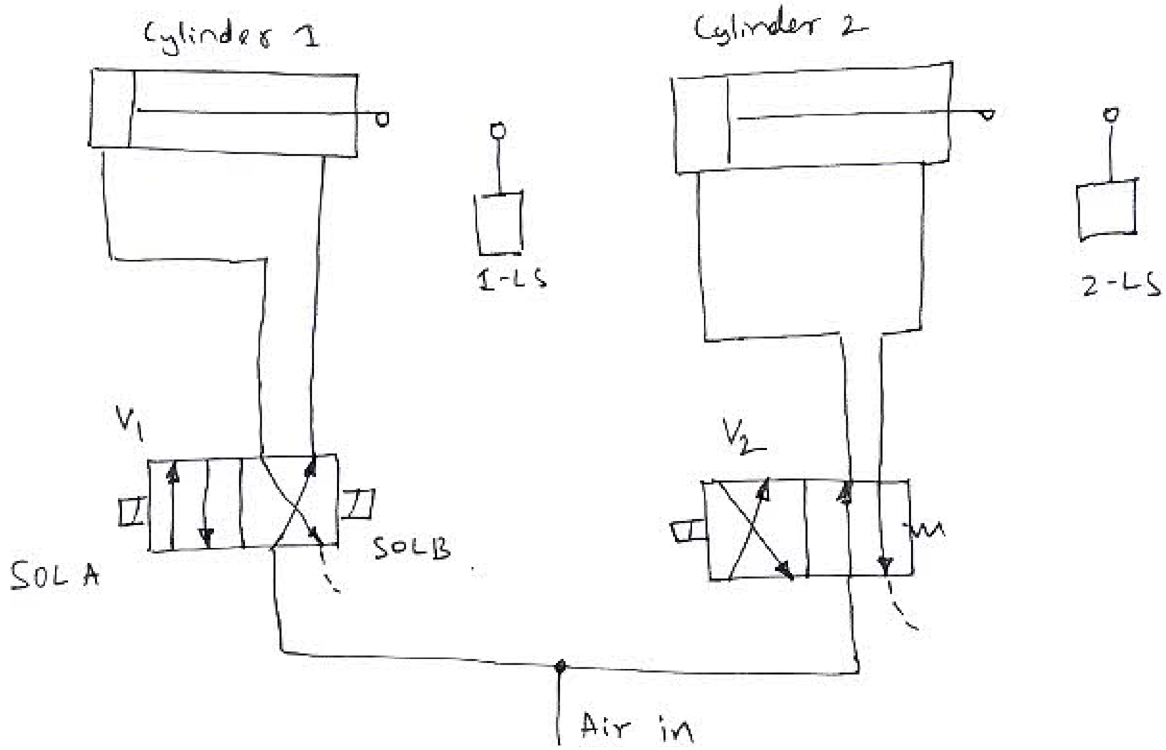


Double pole double throw
Normaly open / Normaly close

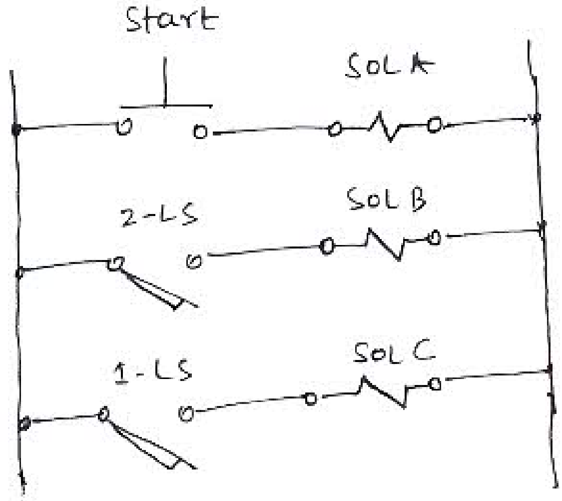
e. LS – NO

Limit switch / Normaly open

8 b. Sequencing of two pneumatic cylinders:



Dual cylinder sequencing circuit



Ladder diagram

Dual cylinder circuit provide a ~~cycle~~ cycle Sequence of two pneumatic cylinders. When ~~the~~ Start button is momentarily pressed, SOL A is momentarily energized to shift V_1, which extends cylinder 1. When 1-LS is activated, SOL C is energized, which shifts valve V_2 into its left mode. this extends cylinder 2 until it actuates 2-LS. As a result, SOL B is energized to shift valve V_1 into its right flow path mode. As cylinder 1 begins to retract, it deactivates 1-LS, which de-energizes SOL C. This puts valve V_2 into its spring offset mode and cylinders 1 and 2 retract together. The complete cycle sequence established by the momentary pressing of the Start button is as follows

1. Cylinder 1 extends
2. cylinder 2 extends
3. Both cylinder retract
4. cycle is ended.