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Pneumatic Systems

Basic Pneumatic system

Introduction:

Pneumatic systems make use of compressed air for obtaining power required for performing various tasks. Greek word 'pneumos' means breath. Extensive use of pneumatics started only after Industrial revolution. Earlier it was used in mines for ventilation and for pumping water. Use of compressed air for rock drill was first done in mid nineteenth century. Discovery of electricity led to the development of compressed air systems powered by small local compressor plants. Earlier the job was done with centralized compressor station. Most of the modern industrial systems operate at pressure of 5 to 7 bar. Nowadays there is increasing and effective use of pneumatics for mechanization and automation, essentially low cost automation systems.

A basic pneumatic system consists of compressed air (an air compressor plant), control valves, piping, pneumatic cylinder or air motor and auxiliary appliances like filter-regulator-lubricator etc. The air is compressed in an air compressor driven by an electrical motor to required high pressure. It is then passed through F.R.L unit for filtration, pressure regulation and lubrication. Oil added is then transported to the cylinder or air motor through piping and control valves. The pipe lines are designed to carry designated flow rate of air with minimum pressure drop. The valves enable the control of flow rate, direction and pressure to ensure the designed and safe performance of the pneumatic circuit.

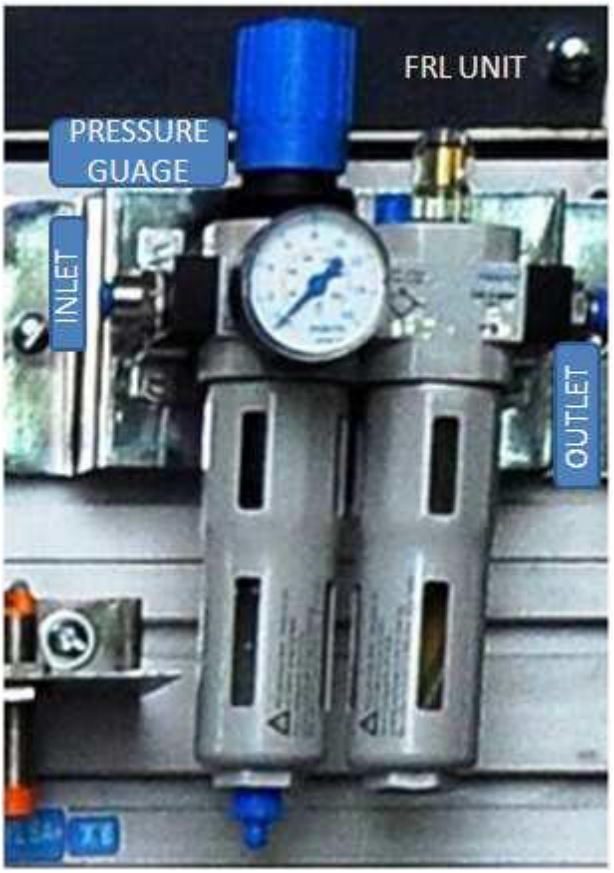
Applications of Pneumatics

Pneumatics deals with the use of compressed air. Most commonly, compressed air is used to do mechanical work – that is to produce motion and to generate forces. Pneumatic drives have the task of converting the energy stored in compressed air into motion. Cylinders are most commonly used for pneumatic drives. They are characterized by robust construction, a large range of types, simple installation and favorable price/performance. As a result of these benefits, pneumatics is used in a wide range of applications.

Filter–Regulator–Lubricator Unit (FRL Unit):

- Compressed air when cooled condenses into water, which must be removed from the compressor. Air contains dust, pipe scales, Oil etc. which also are required to be removed. Hence a filter is required in the air supply line.
- The compressed air is available at a pressure higher than the required pressure. Different systems using compressed air require it at different pressures. Hence the air is required to be supplied at a reduced & constant pressure. Thus there is a requirement of pressure regulator.

- The compressed air passes through different control and actuating systems which requires lubrication. Since it is not possible to lubricate them separately, a small quantity of lubricating oil is mixed in the compressed air itself through a unit called lubricator.



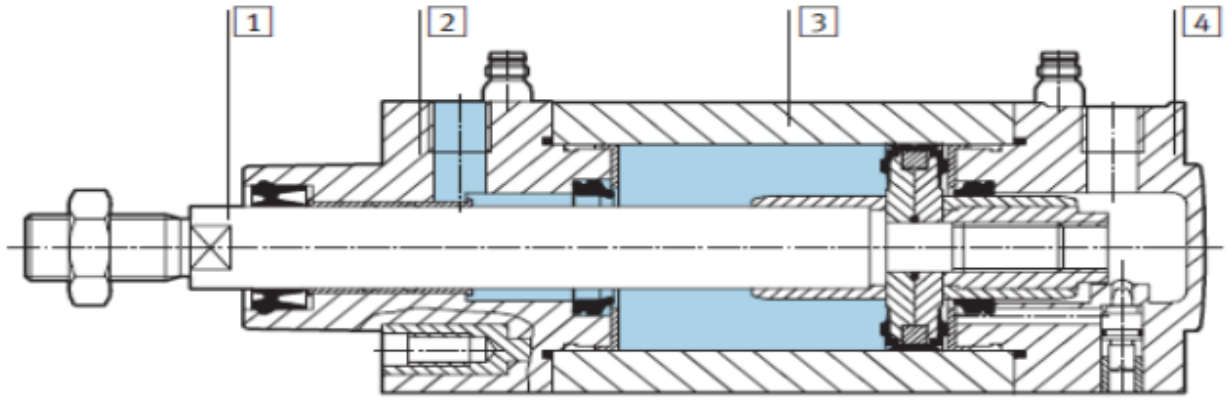
Pneumatic components

Double Acting Cylinder:

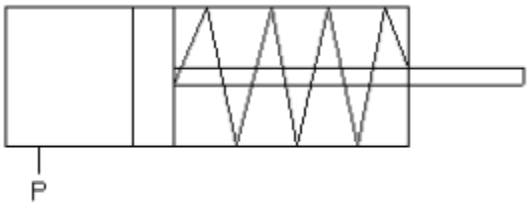
A cylindrical barrel contains a sliding piston inside it. A piston rod is connected to the piston. The two ends are closed by the two covers. A cap side cover and a rod side cover. These covers and barrel are held together by means of four tie rods connected between the two covers. Threaded connections ports are provided in the covers to connect the pipes. Seals are provided on the piston and in the rod end cover through which the piston rod moves. This helps in stopping air from flowing out, so also outside dust from entering in. When the cap side of the piston is connected to the compressed air supply and the rod side to the exhaust, piston moves forward due to the force exerted on it by the compressed air while expanding. The air on the other side is pushed out of the chamber through the exhaust connection. The piston stops moving when it reaches the end. The velocity of piston can be reduced towards the end of the stroke by providing cushioning sleeves, which reduce the impact while stopping the piston at the end. When the rod side is connected to the supply air and the cap side is connected to exhaust the piston reverses and moves till it reaches the cap end. The force exerted during this return stroke is less as the air available is less. Since the area is less, the velocity of piston during the return stroke is more.

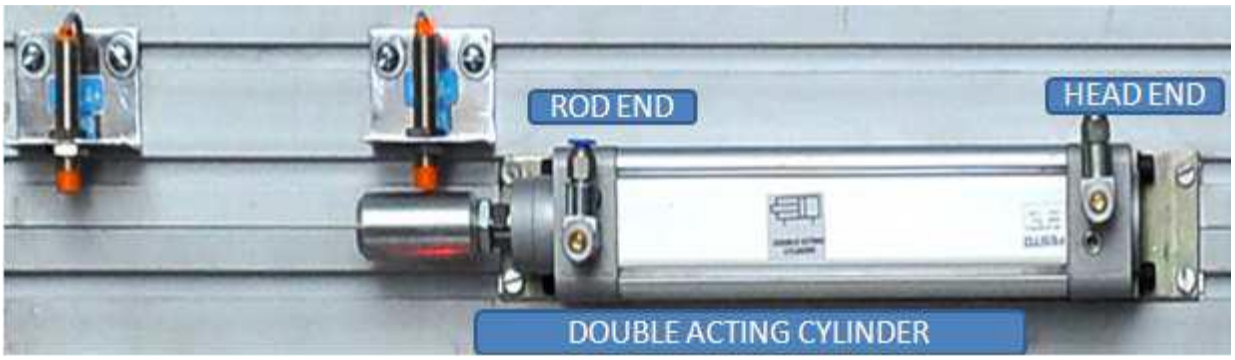
Section of double acting cylinder:

Sectional view:



Standard cylinder		Basic version
1	Piston rod	High-alloy steel
2	Bearing cap	Anodised aluminii
3	Cylinder barrel	Anodised aluminii
4	End cap	Die-cast aluminiu
–	Seals	Polyurethane, nitr
–	Note on materials	Free of copper and PTFE





Single Acting Cylinder:

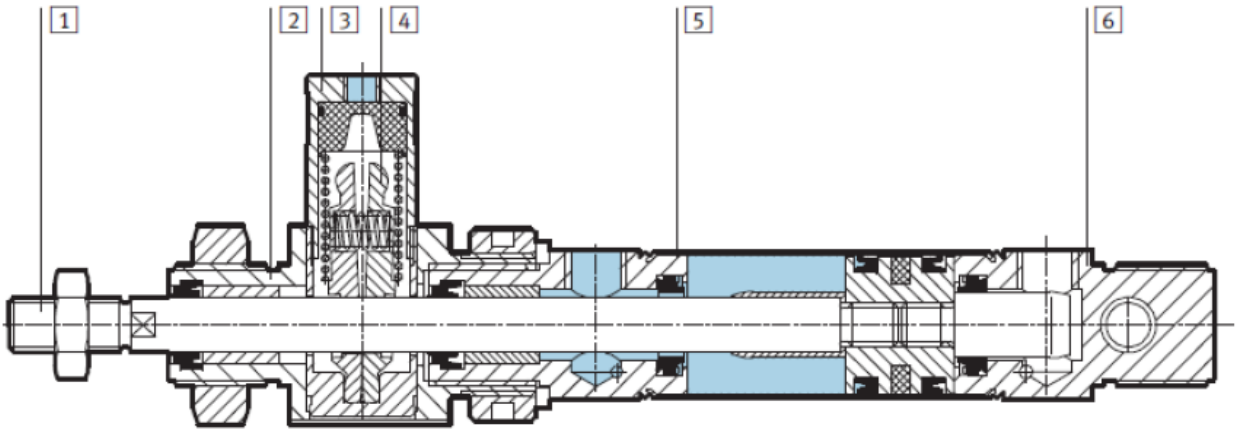
A cylindrical barrel contains a sliding piston inside it. A piston rod is connected to the piston. The two end covers closing the two ends are held together by means of four tie rods. The cap side cover is provided with a port which is connected to the pneumatic system. A helical compression spring is put in the chamber at

the rod side of the piston, with a small initial compression. Seals are provided on the piston to prevent leakage. Seals provided in the rod side cover prevent dust from entering in

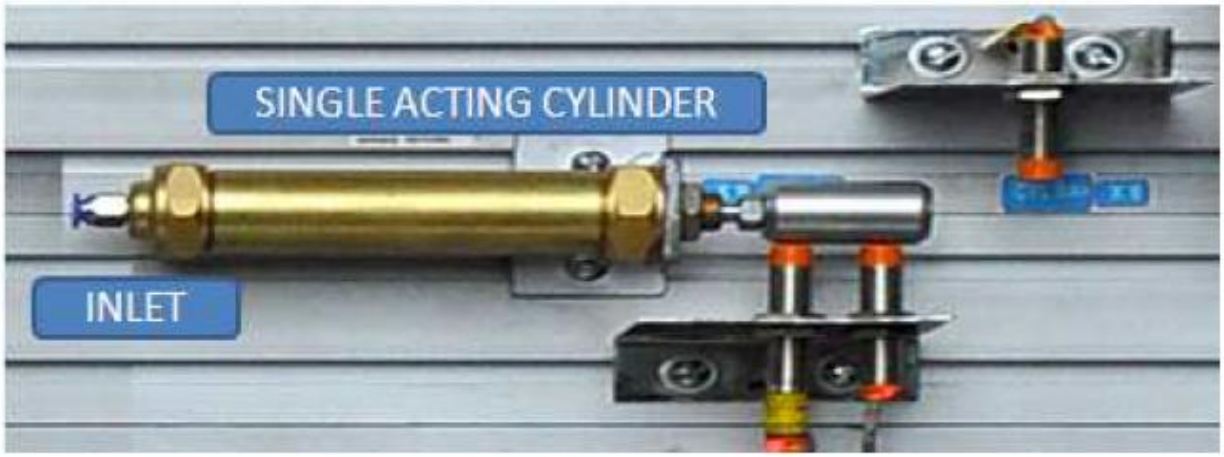
When the cap side chamber is connected to the supply air, the force produced by the air overcomes the spring force and the piston moves forward. When it moves, it compresses the spring provided on the other side, the piston remains in the position as long as air pressure is present. When the port is connected to exhaust, the spring compressed earlier expands and develops sufficient force to push the air in cap side chamber out and moves the piston in. Thus the return operation is provided by the spring.

Section of single acting cylinder:

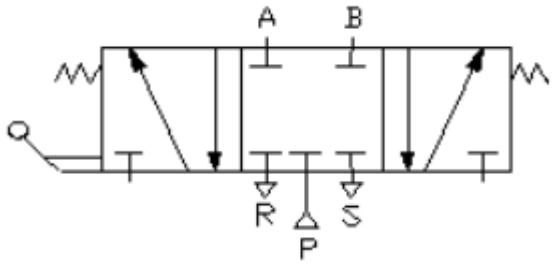
Sectional view:



Standard cylinder		
1	Piston rod	High-alloy stainless steel
2	Bearing cap	Wrought aluminium alloy
3	Housing, clamping unit	Wrought aluminium alloy
4	Clamping jaws	Brass
5	Cylinder barrel	High-alloy stainless steel
6	End cap	Wrought aluminium alloy
–	Piston, clamping unit	Polyacetate
–	Spring	Spring steel
–	Seals	Polyurethane, nitrile rubber


SINGLE ACTING CYLINDER
INLET

5/3 Way Directional Control Valve:



This DCV has five ports:

The Supply Port (P)

2 Cylinder Ports (A & B)

2 Exhaust Ports (R & S)

There are various types of actuation methods for this valve:

1. Double pneumatic actuated spring centered

a. Actuation for either of the two extreme valve positions is done pneumatically

b. Center position is automatically brought by spring only when the Pneumatic actuation is absent

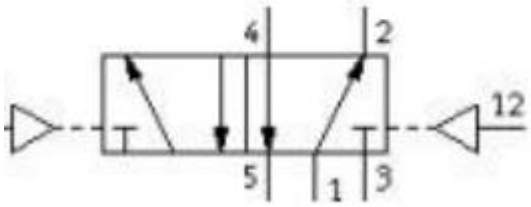
2. Three-positions-hand-Lever operated

a. Either of the three valve positions is obtained by using the lever.

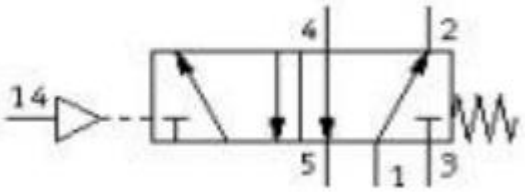
The valve consists of the body having above ports and the spool which slides in the body. The spool is provided with lands at different places which makes the different Internal flow paths possible. These valves are provided with spring on two sides of the spool for centering of the valve position. The spool remains in the shifted position as long as the pilot pressure is present. In the middle positions all the ports are blocked which means that the ports A, B, P, R and S are all blocked.

5/2 Way Directional Control Valve:

5/2 way Double pneumatic actuated DCV:



5/2 way Single pneumatic actuated DCV:



This DCV has five ports:

- The Supply Port (1)
- 2x Cylinder Ports (2& 4)
- 2x Exhaust Ports (3 & 5)

There are various types of actuation methods for this valve:

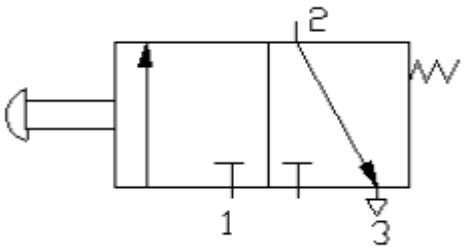
1. Single pneumatic actuated spring return

a. Actuation for one of the two valve position is done pneumatically

b. Other position is automatically brought by spring only when the pneumatic actuation is absent

2. Double pneumatic actuated Actuation both extreme valve positions are done pneumatically.

3/2 Way Directional Control Valve:



This DCV has three ports:

- Supply Port (1)
- Cylinder Port (2)
- Exhaust Ports (3)

And two valve positions In these types of valves there is no center position present. These valves are available on normally open or normally closed types. In case of normally closed valve, the air inlet (1) is closed and the outlet port (2) is vented to atmosphere through the exhaust part (3). In case of normally open valve, the outlet port is normally connected to the inlet port. When the valve is operated

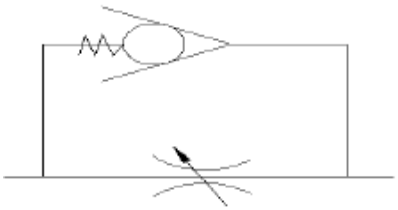
this outlet port gets connected to the exhaust. The valve spool can be operated by different means such as operating a knob, roller, handlers, foot lever, solenoid or pilot pressure. When the spool is made to shift by any of the above methods the inlet port (1) gets internally connected to the outlet port (2) while the exhaust port (3) is blocked. The supply air is supplied through the outlet port to the system

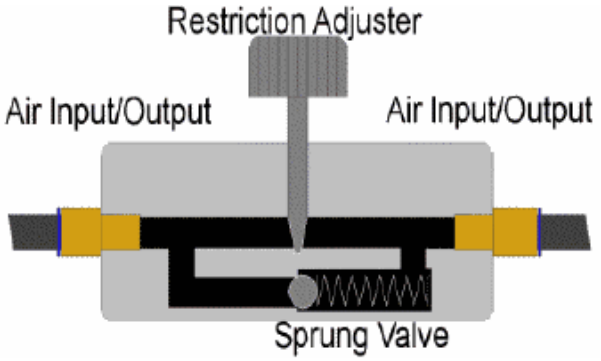
Check Valve:

This is a type of flow control valve which allows flow in one direction and restricts flow in another direction. This means there is a free flow from A to B while there is no flow B to A. This Valve is used when system requires supply of air in one direction only and there should not be any kind of reverse flow.

Unidirectional Flow Control Valve:

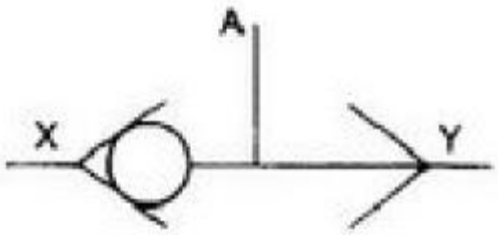
The flow control valve consists of an adjustable restrictor and a check valve. When the air flows through the adjustable restrictor the air flow rate is regulated depending upon the amount of restriction provided. The restriction available is controlled by operating the knob. The throttling function is effective only in one direction, while in the other direction free flow is provided through the check valve. Flow control valves are used to control the speed of cylinder movements.





Shuttle Valve (OR Valve):

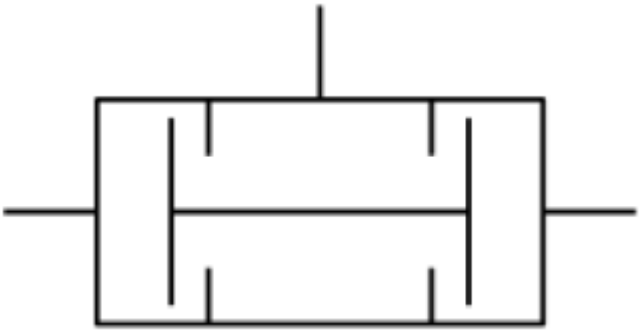
The shuttle valve has two inlets, one outlet port. If there is a signal pressure in any one of the two inlet ports, other ports are closed and air flows through valve to outlet port. In case when both the inlet ports are enjoying pressurized air, the inlet port containing higher pressure is connected to outlet port closing the other inlet port. This valve is used in the circuit where the cylinder is to be operated when anyone of the two DCVs is operated. This valve is also termed as on 'OR' valve.



(b) Symbol

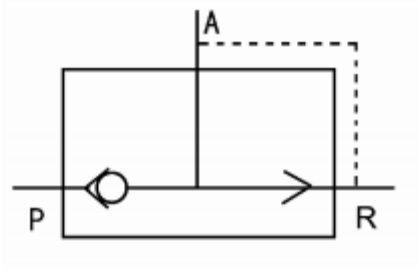
AND Valve:

The AND valve also has two inlets and an outlet. If only there is a signal pressure in both the inlet ports, air flows through valve to outlet port. In case when only anyone inlet port is enjoying pressurized air, the outlet port will still remain closed, thus giving nothing output. This valve is used in the circuit where the cylinder is to be operated when both the DCVs are operated.



Quick Exhaust Valve:

Quick exhaust valve is designed to increase the piston speeds by reducing the back Pressure. This is achieved by opening the exhaust connection directly instead of allowing the return air to pass through the directional and other valves and passages. Air pressure entering at P forces the cup seal against the seat of the exhaust port R and the inlet air flows to the cylinder port A . When the exhaust air flows from A to P, it presses the seal against the port P so that the exhaust air flows freely from A to R in the quick exhaust valve thereby allowing the air to exhaust quickly without passage through any other valves.



Operation of a Single Acting Cylinder with 3/2 way DCV

List of Components:

1. Single Acting Cylinder
2. 3/2 way push button operated DCV

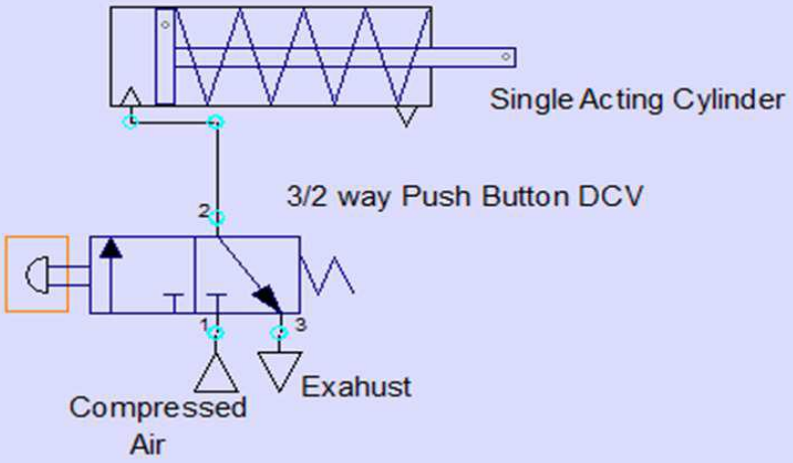
Procedure:

1. Connect the outlet of FRL unit to the inlet port of the 3/2 way Push Button DCV.
2. Connect the outlet (or cylinder) port of 3/2 DCV to the single acting cylinder.
3. Turn air supply ON.
4. Press & release the push button of 3/2 way DCV.
5. Observe the movement of the piston rod.

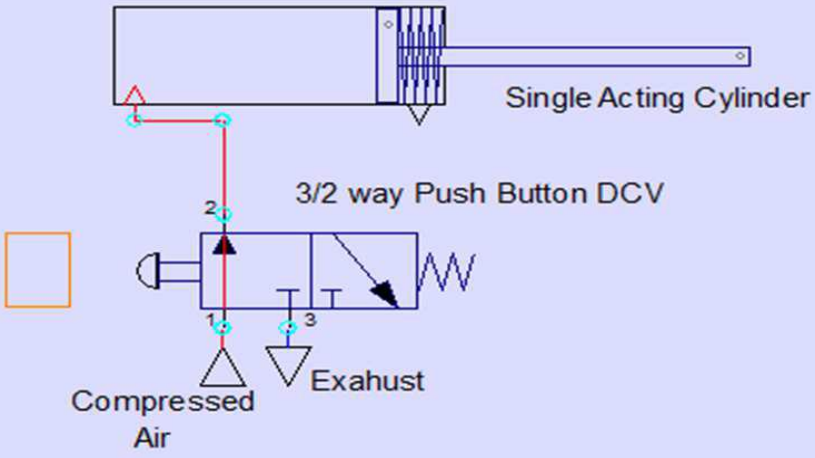
Operation:

1. Initially the pressure line is blocked and hence the single acting cylinder is in retracted position.
2. When the push button of the DCV is pressed, pressure line (P) gets connected internally to the cylinder port. Hence the compressed air is supplied to the cylinder.
3. This compressed air produces the required force to operate the cylinder. Thus piston rod is seen extending out. It remains in this position as long as the button is pressed.
4. When the push button is released, the spring inside the cylinder produces a force on the piston and pushes the piston rod inside. This air escapes out through the exhaust port of DCV to the Atmosphere. Thus the cylinder retracts to its original condition.

1-OPERATION OF SINGLE ACTING CYLINDER WITH 3/2 DCV



1-OPERATION OF SINGLE ACTING CYLINDER WITH 3/2 DCV



Operation of Double Acting Cylinder with 5/3 way Hand-Lever Operated Direction Control Valve

List of Components:

1. Double Acting Cylinder
2. 5/3 Way DCV (Hand-Lever operated)

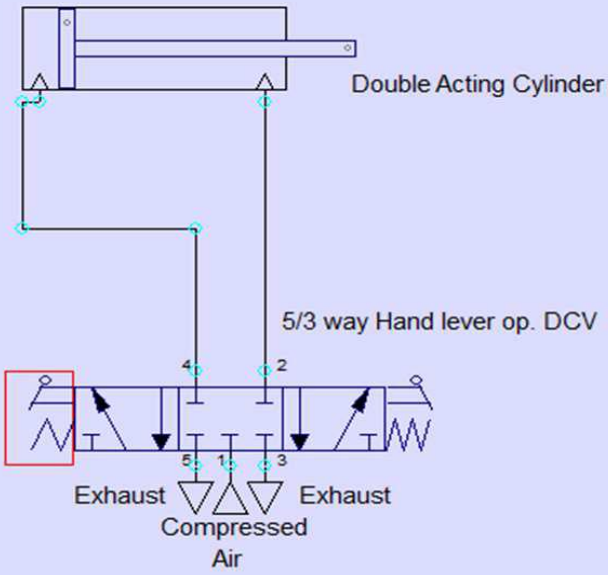
Procedure:

1. Connect outlet of FRL unit to the inlet port of 5/3 way hand lever operated DCV.
2. Now connect both outlet ports of 5/3 way DCV to both the ports of double acting cylinder.
3. Operate the lever of the 5/3 way DCV to one direction such that inlet port is connected to one of the outlet ports internally in the DCV.
4. Observe the movement of the cylinder.
5. Operate the lever of DCV in the opposite direction and again observe the movement of the cylinder.
6. While the cylinder is moving operate the lever to get the middle position.

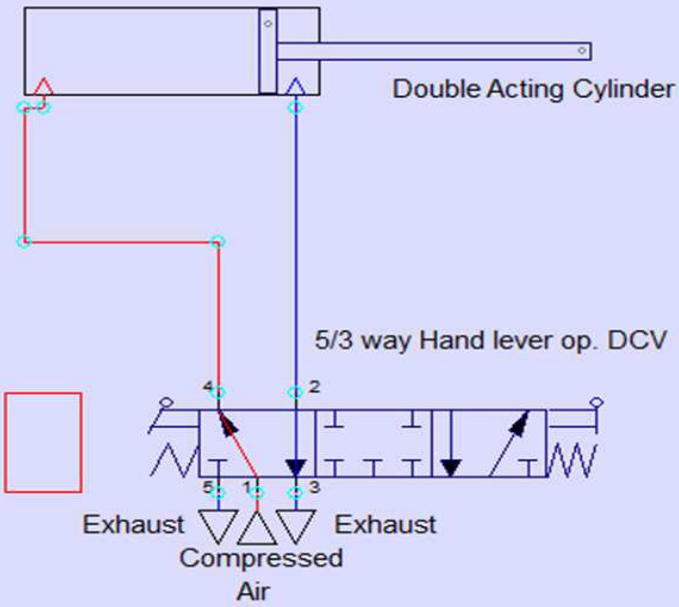
Operation:

1. Initially all the ports of the DCV are blocked. Due to this the cylinder neither extends out nor retracts.
2. When the DCV is operated in one of the sides by means of the lever the supply air is diverted to the cylinder port B by means internal flow passage, while the cylinder port 'B' is connected to the exhaust port 'S' Hence the compressed air is available to the cap end of the cylinder. Due to this the cylinder starts moving out.
3. When it reaches the extreme end the pressure of the compressed air continues to act on the piston and a constant force is developed at the piston as long as the DCV is in this position.
4. Similarly, when DCV is operated on the other side the compressed air supply is connected to the rod end and the piston rod.
5. If the DCV is brought to the middle position while the cylinder is moving, the piston stops moving and stays in the same place. Because at the middle position of the lever, all ports of 5/3 DCV are blocked. Thus air can't pass through it.
6. If the connections between 5/3 DCV & cylinder are made reverse as in the first case, then movement of the piston rod will also get reversed.

2- OPERATION OF DOUBLE ACTING CYLINDER WITH 5/3 DCV



2- OPERATION OF DOUBLE ACTING CYLINDER WITH 5/3 DCV



Operation of Single Acting Cylinder with AND Gate & 3/2 way DCV

List of Components:

1. Single Acting Cylinder
2. 3/2 Way Push Button operated DCV- 2 Nos.
3. AND Gate

Procedure:

1. Connect outlet port of the FRL unit to any port of the 'T' block.
2. Then connect one port of 'T' block to inlet port of any one 3/2 way push button DCV.
3. After that connect another port of 'T' block to the inlet port of second 3/2 way push button DCV.
4. Connect remaining port of 'T' block to any port of Isolator which isolates the extra connection from the system so that air leakage can be prevented.
5. Now connect the outlet ports of both 3/2 DCV to the inlet ports of AND gate.
6. Then connect outlet port of AND gate to the only port of single acting cylinder.
7. Operate the first DCV by pressing the push button and observe whether the single acting cylinder operates.
8. Release the button of first valve and press the second DCV.
9. Observe whether the cylinder operates.
10. Operate both the valves by simultaneously pressing their buttons.
11. Observe whether the cylinder operates.

Operation:

1. The AND valve gives the output signal only when both the signals are present.

Output cannot be obtained if only one of any inputs is present.

2. When the first valve is operated without operating second valve, the AND valve remains closed and the cylinder doesn't extend out.
3. Similarly when only the second valve is operated the cylinder cannot extend.
4. When both the DCV are operated simultaneously, the AND valve operates and the

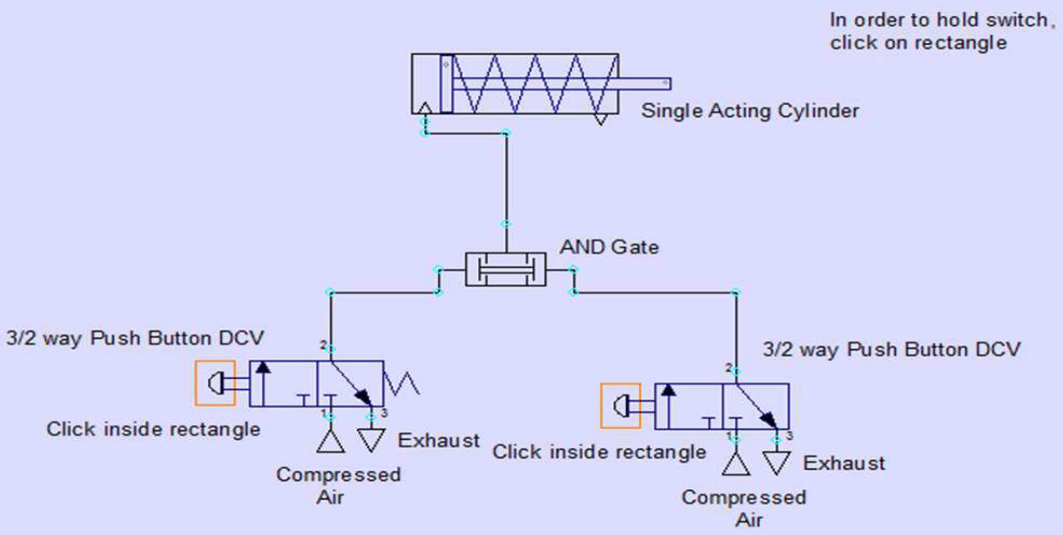
supply air is directed to the cylinder through the AND valve and the cylinder extends out.

5. When one of the valves or both of them are released, the cylinder stops due to non availability

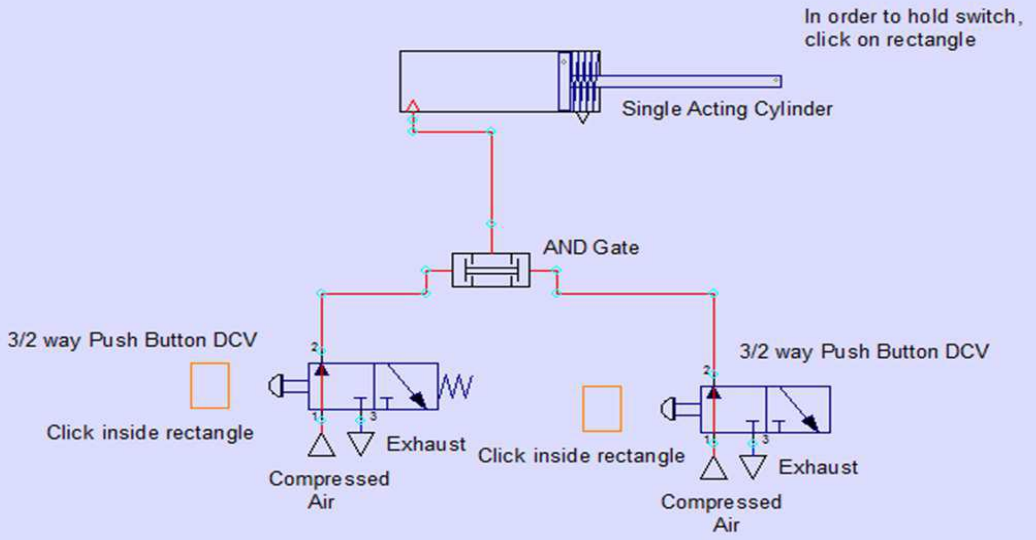
Of air.

6. The spring inside the cylinder produces a force on the piston and pushes the piston rod inside. This air escapes out through the exhaust port of DCV to the atmosphere. Thus the cylinder retracts to its original condition.

7- OPERATION OF SINGLE ACTING CYLINDER WITH AND GATE and 3/2 WAY DCV



7- OPERATION OF SINGLE ACTING CYLINDER WITH AND GATE and 3/2 WAY DCV



Operation of a Single Acting Cylinder with 5/2 way Single Solenoid Valve

List of Components:

1. Single Acting Cylinder
2. 5/2 way Single Solenoid operated DCV

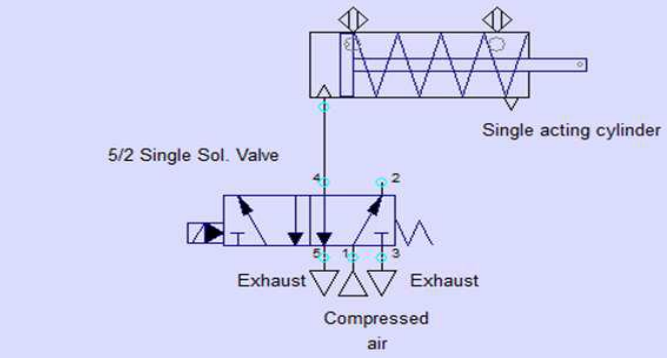
Procedure:

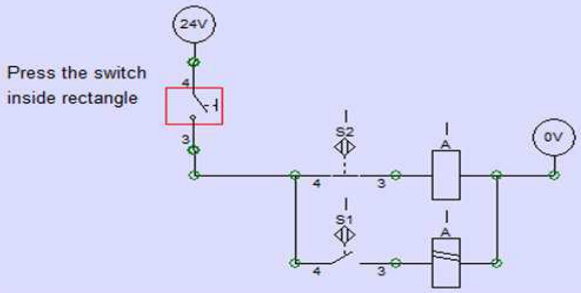
1. Connect the outlet of FRL unit to the inlet port of the 5/2 way single solenoid operated DCV.
2. Connect one outlet port of solenoid valve which is near the coil of the solenoid to single acting cylinder and another port to the isolator.
3. Solenoid has two wires; red, which is for 24V supply & black, which is for 0V.Insert red & black banana clips of solenoid wires (i.e. 24V & 0V) into respective red & black probes of relay
4. Connection should be such that red wire is connected to NO of relay 5.
5. Turn on mains supply and air supply.
6. Observe the movement of the piston rod.

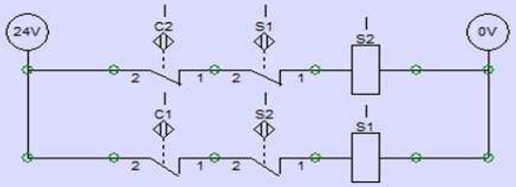
Operation:

1. Initially single acting cylinder will be in retracted position. When power supply is turned on sensor 5 will be on i.e. in NC condition. And sensor 6 will be off i.e. in NO condition.
2. Output of sensor 5 is given to relay 5and solenoid output is also given to relay 5, initially solenoid is energized.
3. When air supply is turned on, air will flow from inlet of solenoid valve to the outlet which is connected to the single acting cylinder. Piston rod will extend.
4. When rod reaches to its extreme position, sensor 6 detects it and turns on i.e. NO will temporarily get connected.
5. As soon as sensor 6 is turned on, sensor 5 will turn off because of latching circuit. Thus NC will temporarily get disconnected.
6. As we have connected solenoid to NO of relay 5, solenoid will turn OFF because of discontinuity in supply.
7. As soon as solenoid turns OFF, spool detracts to its original position and air flow to the cylinder stops.
8. Thus the piston rod retracts to its original condition due to spring action.

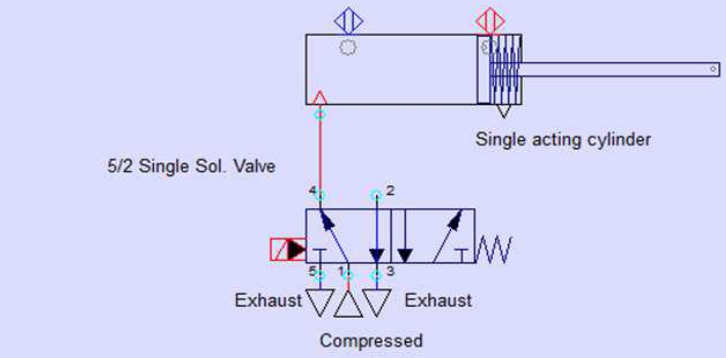
30- Operation of single acting cylinder with 5/2 way single sol valve

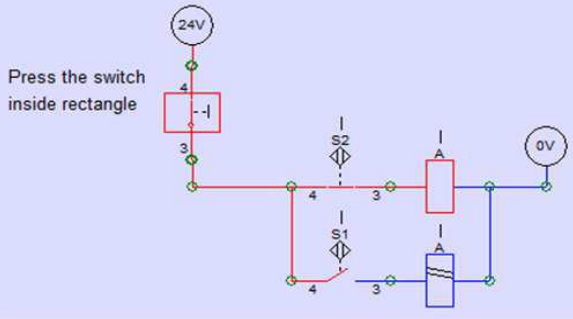


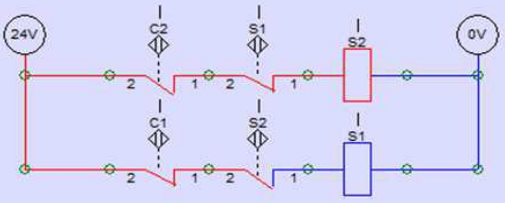




30- Operation of single acting cylinder with 5/2 way single sol valve







Continuous Operation of Double Acting Cylinder with 5/2 Way Single Solenoid Valve

List of Components:

1. 5/2 way Single Solenoid Valve
2. Double Acting Cylinder

Procedure:

1. Connect the outlet of FRL unit to the inlet port of the 5/2 way single solenoid operated DCV.
2. Connect one outlet port of solenoid valve which is near the coil of the solenoid to head end and another to the rod end side of double acting cylinder.
3. Connection should be such that red wire is connected to NO of relay 2.
4. Turn ON mains supply and air supply.
5. Observe the movement of the piston rod.

Operation:

1. Initially when air supply is turned on & electric supply is still off, air will flow from inlet of solenoid valve to the outlet which is connected to rod end side of the cylinder. Thus the cylinder will be in retracted position.

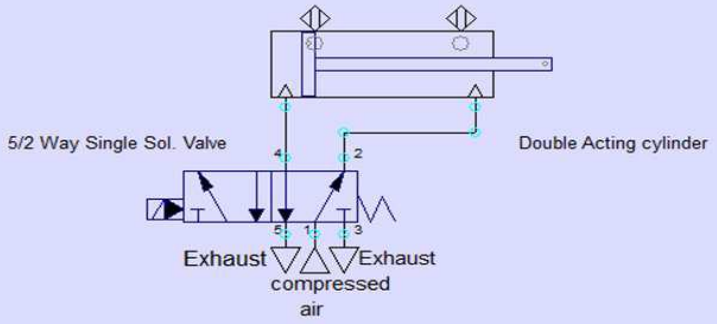
2. When electric supply is given to the system, sensor 1 will detect piston rod & will give output to relay 2. As input to solenoid is given through connection to relay 2, solenoid will turn ON and will attract the spool.

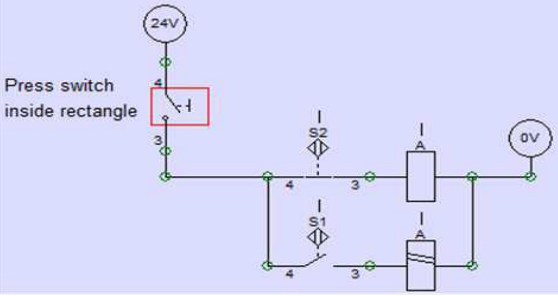
3. As soon as spool changes its position, pressure line will get switched to another port which is connected to head end side of double acting cylinder. Thus piston rod will extend.

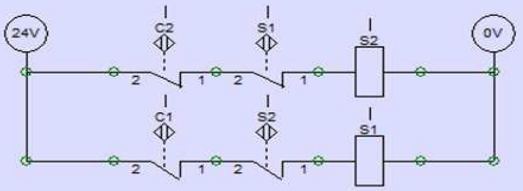
4. When the piston rod reaches the right proximity sensor i.e. sensor 2, the proximity sensor is fired and de-energizes the solenoid coil. This makes the piston rod to retract back.

5. This cycle continues until the air supply or power supply is turned on.

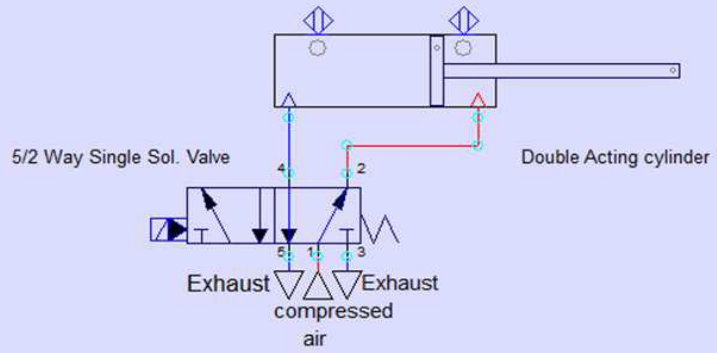
31- Continuous operation of double acting cylinder with 5/2 way single solenoid valve

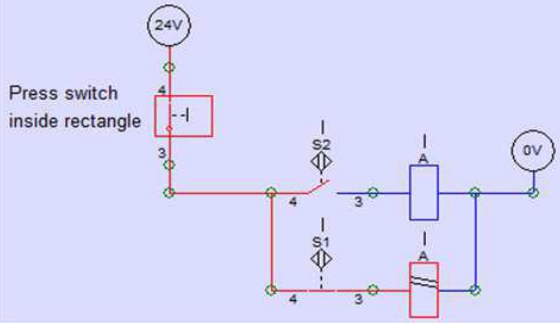


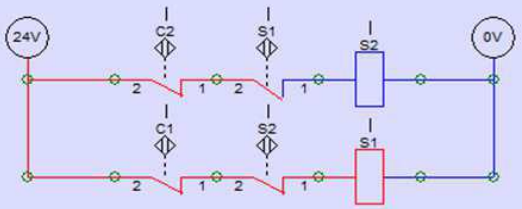




31- Continuous operation of double acting cylinder with 5/2 way single solenoid valve







Operation of D/A Cylinder with Single Solenoid Valve with Electrical AND Gate.

List of Components:

1. Double acting cylinder
2. 5/2 way single solenoid DC valve

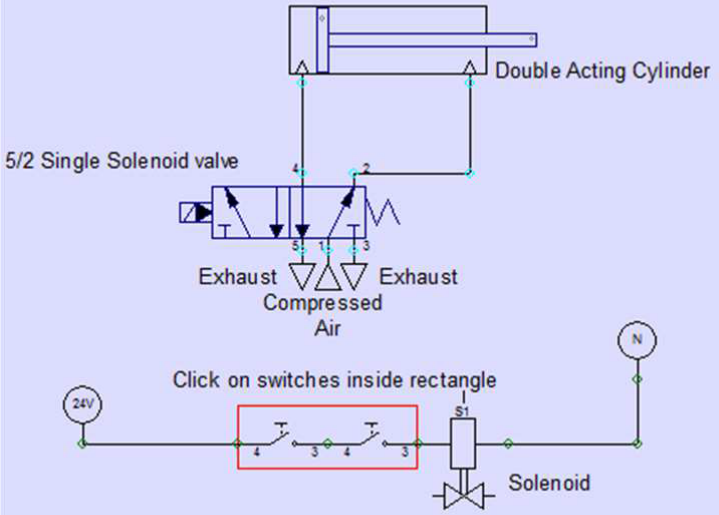
Procedure:

1. Connect the outlet of FRL unit to the inlet port of the 5/2 way single solenoid operated DCV.
2. Connect one outlet port of solenoid valve which is near the coil of the solenoid to head end and another to the rod end side of double acting cylinder.
3. Give electrical input to 5/2 way single solenoid valve from AND GATE switching unit on the electrical control panel.
4. Start air supply first & then electrical supply.
5. Press the first button of AND GATE unit and observe whether the double acting cylinder operates.
6. Release the first button and press the second and observe whether the cylinder operates.
7. Press both buttons by simultaneously observe cylinder movement.

Operation:

1. AND GATE give output only when both switches are electrically closed (i.e. pressed).
2. Initially cylinder is in retracted position as the solenoid is de-energized.
3. When only one button is pressed AND GATE does not give output and cylinder remains in retracted position.
4. When both the buttons are pressed simultaneously AND GATE gives output which activates the solenoid valve and piston rod of cylinder extends out.

32-AND GATE OPERATION WITH ELECTRICAL SWITCHES TO OPERATE D/A CYLINDER WITH 5/2 WAY SINGLE SOLENOID VALVE

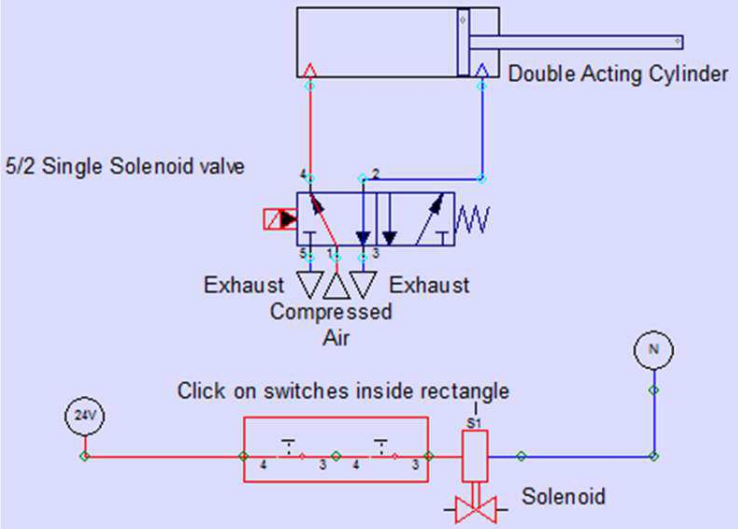


AND Gate of two electrical switches

Logic Table

INPUT 1	INPUT 2	OUTPUT
0	0	0
0	1	0
1	0	0
1	1	1

32-AND GATE OPERATION WITH ELECTRICAL SWITCHES TO OPERATE D/A CYLINDER WITH 5/2 WAY SINGLE SOLENOID VALVE



AND Gate of two electrical switches

Logic Table

INPUT 1	INPUT 2	OUTPUT
0	0	0
0	1	0
1	0	0
1	1	1

Operation of Double Acting Cylinder with 5/2 way Double Solenoid Valve

List of Components:

1. 5/2 Double Solenoid Valve
2. Double Acting Cylinder

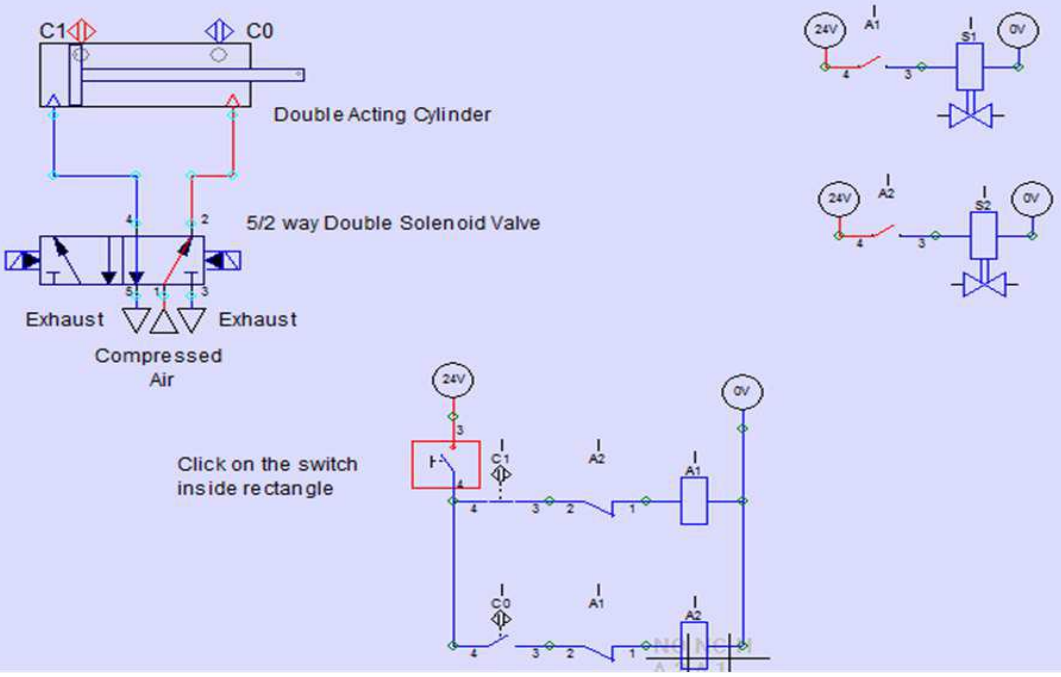
Procedure:

1. Connect the outlet of FRL unit to the inlet port of the 5/2 way double solenoid operated DCV.
2. Connect the outlet port which is near solenoid coil 1 to rod end side & another outlet port near solenoid coil 2 to head end side of double acting cylinder.
3. Connect wires of solenoid 1 to relay 1 & of solenoid 2 to relay 2.
4. Start air supply & electrical connections.
5. Observe the continuous cylinder motion.

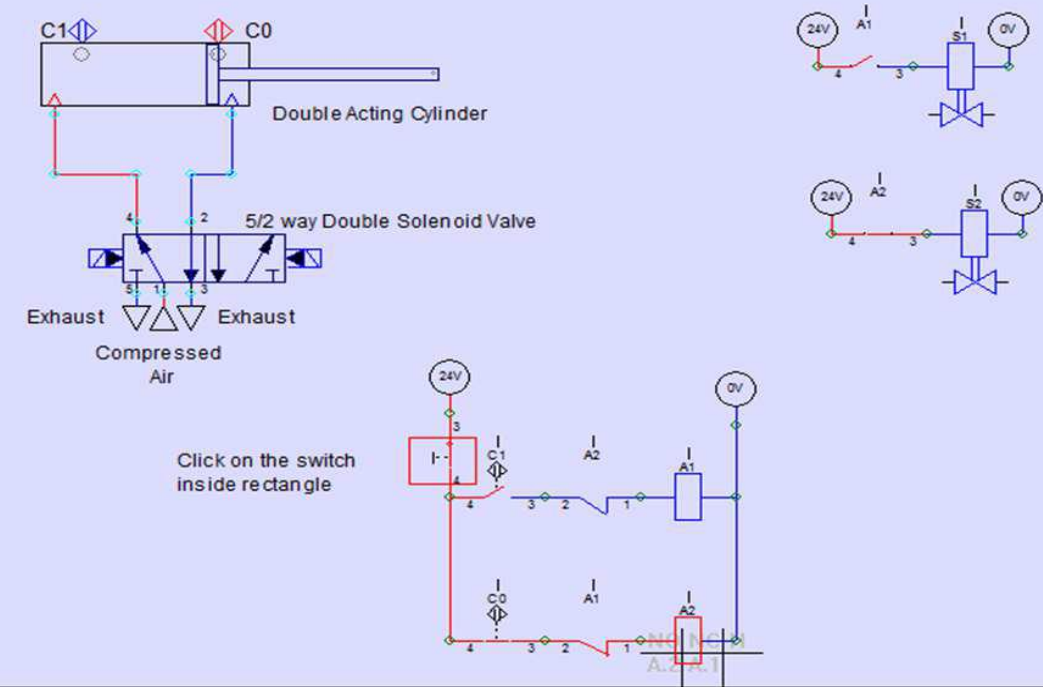
Operation:

1. Initially when electrical connection is OFF & air supply is made ON, cylinder will remain in retracted position.
2. Because of no electrical connection sensor will not sense the metal & relay will not change its position & ultimately solenoid will not get energized.
3. When electrical supply is turned ON, one of the solenoid coils is actuated. The supply air is diverted to the port at the head end side of the cylinder while the cylinder port at rod end side is connected to the exhaust port. Hence the compressed air is available to the cap end of the cylinder and the other end is connected to the exhaust. Due to this the piston rod extends out.
4. When piston rod extends out fully, sensor 2 sense the metal & gives output to relay 2. Due to this previously NO condition of relay 2 changes into NC condition & in case of relay 1, NC changes to NO.
5. As relay 2 is in NC condition, solenoid 2 actuates & valve is operated on the other side the compressed air supply is connected to the rod end side. The piston rod retracts during this position.
6. This cycle continues till electrical supply or air supply is turned OFF.

36- CONTINUOUS OPERATION OF DOUBLE ACTING CYLINDER WITH DOUBLE SOLENOID VALVE



36- CONTINUOUS OPERATION OF DOUBLE ACTING CYLINDER WITH DOUBLE SOLENOID VALVE



Sequencing of two Cylinders: Cylinder A extends, then B extends and then both retracts simultaneously; A+, B+, (A-, B-)

List of Components:

1. 5/2 way double Solenoid Valve (2 Nos.)
2. Double Acting Cylinder (2 Nos.)

Procedure:

1. Connect the outlet of FRL unit to T-block.
2. Then connect the T-block to input ports of both 5/2 way double solenoid valves.
3. Make the connections such that solenoid valve 1 is connected to cylinder A (or upper cylinder) & solenoid valve 2 is connected to cylinder B. (i.e. lower cylinder)
4. Remember that each double solenoid valve has two solenoid coils, make cross connections between double acting cylinders & double solenoid valves i.e. connect
the outlet port which is near solenoid coil 1 to rod end side & another outlet port
near solenoid coil 2 to head end side of double acting cylinder A.
5. Similarly, connect solenoid coil 3 to rod end side & solenoid coil 4 to head end
side of double acting cylinder B.
6. Now, in case of electrical connections, make common connection of solenoid coil 1
& 3 and 2 & 4, and connect to relay 1 & 2 respectively.
7. Start electrical supply and air supply.
8. Observe the sequencing of the two cylinders.

Operation:

1. Initially all the ports of both the 5/3 way valves are blocked and the cylinders are in retracted position.
2. When we switch on the sequencing box, the both the 5/3 way valves are actuated in a sequence such that:

a. First, cylinder A extends out. This fires the upper proximity sensor of cylinder A and the signal is carried forward to sequencing box.

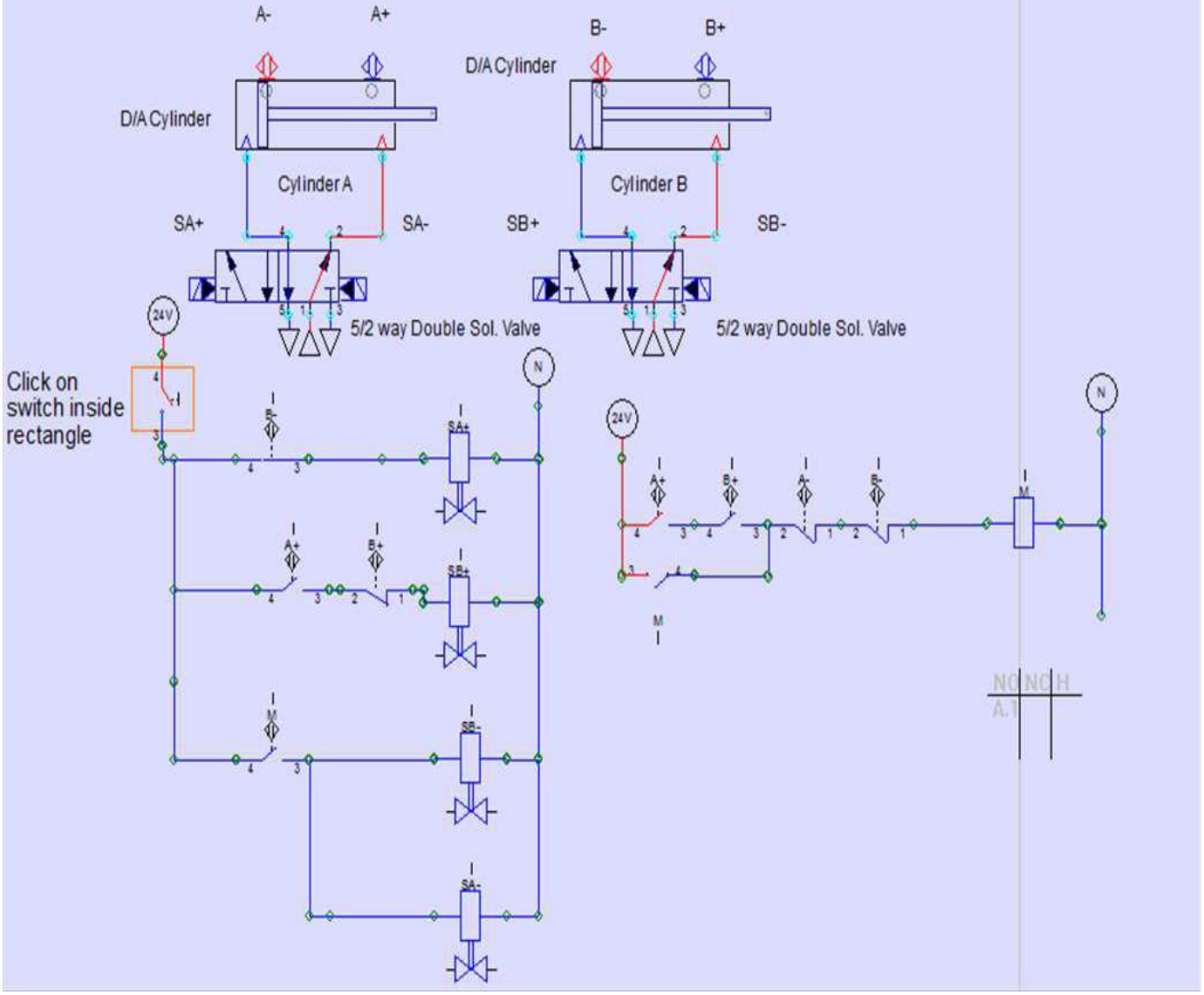
b. Second, cylinder B extends out. This now fires the upper proximity sensor of
cylinder B and the signal is carried forward to sequencing box again.

c. Third, both the cylinders A and B retract back simultaneously. Now both the lower proximity sensors are fired and signal is carried forward to repeat the whole cycle again.

3. The cycle continues until we switch off the sequencing unit

41. Sequencing of two cylinders: Cylinder A is extends, Cylinder B extends, Cylinders A and B retract simultaniously

A+, B+, (A-B-)



41. Sequencing of two cylinders: Cylinder A is extends, Cylinder B extends, Cylinders A and B retract simultaniously

A+, B+, (A-B-)