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Design and Simulation of Electro-Pneumatic Sequential System Using Fluid Sim Software

Muhammed Ishack V[1], Ahammed Adil P[2], Amal P K[3], Rohith V T[4] Jibi R[5]

[1234]*Graduate Student,* [5]*Assistant Professor Department of Mechanical Engineering, AWH Engineering College Calicut, Kerala, India*

Abstract – *Electro-pneumatic control system is an integration of pneumatics and electrical technology. The control of pneumatic components by electrical impulses is known as electro-pneumatics. Electro-pneumatic commonly used in low-cost industrial applications. Electro-Pneumatic system consist of electrical control system operating pneumatic power system. In electro-pneumatic system solenoid valve are used as the interface between electrical and pneumatic system. Control of Electro-pneumatic system is achieved using either a combination of relay and contactors or PLC.In this work consist design and simulation of pneumatic cascade A+B+B-A- sequential circuit using FluidSim -P Software.*

Key Words*: *Electro-Pneumatic Sytem, Simulation, PLC, Relay.

1.INTRODUCTION

Various automation technique plays a key role in enhancing overall industrial productivity. Fluid power has unique role in industrial automation. Pneumatic based on fluid power principle.

Pneumatic is the study of system operated by air under pressure. "Pneuma" is a Greek word which means "Breath". Air taken from the atmosphere is compressed in a compressor, and this compressed air is used to produce necessary work out put. Electro-pneumatic circuits are one of the industrial automation cornerstones. Programmable Logic Controllers (PLC) are one of the main components of these circuits. Electro-pneumatic circuit are commonly used for low-cost industrial automations. In electro -pneumatic system pneumatic power system operated by electrical control system. Solenoid valve act as interface between electrical and pneumatic system.

Fluid SIM is a software tool for creating simulating hydraulic, pneumatic, electro-hydraulic electro-pneumatic digital electronic system. FESTO FluidSim software is used for simulation of pneumatic power system.

Main aim of work is design simulate electro-pneumatic cascade sequential circuit A+B+B-A-configuration, using various electrical and pneumatic components.

2. ELECTRO-PNEUMATICS SYSTEM

In a pneumatic system compressor is the only device which consumes electricity. In industry electro -pneumatic have wide applications. In electro-pneumatic circuit solenoid-operated valves, starter/pushbuttons, make/break switches working using electricity. Generally, in pneumatics, air moves the spool but in Electro-pneumatics instead of using air to move the spool of direction control Valve apply voltage to a solenoid coil. This voltage will generate an electromotive force, resulting in the shifting of spool.

Pneumatic system generally consists pneumatic signal control section and pneumatic power section. Mechanically operated push button is commonly used as signal input elements. Pneumatic signal is getting processed using signal processing unit. Signal output execute extension or retraction of cylinder or clockwise or anti clockwise motion of rotor actuator. Flow control elements act as an interface between pneumatic signal control section and pneumatic power sections.

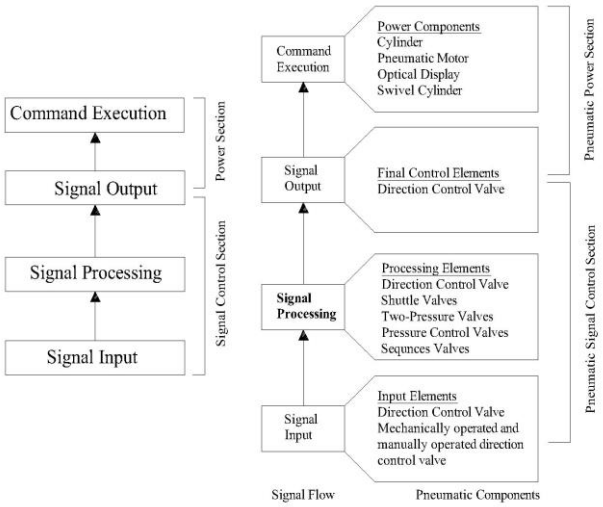

Fig 1: Pneumatic System Control

Electro-pneumatic system consists Electrical signal control section and pneumatic power section.

Electro-pneumatic controls involve three important steps
Signal generation using input devices: Signal is generating using devices such as switches, contactors, sensors.

Processing of signals: Signals are processed using contactors and relays, or programmable logic controllers (PLC).

Signal Output: Output from signal processing units are used to activate output devices like solenoids, indicators or audible alarms.

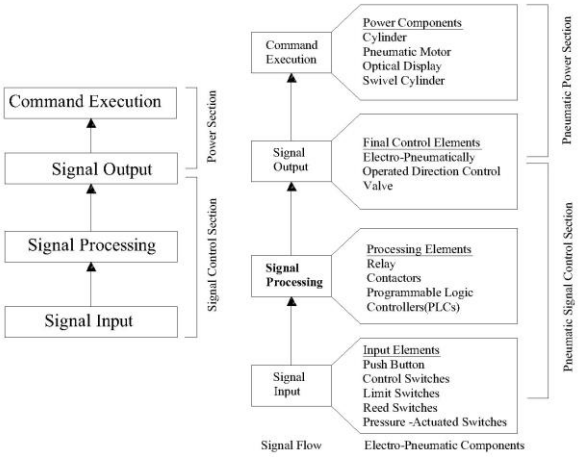

Fig 2: Electro-Pneumatic System Control

In operation of electro-pneumatic controller system, electro-pneumatic control system is not shown in a single over all circuit diagram, but in two separate diagram one for electrical part and one for pneumatic part.

Components of electrical signal control
Seven electrical devices are commonly used in the control of fluid power system

Manually actuated push button switches
Limit switches
Pressure switches
Solenoids
Relay
Timers
Temperature switches
Other devices also used in electro-pneumatic are
Proximity sensor
Electric counter

Manually actuated push button switches: Push button is used to open or close electric control circuit. They are used to apply current to a load or interrupt a circuit. Push button is distinguished according to contact behavior.
Normally open: In the case of normally open contact the circuit is open if the switch is in its initial position (not actuated) The circuit is closed by pressing the push button current flows to the load, when the plunger is released, the spring return the switch to its initial position, interrupting the circuit.
Normally closed: In this case the circuit is closed when the switch is in its initial position. The circuit is interrupted by pressing the push button
Change -over: Change over contact combines the functions of the normally open and normally closed contact in one device. Change over contacts are used to close one circuit and open another in one switching operation circuits are momentarily interrupted during change over.

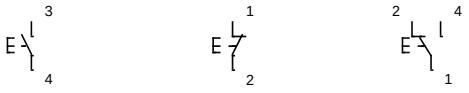

Fig 3: Manually actuated push button switches symbol

Limit switches: Limit switches activated by the position of a fluid power component. The actuation of limit switch provides an electrical signal that causes an appropriate system response.
Limit switches are classified by method of actuation lever actuated and spring actuated.

Fig 4: Limit switch symbol

Pressure switches: Pressure switches are basically electro-pneumatic signal converter, and opens or closes an electrical switch when a pre-determined pressure is reached. Bellows or diaphragm are used to sense the change of pressure and expand or contract in response.

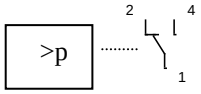

Fig 5: Pressure switch symbol

Solenoids: Electrically actuated direction control valves form the interface between the two parts of an electro-pneumatic control. Main objective of electrically actuated DCVs include controlling air supply and extending and retracting cylinder drives. The DCVs are controlled with the aid of solenoids can be divided in to two group spring return valve which remain actuated as long as current flow through the solenoid. Double solenoid valves which maintain the last switched position even when no current flows through the solenoid.

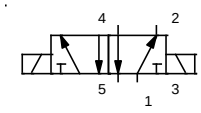

Fig 6: 5/2-way double solenoid valve

Relay: A relay is an electromagnetically actuated switch. When voltage is applied to solenoid coil, an electromagnet field result. This causes the armature to attracted to the coil core. The armature actuates the relay contacts either opening or closing them, depending on the design. A return spring restore the armature to its initial position when current to the coil is interrupted.

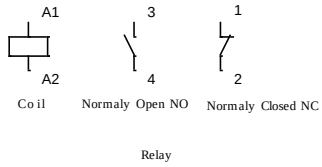

Fig 7: Relay

Time delay relays: Timers are required in control system to introduce time delays between work operations via the associated control elements. Electronic timers are most commonly used. There are two types of time delay on-delay timer and off-delay timer.

Fig 8: Time delay relay

Temperature Switch: Temperature switch automatically senses a change in temperature and open or closes an electrical switch when a predetermined temperature is reached. It can be either normally open or closed.

Proximity sensors: Commonly using proximity sensor in pneumatic circuit as shown below.

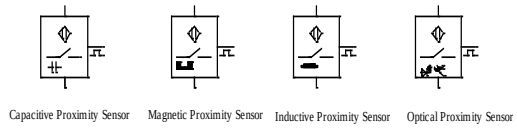

Fig 9: Proximity Sensor

Electronic Counters: Electronic counters are used to count the no of signals passing through it. There are two types of counters up counter counts electrical signals upwards from zero. For each electrical pulse input to the coil, the counter value incremented by one. Down counter counts down electrical signals from preset value.

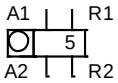

Fig 10: Relay Counter

Identification of components

The components in the circuit diagram of a control system are identified by a letter in accordance with following table. Components with identical identifying letters are assigned consecutive numbers.

Sl No	Component Type	Identification
1	Limit switch	S
2	Manually operated push button	S
3	Reed switch	B
4	Electronic proximity switch	B
5	Pressure switch	B
6	Indicator	H
7	Relay	K
8	Contactor	K
9	Solenoid coil of a valve	Y

Table 1: Identification Letter of Components

3.WORKDONE

In an electro-pneumatic sequence circuit usually have two or more cylinder that extend or retract in pre-defined sequence. In order to avoid signal conflict cascade method is used.

Required Sequence motion A+B+B-A-

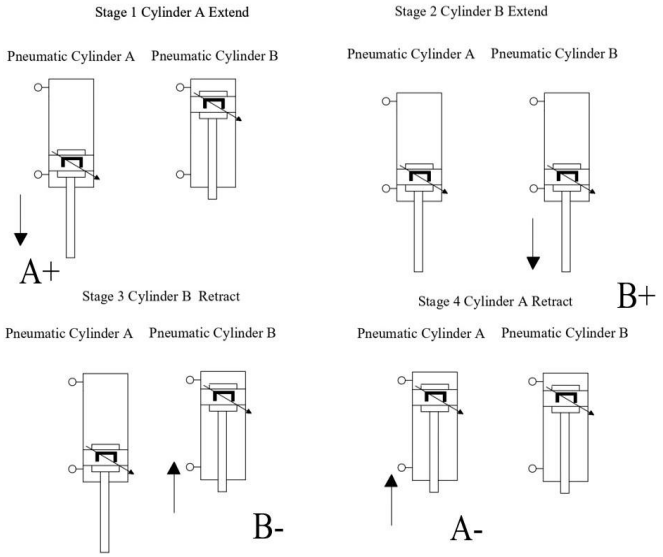

Fig 11: Positional Layout with Notation

Flow Chart for Electro-Pneumatic Circuit Design

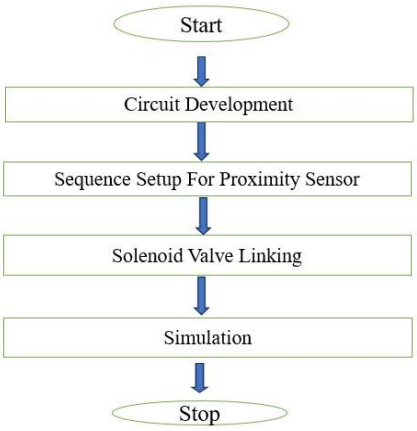

Fig 12: Flow Chart -Electro- Pneumatic Circuit Design

A sequential circuit is designed with A+B+B-A- motion. Total two double acting cylinders are used. Each one respectively designed and dedicated to the sequential operation in system. Each cylinder activates with two specific proximity sensors for the motion function.

Fluid Sim Pneumatic simulation software is used for simulating pneumatic circuit. Fluid Sim Pneumatics is a teaching tool for simulating pneumatics basics and runs using Microsoft Windows. The Fluid Sim Pneumatic Simulation software supports learning, educating, and visualizing pneumatic knowledge. The Pneumatic components which are explained with textual descriptions, figures, animations and its working principles. The user will quickly learn to draw and simulate
electro-pneumatic circuit diagram.

Methods to Control Double Acting Cylinder

Case 1: The electro-pneumatic diagram given below shows a simple A+A- circuit. As the piston is in A0 it is in on condition. Whenever A0 sensor on electric current flow from 24Vto 0V, then left position of valve KA+ will get active compressed air will go to left side of pneumatic cylinder and piston will move forward. When piston completely outward A1 close KA- get electricity right side will become active compressed air go to right side of cylinder piston moves backward direction.

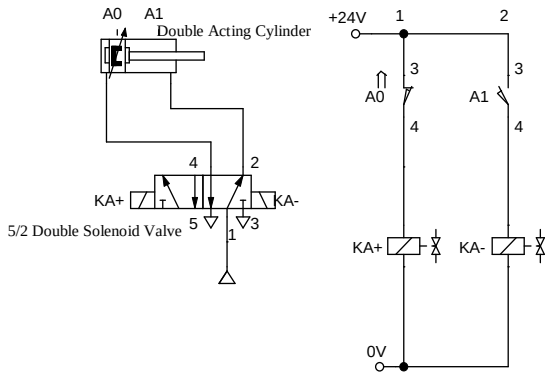

Fig 13: Simple A+A- Circuit.

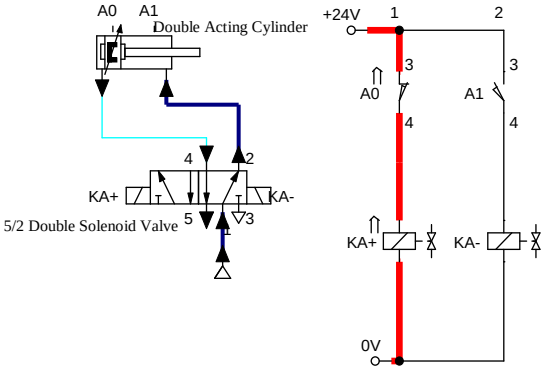

Fig 14: Starting of Extension

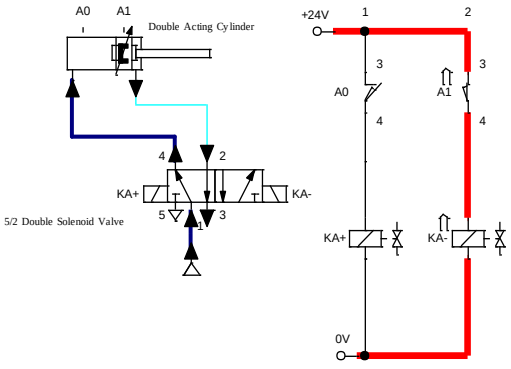

Fig 15: Starting of Retraction

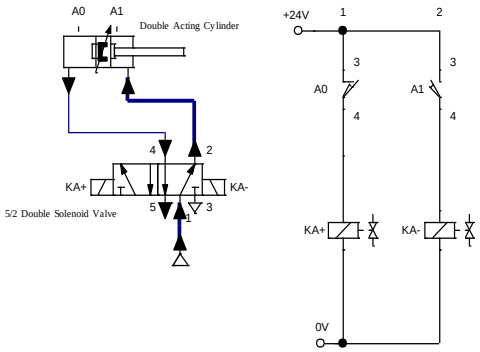

Fig 16: During Retraction

The above circuit piston will move forward and backward continuously with the help of sensors.

Case 2: when pushbutton pressed cylinder moves in forward direction and releasing push button should move back ward direction.

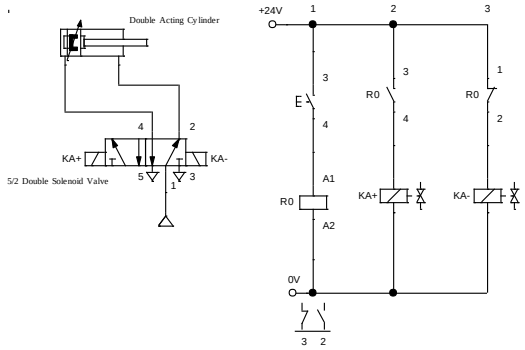

Fig 17: A+A- Push Button Relay Circuit

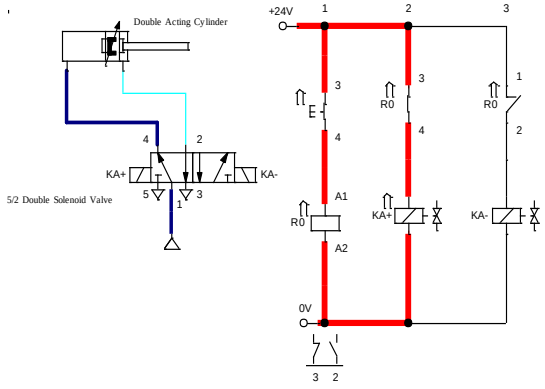

Fig 18: A+A- Push Button Relay Circuit: Extension

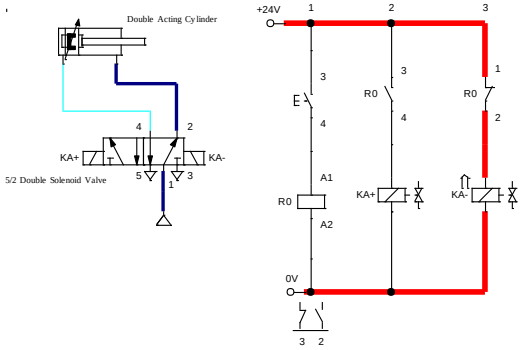

Fig 19: A+A- Push Button Relay Circuit: Retraction

Case 3: Push button can be replaced by switch piston will move forward and stay there, when the switch is again pressed the cylinder retracted.

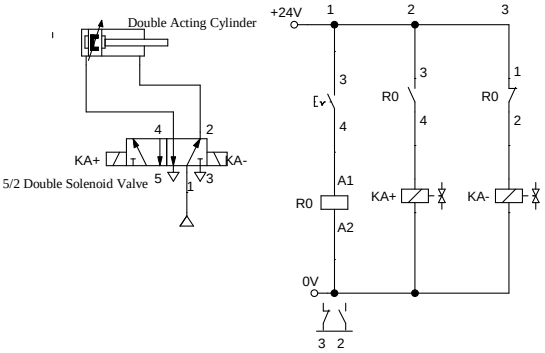

Fig 20: A+A- Switch Relay Circuit

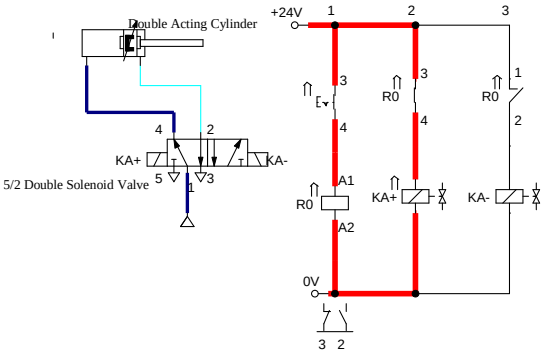

Fig 21: A+A- Switch Relay Circuit: Extension

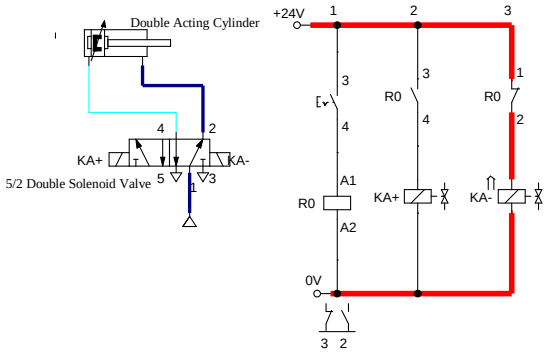

Fig 22: A+A- Switch Relay Circuit: Retraction

Case 4: When pressing switch the piston should move forward and back ward automatically until again pressing switch.

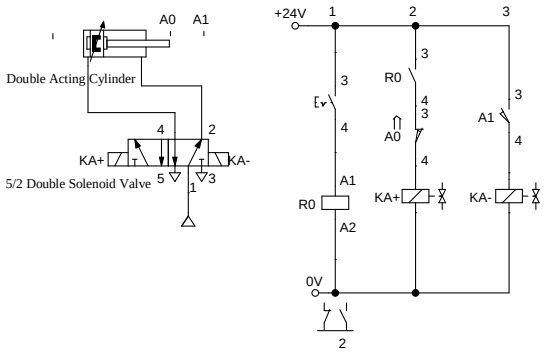

Fig 23: A+A- Switch Relay Sensor Circuit

As soon as switch is pushed relay got electricity R0 is closed A0 functionally initially closed due to piston is in retracted condition KA+ get electricity left side of solenoid valve will active. So compressed air go to left side cylinder, piston has start moving forward. As soon as piston moves a little bit forward A0 open KA+ deactivated. As soon as piston reach A1 the circuit closed, KA- got electricity the right side of solenoid valve activated compressed air goes to right side of valve piston retracted. This will be retracted condition until the switch is again pressed.

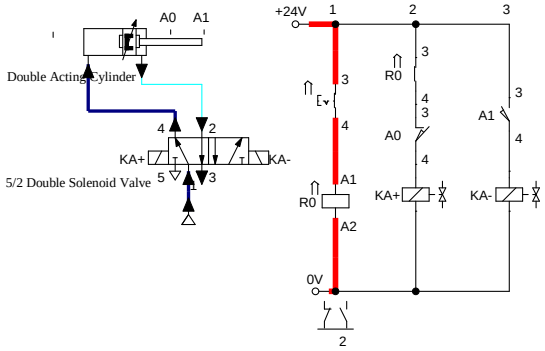

Fig 24: A+A- Switch Relay Sensor Circuit Extension

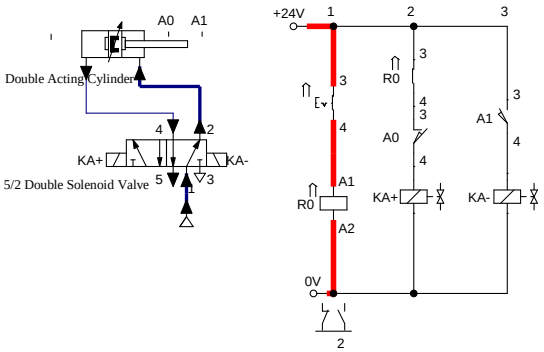

Fig 25: A+A- Switch Relay Sensor Circuit Retraction

Case 5: Latching circuit mainly consist normally open push button, normally closed pushbutton, relay coil and relay No switch.

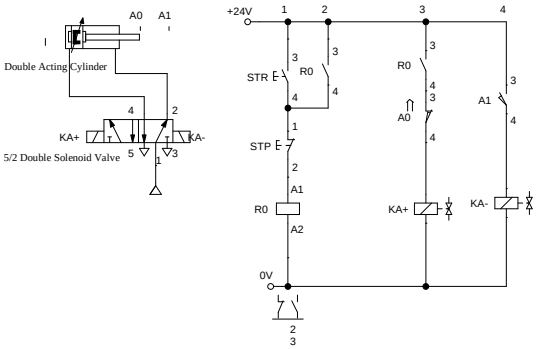

Fig 26: A+A- Latching Circuit

As soon as start button is pushed electricity flowing through start push button, electricity flowing through stop push button. Start button is functionally closed and stop button is normally closed.

As soon as electricity go through R0, R0 normally open switch will close. As soon as R0 closed electricity go through start button and electricity go through R0. Even after push button disengages electricity is going through R0 and reach relay now system will work automatically till push button

pressed. When stop button pressed, R0 deactivated functionally closed of R0 converted in to normally open. Even if stop button come back the circuit not work.

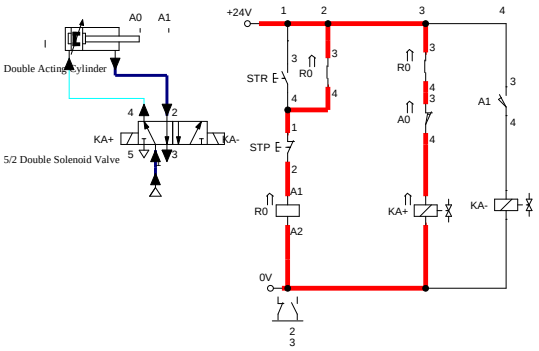

Fig 27: A+A- Latching Circuit: Extension

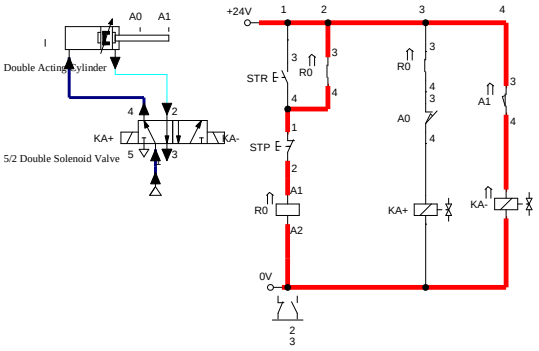

Fig 28: A+A- Latching Circuit: Retraction

Electro Pneumatic Circuit Diagram for The Proposed Design A+B+B-A-

Step 1: Draw the cylinder A and B with 5/2 double solenoid directional control valve. Connect compressed power supply. Indicate the position of the limit switch.

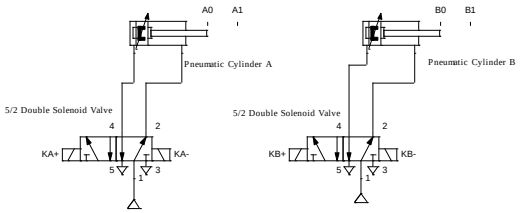

Fig 29: Cylinder with Solenoid Valve

figure below represent electrical circuit diagram for proposed design.

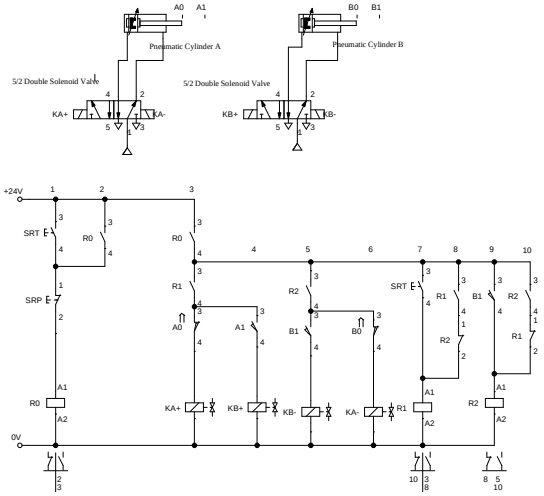

Fig 30: Electrical Circuit Diagram

Table 2 indicate a list of symbols that explains the cycle movement

Symbol	Detail
KA+	Solenoid for forward motion of cylinder A
KA-	Solenoid for backward motion of cylinder A
KB+	Solenoid for forward motion of cylinder B
KB-	Solenoid for backward motion of cylinder B
R1	Relay for group one
R2	Relay for group two
A0	Sensor indicates Cylinder A completely retracted position.
A1	Sensor indicates Cylinder A completely extended position.
B0	Sensor indicates Cylinder B completely retracted position.
B1	Sensor indicates Cylinder B completely retracted position.
SRT	Start push button
STP	Stop push button

Table 2: Symbol used and Their Details

Electro-pneumatic circuit consist two-part pneumatic part and electro part. Pneumatic part of circuit consists two double acting cylinder, two 5/2 double solenoid valve and source of compressed air. Electropneumatic cascade circuit consist two group R1 and R2 are relay assigned to each group. Relay R1used for A+B+ movement and Relay R2 used for A-B- movement. Group one is active when relay one is active and group two is active relay two is active. There are four sensors are used A0, A1, B0, B1. A0 tells in cylinder A piston completely in retracted position, A1tells piston completely in extended position. B0 tells in cylinder B piston completely in retracted position, B1tells piston completely in extended position. For A+ motion R1 should be active B0 sensor should sense. When KA+ get activated A+ motion get activated. For B+ motion R1, A1should be active. KB+ get

activated B+ motion happens. For B- to take place R2 should be active B1 sensor should be sensed. For A- motion R2 should be active and B0 sensor should be sensed.

Step 2: A+ Movement

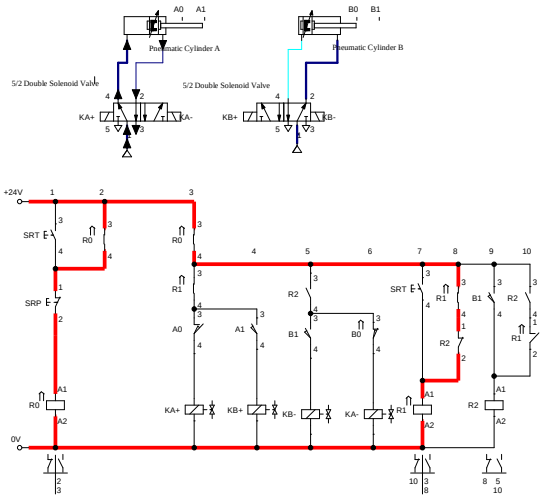

Fig 31: A+ Movement

Step 3: B+ Movement

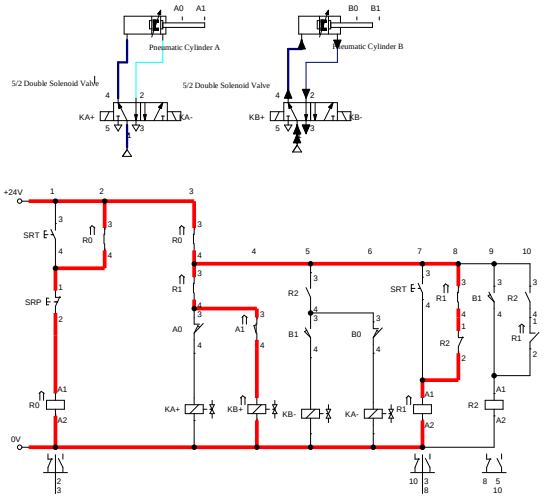

Fig 32: B+ Movement

Step 4: B- Movement

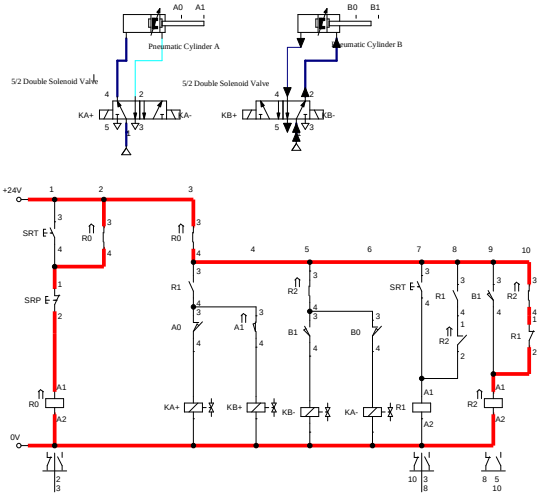

Fig 33: B- Movement

Step 4: A- Movement

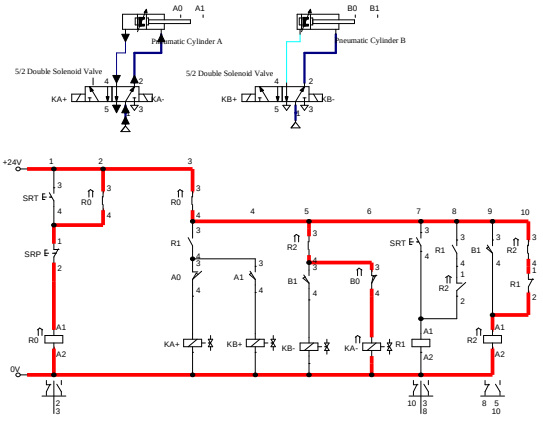

Fig 34: A- Movement

In the above circuit after A- motion completed the circuit stopped. For continuous motion another switch (Normally open contact A0) Placed as shown below.

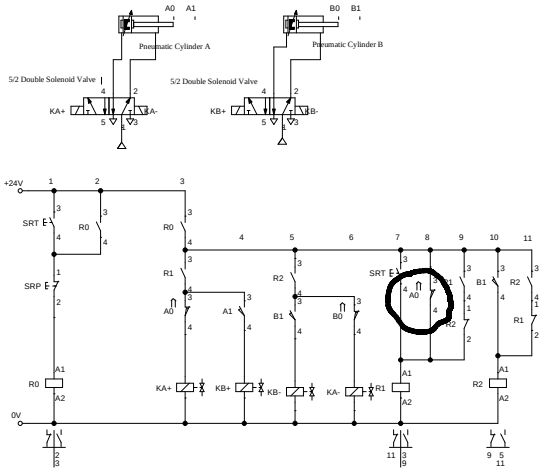

Fig 35: Continuous Motion Circuit

Designing Sequential Electro-Pneumatic System Using PLC Ladder Diagram

The PLC controls industrial machines and processes. In different areas of the industry, PLC are being applied. In the past the movements of industrial machines were controlled by relay circuits. These relay-controlled systems were replaced by PLC. The primary function of the PLC was to perform the sequential operations that were previously implemented with relays.

Ladder logic is a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay logic hardware. Ladder diagrams are used to describe the logic of electrical control system. Ladder diagrams are specialized schematics commonly used to document industrial control logic system. They are called "ladder" diagrams because they resemble a ladder, with two vertical rails (supply power) and as many "rungs" (horizontal lines) as there are control circuits to represent.

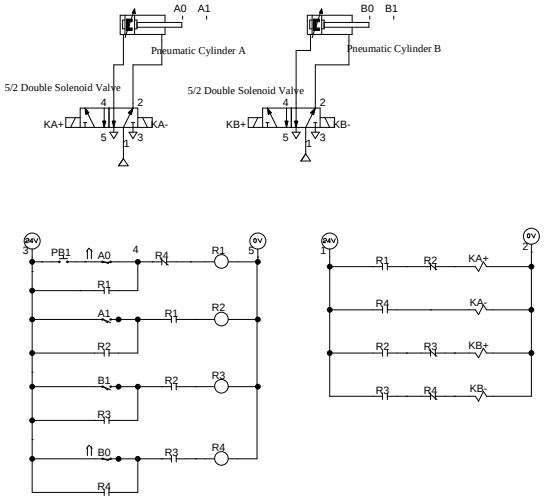

Fig 36: Ladder Diagram

Step 1: A+ Movement

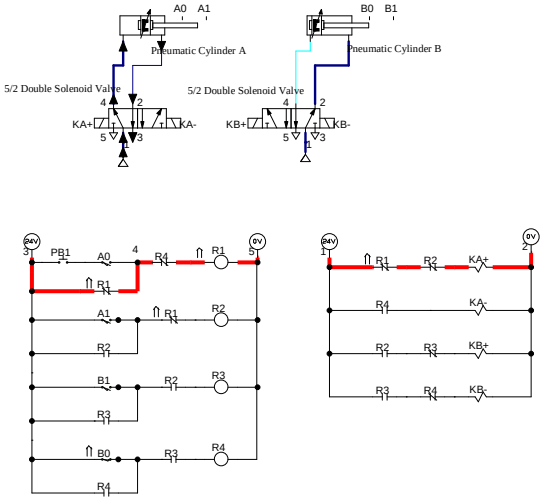

Fig 37: A+ Movement

Step 2: B+ Movement

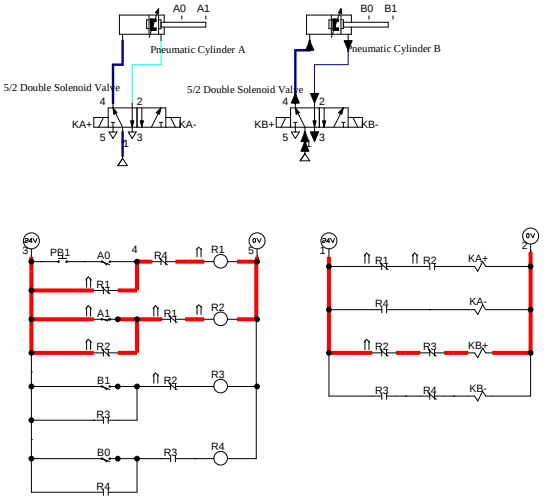

Fig 38: B+ Movement

Step 3: B-Movement

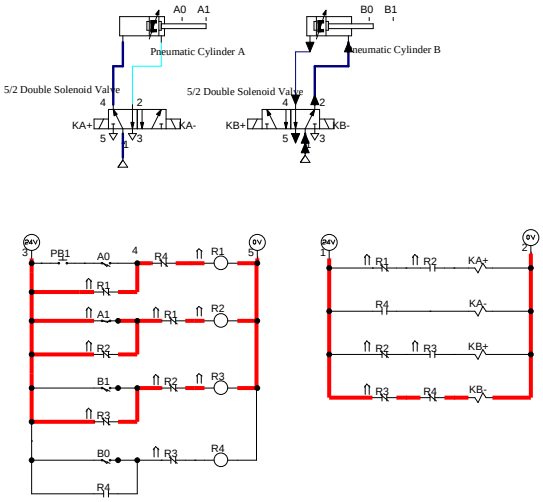

Fig 39: B- Movement

Step 4: A-Movement

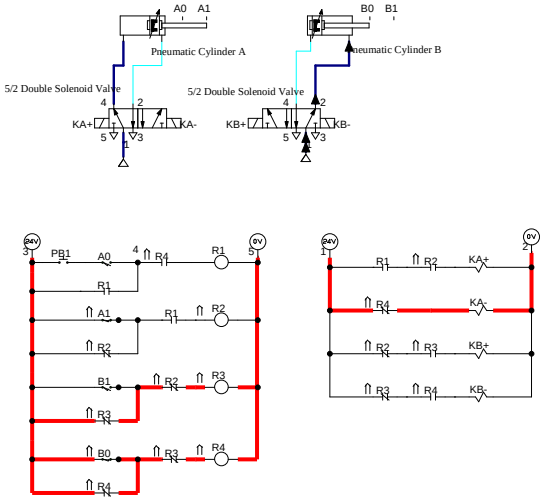

Fig 40: A- Movement

4.CONCLUSION

Nowadays automation is employed in every small and large industry. Automated process has reduced human effort saved time and increased rate of process completion. Work in this article consists design and simulation of electro-pneumatic sequential circuit using Fluid Sim -Pneumatic software. Electric circuit are designed and sequence of operation are tested by using Fluid Sim -Pneumatic Software. Electrical ladder diagram easily converted in to a PLC programming ladder diagram for above sequential motion and simulated using Fluid Sim -Pneumatic software.

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BIOGRAPHIES

Mr. Ahammed Adil P Final Year B-tech student in the Mechanical Engineering Department at AWH Engineering College Calicut Kerala India.

Mr. Muhammed Ishack V Final Year B-tech student in the Mechanical Engineering Department at AWH Engineering College Calicut Kerala India.

Mr. Rohith VT Final Year B-tech student in the Mechanical Engineering Department at AWH Engineering College Calicut Kerala India.

Mr. Amal P K Final Year B-tech student in the Mechanical Engineering Department at AWH Engineering College Calicut Kerala India.

Mr.Jibi.R. Currently working as an Assistant Professor in the mechanical engineering department at AWH Engineering College Calicut Kerala India. He has published 13 International journals and presented two articles in international conference. He has more than 11 years experience in teaching and one-year Industrial experience in Press tool and Mold making. His interested area is computer aided design and analysis, Production Technology and Industrial