

Dhanalakshmi College of Engineering

Manimangalam, Tambaram, Chennai –601 301



DEPARTMENT OF MECHANICAL ENGINEERING

ME6712 – MECHATRONICS LABORATORY

VII SEMESTER - R 2013

LABORATORY MANUAL

Name : _____

Register No. : _____

Section : _____

DHANALAKSHMI COLLEGE OF ENGINEERING

VISION

Dhanalakshmi College of Engineering is committed to provide highly disciplined, conscientious and enterprising professionals conforming to global standards through value based quality education and training.

MISSION

- To provide competent technical manpower capable of meeting requirements of the industry
- To contribute to the promotion of academic excellence in pursuit of technical education at different levels
- To train the students to sell his brawn and brain to the highest bidder but to never put a price tag on heart and soul

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

Rendering the services to the global needs of engineering industries by educating students to become professionally sound mechanical engineers of excellent caliber

MISSION

To produce mechanical engineering technocrats with a perfect knowledge intellectual and hands on experience and to inculcate the spirit of moral values and ethics to serve the society

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Fundamentals

To impart students with fundamental knowledge in mathematics and basic sciences that will mould them to be successful professionals

2. Core competence

To provide students with sound knowledge in engineering and experimental skills to identify complex software problems in industry and to develop a practical solution for them

3. Breadth

To provide relevant training and experience to bridge the gap between theory and practice which enable them to find solutions for the real time problems in industry and organization and to design products requiring interdisciplinary skills

4. Professional skills

To bestow students with adequate training and provide opportunities to work as team that will build up their communication skills, individual, leadership and supportive qualities and to enable them to adapt and to work in ever changing technologies

5. Life-long learning

To develop the ability of students to establish themselves as professionals in mechanical engineering and to create awareness about the need for lifelong learning and pursuing advanced degrees

PROGRAMME OUTCOMES (POs)

On completion of the B.E. (Mechanical) degree, the graduate will be able

1. To apply the basic knowledge of mathematics, science and engineering
2. To design and conduct experiments as well as to analyze and interpret data and apply the same in the career or entrepreneurship
3. To design and develop innovative and creative software applications
4. To understand a complex real world problem and develop an efficient practical solution
5. To create, select and apply appropriate techniques, resources, modern engineering and IT tools
6. To understand the role as a professional and give the best to the society
7. To develop a system that will meet expected needs within realistic constraints such as economical environmental, social, political, ethical, safety and sustainability
8. To communicate effectively and make others understand exactly what they are trying to tell in both verbal and written forms
9. To work in a team as a team member or a leader and make unique contributions and work with coordination
10. To engage in lifelong learning and exhibit their technical skills
11. To develop and manage projects in multidisciplinary environments

ME6712 – MECHATRONICS LABORATORY

SYLLABUS

COURSE OBJECTIVES

To know the method of programming the microprocessor and also the design, modeling & analysis of basic electrical, hydraulic & pneumatic systems, which enable the students to understand the concept of mechatronics

LIST OF EXPERIMENTS:

1. Assembly language programming of 8085 – Addition – Subtraction – Multiplication – Division – Sorting Code Conversion.
2. Stepper motor interface.
3. Traffic light interface.
4. Speed control of DC motor.
5. Study of various types of transducers.
6. Study of hydraulic, pneumatic and electro-pneumatic circuits.
7. Modeling and analysis of basic hydraulic, pneumatic and electrical circuits using software.
8. Study of PLC and its applications.
9. Study of image processing technique.

COURSE OUTCOMES

Upon completion of this course, the students will be able to design mechatronics system with the help of microprocessor, PLC and other electrical and electronics circuits.

ME6712 – MECHATRONICS LABORATORY

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Expt. No.1 ASSEMBLY LANGUAGE PROGRAMMING OF 8085 – ADDITION

Aim:

To perform the 8 - bit addition using 8085 Microprocessor

Apparatus required:

8085 Microprocessor

Algorithm:

1. Start the program.
2. Move the Data1 to the accumulator.
3. Add the Data 2 with the accumulator and the result gets stored in the accumulator.
4. Move the result, which is in the accumulator, to the 30H address location.
5. Stop the program.

Program:

```
ORG 0000H
MOV A, #Data1
ADD A, #Data2
MOV 30H, A
HLT: SJMP HLT
END
```

Input:

Data 1 23
Data 2 11

Output:

9200 34
9201 0

Result:

Thus the program for adding two 8 - bit numbers was executed.

Expt. No.2 ASSEMBLY LANGUAGE PROGRAMMING OF **8085 – 8 BIT SUBTRACTION**

Aim:

To perform the 8 - bit subtraction using 8085 Microprocessor

Apparatus required:

8085 Microprocessor

Algorithm:

1. Start the program.
2. Move the first data lower order byte to a register.
3. Add the second data lower order byte with a register.
4. Move the lower order byte result data from a reg. to 50H memory location.
5. Move the first data higher order byte to a register.
6. Add A reg. and second higher order byte with the carry flag.
7. Move the higher order byte result data from a reg. to 51H memory location.
8. Clear 52H memory location.
9. Check the carry flag; if it is 1, do the increment in 52H address location.
10. Stop the program.

Program:

```
ORG 0000H
CLR C
MOV A, 40h ;LSB Data1
ADD A, 42h ;LSB Data2
MOV 50H,A
MOV A, 41H ;MSB Data1
ADDC A, 43H ;MSB Data2
MOV 51H,A
CLR 52H
JNC HLT
INC 52H
HLT: SJMP HLT
END
```

Input & output:

Data 1 23
Data 2 11
9200 12
9201 0

Result:

Thus the program for subtracting two 8 - bit numbers was executed.

Expt. No.3 ASSEMBLY LANGUAGE PROGRAMMING OF **8085 – 8 BIT MULTIPLICATION**

Aim:

To multiply two 8 - bit hexadecimal numbers using memory pointer with 8085 microprocessor

Apparatus required:

8085 Microprocessor

Algorithm:

1. Move the multiplicand to accumulator.
2. Move the multiplier to 'B' register (SFR with direct address FOH).
3. Multiply the contents of accumulator and 'B' register.
4. Store the lower byte result from 'A' register to 8300 memory location.
5. Store the higher byte result from 'B' register to 8301 memory location.
6. Stop or halt the program execution.

Program:

```
ORG 0000H
MOV DPTR,#8250H
MOVX A, @DPTR
MOV B,A
INC DPTR
MOVX A, @DPTR
MUL AB
MOV DPTR,#8300H
MOVX @DPTR, A
INC DPTR
MOV A,B
MOVX @DPTR,A
HLT: SJMP HLT
END
```

Input & Output:

8201 INPUT 1 5
8202 INPUT 2 3
8203 PRODUCT F
8204 CARRY 0

Result:

Thus the program to multiply two 8 - bit hexadecimal numbers using 8085 was executed.

Expt. No.4 ASSEMBLY LANGUAGE PROGRAMMING OF **8085 – 8 BIT DIVISION**

Aim:

To divide two 8 - bit hexadecimal numbers using 8085 microprocessor

Apparatus required:

8085 Microprocessor

Algorithm:

1. Move the dividend to accumulator.
2. Move the multiplier to 'B' register (SFR with direct address FOH).
3. Multiply the contents of accumulator and 'B' register.
4. Store the lower byte result from 'A' register to 8300 memory location.
5. Store the higher byte result from 'B' register to 8301 memory location.
6. Stop or halt the program execution.

Program:

```
LDA 8201
MOV B,A
LDA 8200
MVI C, 00
JC Store
SUB B
INR C
JMP Again
STA 8203
MOV A,C
STA 8202
HLT
```

Input:

8200 DIVIDEND 6
8201 DIVISOR 3

Output:

8202 REMINDER 2
8203 QUOTIENT 0

Result:

Thus the program for dividing two 8 - bit hexadecimal numbers using 8085 Microprocessor was executed.

Expt. No.5 ASSEMBLY LANGUAGE PROGRAMMING OF **8085 – SORTING IN ASCENDING ORDER**

Aim:

To sort an array of 'n' element in ascending order using 8085 microprocessor

Apparatus Required:

8085 Microprocessor

Algorithm:

1. Load the R6 register with the value of "length of the array – 1".
2. Load the R7 register with the value of "length of the array – Iteration no".
3. Load the R0 register with array starting address
4. Load R1 register with first data and accumulator with second data
5. Subtract the R1 register from the accumulator.
6. Check the carry flag.
7. If carry flag is not there, then a register is greater which means second data is larger than the first data. So, do not exchange the A and R1 register.
8. If carry flag is there, then R1 register is greater which means first data is larger than the second data. So, exchange the first address location data and second address location data.
9. Check the R7 register. If R7 is not equal to zero, repeat from the 4th step for second and third data processing. Else decrement R6.
10. Check the R6 register. If R6 is not equal to zero, repeat from the 4th step for second iteration.
11. Stop the program.

Program:

```
ORG 0000h
MOV R6, #04h
MOV R0, #50h
MOV A, R6
MOV R7, A
MOV A, @R0
MOV R1, A
INC R0
MOV A, @R0
SUBB A, R1
JNC Continue2
MOV A, @R0
```

```
XCH A, R1
MOV @R0, A
DEC R0
MOV A, R1
MOV @R0, A
INC R0
DJNZ R7
DJNZ R6
SJMP
END
```

Input:

```
8200 No. of Elements 6
8201 DATA 1 5
8202 DATA 2 8
8203 DATA 3 3
8204 DATA 4 6
8205 DATA 5 7
8206 DATA 6 15
```

Output:

```
8201 DATA 1 3
8202 DATA 2 5
8203 DATA 3 6
8204 DATA 4 7
8205 DATA 5 8
8206 DATA 6 15
```

Result:

Thus the program to sort an array of 'n' element in ascending order using 8085 microprocessor was executed.

Expt. No.6 ASSEMBLY LANGUAGE PROGRAMMING OF **8085 –SORTING IN DESCENDING ORDER**

Aim:

To sort an array of 'n' element in descending order using 8085 microprocessor

Apparatus Required:

8085 Microprocessor

Algorithm:

1. Load the R6 register with the value of "length of the array = 1".
2. Load the R7 register with the value of "length of the array = Iteration no".
3. Load the R0 register with the array starting address.
4. Load R1 register with the last data and accumulator with the second data from the last one.
5. Subtract the R1 register from the accumulator.
6. Check the carry flag.
7. If carry flag is not there, then A register is greater which means second data is larger than the first data. So, do not exchange the A and R1 register.
8. If carry flag is there, then R1 register is greater which means first data is larger than the second data. So, exchange the first address location data and second address location data.
9. Check the R7 register. If R7 is not equal to zero, repeat from the 4th step for second and third data processing. Else decrement R6.
10. Check the R6 register. If R6 is not equal to zero, repeat from the 4th step for second iteration.
11. Stop the program.

Program:

```
LXI H, 8200
MOV E, M
MOV B, M
MOV C, E
INX H
DCR C
MOV A, M
INX H
CMP M
JNC Ahead
MOV D,M
MOV M,A
```

DCX H
MOV M,D
INX H
DCR C
JNZ
DCR B
JNZ
HLT

Input:

8200 No. of Elements 6
8201 DATA 1 06
8202 DATA 2 18
8203 DATA 3 1B
8204 DATA 4 2C
8205 DATA 5 1A
8206 DATA 6 15

Output:

8201 DATA 1 2C
8202 DATA 2 1B
8203 DATA 3 1A
8204 DATA 4 18
8205 DATA 5 15
8206 DATA 6 06

Result:

Thus the program to sort an array of 'n' element in descending order using 8085 microprocessor was executed.

Expt. No.7 ASSEMBLY LANGUAGE PROGRAMMING OF **8085 – BCD TO HEX CONVERSION**

Aim:

To write an assembly language program to convert 8 - bit two digit BCD number system into hexadecimal number system

Apparatus Required:

8085 Microprocessor

Algorithm:

1. Start the program.
2. Get the data from the 8300 memory location to R5 register (R5 = 99).
3. Separate the MSB and LSB of R5 register using ANL 0FH and ANL F0H commands.
4. Move the MSB to accumulator and LSB to R2 register (A= 09, R2 = 09).
5. Multiply the MSB with 0AH data (09 x 0A = 5A).
6. Add the accumulator with LSB of the data (5A+9 = 63).
7. Move the accumulator to 8301 memory location (8301 = 63).
8. Stop the program.

Program:

```
ORG 0000H
MOV DPTR,#8300h
MOVX A, @DPTR
MOV R5,A
ANL A, #0F0h
SWAP A
MOV R1,A
MOV A,R5
ANL A, #0Fh
MOV R2,A
MOV A,R1
MOV B, #0Ah
MUL AB
ADD A,R2
INC DPTR
MOVX @DPTR, A
HLT: SJMP HLT
```

Input:

8301 BCD Data =

Output:

8301 HEX Data =

Result:

Thus the assembly language program was written to verify the Boolean equation and executed.

Outcome:

Able to read and write the 8085 assembly language program and understood about addition, subtraction, multiplication, division, sorting and code conversions of hexadecimal codes.

Viva - voce

1. What is a Microprocessor?
2. What are the basic functional blocks of a microprocessor?
3. What are the advantages of microprocessor based system?
4. What are the disadvantages of microprocessor based system?
5. What is a bus?
6. Define – Bit, Byte and Word
7. What is meant by an instruction set?
8. What is meant by band width?
9. Define – Mnemonics
10. Define – Op-code and operand
11. What is the difference between the microprocessor and micro controller?
12. How many interrupts are there in 8085?
13. What are the various registers used in 8085?
14. What is a flag?
15. What are the various flags used in 8085?
16. What is meant by program counter?
17. In 8085 which is called as higher order / low order register?
18. What are the drawbacks of first generation microprocessors?
19. What is the difference between CPU bus and System bus?
20. Define – ALE

Expt. No.8

STEPPER MOTOR INTERFACE WITH 8051– MICROCONTROLLER

Aim:

To run a stepper motor at different speeds and different directions using 8051 assembly language

Apparatus required:

1. Stepper motor
2. Interface board

Procedure:

1. Switch 'ON' the micro controller.
2. Initialize the starting address.
3. Enter the mnemonics code in the microcontroller.
4. Reset the microcontroller.
5. Execute the program.

Program:

```
ORG 4100H
START
MOV DPTR, #4500H
MOV R0, #04
MOVX A, @DPTR
PUSH DPH
PUSH DPL
MOV DPTR, #FFCOH
MOV R2, #04H
MOV R1, #FFH
MOV R3, #FFH
DJNZ R3, DLY
DJNZ R1, DLY1
DJNZ R2, DLY1
MOV @DPTR, A
POP DPL
POP DPH
INC DPTR
DJNC R0, J0
SJMP START
END
```

Result:

Thus the program to run the stepper motor at different speeds and different directions was written using 8051 assembly language and executed.

Outcome:

Able to learn the working principle of stepper motor using 8051 microcontroller.

Viva - voce

1. What is microcontroller?
2. What is meant by baud rate?
3. List the interrupts of 8051 – Microcontroller.
4. What are the four distinct types of memory in 8051?
5. What are the register banks in 8051 microcontroller?
6. What is the general purpose registers of 8051?
7. What is the asynchronous data transmission format of 8051 serial port?
8. What is meant by memory – Mapped I/O?
9. Difference between RET and RET 1 instruction in 8051.
10. What is the size of RAM and ROM in 8051?
11. List the various flags in the PSW register.
12. What are the different types of instructions?
13. What are the instructions to access the program memory?
14. What are addressing modes?
15. What is stepper motor?
16. What are the applications of stepper motor in mechatronics system?
17. What is meant by ALU? State its function.
18. What are the interface methods available in stepper motor?
19. State the application of stepper motor and servo motor in mechatronic systems.
20. What is meant by key bounce?

Expt. No.9 MICRO CONTROLLER BASED TRAFFIC LIGHT SYSTEM

Aim:

To control a traffic light system by using 8051 microcontroller

Apparatus required:

1. Traffic light control system
2. Interface board

Procedure:

1. Switch 'ON' the micro controller.
2. Initialize the starting address.
3. Enter the mnemonics code in the microcontroller.
4. Reset the microcontroller.
5. Execute the program.

Program:

```
ORG 4100H
MOV A,#80H
FF 0F MOV DPTR,#CONTRL
MOVX @DPTR,A
MOV R4,#04H
MOV DPTR,#LOOK1
MOV R2,DPH
MOV R3,DPL
MOV DPTR,#LOOK
MOV R0,DPH
MOV R1,DPL
GO:
MOVX A,@DPTR
MOV R0,DPH
MOV R1,DPL
MOV DPTR,#PORTA
MOVX @DPTR,A
INC R1
MOV DPH,R0
MOV DPL,R1
MOVX A,@DPTR
```

```
MOV R0,DPH
MOV R1,DPL
MOV DPTR,#PORTB
MOVX @DPTR,A
INC R1
MOV DPH,R0
MOV DPL,R1
MOVX A,@DPTR
MOV R0,DPH
MOV R1,DPL
MOV DPTR,#PORTC
MOVX @DPTR,A
INC R1
LCALL DELAY
MOV DPH,R2
MOV DPL,R3
MOVX A,@DPTR
MOV R2,DPH
MOV R3,DPL
MOV DPTR,#PORTA
MOVX @DPTR,A
INC R3
MOV DPH,R2
MOV DPL,R3
MOVX A,@DPTR
MOV R2,DPH
MOV R3,DPL
MOV DPTR,#PORTB
MOVX @DPTR,A
INC R3
MOV DPH,R2
MOV DPL,R3
MOVX A,@DPTR
MOV R2,DPH
MOV R3,DPL
```

```

MOV DPTR,#PORTC
MOVX @DPTR,A
INC R3
LCALL DELAY1
MOV DPH,R0
MOV DPL,R1
DJNZ R4,GO
LCALL START
DELAY: MOV R5,#12H
MOV R6,#0ffH
MOV R7,#0ffH
DJNZ R7,L1
DJNZ R6,L2
DJNZ R5,L3
RET
DELAY1: MOV R5,#12H
MOV R6,#0ffH
MOV R7,#0ffH
DJNZ R7,L4
DJNZ R6,L5
DJNZ R5,L6
RET
LOOK: DB 44H,27H,12H
      92 2B 10 DB 92H,2BH,10H
      84 9D 10 DB 84H,9DH,10H
      84 2E 48 DB 84H,2EH,48H
LOOK1: DB 48H, 27H, 12H
      419E 92 4B 10 DB 92H, 4BH, 10H
      41A1 84 9D 20 DB 84H, 9DH, 20H
      41A4 04 2E 49 DB

```

Result:

Thus the program to control traffic light control system was written using 8051 assembly language and executed.

Outcome:

Able to read and write the 8051 assembly language program and learn the working principle of traffic light control system using 8051 microcontroller.

Viva - voce

1. What is meant microcontroller?
2. Distinguish between parallel data transfer and serial data transfer.
3. What are the interfacing devices used in 8051?
4. What is meant by synthesis?
5. Define – Compiler
6. Define – Interpreter
7. Define – Assembler
8. Define – Interrupt Priority
9. Define – Sampling Rate
10. Define – Fetch Cycle
11. How will you interface the I/O devices?
12. What is meant by peripheral mapped I/O?
13. What is the address range of the bit-addressable internal memory of the 8051?
14. Why microcontrollers are often called single chip computers?
15. List the bit size for automobile engine control and robot arm.
16. Define – Stack Pointer
17. Define – PSW
18. Distinguish between register and flags.
19. What is meant by sub-routines and nested sub-routines?
20. Distinguish between direct addressing mode and indexed addressing mode.

Expt. No.10 SPEED MEASUREMENT OF DC MOTOR USING OPTICAL SENSOR

Aim:

To measure the speed of DC motor using optical sensor

Apparatus required:

1. VTT-01 trainer
2. DC servomotor
3. Patch chords

Procedure:

1. Interface the DC motor with VTT-01 trainer (Back Panel).
2. Switch 'ON' the trainer and select the speed transducer using push button.
3. Connect the multi meter across O/P 5 and T13 in "DC - Volt" mode.
4. Vary the control voltage from 0 - 5V in stepwise manner.
5. Measure the output voltage and the speed displayed.
6. Plot the graph between speed and output voltage.

Tabulation:

Sl.No.	Speed (rpm)	Output Voltage (mV)

Result:

Thus the speed of DC motor is measured using optical sensor.

Outcome:

Able to learn the DC motor speed control methods and the working principle of optical sensor.

Viva - voce

1. What is a principle of optical encoder?
2. What is the principle of operation of a D.C Motor?
3. What are the various types of D.C. motors?
4. What is the control methods used in D.C. motors?
5. Compare the functions of series wound D.C. motors and shunt wound D.C. motors.
6. What is back e.m.f or counter e.m.f?
7. How can you reverse the direction of rotation of a D.C Motor?
8. What happens when a D.C motor is connected across an A.C supply?
9. What are the types of starters used for starting of D.C Motors?
10. What are the factors to be considered in the selection of a motor?
11. What is the role of a commutator?
12. What are the different types of losses in DC Machines?
13. What is meant by embedded systems?
14. What are the two types of position encoders?
15. What is meant by an encoder?
16. What are the various types of encoder?
17. What is meant by an incremental encoder?
18. What is meant by an absolute encoder?

STUDY OF VARIOUS TYPES OF TRANSDUCERS

Expt. No.11

STRAIN MEASUREMENT SYSTEM

Aim:

To study the characteristics between the strains applied to the cantilever beam strain sensor and the bridge voltage

Apparatus required:

1. VTT - 01 trainer
2. Multimeter (mV)
3. Cantilever beam strain sensor setup
4. Weight (100 gram x 10 Nos.)
5. Power chord

Formula to be used:

$$\% \text{ Error} = \frac{\text{Actual strain} - \text{Theoretical strain}}{\text{Theoretical strain}} * 100$$

Theoretical Strain:

$$= \frac{6PL}{B t^2 Y} = \frac{6 \times 1 \times 21.58}{2.8 \times 0.25^2 \times 2 \times 10^6} = 370 \mu \text{ strain}$$

Where,

Applied load to the beam (P) = 1 kg

Thickness of the beam (t) = 0.25 cm

Breadth of the beam (B) = 2.8 cm

Length of the beam (L) = 21.58 cm

Young's modulus (Y) of the beam = 2×10^6 kg /cm²

Procedure:

1. Install the cantilever beam strain sensor setup and interface the 9 pin D connector with VTT-01
2. Connect the multimeter in millivolt mode across T2 and T3 for bridge voltage measurement.
3. Switch 'ON' the module and select the strain transducer by switching the select button.
4. Initially, unload the beam and nullify the bridge voltage using a fine adjustment POT.
5. On applying the load to the beam, strain will develop on the beam. Then measure the bridge voltage (mV) across T2 and T3.
6. Gradually increase the load on the beam and note down applied load and the bridge voltage (mV).
7. Tabulate the values of applied load, theoretical strain and the bridge voltage (mV).
8. Plot a graph between theoretical strain versus bridge voltage (mV).

Tabulation:

Applied load (gram)	Theoretical strain	Actual strain	Bridge output voltage (mV)	% Error

Result:

Thus the characteristics between the strain applied to the cantilever beam strain sensor and the bridge voltage was studied and the graph was plotted.

Expt. No.12 EXPERIMENTATION ON THE CHARACTERISTICS OF LVDT POSITION SENSOR WITH RESPECT TO THE DIFFERENTIAL VOLTAGE

Aim:

To study the characteristics of LVDT position sensor with respect to the differential voltage

Apparatus required:

1. VTT-01 trainer
2. LVDT setups
3. Multimeter (CRO)
4. Power chord

Procedure:

1. Install the LVDT position sensor and interface the 9 pin D connector with VTT-01 trainer (Back panel).
2. Switch 'ON' the trainer and select the displacement transducer using "select" button.
3. Connect the multimeter (in AC - mV mode) CRO across the T6 and T7 for the differential voltage measurement.
4. Adjust the micrometer to 0 mm displacement and tune the fine adjustment POT to 0 mm displacement on display.
5. Adjust the micrometer to 20 mm displacement and tune the span adjustment POT to 20 mm on the display. The voltage across the O/P 2 and T7 should be 5V.
6. Repeat the fine and span calibration until the core displacement is 0 for 0mm displacement in micrometer and 20 for 20 mm displacement in micrometer.
7. After completion of the calibration, give the displacement from the micrometer to the core of the LVDT sensor.
8. Gradually increase the micrometer displacement from 0 mm to 20 mm and note down the forward core displacement on the display and differential voltage (mV).
9. Similarly, decrease the micrometer displacement from 20 mm to 0 mm and note down the reverse core displacement on the display and differential voltage (mV) across O/P 2 and T7.
10. Tabulate the readings of the core displacement, micrometer displacement and differential voltage (mV).
11. Plot the graph between core displacement (mm) and differential voltage (mV).

Tabulation:

Micrometer displacement (mm)	Core displacement (mm)	Differential voltage (mV)

Result:

Thus the characteristics of the LVDT position sensor with respect to the differential voltage were studied.

Expt. No.13 EXPERIMENTATION ON THE CHARACTERISTICS OF THE PRESSURE CELL WITH RESPECT TO THE BRIDGE VOLTAGE

Aim:

To study the characteristics of the pressure cell with respect to the bridge voltage

Apparatus required:

1. VTT - 01 trainer
2. Multimeter (mV)
3. Pressure cell setup
4. Power chord

Procedure:

1. Install the pressure cell setup and interface the 9 pin D connector with VTT-01 trainer (Back panel).
2. Connect the multimeter (DC-mV) across T9 and T10 for bridge voltage measurement.
3. Switch 'ON' the module.
4. Initially, open the air release valve and exhaust the tank inlet air and nullify the bridge voltage by using fine adjustment POT.
5. Now, close the air release valve. By pressing the pump piston, the pump sucks the air from atmosphere and supplies it to the cylinder. Then, the pressure will be developed in the cylinder and now measure the bridge voltage (mV) across T9 and T10.
6. Gradually increase the pressure by pressing the pump piston and note down the bridge voltage (mV) for corresponding gauge pressure.
7. Tabulate the readings and plot the graph between gauge pressure and bridge voltage (mV).

Tabulation:

Gauge Pressure (psi)	Bridge voltage (mV)

Result:

Thus the characteristics of the pressure cell with respect to bridge voltage were studied.

Expt. No.14

TEMPERATURE MEASUREMENT SYSTEM

Aim:

To study the characteristics of temperature measurement system and the accuracy of signal conditioning board

Apparatus required:

1. VTT-01 trainer
2. Water bath
3. Thermometer
4. Multimeter
5. Power chord

Formula:

$$\% \text{ Error} = \frac{\text{Displayed Temperature} - \text{Actual Temperature}}{\text{Actual Temperature}} * 100$$

Procedure:

1. Patch the wires of RTD to the VTT-01 trainer (Back panel).
2. Switch 'ON' the VTT-01 trainer. Select the temperature transducer by "select" button.
3. Now adjust the fine potentiometer to read 30°C at the display. This is done for initial setup of the trainer and this adjustment should not be disturbed.
4. Insert the RTD into the water bath and note the temperature without any heating at ambient condition.
5. Place the multimeter in "voltage mode" across the O/P 4 and T14 terminals.
6. Gradually start heating the water bath and note down the actual temperature, output voltage and the displayed temperature of the trainer simultaneously.
7. Plot the graph for temperature Vs voltage.
8. Calculate the % error and plot the graph for temperature Vs % error

Tabulation:

Actual temperature (°C)	Output voltage (V)	Displayed temperature (°C)	% Error

Result:

Thus the study of temperature measurement system and the accuracy of signal conditioning board were done and the graph is drawn.

Outcome:

Able to understand the working principle of strain measurement system, pressure measurement system, temperature measurement system and displacement measurement system.

Viva - voce

1. What is meant by sensor?
2. What is meant by strain?
3. What is meant by Transducer?
4. Write an example for a transducer and state its transduction principle.
5. Distinguish between a measurement system and a control system.
6. What are the various types of control system?
7. Define – Hysteresis
8. Define – Sensitivity
9. Write two factors that need to be considered in selecting a sensor for a particular application.
10. What is meant by signal conditioning?
11. What is meant by RTD? State its applications.
12. What is meant by see back effect?
13. Distinguish between closed loop system and open loop system.
14. What are the various elements of a closed loop system for controlling the temperature?
15. What are the types of strain gauges?
16. Define - LVDT
17. What is a Hall Effect sensor?
18. Define – Range and Span
19. Define – Accuracy and Precision
20. Define – Non-linearity error

STUDY OF HYDRAULIC, PNEUMATIC AND ELECTRO-PNEUMATIC CIRCUITS

Expt. No.15 ACTUATION OF SINGLE ACTING CYLINDER USING A TWO WAY PRESSURE VALVE

Aim:

To construct a pneumatic circuit to actuate the single acting cylinder using a two-way pressure valve

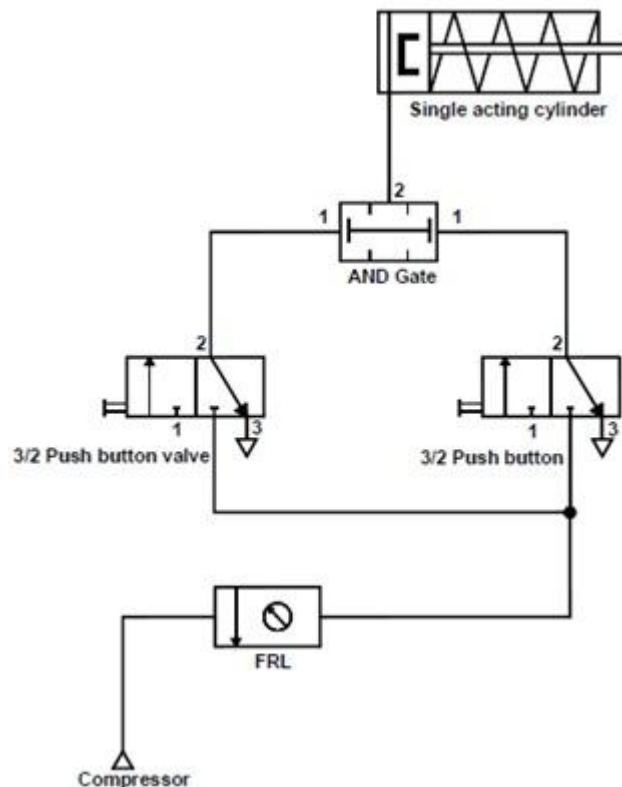
Apparatus required:

1. Compressor
2. FRL unit
3. Two-way pressure valve
4. Single acting cylinder

Procedure:

1. Draw the circuit diagram.
2. Connect the compressed air supply to FRL unit.
3. The output of FRL unit is directly connected to both the 3/2 push button valves.
4. The output of the 3/2 push button valve is connected to the AND gate input.
5. When both the push buttons are pressed, the cylinder gets activated.

Circuit diagram:



Result:

Thus the pneumatic circuit using a two way pressure valve was constructed and executed.

Expt. No.16 ACTUATION OF DOUBLE ACTING CYLINDER USING ELECTRICAL PUSH BUTTON SWITCH IN METER - IN CIRCUIT

Aim:

To study the actuation of double acting cylinder using electrical push button switch in meter - in circuit

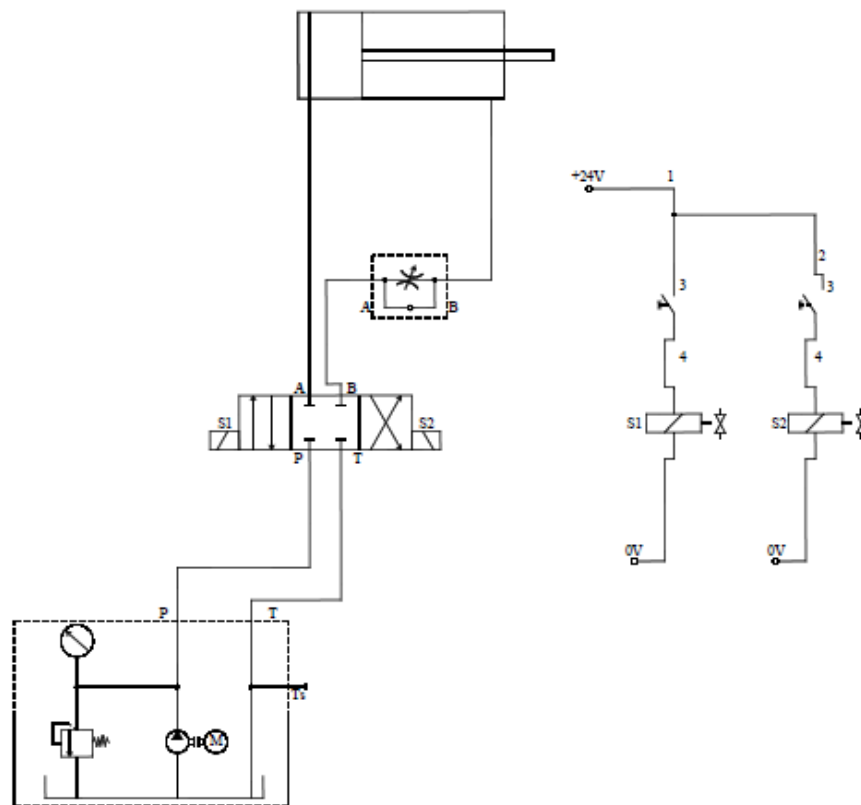
Apparatus required:

1. Pump unit
2. 4/3 hand lever valve
3. Double acting cylinder
4. One way flow control valve
5. Push button
6. Valve solenoid
7. Electrical connection 24 V

Procedure:

1. Draw the circuit.
2. Switch 'ON' the single phase motor.
3. When the push button in the LHS is pressed, the solenoid valve S1 gets actuated.
4. Then the oil will flow through the one way flow control valve, the piston moves on the forward direction.
5. When the push button on the RHS is pressed the solenoid valve (S2) will get activated.
6. Then the oil will flow through the one way flow control valve to push the piston in reverse direction.

Circuit diagram:



Result:

Thus the actuation of double acting cylinder using electrical push button switch in meter - in circuit was experimentally studied.

Expt. No.17 ACTUATION OF DOUBLE ACTING CYLINDER USING ELECTRICAL PUSH BUTTON SWITCH IN METER - OUT CIRCUIT

Aim:

To study the actuation of double acting cylinder using electrical push button switch in meter - out circuit

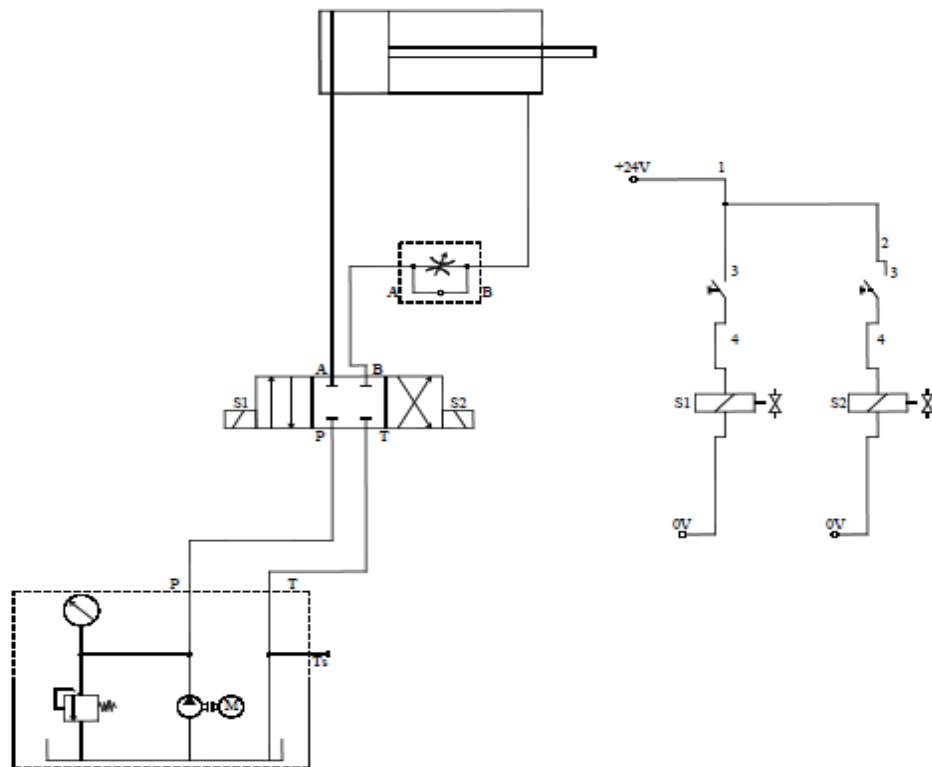
Apparatus required:

1. Pump unit
2. 4/3 hand lever valve
3. Double acting cylinder
4. One way flow control valve
5. Push button
6. Valve solenoid
7. Electrical connection 24V

Procedure:

1. Draw the circuit.
2. Switch 'ON' the single phase motor.
3. When the push button in the LHS is pressed, the solenoid valve S1 gets actuated.
4. Then the oil will flow through the one way flow control valve, the piston moves on the reverse direction.
5. When the push button on the RHS is pressed the solenoid valve (S2) will get activated.
6. Then the oil will flow through the one way flow control valve to push the piston in forward direction.

Circuit diagram:



Result:

Thus the actuation of the double acting cylinder using electrical push button switch in meter - out circuit was experimentally studied.

Expt. No.18**ACTUATION OF ROTARY ACTUATOR USING
ELECTRICAL PUSH BUTTON SWITCH IN METER-OUT
CIRCUIT****Aim:**

To study the actuation of the rotary actuator using electrical push button switch in meter - out circuit

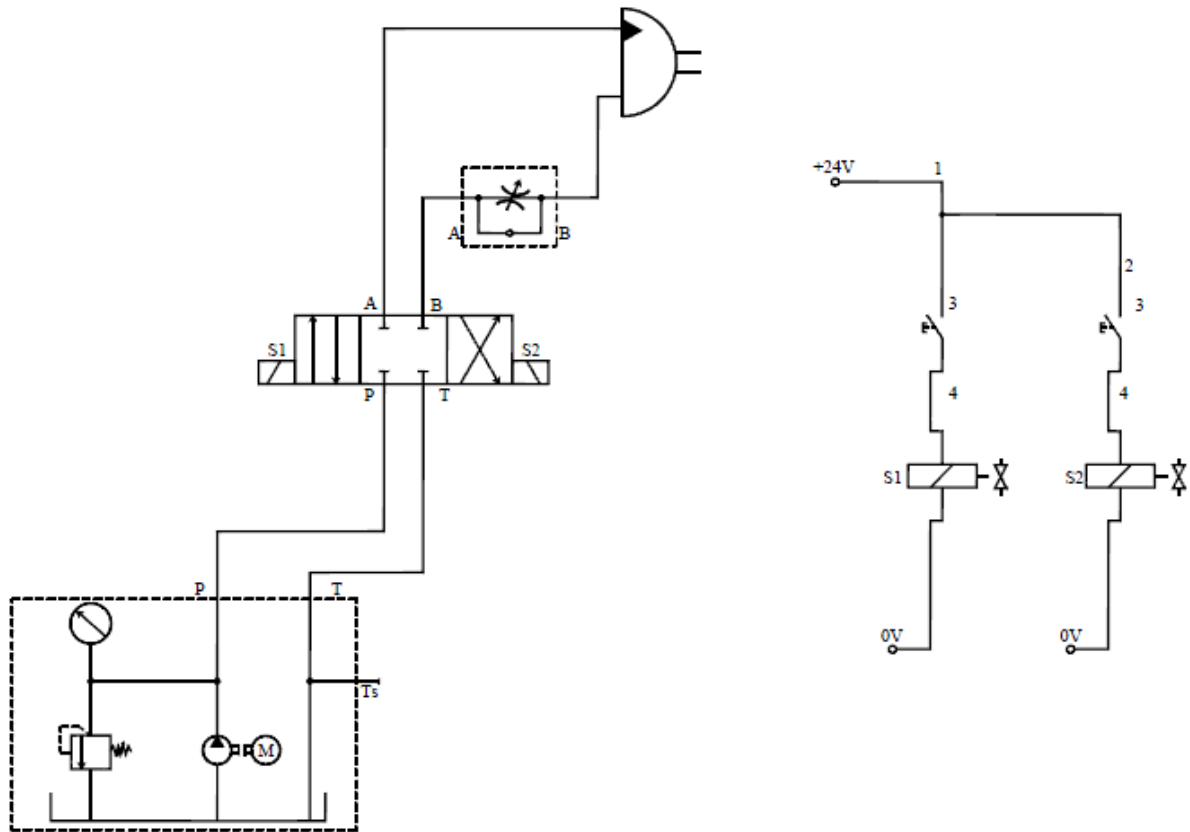
Apparatus required:

1. Pump unit
2. 4/3 hand lever valve
3. Push button
4. Valve solenoid
5. Semi-rotary actuator
6. One way flow control valve
7. Electrical connection 24V

Procedure:

1. Draw the circuit.
2. Switch on the single phase motor.
3. When the push button in the LHS is pressed, the solenoid valve S1 gets actuated.
4. Then the oil will flow through the one way flow control valve, the rotary actuator rotates on the forward direction.
5. When the push button on the RHS is pressed the solenoid valve (S2) will get activated.
6. Then the oil will flow through the one way flow control valve to rotate the rotary actuator on the reverse direction.

Circuit diagram:



Result:

Thus the actuation of the rotary actuator using electrical push button switch in meter - out circuit was experimentally studied.

Expt. No.19

ACTUATION OF ROTARY ACTUATOR USING ELECTRICAL PUSH BUTTON SWITCH IN MANUAL MODE

Aim:

To study the actuation of the rotary actuator using electrical push button switch in manual mode

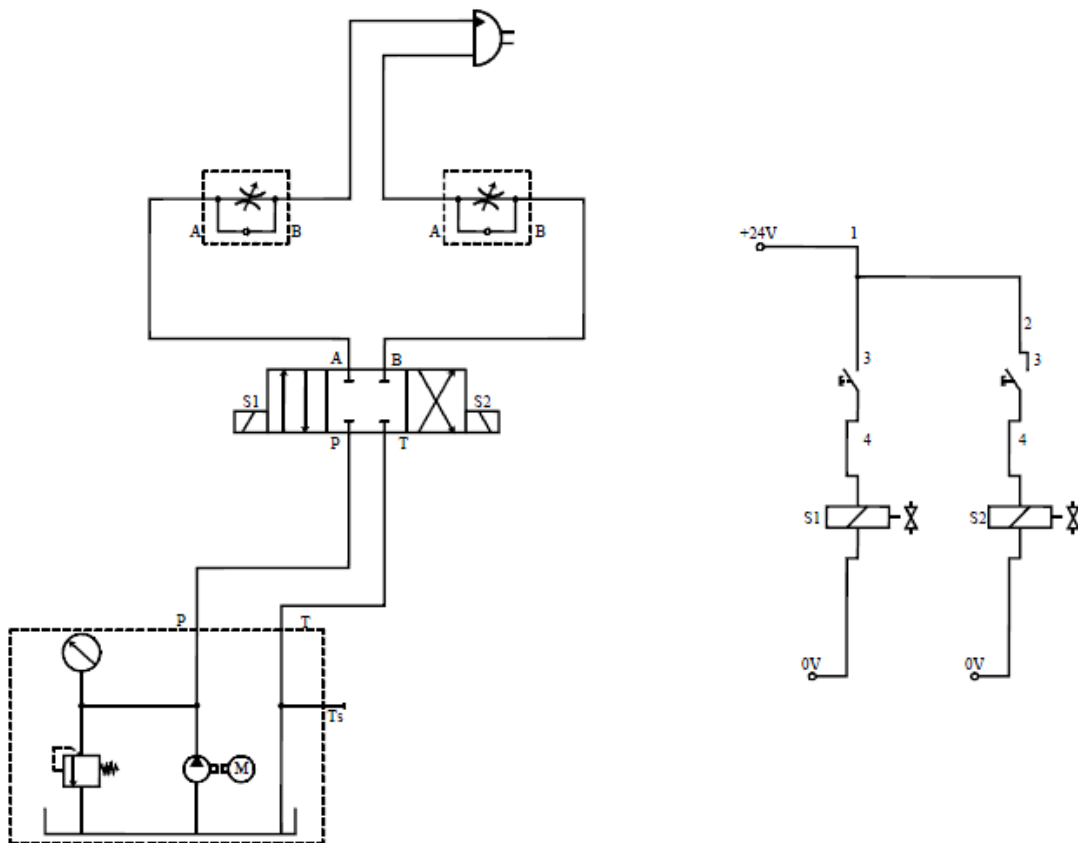
Apparatus required:

1. Pump unit
2. 4/3 hand lever valve
3. Semi-rotary actuator
4. One way flow control valve
5. Push button
6. Valve solenoid

Procedure:

1. Draw the circuit.
2. Switch on the single phase motor.
3. When the push button in the LHS is pressed, the solenoid valve S1 gets actuated.
4. Then the oil will flow through the one way flow control valve, the rotary actuator rotates on the reverse direction.
5. When the push button on the RHS is pressed the solenoid valve (S2) will get activated.
6. Then the oil will flow through the one way flow control valve to rotate the rotary actuator on the forward direction.

Circuit diagram:



Result:

Thus the actuation of the rotary actuator using electrical push button switch in manual mode was experimentally studied.

Expt. No.20 CONTINUOUS RECIPROICATION OF SINGLE ACTING CYLINDER

Aim:

To construct a pneumatic circuit to actuate the single acting cylinder using a pilot operated valve

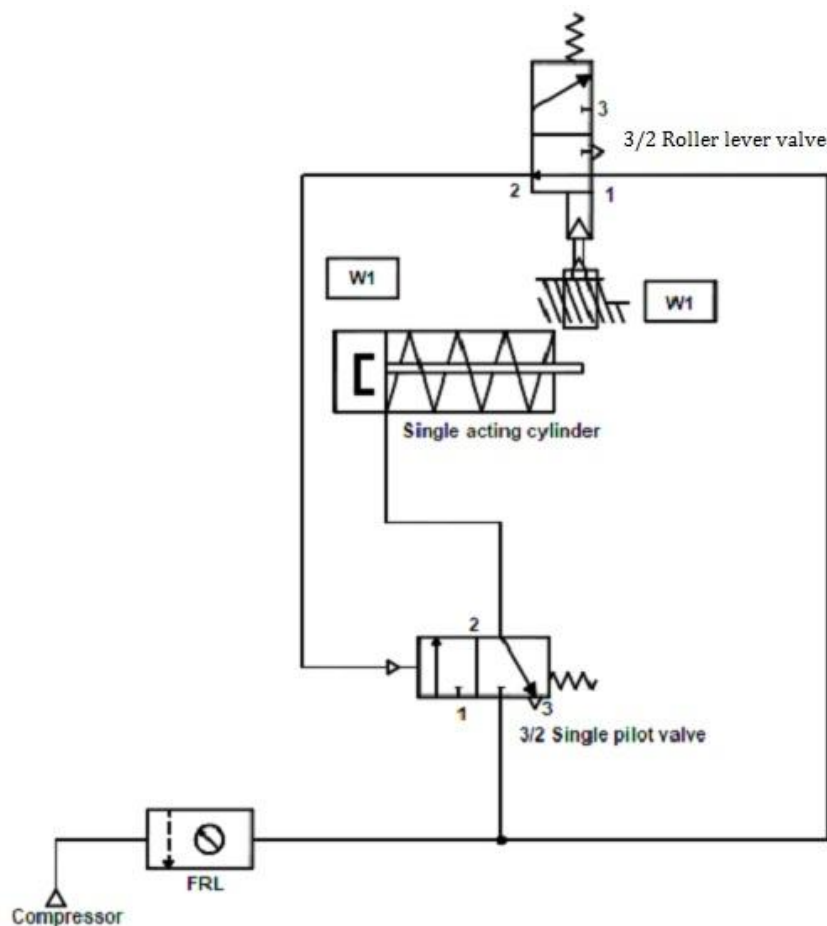
Apparatus required:

1. Compressor
2. FRL unit
3. 3/2 Roller lever valve
4. Single acting cylinder

Procedure:

1. Draw the circuit diagram.
2. Connect the compressor air supply to FRL unit.
3. Connect the circuit as per the circuit diagram.
4. Observe the continuous reciprocation of single acting cylinder.

Circuit diagram:



Result:

Thus the continuous reciprocation of single acting cylinder was achieved using a pilot operated valve.

Expt. No.21 CONTINUOUS RECIPROCATION OF DOUBLE ACTING CYLINDER USING 5/2 DOUBLE PILOT VALVE

Aim:

To construct a pneumatic circuit to control the continuous actuation of a double acting cylinder using 5/2 double pilot valve

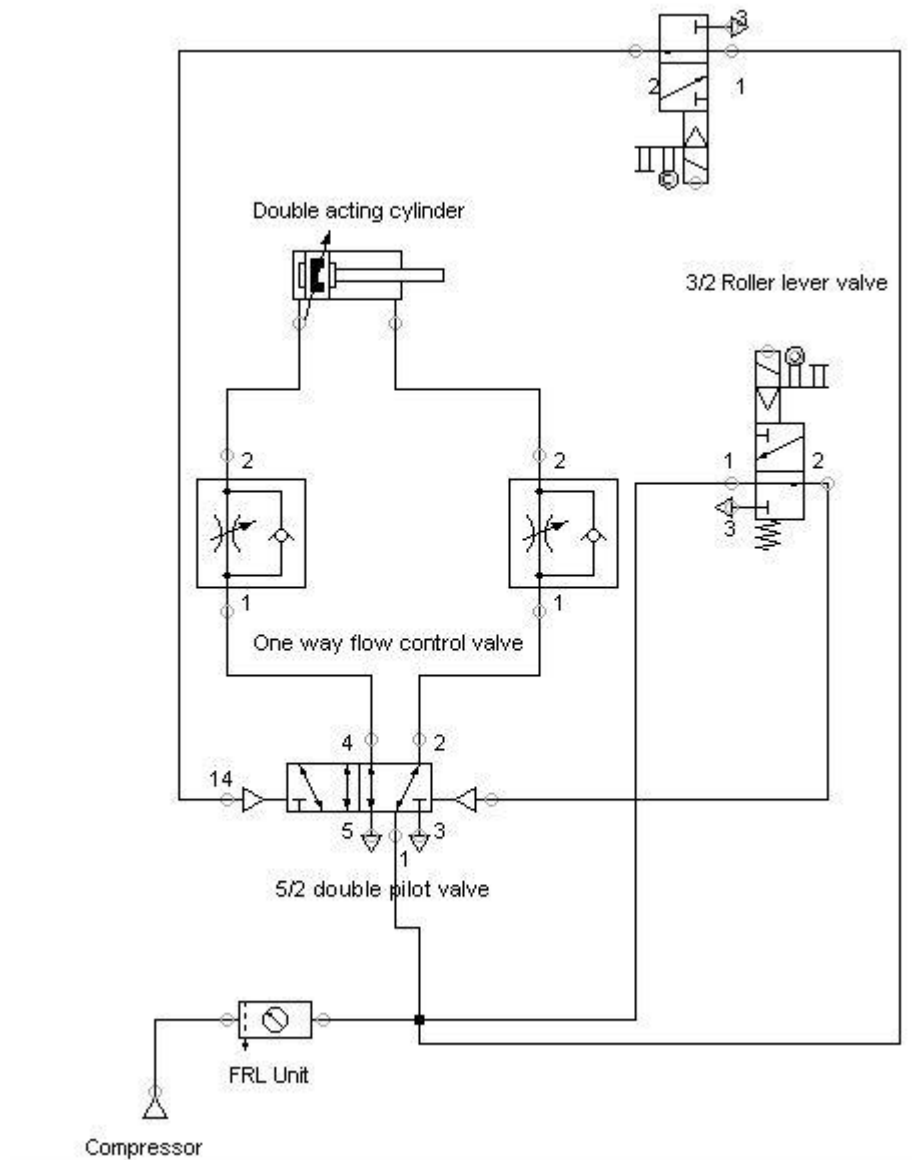
Apparatus required:

1. Compressor
2. Double acting cylinder
3. 3/2 roller lever valve
4. 5/2 double pilot valve
5. Flow control valve

Procedure:

1. Draw the circuit diagram.
2. Connect compressor air supply to FRL unit.
3. One of the output of FRL unit is connected to 5/2 direction control unit (port 1).
4. The port 4 of DCV is connected to blank end of the double acting cylinder.
5. Another output of FRL unit is connected to the input of 3/2 roller lever valve to give pilot pressure for 5/2 double pilot valve.
6. The output of the roller lever valves are connected to both sides of the 5/2 double pilot valve.
7. When the FRL unit is opened, the high pressure air enters the blank end of the cylinder through the DCV and the piston moves forward.
8. At the end of the forward stroke, the piston rod gives pressure to the roller lever valve. The output of roller lever valve is sent to the double acting cylinder to change the position.
9. Now the high pressure air from the FRL unit is sent to the rod end of the double acting cylinder through the second position of the DCV and the piston retracts.
10. At the end of the return stroke, the roller valve is pressed. The output of the roller valve is sent to the DCV to change the position. This will be repeated until the FRL unit is closed.

Circuit diagram:



Result:

Thus the continuous reciprocation of double acting cylinder was achieved.

Expt. No.22 ACTUATION OF DOUBLE ACTING CYLINDER USING **5/2 SINGLE PILOT VALVE**

Aim:

To construct an electro - pneumatic circuit to control the double acting cylinder using 5/2 single pilot valve

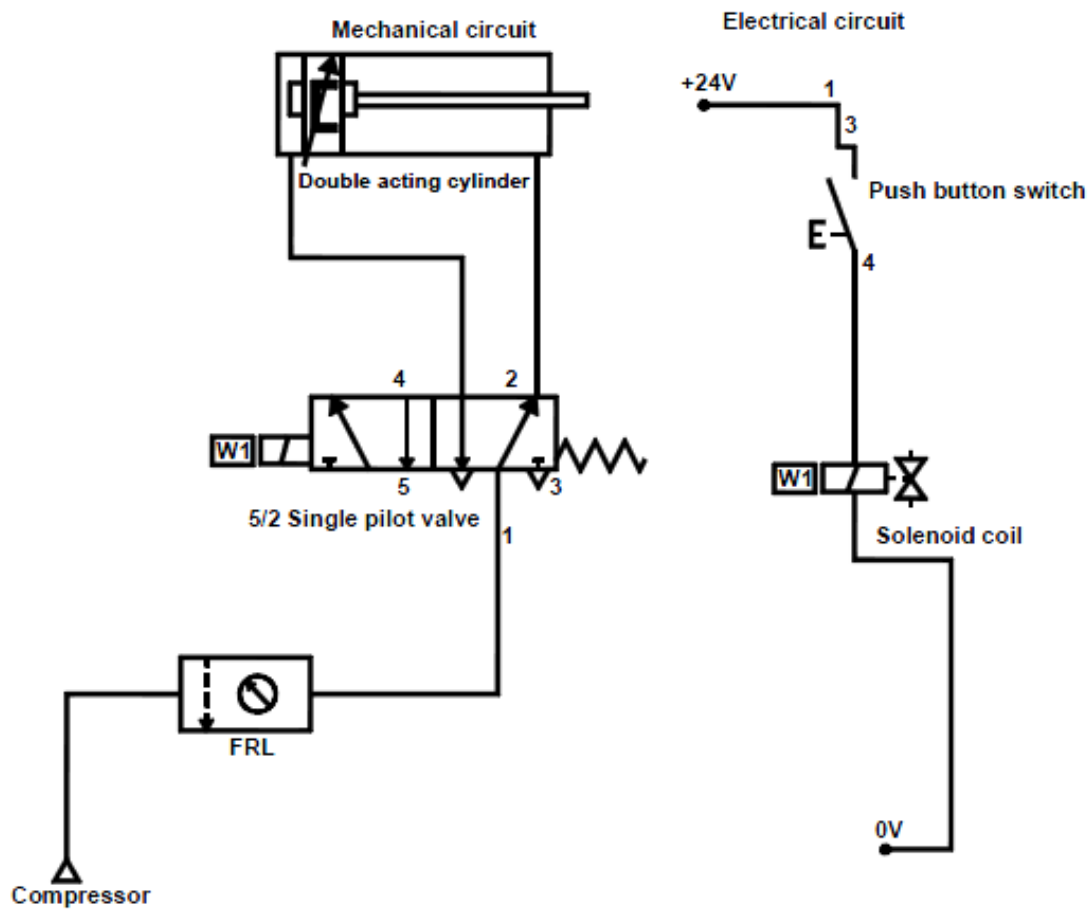
Apparatus required:

1. Compressor
2. FRL unit
3. 5/2 Single pilot valve
4. Electrical trainer
5. Double acting cylinder
6. Batch card

Procedure:

1. Draw the circuit diagram and connect the air supply to FRL unit.
2. Connect the electrical circuit from 24V DC source to ON/OFF switch.
3. Solenoids are connected to the push button switch.
4. When the solenoid is given the signal by a push button switch, the DCV is activated to actuate the double acting cylinder.
5. When the OFF button is pressed, the signal to the solenoid is cut and the solenoids are de-energized and the DCV comes to the original position to retract the cylinder.

Circuit diagram:



Result:

Thus the double acting cylinder was controlled electrically using a 5/2 single pilot valve.

Expt. No.23 ACTUATION OF DOUBLE ACTING CYLINDER USING 5/2 DOUBLE PILOT VALVE

Aim:

To construct a pneumatic circuit to actuate the double acting cylinder using 5/2 double pilot valve

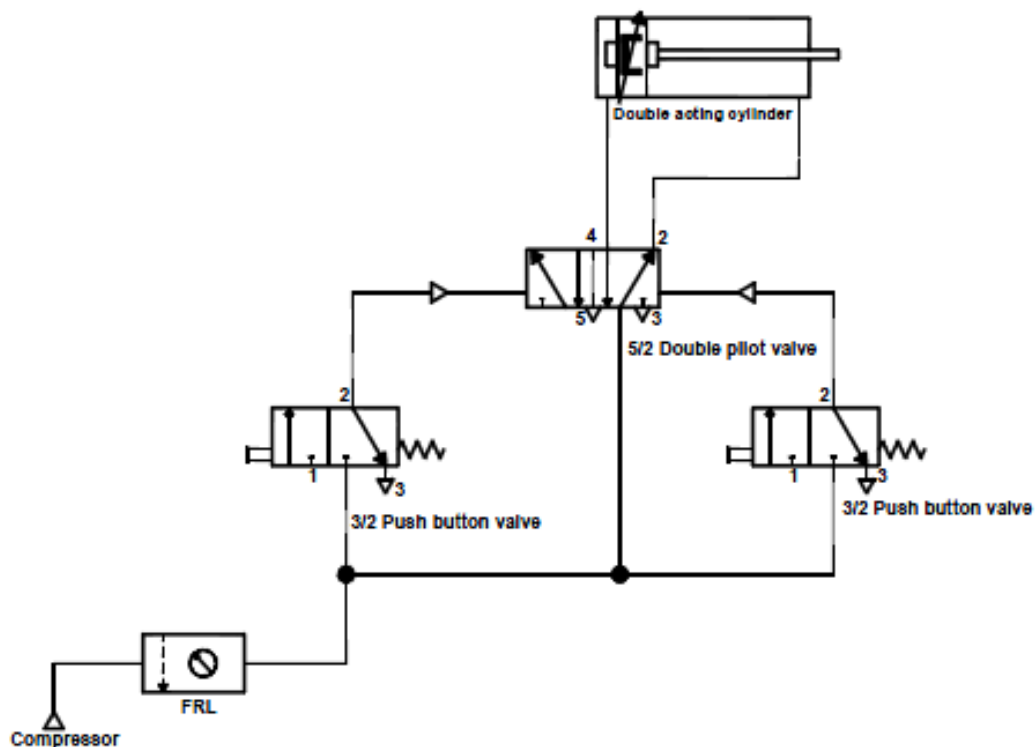
Apparatus required:

1. Compressor
2. 3/2 push button valve
3. 5/2 double pilot valve
4. FRL unit

Procedure:

1. Draw the circuit diagram.
2. Connect the compressor air supply to FRL unit.
3. The outputs of FRL unit are directly connected to 3/2 push button valves inlet. The outputs of 3/2 push button valves are connected to 5/2 double pilot valve.
4. 5/2 double pilot valve outputs are connected to double acting cylinder.
5. Observe the actuation of double acting cylinder.

Circuit diagram:



Result:

Thus the direction control of a double acting cylinder using 5/2 double pilot valve was achieved.

Expt. No.24 ACTUATION OF SINGLE ACTING CYLINDER USING **3/2 SINGLE SOLENOID VALVE** **(ELECTRO - PNEUMATIC)**

Aim:

To construct an electro - pneumatic circuit to actuate the single acting cylinder using 3/2 single solenoid valve

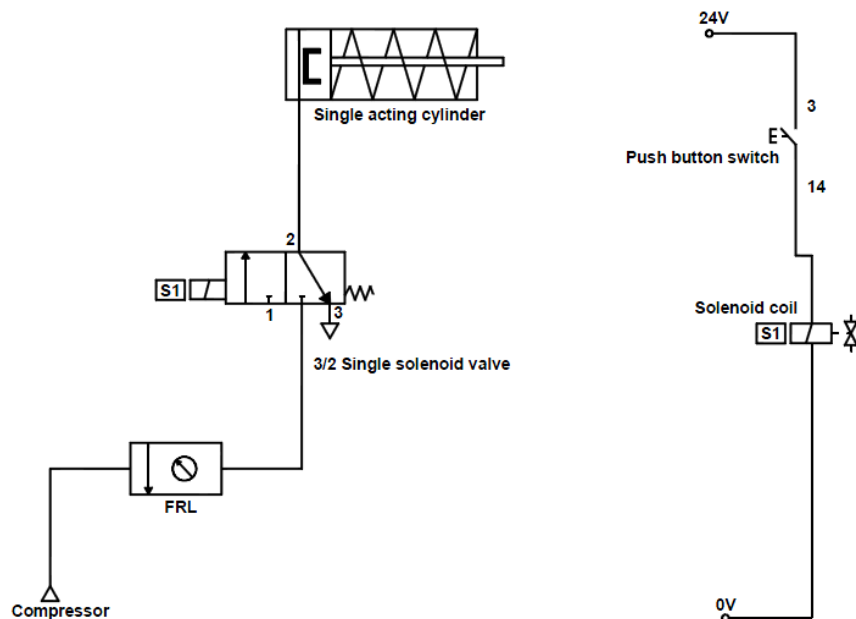
Apparatus required:

1. Compressor
2. FRL unit
3. 3/2 Single solenoid valve
4. Electrical trainer
5. Single acting cylinder
6. Batch card

Procedure:

1. Draw the circuit diagram.
2. The electrical trainer gives voltage to pneumatic panel.
3. Connect the air supply to FRL unit.
4. The output of FRL unit is connected to the 3/2 single solenoid valve which is activated by the electrical trainer.
5. The output of the 3/2 single solenoid valve is connected to the single acting cylinder.
6. Observe the actuation of the single acting cylinder using 3/2 single solenoid valve.

Circuit diagram:



Result:

Thus the actuation of single acting cylinder was carried out using 3/2 single solenoid valve.

Expt. No.25 ACTUATION OF SINGLE ACTING CYLINDER USING 'ON' DELAY TIMER

Aim:

To construct an electro pneumatic circuit for the actuation of single acting cylinder using ON delay timer

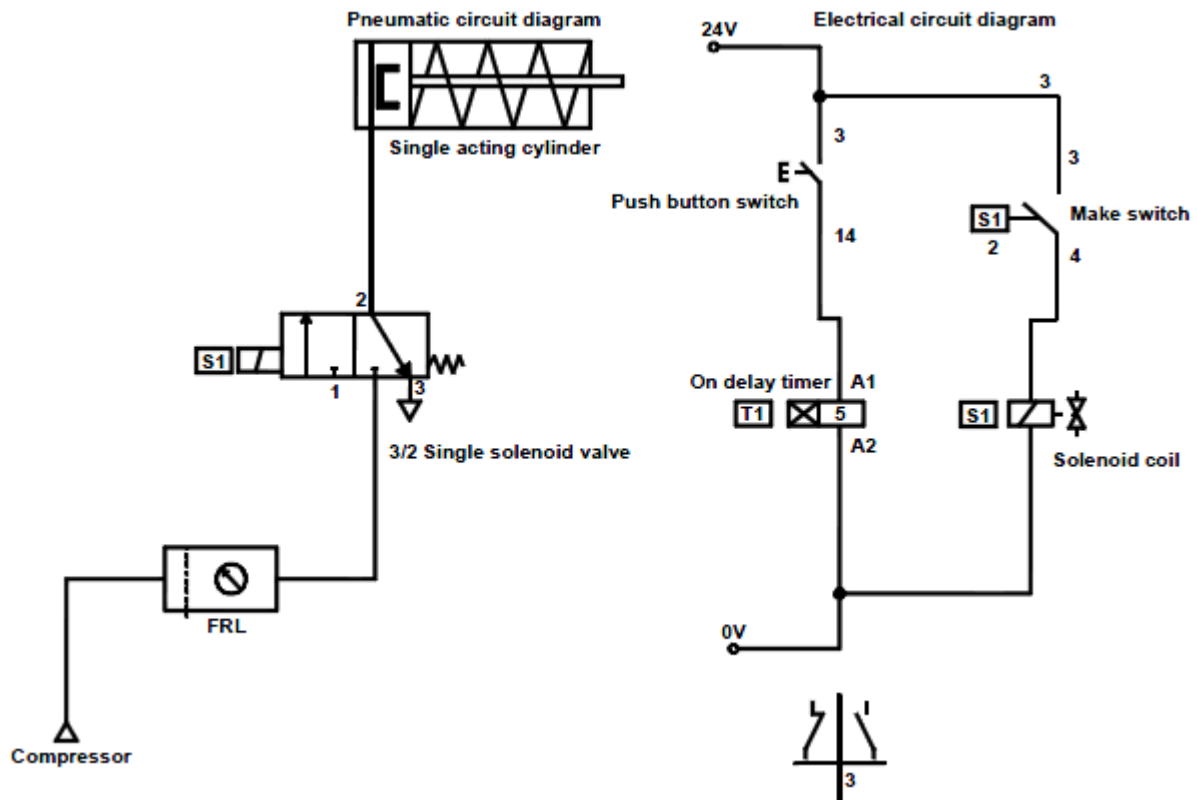
Apparatus Required:

1. Compressor
2. FRL unit
3. Time delay valve
4. Electrical controller
5. Single acting cylinder
6. 3/2 Single solenoid valve
7. Batch card

Procedure:

1. The power supply is provided to electrical controller by interfacing the +ve to +ve and -ve to -ve.
2. The power supply is provided to pneumatic trainer from electrical controller by interfacing 24 +ve to +ve and -ve to -ve.
3. Using the SPDT switch energize the corresponding solenoid to get the desired movement of the cylinder.
4. Actuate the time delay circuit.
5. From the time delay, give connection to single acting cylinder according to the time set.
6. Design and draw the pneumatic circuit.
7. Test the circuit.
8. Observe the working of the cylinder.

Circuit diagram:



Result:

Thus the actuation of single acting cylinder was carried out using ON delay timer.

Expt. No.26 ACTUATION OF SINGLE ACTING CYLINDER USING 'OFF' DELAY TIMER

Aim:

To construct an electro pneumatic circuit for the actuation of single acting cylinder using OFF delay timer

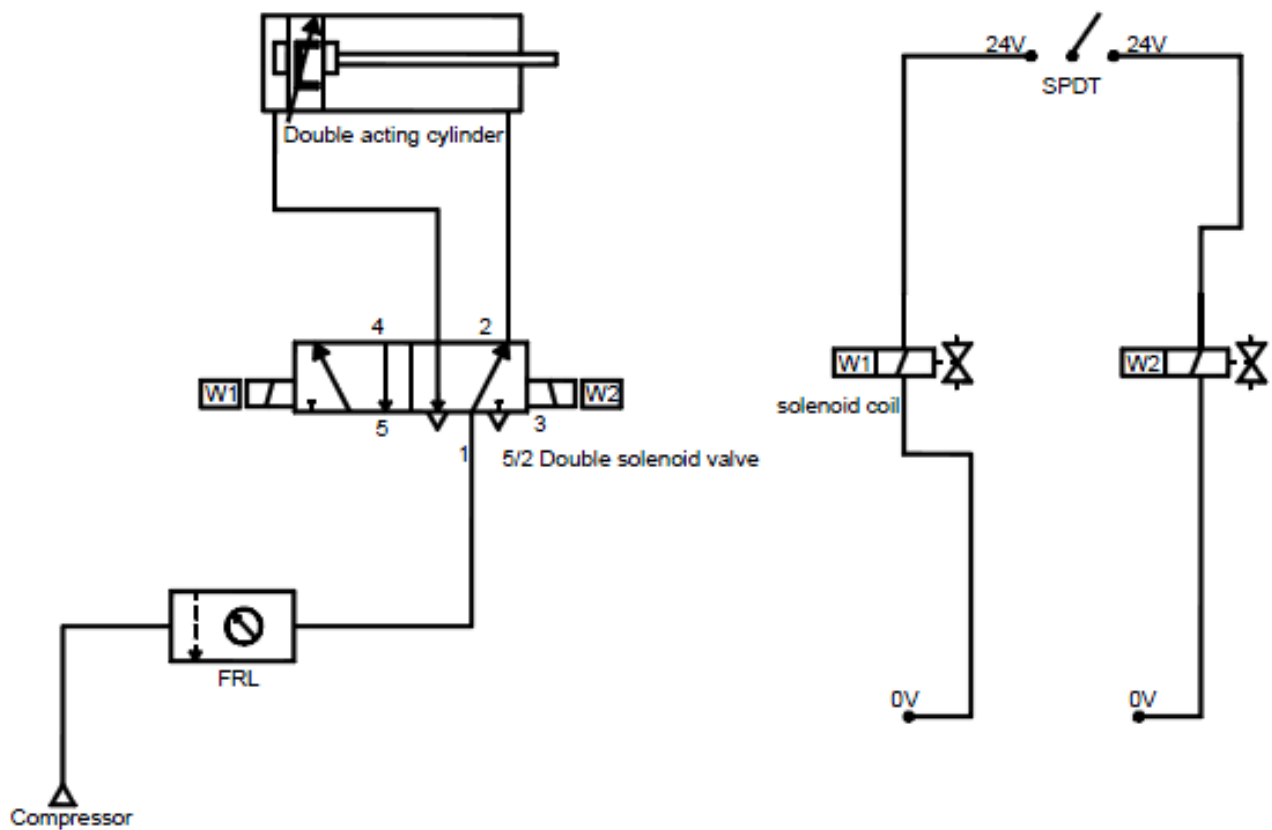
Apparatus required:

1. Compressor
2. FRL unit
3. 3/2 Single acting cylinder
4. Electrical controller
5. Single acting cylinder
6. OFF delay timer
7. Batch card

Procedure:

1. Provide power supply to pneumatic trainer from electrical controller by inter facing 24+ and 24-.
2. Provide 24V power supply to timer.
3. Any one of the output of FRL unit direct connect to 3/2 single solenoid valve.
4. Single solenoid valve output is connecting to single acting cylinder.
5. Give +24V and -24V in Timer.
6. Output of Timer connected to solenoid coil.
7. Check the all circuit.
8. Observe the working of cylinder.
9. Observe the working circuit.

Circuit diagram:



Result:

Thus the movement of single acting cylinder was carried out using OFF delay timer.

Expt. No.27

DESIGN AND TESTING OF LOGICAL CONTROL OF DOUBLE ACTING CYLINDER USING 'OR' GATE

Aim:

To construct the pneumatic circuit to actuate a double acting cylinder using two identical push button operated valves and a shuttle valve

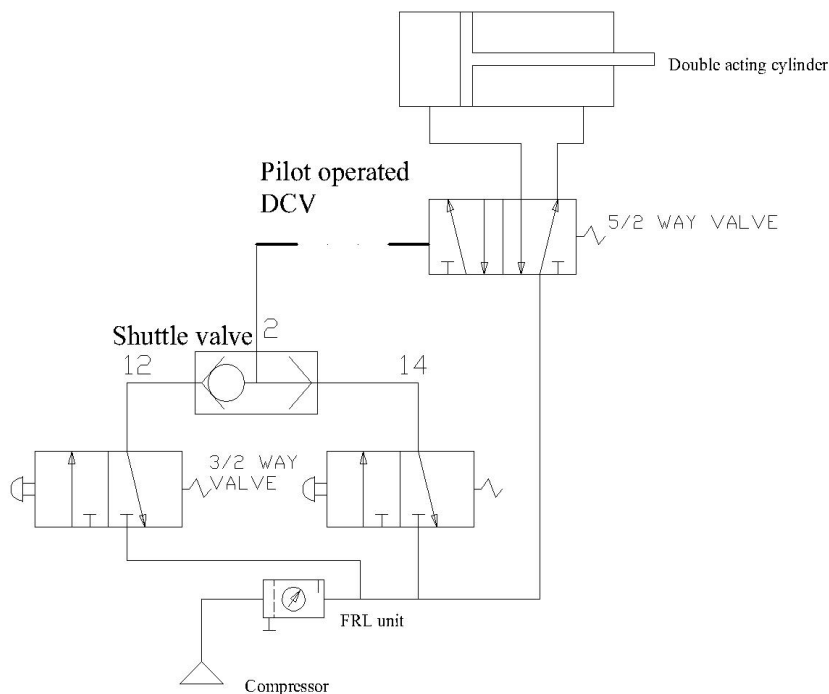
Apparatus required:

1. Double acting cylinder
2. 3/2 way valves
3. 5/2 way valve
4. Compressor
5. Shuttle valve (OR gate)

Procedure:

1. The circuit is constructed as per the diagram.
2. The compressor is connected to the FRL unit.
3. The two 3/2 way valves are connected to the shuttle valve which is pilot operated.
4. When both of the push buttons are pressed or any one of the push button is pressed, the piston extends and retracts upon release.

Circuit diagram:



Result:

Thus the circuit is constructed and tested as per the given application.

Outcome:

1. Able to learn the working principles of hydraulic system, basic pneumatic system and electro-pneumatic system were studied.
2. Able to understand the operation of direction control valves, flow control valves and pressure control valves.

Viva - voce

1. What is meant by fluid power?
2. What is a check valve?
3. What is a solenoid valve?
4. Define – FRL unit
5. Define – DCV
6. Differentiate between meter-in and meter-out controls.
7. What is the function of an unloading valve?
8. What is the function of a sequence valve?
9. What is the function of a shuttle valve?
10. What is the function of a spool valve?
11. What is the function of a process control valve?
12. What is the function of a 2-way pressure valve?
13. Why hydraulic power is especially used in heavy works?
14. Where are pneumatic systems preferred?
15. Name the basic components of a hydraulic system.
16. What is the function of a relief valve in a hydraulic system?
17. Draw the symbols for a pressure relief valve and a pressure reducing valve.
18. What is meant by NC and NO contacts?
19. What is the function of a compressor?
20. What is the function of an accumulator?

MODELING AND ANALYSIS OF BASIC HYDRAULIC, PNEUMATIC AND ELECTRICAL CIRCUITS USING PNEUMOSIM SOFTWARE

Expt. No.28 SIMULATION OF DOUBLE ACTING CYLINDER USING TIME DELAY VALVE

Aim:

To design a pneumatic circuit to actuate a double acting cylinder using time delay valve and simulate the circuit in Pneumosim software

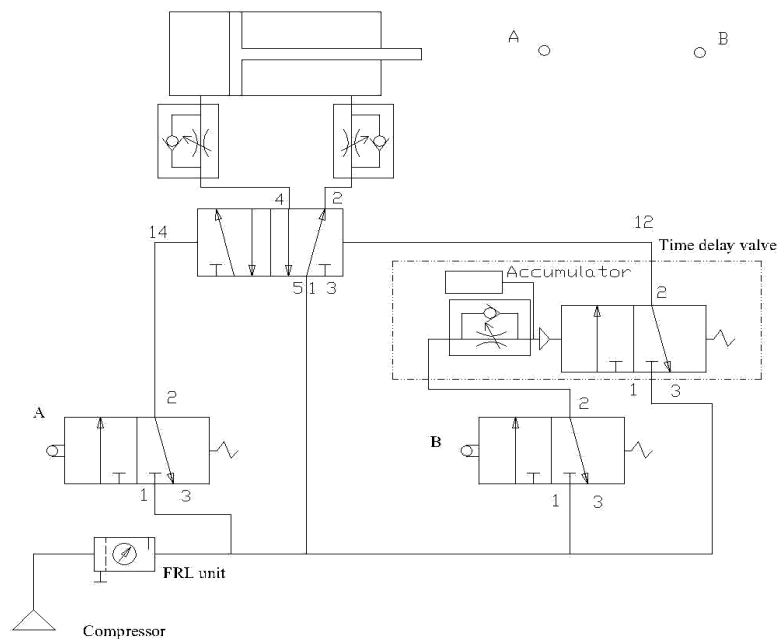
Apparatus required:

1. Flow control valve
2. Time delay valve
3. 3/2 way spring operated valve
4. 5/2 way valve
5. Pneumosim software

Procedure:

1. The circuit is designed as per the given experiment.
2. Open a new file from the pull down menu bar.
3. Select and drag the required components from the components library.
4. Connect the components as per the circuit connection.
5. Simulate the circuit to check the actuation.
6. Observe the actuation of double acting cylinder using time delay valve.

Circuit diagram:



Result:

Thus the circuit is designed and simulated by using Pneumosim software for the given application.

Expt. No.29 SIMULATION OF DOUBLE ACTING CYLINDERS IN THE SEQUENCE OF A⁺ B⁺ B⁻ A⁻

Aim:

To simulate double acting cylinders in the sequence of A⁺ B⁺ B⁻ A⁻ using Pneumosim software

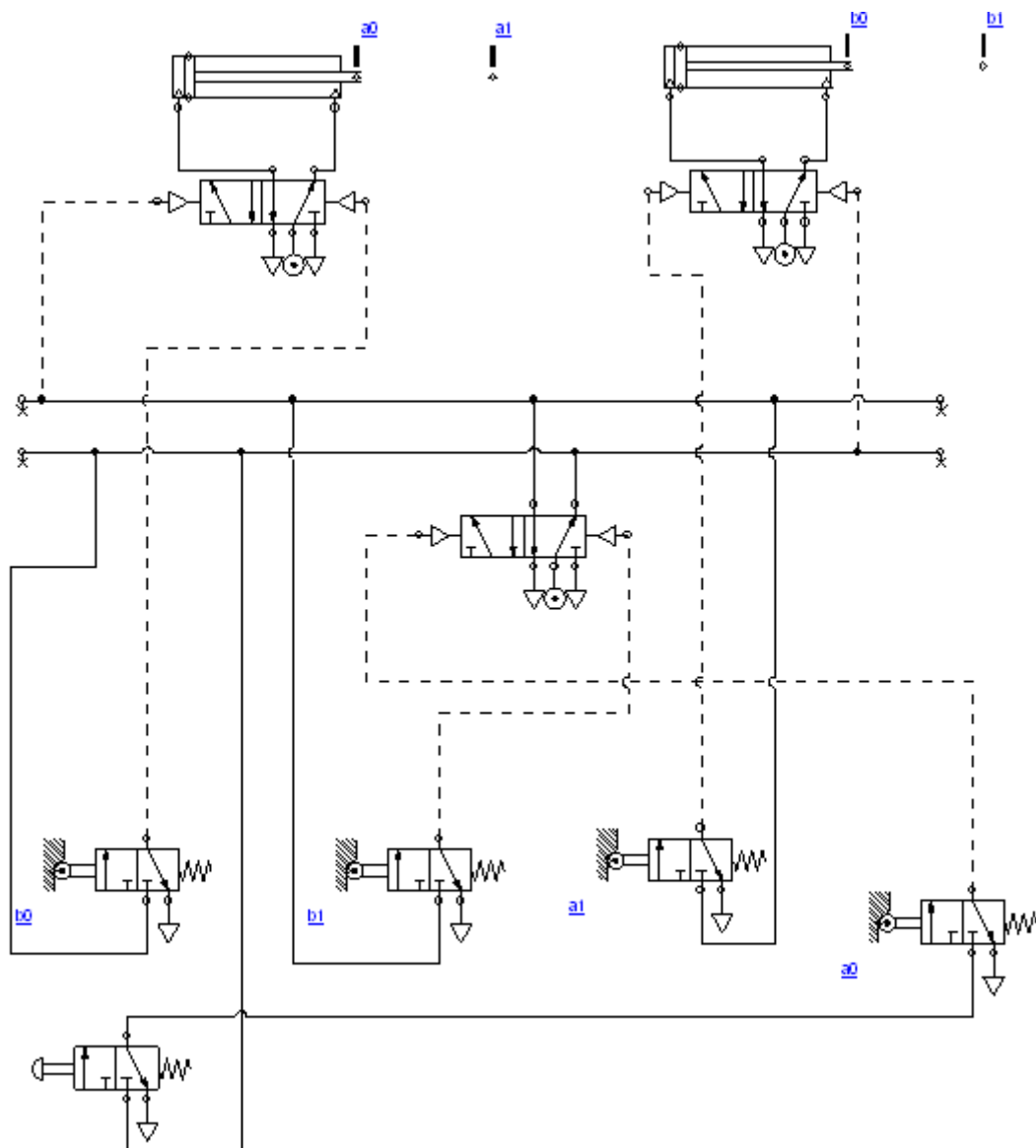
Apparatus required:

1. Double acting cylinders
2. 5/2 double solenoid valve
3. Compressor
4. Limit Switches
5. Push button valves
6. Pneumosim Software

Procedure:

1. The circuit is designed as per the given experiment.
2. Open a new file from the pull down menu bar.
3. Select and drag the required components from the components library.
4. Connect the components as per the circuit connection.
5. Simulate the circuit to check the actuation.

Circuit diagram:



Result:

Thus the simulation of double acting cylinders in the sequence of A+ B+ B- A- was achieved using Pneumosim software.

Expt. No.30 DESIGN AND TESTING OF PNEUMATIC CIRCUIT FOR
SINGLE CYCLE AUTOMATION OF MULTICYLINDERS
IN THE SEQUENCE OF A⁺ B⁺ A⁻ B⁻

Aim:

To design and test a pneumatic circuit for single cycle automation of multicylinders in the sequence of A⁺ B⁺ A⁻ B⁻

Apparatus required:

1. Double Acting Cylinder
2. 5/2 way pilot operated valve
3. 3/2 way pilot operated valve
4. Roller operated valves
5. Pneumosim software

Procedure:

1. The circuit is designed as per the given application.
2. The compressor is connected to FRL unit.
3. The cylinder A extends when the roller operated valve R2 is actuated, which initiates the extension of cylinder B.
4. This actuates the roller operated valve R4 which retracts the cylinder A.
5. The retracted cylinder A actuates the roller operated valve R1 which results in the retraction of cylinder B.

Result:



**Expt. No.31 DESIGN AND TESTING OF PNEUMATIC CIRCUIT FOR
SINGLE CYCLE AUTOMATION OF MULTICYLINDERS
IN THE SEQUENCE OF A⁺ B⁺ B⁻ A⁻**

Aim:

To design and test a pneumatic circuit for single cycle automation of multicylinder in the sequence of A⁺ B⁺ B⁻ A⁻ using cascading method

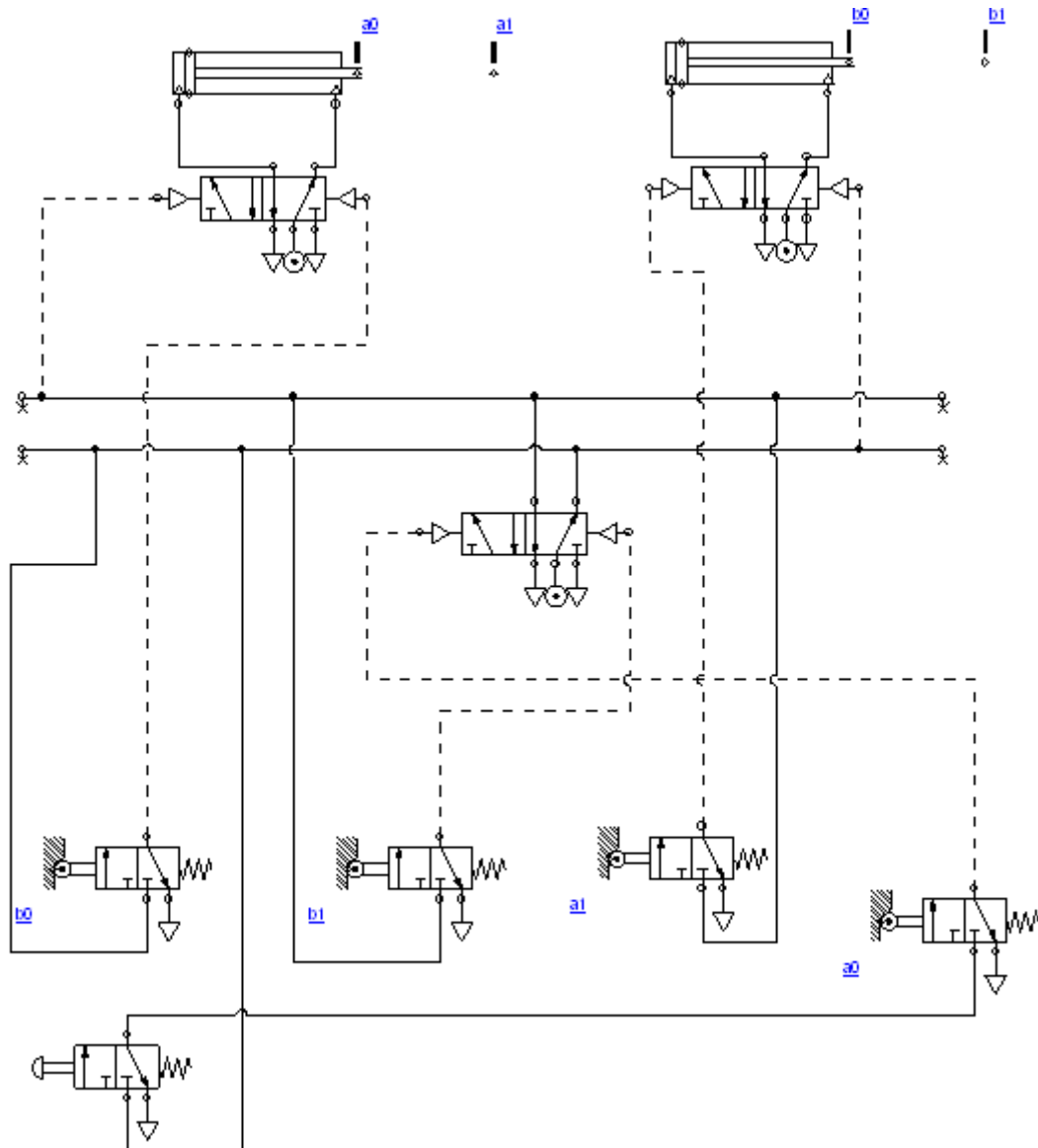
Apparatus required:

1. Double Acting Cylinder
2. 5/2 way pilot operated valve
3. 3/2 way pilot operated valve
4. Roller operated valves
5. Pneumosim software

Procedure:

1. The circuit is designed as per the given application.
2. The compressor is connected to FRL unit.
3. The cylinder A extends when the roller operated valve R2 is actuated which initiates the extension of cylinder B.
4. This actuates the roller operated valve R4 which retracts the cylinder A.
5. The retracted cylinder A actuates the roller operated valve R1 which results in retraction of cylinder B.

Circuit diagram:



Result:

Thus the pneumatic circuit for the given application is designed and tested.

Expt. No.33 DESIGN AND TESTING OF MULTI CYCLE OPERATION OF DOUBLE ACTING CYLINDER USING ELECTRO PNEUMATIC CIRCUIT

Aim:

To actuate a double acting cylinder in multi cyclic continuous reciprocation using electrically operated solenoid valve

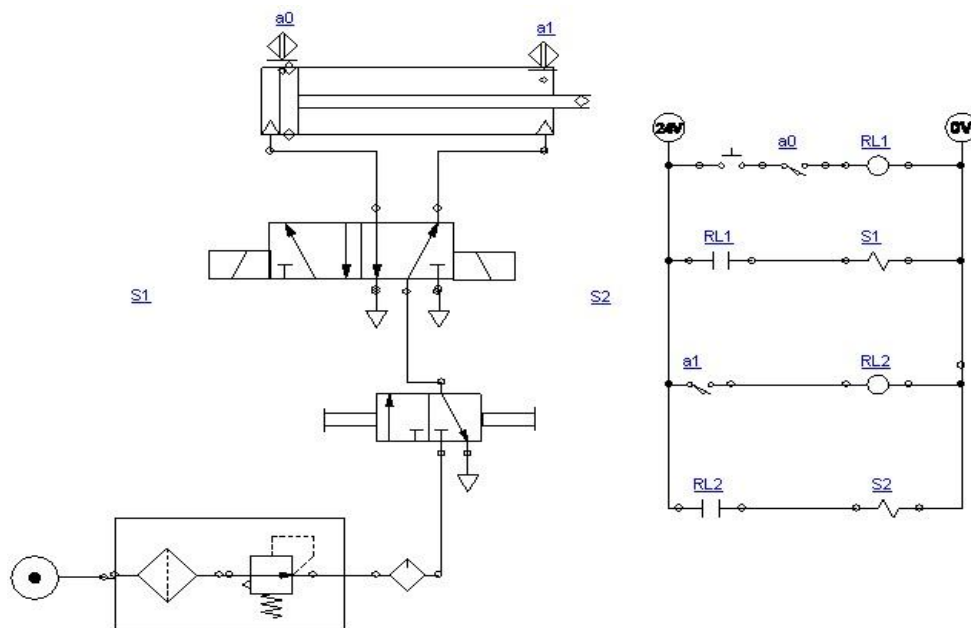
Apparatus required:

1. Double acting cylinder
2. 5/2 double solenoid valve
3. Compressor
4. Pneumosim software

Procedure:

1. The circuit is designed as per the given application.
2. The 5/2 double solenoid valve is operated by switches S1 and S2.
3. When the start button is pressed, it closes the relay coil RL1 and solenoid valve 1 gets energized which moves the cylinder forward direction.
4. At the end of the forward stroke, the switch S1 gets closed and it closes the relay coil RL2, then the solenoid valve S2 gets energized and the cylinder moves in reverse direction.
5. At the end of the return stroke, the switch S2 gets closed and it closes relay coil RL2. Then the solenoid valve 1 gets energized and the cylinder moves in forward direction.
6. This process is repeated.

Circuit diagram:



Result:

Thus the electro pneumatic circuit for given application is designed and simulated.

Expt. No.34 **DESIGN AND TESTING OF ELECTRO PNEUMATIC
CIRCUIT FOR SINGLE CYCLE AUTOMATION OF
MULTICYLINDERS IN THE SEQUENCE OF A⁺ B⁺ B⁻ A⁻**

Aim:

To design and test a electro pneumatic circuit for single cycle automation of multi cylinders in the sequence of A⁺ B⁺ B⁻ A⁻

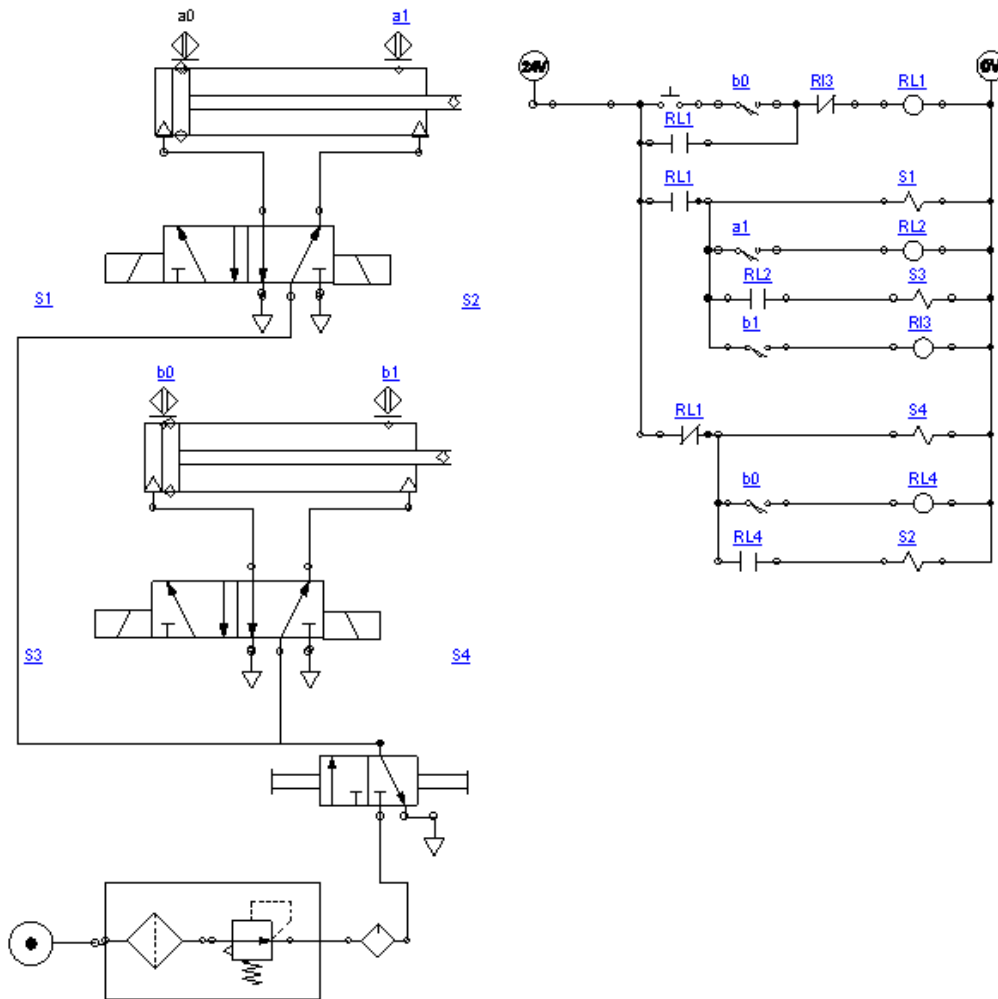
Apparatus required:

1. Double acting cylinders
2. 5/2 double solenoid valve
3. Compressor
4. Pneumosim software

Procedure:

1. The circuit is designed as per the given application.
2. The compressor is connected to FRL unit.
3. The cylinder A extends when the solenoid valve S1 is actuated which further initiates the extension of cylinder B.
4. This actuates the magnetic switch S1 and the solenoid valve S4 which results in the retraction of cylinder B.
5. The retracted cylinder B actuates the solenoid valve which results in retraction of cylinder A.

Circuit diagram:



Result:

Thus the pneumatic circuit for the given application is designed and tested.

Outcome:

Able to understand the design and simulation of hydraulic and pneumatic circuits using Hydrosim and Pneumosim software respectively.

Viva - voce

1. What is meant by an actuator?
2. What are the types of actuators?
3. What is a control valve?
4. What are the types of control valves?
5. What is a circuit control valve?
6. What is the function of flow control valve?
7. Distinguish between flow control and needle valve.
8. What is the function of time delay valve?
9. What is the function of pilot operated valve?
10. What is a quick exhaust valve?
11. What is the difference between a strainer and a filter?
12. Distinguish between hydraulics and pneumatics?
13. What is the purpose of a pressure regulator?
14. Why lubricator is used in pneumatic systems?
15. What are the advantages of hydro- pneumatics?
16. What is meant by logic control?
17. Name the different pneumatic position sensors.
18. How do you rate a compressor?
19. What is the use of a bleed –off circuit?
20. List the importance of Hydrosim and Pneumosim software.

STUDY OF PLC AND ITS APPLICATIONS

Expt. No.35 ACTUATION OF SINGLE ACTING CYLINDER WITH PLC USING 'AND' GATE

Aim:

To actuate the single acting cylinder using AND gate with PLC ladder diagram

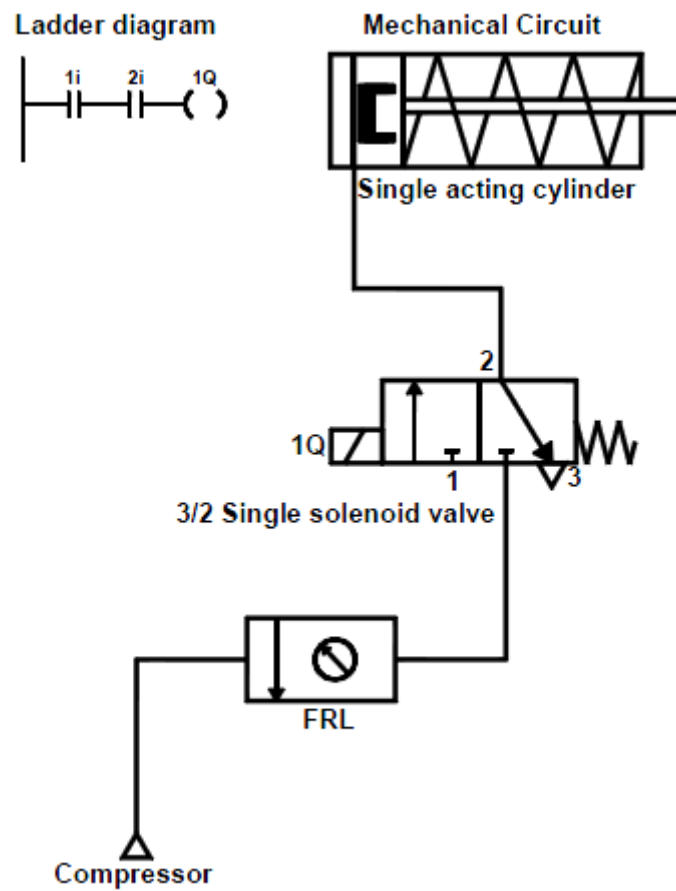
Apparatus required:

1. Compressor
2. FRL unit
3. Single acting cylinder
4. PLC
5. Versa Pro software
6. 3/2 single solenoid valve

Procedure:

1. Draw the circuit diagram.
2. Provide +24 V and -24 V from PLC trainer to electro pneumatic panel.
3. The output of the PLC (Q1) is connected to the input of 3/2 single solenoid valve.
4. Then open the Versa Pro software in desktop.
5. Interface the PLC with the system using RS232 cable.
6. Connect the air supply to FRL unit.
7. The output of FRL unit is connected to the 3/2 single solenoid valve.
8. Check the Ladder diagram.
9. Run the PLC. When two inputs (1i, 2i) are high, then output also will be high.

Circuit diagram:



Result:

Thus the actuation of single acting cylinder with PLC using AND Gate was done.

Expt. No.36 ACTUATION OF SINGLE ACTING CYLINDER WITH PLC USING 'OR' GATE

Aim:

To actuate the single acting cylinder using OR Gate with PLC ladder diagram

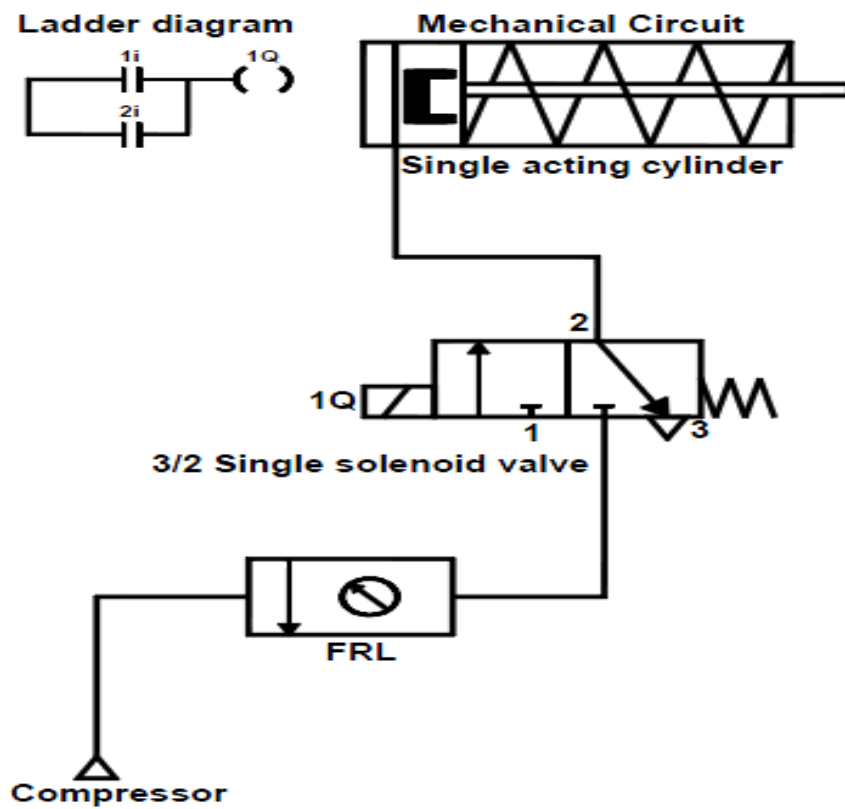
Apparatus required:

1. Compressor
2. FRL unit
3. Versa Pro software
4. 3/2 single solenoid valve
5. PLC
6. Single acting cylinder

Procedure:

1. Draw the circuit diagram.
2. Provide +24 V and –24 V from PLC trainer to Electro pneumatic panel kit.
3. Open the Versa Pro software in desktop.
4. Interface the PLC with the system using RS232 cable.
5. Draw ladder diagram.
6. The output of PLC (q1) is connected to the input of solenoid valve.
7. Check the ladder diagram.
8. Connect the air supply to FRL unit.
9. Run the PLC. When any one input is high, then the output will be high.

Circuit diagram:



Result:

Thus the actuation of single acting cylinder with OR Gate was done using PLC.

Expt. No.37 ACTUATION OF SINGLE ACTING CYLINDER WITH PLC **USING 'ON' DELAY TIMER**

Aim:

To actuate the single acting cylinder with PLC using ON delay timer

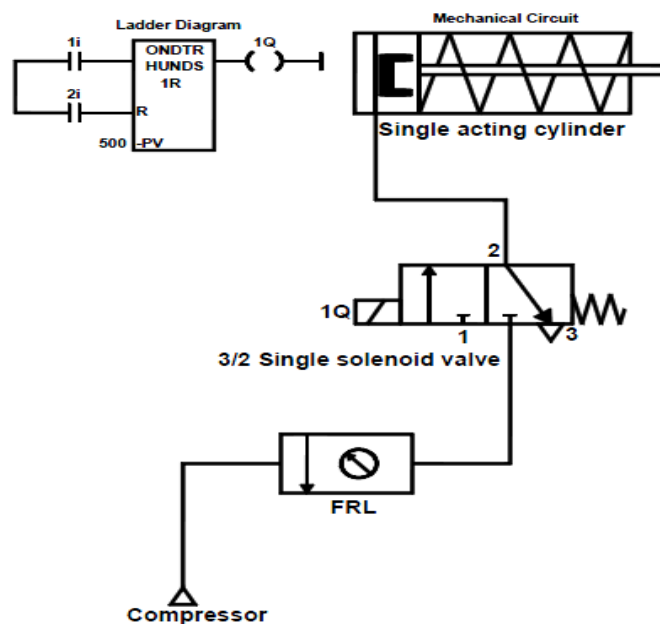
Apparatus required:

1. Compressor
2. FRL unit
3. 3/2 single solenoid valve
4. PLC
5. single acting cylinder
6. Versa Pro software

Procedure:

1. Draw the circuit diagram.
2. Provide +24 V and –24 V from PLC trainer to pneumatic panel kit.
3. Open the Versa Pro software in desktop.
4. Interface the PLC with PC using RS232 cable.
5. Draw a ladder diagram.
6. The output of PLC (q1) is connected to the input of solenoid valve.
7. Check the ladder diagram.
8. Connect the air supply to FRL unit.
9. Run the PLC upon the delay, the cylinder should be activated.

Circuit diagram:



Result:

Thus the actuation of single acting cylinder with PLC using ON delay timer was done.

Expt. No.38**SIMULATE THE ACTUATION OF SINGLE ACTING CYLINDER WITH PLC USING 'OFF' DELAY TIMER****Aim:**

To actuate the single acting cylinder with PLC using OFF delay timer

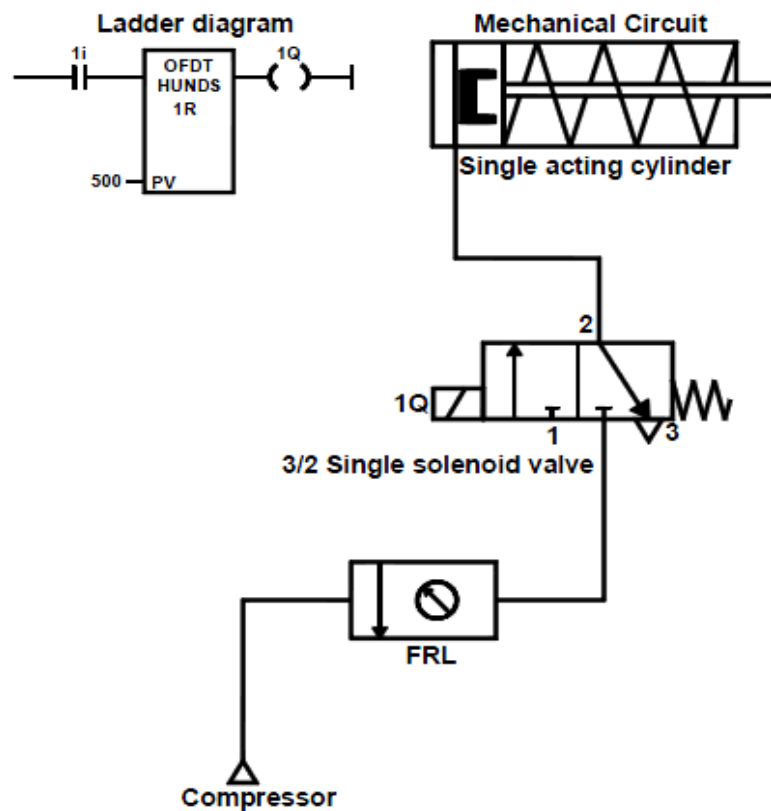
Apparatus required:

1. Compressor
2. FRL unit
3. 3/2 single solenoid valve
4. PLC
5. single acting cylinder
6. Versa Pro software

Procedure:

1. Draw the circuit diagram.
2. Provide +24 V and –24 V from PLC trainer to pneumatic panel kit.
3. Open the Versa Pro software in desktop.
4. Interface the PLC with PC using RS232 cable.
5. Draw the ladder diagram.
6. The output of PLC (q1) is direct connected to the input of solenoid valve.
7. Check the ladder diagram.
8. Connect the air supply to FRL unit.
9. Run the PLC. Observe the working of single acting cylinder.

Circuit diagram:



Result:

Thus the single acting cylinder is actuated with PLC using OFF delay timer.

Expt. No.39 ACTUATION OF DOUBLE ACTING CYLINDER WITH PLC **USING 5/2 SINGLE SOLENOID VALVE**

Aim:

To actuate the double acting cylinder with PLC using 5/2 single solenoid valve

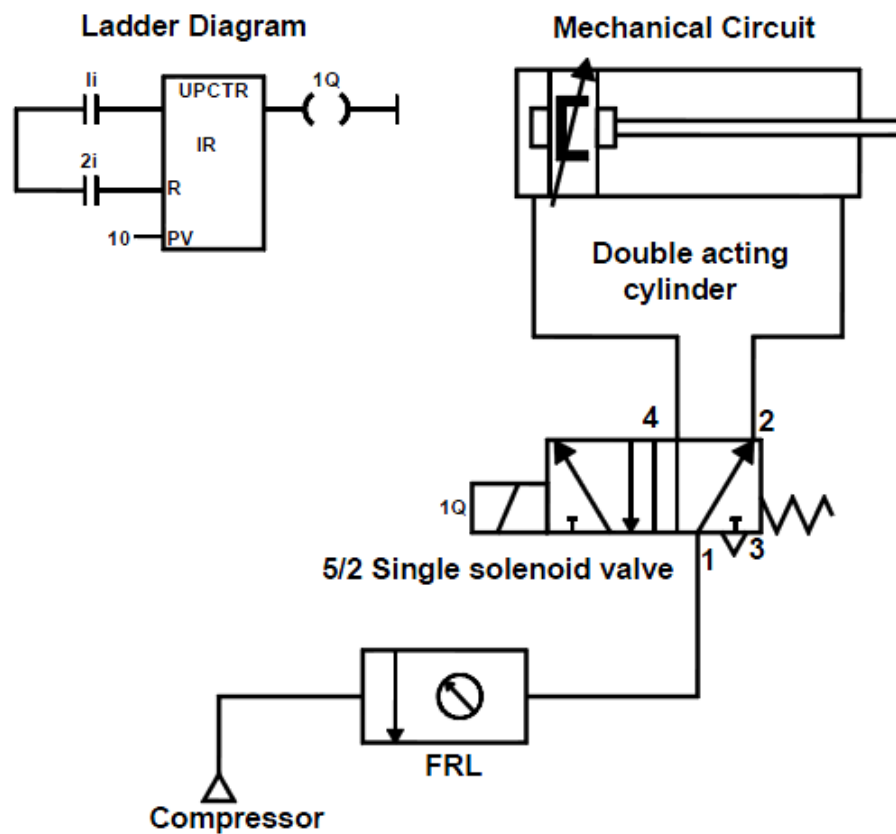
Apparatus required:

1. Compressor
2. FRL unit
3. 5/2 single solenoid valve
4. PLC
5. Double acting cylinder
6. Versa Pro software

Procedure:

1. Draw the circuit diagram.
2. Provide +24 V and –24 V from PLC trainer to pneumatic panel kit.
3. Open the Versa Pro software in desktop.
4. Interface the PLC with PC using RS232 cable.
5. Draw the ladder diagram.
6. The output of PLC (q1) is connected to the input of solenoid valve.
7. Check the ladder diagram.
8. Connect the air supply to FRL unit.
9. Run the PLC input (I1), switch continuously ON and OFF. When it reaches the preset value (pv), the cylinder gets actuated.

Circuit diagram:



Result:

Thus the double acting cylinder is actuated with 5/2 single solenoid valve using PLC.

Expt. No.40**AUTOMATIC ACTUATION OF SINGLE ACTING CYLINDER USING PLC****Aim:**

To simulate the automatic sequence of single acting cylinder by using PLC

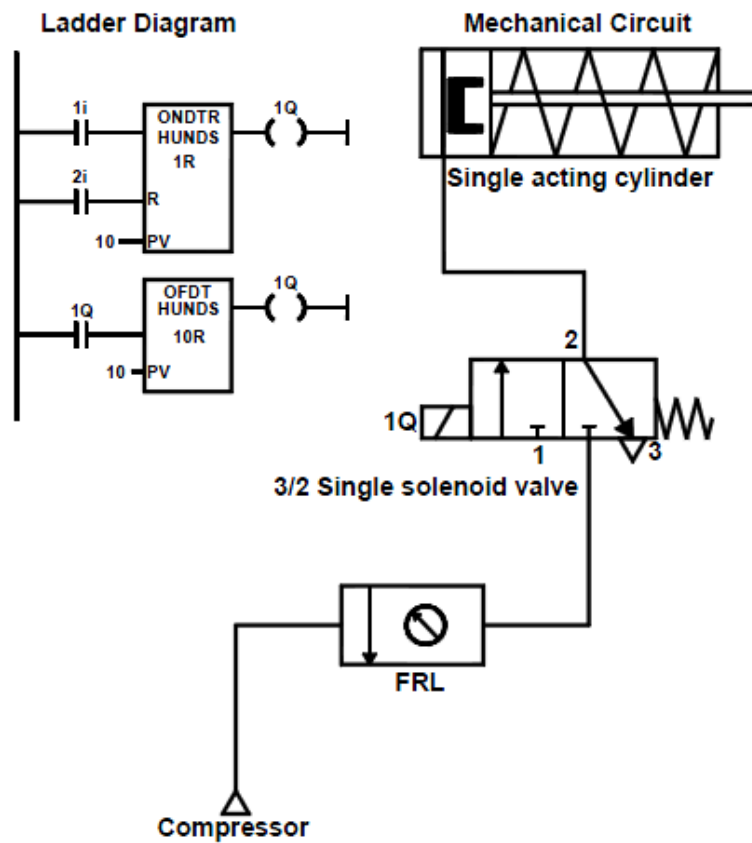
Apparatus required:

1. Compressor
2. FRL unit
3. 3/2 single solenoid valve
4. PLC
5. Single acting cylinder
6. Versa Pro software

Procedure:

1. Draw the circuit diagram.
2. Provide +24 V and –24 V from PLC trainer to pneumatic panel kit.
3. Open the Versa Pro software in desktop.
4. Interface the PLC with PC using RS232 cable.
5. Draw the ladder diagram.
6. The output of PLC (q1) is connected to the input of solenoid valve.
7. Check the ladder diagram.
8. Connect the air supply to FRL unit.
9. Run the PLC. Observe the automatic reciprocation of single acting cylinder.

Circuit diagram:



Result:

Thus the ladder diagram for the automatic running of single acting cylinder is drawn and executed.

Expt. No.41**AUTOMATIC ACTUATION OF DOUBLE ACTING
CYLINDER USING PLC****Aim:**

To simulate the automatic sequence of double acting cylinder using PLC

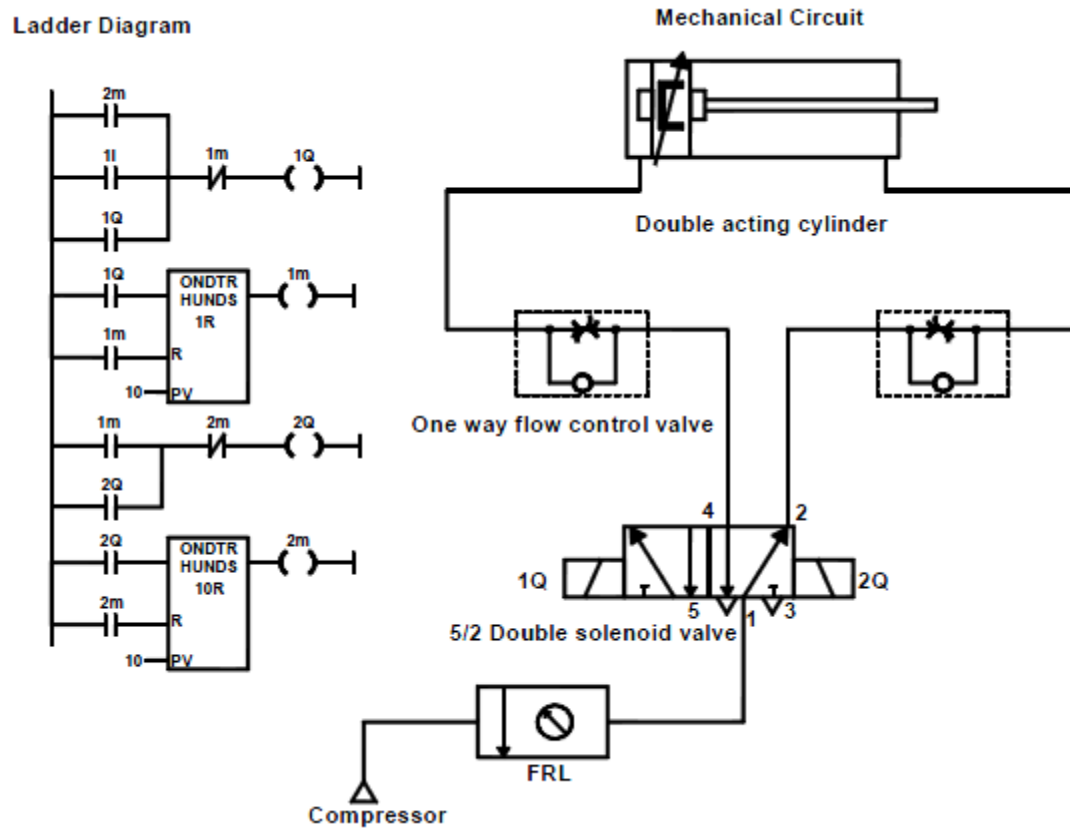
Apparatus required:

1. Compressor
2. FRL unit
3. 5/2 double solenoid valve
4. PLC
5. Double acting cylinder
6. Versa Pro software
7. Flow control valve

Procedure:

1. Draw the circuit diagram.
2. Provide +24 V and –24 V from PLC trainer to pneumatic panel kit.
3. Open the Versa Pro software in desktop.
4. Interface the PLC with PC using RS232 cable.
5. Draw the ladder diagram.
6. Both the outputs of PLC (q1 and q2) are directly connected to the inputs of solenoid valves.
7. Check the ladder diagram.
8. Connect the air supply to FRL unit.
9. Run the PLC. Observe the automatic reciprocation of double acting cylinder.

Circuit diagram:



Result:

Thus the ladder diagram for the automatic running of double acting cylinder is drawn and executed.

Outcome:

1. Able to construct the ladder logic programming for various applications.
2. Also to learn the working principle of programmable logic controller.

Viva - voce

1. What is a programmable logic controller?
2. What are the basic elements of a PLC?
3. What are the various approaches for entering the program for PLC?
4. What is a ladder diagram?
5. What is the purpose of an electrical timer?
6. Draw the general ladder rungs to represent a latch circuit.
7. How does a PLC differ from relay logic?
8. What is the use of JUMP control in PLC?
9. What are the features of a PLC?
10. What is meant by an internal relay in PLC?
11. Define – Logical Rack
12. What is the function of a PLC input module?
13. What is the function of a PLC output module?
14. List the basic sections of an I/O module.
15. What is the function of manually operated switch?
16. What is the function of mechanically operated switch?
17. What is the function of proximity switch?
18. Distinguish between a sequential and a combination control process.
19. Distinguish between the timed and instantaneous contacts of a pneumatic timer.
20. What determines the maximum speed of transitions that a PLC can count?

Expt. No.42

STUDY OF IMAGE PROCESSING TECHNIQUE

Introduction:

We use photography as a way of recording and presenting information visually in everyday life to create a permanent record of our visual experiences. There are two major areas of application of digital image processing techniques: 1) improvement of pictorial information for human interpretation and 2) processing of scene data for autonomous machine perception. In machine perception, interest focuses on procedures for extracting image information in a form suitable for computer processing.

Segmented images are formed from the generalized image by gathering its elements into sets that are likely to be associated with meaningful objects in the scene.

In producing the segmented image, knowledge about the particular domain is important to save computation and also to overcome problems of noise and inadequate data.

Geometric representations are used to capture the all-important data of two-dimensional and three-dimensional shape. These geometric representations must be powerful enough to support complex and general processing, such as 'simulation' of the effects of lighting and motion.

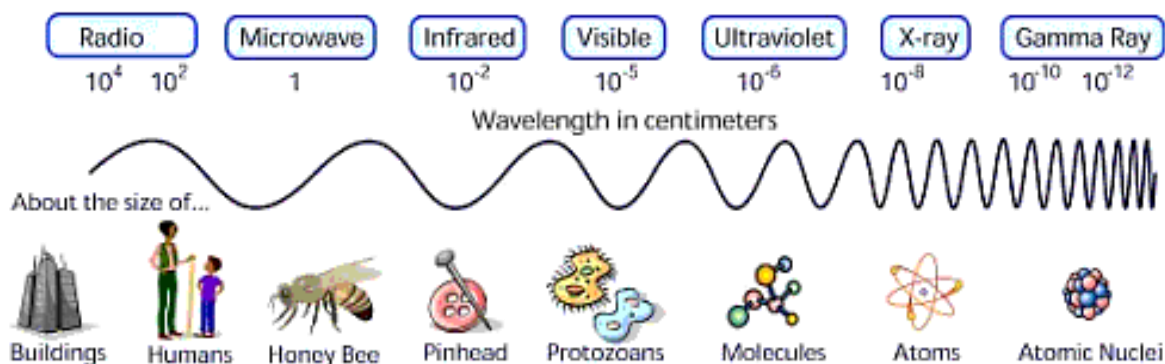
Relational models are complex assemblages of representations that are used to support sophisticated high-level processing.

Image Formation:

Image formation occurs when a sensor registers radiation that has interacted with physical objects. Both human vision and photography require a light source to illuminate a scene. The light interacts with the objects in the scene and some of it reaches the observer, whereupon it is detected by the eyes or by a camera. Information about the objects in the scene is recorded as variations in the intensity and colour of the detected light.

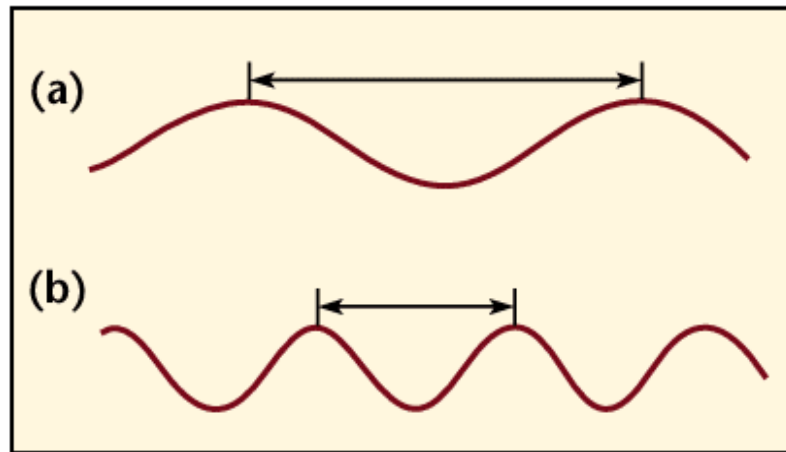
There are other forms of energy, besides light, that can be used to create images. Light is merely the visible portion of the electromagnetic (EM) spectrum. EM radiation is produced by the oscillation of electrically charged material, and has wave-like properties. EM radiation can interact with matter in different ways, depending on its wavelength. Images acquired at different wavelengths may have very different properties.

Electromagnetic (EM) Spectrum:



Electromagnetic Radiation:

Energy emitted in the form of waves (light) or particles (photons). All the devices make use of electromagnetic waves. Radio waves, microwaves, visible light, and x rays are all examples of electromagnetic waves that differ from each other in wavelength.



The full range of wavelengths (and photon energies) is called the "electromagnetic spectrum."

The ALS generates light in the far ultraviolet and soft x-ray regions, which span the wavelengths suited to studying molecules and atoms.

The visible part of the spectrum may be further subdivided according to color, with red at the long wavelength end and violet at the short wavelength end, as illustrated (schematically) in the following figure.



Image /Video Processing – Examples

Image processing is a general term for the wide range of techniques that exist for manipulating and modifying images in various ways.

- Image Enhancement
- Image Restoration
- Image Reconstruction
- Feature Extraction and Recognition
- Compression

Result:

Thus the various techniques of Image processing were studied.

Outcome:

Able to learn the various techniques of image processing.

1. What is meant by lighting system?
2. Define – CCD
3. Define – Resolution
4. Define – Pixel
5. List the hardware oriented color model.
6. What is meant by gray level?
7. What is meant by sample seeding?
8. What is meant by image masking?
9. What is meant by image processing?
10. What is meant by image segmentation?
11. What is meant by image formation?
12. What is meant by image extraction?
13. What is meant by image restoration?
14. What is meant by feature extraction?
15. Define – Sampling and Quantization
16. What is meant by reflectance?
17. What is meant by image enhancement?
18. What are the different methods of image enhancement?
19. What are the various types of redundancies available in the image?
20. What are the various image compression techniques for reducing the size of images?

ADDITIONAL EXPERIMENT – BEYOND THE SYLLABUS

Expt. No.43

STUDY OF PID CONTROLLER

Aim:

To study and verify different control actions such as On-Off control, Proportional control, Derivative control, Integral control, Proportional + Derivative control, Proportional + Integral, Proportional + Integral + Derivative control with a temperature controller

Introduction to PID controller:

A controller is a device which compares the output of a system with the required conditions and converts the error signal into control action, designated to reduce the error in a closed loop control the system. The error might arrive due to changes in the conditions being controlled or due to change in set value.

Types of control actions:

1. On –off/two step mode control

In a two step mode, the controller is just a switch which is activated by the error signal and supplies just an on-off correcting signal. It is a discontinuous control action. A consequence of this is that oscillations of the controlled variable occur about the required condition. Two step control action is used where changes are taking place very slowly i.e. with a process with a large capacitance. On-off controllers are not restricted to mechanical switches such as bimetallic strips. Thyristor circuits can also be employed for rapid switching. This control mode is not precise as it involves oscillations with long periodic times.

2. Proportional control

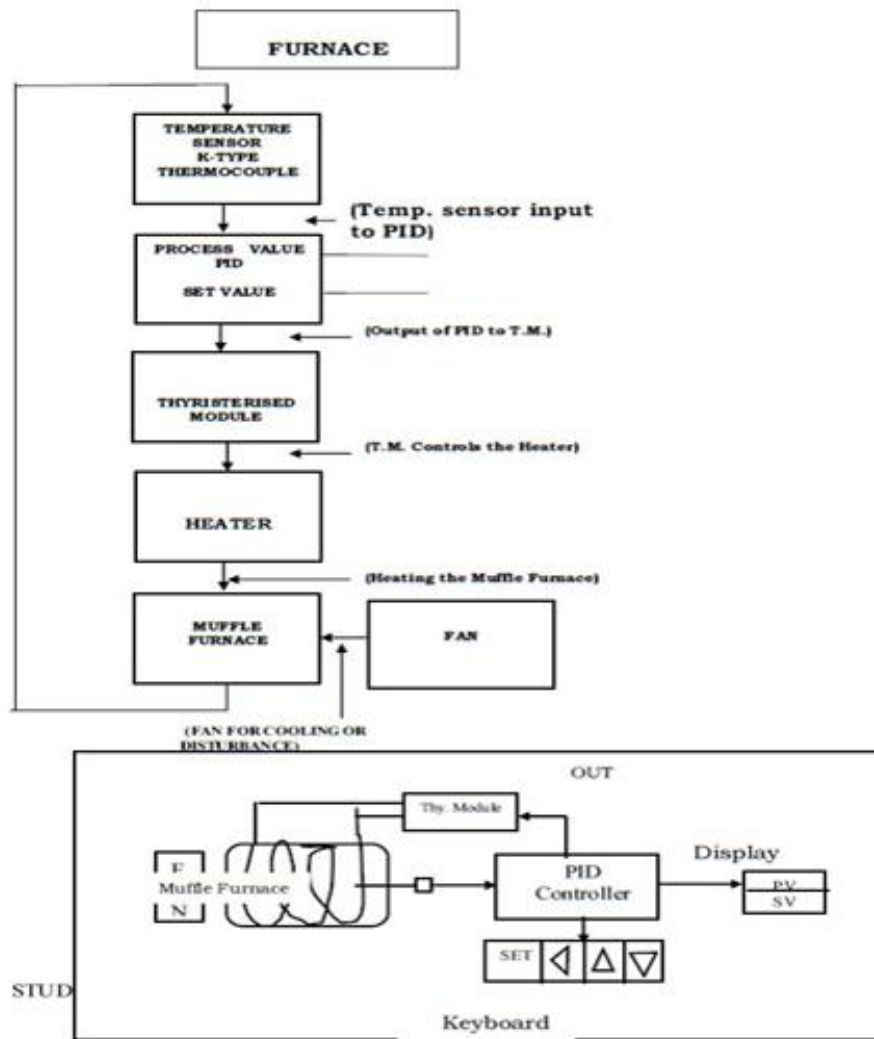
With the proportional mode, the size of the controller output is proportional to the size of the error signal. It means that correction element receives a signal which is equal to the size of the correction required.

Fig. shows how the output of such a controller varies with the size and sign of the error. The linear relationship between controller output and error tends to exist for a specific portion of the graph, which is known as proportional band. Within the proportional band the equation of the straight line is represented as

$$\text{Change in controller output from set point} = K_p e$$

Where e is the error and K_p is a constant known as proportional constant. K_p is thus the gradient of the straight line. The controller output is generally expressed in terms of percentage of the full range of possible outputs within the proportional band. Generally a 50% controller output is specified for zero error. It is not possible to achieve the change in the percent output of controller with the change in set value with zero error setting. It requires a permanent error setting called 'offset'. The size of the offset is proportional to the size of load changes and inversely proportional to K_p , so a higher value of K_p gives more steeper graph. This mode is utilized in processes where the value of transfer function can be increased large enough so as to reduce the offset to an acceptable level.

Block diagram of PID trainer system:



3. Derivative control

With the derivative mode of control the change in controller output from set point is proportional to the rate of change with respect to time of error signal. This can be represented by the equation

$$I_{out} - I_0 = KD \, de/dt$$

Where I_0 is the set point output value and I_{out} is the output value that will occur when the error is 'e' changes at the rate of de/dt . It is usual to express these controller outputs as percentage of the full range of the output and the error as the percentage of full range. With the derivative mode, the error signal begins to change there can be quite a large output since it is proportional to the rate of change of error signal and not the value of error signal. The controller output is constant as the rate of change is also constant and occurs immediately as the deviation occurs. Derivative mode is not suitable for steady state error signals.

4. Integral control

The integral mode of control is one where the rate of change of the control output I is proportional to the error signal e .

$$dI/dt = KI \, e$$

Precautions:

1. Ensure the PID trainer is connected to 230 V AC mains.
2. Ensure no any error detected while self-diagnostic check during power ON.
3. Ensure the proper mode of control action is selected.
4. Ensure the proper PID constants are programmed.
5. Ensure the proper set point is programmed.

Result:

Thus the various types of PID controller were studied.

Expt. No.44 SPEED CONTROL OF SERVO MOTOR USING **PID CONTROLLER**

Aim:

To control the speed of servo motor (PMDC motor)

Requirements:

1. Speed control unit
2. Micro controller PLC/PC
3. Servo motor
4. Optical sensor
5. PC power cord and cable

Procedure:

1. The servo motor PC power cord and optical sensor are connected to the speed control unit and PID controller.
2. The power from PID controller controls the voltage required for the set speed.
3. Now connect PID controller and servo motor by a power cord.
4. Switch on the PID controller.
5. Select INC for auto mode after giving the maximum range of speed of motor as 1000 rpm.
6. Enter the set point as 50 and the value as $K_p = 1000$, $K_i = 0.010$ and $K_d = 0$.
7. Select the enter key.
8. After the few records, the servo motor runs with the given 1000 rpm.
9. The experiment can be repeated and checked for different speeds.

Result:

Thus the speed control of servo motor using PID is studied and the experiment was done.

Expt. No.45 REAL TIME TEMPERATURE CONTROLLER USING PID

Aim:

To control the temperature of the process using PID

Requirements:

1. VRITCOL Unit (Versatile and highly reliable standard real time temperature controller)
2. Microcontroller /PLC
3. Heater setup
4. RTD
5. PC power cord and cable

Procedure:

1. The heater, power supply and sensor are connected to the PID.
2. The switch is provided to control the heater supply voltage either manually or in auto mode.
3. If the switch is selected as "int mode" potentiometer is provided to control the heater supply voltage.
4. If the switch is selected as "ext mode" the heat supply voltage is controlled by any mode of the controller.
5. Interfacing should be followed as 1st pin to grid 2nd pin to ADC (negative), 3rd pin to ADC (Positive).
6. PAL output is fed on to the 4th, 5th pin and 9th pin D connector.
7. Now switch on VRTTC -01 unit and heater setup.
8. Enter the control parameter as
 - a. Maximum range >60°C
 - b. Set point >50°C
 - c. $K_p > 5$
 - d. $K_i > 0.001$
 - e. $K_d > 0$
9. Based on optimum parameter the temperature reaches to the desired level of 60°C.
10. For the given set point, process response varies by temperature change and reaches the desired temperature of 60°C after a few minutes.

Result:

Thus the real time temperature controller is studied and the required is achieved.

Expt. No.46 STUDY OF PERFORMANCE CHARACTERISTICS OF PRESSURE CONTROLLERS

Aim:

To study the performance of ON-OFF/P/PI/PD/PID controller on pressure process

Introduction:

VMPA – 62 is a multi process station which controls flow, pressure and temperature.

Here PC acts as an error detector and controller. Set point is given manually to the computer. It gets process variables from the process and accordingly it generates error. According to instantaneous error controller output is developed and again feedback is sent to the process for controlling.

Water in the reservoir tank is pumped either directly to rotometer or through overhead tank using pump and with the help of some hand valves.

Pressure control:

In pressure control, pressure is developed in the head level of the process tank using the height of the fluid in it. This bottom pressure is taken and transmitted by a piezo resistive pressure transmitter and the output is generated. This is feed to the pneumatic control valve through current to pressure (I to P) converter by opening and closing of valve gets controlled by the amount of flow into the process tank is adjusted. It controls the height of the fluid in the pressure tank and thus the bottom pressure.

Apparatus required:

1. VMPA – 62
2. Data Acquisition card / Digital controller with cable
3. PC with process control software
4. Patch chords

Hand valve settings:

HV1 – Partially closed
HV2 – Fully opened
HV3 – Fully closed
HV4 – Fully closed
HV5 – Fully opened
HV6 – Fully closed
HV7 – Partially opened

Pressure range:

Input = 0 –500 mm of water column
Output = 4 -20 mA

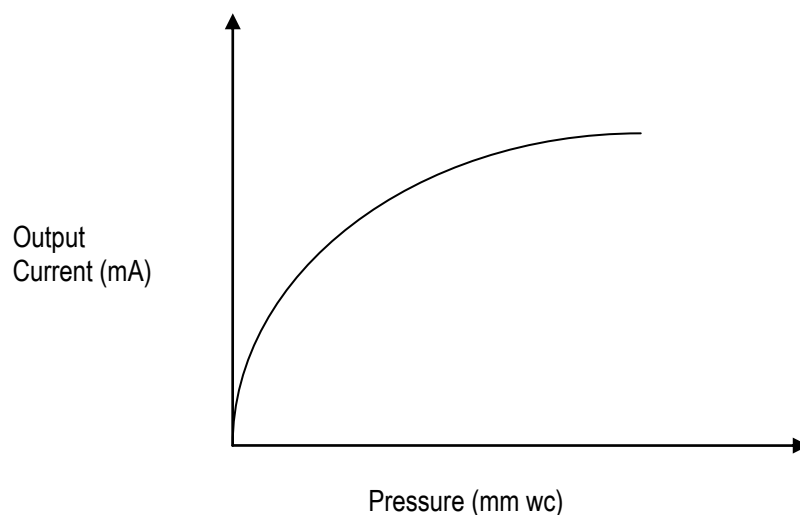
Procedure:

1. Ensure the availability of Air and water.
2. Interface the Data Acquisition card or Digital controller with the process and PC.
3. Make the connections as required.
4. Maintain the gauge pressure (G2) at 20 psi by using air regulator knob.
5. Ensure the hand valve settings are correct.
6. Switch on the VMPA – 62 unit and Data Acquisition card with PC.
7. Invoke process control software.
8. Select "Pressure <<control<<ON-OFF/P/PI/PD/PID".
9. Switch ON the pump and select desired speed of the pump by varying speed control knob.
10. Enter the parameters and observe the responses of various controllers at various set points.
11. Note down the current readings for various pressure readings.
12. Switch OFF the pump.
13. Save the response and draw the graph between pressure Vs output current and conclude the behavior of pressure process.

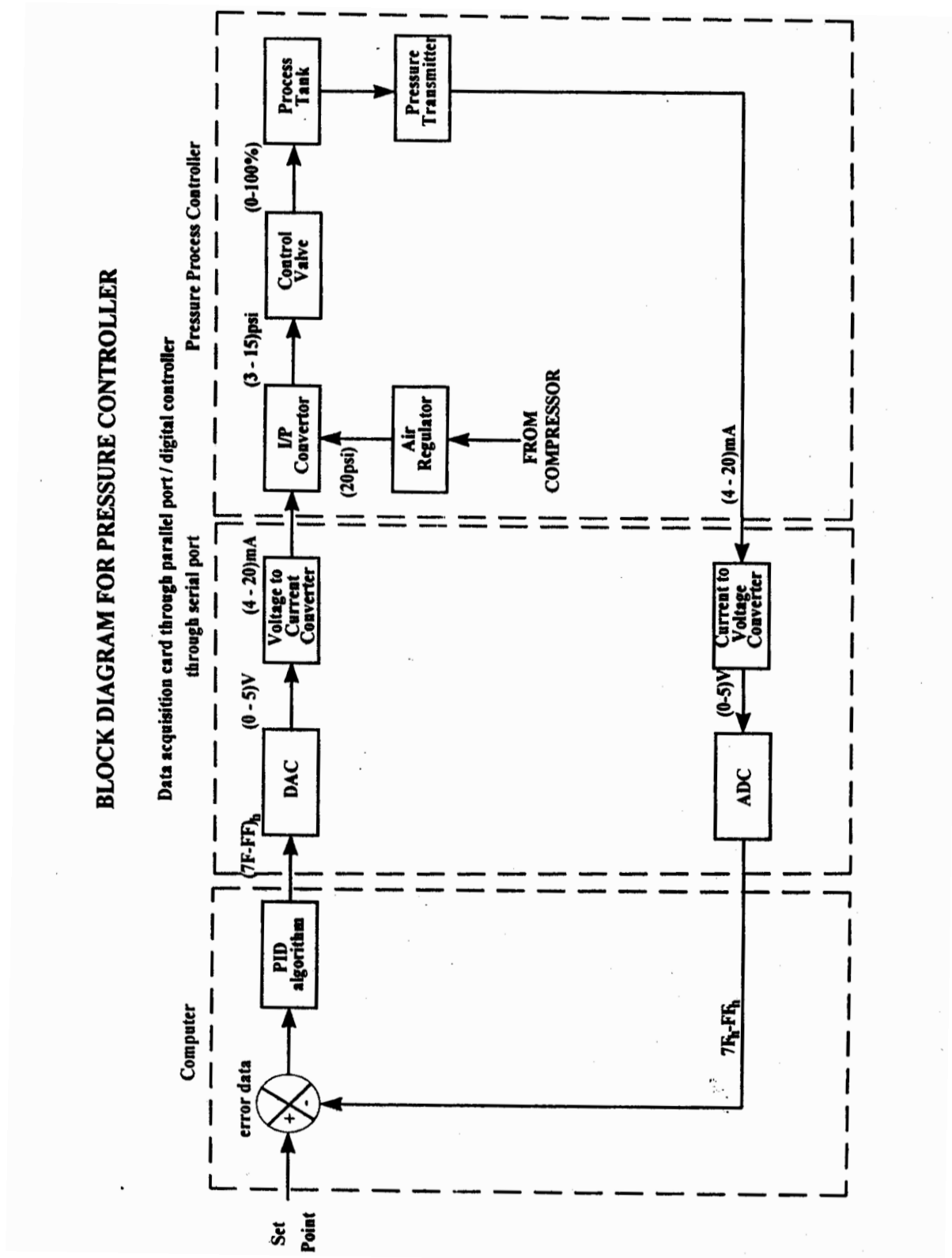
Tabulation:

Sl. No.	Gauge Pressure (mm of water column)	Pressure transmitter current Output (mA)

Model graph:



Block diagram:



Result:




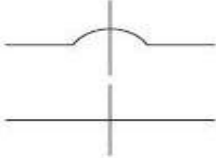

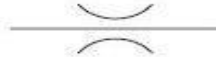



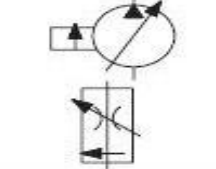



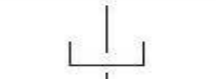
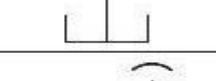
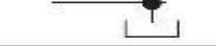
Thus the performance of ON-OFF/P/PI/PD/PID controller on pressure process was studied.



Outcome:



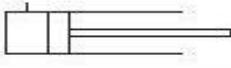
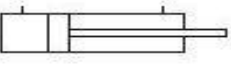
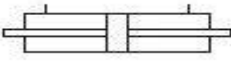
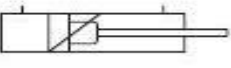
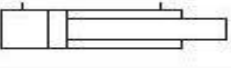
Able to learn the types of control modes and the function of elements in the closed loop control system.





Viva - voce

1. What are the types of controllers?
2. Define – PID Controller
3. Define – Derivative Gain
4. Define – Integral Gain
5. Define – Proportional Gain
6. Define – Reset Rate
7. What is meant by feed back?
8. What is the function of an ON/OFF controller?
9. What is the function of a proportional controller?
10. What is the function of a derivative controller?
11. What is the function of an integral controller?
12. Define – MRAC
13. Define – Proportional Band
14. What is meant by self tuning?
15. What is meant by error?

■ Lines	
	Line, Working (Main)
	Line, Pilot or Drain
	Flow Direction Hydraulic Pneumatic
	Lines Crossing
	Lines Joining
	Lines With Fixed Restriction
	Line, Flexible
	Station, Testing, Measurement or Power Take-Off
	Variable Component (run arrow through symbol at 45°)
	Pressure Compensated Units (Arrow parallel to short side of symbol)
	Temperature Cause or Effect
Reservoir	
	Vented
	Pressurized
Line, To Reservoir	
	Above Fluid Level
	Below Fluid Level
	Vented Manifold

■ Hydraulic Pumps	
	Fixed Displacement
	Variable Displacement

■ Motors and Cylinders	
Hydraulic	
	Fixed Displacement
	Variable Displacement
	Cylinder, Single-Acting
Cylinder, Double-Acting	
	Single End Rod
	Double End Rod
	Adjustable Cushion Advance Only
	Differential Piston

Miscellaneous Units	
	Electric Motor
	Accumulator, Spring Loaded
	Accumulator, Gas Charged
	Heater

Miscellaneous Units

	Cooler
	Temperature Controller
	Filter, Strainer
	Pressure Switch
	Pressure Indicator
	Temperature Indicator
	Component Enclosure
	Direction of Shaft Rotation (assume arrow on near side of shaft)

Methods of Operation

	Spring
	Manual
	Push Button
	Push-Pull Lever
	Pedal or Treadle
	Mechanical
	Detent
	Pressure Compensated

Methods of Operation

	Solenoid, Single Winding
	Servo Control
Pilot Pressure	
	Remote Supply
	Internal Supply

Color Code for Fluid Power Schematic Drawings

Black	Intensified Pressure
Red	Supply
Intermittent Red	Charging Pressure
Intermittent Red	Reduced Pressure
Intermittent Red	Pilot Pressure
Yellow	Metered Flow
Blue	Exhaust
Green	Intake
Green	Drain
Blank	Inactive

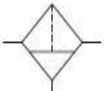
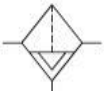

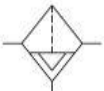
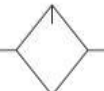
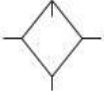


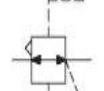
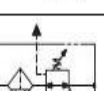
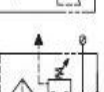
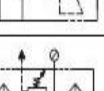
Valves

	Check
	On-Off (manual shut-off)
	Pressure Relief
	Pressure Reducing
	Flow Control, Adjustable - Non-Compensated
	Flow Control, Adjustable (Temperature and pressure compensated)
	Two-Position Two Connection
	Two-Position Three Connection
	Two-Position Four Connection
	Three-Position Four Connection
	Two-Position In Transition
	Valves Capable of Infinite Positioning (Horizontal bars indicate infinite positioning ability)

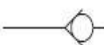
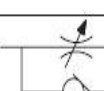
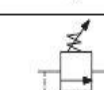
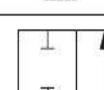



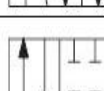
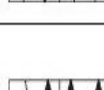
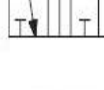
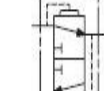
Expt. No.48

PNEUMATIC SYMBOLS

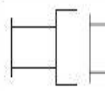
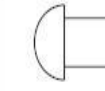
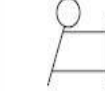
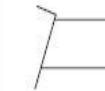
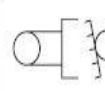

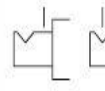


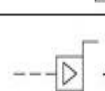


■ Air Prep Units

	Filter/Separator with manual drain
	Filter/Separator with automatic drain
	Oil Removal Filter
	Automatic Drain
	Lubricator less drain
	Lubricator with manual drain
	Lubricator with automatic filling
	Air Line Pressure Regulator adjustable, relieving
	Air Line Pressure Regulator pilot controlled, relieving
	Filter/Regulator (piggyback) Manual Drain Relieving (without gauge)
	Filter/Regulator (piggyback) Auto Drain Relieving
	Air Line Combo F-R-L simplified

■ Pneumatic Valves

	Check
	Flow Control
	Relief Valve
	2-Position, 2-Way
	2-Position, 3-Way
	2-Position, 4-Way 4-Ported
	2-Position, 4-Way 5-Ported
	3-Position, 4-Way ports closed, center position
	3-Position, 4-Way, 5-Ported cylinder ports open to pressure in center position
	Quick Exhaust
	Shuttle

■ Valve Actuators

	Manual General Symbol
	Push Button
	Lever
	Pedal or Treadle
	Mechanical Cam, Toggle, etc.
	Spring
	Detent - Line indicates which detent is in use
	Solenoid
	Internal Pilot Supply
	Remote Pilot Supply
	And/Or Composite solenoid and pilot or manual override
	And/Or Composite solenoid and pilot or manual override and pilot

■ Lines & Functions

	Main Line
	Pilot Line
	Exhaust or Drain Line
	Enclosure Line
	Lines Crossing
	Lines Joining
	Flow Direction Hydraulic Medium
	Flow Direction Gaseous Medium
	Energy Source
	Line with Fixed Restriction
	Line with Adjustable Restriction
	Flexible Line
	Plugged Port, Test Station, Power Take-Off

■ Lines & Functions

	Quick Disconnect without checks connected
	Quick Disconnect without checks disconnected
	Quick Disconnect with checks connected
	Quick Disconnect with checks disconnected
	Quick Disconnect with one check connected
	Quick Disconnect with one check disconnected