# NEHRU COLLEGE OF ENGINEERING AND RESEARCH CENTRE

*(Accredited by NAAC, Approved by AICTE New Delhi, Affiliated to APJKTU)*

**Pampady, Thiruvilwamala(PO), Thrissur(DT), Kerala 680 588**

## DEPARTMENT OF MECHATRONICS

# LAB WORK BOOK

# MECHATRONICS  LABORATORY

## VISION

To mould true citizens who are millennium leaders and catalysts of change through excellence in education.

## MISSION

NCERC is committed to transform itself into a center of excellence in Learning and Research in Engineering and Frontier Technology and to impart quality education to mould technically competent citizens with moral integrity, social commitment and ethical values.

We intend to facilitate our students to assimilate the latest technological know-how and to imbibe discipline, culture and spiritually, and to mould them in to technological giants, dedicated research scientists and intellectual leaders of the country who can spread the beams of light and happiness among the poor and the underprivileged.

## ABOUT DEPARTMENT

⬧ Established in: 2013

⬧ Course offered: B.Tech Mechatronics Engineering

⬧ Approved by AICTE New Delhi and Accredited by NAAC

⬧ Affiliated to the University of Dr. A P J Abdul Kalam Technological University.

## DEPARTMENT VISION

To develop professionally ethical and socially responsible Mechatronics engineers to serve the humanity through quality professional education.

## DEPARTMENT MISSION

**MD 1:** The department is committed to impart the right blend of knowledge and quality education to create professionally ethical and socially responsible graduates.

**MD 2:** The department is committed to impart the awareness to meet the current challenges in technology.

**MD 3:** Establish state-of-the-art laboratories to promote practical knowledge of mechatronics to meet the needs of the society.

## PROGRAMME EDUCATIONAL OBJECTIVES

**PEO1:** Graduates shall have the ability to work in multidisciplinary environment with good professional and commitment.

**PEO2:** Graduates shall have the ability to solve the complex engineering problems by applying electrical, mechanical, electronics and computer knowledge and engage in lifelong learning in their profession.

**PEO3:** Graduates shall have the ability to lead and contribute in a team with entrepreneur skills, professional, social and ethical responsibilities.

**PEO4:** Graduates shall have ability to acquire scientific and engineering fundamentals necessary for higher studies and research.

## PROGRAM OUTCOMES (PO'S)

**Engineering Graduates will be able to:**

**PO 1. Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

**PO 2. Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

**PO 3. Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

**PO 4. Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

**PO 5. Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

**PO 6. The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

**PO 7. Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

**PO 8. Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

**PO 9. Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

**PO 10. Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

**PO 11. Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

**PO 12. Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

# PROGRAM SPECIFIC OUTCOMES (PSO'S)

**PSO 1:** Design and develop Mechatronics systems to solve the complex engineering problem by integrating electronics, mechanical and control systems.

**PSO 2:** Apply the engineering knowledge to conduct investigations of complex engineering problem related to instrumentation, control, automation, robotics and provide solutions.

## COURSE OUTCOME

| | |
|---|---|
| C409.1 | Examine various valves and cylinders used in pneumatic kits for various operations. |
| C409.2 | Experimentally acquire the basic knowledge in assemble of electro-pneumatic kits for various operations. |
| C409.3 | Experimentally analyze the speed control of stepper motor and servo motors, various sensors used in automotives. |
| C409.4 | Analyze working of a pick and place robot. |
| C409.5 | Apply the virtual instrumentation technique to analyze the operation of ADC and DAC. |
| C409.6 | Apply the virtual instrumentation technique to analyze the operation of data acquisition and various mathematical and logical operation using Labview software and to study the automatic door opening and closing system using PLC. |

## CO VS PO'S AND PSO'S MAPPING

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PS0 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C409.1 | 3 | 2 | 2 | 2 | - | - | - | - | 3 | - | - | 3 | 3 | 3 |
| C409.2 | 3 | 2 | 2 | 2 | - | - | - | - | 3 | - | - | 3 | 3 | 3 |
| C409.3 | 3 | 2 | 2 | 2 | - | - | - | - | 3 | - | - | 3 | 3 | 3 |
| C409.4 | 2 | 2 | 2 | 2 | 3 | - | - | - | 2 | - | - | 3 | 3 | 3 |
| C409.5 | 3 | 2 | 2 | 2 | 3 | - | - | - | 3 | - | - | 3 | 3 | 3 |
| C409.6 | 3 | 2 | 3 | 2 | 3 | - | - | - | 3 | - | - | 3 | 3 | 3 |
| ATTAINMENT | 2.83 | 2.00 | 2.16 | 2.00 | 2.00 | 0.00 | 0.00 | 0.00 | 3.00 | 0.00 | 0.00 | 3.00 | 3.00 | 3.00 |

**Note: H-Highly correlated=3, M-Medium correlated=2, L-Less correlated=1**

# PREPARATION FOR THE LABORATORY SESSION
## GENERAL INSTRUCTIONS TO STUDENTS

1. Read carefully and understand the description of the experiment in the lab manual. You may go to the lab at an earlier date to look at the experimental facility and understand it better. Consult the appropriate references to be completely familiar with the concepts and hardware.

2. Make sure that your observation for previous week experiment is evaluated by the faculty member and your have transferred all the contents to your record before entering to the lab/workshop.

3. At the beginning of the class, if the faculty or the instructor finds that a student is not adequately prepared, they will be marked as absent and not be allowed to perform the experiment.

4. Bring necessary material needed (writing materials, graphs, calculators, etc.) to perform the required preliminary analysis. It is a good idea to do sample calculations and as much of the analysis as possible during the session. Faculty help will be available. Errors in the procedure may thus be easily detected and rectified.

5. Please actively participate in class and don't hesitate to ask questions. Please utilize the teaching assistants fully. To encourage you to be prepared and to read the lab manual before coming to the laboratory, unannounced questions may be asked at any time during the lab.

6. Carelessness in personal conduct or in handling equipment may result in serious injury to the individual or the equipment. Do not run near moving machinery/equipment's. Always be on the alert for strange sounds. Guard against entangling clothes in moving parts of machinery.

7. Students must follow the proper dress code inside the laboratory. To protect clothing from dirt, wear a lab coat. Long hair should be tied back. Shoes covering the whole foot will have to be worn.

8. In performing the experiments, please proceed carefully to minimize any water spills, especially on the electric circuits and wire.

9. Maintain silence, order and discipline inside the lab. Don't use cell phones inside the laboratory.

10. Any injury no matter how small must be reported to the instructor immediately.

11. Check with faculty members one week before the experiment to make sure that you have the handout for that experiment and all the apparatus.

## AFTER THE LABORATORY SESSION

1. Clean up your work area.

2. Check with the technician before you leave.

3. Make sure you understand what kind of report is to be prepared and due submission of record is next lab class.

4. Do sample calculations and some preliminary work to verify that the experiment was successful

## MAKE-UPS AND LATE WORK

Students must participate in all laboratory exercises as scheduled. They must obtain permission from the faculty member for absence, which would be granted only under justifiable circumstances. In such an event, a student must make arrangements for a make-up laboratory, which will be scheduled when the time is available after completing one cycle. Late submission will be awarded less mark for record and internals and zero in worst cases.

## LABORATORY POLICIES

1. Food, beverages & mobile phones are not allowed in the laboratory at any time.

2. Do not sit or place anything on instrument benches.

3. Organizing laboratory experiments requires the help of laboratory technicians and staff. Be punctual.

# SYLLABUS

| Course code | Course Name | L-T-P - Credits | Year of Introduction |
|---|---|---|---|
| MR431 | Mechatronics Lab | 0-0-3-1 | 2016 |

Prerequisite : Nil

**Course Objectives**

- To provide hands on experience on the working of hydraulic and pneumatic controls, speed control, and PID controllers
- To impart proficiency in programming of robots
- To impart knowledge on virtual instrumentation and vision systems

**List of Exercises/Experiments :**

1. Design and assembly of pneumatic/hydraulic kit
2. Study of different type of pneumatic and hydraulic valve.
3. Study of reciprocating movement of double acting cylinder using pneumatic direction control valve.
4. Speed control stepper and servo motor using micro processor kit.
5. Programming Robot (Pick and place robot)
6. Sensors for automotives
7. Tool condition monitoring using sensors.
8. PID Controller
9. Automatic door opening and closing
10. Virtual Instrumentation
    a. Data acquisition
    b. Image acquisition
    c. Stepper and servo control device
    d. Signal conditioning of strain gauge. LVDT, Thermocouple, pressure transducer, etc.,
11. A/D and D/A conversion
12. Machine Vision system
13. Study of robot end effectors

**Expected outcome.**

The students will be able to

- Develop pneumatic circuits for automating various operations
- Program a robot for a pick and place operation
- Prescribe sensors for monitoring and control operations
- Acquire knowledge on analog and digital data convertors

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### FINAL VERIFICATION BY THE FACULTY

**TOTAL MARKS:**

**INTERNAL EXAMINER**                    **EXTERNAL EXAMINER**

# EXP NO:1

# STUDY OF PNEUMATIC SYSTEM COMPONENTS

**AIM:**

To study the various pneumatic components used in pneumatic systems and to understand the working of them.

**COMPONENTS:**

Air Tank, Air compressor, Electric motor ,Air conditioners and Control valves, Actuator, Air hoses

**DESCRIPTION**:

### 1. AIR TANK

An air tank is used to store a given volume of compressed air. An air tank consists of air filter, air pressure indicator, water drainage tap.  In small compressor units generally compressor is fit on the air tank.

### 2. AIR COMPRESSOR

An air compressor is a machine that compresses air from a low inlet pressure (usually atmospheric) to a higher desired pressure level. This is accomplished by reducing the volume of the gas. Air compressors are generally positive displacement units and are either of the reciprocating piston type or the rotary screw or rotary vane types.

### 3. ELECTRIC MOTOR

An electric motor is used to drive the compressor. Then the compressor compresses air from a low inlet pressure to a higher desired pressure level. This compressed air pressure is used to do the useful work.

### 4. AIR CONDITIONING UNIT AND CONTROL VALVES

The conditioning of air is done by the FRL unit.  The filter removes the unwanted contaminants from the compressed air and the regulator is used to regulate the pressure to the required level from the higher level.  The lubricator adds the lubricating oil to the air so that the air gains some lubricating properties to minimize friction during movement of components.  Control components such as directional control valves, flow control valves are also used in the pneumatic circuits.

### 5. ACTUATORS

Compressor performs the function of adding pressure energy to the atmospheric air in the pneumatic system. Pneumatic actuators and motors do just the opposite. They extract energy from compressed air and convert into mechanical energy to perform useful work. There are three types of actuators: 1. Linear actuators (Pneumatic cylinders) 2.Rotary actuators (Air motors) and 3. Oscillators (Partial rotary movement).

## 6. AIR HOSES

Air hoses are used to carry the pressurized air from one location to other location. Steel, copper pipes and PU tubing are normally used air hoses.
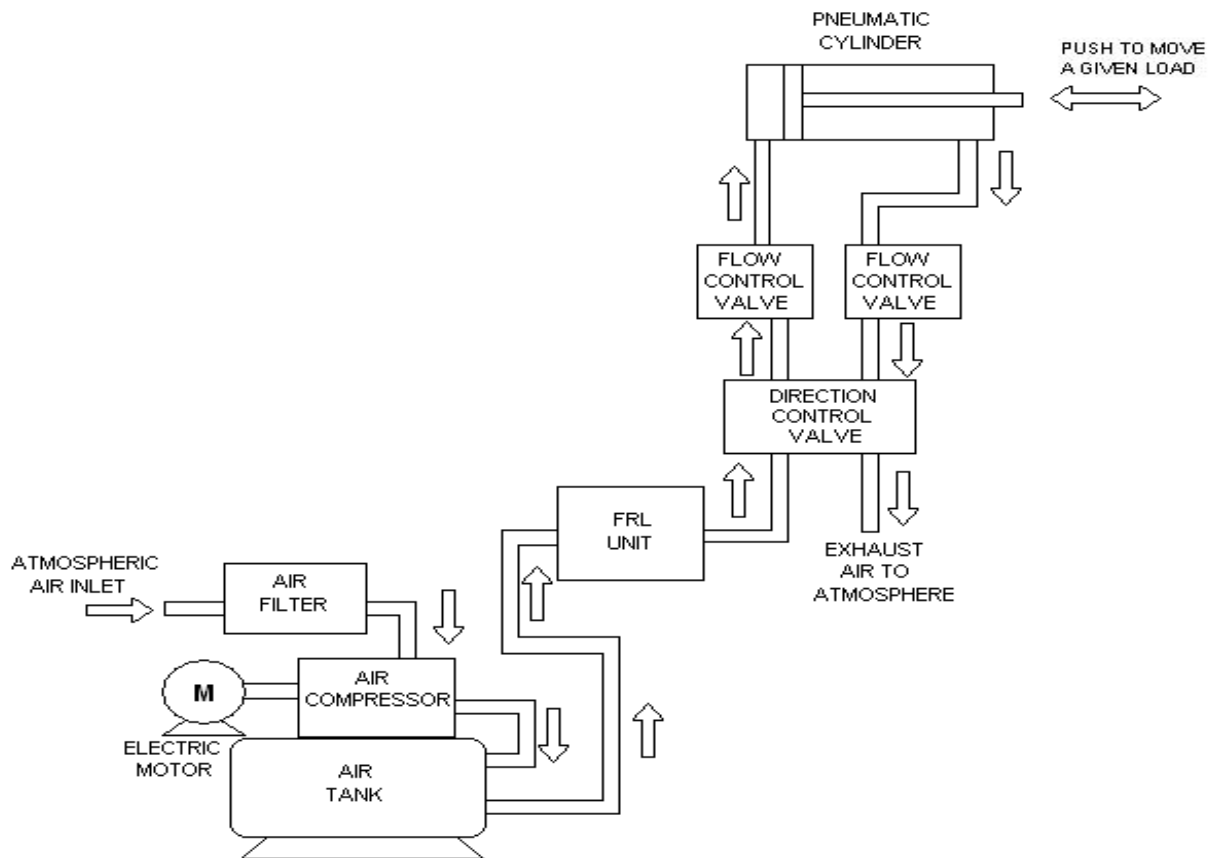


**RESULT:**

**INFERENCE**

## EXP NO: 2
## ELECTRO PNEUMATIC CIRCUIT TO CONTROL THE SINGLE ACTING CYLINDER

**AIM:**

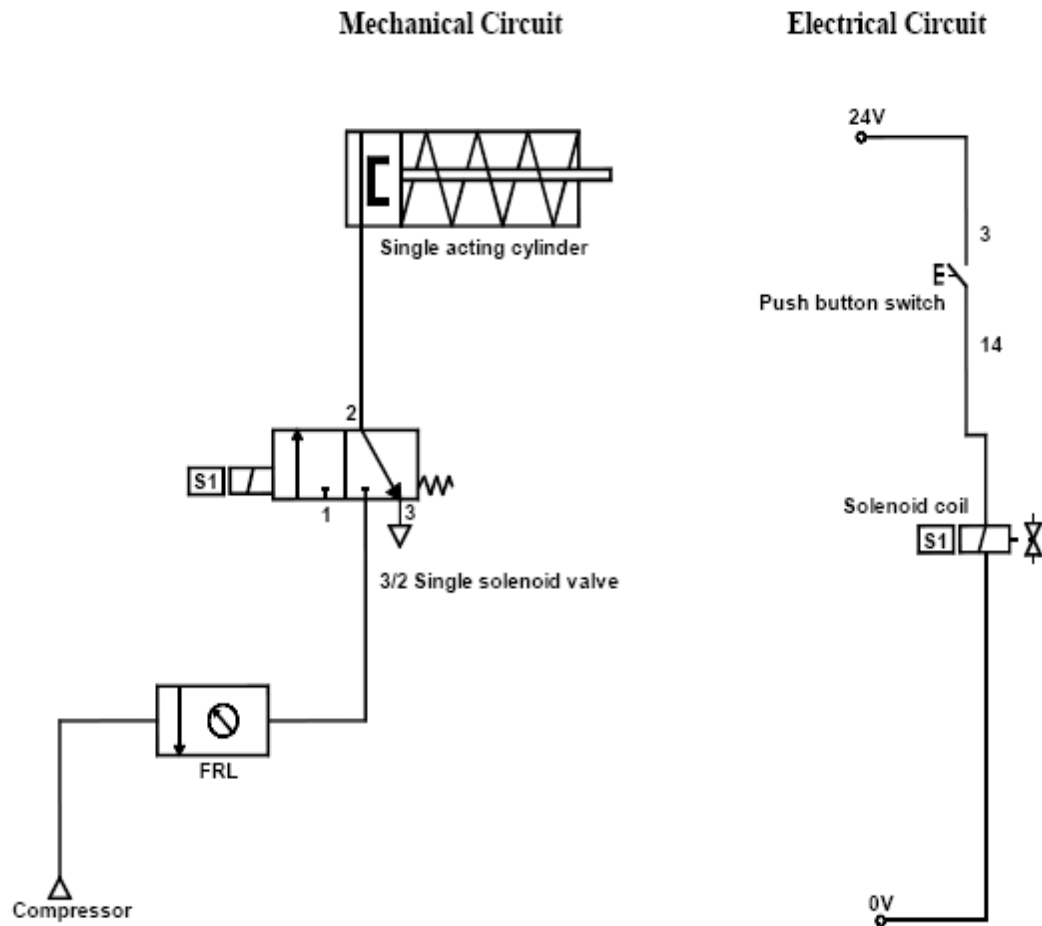To construct a pneumatic circuit to control the single acting cylinder electrically using push button switch.

**REQUIREMENTS:**

1.Compressor,

2.FRL

3. solenoid coil

4.electrical trainer

5. single acting cylinder

**PROCEDURE:**

1. Draw the circuit diagram.

2. Electro controller gives - voltage to pneumatic panel.

3. Input of push button is getting from solenoid valve output.

4. Connect the air supply to FRL unit.

5. Check all the connections carefully

6. Test the circuit.

7. Observe the working of the cylinder using the 3/2 single solenoid valve.

## CIRCUIT DIAGRAM

**Mechanical Circuit**



Single acting cylinder

2

S1

1  3

3/2 Single solenoid valve

FRL

Compressor

**Electrical Circuit**

24V

3

E

Push button switch

14

Solenoid coil

S1

0V

## RESULT

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

**EXP NO: 3**
**ELECTRO-PNEUMATIC CIRCUIT FOR EXTENSION AND**
**RETRACTION OF DOUBLE ACTING CYLINDER.**

**AIM:**

To develop a electro-pneumatic circuit for extension and retraction of double acting cylinder.

**REQUIREMENTS:**
1. Double acting cylinder

2. 3/2 solenoid valve

3. 5/2 single and double solenoid valve

4. FRL unit

5. Relay

6. SPDT Switch

7. Pushbutton switch

8. Connecting tubes & wires

**PROCEDURE:**
**A.CONTROL OF DOUBLE ACTING CYLINDER USING 3/2 SOLENOID VALVE**

1. Provide power supply to the pneumatic trainer from control trainer by interfacing 24+vand-v

2. Using the SPDT switch energize the corresponding solenoid valve to get the desired movement in the cylinder.

3. Supply the Air to FRL unit.

4. Assemble all the components.

5. Check all the connections carefully.

   Test the circuit. Observe the working of the cylinder using the 3/2 and 5/2 solenoid valve

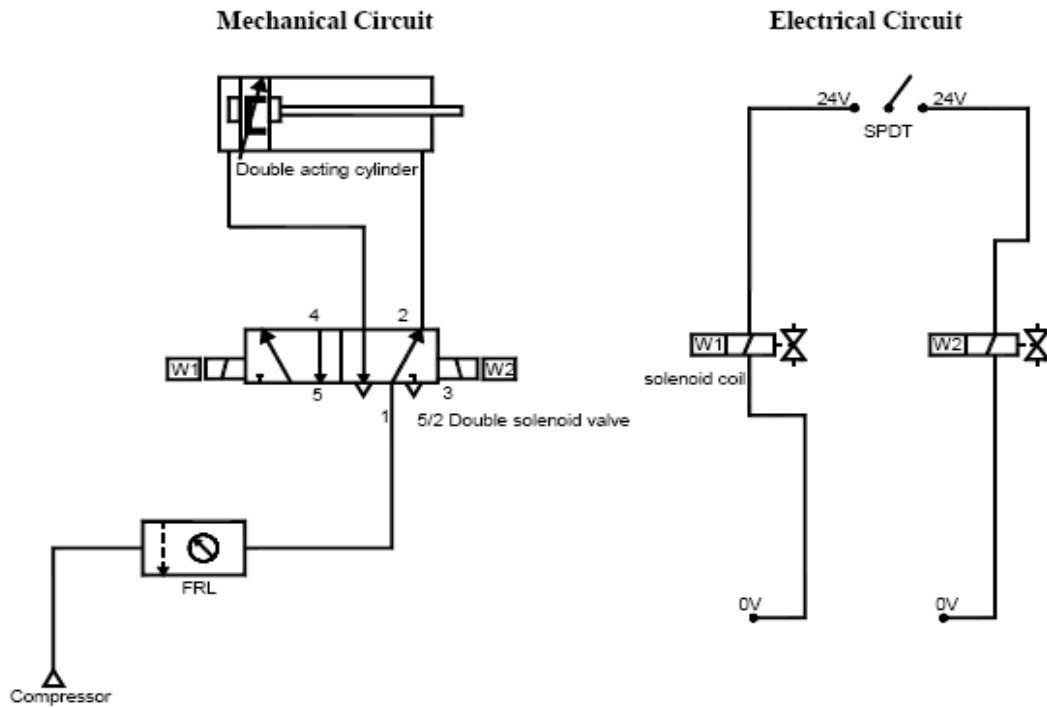## B. CONTROL OF DOUBLE ACTING CYLINDER USING 5/2 DOUBLE SOLENOID VALVE

1. Draw the circuit diagram and connect the air supply to FRL unit.

2. Connect the electrical circuit from 24 dc source to ON/OFF switch.

3. Solenoids are connected to the pushbutton switch.

4. When the solenoid is given a signal solenoid are cut and the solenoids are de-energized and the DCV activated to single and double acting cylinder.

5. When off button is pressed the signal solenoid are cut and the solenoids are de-energized and the DCV comes to the original position.

## CIRCUIT DIAGRAM

## A. CONTROL OF DOUBLE ACTING CYLINDER USING 3/2 SOLENOID VALVE

## B.CONTROL OF DOUBLE ACTING CYLINDER USING 5/2 DOUBLE SOLENOID

Mechanical Circuit                                   Electrical Circuit
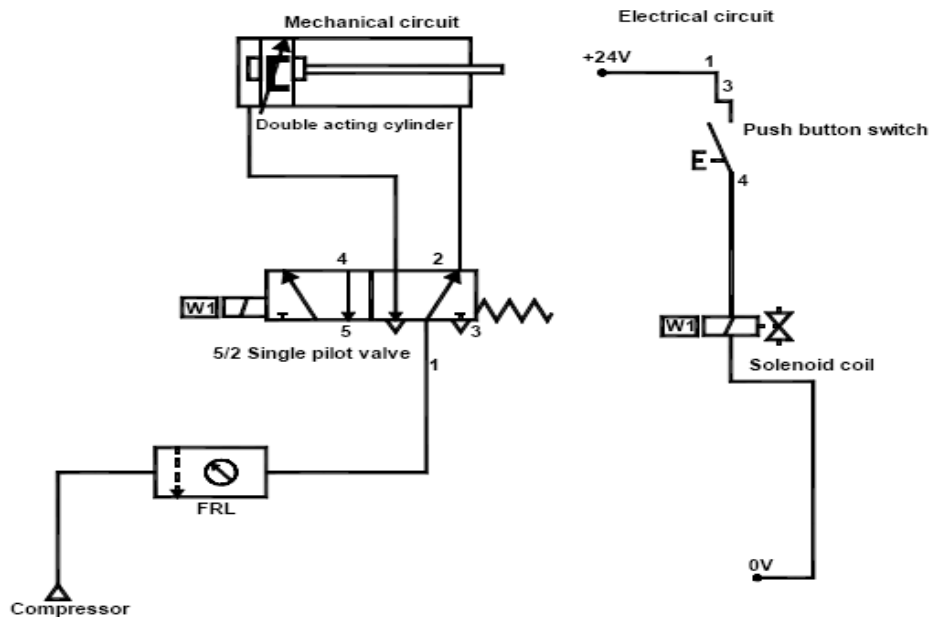


**RESULT**


**INFERENCE**

## EXP NO: 4

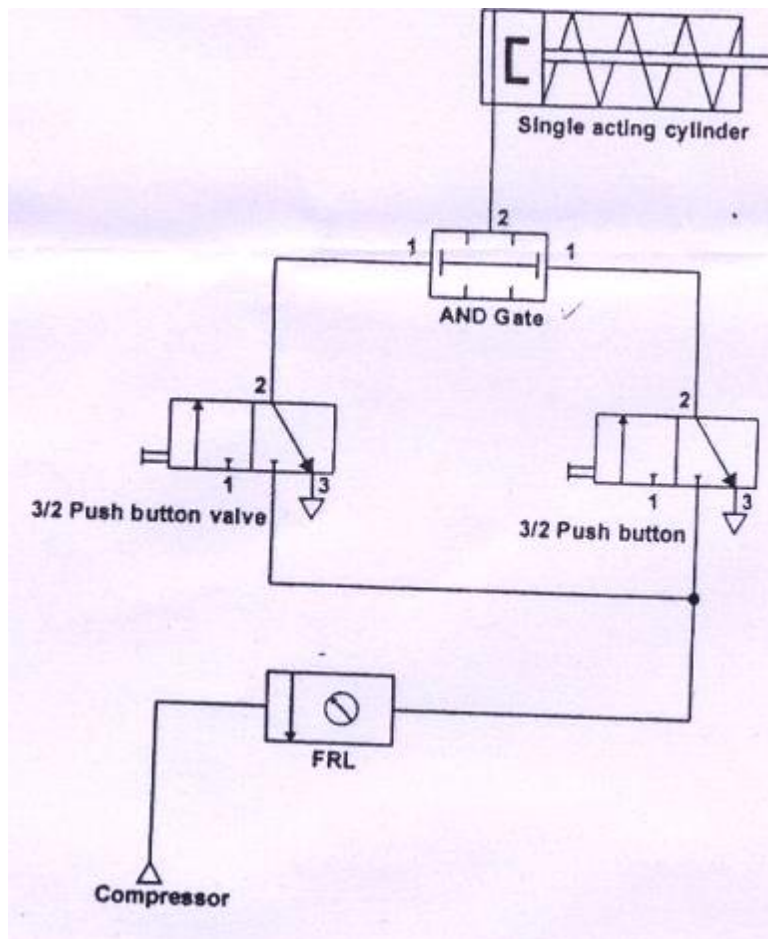## CONTROL THE SINGLE ACTING AND DOUBLE ACTING CYLINDERS USING PILOT VALVES

**AIM:**

To actuate single and double acting cylinders in a pneumatic circuit.
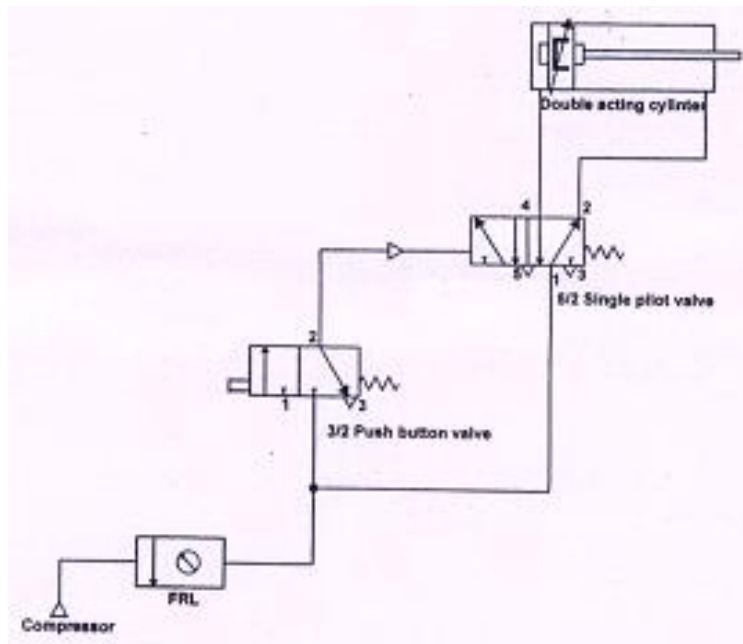
**APPARATUS REQUIRED:**

1. Single acting cylinder
2. 3/2 push button spring return DCV
3. 3/2 single pilot valve
4. 5/2 single, double pilot DCV
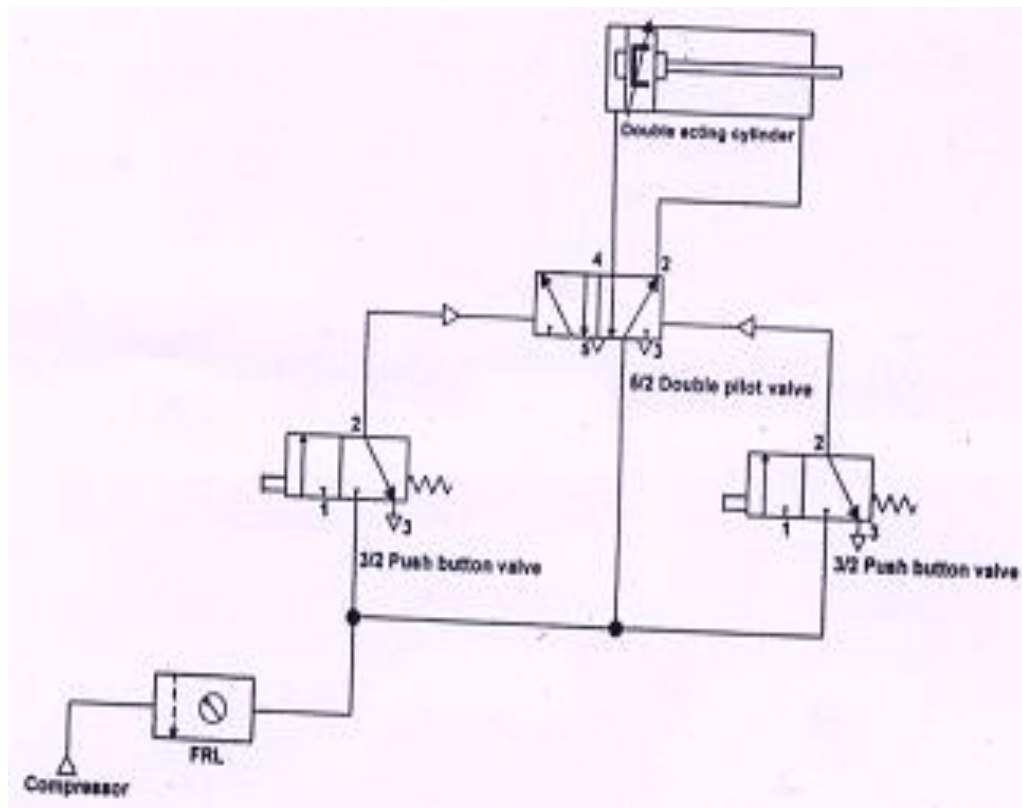5. Air service unit
6. Connecting tubes

**CIRCUIT DIAGRAM-SINGLE ACTING CYLINDER**

## DOUBLE ACTING CYLINDER WITH 5/2 SINGLE PILOT VALVE



## CIRCUIT DIAGRAM-DOUBLE ACTING CYLINDER WITH 5/2 DOUBLE PILOT

**PROCEDURE:**

1. The connection is made as shown in figure.

2. The pilot pressure are fed into the 3/2 direction control valve.

3. When the button is pushed the air is sent into single acting cylinder.

4. The cylinder moves in forward position.

5. When the push button is released, it retracts because of the spring.

6. Feed the air through different valves and make the cylinder to actuate.

**RESULT:**

.

**INFERENCE**

**EXP NO:5**
**CONTINUOUS RECIPROCATING OF SINGLE ACTING AND DOUBLE ACTING CYLINDER USING PILOT VALVES**
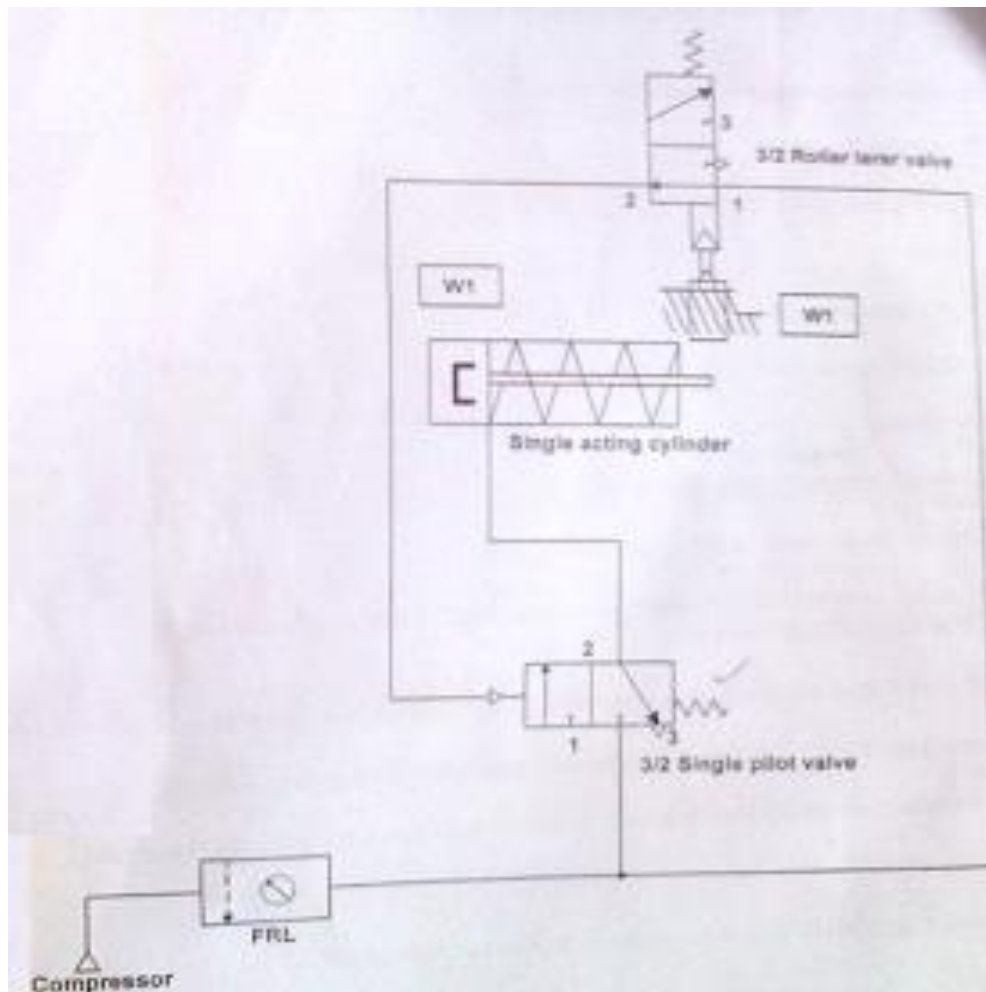
**AIM:**

To actuate a single and double acting cylinders using pilot valves

**APPARATUS REQUIRED:**

1. Double acting cylinder
2. 3/2 single pilot DCV
3. 5/2 single pilot DCV
4. 5/2 double pilot DCV
5. 3/2 roller lever valves
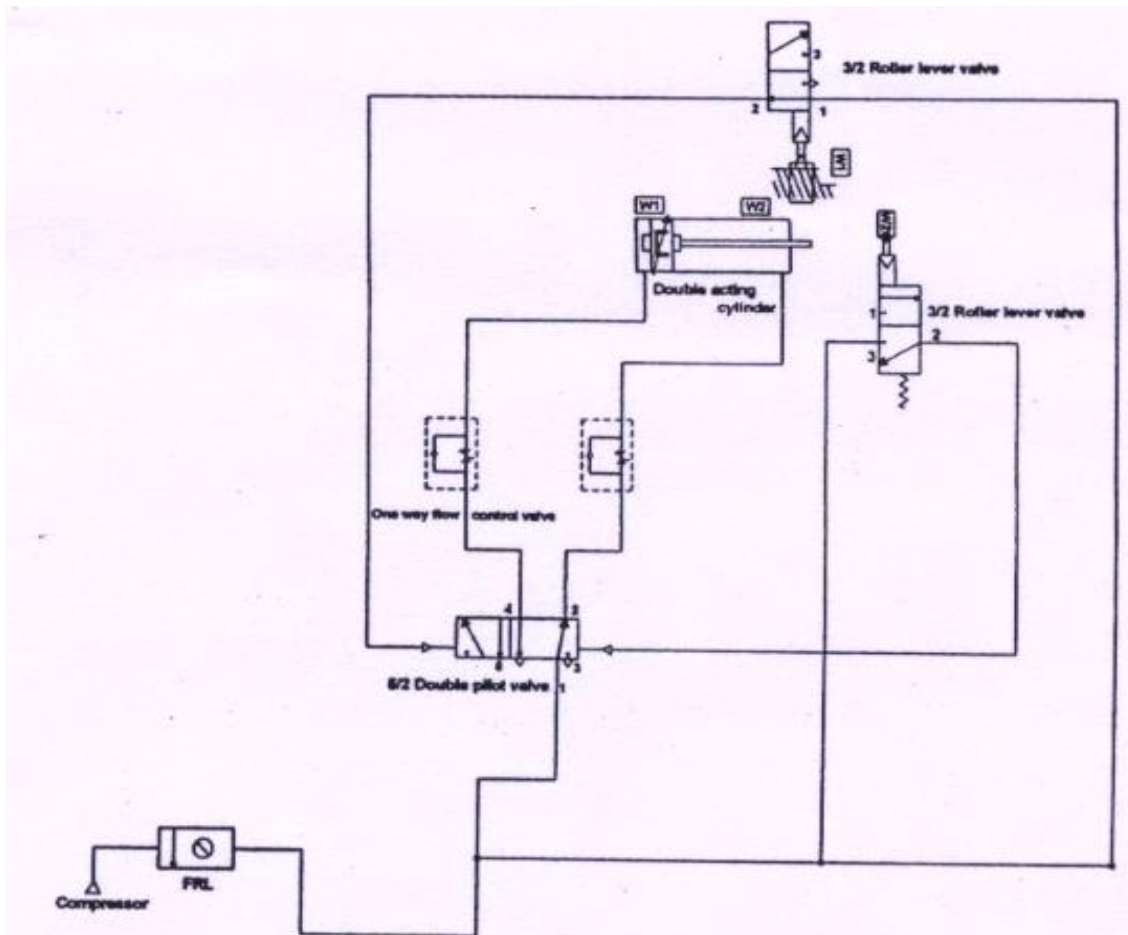6. FRL unit
7. Connecting tubes

**CIRCUIT DIAGRAM-SINGLE ACTING CYLINDER:**

## PROCEDURE: SINGLE ACTING CYLINDER:

1. The circuit is given as shown in figure.
2. Connect the compressed air supply to FRL unit
3. Check the all circuit
4. Open the hand slide valve
5. Observe the working of continuous running single acting cylinder

## CIRCUIT DIAGRAM-DOUBLE ACTING CYLINDER-5/2 DOUBLE PILOT VALVE

## PROCEDURE: DOUBLE ACTING:

1. Draw the circuit diagram
2. connect compressor air supply to FRL unit
3. Connect any one of the outputs of FRL unit to 5/2 direction control unit port 1
4. Connect port 4 of DCV to blank end of the double acting cylinder
5. Connect the output of FRL unit to the input of two 3/2 roller lever valves to give pilot pressure for 5/2 double pilot valve
6. The output of the two roller valves are connected to the either side of the 5/2 double pilot valve properly.
7. When the FRL valve is opened the higher pressure air enters the blank end of the cylinder through DCT and the piston moves forward.
8. At the end of the forward stroke the piston rod pressures the roller valve. The output of roller valve is sent to double acting cylinder to change the position.
9. Now the high pressure air from FRL unit is sent to rod end of the double acting cylinder through the second position of the DCV the piston retracts.
10. At the end of return stroke the roller valve is pressed. The output of the roller valve is sent to dc change the piston. This is repeated until the FRL valve is closed.

## RESULT:

## INFERENCE

## EXP NO: 6

## RUN THE STEPPER MOTOR AT DIFFERENT SPEED AND DIFFERENT DIRECTION

**AIM:**

To run a stepper motor at different speed and different direction by using 8051 assemble language.

**REQUIREMENTS:**

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:**

| Address | Label | Instruction | Opcode |
|---------|-------|-------------|--------|
| 4100 | | ORG 4100H | ENTER |
| 4100 | START | MOV DPTR, #4500H | 90 45 00 |
| 4103 | | MOV R0, #04 | 78 04 |
| 4105 | J0 | MOVX A, @DPTR | E0 |
| 4106 | | PUSH DPH | C0 83 |
| 4108 | | PUSH DPL | CO 82 |
| 410A | | MOV DPTR, #FFCOH | 90 FF |
| 410D | | MOV R2, #04H | 7A 04 |

| Address | Label | Instruction | Opcode |
|---------|-------|-------------|--------|
| 410F | | MOV R1, #FFH | 79 0F |
| 4111 | DLY 1 | MOV R3, #FFH | 7B 0F |
| 4113 | DLY | DJNZ R3, DLY | DB FE |
| 4115 | | DJNZ R1, DLY1 | D9 FA |
| 4117 | | DJNZ R2, DLY1 | DA F8 |
| 4119 | | MOV @DPTR, A | FO |
| 411A | | POP DPL | D0 82 |
| 411C | | POP DPH | D0 83 |

| | | | |
|---|---|---|---|
| 411E | | INC DPTR | A3 |
| 411F | | DJNC R0 ,J0 | D8      E4 |
| 4121 | | SJMP START | 80      DD |
| 4123 | | END | . ENTER |
| 4500 | TABLE | DB 09, 05, 06, 0A | 09   05   06<br>0A.ENTER |

**RESULT**

**INFERENCE**

## EXP NO: 7

## RUN THE STEPPER MOTOR IN FORWARD AND REVERSE DIRECTION

**AIM:**

To run a stepper motor in forward and reverse rotation using 8051 assembly language

**REQUIREMENTS:**

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:**

| Address | Label | Instruction | Opcode |
|---------|-------|-------------|--------|
| 4100 | | ORG 4100H | |
| 4100 | START: | MOV R4, #33H | 7C  33 |
| 4102 | L2: | DPTR, #FORWARD | 90  41  44 |
| 4105 | | L1 | 12  41  1C |
| 4108 | | R4, L2 | DC  F8 |

| | | | |
|---|---|---|---|
| 410A | | DELAY | 12 41 3B |
| 410D | | R4, #33H | 7C 33 |
| 410F | L3: | DPTR, #REVERSE | 90 41 48 |
| 4112 | | L1 | 12 41 1C |
| 4115 | | R4, L3 | DC F8 |
| 4117 | | DELAY | 12 41 3B |
| 411A | | START | 80 E4 |
| 411C | L1: | R0, #04H | 78 04 |
| 411E | LOOP : | A,@DPTR | E0 |
| 411F | | 83H | C0 83 |
| 4121 | | 82H | C0 82 |
| 4123 | | DPTR, #OFFCOH | 90 FF C0 |
| 4126 | | R2, #04H | 7A 04 |
| 4128 | L7: | R1, #05H | 79 05 |
| 412A | L6: | R3, #OFFH | 7B FF |
| 412C | L4 : | R3, L4 | DB FE |
| 412E | | R1, L6 | D9 FA |
| 4130 | | R2, L7 | DA F6 |
| 4132 | | @DPTR ,A | F0 |

| 4133 | | 82H | D0 82 |
|---|---|---|---|
| 4135 | | 83H | D0  83 |
| 4137 | | DPTR | A3 |
| 4138 | | R0, LOOP | D8 E4 |
| 413A | | | 22 |
| 413B | DELAY : | R5, #01H | 7D  01 |

| 413D | L9 : | R2, #05H | 7A  05 |
|---|---|---|---|
| 413F | L8: | R2, L8 | DA  FE |
| 4141 | | R5, L9 | DD  FA |
| 4143 | | RET | 22 |
| 4144 | FORWARD : | DB 09H,05H,06H,0AH | 09  05  06  0A |
| 4148 | REVERSE : | DB 0AH,06H,05H,09H | 0A  06  05  09 |

| Anticlock wise | | | | | Clock wise | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Step | A1 | A2 | B1 | B2 | Step | A1 | A2 | B1 | B2 |
| 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 0 |
| 3 | 0 | 1 | 0 | 0 | 3 | 0 | 1 | 0 | 0 |
| 4 | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 0 |

**RESULT**

Thus the program to rotate the stepper motor in forward and reverse direction was derived using 8051 assemble language and was verified.
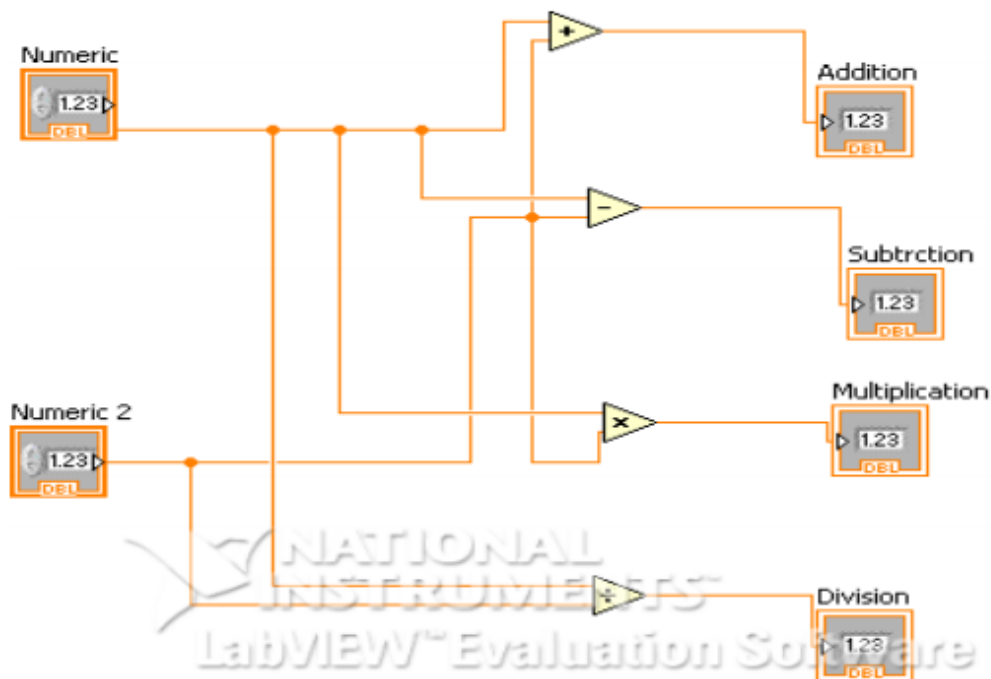
## EXP NO: 8

## BASIC ARITHMETIC OPERATIONS

**AIM**
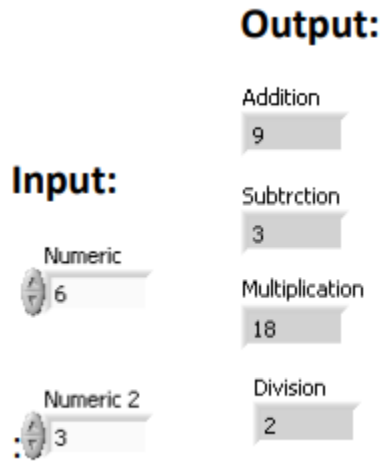
To perform basic arithmetic operations using Labview.

**PROCEDURE**

1: Start the Lab view and select the blank VI.

2: Create front and block diagram panel.

3: Numeric controls are given as inputs and numeric indicators are given as output they are selected by right clicking on the front panel.

4: Different arithmetic operators such as addition, subtraction, multiplication and division are generated in block diagram panel.

5: Using wiring operation inputs and outputs are connected to the respective operators in the block diagram panel.

6: Input values are given in the front panel and the program is executed. Hence the output is generated.

**Block Diagram Panel**:

## FRONT PANEL

**Output:**

Addition
9

**Input:**

Numeric
6

Subtrction
3

Multiplication
18

Numeric 2
3

Division
2

## RESULT

## INFERENCE

## EXP NO: 9

## BOOLEAN OPERATIONS

**Aim:**

To perform Boolean operations using Labview.

**Procedure**

1: Start the Labview and select the blank VI.

2: Create front and block diagram panel.

3: To perform Boolean operation push buttons are taken as inputs and round LED as output.

4: Different Boolean operations such as AND, OR, XOR, NOT, NAND are selected from the block diagram panel.

5: Boolean inputs and outputs are wired in the block diagram panel.

6: Logic values 0 & 1 are given in the front panel and the program is executed.

**Block diagram**
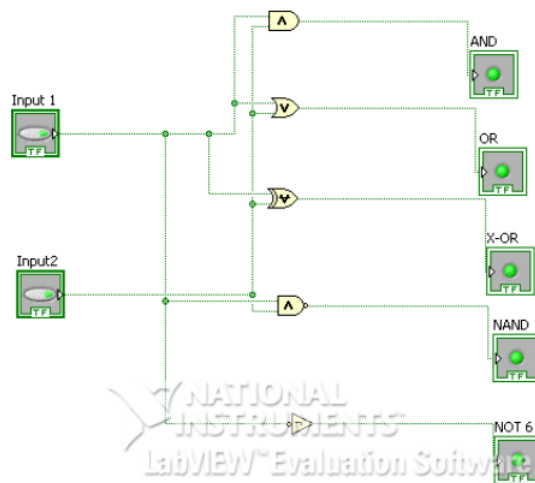
**Front Panel:**



**Truth Table:**

**AND:**
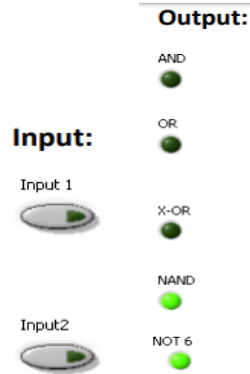
| X1 | X2 | Y |
|----|----|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

**OR:**

| X1 | X2 | Y |
|----|----|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

**XOR:**

| X1 | X2 | Y |
|----|----|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

**NAND:**

| X1 | X2 | Y |
|----|----|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

**NOT:**

| X | Y |
|---|---|
| 0 | 1 |
| 1 | 0 |

**RESULT**

**INFERENCE**

## EXP NO: 10

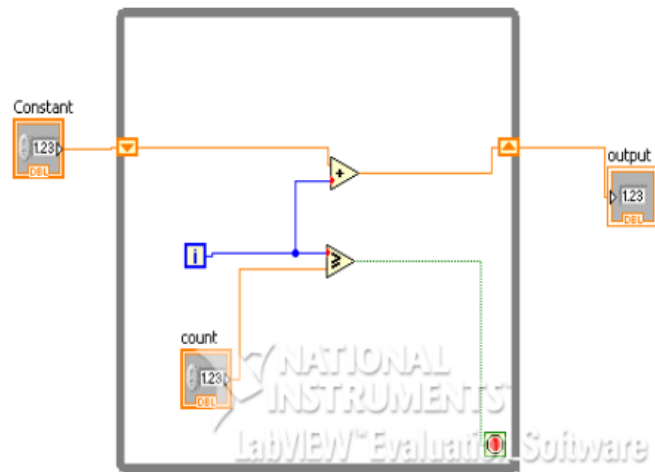## SUM OF 'n' NATURAL NUMBERS USING WHILE LOOP

**AIM:**

To find the sum of n natural numbers using while loop.

**PROCEDURE**:

1: Create blank VI.

2: Right click on the block diagram panel , select program , go to structures and select a WHILE loop

3: The tunnels of the border are converted to shift register.

4: Generate an adder and greater than equal to inside the WHILE loop .

5: Using wiring operation required wiring is done in the block diagram panel.

6: Input values are given in front panel and the output is generated.

**BLOCK DIAGRAM**

**FRONT PANEL**



**RESULT**

**INFERENCE**

## EXP NO: 11

## FACTORIAL OF A GIVE NUMBER USING WHILE LOOP

**AIM:**

To perform the factorial of a given number using WHILE loop.

**PROCEDURE:**

1: Create blank VI.

2: Right click on the block diagram panel , select program , go to structures and select a WHILE loop.

3: Right click on the border of the WHILE loop and select add shift register, borders are converted into shift register.

4: Using wiring operations required connections are given in the block diagram.

5: Inputs are given in the front panel and the program is executed.

**Block diagram**                                                        **Front panel**
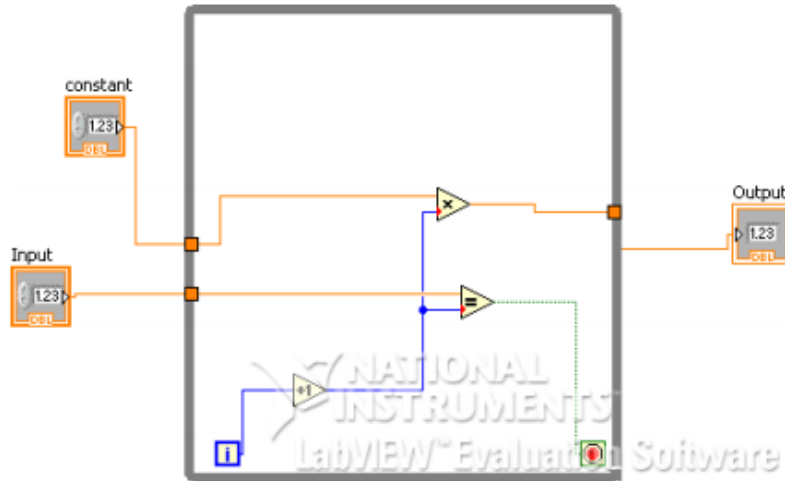


**RESULT**

**INFERENCE**

## EXP NO: 12

## DATA ACQUISITION USING LABVIEW

### AIM:

To gather data from thermocouple and strain gauge using labview software

### EQUIPMENTS REQUIRED:

NI-DAQ hardware(cDAQ-9174 ), J-Type thermocouple, 4 wire strain gauge

### SOFTWARE REQUIRED

Labview16

### THEORY

LabVIEW is very powerful when it comes to creating DAQ applications. LabVIEW includes a set of VIs that let you configure, acquire data from, and send data to DAQ devices. Often, one device can perform a variety of functions, such as analog-to-digital (A/D) conversion, digital-to-analog (D/A) conversion, digital I/O, and counter/timer operations. Each device supports different DAQ and signal generation speeds.

The DAQ system has the following parts
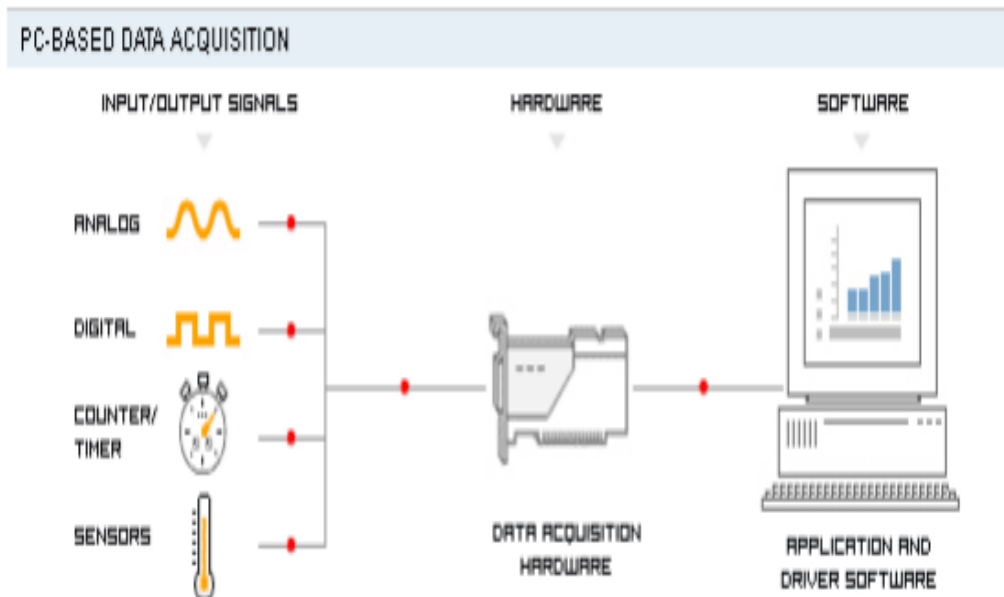
The parts are:

• Physical input/output signals

• DAQ device/hardware

• Driver software

• Application software

**Transducers**

Data acquisition begins with the physical phenomenon to be measured. This physical phenomenon could be the temperature of a room, the intensity of a light source, the pressure inside a chamber, the force applied to an object, or many other things. An effective data acquisition system can measure all of these different phenomena. A transducer is a device that converts a physical phenomenon into a measurable electrical signal, such as voltage or current

| Phenomenon | Transducer |
|---|---|
| Temperature | Thermocouple, RTD, Thermistor |
| Light | Photo Sensor |
| Sound | Microphone |
| Force and Pressure | Strain Gage<br>Piezoelectric Transducer |
| Position and Displacement | Potentiometer, LVDT, Optical Encoder |
| Acceleration | Accelerometer |
| pH | pH Electrode |

**Data Acquisition Hardware**

Data acquisition hardware acts as the interface between the computer and the outside world. It primarily functions as a device that digitizes incoming analog signals so that the computer can interpret them. Other data acquisition functionality includes the following:
· Analog input/output
· Digital input/output
· Counter/timers
· Multifunction - a combination of analog, digital, and counter operations on a single device

National Instruments offers several hardware platforms for data acquisition. The most readily available platform is the desktop computer.

### DAQ Assistant

The DAQ Assistant, included with NI-DAQmx, is a graphical, interactive guide for configuring, testing, and acquiring measurement data. With a single click, you can even generate code based on your configuration, making it easier and faster to develop complex operations. Because DAQ Assistant is completely menu-driven, you will make fewer programming errors and drastically decrease the time from setting up your DAQ system to taking your first measurement.

### PROCEDUE

1) Configure and interface the DAC hardware with PC

2) Provide proper connection of the input transducer to DAQ module

3) Open labVIEW software and open a new VI

4) In block diagram , create a while loop controlled by a stop pushbutton.

5)Copy DAQ Assistant icon on your Block Diagram, and a window will appear.

6) In this window you need to select either "Acquire Signals" (i.e., Input Signals) or "Generate Signals" (i.e., Output Signals).

Select Acquire Signals → Analog Input → Temperature (for thermocouple)/ resistance (for strain guage)

7) In the next window you select which Analog Input you want to use. Select ai0 (Analog Input channel 0) and click Finish.

8) In the next window set input range, input type and sampling rate .

9) Click OK in the DAQ Assistant window The DAQ Assistant icon appears on the Block Diagram:



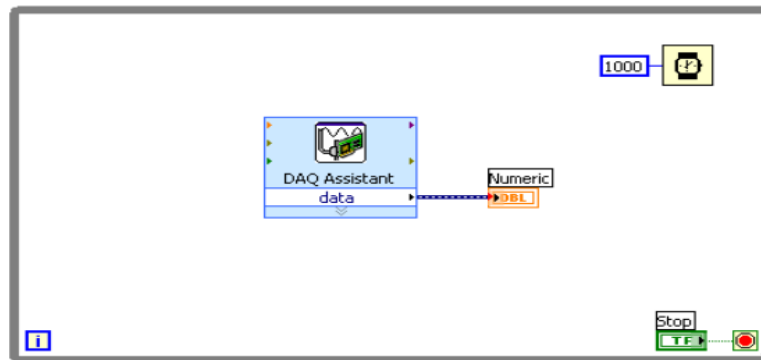10) Wire the data output to a numeric indicator

Then numeric indicator will show, e.g., the following value:



Input sensor data will be displayed in the front panel

## **BLOCK DIAGRAM**



**RESULT**

**INFERENCE**

## EXP NO: 13
## DAC-0808

**AIM**

To study and test DAC-0808 Circuit

**APPARATUS**

Digital to analog trainter kit

**THEORY**

The DAC0808 is an 8-bit monolithic digital-to-analog converter (DAC) featuring a full scale output current settling time of 150 ns while dissipating only 33 mW with ±5V supplies. No reference current (IREF) trimming is required for most applications since the full scale output current is typically ±1 LSB of 255 IREF/256. Relative accuracies of better than ±0.19% assure 8-bit monotonicity and linearity while zero level output current of less than 4 µA provides 8-bit zero accuracy for IREF≥2 mA. The power supply currents of the DAC0808 is independent of bit codes, and exhibits essentially constant device characteristics over the entire supply voltage range.

## Block and Connection Diagrams



**Dual-In-Line Package**
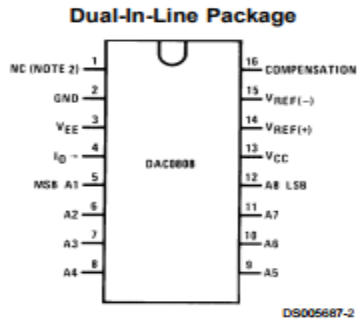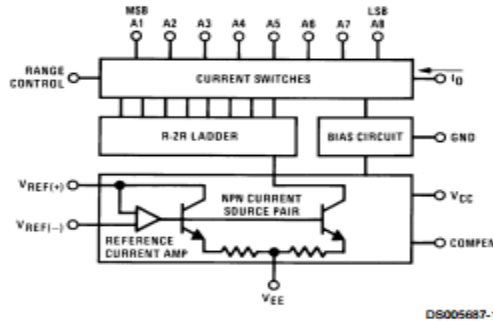


**Top View**
**Order Number DAC0808**
**See NS Package M16A or N16A**

## PROCEDURE

1. Connect the AC supply to the kit
2. Connect D0 to I0, D1 to I1, D2 to I2 upto D7 to I7.
3. Set the multimeter in voltmeter mode, select 20V and connect (+) to T6 and (-) to GND.
4. Set the input switches initially to 'L' Position.
5. Observe the Output at T6 on a multimeter.
6. For different combination of digital input .input note the analog output.

## OBSERVATION TABLE

| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | VOLT |
|----|----|----|----|----|----|----|----|------|
|    |    |    |    |    |    |    |    |      |
|    |    |    |    |    |    |    |    |      |
|    |    |    |    |    |    |    |    |      |
|    |    |    |    |    |    |    |    |      |
|    |    |    |    |    |    |    |    |      |
|    |    |    |    |    |    |    |    |      |
|    |    |    |    |    |    |    |    |      |

## RESULT

## INFERENCE

## EXP NO: 14
## R-2R LADDER DAC

**AIM**

To study and test R-2R ladder DAC Circuit

**APPARATUS**

Digital to analog trainter kit

**THEORY**
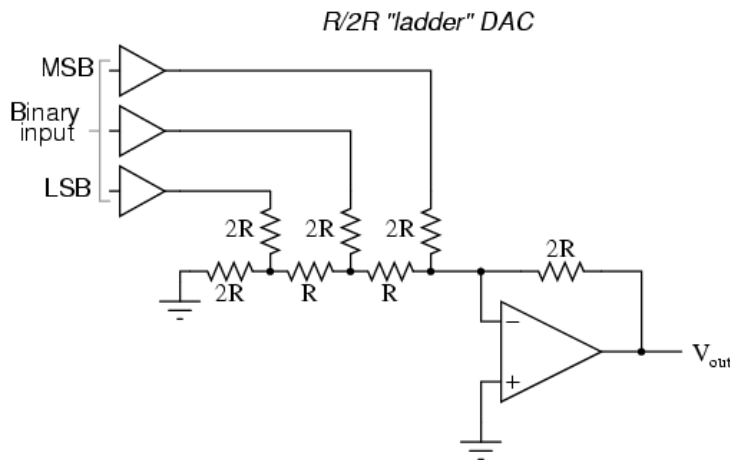


R/2R "ladder" DAC

The following circuit diagram shows the basic 2 bit R-2R ladder DAC circuit using op-amp. Here only two values of resistors are required i.e. R and 2R. The number of digits per binary word is assumed to be two (i.e. $n = 2$). The switch positions decides the binary word ( i.e. B1 B0 )
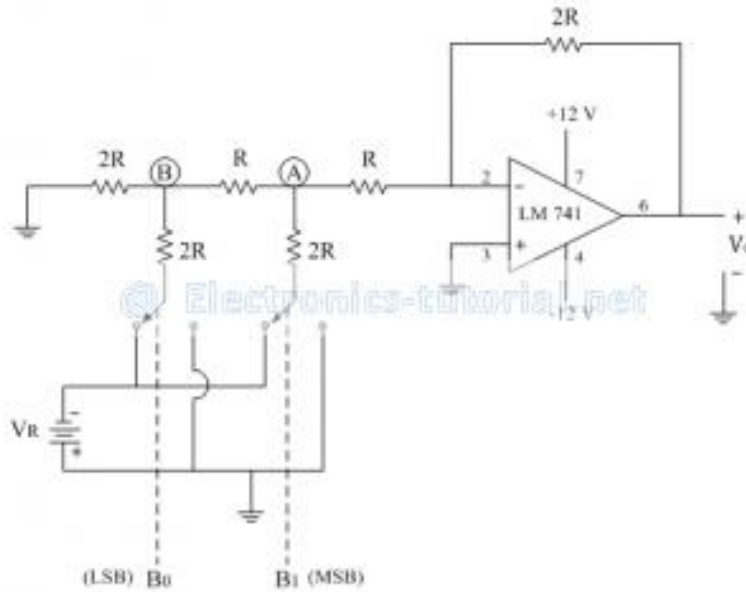
The typical value of feedback resistor is Rf = 2R. The resistance R is normally selected any value between 2.5 kΩ to 10 kΩ.

The generalized analog output voltage equation can be given as

$$V_o = -V_R \frac{R_f}{R} \left[ \frac{B_1}{2^1} + \frac{B_2}{2^2} + \frac{B_3}{2^3} + \cdots + \frac{B_n}{2^n} \right]$$

$$\therefore V_o = -V_R \frac{R_f}{R \times 2^n} [B_1 2^{n-1} + B_2 2^{n-2} + B_3 2^{n-3} + \cdots + B_n 2^{n-n}]$$

$$\therefore V_o = -V_R \frac{R_f}{R \times 2^n} [B_1 2^{n-1} + B_2 2^{n-2} + B_3 2^{n-3} + \cdots + B_n 2^0]$$

The operation of the above ladder type DAC is explained with the binary word (B1B0= 01)

**PROCEDURE**

1. Connect the AC supply to the kit
2. Connect D0 to I3, D1 to I2, D2 to I1 and D3 to I0.
3. Set the multimeter in voltmeter mode, select 20V and connect (+) to T1 and (-) to GND.
4. Set the input switches initially to 'L' Position.
5. Observe the Output at T1 on a multimeter.
6. For different combination of digital input .input note the analog output.

**OBSERVATION TABLE**

| D0 | D1 | D2 | D3 | VOLT |
|----|----|----|----|------|
|    |    |    |    |      |
|    |    |    |    |      |
|    |    |    |    |      |
|    |    |    |    |      |
|    |    |    |    |      |
|    |    |    |    |      |
|    |    |    |    |      |

**RESULT**

**INFERENCE**

## EXP NO: 15
## BINARY WEIGHTED DAC

### AIM
To study and test binary weighted DAC Circuit

### APPARATUS
Digital to analog trainter kit

### THEORY
The binary-weighted-resistor DAC employs the characteristics of the inverting summer Op Amp circuit. In this type of DAC, the output voltage is the inverted sum of all the input voltages. If the input resistor values are set to multiples of two: 1R, 2R and 4R, the output voltage would be equal to the sum of V1, V2/2 and V3/4. V1 corresponds to the most significant bit (MSB) while V3 corresponds to the least significant bit (LSB).
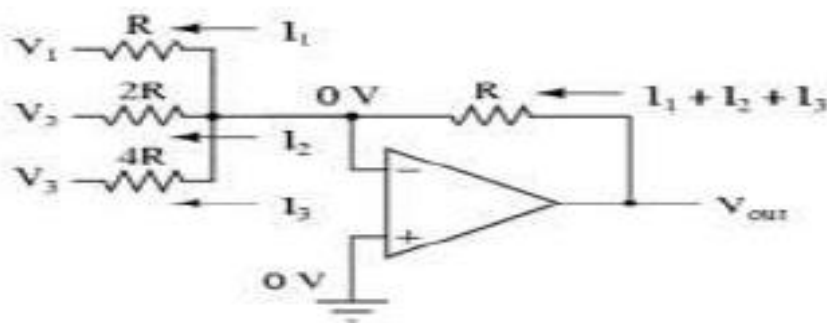


$$V_{out} = -(V_1 + \frac{V_2}{2} + \frac{V_3}{4})$$

The circuit for a 4-bit DAC using binary weighted resistor network is shown below:
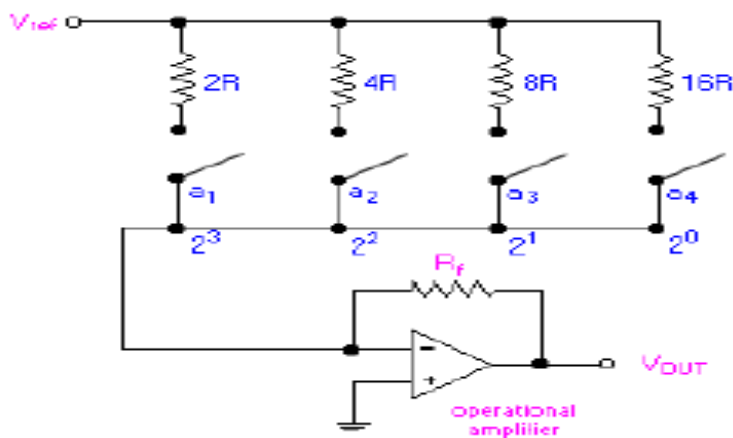
The binary inputs, ai (where i = 1, 2, 3 and 4) have values of either 0 or 1. The value, 0, represents an open switch while 1 represents a closed switch.

The operational amplifier is used as a summing amplifier, which gives a weighted sum of the binary input based on the voltage, Vref.

For a 4-bit DAC, the relationship between Vout and the binary input is as follows:

$$V_{OUT} = -iR_f$$
$$= -\left[V_{ref}\left(\frac{a_1}{2R} + \frac{a_2}{4R} + \frac{a_3}{8R} + \frac{a_4}{16R}\right)\right]R_f$$
$$= -\frac{V_{ref}R_f}{R}\left(\frac{a_1}{2} + \frac{a_2}{4} + \frac{a_3}{8} + \frac{a_4}{16}\right)$$
$$= -\frac{V_{ref}R_f}{R}\left(\frac{a_1}{2^1} + \frac{a_2}{2^2} + \frac{a_3}{2^3} + \frac{a_4}{2^4}\right)$$

The negative sign associated with the analog output is due to the connection to a summing amplifier, which is a polarity-inverting amplifier. When a signal is applied to the latter type of amplifier, the polarity of the signal is reversed (i.e. a + input becomes -, or vice versa).

For a n-bit DAC, the relationship between Vout and the binary input is as follows:

$$V_{OUT} = -\frac{V_{ref}R_f}{R}\sum_{i=1}^{n}\frac{a_i}{2^i}$$

**PROCEDURE**

1. Connect the AC supply to the kit
2. Connect D0 to I0, D1 to I1, D2 to I2 and D3 to I3.
3. Set the multimeter in voltmeter mode, select 20V and connect (+) to T2 and (-) to GND.
4. Set the input switches initially to 'L' Position.
5. Observe the Output at T2 on a multimeter.
6. For different combination of digital input .input note the analog output.

**OBSERVATION TABLE**

| D3 | D2 | D1 | D0 | VOLT |
|---|---|---|---|---|
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**RESULT**

**INFERENCE**

## EXP NO –16
## ADC- 0808

**AIM:**

To study and test ADC- 0808 circuit

**APPARATUS:**

Analog to digital trainer

**THEORY:**

The ADC0808, ADC0809 data acquisition component is a monolithic CMOS device with an 8-bit analog-to- digital converter, 8-channel multiplexer and microprocessor compatible control logic. The 8-bit A/D converter uses successive approximation as the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register. The 8-channel multiplexer can directly access any of 8-single-ended analog signals.

The device eliminates the need for external zero and full-scale adjustments. Easy interfacing to microprocessors is provided by the latched and decoded multiplexer address inputs and latched TTL TRI-STATE outputs.
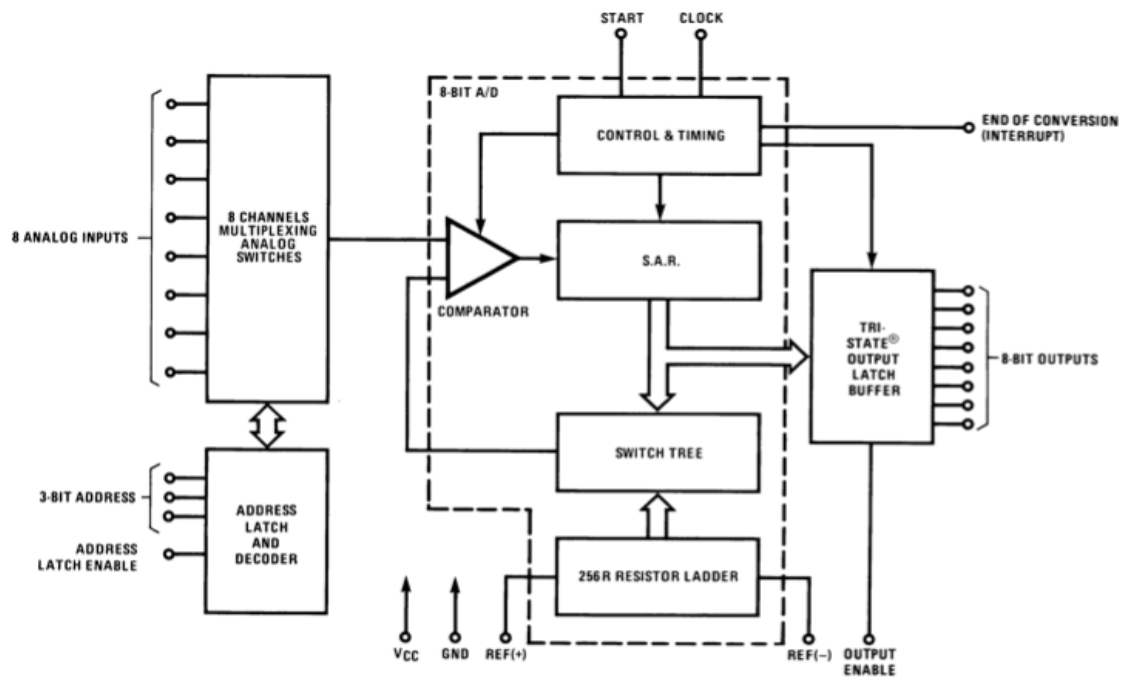
**PROCEDURE:**

Note: Supply (+/- 12V) for Op-Amp is internally provided.

1. Connect the AC supply to the kit.
2. Connect CLK OUT to CLK
3. Connect / short SOC to EOC
4. Connect input 10 to A, I1 to B and I2 to C
5. Switch ON the power.
6. Apply analog input by connecting 0-5V to CH0
7. Select the channel CH0 by combination as explained below table 1
8. Observe the output at D7 – D0 on a CRO
9. Select the channel CH1-CH7 by the combination as explained below table 1
10. Observe the output for each channel at D7 – D0 on a CRO

Table 1

| SELECTED ANALOG CHANNEL | ADDRESS LINE | | |
|---|---|---|---|
| | C | B | A |
| CH0 | L | L | L |
| CH1 | L | L | H |
| CH2 | L | H | L |
| CH3 | L | H | H |
| CH4 | H | L | L |
| CH5 | H | L | H |
| CH6 | H | H | L |
| CH7 | H | H | H |

**OBSERVATION TABLE**

| VOLTS | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | DIGITAL O/P |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | |
| 0.5 | | | | | | | | | |
| 1 | | | | | | | | | |
| 1.5 | | | | | | | | | |
| 2 | | | | | | | | | |
| 2.5 | | | | | | | | | |
| 3 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 4 | | | | | | | | | |

**RESULT:**

**INFERENCE:**

## EXP NO: 17

## SENSORS FOR AUTOMOTIVES

**AIM:**
**To understand the operation of various sensors used in automotives**

**APPARATUS:**
Vehicle speed sensor, Crankshaft Sensor, Camshaft speed sensor, Mass Airflow Sensor, Oxygen Sensor, Manifold Absolute Pressure Sensor, Throttle position sensor, Coolant temperature sensor, Electronic Control Unit (ECU), Exhaust Oxygen Sensor, Distribution pulse sensor, Knock Sensor

**THEORY:**
**Vehicle speed sensor**
A **wheel speed sensor** or **vehicle speed sensor** (VSS) is a type of tachometer. It is a sender device used for reading the speed of a vehicle's wheel rotation. It usually consists of a toothed ring and pickup.

**Crankshaft Sensor**
A **crank sensor** is an electronic device used in an internal combustion engine, both petrol and diesel, to monitor the position or rotational speed of the crankshaft. This information is used by engine management systems to control the fuel injection or the ignition system timing and other engine parameters. Before electronic crank sensors were available, the distributor would have to be manually adjusted to a timing mark on petrol engines.

**Camshaft speed sensor**
The crank sensor can be used in combination with a similar camshaft position sensor to monitor the relationship between the pistons and valves in the engine, which is particularly important in engines with variable valve timing. This method is also used to "synchronise" a four stroke engine upon starting, allowing the management system to know when to inject the fuel. It is also commonly used as the primary source for the measurement of engine speed in revolutions per minute.

**Mass Airflow Sensor**
A **mass (air) flow sensor** (MAF) is used to find out the mass flow rate of air entering a fuel-injected internal combustion engine. The air mass information is necessary for the engine control unit (ECU) to balance and deliver the correct fuel mass to the engine. Air changes its density as it expands and contracts with temperature and pressure. In automotive applications, air density varies with the ambient temperature, altitude and the use of forced induction, which means that mass flow sensors are more appropriate than

volumetric flow sensors for determining the quantity of intake air in each cylinder.

### Oxygen Sensor

An **oxygen sensor** (or *lambda sensor*) is an electronic device that measures the proportion of oxygen ($O_2$) in the gas or liquid being analyzed. The most common application is to measure the exhaust gas concentration of oxygen for internal combustion engines in automobiles and other vehicles in order to calculate and, if required, dynamically adjust the air fuel ratio so that catalytic converters can work optimally, and also determine whether a catalytic converter is performing properly or not. Divers also use a similar device to measure the partial pressure of oxygen in their breathing gas.

Scientists use oxygen sensors to measure respiration or production of oxygen and use a different approach. Oxygen sensors are used in oxygen analyzers which find a lot of use in medical applications such as anesthesia monitors, respirators and oxygen concentrators.

### Manifold Absolute Pressure Sensor

The **manifold absolute pressure sensor** (**MAP sensor**) is one of the sensors used in an internal combustion engine's electronic control system.

Engines that use a MAP sensor are typically fuel injected. The manifold absolute pressure sensor provides instantaneous manifold pressure information to the engine's electronic control unit (ECU). The data is used to calculate air density and determine the engine's air mass flow rate, which in turn determines the required fuel metering for optimum combustion (see stoichiometry) and influence the advance or retard of ignition timing. A fuel-injected engine may alternatively use a mass airflow sensor (MAF sensor) to detect the intake airflow. A typical naturally aspirated engine configuration employs one or the other, whereas forced induction engines typically use both; a MAF sensor on the intake tract pre-turbo and a MAP sensor on the charge pipe leading to the throttle body.

### Manifold Air Temperature

Air Temperature Sensors are continuous function devices that change resistance inversely to temperature. They measure engine intake air temperature in the manifold, intake air duct, and air cleaner. A signal is then sent to the powertrain control module.

### Throttle position sensor

A throttle position sensor (TPS) is a sensor used to monitor the throttle position of a vehicle. The sensor is usually located on the butterfly spindle/shaft so that it can directly monitor the position of the throttle. More advanced forms of the sensor are also used, for example an extra *closed throttle position sensor* (CTPS) may be employed to indicate that the throttle is completely closed. Some engine control units (ECUs) also control the

throttle position electronic throttle control (ETC) or "drive by wire" systems and if that is done the position sensor is used in a feedback loop to enable that control.

### Coolant temperature sensor

The *coolant temperature sensor* is used to measure the temperature of the engine coolant of an internal combustion engine. The readings from this sensor are then fed back to the engine control unit (ECU), which uses this data to adjust the fuel injection and ignition timing. On some vehicles the sensor may also be used to switch on the electric cooling fan. The data may also be used to provide readings for a coolant temperature gauge on the dashboard.

### Exhaust Oxygen Sensor

The *exhaust oxygen sensor* includes a sensing portion that is exposed to the exhaust gas stream to detect residual oxygen in the exhaust gas and transmit the data to the control unit. A control unit fine-tunes the electric pulses transmitted to the fuel injectors. It includes a zirconia ceramic tube that is covered by a louvred metal shroud to protect it from breaking. A wire contacts the inner surface of the tube through a spring and an electrode bush.

### Distribution pulse sensor

On newer vehicles, a coil pack replaces the distributor. It is an electronically controlled pack of ignition coils regulated by the car's computer and is used to create the spark for each engine cylinder's spark plug. Generally speaking, coil packs are much more reliable than distributors, because there are no moving parts and because they fire much less often than a distributor. Coil packs usually create a better spark, which in turn produces better combustion and horsepower in a car's engine.

### Knock Sensor

This sensor creates a voltage signal based on the vibrations caused by detonation. The computer uses this signal to retard timing when spark knock occurs. The Knock sensor is typically located in the lower engine block, cylinder head or intake manifold.

### Electronic Control Unit (ECU)

*Electronic Control Unit (ECU)* is any embedded system that controls one or more of the electrical system or subsystems in a transport vehicle.

Types of ECU include Electronic/engine Control Module (ECM), Powertrain Control Module (PCM), Transmission Control Module (TCM), Brake Control Module (BCM or EBCM), Central Control Module (CCM), Central Timing Module (CTM), General Electronic Module (GEM), Body Control Module (BCM), Suspension Control Module (SCM), control unit, or control module. Taken together, these systems are sometimes

referred to as the car's computer (Technically there is no single computer but multiple ones.) Sometimes one assembly incorporates several of the individual control modules (PCM is often both engine and transmission).



**RESULT**

**INFERENCE**

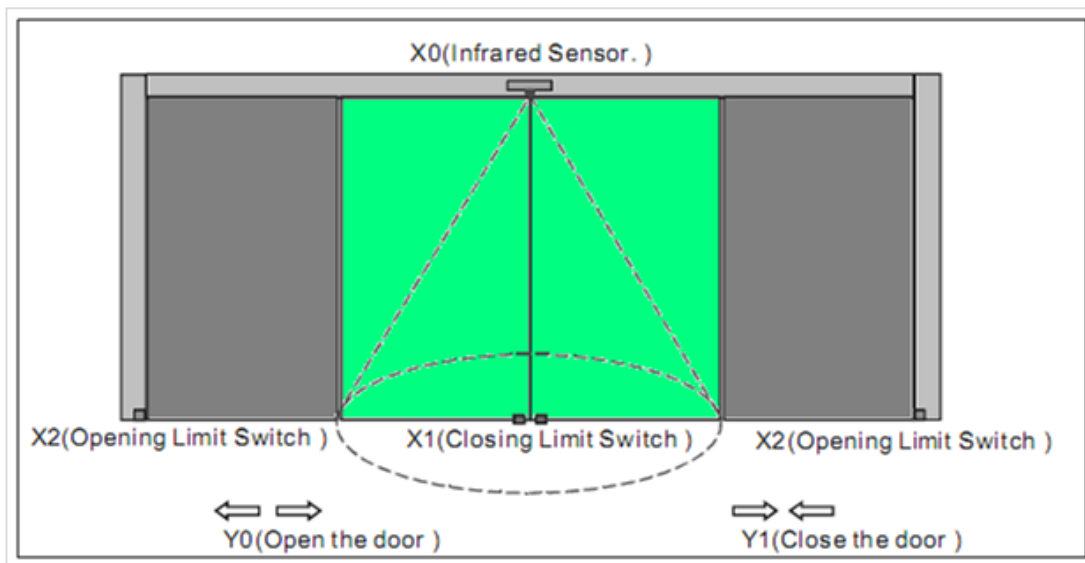**EXP NO: 18**
**AUTOMATIC DOOR OPENING AND CLOSING**

**AIM**
To simulate a automatic door opening and closing system using PLC

**APPARATUS:**
- Scientech 2400I Universal PLC Platform
- Ethernet Cable
- Mains cord

**THEORY**



1. When someone enters the infrared sensing field, opening motor starts working to open the door automatically till the door touches the opening limit switch
2. If the door touches the opening limit switch for 7 sec and nobody enters the sensing field, the closing motor starts working to close the door automatically till the closing limit switch touched together.
3. Stop the closing action immediately if someone enters the sensing field during the door closing process.

## PLC PROGRAMMIG

## Number of PLC Inputs Required

X0 - X0 = ON when someone enters the sensing field.

X1 - Closing limit switch. X1 = ON when 2 switches touched together.

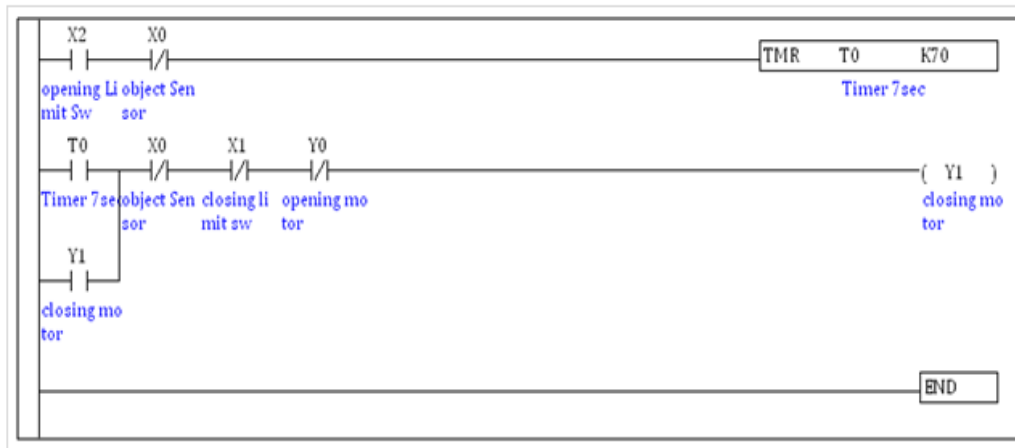X2 - Opening limit switch. X2 = ON when the door touched the switches.

## Number of PLC Outputs Required

Y0 - Opening motor

Y1 - Closing motor

## Number of PLC Timers Required

T0 - 7 sec timer. Time base: 100ms



PLC Ladder Program for Automatic Door open Close

## PROCEDURE

1. Connect mains cord to mains socket of **Scientech 2400I.**

3. Connect the water control trainer to the PLC board.

3. Turn the Rocker switch (Power switch) in ON position.

4. Connect Serial Ethernet Cable between PLC and PC.

5. Open **"RSLogix Micro Starter"** software.

6. Create Ladder Logic Program

7. Simulate and Test Ladder Logic Program

8. Transfer Ladder Logic Program.

9. Then put the PLC in RUN mode.

## RESULT

## INFERENCE

## EXP NO: 19
## P, PI, PD AND PID CONTROLLER

**Aim:**
To obtain step response of the given system and evaluate the effect P,PD,PI and PID controllers.

**APPARATUS:**
Software: MATLAB

**THEORY:**
PID controllers are commercially successful and widely used as controllers in industries. For example, in a typical paper mill there may be about 1500 controllers and out of these 90 percent would be PID controllers. The PID controller consists of a proportional mode, an Integral mode and a Derivative mode. The first letters of these modes make up the name PID controller. Depending upon the application one or more combinations of these modes are used. For example, in a liquid control system where we want zero steady state error, a PI controller can be used and in a temperature control system where zero stead state error is not specified, a simple P controller can be used.

**PROCEDURE:**
1) Consider the open loop transfer function

$$G(s) = \frac{1}{0.5S^2 + S + 4}$$

2) Write the program using matlab to simulate step response of the given System.
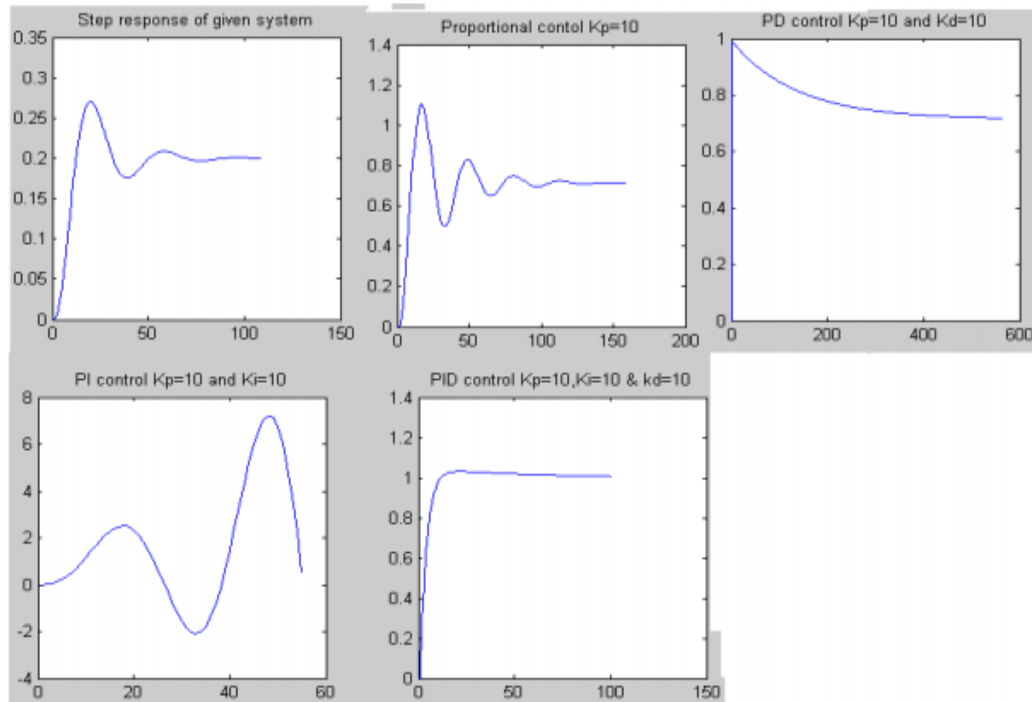3) Evaluate the effect of P,PI,PD and PID controllers

**PROGRAM**
**%Program to observe the effect P,PD,PI and PID controllers**
```
num=[1];
den=[0.5 1 4];
sys1=tf(num,den);
f=feedback(sys1,1);
f1=step(f);
subplot(2,3,1);plot(f1);
title('Step response of given system')
```
**% Proportional controller**
```
kp=10;
numP=kp*num;
sys=tf(numP,den);
G=feedback(sys,1)
```

```
m=step(G);
subplot(2,3,2);plot(m);
title('Proportional contol Kp=10')
k=dcgain(G)
essP=1/(1+k)
% PD controler
Kd=10;
numc=[Kd*kp kp];
nr=conv(numc,num);
sys1=tf(nr,den);
G1=feedback(sys1,1)
m=step(G1);
subplot(2,3,3);plot(m);
title('PD control Kp=10 and Kd=10')
%PI controller
ki=10;
numI=[kp ki*kp];
denI=[1 0];
dr=conv(denI,den);
sys2=tf(numI,dr)
G2=feedback(sys2,1);
m=step(G2);
subplot(2,3,4);plot(m);
k=dcgain(G2)
essPI=1/(1+k)
title('PI control Kp=10 and Ki=10')
%PID controller
nr1=conv(numc,[1 ki]);
sys3=tf(nr1,dr);
G3=feedback(sys3,1);
m=step(G3);
subplot(2,3,5);plot(m);
k=dcgain(G3)
essPID=1/(1+k)
title('PID control Kp=10,Ki=10 & kd=10')
```

**Graph:**



**RESULT**

**INFERENCE**