EXERCISE NO. :7

CLOSED LOOP PNEUMATICS

THREE STEP ACTION CONTROLLER

DATE: 17-10-2020

Reg. No. : RA1711018010101

PREREQUISITE KNOWLEDGE:

- Fundamentals of pneumatics and its basic components.
- Fundamentals of FluidSIM software for simulation of pneumatic and electrical circuits.

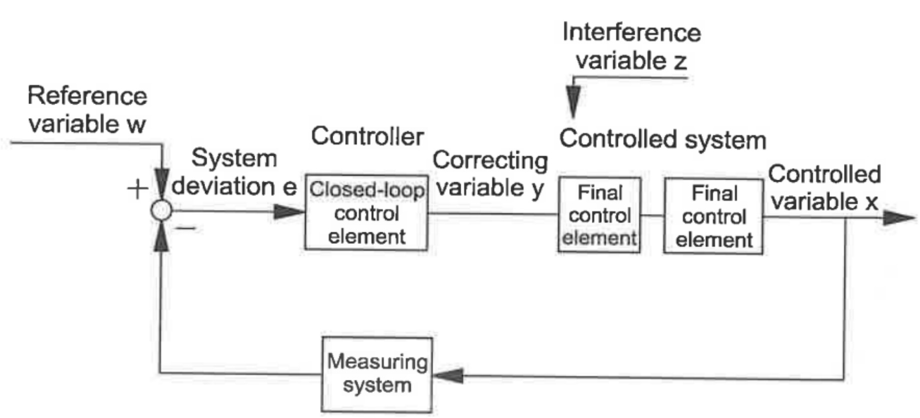
OBJECTIVES:

- To be able to explain the mode of operation of a three step-action controller
- To be able to commission a three step action controller.

THEORY:

Closed Loop Control System

Fig. A4.2: Block diagram of a closed-loop control circuit



Comparator

A comparator compares two analogue voltages with each other. One voltage forms the setpoint and is compared with the input voltage. The comparator output is energised in accordance with the result of this comparison. A positive-switching comparator exhibits the following behaviour:

- The output is set when the input signal exceeds the setpoint.
- The output is reset when the input signal falls below the setpoint.

A negative-switching comparator behaves in the opposite way.

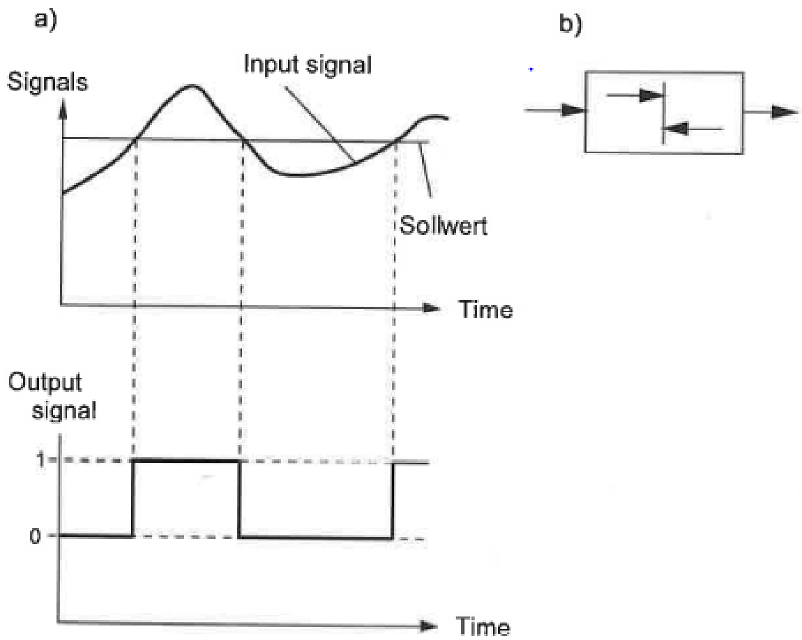


Fig. A2.1: Mode of operation and symbol for a positive-switching comparator

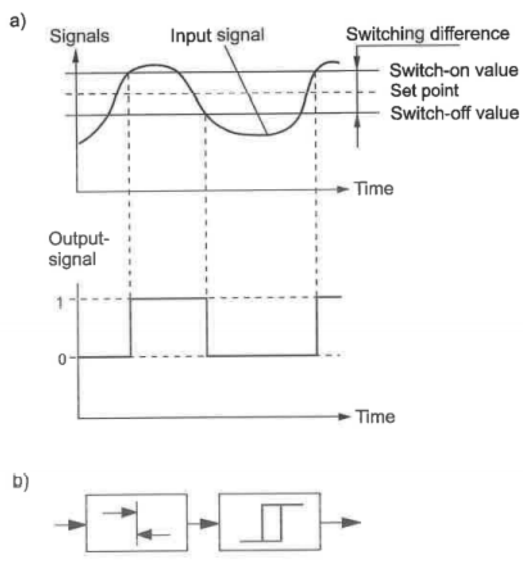
With some comparators, the switching behaviour depends on whether the input signal is rising or falling. In this case, the comparator output switches at two different input signal values (switch-on and switch-off value). The difference between these two input signal values is known as the switching difference or hysteresis.

A positive-switching comparator with switching difference exhibits the following behaviour:

- The output is set when the input signal exceeds the switch-on value.
- The output is reset when the input signal falls below the switch-off value.

The output of a negative-switching comparator with switching difference behaves in the opposite way.

Fig. A2.2: Mode of operation and symbolic representation a positive-switching comparator with switching difference



A comparator with switching difference is also known as a *Schmitt trigger*.

Festo Comparator Card

The comparator card used here has two separate inputs (IN A, IN B), each of which acts on one of two independent comparators. The outputs of these are designated OUT A1, A2 and OUT B1, B2. The energisation of outputs is shown by LEDs.

The following voltage values can be set on each comparator:

– Setpoint voltage: - 10 V ... 10 V,

– Hysteresis: 0 V ... 5 V.

The switch-on and switch-off values are defined as follows:

– Switch-on value = Setpoint + 1/2 hysteresis,

– Switch-off value = Setpoint - 1/2 hysteresis.

The setpoints and hysteresis values are selected by means of a selector switch. The voltage settings are made with the aid of an adjusting knob. The values can be read on a display.

The power supply for the comparator card is 24 V.

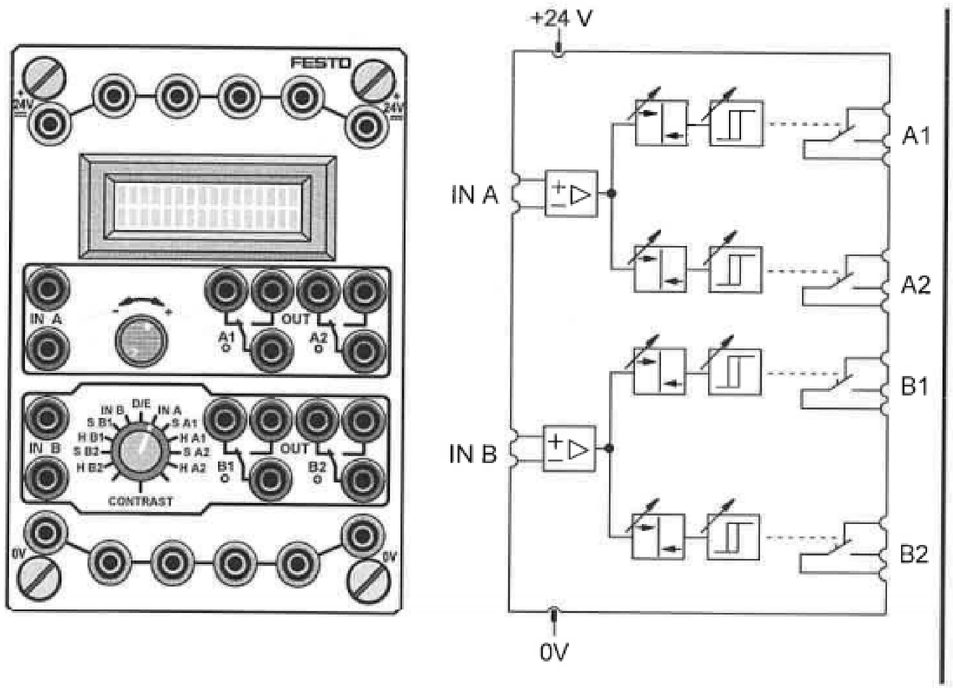


Fig. A2.3: Front panel and schematic representation of comparator card

Festo Input Module and Comparator Module

Three-step Action Controller

A three-step-action controller uses an input variable to produce up to three different correcting variables. These may be used, for example, to energise a 5/3-way solenoid valve. The range between the upper and lower switching values is known as the dead zone Ut.

Three-step-action controllers may exhibit one or two switching differences. Figs. A5.2 and A5.3 show the symbols for these.

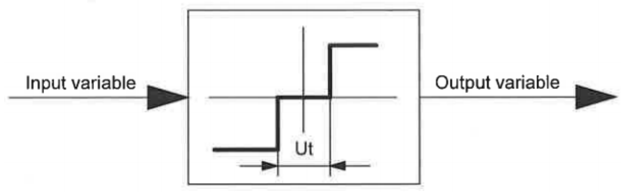


Fig. A5.1: Symbol for three-step-action controller

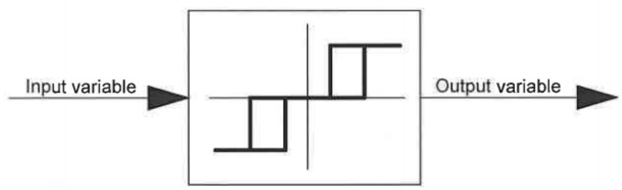
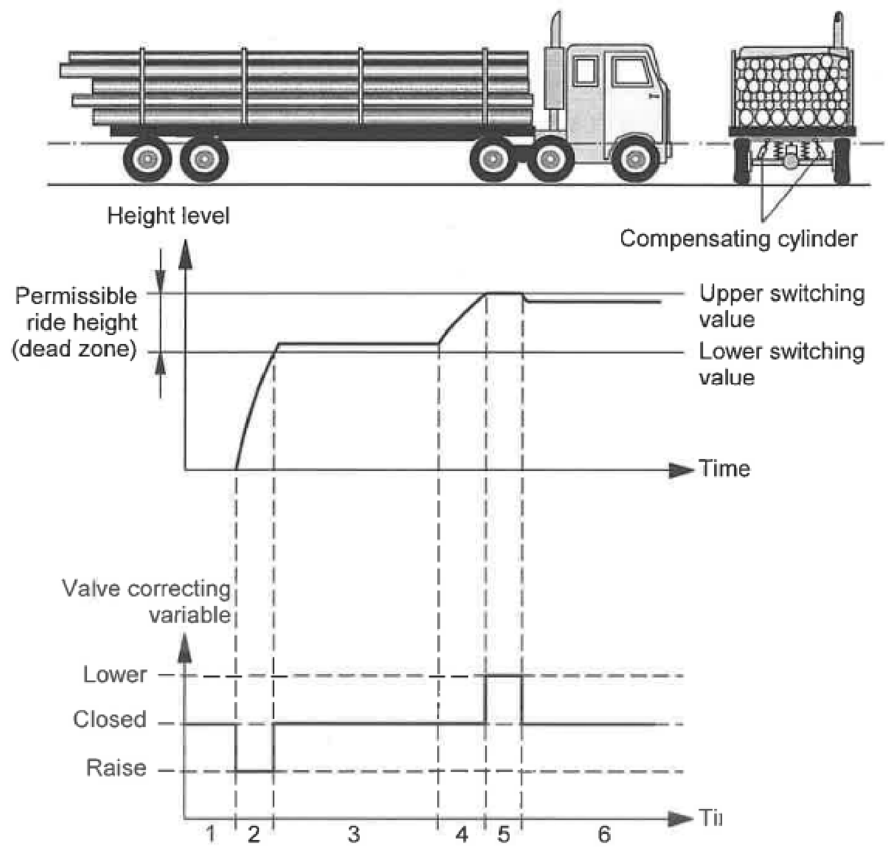


Fig. A5.2: Symbol for three-step-action controller with two switching differences

The time curve for the correcting and controlled variables of a three-step-action controller can be explained by taking the example of a truck ride-height control system. This system compensates for the changes in ride height which result from the loading and unloading of the truck. The truck chassis can be raised or lowered with the aid of a 5/3-way solenoid valve and two compensating cylinders.

TASK 1 – TYRE PRESSURE COMPENSATION SYSTEM

Fig. A5.3: Examples of curves for a controlled variable and correcting variable for a three-step-action controller



Mode of operation of a three-step-action controller

Phase 1: The closed-loop control process is started at the end (phase 1.

Phase 2: The chassis height lies outside the permissible level. The switching valve is switched to "raise" and the compensating cylinders advance.

Phase 3: The permissible level is reached. The valve is closed.

Phase 4: The truck is unloaded, as the result of which the chassis rises.

Phase 5: Due to the unloading of cargo, the permissible level is exceeded. To prevent the truck chassis from rising further, the valve is switched to "lower" and compressed air is blown off.

Phase 6: The permissible level is reached again, allowing the valve to be closed.

Drafting of Closed Loop Circuit

- The tyre pressure represents the controlled variable.
- A pressure sensor acts as a measuring system. It measures the tyre pressure.
- The three-step-action controller takes the form of two comparators. These are used to set the two switching values (comparator set-points). The associated switching differences are zero.
- The tyre is represented by a pneumatic reservoir.
- A 5/3-way solenoid valve is used as a final control element. This valve and the reservoir form the controlled system.
- Pressure fluctuations are produced using two 3/2-way panel-mounted valves.

Assembly of Three-Stage Action Controller

Follow the instructions below when assembling the three-step-action controller:

- The 5/3-way solenoid valve is installed between the service unit and the reservoir. Outlet port 2 should be blanked off.
- The function of the two panel-mounted valves (1S1 and 1S2) is defined as follows:
  - Actuation of SV1 causes the tyre pressure to be increased.
  - Actuation of SV2 causes the tyre pressure to be reduced.
- A pressure gauge is fitted to the reservoir to show the tyre pressure.
- Two one-way flow control valves (1V1 and 1V3) regulate the flow of compressed air. 1V1 is fitted to the working port of 1S1 in order to prevent a discharge of compressed air via 1S1. 1V3 is fitted to port 1 of 1S2 to limit the volumetric flow via 1S2 (check that the valve is installed in the correct direction!).

The 5/3-way solenoid valve and the comparators should be connected up as follows:

- The solenoid (1Y1 supply air) should be energised when the tyre pressure is below the lower switching value
- The solenoid (1Y2 exhaust air) should be energised when the tyre pressure is above the upper switching value
- Neither solenoid should be energised when the tyre pressure lies between the two switching values.

Commissioning of Three-Step Action Controller

.The one-way flow control valves should be set as follows:

- 1V1 should be fully closed.
- 1V3 should be half-closed.

Switch on the electrical power supply and the compressed air.

Set the following values on the comparators:

- Comparator A1
  - Lower switching value SA1 = 3 V
  - Switching difference HA1 = 0 V
- Comparator A2
  - Upper switching value SA2 = 4 V
  - Switching difference HA2 = 0 V

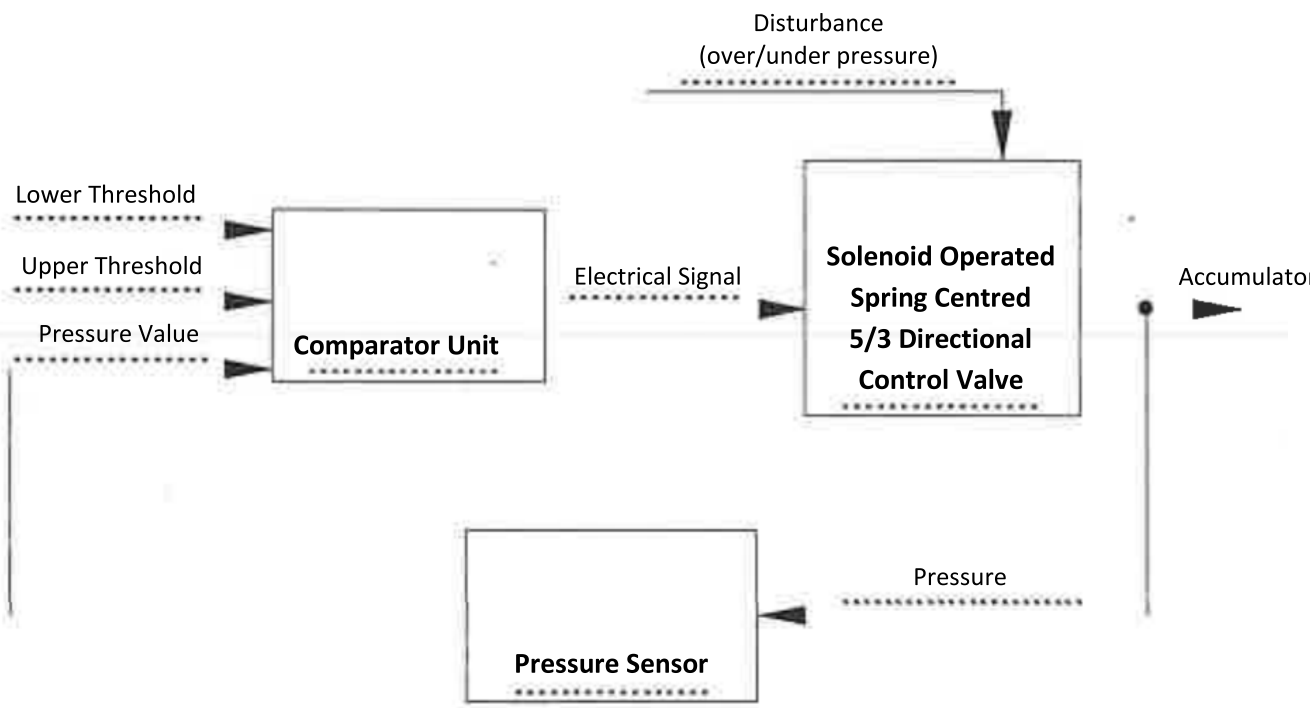
Now actuate the two switching valves alternately and observe the resulting switching behaviour.

Name the characteristics of various two-step-action and three-step-action controllers by completing the prepared table.

DELIVERABLES

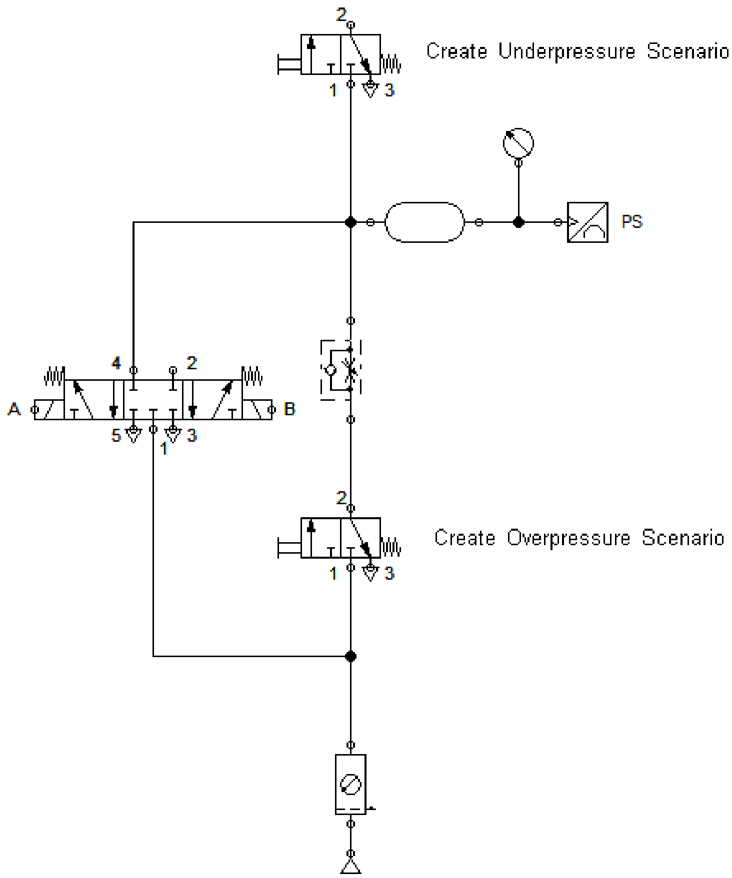
TASK 1

- Filling up of closed loop control block diagram with Figure A4.2 as reference.

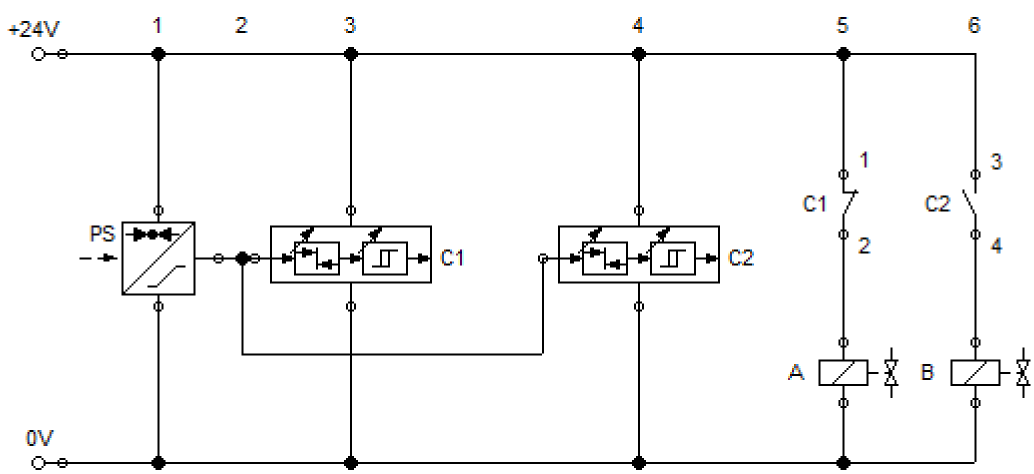


- Pneumatic and Electrical circuit diagrams
- State diagram of the Pressure Sensor and Switching Position of the 5/3 solenoid valve for the various possible cases applicable for a three-step action controller.

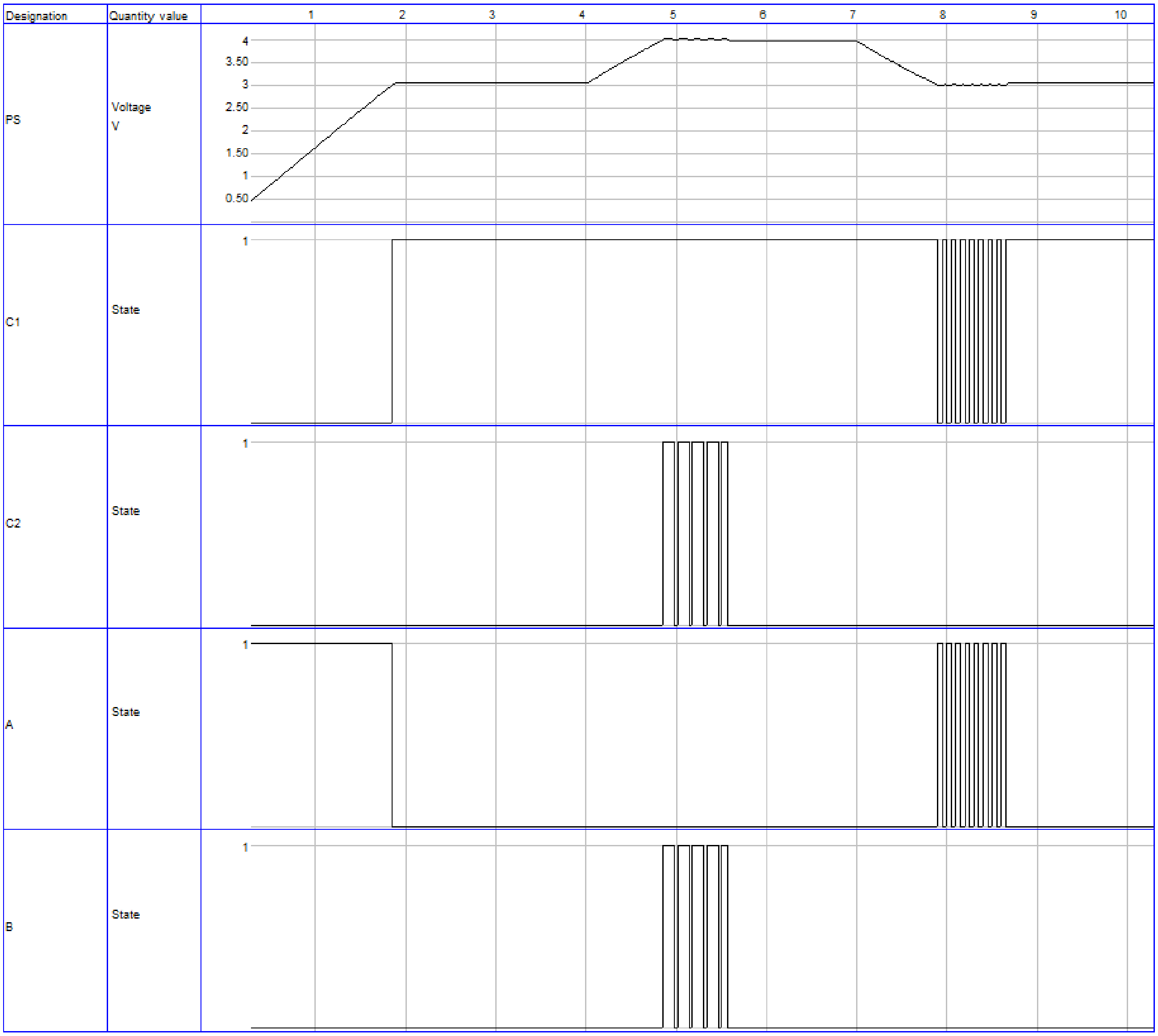
Pneumatic Circuit Diagram:



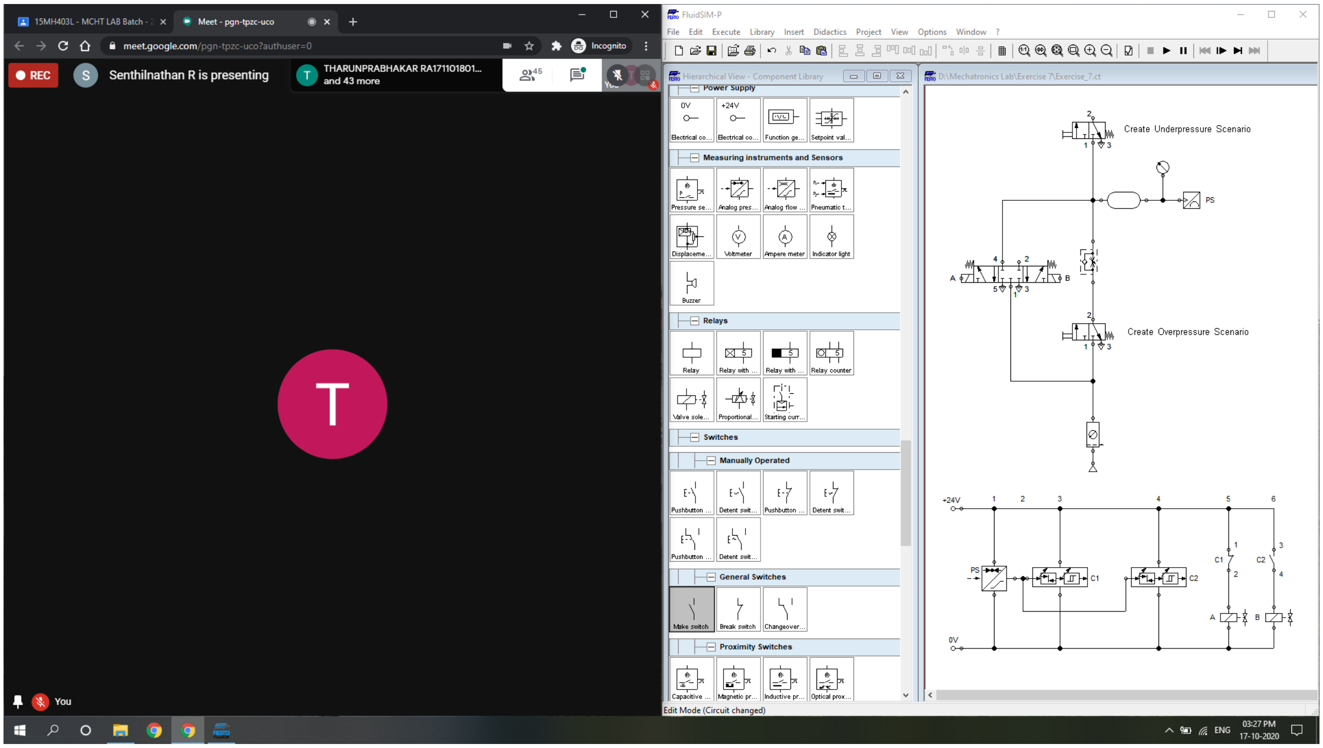
Electrical Circuit Diagram:



State Diagram:



Lab Session Screenshot:



Inference:

This experiment was an introduction to closed loop pneumatics. Festo FluidSIM was used to simulate a closed loop pneumatic system wherein the main task was to maintain the air pressure within an accumulator within the specified bounds. The bounds were specified as upper and lower limits (dead band) which makes the system respond only outside the specified thresholds (as opposed to single threshold/limiting value for pressure which starts responding as soon as the process variable is disturbed from its setpoint).

This technique of introducing a dead band within the controller is extremely useful for practical implementation of such systems as it significantly reduces wearing of the actuating components due to rapid oscillations/switching.