Chapter Four

Simulation and Result

4.1 Introduction

Drive elements (actuators) for industrial automation fall into one of three categories: electrical, hydraulic, or pneumatic. As a very general rule, electrical drive systems are used in high precision, relatively low load applications where control flexibility is paramount. Hydraulic drive systems tend to be used where large loads must be manipulated. Pneumatic drives are generally limited to simple two position operations where low cost and simple programming are necessary. A large percentage of heavy-duty industrial applications require the use of hydraulic actuators. Both linear and rotary actuators have large force- or torque-to-weight ratios, which is the primary benefit in many applications. Many of the problems with hydraulic systems are due to the complex system of components required. The minimum set of equipment required to drive even a single axis includes: hydraulic pump and oil supply, electric motor to drive pump, water cooling system for pump, pressure relief valves, safety shut-off valves, filters, directional control valves, hydraulic hoses, and at least one hydraulic actuator. Additional components such as accumulators, manifolds, oil-cooling heat exchangers, or additional reservoirs may be required in some applications.

In this chapter the simple hydraulic system using PLC ladder diagram and the adding feature of the design of hydraulic system add PLC have PID controller using ladder diagram.

4.2 Hydraulic Circuit Design

Many useful hydraulic circuits can be constructed by assembling basic building blocks, once the underlying principles are understood. Figure 4.1 shows the manual position control of a double acting hydraulic cylinder.

Four-way, three position valves are commonly used in these applications since the center position allows the cylinder to be stopped at any intermediate position. While the valve is in the center position, the fixed displacement, single direction pump is unloaded. All flow from the pump is immediately returned to the tank reservoir under a relatively low pressure. If the valve is shifted to either of the two end positions, the flow from the pump is routed to the selected end of the cylinder. The pressure will then start to build rapidly until it reaches a pressure that is sufficient to move the load against gravity and friction. The purpose of the pressure relief valve is to set the maximum operating pressure in the system. When the force created by the pressure in the pilot inlet line (shown dashed in the figure) balances the spring force, the relief valve cracks and flow is diverted from the cylinder to the tank. This operation is somewhat similar to that of a voltage regulator in an electrical circuit. Different types of pressure relief control valves are available to provide various pressure-flow characteristics.

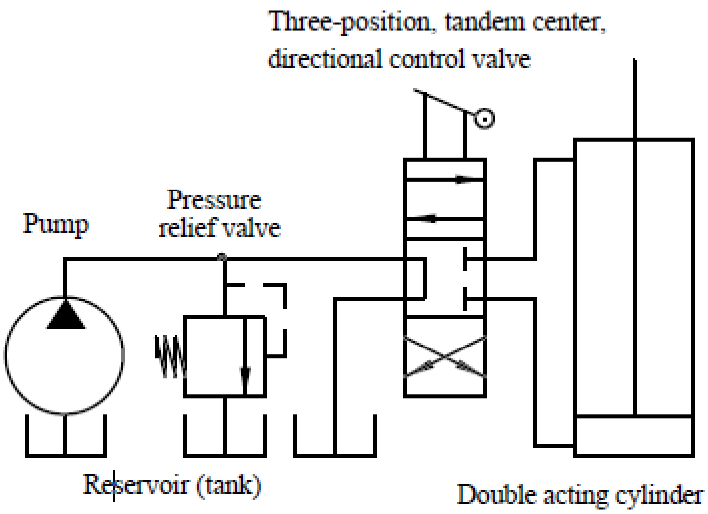

Figure 4.1: Simple hydraulic circuits

4.3 ladder diagram of hydraulic system

The design of hydraulic system using:

4.3.1 PLC ladder diagram

In Figure 4.2 design the simple hydraulic system using leader diagram and the explained this design in the chapter three.

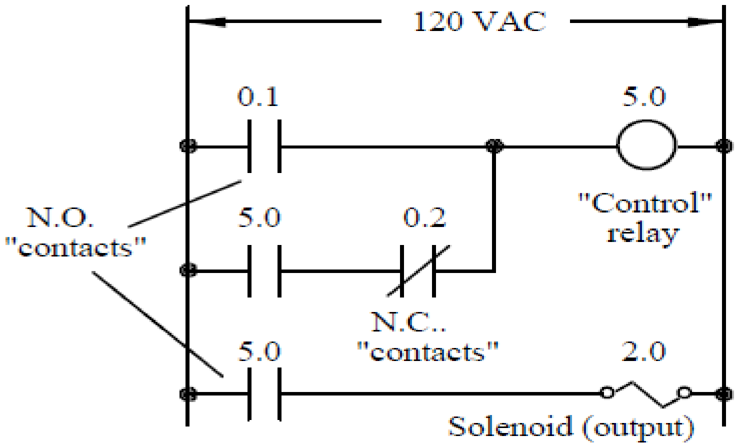

Figure 4.2: Simple hydraulic with PLC ladder logic

- **Rules for ladder logic**

Rules for designing ladder logic are summarized below.

1. Ladder diagrams are drawn vertically with inputs on the left and outputs on the right.
2. Each rung of the ladder has one (and only one) output.
3. An individual output device can appear on the ladder diagram only once.
4. An individual physical input device (limit switch, push-button, pressure switch, etc.) may be used as many times as necessary on the ladder diagram in both normally open and normally closed configurations, and is drawn using a representative schematic symbol.
5. Internal contacts of the PLC are represented as conventional control relays and contacts.
6. Control relay coils are outputs and can appear on the ladder diagram only once.

7. Control relay contacts are inputs and may be used as many times as necessary on the ladder diagram in both normally open and normally closed configurations.
8. Unlimited "OR"ing of ladder rungs is allowed, but any rung of the ladder diagram may be "OR"ed with a following rung at only one location [9].

4.3.2 Testing

To run the above design using the software SIEMENS V3.2 STEP7 MicroWIN SP4 SIMATIC S7-200, and then show the below the results:

Step 1

Choose the contacts from the library of the chosen software,

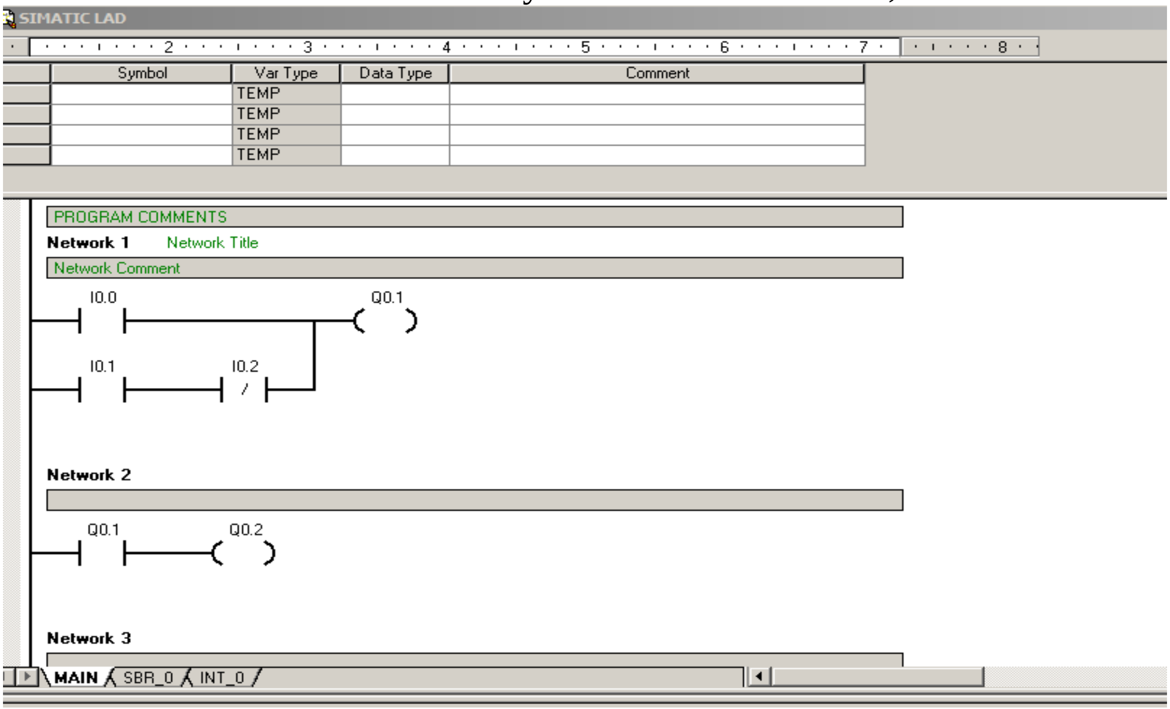

Figure 4.3: choose the contacts

And then save the design shown in Figure 4.3.

Step 2

Figure 4.4 shows the result after running the program.

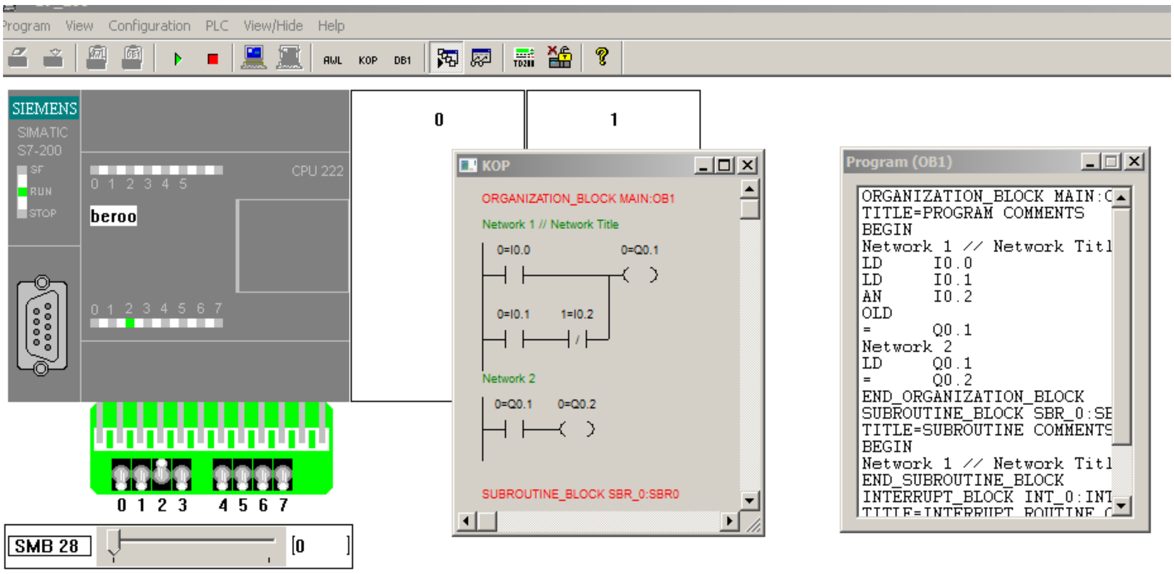

Figure 4.4: Result after running the program

Table 4.1 shows the results under different status of contacts.

Table 4.Results output under different status of contacts

I0.0	I0.1	I0.2	output
0	0	1	Q0.1=0 and Q0.2 =0 The hydraulic cylinder will retract fully.
1	0	1	Q0.1 =1 and Q0.2=1 Provide for initiating motion.
1	1	1	Q0.1=1 and Q0.2=1 Q0.1 to be energize and the piston in cylinder to be lower down that means the liquid pumping by the hydraulic pump and then to flow to control valve, Q0.1 remain energized until the I0.2 is activated by cylinder.
0	0	0	I0.2 is active indicator high source pressure, Q0.1=0 interrupt the pumping, Q0.2 is de-energize therefore the spring shifts the

			solenoid back to the right position, which causes the cylinder to retract. The system is inactive until press of the contact I0.0.

4.3.3 PID control of hydraulic pump using PLC

A control system is any interconnection of components to provide a desired function show in Figure 4.5. The portion of a system that is to be controlled is called process. The controller generates process input signals designed to produce desired outputs. A path (or loop) is provided from the output back to the controller. Some or all of the system outputs are measured and used by the controller, as indicated in Figure 4.5. Controller may then compare a desired process output with the actual output and act to reduce the difference between the two [13].

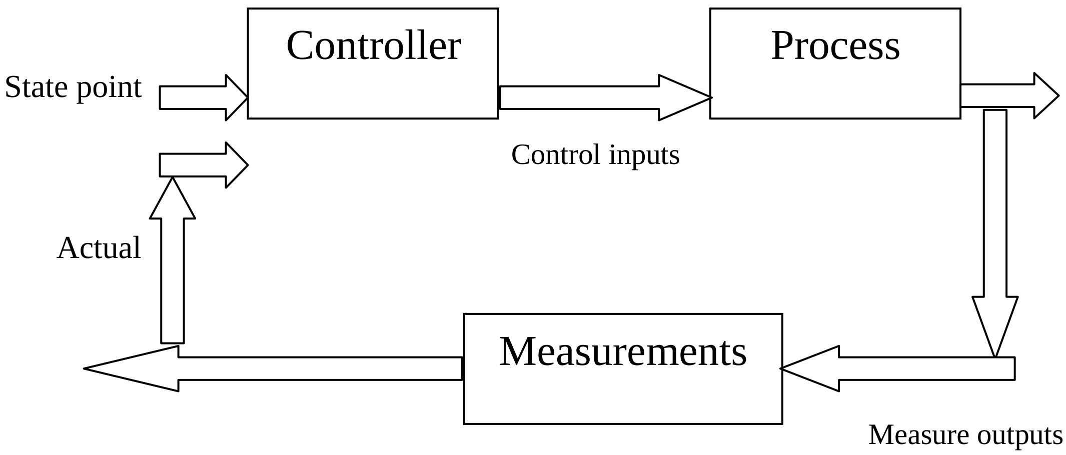

Figure 4.5 Close -loop system

Some of the advantages that feedback control offers the designer are:

1. Increased accuracy. The closed-loop system may be designed to drive the error (difference between desired and measures response) to zero.
2. Reduces sensitivity to changes in components.
3. Reduced effects of disturbances.

4. Increased speed of response and bandwidth. Feedback may be used to increase the range of frequencies over which a system will respond more desirably [13].

In the hydraulic system have two feedback systems: at pressure regulator and control valve. Pressure, along with the size of the cylinders dictates the force the system has available to use (Pressure in fluid has no one specific direction. The flow of fluid is directional. The direction fluid flows in a system can be changed by opening or closing valves but pressure in the system just is). Fluid can provide a great increase in work force. This is the main reason HWH has chosen to use hydraulic systems instead of electric motors, electric actuators, pulley and gear systems, etc. The formula used to calculate force as shown in EQ.3.3. Area can be any shape but for this study we are dealing with circles. The area of a circle is π (r2). The value of π is 3.14 and r is the radius of a circle or ½ the diameter of the circle.

4.4 Example

Jack has a diameter of 2 inches. The radius of that rod is 1 inch. The area of the rod is 3.14 (π) x (1x1) (r2) = 3.14 sq. in. Although most of the pumps HWH uses have a relief set at 3,500 psi, the working pressure HWH uses when figuring jack capacity is 3,000 psi. 3,000 (pressure) x 3.14 (area) = 9,420 (force) or 9,000 pounds. The amount of fluid the pump can move dictates how fast a cylinder will move. This is measured in gallons per minute or (GPM). It should be noted at this time that all a hydraulic pump does is move the fluid through the system. Pumps will only create pressure if there is resistance to the moving fluid. So in a given system, the more pressure the system will produce, the more force the cylinders can create. The more fluid the pump moves, GPM, the quicker the cylinders can move as shown in Figure 4.6. So that. The State Point (SP) is 3500psi and Process Value (PV) from 1000 to 3500.

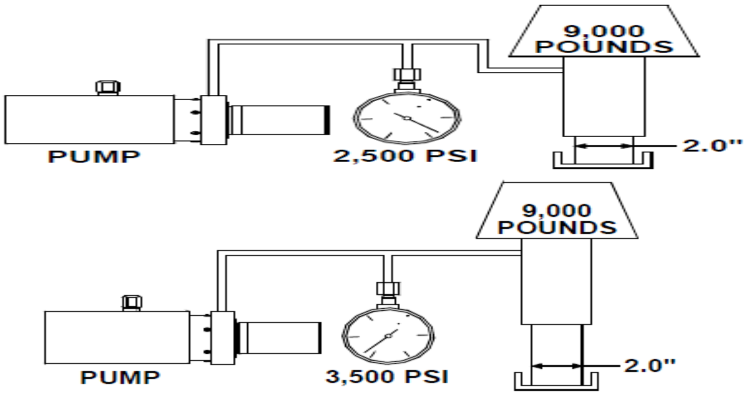

Figure 4.6: Speed a cylinder will move

To execute the PID PLC function using the software SIEMENS SIMITIC step7 V5.5 and the block diagram shown in Figure 4.7.

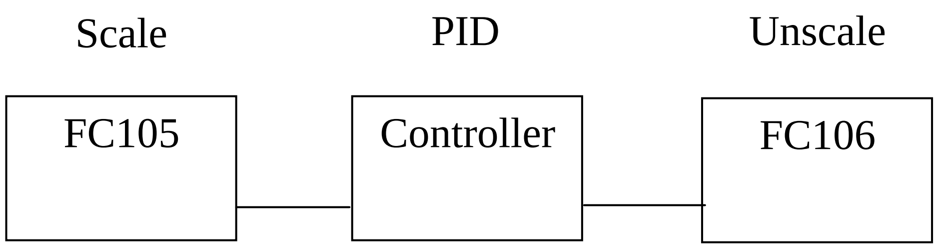

Figure 4.7: Block diagram of the system

Scale: FC105

The Scaling Values (SCALE) function takes an integer value (IN) and converts it to a real value in engineering units scaled between a low and a high limit (LO_LIM and HI_LIM). The result is written to OUT. In Table 4.2 describes the Scaling Values (SCALE) parameters.

Table 4.2 Scaling Values (FC105) Parameters

Parameter	Declaration	Data Type	Memory Area	Description
EN	Input	BOOL	I, Q, M, D, L	Enable input with signal state of 1 activates the box
ENO	Output	BOOL	I, Q, M, D, L	Enable output has a signal state of 1 if the function executed without error
IN	Input	INT	I, Q, M, D, L, P, or constant	The input value to be scaled to a REAL value in engineering units
HI_LIM	Input	REAL	I, Q, M, D, L, P, or constant	Upper limit in engineering units
LO_LIM	Input	REAL	I, Q, M, D, L, P, or constant	Lower limit in engineering units
BIPOLAR	Input	BOOL	I, Q, M, D, L	A signal state of 1 indicates the input value is bipolar and a signal state of 0 indicates unipolar
OUT	Output	REAL	I, Q, M, D, L, P	The result of the scale conversion
RET_VAL	Output	WORD	I, Q, M, D, L, P	Returns a value of W#16#0000 if the instruction executes without error; see Error Information for values other than W#16#0000

PID

To calculate the PID parameters see EQ. 3.4:
The procedure is as follows:

1) Turn off the I-term and the D-term in the controller.

2) Turn P to zero, and then increase it slowly, while looking at time responses then P=6.5

3) At this "quasi steady-state" point we have reached the critical gain, called P=P_K, and period T_K=5.34 s.

4) Then the Ti and Td should be turned on with the following configuration values (see the Table 4.3).

Table 4.3 closed-loop calculations of PID parameters

	Kp	Ti	Td
P controller	P_K / 2	-	-
PI controller	P_K / 2.2	T_K / 1.2	-
PID controller	P_K / 2.7	T_K / 2	T_K / 8

From Table 4.3, K_p, T_i, and T_d can be calculated for all three types of controllers. The results are shown in (Table 4.4 and Table 4.5).

Table 4.4 parameters of PID controller (see EQ. 3.4)

	Kp	Ti	Td
P controller	3.25	-	-
PI controller	2.95	4.45	-
PID controller	3.85	2.67	0.67

Table 4.5 parameters of PID controller (see EQ. 3.4)

	P	I	D
P controller	3.25	-	-
PI controller	2.95	0.66	-
PID controller	3.82	1.43	2.55

Unscaling Values (UNSCALE): FC106

The Unscaling Values (UNSCALE) function takes a real input value (IN) in engineering units scaled between a low and a high limit (LO_LIM and HI_LIM) and converts it to an integer value. The result is written to OUT. In Table 4-6 describes the Unscaling Values (UNSCALE) parameters.

Then substances the follow variables in SEMANS software and shown in Figures 4.8, 4.9, 4.10, 4.11 and 4.12

Table 4-6 Unscaling Values (FC106) Parameters

Parameter	Declaration	Data Type	Memory Area	Description
EN	Input	BOOL	I, Q, M, D, L	Enable input with signal state of 1 activates the box
ENO	Output	BOOL	I, Q, M, D, L	Enable output has a signal state of 1 if the function is executed without error
IN	Input	REAL	I, Q, M, D, L, P, or constant	The input value to be unscaled to an integer value
HI_LIM	Input	REAL	I, Q, M, D, L, P, or constant	Upper limit in engineering units
LO_LIM	Input	REAL	I, Q, M, D, L, P, or constant	Lower limit in engineering units
BIPOLAR	Input	BOOL	I, Q, M, D, L	A signal state of 1 indicates the input value is bipolar and a signal state of 0 indicates unipolar
OUT	Output	INT	I, Q, M, D, L, P	The result of the unscale conversion
RET_VAL	Output	WORD	I, Q, M, D, L, P	Returns a value of W#16#0000 if the instruction executes without error; see Error Information for values other than W#16#0000

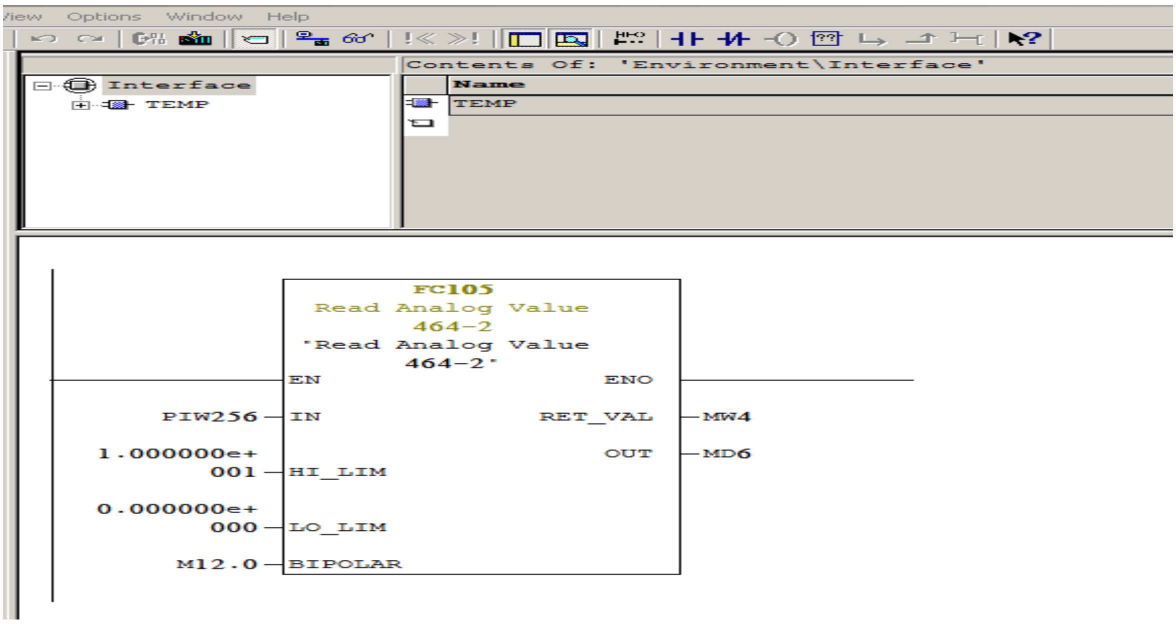

Figure 4.8: State Point (SP)

In the follow figure show the SP as IN and symbolic in PIW256 and this SP in this designed as variable not fixed. The output is MD6 and input in the PID.

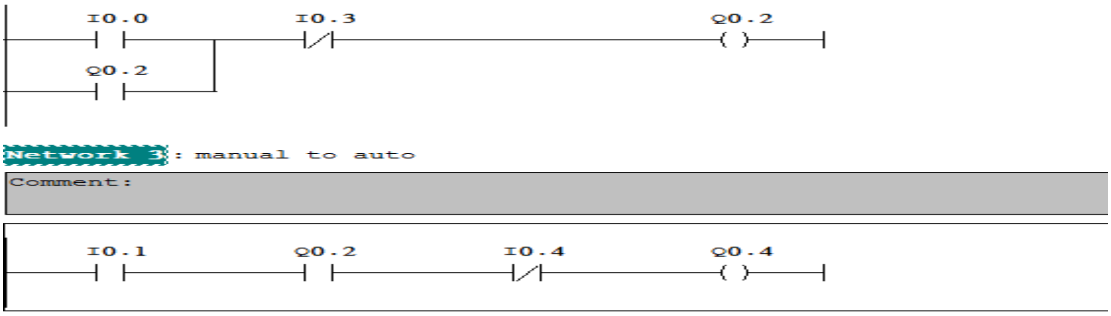

Figure 4.9: Hydraulic pump functions

Here in Figure 4.11 design for hydraulic pump using leader diagram to control the pumping from manual to auto and then to input in PID.

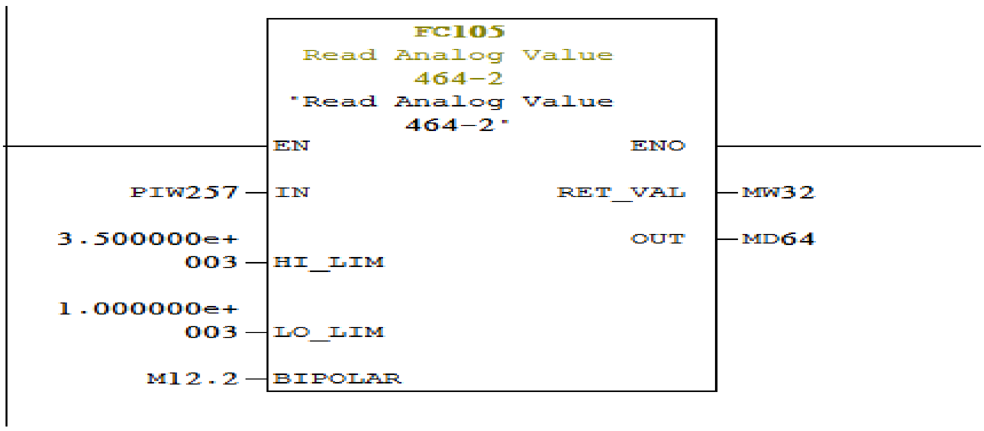

Figure 4.10 Process Value (PV)

In Figure 4.10 to show the PV as input from 1,000 to 3,500 and output MD64 input in PID.

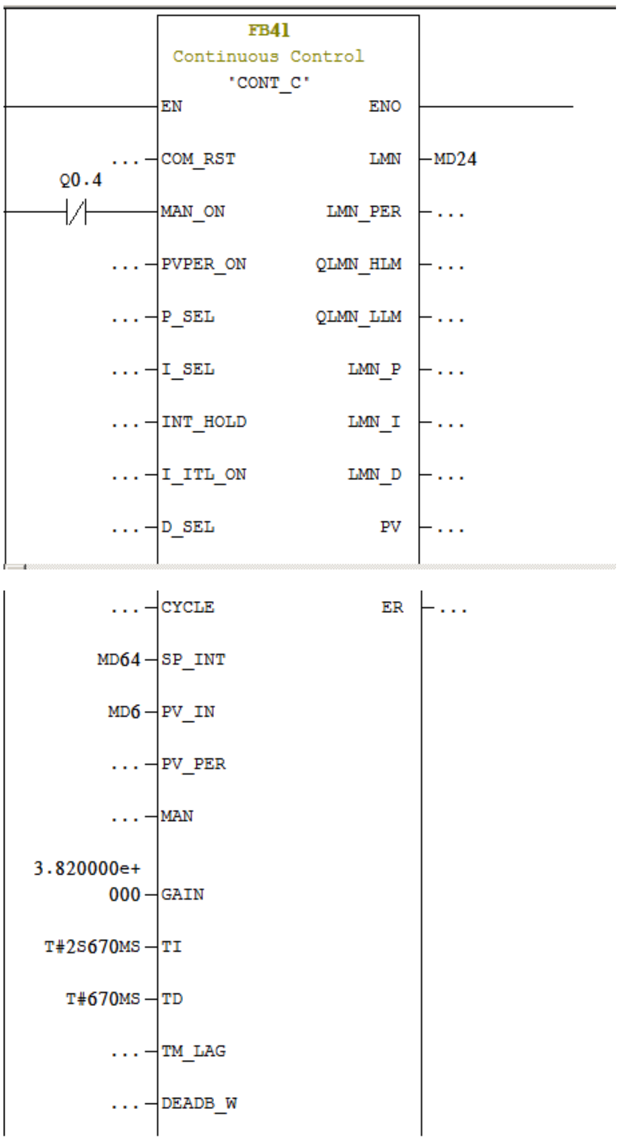

Figure 4.11: PID function

In Figure 4.11 show the PID function to control of the pressure and output is MD24 input in FC106.

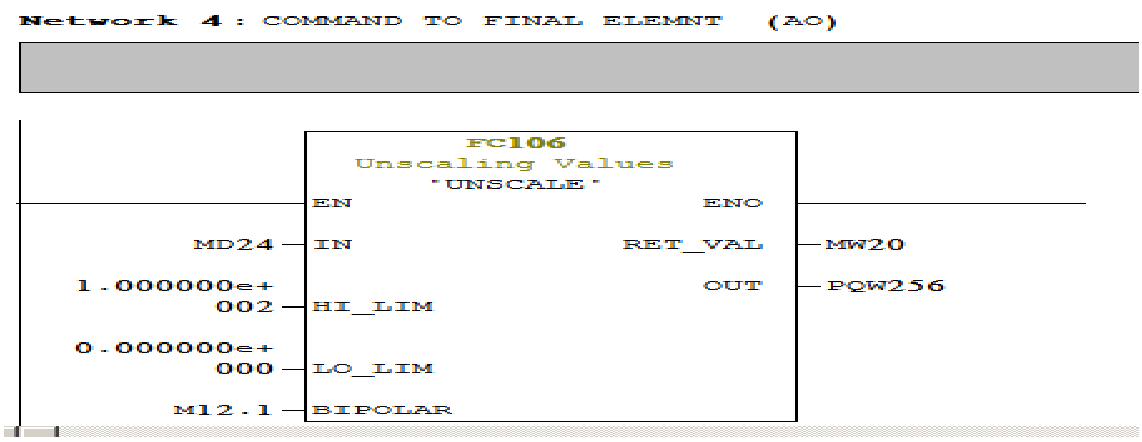

Figure 4.12: Unscaling Values (output)

In Figure 4.12 show the output of this design is PQW256and then to real system.

Table 4.7 shows the results under different status of state point.

Table 4.7 Results under different status of state point

I0.0	I0.1	I0.4	PIW256	output
1	1	0	3500	Start the pumping and convert to auto in PID.
1	1	0	1000	Continues the pumping and stable system.
1	1	0	40000	Stop the pumping and PID result error
0	1	0	3500	Stop the pumping because the end of process.