Faculty of engineering ain shams university

Team:A-2

AUTOMATION
MCT 313

Ahmed Hisham Fathy Hassabou 19P4007
Abdel Rahman Ahmed Habash 19P5553
Mohamed Fathi Abdel Hamid 19P4401
Mohamed Maged El-Berry 19P2698

MCT313
Automation

Major Task Phase 1

Supervised by

Dr. Mohamed Omar

Eng. Hesham Salah

Submitted by

Ahmed Hisham Fathy Hassabou	*19P4007*	*25%*
Mohamed Fathi Abdelhamid Ali	*19P4401*	*25%*
Abdel Rahman Ahmed Habash	*19P5553*	*25%*
Mohamed Maged El-Berry	*19P2698*	*25%*

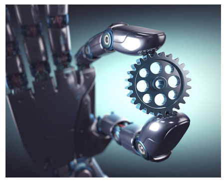


Table of Contents

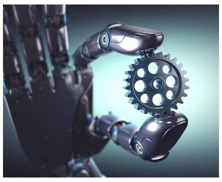
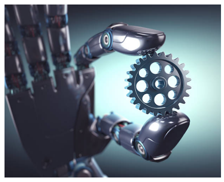


Table of Figures



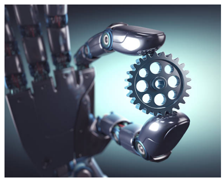
ABSTRACT

In industrial automation, controlling the water level in a tank is a common process requirement. To achieve this, programmable logic controllers (PLCs) are often used along with specialized software such as TIA Portal and Factory IO. TIA Portal is a powerful engineering software used for configuring, programming, and commissioning industrial automation systems, while Factory IO is a virtual factory simulation software that enables the testing and visualization of automation projects.

PID control is a widely used control technique for regulating process variables such as temperature, pressure, and flow rate. In this project, TIA Portal is used to implement a PID control algorithm to regulate the water level in a tank in Factory IO. The system is modeled in Factory IO, and the level of water in the tank is sensed by a simulated level sensor. The PID controller is designed to adjust the flow rate of water into the tank to maintain the desired water level.

The performance of the control system is evaluated by measuring the rise time, settling time, and overshoot of the water level response. The simulation results demonstrate that the PID controller is capable of regulating the water level in the tank accurately and efficiently.

In conclusion, this project highlights the effectiveness of TIA Portal and Factory IO in implementing a PID control algorithm to regulate the water level in a tank. This approach can be used in real-world applications to control the water level in industrial processes, such as in chemical plants, water treatment plants, and food processing plants.



1.0 Introduction

Controlling liquid levels in tanks is important in several industrial applications, and it is often achieved through PLCs and specialized software. TIA Portal is a widely-used engineering software that enables automation system configuration, programming, and commissioning in various industries. This project aims to demonstrate the implementation of a water level control system using TIA Portal, where the control of a water level tank simulated in Factory IO is regulated. The project involves modeling the tank in Factory IO, designing a ladder diagram-based control logic in TIA Portal, and programming the PLC to control the tank's water level. The performance of the control system will be evaluated using metrics such as rise time, settling time, and overshoot. The project showcases the effectiveness of combining TIA Portal and Factory IO to develop a dependable and robust water level control system.

2.0 Components

2.1 S7-1200 CPU 1211C DC/DC/DC

Figure 1 S7-1200 CPU 1211C DC/DC/DC

2.2 HMI KTP900 Basic PN

Figure 2 HMI KTP900 Basic PN

2.3 Liquid Level Control System

Figure 3 Liquid Level Control System

2.4 Fill Valve

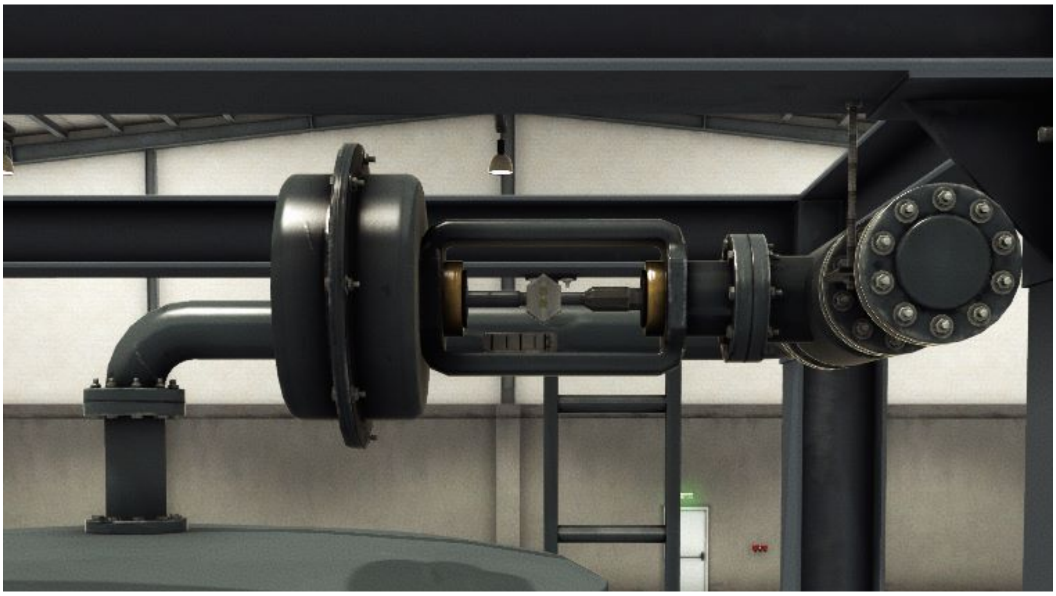


Figure 4 Fill Valve

2.5 Level Meter

Figure 5 Level Meter

2.6 Discharge Valve

Figure 6 Discharge Valve

2.7 Flow Meter

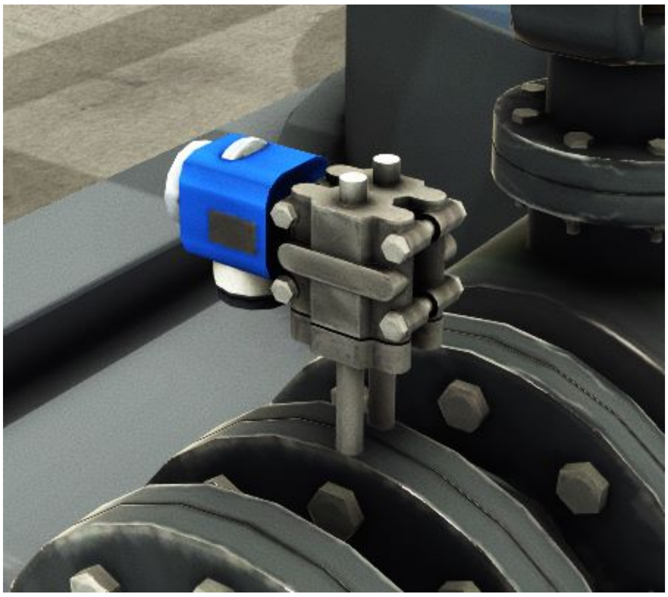


Figure 7 Flow Meter

2.8 Electric Board

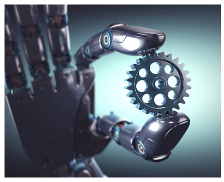
Figure 8 Electric Board

2.9 Warning Light

Figure 9 Warning Light

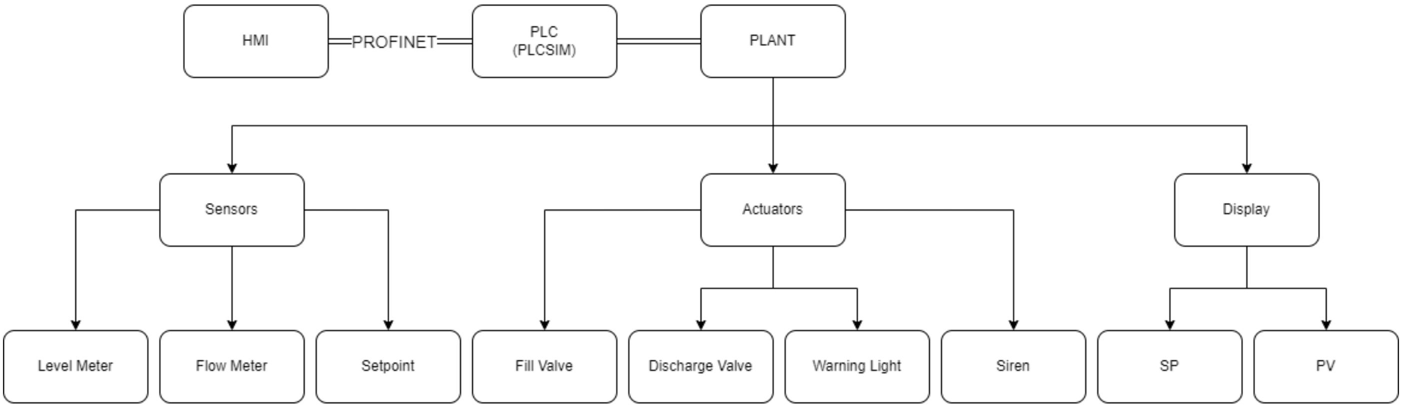
2.10 Alarm Siren

Figure 10 Alarm Siren



3.0 Block Diagrams

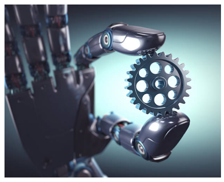
3.1 System Block



3.2 Controller Block

3.2.1 Data log output results

Ak	0.632Ak	Tc	A	K	zeta
41	25.912	28.9649957	58	0.70689655	0.9
					natural freq
Kp	Ti				1
72.3401354	1.76547557				



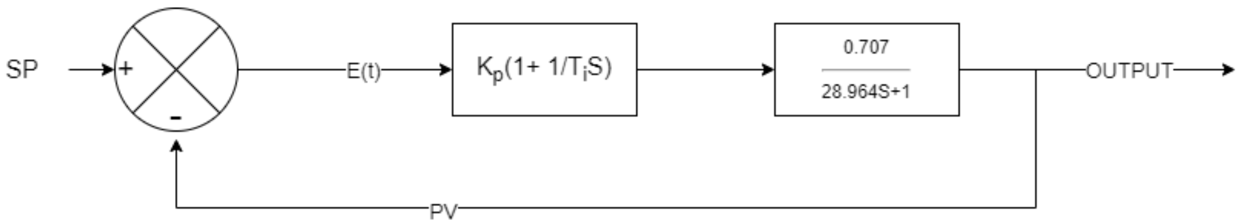
3.2.2 Transfer function

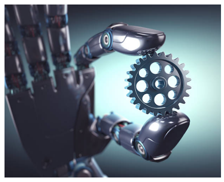
$$G = \frac{K}{TcS + 1} = \frac{0.707}{28.964\,S + 1}$$

$$S^2 + \frac{Ti + 0.707KpTi}{28.964}\,S + \frac{0.707 * kp}{28.964 * Ti} = S^2 + 2\varepsilon\omega S + \omega^2$$

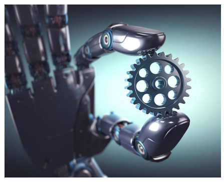
$$\frac{1 + 0.707Kp}{28.964} = 2\varepsilon\omega$$

$$\frac{0.707 * kp}{28.964 * Ti} = \omega^2$$

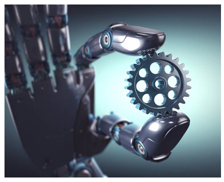




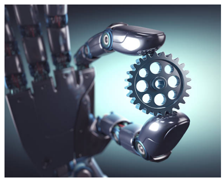
VarName	TimeString	VarValue	Validity	Time_ms	time	pV
Pv	4/18/2023 8:1	0	1	4.5034E+10	0	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	0.99944152	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	1.99888369	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	2.99733043	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	3.99678112	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	4.99622263	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	5.9956648	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	6.99312398	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	7.99256615	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	8.99200832	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	9.99045442	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	10.9879136	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	11.9853734	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	12.984815	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	13.9842571	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	14.9827124	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	15.98315	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	16.9825921	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	17.9800428	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	18.9784974	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	19.9779396	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	20.9763949	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	21.9758364	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	22.9762746	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	23.9747207	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	24.9741629	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	25.9736051	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	26.9730557	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	27.9715018	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	28.9719394	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	29.9703862	0
Pv	4/18/2023 8:1	0	1	4.5034E+10	30.9688408	0
Pv	4/18/2023 8:1	2	1	4.5034E+10	31.9672875	2
Pv	4/18/2023 8:1	3	1	4.5034E+10	32.9677251	3
Pv	4/18/2023 8:1	4	1	4.5034E+10	33.9671673	4
Pv	4/18/2023 8:1	5	1	4.5034E+10	34.9646265	5
Pv	4/18/2023 8:1	7	1	4.5034E+10	35.9630811	7
Pv	4/18/2023 8:1	8	1	4.5034E+10	36.9625232	8
Pv	4/18/2023 8:1	9	1	4.5034E+10	37.9599739	9
Pv	4/18/2023 8:1	10	1	4.5034E+10	38.9584292	10
Pv	4/18/2023 8:1	11	1	4.5034E+10	39.9588668	11
Pv	4/18/2023 8:1	12	1	4.5034E+10	40.9573129	12
Pv	4/18/2023 8:1	13	1	4.5034E+10	41.9567635	13
Pv	4/18/2023 8:1	14	1	4.5034E+10	42.9552103	14
Pv	4/18/2023 8:1	15	1	4.5034E+10	43.9546518	15



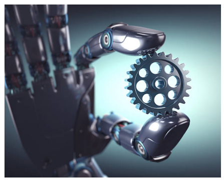
Pv	4/18/2023 8:1	16	1	4.5034E+10	44.9531071	16
Pv	4/18/2023 8:1	16	1	4.5034E+10	45.9525492	16
Pv	4/18/2023 8:1	17	1	4.5034E+10	46.9509953	17
Pv	4/18/2023 8:1	18	1	4.5034E+10	47.9504375	18
Pv	4/18/2023 8:1	19	1	4.5034E+10	48.9478967	19
Pv	4/18/2023 8:1	19	1	4.5034E+10	49.9463519	19
Pv	4/18/2023 8:1	20	1	4.5034E+10	50.9438026	20
Pv	4/18/2023 8:1	21	1	4.5034E+10	51.9432441	21
Pv	4/18/2023 8:1	21	1	4.5034E+10	52.9426948	21
Pv	4/18/2023 8:1	22	1	4.5034E+10	53.942137	22
Pv	4/18/2023 8:1	23	1	4.5034E+10	54.9415791	23
Pv	4/18/2023 8:1	23	1	4.5034E+10	55.9400344	23
Pv	4/18/2023 8:1	24	1	4.5034E+10	56.9374844	24
Pv	4/18/2023 8:1	24	1	4.5034E+10	57.9359397	24
Pv	4/18/2023 8:1	25	1	4.5034E+10	58.9333903	25
Pv	4/18/2023 8:1	25	1	4.5034E+10	59.931845	25
Pv	4/18/2023 8:1	26	1	4.5034E+10	60.9322832	26
Pv	4/18/2023 8:1	26	1	4.5034E+10	61.9307293	26
Pv	4/18/2023 8:1	27	1	4.5034E+10	62.9311669	27
Pv	4/18/2023 8:1	27	1	4.5034E+10	63.9296136	27
Pv	4/18/2023 8:1	28	1	4.5034E+10	64.9280682	28
Pv	4/18/2023 8:1	28	1	4.5034E+10	65.9275104	28
Pv	4/18/2023 8:1	29	1	4.5034E+10	66.9259657	29
Pv	4/18/2023 8:1	29	1	4.5034E+10	67.9254072	29
Pv	4/18/2023 8:1	29	1	4.5034E+10	68.9238539	29
Pv	4/18/2023 8:1	30	1	4.5034E+10	69.9223085	30
Pv	4/18/2023 8:1	31	1	4.5034E+10	70.9207553	31
Pv	4/18/2023 8:1	31	1	4.5034E+10	71.9192099	31
Pv	4/18/2023 8:1	31	1	4.5034E+10	72.9176566	31
Pv	4/18/2023 8:1	32	1	4.5034E+10	73.9170982	32
Pv	4/18/2023 8:1	32	1	4.5034E+10	74.9165403	32
Pv	4/18/2023 8:1	32	1	4.5034E+10	75.9169786	32
Pv	4/18/2023 8:1	32	1	4.5034E+10	76.9154332	32
Pv	4/18/2023 8:1	33	1	4.5034E+10	77.9138793	33
Pv	4/18/2023 8:1	33	1	4.5034E+10	78.9133214	33
Pv	4/18/2023 8:1	33	1	4.5034E+10	79.9117767	33
Pv	4/18/2023 8:1	34	1	4.5034E+10	80.9112189	34
Pv	4/18/2023 8:1	34	1	4.5034E+10	81.907682	34
Pv	4/18/2023 8:1	34	1	4.5034E+10	82.9071241	34
Pv	4/18/2023 8:1	34	1	4.5034E+10	83.9055794	34
Pv	4/18/2023 8:1	35	1	4.5034E+10	84.9040255	35
Pv	4/18/2023 8:1	35	1	4.5034E+10	85.9024808	35
Pv	4/18/2023 8:1	35	1	4.5034E+10	86.8999308	35
Pv	4/18/2023 8:1	35	1	4.5034E+10	87.8993729	35
Pv	4/18/2023 8:1	35	1	4.5034E+10	88.8978282	35
Pv	4/18/2023 8:1	36	1	4.5034E+10	89.8962743	36



Pv	4/18/2023 8:13	36	1	4.5034E+10	90.8937335	36
Pv	4/18/2023 8:13	36	1	4.5034E+10	91.8911927	36
Pv	4/18/2023 8:13	36	1	4.5034E+10	92.8886433	36
Pv	4/18/2023 8:13	36	1	4.5034E+10	93.8870986	36
Pv	4/18/2023 8:13	36	1	4.5034E+10	94.8855447	36
Pv	4/18/2023 8:13	37	1	4.5034E+10	95.8839999	37
Pv	4/18/2023 8:13	37	1	4.5034E+10	96.882446	37
Pv	4/18/2023 8:13	37	1	4.5034E+10	97.8818882	37
Pv	4/18/2023 8:13	37	1	4.5034E+10	98.8803428	37
Pv	4/18/2023 8:13	37	1	4.5034E+10	99.879785	37
Pv	4/18/2023 8:13	37	1	4.5034E+10	100.878232	37
Pv	4/18/2023 8:13	37	1	4.5034E+10	101.877682	37
Pv	4/18/2023 8:13	38	1	4.5034E+10	102.876129	38
Pv	4/18/2023 8:13	38	1	4.5034E+10	103.874575	38
Pv	4/18/2023 8:13	38	1	4.5034E+10	104.876008	38
Pv	4/18/2023 8:13	38	1	4.5034E+10	105.873467	38
Pv	4/18/2023 8:13	38	1	4.5034E+10	106.873905	38
Pv	4/18/2023 8:13	38	1	4.5034E+10	107.874343	38
Pv	4/18/2023 8:13	38	1	4.5034E+10	108.872789	38
Pv	4/18/2023 8:13	38	1	4.5034E+10	109.902043	38
Pv	4/18/2023 8:13	39	1	4.5034E+10	110.901485	39
Pv	4/18/2023 8:13	39	1	4.5034E+10	111.899931	39
Pv	4/18/2023 8:13	39	1	4.5034E+10	112.899373	39
Pv	4/18/2023 8:13	39	1	4.5034E+10	113.898824	39
Pv	4/18/2023 8:13	39	1	4.5034E+10	114.898266	39
Pv	4/18/2023 8:13	39	1	4.5034E+10	115.896712	39
Pv	4/18/2023 8:13	39	1	4.5034E+10	116.894172	39
Pv	4/18/2023 8:14	39	1	4.5034E+10	117.894609	39
Pv	4/18/2023 8:14	39	1	4.5034E+10	118.893055	39
Pv	4/18/2023 8:14	39	1	4.5034E+10	119.891511	39
Pv	4/18/2023 8:14	39	1	4.5034E+10	120.889957	39
Pv	4/18/2023 8:14	39	1	4.5034E+10	121.888412	39
Pv	4/18/2023 8:14	39	1	4.5034E+10	122.885863	39
Pv	4/18/2023 8:14	40	1	4.5034E+10	123.8863	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	124.884755	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	125.884197	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	126.883639	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	127.883081	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	128.882524	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	129.881974	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	130.88042	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	131.878866	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	132.878317	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	133.877759	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	134.877202	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	135.876644	40

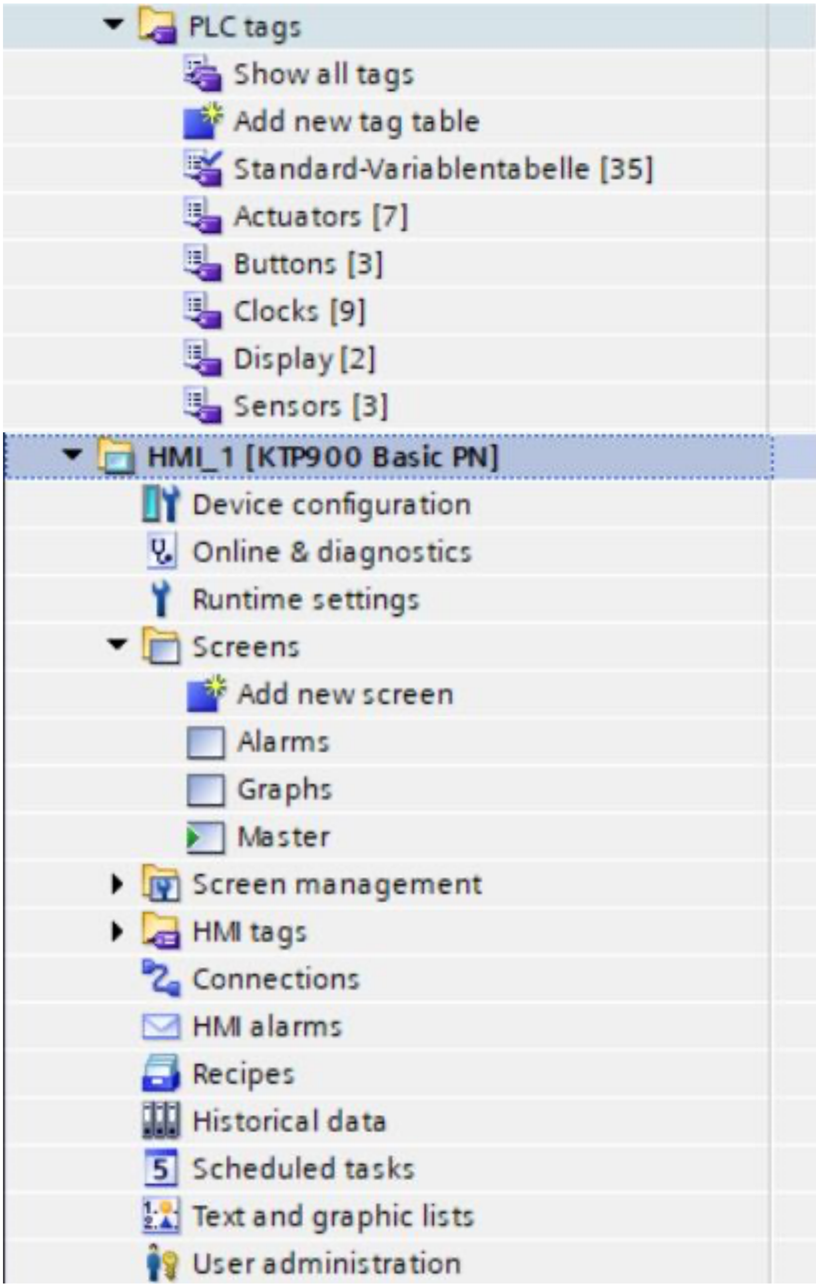


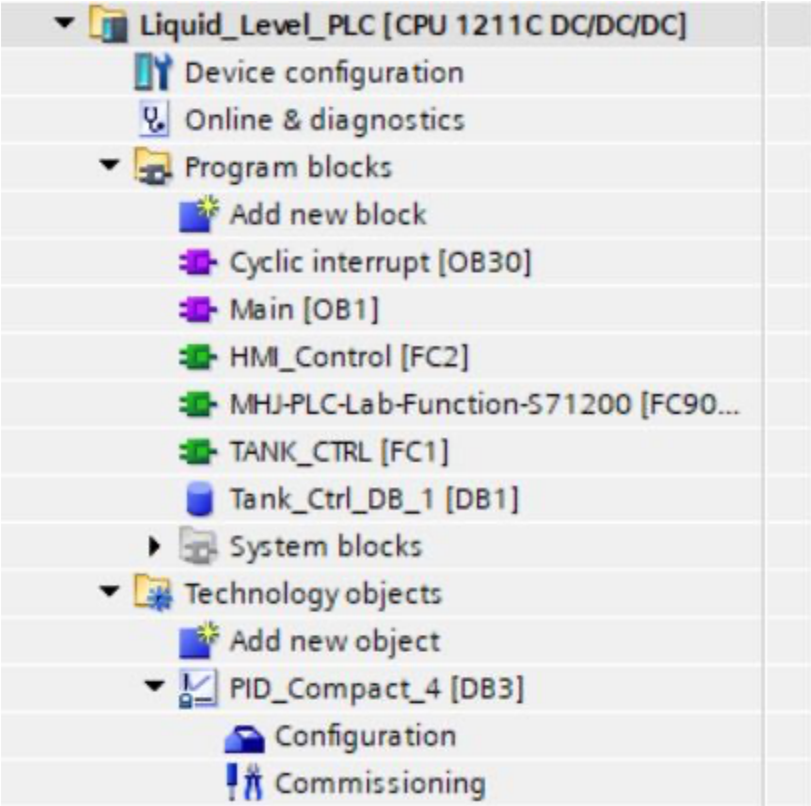
Pv	4/18/2023 8:14	40	1	4.5034E+10	136.876086	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	137.875537	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	138.874978	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	139.87442	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	140.872867	40
Pv	4/18/2023 8:14	40	1	4.5034E+10	141.871322	40
Pv	4/18/2023 8:14	41	1	4.5034E+10	142.871759	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	143.871201	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	144.869648	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	145.869099	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	146.867545	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	147.866	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	148.86345	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	149.861905	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	150.860351	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	151.859794	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	152.858249	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	153.856695	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	154.857133	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	155.855588	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	156.854034	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	157.852481	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	158.84994	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	159.849382	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	160.847837	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	161.846283	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	162.845725	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	163.84418	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	164.843622	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	165.842068	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	166.841519	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	167.841957	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	168.841399	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	169.83885	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	170.837305	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	171.835751	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	172.835193	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	173.833648	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	174.832094	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	175.830549	41
Pv	4/18/2023 8:14	41	1	4.5034E+10	176.828008	41
Pv	4/18/2023 8:15	41	1	4.5034E+10	177.828437	41
Pv	4/18/2023 8:15	41	1	4.5034E+10	178.827888	41
Pv	4/18/2023 8:15	41	1	4.5034E+10	179.826335	41
Pv	4/18/2023 8:15	41	1	4.5034E+10	180.822798	41
Pv	4/18/2023 8:15	41	1	4.5034E+10	181.821245	41



Pv	4/18/2023 8:1!	41	1	4.5034E+10	182.819699	41
Pv	4/18/2023 8:1!	41	1	4.5034E+10	183.818146	41
Pv	4/18/2023 8:1!	41	1	4.5034E+10	184.818584	41
RT_OFF	4/18/2023 8:1!	0	2	4.5034E+10		
RT_COUNT	188					

3.2.3 Program Blocks





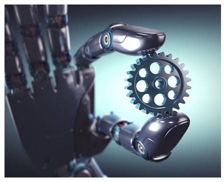
4.0 Results

4.1 PID Parameters (No Disturbance, Trial & Error)

These Parameters are used when there’s no disturbance in the system meaning that the discharge valve is not opened at all

PID Parameters:

- Kp = 2.5
- Ti = 0.0
- Td = 0.0



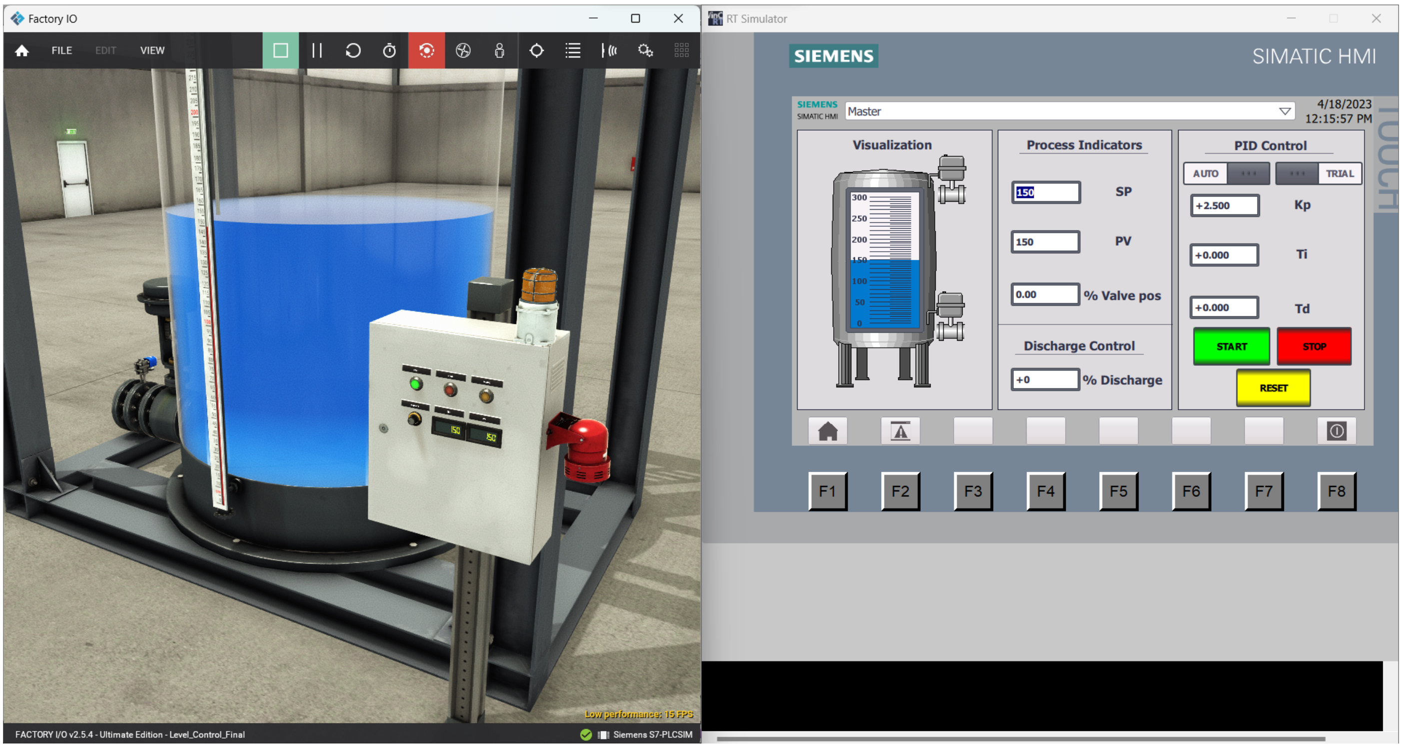


Figure 11 PID Parameters (No Disturbance)

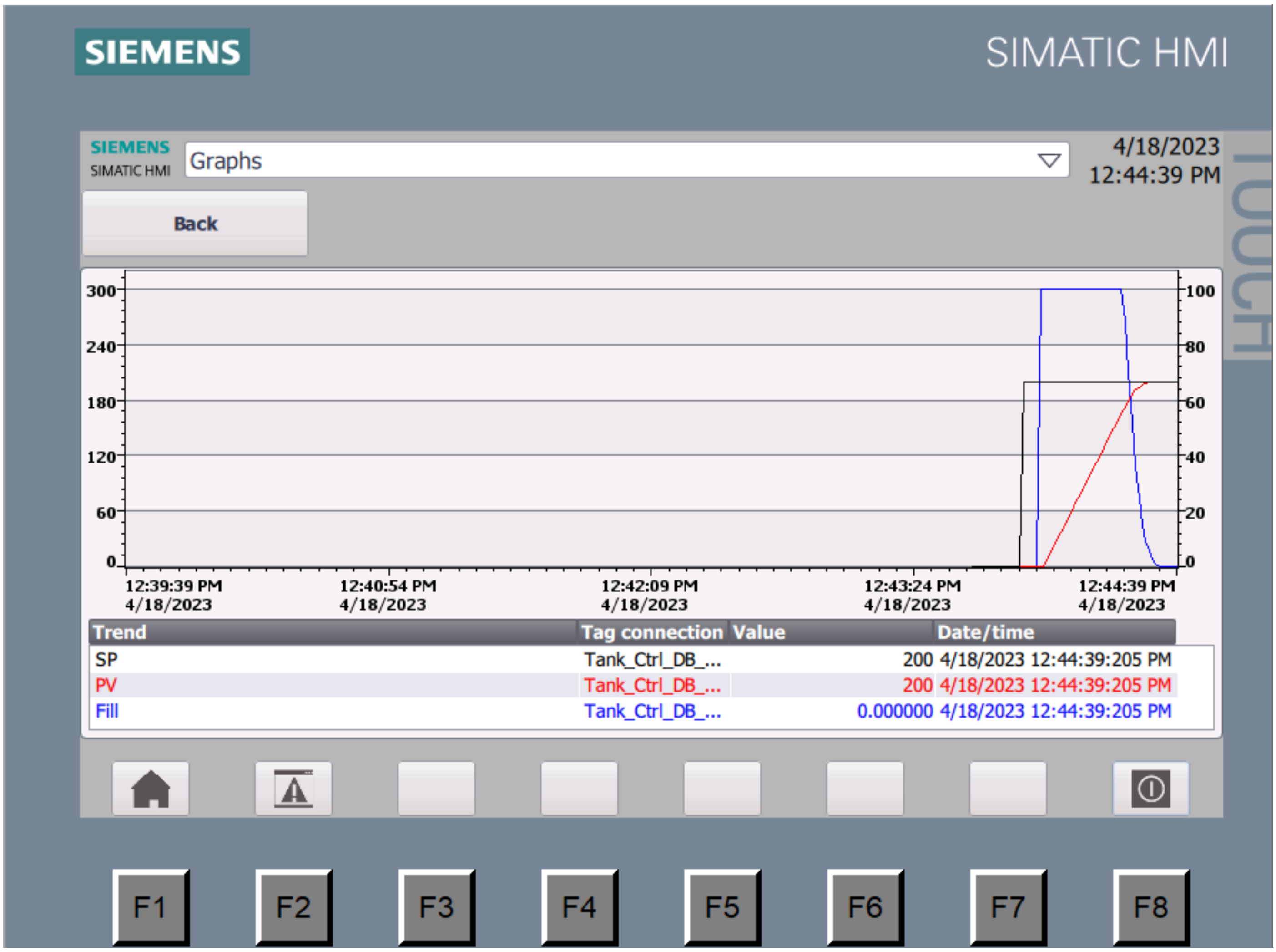
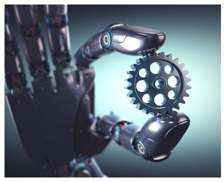


Figure 12 Graph PID Parameters (No Disturbance)



4.2 PID Parameters (With Disturbance, Trial & Error)

These Parameters are used when there's disturbance in the system meaning that the discharge valve is opened

PID Parameters:

- Kp = 2.5
- Ti = 10.0
- Td = 0.0

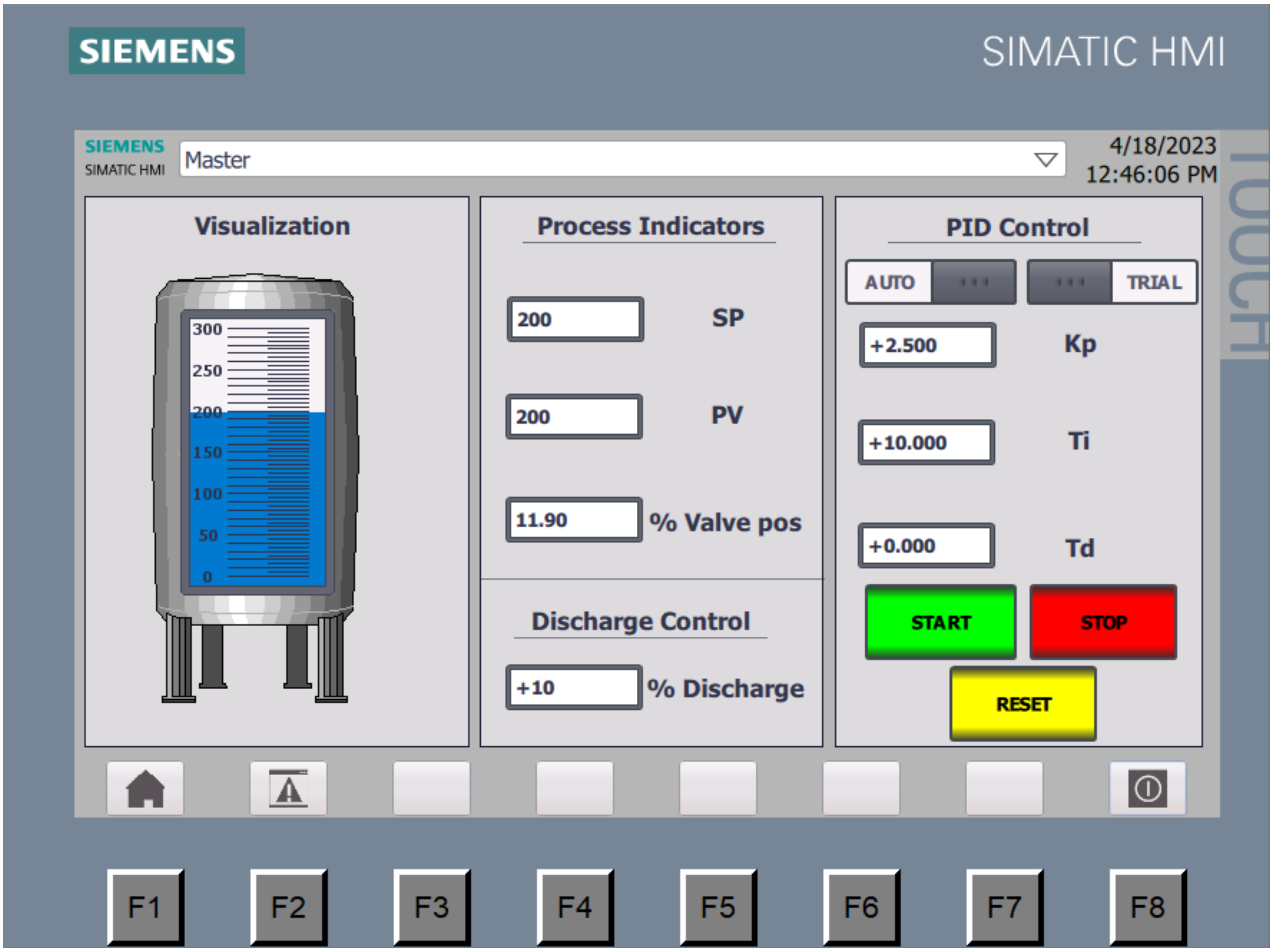


Figure 13 PID Parameters (With Disturbance)

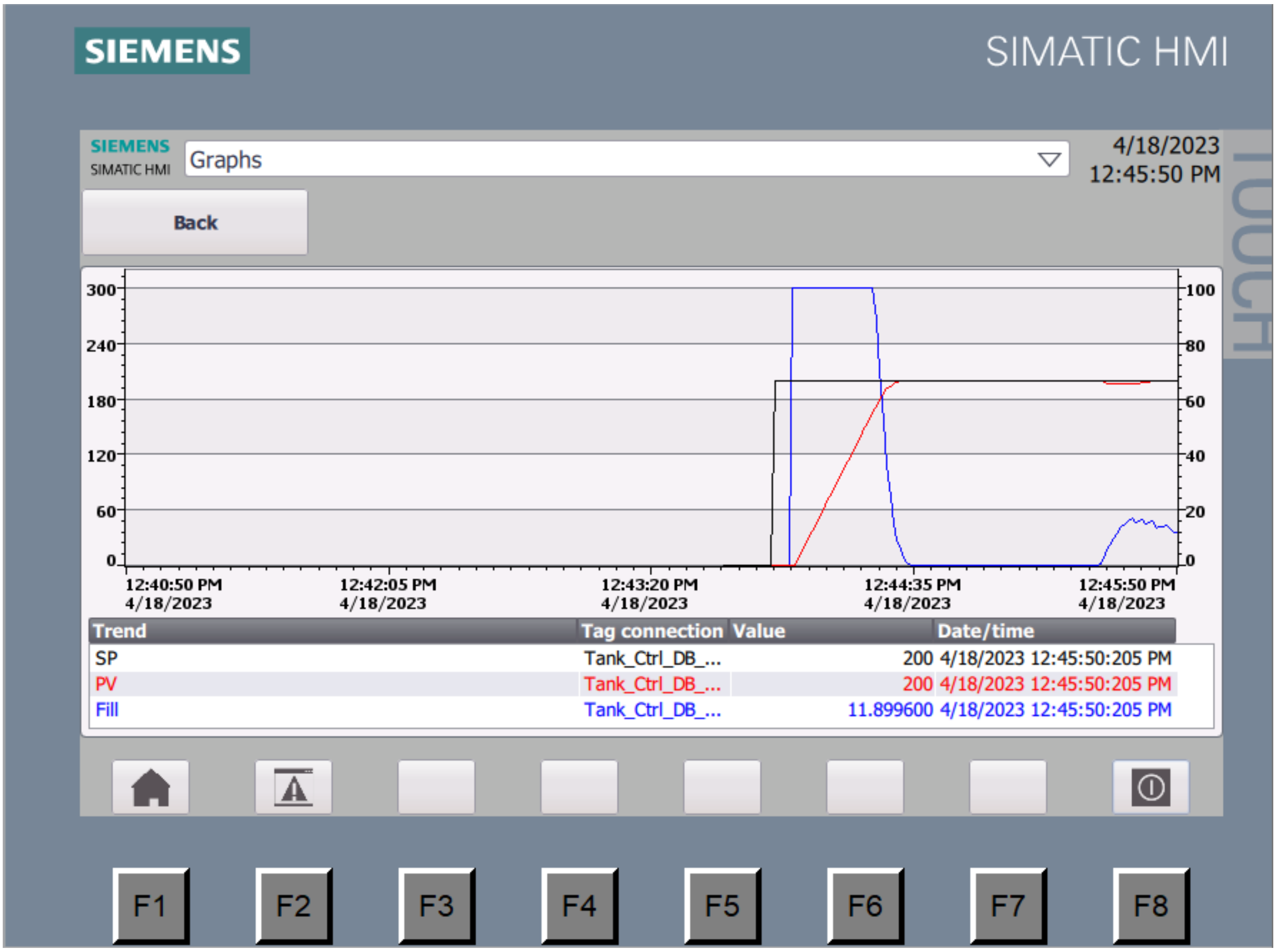
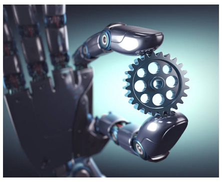


Figure 14 Graph PID Parameters (With Disturbance)



4.3 PID Parameters (With Disturbance, Calculated)

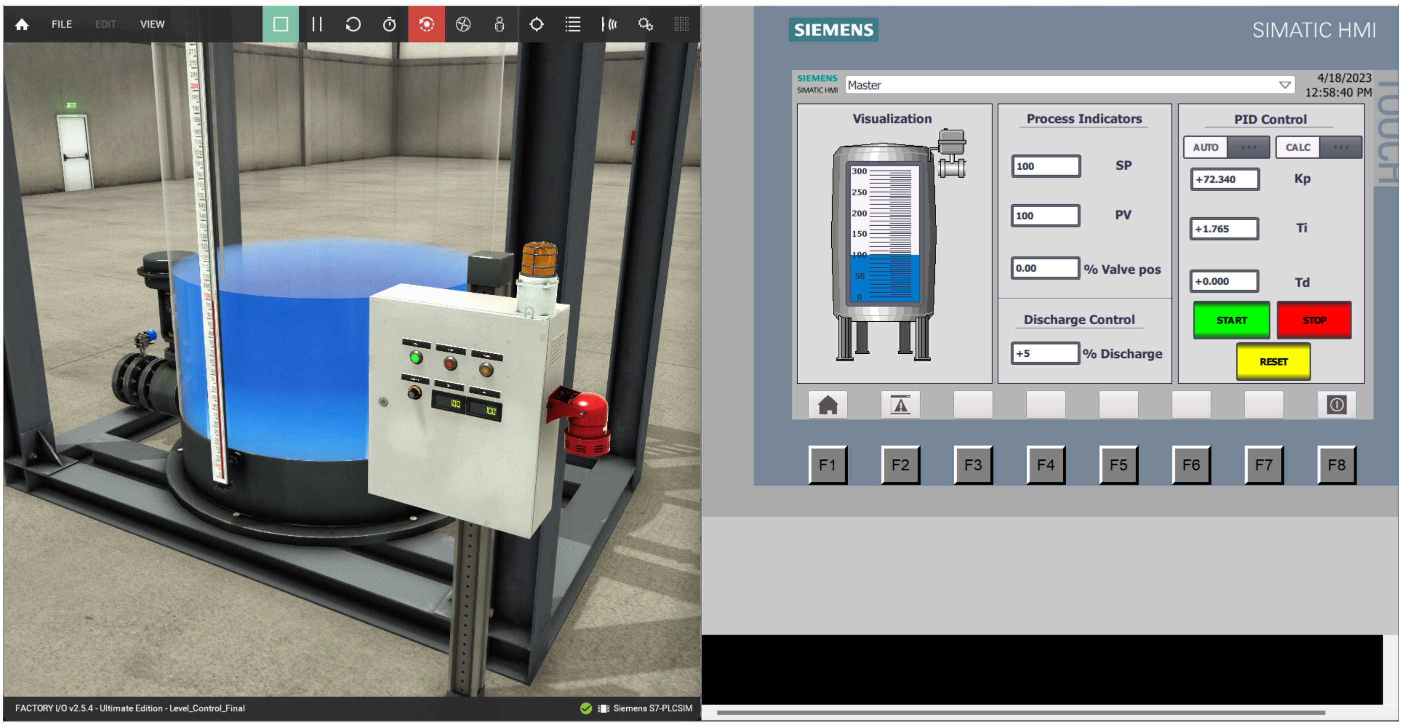


Figure 15: Calculated Parameters

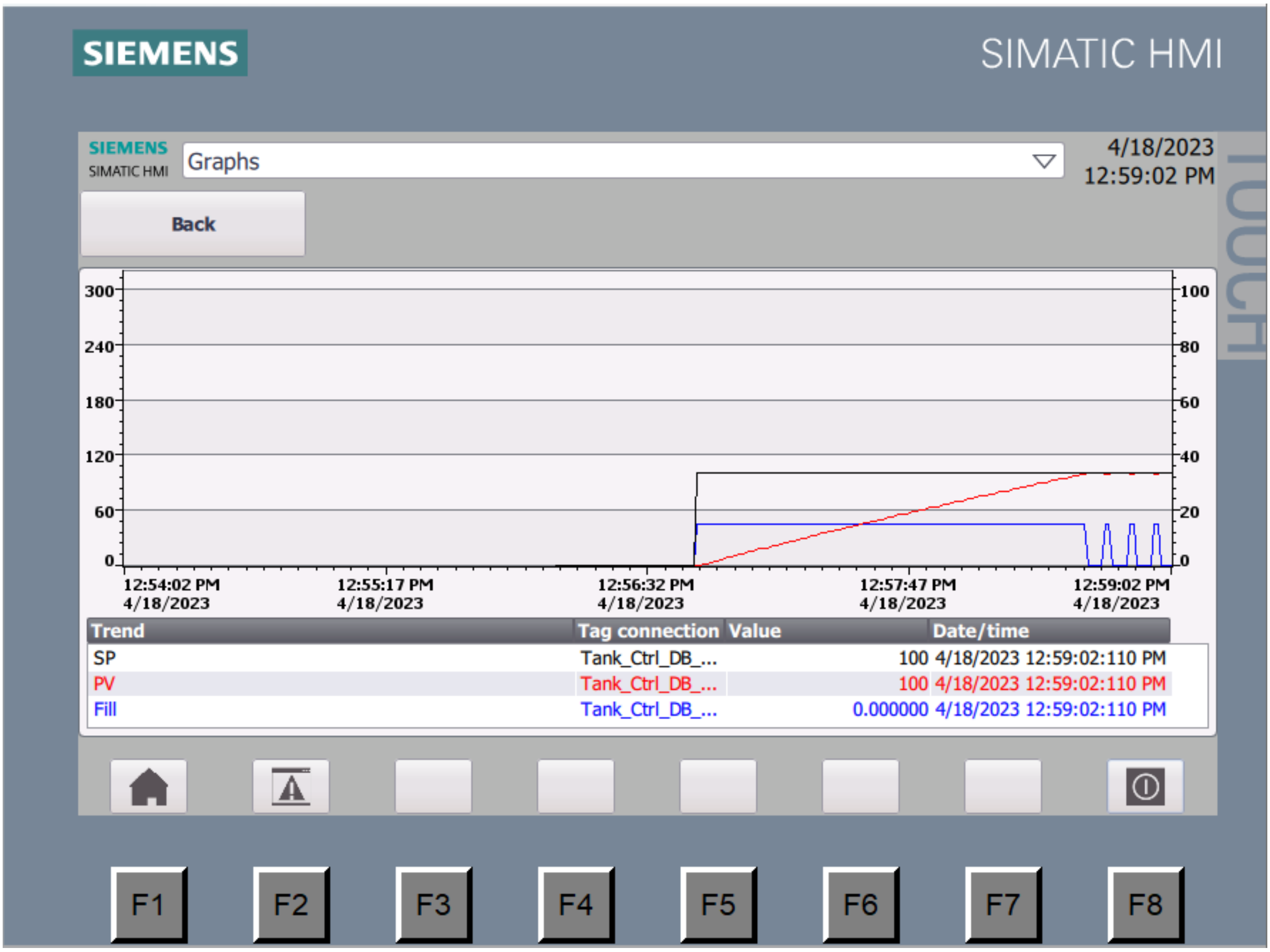
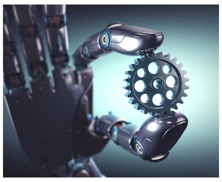


Figure 16: Graph for system with PID parameters calculated

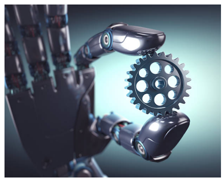


4.4 Out of Range Setpoint Setting

If the Setpoint is out of range the following events occur

- System Stops
- Warning Light lights
- Warning appears inside alarm HMI

Figure 17 Out of range setpoint setting



The Alarm HMI is where all Error and Warning messages appear.
In Figure 16, a warning message appears when the setpoint was declared out of range

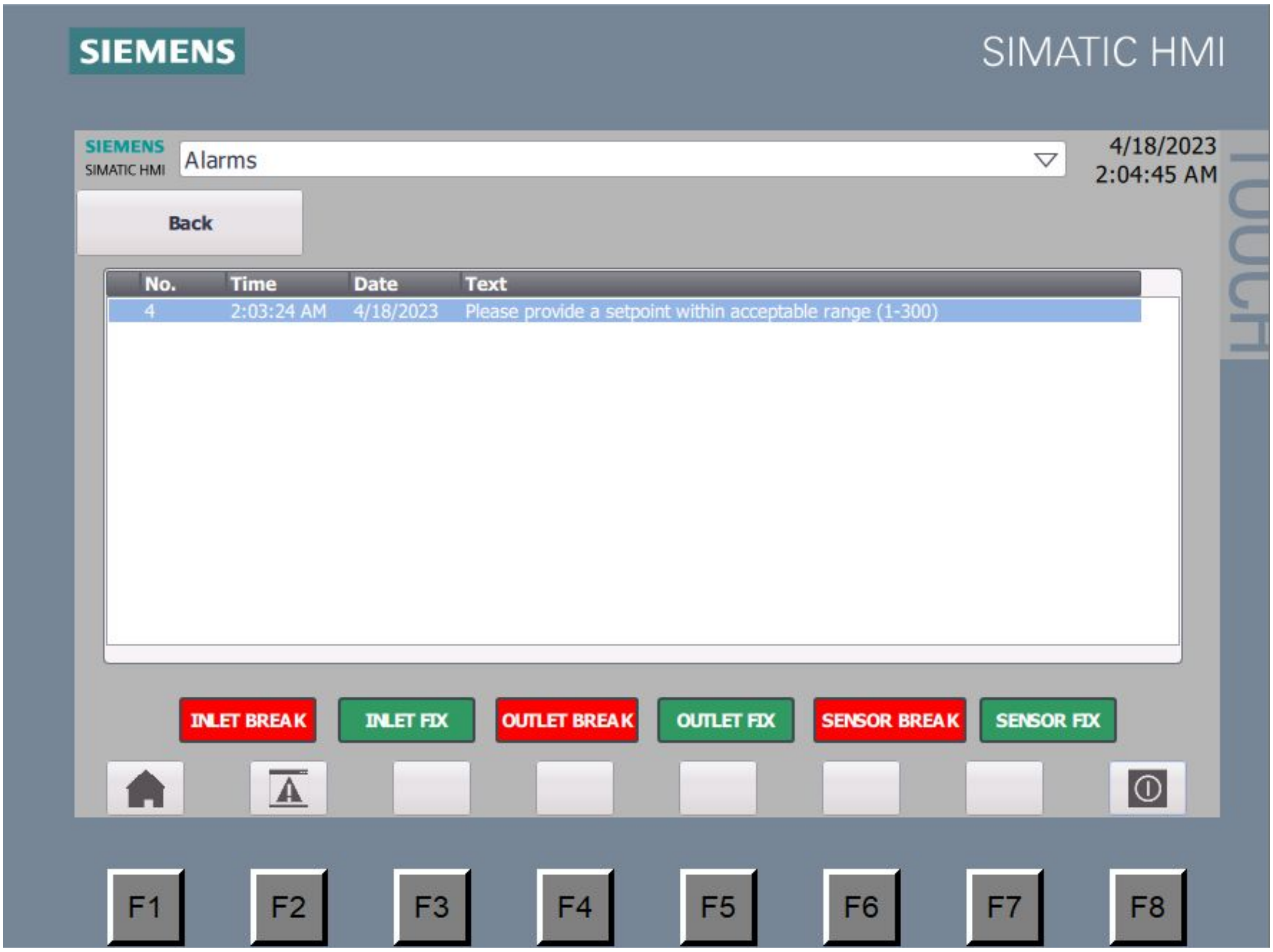
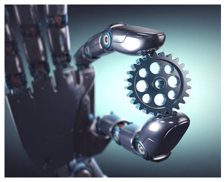
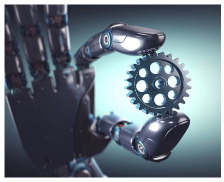


Figure 18 Warning Notification for out-of-range setpoint setting



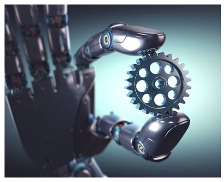
4.5 Forcing outflow while discharge valve is closed

Figure 19 Forcing outflow while discharge valve is closed



In Figure 18, a warning message appears when valve is not operating properly as flow meter is reading while valve is closed

Figure 20 Warning Notification for forcing outflow while discharge valve is closed



4.6 Forcing errors in Inlet, Discharge valves and level meter sensor

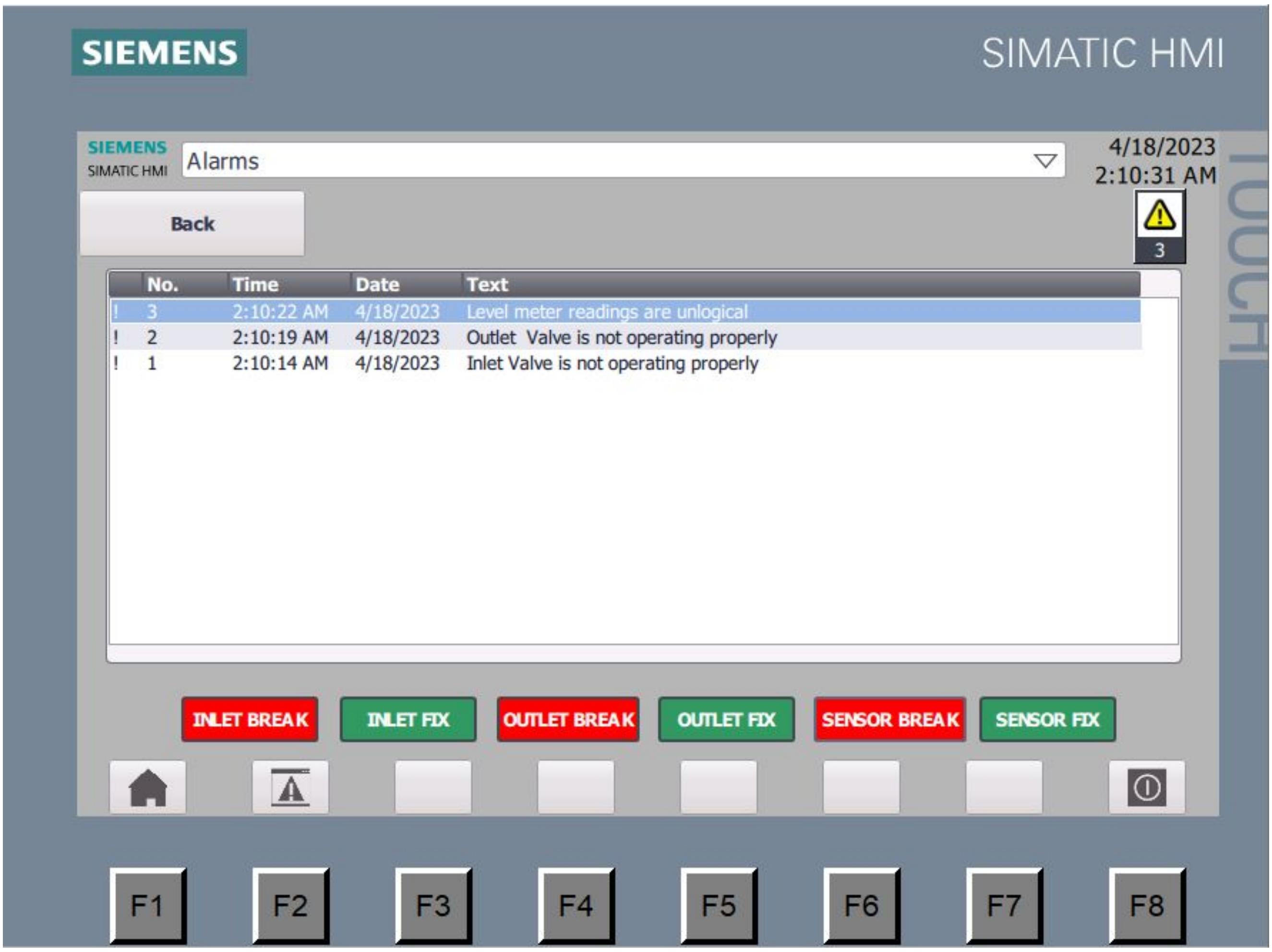
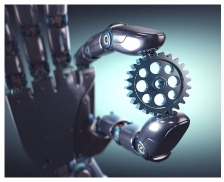
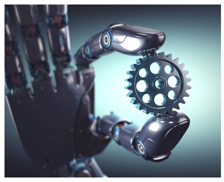


Figure 21 Forcing errors in Inlet, Discharge valves and level meter sensor



5.0 Drive Link

Link: https://drive.google.com/file/d/1G1T_TvJkfsN_ua211MG8a_QHr-3YHPZ6/view?usp=share_link



6.0 Conclusion

In conclusion, using TIA Portal to control a water level tank on Factory IO using a PID controller is a highly effective method for regulating fluid levels in industrial processes. The PID controller algorithm continuously monitors and adjusts the control parameters to maintain a desired level of fluid in the tank, ensuring accuracy and stability in the system. Additionally, TIA Portal offers a user-friendly interface and a wide range of tools and functions for programming and monitoring the system, making it a popular choice for industrial automation applications. Overall, the combination of TIA Portal and PID control provides an efficient and reliable solution for managing water levels in industrial processes.