Lab 10: Temperature PID Control

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Humber Polytechnics
Programmable Logic Controllers: MENG 3500 0NB
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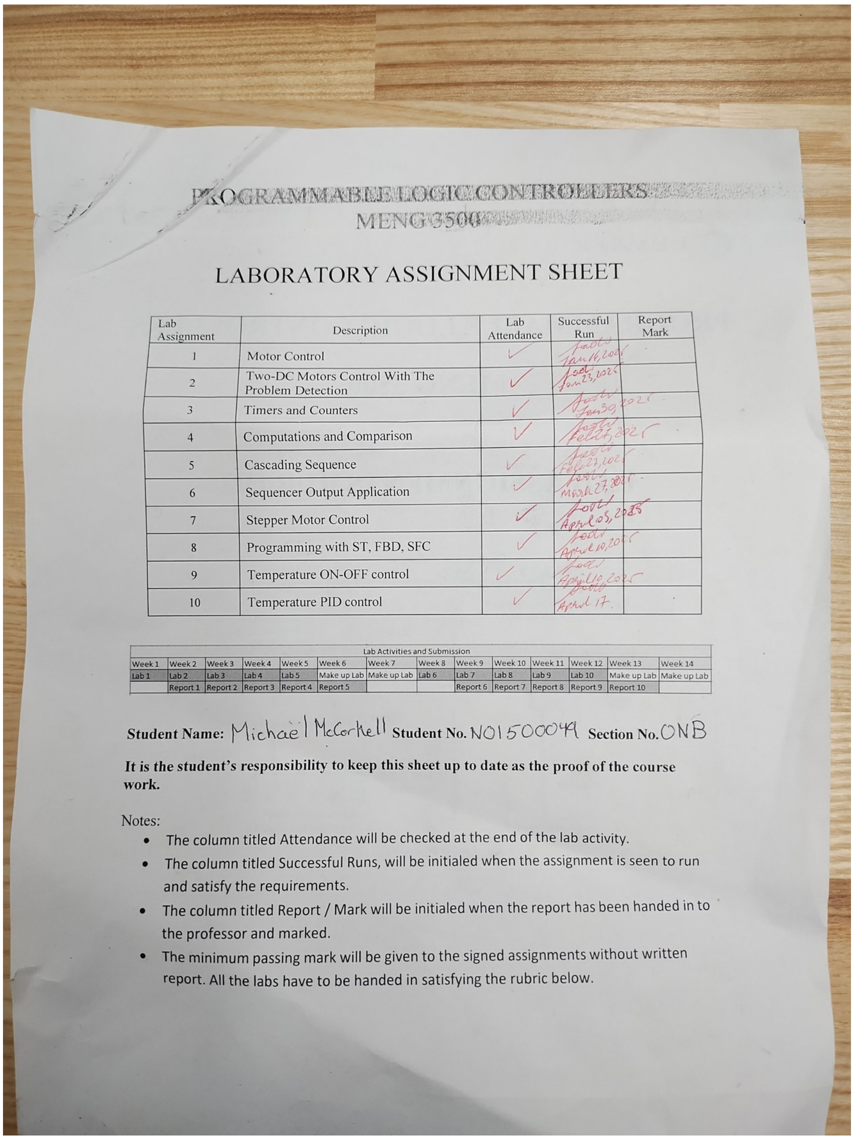
April 17th, 2025



PROGRAMMABLE LOGIC CONTROLLERS
MENG 3500

LABORATORY ASSIGNMENT SHEET

Lab Assignment	Description	Lab Attendance	Successful Run	Report Mark
1	Motor Control	✓	Jan 16, 2025	
2	Two-DC Motors Control With The Problem Detection	✓	Jan 23, 2025	
3	Timers and Counters	✓	Jan 30, 2025	
4	Computations and Comparison	✓	Feb 27, 2025	
5	Cascading Sequence	✓	Feb 27, 2025	
6	Sequencer Output Application	✓	March 27, 2025	
7	Stepper Motor Control	✓	April 03, 2025	
8	Programming with ST, FBD, SFC	✓	April 10, 2025	
9	Temperature ON-OFF control	✓	April 10, 2025	
10	Temperature PID control	✓	April 17.	

Lab Activities and Submission													
Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Make up Lab	Make up Lab	Lab 6	Lab 7	Lab 8	Lab 9	Lab 10	Make up Lab	Make up Lab
	Report 1	Report 2	Report 3	Report 4	Report 5			Report 6	Report 7	Report 8	Report 9	Report 10	

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It is the student's responsibility to keep this sheet up to date as the proof of the course work.

Notes:
- The column titled Attendance will be checked at the end of the lab activity.
- The column titled Successful Runs, will be initialed when the assignment is seen to run and satisfy the requirements.
- The column titled Report / Mark will be initialed when the report has been handed in to the professor and marked.
- The minimum passing mark will be given to the signed assignments without written report. All the labs have to be handed in satisfying the rubric below.

Objectives

This lab focused on implementing PID (Proportional-Integral-Derivative) control using RSLogix 5000 and integrating it with an HMI in FactoryTalk Studio SE for continuous temperature regulation. The main objectives were:

- Configuring analog input/output modules for temperature control.
- Applying PID function blocks to maintain precise temperature conditions.
- Designing a user interface for real-time monitoring and adjustment of PID parameters.
- Fine-tuning Kp, Ki, and Kd values to achieve optimal control performance.
- Monitoring system behavior through real-time and historical trending.
- Verifying the performance of the system under changing set points (30°C, 35°C, 40°C).

Description of Work Completed

1. Wiring and Initialization
   - The RTD sensor was connected to Analog Input Channel 0 (`Local:3:I.CH0Data`).
   - The Analog Output Channel 0 (`Local:4:O.CH0Data`) was wired to control the DC drive that regulates heater power.
   - Input devices such as START_PB and STOP_PB were also connected and verified.

2. PLC Programming in RSLogix 5000
   - A PID function block was created in a new RSLogix project (PID.ACD).
   - A Start-Stop-Run rung controlled the process logic:
   - START_PB (N.O.) activated the system.
   - STOP_PB (N.C.) deactivated the system.
   - RUN tag was used to enable PID control only when active.
   - PID block parameters:
   - Set Point (PID1.SP) was initially set to 30°C.
   - Process Variable (PID1.PV) came from the scaled analog input.
   - Error (PID1.ERR) was the difference between SP and PV.
   - Tuning began with estimated Kp, Ki, Kd values, later refined.

3. HMI Development in FactoryTalk Studio SE
   - Display 1: Control Panel
     - START and STOP pushbuttons.
     - Multistate Indicator to show RUNNING status.
     - Numeric Inputs for:
       - Set Point (PID1.SP)
       - Kp, Ki, Kd
     - Numeric Displays for:
       - Temperature (PID1.PV)
       - Set Point (PID1.SP)
       - Error (PID1.ERR)
   - Display 2: Process Monitoring
     - Real-Time Trend for SP, PV, and ERR.
     - Historical Trend for evaluating PID response over time.
     - Navigation buttons for seamless display switching.

4. PID Controller Tuning and Testing

- The Scaling tab in the PID setup was configured to map the 1–5 V analog range to 0–100°C.
- Using the Tuning tab, PID parameters were incrementally adjusted to:
    - Minimize overshoot.
    - Reduce settling time.
    - Maintain steady-state accuracy.
- Set Point Adjustments and Monitoring:
    - 30°C: Initial set point used for baseline tuning.
    - 35°C: Evaluated system's ability to ramp and stabilize with minimal overshoot.
    - 40°C: Final test for rapid response and low error margin.

Screenshots and trend graphs were captured to visualize and analyze temperature behavior.

5. Output Devices and Status Indicators

- GREEN_LIGHT: Illuminated when system was actively running.
- RED_LIGHT: Turned on during fault or stop conditions.

Analog Output: Controlled heater power via a DC drive.

Conclusions

The lab successfully demonstrated closed-loop control using PID in a PLC environment. By integrating the RSLogix PID function with a real-time HMI, the system achieved automated temperature regulation with user-adjustable control parameters. Fine-tuning the Kp, Ki, and Kd values allowed for an optimized response, with reduced overshoot and improved steady-state stability. The use of real-time and historical trending provided valuable insights into system performance, reinforcing key principles of control theory, process automation, and user interface design.

Initiates the "MM_Run" status when the start pushbutton (MM_StartPB) is pressed and the stop pushbutton (MM_StopPB) is not active, enabling the main control sequence. Uses and as conditions.

0
MM_StopPB <Local:1:I.Data.5>
MM_StartPB <Local:1:I.Data.4>
MM_Run
MM_Run

Activates the MM_TON timer when MM_Run is true, controlling the timing of the MM_PID process variable. Ensures proper timing for PID loop execution with a preset of 50.

1
MM_TimerPID.DN

TON	
Timer	MM_TimerPID
Preset	50
Accum	43

EN
DN

Moves the input data from Local:3:I.Ch0Data to MM_PID.PV (Process Variable) when the MM_TimerPID timer is done, updating the PID with the current process value.

2

MOV	
Source	Local:3:I.Ch0Data
	31.001648
Dest	MM_PID_PV
	31

Executes the MM_PID instruction block when MM_Run is true, managing the PID control loop with process variable (MM_PID.PV), setpoint (MM_PID.SP), and output (MM_PID.OUT) parameters.

3
MM_TimerPID.DN
MM_Run

PID	
PID	MM_PID ...
Process Variable	MM_PID_PV
Tieback	0
Control Variable	MM_PID_CV
PID Master Loop	0
Inhold Bit	0
Inhold Value	0
Setpoint	30.0
Process Variable	31.0
Output %	0.0

Transfers the PID control variable (MM_PID.CV) to Local:4:O.Ch0Data, providing the control output to an external device or system.

4

MOV	
Source	MM_PID_CV
	0
Dest	Local:4:O.Ch0Data
	0.0

Computes MM_LowLimit as MM_PID.SP + 2 using a CPT instruction, defining the lower limit for the process variable based on the setpoint.

5

CPT	
Dest	MM_LowLimit
	32
Expression	MM_PID.SP + 2

Computes MM_HighLimit as MM_PID.SP - 2 using a CPT instruction, defining the upper limit for the process variable based on the setpoint.

6

CPT	
Dest	MM_HighLimit
	28
Expression	MM_PID.SP - 2

Activates MM_GreenLight () when MM_PID.PV is within limits (between MM_LowLimit and MM_HighLimit), and MM_RedLight () when out of range, indicating process status.

7
LIM
Low Limit MM_LowLimit
32
Test MM_PID_PV
31
High Limit MM_HighLimit
28

MM_GreenLight
<Local:2:O.Data.1>
( )

Activates when Rung 7 is denergized, activating "MM_RedLight".

8
MM_GreenLight
<Local:2:O.Data.1>
]/[

MM_RedLight
<Local:2:O.Data.3>
( )

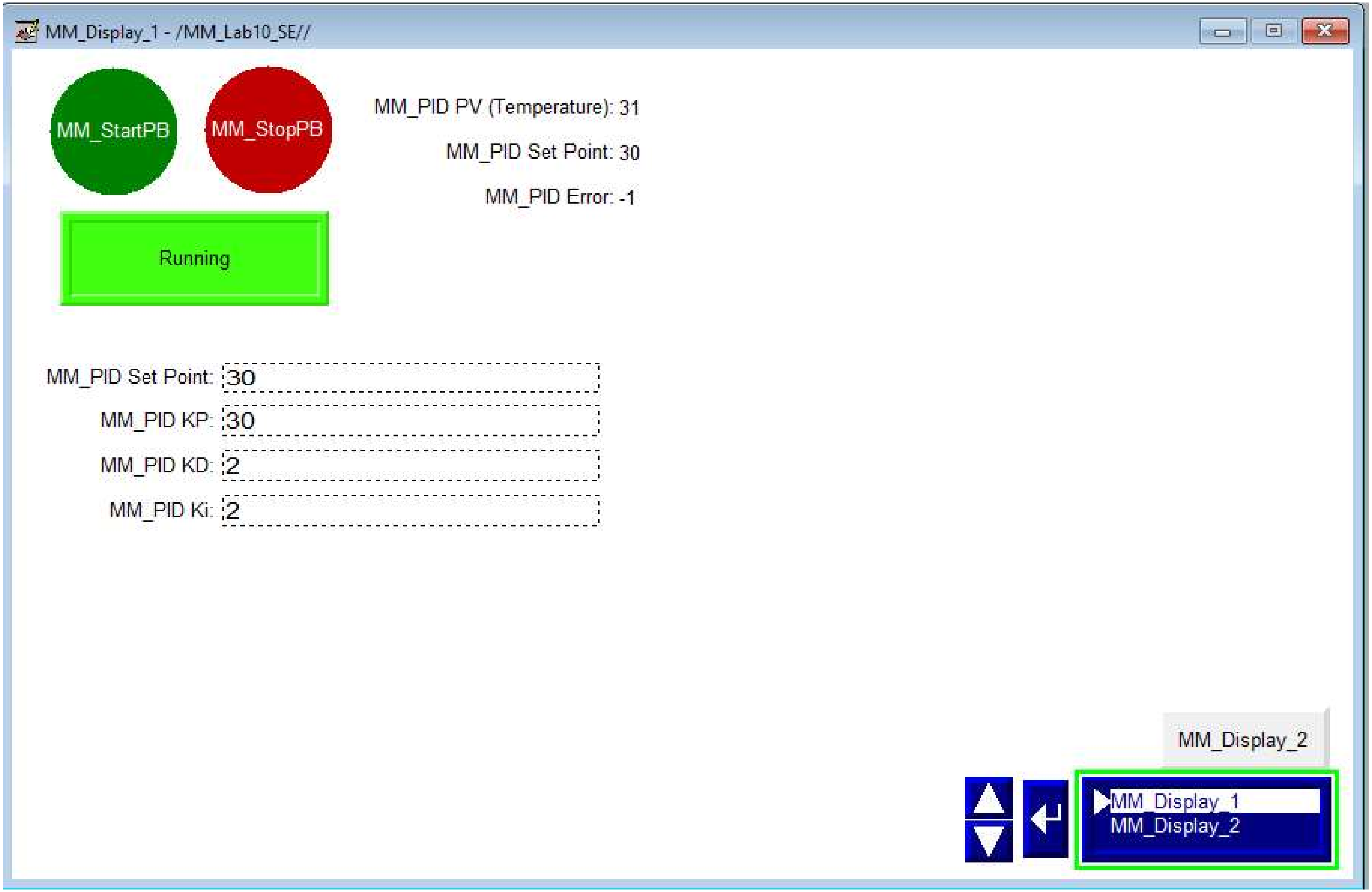
Moves 0 to Local:4:O.Ch0Data and MM_PID.OUT to reset the control output and PID output, ensuring a safe state or initialization when MM_Run is false.

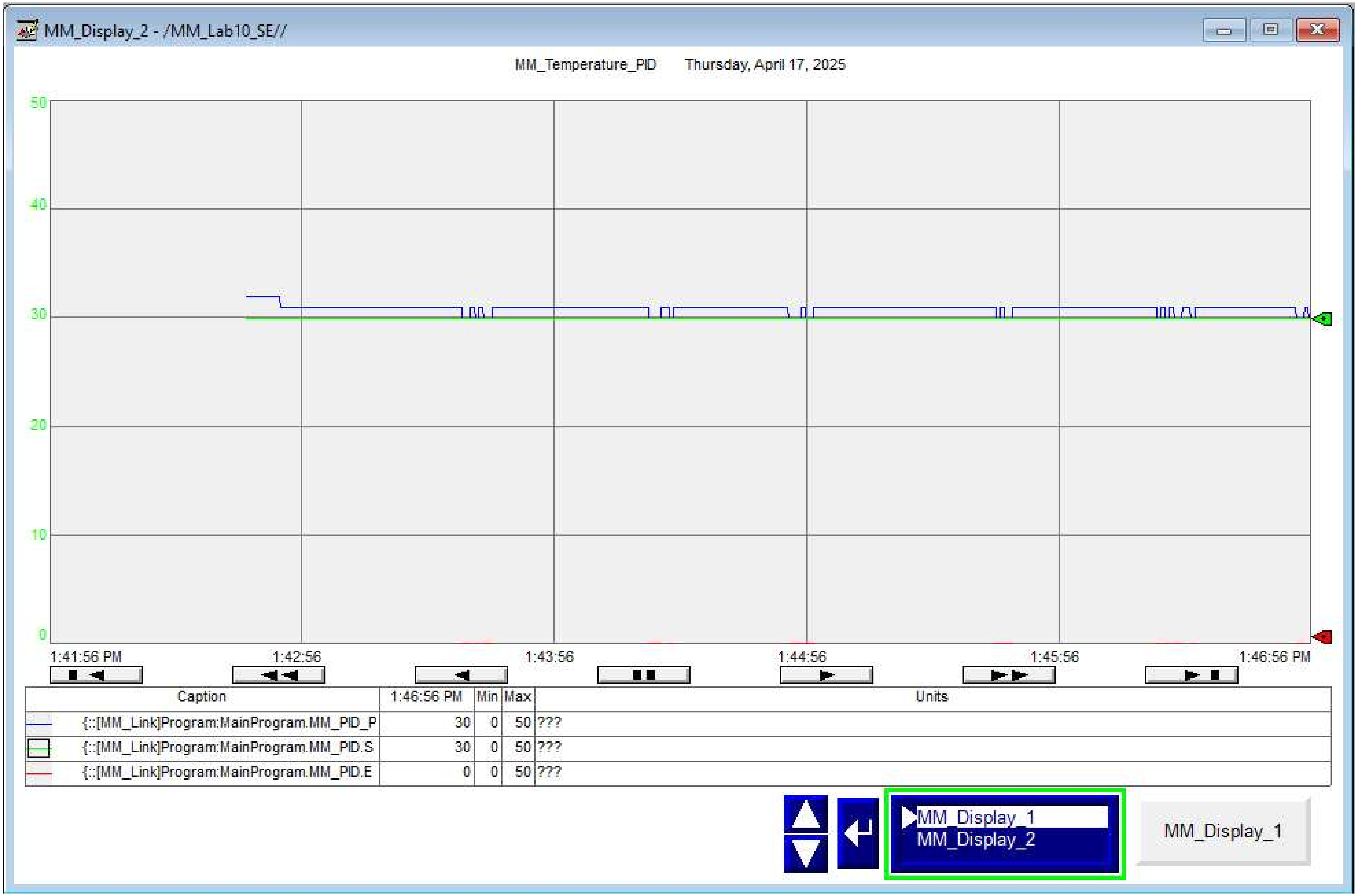
9
MM_Run
]/[

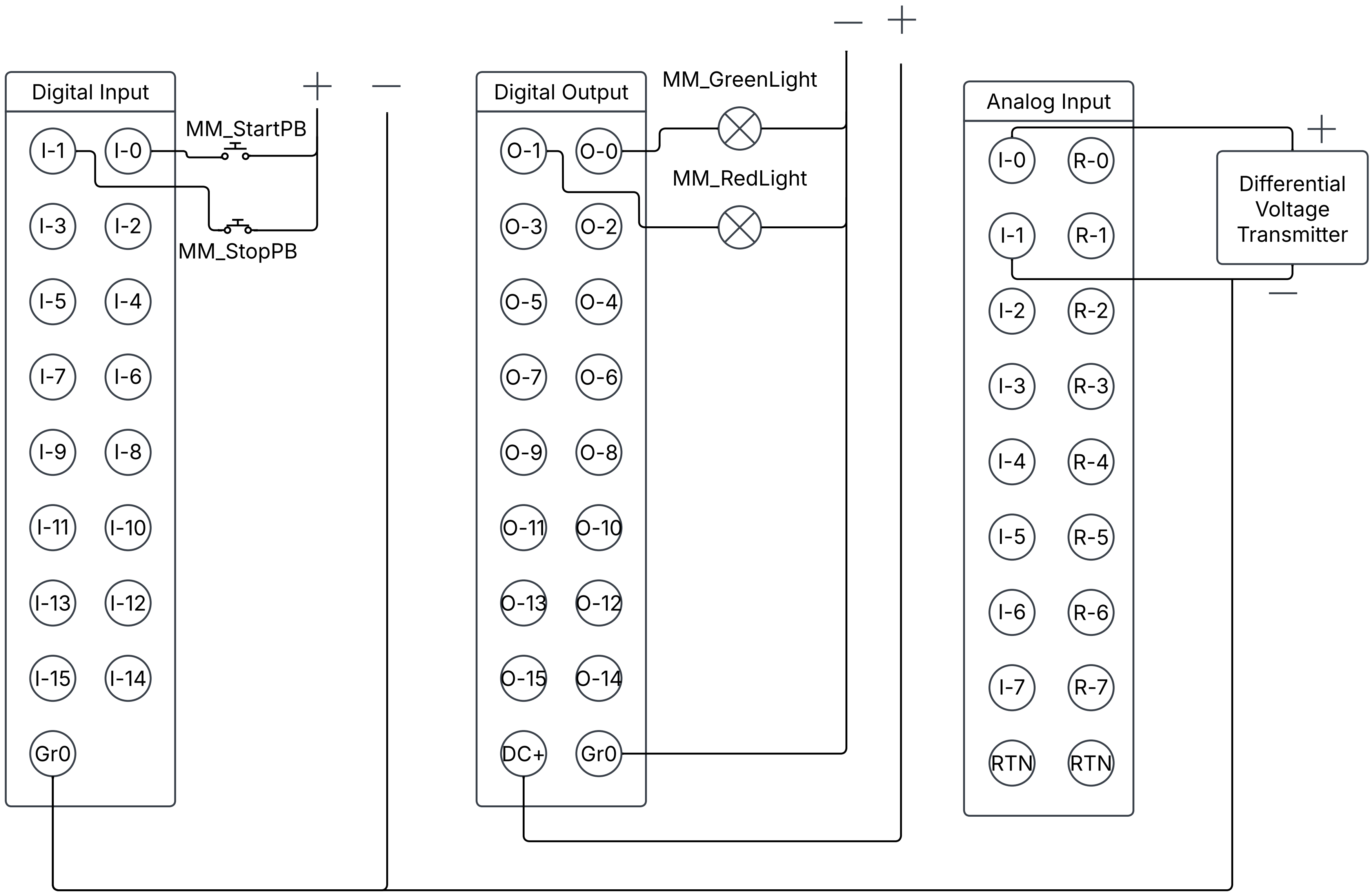
MOV
Source 0
Dest Local:4:O.Ch0Data
0.0

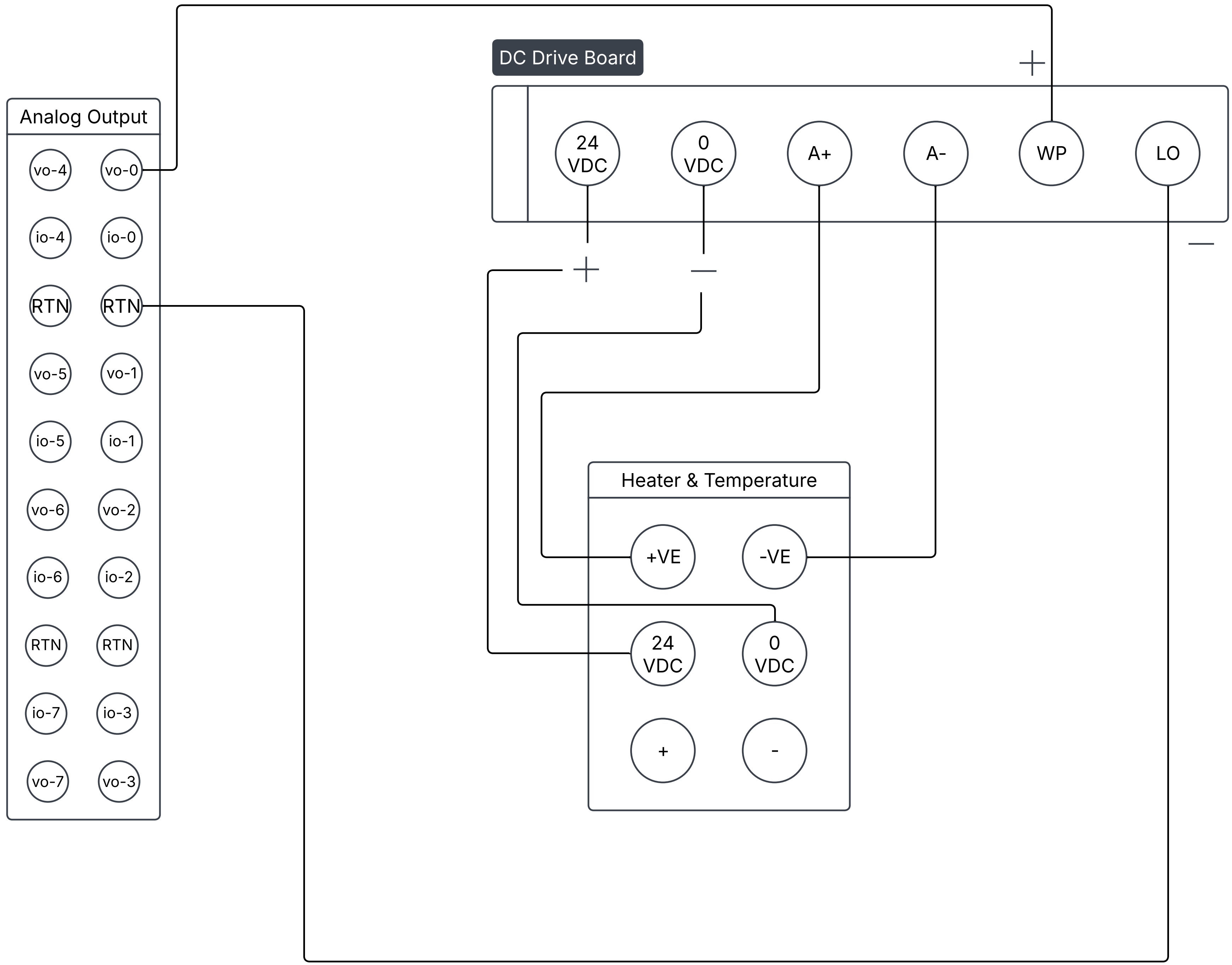
MOV
Source 0
Dest MM_PID.OUT
0.0

(End)


MM_Display_1 - /MM_Lab10_SE//
MM_StartPB
MM_StopPB
MM_PID PV (Temperature): 31
MM_PID Set Point: 30
MM_PID Error: -1
Running
MM_PID Set Point: 30
MM_PID KP: 30
MM_PID KD: 2
MM_PID Ki: 2
MM_Display_2
MM_Display_1
MM_Display_2


MM_Display_2 - /MM_Lab10_SE//
MM_Temperature_PID
Thursday, April 17, 2025
50
40
30
20
10
0
1:41:56 PM
1:42:56
1:43:56
1:44:56
1:45:56
1:46:56 PM
Caption
1:46:56 PM
Min
Max
Units
{::[MM_Link]Program:MainProgram.MM_PID_P 30 0 50 ???
{::[MM_Link]Program:MainProgram.MM_PID.S 30 0 50 ???
{::[MM_Link]Program:MainProgram.MM_PID.E 0 0 50 ???
MM_Display_1
MM_Display_2
MM_Display_1


Digital Input
I-1
I-0
I-3
I-2
I-5
I-4
I-7
I-6
I-9
I-8
I-11
I-10
I-13
I-12
I-15
I-14
Gr0
MM_StartPB
MM_StopPB
+
—
Digital Output
O-1
O-0
O-3
O-2
O-5
O-4
O-7
O-6
O-9
O-8
O-11
O-10
O-13
O-12
O-15
O-14
DC+
Gr0
MM_GreenLight
MM_RedLight
—
+
Analog Input
I-0
R-0
I-1
R-1
I-2
R-2
I-3
R-3
I-4
R-4
I-5
R-5
I-6
R-6
I-7
R-7
RTN
RTN
Differential Voltage Transmitter
+
—



Analog Output
vo-4
vo-0
io-4
io-0
RTN
RTN
vo-5
vo-1
io-5
io-1
vo-6
vo-2
io-6
io-2
RTN
RTN
io-7
io-3
vo-7
vo-3
DC Drive Board
24 VDC
0 VDC
A+
A-
WP
LO
Heater & Temperature
+VE
-VE
24 VDC
0 VDC
+
-