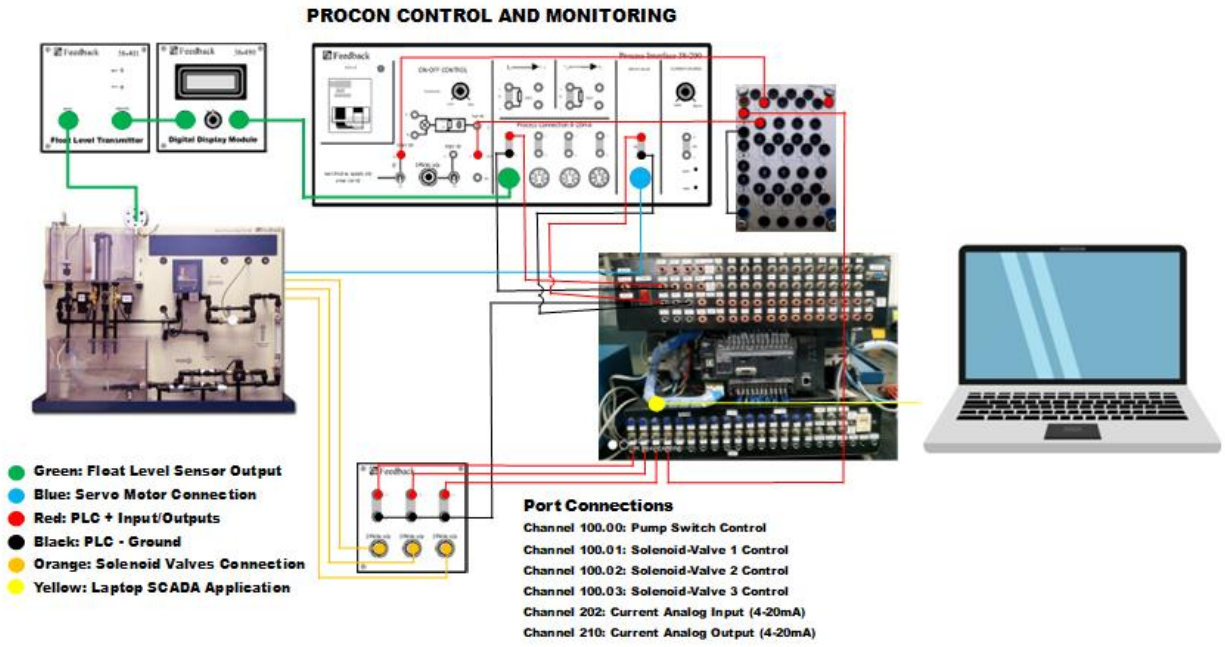
PROCON Water Tank Monitoring and Control with SCADA

1. TASK Assignment

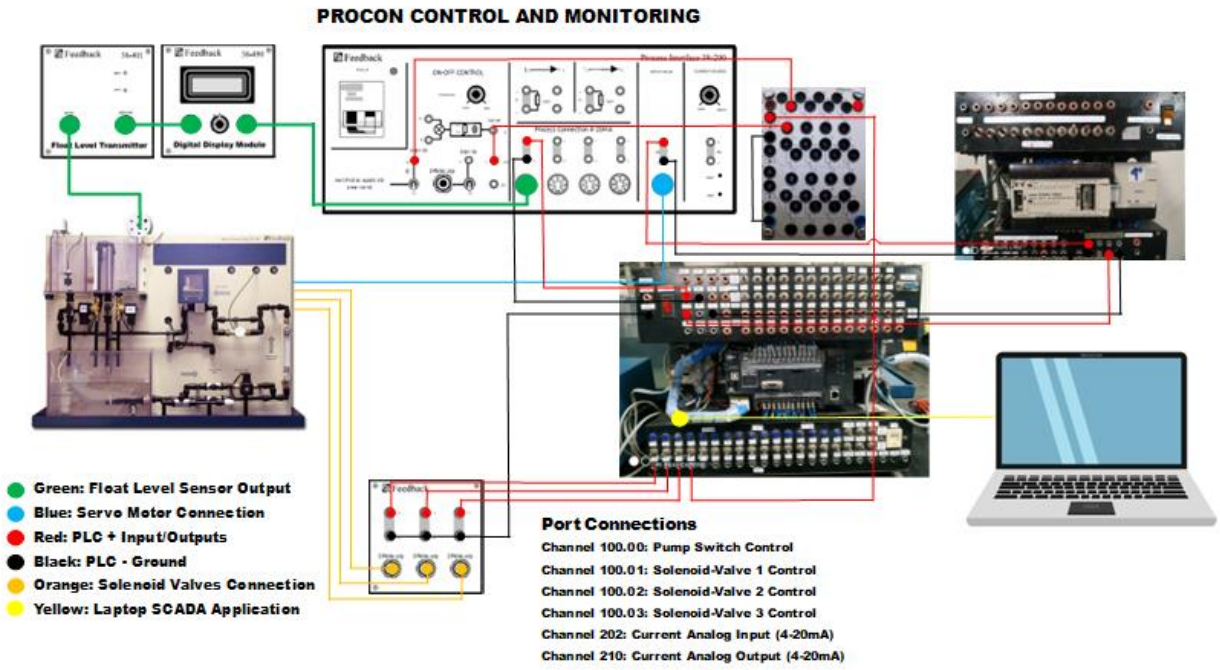
The task given for the module 3 project is the design application of SCADA layout with the PROCON interface. This implements both software and hardware configuration. The OMRON CX-Programmer and CX-Supervisor software are used together with the CP1H PLC for this activity.

2. SCADA Application



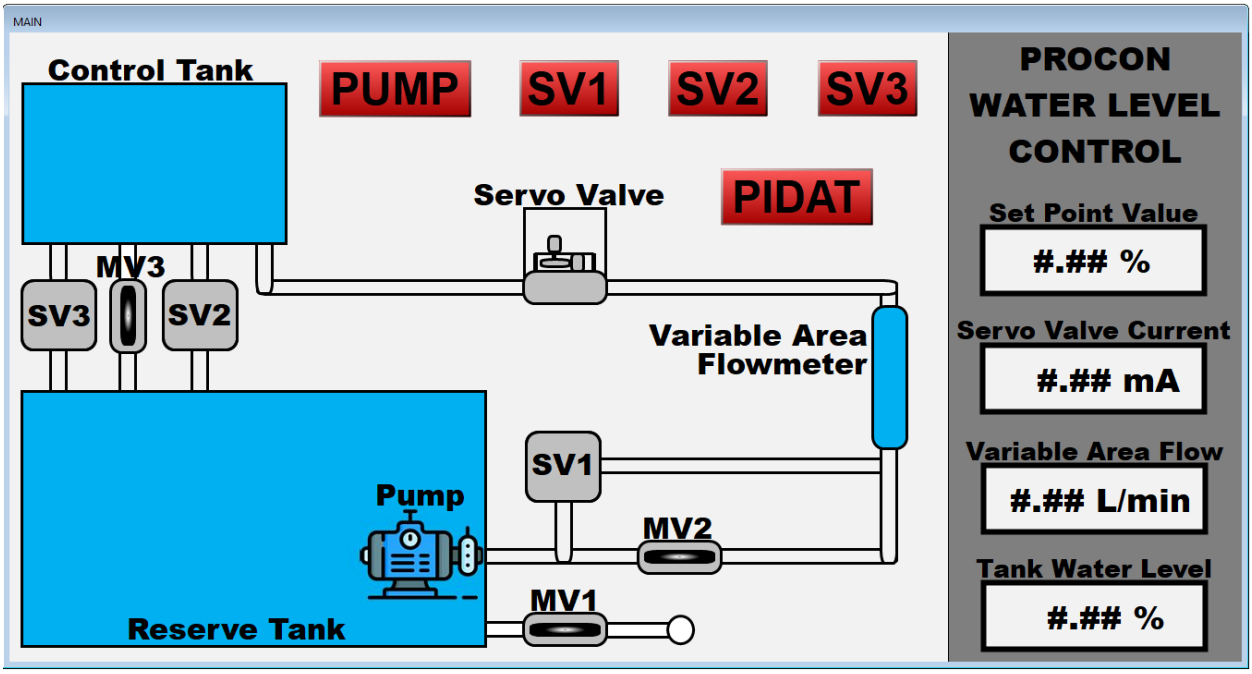
For the ideal wiring connection, the wiring diagram consists of the PROCON component interfaces, PLC, and a laptop with SCADA design. There are 4 digital outputs wherein 3 are designated for each solenoid valves while the other logic output is for controlling the water pump. On the other hand, there is also 1 analog input as well as 1 analog output. The analog input is from the float level sensor that will be connected to channel 202 to obtain a current input from 4-20mA.

The output of the PLC will be sent from the channel 210 that is connected to the servo-valve which is also programmed to output 4-20mA.

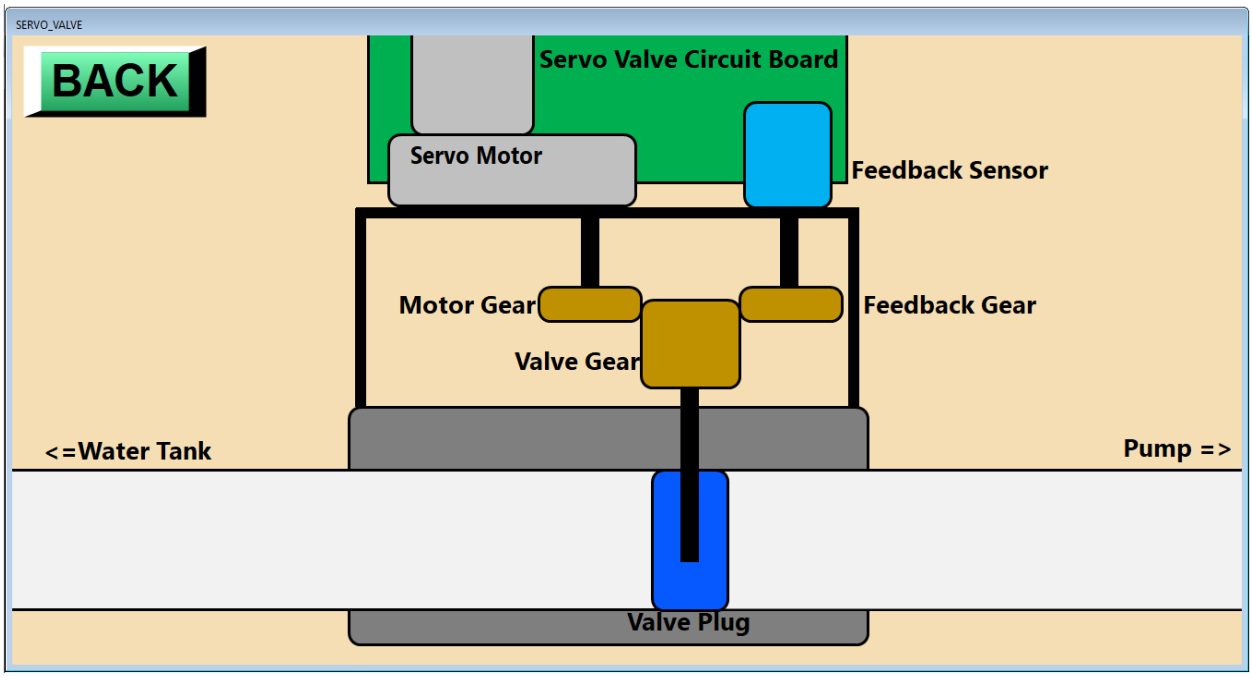


However, due to hardware limitations, a second PLC will be used. The CPM2A will be used to convert the voltage output of the CP1H PLC to the required current output. From 0 to 10V, the output will become 4-20mA which is the accepted range for servo valve.

3. SCADA Layout



For the SCADA layout, the laptop displays the graphic representation of how the water level can be monitored and controlled remotely. The pump and solenoid valves 1, 2, and 3 are controllable by Boolean state which can either be on or off. On the other hand, the input tank water level from the float level sensor and the output for the servo valve current are analog values. The variable area flow is the derivation based on the valve opening and pump strength. The only analog value that the user can modify is the set point value that ranges from 0 to 100%.



The second page is a simple visual demonstration for the servo animation. The valve gear moves vertically together with the valve plug as the current input increases from 4mA to 20mA. The pipe will also demonstrate water flow as it varies color if the pump is on indicating that there should be water flowing.

4. PLC (CX-PROGRAMMER) Program

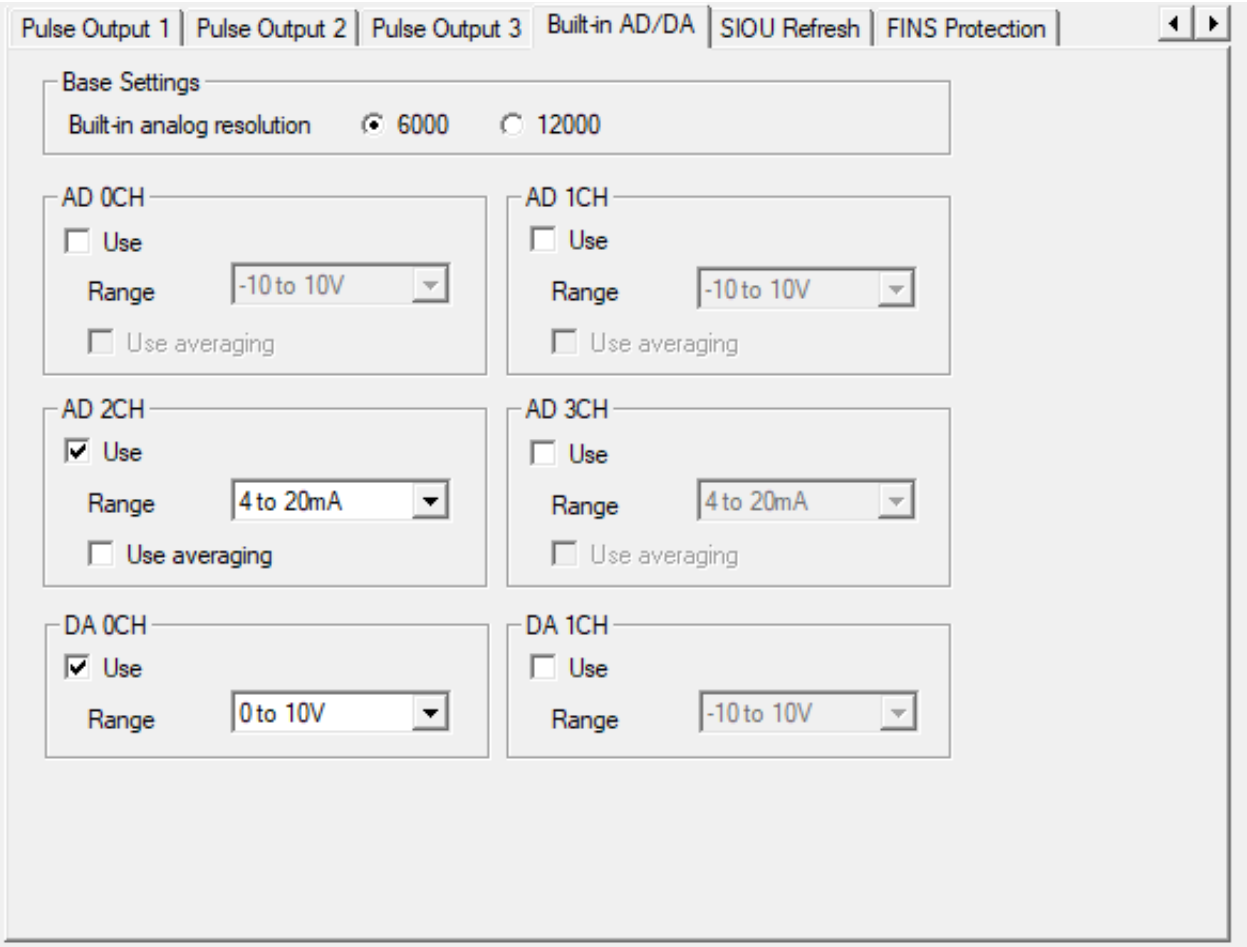
The PLC ladder program is composed of two major parts, CP1H program and CPM2A program.

Channel/ Memory	Connection	Data Type	Range
D40	$CX - Programmer \Rightarrow SCADA$	Integer (BCD)	#0-1000
D41	$SCADA \Rightarrow CX - Programmer$	Integer (BCD)	#0-1000
D42	$CX - Programmer \Rightarrow SCADA$	Integer (BCD)	#400-2000
CH 7.00	$SCADA \Rightarrow CX - Programmer$	Boolean	0 or 1
CH 10.00	$SCADA \Rightarrow CX - Programmer$	Boolean	0 or 1
CH 11.00	$SCADA \Rightarrow CX - Programmer$	Boolean	0 or 1
CH 12.00	$SCADA \Rightarrow CX - Programmer$	Boolean	0 or 1
CH 13.00	$SCADA \Rightarrow CX - Programmer$	Boolean	0 or 1
CH 100.00	$CX - Programmer \Rightarrow PLC\ CP1H$	Boolean	0 or 1
CH 100.01	$CX - Programmer \Rightarrow PLC\ CP1H$	Boolean	0 or 1
CH 100.02	$CX - Programmer \Rightarrow PLC\ CP1H$	Boolean	0 or 1
CH 100.03	$CX - Programmer \Rightarrow PLC\ CP1H$	Boolean	0 or 1
CH 202	$PLC\ CP1H \Rightarrow CX - Programmer$	Integer (Hexadecimal)	#0-1770
CH 210	$CX - Programmer \Rightarrow PLC\ CP1H$	Integer (Hexadecimal)	#0-1770

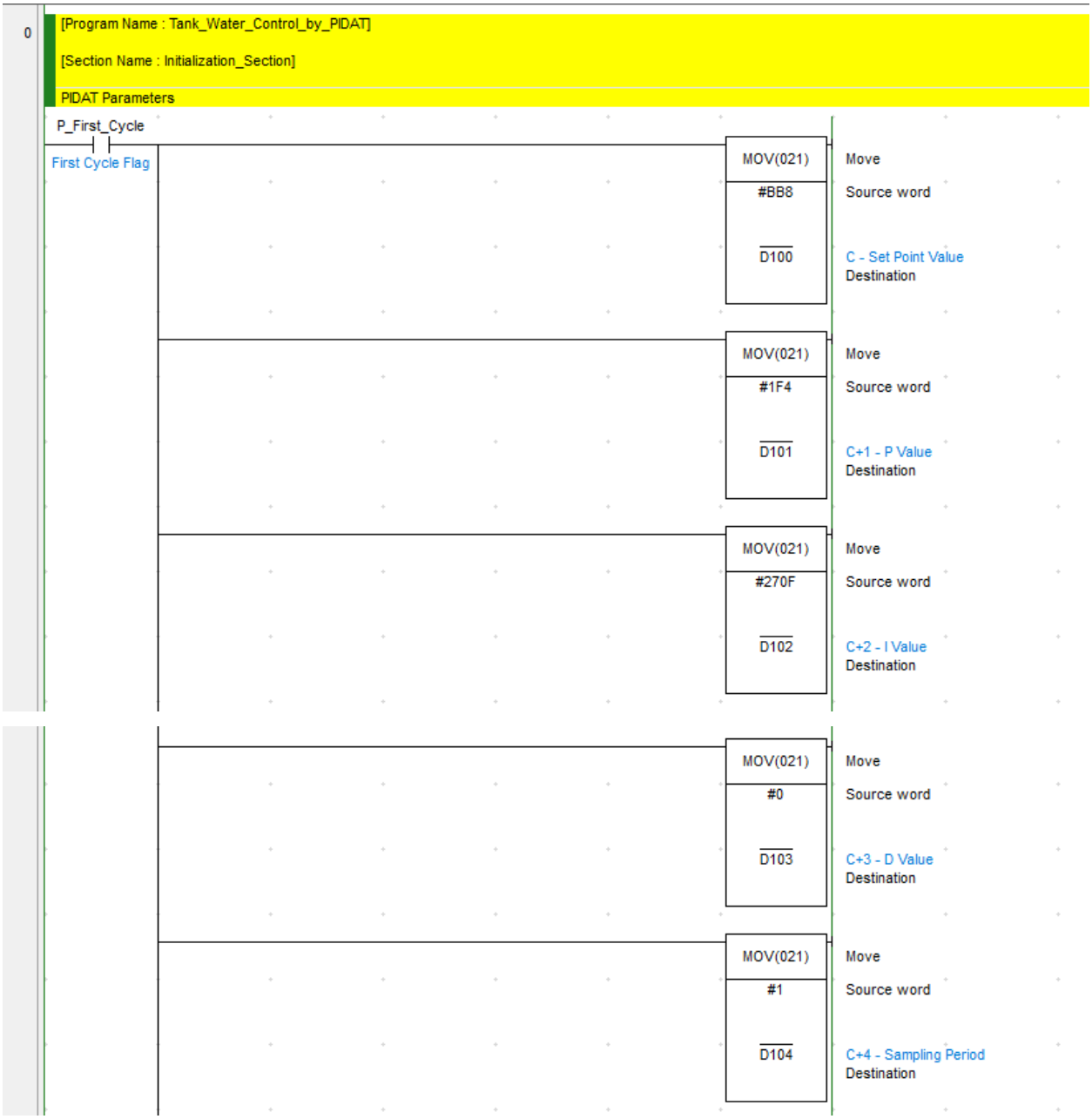
The table shows the channels or memory used in the program as well as the data flow, specific range and data type.

Name	Data Type	Address / Value	Rack Locati...	Usage	Comment
START	BOOL	7.00		Work	7.00 - START
PUMP	BOOL	10.00		Work	10.00 - PUMP
SV1	BOOL	11.00		Work	11.00 - SV1
SV2	BOOL	12.00		Work	12.00 - SV2
SV3	BOOL	13.00		Work	13.00 - SV3

There are only 5 address flags as relay for the ladder diagram program aside from the 4 digital output addresses, 1 analog input channel, and 1 analog output channel.

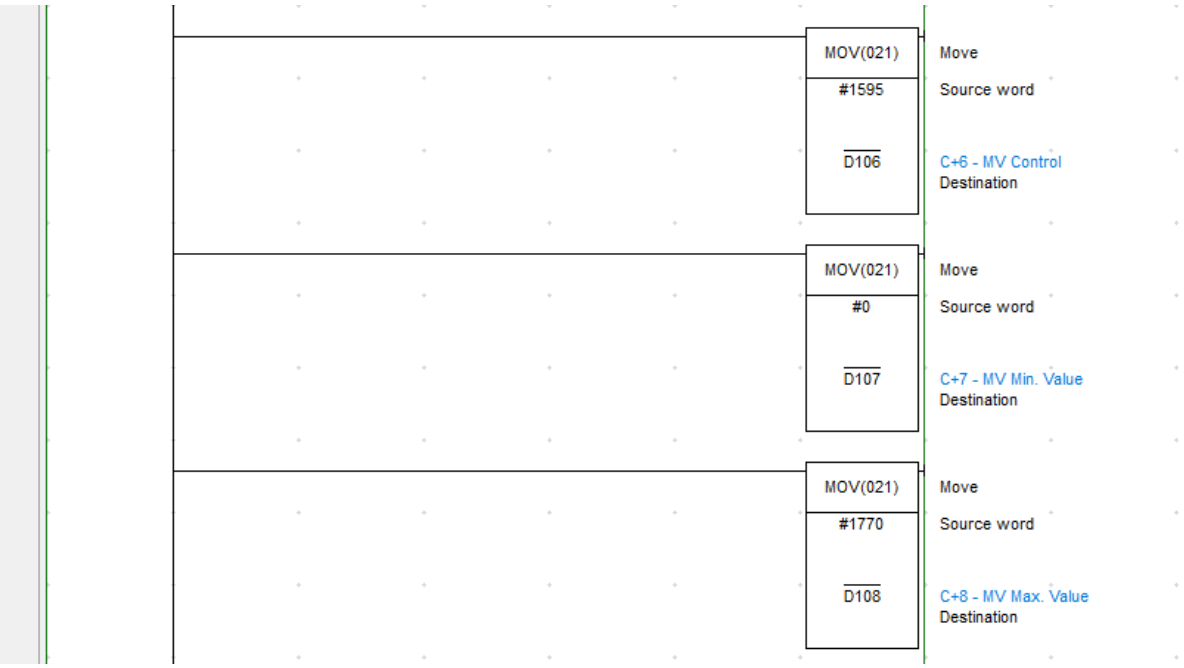


The channel used are channel 202 for the analog input of 4-20 mA from the float level sensor and channel 210 for the analog output 0-10V for the servo valve current



The parameters C to C+4 are the basic parameters settings of a PID Model. C or SV is the target value of the PID process being controlled which will be ranged based on the measured variable input range. C+1 or P value is for the proportional control range while C+2 or I value is for the integral and C+3 or D value for the derivative of the PID model. C+4 is just the sampling period that ranges from 0.01s to 99.99s. The P, I, and D value range can be modified in C+5.

This parameter is further divided into specific PID settings. Bit 00 is for forward or reverse action, but in this case, the PID control for the water tank system used is the reverse action. Bit 01 is for the PID constant change whether it is enabled only at the start of execution or also at each sampling period which is also the control for changing the setting range of the P, I, and D. Bit 03 is set as 0 so that the manipulated or controlled variable will output 0% when measured variable is equal to the set value. Bit 04 to 15 is for the 2-PID parameter specifically the filter coefficient which has a default value of 0.65.

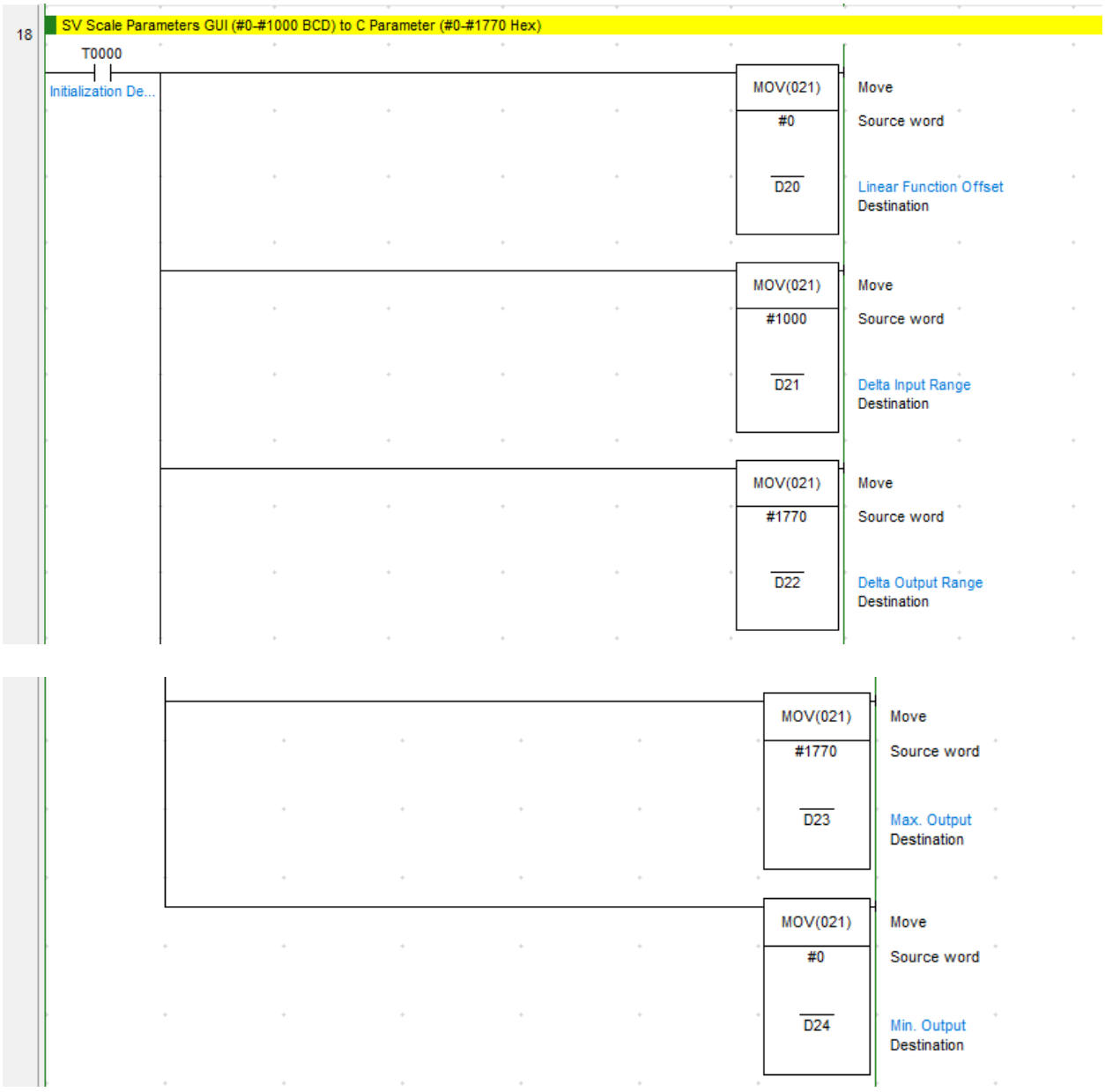


C+6 is basically the control settings for the C+7 and C+8 or the maximum and minimum values of the controlled variable. Bit 00 to 03 and 08 to 11 are just the designation of data bits for output and inputs, respectively. Since the resolution set on the PLC settings is 6000, the equivalent word is #1770 or binary 0001 0111 0111 0000 which only uses 13 bits thus, using the value #5 to the respective bits. Bits 04 to 07 is for determining the I and D units whether it is based on sampling period multiple or by 100ms.

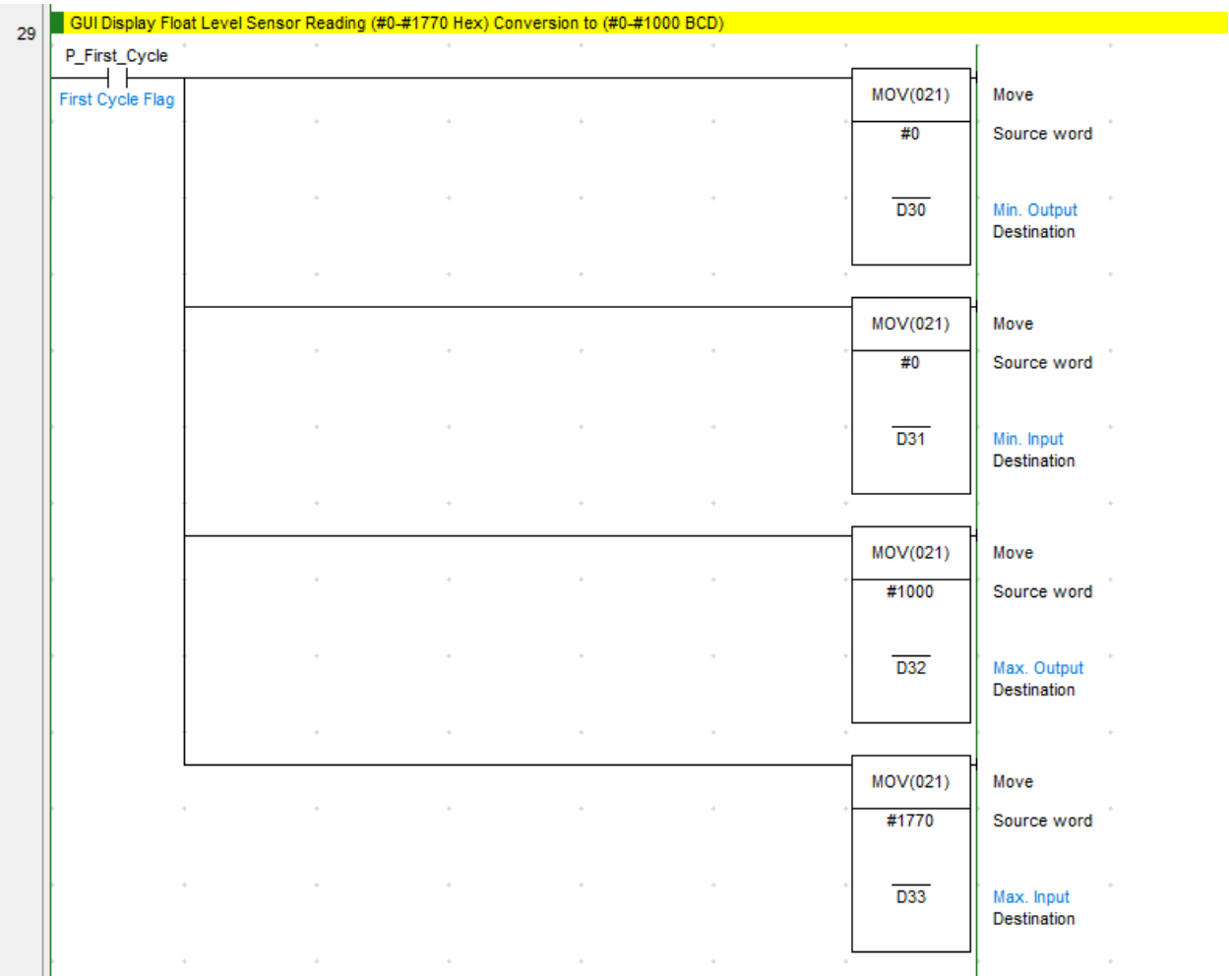
In this case, the choses parameter is to base on 100ms. Bit 12 is for determining whether or not the limit control will be applied on the controlled variable which just specify whether to use C+7 and C+8 or not. A value of 1 means that it will be used as well as the other parameters included in the C+6.

C+9 is only composed of autotuning command and the autotuning gain. Changing the bit 15 state will control the PID autotuning process. Bits 00 to 11 for the AT gain can be ignored so the default gain is 1.00.

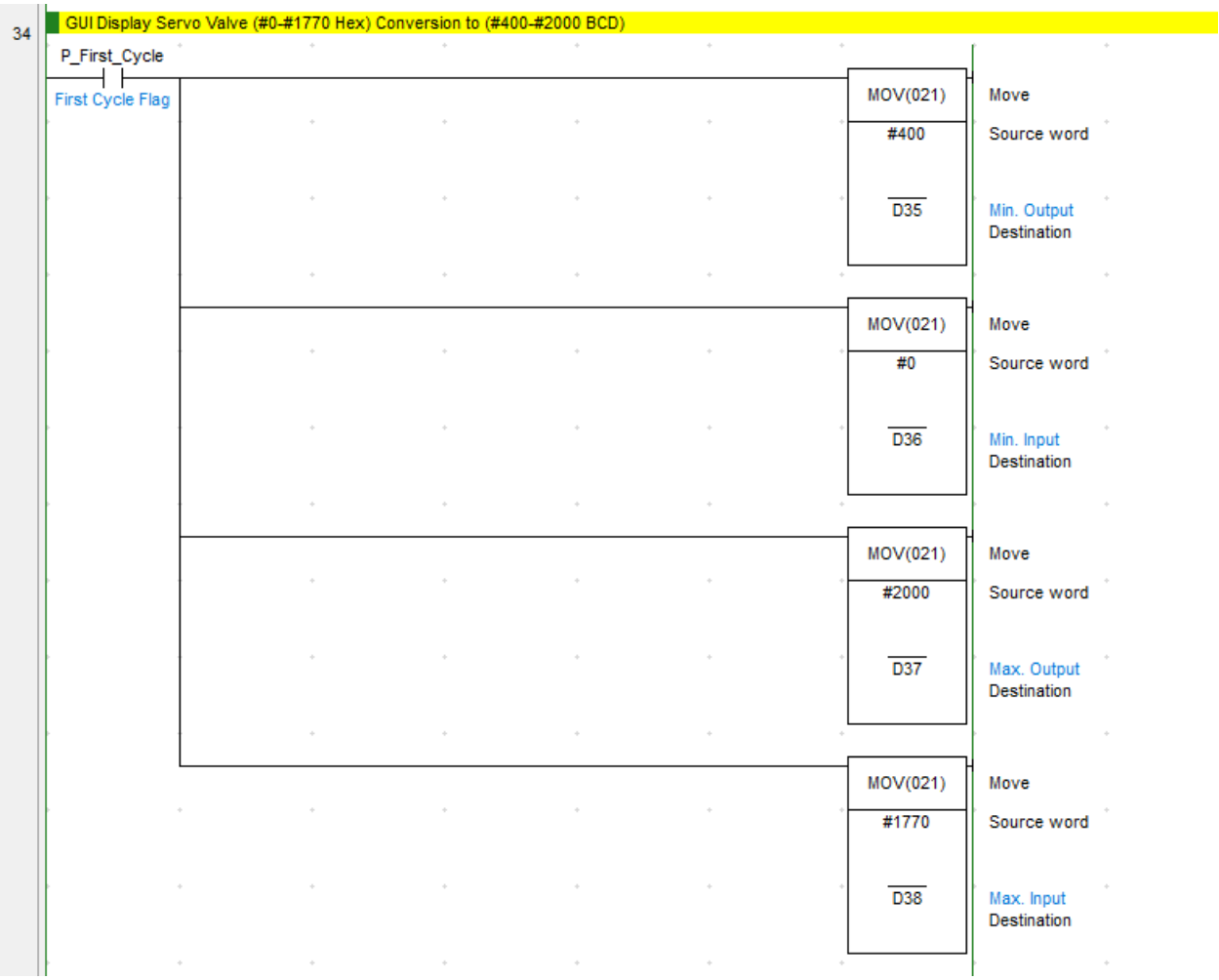
C+10 sets the hysteresis when the limit cycle is generated which has a default hysteresis of 0.20%.



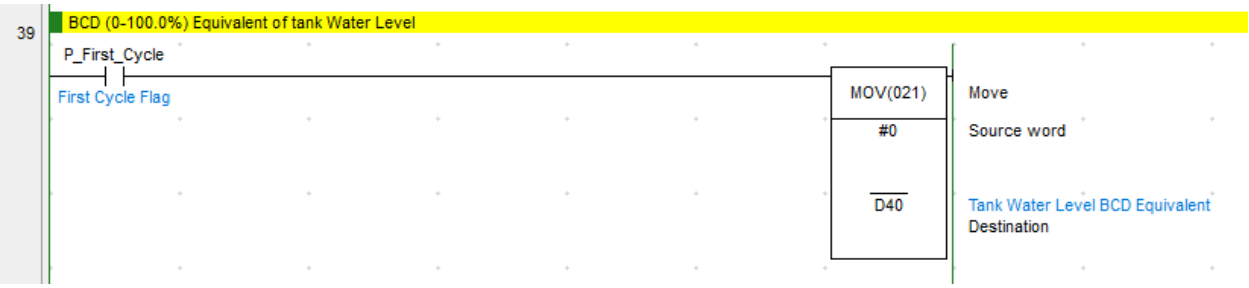
Another process that uses a specific parameter is the SCL3 which is for scaling the BCD input for SV to the accepted range of SV in C parameter of PID. From an input of 0 to 1000 (0-100.0%) BCD it is scaled to #0 – #1770.



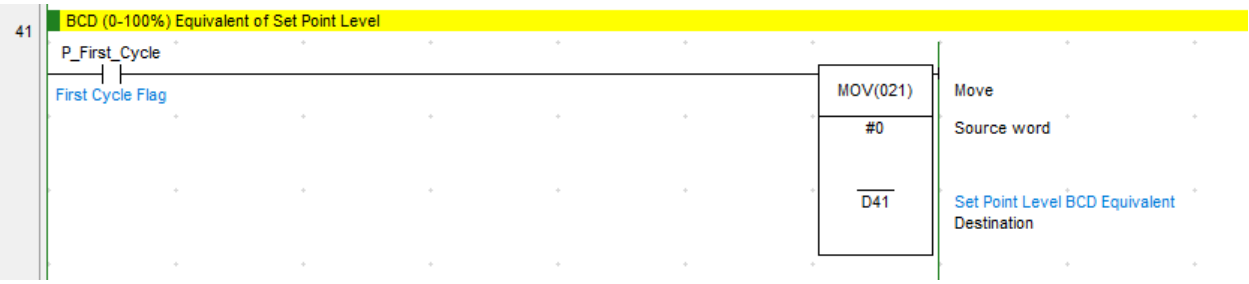
A conversion from binary to BCD will be implemented in the program thus, the following data memories are used as the SCL parameter for converting an input range #0 - #1770 hex to an output range #0 - #1000 in BCD.



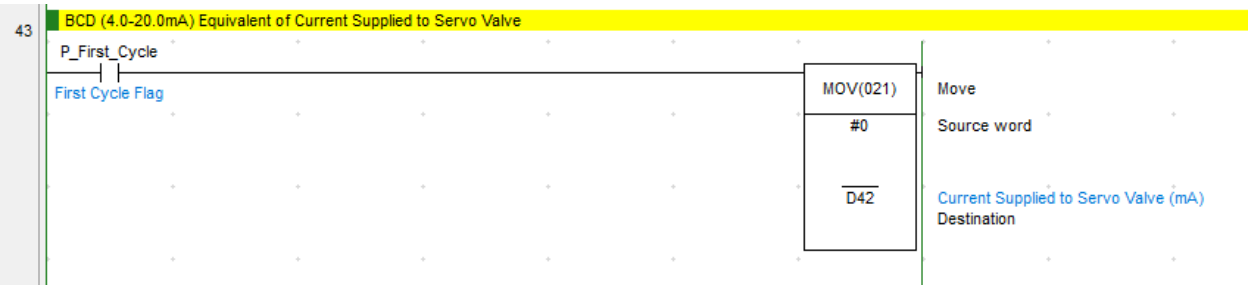
A conversion from binary to BCD will be implemented in the program thus, the following data memories are used as the SCL parameter for converting an input range #0 - #1770 hex to an output range #400 - #2000 in BCD.



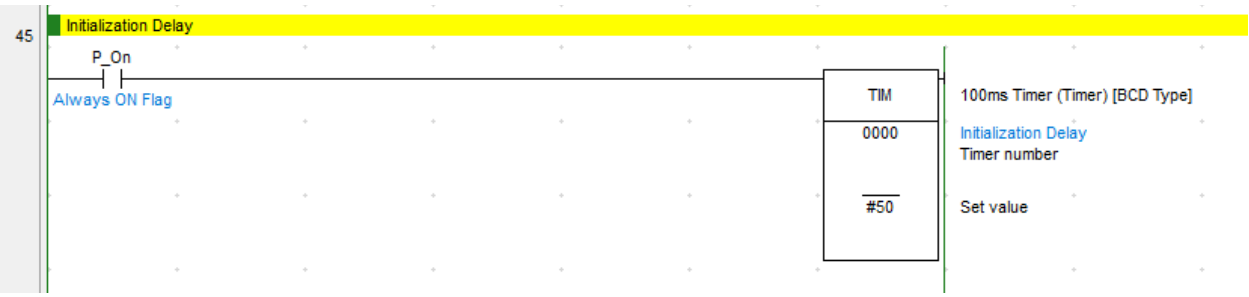
The BCD equivalent of tank water level will be stored in D40 as the output of an SCL in the main program.



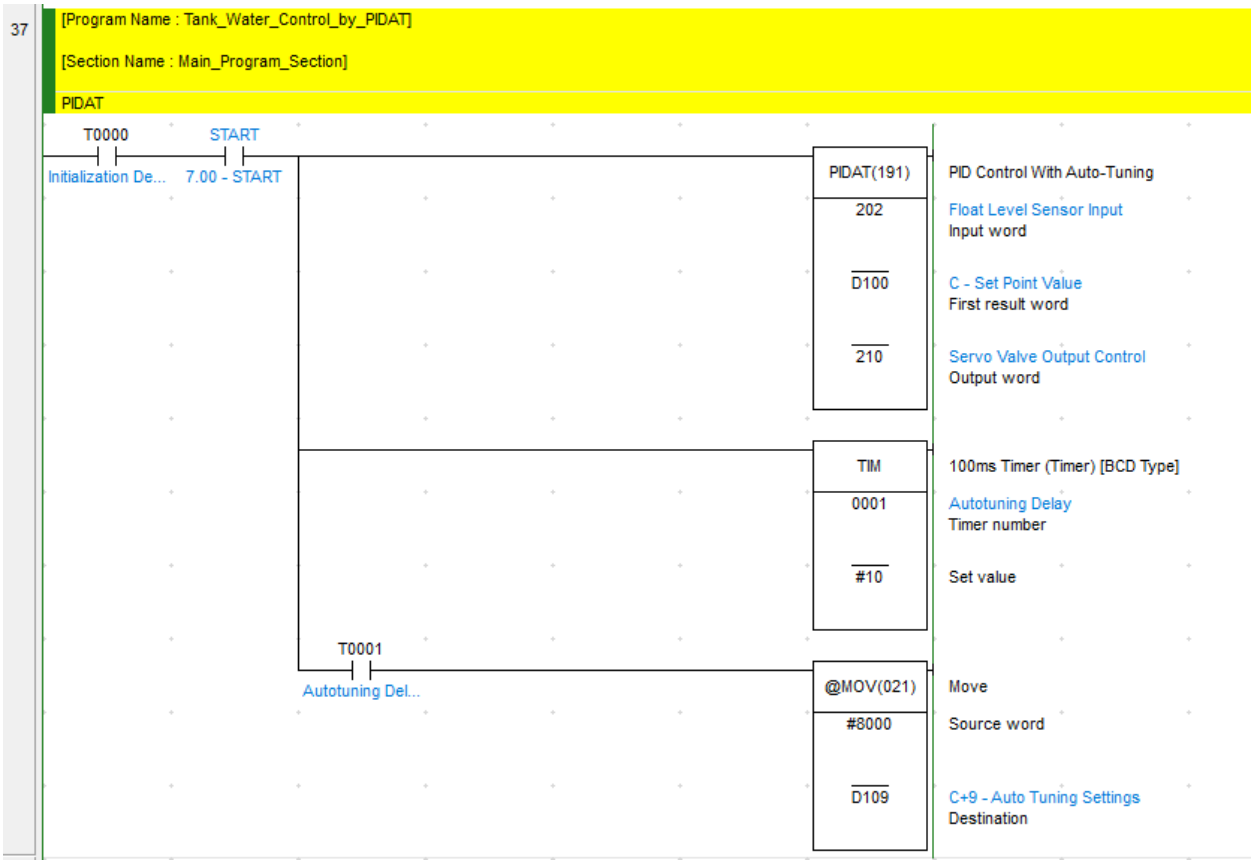
The BCD equivalent of set point level will be stored in D41 as the output of an SCL in the main program.



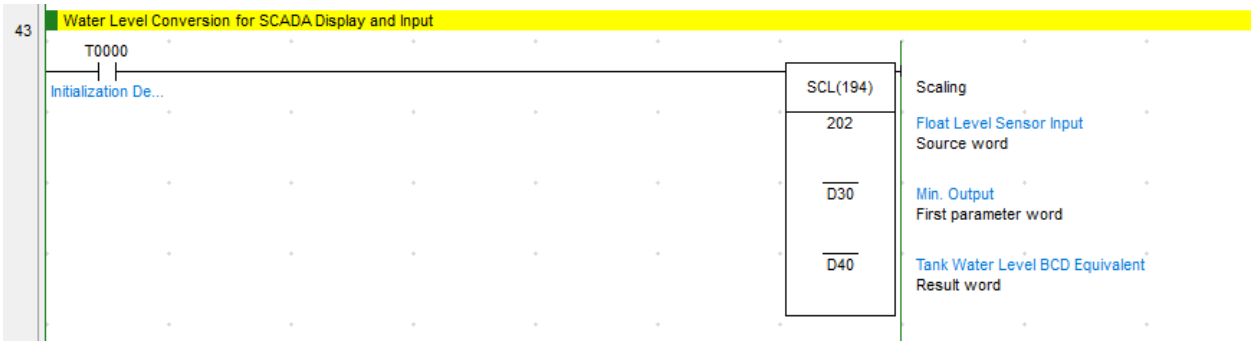
The BCD equivalent of current supplied to the servo valve will be stored in D42 as the output of an SCL in the main program.



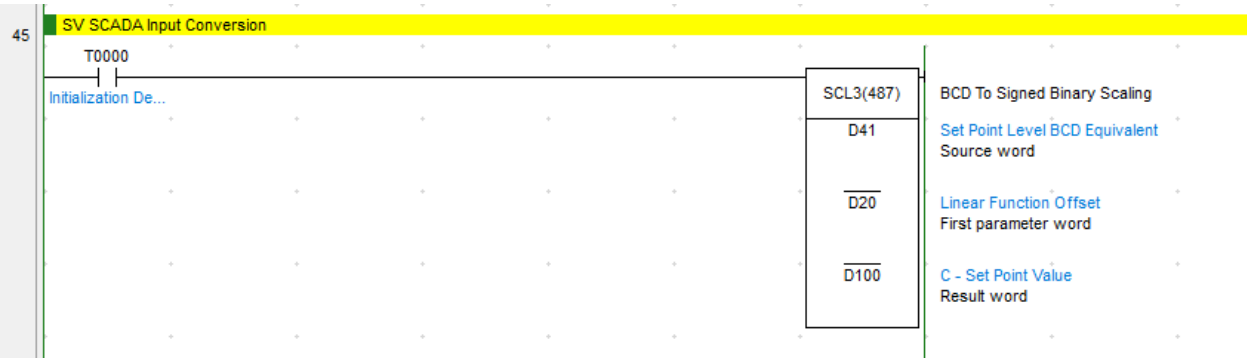
A short delay was implemented to allow the system to finish the initialization. This timer will be used before the other program or function is allowed to run to avoid any possible error at the start.



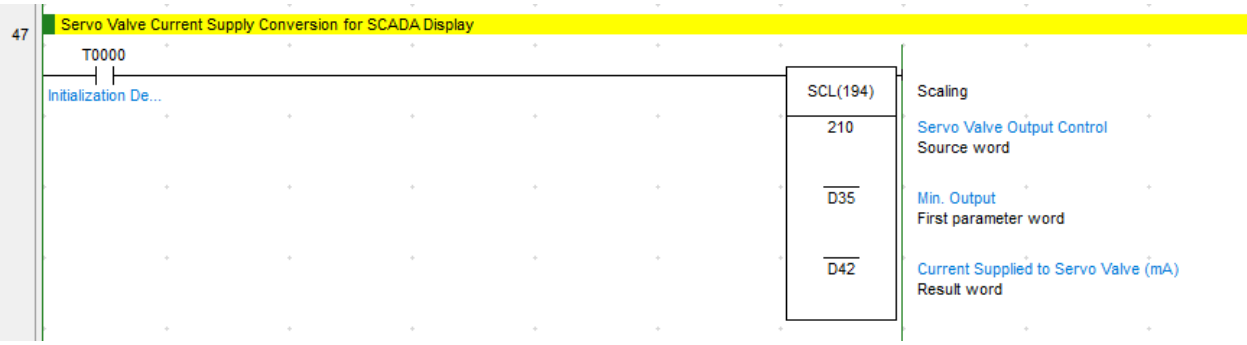
For the main program, the start can be pressed in the SCADA display which will enable the PID the autotuning after one second delay.



At any point in the program, the user can monitor the current water level in the tank through the HMI numerical display. The SCL conversion of the input uses the parameters configured at the initialization section.

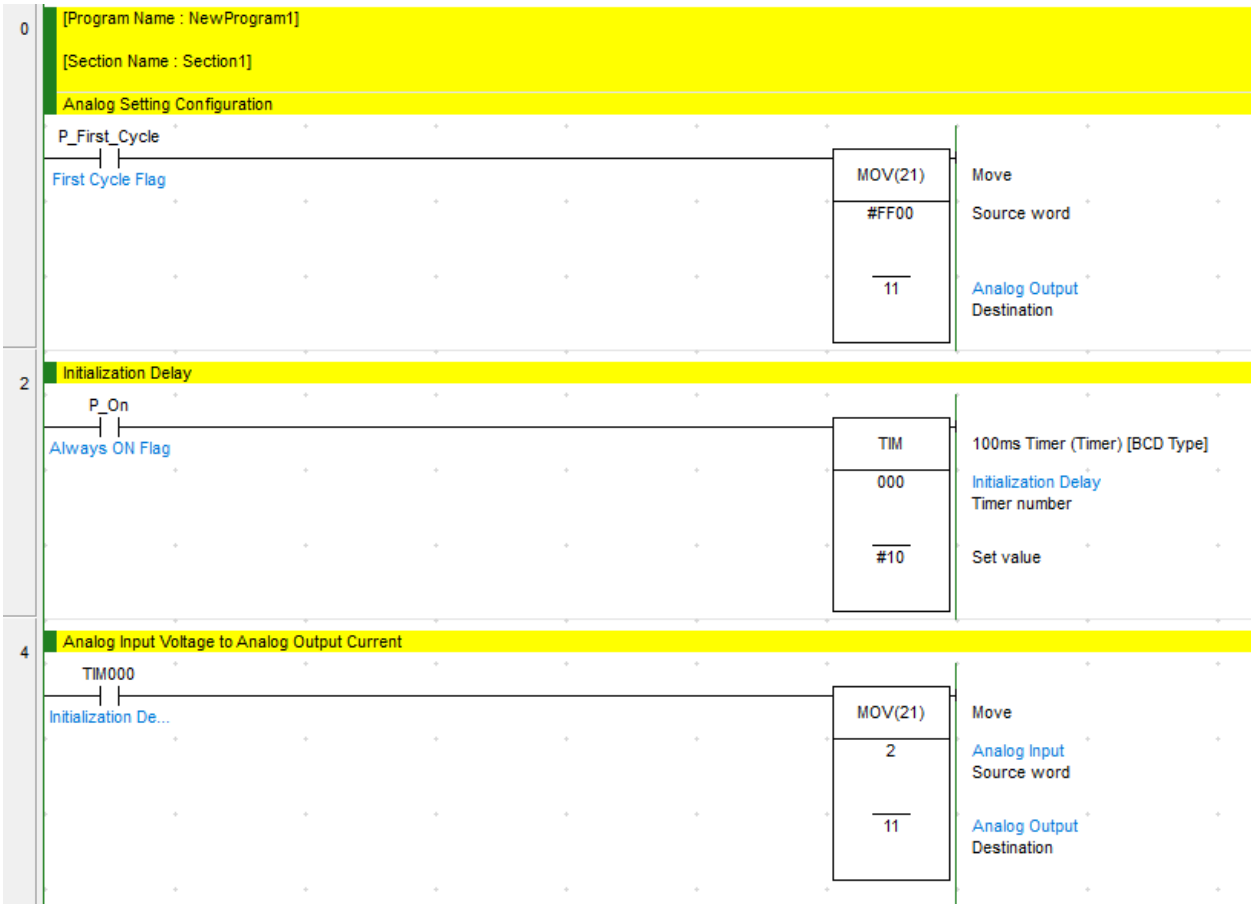


At any point in the program, the user can monitor the set point value or target water level of the tank through the SCADA numerical display. The SCL conversion of the input uses the parameters configured at the initialization section.



At any point in the program, the user can monitor the current supplied to the servo valve through the SCADA numerical display. The SCL conversion of the input uses the parameters configured at the initialization section.

For the digital control of the pump and solenoid valves 1, 2, and 3, the respective button are also available in the SCADA design.



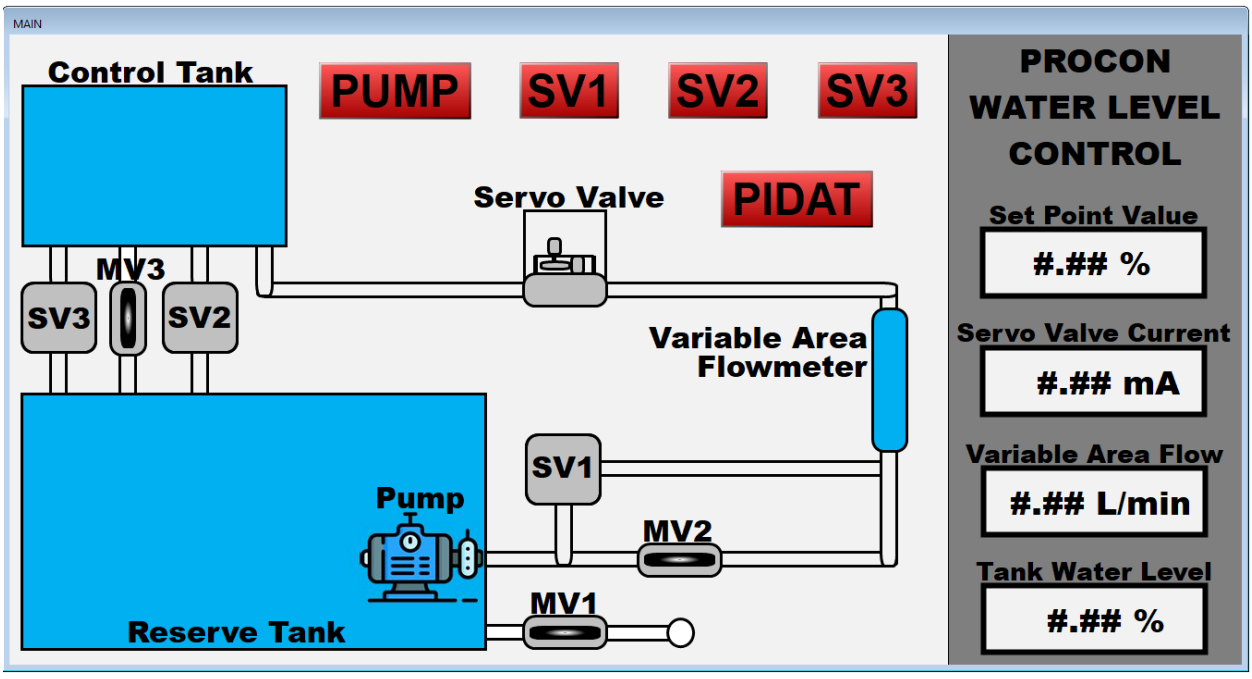
The CPM2A is an older version which uses different program in the configuration. The first rung is to enable the analog input of 0 to 10V in analog input ports 1 and 2 and at the same time enabling the analog output of either 0-10V or 4-20mA depending on the connection. The second rung is just a short delay to avoid error before beginning to the main program. The last rung is just a basic data transfer from channel 2, the analog input voltage, to channel 11, the analog output voltage.

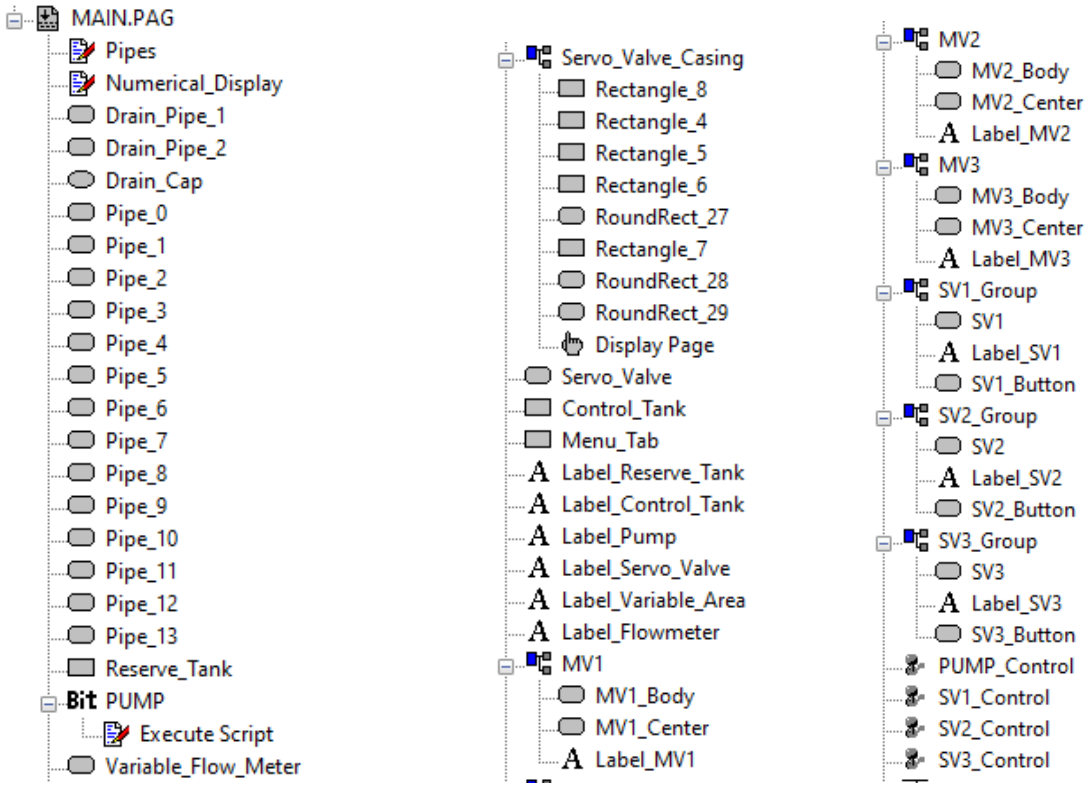
5. SCADA Program

The SCADA design is composed of two pages: Main page and Servo Animation page. This SCADA design will be connected to the cx-server which the cx-programmer and plc will interact to transfer data between each other.

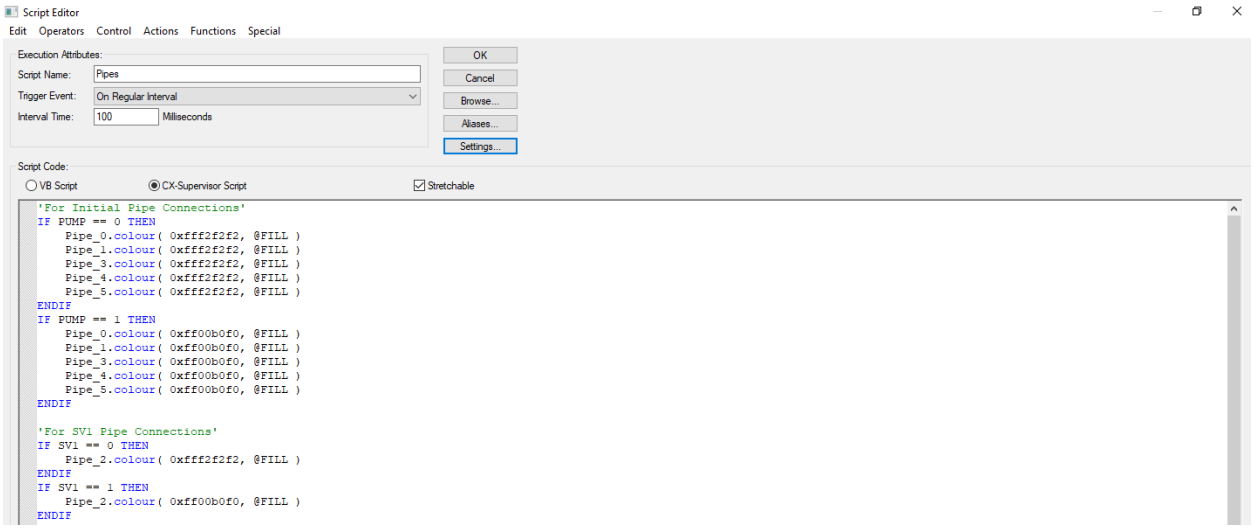
Point	Type	I/O Type	Address	Description
Display_Servo_Valve	Real	Memory		
Display_Set_Point	Real	Memory		
Display_VAF	Real	Memory		
Display_Water_Level	Real	Memory		
Servo_Animation	Integer	Memory		
Servo_Current	Integer	PLC Input	PLC_1[D42]	
Water_Level	Integer	PLC Input	PLC_1[D40]	
PUMP	Boolean	PLC Output	PLC_1[10.0]	
Set_Point	Integer	PLC Output	PLC_1[D41]	
START	Boolean	PLC Output	PLC_1[7.0]	
SV1	Boolean	PLC Output	PLC_1[11.0]	
SV2	Boolean	PLC Output	PLC_1[12.0]	
SV3	Boolean	PLC Output	PLC_1[13.0]	

All the data points used in this program is shown above. There are only two inputs which is the BCD equivalent values as converted earlier from the cx-programmer ladder diagram. Aside from that, there are 5 outputs wherein 4 are digital while 1 is an analog output. Other data points are only used for the SCADA animation and not directly involved in PLC.



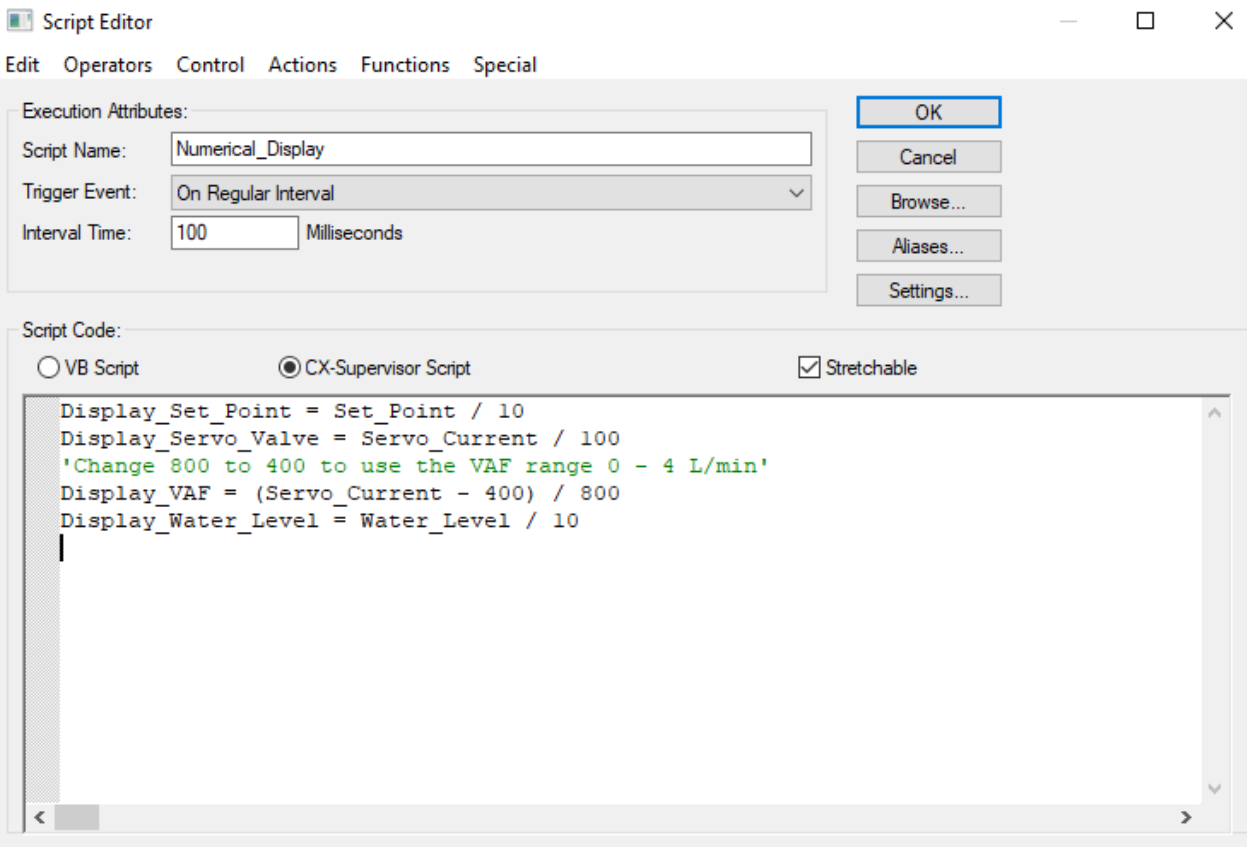


As explain in the beginning, the layout is for graphical demonstration of remote control of PROCON water level which is composed of multiple symbols and scripts.



```
'For SV3 and SV2 Pipe Connections'
IF Water_Level == 0 THEN
    Pipe_9.colour( 0xfff2f2f2, @FILL )
    Pipe_13.colour( 0xfff2f2f2, @FILL )
ENDIF
IF Water_Level > 0 THEN
    IF SV2 == 0 THEN
        Pipe_9.colour( 0xfff2f2f2, @FILL )
    ENDIF
    IF SV2 == 1 THEN
        Pipe_9.colour( 0xff00b0f0, @FILL )
    ENDIF

    IF SV3 == 0 THEN
        Pipe_13.colour( 0xfff2f2f2, @FILL )
    ENDIF
    IF SV3 == 1 THEN
        Pipe_13.colour( 0xff00b0f0, @FILL )
    ENDIF
ENDIF

'For Servo Valve Pipe Connections'
IF Servo_Current <= 400 THEN
    Pipe_6.colour( 0xfff2f2f2, @FILL )
    Pipe_7.colour( 0xfff2f2f2, @FILL )
ENDIF
IF Servo_Current > 400 THEN
    Pipe_6.colour( 0xff00b0f0, @FILL )
    Pipe_7.colour( 0xff00b0f0, @FILL )
ENDIF
```

The first script program is for animating the varying pipe color which indicates whether water is flowing or not.



The second script program is for the numerical display. Although the values received after converting to BCD from the cx-programmer, it can be equated to show a more accurate representation of the measured values.

Script Editor

Edit Operators Control Actions Functions Special

Execution Attributes:

Trigger Event: On Left Button Click

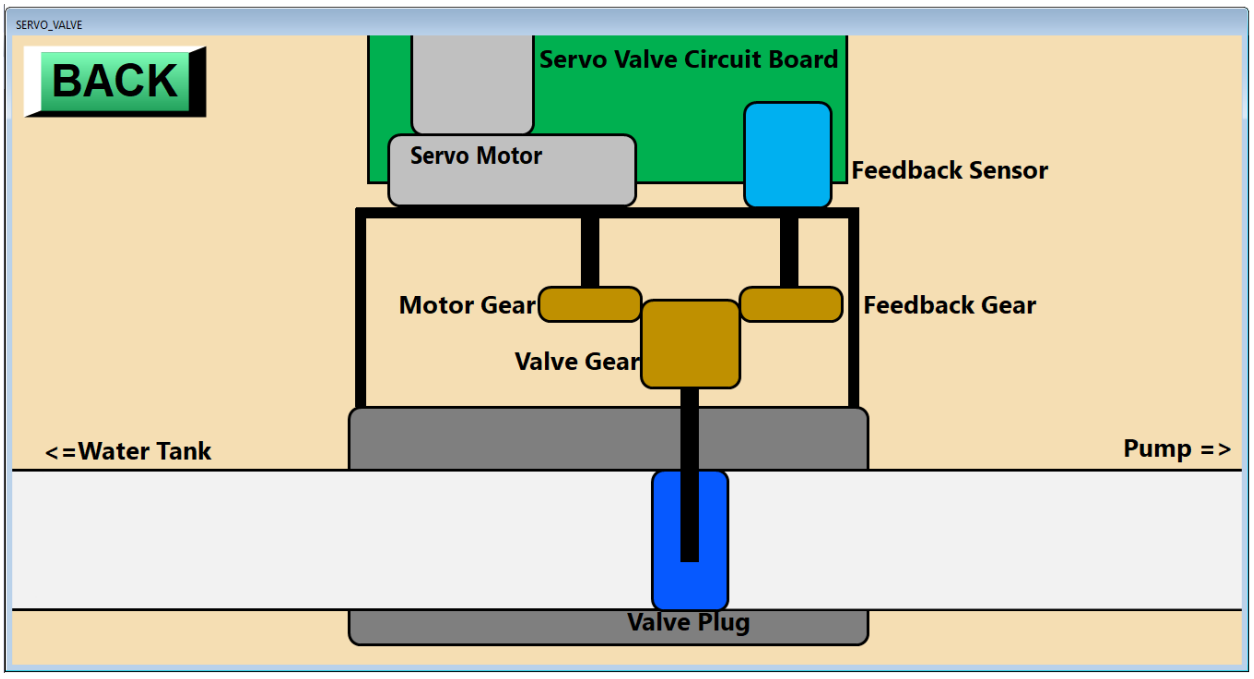
OK
Cancel
Browse...
Aliases...
Settings...

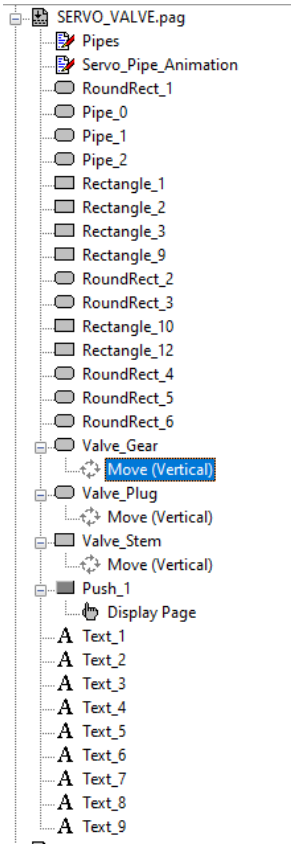
Script Code:

VB Script CX-Supervisor Script Stretchable

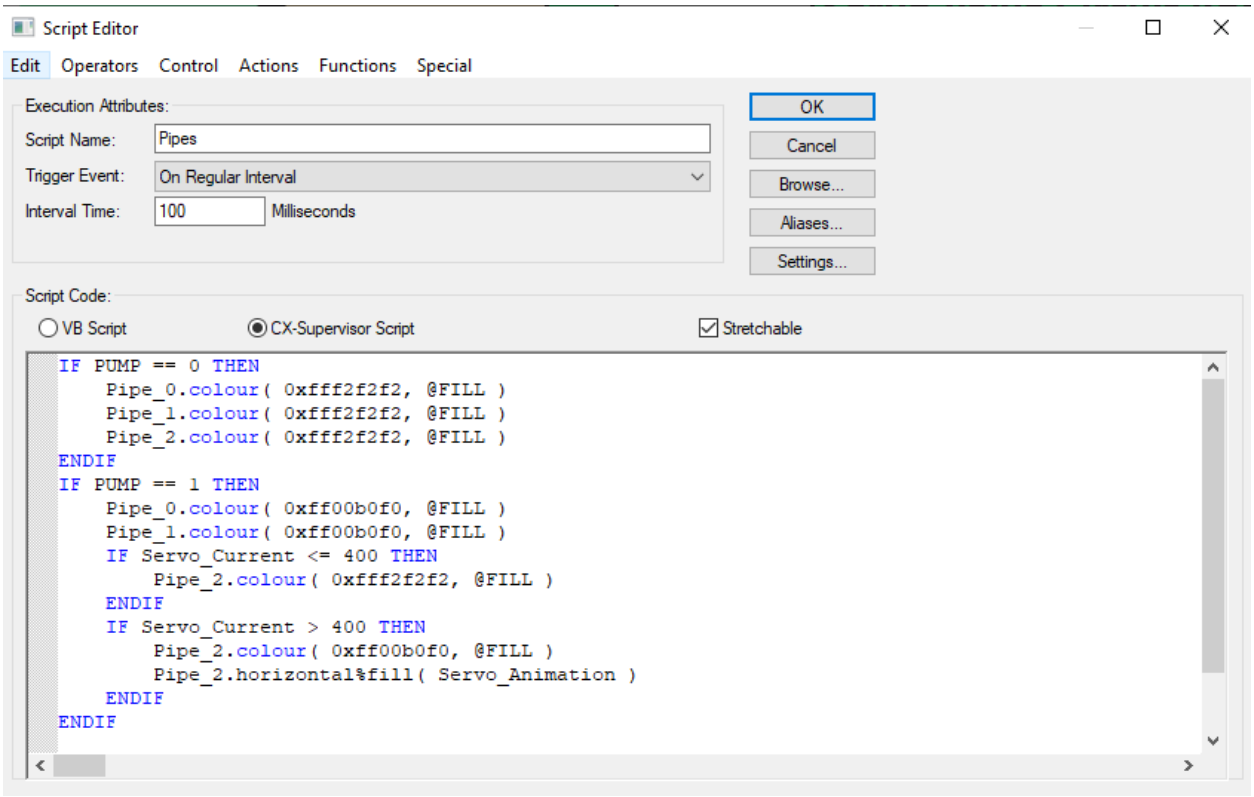
```
IF PUMP == 0 THEN
    Pipe_0.colour( 0xfff2f2f2, @FILL )
    Pipe_2.colour( 0xfff2f2f2, @FILL )
    Pipe_3.colour( 0xfff2f2f2, @FILL )
    Pipe_4.colour( 0xfff2f2f2, @FILL )
    Pipe_5.colour( 0xfff2f2f2, @FILL )
    PUMP = 1
ENDIF

IF PUMP == 1 THEN
    Pipe_0.colour( 0xff00b0f0, @FILL )
    Pipe_2.colour( 0xff00b0f0, @FILL )
    Pipe_3.colour( 0xff00b0f0, @FILL )
    Pipe_4.colour( 0xff00b0f0, @FILL )
    Pipe_5.colour( 0xff00b0f0, @FILL )
    PUMP = 0
ENDIF
```

The third script program is an on-click trigger event which the PUMP button can be used to demonstrate the water flow to the pipes.

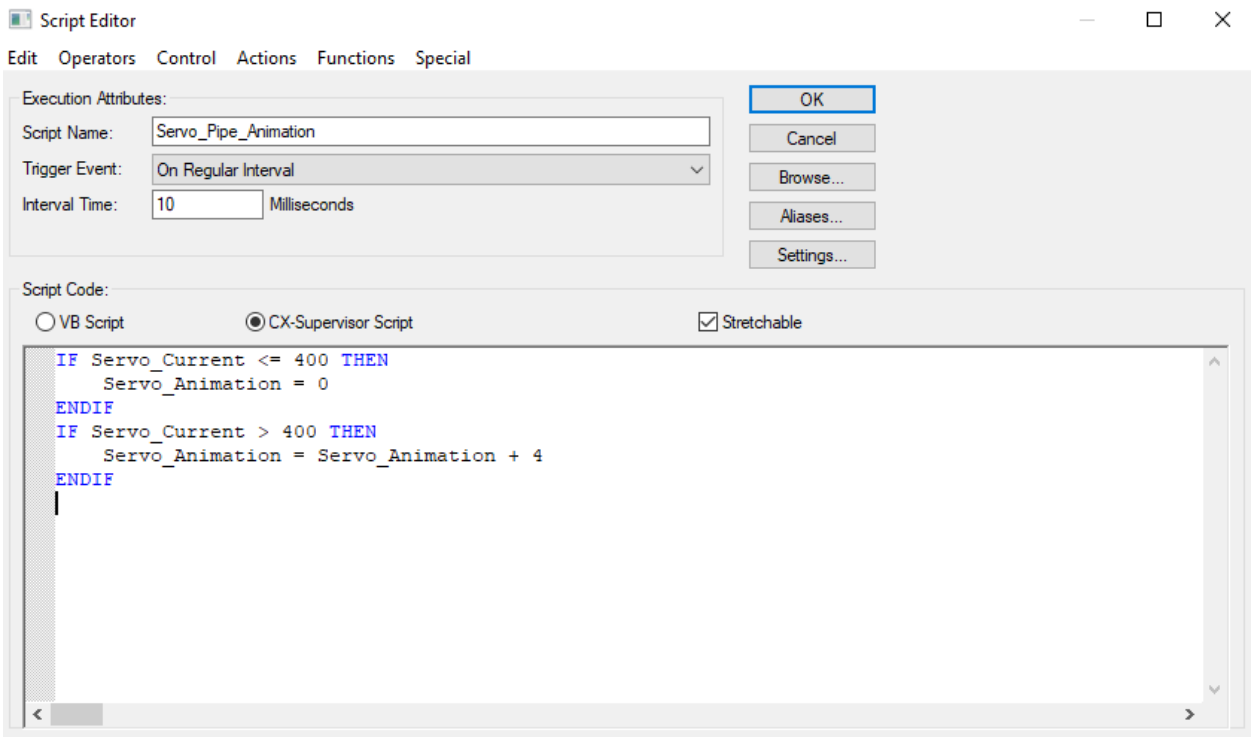




Aside from the main page, there is another page which is mainly for demonstrating the servo valve operation. The valve gear moves vertically together with the valve plug as the current input increases from 4mA to 20mA. The pipe will also demonstrate water flow as it varies color if the pump is on indicating that there should be water flowing.



There is also a script program for the second page that simulate the water flow in the pipe depending on the pump state and servo valve current.



The last script program is for the water flow animation by horizontal filling the component. The speed of the water flow can be varied by changing the value to be added to the point Servo_Animation.