Chapter 24 Valve on Wall

Water Flow Lab

The Water Flow Lab uses city water in a ¾ in pipe as a source to control flow of the water. The valve was purchased commercially and includes a flow transmitter. Both signals are 4-20 mA. Industrial air is required to power the water valve. The cost of the assembly is about $1500. Two were installed in the room.

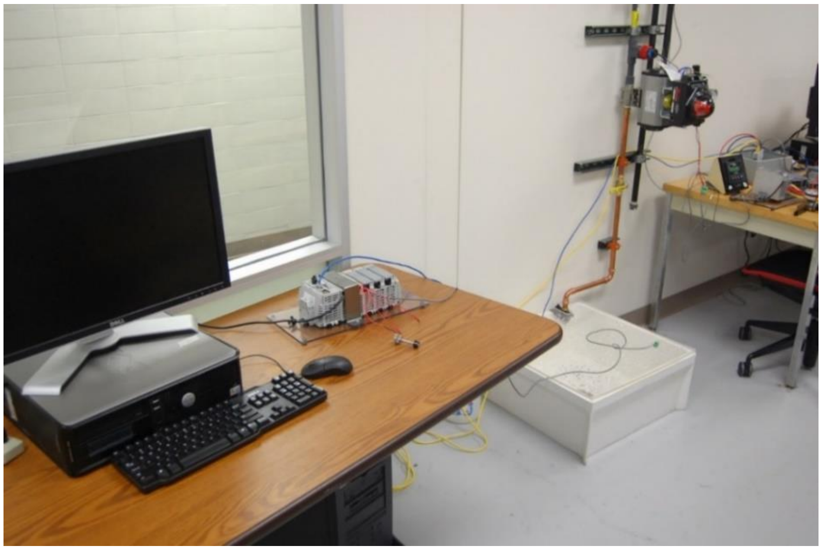
Purpose of the Lab – This lab was designed many years ago to give students in the PLC course(s) first-hand experience in implementing a PID loop. The PLC used has been the A-B compact logix processor. The lab provides experience developing the start-up sequence used to program the PID algorithm and the development of an HMI for use in industry.

Materials - The system includes a flow transmitter and control valve.

Cost – The cost is in the range of $1500.

Benefit – The benefit of the lab include the training of students in the commissioning of the PID algorithm as well as programming of a single-loop system.

Challenges – This lab has recently been re-built after an accident in the compressed air system. Water was introduced into the air system destroying the I/P (current to pressure) transducer. These units were completely replaced and the systems re-built with the new I/P components.



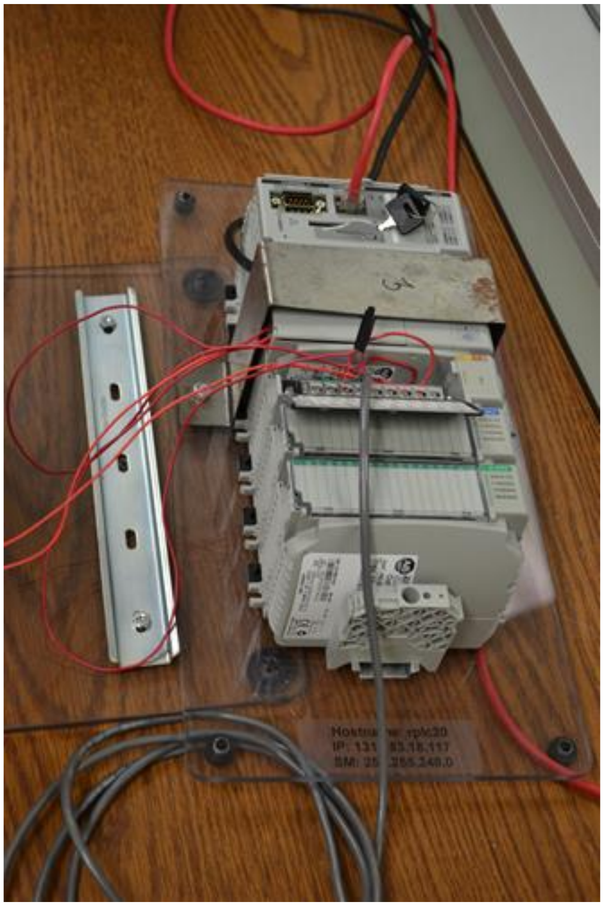
Flow Valve on Wall

There are two of these systems in the lab. They may be used by two different groups with cabling shared between the groups who share the cable from the valve assembly. The course served is the advanced PLC or Mechatronics II course. A main advantage of this system is that tuning is done manually with stability problems occurring if the valve is not tuned precisely.

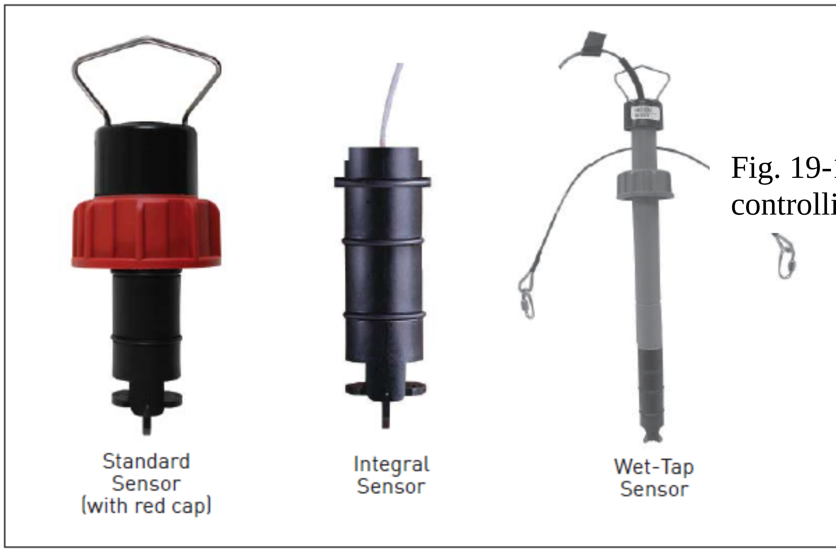
Stability/instability problems can be experienced in this lab by slight changes in the tuning variables. Also, the splash guard and catch basin are extremely important in that the flow can reach 90 gpm from this valve. Yes, a lot of water.

The following is a bill of material to construct the flow valve system shown below.

Quantity	Item	Description	Unit Price	Amount
1.00	FLO-7104 3/4"	FLOW-TEK BALL VALVE 316SS FULL PORT, NPT ENDS WITH MOUNTING BRACKET AND COUPLING		
1.00	MAX-UT-26-DA	DOUBLE ACTING PNUEMATIC ACTUATOR P/N UT26	1,268.00	1,268.00
1.00	ACC-A51236AT	ACCORD 4-20mA POSTIONER P/N A51236AT SAME AS A51136AT W/BEACON COMPLETELY ASSEMBLED AND TESTED		
1.00	MAR-M1FR2NHFM	0-120 PSI REGULATOR 5 MICRON P/N M1FR2NHFM COMPLETE CONTROL VALVE ASSEMBLY MOUNTED AND TESTED WITH PRESURE GUAGES PER		



Signet 515 Rotor-X Paddlewheel Flow Sensors



Features

- Operating range 0.3 to 6 m/s (1 to 20 ft/s)
- Wide turndown ratio

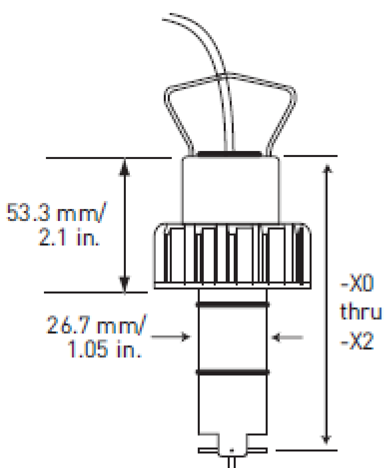
Fig. 19-19 The A-B PLC shown controlling the Flow Valve

- Simple, economical design
- Installs into pipe sizes DN15 to DN900 (½ to 36 in.)
- Self-powered/no external power required
- Test certificate included for -X0, -X1

The flow sensor is a paddle wheel placed in the flow of water. There is a calibrated readout for the flow meter that displays the flow in gallons per minute.

Dimensions

515 Standard Mount Sensor



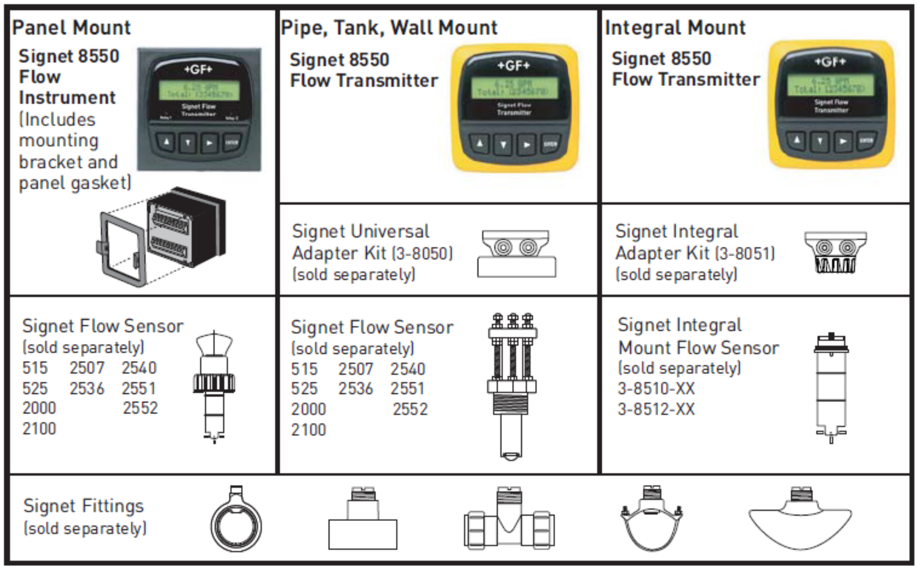
Pipe Range
½ to 4 in.: **-X0** = 104 mm (4.1 in.)
5 to 8 in.: **-X1** = 137 mm (5.4 in.)
10 in. and up: **-X2** = 213 mm (8.4 in.)

Specifications

General

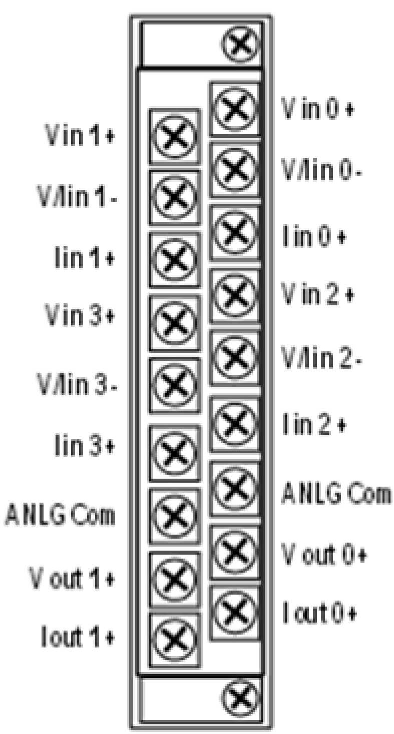
Operating Range:
0.3 to 6 m/s (1 to 20 ft/s)
Pipe Size Range:
DN15 to DN900 (½ to 36 in.)
Linearity:
±1% of max. range @ 25 °C (77 °F)
Repeatability:
±0.5% of max. range @ 25 °C (77 °F)
Min. Reynolds Number Required: 4500

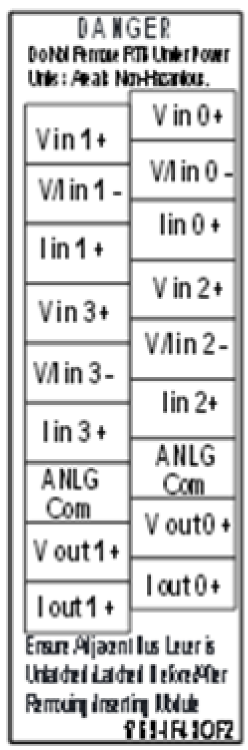
System Overview



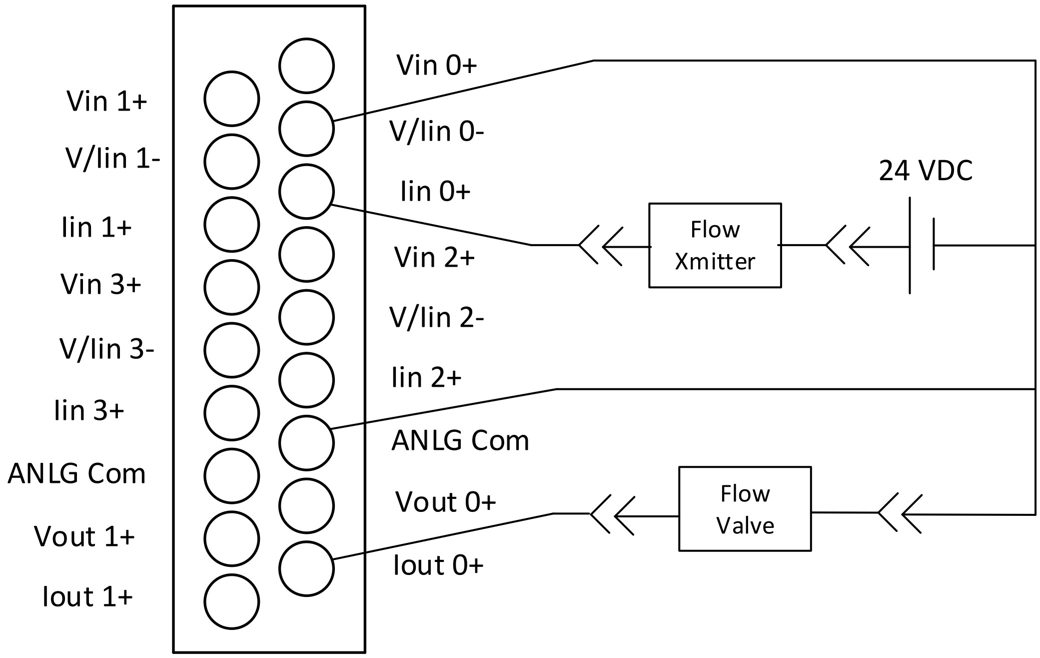
Allen-Bradley Analog Inputs and Outputs

Wiring diagrams for the card as well as the engineering range of the input and output channels are found on the next two pages.

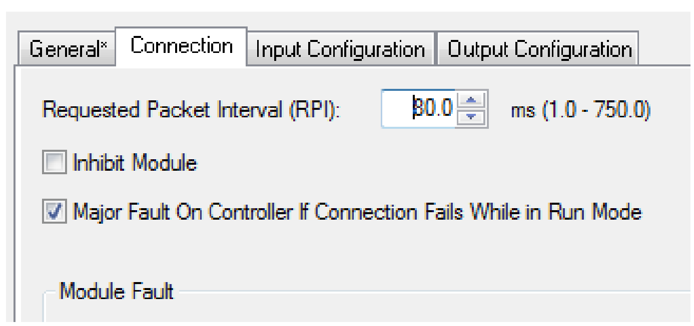


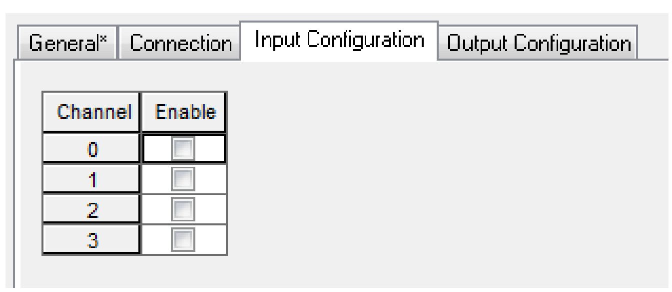


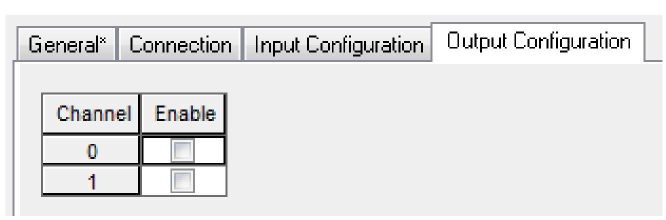
1769-IF4XOF2/A
Terminal Door Label



The wiring diagram of the card is shown above. The input and output range of the 4-20 mA engineering units can be found by looking up the accuracy of the signals. Both have a range of 0 mA to 21 mA – 0 to 32640 decimal range. So, 4 mA would be 6217 (32640/21)*4 and 20 mA would be 31085. Our range for the raw input and output then is 6217 – 31085.





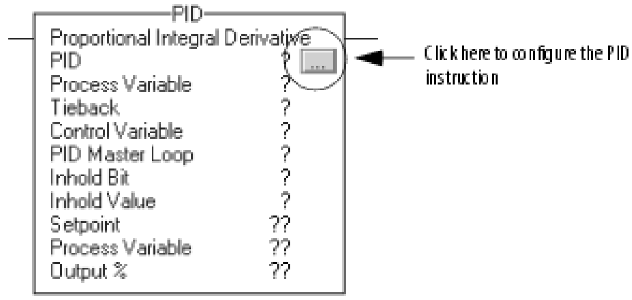


Using the CompactLogix PID Block with RSView ME

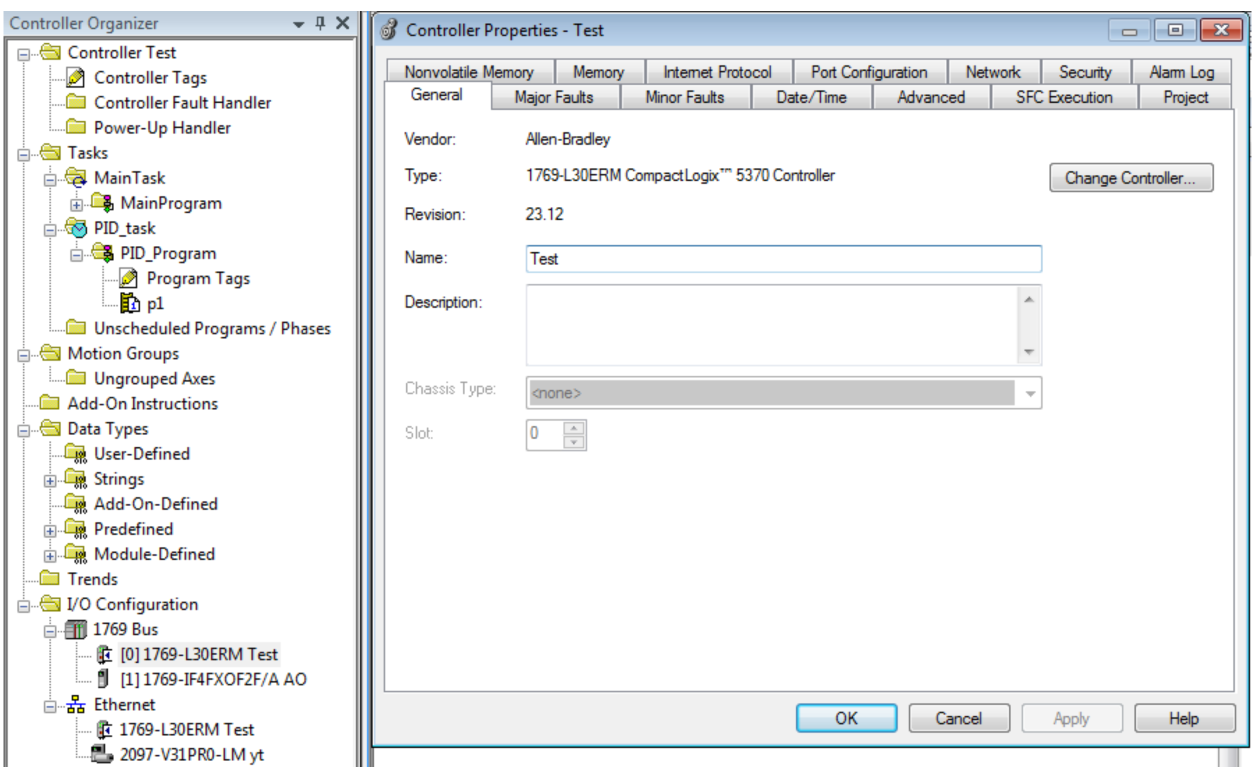
The PID algorithm will be introduced in an application using the CompactLogix hardware and software to provide control of the same valve used in the SLC programming experiences. The graphical operator interface will be upgraded to the newer RSView ME operator interface.

Configure a PID Instruction

After you enter the PID instruction and specify the PID structure, you use the configuration tabs to specify how the PID instruction should function.

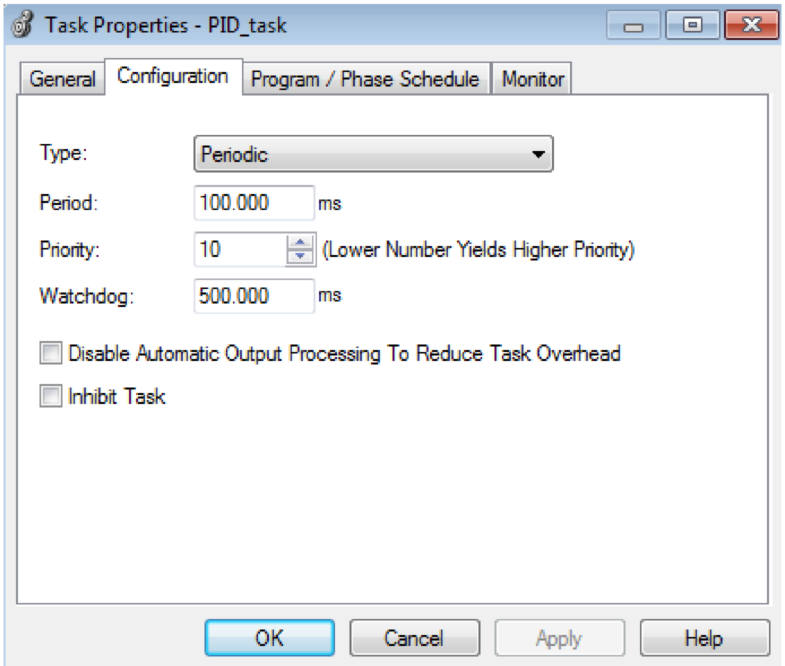


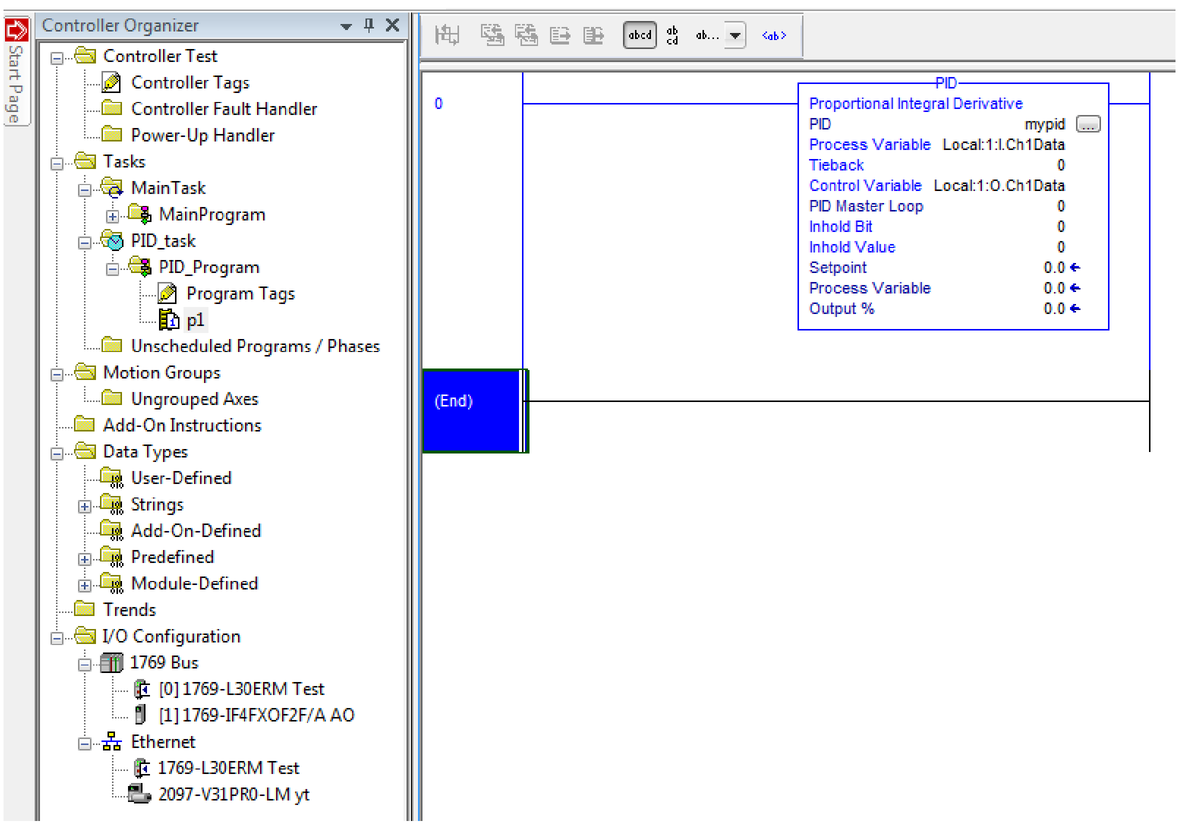
Inclusion of the data tag to create the list shown above. The PID algorithm uses these data tags to calculate and control a PID block. For instance, the PV value for the block is mypid.PV. The SP or setpoint is mypid.SP. The example screens that follow show the newer IF4XOF2F/A card and are used to set up the scaling for the present system in the lab.

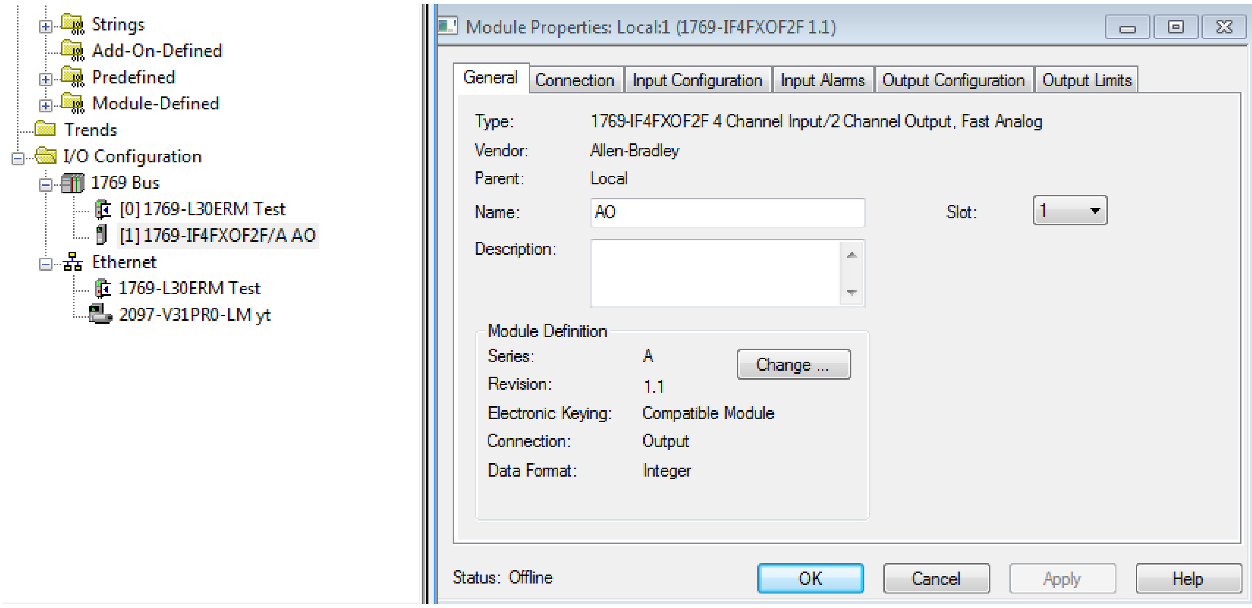


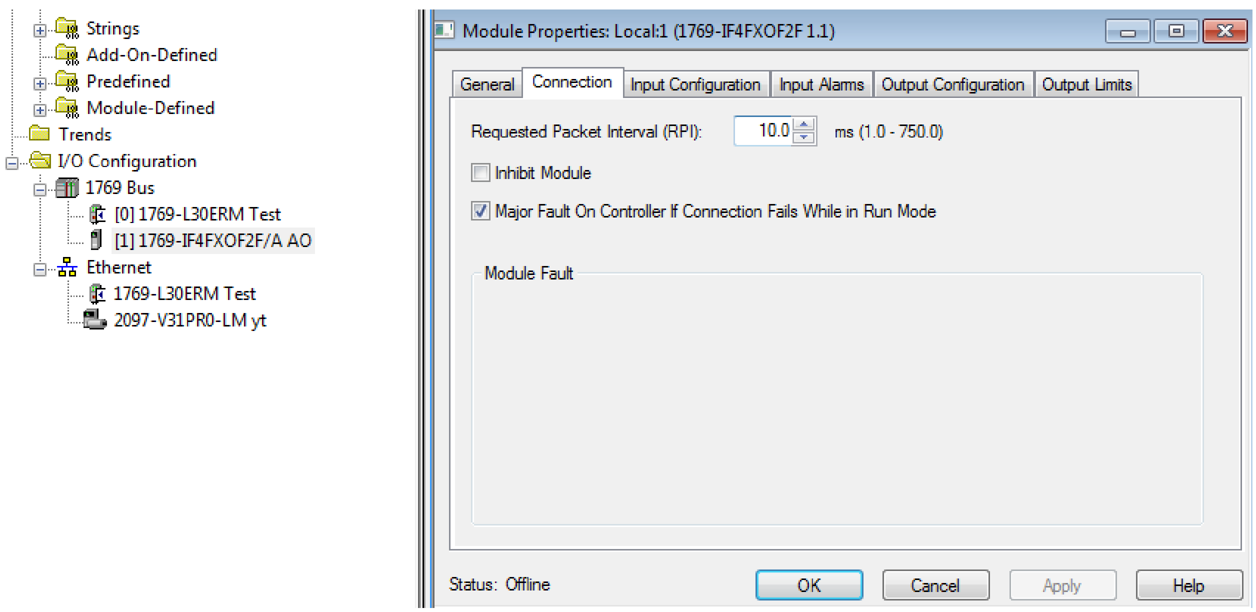
Configuration of the L30ERM

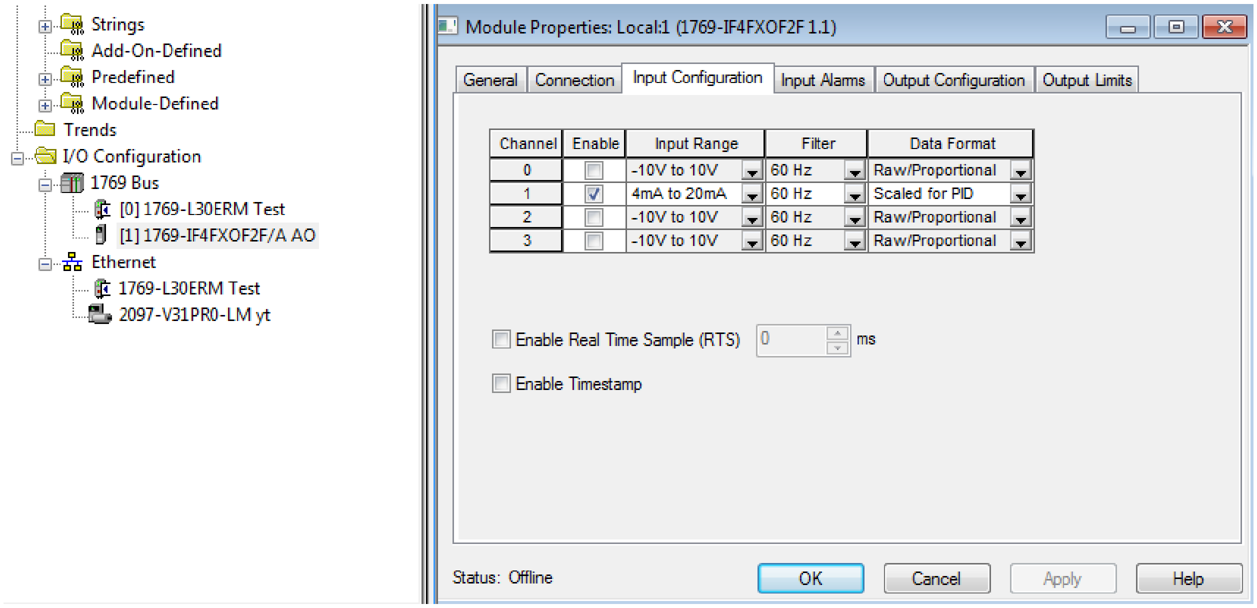
The task was set up to execute every 100 msec. This is shown in the figure below:

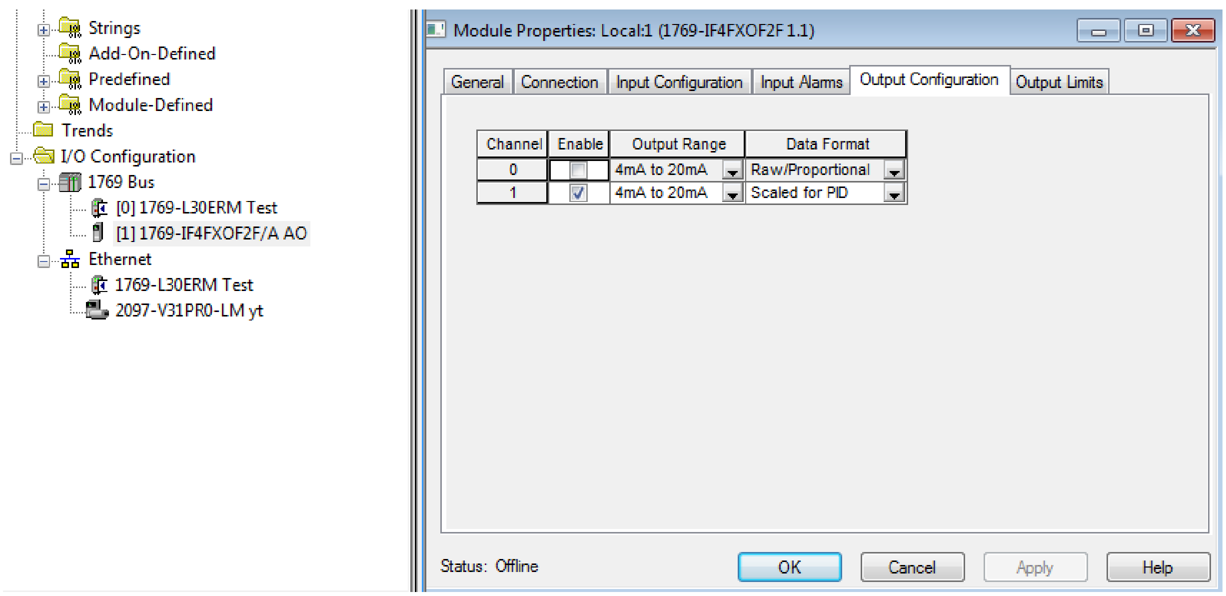


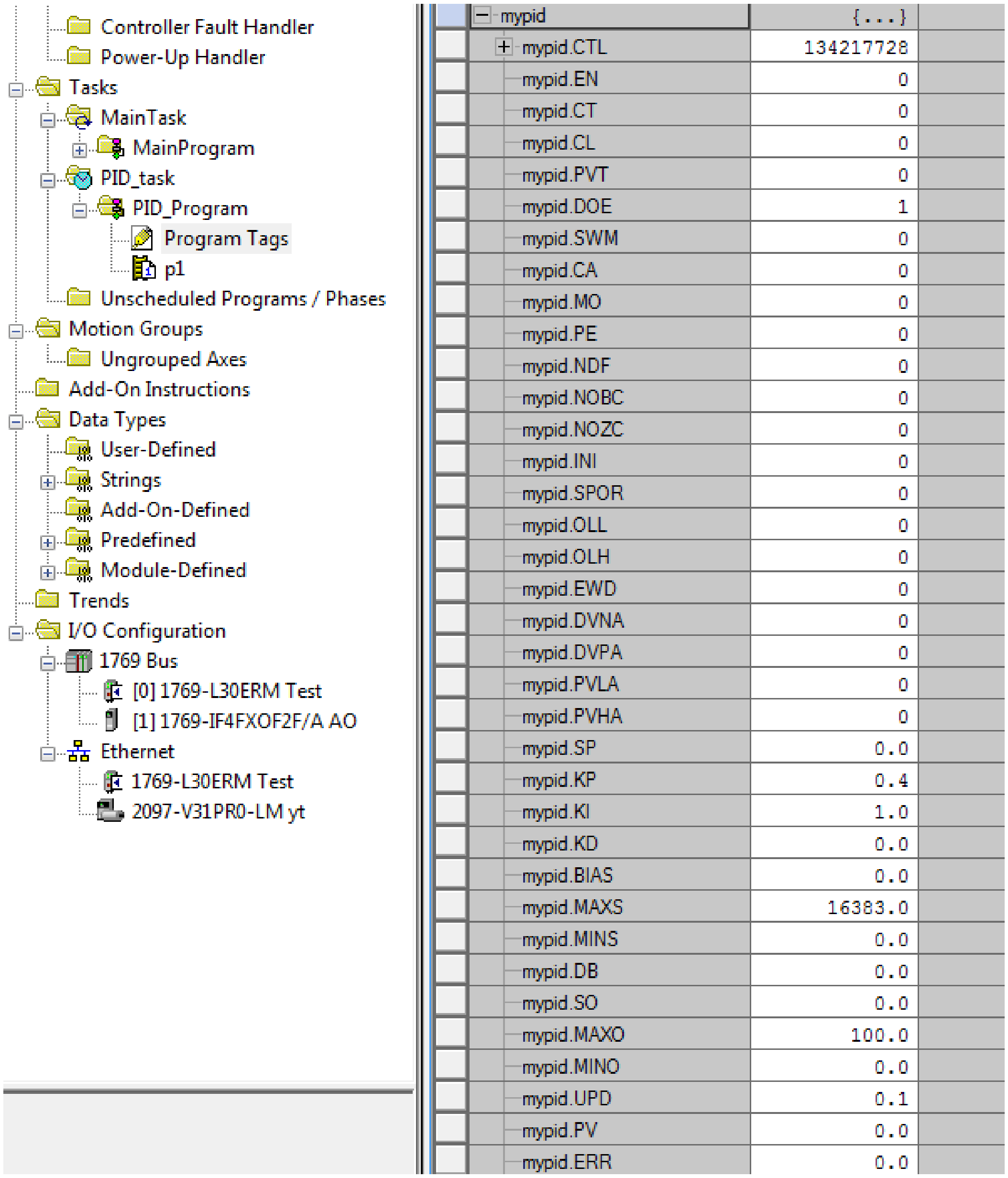



Strings
Add-On-Defined
Predefined
Module-Defined
Trends
I/O Configuration
1769 Bus
[0] 1769-L30ERM Test
[1] 1769-IF4FXOF2F/A AO
Ethernet
1769-L30ERM Test
2097-V31PR0-LM yt
Module Properties: Local:1 (1769-IF4FXOF2F 1.1)
General
Connection
Input Configuration
Input Alarms
Output Configuration
Output Limits
Type: 1769-IF4FXOF2F 4 Channel Input/2 Channel Output, Fast Analog
Vendor: Allen-Bradley
Parent: Local
Name: AO
Slot: 1
Description:
Module Definition
Series: A
Change ...
Revision: 1.1
Electronic Keying: Compatible Module
Connection: Output
Data Format: Integer
Status: Offline
OK
Cancel
Apply
Help

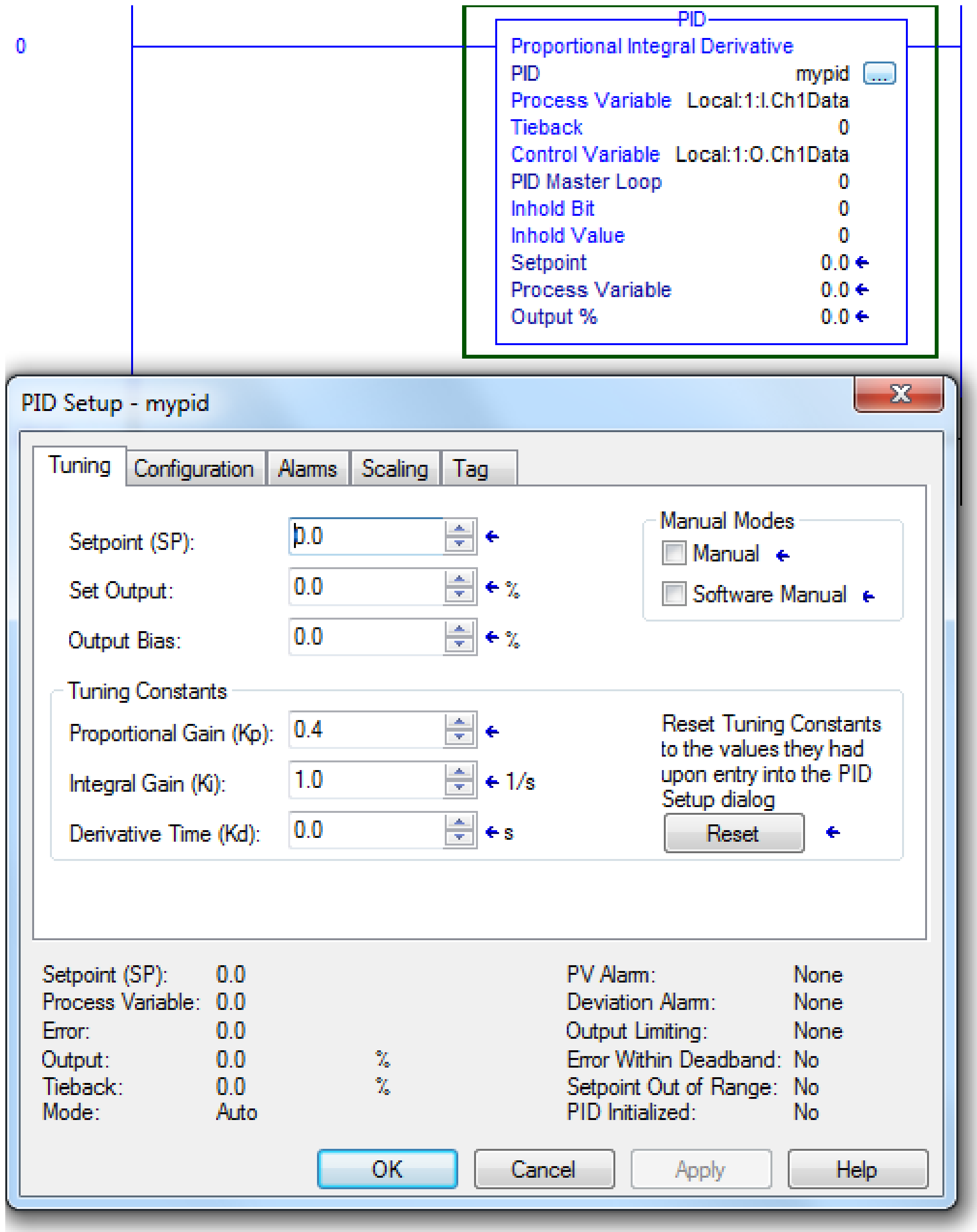

Strings
Add-On-Defined
Predefined
Module-Defined
Trends
I/O Configuration
1769 Bus
[0] 1769-L30ERM Test
[1] 1769-IF4FXOF2F/A AO
Ethernet
1769-L30ERM Test
2097-V31PR0-LM yt
Module Properties: Local:1 (1769-IF4FXOF2F 1.1)
General
Connection
Input Configuration
Input Alarms
Output Configuration
Output Limits
Requested Packet Interval (RPI): 10.0 ms (1.0 - 750.0)
Inhibit Module
Major Fault On Controller If Connection Fails While in Run Mode
Module Fault
Status: Offline
OK
Cancel
Apply
Help


Strings
Add-On-Defined
Predefined
Module-Defined
Trends
I/O Configuration
1769 Bus
[0] 1769-L30ERM Test
[1] 1769-IF4FXOF2F/A AO
Ethernet
1769-L30ERM Test
2097-V31PR0-LM yt
Module Properties: Local:1 (1769-IF4FXOF2F 1.1)
General
Connection
Input Configuration
Input Alarms
Output Configuration
Output Limits
Channel
Enable
Input Range
Filter
Data Format
0
-10V to 10V
60 Hz
Raw/Proportional
1
4mA to 20mA
60 Hz
Scaled for PID
2
-10V to 10V
60 Hz
Raw/Proportional
3
-10V to 10V
60 Hz
Raw/Proportional
Enable Real Time Sample (RTS)
0
ms
Enable Timestamp
Status: Offline
OK
Cancel
Apply
Help

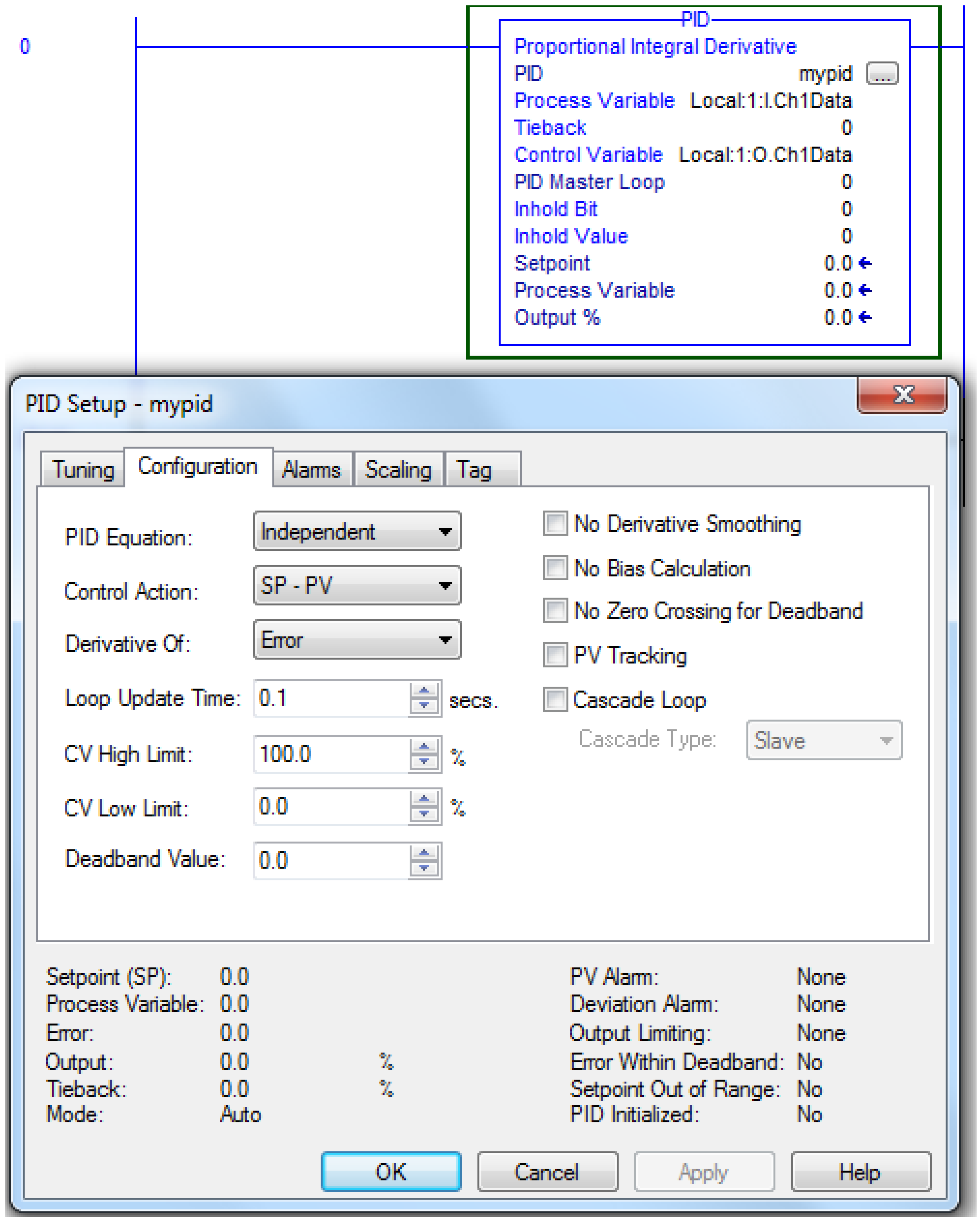

Strings
Add-On-Defined
Predefined
Module-Defined
Trends
I/O Configuration
1769 Bus
[0] 1769-L30ERM Test
[1] 1769-IF4FXOF2F/A AO
Ethernet
1769-L30ERM Test
2097-V31PR0-LM yt
Module Properties: Local:1 (1769-IF4FXOF2F 1.1)
General
Connection
Input Configuration
Input Alarms
Output Configuration
Output Limits
Channel
Enable
Output Range
Data Format
0
4mA to 20mA
Raw/Proportional
1
4mA to 20mA
Scaled for PID
Status: Offline
OK
Cancel
Apply
Help



The Program Tags for the PID mypid are shown with variable contents. These variables are useful as tag references used for communicating with the variables through program control.

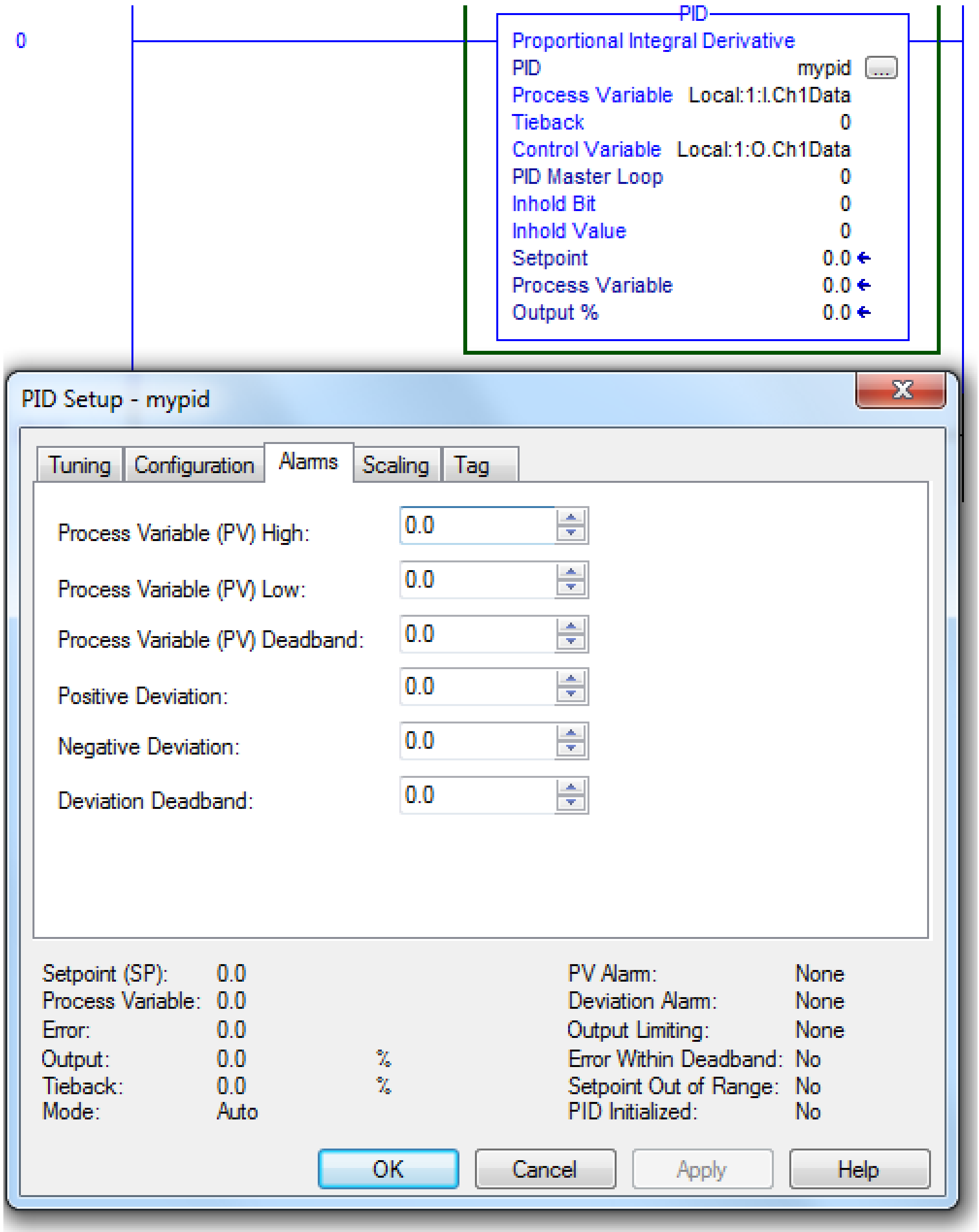


The tuning tab shows the variables used to tune the PID block. The Kp, Ki and Kd tuning constants are probably the best variables for the water valve. These constants should not vary too much from the numbers shown or the PID block may become unstable.



PID Configuration

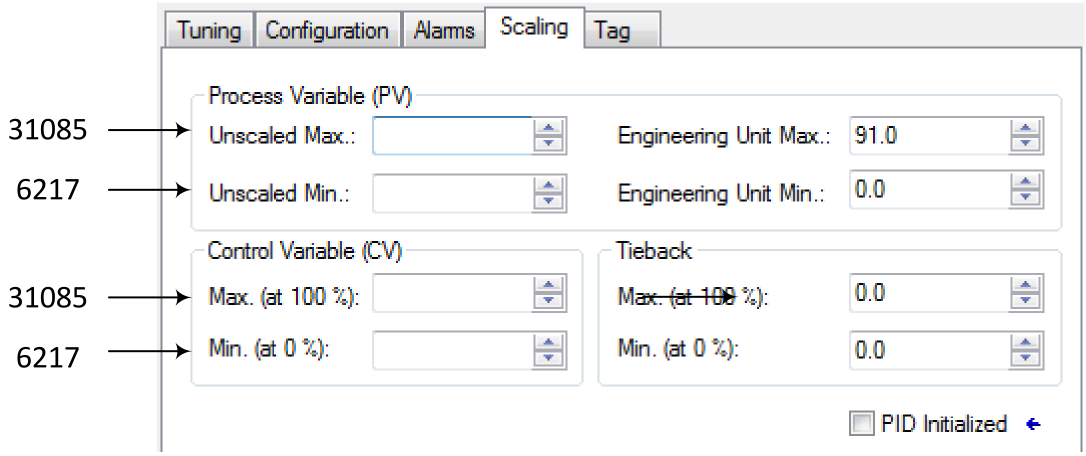
The configuration tab shows the variables used to set up the type of block used. The variables seen above are the ones used in the download example. There are a number of variables that are not used.

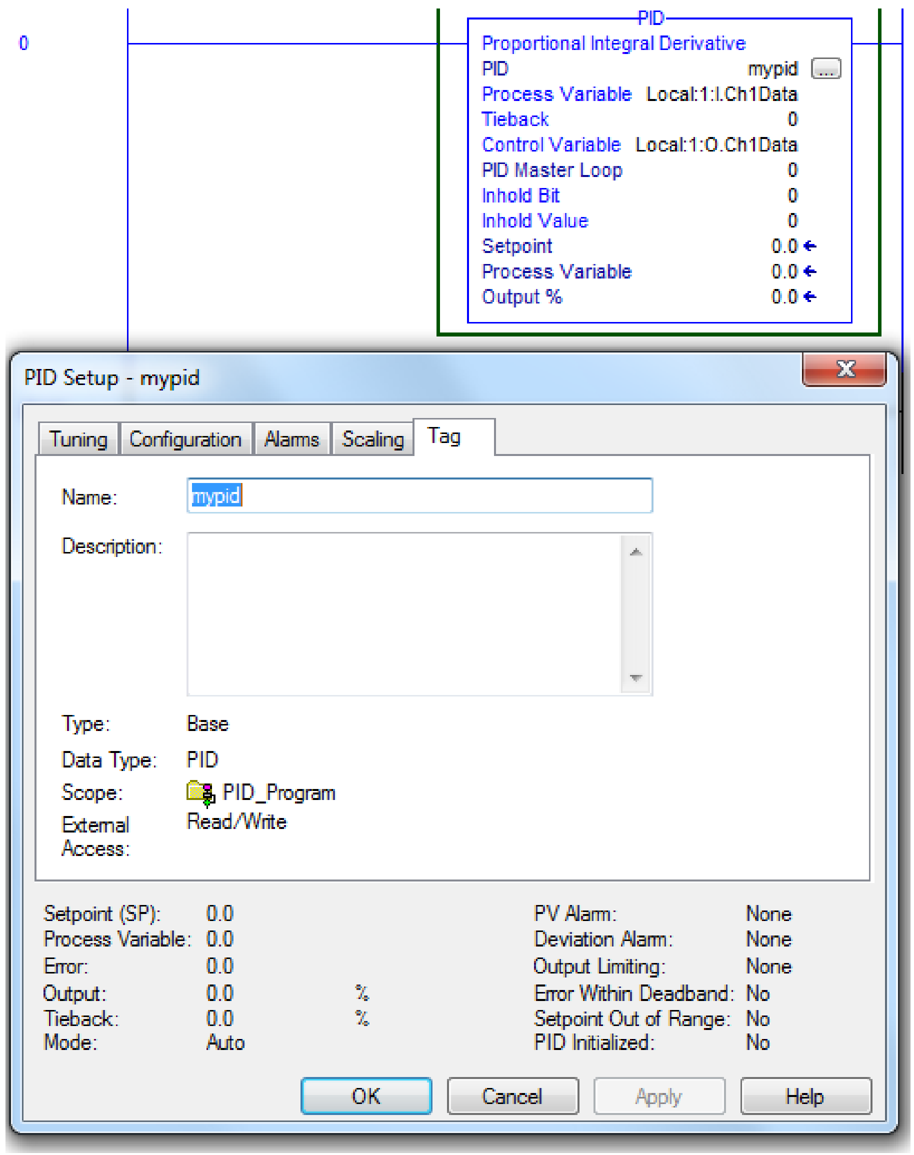


PID Alarms

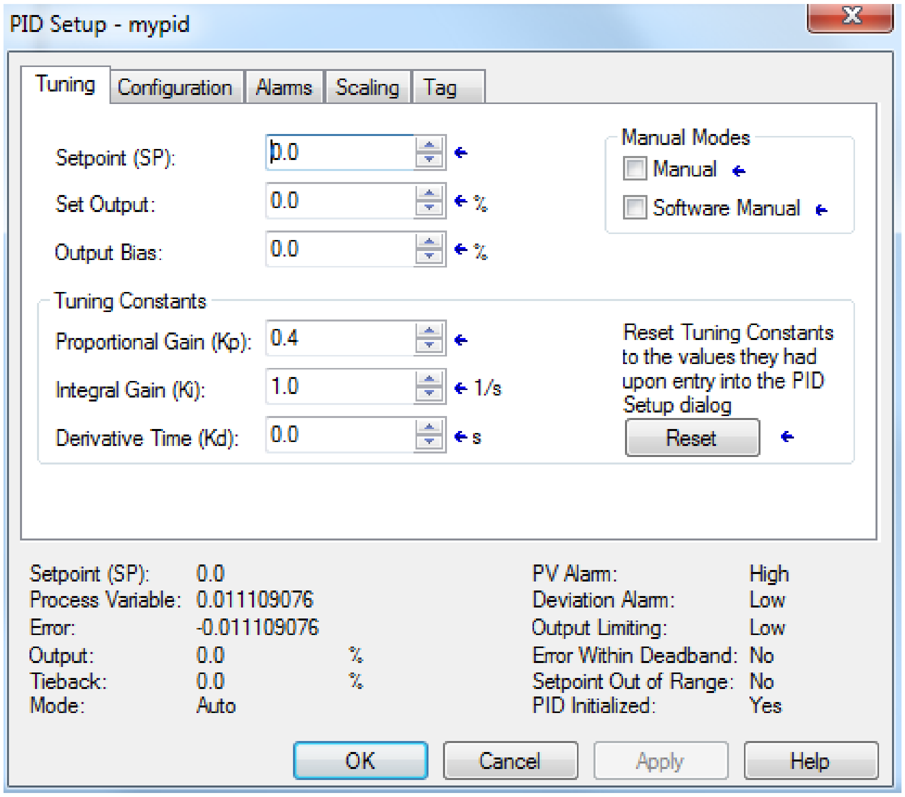
The alarms tab shows the alarm variables used to set up the block. The alarm limits are ignored for now but in a real application will be necessary when setting up a system of alarms.

The scaling tab shows the variables as set up in the block. We need to make a decision whether to scale the engineering units. The unscaled PV and CV are listed at 3200 low to 21000 high. The Engineering Units for the PV may be changed or left as is. For water, the engineered units should be 91 gpm max.

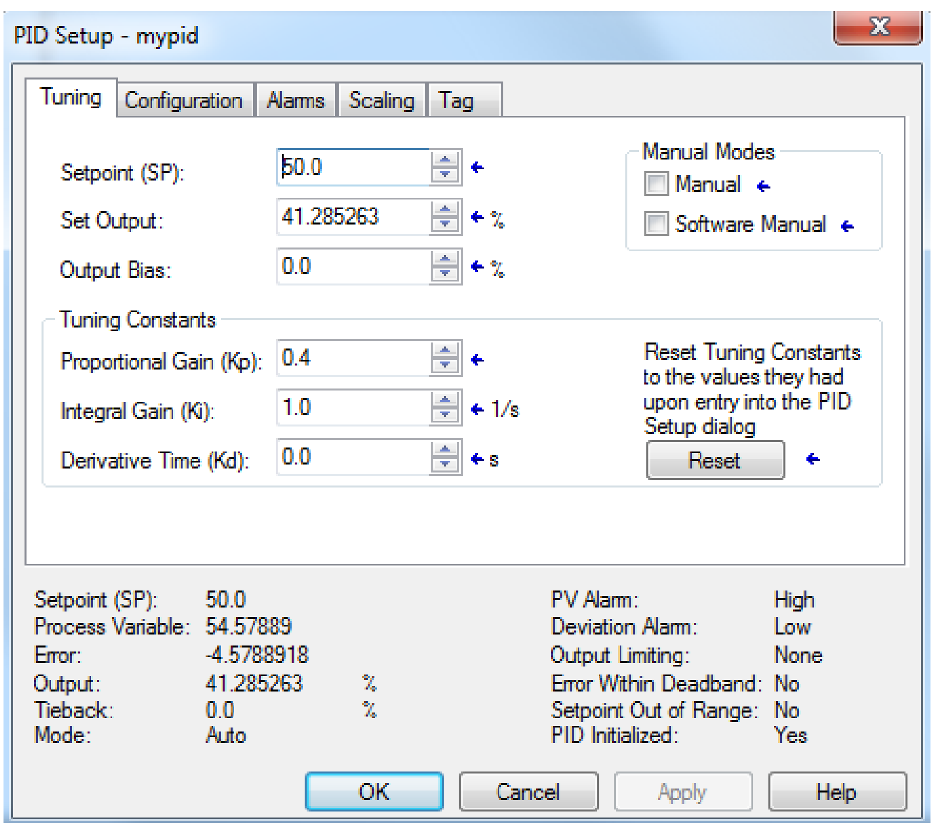

Tuning
Configuration
Alarms
Scaling
Tag
Process Variable (PV)
31085
Unscaled Max.:
Engineering Unit Max.: 91.0
6217
Unscaled Min.:
Engineering Unit Min.: 0.0
Control Variable (CV)
31085
Max. (at 100 %):
6217
Min. (at 0 %):
Tieback
Max. (at 100 %): 0.0
Min. (at 0 %): 0.0
PID Initialized

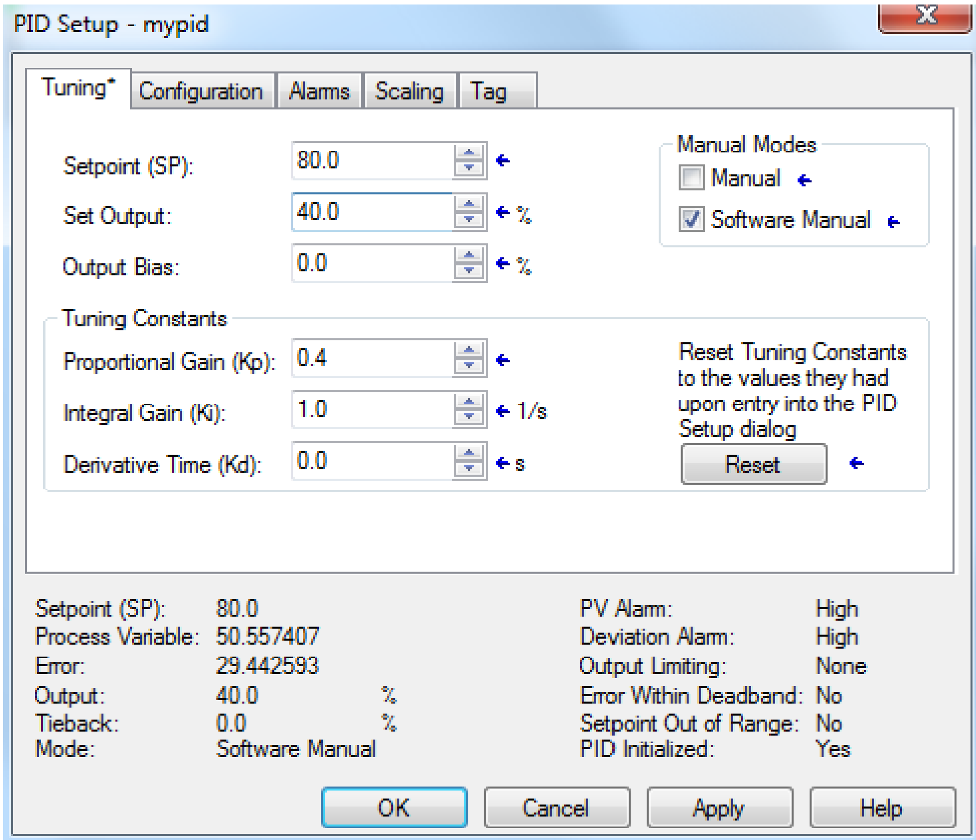

0
PID
Proportional Integral Derivative
PID mypid
Process Variable Local:1:I.Ch1Data
Tieback 0
Control Variable Local:1:O.Ch1Data
PID Master Loop 0
Inhold Bit 0
Inhold Value 0
Setpoint 0.0
Process Variable 0.0
Output % 0.0
PID Setup - mypid
Tuning
Configuration
Alarms
Scaling
Tag
Name: mypid
Description:
Type: Base
Data Type: PID
Scope: PID_Program
External Access: Read/Write
Setpoint (SP): 0.0
Process Variable: 0.0
Error: 0.0
Output: 0.0 %
Tieback: 0.0 %
Mode: Auto
PV Alarm: None
Deviation Alarm: None
Output Limiting: None
Error Within Deadband: No
Setpoint Out of Range: No
PID Initialized: No
OK
Cancel
Apply
Help

PID Setup

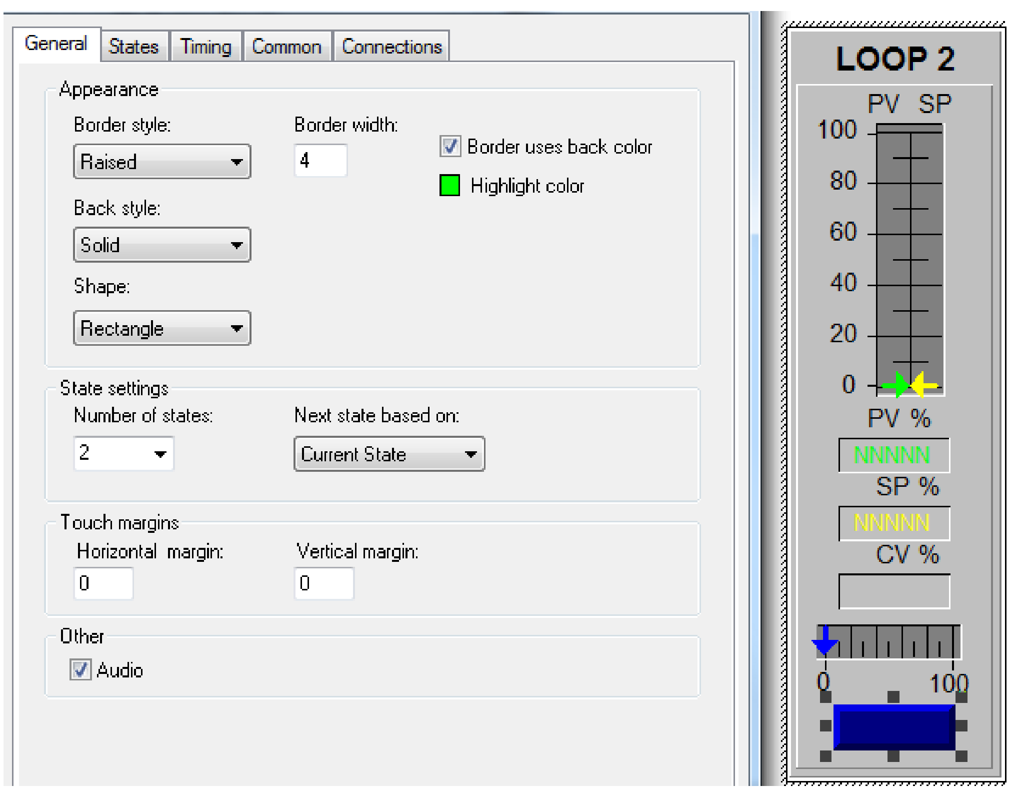


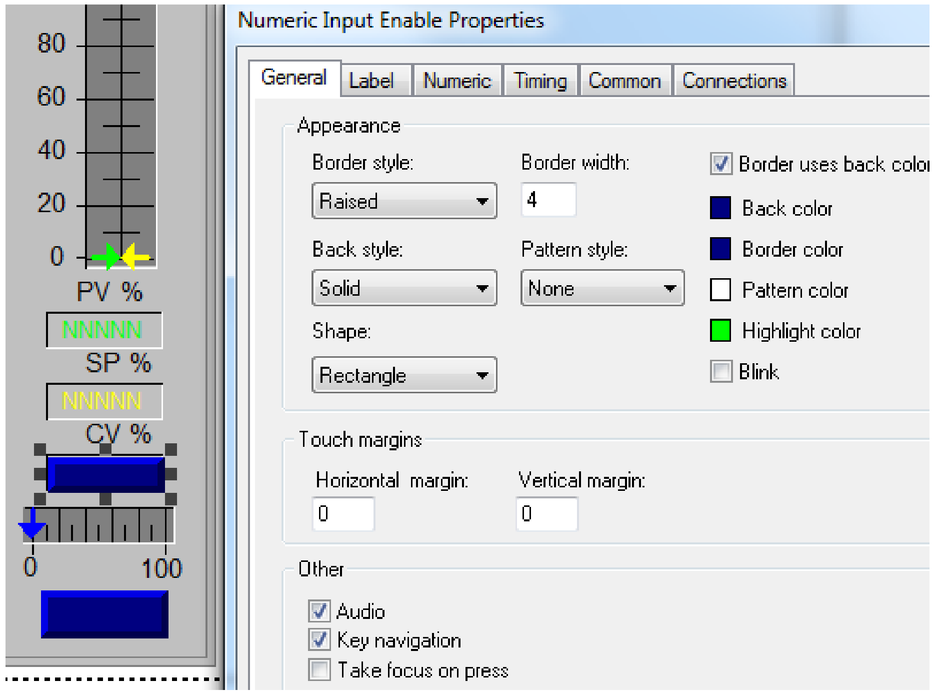
Tuning Parameters

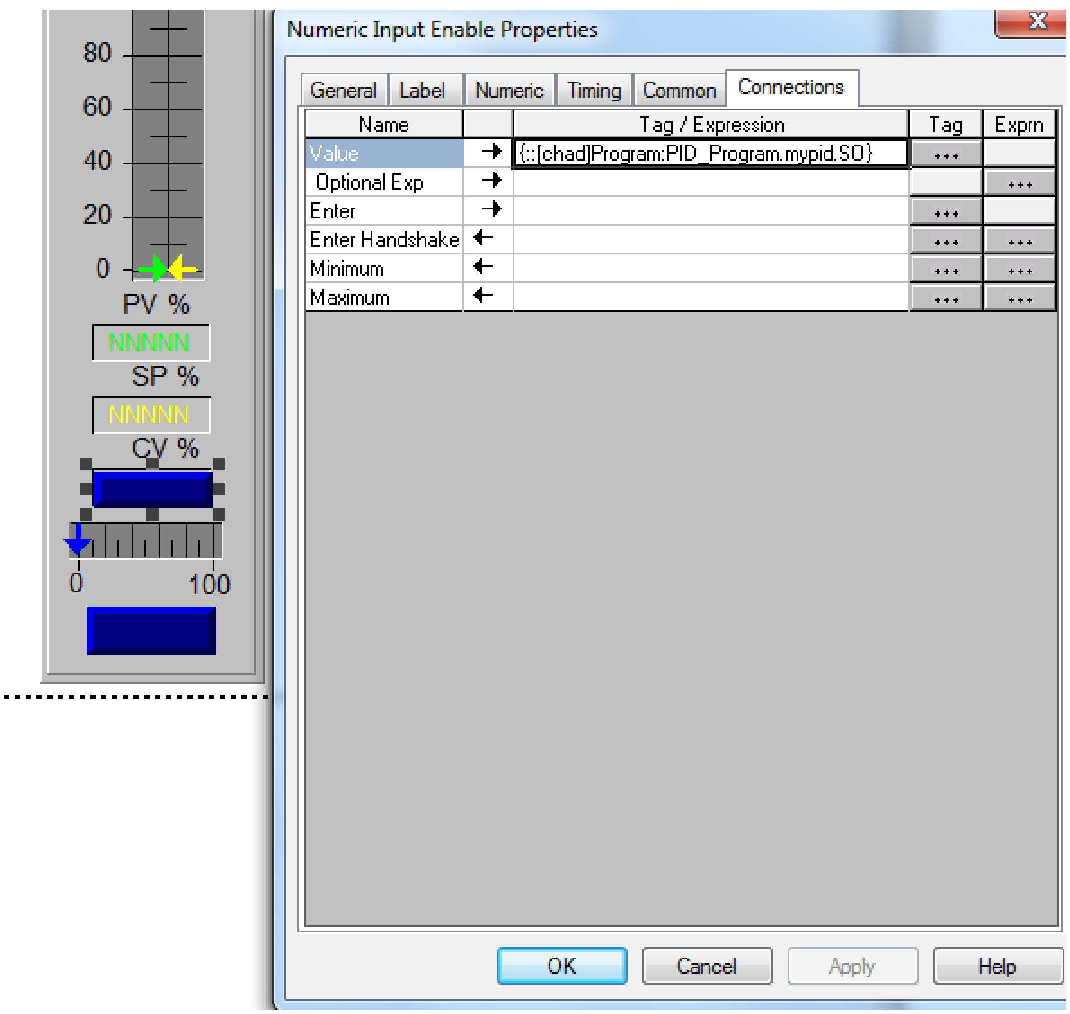




Manual Trial




80
60
40
20
0
PV %
NNNNN
SP %
NNNNN
CV %
0
100
Numeric Input Enable Properties
General
Label
Numeric
Timing
Common
Connections
Appearance
Border style:
Raised
Border width:
4
Border uses back color
Back color
Back style:
Solid
Pattern style:
None
Border color
Pattern color
Shape:
Rectangle
Highlight color
Blink
Touch margins
Horizontal margin:
0
Vertical margin:
0
Other
Audio
Key navigation
Take focus on press


80
60
40
20
0
PV %
NNNNN
SP %
NNNNN
CV %
0
100
Numeric Input Enable Properties
General
Label
Numeric
Timing
Common
Connections
Name
Tag / Expression
Tag
Exprn
Value
{::[chad]Program:PID_Program.mypid.SO}
Optional Exp
Enter
Enter Handshake
Minimum
Maximum
OK
Cancel
Apply
Help

Continuing the Allen-Bradley Configuration Pages

After you enter the PID instruction and specify the PID structure, you use the configuration tabs to specify how the PID instruction should function.

To specify tuning, select the Tuning tab. Changes take effect as soon as you click on another field.

To configure the PID:

Specify Setpoint (SP)	Enter a setpoint value (.SP).
Set output %	Enter a set output percentage (.SO) (In software manual mode, this value is used for the output. In auto mode, this value displays the output %.)
Output bias	Enter an output bias percentage (.BIAS).
Proportional gain (Kp)	Enter the proportional gain (.KP).For independent gains, it's the proportional gain (unitless). For dependent gains, it's the controller gain (unitless).
Integral gain (Ki)	Enter the integral gain (.KI). For independent gains, it's the integral gain (1/sec). For dependent gains, it's the reset time (minutes per repeat).
Derivative time (Kd)	Enter the derivative gain (.KD). For independent gains, it's the derivative gain (seconds). For dependent gains, it's the rate time minutes).
Manual mode	Select either manual (.MO) or software manual (.SWM). Manual mode overrides software manual mode if both are selected.
PID equation	Select independent gains or dependent gains (.PE). Use independent when you want the three gains (P, I, and D) to operate independently. Use dependent when you want an overall controller gain that affects all three terms (P, I, and D).
Control action	Select either E=PV-SP or E=SP-PV for the control action (.CA).
Derivative of:	Select PV or error (.DOE). Use the derivative of PV to eliminate output spikes resulting from set-point changes. Use the derivative of error for fast responses to set-point changes when the algorithm can tolerate overshoots.
Loop update time	Enter the update time (.UPD) for the instruction.
CV high limit	Enter a high limit for the control variable (.MAXO).

CV low limit Enter a low limit for the control variable (.MINO).

Deadband value Enter a deadband value (.DB)

No derivative smoothing Enable or disable this selection (.NDF)

No bias calculation Enable or disable this selection (.NOBC).

No zero crossing in dbnd Enable or disable this selection (.NOZC).

PV tracking Enable or disable this selection (.PVT).

Cascade loop Enable or disable this selection (.CL).

Cascade type If cascade loop is enabled, select either slave or master (.CT).

Specify Alarms

PV high: Enter a PV high alarm value (.PVH).

PV low: Enter a PV low alarm value (.PVL).

PV deadband: Enter a PV alarm deadband value (.PVDB).

Positive deviation Enter a positive deviation value (.DVP).

Negative deviation Enter a negative deviation value (.DVN).

Deviation deadband Enter a deviation alarm deadband value (.DVDB).

Specify Scaling

PV unscaled maximum Enter a maximum PV value (.MAXI) that equals the maximum unscaled value received from the analog input channel for the PV value.

PV unscaled minimum Enter a minimum PV value (.MINI) that equals the minimum unscaled value received from the analog input channel for the PV value.

PV engineering units maximum Enter the maximum engineering units corresponding to .MAXI (.MAXS)

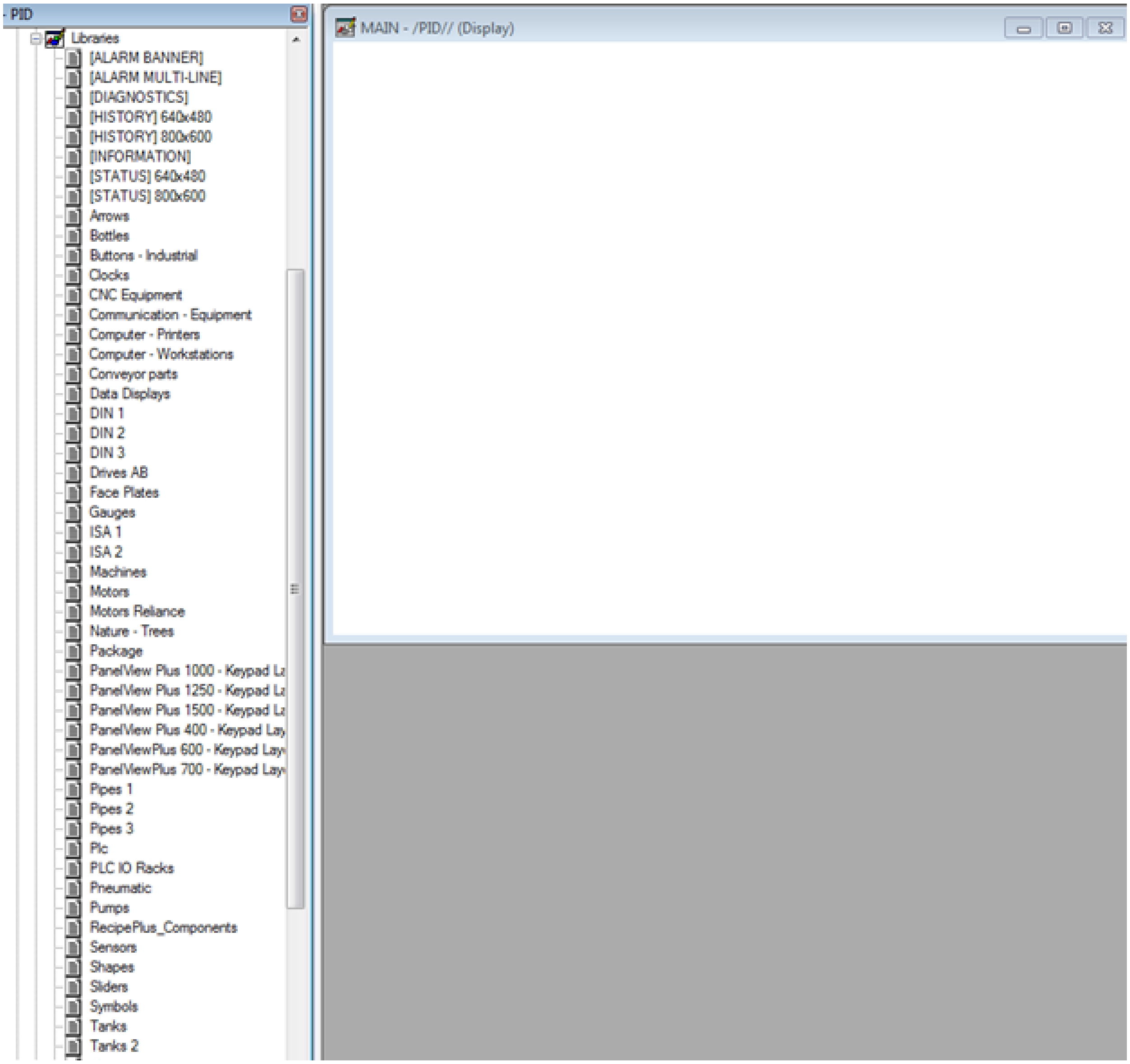
PV engineering units minimum Enter the minimum engineering units corresponding to .MINI (.MINS)

CV maximum Enter a maximum CV value corresponding to 100% (.MAXCV).

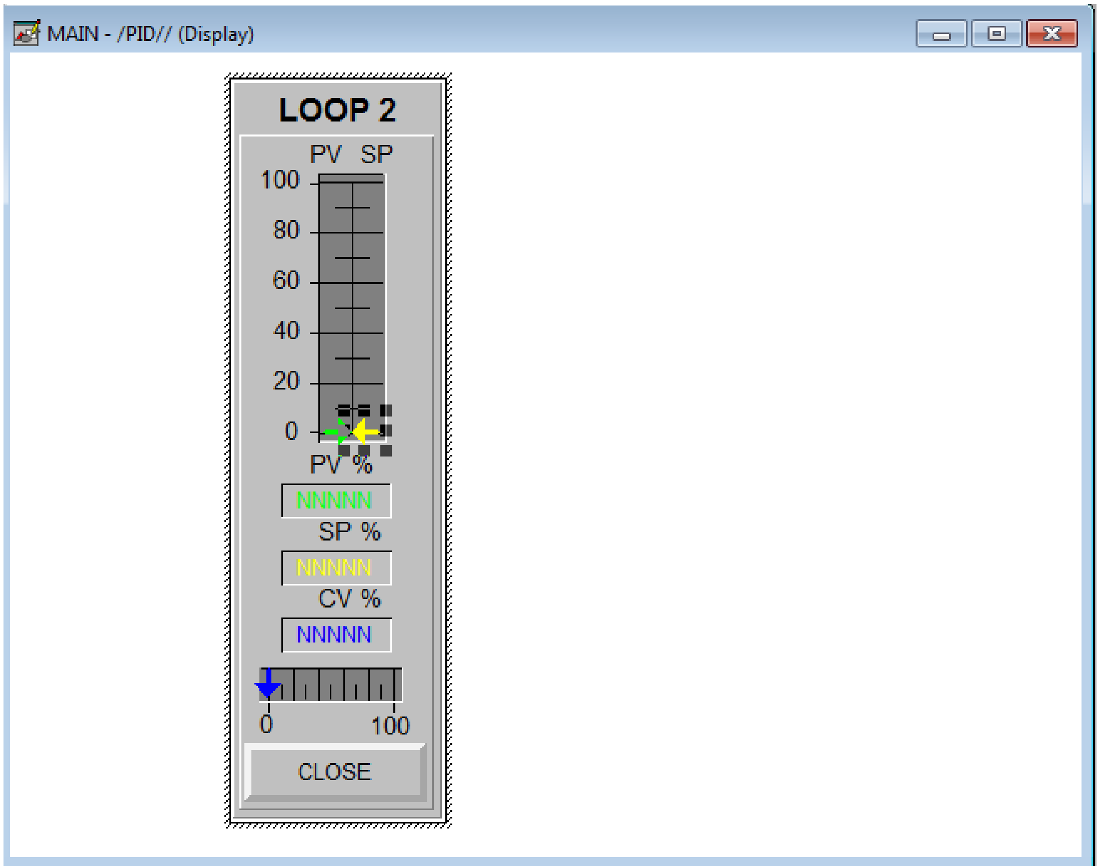
CV minimum Enter a minimum CV value corresponding to 0% (.MINCV).

Tieback maximum	Enter a maximum tieback value (.MAXTIE) that equals the maximum unscaled value received from the analog input channel for the tieback value.
Tieback minimum	Enter a minimum tieback value (.MINTIE) that equals the minimum unscaled value received from the analog input channel for the tieback value.
PID Initialized	If you change scaling constants during Run mode, turn this off to reinitialize internal descaling values (.INI)

Shifting to the HMI Program, RS Studio is entered and the Libraries choice and then Face Plates choice is entered.

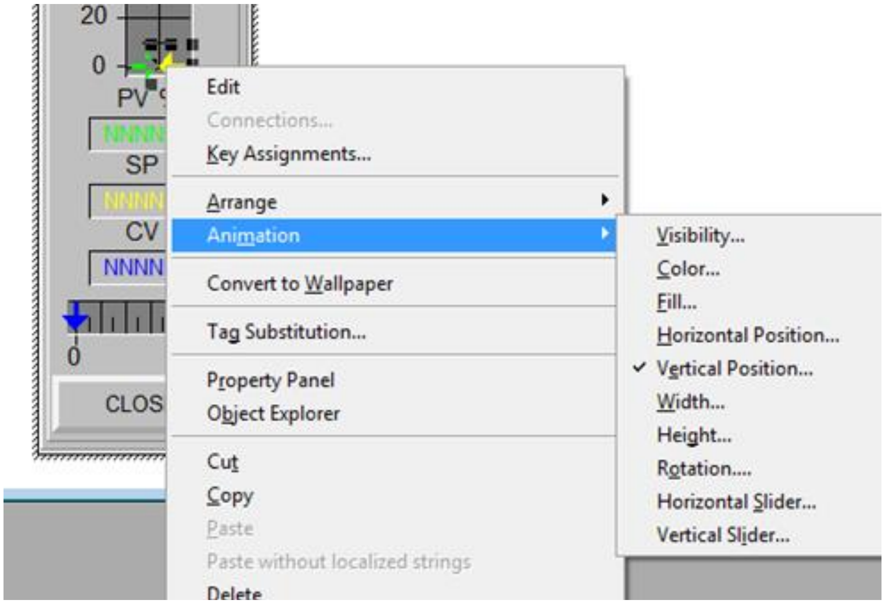


With RSStudio, build a screen from scratch using a face plate. There are a number of face plates in the template from which to choose.

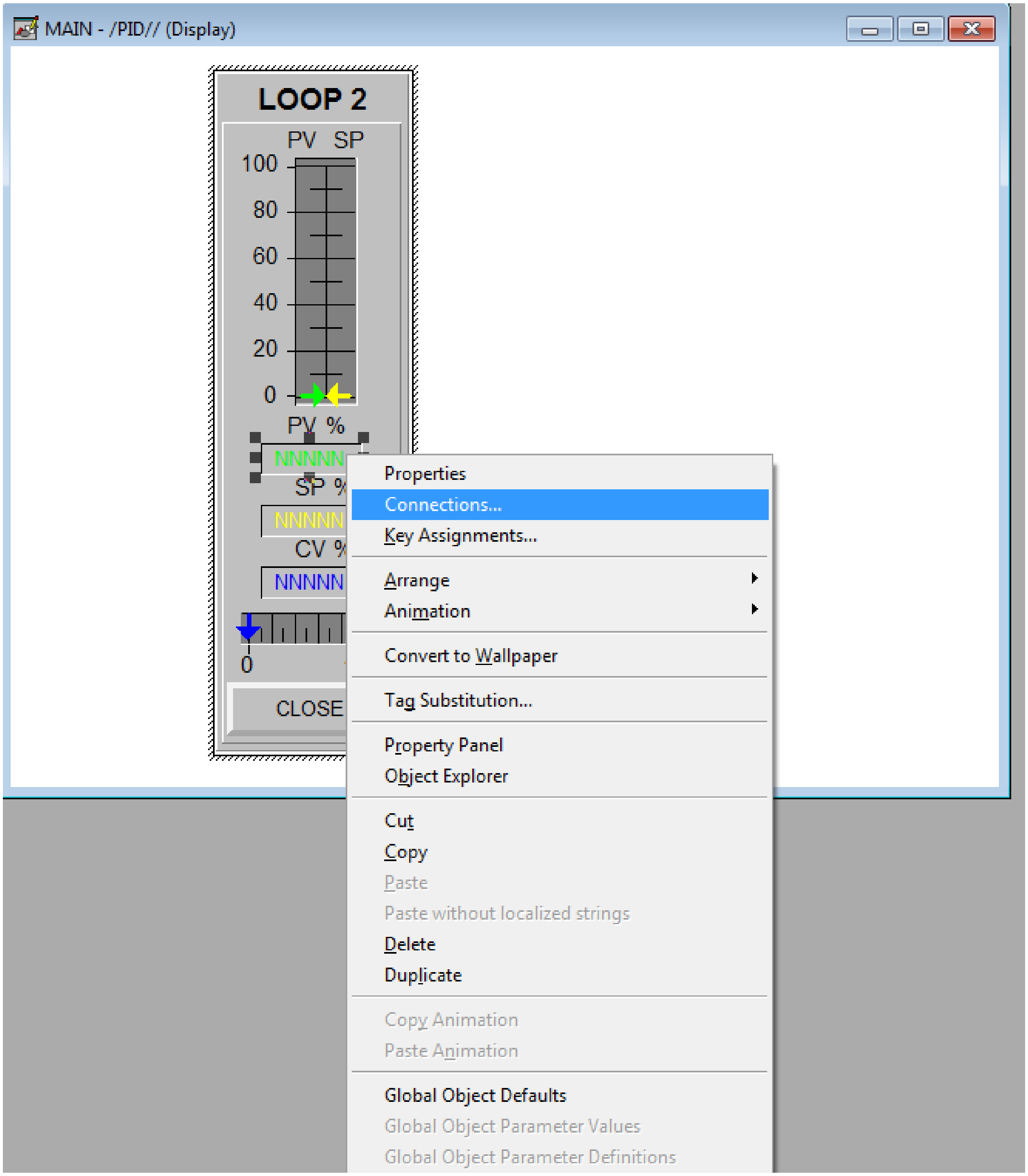


HMI Loop Face Plate

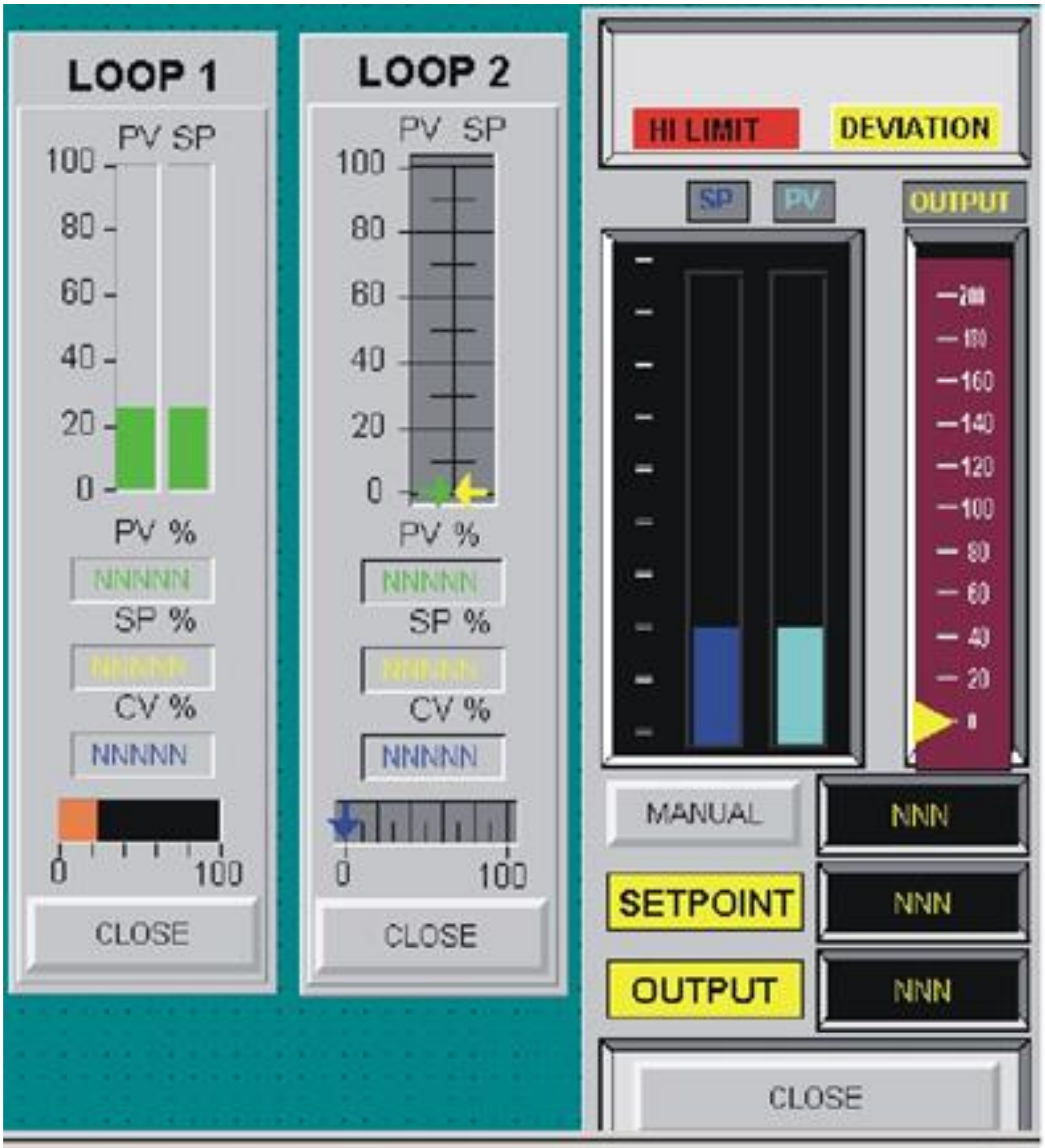
The various parts of the face plate are animated. The next screen shows the details:



Animation of the Arrow



Animation of the Numeric Entry



Choose a faceplate and begin modifying it for the application. Several tags are provided with each faceplate. These tags may set a number, allow entry of a number, move an animated arrow or fill a sliding window. Bits may be added for auto/manual and local/remote. Note that alarms may also be included such as the red and yellow tags above.

These faceplates may be modified with additional components. They may also be built from scratch using existing components. At one time, the faceplate could be unbundled. While no longer possible, the individual components may be animated by clicking them and then answering the questions.