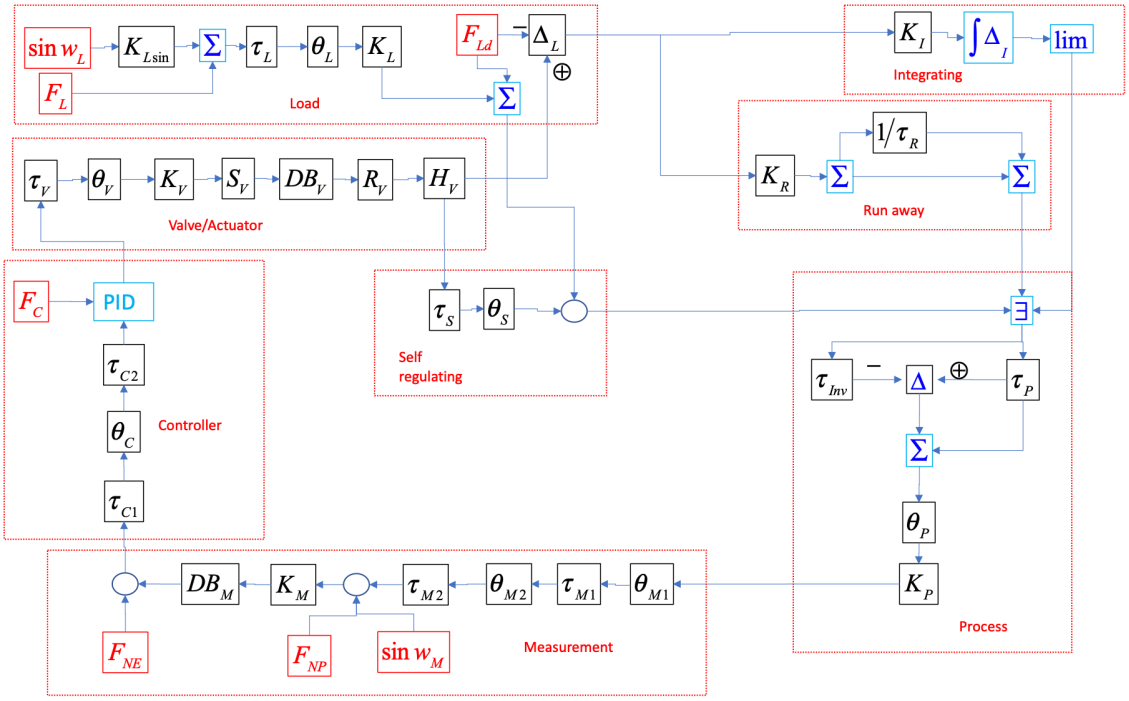
DPAS

"Process Simulation"
A Rockwell Logix v21 Add On Instruction (AOI)

This AOI was developed to simulate a single-input single-output (SISO) process dynamic response. The purpose is to aid in testing and simulating a PID control loop. While it is sufficient in most cases to create a simple simulation of a first order plus deadtime (FOPDT) process, a more comprehensive approach is taken to assign attributes that can originate in a valve (actuator), load, process characteristic, measurement, and controller. This is based on the illustration derived by Greg McMillan and incorporated into the ISA 5.9 committee report, in which the Process Simulation section was authored by Pat Dixon.



The features consist of the following:

PID_OUT: The output of the PID loop, or input to the process simulation
PID_IN: The result of the process simulation, which can be wired to the input of a PID

VALVE (ACTUATOR): These features pertain to the final control element and are designated with the suffix "_V"

SCL_V_InRawMax: The maximum value of the final control element (input to process simulation). This defaults to 100% and ordinarily should not be changed
SCL_V_InRawMin: The minimum value of the final control element (input to process simulation). This defaults to 0% and ordinarily should not be changed

LDLG_V_Lag τ_V: First order lag

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DEDT_V_Deadtime θ_V: Deadtime

FGen_V_Select K_V: Integer selection of the type of valve characteristic:

1=Linear
2=Equal percentage (squared, F[x]=x^2)
3=Quick opening (square root, F[x] = SQRT[x])
4=Custom; an array FGEN_V_Y1_Array can be modified to create a custom valve characteristic curve

Input_Start_V: Allows the valve characteristic for equal percentage or quick opening to be flattened by making the value greater than 0. The default is 0

RLIM_V S_V: Slew rate, the maximum rate of change for valve movement. Setting the value < 100% slows down the valve response

Deadband_V DB_V: Specifies a deadband in which the new value must exceed the previous value by this amount in order to move, to simulate backlash

Resolution_V R_V: This determines how fine the output is controlled, to simulate stiction and input card resolution. The output is rounded to the nearest value specified by the resolution

Hysterisis_V_Gain H_V: This is the gap width of the hysteresis curve, in which the actuator will not change direction until it exceeds this gap

Hysterisis_V_Type: This is a Boolean that is set false is the typical non-linear hysteresis curve, if set true is a linear curve

LOAD: These features pertain to load disturbances and are designated with the suffix "_L"

Sin_Period_L $\sin w_L$: The period of a sin wave in units of number of scans of the task

Sin_Gain_L: $K_{L\sin}$: The gain of the sin wave amplitude

In_L F_L: A free-form input for the process load

LDLG_L_Lead: A lead term for the load disturbance

LDLG_L_Lag τ_L: A lag term for the load disturbance

DEDT_L_Deadtime θ_L: Deadtime term for the load disturbance

In_Ld F_{Ld}: A load disturbance for an integrating or runaway process, which provides a difference calculation for the value of the final control element

PROCESS-SELF REGULATING: These parameters are used to specify the dynamic response of a self-regulating process and are designated with the suffix "_S"

LDLG_S_Lag τ_S: A lag term for the process response

DEDT_S_Deadtiume θ_S: Deadtime term for the process response

PROCESS-INTEGRATING: These parameters are used to specify the dynamic response of a self-regulating process and are designated with the suffix "_I"

MUL_S_IntGain K_I: The gain for the integrating process, where the difference of the final control element (PID_OUT) to the specified load (In_Ld) is multiplied by this gain to determine how fast the process will integrate

PROCESS-RUN AWAY: These parameters are used to specify the dynamic response of a run away process and are designated with the suffix "_Runaway"

Gain_P_Runaway K_R: The gain for the runaway process, where the difference of the final control element (PID_OUT) to the specified load (In_Ld) is multiplied by this gain to determine how fast the process will move

Lag_P_Runaway $1/\tau_R$: This is the denominator of the reciprocal which will determine the time constant for the runaway process

PROCESS: These parameters select which of the 3 process types above (self-regulating, integrating, or runaway) is used and applies the process dynamic response, which is second order with deadtime and inverse response. Configuration parameters are designated with the suffix "_P"

SEL_S_Selection ∃: Selects the type of process:
1=Self regulating
2=Integrating
3=Run away

LDLG_P_Lag τ_P: A lag term for the process response
LDLG_P_Lead_Inv: A lead term for the inverse process response

LDLD__P_Lag_Inv τ_{Inv}: A lag term for the inverse process response. Setting this less than LDLG_P_Lag will produce an inverse response for the duration of this lag
Gain_Inv_P: The gain of the inverse response (how far the response will dip in the opposite direction of the settled response

DEDT_P_Deadtime θ_P: Deadtime term for the process response

FGEN_P_Select K_P: Determines which steady state gain curve to use:
1=Linear (F[x]=x)
2=Squared (F[x]=x^2)
3=Square root (F[x]=SQRT[x])
4=Parabolic/inverse gain
5=pH

6=Custom; an array FGEN_P_Y1_Array can be modified to create a custom gain characteristic curve

Input_Start_P: Allows flattening of the Square and Square root curves by setting the value greater than 0%. For more detail, see the description of the DPAS_Curve_Square and DPAS_Curve_SQRT AOIs.

Input_Center_P: Allows locating the center (maximum point) on the X-axis for the inverse response. For more detail, see the description of the DPAS_Curve_Parabola AOI

Input_pH_Hi_P: Allows specifying the maximum range of pH for locating the curve, from 0 to 14. For more detail, see the description of the DPAS_Curve_pH AOI

Input_pH_Lo_P: Allows specifying the maximum range of pH for locating the curve, from 0 to 14. For more detail, see the description of the DPAS_Curve_pH AOI

MEASUREMENT: These features pertain to the measurement and are designated with the suffix "_M"

LDLG_M1_Lag τ_{M1}: A lag term for the measurement

DEDT_M1_Deadtime θ_{M1}: Deadtime term for the measurement

LDLG_M2_Lag τ_{M2}: A lag term for the measurement, for transmitter including damping settings

DEDT_M2_Deadtime θ_{M2}: Deadtime term for the measurement, for sampling instruments, or ½ of wireless update rate

Sin_Period_M1 $\sin w_M$: The period of a sin wave in units of number of scans of the task

Sin_Gain_M1: The gain of the sin wave amplitude

Random_Amplitude_M1 F_{NP}: This represents the noise in the process, measurement, or electrical circuit

Deadband_M1_Deadband DB_M: Specifies a deadband in which the new value must exceed the previous value by this amount in order for the measurement to change. Specified in engineering units for report by exception measurements

Random_Amplitude_M2 F_{NE}: This represents the noise in the digital conversion, electrical/grounding problems

SCL_M2_EuMax K_M: Maximum value of measurement for scaling from 0%-100% to the engineering units of the measurement

SCL_M2_EuMin K_M: Minimum value of measurement for scaling from 0%-100% to the engineering units of the measurement

CONTROLLER: These features pertain to the measurement and are designated with the suffix "_C"

LDLG_C1_Lag τ_{C1}: A first order lag term for the controller, scan filter and/or analog input block filter

DEDT_C_Deadtime θ_C: Deadtime term for the controller, controller sampling or execution delay

LDLG_C2_Lag τ_{C2}: A second order lag term for the controller, which may include built in filter for PID block

The parameters on the AOI are as follows:

Name	Usage	Data Type	Alias For	Default	Style	Re	Vis	Description	External Acces	Constant
PID_OUT	Input	REAL		0.0	Float	☑	☑	Output from PID that feeds into simulation	Read/Write	☐
PID_IN	Output	REAL		0.0	Float	☑	☑	Input to PID (PV), result of simulation	Read Only	☐
Deadband_M1_Deadband	Input	REAL		0.0	Float	☐	☐	Deadband, (resolution, wireless report by e...	Read/Write	☐
Deadband_V	Input	REAL		0.0	Float	☐	☐	Deadband, stiction	Read/Write	☐
DEDT_C_Deadtime	Input	REAL		0.0	Float	☐	☐	Deadtime, controller (execution cycle)	Read/Write	☐
DEDT_L_Deadtime	Input	REAL		0.0	Float	☐	☐	Deadtime, load disturbance	Read/Write	☐
DEDT_M1_Deadtime	Input	REAL		0.0	Float	☐	☐	Deadtime, measurement 1	Read/Write	☐
DEDT_M2_Deadtime	Input	REAL		0.0	Float	☐	☐	Deadtime, measurement 2	Read/Write	☐
DEDT_P_Deadtime	Input	REAL		0.0	Float	☐	☐	Deadtime, process primary	Read/Write	☐
DEDT_S_Deadtime	Input	REAL		0.0	Float	☐	☐	Deadtime, process secondary	Read/Write	☐
DEDT_V_Deadtime	Input	REAL		0.0	Float	☐	☐	Deadtime, valve	Read/Write	☐
+ FGEN_P_Select	Input	DINT		0	Decim...	☐	☐	Characterization, process (1=Linear, 2=Squ...	Read/Write	☐
+ FGEN_V_Select	Input	DINT		0	Decim...	☐	☐	Characterization, valve (1=Linear, 2=Equal ...	Read/Write	☐
Gain_P_Runaway	Input	REAL		0.0	Float	☐	☐	Gain for runaway process	Read/Write	☐
Lag_P_Runaway	Input	REAL		0.0	Float	☐	☐	Lag for runaway process (1-1000)	Read/Write	☐
LDLG_C1_Lag	Input	REAL		0.0	Float	☐	☐	Lag, controller 1	Read/Write	☐
LDLG_C2_Lag	Input	REAL		0.0	Float	☐	☐	Lag, controller 2	Read/Write	☐
LDLG_L_Lag	Input	REAL		0.0	Float	☐	☐	Lag, load disturbance	Read/Write	☐
LDLG_L_Lead	Input	REAL		0.0	Float	☐	☐	Lead, disturbance	Read/Write	☐
LDLG_M1_Lag	Input	REAL		0.0	Float	☐	☐	Lag, measurement 1	Read/Write	☐
LDLG_M2_Lag	Input	REAL		0.0	Float	☐	☐	Lag, measurement 2	Read/Write	☐
LDLG_P_Lag	Input	REAL		0.0	Float	☐	☐	Lag, process primary	Read/Write	☐
LDLG_P_Lead	Input	REAL		0.0	Float	☐	☐	Lead, process primary	Read/Write	☐
LDLG_S_Lag	Input	REAL		0.0	Float	☐	☐	Lag, process, secondary	Read/Write	☐
LDLG_S_Lead	Input	REAL		0.0	Float	☐	☐	Lead, process secondary	Read/Write	☐
LDLG_V_Lag	Input	REAL		0.0	Float	☐	☐	Lag, valve	Read/Write	☐
LDLG_V_Lead	Input	REAL		0.0	Float	☐	☐	Lead, valve	Read/Write	☐
Hysterisis_V_Gain	Input	REAL		0.0	Float	☐	☐	Gain for maximum hysterisis gap	Read/Write	☐
Hysterisis_V_Type	Input	BOOL		0	Decim...	☐	☐	False=NonLinear True=Linear	Read/Write	☐
In_L	Input	REAL		0.0	Float	☐	☐	Freeform input for load disturbance in %	Read/Write	☐

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Name	Usage	Data Type	Alias For	Default	Style	Re	Vis	Description	External Acces	Constant
MUL_S_IntGain	Input	REAL		0.0	Float	☐	☐	Gain for integrator (Valve-Load)	Read/Write	☐
Out_P_Integrator	Input	REAL		0.0	Float	☐	☐	Output of integrating process	Read/Write	☐
Random_Amplitude_M1	Input	REAL		0.0	Float	☐	☐	Amplitude of measurement process/analog...	Read/Write	☐
Random_Amplitude_M2	Input	REAL		0.0	Float	☐	☐	Apmlitude of noise from electrical/data com...	Read/Write	☐
SCL_V_InRawMax	Input	REAL		100.0	Float	☐	☐	Raw scale for input, max, valve	Read/Write	☐
SCL_V_InRawMin	Input	REAL		0.0	Float	☐	☐	Raw scale for input, min, valve	Read/Write	☐
Sin_Gain_L	Input	REAL		1.0	Float	☐	☐	Gain, load, sin wave disturbance in %	Read/Write	☐
+ Sin_Period_L	Input	DINT		1000	Decim...	☐	☐	Period, load (in task periods) for full Sin wave	Read/Write	☐
SCL_M2_InEUMax	Input	REAL		100.0	Float	☐	☐	Measurement engineering range Max	Read/Write	☐
SCL_M2_InEUMin	Input	REAL		0.0	Float	☐	☐	Measurement engineering range Min	Read/Write	☐
+ SEL_S_Selection	Input	DINT		0	Decim...	☐	☐	Process type (1=Self Regulating, 2=Integrat...	Read/Write	☐
RLIM_V	Input	REAL		0.0	Float	☐	☐	Rate limiter (slew rate) for valve in % for bot...	Read/Write	☐
Resolution_V	Input	REAL		0.0	Float	☐	☐	Resolution of final control element (valve, V...	Read/Write	☐
Out_L	Output	REAL		0.0	Float	☐	☐	Output of load disturbance in %	Read Only	☐
Out_M	Output	REAL		0.0	Float	☐	☐	Output of measurement simulation in EU	Read Only	☐
Out_P	Output	REAL		0.0	Float	☐	☐	Output of process simulation in %	Read Only	☐
Out_V	Output	REAL		0.0	Float	☐	☐	Output of V (Valve) sheet in %	Read Only	☐
LDLG_P_Lead_Inv	Input	REAL		0.0	Float	☐	☐	Lead term for inverse response block	Read/Write	☐
LDLG_P_Lag_Inv	Input	REAL		0.0	Float	☐	☐	Lag term for inverse response block	Read/Write	☐
In_Ld	Input	REAL		0.0	Float	☐	☐	Free form input for deviation	Read/Write	☐
+ Sin_Period_M1	Input	DINT		0	Decim...	☐	☐	Sin period for measurement noise, number ...	Read/Write	☐
Sin_Gain_M1	Input	REAL		0.0	Float	☐	☐	Sin gain for measurement noise	Read/Write	☐
Input_Start_V	Input	REAL		0.0	Float	☐	☐	Start of input x axis for valve characteristic	Read/Write	☐
Input_Start_P	Input	REAL		0.0	Float	☐	☐	Start of response for process characteristic	Read/Write	☐
Input_Center_P	Input	REAL		50.0	Float	☐	☐	Center of response (x axis) for parabolic cur...	Read/Write	☐
Input_pH_Hi_P	Input	REAL		14.0	Float	☐	☐	Hi range of pH for process response	Read/Write	☐
Input_pH_Lo_P	Input	REAL		0.0	Float	☐	☐	Lo range of pH for process response	Read/Write	☐
MUL_S_Integrator_Input	Input	REAL		0.0	Float	☐	☐	Integration after initiatilzation check	Read/Write	☐
Gain_Inv_P	Input	REAL		1.0	Float	☐	☐	Gain for inverse response	Read/Write	☐

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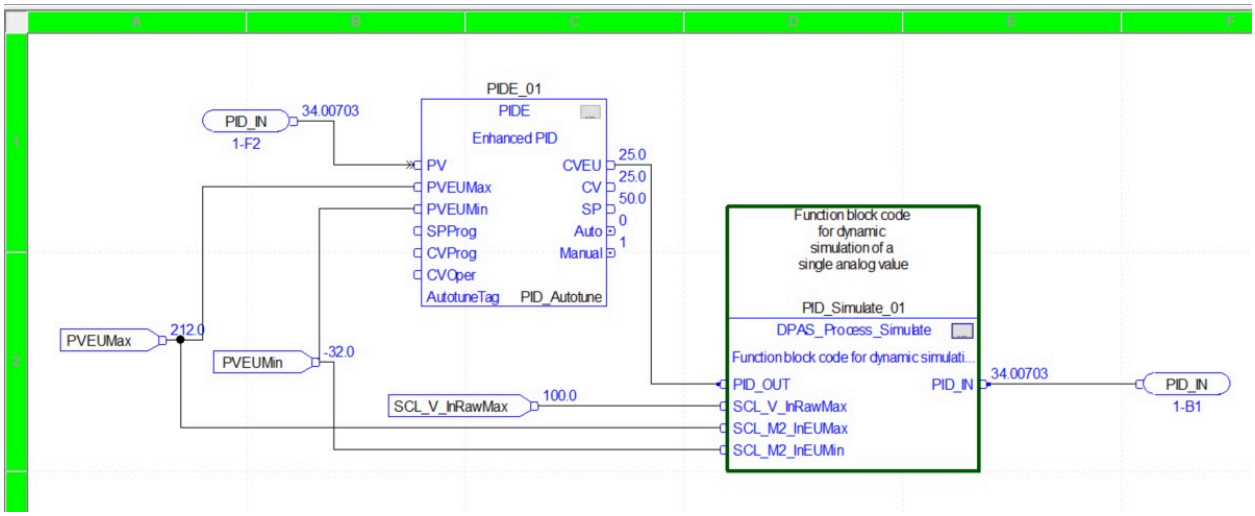
In runtime, it appears as:



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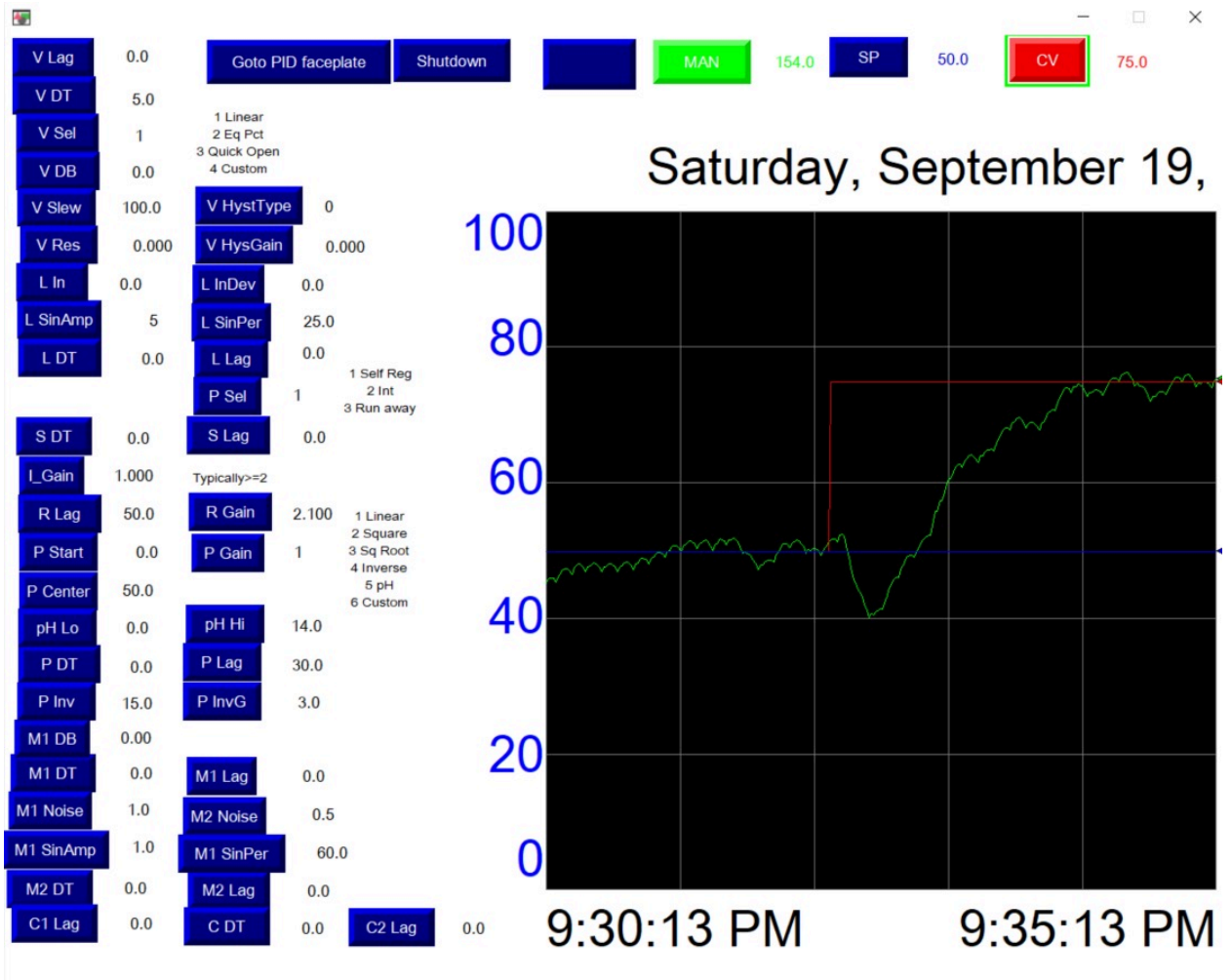
Also provided is a simple FactoryTalk ME display for visualizing the simulation:



This AOI (DPAS_Process_Simulate.L5X) was developed in Logix v21. It can be imported into any later version of Logix.

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