PID Control in CLICK

Purpose

The CLICK PLC, like other controllers, has attributes that are common to any PID control system, but it also has its own features unique to CLICK. Most of the CLICK PID configuration, monitoring and tuning can be done in the **PID Configuration** and **PID Monitor** window. But some users would rather have the flexibility to implement this feature in ladder logic and use another user interface such as a C-more HMI to configure, monitor and tune their PID control loops. This help topic is intended to give the user what they need to implement the CLICK PID feature in ladder logic without using those tools.

CLICK PID Function Overview

- PID maximum number of loops: 8 Loops
- Required memory: 40 C coils, 15 DS registers, 25 DF registers
- Control Algorithm: Position only
- Control Action: Direct or Reverse
- Error Term: Linear or Squared
- Error Dead band: Configurable
- Sampling rate: 100 to 30,000 ms
- Control Algorithm: PID or PI
- PV filter: Configurable
- Set Point: maximum and minimum values can be set
- Control Output: maximum and minimum values can be set
- Derivative Gain Limit: Configurable
- Anti-Windup (Bias freeze): Selectable
- Bumpless transfer: two modes
- PWM Output: Duty Cycle corresponding to the Control Output value
- Autotuning: Limit Cycle (closed loop)

PID Loop Addressing

Each PID Loop requires consecutive C, DS and DF memory areas. All of the PID Loop Configuration parameters are stored in these memory locations.

C Memory Area: 40 Consecutive bits

DS Memory Area: 15 Consecutive Integers

DF Memory Area: 25 Consecutive Floats

<u>PID Address Descriptions</u>

For a complete list and description of each PLC Address used in each PID Loop Configuration and their Nicknames, see the topic **PID Address Description**.

PID Control Algorithm

CLICK utilizes a position PID control algorithm only. The implementation of the PID algorithm in the PLC is shown below.

= Control Output

= Initial Output

= Proportional Gain (P)

= error (SP - PV)

= Sample Rate in seconds

= Reset Time (I) in seconds

= Derivative Gain (D) in seconds

= present sample

= previous sample

Setpoint (SP)

The **Setpoint (DFn+00)** is the value to which the PID Control Loop is trying to drive the PV.

Setpoint Upper and Lower Limits: You may select to limit the allowed upper and lower settings for the Setpoint. This is useful in preventing someone from accidentally entering a value that is outside the process limits.

When enabled, if a Setpoint value is entered outside of the limits, the PLC will automatically change the Setpoint to the limit that is closest to the value entered.

The limits are enabled individually:

Upper Limit enable (Cn+01)

Lower Limit enable (Cn+00)

The limit values must be set if the limit is enabled:

Upper Limit value (DFn+02)

Lower Limit value (DFn+01)

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Process Variable (PV)

The **Raw Process Variable** (DFn+11) is the measured value that the PID loop controls. It is directly affected by the process being controlled. The **Process Variable** (DFn+12) is the filtered **Raw Process Variable** used by the PID calculation. If the PV filter is not enabled, then the PV is equal to the Raw PV.

PV Upper and Lower Limits

The PV Upper (DFn+23) and Lower (DFn+22) Limits are the expected process range values for the full range of the Control Output. They are used to calculate the Process gain which in turn is used by Autotune to calculate the Proportional Gain tuning constant.

This is not the range of the process measurement device or the PLC input configuration. For example the Input may be a RTD input with a range of -328 to 1562 Deg F. But the Process range for a CO of 0 to 100 may only be 40 to 140 Deg F. The **PV Upper and Lower Limits** would be 140 and 40 respectively.

PV Filter

A noisy Raw PV can cause a PID loop to become unstable as well as make the loop difficult to tune. The CLICK PLC provides a **PV Filter** to reduce the high frequency noise in the Raw PV value to provide a clean PV to the PID Controller.

PV Filter(Cn+11): turns on the PV filter.

Filter Constant (DSn+8): the Filter Constant is the percentage of the Raw PV that is passed each PID sample time. The smaller the filter value, the more filtering that will occur. A value of 100 will result in no filtering and 100% of the Raw PV is passed.The default value is 100.

 Enabling the PV Filter and entering a small filter value can cause some lag in the PV. This should be taken

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Error Term

The Error is the difference between the Setpoint and the Process Variable: Error = SP - PV.

<u>Error Squared Option</u>

When the Error Squared (Cn+02) option is selected, the error term is squared (preserving the original sign), before it is used in the PID calculation. This lessens the response to smaller error values, but increases the response to larger errors.

Two situations in which the error squared term might be useful are:

- Noisy PV signal – using a squared error term can reduce the effect of electrical noise on the PV, which will make the control system jittery. A squared error maintains the response to larger errors.
- Non-linear process – some processes (such as chemical pH control) require non-linear controllers for best results.

<u>Error Deadband Option</u>

When the **Error with Deadband** (Cn+03) option is selected, no control action is taken if the PV is within the specified **Error Deadband (**DFn+03) around the SP. The error deadband is the same above and below the SP and is in the same units as the PV and SP.

Once the PV is outside of the error deadband around the SP, the entire error is used in the loop calculation.

If Error Squared is enabled, the error will be squared before it is applied to the deadband calculation.

Control Output (CO)

The Control Output (DFn+08) is the result of the PID calculation. It is usually tied to a physical output on the PLC, which is wired to a control device such as a valve actuator.

The Control Output is Read Only when the loop is in Auto. To change the Control Outout, the loop must be in Manual Mode.

The Control Output range is 0 to 100% by default. But it can be changed by setting the **Upper Limit(DFn+10)** and **Lower Limit(DFn+09)**.

The PID control will not exceed these limits in Auto or Autotuning Mode. The limit values have no effect in Manual mode.

If the Upper Limit is set to zero, the CO will never get above zero and the control loop will not function properly.

PWM Control

PWM (Pulse Width Modulated) control turns the Control Output signal into a series of pulses. The width of the pulse (or duty cycle) is the ratio of ON time to OFF time determined by the Control Output percentage of the **Time Period**.

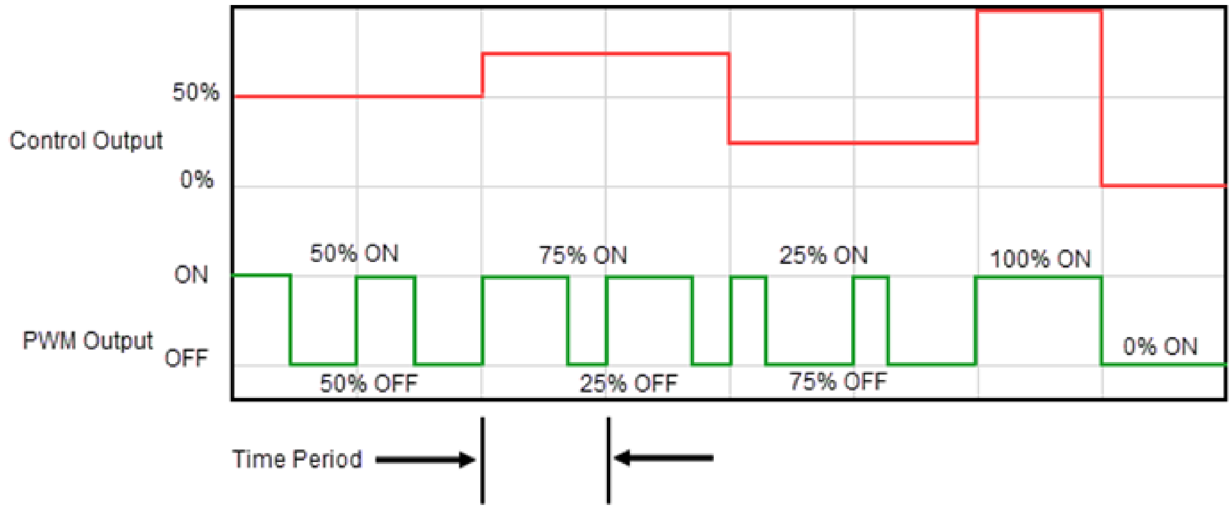
PWM is useful when the Control element in the process is not an analog device such as a valve position actuator, but a discrete device such as a heating element. For example, temperature can be controlled by turning the heating element ON and OFF.

This can be accomplished by assigning the **Bit Address** of a Discrete Output, such as a relay output, to the PWM Control.

Since PWM Control is determined by the type of output, it is enabled in the PID configuration, but unlike most other parameters, it is not modifiable by the Ladder Logic. No Address is assigned to the PWM Enable setting.

Bit Address: The is the address of the discrete output that is tied to the control element in the process. The programmer assigns this.

Time Period: (DSn+07): The total of the ON and OFF time. This value can be 1 to 600 seconds.



Action

The Action (Cn+09) of a control loop is either Direct (forward) acting or Reverse acting.

A **Direct** acting control loop means that whenever the control output increases, the PV will also increase. For example, if the Control Output drives open a gas valve to a flame control, the temperature will increase as the Control Output increases.

A **Reverse** acting control loop is one where an increase in the control output results in a decrease in the PV. A common example of this would be a refrigeration system, where an increase in the cooling input causes a decrease in the PV (temperature).

Tuning Constants

The CLICK PID Algorithm uses Proportional Gain(K_P), Integral Time (T_I) and Derivative(T_D) constants for tuning the control loop.

Proportional Gain (DFn+05)

Proportional Gain, in the equation above is the constant K_P and has no units. The value can be 0.01 to 10000. Each sample time (T_S), the Error is multiplied by K_P and the result is added to the previous CO value. So, the adjustment made to CO is Proportional to the error for that sample.

In some controllers, you can remove the effect of the Proportional term from the calculation by setting P to 0 or a very small number. This is not the case in the CLICK PLC since as seen above in the equation, the K_P is used in both the Integral and Derivative terms.

Integral or Reset Time (DFn+06)

Reset time, in the equation is the constant T_I and is expressed in seconds. The value can be 0.01 to 6000. Each sample time, the Error accumulated over the time the loop has been running is multiplied by the T_S times K_P divided by T_I . The result (Bias term) is added to the previous CO value. So, the adjustment made to CO is proportional to the Integral Sum of the error.

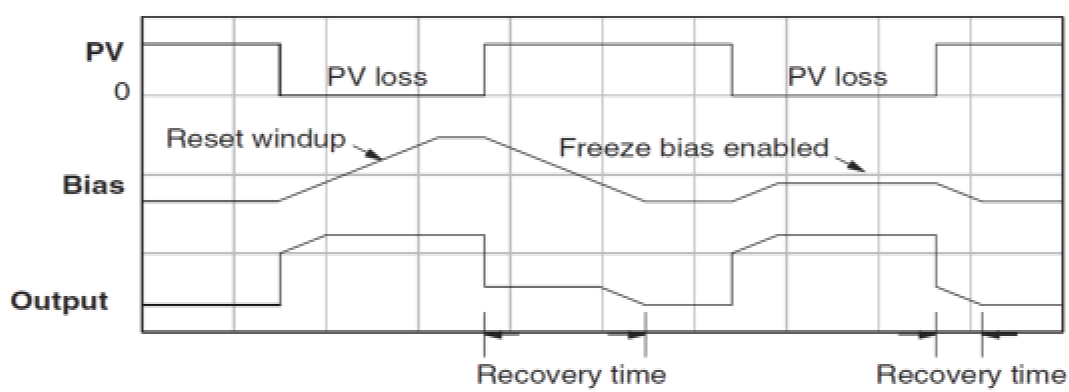
To remove the effects of the Integral term from the calculation, make the Reset Time very large in the order of 1000 seconds or so.

Freeze Bias (Anti-Windup) (Cn+05)

Freeze Bias, also known as Anti-Windup, is a feature of the CLICK PID that can make your process more stable and recover more quickly from process disturbances. To understand Freeze Bias and Anti-Windup, you must first understand Bias and Reset Windup.

The Bias term is the Integrator portion of the PID calculation. It is the accumulated Error times the Sample Rate divided by the Reset Time. Reset Windup refers to the fact that so long as there is error, this value continues to accumulate and drive CO to its limit.

Refer to the figure below. When there is a large Error caused by a SP change, process disturbance, or as in the example below a lost PV signal, the bias term keeps integrating normally during the lost PV until its upper limit is reached. When the PV signal returns, the bias value is saturated (windup) and takes a long time to return to normal. The loop output consequently has an extended recovery time. Until recovery, the output level is locked at its extreme limit and causes further problems by not allowing the loop to recover quickly.

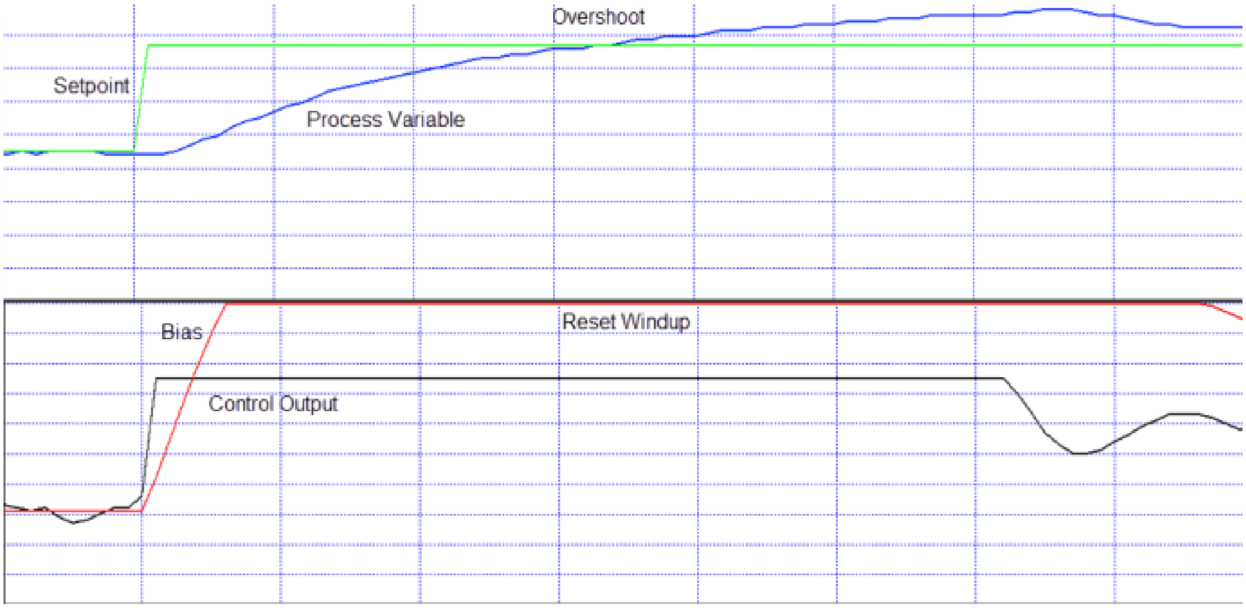


In the second PV signal loss example, the Freeze Bias feature is enabled. It causes the bias value to freeze when the control output goes to its upper limit. The reset windup is avoided and the output recovery time is much less.

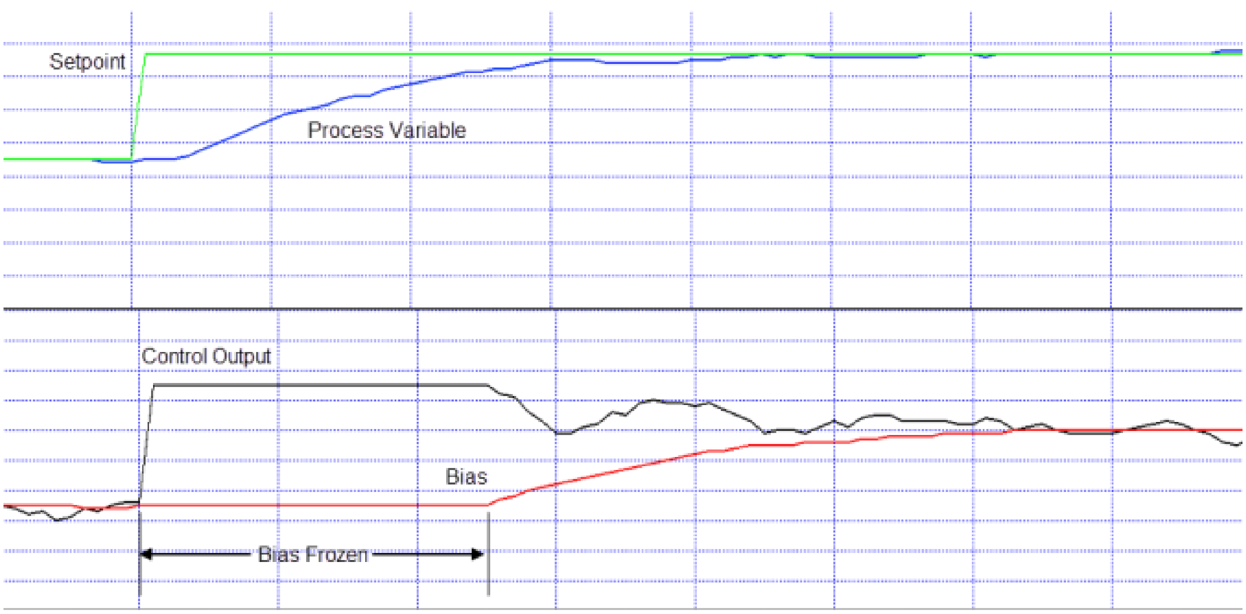
The Freeze Bias will occur when the Control Output has reached the Upper or Lower limit set in the **Output** tab.

The example shows a large Setpoint change with No Freeze Bias vs Freeze Bias enabled.

No Freeze Bias



Freeze Bias



<u>Derivative Gain (DFn+07)</u>

In the equation, Derivative Gain is the constant T_D and is expressed in seconds. For each sample time, the difference in the present error and the previous error is multiplied by T_D time K_P divided by the T_S. The result is added to the previous CO. So, the adjustment made to the CO is proportional to the Derivative of the error, or the rate of change of the error since the last sample.

Derivative Gain is useful for reacting quickly to a sudden change in the error. But as a result, it is also negatively affected by high frequency noise in the PV and may cause the CO to be erratic.

To remove the effects of the Derivative term from the calculation, make the Derivative Gain equal to 0.

Derivative Gain Limit

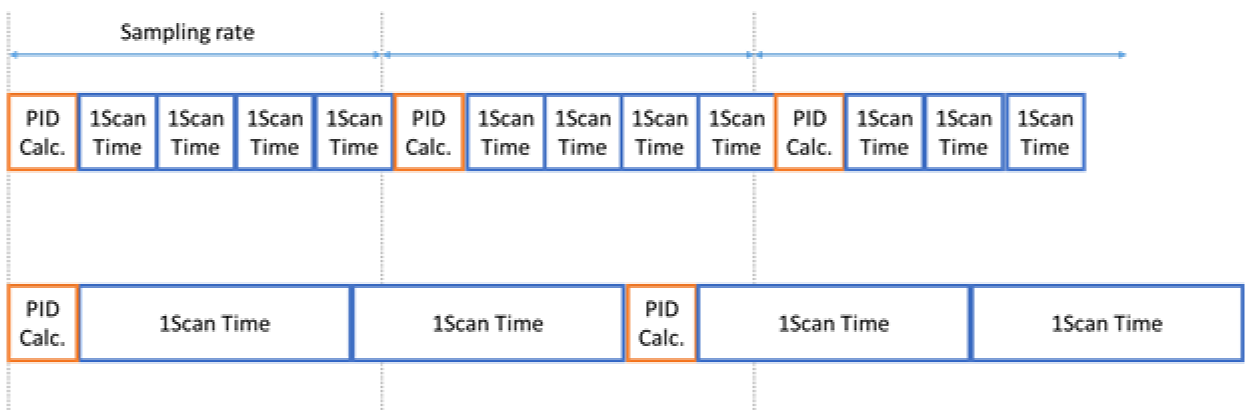
The Derivative Term in the PID calculation is very useful in allowing the control loop to respond quickly to a sudden change in the error. The disadvantage of this is that high frequency noise in the PV signal will be amplified significantly, causing the CO to be erratic.

The **Derivative Gain Limit (Cn+04)** is a high frequency filter for the Derivative Gain. With it you can limit how much high frequency noise affects the Derivative Term of the calculation.

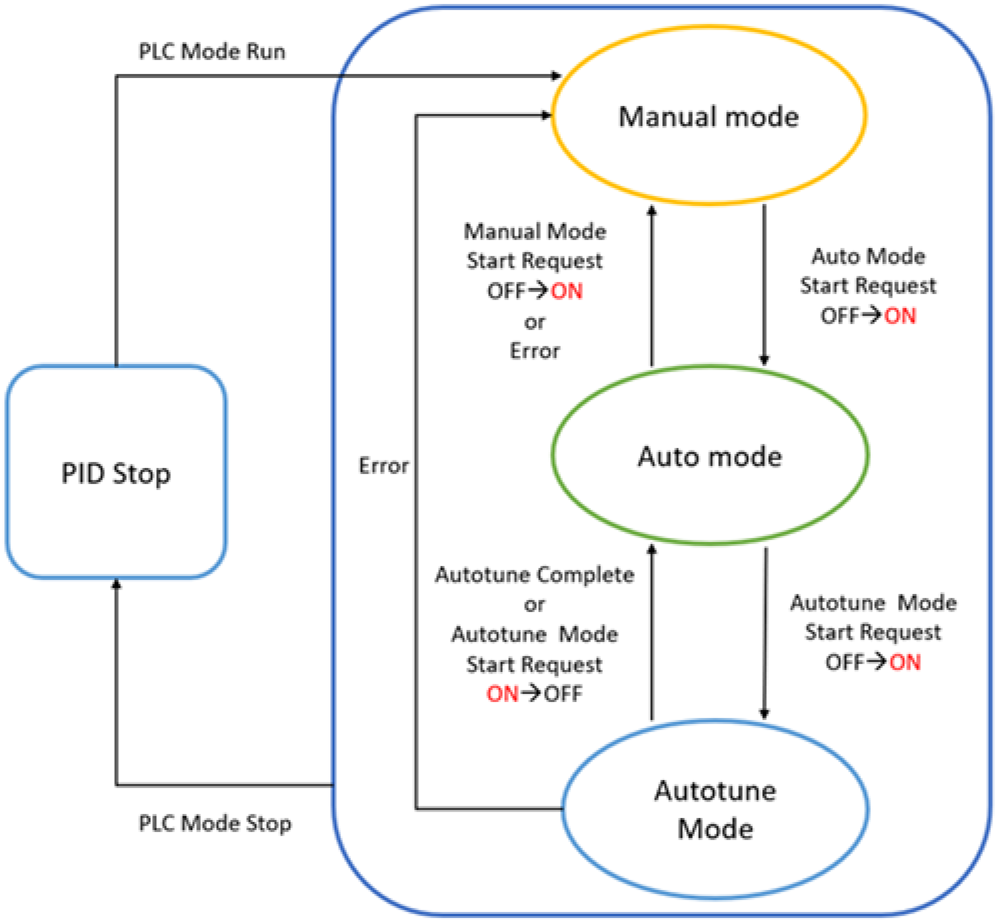
The **Gain Limit Factor** (**DSn+06)** can be 1 to 100, although a value from 8 to 20 is more typical. A value of 100 will essentially apply no filter to the Derivative. As the Limit is reduced, the effect of PV noise on the CO is reduced. A value of 0 is the same as setting the Derivative Gain to 0.

Sample Rate(T_S)

PID control is performed as part of the Main Program, but the new CO is calculated when the sampling rate time (DSn+05) has elapsed. Therefore, if the scan time is long, the new CO may not be calculated as quickly as the sample rate setting. The Sample rate can be 100 to 30000 ms.



PID Mode Operations



1. **PID Stop Mode**

- When the PLC Mode is STOP, the CLICK PID control loops stop executing.
- When the PLC Mode shifts from STOP to RUN, CLICK PID control loops begin executing in Manual Mode.

2. **Manual Mode**

CLICK PID control loops shift to Manual Mode when the following conditions are met:

- When the PLC switches from STOP to RUN. **This affects all PID control loops.**
- When C(n+15) Manual Mode Start Request is turned ON.
- When a PID error occurs.

3. **Auto Mode**

CLICK PID control loops shift to Auto Mode when the following conditions are met:

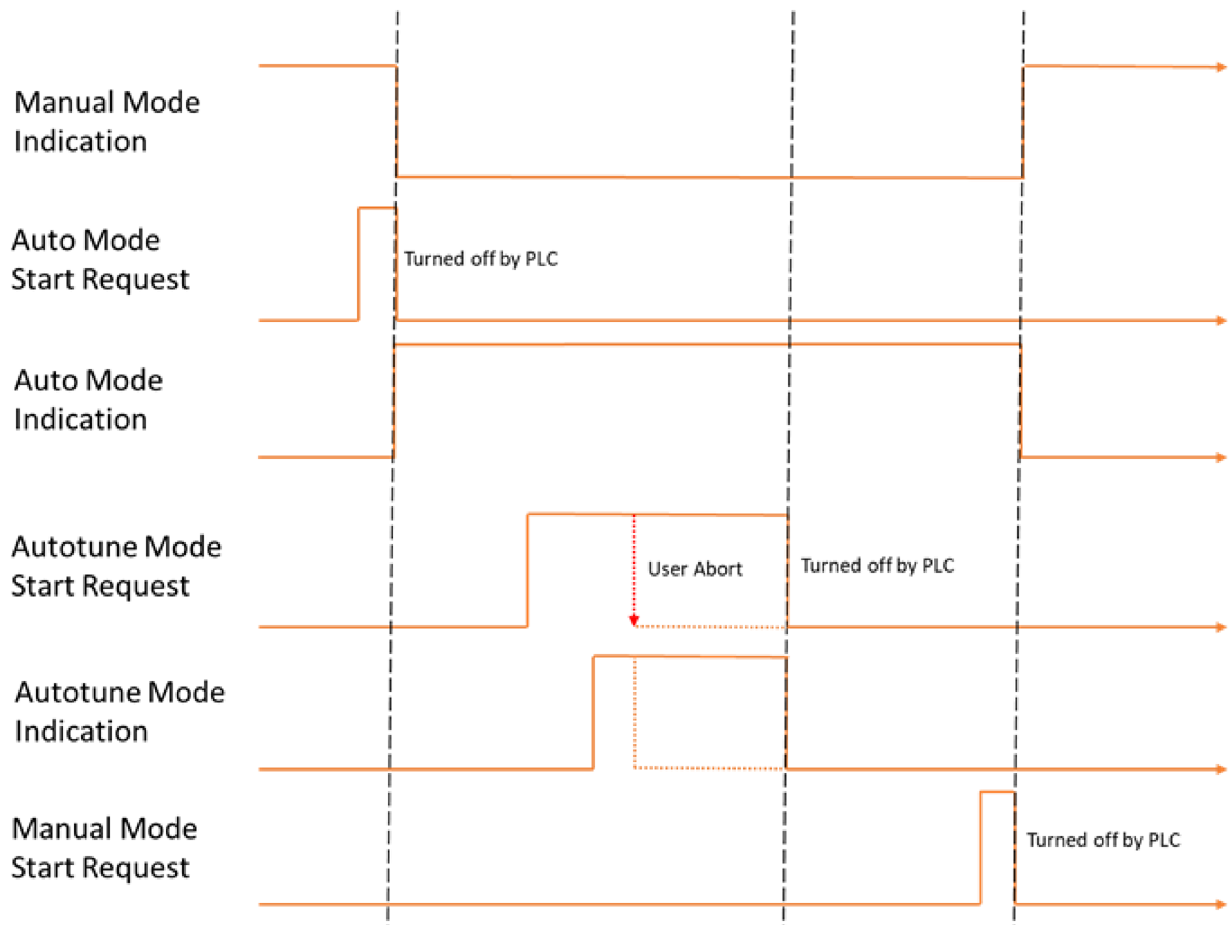
- When C(n+16) Auto Mode Start Request is turned ON while the PID control loop is in Manual Mode.
- When Autotune is completed.
- When C(n+17) Autotune Mode Start Request is turned off.

4. **Autotune Mode**

CLICK shifts to Autotune Mode when the following conditions are met:

- When C(n+17) Autotune Mode Start Request is turned on while the PID control loop is in Auto Mode.
- See **CLICK PID Autotuning**for other conditions necessary to enter Autotune Mode.

Below is a timing chart for all of the PID Modes.



Manual and Auto Mode Transitions

Notice in the chart above that the Manual and Auto Mode Requests are not maintained bits. These bits submit a "request" to the PLC. If there are no errors, then the PLC PID loop is switched to the respective mode and the Mode Indication bit is turned on.

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Bumpless Transfer

A Bumpless Transfer (Cn+08) refers to the method of switching from Manual Mode to Auto Mode without causing a "bump" in the process by sudden movement of the Control Output.

Mode 1 (OFF): Accomplishes no bump because the SP and PV are made equal, requiring no immediate change in the CO.

- The Bias Term is made equal to the CO.
- The SP is made equal to the PV.

Mode 2 (ON): Since the SP is not made equal to the PV, a bump in the CO can occur when the control is switched from Manual to Auto. It is up to the Operator to make changes to the process settings to prevent a bump in the process.

- The Bias Term is made equal to the CO.

Autotuning

The P, I and D parameters as well as the Sample Rate can be set automatically by using the Autotune features of the CLICK PID. See the **PID Autotuning** topic for more information.

PID Errors

The CLICK PID Errors are indicated in register DS(n+00). If there is more than one error, the DS register will contain the lowest active error number. When it is cleared, the next lowest error is indicated.

The list of PID Errors can be found in help topic **CLICK PID Errors**.

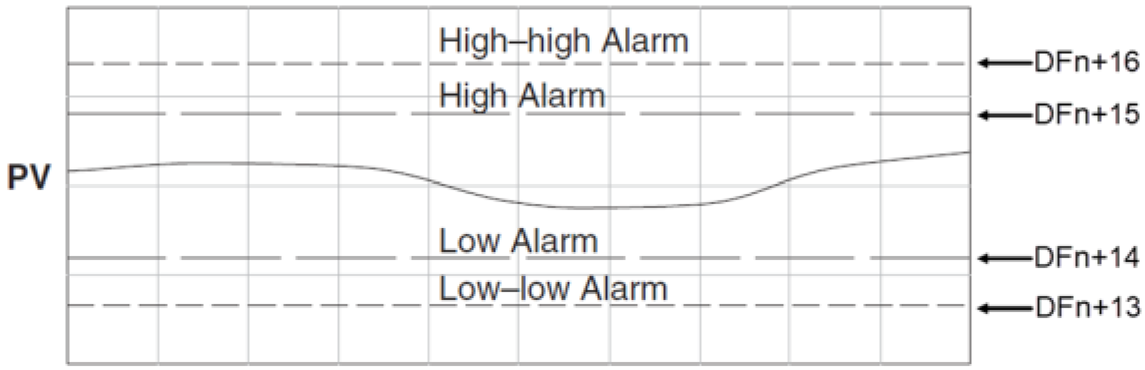
PID Loop Alarms

The CLICK allows the user to specify alarm conditions that can be monitored for each loop.

Use PV Alarm (Cn+12): these are limit alarms. If the PV passes the limit, the corresponding C-bit is turned on.

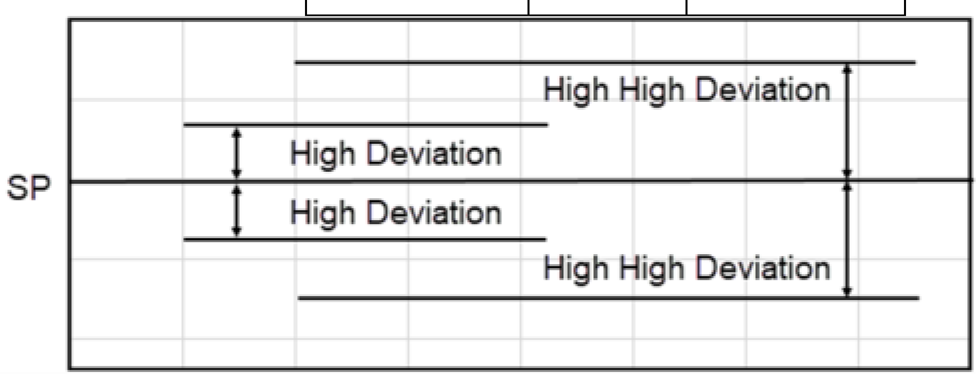
Alarm Type	Alarm Limit	Alarm Status Bit

High-High Alarm	DFn+16	Cn+34
High Alarm	DFn+15	Cn+33
Low Alarm	DFn+14	Cn+32
Low-Low Alarm	DFn+13	Cn+31



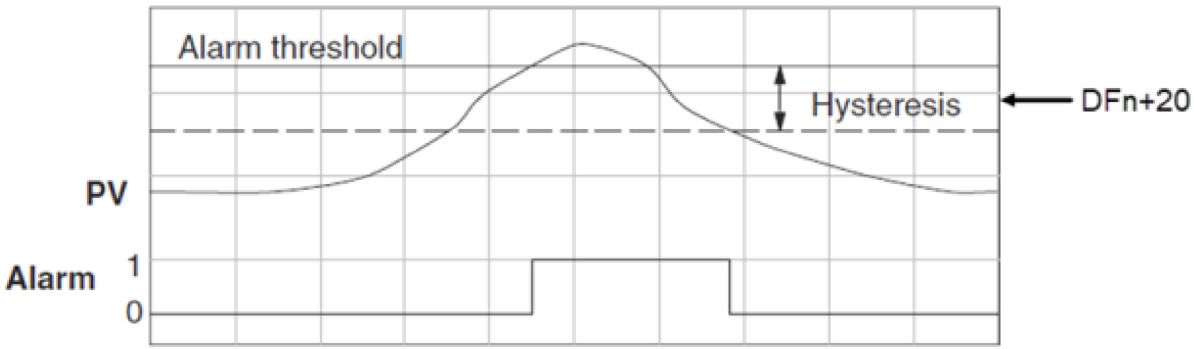
Use PV Deviation Alarm (Cn+13): Sometimes the PV value is not a concern, but the difference between the PV and SP. You can specify a High Deviation Alarm or High High Deviation Alarm from the SP. When the PV is further from the SP than the programmed Deviation Limit, the corresponding C-bit is turned on. The deviation is the amount **above or below** the SP.

Alarm Type	Alarm Limit	Alarm Status Bit
High-High Alarm	DFn+18	Cn+36
High Alarm	DFn+17	Cn+35



PV Alarm Hysteresis (DFn+20): The **PV Limit Alarms** and **PV Deviation Alarms** are programmed using limit values. When the PV value or deviation exceeds the configured limit, the alarm status bit becomes true. Real-world PV signals fluctuate. As the PV value crosses an alarm limit, its fluctuations will cause the alarm to be intermittent and trigger repeatedly.

The figure below shows how the hysteresis is applied when the PV value goes past a limit and descends back through it.



The alarm activates immediately when the Alarm limit is crossed. But the alarm delays turning off until the PV value has dropped below the limit by the hysteresis amount.

Use PV Rate of Change (Cn+14): When the PV changes faster than a specified rate-of-change limit (DFn+19), the Rate of Change C-bit (Cn+37) is set. The rate-of-change units are PV. Units change per sample time.

As an example, suppose the PV is the temperature for your process, and you want an alarm whenever the temperature changes faster than 15 degrees/minute. Suppose the sample rate is 2 seconds.

Related Topics:

[Find Available Addresses]

[PID Address Descriptions]

[PID Configuration Mode]

[PID Monitor Mode]

[PID List View]

[Autotuning]

[Filter Examples]

[Managing Retentive Memory]

[PID Error Codes]

PID Configuration Mode

Overview

The CLICK Ethernet PLC is capable of supporting up to 8 PID Control Loops. For more information on how PID is implemented in the CLICK PLC, see Help topic **PID Control in CLICK**.

A PID control loop is a continuous feedback loop that uses the error between a Setpoint (SP) and a Process Variable (PV) to determine the value of a Control Output (CO). The SP is usually an operator-entered value and is the desired value of the PV. The PV is usually an Analog Input to the PLC and is a measured value in the Process being controlled. The PV may be a flow rate, pressure, temperature or process variable that can be measured by process instrumentation. The CO may be a control valve position, a damper actuator position, a variable speed drive speed setting, etc.

When the SP is changed or a disturbance in the process causes the PV to change, an error occurs between the SP and PV. The PID Control uses Proportional, Integral and Derivative terms with the error to determine the CO that will return the PV equal to the SP.

Each PID Loop requires consecutive C, DS and DF memory areas. All PID Loop Configuration parameters are stored in these memory locations.

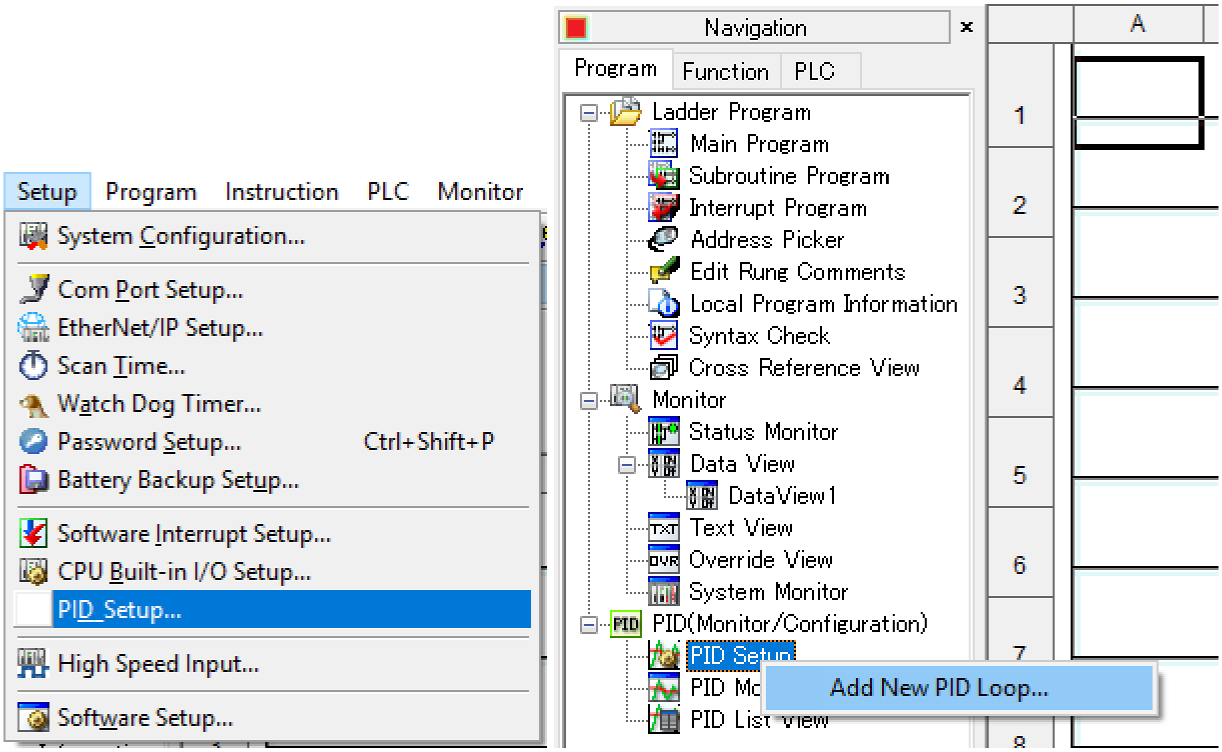
Tools in the Configuration dialog will assist in selecting available consecutive addresses for each.

Purpose

The PID Configuration Mode dialog is used to configure each PID Loop. In this dialog you can find available addresses for the PID Loop parameters. You can also Read and Write PID Loop configuration values to an existing PID Loop configuration in a connected CLICK PLC.

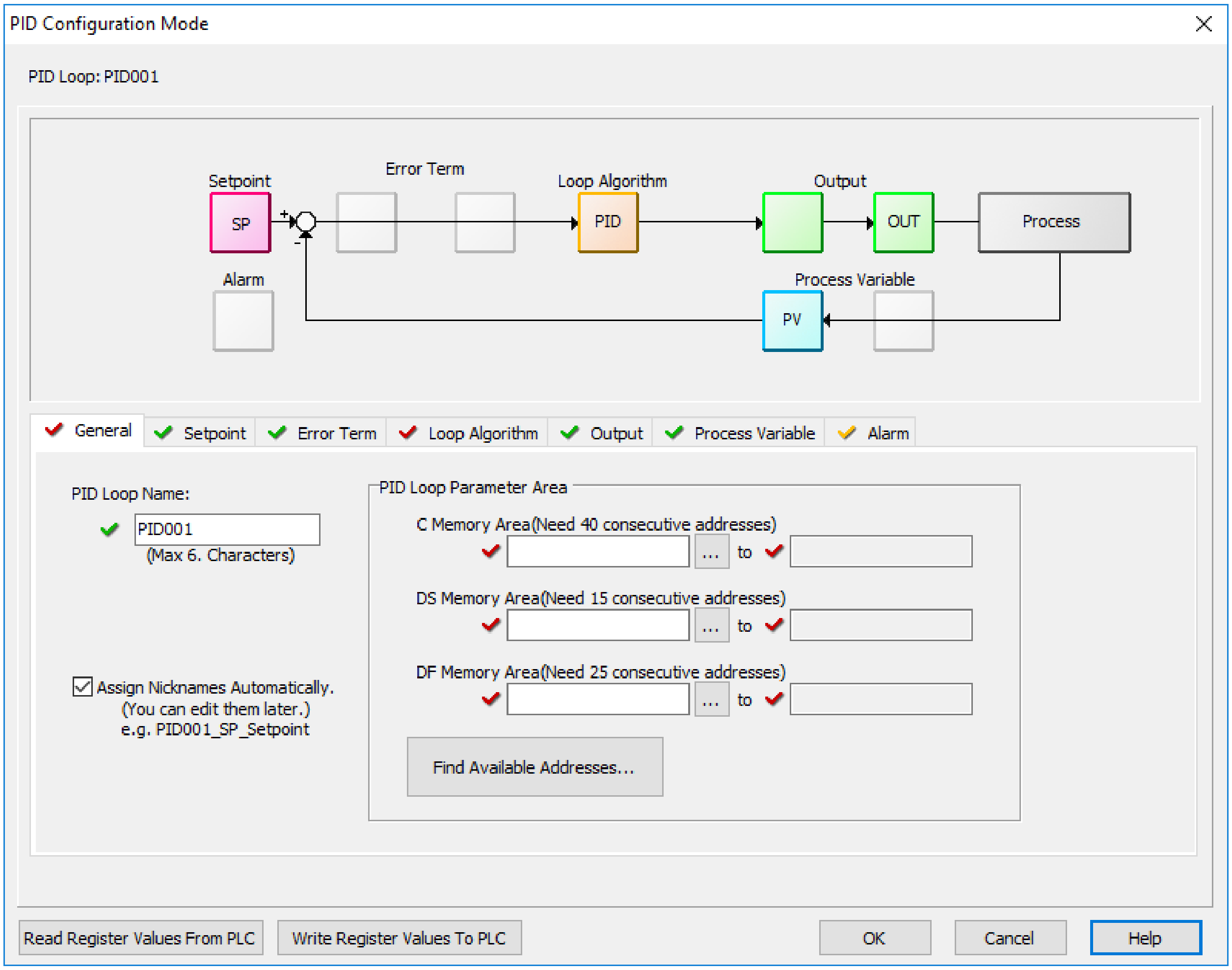
Adding a PID Control Loop

To set up a PID Control Loop, from the Menu select **Setup> PID Setup**. Alternately, from the **Program** tab, double-click **PID Setup**.



General Tab

The **General** tab opens. By default, the first PID Loop Name to be created is **PID001**. This can be changed at any time.



PID Loop Name: The **PID Loop Name** can be a maximum of 6 characters.

Assign Nicknames Automatically: The PID Loop Name will be appended to the beginning of all of the Nicknames for the Memory addresses associated with this PID Loop. For example, PID001_SP_Setpoint. These may be edited later.

Read Register Values From PLC: Click this button to read all the registers associated with the current PID Loop into the PID Configuration dialog.

Write Register Values to PLC: Click this button to write all of the PID Configuration Registers in the PID Configure dialog into the PLC memory locations configured in the PID Loop Parameter address.

Note: Best practice is to first Read the Register Values from the PLC before selecting to Write Register V

PID Loop Parameter Area

Each PID Loop requires consecutive C, DS and DF memory areas. All the PID Loop Configuration parameters are stored in these memory locations.

C Memory Area - 40 Consecutive Bits

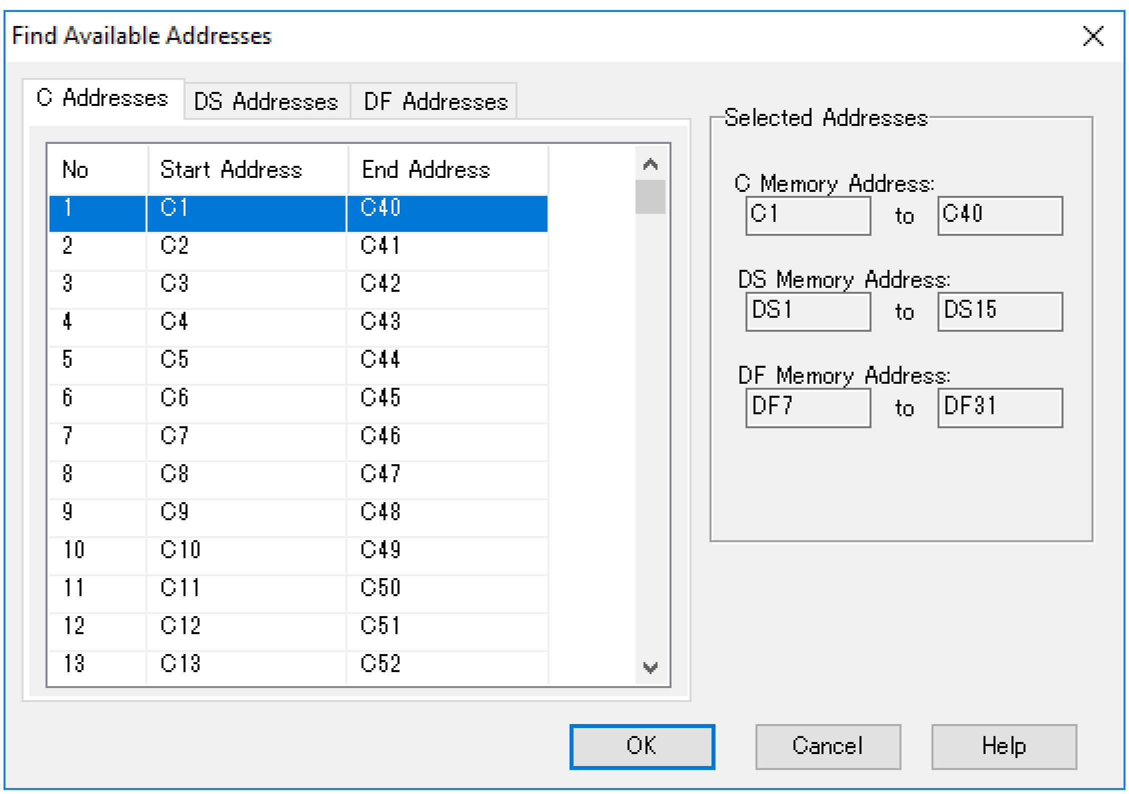
DS Memory Area - 15 Consecutive Integers

DF Memory Area - 25 Consecutive Floats

In the other tabs in the Configuration dialog box, the address assigned will be shown next to each parameter. Throughout this Help file, the beginning address for each address range is symbolized as Cn, DSn and DFn.

Select the Memory Areas in one of two ways:

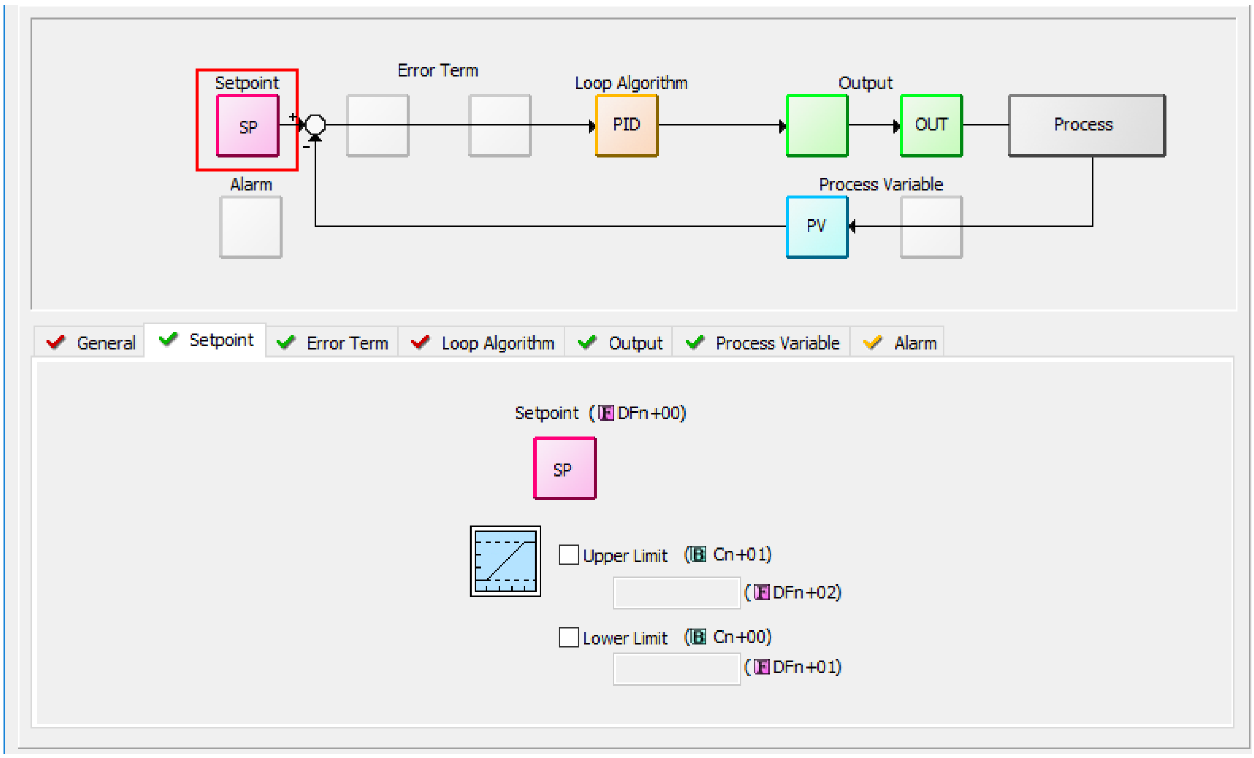
1. The best option is to let the software select the address for you from the available unused addresses by clicking the **Find Available Address...** button. The Find Available Addresses dialog allows you to select which range of addresses you want to use for each memory type with the present PID Loop configuration from the "available" addresses.
2. In the **General** tab you can select the beginning address for each Memory Area and the software will automatically allocate the number of addresses for the PID Loop. Care must be taken not to select a range of addresses already used in the PLC program for another purpose.



See the Help topic PID Address Descriptions for a full list of the addresses and nicknames assigned for each PID Loop configuration parameter.

Setpoint Tab

The Setpoint (SP) (DFn+00) is the value to which the PID Control Loop is trying to drive the Process Variable (PV).



Setpoint Upper and Lower Limits: You may select to limit the allowed upper and lower settings for the Setpoint. This is useful in preventing someone from accidentally entering a value that is outside the process limits.

When enabled, if a Setpoint value is entered outside of the limits, the PLC will automatically change the Setpoint to the limit that is closest to the value entered.

The limits are enabled individually:

Upper Limit enable (Cn+01)

Lower Limit enable (Cn+00)

The limit values must be set if the limit is enabled:

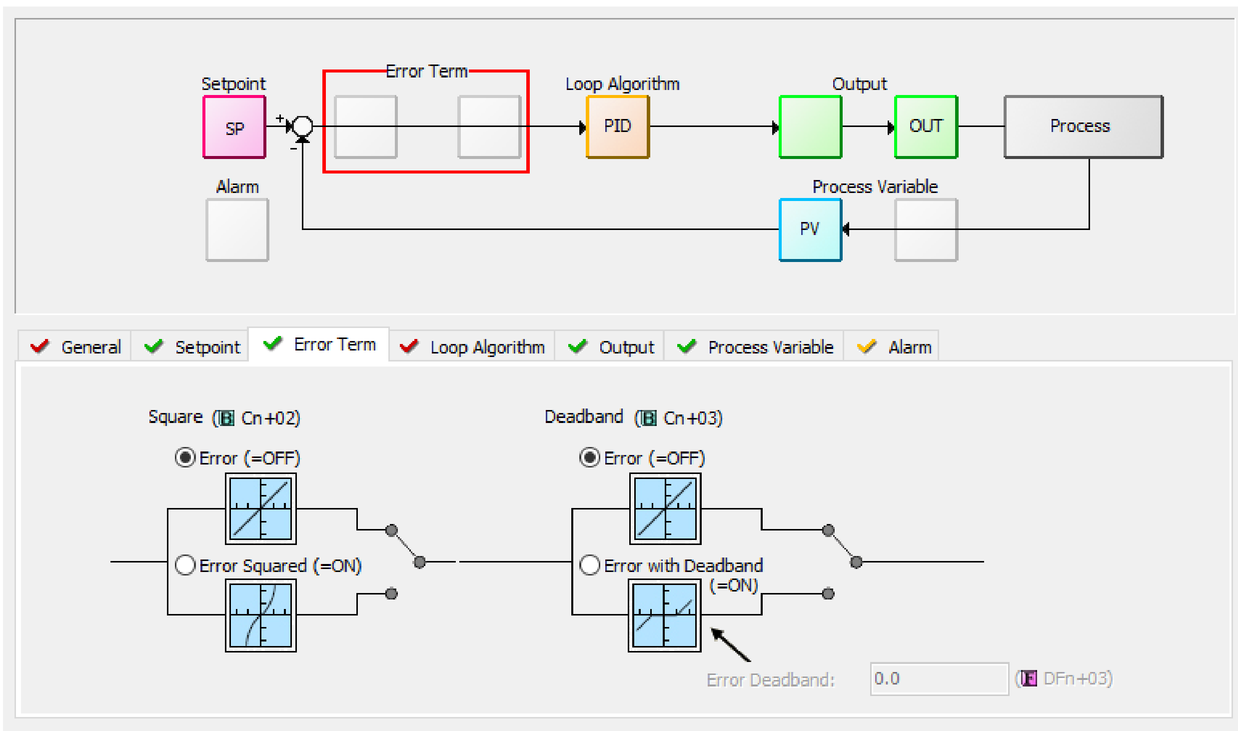
Upper Limit value (DFn+02)

Lower Limit value (DFn+01)

Error Term Tab

The Error is the difference between the Setpoint (SP) and the Process Variable (PV). Error = SP - PV.

The Error Term tab is used to select from a couple of ways the Error can be manipulated to better control certain processes. To use the Error as is, leave both options off.



<u>Error Squared Option</u>

When the Error Squared (Cn+02) option is selected, the error term is squared (preserving the original sign), before it is used in the PID calculation. This lessens the response to smaller error values, but increases the response to larger errors.

<u>Error Deadband Option</u>

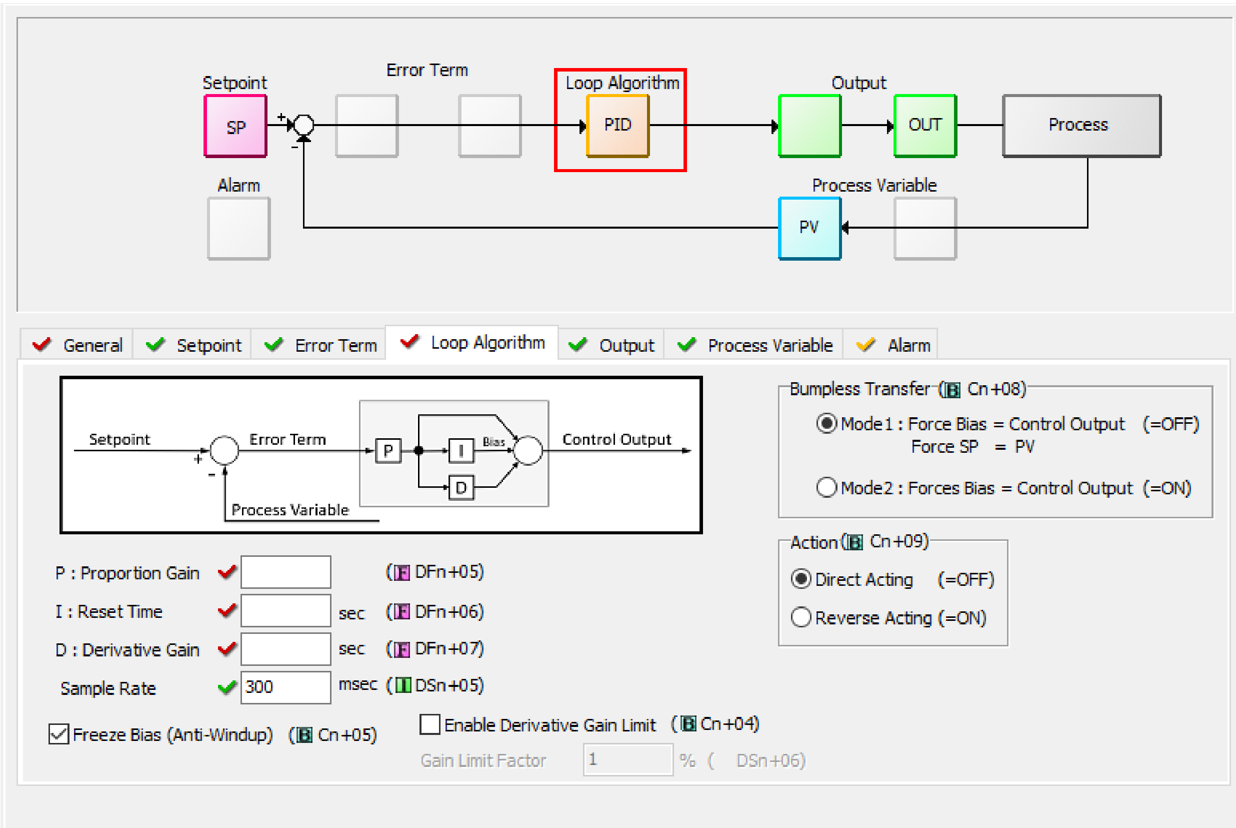
When the **Error with Deadband** (Cn+03) option is selected, no control action is taken if the Process Variable (PV) is within the specified **Error Deadband (**DFn+03) around the Setpoint (SP). The error deadband is the same above and below the SP and is in the same units as the PV and SP.

Once the PV is outside of the error deadband around the SP, the entire error is used in the loop calculation.

If Error Squared is enabled, the error will be squared before it is applied to the deadband calculation.

Loop Algorithm Tab

The Loop Algorithm tab is the heart of the PID Loop setup.



PID Tuning Parameters

The PID calculation utilizes the following parameters and equation. The P, I and D are often referred to as "Tuning Parameters" because their values affect the responsiveness and stability of the control loop. Incorrect tuning parameters can lead to an unresponsive, oscillatory or unstable (out of control) process loop. There are many resources available about tuning PID control loops.

P: Proportional Gain (DFn+05) (0.01 - 10000)

I: Reset time (DFn+06) (0.01 - 6000 seconds)

D: Derivative Gain (DFn+07) (0 - 6000 seconds)

The P, I and D parameters as well as the Sample Rate can be set automatically by using the Autotune features of the CLICK PID. See the PID Autotuning Help topic for more information.

Sample Rate(DSn+05)

Range: 100 - 30000 ms

The PID control is performed as part of the Main Program, but the new CO is calculated when the sampling rate time has elapsed.

Freeze Bias (Anti-Windup) (Cn+05)

Freeze Bias, also known as Anti-Windup, is a feature of the CLICK PID that can make your process more stable and recover more quickly from process disturbances. See the Help topic **PID Control in CLICK** for more information about this feature.

Derivative Gain Limit

Range: 1 - 100

The Derivative Gain Limit (Cn+04) is a high frequency filter for the Derivative Gain. With it you can limit the effect that high frequency noise has on the Derivative portion of the calculation.

The Gain Limit Factor (DSn+06) can be 1 to 100, although a value from 8 to 20 is more typical. A value of 100 will essentially apply no filter to the Derivative. As the Limit is reduced, the effect of PV noise on the Control Output is reduced. A value of 0 is the same as setting the Derivative Gain to 0.

Action

The Action (Cn+09) of a control loop is either Direct acting or Reverse acting. It is important to know in which direction the control output will respond to the error.

A **Direct** acting control loop means that whenever the control output increases, the PV will also increase. For example, if the Control Output drives open a gas valve to a flame control, the Temperature will increase as the Control Output increases.

A **Reverse** acting control loop is one where an increase in the control output results in a decrease in the PV. A common example of this would be a refrigeration system, where an increase in the cooling input causes a decrease in the PV (temperature).

Bumpless Transfer

A Bumpless Transfer (Cn+08) refers to the method of switching from Manual Mode to Auto Mode without causing a "bump" in the process by sudden movement of the Control Output.

Mode 1(ON): Accomplishes no bump because the SP and PV are made equal, requiring no immediate change in the Control Output.

- The Bias Term is made equal to the Control Output.
- The SP is made equal to the PV.

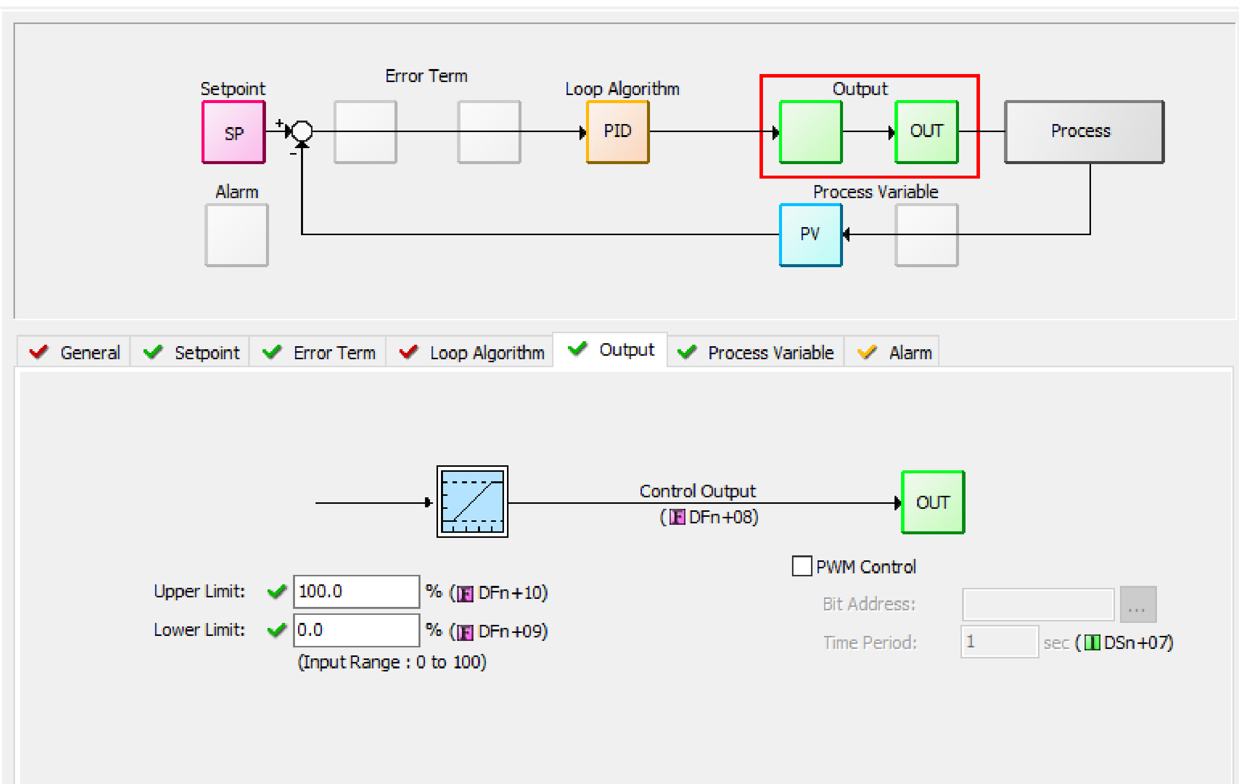
Mode 2(OFF): Since the SP is not made equal to the PV, a bump in the Control Output can occur when the control is switched from Manual to Auto. It is up to the Operator to make changes to the process settings to prevent a bump in the process.

- The Bias Term is made equal to the Control Output.

Output Tab

The Control Output (CO) (DFn+08) is the result of the PID calculation. It is usually tied to a physical output on the PLC, which is wired to a control device such as a valve actuator.

The Control Output is Read Only when the loop is in Auto. To change the Control Outout, the loop must be in Manual Mode.



The Control Output range is 0 to 100% by default. But it can be changed by setting the Upper Limit (DFn+10) and Lower Limit (DFn+09).

If the Upper Limit is set to zero, the CO will never get above zero and the control loop will not function properly.

PWM Control

PWM (Pulse Width Modulated) control turns the Control Output signal into a series of pulses. The width of the pulse (or duty cycle) is the ratio of ON time to OFF time determined by the Control Output percentage of the **Time Period**.

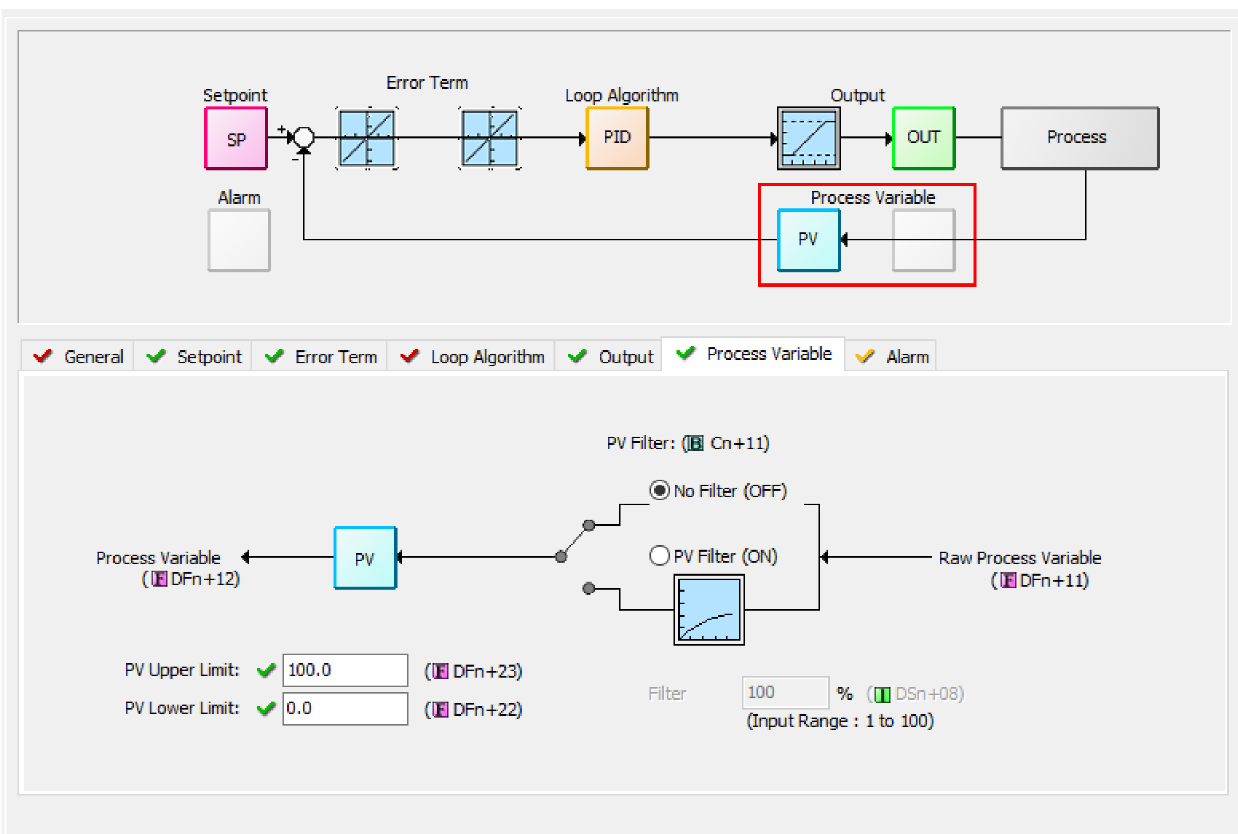
Since **PWM Control** is determined by the type of output, it is enabled in the PID configuration; but unlike most other parameters, it is not modifiable by the Ladder Logic. No Address is assigned to the PWM Enable setting.

Bit Address: The address of the discrete output that is tied to the control element in the process. The programmer assigns this.

Time Period (DSn+07): The total of the ON and OFF time. This value can be 1 to 600 seconds.

Process Variable Tab

The **Raw Process Variable** (DFn+11) is the measured value that the PID loop controls. It is directly affected by the process being controlled. The **Process Variable** (DFn+12) is the filtered **Raw Process Variable** used by the PID calculation. If the PV filter is not enabled, then the PV is equal to the Raw PV.



<u>PV Upper and Lower Limits</u>

The PV Upper (DFn+23) and Lower (DFn+22) Limits are the expected process range values for the full range of the Control Output. They are used to calculate the Process gain which in turn is used by Autotune to calculate the Proportional Gain tuning constant.

This is not the range of the process measurement device or the PLC input configuration. For example the Input may be a RTD input with a range of -328 to 1562 Deg F. But the Process range for a CO of 0 to 100 may only be 40 to 140 Deg F. The **PV Upper and Lower Limits** would be 140 and 40 respectively.

<u>PV Filter</u>

Range: 1 - 100%

A noisy Raw PV can cause a PID loop to become unstable as well as make the loop difficult to tune. The CLICK PLC provides a PV Filter to reduce the high frequency noise in the Raw PV value to provide a clean PV to the PID Controller.

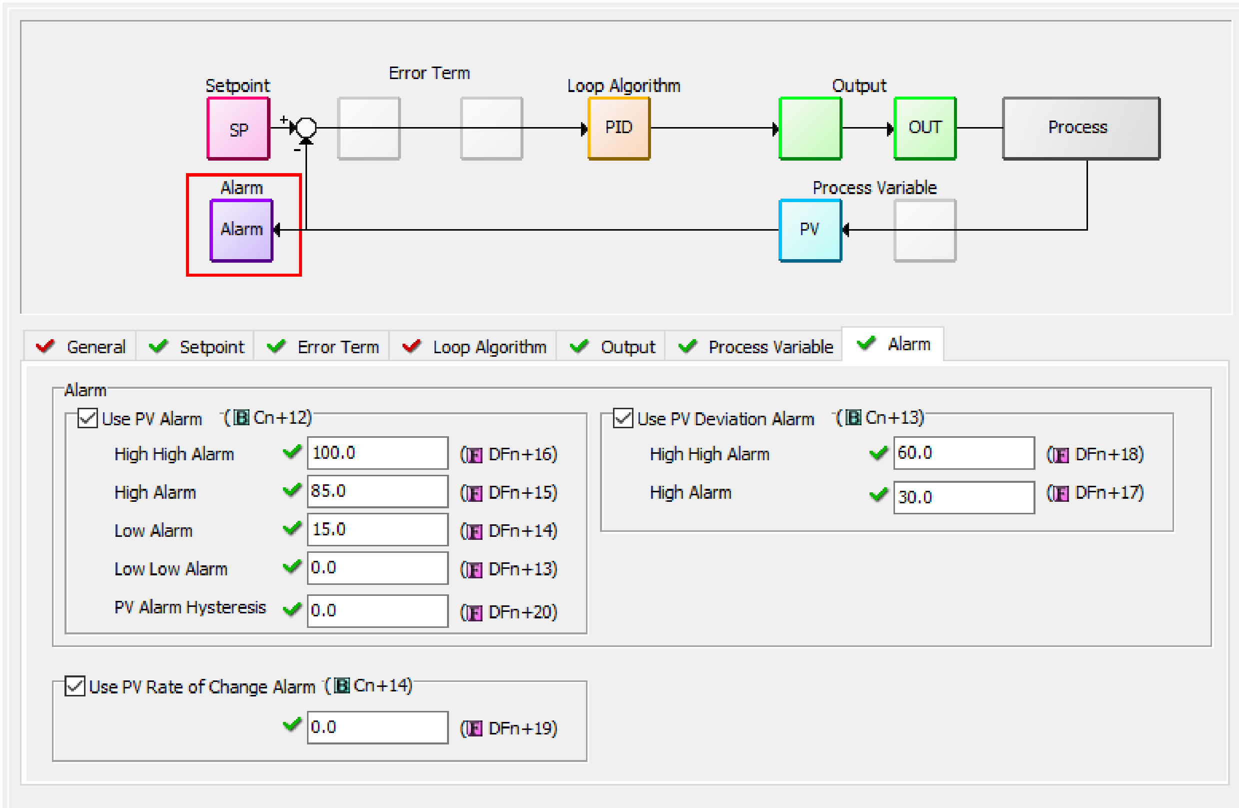
PV Filter(Cn+11): turns on the PV filter.

Filter Constant (DSn+8): the Filter Constant is the percentage of the Raw PV that is passed each PID sample time. The smaller the filter value, the more filtering that will occur. A value of 100 will result in no filtering and 100% of the Raw PV is passed The default value is 100.

Enabling the PV Filter and entering a small filter value can cause some lag in the PV. This should be taken

Alarm Tab

The CLICK PLC allows the user to specify alarm conditions that can be monitored for each loop. These alarms and alarm levels can be enabled and configured in the Alarm tab or though the PLC addresses. For more information on Alarms, see the Help topic **<u>PID Control in CLICK</u>**.



Use PV Alarm (Cn+12) - these are limit alarms. If the PV passes the limit, the corresponding C-bit is turned on.

Alarm Type	Alarm Limit	Alarm Status Bit
High-High Alarm	DFn+16	Cn+34
High Alarm	DFn+15	Cn+33
Low Alarm	DFn+14	Cn+32
Low-Low Alarm	DFn+13	Cn+31

Use PV Deviation Alarm (Cn+13): Sometimes the PV value is not a concern, but the difference between the PV and SP is a concern. You can specify a High Deviation Alarm or High High Deviation Alarm from the Setpoint. When the PV is further from the Setpoint than the programmed Deviation Limit, the corresponding C-bit is turned on. The deviation is the amount **above or below** the Setpoint.

Alarm Type	Alarm Limit	Alarm Status Bit
High-High Alarm	DFn+18	Cn+36

High Alarm	DFn+17	Cn+35

PV Alarm Hysteresis (DFn+20): The **PV Limit Alarms** and **PV Deviation Alarms** are programmed using limit values. When the PV value or deviation exceeds the configured limit, the alarm status bit becomes true. Real-world PV signals fluctuate. As the PV value crosses an alarm limit, its fluctuations will cause the alarm to be intermittent and trigger repeatedly.

The hysteresis is applied when the PV value passes a limit and descends back through it.

The alarm activates immediately when the Alarm limit is crossed. But the alarm delays turning off until the PV value has dropped below the limit by the hysteresis amount.

Use PV Rate of Change (Cn+14): When the PV changes faster than a specified rate-of-change limit (DFn+19). The Rate of Change C-bit (Cn+37) is set. The rate-of-change units are PV. Units change per sample time.

As an example, suppose the PV is the temperature for your process, and you want an alarm whenever the temperature changes faster than 15 degrees/minute. Suppose the sample rate is 2 seconds.

Related Topics:

PID Control in CLICK

PID Monitor

Find Available Addresses

PID Address Descriptions

Autotuning

PID View List

Filter Examples

PID Error Codes

Topic: CL24

PID Monitor

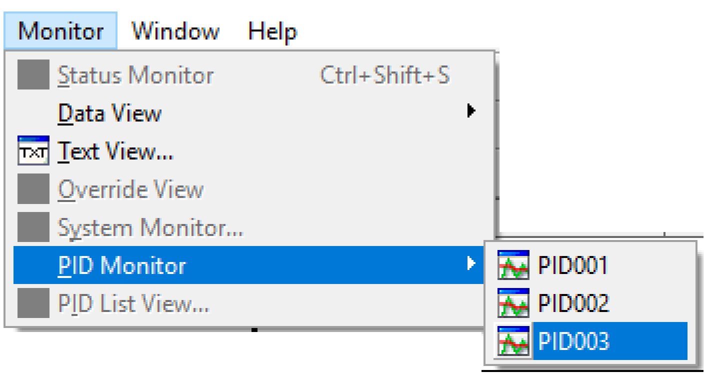
Overview

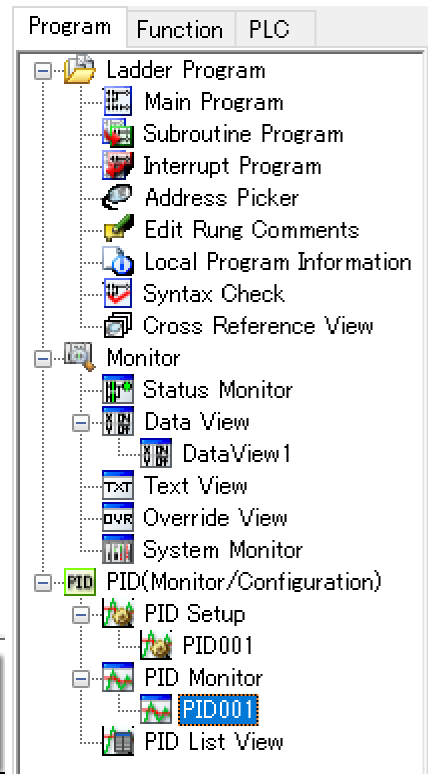
The CLICK PID Monitor is a very useful tool which can be used to help test and tune your PID loops. The PID Monitor gives access to all the PID parameters necessary to tuning a PID Loop. There is a PID chart that displays the SP, PV's, CO and Bias. There is also an Autotune interface that allows you to set up and initiate Autotuning. Alarms can be enabled or disabled while tuning.

Opening the PID Monitor

The CLICK software must be connected to a CLICK PLC that contains the configured PID Loop.

To open the PID Monitor for a configured PID Loop, from the Menu select **Monitor> PID Monitor** and select the PID Loop. Alternately, from the **Program** tab, double-click the PID Loopunder **PID Monitor**.



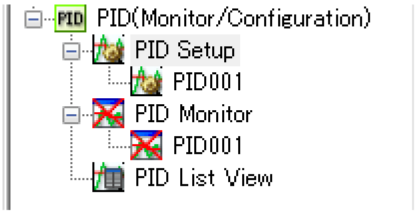


__**PID Monitor Errors**__

The PID Monitor PID Loops may look different above.

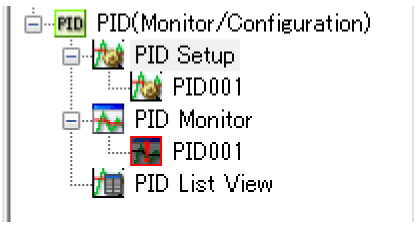
PID Monitor not connected to a PLC

If the PID Monitor Icon looks like this, then the CLICK Software is not connected to the PLC. Connect to a CLICK PLC and the Red X will disappear.



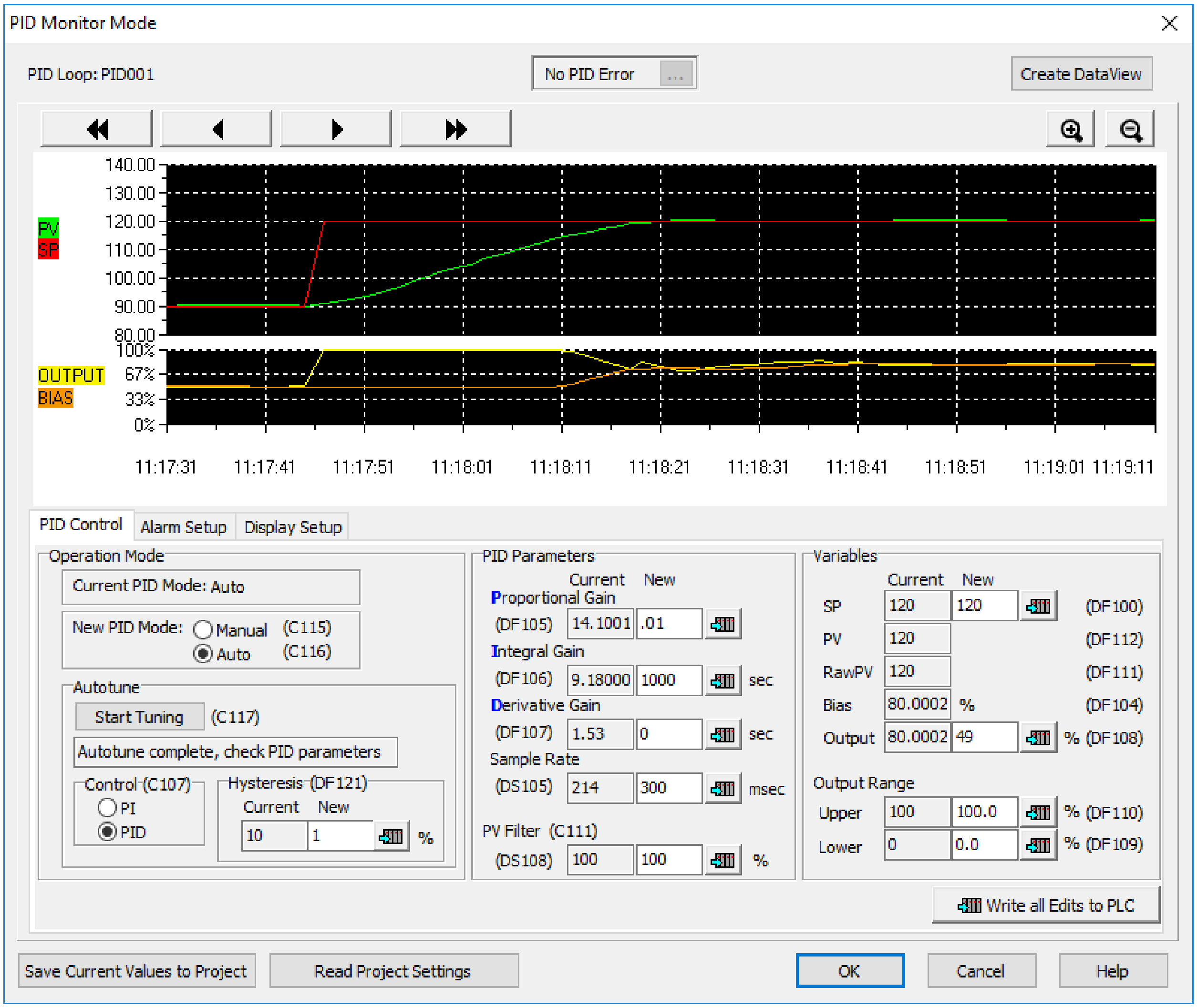
PID Loop has a Error

If the PID Monitor Icon has a Red Exclamation mark, then the PID Loop has a error. See **PID Error Codes** for more information.



This typically occurs if the PID Loop was configured in the PID Configuration, the program was downloaded to the PLC, but the PID Configuration data was not written to the PLC registers. Open the PID Loop Configuration and select **Write Register Values to PLC**.

When the PID Monitor is opened, the PLC PID Loop values are read from the PLC and displayed in the **Current** value columns. The **New** value columns are filled in with the PC project values.



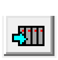
Read and Write buttons

There are three buttons for writing to the PLC and the PC project or reading from the PC project.

Read Project Setting: Reads the settings saved in the PC project and places them in the **New** value columns. These are the same values configured in the [PID Configuration](#).

Save Current values to Project: Saves all values in the **Current** value columns (current PLC values) to the project on the PC.

Write all edits to the PLC: Writes all values in the **New** value columns to the corresponding PLC addresses. Fields with no values will not be written; the PLC values will remain unchanged.

Individual **Write** buttons  will write only the one value next to it in the **New** value field to the corresponding PLC address.

Chart

The chart can display the SP, PV's Output, Bias and PV Alarm Limits. The chart layout and pens are configured in the **Display Setup** tab.

PID Control Tab

The PID Control tab contains the Autotuning interface as well as areas for setting the PID parameters and for adjusting the Set Point and Output variables.

Alarm Setup Tab

The Alarm Setup tab is the same as the PID Configuration Alarm tab. This tab allows you to adjust the alarm settings during tuning as well as test your alarm values and change them if needed.

Display Setup Tab

The Display Setup tab is used to adjust the chart colors, pens, sample rate, X and Y axis labels and divisions.

Error Indicator

The Error Indicator located at the top of the window will indicate a PID Error and provide a list of the current errors.

The PID Loop goes to Manual mode when there is an error. The error indicator will clear when the error is fixed and the loop is placed back into Auto mode.

See **PID Error Codes** for more information.

Create DataView

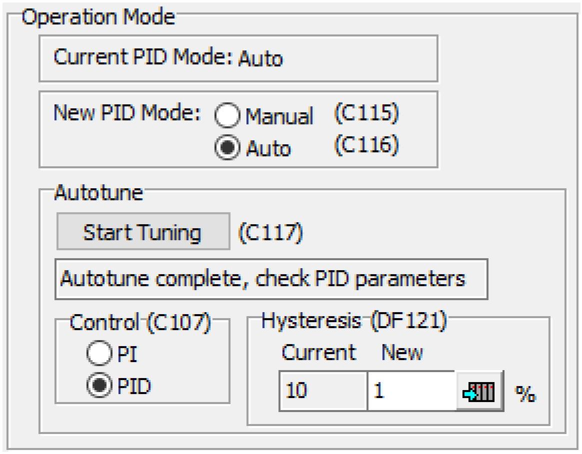
Used to create a DataView with all the PID Loop Parameter addresses.

PID Control Tab

Operation Mode

Current PID Mode: This value can be Auto or Manual and indicates the present mode the PID loop. It is a representation of Cn+25 and Cn+26.

New PID Mode: These radio buttons are used to select the mode of the PID Control, either Auto or Manual. It is a representation of Cn+15 and Cn+16.



Autotune

The loop must be in Auto for the selections under Autotune to be available. See the **Autotuning** Help topic for more details using the Autotune feature of the software.

Start Tuning (Cn+17) - This button initiates the Autotune process.

Autotune Status (Cn+27) - has two possible values

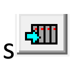
- Autotune in Progress

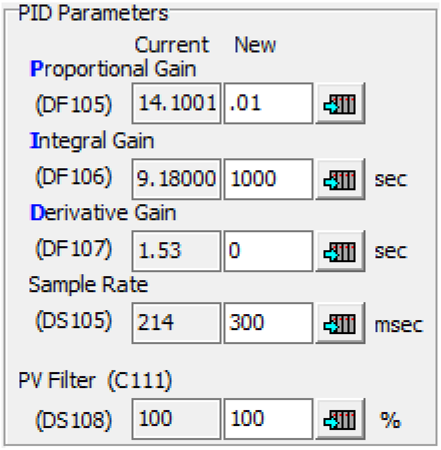
- Autotune complete, check PID parameters

Control (Cn+07) - This is the Control Algorithm selection for the Autotune calculation. If PI is selected, then the Derivative Gain will automatically be set to 0.

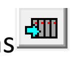
Hysteresis (DFn+21) - The Autotune Hysteresis is the percentage of the PV Span that the PV will go beyond the SP before the Control Output is changed for the next Autotune bump. If the PV is noisy, it could cross the SP momentarily causing a bad Autotune calculation. The Hysteresis can be 0.1% to 10%.

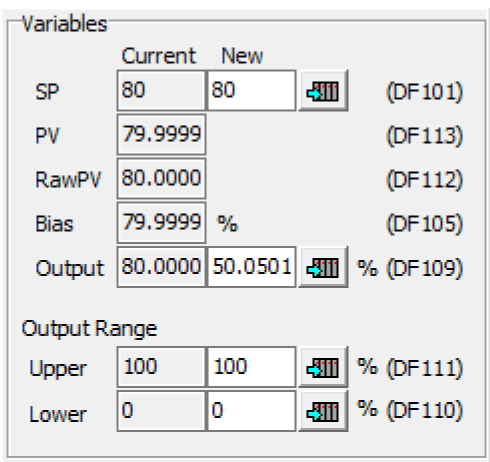
PID Parameters

The PID Parameters listed can be directly adjusted here by entering them in the **New** value field and clicking the **Write all edits to the PLC** button or the individual write buttons . See the **PID Control in CLICK** Help topic for more details about these parameters.



Variables

The necessary parameters for bumping and monitoring the PID Loop are accessible here. The SP, Output and its limits can be directly adjusted here by entering them in the **New** value field and clicking the **Write all edits to the PLC** button or the individual write buttons  . See the [PID Control in CLICK] Help topic for more details about these parameters.



Alarm Setup Tab

While in the Monitor mode, you can modify the Alarm configuration. This may be useful to determine new alarm limits, or to disable alarms during the tuning process. See the **Alarm** section of the [PID Configuration Mode] topic for details on these settings.

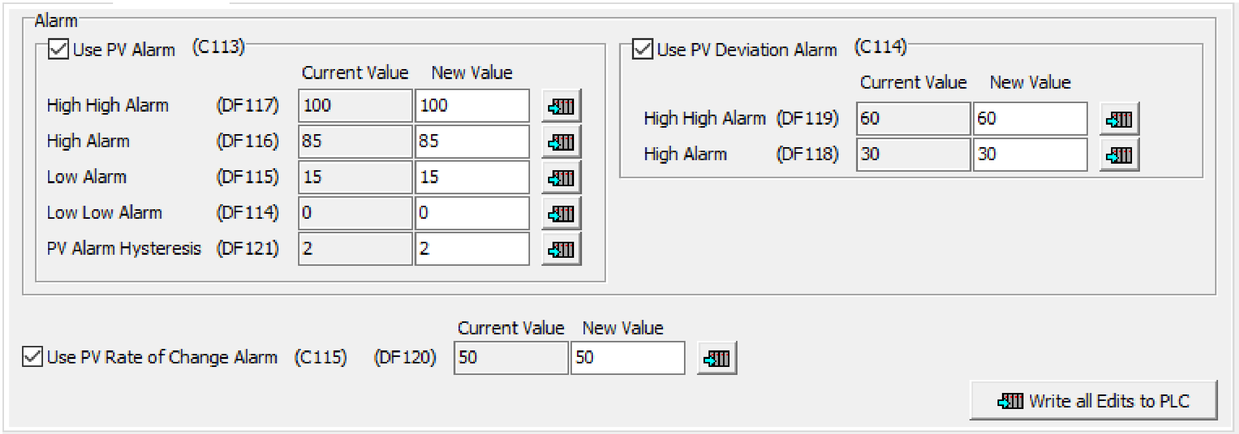


Chart and Display Setup Tab

The Display Setup tab is used to configure the Chart view.

<u>Plot Interval</u>

The plot interval can range from 1 second to 60 minutes. When the plot interval is changed and the **Apply** button is pressed, the PID Monitor chart is cleared.

<u>X-axis</u>

Divisions - This is the number of sections the Chart will display. You can set the Divisions from 1 to 10 divisions viewable on the chart. At the default Zoom setting, each division contains 10 data points. If the Plot Interval is 1 second and Divisions is 5, then the Chart will display 50 seconds of data.

The Zoom buttons can be used to change the points per division from 1 point per division (Zoom in full) to 140 points per division (Zoom out full).

You can choose to display the X-axis grid, which corresponds with the divisions and different X-axis labels: Tick numbers for points, Date and Time.

Y-axis

Divisions are simply dividing the Y-axis into sections and determining where the grid lines will be displayed if enabled.

Scaling

Auto Scale: The minimum and maximum of the Y-axis will automatically be adjusted to the minimum and maximum values displayed on the chart.

Manual Scale: You can choose to set hard min and max limits to display on the chart.

Display

The Display sections lets you choose which available PID pens to show on the chart. You can also select the color for each pen.

Background - choose the background color for the chart that will easily contrast with the pen colors.

Show Point - Turn on and off the point symbols on the chart. The lines on the chart are interpolated between the actual points of data. Sometimes it is useful to see the actual data points

Related Topics:

PID Control in CLICK

Find Available Addresses

PID Address Descriptions

PID Configuration Mode

Autotuning

[PID View List](#)

[Filter Examples](#)

[PID Error Codes](#)

PID Address Descriptions

Overview

Each of the eight PID Loops has its own list of addresses associated with it.

C Memory Area - 40 Consecutive Bits

DS Memory Area - 15 Consecutive Integers

DF Memory Area - 25 Consecutive Floats

The table below list Bits, Integers and Floats along with their Nicknames and Descriptions used in the CLICK software Address Picker.

Conventions

Address Nomenclature

Since the user selects the beginning address for each PID Loop and each address type, addresses are listed by Type, Starting Address plus an Offset.

Example:

Cn+00 = Type C, n=starting address + 00

Nickname Conventions

The Nicknames use abbreviations that make it easy to select the correct parameter for the proper function in the PLC Ladder code or your Operator Interface

EN Enable a function

SEL Select between multiple functions

IND Indicator of function that has been enabled

ALM Alarm Indication or setting

LMT Upper or Lower Limit

C Memory

C Memory PID Configuration Bits				
Address	**Data Type**	**Read/Write**	**Nickname**	**Comment**
Cn+00	BIT	RW	[PID Loop Name]_EN_SP_LimitLower	SP Lower Limit Enable
Cn+01	BIT	RW	[PID Loop Name]_EN_SP_LimitUpper	SP Upper Limit Enable
Cn+02	BIT	RW	[PID Loop Name]_SEL_ErrorSquared	Error Term Selection (Linear /Squared)
Cn+03	BIT	RW	[PID Loop Name]_EN_ErrorDeadband	Error Deadband Enable
Cn+04	BIT	RW	[PID Loop Name]_EN_DerivativeLmt	Derivative Gain Limit Enable
Cn+05	BIT	RW	[PID Loop Name]_EN_AntiWindup	Anti-Windup Enable (Bias Freeze)
Cn+06	BIT	RW	[PID Loop Name]_SEL_AutotuneMthd	Autotune PID Algorithm Selection (Open/Closed)
Cn+07	BIT	RW	[PID Loop Name]_SEL_AutotunePIDPI	Autotune Algorithm Selection (PID or PI)
Cn+08	BIT	RW	[PID Loop Name]_SEL_BumplessMode	Bumpless Transfer Selection (Mode 1/Mode 2)
Cn+09	BIT	RW	[PID Loop Name]_SEL_DirectReverse	Loop Action Selection (Forward or Reverse)
Cn+10	BIT	RW	[PID Loop Name]_C_Reserved_01	Reserved
Cn+11	BIT	RW	[PID Loop Name]_EN_PV_InputFiltr	Analog Input (PV) Filter Enable

Cn+12	BIT	RW	[PID Loop Name]_EN_PV_HiLoAlarms	PV Alarm Enable
Cn+13	BIT	RW	[PID Loop Name]_EN_PV_DevAlarms	PV Deviation Alarm Enable
Cn+14	BIT	RW	[PID Loop Name]_EN_PV_RateAlarm	PV Rate-of-change Alarm Enable

-

PID Operation Bits				
Address	**Data Type**	**Read/Write**	**Nickname**	**Comment**
Cn+15	BIT	RW	[PID Loop Name]_EN_RunManualMode	Manual Mode Start Request
Cn+16	BIT	RW	[PID Loop Name]_EN_RunAutoMode	Auto Mode Start Request
Cn+17	BIT	RW	[PID Loop Name]_EN_RunAutoTune	Auto-Tune Mode Start Request
Cn+18	BIT	RW	[PID Loop Name]_C_Reserved_02	Reserved
Cn+19	BIT	RW	[PID Loop Name]_C_Reserved_03	Reserved
Cn+20	BIT	RW	[PID Loop Name]_C_Reserved_04	Reserved
Cn+21	BIT	RW	[PID Loop Name]_C_Reserved_05	Reserved
Cn+22	BIT	RW	[PID Loop Name]_C_Reserved_06	Reserved
Cn+23	BIT	RW	[PID Loop Name]_C_Reserved_07	Reserved
Cn+24	BIT	RW	[PID Loop Name]_C_Reserved_08	Reserved

PID Indication Bits				
Address	**Data Type**	**Read/Write**	**Nickname**	**Comment**

Cn+25	BIT	Read Only	[PID Loop Name]_IND_RunManualMode	Manual Mode Indication
Cn+26	BIT	Read Only	[PID Loop Name]_IND_RunAutoMode	Auto Mode Indication
Cn+27	BIT	Read Only	[PID Loop Name]_IND_RunAutoTune	Auto-Tune Mode Indication
Cn+28	BIT	RW	[PID Loop Name]_C_Reserved_09	Reserved
Cn+29	BIT	RW	[PID Loop Name]_C_Reserved_10	Reserved
Cn+30	BIT	RW	[PID Loop Name]_C_Reserved_11	Reserved
Cn+31	BIT	Read Only	[PID Loop Name]_ALM_PV_Input_LoLo	PV Input Low Low Alarm
Cn+32	BIT	Read Only	[PID Loop Name]_ALM_PV_Input_Low	PV Input Low Alarm
Cn+33	BIT	Read Only	[PID Loop Name]_ALM_PV_Input_High	PV Input High Alarm
Cn+34	BIT	Read Only	[PID Loop Name]_ALM_PV_Input_HiHi	PV Input High High Alarm
Cn+35	BIT	Read Only	[PID Loop Name]_ALM_PV_Dev_High	PV Input Deviation High Alarm
Cn+36	BIT	Read Only	[PID Loop Name]_ALM_PV_Dev_HiHi	PV Input Deviation High High Alarm
Cn+37	BIT	Read Only	[PID Loop Name]_ALM_PV_RateOfChng	PV Input Rate-of-Change Alarm
Cn+38	BIT	RW	[PID Loop Name]_C_Reserved_11	Reserved
Cn+39	BIT	RW	[PID Loop Name]_C_Reserved_12	Reserved

DS Memory

PID Operation Status Registers

Address	Data Type	Read/Write	Nickname	Comment
DSn+00	INT	Read Only	[PID Loop Name]_PID_ErrorCode	PID Error Code
DSn+01	INT	Read Only	[PID Loop Name]_DS_Reserved_01	Reserved
DSn+02	INT	RW	[PID Loop Name]_DS_Reserved_02	Reserved
DSn+03	INT	RW	[PID Loop Name]_DS_Reserved_03	Reserved
DSn+04	INT	RW	[PID Loop Name]_DS_Reserved_04	Reserved

PID Configuration Registers				
Address	**Data Type**	**Read/Write**	**Nickname**	**Comment**
DSn+05	INT	RW	[PID Loop Name]_Sample_Rate	PID Sample Rate (ms)
DSn+06	INT	RW	[PID Loop Name]_DerivitiveGainLmt	Derivative Gain Limit Factor
DSn+07	INT	RW	[PID Loop Name]_PWM_Period	Output PWM period (sec)
DSn+08	INT	RW	[PID Loop Name]_PVFilterFactor	PV Filter Factor
DSn+09	INT	RW	[PID Loop Name]_DS_Reserved_05	Reserved
DSn+10	INT	RW	[PID Loop Name]_DS_Reserved_06	Reserved
DSn+11	INT	RW	[PID Loop Name]_DS_Reserved_07	Reserved
DSn+12	INT	RW	[PID Loop Name]_DS_Reserved_08	Reserved
DSn+13	INT	RW	[PID Loop Name]_DS_Reserved_09	Reserved
DSn+14	INT	RW	[PID Loop Name]_DS_Reserved_10	Reserved

DF Memory

PID Status Registers				
Address	**Data Type**	**Read/Write**	**Nickname**	**Comment**
DFn+08	FLOAT	RW	[PID Loop Name]_OUT_Control	Control Output

DFn+11	FLOAT	RW	[PID Loop Name]_PV_ProcessRaw	Raw Process Variable (PV)

PID Configuration Registers				
Address	**Data Type**	**Read/Write**	**Nickname**	**Comment**
DFn+00	FLOAT	RW	[PID Loop Name]_SP_Setpoint	Setpoint Value (SP)
DFn+01	FLOAT	RW	[PID Loop Name]_LMT_SP_LimitLower	Setpoint Lower Limit
DFn+02	FLOAT	RW	[PID Loop Name]_LMT_SP_LimitUpper	Setpoint Upper Limit
DFn+03	FLOAT	RW	[PID Loop Name]_ErrorDeadband	Error Deadband
DFn+04	FLOAT	RW	[PID Loop Name]_Bias	Bias (Integrator)
DFn+05	FLOAT	RW	[PID Loop Name]_P_Gain	Proportional Gain
DFn+06	FLOAT	RW	[PID Loop Name]_I_Reset	Reset Time (Integral Time)
DFn+07	FLOAT	RW	[PID Loop Name]_D_Rate	Rate Time (Derivative Gain)
DFn+09	FLOAT	RW	[PID Loop Name]_LMT_CO_LimitLower	Control Output Lower Limit
DFn+10	FLOAT	RW	[PID Loop Name]_LMT_CO_LimitUpper	Control Output Upper Limit
DFn+12	FLOAT	RW	[PID Loop Name]_PV_ProcessVar	Process Variable (PV)
DFn+13	FLOAT	RW	[PID Loop Name]_ALM_PV_LoLo	PV - Low Low Alarm Value
DFn+14	FLOAT	RW	[PID Loop Name]_ALM_PV_Lo	PV - Low Alarm Value
DFn+15	FLOAT	RW	[PID Loop Name]_ALM_PV_Hi	PV - High Alarm Value
DFn+16	FLOAT	RW	[PID Loop Name]_ALM_PV_HiHi	PV - High High Alarm Value
DFn+17	FLOAT	RW	[PID Loop Name]_ALM_PV_DevHi	PV - Deviation Alarm High Value

DFn+18	FLOAT	RW	[PID Loop Name]_ALM_PV_DevHiHi	PV - Deviation Alarm High High Value
DFn+19	FLOAT	RW	[PID Loop Name]_ALM_PV_RateAlarm	PV - Rate of Change Alarm Limit Value
DFn+20	FLOAT	RW	[PID Loop Name]_ALM_PV_AlarmHyst	PV - Hysteresis Alarm Limit Value
DFn+21	FLOAT	RW	[PID Loop Name]_Autotune_Hyst	Autotune Hysteresis
DFn+22	FLOAT	RW	[PID Loop Name]_LMT_PV_LimitLower	Process Variable Lower Limit
DFn+23	FLOAT	RW	[PID Loop Name]_LMT_PV_LimitUpper	Process Variable Upper Limit
DFn+24	FLOAT	RW	[PID Loop Name]_DF_Reserved_04	Reserved

Related Topics:

PID Control in CLICK

Find Available Addresses

PID Configuration Mode

PID Monitor Mode

PID List View

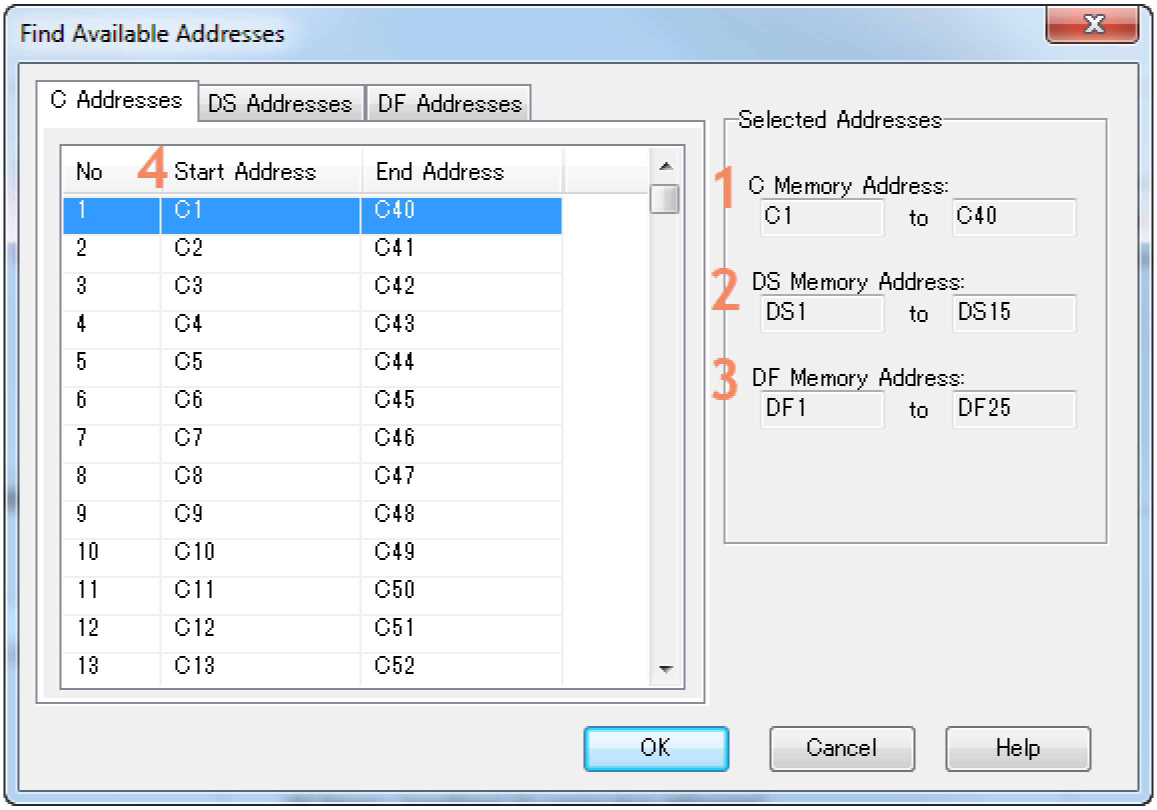
Autotuning

Filter Examples

PID Error Codes

Find Available Addresses

The Find Available Addresses dialog gives the user an easy method of assigning address blocks when creating a new PID loop. This dialog searches the current project for unused Addresses of the required block sizes. Any addresses assigned in Ladder, High-Speed I/O, Built-In I/O, and EtherNet/IP are considered unavailable by this dialog.



1 **C Addresses:** A continuous block of 40 bits is required.

2 **DS Addresses:** A continuous block of 15 DS Addresses is required.

3 **DF Addresses:** A continuous block of 25 DF Addresses is required.

4 **Start Address:** The lowest available starting blocks are selected by default. The user may choose any Start Address from the list for each Address type.

DF Addresses

Analog CPUs by default use a starting address of DF1 and consume these addresses. Analog Input and Output modules are also assigned to DF Addresses.

Auto Transfer

Auto Transfer from Analog Inputs and Auto Transfer to Analog Outputs can be configured. First, configure the PID normally. Then open the System Configuration for the Analog Modules, or the CPU Built-in I/O Setup for Analog CPUs. De-select the Continuous Address mode. For the Analog Input, select the PID_PV_ProcessRaw Address. For the Analog Output, select the PID_OUT_Control Address.

Related Topics:

[PID Control in CLICK]

[PID Address Descriptions]

[PID Configuration Mode]

[PID Monitor Mode]

[PID List View]

[Autotuning]

[Filter Examples]

[PID Error Codes]

PID Autotuning

Purpose

Autotuning can eliminate much of the trial and error of a manual tuning approach, especially if you do not have a lot of loop tuning experience. Performing the Autotuning procedure will get the Tuning Parameters close to their optimal values, but additional manual tuning may be required to get the Tuning Parameters to their optimal values.

WARNING: Only authorized personnel fully familiar with all aspects of the process should make changes that affect the loop tuning constants. Using the Autotune procedures will affect the process, including inducing large changes in the control output value. Make sure you thoroughly consider the impact of any changes to minimize the risk of injury to personnel or damage to equipment. The Autotune in the CLICK PLC is not intended to be used as a replacement for your process knowledge.

Autotuning Procedure

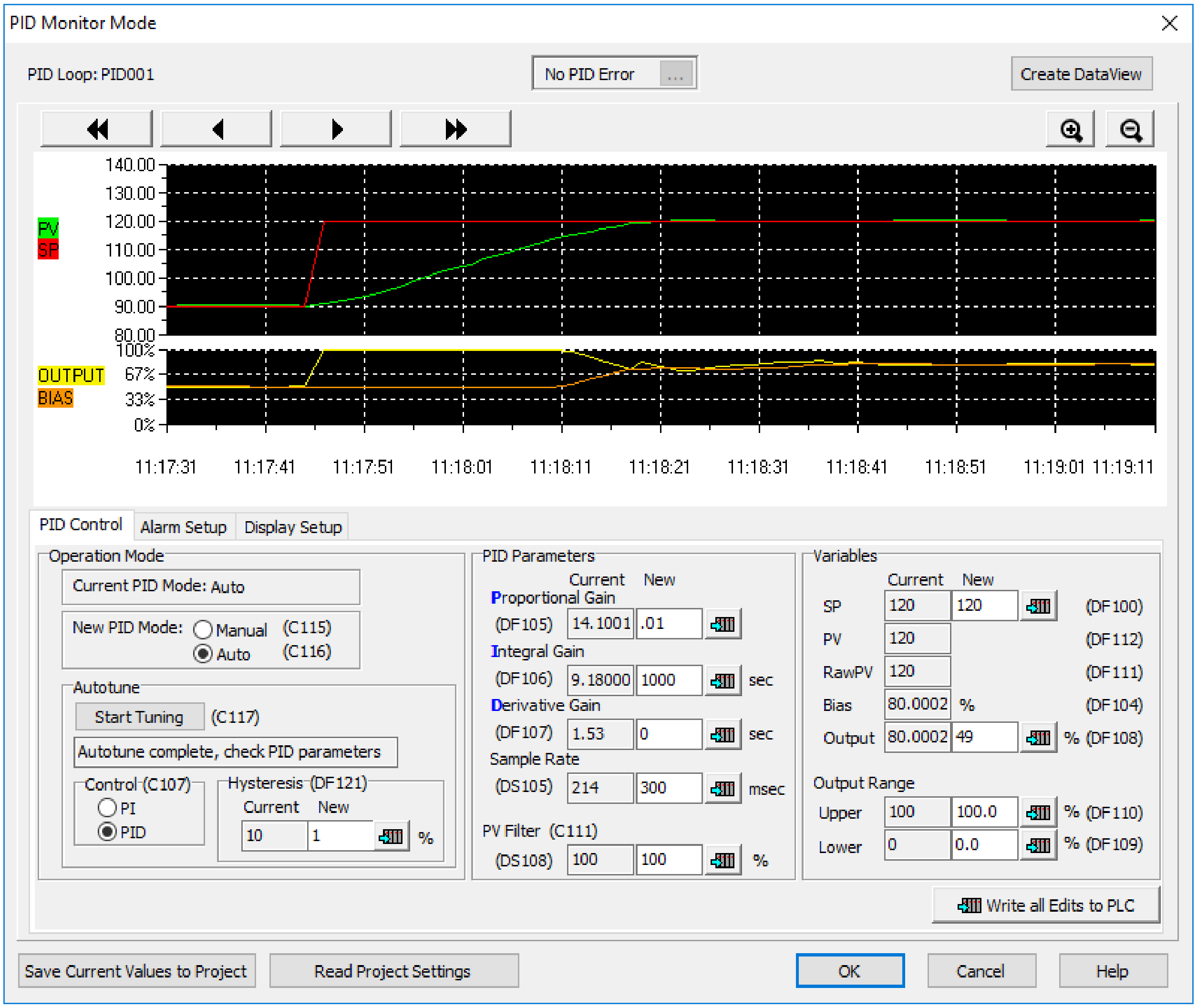
The Autotune feature for the CLICK PLC PID loop controller will only run once each time it is enabled. In other words, Autotuning does not run continuously during operation. Whenever there is a substantial change in the process dynamics, such as the mass of process, size of a valve, etc., the tuning process will need to be repeated in order to derive new constants required for optimal control.

The controls for the Autotune function use three bits and one floating-point number. The **PID Monitor** can manipulate these values automatically. Or, you may use your ladder logic to access these values directly and use a connected operator interface. The individual control bits allow you to select PID or PI control and start the Autotune procedure.

The floating-point number allows you to select a **Hysteresis** for the tuning procedure. The Hysteresis is the percentage of the SP that the PV must go beyond the SP before the Control Output changes values in the next bump. A larger value will result in a slower tuned loop but may be necessary to account for noise in the PV.

If you select the PI control, the Autotune procedure sets the Derivative Gain to 0.0. The Autotuning Mode Running Indicator bit and PID Error Code word report the Autotune status and error code. An Error Code of 200 indicates a problem with Autotune.

Autotuning Bits and Registers	
Address	**Function**
Cn+07	Autotune PID Algorithm Selection (PI/PID)
Cn+17	Autotune Mode Start Request
Cn+27	Autotune Mode running indication
DSn+00	PID Error Code
DFn+21	Autotune Hysteresis



Before starting the Autotune procedure:

1. Place the PID Loop in **Manual** Mode.
2. Adjust the **Control Output** so that the PV is no higher than 90% and no lower than 10% of it's extremes.
3. Let the **PV** stabilize.
4. Set the **Tuning Parameters**:
    a. P = 0.01
    b. I = 1000
    c. D = 0.0

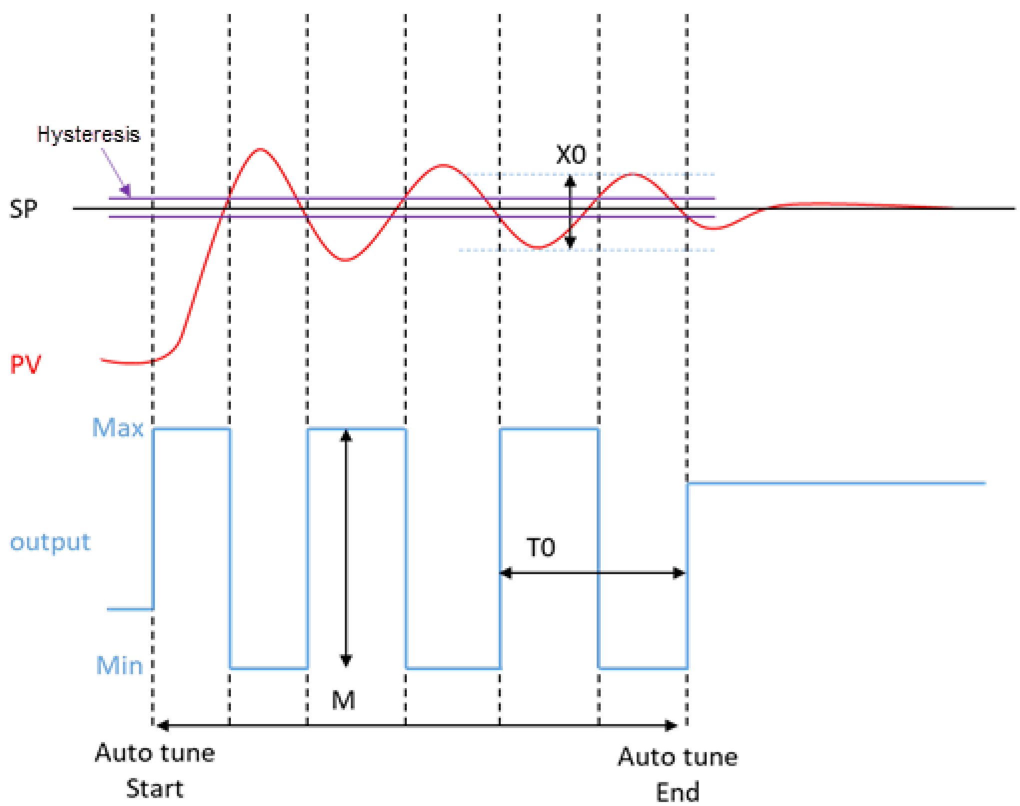
d. Sample Rate = 300ms

To start the Autotuning process:

1. Enter a **Hysteresis** depending on the amount of noise in the PV. 1.0% is a good starting place.
2. Set the Mode to Auto.
   The SP, PV and Control Output should not change if everything is set correctly.
3. Adjust the **SP** to be a small amount higher or lower than the PV.
4. Select the **Control Method** – **P**I or **PID**.
5. Select **Start Tuning**.

<u>Autotune Process:</u>

The following diagram shows the events which occur in the Autotune cycle.



- The Autotune compares the SP and PV and adjusts the Control Output to its extreme to cause the PV to cross over the SP.

- When the PV has crossed over the SP by the Hysteresis amount, the Control Output is adjusted to the opposite extreme.
- This is repeated 2 more times.
- The Autotune process computes Kpc and Tpc from M (Bump size), To (bump period) and Xo (amplitude of the PV as a percentage of the PV Span).
- Tuning Parameters (P, I, D and Sample Time) are calculated according to the Zeigler-Nichols equations, shown below and automatically updated in the PLC addresses DFn+5, DFn+6, DFn+7 and DSn+05 respectively.
- The loop switches to Auto mode.

Notes: If the response speed of PV is too fast, the optimum value may not be calculated. When set to Re

$Kpc = 4M / \pi * X0$
$Tpc = T0$ (sec)

PID Tuning	PI Tuning
P = 0.45 * Kpc	P = 0.30 * Kpc
I = 0.60 * Tpc	I = 1.00 * Tpc
D = 0.10 * Tpc	D = 0
Sample Rate = 0.014 * Tpc	Sample Rate = 0.03 * Tpc

Note: If your PV fluctuates rapidly, you need to use the PV Filter explained in the **PID Configuration** Help t

Using Hysteresis and PV Filter for Autotuning

When the PV is fluctuating or noisy, there are a couple of approaches you can take to achieve accurate tuning constants. You can enable the **PV Filter** or you can increase **Autotune Hysteresis**.

The PV Filter filters the Raw PV and can reduce the noise the PID loops sees, but it also causes lag in the PID control resulting in both a slow reacting and a slowly tuned loop. This is good to use if you do not want to see the noise in the PV during normal process run-time.

The Autotune Hysteresis has the same effect but only during the Autotune process. The noise in the PV is ignored. The higher the Hysteresis the more noise is ignored. This will result in slower tuning, but will not cause lag in the PID control. If you do not mind seeing the noise in the PV, this is a better parameter to adjust to get more accurate tuning constants..

Related Topics:

[PID Control in CLICK]

[PID Monitor]

[Find Available Addresses]

[PID Address Descriptions]

[PID Configuration Mode]

[PID View List]

[Filter Examples]

[PID Error Codes]

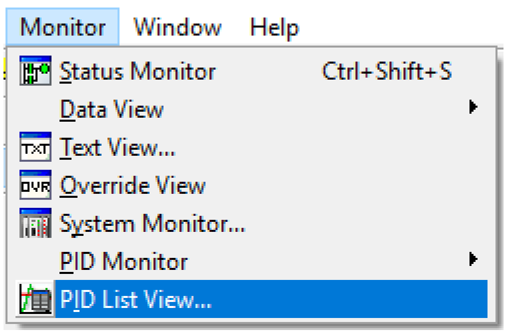
PID List View

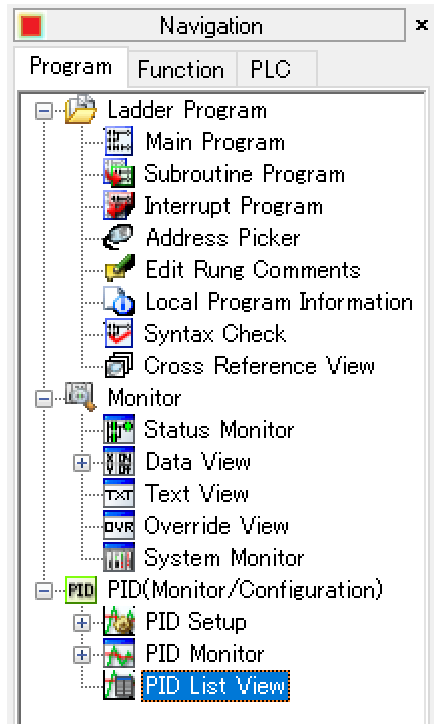
Overview

The PID List View provides a tabular view of the PID Parameters for a selected PID Loop.

Opening the PID List View

To open the PID List View, from the **Monitor** menu, select **Setup**, then **Monitor**, then **PID List View**; or, from the **Program** tab under **PID (Monitor/Configuration)**, double-click **PID List View**.

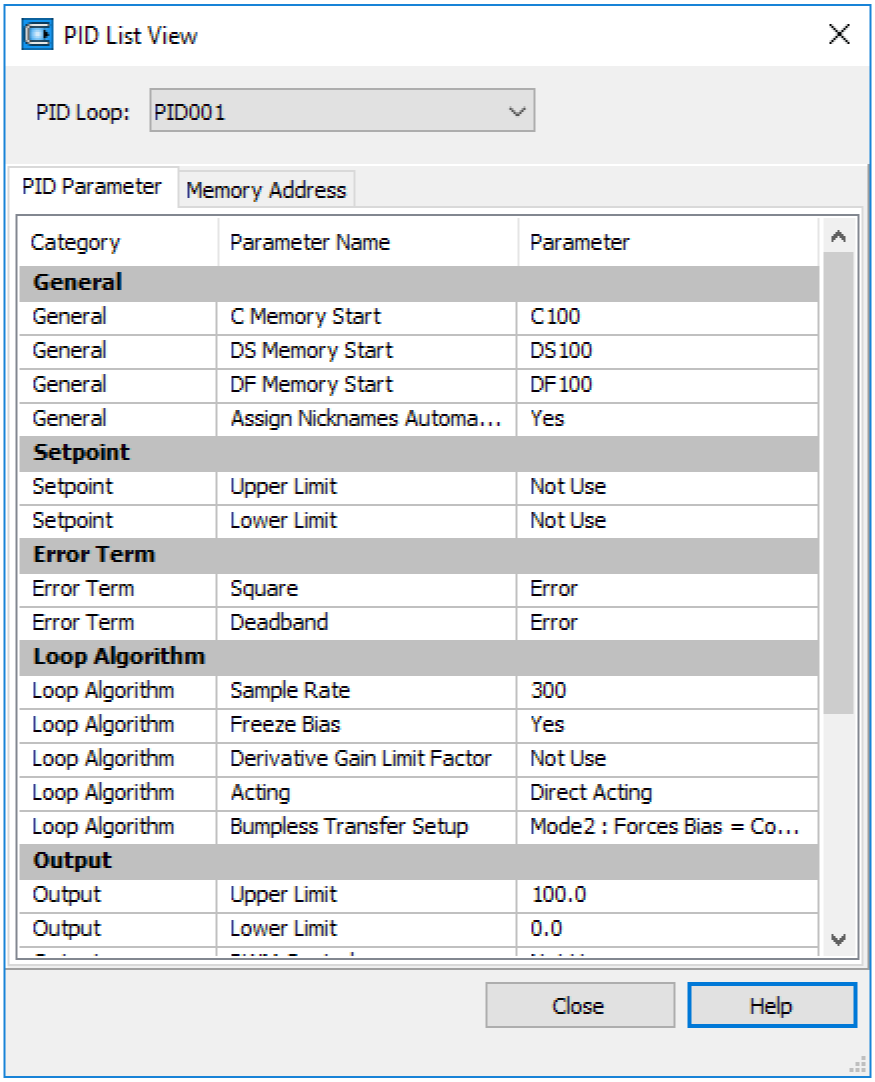




Parameter Tab

The **PID List View** dialog box opens. Each parameter is listed by category. The category corresponds to the tabs in the PID Configuration dialog box. The parameters listed are the same as those found in the PID Configuration dialog box.

The parameters and values listed here are for reference only and are not editable.



Memory Address Tab

The Memory Address tab lists all of the PLC Addresses associated with the PID Loop. The list contains:

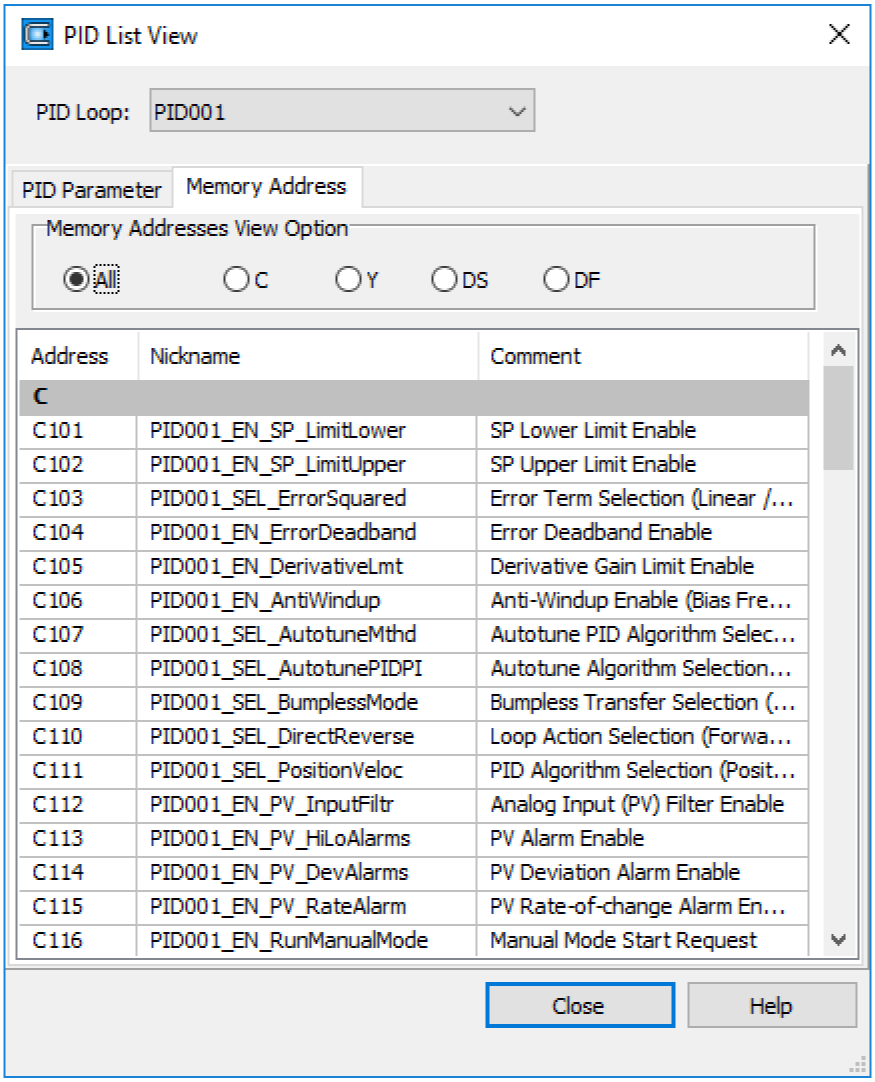
PLC Address

Address Nickname

Address Comment

<u>Memory Address View Option</u>

Each Address Range can be viewed separately by choosing a C, Y, DS or DF address view option.



Related Topics:

PID Control in CLICK

PID Monitor

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PID Address Descriptions

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Autotuning

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PID Error Codes

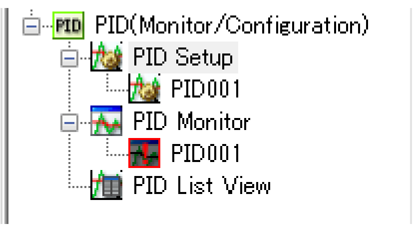
CLICK PID Errors

Overview

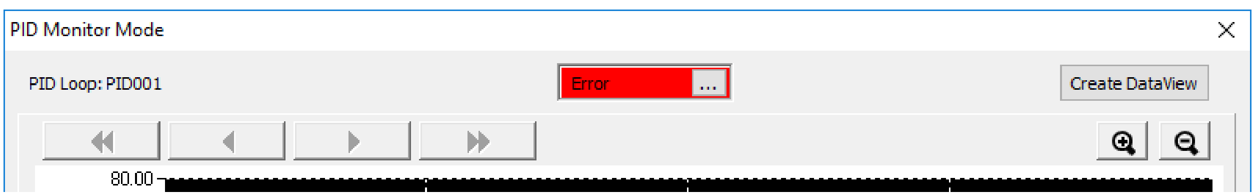
The CLICK PID Errors are indicated in two places; 1) the PID Monitor Window and 2) register DSn+00.

PID Monitor Window

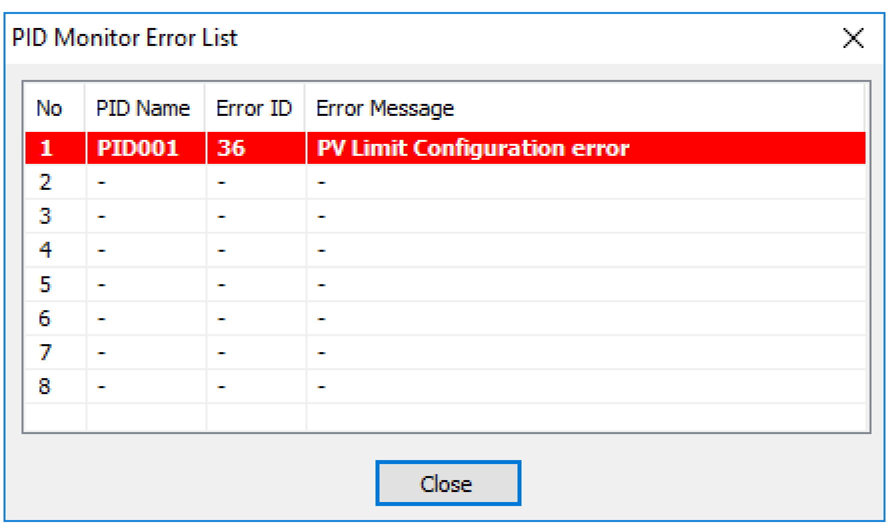
You may see an error indication on the PID Loop in the PID Loop Monitor selection in the Project tab.



Opening the PID Monitor you will see an Error indicator at the top of the PID Monitor Window.



Clicking on this indicator opens the PIS Monitor Error List.



Error Register

If there is more than one error, the DS register will contain the lowest active error number. When it is cleared, the next lowest error is indicated.

The most likely cause of errors on a new PID Loop is the PID Loop was configured in the PID Configuration, the program was downloaded to the PLC, but the PID Configuration data was not written to the PLC registers. Open the PID Loop Configuration and select **Write Register Values to PLC** as a first step to clear errors.

CLICK PID Errors				
No.	**Error contents**	**Function**	**Associated Register**	**Conditions**
0	No error （ normal ）	--	--	--
10	Sample Rate out of range	Calc.	DSn+05	<100 or >30000
11	Derivative Gain out of range	Calc.	DSn+06	>100
12	PWM period out of range	Output	DSn+07	<1 or >600
13	PV Input Filter out of range	PV	DSn+08	<1 or >100
20	Set point Value out of range	SP	DFn+00	Setpoint is out of range when value is not a number
21	SP Lower Limit out of range	SP	DFn+01	Out of range, when the value is not a number
22	SP Upper Limit out of range	SP	DFn+02	Out of range, when the value is not a number
23	SP Limit configuration error	SP	DFn+02	Lower Limit > Upper Limit
24	Error Dead band out of range	Err Term	DFn+03	NA

CLICK PID Errors				
25	Bias (Integrator) out of range	Calc.	DFn+04	NA
26	Proportional Gain (P) out of range	Calc.	DFn+05	<0.01 or >10000.0
27	Reset (I) Time out of range	Calc.	DFn+06	<0.01 or >6000.0
28	Derivative Gain (D) out of range	Calc.	DFn+07	<0 or >6000.0
30	Control Output Lower Limit out of range	Output	DFn+09	<0 or >100
31	Control Output Upper Limit out of range	Output	DFn+10	<0 or >100
32	Control Output Limit configuration error	Output	DFn+10 DFn+11	Lower Limit > Upper Limit
33	Raw Process Variable (PV) out of range	PV	DFn+11	NA
34	PV Lower Limit out of range	PV	DFn+22	Out of range, when the value is not a number
35	PV Upper Limit out of range	PV	DFn+23	Out of range, when the value is not a number
36	PV Limit Configuration error	PV	DFn+22 DFn+23	Lower Limit > Upper Limit
40	PV-LL Alarm out of range	Alarm	DFn+13	NA
41	PV-LAlarm out of range	Alarm	DFn+14	NA
42	PV-HAlarm out of range	Alarm	DFn+15	NA

CLICK PID Errors				
43	PV-HH Alarm out of range	Alarm	DFn+16	NA
44	PV Alarm configuration error	Alarm	DFn+13	(LL>L)or(L>H)or(H>HH)
			DFn+14	
			DFn+15	
			DFn+16	
45	PV Deviation Alarm (H) out of range	Alarm	DFn+17	<0
46	PV Deviation Alarm (HH) out of range	Alarm	DFn+18	<0
47	PV Deviation Alarm configuration error	Alarm	DFn+17	H>HH
			DFn+18	
48	PV Rate of Change out of range	Alarm	DFn+19	<0
49	PV Alarm Hysteresis out of range	Alarm	DFn+20	<0
200	Auto tuning Output Hysteresis out of range	Autotune	DFn+21	<0.1 or >10
202	Autotune Control Output out of range	Autotune	--	When control output exceeds a limit during autotuning.

Note: Any other Error number is not a invalid error. Check that some other process is not writing data in

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Related Topics:

[PID Control in CLICK]

[Find Available Addresses]

[PID Address Descriptions](#)

[PID Configuration Mode](#)

[PID Monitor Mode](#)

[PID List View](#)

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[Filter Examples](#)

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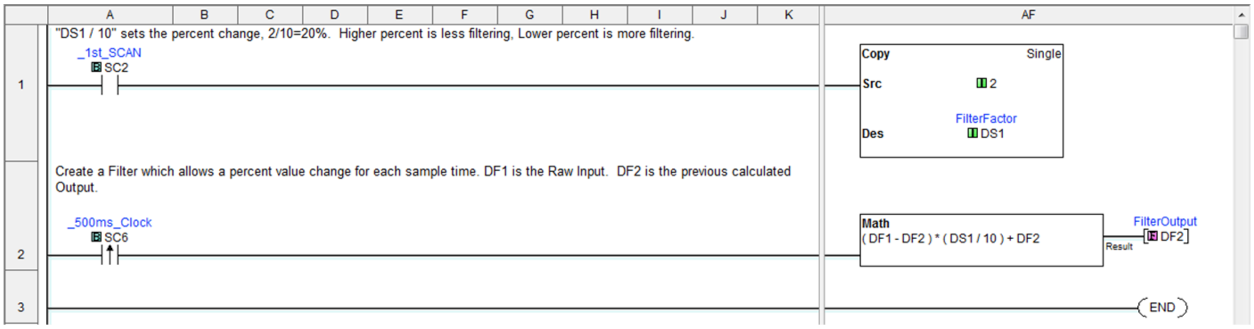
Filter Example

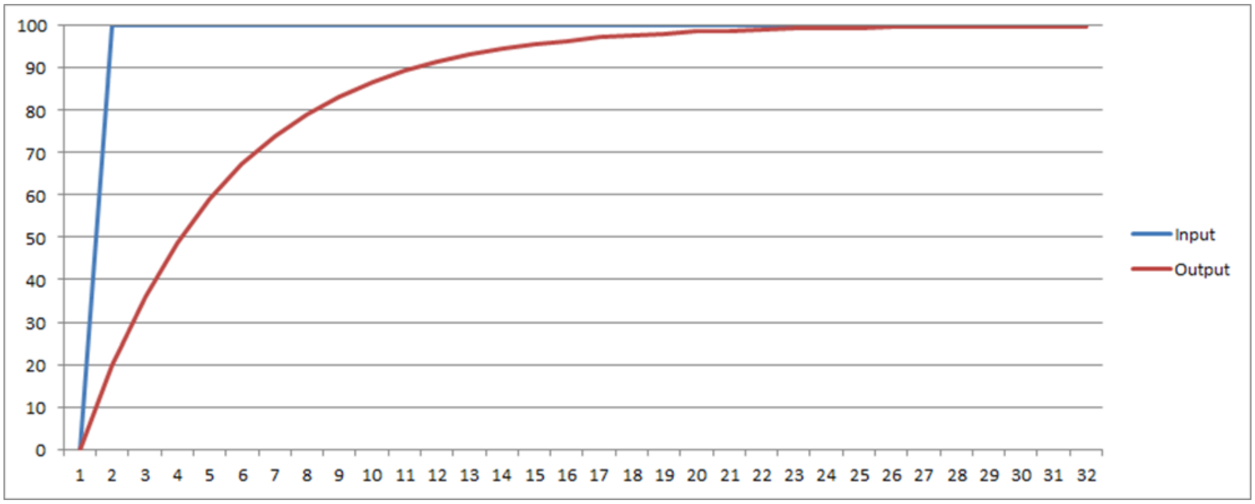
Two methods of creating an Analog Filter in Ladder Logic are shown here. These can be useful for filtering analog inputs. The following examples provide simple methods to create a filter and average. Be sure to change the addresses to unused memory addresses in your project.

Filter Example

This method provides the flexibility to adjust the sample time and percent change. At each sample time the difference is calculated between the Input and Output, then a percentage of this difference is applied to the new Output. A higher value in DS1 allows more change, or less filtering. A lower value in DS1 allows less change, or more filtering.

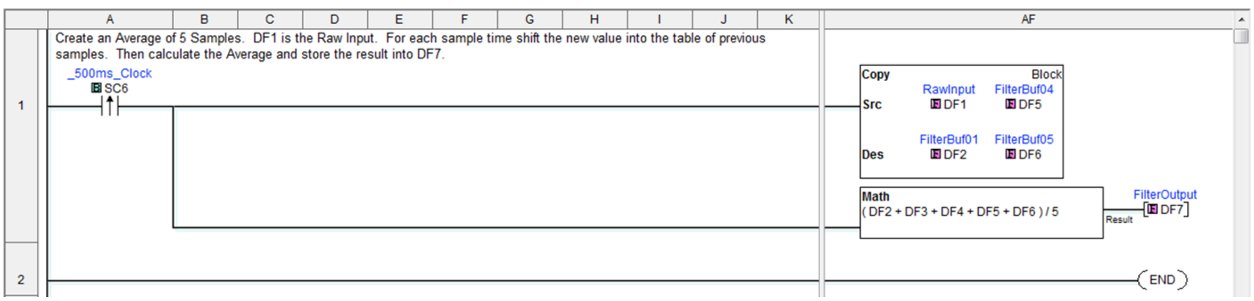


In this step response, the Input changes from 0 to 100.

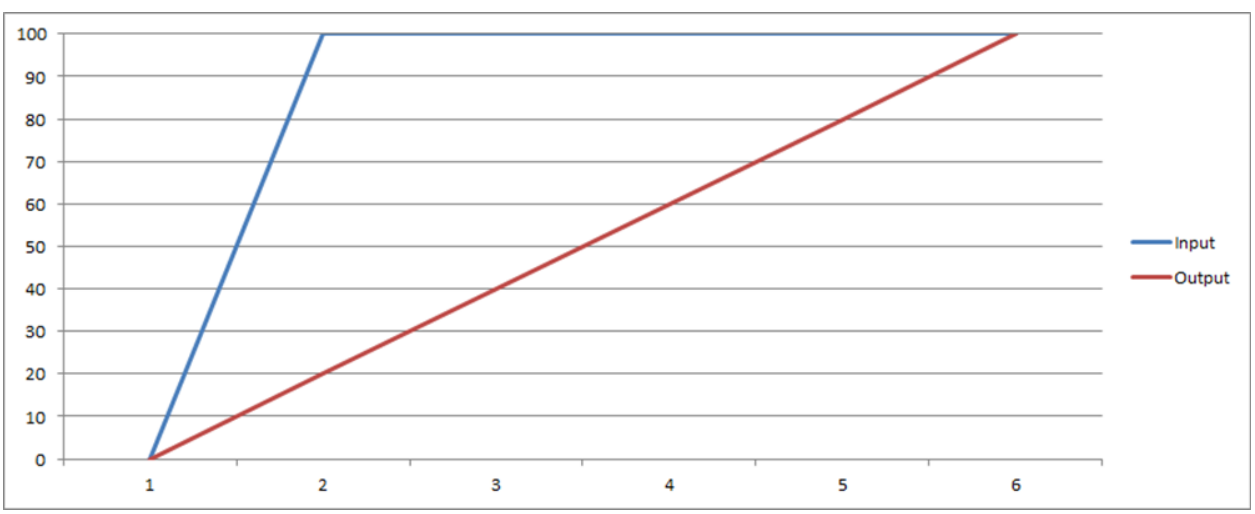


Average Example

This method enables the flexibility to adjust the sample time and number of samples. At each sample time a new Raw Input is shifted into the group of 5 samples. A new Average is then calculated. In this example, it takes 5 sample times for the Input to reach the Output.



In this step response, the Input changes from 0 to 100.



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Related Topics:

Copy Instruction: Block Copy

Math (Decimal)

PID Control in CLICK

Find Available Addresses

PID Address Descriptions

PID Configuration Mode

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PID List View

Autotuning

PID Error Codes