# PID CONTROL

APPENDIX F

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# Function of PID Control

GS4 series AC drives can be used to control an automated process by the Proportional-Integral-Derivative (PID) control method.

## *What Does PID Control Accomplish?*

The primary benefit of PID control is that it acheives and maintains the desired steady-state condition of a process better and more smoothly than does ON-OFF control.

The GS4 drive PID algorithm constantly assesses the amount and rate of change of the quantity being controlled (Process Variable) and its deviation (Process Error) from the desired steady-state value (Setpoint). The GS4 drive then variably adjusts its frequency output as much or as little as needed to keep the Process Variable as close as possible to the Setpoint.

Simple ON-OFF control systems, on the other hand, continually bounce back and forth above and below the Setpoint value, but cannot maintain the Process Variable at the Setpoint value.

## *PID Control Analogy*

PID controllers are all around us. Many times we don't realize that we are the PID controller in a control loop. For example, the driver of a car is the PID controller for the car's speed.

*PID Control System Variables*:

- *Desired Speed ≈ Setpoint*
- *Actual Speed ≈ Process Variable*
- *Gas Pedal ≈ Control Variable*
- *Speedometer ≈ Feedback*

*Proportional Control*: The farther away you are from your Desired Speed, the more you press the gas pedal. If you did this starting from a stand-still, you would floor it and probably shoot far past the Desired Speed. Once the speed "settled in," you would never hold exactly at your Desired Speed because the difference between Desired and Actual Speed would get very small and you only have so much control over the pedal and your foot; not enough to hold the perfect speed consistently. So, Proportional Control adjusts the output based on the *difference* between the Setpoint and Process Variable much more accurately in a fine-tuned way.

*Integral Control*: If your Desired Speed is 70mph and your car consistently goes 69mph, you will realize that you need to press the gas pedal a little more (to overcome wind resistance, a hill, etc.). The longer you are under the Desired Speed, the more gas you give the car. That is fundamentally what Integral Control does; adjust the output based on *how long* the system is away from the setpoint.

*Derivative Control*: In the situation above, assume that you start going up a hill. The car's Actual Speed gets farther away from the Desired Speed, so the Proportional Control makes you press the gas pedal more. The longer the speed stays below setpoint, Integral Control makes you press the gas even more. Now assume that your car tops the hill and starts going downhill. Your speed suddenly gets faster (the error between Desired Speed and Actual Speed), so Proportional causes you to slightly let off the gas. But Integral still keeps adding to the pedal (since you still haven't reached Desired Speed). Your internal Derivative Control sees that you are rapidly approaching the Desired Speed, so you begin to let off the gas quickly. That is Derivative Control; it adds or subtracts to the Control Variable based on *how quickly* the system is approaching (or leaving) the setpoint.

## Common Applications for PID Control

1) *Flow control: A flow sensor is used to feed back the flow rate in a pipe, and the GS4 drive PID adjusts its output frequency to the pump that forces the liquid or gas throught that pipe.*
2) *Level control: A level sensor is used to feed back the liquid level in a resevoir or tank, and the GS4 drive PID adjusts its output frequency to the pump that fills or empties that tank.*
3) *Pressure control: A pressure sensor is used to feed back the pressure in a tank, and the GS4 drive PID adjusts its output frequency to the pump that pressurizes or vacuums that tank.*
4) *Speed control: A speed sensor is used to feed back the shaft speed of a motor or machine driven by that motor, and the GS4 drive PID adjusts its output frequency to that motor.*
5) *Temperature control: A thermocouple or thermistor is used to feed back the temperature of an area or device, and the GS4 drive PID adjusts its output frequency to the fan that affects that temperature.*

## Definition of PID Loop "Directions"

*Please note that the following nomenclature describes how the GS4 PID system operates, which may differ from the operation of some other PID systems.*

### *Forward-Acting PID Loop (Heating Loop) (Negative-Feedback Loop)*

The terms "Forward-Acting," "Direct-Acting," "Heating," and "Negative-Feedback" are used to describe a PID loop that can be used to control processes such as pressure, heating, and flow (among others).

- *Greater Output Frequency (Hz) drives the Process Variable (PV) upward toward the Setpoint (SP)*
- *GS4 drive frequency output increases if the Process Error is negative (SP>PV)*

### *Reverse-Acting PID Loop (Cooling Loop) (Positive-Feedback Loop)*

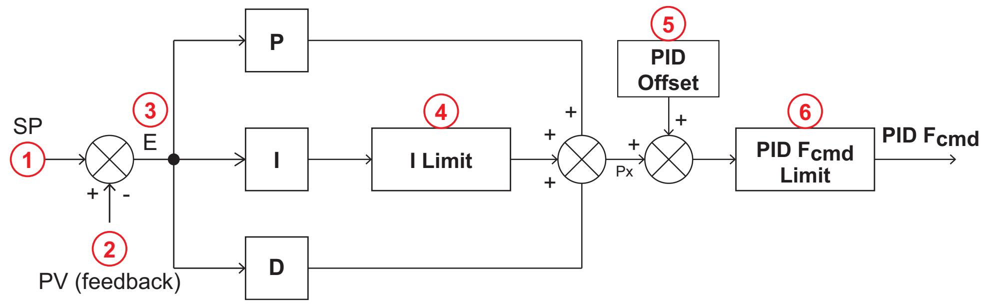
The terms "Reverse-Acting," "Cooling," and "Positive-Feedback" are used to describe a PID loop that can be used to control applications such as cooling.

- *Greater Output Frequency (Hz) drives the Process Variable (PV) downward toward the Setpoint (SP)*
- *GS4 drive frequency output increases if the Process Error is positive (SP<PV)*

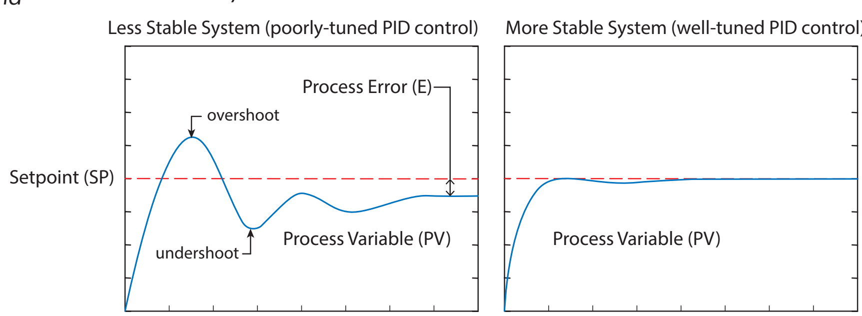
## PID Control Overview

PID control is a closed output and feedback loop for the purpose of automatically controlling a portion of a process to a specific condition by utilizing a target setpoint and the process's actual condition as feedback to the controller. You determine the setpoint and let the system reach that setpoint using the process's conditional feedback and the PID control system.

- *P = Proportional control (also known as "Gain")*
- *I = Integral control (also known as "Reset")*
- *D = Derivative control (also known as "Rate")*
- *Process Variable (PV) = the quantity being measured and controlled*
- *Setpoint (SP) (also known as Target Value) = the desired value of the Process Variable*
- *Error (E) = the difference between the Setpoint and the Process Variable*



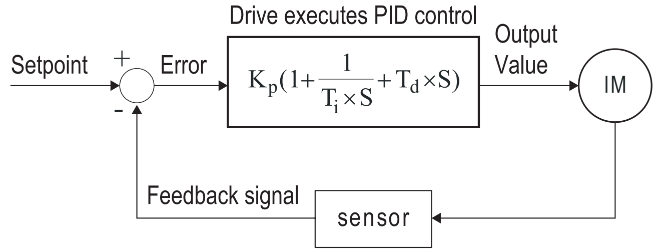

1) *Setpoint: -100% to +100% (PID Setpoint Gain + PID Setpoint Offset)*
2) *Feedback: -100% to +100% (Feedback Gain)*
3) *Error: -100% to +100% (in percent change)*
4) *I Limit: 0~150% (Upper Limit for Integral Time P7.16)*
5) *PID Offset: P7.24 determines how the PID Offset will be controlled; by P7.04, or by an Analog Input (P4.02, P4.03, P4.04)*
6) *PID $F_{cmd}$ Limit: See P6.25/P6.26*




Since a PID controller relies only on the measured Process Variable, instead of knowledge of the underlying process, it is applicable to a broad variety of system processes. By tuning the three parameters of the model, a PID controller can deal with specific process requirements. The response of the controller can be described in terms of its responsiveness to an error, the degree to which the system overshoots a setpoint, and the degree of any system oscillation. The use of the PID algorithm does not guarantee optimal control of the system or even its stability.

Some applications may require using only one or two terms to provide the appropriate system control. This is achieved by setting the other parameters to zero. A PID controller is called a PI, PD, P, or I controller in the absence of the other respective control actions. PI controllers are fairly common, since Derivative action is sensitive to measurement noise, whereas the absence of an Integral term may prevent the system from reaching its target value.

## Concept of GS4 PID Control & Tuning




$K_p$: Proportional Gain (P) $T_i$: Integral Time (I) $T_d$: Derivative Value (D) S: Operator

When ***GS4 drive PID is enabled by P7.00 [PID Action/Mode]***, P7.02 "reflects" the PID Setpoint Source determined by what is set in P4.00 (Remote) or P4.01 (Local), and what Mode the Drive is in, i.e. Remote or Local Mode. PID control operates with the feedback signal as reflected by P7.02 either 0~10V voltage or 4~20mA current.

### *Proportional Gain (P)*

The first parameter of GS4 PID control is *Proportional Gain (P7.13)*.

The GS4 drive's frequency output is proportional to the Process Error (when the GS4 is configured for PID control). If only the Proportional Gain control component is used, the controller will not be able to get the Process Variable to exactly match the Setpoint at steady-state.

For a given process, if the Proportional Gain value is set too low, the control action will be too sluggish. If the Proportional Gain value is set too high, the control action will be unstable. To find the correct setting for Proportional Gain, set the Integral Time (I) and Derivative Value (D) to zero (0). Begin tuning the process with a low Proportional Gain value, and increase the Proportional value until the system becomes unstable. When instability is reached, reduce the Proportional value slightly until the system becomes stable (smaller values reduce system gain).

### *Integral Time (I)*

The second parameter of GS4 PID control is *Integral Time (P7.14)*.

The GS4 drive's frequency output compensation due to the integral component is proportional to the integral of the Process Error. To eliminate the steady-state Process Error, an "integral component" needs to be added to the controller.

The Integral Time (I) decides the relation between integral component and Process Error. The integral component will be increased even if the error is small. It gradually increases the controller output to eliminate the error until it is 0.

Begin tuning with a higher number for Integral Time (100.0 is max; 1.0 is default), and slowly move to a smaller number until you reach the setpoint with minimized overshoot/undershoot. Tuning is normally done utilizing the GSoft2 software scope function (or an oscilloscope) to monitor the Process Variable as you incrementally change the Integral Time value until the Setpoint is satisfactorily maintained.

- *Overshoot: The Process Variable moves further past the Setpoint than desired.*
- *Undershoot: The Process Variable does not reach the desired Setpoint.*

*Refer to "Tuning Example for PID Control" on page F–7 of this appendix for more PID tuning information.*

### Derivative Value (D)

The third parameter of GS4 PID control is *Derivative Value (P7.15)*.

The GS4 drive's frequency output compensation due to the derivative component is proportional to the derivative of the Process Error. Derivative Value (D)control is performed based on the quickness of changes in the Process Error.

When the Proportional Gain (P) and Integral Time (I) control components are set to eliminate the Process Error so that the system runs at steady state, outside forces may suddenly cause oscillation or instability within the system. Without a Derivative Value component, the control output may be too sluggish to quickly respond to these sudden changes. The derivative component can suppress these effects by acting before the error occurs.

Begin tuning with a high Derivative Value and reduce the value to the point of system instability. Then increase the Derivative Value until the control output regains stability. Stability can be tested by moving between two wide-spread setpoint values.

*Since Derivative Control is performed based on sudden changes in Process Error, it is a very sensitive control. Therefore, it may also react to extraneous signals and noise, and can easily lead to unstable system control. Derivative control is not normally required for the control of processes such as flow, pressure and temperature.*

*Refer to "Tuning Example for PID Control" on page F–7 of this appendix for more PID tuning information.*

### Proportional Integral Control (PI)

When processes are controlled by Proportional Gain only, Process Error cannot be eliminated entirely. Proportional + Integral control (PI) can be used to eliminate Process Error incurred by the targeted value changes and the constant external disturbances. However, if the I action is excessively powerful, it will delay the responding correction, and will allow unstable system operation.

### Proportional Derivative Control (PD)

In deciding when to use Proportional-Derivative Control, we need to understand how the system would react as a Proportional-Integral-Derivative system. When a Process Error due to a disturbance in the process occurs in a controlled system, the system sees a greater load than the derivative has provided energy to control. If that Process Error is small, the system PV can oscillate if the Proportional Gain and the Integral Time are being applied to the system too often within a small length of time. To prevent this type of system reaction, the use of Proportional and Derivative (PD) alone may be warranted. The use of Proportional Gain *and* the feed-forward action of the Derivative Value can result in a faster-acting operation to stabilize the system.

### Proportional Integral Derivative Control (PID)

When choosing to use Proportional-Integral-Derivative (sometimes called PID) control, the Integral Time is utilized to provide better control of the Process Error while the Derivative Value is used to restrain PV oscillation.

## Tuning Example for PID Control

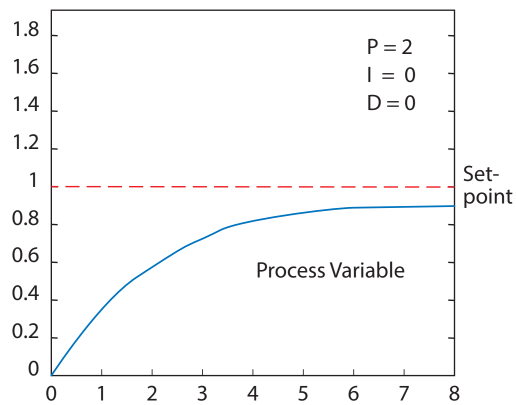
The PID settings should be adjusted, or "tuned," with the controlled process in actual operation while monitoring the actual Process Variable. The tuning can be done using the GSoft2 software scope function, or with an oscilloscope.

We recommend starting by first adjusting the Proportion Gain only, with the Integral Time and Derivative Value set to zero. The following hypothetical example illustrates PID tuning with settings as shown:

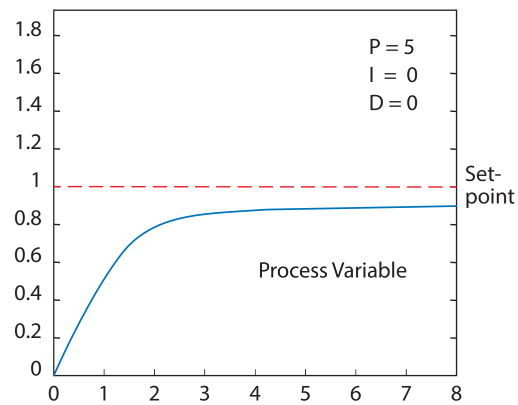
- *P = Proportional Gain = GS4 drive parameter P7.13,*
- *I = Integral Time = GS4 drive parameter P7.14,*
- *D = Derivative Value = GS4 drive parameter P7.15.*

***Proportional Gain***: Adjust the P setting so that the PV response is neither too sluggish, nor too fast, and without excessive overshoot or undershoot. (Process error cannot be eliminated by P)

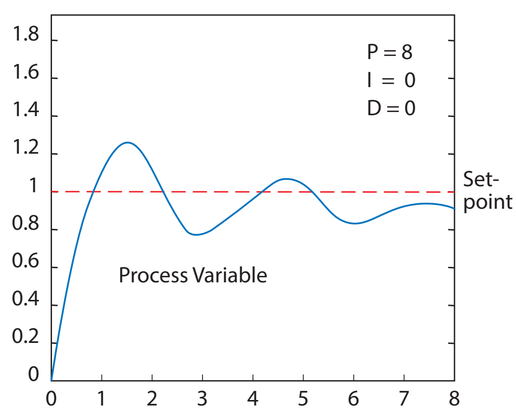
Sluggish PV response; process error




More practical PV response; process error



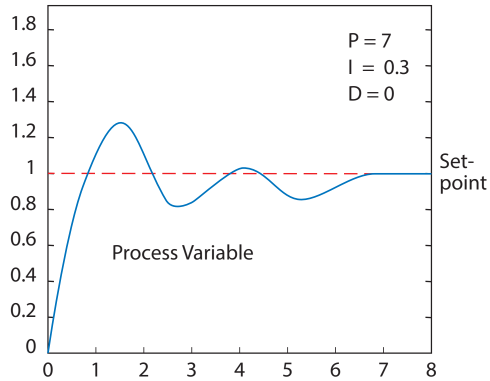

Overshoot & undershoot; process error

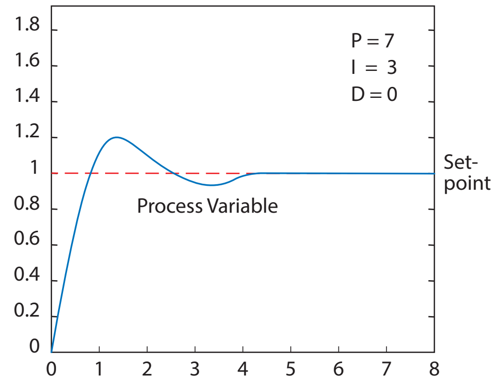



*(Example continued next page)*

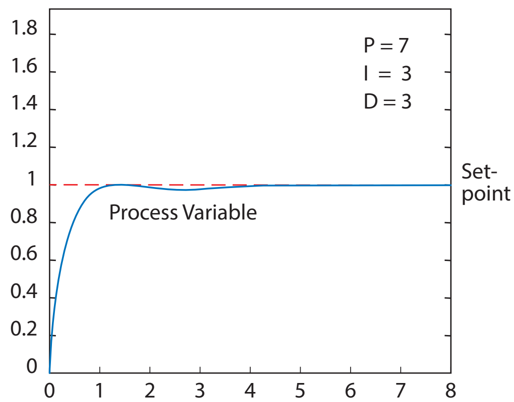
***PID Tuning Example (continued)***

_Integral Time_: Adjust the I setting to minimize over/undershoot, and to eliminate the process error.




_Derivative Value_: Adjusting the D setting may not be neccessary for all processes, but it can be particularly helpful in reducing over/undershoot and instability that may be caused by sudden changes in the system input variable.



## *DURAPULSE* GS4 AND GS3 PID PARAMETER COMPARISONS

| *DURAPULSE* GS4 & GS3 PID Parameter Comparisons – Summary | | | |
|---|---|---|---|
| **GS4 PID Parameter** | | **GS3 PID Parameter** | |
| ***P7.00*** | PID Action/Mode | ***P7.00*** | Input Terminal for PID Feedback |
| ***P7.01*** | reserved | ***P7.01*** | PV 100% Value |
| ***P7.02*** | PID Setpoint Source<br>(when PID enabled, this parameter data will be mapped from P4.00~P4.01 dependent upon whether in Remote=4.00 or Local=4.01) | ***P7.02*** | PID Setpoint Source |
| ***P7.03*** | PID Feedback Gain | ***P7.03*** | PID Feedback Gain |
| ***P7.04*** | PID Offset Value | ***P7.04*** | PID Setpoint Offset Polarity |
| | | ***P7.05*** | PID Setpoint Offset |
| ***n/a*** | n/a | ***P7.06*** | PID Setpoint Gain |
| ***P7.05*** | Keypad PID Setpoint | ***P7.10*** | Keypad PID Setpoint |
| ***P7.06*** | PID Multi-Setpoint 1 | ***P7.11*** | PID Multi-setpoint 1 |
| ***P7.07*** | PID Multi-Setpoint 2 | ***P7.12*** | PID Multi-setpoint 2 |
| ***P7.08*** | PID Multi-Setpoint 3 | ***P7.13*** | PID Multi-setpoint 3 |
| ***P7.09*** | PID Multi-Setpoint 4 | ***P7.14*** | PID Multi-setpoint 4 |
| ***P7.10*** | PID Multi-Setpoint 5 | ***P7.15*** | PID Multi-setpoint 5 |
| ***P7.11*** | PID Multi-Setpoint 6 | ***P7.16*** | PID Multi-setpoint 6 |
| ***P7.12*** | PID Multi-Setpoint 7 | ***P7.17*** | PID Multi-setpoint 7 |
| ***P7.13*** | Proportional Gain | ***P7.20*** | Proportional Control |
| ***P7.14*** | Integral Time | ***P7.21*** | Integral Control |
| ***P7.15*** | Derivative Value | ***P7.22*** | Derivative Control |
| ***P7.16*** | Upper Limit for Integral Time | ***P7.23*** | Upper Bound for Integral Control |
| ***P7.17*** | Derivative Filter Time Constant | ***P7.24*** | Derivative Filter Time Constant |
| ***P7.18*** | PID Output Frequency Limit | ***P7.25*** | PID Output Frequency Limit |
| ***P7.19*** | PID Feedback Value | ***n/a*** | n/a |
| ***P7.20*** | Feedback Signal Detection Time | ***P7.26*** | Feedback Signal Detection Time |
| ***P7.21*** | PID Feedback Loss | ***P7.27*** | PID Feedback Loss |
| ***P7.22*** | PID Feedback Loss Speed Level Default | ***P7.28*** | PID Feedback Loss Preset Speed |
| ***P7.23*** | reserved | ***n/a*** | n/a |
| ***P7.24*** | PID Offset Selection | | |
| ***P7.25*** | PID Mode Selection | | |
| ***P7.26*** | PID Reverse Enable | | |
| ***P7.27*** | Source of Sleep | | |
| ***P7.28*** | Integral Limit During Sleep | | |
| ***P7.29*** | Sleep Reference | | |
| ***P7.30*** | Wake-up Reference | | |
| ***P7.31*** | Sleep Time | | |
| ***P7.32*** | Wake-up Delay Time | | |
| ***P8.00*** | User Display (can be set to display PID values) | ***P8.00*** | User Defined Display Function |
| ***P8.01*** | Start-up Display Selection | ***n/a*** | n/a |
| ***P8.02*** | User Defined Format | | |
| ***P8.03*** | User Defined Max | | |
| ***P8.04*** | User Defined Setpoint | | |

## GS4 Parameters Involved in PID Control – Summary

The following GS4 AC drive parameters are often involved in setting up PID control.
*NOTE: The information provided herein is applicable only to the PID function. For fully detailed parameter information and for the complete set of GS4 parameters, please refer to "Chapter 4: AC Drive Parameters."*

| *DURApulse* GS4 Parameters for PID Control – Summary | | | |
|---|---|---|---|
| ***Parameter / Description*** | | | |
| **P3.03** | Multi-Function Input (DI1) | **P7.19** | PID Feedback Value |
| **P3.04** | Multi-Function Input (DI2) | **P7.20** | Feedback Signal Detection Time |
| **P3.05** | Multi-Function Input (DI3) | **P7.21** | PID Feedback Loss |
| **P3.06** | Multi-Function Input (DI4) | **P7.22** | PID Feedback Loss Speed Level Default |
| **P3.07** | Multi-Function Input (DI5) | **P7.23** | reserved |
| **P3.08** | Multi-Function Input (DI6) | **P7.24** | PID Offset Selection |
| **P3.09** | Multi-Function Input (DI7) | **P7.25** | PID Mode Selection |
| **P3.10** | Multi-Function Input (DI8) | **P7.26** | PID Reverse Enable |
| **P3.11** | Multi-Function Input (option card DI10 or PLC X12) | **P7.27** | Source of Sleep |
| **P3.12** | Multi-Function Input (option card DI11 or PLC X13) | **P7.28** | Integral Limit During Sleep |
| **P3.13** | Multi-Function Input (option card DI12 or PLC X14) | **P7.29** | Sleep Reference |
| **P3.14** | Multi-Function Input (option card DI13 or PLC X15) | **P7.30** | Wake-up Reference |
| **P3.15** | Multi-Function Input (option card DI14 or PLC X16) | **P7.31** | Sleep Time |
| **P3.16** | Multi-Function Input (option card DI15 or PLC X17) | **P7.32** | Wake-up Delay Time |
| **P3.17** | Multi-Function Output Terminal 1 (Relay 1) | **P8.00** | User Display |
| **P3.36** | PID Deviation Level | n/a | |
| **P3.37** | PID Deviation Time | | |
| **P3.57** | AUTO to HAND Switching Behavior | | |
| **P4.00** | 1st Source of Frequency Command [Remote] | | |
| **P4.01** | 2nd Source of Frequency Command [Local] | | |
| **P4.02** | Analog Input 1 (AI1) Function | | |
| **P4.03** | Analog Input 2 (AI2) Function | | |
| **P4.04** | Analog Input 3 (AI3) Function | | |
| **P6.25** | Upper Limit of Output Frequency | | |
| **P6.26** | Lower Limit of Output Frequency | | |
| **P7.00** | PID Action/Mode | | |
| **P7.02** | PID Setpoint Source | | |
| **P7.03** | PID Feedback Gain | | |
| **P7.04** | PID Offset Value | | |
| **P7.05** | Keypad PID Setpoint | | |
| **P7.06** | PID Multi-Setpoint 1 | | |
| **P7.07** | PID Multi-Setpoint 2 | | |
| **P7.08** | PID Multi-Setpoint 3 | | |
| **P7.09** | PID Multi-Setpoint 4 | | |
| **P7.10** | PID Multi-Setpoint 5 | | |
| **P7.11** | PID Multi-Setpoint 6 | | |
| **P7.12** | PID Multi-Setpoint 7 | | |
| **P7.13** | Proportional Gain | | |
| **P7.14** | Integral Time | | |
| **P7.15** | Derivative Value | | |
| **P7.16** | Upper Limit for Integral Time | | |
| **P7.17** | Derivative Filter Time Constant | | |
| **P7.18** | PID Output Frequency Limit | | |

## GS4 Parameters Involved in PID Control – Details

*NOTE: The information provided herein is applicable only to the PID function. For fully detailed parameter information and for the complete set of GS4 parameters, please refer to "Chapter 4: AC Drive Parameters."*

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P3.03~P3.16** | ***Multi-Function Input Terminal Functions*** | R/W | varies by parameter | |
| | *Range/Units (Abbreviated listing; includes only settings applicable to PID)* | *Default* | | |
| | 0~50 | varies by parameter | | |

These parameters set the functions of the Multi-Function input terminals.

| ***Multi-Function Input Terminal (P3.03~P3.16) Function Settings Applicable for PID Control*** | | | | | |
|---|---|---|---|---|---|
| ***Setting: Function*** | ***Function Description*** | | | | |
| 0: No function | Setting a Multi-Function Input to 0 will disable that input. The purpose of this function is to provide isolation for unused Multi-Function Input Terminals. ***Any unused terminals should be programmed to 0 to make sure they have no effect on drive operation.*** | | | | |
| 1: Multi-Speed/PID Multi-Setpoint bit 1<br>2: Multi-Speed/PID Multi-Setpoint bit 2<br>3: Multi-Speed/PID Multi-Setpoint bit 3 | When settings 1, 2, & 3 are selected and registers P7.06~P7.12 are populated, the Multi-Function Inputs refer to PID Multi-Setpoints. The SPs are determined by P7.06~P7.12.<br>1) In order to use the Multi-PID SPs, P7.06~P7.12 must be set, and P7.00≠0.<br>2) When all PID Multi-Setpoint inputs are off, the GS4 drive reverts to the PID Setpoint Source (P7.02). | ***PID Setpoint*** | | | ***Selection*** |
| | | ***Bit 3*** | ***Bit 2*** | ***Bit 1*** | ***PID Setpoint*** |
| | | OFF | OFF | OFF | P7.02: SP Source |
| | | OFF | OFF | ON | P7.06: Setpoint 1 |
| | | OFF | ON | OFF | P7.07: Setpoint 2 |
| | | OFF | ON | ON | P7.08: Setpoint 3 |
| | | ON | OFF | OFF | P7.09: Setpoint 4 |
| | | ON | OFF | ON | P7.10: Setpoint 5 |
| | | ON | ON | OFF | P7.11: Setpoint 6 |
| | | ON | ON | ON | P7.12: Setpoint 7 |
| 21: PID function Disable | When the contact is activated, the PID function is disabled. | | | | |

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P3.36** | ***PID Deviation Level*** | ♦R/W | 0324 | 40805 |
| | *Range/Units* | *Default* | | |
| | 1.0~50.0% | 10.0 | | |

If a Multi-Function Output terminal is set to PID Deviation Alarm (setting = 15), then the output will be activated when the amount of deviation between the SP (set point) and PV (process variable) in the PID loop exceeds the threshold set by this parameter for the period of time set by P3.37.

- *This parameter is used in conjunction with P3.37, PID Deviation Time.*

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P3.37** | ***PID Deviation Time*** | ♦R/W | 0325 | 40806 |
| | *Range/Units* | *Default* | | |
| | 0.1~300.0 sec | 5.0 | | |

If a Multi-Function Output terminal is set to PID Deviation Alarm (setting = 15), then the output will be activated when the amount of deviation between the SP (set point) and PV (process variable) in the PID loop exceeds the threshold set by P3.36 for the period of time set by this parameter.

- *This parameter is used in conjunction with P3.36, PID Deviation Level.*

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P3.57** | ***AUTO to HAND Switching Behavior*** | ♦R/W | 0339 | 40826 |
| | *Range/Units (Abbreviated listing; includes only settings applicable to PID)* | *Default* | | |
| | 0~Fh<br>bit 2: PID control bit<br>0: Cancel PID control<br>1: PID control follows the setting of Auto mode (P8.02) | 0 | | |

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P4.00*** | ***1st Source of Frequency Command [Remote]*** | ♦R/W | 0400 | 41025 |
| ***P4.01*** | ***2nd Source of Frequency Command [Local]*** | ♦R/W | 0401 | 41026 |

| Range/Units | Default |
|---|---|
| 0: Digital Keypad<br>1: RS485 Communication (Modbus/BACnet)<br>2: Analog Input<br>3: External UP/DOWN Terminal<br>4: Comm Card | P4.00: 0<br>P4.01: 0 |

Parameters P4.00 & P4.01 establish the source of the master Frequency.

- *Parameter P4.00 selects the source of the Frequency Command in REMOTE mode.*
- *Parameter P4.01 selects the source of the Frequency Command in LOCAL mode.*

*Related Parameters*: PID parameters P7.00.

- *When PID is enabled (P7.00 > 0), the frequency command sources selected in P4.00 and P4.01 become the PID setpoint source. The selected PID setpoint source is mapped to P7.02, and can be read there.*

*NOTE: GS4's output frequency can be affected by the Trim Function. If P4.08 Trim Function is set to a non-zero value, the drive's actual output frequency may not match the Local or Remote Command Frequency. See P4.08 for ways to add or subtract to the command frequency.*

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P4.02*** | ***Analog Input 1 (AI1) Function*** | ♦R/W | 0402 | 41027 |
| ***P4.03*** | ***Analog Input 2 (AI2) Function*** | ♦R/W | 0403 | 41028 |
| ***P4.04*** | ***Analog Input 3 (AI3) Function*** | ♦R/W | 0404 | 41029 |

| Range/Units (ABBREVIATED LISTING; INCLUDES ONLY SETTINGS APPLICABLE TO PID) | Default |
|---|---|
| 0: No Function<br>1: Frequency Command/PID Setpoint REMOTE*<br>2: Frequency Command/PID Setpoint LOCAL*<br>3: Frequency Command/PID Setpoint REMOTE & LOCAL*<br>5: PID Feedback Signal* | P4.02: 1<br>P4.03: 0<br>P4.04: 0 |

*(*1,2,3) Frequency Command: The analog value present on the selected input channel (0~10VDC / 4~20mA) corresponds to the drive output frequency from zero to maximum, as defined in parameter P0.04 (Drive Maximum Output Frequency).*

*Frequency Command selection is a function of P4.00 or P4.01. If either parameter contains a value of 2 (Analog Input), then the corresponding Analog Input Function will be automatically set to 1, 2, or 3 (Frequency Command/PID Setpoint REMOTE, LOCAL, or REMOTE & LOCAL, respectively).*

*Example:*

*• If P4.00 (1st Source of Frequency Command (Remote)) is configured to a value of 2 (Analog Input), and P4.04 (Analog Input 3) is set to a value of 1 (Remote Frequency Command/PID Set Point), then P7.02 (PID Setpoint Source) will be automatically updated to "Analog In3 (AI3)."*

*• The changes may not update until the drive enters RUN mode.*

*(*5) PID functions 5: Refer to Parameter Group 7 to define the analog inputs for PID Setpoint and Feedback use.*

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P6.25*** | ***Upper Limit of Output Frequency*** | ♦R/W | 0619 | 41562 |
| | *Range/Units* | *Default* | | |
| | 0.00~599.00 Hz | 599.00 | | |

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P6.26*** | ***Lower Limit of Output Frequency*** | ♦R/W | 061A | 41563 |
| | *Range/Units* | *Default* | | |
| | 0.00~599.00 Hz | 0.00 | | |

The setting of output frequency upper/lower limit is used to prevent mis-operation, machine damage, overheating due to too low operation frequency, and damage due to too high speed.

P6.25 Output Frequency Upper Limit:

- *This setting limits the maximum output frequency of the drive. When the drive frequency command or feedback control frequency is higher than this setting, the drive output frequency will be limited by the upper limit of output frequency.*
- *This parameter must be equal to or greater than the Lower Limit of Output Frequency (P6.26).*
- *If the Upper Limit of Output Frequency is 50Hz and the Maximum Output Frequency is 60Hz, then any Command Frequency above 50Hz will generate a 50Hz output from the drive.*
- *If the frequency output upper limit is 60Hz and frequency command is also 60Hz, the drive won't exceed 60Hz even after slip compensation. If the output frequency needs to exceed 60Hz, then increase output frequency upper limit limit or max operation frequency.*
- *When the drive enters into the function of slip compensation (P2.01) or PID feedback control, the drive output frequency may exceed the frequency command but still be limited by this setting.*
- *The Output Frequency is also limited by the Motor Maximum RPM (P0.04).*

P6.26 Output Frequency Lower Limit:

- *This setting limits the minimum output frequency of the drive. When the drive frequency command or feedback control frequency is lower than this setting, the drive output frequency will be limited by the lower limit of output frequency.*
- *This parameter must be equal to or less than the Upper Limit of Output Frequency (P6.25).*
- *When the drive starts, it will operate from min output frequency (P2.08, 2.12) and accelerate to the setting frequency. The starting ramp won't be limited by this parameter setting; it will only limit the minimum setpoint frequency.*
- *If the Lower Limit of Output Frequency is 10Hz, and the Minimum Output Frequency (P2.08, P2.16) is set at 5.0Hz, then any Command Frequency between 5~10 Hz will generate a 10Hz output from the drive. A Command Frequency of less than 5Hz will not result in an output from the drive.*
- *When the drive enters into the function of slip compensation (P2.01) or PID feedback control, the drive output frequency may exceed the frequency command but still be limited by this setting.*

Related parameters: P0.04, P2.01, P2.08, P2.16, P6.25

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P7.00** | ***PID Action/Mode*** | ♦R/W | 0700 | 41793 |
| | *Range/Units* | *Default* | | |
| | 0: PID Disabled<br>1: PID Reverse Local/Remote<br>2: PID Forward Local/Remote<br>3: PID Reverse Remote Only<br>4: PID Forward Remote Only<br>5: PID Reverse Local Only<br>6: PID Forward Local Only | 0 | | |

This parameter sets the input terminal to use for the process variable PID feedback.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P7.02** | ***PID Setpoint Source*** | Read | 0702 | 41795 |
| | *Range/Units* | *Default* | | |
| | 00: Keypad<br>01: RS485<br>02: AI1<br>03: AI2<br>04: AI3<br>05: Ext Up/Down Key<br>06: Comm Card<br>07: Reserve (PID off) | 7 | | |

*When PID is enabled (P7.00>0), P7.02 parameter data will be mapped from P4.00~P4.01 dependent upon whether in Remote (P4.00) or Local (P4.01).*

This parameter indicates the source for the PID Setpoint, which is determined by setting of the appropriate parameter P4.00 (Remote) or P4.01 (Local).

The user can change the display to show the PID Setpoint by changing parameter P8.00 to 42, PID Reference.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P7.03** | ***PID Feedback Gain*** | ♦R/W | 0703 | 41796 |
| | *Range/Units* | *Default* | | |
| | 0.00~300.00% | 100.00 | | |

This parameter can be used to set a gain for the Process Variable feedback signal.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P7.04** | ***PID Offset Value*** | ♦R/W | 0704 | 41797 |
| | *Range/Units* | *Default* | | |
| | -100.0% to +100.0% | 0.0 | | |

This parameter is for fine tuning a PID setting. You can input a PID offset to provide the desired operating condition. It functions similarly to parameters P4.10, P4.15, and P4.19.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P7.05** | ***Keypad PID Setpoint*** | Read | 0705 | 41798 |
| | *Range/Units* | *Default* | | |
| | 0.00~100.00% | 0.0 | | |

This parameter is used for keypad and serial communication PID Setpoints.

If keypad is the source of Frequency Command when Lv or Fault occurs, the present Frequency Command will be saved in this parameter.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P7.06** | **PID Multi-Setpoint 1** | ♦R/W | 0706 | 41799 |
| **P7.07** | **PID Multi-Setpoint 2** | ♦R/W | 0707 | 41800 |
| **P7.08** | **PID Multi-Setpoint 3** | ♦R/W | 0708 | 41801 |
| **P7.09** | **PID Multi-Setpoint 4** | ♦R/W | 0709 | 41802 |
| **P7.10** | **PID Multi-Setpoint 5** | ♦R/W | 070A | 41803 |
| **P7.11** | **PID Multi-Setpoint 6** | ♦R/W | 070B | 41804 |
| **P7.12** | **PID Multi-Setpoint 7** | ♦R/W | 070C | 41805 |

| Range/Units | Default |
|---|---|
| 0.00~100.00% | 0.00 |

Parameters P7.06~P7.12 are used to provide seven different PID Setpoints. Multi-Function Input Terminals DI1~DI15 are assigned in parameters P3.03~P3.16 to select which one of the PID Multi-Setpoints is to be used.

**Multi-Function Input Terminal Function Settings (P3.03~P3.16) for Input Terminals DI1~DI16**
(Abbreviated listing; includes only settings applicable to PID)

| Setting: Function | Function Description |
|---|---|
| 0: No function | Setting a Multi-Function Input to 0 will disable that input. The purpose of this function is to provide isolation for unused Multi-Function Input Terminals. ***Any unused terminals should be programmed to 0 to make sure they have no effect on drive operation.*** |
| 1: Multi-Speed/PID Multi-Setpoint bit 1 | When settings 1, 2, & 3 are selected and registers P7.06~P7.12 are populated, the Multi-Function Inputs refer to PID Multi-Setpoints. The SPs are determined by P7.06~P7.12.<br>1) In order to use the Multi-PID SPs, P7.06~P7.12 must be set, and P7.00≠0.<br>2) When all PID Multi-Setpoint inputs are off, the GS4 drive reverts to the PID Setpoint Source (P7.02). |
| 2: Multi-Speed/PID Multi-Setpoint bit 2 | |
| 3: Multi-Speed/PID Multi-Setpoint bit 3 | (see table below) |

| PID Setpoint | | | Selection |
|---|---|---|---|
| **Bit 3** | **Bit 2** | **Bit 1** | **PID Setpoint** |
| OFF | OFF | OFF | P7.02: SP Source |
| OFF | OFF | ON | P7.06: Setpoint 1 |
| OFF | ON | OFF | P7.07: Setpoint 2 |
| OFF | ON | ON | P7.08: Setpoint 3 |
| ON | OFF | OFF | P7.09: Setpoint 4 |
| ON | OFF | ON | P7.10: Setpoint 5 |
| ON | ON | OFF | P7.11: Setpoint 6 |
| ON | ON | ON | P7.12: Setpoint 7 |

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.13*** | ***Proportional Gain (P)*** | ♦R/W | 070D | 41806 |
| | *Range/Units* | *Default* | | |
| | 0.0~100.0 | 1.0 | | |

Proportional Gain is used to eliminate system error. It is most often used to decrease error and increase response speed. But a P7.13 setting value that is too large may cause system oscillation and instability.

If the other two controls (I and D) are set to zero, Proportional Gain is the only one effective in the PID loop.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.14*** | ***Integral Time (I)*** | ♦R/W | 070E | 41807 |
| | *Range/Units* | *Default* | | |
| | 0.00~100.00 sec | 1.00 | | |

This parameter is used to set the time of the Integral (I) controller. The integral controller is used to eliminate error in a stable system. The integral time of the PID controller is acted upon by the change in integral time. When the integral time is long, it will provide a small gain of integral control, a slower response, and lesser/sloppy external control. When the integral time is short, it will provide a large gain of Integral control, a faster response ,and more rapid external control. The Integral Time doesn't stop working until error is 0. The smaller integral time is set, the stronger integral action will be. It is helpful to reduce overshoot and oscillation to make a stable system. As it functions the decreasing error will be slowed. The Integral Time is often used with the other two controls to become PI controller or PID controller. Remember when the integral time is too small, it may cause system oscillation.

If the integral time is set as 0.00, P7.14 will be disabled.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.15*** | ***Derivative Value (D)*** | ♦R/W | 070F | 41808 |
| | *Range/Units* | *Default* | | |
| | 0.00~1.00 sec | 0.00 | | |

This parameter is used to set the value of the Derivative (or Rate) (D) controller to decide the response of error change. A suitable derivative time can reduce the overshoot of a P and I controller to decrease oscillation for a more stable system. The derivative controller is used to show the change of system error, is helpful to preview the change of error, and is used to eliminate error to improve a systems operating state. With a suitable derivative time, it can reduce overshoot and shorten adjustment time. However, the derivative operation does increase (because of its effect) noise interference. Please note that too large of a derivative can cause a large amount of noise interference. The derivative shows the change and the output of the derivative will be 0 when there is no change. Therefore, the derivative control can't be used independently. It needs to be used with the other two controllers to make a PD controller or PID controller. Too long a derivative time may cause system oscillation. The derivative controller acts to minimize the change of error and can't filter noise. It is not recommended to use this function in noisy or noise-prone applications.

*NOTE: Derivative Control cannot be used independently. It needs to be used with the other PID controls to make a PD controller or PID controller.*

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.16*** | ***Upper Limit for Integral Time*** | ♦R/W | 0710 | 41809 |
| | *Range/Units* | *Default* | | |
| | 0.0~100.0% | 100.0 | | |

This parameter defines an upper limit for the Integral Time (I), and therefore limits the Master Frequency.

- *Integral upper limit = Maximum Output Frequency (P0.04) x Upper Limit for Integral Time (P7.16).*

An integral value that is too high will slow the system response due to sudden load changes, and therefore may cause motor stall or machine damage. Therefore, use caution when setting this parameter.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.17*** | ***Derivative Filter Time Constant*** | ♦R/W | 0711 | 41810 |
| | *Range/Units* | *Default* | | |
| | 0.0~2.5 sec | 0.0 | | |

To avoid amplification of measured noise in the controller output, a digital filter is inserted. This filter helps smooth oscillations. Larger values for P7.17 provide more smoothing.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.18*** | ***PID Output Frequency Limit*** | ♦R/W | 0712 | 41811 |
| | *Range/Units* | *Default* | | |
| | 0.0~110.0% | 100.0 | | |

This parameter defines the percentage of output frequency limit during PID control.

- *Output frequency limit = Maximum Output Frequency (P0.04) x PID Output Frequency Limit (P7.18).*

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.19*** | ***PID Feedback Value*** | Read | 0713 | 41812 |
| | *Range/Units* | *Default* | | |
| | -200.00% to +200.00% | 0.00 | | |

This parameter shows the value of feedback signal under PID control.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.20*** | ***Feedback Signal Detection Time*** | ♦R/W | 0714 | 41813 |
| | *Range/Units* | *Default* | | |
| | 0.0~3600.0 sec | 0.0 | | |

This parameter is valid only when the feedback signal is AI2 4~20mA.

This parameter defines the time during which the PID feedback must be abnormal before a warning is given. It also can be modified according to the system feedback signal time.

If this parameter is set to 0.0, the system would not detect any signal abnormality.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P7.21** | **PID Feedback Loss** | R/W | 0715 | 41814 |
| | Range/Units | Default | | |
| | 0: Warn and Continue Operation<br>1: Warn (fault) and Ramp to Stop<br>2: Warn (fault) and Coast to Stop<br>3: Warn and Operate at Last Frequency<br>4: Warn and Run at P7.22 | 0 | | |

***Loss detected only if P7.20 (Loss Detect Time) > 0.***

This parameter is valid only when the feedback signal is AI2 4~20mA.

GS4 AC drive acts when the feedback signals (analog PID feedback) are abnormal.

If the command frequency falls below the Sleep Reference frequency (P7.29), for the specified Sleep Time (P7.31), then the drive will shut off the output and wait until the command frequency rises above Wake-up Reference (P7.30).

*Setting Explanations:*

0: Drive goes to 0Hz, but does not fault (warning only). Drive will restart if signal returns.

1 & 2: AFE Fault (PID Feedback AI2 Loss). Requires reset.

3: Drive warns and runs at the last PID Feedback Frequency.

4: Drive warns and runs at setting of P7.22.

***IF P7.21 = 0 OR 3 (KEEP RUNNING ON 4-20MA LOSS) AND P7.00 PID FEEDBACK IS SET FOR "FORWARD OPERATION" (P7.00 = 2, 4, OR 6), THE DRIVE WILL ACCELERATE TO P7.18 PID OUTPUT LIMIT IF THE ANALOG SIGNAL IS LOST.***

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P7.22** | **PID Feedback Loss Speed Level Default Value** | ♦R/W | 0716 | 41815 |
| | Range/Units | Default | | |
| | 0.00~400.00 Hz | 0.00 | | |

This parameter sets the speed of operation of the GS4 drive when there is a loss of the PID feedback signal, if P7.21 is set to 3.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P7.23** | **reserved** | ~ | 0717 | 41816 |

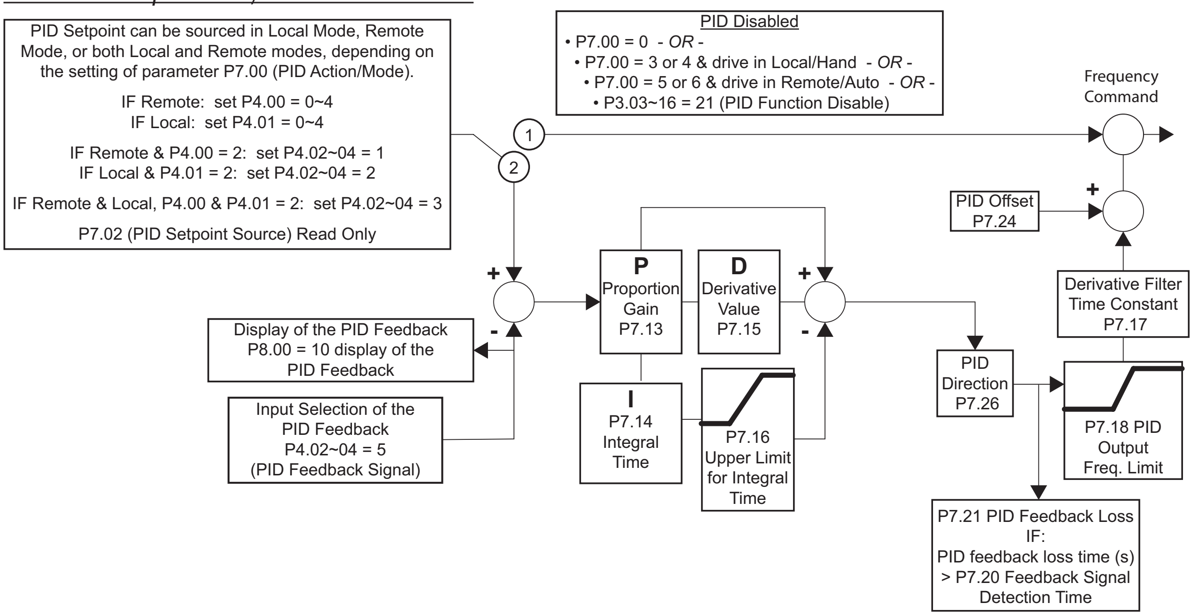
| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P7.24** | **PID Offset Selection** | ♦R/W | 0718 | 41817 |
| | Range/Units | | | Default |
| | 0: Set by P7.04<br>1: Set by an Analog Input<br>[AI1 (P4.02), AI2 (P4.03), or AI3 (P4.04) must be set to 7: PID Offset (Input)] | | | 0 |

This parameter sets the source of the PID Offset.

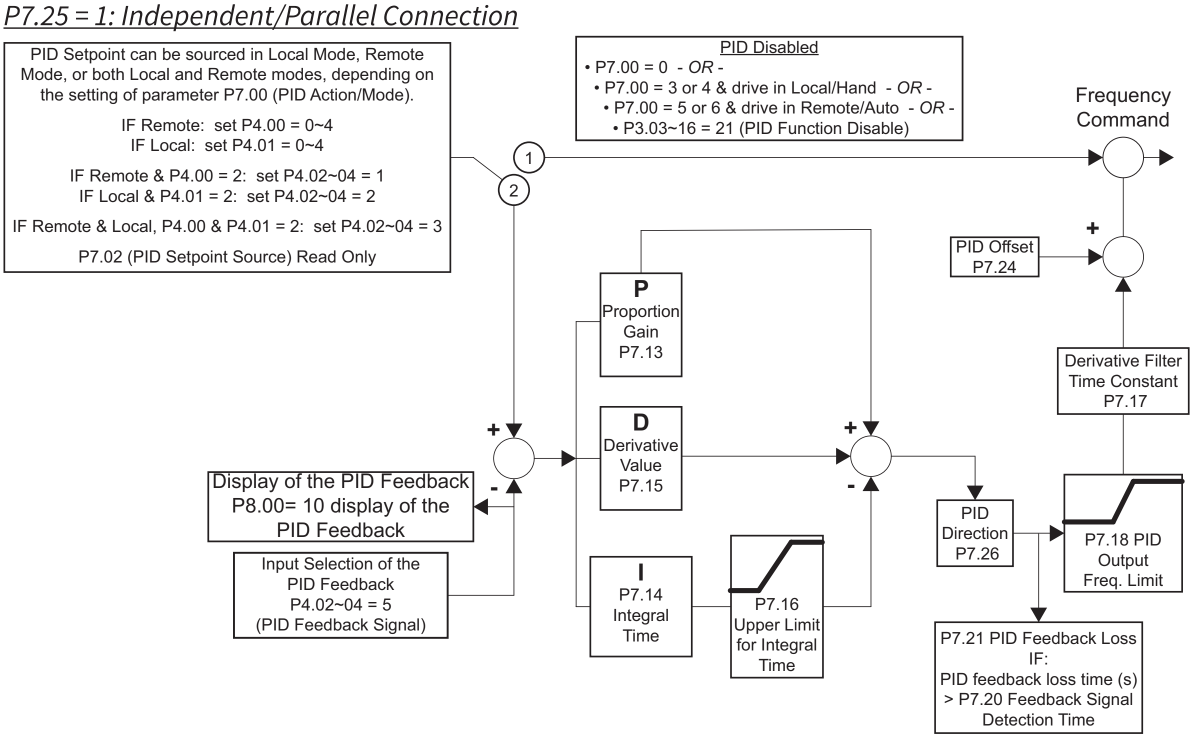
| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P7.25** | **PID Mode Selection** | R/W | 0719 | 41818 |
| | Range/Units | Default | | |
| | 0: Old PID mode, Kp, Kp•Ki, Kp•Kd are dependent/serial<br>1: New PID mode, Kp, Ki, Kd are independent/parallel<br>*NOTE: Refer to diagrams below for P7.25=0 and P7.25=1*<br>• *Kp = Proportional Gain/Control (P7.13)*<br>• *Ki = Integral Time/Control (P7.14)*<br>• *Kd = Derivative Value/Time (P7.15)* | 0 | | |

The Serial or parallel connection PID mode selections are explained in the 2 graphics found in the detailed information found below.

*P7.25 = 0: Dependent/Serial Connection*




*P7.25 = 1: Independent/Parallel Connection*



| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.26*** | ***PID Reverse Enable*** | R/W | 071A | 41819 |
| | *Range/Units (Format: 16-bit binary)* | *Default* | | |
| | 0: PID can't change command direction<br>1: PID can change command direction | 0 | | |

This parameter when engaged changes the ability of PID to change the direction of the drive.

- *When set to 0 it prevents PID from changing the direction of the output.*
- *When set to a 1 it enables the changing of direction by the level of PID.*

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.27*** | ***Source of Sleep*** | R/W | 071B | 41820 |
| | *Range/Units (Format: 16-bit binary)* | *Default* | | |
| | 0: Frequency/PID Command Frequency (CV)<br>1: Feedback | 0 | | |

This parameter selects how the Sleep Mode function will be actuated; either by the *Command Frequency (speed reference)* if the drive is operating with *PID disabled*, or by the *PID Command Frequency (CV)* if the *PID is enabled*.

In application, the trigger for sleep mode is the commanded frequency, (speed reference or PID, CV) and *NOT* the actual drive output frequency.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.28*** | ***Integral Limit During Sleep*** | R/W | 071C | 41821 |
| | *Range/Units (Format: 16-bit unsigned)* | *Default* | | |
| | 0.0~200.0 | 50.0 | | |

This upper integral limit of the drive is to avoid running at high speed right after the drive has been awakened.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.29*** | ***Sleep Reference*** | ♦R/W | 071D | 41822 |
| | *Range/Units (Format: 16-bit unsigned)* | *Default* | | |
| | P7.27=0: 0.0~599.00 Hz<br>P7.27=1: 0.0~200.00% | 0.00 | | |

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.30*** | ***Wake-up Reference*** | ♦R/W | 071E | 41823 |
| | *Range/Units (Format: 16-bit unsigned)* | *Default* | | |
| | P7.27=0: 0.0~599.00 Hz<br>P7.27=1: 0.0~200.00% | 0.00 | | |

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.31*** | ***Sleep Time*** | ♦R/W | 071F | 41824 |
| | *Range/Units (Format: 16-bit unsigned)* | *Default* | | |
| | 0.0~6000.0 sec | 0.0 | | |

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P7.32*** | ***Wake-up Delay Time*** | R/W | 0720 | 41825 |
| | *Range/Units (Format: 16-bit unsigned)* | *Default* | | |
| | 0.00~600.00 sec | 0.00 | | |

*Parameters P7.29, P7.30, P7.31, P7.32*:

The Sleep Reference point (P7.29) provides the setpoint at which, should the drive reach or go below, causes the drive to go to sleep. When asleep the drive does nothing (its output being off) besides monitoring its operating point.

In order to Wake-up and again operate, it should reach the Wake-up Reference point (P7.30). If the Command Frequency falls below the Sleep Reference point (P7.29) for the Sleep Time specified in P7.31, then the drive will shut off the output and wait until the Command Frequency rises above what is set in Wake-Up Reference point (P7.30).

The Wake-up Delay Time (P7.32) delays the drive from Waking-Up once the Wake-Up Level has been exceeded by the amount of time set in this parameter.

The Wake-up Timer is not cumulative: the reference needs to stay above Wake-up Reference for the entire length of Wake-up Delay, otherwise the Delay timer will reset.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P8.00*** | ***User Display*** | ♦ R/W | 0800 | 42049 |

*User Display (P8.00) Function Settings Applicable for PID Control* — *Default*: 3

| *As Seen During Setup* | *As Displayed During Operation* | | |
|---|---|---|---|
| 10: PID Feedback % | b | displayed value | % |
| 42: PID Reference | h. | displayed value | % |
| 43: PID Offset | o. | displayed value | % |
| 44: PID Output Hz | b. | displayed value | Hz |

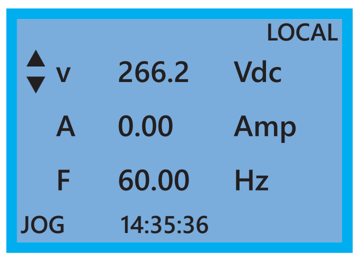
| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| ***P8.01*** | ***Start-up Display Selection*** | ♦ R/W | 0801 | 42050 |

*Range/Units (Format: 16-bit binary)* — *Default*: 0

0: Freq Setpoint (F)
1: Output Hz (H)
2: User Display (U)
3: Output Amps (A)

This parameter determines the start-up display page after power is applied to the drive. The sequence does not change; the order of appearance is always (F), (H), (U), then (A). Only three parameters can be displayed on the keypad screen at a time. P8.01 specifies only which parameter appears on the top row when the drive is powered up. All four parameters can always be scrolled to using the keypad up and down arrows. User defined choice (U) displays values and units according to the setting in P8.00.

*Example*: If P8.00 = 3, the User Display shows DC Bus Voltage.
If P8.01 = 2, the User Display appears in the top row at power up.



| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P8.02** | ***User Defined Format*** | R/W | 0802 | 42051 |
| | *Range/Units (Format: 16-bit binary)* | *Default* | | |

| | | |
|---|---|---|
| Bits 0~3:<br>User defined decimal place<br>0000b: no decimal place<br>0001b: one decimal place<br>0010b: two decimal place<br>0011b: three decimal place<br>Bits 4~9: User defined unit<br>000xh: Hz<br>001xh: rpm<br>002xh: %<br>003xh: kg<br>004xh: m/s<br>005xh: kW<br>006xh: hp<br>007xh: ppm<br>008xh: 1/m<br>009xh: kg/s<br>00Axh: kg/m<br>00Bxh: kg/h<br>00Cxh: lb/s<br>00Dxh: lb/m<br>00Exh: lb/h | 00Fxh: ft/s<br>010xh: ft/m<br>011xh: m<br>012xh: ft<br>013xh: °C<br>014xh: °F<br>015xh: mbar<br>016xh: bar<br>017xh: Pa<br>018xh: kPa<br>019xh: mWG<br>01Axh: inWG<br>01Bxh: ftWG<br>01Cxh: psi<br>01Dxh: atm<br>01Exh: L/s<br>01Fxh: L/m<br>020xh: L/h<br>021xh: $m^3/s$<br>022xh: $m^3/h$<br>023xh: gpm<br>024xh: cfm | 0 |

The user defined format sets the attributes (or units) that are enabled when P8.03 > 0. These settings allow the user to define a display field according to specific system processes. The frequency command signal will be scaled according to P0.04 (Max Output Freq) and P8.03 (User Coefficient Max)

Example:

- *P0.04 Max Output Freq = 60 Hz*
- *P8.00 User Display = 30 (User Defined)*
- *P8.02 User Defined Format = 0072h (unit = ppm, two decimal places)*
- *P8.03 User Defined Max = 115.00*

An analog frequency setting of 50% will result a 30Hz setting, but the keypad will display the user format 57.50ppm (50% x 115.00ppm). Likewise a commanded frequency input value of 100.00ppm will result in an output frequency of 52.17Hz = (100ppm/115ppm) x 60Hz.
*Note: Running in forward or reverse will display a positive value.*

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P8.03** | ***User Defined Max*** | R/W | 0803 | 42052 |
| | *Range/Units (Format: 16-bit unsigned)* | *Default* | | |
| | 0: Disable<br>0~65535 (when P8.02 set to no decimal place)<br>0.0~6553.5 (when P8.02 set to 1 decimal place)<br>0.00~655.35 (when P8.02 set to 2 decimal place)<br>0.000~65.535 (when P8.02 set to 3 decimal place) | 0 | | |

User defined is enabled when P8.03 is not 0. The setting of P8.03 is linearly scaled to P0.04 (Max Output Frequency). *See example in P8.02 for further information*.

| | | Type | Hex Addr | Dec Addr |
|---|---|---|---|---|
| **P8.04** | ***User Defined Setpoint*** | Read | 0804 | 42053 |
| | *Range/Units (Format: 16-bit unsigned)* | *Default* | | |
| | 0~65535 | 0 | | |

This parameter shows commanded frequency or user defined value when P8.03 is not set to 0.