

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 achieves 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 \approx Setpoint*
- *Actual Speed \approx Process Variable*
- *Gas Pedal \approx Control Variable*
- *Speedometer \approx 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 through that pipe.*
- 2) *Level control: A level sensor is used to feed back the liquid level in a reservoir 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)

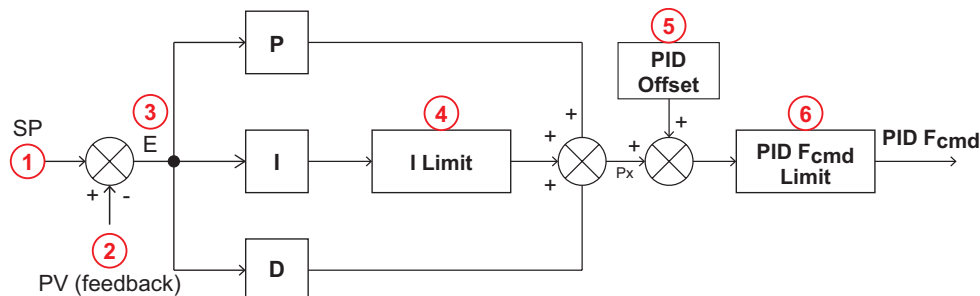
The terms "Reverse-Acting," "Cooling," and "Positive-Feedback" are used to describe a PID loop that can be used to control applications such as cooling.

- 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 ($SP < PV$)

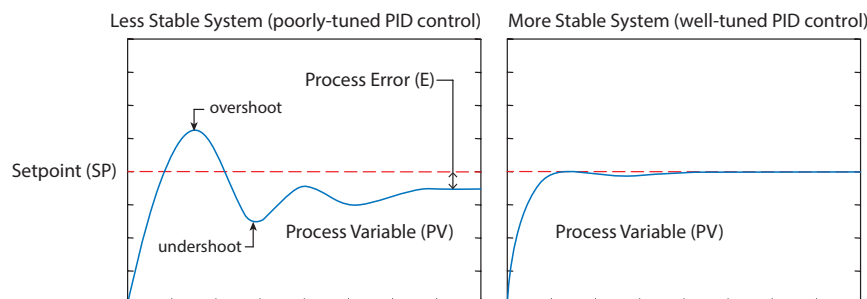
PID CONTROL OVERVIEW

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



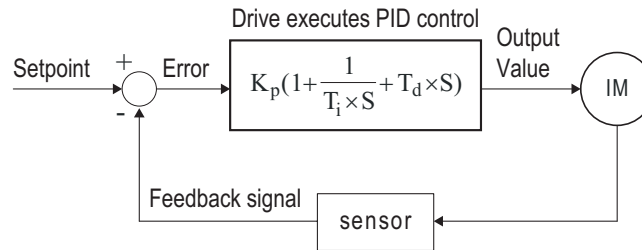
- 1) Setpoint: -100% to +100% (PID Setpoint Gain + PID Setpoint Offset)
- 2) Feedback: -100% to +100% (Feedback Gain)
- 3) Error: -100% to +100% (in percent change)
- 4) I Limit: 0~150% (Upper Limit for Integral Time P7.16)
- 5) PID Offset: P7.24 determines how the PID Offset will be controlled; by P7.04, 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

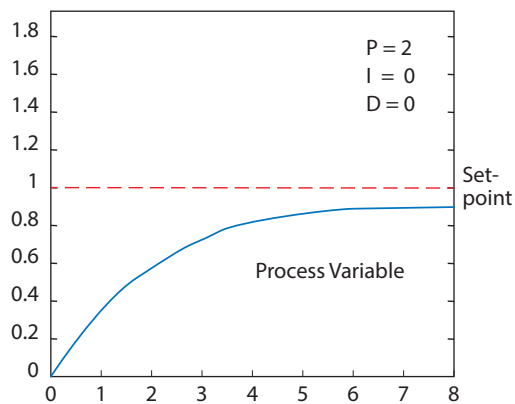
The PID settings should be adjusted, or "tuned," with the controlled process in actual operation while monitoring the actual Process Variable. The tuning can be done using the GSoft2 software scope function, or with an oscilloscope.

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:

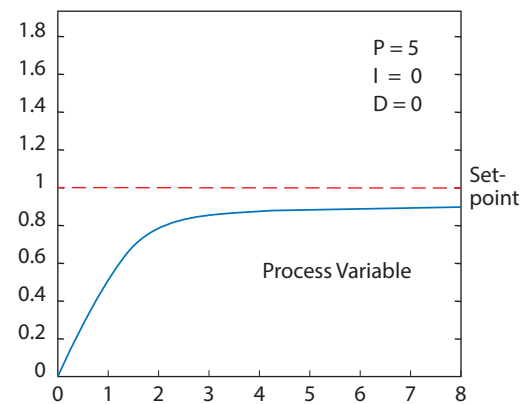
- P = Proportional Gain = GS4 drive parameter P7.13,
- I = Integral Time = GS4 drive parameter P7.14,
- D = Derivative Value = GS4 drive parameter P7.15.

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)

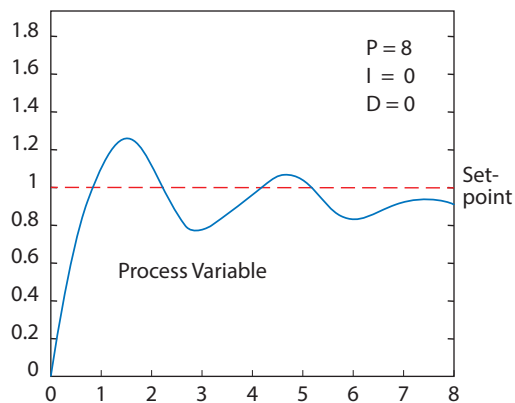
Sluggish PV response; process error



More practical PV response; process error



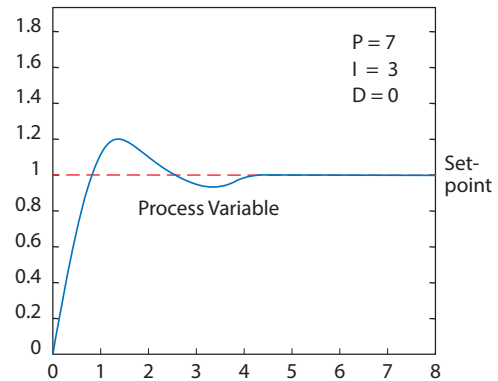
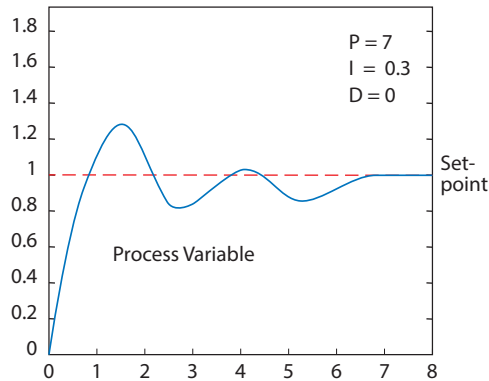
Overshoot & undershoot; process error



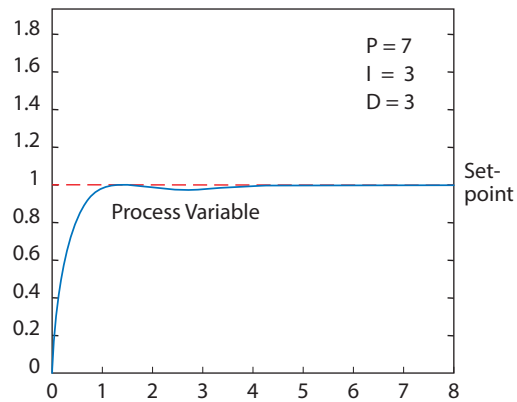
(Example continued next page)

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 necessary 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 (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
n/a	n/a	P7.05	PID Setpoint Offset
P7.05	Keypad PID Setpoint	P7.06	PID Setpoint Gain
P7.06	PID Multi-Setpoint 1	P7.10	Keypad PID Setpoint
P7.07	PID Multi-Setpoint 2	P7.11	PID Multi-setpoint 1
P7.08	PID Multi-Setpoint 3	P7.12	PID Multi-setpoint 2
P7.09	PID Multi-Setpoint 4	P7.13	PID Multi-setpoint 3
P7.10	PID Multi-Setpoint 5	P7.14	PID Multi-setpoint 4
P7.11	PID Multi-Setpoint 6	P7.15	PID Multi-setpoint 5
P7.12	PID Multi-Setpoint 7	P7.16	PID Multi-setpoint 6
P7.13	Proportional Gain	P7.17	PID Multi-setpoint 7
P7.14	Integral Time	P7.20	Proportional Control
P7.15	Derivative Value	P7.21	Integral Control
P7.16	Upper Limit for Integral Time	P7.22	Derivative Control
P7.17	Derivative Filter Time Constant	P7.23	Upper Bound for Integral Control
P7.18	PID Output Frequency Limit	P7.24	Derivative Filter Time Constant
P7.19	PID Feedback Value	P7.25	PID Output Frequency Limit
P7.20	Feedback Signal Detection Time	n/a	n/a
P7.21	PID Feedback Loss	P7.26	Feedback Signal Detection Time
P7.22	PID Feedback Loss Speed Level Default	P7.27	PID Feedback Loss
P7.23	reserved	P7.28	PID Feedback Loss Preset Speed
P7.24	PID Offset Selection	n/a	n/a
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	
<u>Range/Units</u> (ABBREVIATED LISTING; INCLUDES ONLY SETTINGS APPLICABLE TO PID)		<u>Default</u>	
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		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. 1) In order to use the Multi-PID SPs, P7.06~P7.12 must be set, and P7.00≠0. 2) When all PID Multi-Setpoint inputs are off, the GS4 drive reverts to the PID Setpoint Source (P7.02).	PID Setpoint		Selection	
2: Multi-Speed/PID Multi-Setpoint bit 2			Bit 3	Bit 2	Bit 1	PID Setpoint
3: Multi-Speed/PID Multi-Setpoint bit 3			OFF	OFF	OFF	P7.02: SP Source
			OFF	OFF	<u>ON</u>	P7.06: Setpoint 1
			OFF	<u>ON</u>	OFF	P7.07: Setpoint 2
			OFF	<u>ON</u>	<u>ON</u>	P7.08: Setpoint 3
			<u>ON</u>	OFF	OFF	P7.09: Setpoint 4
			<u>ON</u>	OFF	<u>ON</u>	P7.10: Setpoint 5
			<u>ON</u>	<u>ON</u>	OFF	P7.11: Setpoint 6
			<u>ON</u>	<u>ON</u>	<u>ON</u>	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
<u>Range/Units</u>	<u>Default</u>		
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
<u>Range/Units</u>	<u>Default</u>		
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
<u>Range/Units</u> (ABBREVIATED LISTING; INCLUDES ONLY SETTINGS APPLICABLE TO PID)	<u>Default</u>		
0~Fh			
bit 2: PID control bit			
0: Cancel PID control	0		
1: PID control follows the setting of Auto mode (P8.02)			

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

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

(*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.

		<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
P6.25	Upper Limit of Output Frequency	◆R/W	0619	41562
	<u>Range/Units</u>	<u>Default</u>		
	0.00~599.00 Hz	599.00		
		<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
P6.26	Lower Limit of Output Frequency	◆R/W	061A	41563
	<u>Range/Units</u>	<u>Default</u>		
	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

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

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

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

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.

P7.03	PID Feedback Gain	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
		◆R/W	0703	41796
	<u>Range/Units</u>	<u>Default</u>		
	0.00~300.00%	100.00		

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

P7.04	PID Offset Value	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
		◆R/W	0704	41797
	<u>Range/Units</u>	<u>Default</u>		
	-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.

P7.05	Keypad PID Setpoint	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
		Read	0705	41798
	<u>Range/Units</u>	<u>Default</u>		
	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
<u>Range/Units</u>		<u>Default</u>		
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. 1) In order to use the Multi-PID SPs, P7.06~P7.12 must be set, and P7.00≠0. 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		<table><tr><th colspan="3">PID Setpoint</th><th>Selection</th></tr><tr><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>PID Setpoint</th></tr><tr><td>OFF</td><td>OFF</td><td>OFF</td><td>P7.02: SP Source</td></tr><tr><td>OFF</td><td>OFF</td><td><u>ON</u></td><td>P7.06: Setpoint 1</td></tr><tr><td>OFF</td><td><u>ON</u></td><td>OFF</td><td>P7.07: Setpoint 2</td></tr><tr><td>OFF</td><td><u>ON</u></td><td><u>ON</u></td><td>P7.08: Setpoint 3</td></tr><tr><td><u>ON</u></td><td>OFF</td><td>OFF</td><td>P7.09: Setpoint 4</td></tr><tr><td><u>ON</u></td><td>OFF</td><td><u>ON</u></td><td>P7.10: Setpoint 5</td></tr><tr><td><u>ON</u></td><td><u>ON</u></td><td>OFF</td><td>P7.11: Setpoint 6</td></tr><tr><td><u>ON</u></td><td><u>ON</u></td><td><u>ON</u></td><td>P7.12: Setpoint 7</td></tr></table>			PID Setpoint			Selection	Bit 3	Bit 2	Bit 1	PID Setpoint	OFF	OFF	OFF	P7.02: SP Source	OFF	OFF	<u>ON</u>	P7.06: Setpoint 1	OFF	<u>ON</u>	OFF	P7.07: Setpoint 2	OFF	<u>ON</u>	<u>ON</u>	P7.08: Setpoint 3	<u>ON</u>	OFF	OFF	P7.09: Setpoint 4	<u>ON</u>	OFF	<u>ON</u>	P7.10: Setpoint 5	<u>ON</u>	<u>ON</u>	OFF	P7.11: Setpoint 6	<u>ON</u>	<u>ON</u>	<u>ON</u>	P7.12: Setpoint 7
		PID Setpoint			Selection																																							
		Bit 3	Bit 2	Bit 1	PID Setpoint																																							
		OFF	OFF	OFF	P7.02: SP Source																																							
		OFF	OFF	<u>ON</u>	P7.06: Setpoint 1																																							
		OFF	<u>ON</u>	OFF	P7.07: Setpoint 2																																							
		OFF	<u>ON</u>	<u>ON</u>	P7.08: Setpoint 3																																							
		<u>ON</u>	OFF	OFF	P7.09: Setpoint 4																																							
		<u>ON</u>	OFF	<u>ON</u>	P7.10: Setpoint 5																																							
<u>ON</u>	<u>ON</u>	OFF	P7.11: Setpoint 6																																									
<u>ON</u>	<u>ON</u>	<u>ON</u>	P7.12: Setpoint 7																																									

P7.13	Proportional Gain (P)	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
		◆R/W	070D	41806
		<u>Default</u>		
	<u>Range/Units</u>			
	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.

P7.14	Integral Time (I)	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
		◆R/W	070E	41807
		<u>Default</u>		
	<u>Range/Units</u>			
	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.

P7.15	Derivative Value (D)	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
		◆R/W	070F	41808
		<u>Default</u>		
	<u>Range/Units</u>			
	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.

P7.16	Upper Limit for Integral Time	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
		◆R/W	0710	41809
	<u>Range/Units</u>	<u>Default</u>		
	0.0~100.0%	100.0		

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

- $\text{Integral upper limit} = \text{Maximum Output Frequency (P0.04)} \times \text{Upper Limit for Integral Time (P7.16)}$.

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.

P7.17	Derivative Filter Time Constant	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
		◆R/W	0711	41810
	<u>Range/Units</u>	<u>Default</u>		
	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.

P7.18	PID Output Frequency Limit	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
		◆R/W	0712	41811
	<u>Range/Units</u>	<u>Default</u>		
	0.0~110.0%	100.0		

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

- $\text{Output frequency limit} = \text{Maximum Output Frequency (P0.04)} \times \text{PID Output Frequency Limit (P7.18)}$.

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

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

P7.20	Feedback Signal Detection Time	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
		◆R/W	0714	41813
	<u>Range/Units</u>	<u>Default</u>		
	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.

P7.21	PID Feedback Loss	Type	Hex Addr	Dec Addr
		R/W	0715	41814
	<u>Range/Units</u>	<u>Default</u>		

0: Warn and Continue Operation
 1: Warn (fault) and Ramp to Stop
 2: Warn (fault) and Coast to Stop
 3: Warn and Operate at Last Frequency
 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.

P7.22	PID Feedback Loss Speed Level Default Value	Type	Hex Addr	Dec Addr
		◆R/W	0716	41815
	<u>Range/Units</u>	<u>Default</u>		
	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.

P7.23	reserved	Type	Hex Addr	Dec Addr
		~	0717	41816

P7.24	PID Offset Selection	Type	Hex Addr	Dec Addr
		◆R/W	0718	41817
	<u>Range/Units</u>	<u>Default</u>		

0: Set by P7.04
 1: Set by an Analog Input
 [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.

P7.25 PID Mode Selection

Range/Units

0: Old PID mode, K_p , $K_p \cdot K_i$, $K_p \cdot K_d$ are dependent/serial

1: New PID mode, K_p , K_i , K_d are independent/parallel

NOTE: Refer to diagrams below for $P7.25=0$ and $P7.25=1$

• K_p = Proportional Gain/Control (P7.13)

• K_i = Integral Time/Control (P7.14)

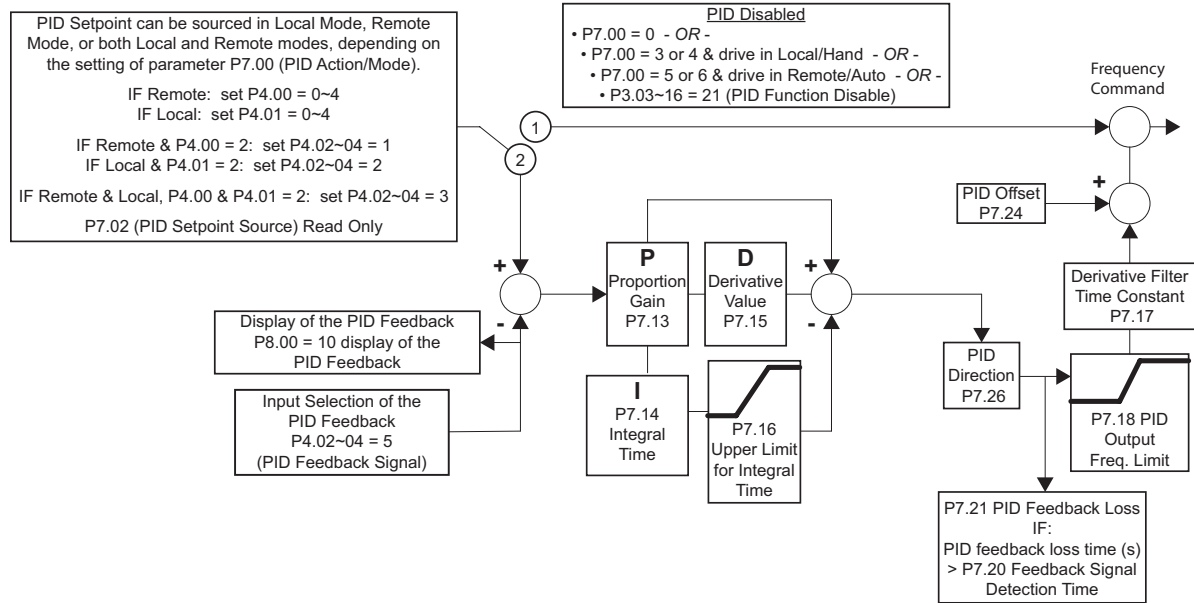
• K_d = Derivative Value/Time (P7.15)

Type	Hex Addr	Dec Addr
R/W	0719	41818
Default		

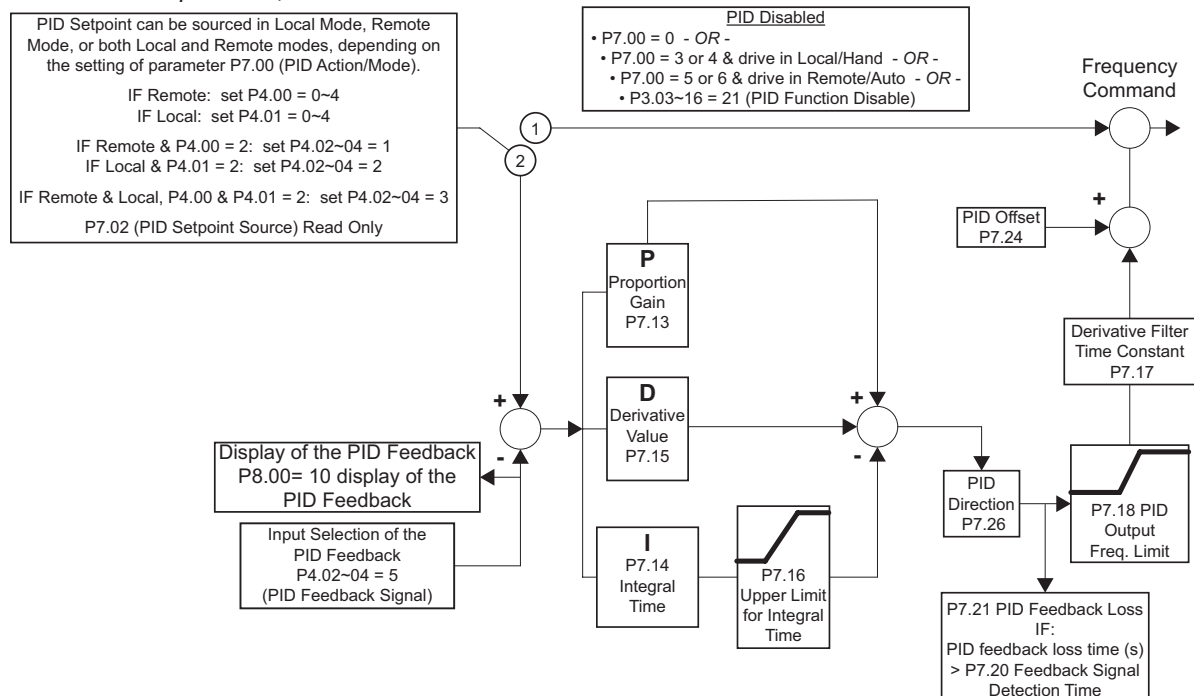
0

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



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

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.

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

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.

P7.28	Integral Limit During Sleep	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
		R/W	071C	41821
	<u>Range/Units (Format: 16-bit unsigned)</u>	<u>Default</u>		
	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.

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

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

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

P7.32	Wake-up Delay Time	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
		R/W	0720	41825
	<u>Range/Units (Format: 16-bit unsigned)</u>	<u>Default</u>		
	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
<i>User Display (P8.00) Function Settings Applicable for PID Control</i>		<i>Default</i>		
<i>As Seen During Setup</i>		3		
<i>As Displayed During Operation</i>				
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			

P8.01 Start-up Display Selection		<i>Type</i>	<i>Hex Addr</i>	<i>Dec Addr</i>
<i>Range/Units (Format: 16-bit binary)</i>		◆ R/W	0801	42050
		<i>Default</i>		
0: Freq Setpoint (F)		0		
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.

LOCAL			
▲▼ v	266.2	Vdc	
A	0.00	Amp	
F	60.00	Hz	
JOG	14:35:36		

P8.02	User Defined Format	Type	Hex Addr	Dec Addr
		R/W	0802	42051
	<u>Range/Units (Format: 16-bit binary)</u>	<u>Default</u>		
	Bits 0~3:			
	User defined decimal place	00Fxh: ft/s		
	0000b: no decimal place	010xh: ft/m		
	0001b: one decimal place	011xh: m		
	0010b: two decimal place	012xh: ft		
	0011b: three decimal place	013xh: °C		
	Bits 4~9: User defined unit	014xh: °F		
	000xh: Hz	015xh: mbar		
	001xh: rpm	016xh: bar		
	002xh: %	017xh: Pa		
	003xh: kg	018xh: kPa		
	004xh: m/s	019xh: mWG	0	
	005xh: kW	01Axh: inWG		
	006xh: hp	01Bxh: ftWG		
	007xh: ppm	01Cxh: psi		
	008xh: 1/m	01Dxh: atm		
	009xh: kg/s	01Exh: L/s		
	00Axh: kg/m	01Fxh: L/m		
	00Bxh: kg/h	020xh: L/h		
	00Cxh: lb/s	021xh: m ³ /s		
	00Dxh: lb/m	022xh: m ³ /h		
	00Exh: lb/h	023xh: gpm		
		024xh: cfm		

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.

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

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.

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

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