Application Note AN-VTC-32

PID control using Parameter group 3

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- ***General***

Optidrive VTC has a built-in flexible PID feedback controller that can be used for a variety of process control applications. Typical applications include pressure control, flow rate control, temperature control etc.

This document describes the setup procedure for each of the operating modes available.

- ***PID controller operating mode selection***

The PID controller mode is set using parameter P3-04.

In all cases, the P3-04 allows the user to select either direct PID control, where an increase in the speed of the motor increases the feedback value, or to select inverse mode, where an increase in the speed of the motor reduces the feedback value.

Hence,	P3-04 = 0	Direct mode	(eg compressor control)
	P3-04 = 1	Inverse mode	(eg condenser fan control)

- ***PID feedback input***

The PID feedback can be selected from two different sources: 2nd analog input or bipolar analog input. This can be selected by setting 0 or 1 in parameter P3-10.

When using 2nd analog input as PID feedback, the PID feedback signal should be connected to the 2nd analog input. This will usually originate from a feedback transducer which produces an output proportional to the quantity being controlled. (eg pressure, flow rate etc).

The format of the feedback signal can be configured by setting up P2-33 as required. Most feedback transducers use the 4..20mA format. See AN-ODP-06 for more information about how to select the analog input signal format.

When connecting a 2-wire feedback transducer (eg 4..20mA type), check that the transducer is suitable for 24V operation, then connect the transducer supply to pin 5 and the transducer output to pin 4. Set P2-33 = 4..20mA.

When using bipolar analog input as PID feedback, the PID feedback signal should be connected to the bipolar analog input (Terminal 6). Note that the bipolar analog input only supports voltage inputs (eg 0.. 10V), not current inputs (4 .. 20mA).

The format of the bipolar analog input can be configured to match the feedback signal by setting up P2-30 as required.

If the bipolar analog input is selected for the feedback signal, digital input 3 (2nd analog input) can be used as external trip input, which enables the user to connect a motor thermistor for motor protection. Digital input 3 must be configured as an external trip input using P2-01 to support this function.
Note that this external trip function is not available if the 2nd analog input is selected as a PID feedback input.

- ***PID reference select***

The PID controller reference can be given by an external analog input signal or by a digital preset value depending on application requirements. This is set up using P3-05.

P3-05 = 0 : PID control using the digital preset value for the reference input. The digital preset reference value is defined in Parameter P3-06, which will give a 0 to 100% range which corresponds to the full control range of the feedback transducer signal.

P3-05 = 1 : PID control using the bipolar analog input for the reference input. In PID control mode, the bipolar analog input should be configured as a unipolar input. Any input value less than zero will be treated at zero.

- ***PID output digital preset limit :***

P3-07: PID controller output high limit. This parameter defines the maximum output value of the PID controller. The limit value is calculated as :

Limit = P3-07 * P1-01

A value of 100% limits the maximum speed of the PID controller to the maximum speed limit defined in P1-01.

P3-08: PID controller output low limit. This parameter defines the minimum output value of the PID controller. The limit value is calculated as:

Limit = P3-08 * P1-01

- ***PID output limit control***

P3-09 = 0: Digital preset limit values in P3-07 and P3-08 will be used to limit the PID controller output.

P3-09 =1: Bipolar analog input will be use as maximum output limit.

P3-09 =2: Bipolar analog input will be use as minimum output limit.

P3-09 =3: Bipolar analog input will be used as an offset value and added to the PID controller output.

- ***Note***

To get the best control performance, it may be necessary for the user has to adjust the PID control parameters (P-gain, I-gain and D-gain) in P3-01, P3-02 and P3-03 respectively. The values will vary dependent on the inertia and the time constant (rate of change) of the system being controlled.

Application Examples

- ***Using a condenser fan to control the pressure in a refrigeration system***

1. Set the 2nd analog input format to suit the signal from the feedback transducer using parameter P2-33 (typically 4...20mA).

2. For a 2-wire 4...20mA transducer, connect the +ve terminal of the transducer to the +24V supply (usually terminal 5) and the –ve terminal of the transducer to terminal 4 of the drive (2nd analog input).

3. Set P3-04 = 1 to select the inverse PID control mode. This ensures that as the feedback signal falls (pressure drops), the speed of the fan also falls.

4. Set P3-05 to determine where the controller reference (set point) comes from. If P3-05 = 1, it means that the reference comes from the preset value (P3-06 value)

5. Set P3-06 to the required level. A value of 100% in P3-06 equates to the rated value from the feedback control transducer (10V or 20mA).

6. Set a suitable value for the P-gain, I-gain and D-gain by giving the correct value into parameters P3-01, P3-02 and P3-03.

7. Set P1-12 to 3. This will active the PID control function automatically. If the enable signal is given on terminal 1 and 2, the drive will run immediately.

- ***Using standby mode in PID control for energy saving***

In a typical PIC control application, it is beneficial from an energy saving viewpoint if the drive can be configured to disable its output (standby mode activated) if the system runs at minimum speed (P1-02) for a presettable time interval. This mode of operation is referred to as Standby mode and is enabled when the Standby mode parameter (P2-20) is set to a non-zero value. Standby mode exits automatically when the speed reference output from the PID controller exceeds a user-definable preset limit.

The VTC drive has dedicated parameter settings to fully support standby mode :

P2-16 Standby mode wake up speed

The drive will wake up from standby mode when the speed reference exceeds the value set in this parameter. The parameter is scaled such that 100% equals P1-01.
Note that if this parameter is set to a value less than or equal to the minimum speed value in P1-02, the drive will wake up if the speed reference exceeds P1-02.

Note that this function is only available in firmware versions V2.21 or later

P2-20 Standby mode enable

The VTC drive provides a Standby function which automatically disables the drive output whenever the drive output speed remains at minimum speed (P1-02) for greater than the time specified in this parameter.

P2-20 = 0: The standby function is disabled. The drive will continue to deliver power to the motor and run at minimum speed as long as the drive is enabled.

P2-20 = 1 ~ 60: The drive will enter Standby mode when drive has remained at minimum speed for the time set in this parameter. When this time has elapsed, the output of the drive will be disabled automatically. As soon as the target speed reference increases above the value set in P1-02 or in P2-16, whichever is the greater, the drive will automatically re-enable and ramp to the target speed.

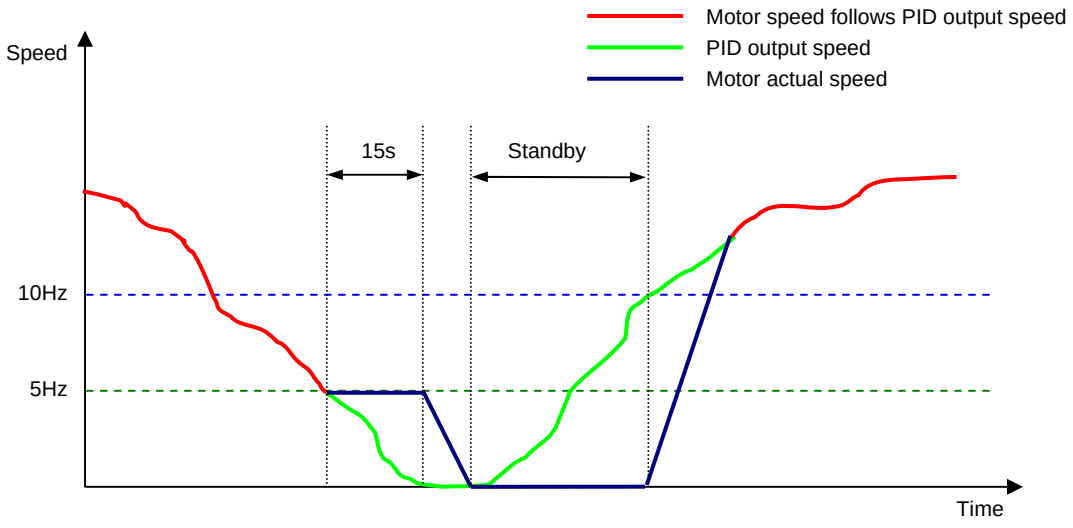
Note that for drives with firmware versions older than 2.21, standby mode is only entered when the reference speed remains at 0Hz (not minimum speed) for the preset interval set in P2-20

Example:

For a typical PID speed control system, standby mode must be entered if the system runs at 5Hz for 15s. The system must rewake automatically if the PID control output speed exceeds 10Hz.

Suppose the maximum speed in parameter P1-01 is set to 50Hz. In this case, we can set P1-02 = 5Hz, so the system will hold a speed of 5Hz if the PID output speed reference drops below this level. The standby mode activation interval is defined by setting P2-20 = 15s. This will enable the drive to enter standby mode if the motor runs at 5Hz for 15s. Setting P2-16 = 20% sets a wake up speed of 50Hz * 20% = 10Hz.

See the diagram below for more details on how this configuration works:



- ***Advanced features using parameter group 6***

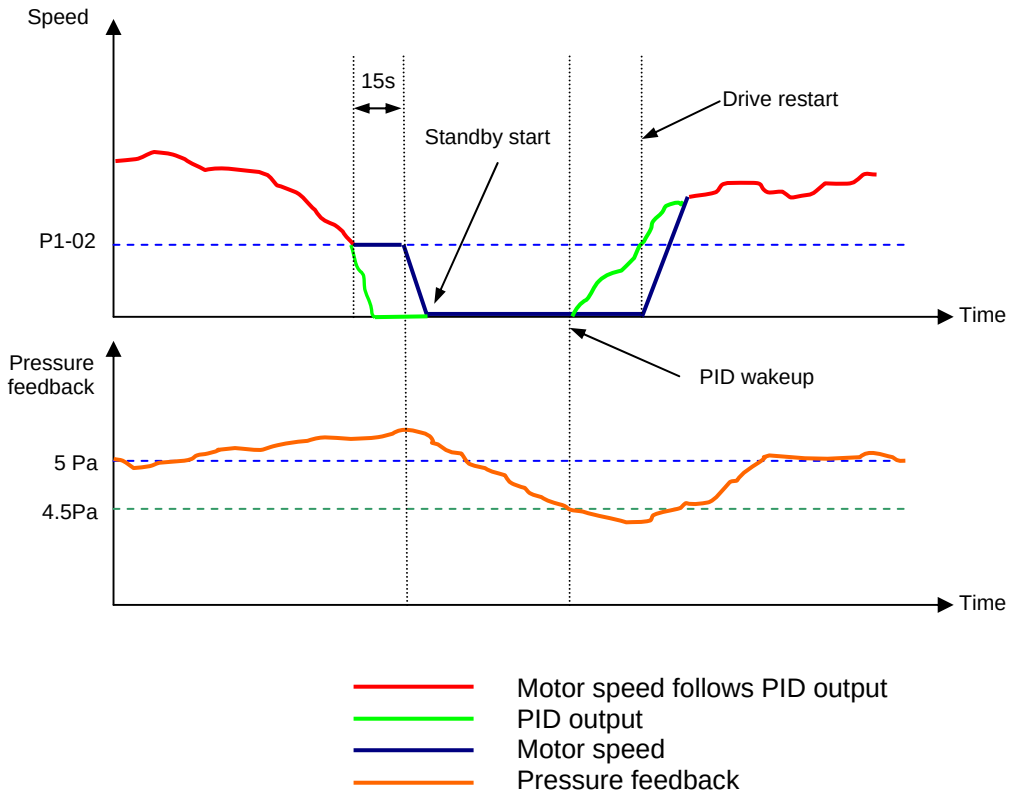
P6-09 PID wake-up / restart level

This parameter works in conjunction with the PID controller and standby mode, allowing the user to specify the level at which the PID controller will wake from Standby mode. This level is expressed as a percentage of the feedback control signal (from the feedback transducer) and operates relative to the PID controller set-point, ie the difference (or error) between the PID controller set-point and the feedback signal.

Example : If the PID controller set point is 40% (representing 40% of the feedback transducer control range) and the PID wake-up / restart level is set to 5%, the drive will only re-wake from Standby mode when the feedback signal drops below 35% (ie 40% - 5%).

Consider an actual pressure control system working in direct PID control mode with a feedback signal range of 4…20mA, representing a pressure from 0 to 10 Pa. If the reference set point is set to 50%, this equates to a target control pressure of 5 Pa.
If the PID controller must only restart when the pressure drops below 4.5 Pa, then P6-09 must be set to 5%. (5 Pa - 4.5 Pa) / 10 Pa = 0.05, ie 5% .
Setting P2-20 = 15s configures the system to enter standby mode if minimum speed is maintained for 15s.

See the following diagram for more details



Standby mode will be entered as usual when the speed drops down to the minimum speed set in P1-02 and remains there for the period set in the standby mode parameter P2-20.

Once the drive and PID controller have entered standby mode, the PID controller only rewakes when the feedback signal drops below 4.5 Pa. The PID output then increases and the drive rewakes when the PID output speed reference exceeds the setting in P1-02.

Further notes :

If the PID controller is operating in Inverse mode (P3-04 = 1), the drive would wake from Standby mode if the speed increases above 45% (40% + 5%) in the above example.

Since the wake-up level is expressed as a value relative to the PID set-point, the wake-up level will track any changes to the set-point (eg if the set-point comes from an analog input).

If this parameter is set to zero, this function is disabled.

Note that this function is only available in firmware versions V2.21 or later

P6-10 Minimum integral error

This parameter defines the minimum integral error input for the User PID controller. The parameter value is defined as a percentage of reference input range.
If the actual control error is less than this limit, the integral component of the PID controller will hold its value, keeping the output unchanged.

This parameter can be used to reduce the effect of jitter or quantisation on the feedback signal, and to help to reduce oscillation of the control system. It is particularly useful for systems which have coarse resolution feedback transducers.

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