Application Note

Using the SMVector Drive for PID Process Control

> **i** **NOTE:**
>
> Read the PID parameter notes in the SV01 manual, section 4.5.4 before attempting to use the drive for PID control.

PID Mode Operation

Normal-acting PID control will command a decrease in motor speed in response to an increasing process variable feedback. An example of normal PID mode is a direct acting system that maintains duct pressure. Duct pressure is the process variable that is monitored by the feedback device. As duct pressure rises, motor speed will decrease to maintain the pressure.

Reverse acting PID control will command an increase in motor speed in response to an increasing process variable feedback. An example of reverse PID mode is a reverse acting system that maintains water temperature in a cooling tank. Water temperature is the process variable that is monitored by the feedback device. As water temperature rises, motor speed needs to be increased to pump more cold water and thereby lowers the temperature in the tank.

PID Functionality with SMV Drives

The SMVector drive has an advantage over the MC series in that it can be switched from open-loop mode to PID mode without having to disable the PID function parameter. To activate PID mode, one of the TB-13x inputs (controlled with parameters P121 through P124) is used to select the "Auto reference" that will become the desired set-point reference. When using the PID function, a feedback device such as a transducer must be provided by the customer to maintain the control process. This feedback loop will be fed back into the drive and compared internally to this set-point reference. This reference can be anything from a keypad, 0-10V, 4-20mA or a preset speed. However, it cannot be the same source as the feedback itself.

TB13x inputs are what "activate" the PID function and selects the set-point reference. Assuming the analog feedback signal is 4-20mA from a transducer, this signal connects between TB25 and TB2 on the drive. 0 to 10 VDC would connect between TB5 and TB2. The SMV has a built-in 12v 50mA power supply that can be utilized to power the transducer. If a higher voltage is needed, an external supply will have to be used.

PID Parameter Setup

Determine the PID mode (normal or reverse acting) required and set P200 accordingly. Refer to Figure 1 for an illustration of the PID loop.
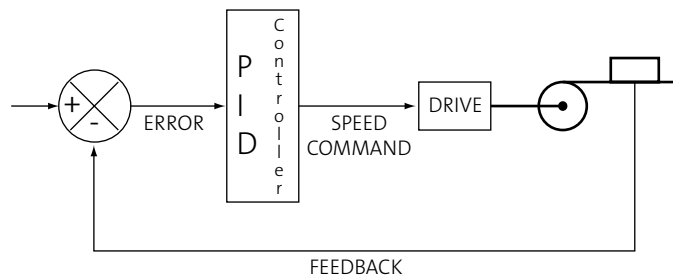

Figure 1: PID Loop

Set up the following parameters for PID operation:

1. Set the transducer method using P201 to select the desired PID feedback source.

2. Set the decimal point with P202 to the number of desired decimal places for the accuracy required.

3. Set up the range for the transducer with P204 and P205 (FEEDBACK AT MIN & MAX).

4. P207 (proportional gain) and P208 (integral gain) will be adjusted based on the feedback to tune the drive's response to level changes in the PID loop.

5. P209 (differential gain) is very seldom used but can be adjusted to smooth out dramatic changes in response to varying levels. It is used as a shock absorber to dampen overshoots for extremely fast-acting systems.

6. P210 (PID ACCEL) is used to set the proper ramp up time in PID mode to smooth the transition when going from one set-point level to another within the feedback range.

7. P214 and P215 (MIN and MAX ALARM) will adjust the desired trip points where the drive may give status/ optionally control based on these two thresholds and the relay and/or the open collector output as programmed by P140 and/or P142.

PID - Wiring and Tuning the Drive

Connect a transducer as needed to the drive's control terminals. For the 4-20mA input, connect between TB25 and TB2 on the drive. For the 0 to 10 VDC input, connect between TB5 and TB2. Test the feedback response in normal "speed mode" first. If the level seems unstable because of noise in the analog signal, adjust for this with the AIN filter (P162) to filter noise or oscillations. Having a stable signal to start with will be critical to the stability of the PID loop. As in all applications, make sure the system is properly grounded and the control and power wiring is properly isolated. If tuning does not provide the desired affect, then it's possible there exists noisy feedback that cannot keep up with the level.

Once this is completed, the drive's PID loop is ready to be tuned. Start by giving the drive a desired set-point and confirm this level on the display. To tune the PID loop, follow the tuning instructions herein.

1. Adjust the P-gain. Increase the P-gain until the drive's feedback bounces above and below the desired set-point. The overall affect is that the system becomes unstable. Monitor the feedback in P522 for voltage and P523 for current.

> **ℹ** **NOTE:**
> Changing the P-gain (P207) will always result in a small amount of error.

2. Decrease the P-gain until the bouncing on the drive's display stops.

3. Decrease the P-gain 10 to 15% below this value. The difference in levels for feedback and set-point will be close but not exact. Refer to Figure 3.
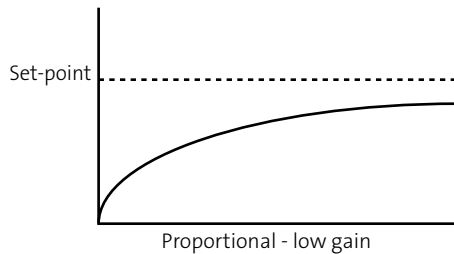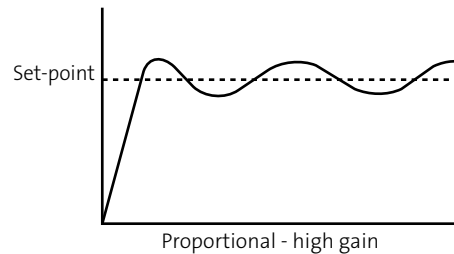
Figure 2: low gain

Figure 3: high gain

> **NOTE:**
>
> Anytime changes are made to parameter P208 (integral gain), it is necessary to stop the drive and start it again for the changes to take affect.

4. Tune the loop with the I-gain parameter (P208) to get the feedback level exactly equal to the set-point. The integral gain is used to eliminate the error between feedback and set-point. This parameter changes the time-constant of the level and the response will be slower for small increases of P208. It will continue to increase the output speed command based on the accumulated error over time (or decrease the speed in the event of a negative error). Small amounts of integral gain can have a significant effect on the set-point controller's performance. If set too high the system will overshoot too far above the set-point, especially when large step changes occur in the error. Refer to Figure 4 for the correct response curve.
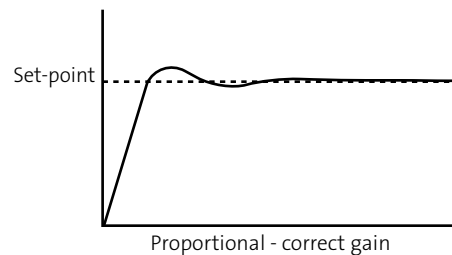

Figure 4: correct gain

5. Lastly, if the loop still needs to be tuned for stability in its response, use the D-gain parameter (P209).

> ⚠ **CAUTION:**
>
> Under most conditions, Parameter P209 (differential gain) does NOT need to be changed. P209 is very sensitive to noise on the feedback signal, so care must be taken. Make any changes in small increments and observe the effect. It is based on the rate of change of the actual error.

P210 can be adjusted if quicker acceleration times are needed to go from 0 to the set-point or to another set-point. Typically, the default setting of 20 seconds is the best setting, which is the same value for the normal acceleration time P104 for the drive. Sometimes P210 needs to be modified where reaction time to reach the set-point is critical.

Once all of these changes are made, the drive's PID loop is properly tuned. Test the result by running the system. Simulate a change in the system by modifying the feedback from the transducer and watch the drive try to compensate as explained in the PID Mode Operation and PID Functionality sections.