Actual PID Algorithm

The actual equation used in the PID algorithm to compute the commanded output for motor x is as follows:

$$DACout(n) = 2^{-19} \cdot Ix30\left[Ix08 \cdot \{FE(n) + \frac{Ix32 \cdot CV(n) + Ix35 \cdot CA(n)}{128} + \frac{Ix33 \cdot IE(n)}{2^{23}}\} - \frac{Ix31 \cdot Ix09 \cdot AV(n)}{128} \right]$$

where:

- DACout(n) is the 16-bit output command (-32768 to +32767) in servo cycle n. It is converted to a -10V to +10V output. DACout(n) is limited by Ix69.
- Ix08 is an internal position scaling term for motor x (usually set to 96).
- Ix09 is an internal scaling term for the velocity loop for motor x.
- FE(n) is the following error in counts in servo cycle n, which is the difference between the commanded position and the actual position for the cycle [CP(n) - AP(n)].
- AV(n) is the actual velocity in servo cycle n, which is the difference between the last two actual positions [AP(n) - AP(n-1)] in counts per servo cycle.
- CV(n) is the commanded velocity in servo cycle n: the difference between the last two commanded positions CP(n) - CP(n-1)] in counts per servo cycle.
- CA(n) is the commanded acceleration in servo cycle n, which is the difference between the last two commanded velocities [CV(n) - CV(n-1)] in counts per servo cycle

IE(n) is the integrated following error in servo cycle n, which is:

$$\sum_{j=0}^{n-1} [FE(j)]$$

(For all servo cycles for which the integration is active. Ix34=1 turns off the input to, but not the output from the integrator when CV does not equal zero.)

Notch Filters

The PMAC can be used to set up notch filters. A notch filter is an anti-resonance (band-reject) filter used to counteract a physical resonance. While there are many different philosophies as to how to set up a notch filter, we recommend setting up a lightly damped band-reject filter at about 90% of the resonant frequency, and a heavily damped band-pass filter somewhat greater than the resonant frequency (to reduce the high-frequency gain of the filter itself).

For those familiar with control theory (not necessary to use the notch), the form of the PMAC notch filter system is:

$$\frac{N(z)}{D(z)} = \frac{1 + N1z^{-1} + N2z^{-2}}{1 + D1z^{-1} + D2z^{-2}}$$

where the numerator – N(z) – is the band-reject filter, and the denominator – D(z) – is the band-pass filter. The notch filter acts on the output of the PID filter itself.

PMAC uses four I-variables to specify the full notch filtering system: two (Ix36 [N1] and Ix37 [N2]) for the band-reject filter, and two (Ix38 [D1] and Ix39 [D2]) for the band-pass filter. These I-variables represent the actual coefficients used in the difference equations for the notch. These I-variables have a range of -2.0 to +2.0; they are 24-bit values, with one sign bit, two integer bits, and 21 fractional bits.

Before implementing a notch filter in the PID-Plus algorithm, tune the PID parameters somewhat to get at least minimal performance, even if control of oscillations is poor.