Tuning Procedure

For the Sigma II Servo System

FINDING THE INERTIA RATIO

METHOD 1: Use ratio calculated from sizing.
METHOD 2: Use the Excel spreadsheet, *Inertia by Graphical Analysis.*
METHOD 3: Use the amplifier's Online Auto-Tuning algorithm.

1. Turn auto-tuning 'Always On' (Pn110.0=1, cycle power)
2. Select an appropriate rigidity (Fn001)
3. Run machine under normal pattern and load
4. Monitor the identified inertia as it settles into a range of values
5. Put this value into Pn103.

PRELIMINARY SETUP

1. Set **Pn103** = Inertia RatioX100
2. Turn OFF online Auto-tuning (**Pn110.0=2**)
3. Turn OFF automatic mode switch (**Pn10B.0=4**)
4. Cycle control power

TUNING

Note: ***Instability and vibration may not become apparent until the motor starts to move. Tune the machine while the servomotor is running.***

I. The Torque Loop

Goals of tuning the torque loop

- *Set Pn401 as low as possible so that speed loop gains can later be raised.*
- *Use the notch filter(s) to eliminate problem frequencies and further decrease Pn401.*
- *For machine tool applications where the surface finish is important, Torque Reference peak-to-peak ripple should be less than 5%. If it is expected that the speed loop gain will also be raised, shoot for torque ripple even lower.*

1. Decrease the torque reference filter time constant (Pn401) until servomotor vibrates.
   - If it is already vibrating, decrease Pn100 until vibration is minimal.
2. Graph the Torque Reference during vibration using the lowest sample time and measure the frequency.
   - For a frequency <500Hz
     - ❑ Activate Notch Filter (Pn408.0=1) at the resonant frequency (Pn409)
       - If the resonance does not change, try moving Pn409 up or down.
     - ❑ Decrease Pn401 further until the servomotor vibrates again.
3. Increase Pn401 until the servomotor stops vibrating. Torque signal noise should be less than 5% (peak-peak).
   - This sets the frequency response of the torque loop, resulting in a cutoff frequency of $f_c \cong \frac{15{,}900}{Pn401}(Hz)$.

II. The Speed Loop

Goals of tuning the speed loop may include the following:

- *Make SPEED REFERENCE and FEEDBACK SPEED match as closely as possible*
- *Maintain proper bandwidth separation between speed and torque loop*
- *For machine tool applications where the surface finish is important, Torque Reference peak-to-peak ripple should be less than 5%.*

1. Set $Kv = \frac{f_C}{4}(Hz)$ as a starting value
   - Assume K_V=*Pn100* when Pn103 is set to the machine's inertia ratio.
   - If this is not possible, use $K_V = \frac{(\frac{Pn103}{100}+1)\times J_M}{J_L + J_M} \times Pn100$
   - Adjust Pn100 up or down while monitoring the graphed response.
   - A higher value of Pn100 will bring feedback speed closer to speed reference during acceleration
   - K_V must NEVER get too close to the torque loop bandwidth (fc), or the system will become unstable.

2. Set $Pn101 \cong \frac{36{,}600}{Kv}(units: 0.01ms)$ for the critically damped response.
   - A higher value of Pn101 reduces the integral gain, giving an over-damped response. A lower value of Pn101 increases the integral gain, giving to an under-damped response.
   - The high frequency sensitivity of the speed loop is increased as the time constant is decreased.

3. Other speed loop tuning parameters:
   - Pn10B.0, Pn10C-F (Mode Switch) – deactivates Pn101 during acceleration
   - Pn10B.1 (IP control) –Allows higher gains without overshoot
   - Pn110.1, Pn111 (Speed Feedback Compensation)
   - Pn305, 306 (Soft start acceleration and deceleration)
   - Pn307 (Speed reference filter)
   - Pn308 (Speed feedback filter)

III. The Position Loop

The Position loop is tuned when the trace of

- *Position Settling Time is as low as possible*
- *REFERENCE PULSE SPEED and SPEED REFERENCE are as close as possible.*
- *POSITION ERROR is as low as possible*
- *TORQUE REFERENCE peak-to-peak ripple is less than 5%.*

1. Set $Pn102 = Pn100$
   - The position loop frequency response is $f_P = \frac{Pn102}{2\pi}$
   - f_P must NEVER be set higher than the speed loop frequency response, K_V ,or the servo system will become unstable due to improper bandwidth relationships.

2. Add Feed-forward gain (Pn109, Pn10A) to dramatically reduce position error and position settling time.

3. Other Position Loop tuning parameters
   - Pn207.1, Pn300 (speed feed forward through the V-REF input)
   - Pn207.0, Pn204, Pn208 (accel or average movement filter)
   - Pn107, 108 (Position bias gain)