TB295 – Yaskawa Sigma I and II with Centroid CNC11 based CNC controls

Overview: Excellent cnc machine tool motion can be achieved with the Centroid OAK CNC control board or MPU11/GPIO4/Opticdirect based systems running older Yaskawa Sigma I or Sigma II servo drives and motors. Centroid CNC11 Version 3.14+ supports Yaskawa Sigma I and II drives and motors in Position mode. With Autotuning in the Yaskawa drive and Auto delay calculation in CNC11 this configuration yields excellent results while being simple to setup and get running well in a short period of time. Running the Yaskawas in position mode as described in this Tech Bulletin is highly recommended over velocity mode setup. (if you have Yaskawa Sigma V drives, please refer to TB267)

CNC11 with Sigma I and II Setup Procedure

1.) Connect to Yaskawa drive using SigmaWin software and a serial cable with USB to serial adapter.
2.) Program the Drive parameters for Position Mode.
3.) Configure CNC11 parameters for Yaskawa Sigma I or II position mode.
4.) Use Yaskawa Autotune to tune the axes.
5.) Set Timing Delay using Centroid Autotune.

Wire system according to the Oak or MPU11/GPIO4 system yaskawa schematics. Here is a photo of an Oak board installed in a 15 year old control cabinet with Yaskawa Sigma I drives. Ready to for the drives and CNC11 to be configured. The Centroid Yaskawa cable, (Centroid part number #13134 works with Sigma,I,II,V drives) directly connects the Oak board to the Yaskawa Servo drives with two way digital drive communication with encoder feed back and drive load output (load meters). No extra encoder cables going back to the cnc cpu are necessary.

Items needed for the steps in this Tech Bulletin are: Laptop running SigmaWin+ software, Serial Cable and USB to serial converter, USB stick, Centroid system schematic, Latest Centroid CNC11 software, and for Sigma I only, a Yaskawa JUSP-OP02A1-E programming/operator module.
1.) Connect to Yaskawa drive using SigmaWin software and a serial cable with USB to serial adapter.

a.) Build or buy a yaskawa serial cable communication cable. Buy: Yaskawa part #YS-11(A) Build: Follow instructions in Appendix A of this Tech Bulletin to build your own cable.

b.) Buy a Serial to USB converter. We used a Manhattan USB to Serial Converter with success. Many other brands are available, reports have come in that some other brands work and some do not.

c.) Install Yaskawa SigmaWinplus 5.70A (which was the latest version as of this writing) on your laptop.

d.) Connect cable to Yaskawa and PC with drive power on and Estop depressed.

e.) Connect to the servo drive thru the SigmaWin software, make sure the “online tab” is selected and click on the “search” box, select the drive type you are connected to and the USB tab and the little Search box is checked and then click on Search at the bottom of the window.

f.) If the search was successful, the servo drive name will appear, highlight it and click the “Connect” Box. If the servo drive does not appear, you may have to try a different tab in step #4 in figure 2 above. Sometimes depending on your computer even though you are connected thru a USB port a Tab will appear in the SigmaWin software labeled RS232 or RS422, select this new tab and run the search again.
g.) Once connected it is advisable to make a backup of the servo drives existing parameters. Click “Parameters(U)” and select “Edit Parameters” from the drop down menu. Click on the Floppy disk icon and save the .USR file to your laptop. (.USR file is the extension given to the yaskawa servo drive parameter backup file) Note: Give the .USR file a name that indicates that it is the initial/original backup of that particular drive and axis.

![Parameter Editing: SGDB-***D]

1. Click “Parameters(U)” and select “edit parameters” from drop down menu.
2. Save .USR file to laptop.

- **No.**
- **Name**
- **Value**
- **Unit**
- **Min**
- **Max**
- **Default**

- **Memory switch setting 1**
  - Value: 0100H
  - Unit: -
  - Min: -
  - Max: -
  - Default: 0093H

- **Memory switch setting 2**
  - Value: 0000H
  - Unit: -
  - Min: -
  - Max: -
  - Default: 0000H

- **Number of encoder pulses**
  - Value: 8192
  - Unit: P/R
  - Min: 513
  - Max: 32768
  - Default: 8192

- **Control method selection**
  - Value: 2
  - Unit: -
  - Min: -
  - Max: 11
  - Default: 0

- **Motor selection**
  - Value: 143
  - Unit: -
  - Min: 0
  - Max: 264
  - Default: 143

- **Speed reference adjustment**
  - Value: 250
  - Unit: (min-1)/V
  - Min: 10
  - Max: 2000
  - Default: 250

- **Speed loop gain**
  - Value: 80
  - Unit: Hz
  - Min: 1
  - Max: 2000
  - Default: 80

- **Speed loop integration time constant**
  - Value: 2000
  - Unit: 0.01ms
  - Min: 200
  - Max: 51200
  - Default: 2000

- **Position loop gain**
  - Value: 40
  - Unit: 1/s
  - Min: 1000
  - Max: 40
  - Default: 40

- **Bias**
  - Value: 0
  - Unit: min-1
  - Min: 0
  - Max: 450
  - Default: 0

- **Feed-forward**
  - Value: 0
  - Unit: %
  - Min: 0
  - Max: 100
  - Default: 0

- **Torque reference filter time constant**
  - Value: 0.1ms
  - Unit: -
  - Min: -
  - Max: 250
  - Default: 0

- **Speed loop compensation coefficient**
  - Value: 0
  - Unit: -
  - Min: -
  - Max: 100
  - Default: 0

- **Mode switch (torque reference)**
  - Value: 200
  - Unit: %
  - Min: 0
  - Max: 800
  - Default: 200

- **Mode switch (speed reference)**
  - Value: 0
  - Unit: min-1
  - Min: -
  - Max: 10000
  - Default: 0

- **Mode switch (acceleration reference)**
  - Value: 0
  - Unit: 10(min-1)
  - Min: -
  - Max: 3000
  - Default: 0

- **Mode switch (torque reference)**
  - Value: 0
  - Unit: reference
  - Min: -
  - Max: 10000
  - Default: 0

- **PGA dividing ratio**
  - Value: 2048
  - Unit: P/R
  - Min: 16
  - Max: 32768
  - Default: 8192
2.) Program the Servo Drive parameters for Position Mode.

a.) In SigmWin use the "Edit Parameters" menu and check the box beside the parameter you need to edit and click the Edit box. Edit the parameter value and click OK. Do this for all parameters in the chart below.

<table>
<thead>
<tr>
<th>Yaskawa Sigma I</th>
<th>Sigma I param</th>
<th>Sigma I parameter description</th>
<th>Yaskawa Sigma II</th>
<th>Sigma II param</th>
<th>Sigma II parameter description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Param #</td>
<td>Change value</td>
<td></td>
<td>Param #</td>
<td>Change value</td>
<td></td>
</tr>
<tr>
<td>Cn-01 000C</td>
<td>000C</td>
<td>Position Mode</td>
<td>Pn000 0010H</td>
<td>Position control</td>
<td></td>
</tr>
<tr>
<td>Cn-02 0020</td>
<td>0020</td>
<td>Position Mode</td>
<td>Pn002 0100H</td>
<td>Absolute encoder as incremental</td>
<td></td>
</tr>
<tr>
<td>Cn-11 8192</td>
<td>8192</td>
<td>Number of encoder pulses</td>
<td>Pn102 80-120</td>
<td>Gain, adjust by trial and error. Start with 90, machine dependent</td>
<td></td>
</tr>
<tr>
<td>Cn-2B 1</td>
<td>1</td>
<td>Control Method Selection Position Mode</td>
<td>Pn110 0</td>
<td>Autotuning 1=ON, 0=OFF</td>
<td></td>
</tr>
<tr>
<td>Cn-1A 50 to 70</td>
<td>50 to 70</td>
<td>are typical values*</td>
<td>Pn200 0004H</td>
<td>Input signal A phase B phase X4</td>
<td></td>
</tr>
<tr>
<td>Cn-0A 8192</td>
<td>8192</td>
<td>PG dividing ration</td>
<td>Pn201 8192</td>
<td>PG divider (Needed if Pn207 is 16 bit)</td>
<td></td>
</tr>
<tr>
<td>Cn-24 1</td>
<td>1</td>
<td>Electronic Gear Ratio Numerator</td>
<td>Pn202 4</td>
<td>Electronic gear ratio Numerator</td>
<td></td>
</tr>
<tr>
<td>Cn-25 1</td>
<td>1</td>
<td>Electronic gear ratio Denominator</td>
<td>Pn203 1</td>
<td>Electronic gear ratio Denominator</td>
<td></td>
</tr>
<tr>
<td>Cn-1B 7</td>
<td>7</td>
<td>Positioning completion range</td>
<td>Pn207 0100H</td>
<td>17 bit output (Not on Early sigma 2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pn212 8192</td>
<td>Divider</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pn500 7</td>
<td>7 Position completed width</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pn50A 8100H</td>
<td>Over travel off</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pn50B 6548H</td>
<td>Over travel off</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pn50E 3200H</td>
<td>Servo ready</td>
<td></td>
</tr>
</tbody>
</table>
Once editing is complete click on “Write” to write the new values to the servo drive. Once written the servo drive will need to be rebooted, power off the servo drive power, wait 30 seconds and power back up. At this point its a good idea to double check the parameter values. Using SigmaWin reconnect to the servo drive and click edit parameters and review that the proper values are being displayed.

3.) Configure CNC11 parameters for Yaskawa Sigma I or II position mode.

a.) Follow the CNC11 configuration instructions in its entirety using the Installation manual for the system you are using. OAK board installation manual or the MPU11/GPIO4/Optic Direct manuals as usual. Then proceed...

b.) In CNC11 set the Encoder Counts per Rev to 32768. (Review TB267 on the limits of encoder count maximums for MPU11 based systems)

c.) In CNC11 Set PID values as follows

<table>
<thead>
<tr>
<th>Kp</th>
<th>Ki</th>
<th>Kd</th>
<th>Limit</th>
<th>Kg</th>
<th>Kv1</th>
<th>Ka</th>
<th>Accel</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>256000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>.375</td>
</tr>
</tbody>
</table>

c.) Set parameter 256 = 2 which enables Precision/Position Mode

d.) Release estop with machine in middle of travels, slow jog axes to test basic control of motion.

4.) Use Yaskawa Autotune to tune the axes.

Sigma I: Follow Sigma I Autotune procedure found in the Yaskawa Sigma I users manual. A plug in programming module is required to Autotune a Sigma I drive. We have successfully used the Yaskawa JUSP-OP02A1-E (also known as a DAPSX3000) operator module to Autotune Sigma I drives. These are available new and used (ebay). Unlike other yaskawa drives you can not use the SigmaWin+ software to Autotune a Sigma I, the plug-in module JUSP-OP02A1-E is required for this step.

a.) Using a JUSP-OP02A1-E follow the Sigma I User's Manual section 4.2.3 and Autotune the drive.

b.) Move the machine at all the speeds and listen for noise or bad characteristics. Adjust GAIN (CN-1a) as necessary to achieve smooth sounding nice action motion and then re-Autotune once you have the gain set for satisfactory motion.

Sigma II: Follow Yaskawa Sigma II User's Manual and follow the Autotune instructions in Chapter 6 starting on page 24. You can use SigmaWin+ software to Autotune a Sigma II drive.

a.) Start the tuning process by setting the Moment of Inertia using the instructions for the Sigma I drives above.

b.) Once the Moment of Inertia has been determined use the Yaskawa Sigma II User's Manual Section 6.3. Adjust the “Rigidity” setting (Fn0001) using the keypad on the drive face. A good starting point is to set Fn0001 to 6 for a mill.

c.) Set the Autotuning Parameter Pn110 to 1 (1= Autotune ON). Move (with CNC11) the axis at rapids, typical cutting feedrates and at slow speeds to see how it responds if the axis is noisy or sluggish use Fn0001 to adjust the rigidity.

d.) After the drive is tuned set Parameter Pn110 to 0. (Pn110=0 Autotune OFF, Pn110=1 Autotune ON)
5.) Measure and Set Timing Delay Parameter Automatically with Centroid's Autotune.

Position each axis in middle of travel and run “Autotune” in the Centroid PID menu. Centroid's Autotune will automatically calculate and set the delay timing parameter for that axis. Perform the Centroid Autotune procedure on each axis, one axis at a time.

Typically Timing Delays are: Sigma I 10 – 20 milliseconds and Sigma II 5-10 milliseconds. If the Delay times are longer than these typical values then the gain is set too low, increase gain, check for good axis motion at various speeds, reautotune on servo drive and then reset the Delay Timing using the Centroid Autotune. (Note: Each time you adjust the Gain settings in the Yaskawa drive or Run Autotune in the Yaskawa, be sure to re-autotune on the Centroid side to calculate a new Timing Delay.)

f.) Once satisfied with the motion, backup good the good .USR files for each drive. Backup CNC11 parameters by making a "report" file. Email the files to support@centroidcnc.com and they will be filed with the Centroid cnc system folder for safe keeping and future reference.

Notes:

1.) Useful links

- Oak board Installation Manual
- Yaskawa Sigma II User's Manual
- MPU11/GPIO4D with Opticdirect and Yaskawa User's manual
- Latest Schematics, Oak Sigma I and II, MPU11/GPIO4D/OpticDirect Sigma I and II
- Latest CNC11 Software download
- Yaskawa SigmaWinplus 5.70A download
- TB267 Yaskawa Sigma 5 setup with CNC11 (for reference, First and Last page applys to Sigma I and II as well)
- Manhattan USB to Serial Converter
- Example Position Mode Yaskawa ".USR" files. Download this Zip file which contains both a sigma I and sigma II working Position Mode .USR files for your reference.

Note: These can be opened in SigmaWin+ in the Offline Mode and reviewed without being connected to a servo drive.

2.) The Yaskawa JUSP-OP02A1-E programming/operator module required for Autotuning a Sigma I drive can be purchased new from Yaskawa for around $220 and on ebay used for around $75-$100. It plugs into the same 3CN connector on the drive as the serial cable.
3.) **DRO Flicker and Load Meter Bounce control.** Sometimes on a light load axis (like a Z axis on a knee mill) the DRO and Load Meters will flicker or bounce around since there is not a lot of mechanical damping on that axis and the servo motor is hunting around trying to hold .0001". With CNC11 Version 3.14+ the Load Meters and DRO Flicker can be dampened in the CNC11 software with Parameters 137 (load meter) and 138 (DRO). Typical value for P137 is 2 or 4, Typical value for P138 2 or 4. (Leave both set to 0 for an axis that is not flickering)

4.) **Load Meters.** CNC11 Load meters receive a low voltage signal feedback from the 5CN connector on the Yaskawa servo drive. The Centroid Yaskawa interface cable has a small two wire connector pig tail that comes off the Servo drive end of the Cable. Simply plug this small 4 lug (two wire) connector into the 5CN connector on the Yaskawa (see image below) and configure CNC11 for Load Meter display. Set Parameter # 143 to 1 (Load meters ON) or 3 (Load meters ON with outline) or 11 for all on with mini DRO. See Centroid Operator Manual for details page 14-31
Yaskawa Sigma I or II RS 232 to USB serial cable

Build your own Yaskawa serial communication cable.

Serial Cable pin out connections from the Yaskawa Sigma I manual

<table>
<thead>
<tr>
<th>SERVOPACK End (3CN)</th>
<th>RS-232 Port (Personal Computer End)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RXD= Pin 2</td>
<td>RXD= Pin 2</td>
</tr>
<tr>
<td>TXD= Pin 3</td>
<td>TXD= Pin 3</td>
</tr>
<tr>
<td>0V= Pin 5</td>
<td>0V= Pin 5</td>
</tr>
<tr>
<td>RTS= Pin 7</td>
<td>RTS= Pin 7</td>
</tr>
<tr>
<td>CTS= Pin 8</td>
<td>CTS= Pin 8</td>
</tr>
<tr>
<td>FG= Case (bare wire soldered to case)</td>
<td>FG= Case (bare wire soldered to case)</td>
</tr>
</tbody>
</table>

Notes:
- We used a Manhattan USB to Serial converter with success. Many other brands are available, reports have come in that some others work and some do not.
- We used 22 awg shileded cable from west penn wire.
- We tested our cable and sigmawin software connection before going out to the job site with a spare sigma 1 drive on the bench. You can connect single 220 vac phase power to the sigma one and it will boot up and communicate thru the 3CN connection without a motor connected (or anything else).
- Rather than build your own, you can purchase the serial cable from Yaskawa part #YS-11(A)