Application Note YASKAWA

Title: Fully Closed Loop Setup Using a SigmaLink Linear Encoder	
Product(s): Sigma-7, SigmaWin+ ver. 7, FCL Option Card, SigmaLink Encoder	**DOC. NO. AN.SIGMA-7.03**

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1 Summary

This procedure outlines setting up Fully Closed Loop operation (referred to as FCL in the remainder of the document) using the SGDV-OFA01A option card and a SigmaLink linear encoder as the external encoder on a rotary ball screw system mounted to a Yaskawa servo. The procedure is described using SigmaWin+ ver. 7.

2 Initialize

2.1 Initialize Parameters as described in the SigmaWin+ help file

2.2 If not using over-travel switches set Pn50A.3 and Pn50B.0 to 8

2.3 Set Pn002.2 to 1 to use the rotary absolute encoder as an incremental encoder

- Note: The absolute data is provided by the absolute linear encoder

2.4 Set Pn002.3 = 1 to enable FCL (This may change in a later step)

3 Aligning Motor and Encoder Directions

3.1 The direction of motor rotation and linear encoder direction need to be aligned to avoid getting an A.D10 alarm, to avoid this while checking direction disable A.D10 by setting Pn51B = 0 for this setup.

3.2 Decouple the ball screw mechanism from the linear encoder system if possible

3.3 Bring up the Monitor function in SigmaWin+

- Using the  button select the following items to monitor
  - Feedback pulse counter
  - Fully Closed Feedback Pulse Counter

3.4 Rotary Axis:

- Move the rotary mechanism in the desired positive direction (via Jog or by hand)
- Watch the Feedback pulse counter item in SigmaWin+
- If it increased leave Pn000.0 as is
- If it decreased invert Pn000.0

3.5 Linear Encoder Axis:

- Move the linear encoder system in the desired positive direction
- Watch the Fully Closed Feedback Counter in SigmaWin+
- If it increased leave Pn002.3 as 1
- If it decreased set Pn002.3 to 3

3.6 Procedure if unable to decouple:

- Attempt to Jog the mechanism in the positive direction
- The Feedback pulse counter and the Fully Closed Feedback Counter should both increase when moving in the positive direction
  - Note: they will likely not increase at the same rate as we haven't set all appropriate parameters
- If the Feedback pulse counter decreases invert Pn000.0

- If the Fully Closed Feedback Counter decreases change Pn002.3 from 1 to 3 or 3 to 1 until both monitor items increase and decrease together

3.7 Confirming Correct configuration

- Attempt a forward and back Program Jog
  - Recommend a short and slow move profile
- Check to see that both Counters in monitor change correctly
  - If an A.D10 error is thrown:
    - Double check that Pn51B = 0.
- For further troubleshooting see Section 5

4 Setting External Encoder Parameters

4.1 Determine External Linear Encoder pitch and Resolution. The pitch will be used to calculate Pn20A.

Manufacturer	Model	Relay Device	Pitch [µm]	Resolution [nm]	Max speed [m/s]
Magnescale Co., Ltd.	SQ47-□□□□S□F□□□	-	20.48	5	3.33
	SQ47-□□□□T□F□□□	-			
	SQ47-□□□□A□F□□□	-	40.96	10	3.33
	SQ47-□□□□F□F□□□	-			
	SQ57-□□□□S□F□□□	-	20.48	5	3.33
	SQ57-□□□□T□F□□□	-			
	SQ57-□□□□A□F□□□	-	40.96	10	3.33
	SQ57-□□□□F□F□□□	-			
	SR77-□□□□□LF	-	80	9.8	3.33
	SR77-□□□□□MF	-	80	78.1	3.33
	SR87-□□□□□LF	-	80	9.8	3.33
	SR87-□□□□□MF	-	80	78.1	3.33
Mitutoyo Corporation	ST781A	-	256	500	5
	ST782A	-			
	ST783A	-	51.2	100	5
	ST784A	-			
	ST788A	-			
	ST789A	-	25.6	50	5
	ST1381	-	5.12	10	8
	ST1382	-	0.512	1	3.6

	Model	Relay Device	Pitch [µm]	Resolution [nm]	Max speed [m/s]
Heidenhain	LIC4100 Series	EIB3391Y	20.48	5	10
	LIC2100 Series	EIB3391Y	204.8	50	10
		EIB3391Y	409.6	100	10
	LC115	EIB3391Y	40.96	10	3
	LC415	EIB3391Y			
Renishaw plc	EL36Y-□□050F□□□	-	12.8	50	100
	EL36Y-□□100F□□□	-	25.6	100	100
	EL36Y-□□500F□□□	-	128	500	100
	RL36Y-□□050□□□	-	12.8	50	100
	RL36Y-□□001□□□	-	0.256	1	3.6
Fagor Automation S. Coop.	L2AK208	-	20	78.1	8
	L2AK211	-	20	9.8	8
	LAK209	-	40	78.1	3
	LAK212	-	40	9.8	3
	S2AK208	-	20	78.1	3
	SV2AK208	-			
	G2AK208	-			
	S2AK211	-	20	9.8	3
	SV2AK211	-			
	G2AK211	-			

*See Doc number sieps80000132 section 9.1 for complete table

*Table values are reference values for SERVOPACK parameters

4.2 Pn20A

This parameter relates the rotary motor turns to movement of the linear encoder

- Pn20A = Ball Screw Pitch [µm] / External Encoder Pitch [µm]
- Example:
  - Ball Screw pitch = 12 [mm] / 1 [rev of motor]
  - Encoder = Fagor L2AK211
  - Pn20A = 12,000 [µm/rev] / 20 [µm] = **600** [scale pitch/rev]

4.3 Pn281

This parameter is for setting the resolution of the PAO and PBO outputs. If the controller is not using external encoder data, then this can remain at default, unless an alarm occurs indicating that this resolution exceeds the allowed range.

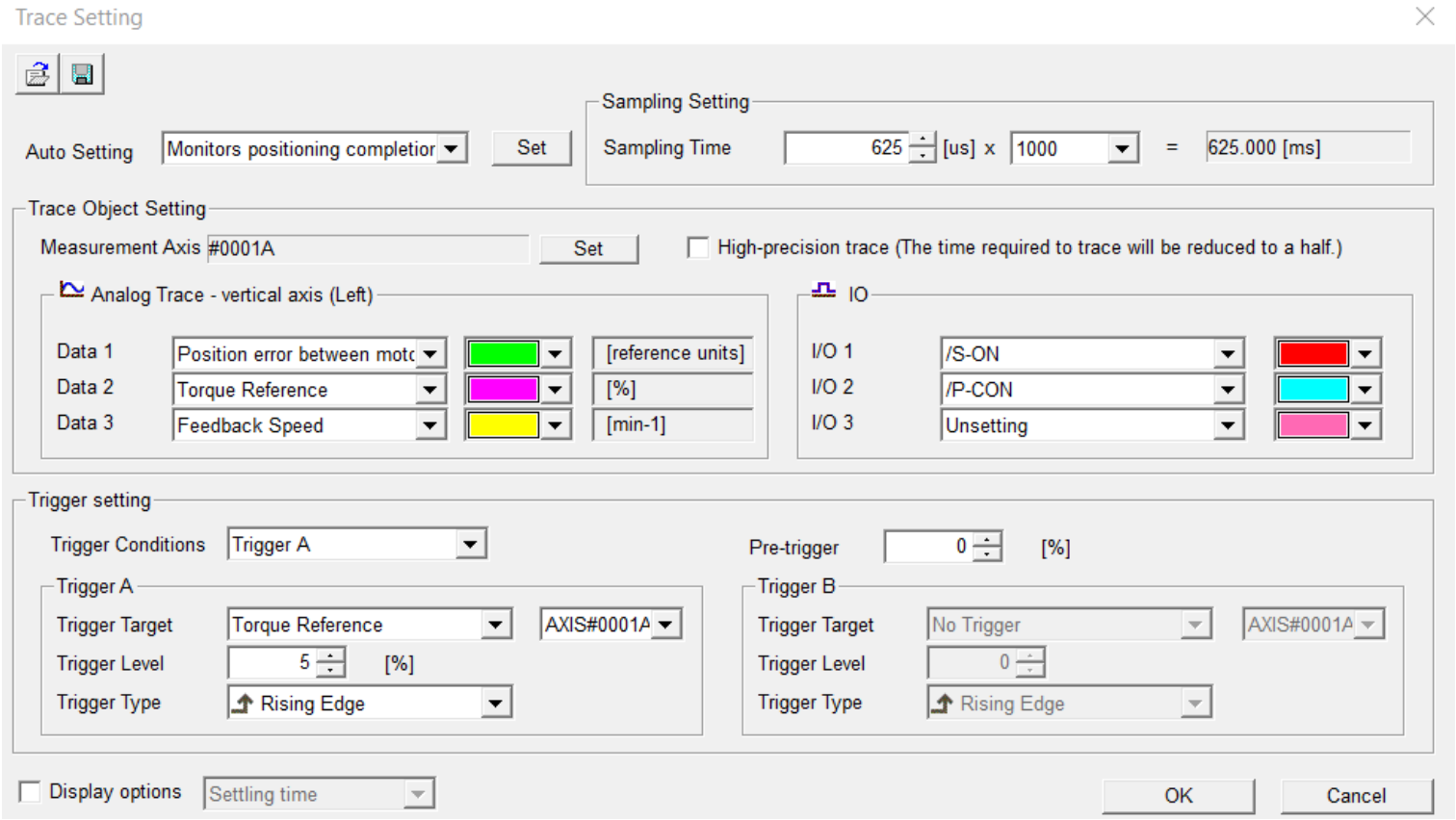
- Pn281 = Encoder Pitch / Desired distance for one output pulse
- Example:
  - Encoder = Fagor L2AK211
  - Desired Resolution = 0.05 [µm] / 1 [controller pulse]
  - Pn281 = 20 [µm] / 0.05 [µm] = 400 [Edge/pitch]
- Encoder output is limited to 6.4 [Mega pulses/s] so Pn281 has to be set to prevent that
- To check:
  - Max speed [µm/s] / Desired resolution [µm/pulse] < 6,400,000 [pulses/s]
    - **Correct** Example:
      - Max Speed = 12 [mm/s] = 12,000 [µm/s]
      - Resolution = 0.05 [µm]
      - 12000 [µm/s] / 0.05 [µm] = 240,000 [p/s] < 6.4 [Mp/s]
    - **Incorrect** Example:
      - Max Speed = 7 [m/s] = 7,000,000 [µm/s]
      - Resolution = 1 [µm]
      - 7,000,000 [µm/s] / 1 [µm] = 7,000,000 [p/s] > 6.4[Mp/s]

4.4 Pn51B

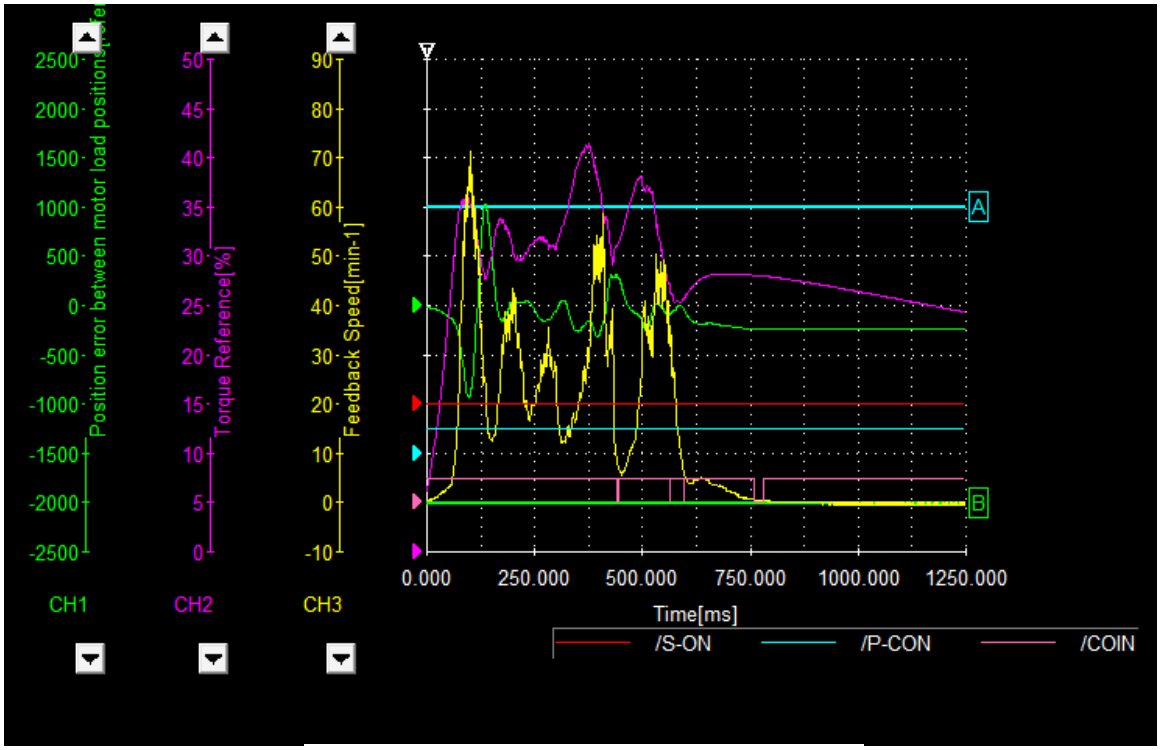
This parameter is for setting the position deviation threshold between the rotary and linear encoder, this level controls when A.D10 will throw. This is not to be confused with Pn520, which controls the position error threshold of just the external encoder.

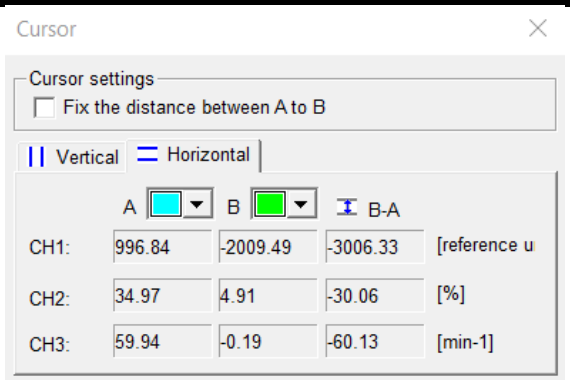
- It is recommended the machine be tuned before setting this parameter
- Set Pn51B to 0 or 1073741824 to start with (0 disables the deviation alarm)
- Cycle power to reset monitor items Feedback pulse counter and Fully Closed Feedback Pulse to 0
- Set up a one directional move in program jog that will be similar to the most aggressive move of the application
- Set a distance in Program Jog [Reference Units], the units do go through Pn20E & Pn210 (electronic gear ratio)
  - Example:
    - Pn20E = 16
    - Pn210 = 1
    - Move command= 20,000 [Reference Units]
    - Moves seen in monitor ≈ 320,000 [pulses] (20,000 * (16/1))

- Take a trace in SigmaWin+ to measure maximum position error between motor and load positions.
  - Example setup:
    - Trace setting:



- Trace and measurement:





- Max measured deviation was about 1000 so setting Pn51B to 1500 would give us a 1.5x factor of safety.

5 Troubleshooting

5.1 A.041

- Double check that Pn281 is between 1 and 4096
- Make sure you haven't changed Pn212, it isn't used in FCL with linear encoders but will still throw an error if the setting doesn't follow the correct increments (found in sieps80000126)

5.2 A.511

- Double check that encoder output pulses never exceeds 6.4 [Mp/s]
- Reduce the encoder output resolution (Pn281)

5.3 A.D10

- Ensure external encoder and motor directions are aligned (see 3.7)
- Remember to set Pn002.2 = 1
- Do program job for just one cycle
- Lower Program Jog move parameters
- Increase mechanism rigidity

5.4 Program Jog moves incorrectly

- Invert Pn000.0 or Pn002.3
- Disable Tuningless (Pn170.0 = 1)