

# Sigma-7 & SigmaWin+ Ver.7 Servo Tuning

**Class No.** TRM010-Sigma7-Tuning-selfguided

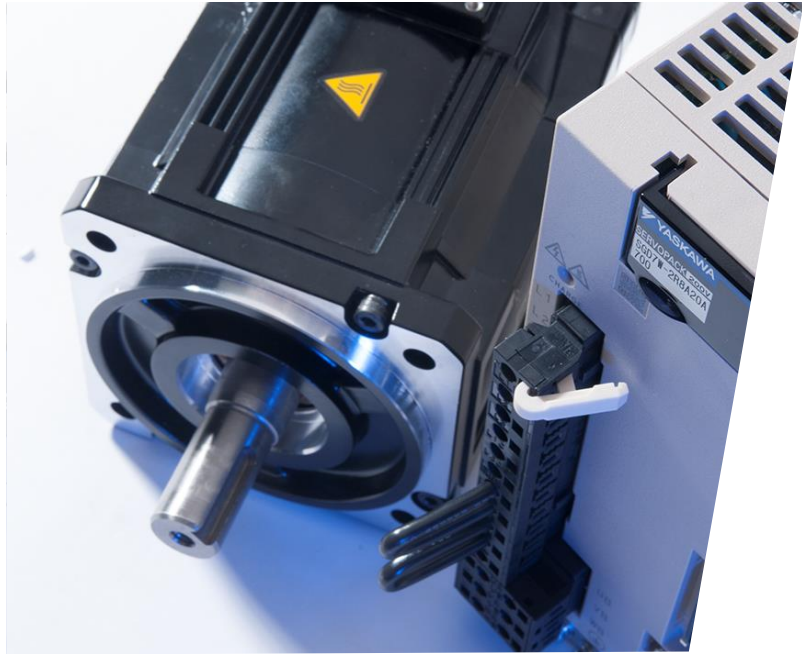
**Rev.** 1.00

**Date:** February 16, 2018



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  - *Tuning Less*
  - *Advanced Auto Tuning*
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  - *Tuning for Low Position Error*
  - *Speed Ripple Compensation*



# Sigma-7 & SigmaWin+ Ver.7 Connection

How to establish communication between software and SERVOPACK

- *Load Demo Program*
- *SigmaWin+ Ver.7 Connection*

# Demo Program - Status

- *Camera*
- *Remote I/O*
- *Web UI*
- *Alarms?*
- *Remote I/O Interface?*

# Demo Program

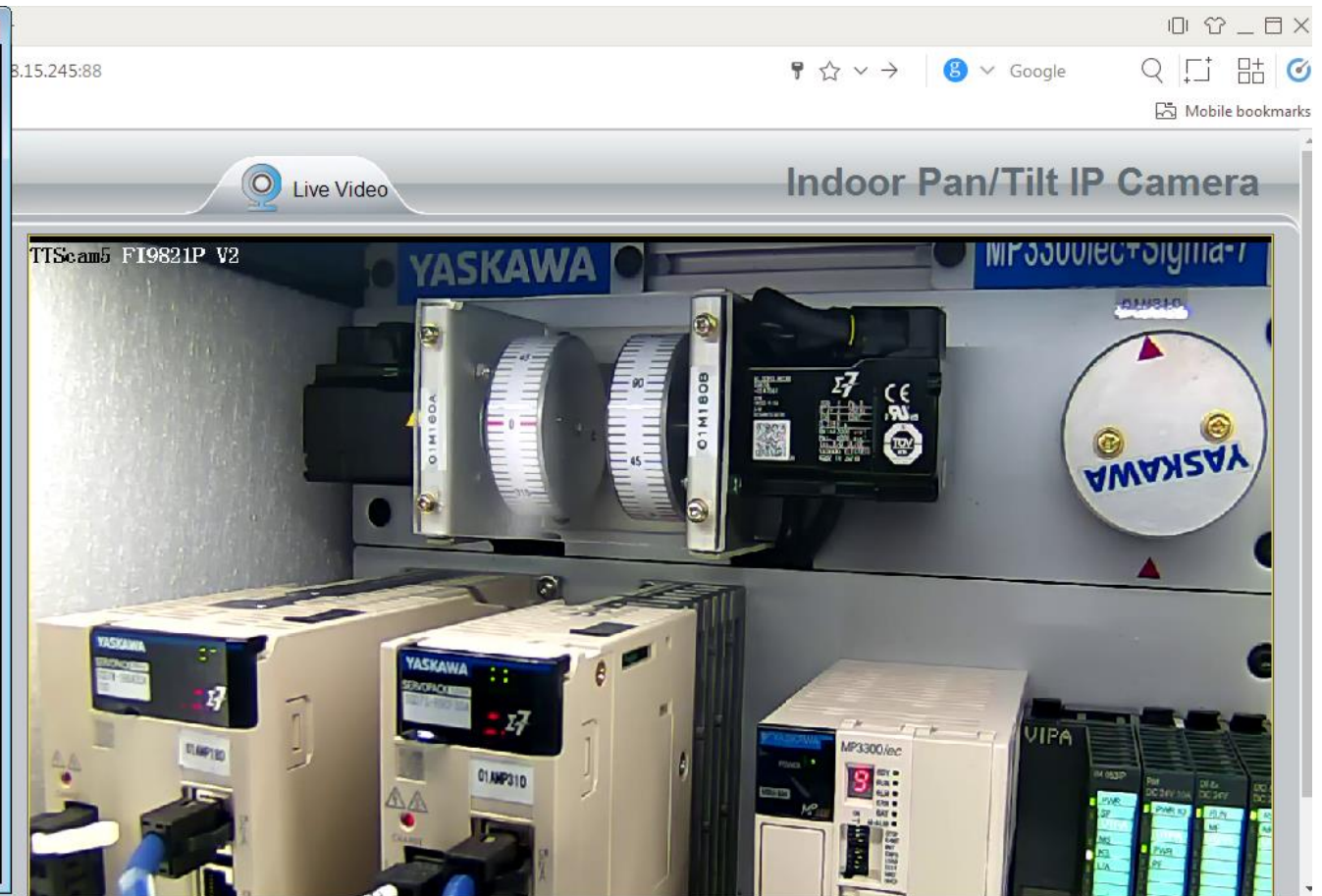
1. *Web UI – User – Login – “Admin”, “MP3300”*
2. *Setup – Archive – Send – Add Archive*
3. *Navigate, select archive, open, send, Install*
4. *Reboot (30 seconds)*
5. *Setup – Drive Parameters – Write All User Pns – Write*
6. *Reboot (30 seconds)*
7. *Alarms - Clear*

The screenshot displays the YASKAWA web interface. At the top, there is a navigation bar with the YASKAWA logo, a notification bell, and menu items for Status, Operations, Setup, and Reboot. Below this, the 'Archive' section is visible, containing a 'Version' field and a 'Status' field. There are three action buttons: 'Send', 'Receive', and 'Delete'. A 'Display' section includes checkboxes for 'Unmodified', 'Modified', 'New', and 'Deleted', all of which are checked. Below the display options is a 'File' dropdown menu with a downward arrow, listing several files in a tree structure under the path '/flash/user/config/startup/':

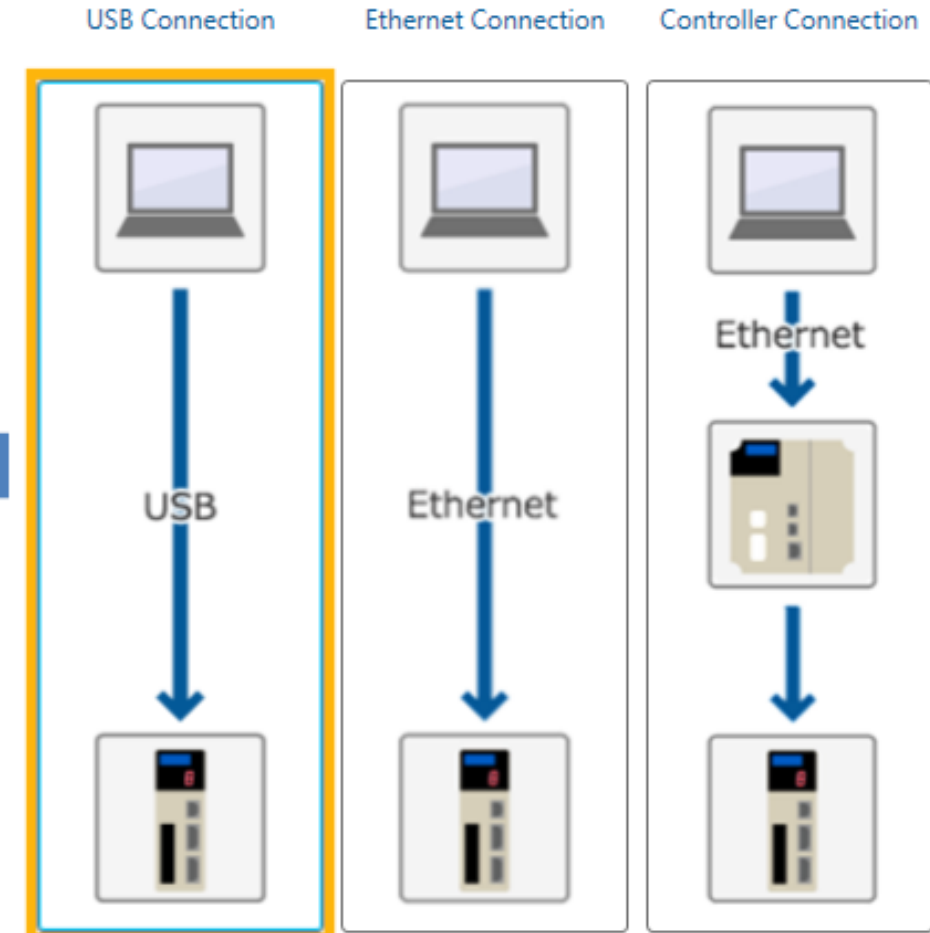
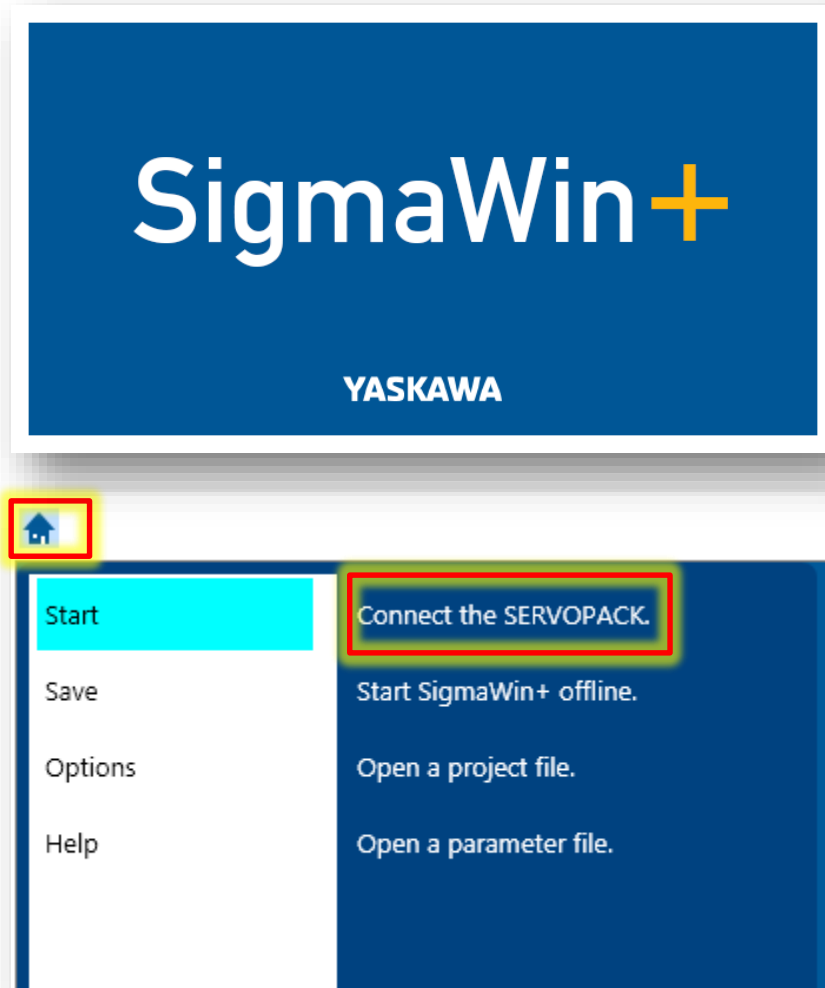
- /flash/procon/any/image
- /flash/user/config/current.xml
- /flash/user/config/startup/axis.xml
- /flash/user/config/startup/group.xml
- /flash/user/config/startup/hardware.xml
- /flash/user/config/startup/io.xml
- /flash/user/config/startup/servonet.xml
- /flash/user/config/startup/taskdata.xml

# Demo Program

- *Servo ON*
- *Speed = 10*
- *Jog+*
- *Jog-*

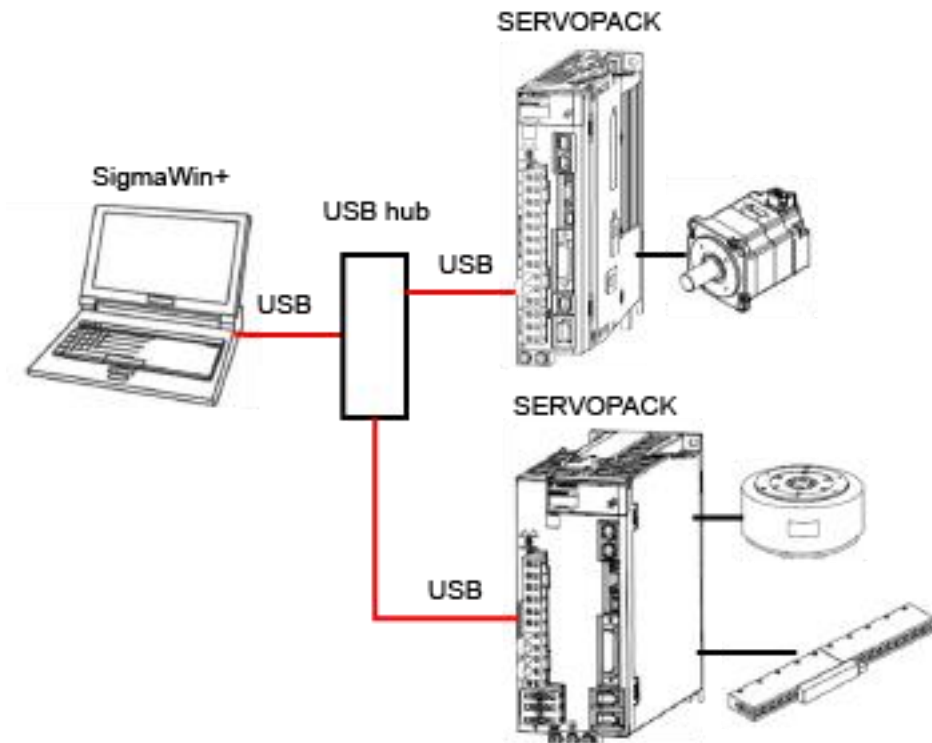


# SigmaWin+ Ver7. Connection



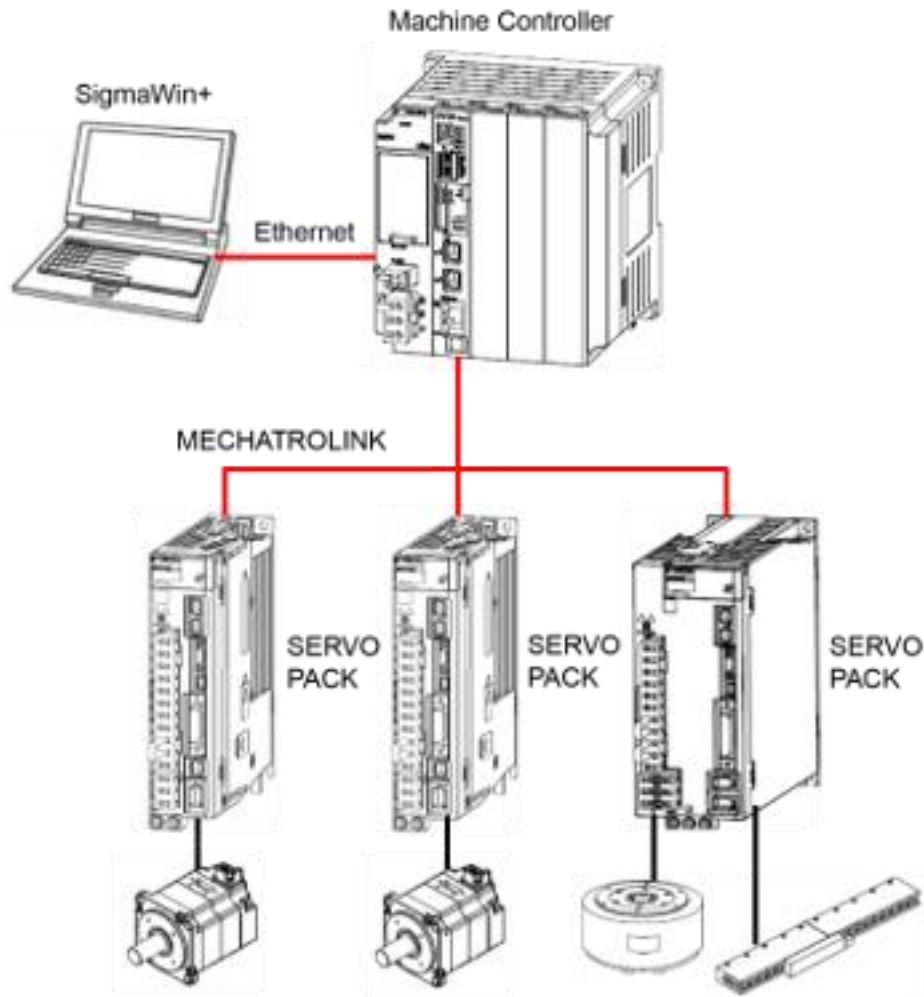
# USB Connection

- *Single Axis*
  - *Direct Cable*
- *Multi Axis*
  - *USB Hub*
  - *Multiple cables*
- *USB Driver*
  - *Manual installation required*



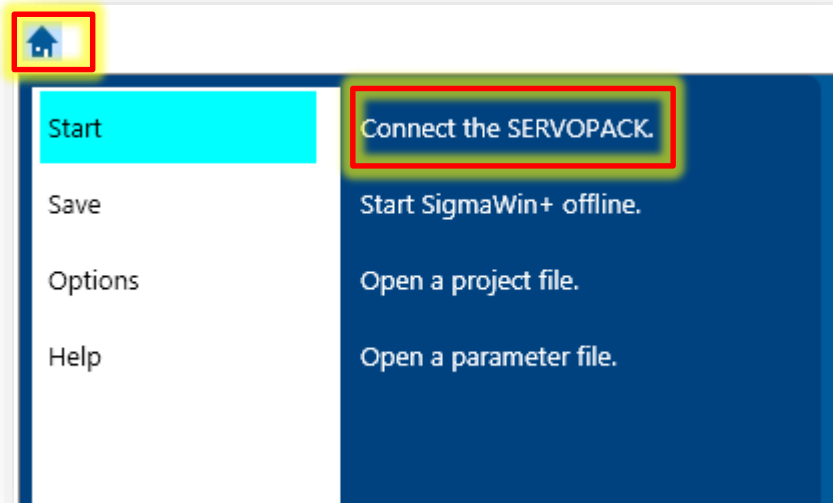


# Ethernet Connection

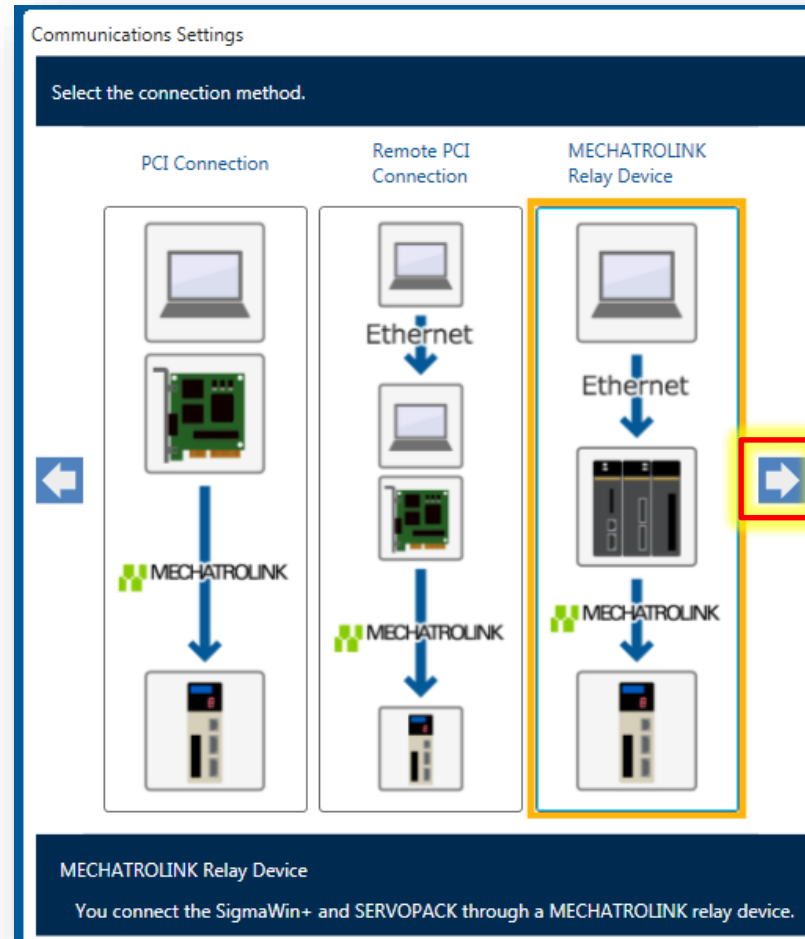


- *Ethernet Connection to Controller*
- *Mechatrolink Connection to Servos*

# Connection via MPiec



## ■ *Mechatrolink Relay Device*



# Connection via MPiec

## Computer Communication Settings

- Choose network adapter
- Start – cmd – ipconfig
- Enter IP address of PC network adapter

Find IP address of PC network adapter with ipconfig

```

C:\Windows\system32\cmd.exe
C:\Users\Win7-32-Ubox>ipconfig

Windows IP Configuration

Ethernet adapter LinkManager Adapter:

    Connection-specific DNS Suffix  . :
    Link-local IPv6 Address . . . . . : fe80::80ba:2e5f:d9e6:44e7%20
    IPv4 Address. . . . .             : 10.127.128.158
    Subnet Mask . . . . .            : 255.255.255.0
    Default Gateway . . . . .        :

Ethernet adapter Local Area Connection:
    
```

Computer Network Settings

Change the computer network settings.

Network adapter: Local Area Connection

IP Address: 10 . 0 . 2 . 15

Subnet Mask: 255 . 255 . 255 . 0

Default Gateway: 10 . 0 . 2 . 2

Set

Computer

Local Area Connection: Intel(R) PRO/1000 MT Deskto...

IP Address: 10 . 0 . 2 . 15

Relay Device

IP Address: 192 . 168 . 15 . 77

Communications are OK. Test (Ping)

MECHATROLINK: MECHATROLINK-III

Circuit No.: 1 (0-255)

Station Address: 3 - 5 H (3-EF)

Search for SERVOPACKS Cancel

# Connection via MPiec

- *Relay Device*
  - *IP Address*
  - *Test (Ping)*

Computer Communications Settings

Local Area Connection: Intel(R) PRO/1000 MT Deskto...

IP Address: 10 . 0 . 2 . 15

Relay Device

IP Address: 192 . 168 . 15 . 77

Communications are OK. Test (Ping)

MECHATROLINK: MECHATROLINK-III

Circuit No.: 1 (0-255)

Station Address: 3 - 5 H (3-EF)

Search for SERVOPACKs Cancel

# Connection via MPiec

- *Mechatrolink-III*
  - *Station Address*
  - *3 to 5*

Computer Communications Settings

Local Area Connection: Intel(R) PRO/1000 MT Deskto...

IP Address: 10 . 0 . 2 . 15

Relay Device

IP Address: 192 . 168 . 15 . 77

Communications are OK. Test (Ping)

MECHATROLINK: MECHATROLINK-III

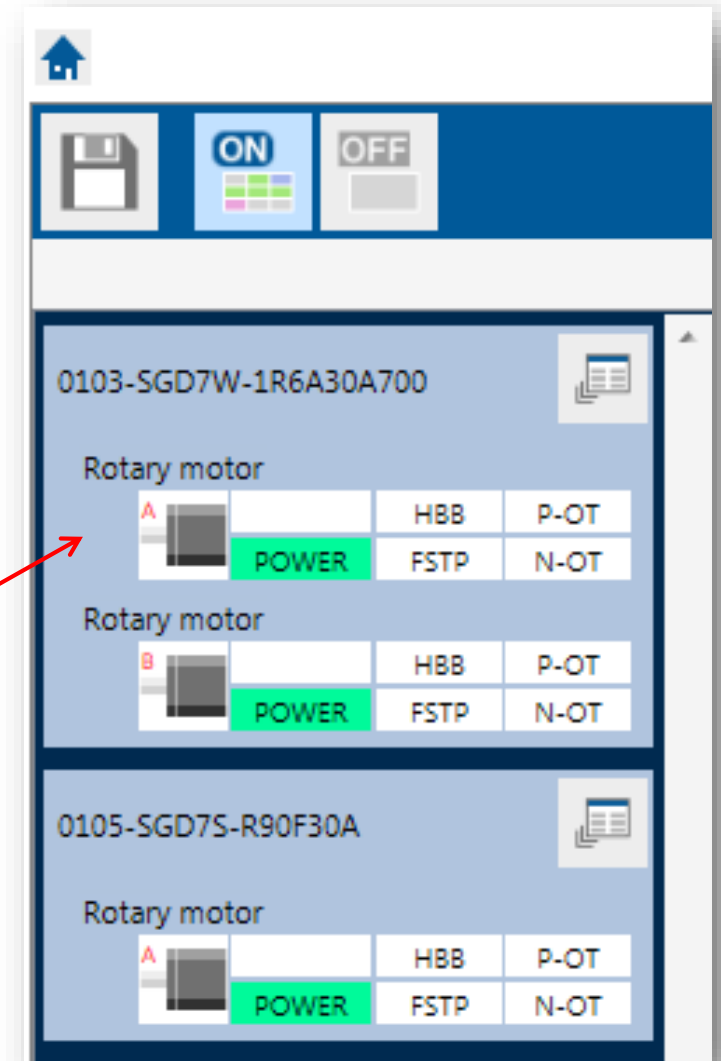
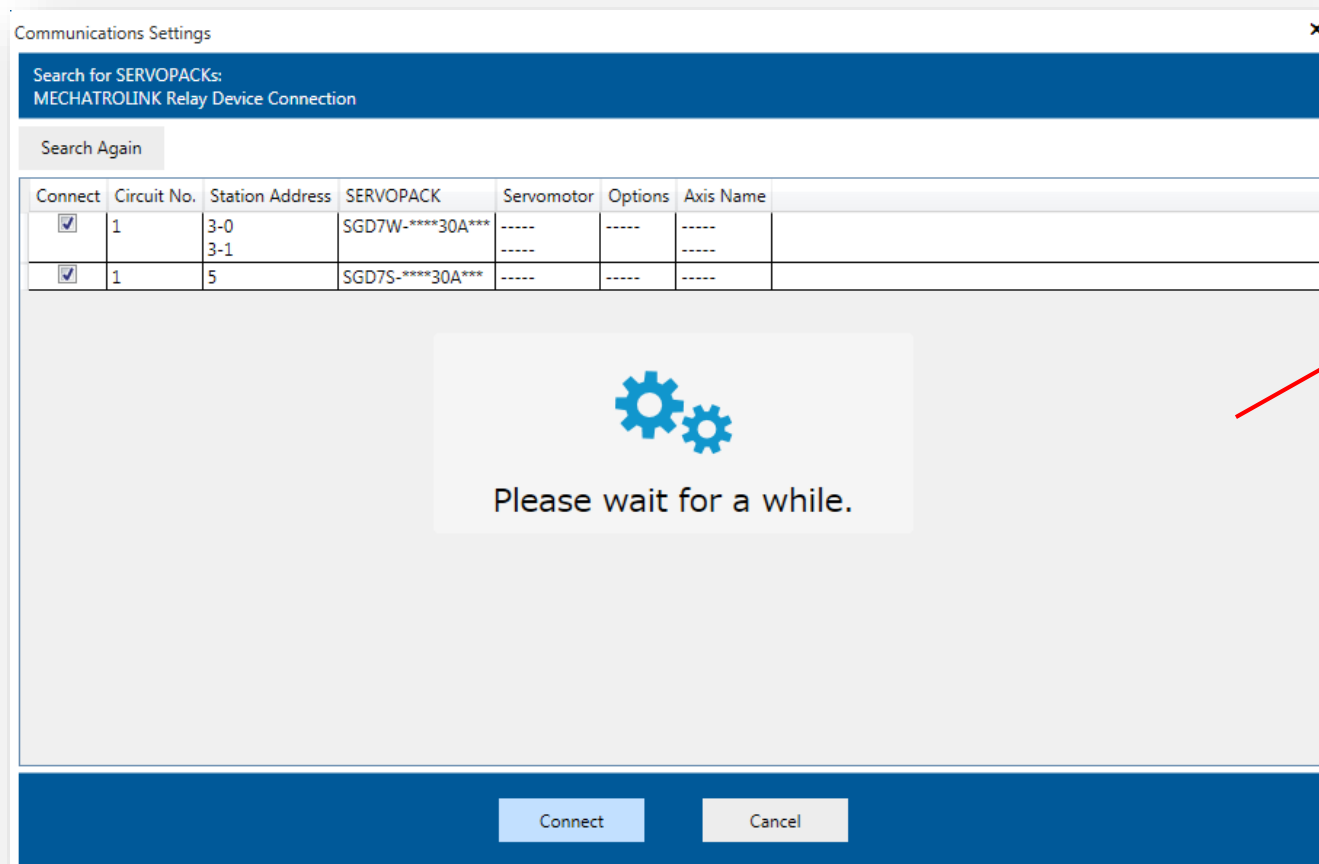
Circuit No.: 1 (0-255)

Station Address: 3 5 H (3-EF)

Search for SERVOPACKs Cancel

# Connection via MPiec

- *Successful Search and Connection*



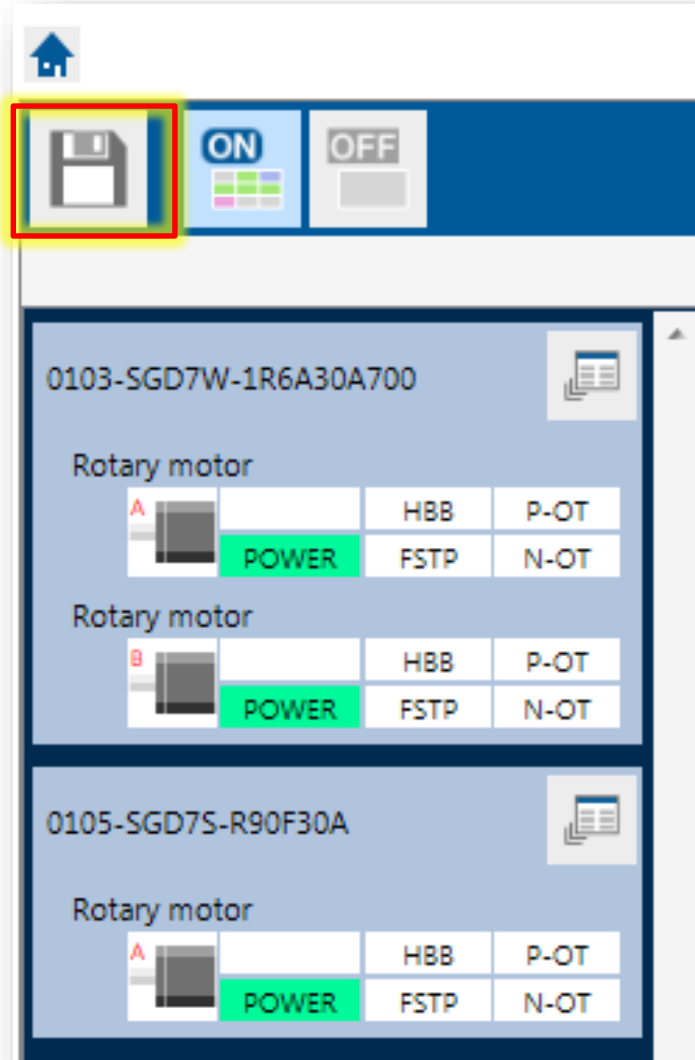
Result

# Software Navigation

- *Menu for each Amplifier*
  - *Choose Axis A or B*
- *Unavailable items grayed out*
  - *Close conflicting window or function*

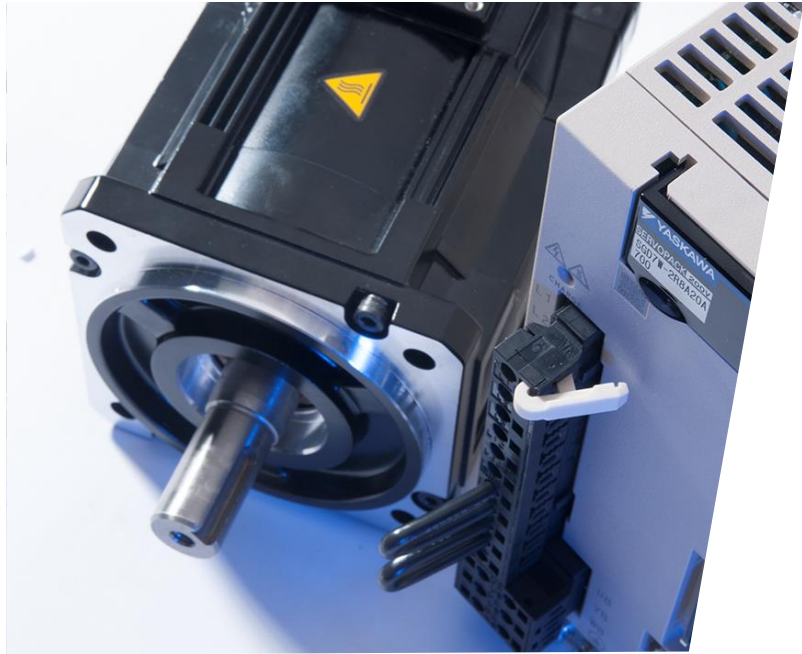
The screenshot displays the software interface for a Yaskawa amplifier. On the left, a vertical panel shows the amplifier model '0103-SGD7W-1R6A30A700' and its status, including 'Rotary motor' and 'POWER' indicators. A red box highlights a menu icon in the top right corner of this panel. The main window, titled 'Menu', shows the same amplifier model and a 'Display Method' dropdown set to 'Standard'. Below the title bar, there are 'Connect' and 'Disconnect' buttons. The main area is divided into two columns for 'Axis A' and 'Axis B', each with a 'Rotary motor' status indicator. The bottom section of the interface is a grid of functional panels: Parameters (with 'Edit Parameters' and 'Edit Online Parameters' options), Alarm (with 'Display Alarm' and 'Reset Motor Type Alarm'), Monitor (with 'Read Product Information', 'Monitor', and 'Wiring Check'), Setup (with 'Servopack Axis Name Setting' and other sub-options), Trace (with 'Trace' and 'Real Time Trace'), Test Run (with 'Jog' and 'Program JOG Operation'), Edit Table (with 'Edit Program Table', 'Edit Zone Table', and 'Edit Jog Speed Table'), Tuning (with 'Tuning'), and Solution (with 'Mechanical Analysis' and 'Ripple Compensation').

# Save Project



- *Project file organizes saved data*
  - *Parameters*
  - *By Axis*
  - *By Date*





# Sigma-7 & SigmaWin+ Ver.7 Alarms & Monitors

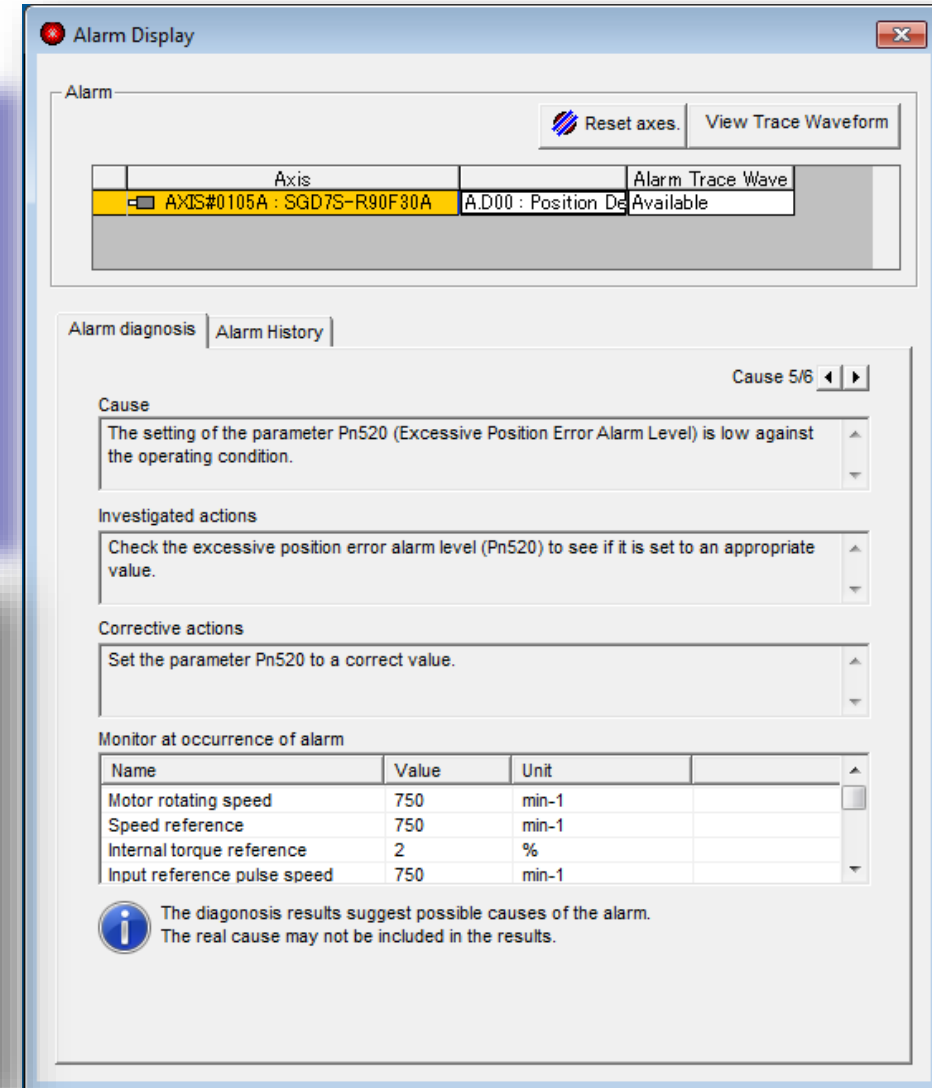
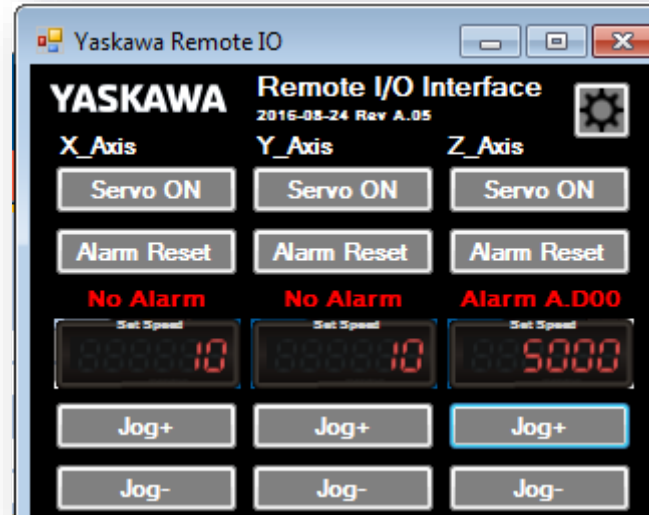
Basic Troubleshooting Tools

- *Alarm Diagnosis*
- *Alarm Trace*
- *Monitors*
- *Software Reset*

# Alarm Diagnosis

- *Alarm*
  - *Display Alarm*
- *Alarm Diagnosis*
  - *Causes*
  - *Investigate*
  - *Correct*
  - *Monitor at Occurrence*
  - *Alarm History*

1. Close all SW+ windows
2. Use Remote IO
3. Z\_Axis speed 4500 Jog+



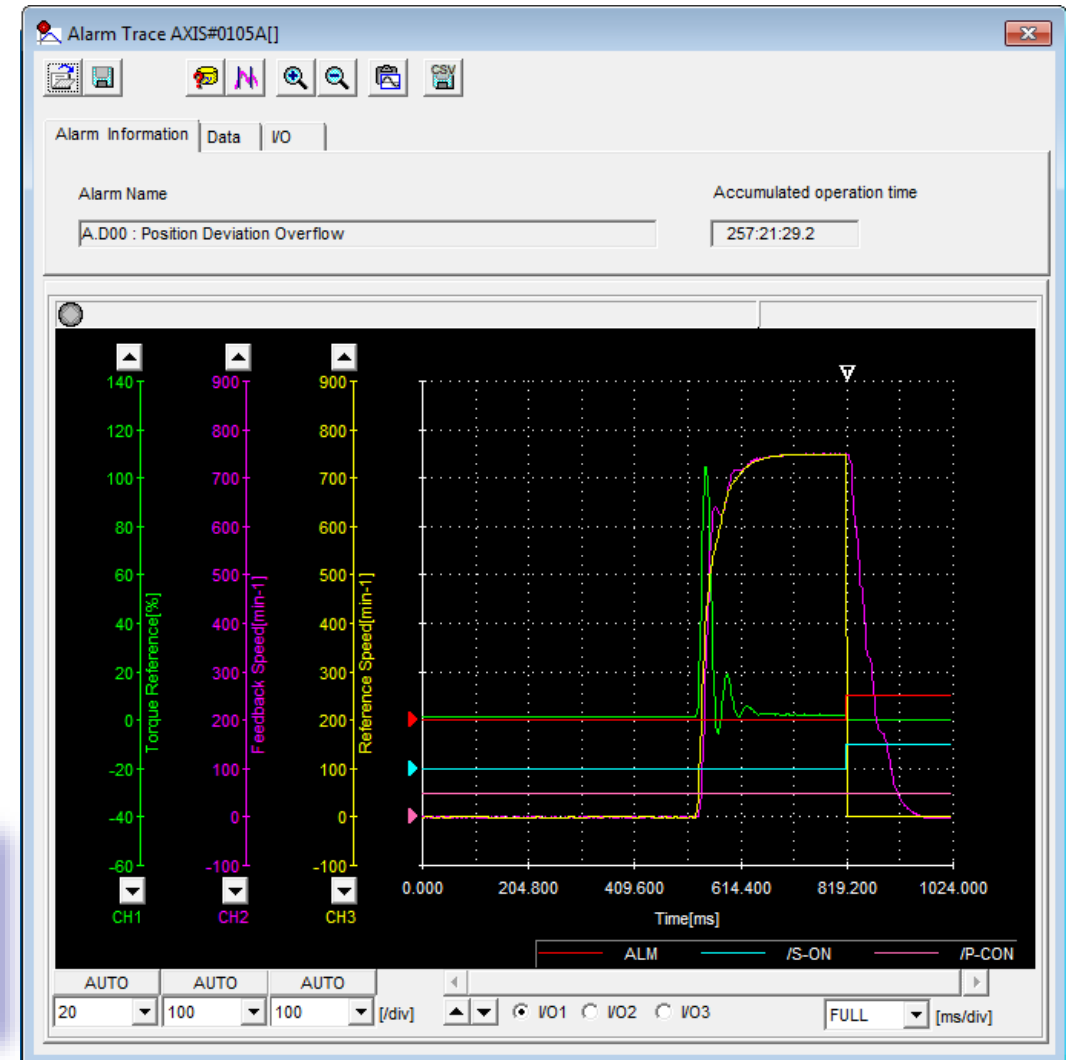
# Alarm Trace

- *Alarm History*
  - *Up to 10 alarm traces stored*
- *Alarm – Alarm Trace*
  - *Current Alarm only*

To create alarm A.d00

1. Close all SW+ windows
2. Use Remote IO
3. Z\_Axis speed 4500 Jog+

Alarm Trace  
only available when  
SigmaWin+ functions  
are not open



# Alarm Diagnosis

## ■ Alarm

- *Motion cannot continue under current conditions*
- *Servo Off*
- *Display Code A. □□□*
  - » *Reset may require power cycle*
- *Examples*
  - » *A.d00 Position Error*
  - » *A.710 Overload: High Load*
  - » *A.410 Undervoltage*
  - » *A.510 Overspeed*

## ■ Warning

- *Future alarm under current conditions*
- *Servo On*
- *Display Code A. 9□□*
  - » *Possible automatic reset*
- *Examples*
  - » *A.900 Position Error*
  - » *A.910 Overload*
  - » *A.971 Undervoltage*
  - » *A.95A Command Warning*

# Monitors

- *Multiple Servo Display*
  - *Read Product Information*
  - *Monitor*
- *How to Use*
  - *Status and I/O Tabs*
    - » *Over-travel Inputs*
  - *Filter*
    - » *Show/Hide control mode*
    - » *Standard filter*
    - » *“Clear” to show all monitors*

The screenshot displays the Yaskawa Monitor software interface, divided into two main sections: 'Operation' and 'Status'.

**Operation Table:**

Control	I/F	Item	Unit	0103-SGD7W-1R6A3C		0105-SGD
				Axis A	Axis B	Axis A
POS SPD TRQ	Common	Motor rotating speed	min-1	0	0	0
SPD	Common	Speed reference	min-1	0	0	0
POS SPD TRQ	Common	Internal torque reference	%	0	0	0
POS SPD TRQ	Common	Rotational angle 1 (encoder)	encoder puls	2417085	7328485	4996632
POS SPD TRQ	Common	Rotational angle 2 (from pol)	deg	259	66	176
POS SPD TRQ	Common	Input reference pulse speed	min-1	0	0	0
POS SPD TRQ	Common	Position error amount	reference ur	6	3	0
POS SPD TRQ	Common	Accumulated load ratio	%	0	0	0
POS SPD TRQ	Common	Regenerative load ratio	%	0	0	0
POS SPD TRQ	Common	Power consumed by DB resi	%	0	0	0
POS	Common	Input reference pulse count	reference ur	-14668	-162747	0
POS SPD TRQ	Common	Feedback pulse counter	encoder puls	3131590	8934133	4

**Status Table:**

Control	I/F	Item		0103-SGD7W-1R6A3C		0105-SGD
				Axis A	Axis B	Axis A
POS SPD TRQ	Common	Main Circuit	ON(ALL)	ON	ON	ON
POS SPD TRQ	Common	Encoder (PGRDY)	ON(ANY)	ON	ON	OFF
POS SPD TRQ	Common	Motor Power (Request)	-	OFF	OFF	OFF
POS SPD TRQ	Common	Dynamic Brake (DB)	ON(ALL)	ON	ON	ON
POS SPD TRQ	Common	Rotation Direction	ON(ANY)	OFF	ON	OFF
POS SPD	Common	Mode Switch	-	OFF	OFF	OFF
SPD	Common	Speed Reference (V-Ref)	-	OFF	OFF	OFF
TRQ	Common	Torque Reference (T-Ref)	-	OFF	OFF	OFF
POS	Common	Position Reference (PULS)	ON(ANY)	OFF	ON	OFF
POS	Common	Position Reference Direction	ON(ANY)	ON	OFF	OFF
POS	Common	Analog / Pul Clear Signal	-			OFF

**Filter Section:**

Filter:

Read Product Information Monitor

# Monitors

- IO Signal Allocation
  - Input Terminals
  - Forced Output Mode

“Lo” = closed circuit



Status	Forced Output
Forced Lo	<input type="checkbox"/> Lo

“Hi” = open circuit



Status	Forced Output
Forced Hi	<input checked="" type="checkbox"/> HI

I/O Signal Allocation : 0105

0105-SGD7S-R90F30A

Write Change Method Display List

Allocate Signals

Input Signal Output Signal

Output Signal

Monitor Mode Forced Output Mode

	xis Nam	Status	Forced Output
CN1-1,2		Forced Hi	<input checked="" type="checkbox"/> HI
CN1-23,24	Axis A	Forced Hi	<input checked="" type="checkbox"/> HI
CN1-25,26		Forced Hi	<input checked="" type="checkbox"/> HI

Activate SERVOPACK Outputs

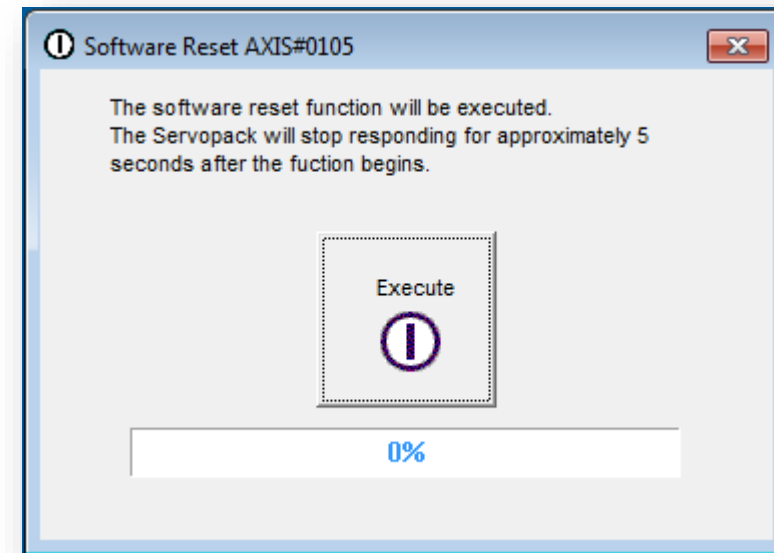
Yaskawa Remote IO

YASKAWA Remote I/O Interface  
2016-05-24 Rev A.05

X Axis	Y Axis	Z Axis
Servo ON	Servo ON	Servo ON
Alarm Reset	Alarm Reset	Alarm Reset
Alarm_X	Alarm_Y	Alarm_Z
Set Speed 0	Set Speed 0	Set Speed 0
Jog+	Jog+	Jog+
Jog-	Jog-	Jog-
Set Distance 0	Set Distance 0	Set Distance 0
Move Rel	Move Rel	Move Rel
Set Position 0	Set Position 0	Set Position 0
Move Abs	Move Abs	Move Abs
Actual Position 0	Actual Position 0	Actual Position 0
Actual Speed 0	Actual Speed 0	Actual Speed 0
Write Pn	Write Pn	Write Pn
AbsEnc-Rst	AbsEnc-Rst	AbsEnc-Rst
Set Zero	Set Zero	Set Zero
Soft Reboot Controller and Servos (wait 30 sec)		
Z Axis Hardware Connection Options		
Abs. Encoder Battery Connected	Control Power Connected	P-OT Conn.
		N-OT Conn.

# Software Reset

- *Basic Functions – Software Reset*
  - *Soft Reboot the SERVOPACK*
  - *Recover from alarms that cannot be cleared*
    - » *Example: A.0b0*
    - » *Example: A.810*



# Monitors

## ■ Life Monitor

### • Installation Environment Monitor

#### » Servopack Temperature

- Range: 0-115%
- 100% = 85 C
- Un25A

#### » Servomotor Temperature

- Range: 0-115%
- Un25B
- 100% = 85 C

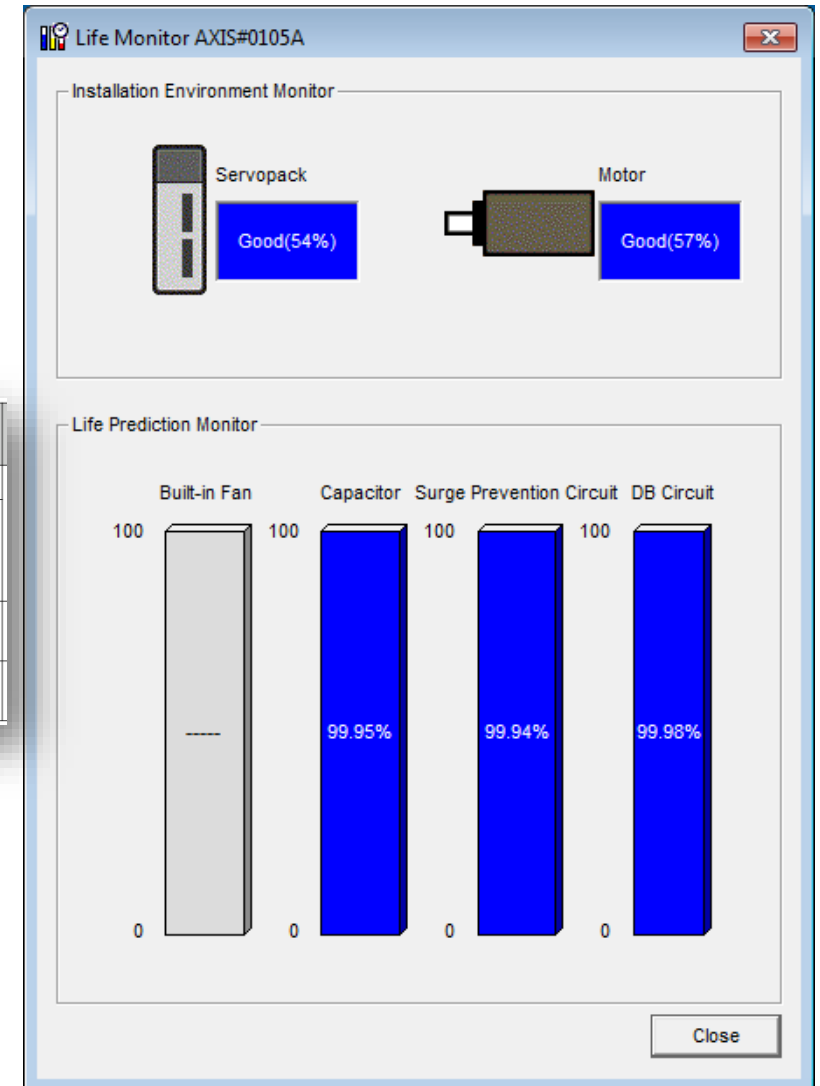
Part	Standard Replacement Period
Cooling Fan	4 to 5 years
Electrolytic Capacitor	10 years
Relays	100,000 power ON operations
Battery	3 years without power supplied

Product Manual 12.1.2

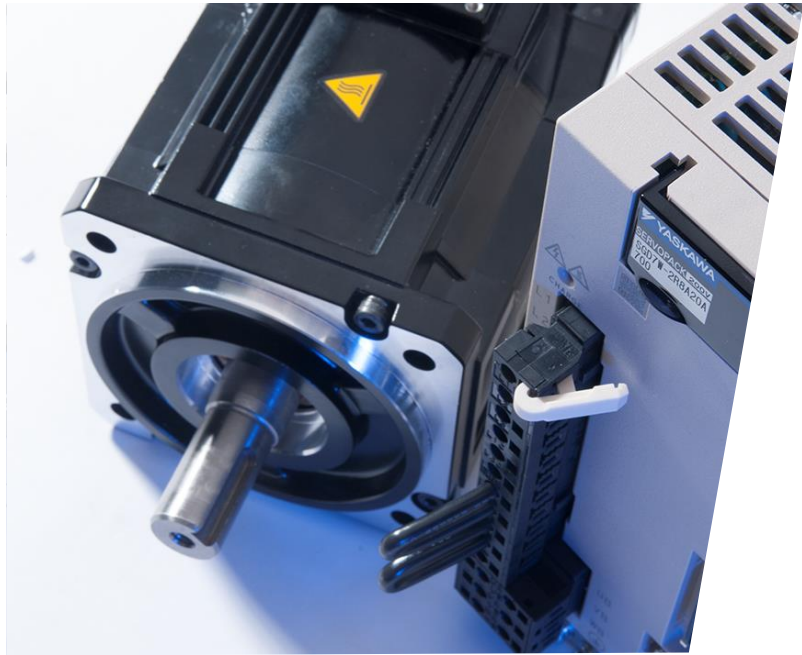
### • Life Prediction Monitor

#### » If Level $\leq 10\%$ → warning A.9b0

- Disable warning Pn00F.0=1







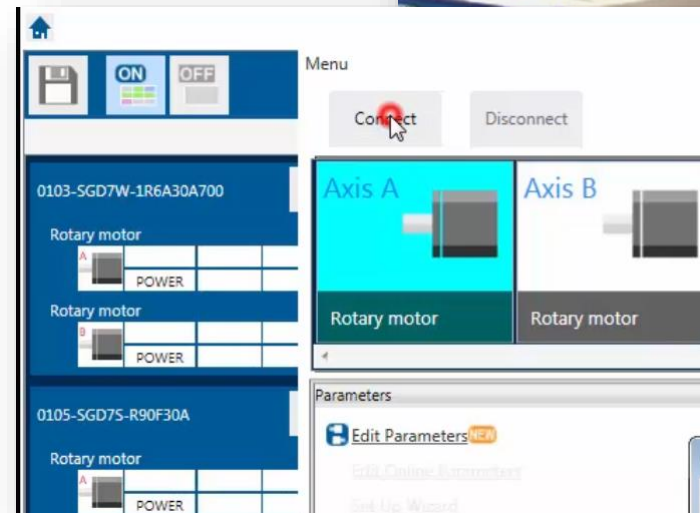
# Sigma-7 & SigmaWin+ Ver.7 Parameters

Backup, restore, and change amplifier settings

- *Connect Project*
- *Backup Parameters*
- *Edit Parameter Settings*
- *Initialize to factory setting*
- *Parameter Restore*

# Status

- *Remote Demo*
- *SW+7 online with project*
  - *Open SW+7*
  - *Home - Open Project*
  - *Menu*
  - *Connect*



# Backup

- *Connect*
- *Open edit parameters for all axes*
- *Save to project*
  - *each servo (not each axis)*
  - *save project*
- *Export*
  - *To another system*

The screenshot shows the 'Edit Parameters' window in YASKAWA SigmaWin+ Ver.7. The window is titled 'SERVOPACK' and contains a toolbar with buttons for 'Read from Servo', 'Write to Servo', 'File', and 'Project'. Below the toolbar is a table of parameters. A dialog box is overlaid on the table, displaying the message: 'The parameter list was temporarily saved in the project file. To complete saving them, click the Save Button in the main window.' The dialog box has an 'OK' button.

No.	Name	Unit	Axis A	Axis B
Pn000.0	Direction Selection	-	0 : Use CCW as t...	1 : Use CW as th...
Pn000.1	Reserved parameter (Do not chang	-	0 : Reserved para...	0 : Reserved para...
Pn002.1	Torque Control Option	-	1 : Use the speed...	1 : Use the speed...
Pn002.2	Absolute Encoder Usage	-	1 : Use the absol...	1 : Use the absol...
Pn002.3	Reserved parameter (Do not chang	-	0 : Reserved para...	0 : Reserved para...
Pn006.0-1	Analog Monitor 1 Signal Selection	-	02 : Torque refer...	02 : Torque refer...

# Edit

- *Category*
- *Edit*
  - *Pn520*
  - *Pn316*
- *Write*
- *Software Reset*
- *Save / Read*
- *Initialize*
- *Import / Export*

No.	Name	Unit	0103-SGD7W-1R6A30A700		*0105-SGD
			Axis A	Axis B	Axis A
Pn502	Rotation Detection Level	min-1	20	20	20
Pn503	Speed Coincidence Detection Signa	min-1	10	10	10
Pn506	Brake Reference-Servo OFF Delay T	10ms	0	0	0
Pn507	Brake Reference Output Speed Lev	min-1	100	100	100
Pn508	Servo OFF-Brake Command Waiting	10ms	50	50	50
Pn509	Momentary Power Interruption Hok	ms	20	20	20
-	-	-	1000	1000	
Pn51B	Motor-Load Position Deviation Over	reference ur			1000
Pn51E	Position Deviation Overflow Warnin	%	100	100	100
Pn520	Position Deviation Overflow Alarm L	reference ur	5242880	5242880	524288000
Pn522	Positioning Completed Width	reference ur	7	7	7
Pn524	Near Signal Width	reference ur	1073741824	1073741824	1073741824
Pn526	Position Deviation Overflow Alarm L	reference ur	5242880	5242880	5242880
Pn528	Position Deviation Overflow Warnin	%	100	100	100
Pn529	Speed Limit Level at Servo ON	min-1	10000	10000	10000
-	-	-	20	20	
Pn52A	Multiplier per Fully-closed Rotation	%			20

Details in Help section 4.2.3 “Setting Individual Parameters”

# Initialize to Factory Default

- *Compare*
- *Initialize*
- *SW reset*

The screenshot shows the YASKAWA SERVOPACK software interface. The top menu bar includes options like 'Read from Servo', 'Write to Servo', 'File', and 'Project'. A dialog box is open in the center, showing a progress bar and the text 'Initializing'. The background shows a parameter list for Axis A, with the 'Reserved parameter' row highlighted.

No.	Parameter Name	Value
Pn000.		0 : Use CCW as t...
Pn000.		0 : Reserved para...
Pn000.		0 : Reserved para...
Pn000.		0 : Start as a rota...
Pn001.		0 : Stop the moto...
Pn001.		1 : Decelerate the...
Pn001.		0 : Input AC pow...
Pn001.		0 : Reserved para...
Pn002.		1 : Use TLIM as t...
Pn002.		1 : Use the speed...
Pn002.2	Absolute Encoder Usage	-
		1 : Use the absol...

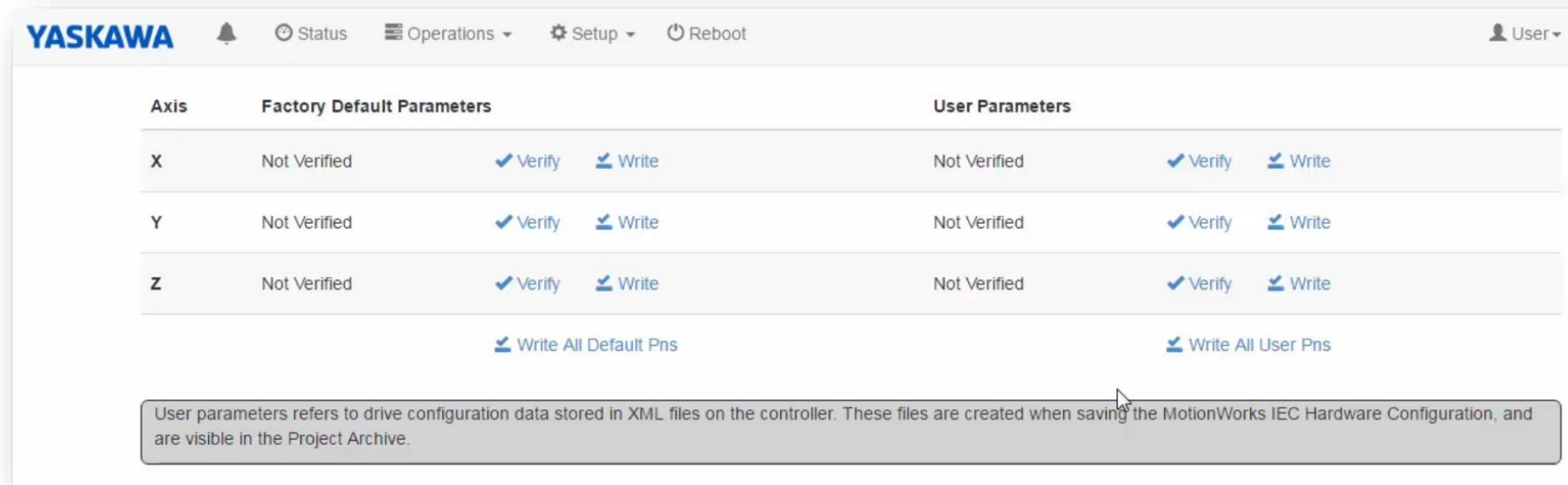
# Restore from Project

- *Read from Project*
- *Write Parameters*
- *Software Reset*

The screenshot displays the 'SERVOPACK' software interface. At the top, there are several toolbars: 'Read from Servo' (with 'Edited Parameters' and 'All Parameters' buttons), 'Write to Servo' (with 'Edited Parameters', 'All Parameters', and 'Save to Flash Memory' buttons), 'File' (with 'Import' and 'Export' buttons), and 'Project' (with 'Save to Project' and 'Read from Project' buttons). Below these toolbars is a table of parameters for a servo motor. The table has columns for 'No.', 'Unit', and two axes: 'Axis A' and 'Axis B'. The 'No.' column lists parameters from Pn000.0 to Pn002.3. The 'Unit' column shows various units like '—', 'r/min', 'mm', and 'V'. The 'Axis A' and 'Axis B' columns show parameter values and descriptions, such as '0 : Use CCW as t...' and '1 : Use CW as th...'. A 'Parameter List' dialog box is overlaid on the table, showing a dropdown menu with 'SERVOPACK' and '0105-SGD7S-R90F30A' selected. Below the dropdown is a list of parameter sets with timestamps: '11/10/2016 4:45:36 PM', '11/10/2016 4:38:07 PM', and '11/10/2016 4:25:52 PM'. The 'Read' button is highlighted, and a mouse cursor is pointing at it.

No.	Unit	0103-SGD7W-1R6A30A700	Axis A	Axis B
Pn000.0	—		0 : Use CCW as t...	1 : Use CW as th...
Pn000.1	—		0 : Reserved para...	0 : Reserved para...
Pn000.2	—		0 : Reserved para...	0 : Reserved para...
Pn000.3	—		0 : Start as a rota...	0 : Start as a rota...
Pn001.0	—		0 : Stop the moto...	0 : Stop the moto...
Pn001.1	—		1 : Decelerate the...	1 : Decelerate the...
Pn001.2	—		0 : Input AC pow...	0 : Input AC pow...
Pn001.3	—		0 : Reserved para...	0 : Reserved para...
Pn002.0	—		1 : Use TLIM as t...	1 : Use TLIM as t...
Pn002.1	—		1 : Use the speed...	1 : Use the speed...
Pn002.2	—		1 : Use the absol...	1 : Use the absol...
Pn002.3	—		0 : Reserved para...	0 : Reserved para...

# Write All User Pns



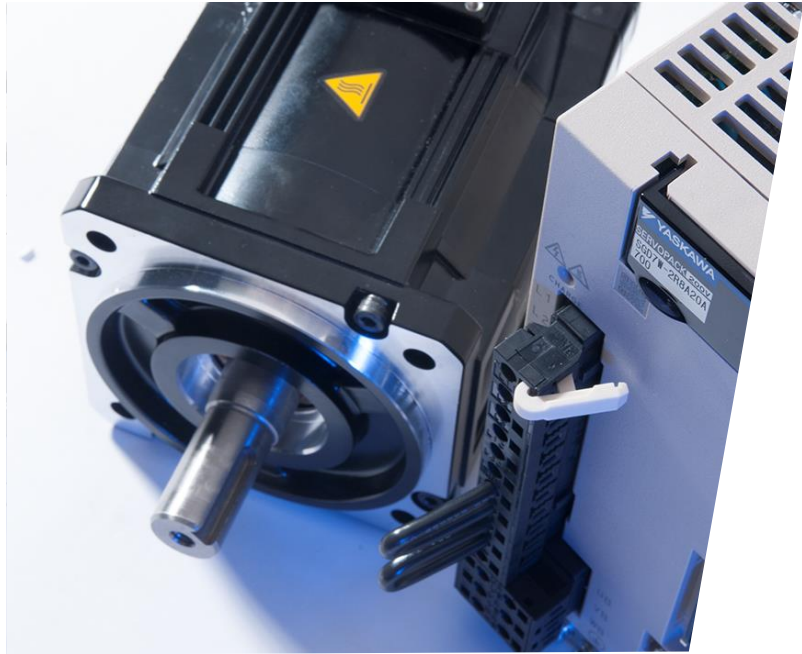
The screenshot shows the YASKAWA web interface for parameter management. At the top, there is a navigation bar with the YASKAWA logo, a notification bell, and menu items for Status, Operations, Setup, and Reboot. A user profile icon labeled 'User' is in the top right. Below the navigation bar is a table with two main columns: 'Factory Default Parameters' and 'User Parameters'. Each column contains three rows for axes X, Y, and Z. Each row shows 'Not Verified' status and 'Verify' and 'Write' buttons. At the bottom of each column, there is a 'Write All' button. A tooltip at the bottom of the screen explains that user parameters are stored in XML files on the controller and are visible in the Project Archive.

Axis	Factory Default Parameters	User Parameters
X	Not Verified <a href="#">Verify</a> <a href="#">Write</a>	Not Verified <a href="#">Verify</a> <a href="#">Write</a>
Y	Not Verified <a href="#">Verify</a> <a href="#">Write</a>	Not Verified <a href="#">Verify</a> <a href="#">Write</a>
Z	Not Verified <a href="#">Verify</a> <a href="#">Write</a>	Not Verified <a href="#">Verify</a> <a href="#">Write</a>

[Write All Default Pns](#) [Write All User Pns](#)

User parameters refers to drive configuration data stored in XML files on the controller. These files are created when saving the MotionWorks IEC Hardware Configuration, and are visible in the Project Archive.

- *Recover in Web UI*
  - *Login*
  - *Setup – Drive Parameters*
  - *Write All User Pns*



# Sigma-7 & SigmaWin+ Ver.7 Motor Test Run

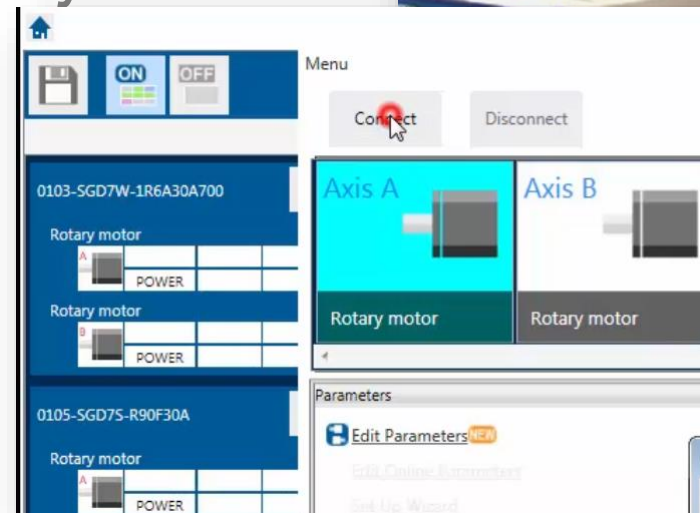
Basic motor Jog and positioning

- *Jog*
- *Program Jog*



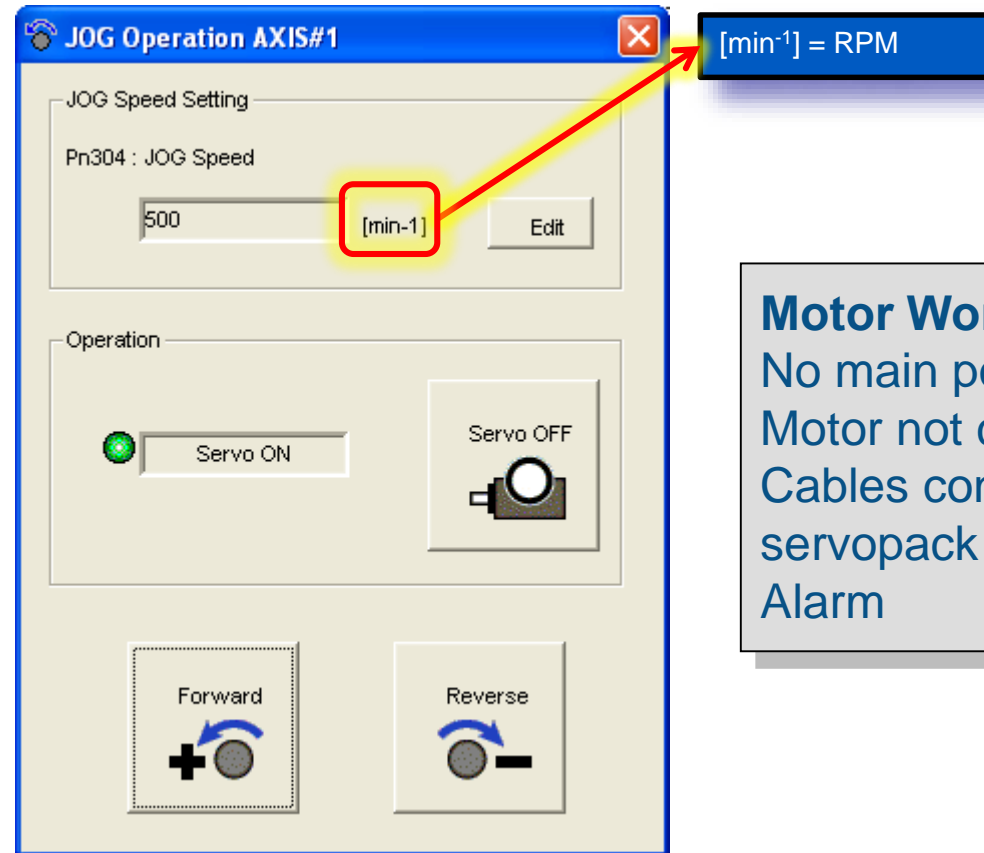
# Remote Demo

- *Demo Status*
  - *Servos off*
- *SW+7 online with project*
  - *Open SW+7*
  - *Home - Open Project*
  - *Menu*
  - *Connect*



# Jog Operation

- *SGD7S Menu*
- *Test Run – Jog*
- *Edit Speed*
- *Servo ON*
- *Hold “Forward”*



## Motor Won't Jog?

No main power  
Motor not connected  
Cables connected to wrong servopack  
Alarm

# Jog & Over-Travel

- *Over-Travel are Amplifier Inputs*
- *No p-n display during Jog Operation*
- *Startup and maintenance*

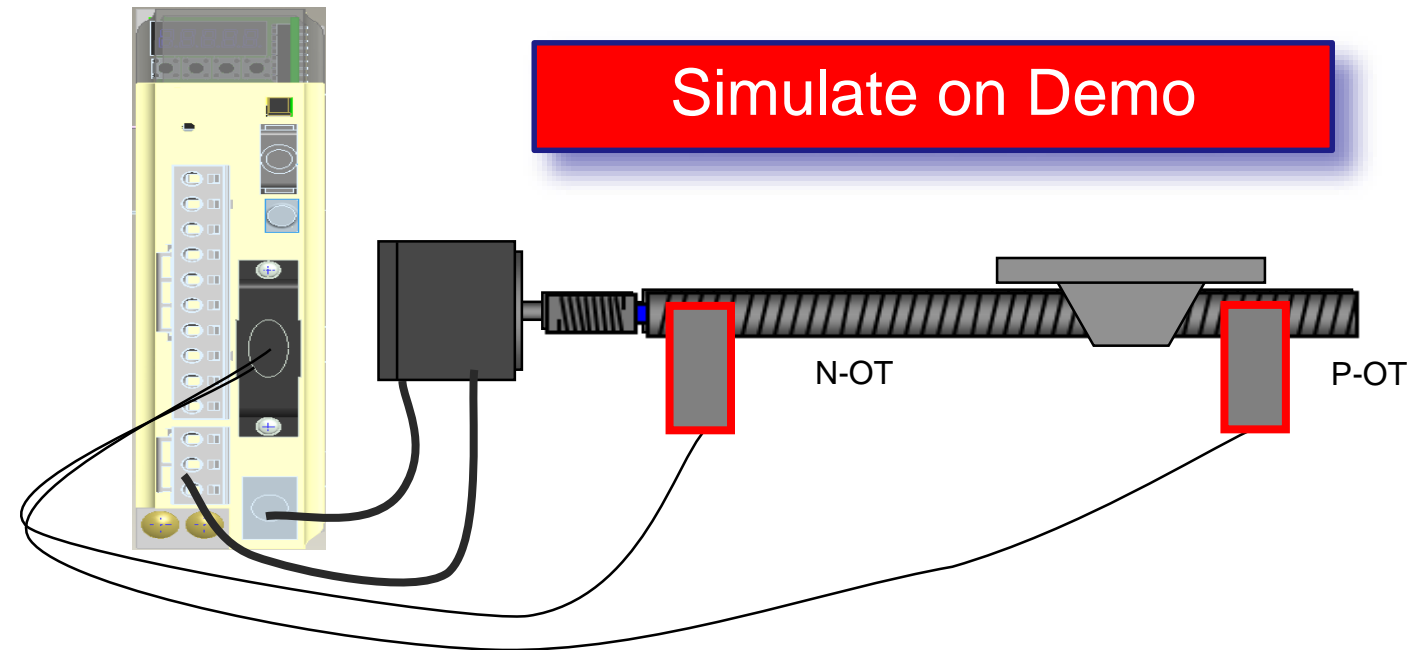
## Motor Won't Jog?

Alarm

No main power

Motor not connected

Cables connected to wrong servopack

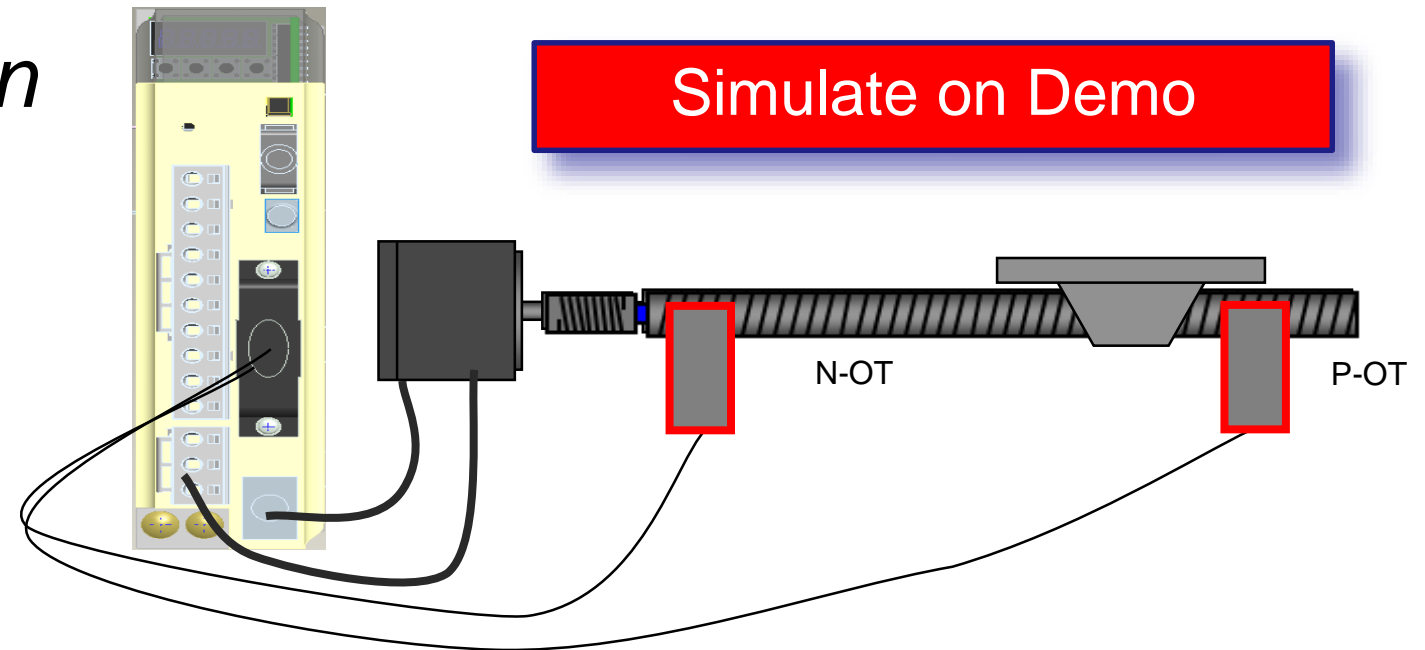


JOG Operation ignores P-OT and N-OT

# Troubleshooting

- *Alarm*
- *Main Power Connection*
- *Motor Connection*
  - *Cables mixed up?*

Simulate on Demo

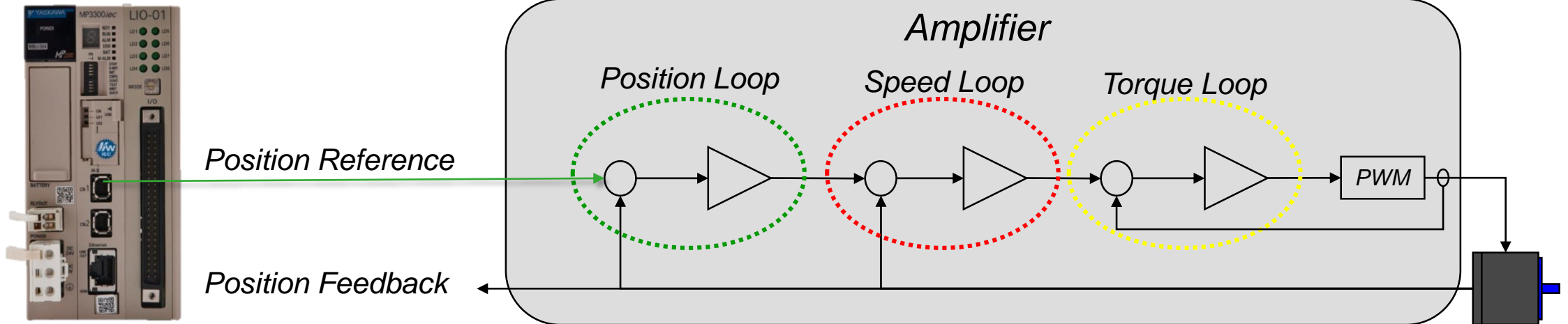
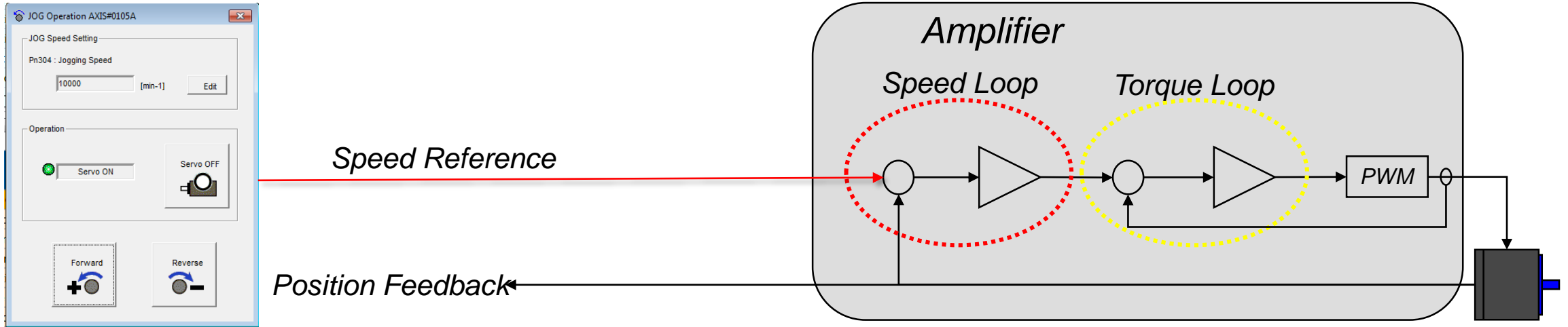


## Motor Won't Jog?

Alarm  
No main power  
Motor not connected  
Cables connected to wrong servopack

JOG Operation ignores P-OT and N-OT

# Jog Theory of Operation



# Program Jog

- *Program Jog is a simple motion controller inside the servo*
  - *Move profile saved in Pn530 – Pn536*

Jog Program AXIS#0105A

AUTO [min-1/div]

4000  
3500  
3000  
2500  
2000  
1500  
1000  
500  
0  
-500  
-1000

0 247 494 741 988 1235

FULL [ms/div]

Running Condition

Pn531: Program Jogging Travel Distance  
167772160 [reference units] (1-1073741824)

Pn533: Program Jogging Movement Speed  
3000 [min-1] (1-10000)

Pn534: Program Jogging Acceleration/Deceleration  
35 [ms] (2-10000)

Pn535: Program Jogging Waiting Time  
1000 [ms] (0-10000)

Pn536: Program Jogging Number of Movements  
0 [times] (0-1000) (0: Infinite)

Pn530.0: Program Jogging Operation Pattern  
0 : (Waiting time in Pn535 -> Forward by travel d)

Apply

Run

Running Information

Total Time 1236[ms][times]

The total amount of movements +167772160[reference units][times]

10 Rotations  
Units = Encoder Pulse

Pn536=0 for infinite repeat

# Program Jog

- Repeat Options

- 0: Infinite

Program JOG Operation AXIS#42

AUTO [min-1/div]

FULL [ms/div]

Running Condition

Pn531:Program JOG Movement Distance  
10485760 [reference units] (1-1073741824)

Pn533:Program JOG Movement Speed  
3000 [min-1] (1-10000)

Pn534:Program JOG Acceleration/Deceleration Time  
35 [ms] (2-10000)

Pn535:Program JOG Waiting Time  
750 [ms] (0-10000)

Pn536:Number of Times of Program JOG Movement  
3 [times] (0-1000) (0: Infinite)

Pn530.0:Program JOG Operation Related Switch  
4 : (Waiting:Pn535 -> Forward:Pn531 -> Waiting: )

Apply

Run

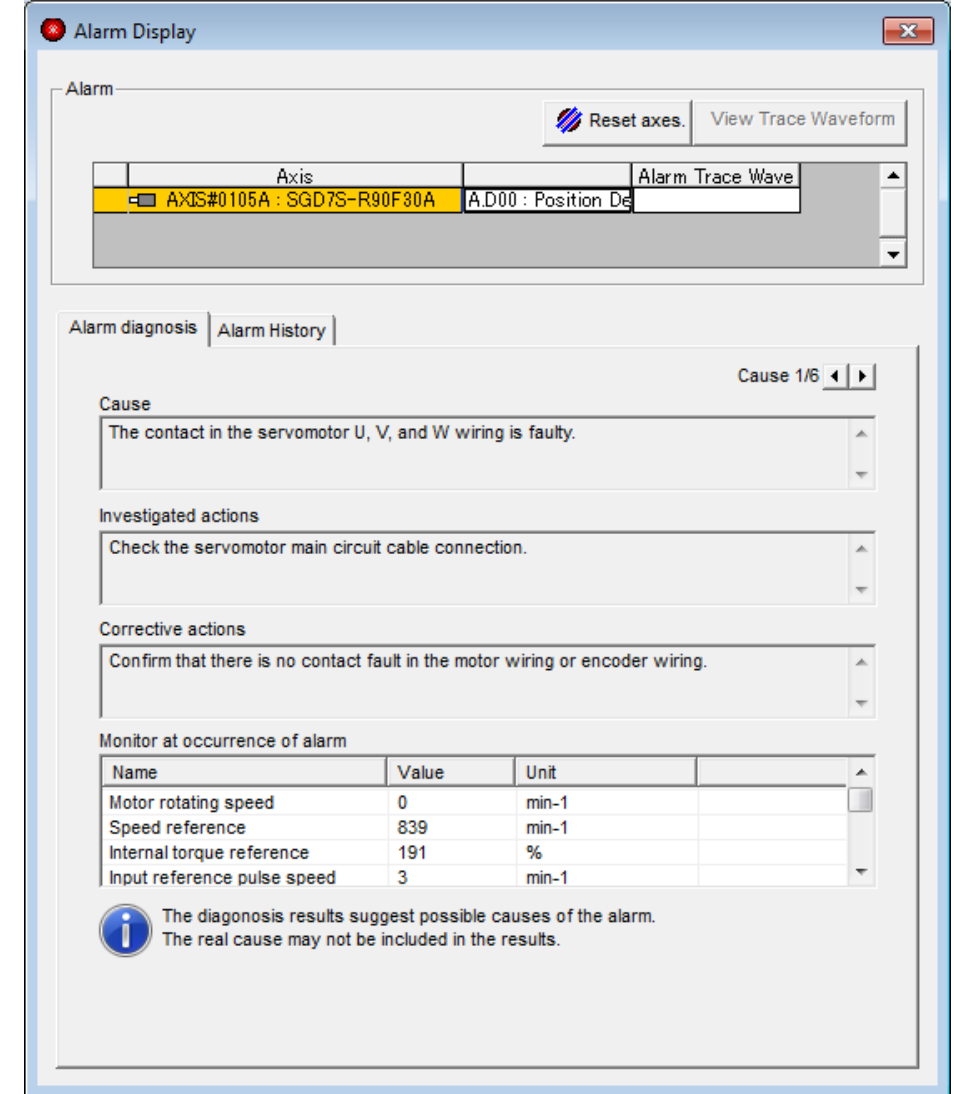
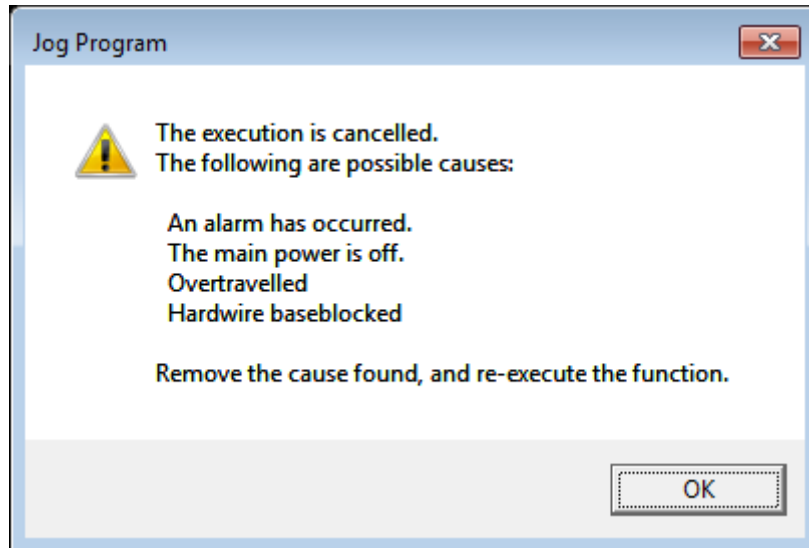
Running Information

Total Time 5916[ms]

The total amount of movements +0[reference units]

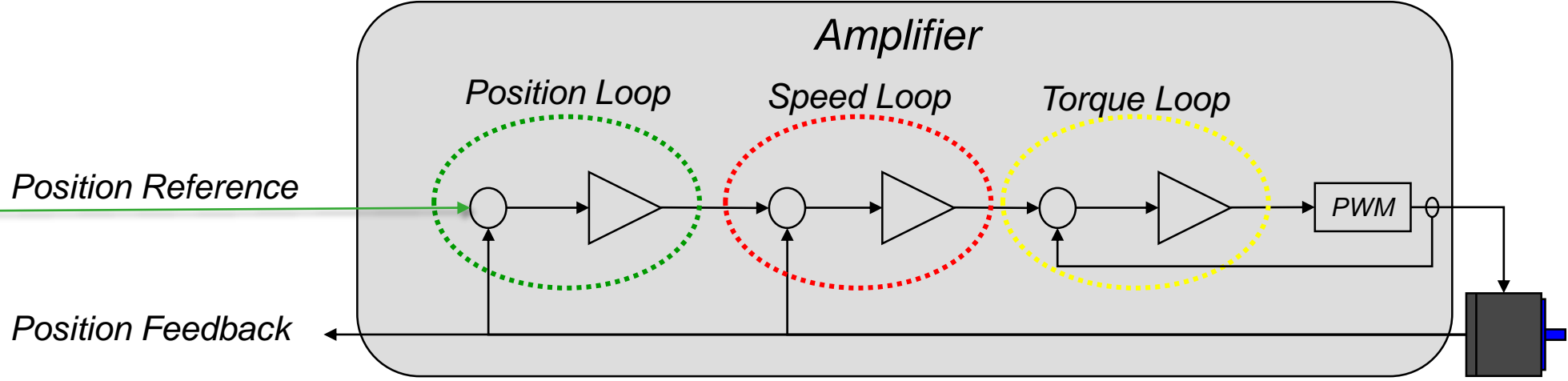
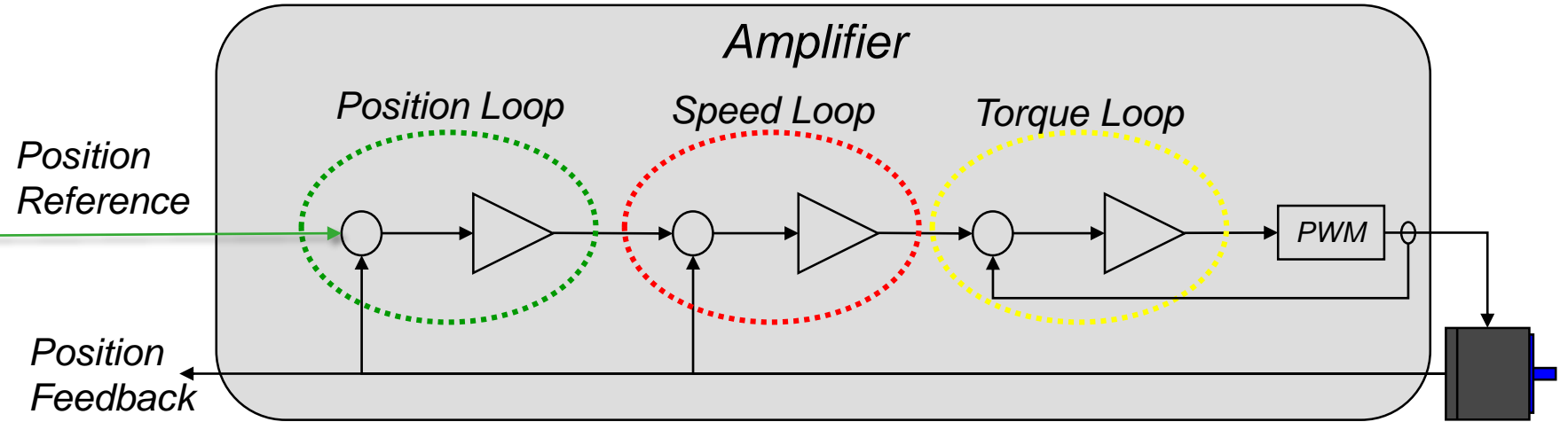
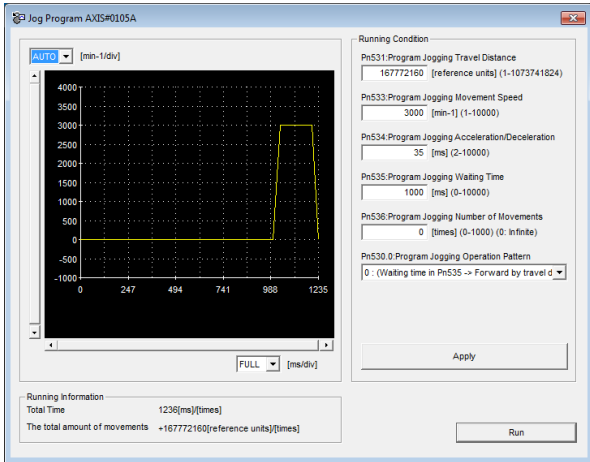
# Program Jog

- *Alarm A.D00: Position Deviation Overflow*
  - *What parameter setting may be involved?*
  - *Clear the alarm*
  - *Edit the parameter*
  - *Execute Program Jog*



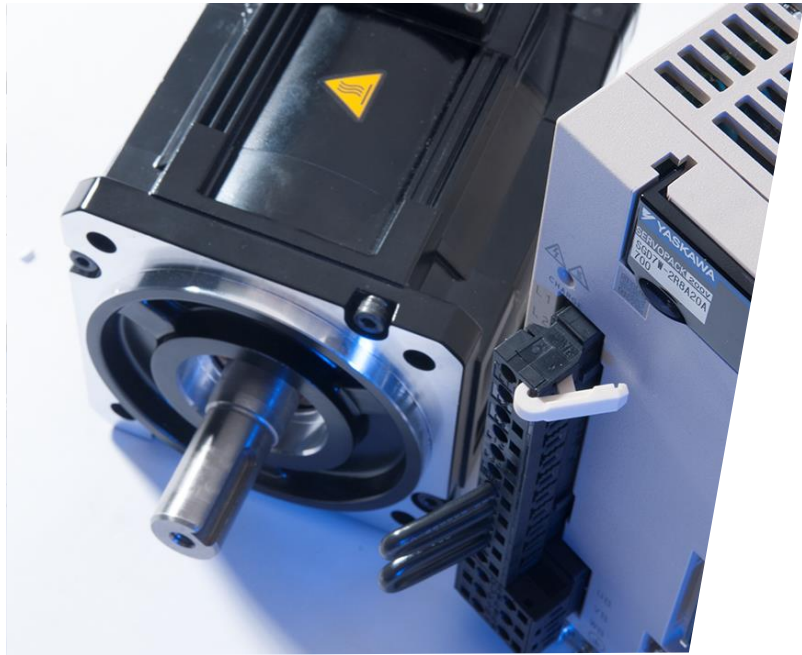


# Program Jog Theory of Operation



# Recovery

- *Cancel*
  - *Running condition resetting*
- *Parameter save to project*
- *System Reboot*
  - *Servo on results in A.0B0*
- *Verify machine position*



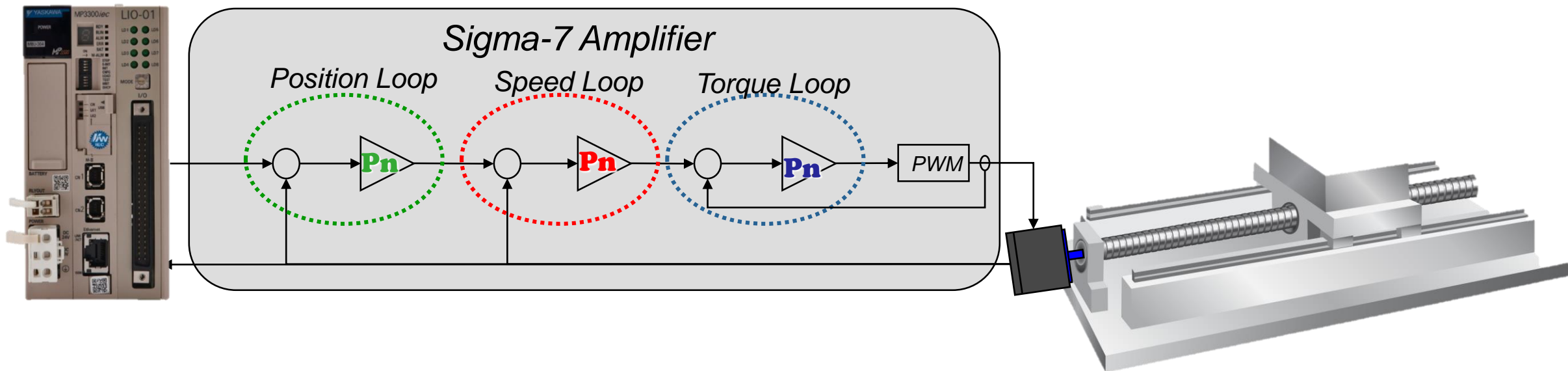
# Sigma-7 Servo Tuning Servo Tuning Basics

Basic Concepts for Sigma-7 Servo Tuning

- *What is Tuning?*
- *Control Loops*
- *Bandwidth*
- *Tuning Process*
- *Sigma-7 Tuning: Three Methods*
- *When is Tuning Required*
- *Mechanical System Check*

# What is Tuning?

- *Optimizing how the amplifier responds to feedback*
- *Adjusting the error compensation of the control loops*
  - *Torque*
  - *Speed*
  - *Position*



# Control Loops

## Position

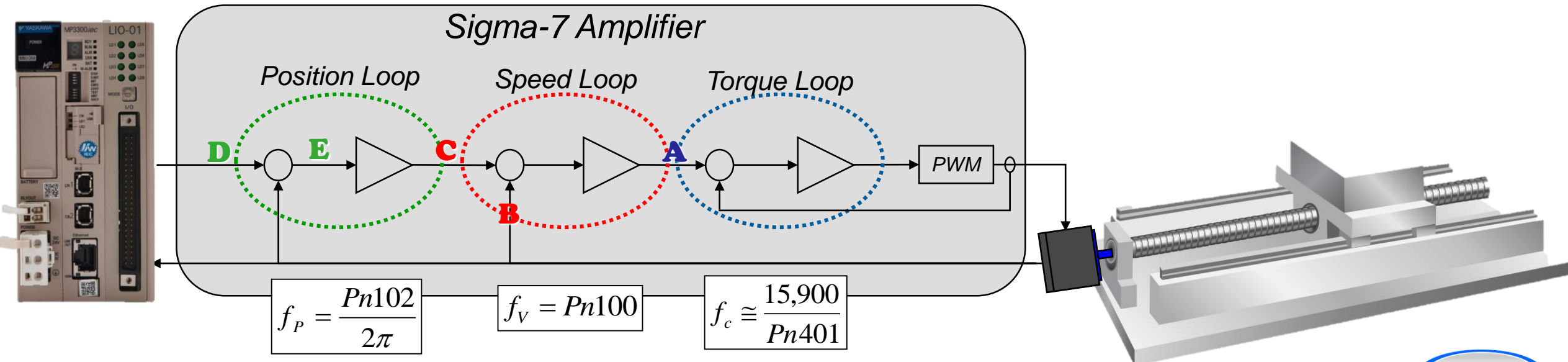
- Tune to load
- Position Ref. Speed (D)
- Position Error (E)

## Speed

- Tune to load
- Speed Ref. (C)
- Feedback Speed (B)

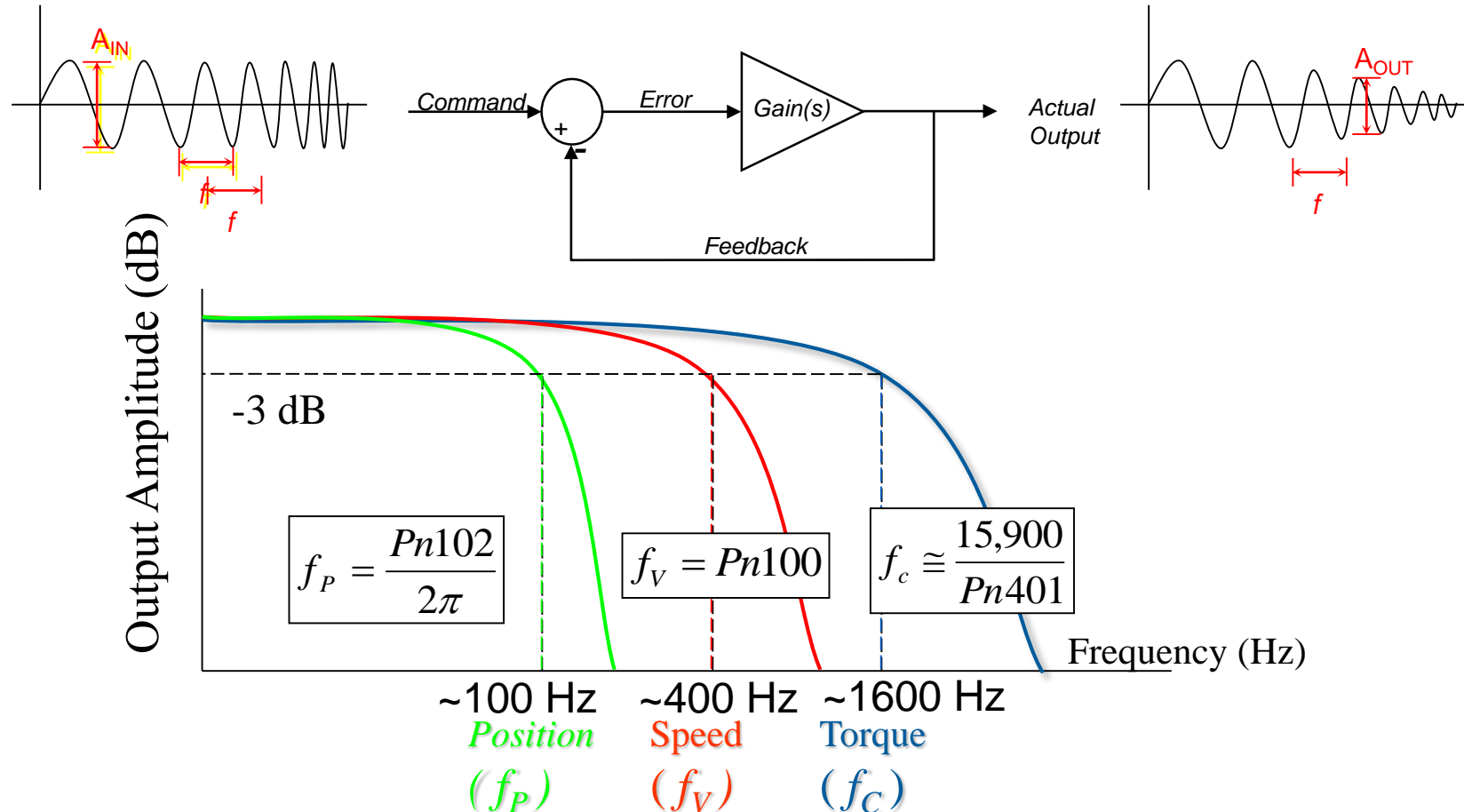
## Torque

- Torque Ref. (A)
- Tune To motor
- Factory Set
- Filters



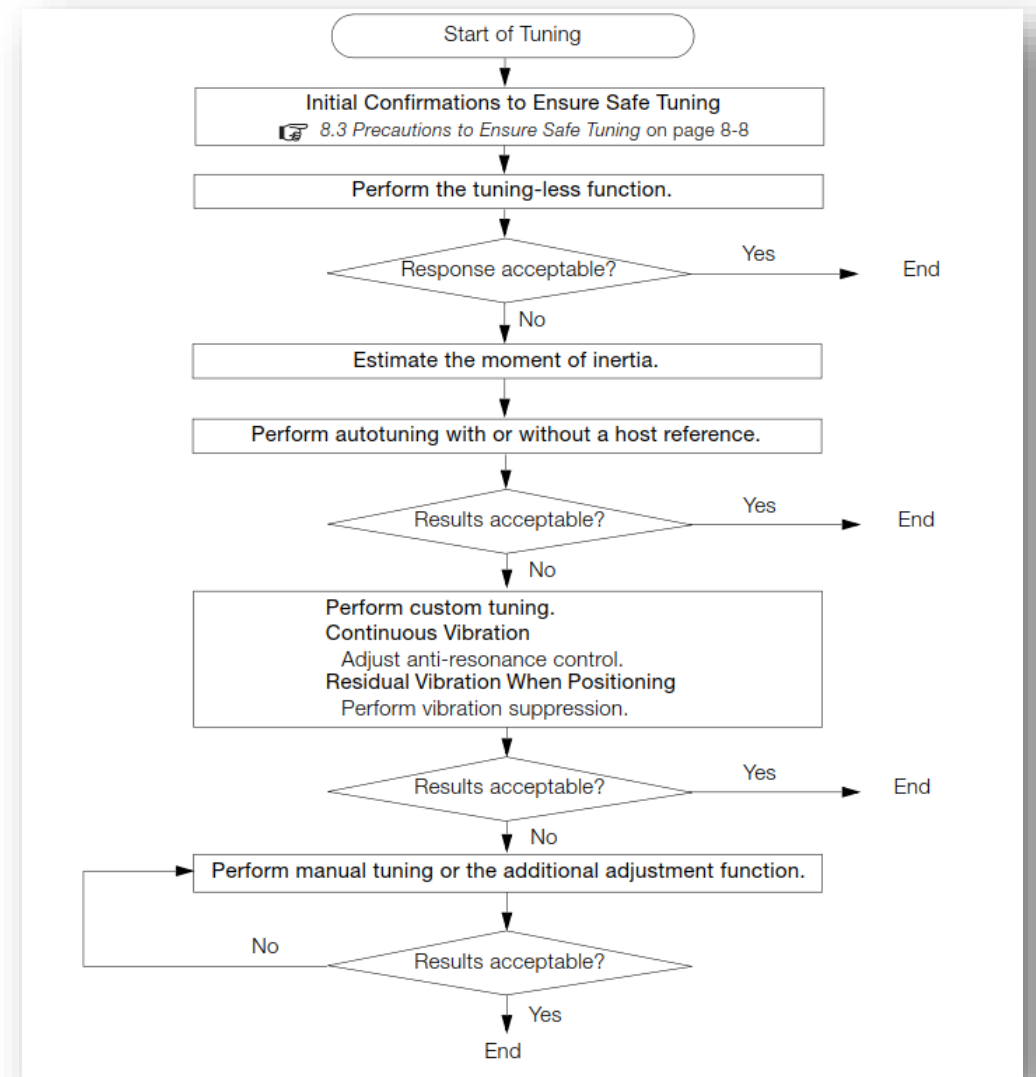
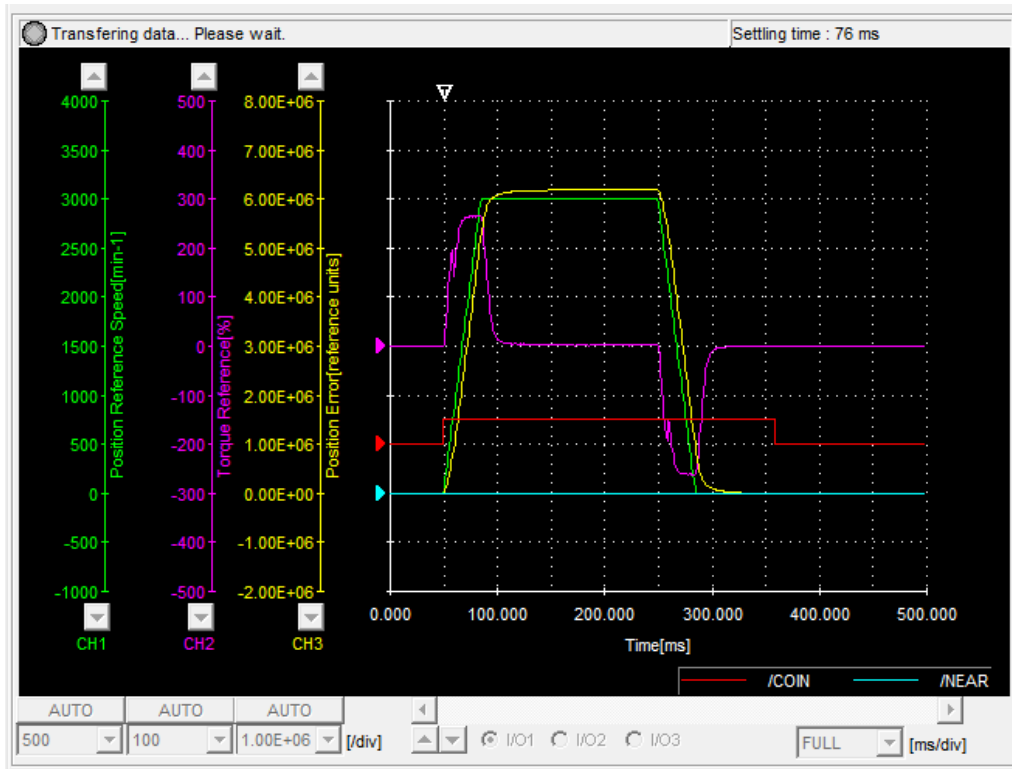
# Control Loop Bandwidth

- Bandwidth determined by tuning parameters
- Maintain stable bandwidth ~ 4x separation between loops
- Use SigmaWin+ Advanced Auto Tuning and Custom Tuning

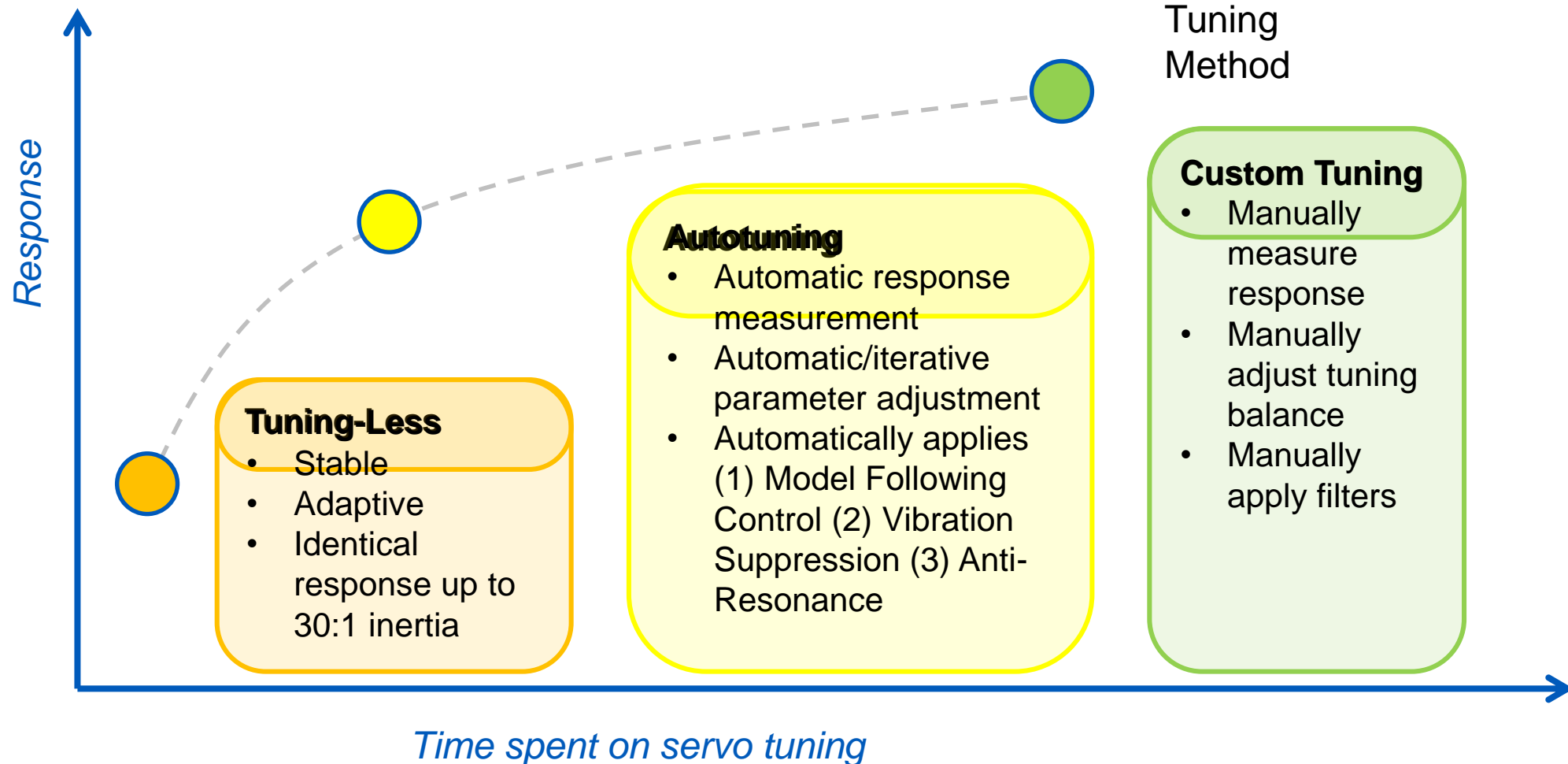


# Tuning Process

1. *Worst-case move profile*
2. *Is response acceptable?*
3. *Adjust or apply new tuning method*



# Sigma-7 Tuning Methods

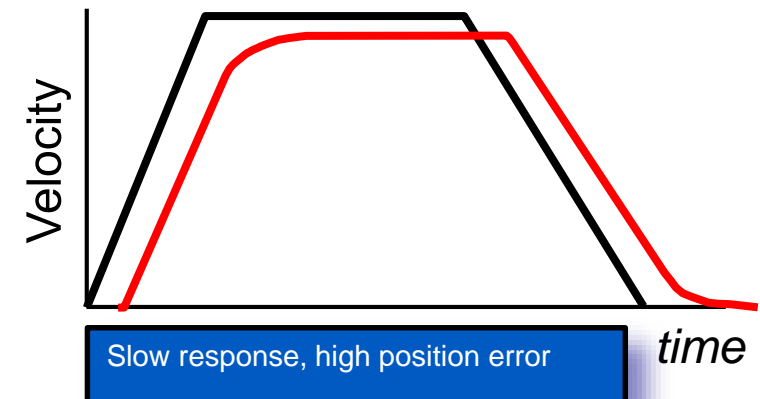
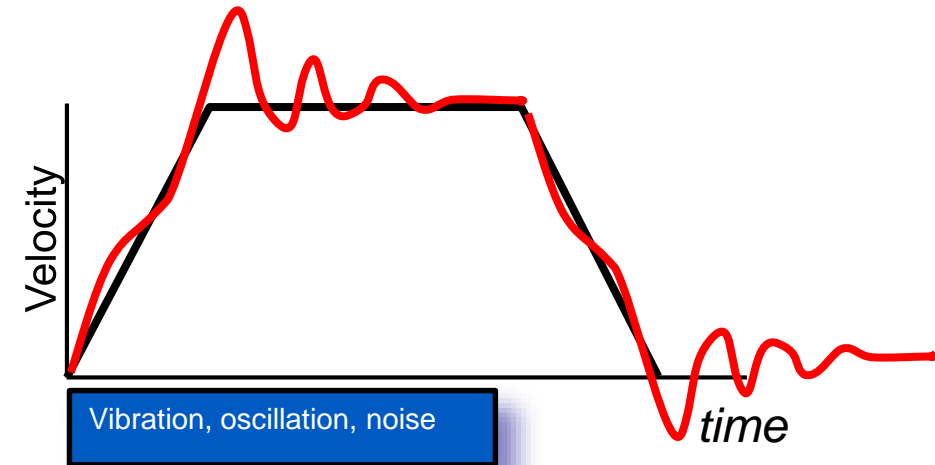
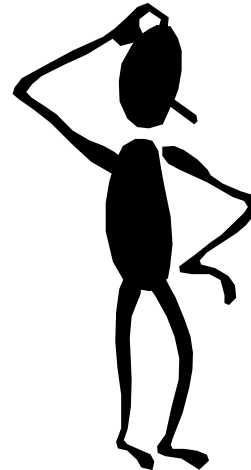




# When is Tuning Required?

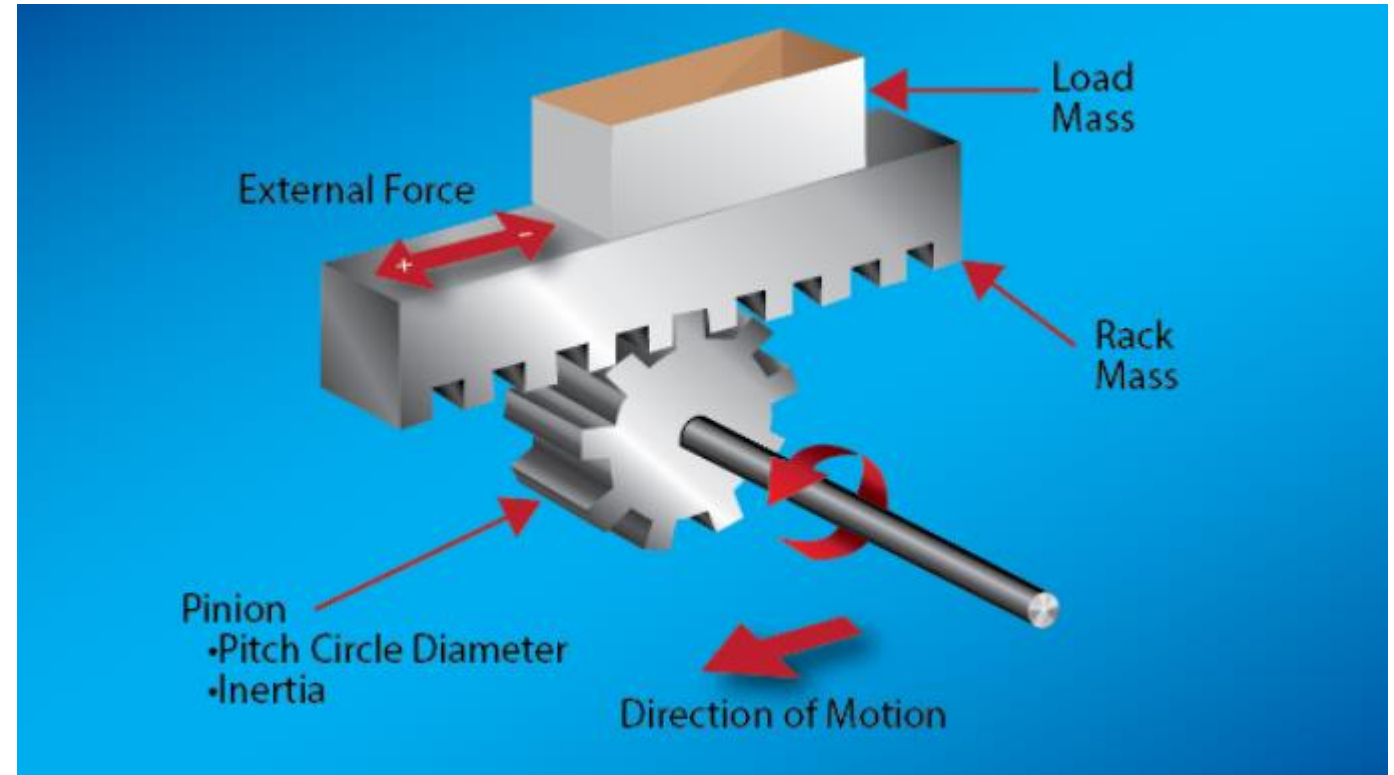
- *Slow response*
- *Noisy operation*
- *Vibration or oscillation*
- *Alarms*
  - *Torque overload*
  - *Overspeed*
  - *Position error*
- *Graph Response*

For many applications the factory default tuning is OK

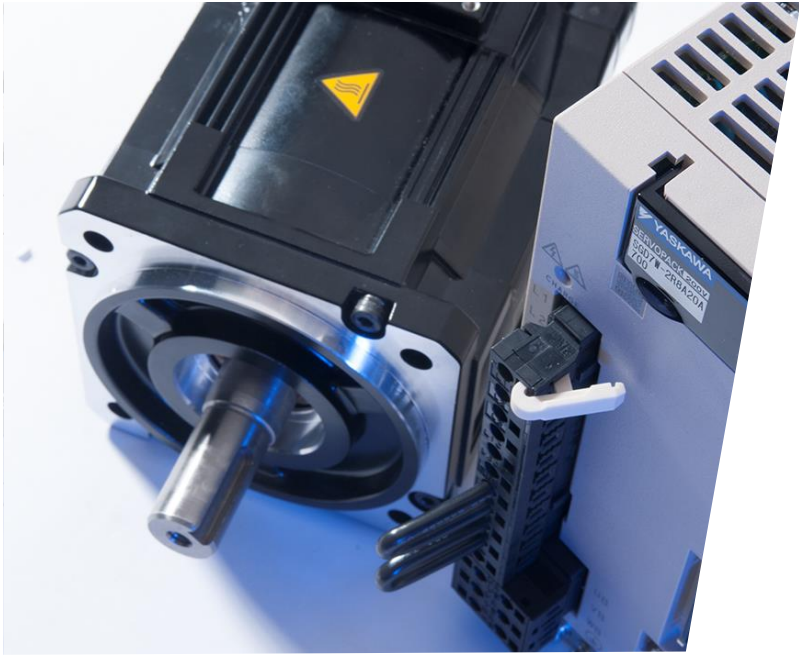


# Mechanical System Check

- *Loose parts*
  - *Belt*
  - *Coupling*
- *High Friction*
  - *Brakes*
  - *Components dragging*
  - *Lubricant*
- *Servo Flexible Coupling*
  - *Alignment*
  - *Zero Backlash*
  - *Torsional Stiffness*
  - *Bellows, Spider, Helical*
- *Large Inertia*
- *Mechanical Compliance*



Check the mechanical system integrity before tuning!

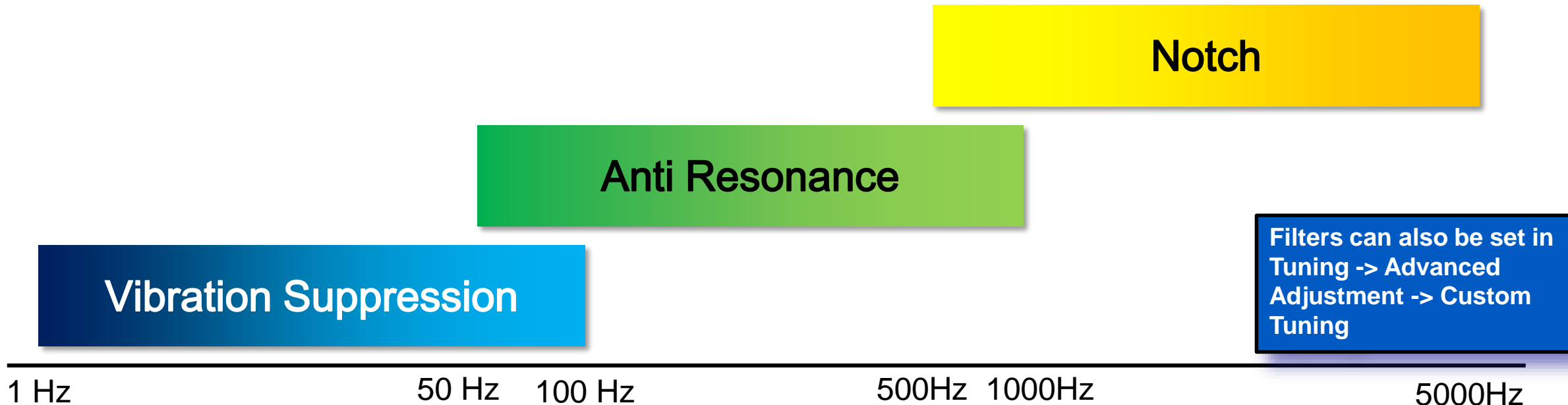


# Sigma-7 Servo Tuning Tuning Filters

Reduce noise and vibration at different frequencies

- *Overview*
- *Mechanical Analysis (FFT)*
- *Notch Filter*
- *Anti-Resonance Filter*
- *Vibration Suppression Filter*

# Overview



Filters can also be set in  
Tuning -> Advanced  
Adjustment -> Custom  
Tuning

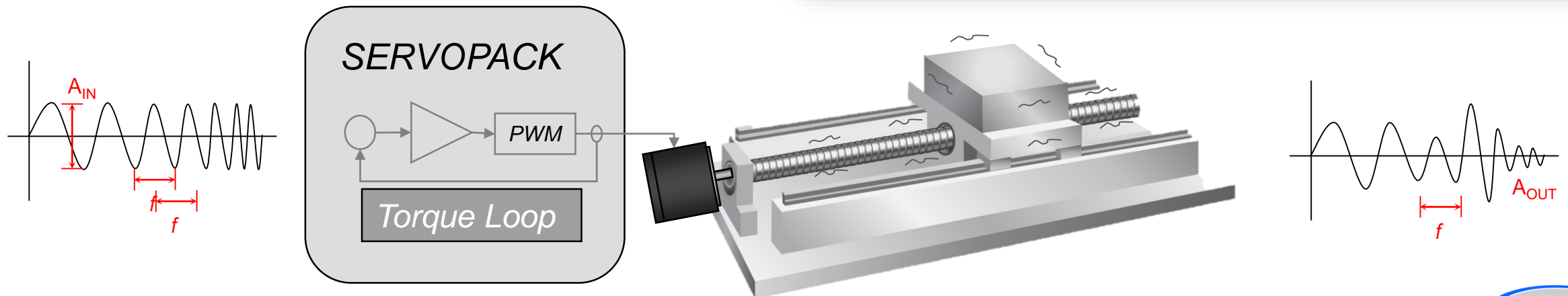
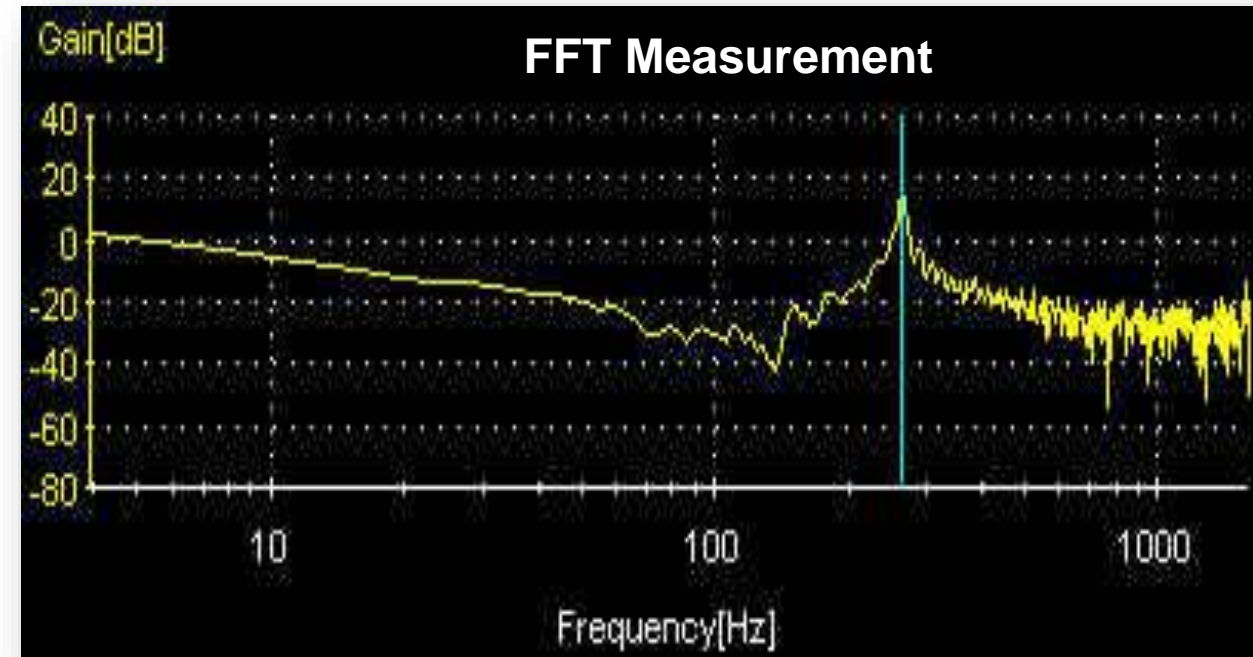
- *Control Mode: Position*
  - » *only when Model Following Control enabled Pn140.0=1*
- *Automatic Setting: During Advanced Auto-Tuning*
- *Manually Adjust*
  - » *Pn140, Pn145, Pn146, Pn14A, Pn14B*

- *Control Mode: Speed, Position*
- *Automatic Setting: During Advanced Auto-Tuning*
- *Manually Adjust*
  - » *Pn160-Pn165*

- *Control Mode: Torque, Speed, Position*
- *Automatic setting: Always active (Pn460)*
- *Manually adjust*
  - » *Pn409-Pn40E*

# Mechanical Analysis

- **FFT**
  - *Fast Fourier Transform*
- **Bode plot**
  - *Gain vs. Frequency [Hz]*
- **Algorithms recognize and cancel frequencies**



# Mechanical Analysis

- *Machine response from 0 Hz to 3200 Hz*
- *A peak in the gain graph means there is resonance at that frequency*
  - *Sampling Time*
    - » *Controls the maximum measurement frequency.*
    - » *Increase the time to show more detail at low frequency.*
  - *Excitation Amplitude*
    - » *Peak-to-peak sinusoidal torque waveform that will be generated.*
    - » *Set according to machine's typical operating torque level*

Mechanical Analysis (Reference Conditions Setting)

Reference Conditions Setting → Reference Transmission → Excitation / Measurement

Please set Reference Conditions for analysis.

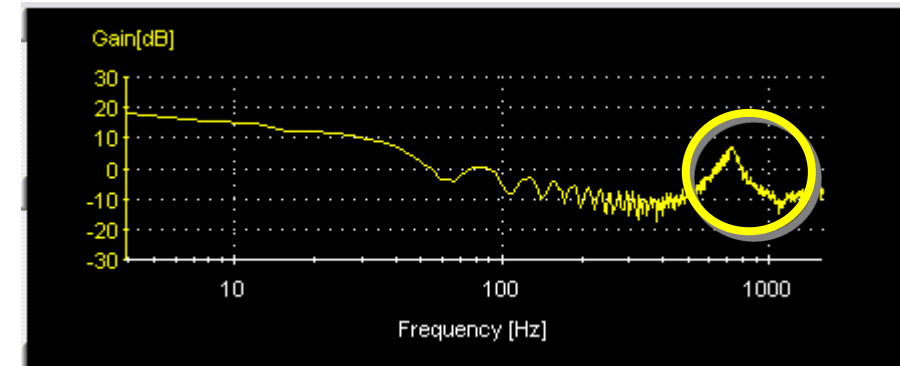
Driving Mode Selection  
 Horizontal mode  Vertical mode

Sampling Time: 125 [us]      Measurement Frequency: 3200.00 [Hz]      Excitation Time/iteration: 125 [ms]

Excitation Signal: Cycle wave  
 Excitation Amplitude: ± 50 [%]  
 Allowable Rotations: 1 [Rotations]  
 No. of Measurements: 2 [Sets]  
 Line color: [Yellow]

**CAUTION**  
 The servomotor may turn up to the Allowable Rotations per one excitation. Please confirm the allowable rotation ranges of your machine, and always set an appropriate value.

Reference Conditions Setting File

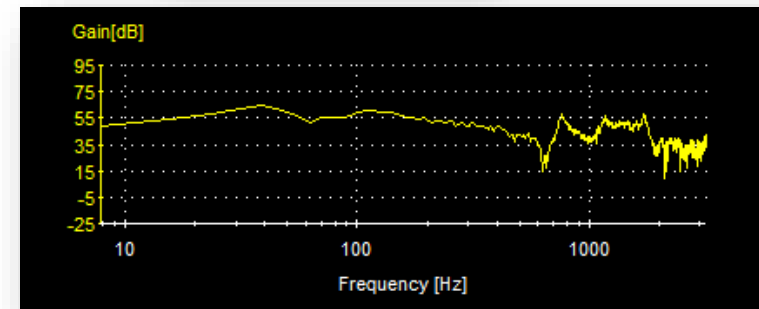
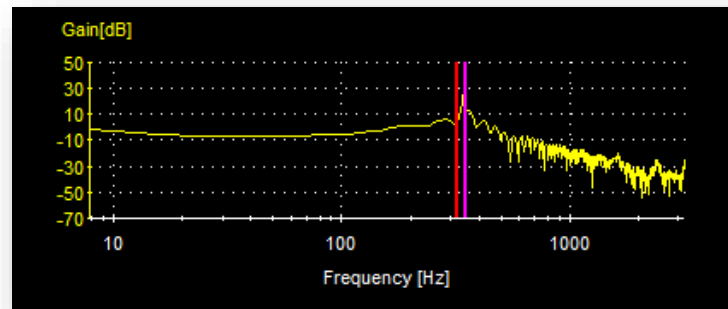
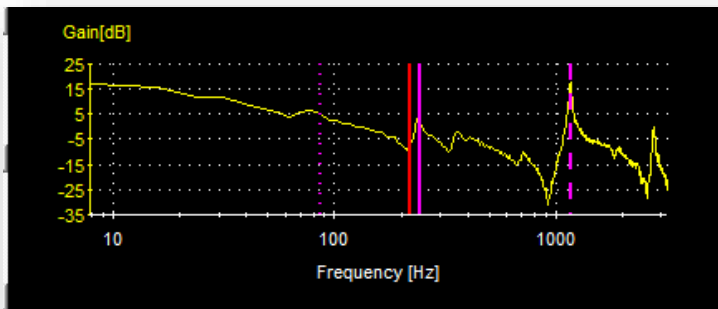
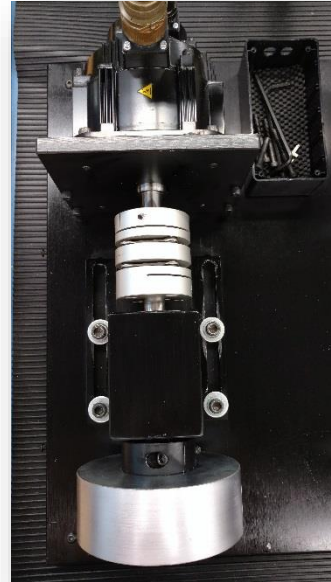


# Mechanical Analysis

- *Ballscrew*

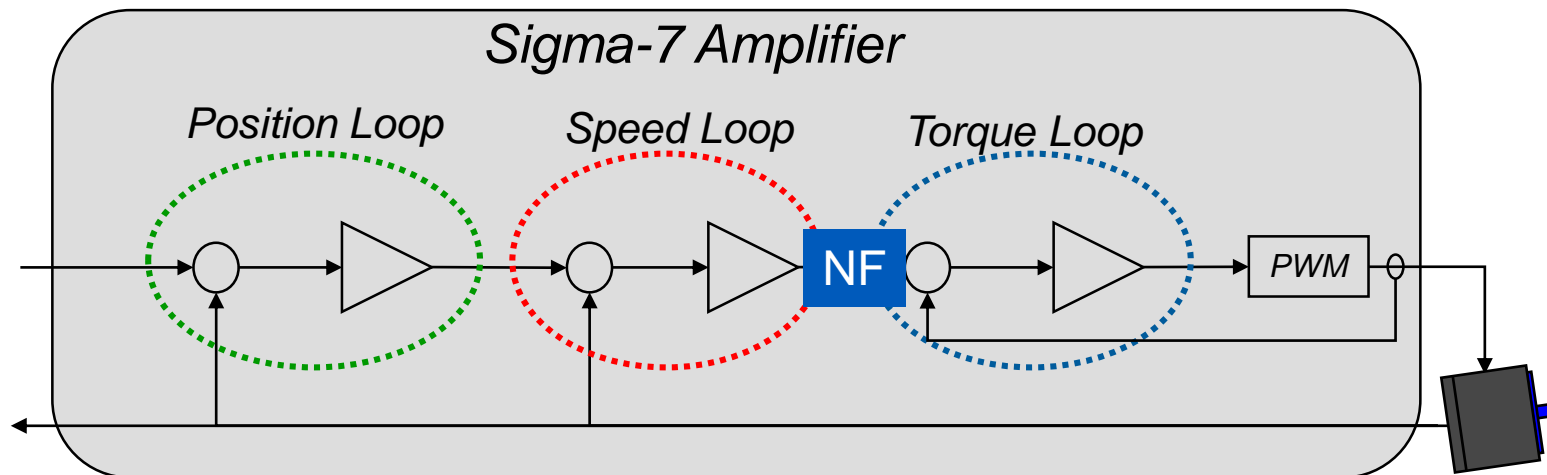
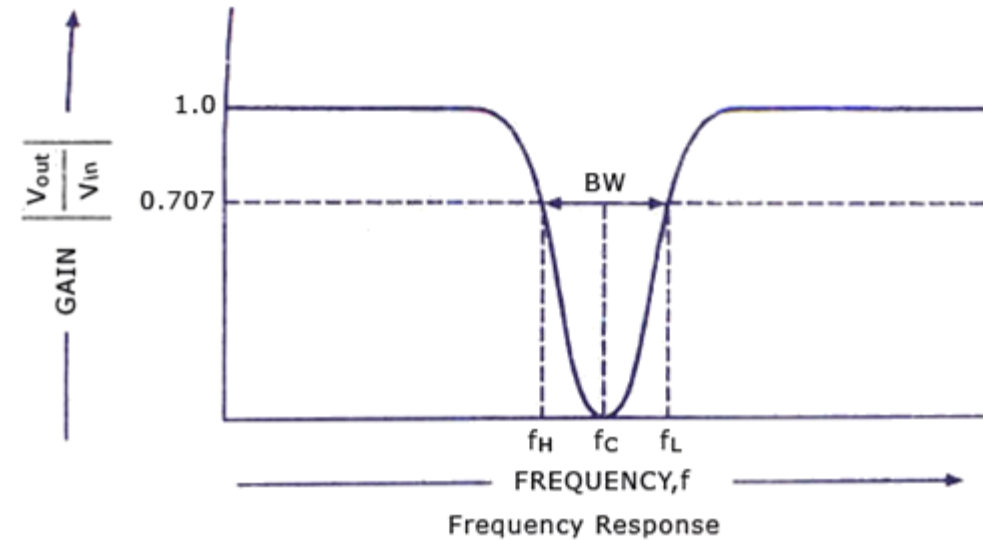
- *Rotary Drive*

- *SigmaTrac*



# Notch Filter

- *Range: 50-5000 Hz*
  - *Most effective above 500Hz*
- *Automatic Notch Filter*
  - *Pn460*
  - *High Frequencies >500Hz*
- *5 Notch Filters*





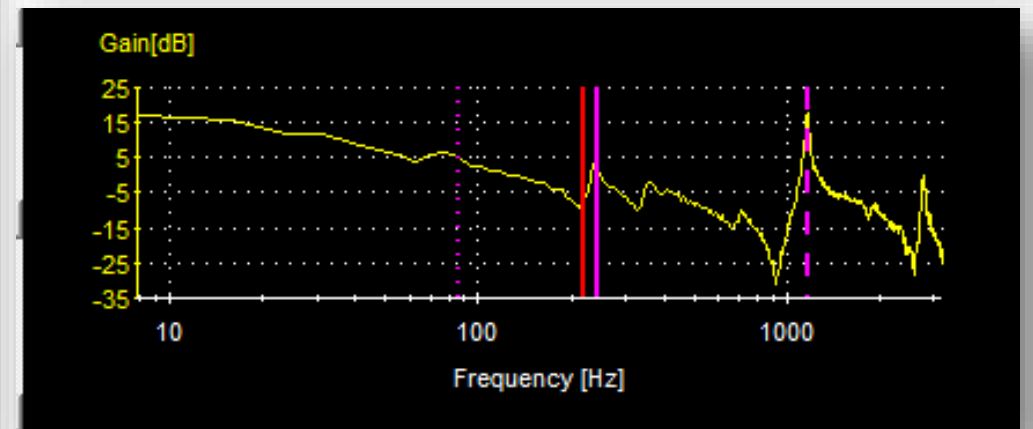
# Notch Filter

- *Selection*
  - *Turn on/off*
- *Frequency*
  - *Center of frequency band most attenuated*
- *Depth*
  - *Strength of the filter*
- *Q Value*
  - *Depth-to-Width ratio*

Pn408.0	Notch Filter Selection 1	–	0 : Disable first st...	0 : Disable first st...	0 : Disable first st...
Pn408.1	Speed Limit Selection	–	0 : Use the small...	0 : Use the small...	0 : Use the small...
Pn408.2	Notch Filter Selection 2	–	0 : Disable secon...	0 : Disable secon...	0 : Disable secon...
Pn408.3	Friction Compensation Function Sel	–	0 : Disable frictio...	0 : Disable frictio...	0 : Disable frictio...
Pn409	First Stage Notch Filter Frequency	Hz	5000	5000	5000
Pn40A	First Stage Notch Filter Q Value	0.01	70	70	70
Pn40B	First Stage Notch Filter Depth	0.001	0	0	0
Pn40C	Second Stage Notch Filter Frequenc	Hz	5000	5000	5000
Pn40D	Second Stage Notch Filter Q Value	0.01	70	70	70
Pn40E	Second Stage Notch Filter Depth	0.001	0	0	0
Pn40F	Second Stage Second Torque Refer	Hz	5000	5000	5000
Pn410	Second Stage Second Notch Filter C	0.01	50	50	50
Pn412	First Stage Second Torque Referenc	0.01ms	100	100	100
Pn416.0	Notch Filter Selection 3	–	0 : Disable third s...	0 : Disable third s...	0 : Disable third s...
Pn416.1	Notch Filter Selection 4	–	0 : Disable fourth...	0 : Disable fourth...	0 : Disable fourth...
Pn416.2	Notch Filter Selection 5	–	0 : Disable fifth st...	0 : Disable fifth st...	0 : Disable fifth st...
Pn416.3	Reserved parameter (Do not chang	–	0 : Reserved para...	0 : Reserved para...	0 : Reserved para...
Pn417	Third Stage Notch Filter Frequency	Hz	5000	5000	5000
Pn418	Third Stage Notch Filter Q Value	0.01	70	70	70
Pn419	Third Stage Notch Filter Depth	0.001	0	0	0
Pn41A	Fourth Stage Notch Filter Frequenc	Hz	5000	5000	5000
Pn41B	Fourth Stage Notch Filter Q Value	0.01	70	70	70
Pn41C	Fourth Stage Notch Filter Depth	0.001	0	0	0
Pn41D	Fifth Stage Notch Filter Frequency	Hz	5000	5000	5000
Pn41E	Fifth Stage Notch Filter Q Value	0.01	70	70	70
Pn41F	Fifth Stage Notch Filter Depth	0.001	0	0	0

# Notch Filter

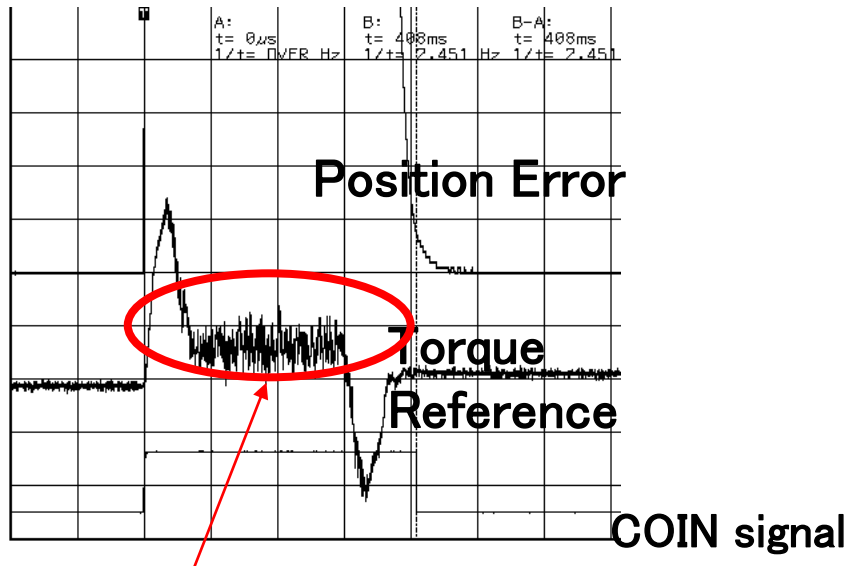
- *Example: Ballscrew*



Display Comparison				
<span>Export</span> <span>End Comparison Display</span> <span>File</span> <span>Close</span>				
No.	Name	Unit	Default Setting	0001-SGD7W-1F Axis A
Pn401	First Stage First Torque Reference F	0.01ms	100	82
Pn408.2	Notch Filter Selection 2	-	0 : Disable second :	1 : Enable secon...
Pn40C	Second Stage Notch Filter Frequenc	Hz	5000	1240
Pn40D	Second Stage Notch Filter Q Value	0.01	70	150

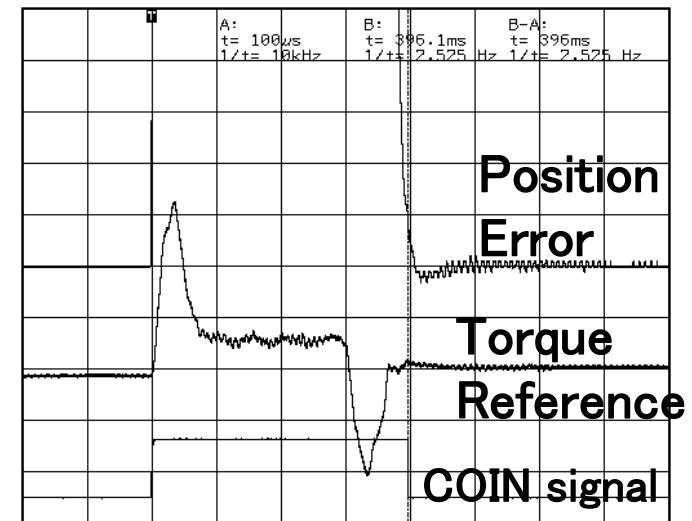
# Anti-Resonance

- *Anti-Resonance = OFF*



Vibration (sound) during movement

- *Anti-Resonance = ON*



Vibration (sound) reduced

# Anti-Resonance

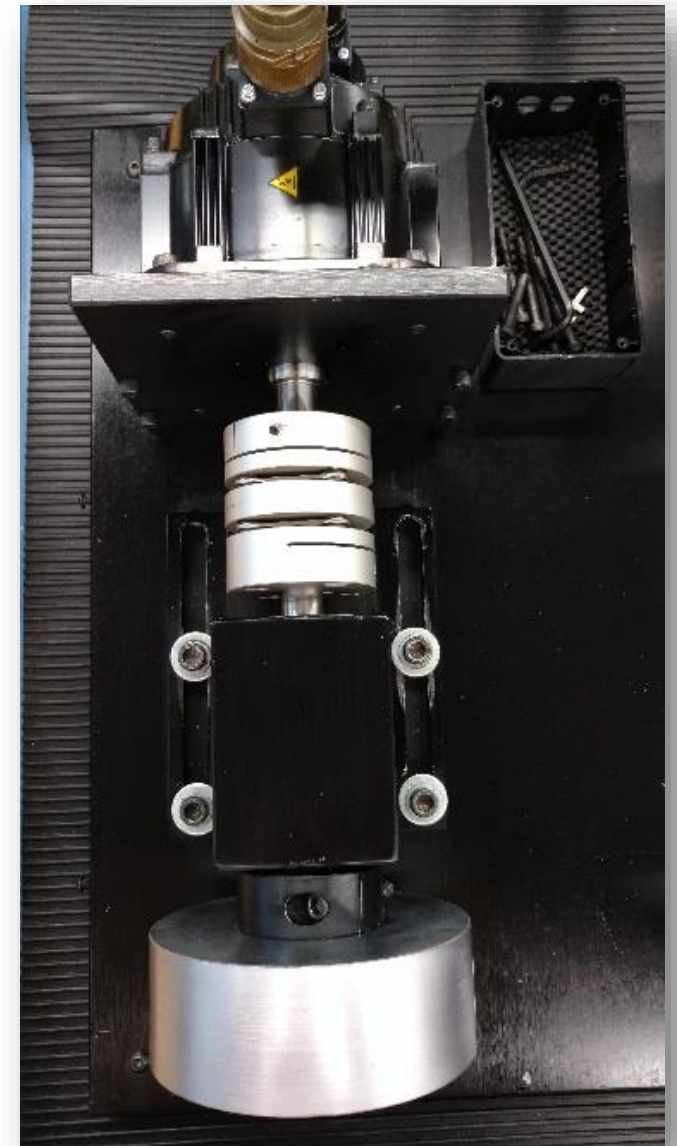
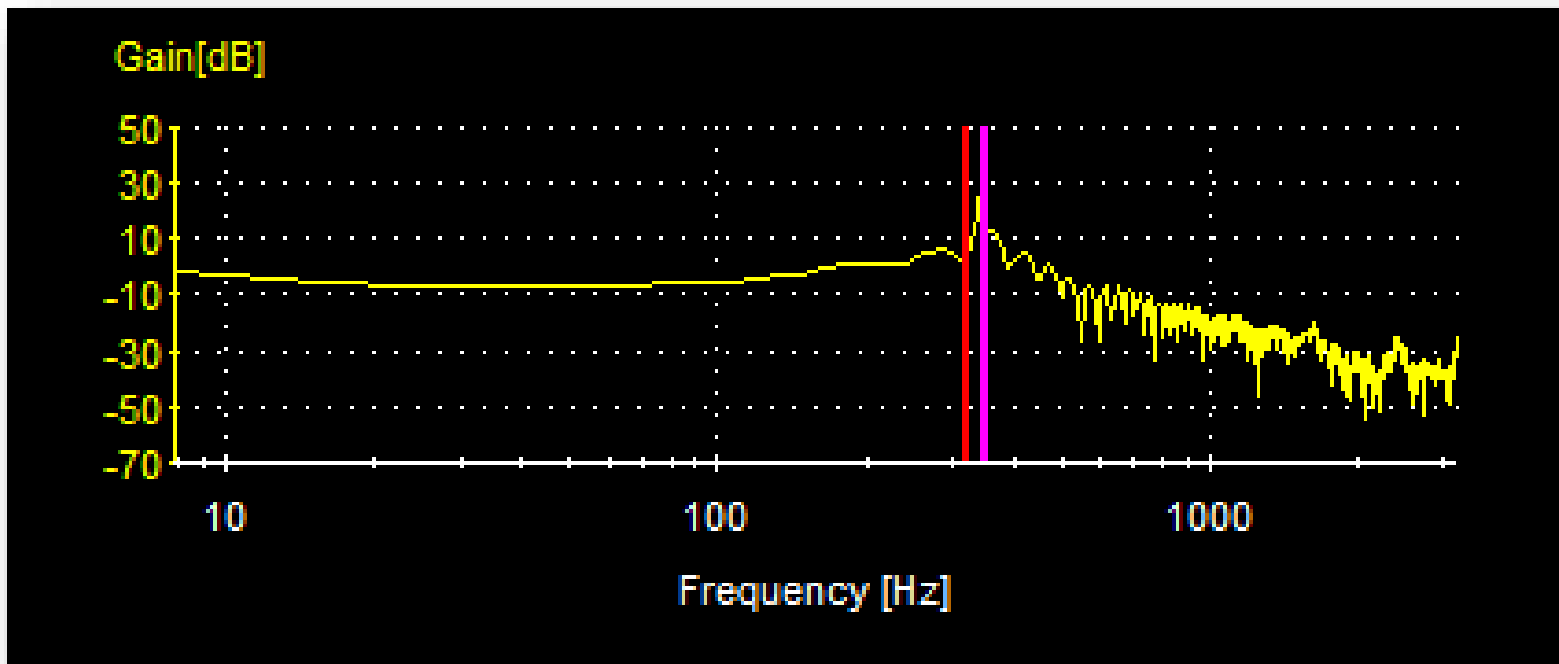
- *Range: 100-1000 Hz*
- *Auto Detect or Manual*
  - *Frequency*
  - *Damping Gain*

The image displays the Yaskawa Anti-Resonance Control software interface. On the left, a flowchart titled "Adjust Anti-resonance Control AXIS#0002A" outlines the process: Determine frequency (Click the Auto Detect button to automatically set the frequency.), Set frequency (Click the Start adjustment button.), Adjust damping gain (Increase [Damping Gain].), and Finish. On the right, the "Adjustment" window is shown. It features "Frequency Setting Methods" with "Auto Detect" and "Manual Set" buttons, where "Manual Set" is highlighted. The "Frequency" display shows 00345 Hz, and the "Damping Gain" display shows 00180%. A "Reset" button with a red cross icon is present. A red-bordered box highlights the "Anti-res Ctrl Adj" button in the top right corner of the adjustment window. A red-bordered box also highlights the "Finish" button at the bottom right. A red-bordered box highlights the "Anti-res Ctrl Adj" button in the top right corner of the adjustment window. A red-bordered box highlights the "Anti-res Ctrl Adj" button in the top right corner of the adjustment window. A red-bordered box highlights the "Anti-res Ctrl Adj" button in the top right corner of the adjustment window.

# Anti-Resonance

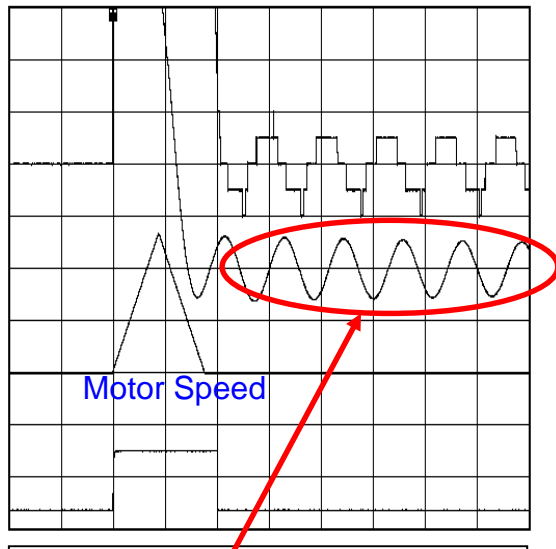
## Example: Rotary Drive

No.	Name	Unit	Default Setting	0105-SGD7S-R90F30A Axis A
Pn103	Moment of Inertia Ratio	%	100	2600
Pn160.0	Anti-Resonance Control Selection	–	0 : Do not use ant	1 : Use anti-resonance control.
Pn161	Anti-Resonance Frequency	0.1Hz	1000	3440
Pn163	Anti-Resonance Damping Gain	%	0	180
Pn170.0	Tuning-less Selection	–	1 : Enable tuning-	0 : Disable tuning-less function.

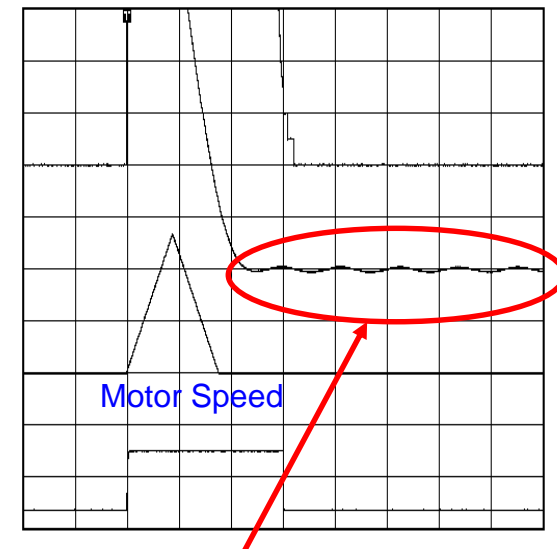
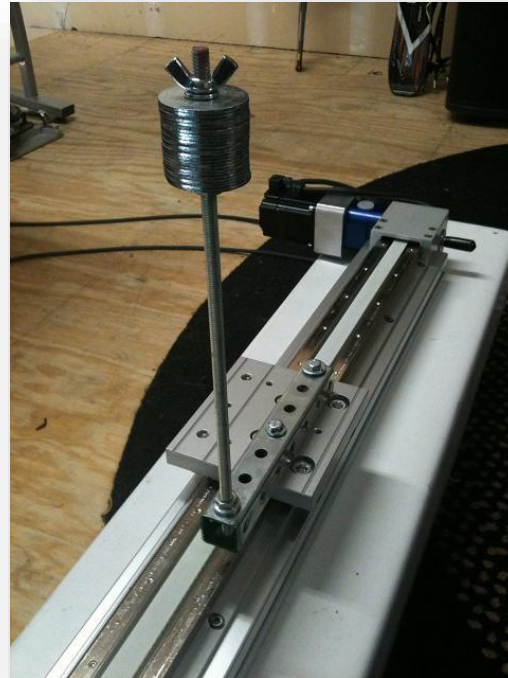


# Vibration Suppression

- *Low-Frequency Oscillations Cancelled Out*
- *Start and stop*
- *Anticipation of load reaction based on frequency setting*
- *Requires Model Following Control*



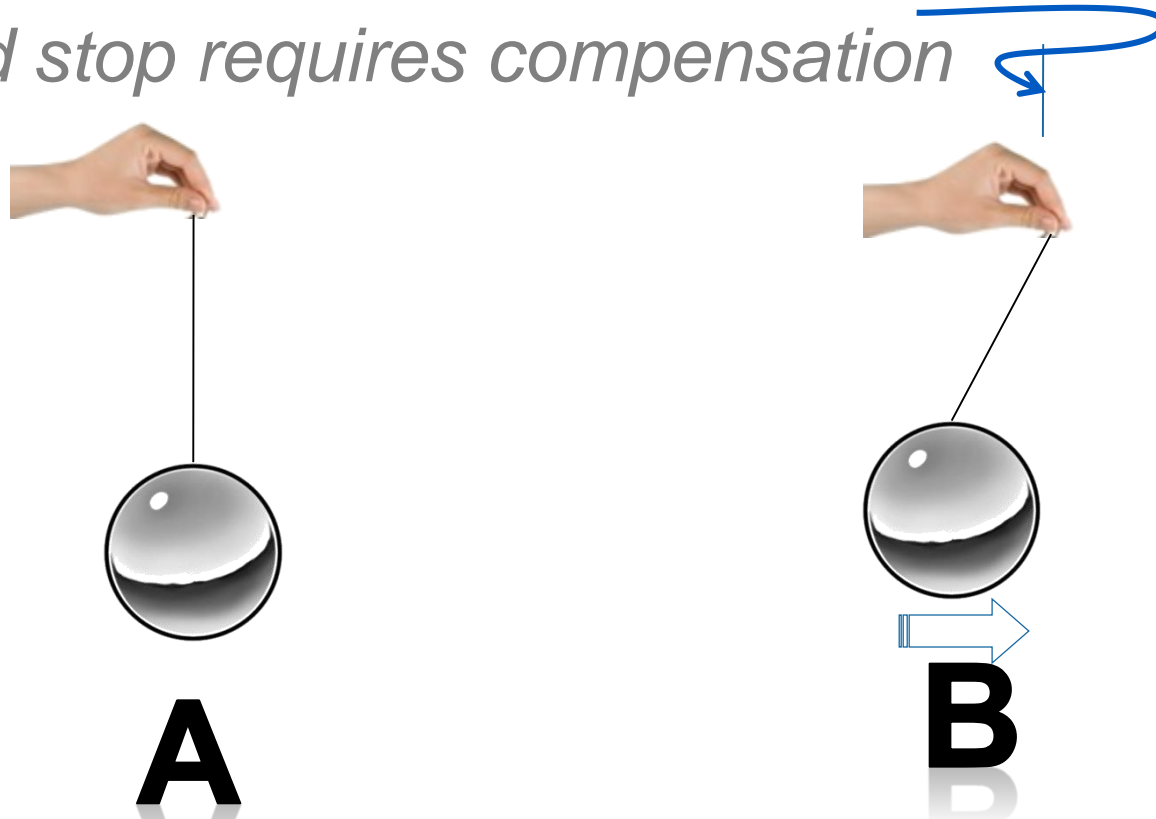
**Without Vibration Suppression**  
Vibration in Position Error Signal is severe at move stop



**Vibration Suppression Active**  
Position Error Signal shows reduced vibration at move stop

# Vibration Suppression

- *Position a pendulum from point A to point B*
- *Slow is easy*
- *Fast is difficult*
  - *Start and stop requires compensation*



# Vibration Suppression

- *Effective Range: 1 Hz – 100 Hz*
- *Control Mode: Position*
  - *When Model Following Control enabled Pn140.0=1*
- *Automatic Setting: During Advanced Auto-Tuning*
- *Manually Adjust*
  - *Pn140, Pn145, Pn146, Pn14A, Pn14B*
- *Not Adaptive*

Auto-setting

Notch filter Failed to detect the peak val

1 step ----- inactive Cancel

2 step ----- inactive Cancel

Anti-res Ctrl Adj Vibration not detected

Anti-res Adj 500.0Hz active Cancel

Vib Suppression

Frequency 1 ----- inactive Cancel

Vib Detect

Anti-res Ctrl Adj

Vib Suppress

< Back To Autotuning Completed. Cancel

Vibration Suppression Function AXIS#42

Determine the frequency for setting.

Click the Import button. Manual setting is also possible.

Set the frequency.

Click the Set button. If the vibration problem could not be solved, finely adjust the frequency and then click the Set button again.

Finish

Adjustment

Residual Vibration Frequency 0.0 [Hz]

Import

Set frequency 0004.0 [Hz]

( 1.0 - 100.0 )

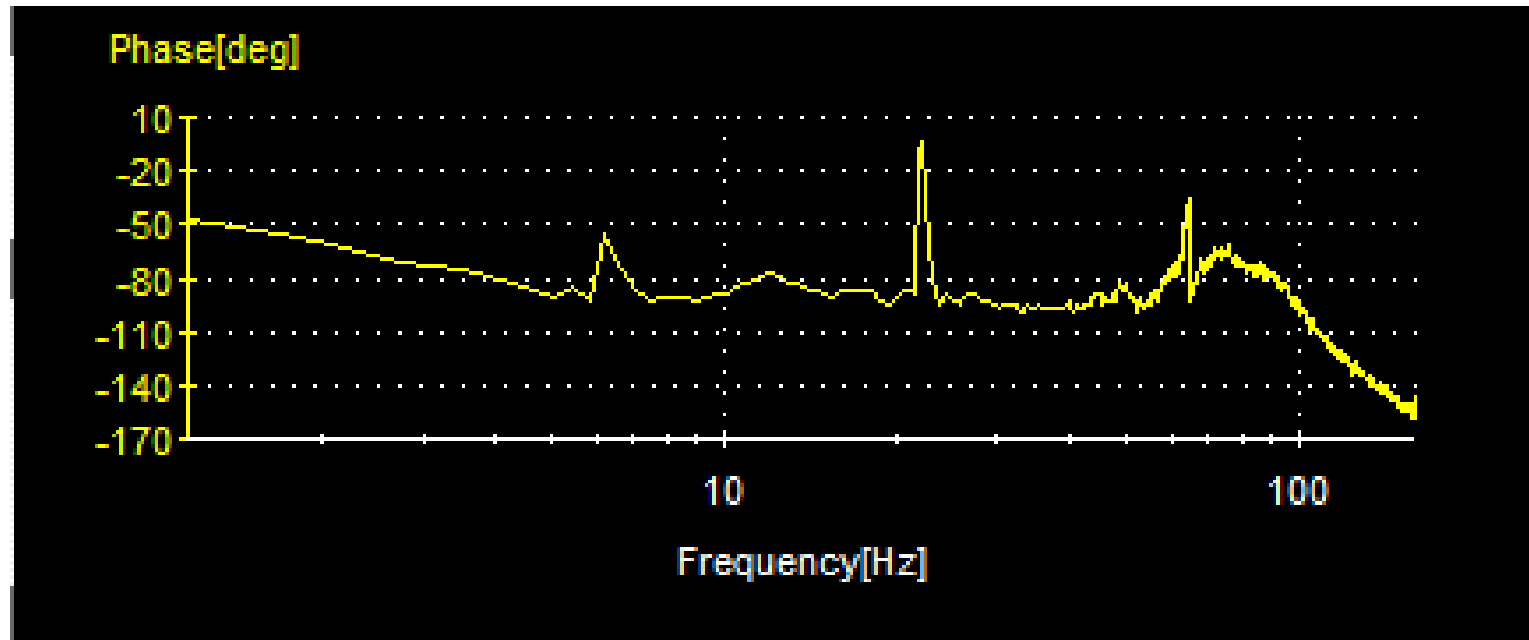
Current value: 4.0 Hz

Precautions



# Vibration Suppression

- *Example: Sigma Trac Linear motor with two vibrating loads*



# Vibration Suppression

Vibration Suppression AXIS#0003A

Determine the frequency for setting.  
Click the Import button.  
Manual setting is also possible.

Set the frequency.  
Click the Set button.  
If the vibration problem could not be solved, finely adjust the frequency and

Adjustment

Residual Vibration Frequency 23.8 [Hz]

Import

Set frequency 6.9 [Hz]

( 1.0 - 100.0 )  
Current value: 6.9 Hz

Set

Reset

Vib Suppression: Active

Finish Cancel

Edit Parameters

Category

- All constant number
- Function Selection(Pn0xx-)
- Gain(Pn1xx-)
- Position(Pn2xx-)
- Speed(Pn3xx-)
- Torque(Pn4xx-)
- Force(Pn4xx-)
- Sequence(Pn5xx-)
- I/O Sign
- Mechatrolink(Pn8xx-)
- Common Parameters(PnAxx-)

Display Comparison

Export

End Comparison Display

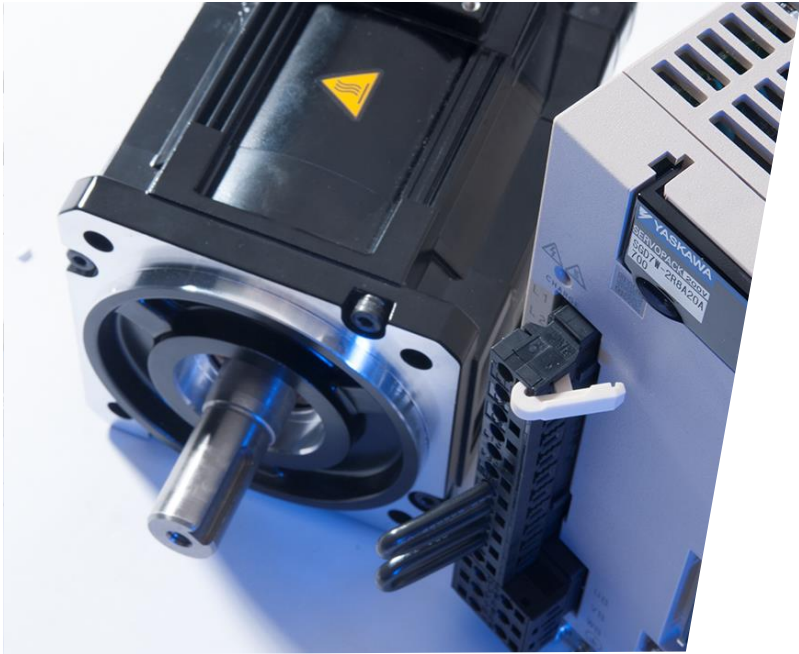
File Close

No.	Name	Unit	Default Setting	*0003-SGD7S-2R1F30A
				Axis A
Pn103	Mass Ratio	%	100	546
Pn140.0	Model Following Control Selection	-	0 : Do not use mod	1 : Use model following c...
Pn140.1	Vibration Suppression Selection	-	0 : Do not perform	2 : Perform vibration sup...
Pn140.2	Vibration Suppression Adjustment Selection	-	1 : Adjust vibration	0 : Do not adjust vibratio...
Pn141	Model Following Control Gain	0.1/s	500	200
Pn145	Vibration Suppression 1 Frequency A	0.1Hz	500	71
Pn146	Vibration Suppression 1 Frequency B	0.1Hz	700	71
Pn14A	Vibration Suppression 2 Frequency	0.1Hz	800	238
Pn170.0	Tuning-less Selection	-	1 : Enable tuning-le	0 : Disable tuning-less fu...

Display Settings

Hierarchy:  off

Descriptions:  on



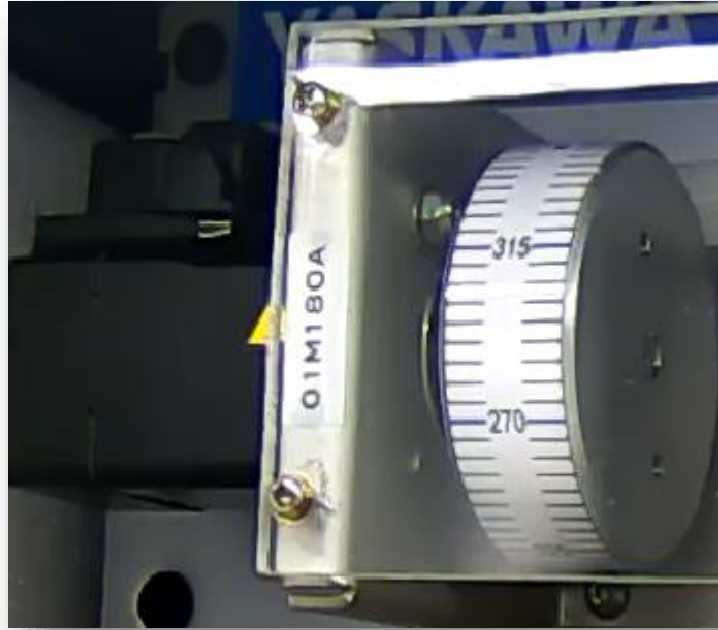
# Sigma-7 Servo Tuning Data Trace

Hands-on skills for Sigma-7 Servo Tuning

- *Trace Setup*
- *Measurement*
- *Position Settling Time*
- *Position Error*
- *Torque Ripple*

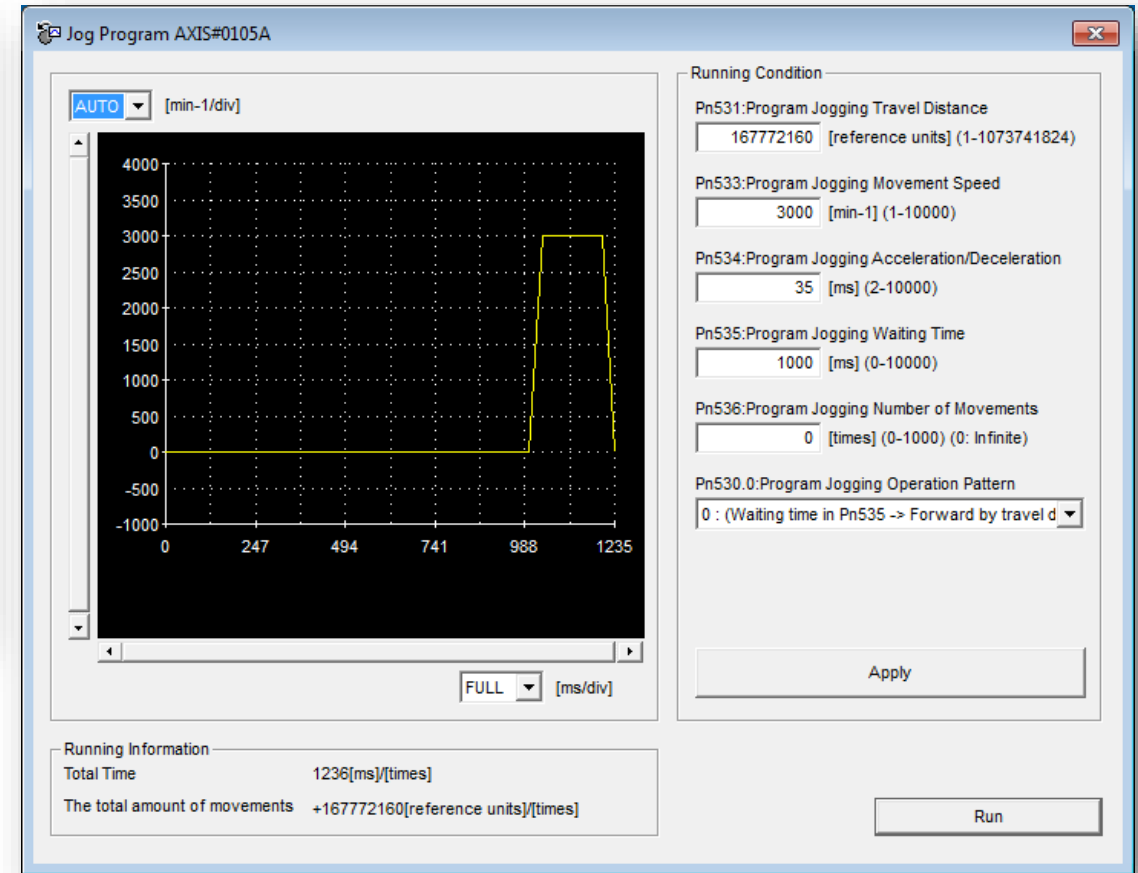
# Move Profile

- *X-Axis*
  - *Pn520*



- *Set Program Jog to “worst case” move profile*

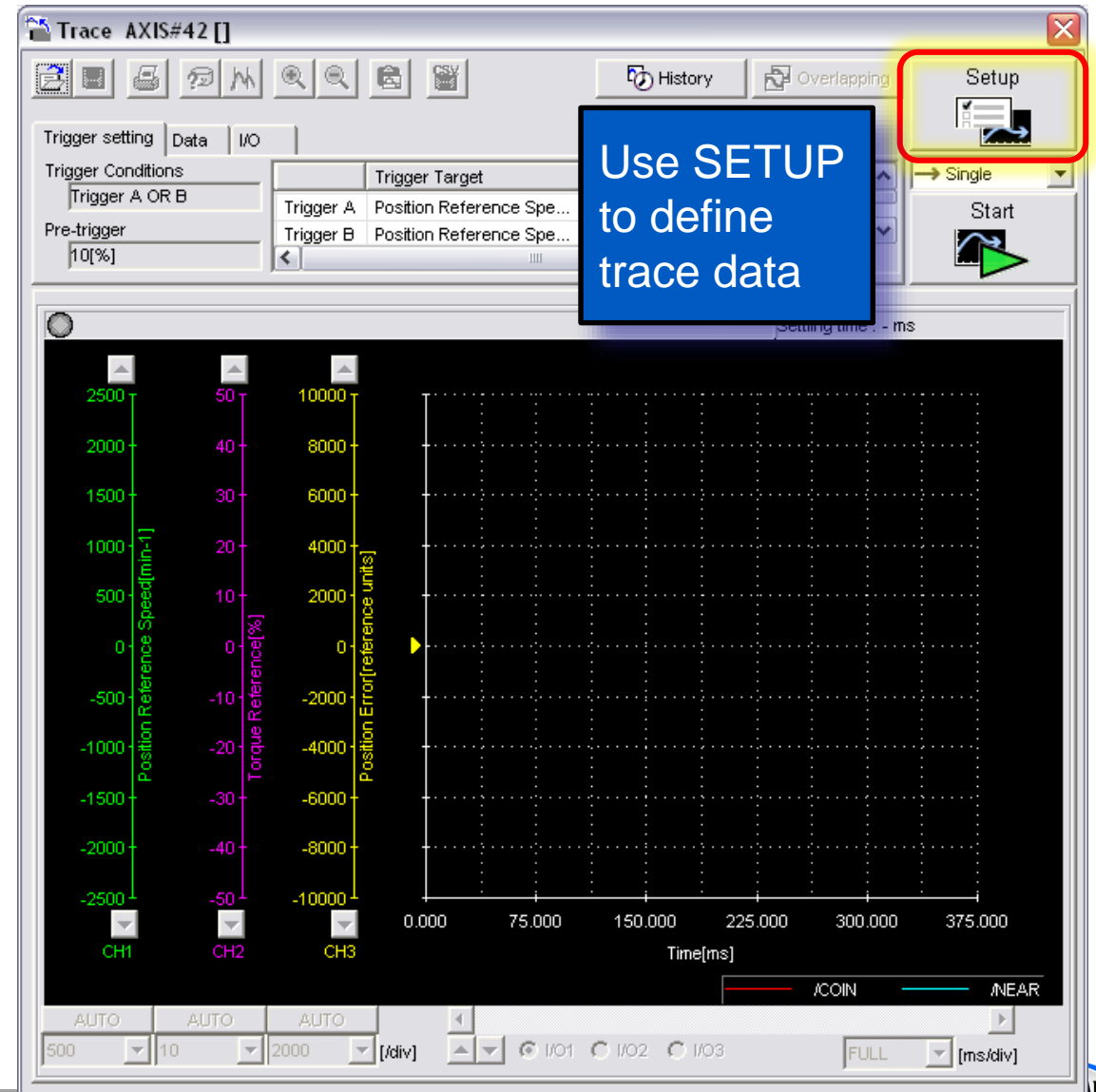
- *Highest speed, accel, decel*
- *Long time between moves*
- *Use Controller or Program Jog*



X-Axis worst case move profile in Program Jog

# Features Overview

- *Simultaneous operation*
  - *Program Jog*
  - *IEC controller*
- *Simultaneous trace of both axes in SGD7W dual-axis amplifier*
- *Zoom & Cursors*
- *Single / Continuous trace mode*
- *Overlapping History*
- *Hide unwanted data*



# Trace Setup

**Trace Setting**

Auto Setting: Checks position reference. **Set**

Trace Object Selection: Checks position reference.

Sampling Setting: Sampling Time: 625 [us] × 1000 = 625.000 [ms]

Data 1: Position Reference Speed [min-1]

Data 2: Torque Reference [%]

Data 3: Feedback Speed [min-1]

IO: I/O 1: /COIN, I/O 2: /NEAR, I/O 3: Unsetting

Trigger setting: Trigger Conditions: Trigger A, Pre-trigger: 10 [%]

Trigger A: Trigger Target: Position Reference Speed, Trigger Level: 5 [min-1], Trigger Type: Rising Edge

Trigger B: Trigger Target: Position Reference Speed, Trigger Level: -5 [min-1], Trigger Type: Falling Edge

Display options:  Display options, Settling time

Settling time automatically measured.

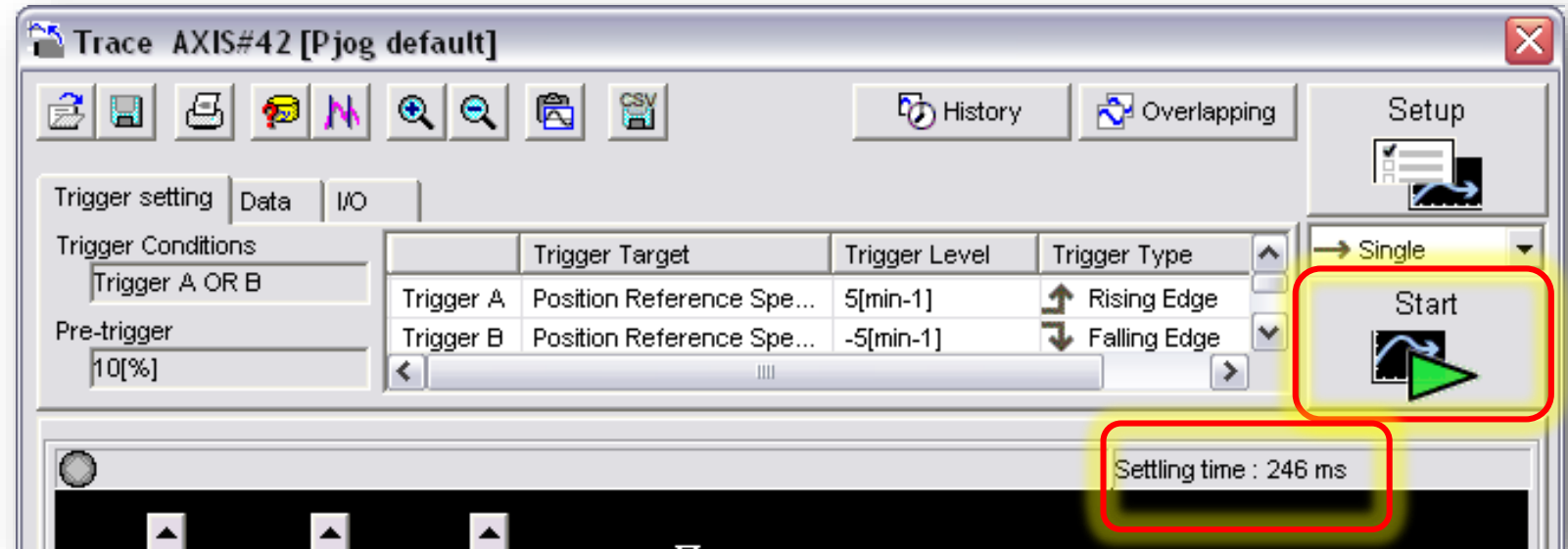
Trace must show one move with /COIN low after command complete

1000 Data Points captured on Servopack.

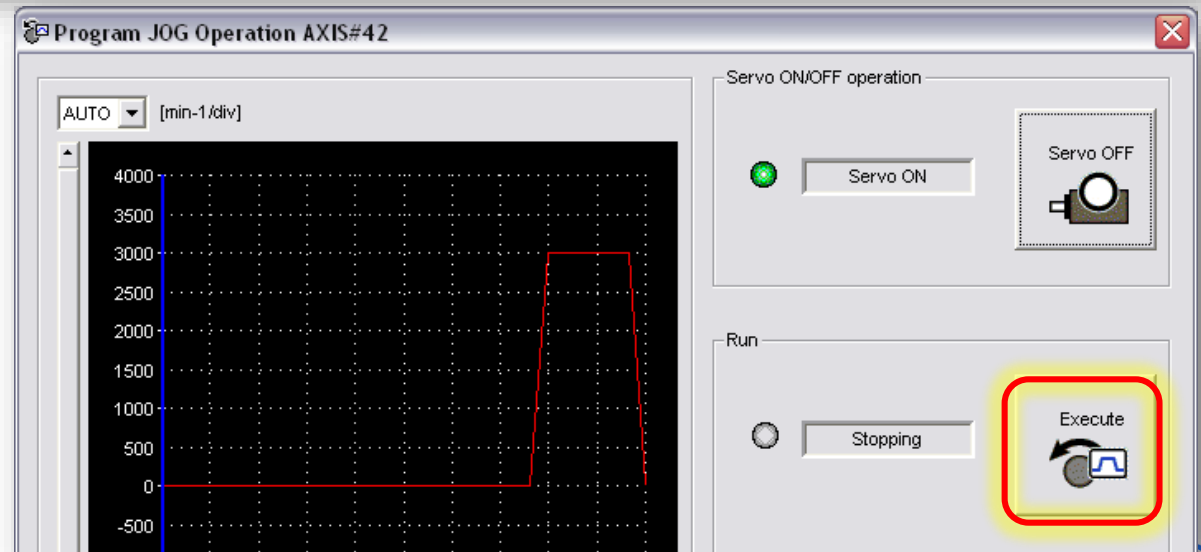
Data uploads to SigmaWin+ Trace

# Start Trace

- *Start Button*

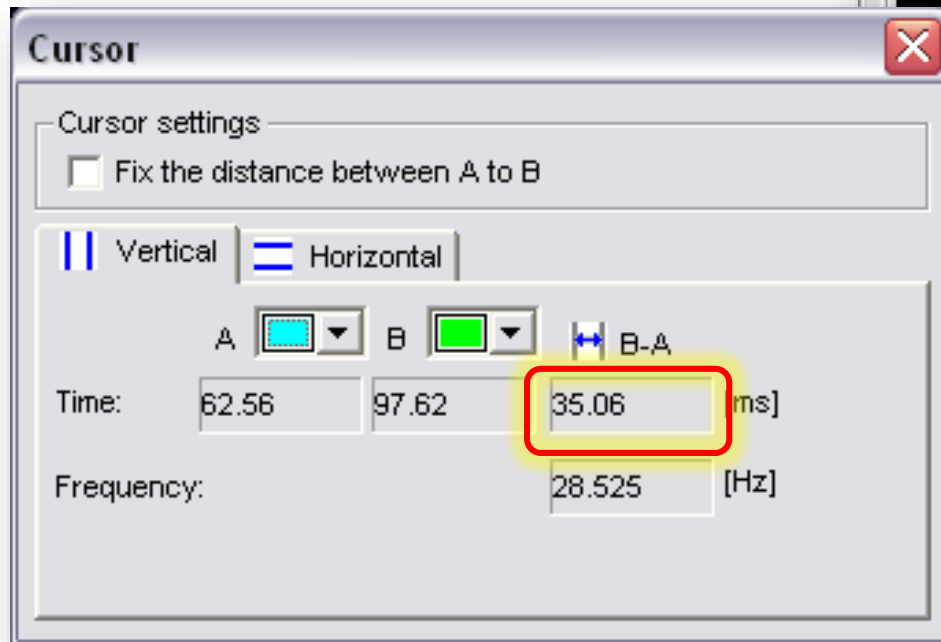
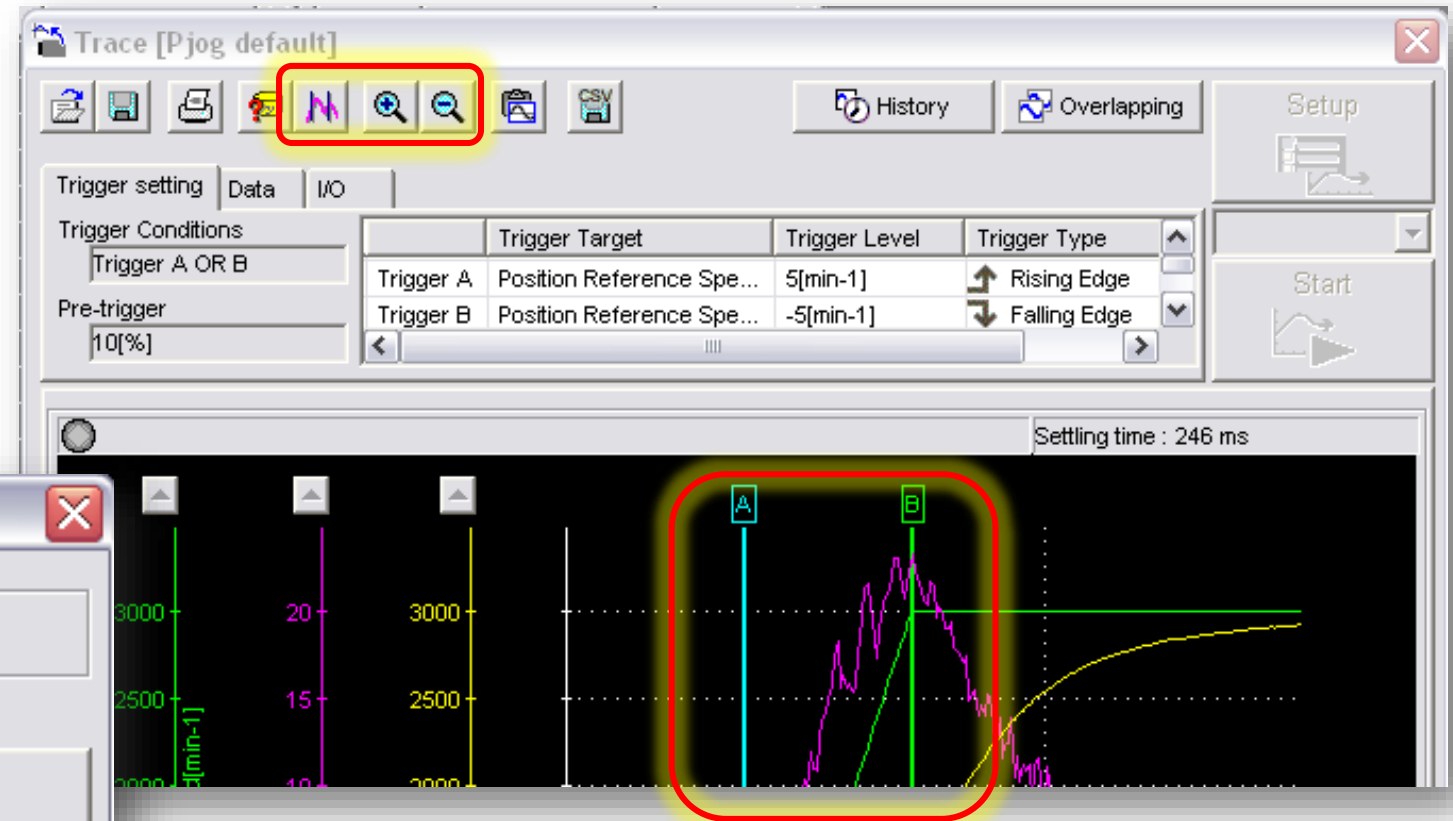


- *Execute Motion*



# Measurement

- *Zoom*
  - *Zoom to acceleration profile*
- *Cursors*
  - *Measure acceleration time*
  - *Confirm 35 ms*








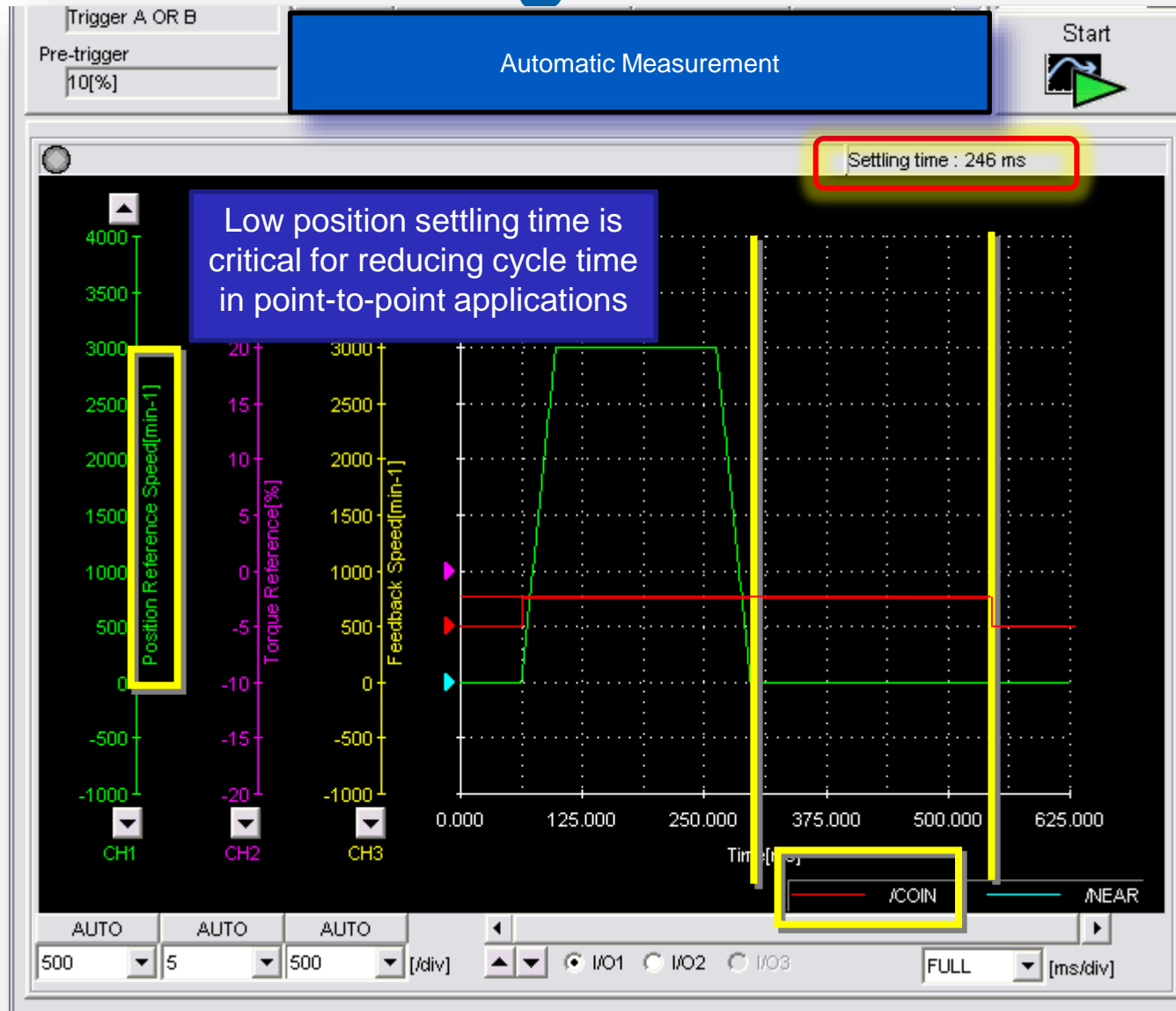
# Tuning Results Table

- Measure and record values in the table

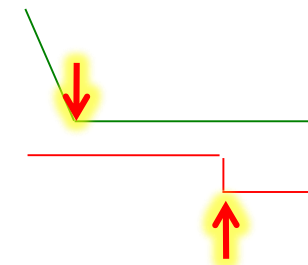
Tuning Results Table: MP3300iec & Sigma-7 Demo

Axis	Tuning Algorithm	Position Settling Time	Maximum Position Error	Torque Ripple / Noise
SGD7W Axis A <input type="text" value="X_Axis"/>	Default "Tuning-Less"			
SGD7W Axis A 	Optimized Tuning-Less			
SGD7W Axis A	Advanced Auto-Tuning			
SGD7W Axis A	Custom Tuning			
SGD7W Axis B <input type="text" value="Y_Axis"/>	Default "Tuning-Less"	x	x	x
SGD7W Axis B 	Optimized Tuning-Less	x	x	x
SGD7W Axis B	Advanced Auto-Tuning			
SGD7W Axis B	Custom Tuning			
SGD7S AxisA <input type="text" value="Z_Axis"/>	Default "Tuning-Less"			
SGD7S AxisA 	Optimized Tuning-Less	x	x	x
SGD7S AxisA	Advanced Auto-Tuning			
SGD7S AxisA	Custom Tuning			

# Position Settling Time



- *Measure Position Settling Time*
  - *Position Reference*
  - *Pulse Speed*
  - */COIN*



# Position Settling Time

## ■ /COIN Signal

- Pn522 [Encoder Pulse]
- Set Pn522 to 0.1°
  - » Sigma-7: Pn522= 4660 (24-bit = 16,777,216 pulse/rev)
  - » Sigma-5: Pn522=291 (20-bit = 1,048,576 pulse/rev)

Pn522	Positioning Completed Width	reference	4660
-------	-----------------------------	-----------	------

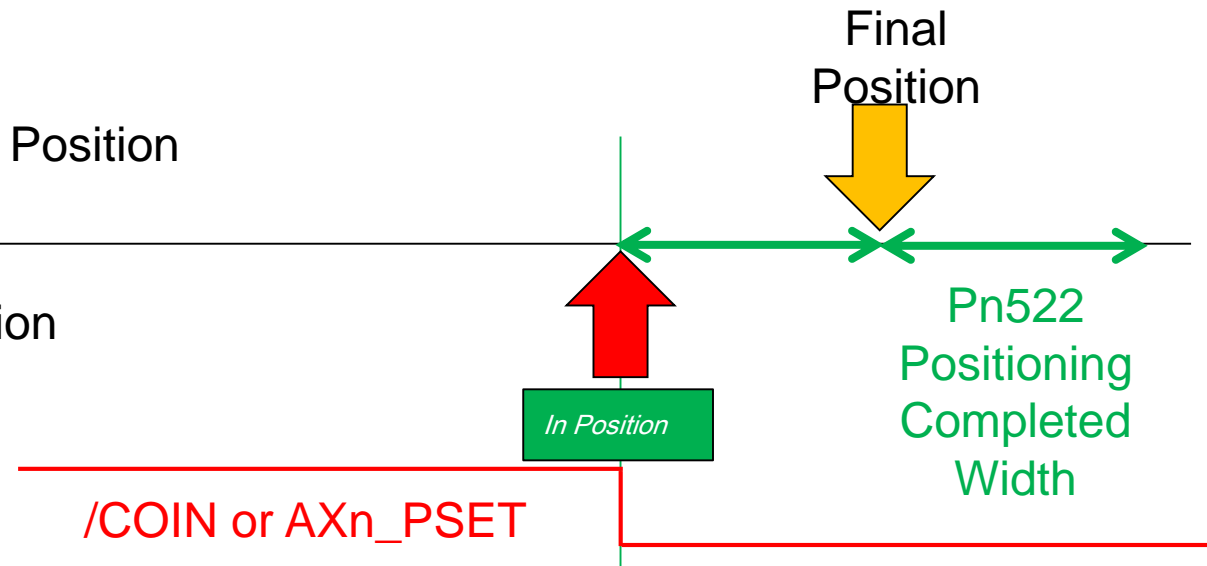
$$\frac{16,777,216 \text{ encoder pulse}}{\text{rev}} \times \frac{1 \text{ rev}}{360^\circ} = 46603 \text{ pulse/degree}$$



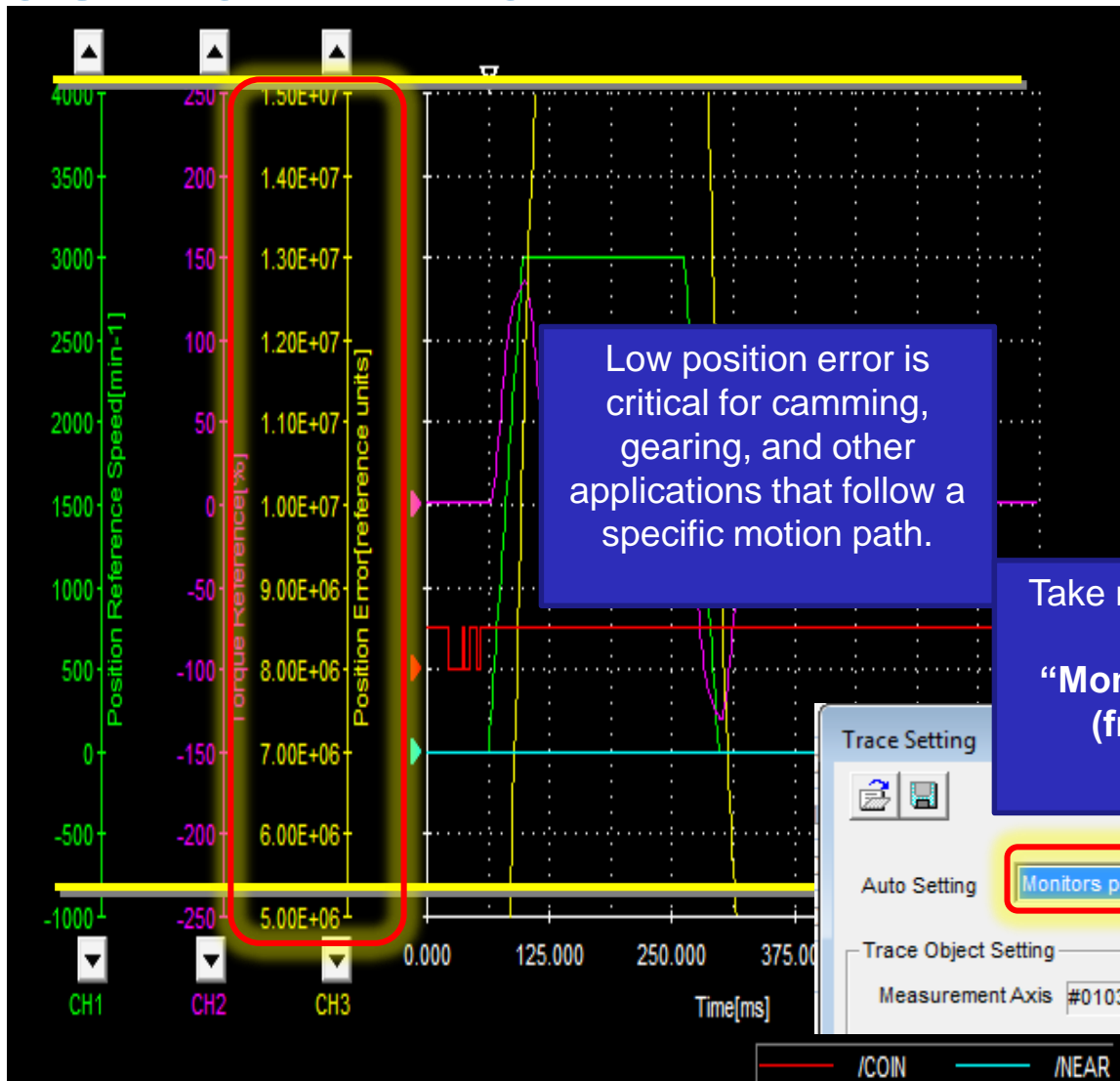
Commanded Position  
(Reference)



Actual Position  
(Feedback)



# Position Error



- *Measure Position Error*
  - *Maximum Position Error*
  - *Measure ZERO to Max*

Take new trace with Auto Setting  
**“Monitors Positioning (from the start)”**

**High-Precision Trace**  
 Shows 32-bit data – the true position error will be shown

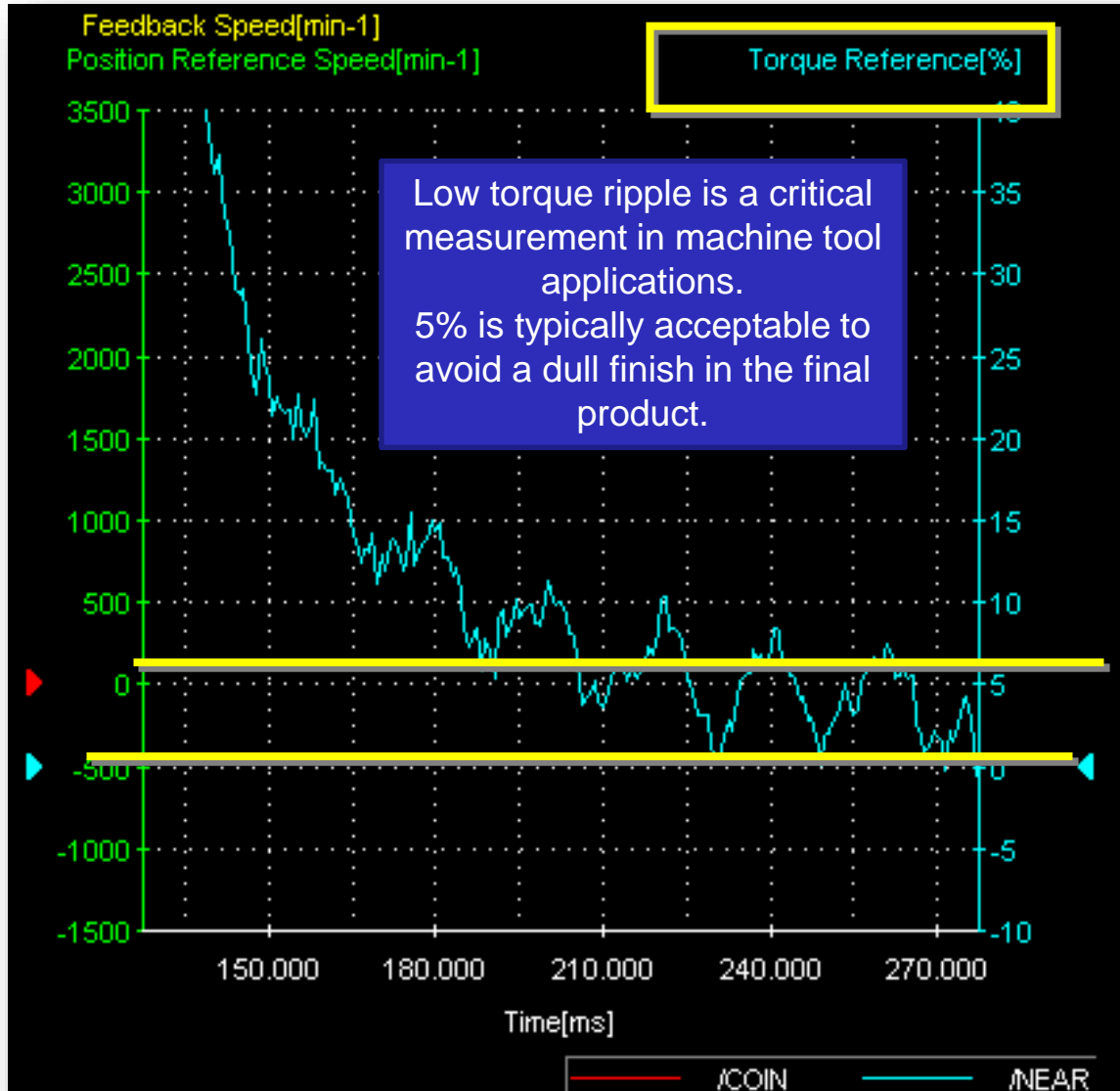
Trace Setting

Auto Setting: **Monitors positioning (From the start)** [Set]

Sampling Setting: Sampling Time 1250 [us] x 500 = 625.000 [ms]

Trace Object Setting: Measurement Axis #0103A [Set]  **High-precision trace** (The time required to trace will be reduced to a half.)

# Torque Ripple



## Measure Torque Ripple

- *Torque Reference*
- *During move*

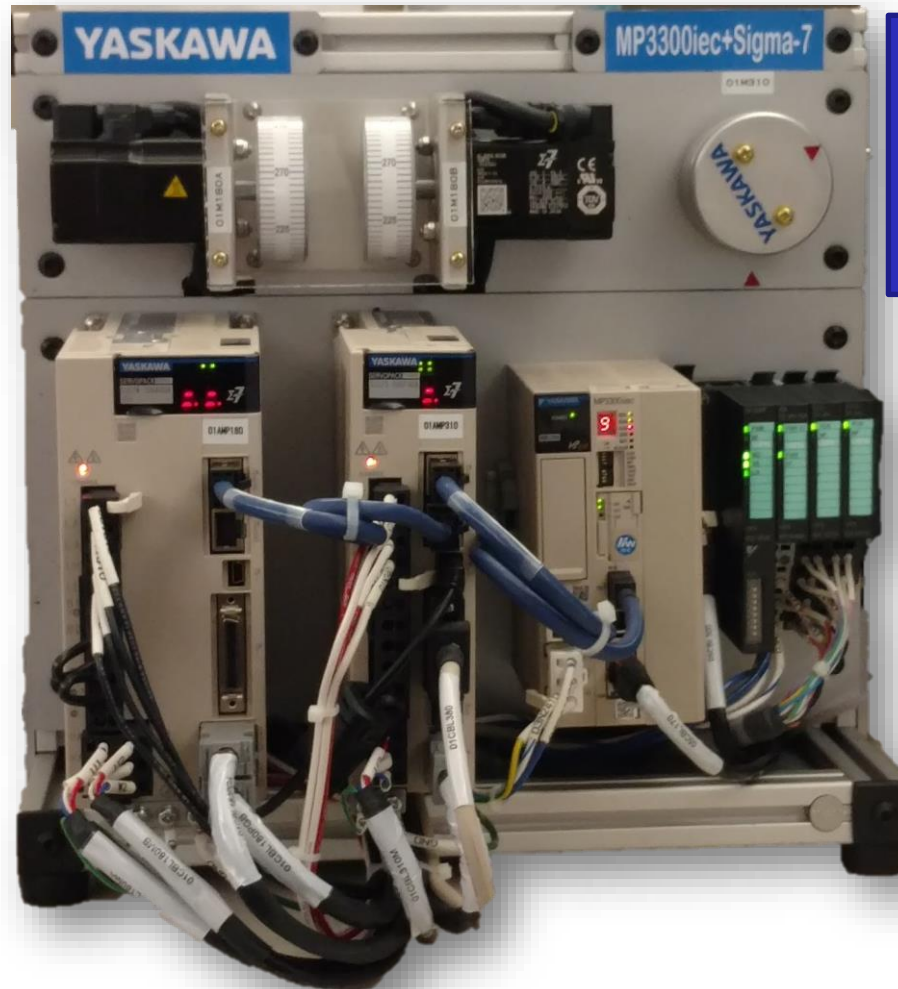
## Measure:

- *Peak-to-peak average*
- *Zoom In*

# Overview

Tune for low position settling time.

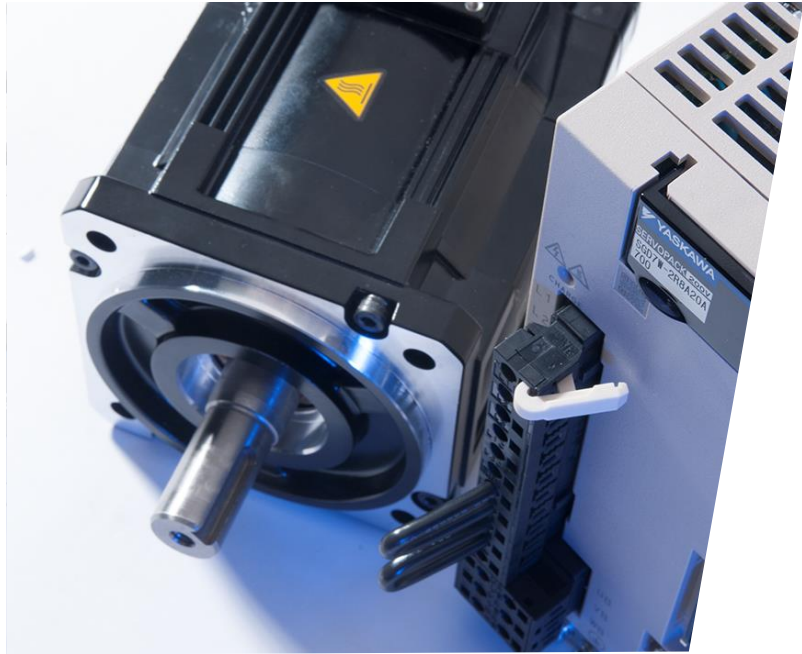
Axes synchronized to each other



Tune for lowest position error.

Synchronized to external axis

Typical electronic cam application; rotary knife

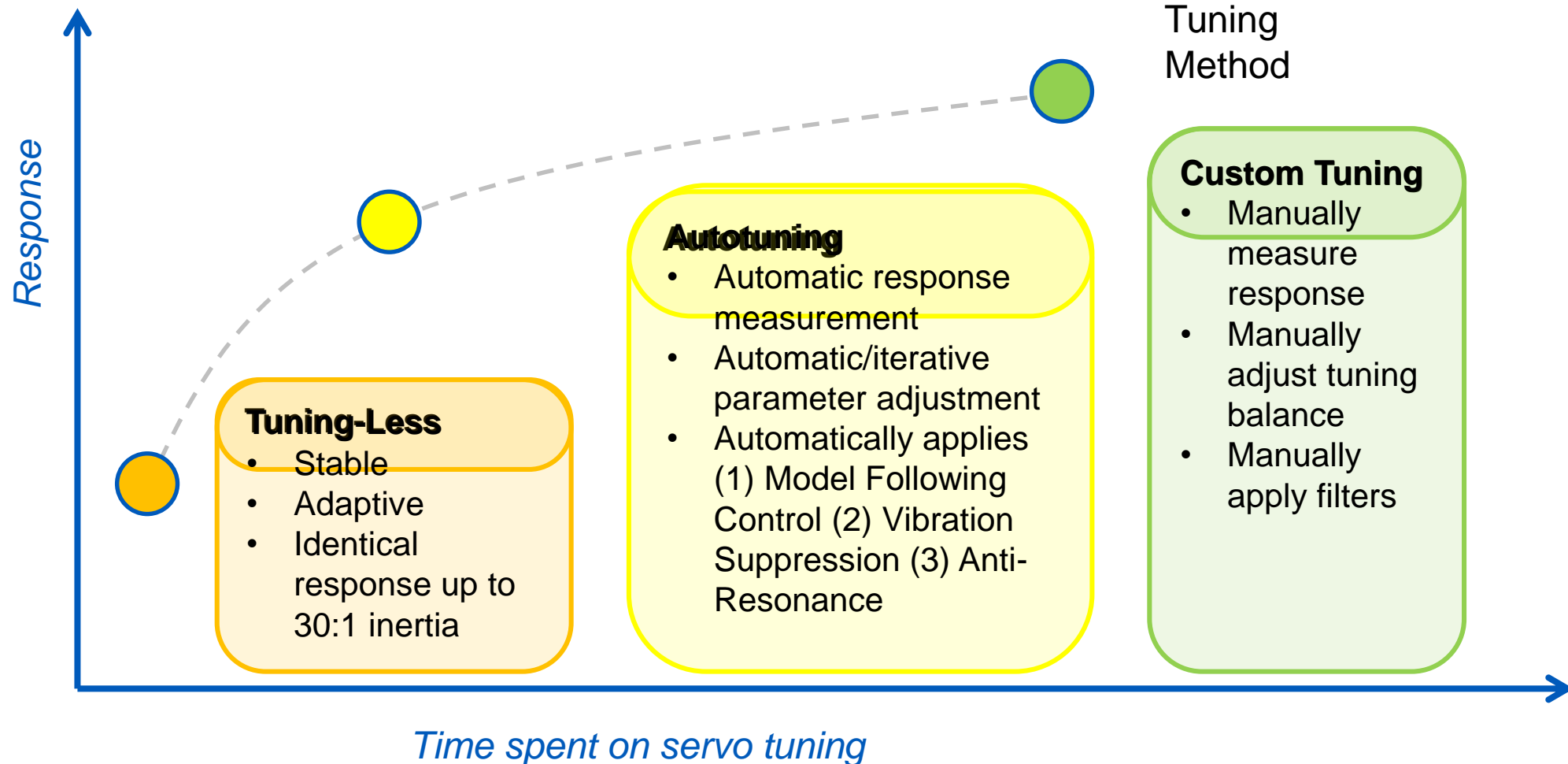


# Sigma-7 Servo Tuning Tuning-Less

Optimize the “Tuning-Less” Tuning Method on the Demo X Axis

- *Overview*
- *Basic Adjustments*
- *Feed Forward*
- *Advanced Adjustments*

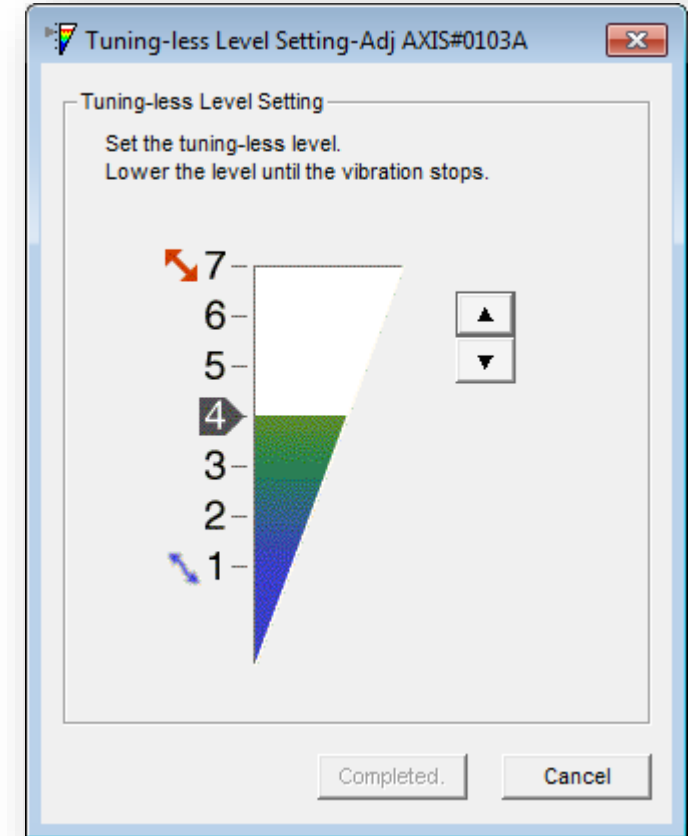
# Sigma-7 Tuning Methods





# Overview

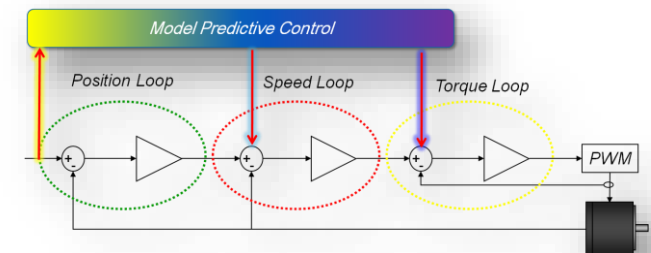
- **How It Works**
  - *Adjusts the servo control loops internally*
  - *No parameters are automatically set*
  - *Standard tuning parameters have no effect when Tuning-Less is ON*
- **When To Use**
  - *Default is ON*
  - *Changing load*
  - *Any type of machine*
  - *Speed Mode or Position Mode*
- **How To Use**
  - *Turn up Rigidity Level*
  - *Turn down Rigidity Level if you hear resonance*
  - *Apply Feed Forward (Pn109)*
  - *Other Configuration Options in Pn170*



# Basic Adjustments

- *Feed-Forward (Pn109)*
- *Rigidity Level (Pn170.2)*
  - *If noisy, reduce level*

Pn109	Feedforward	%	74
Pn170.0	Tuning-less Selection	—	1 : Enable tuning-less function.
Pn170.1	Speed Control Method	—	0 : Use for speed control.
Pn170.2	Rigidity Level	—	7 : Tuning-less Level 7
Pn170.3	Tuning-less Load Level	—	1 : Tuning-less Load Level 1

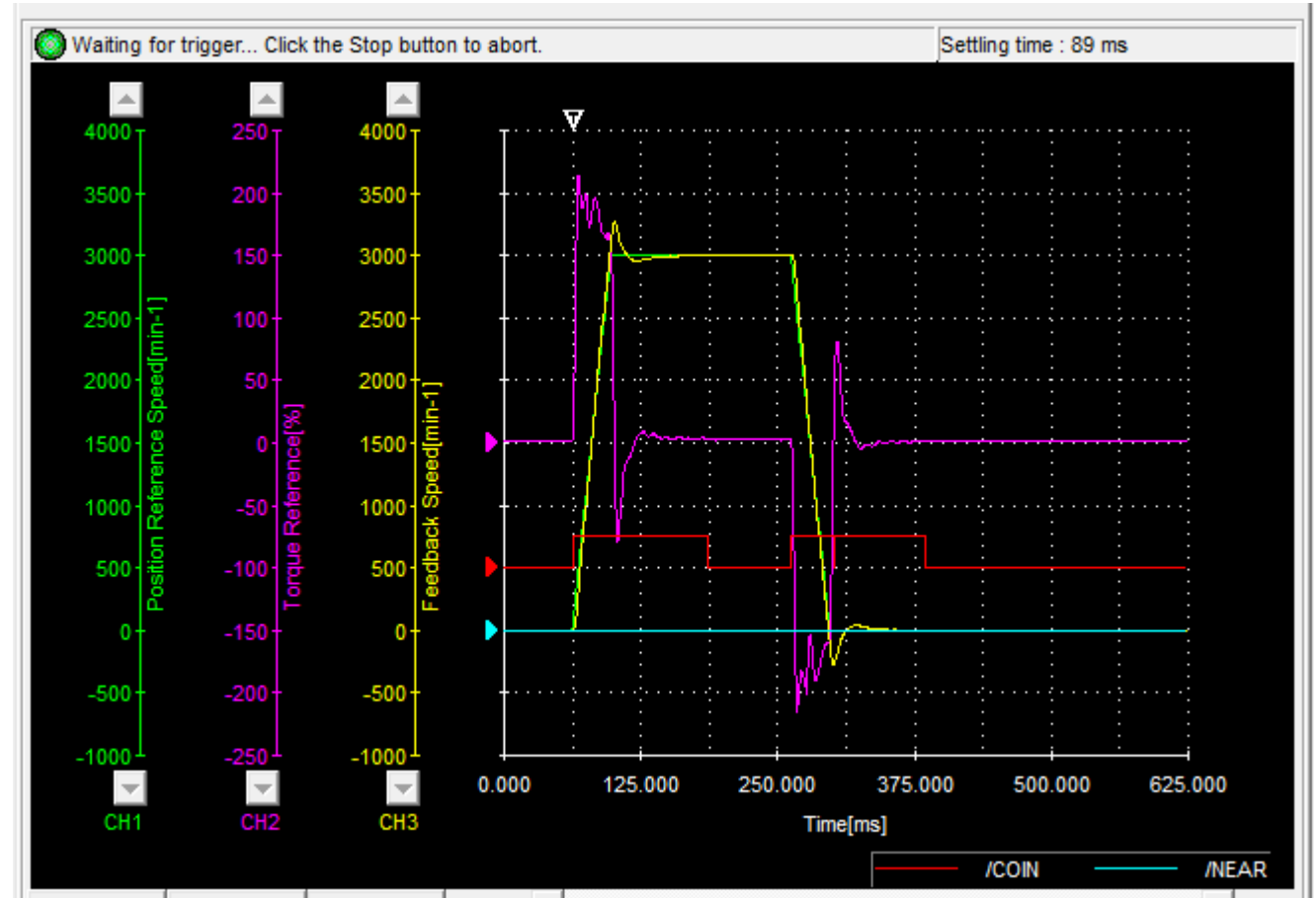


# Feed-Forward

- *Improve Tuning-Less with Feed Forward Pn109*
  - *Updates at 0.0625 ms*
  - *Settling time reduced to ~100ms*
- *Trace and measure the result*
- *Record results in the Tuning Results Table*

MP3300iec & Sigma-7 Demo Tuning

Axis	Tuning Algorithm	Position Settling Time	Maximum Position Error	Torque Ripple / Noise
SGD7W Axis A	Default "Tuning-Less"			
SGD7W Axis A 	Optimized Tuning-Less			
SGD7W Axis A	Advanced Auto-Tuning			
SGD7W Axis A	Custom Tuning			
SGD7W Axis B	Default "Tuning-Less"			
SGD7W Axis B 	Optimized Tuning-Less			
SGD7W Axis B	Advanced Auto-Tuning			
SGD7W Axis B	Custom Tuning			
SGD7S AxisA	Default "Tuning-Less"			
SGD7S AxisA 	Optimized Tuning-Less			
SGD7S AxisA	Advanced Auto-Tuning			
SGD7S AxisA	Custom Tuning			



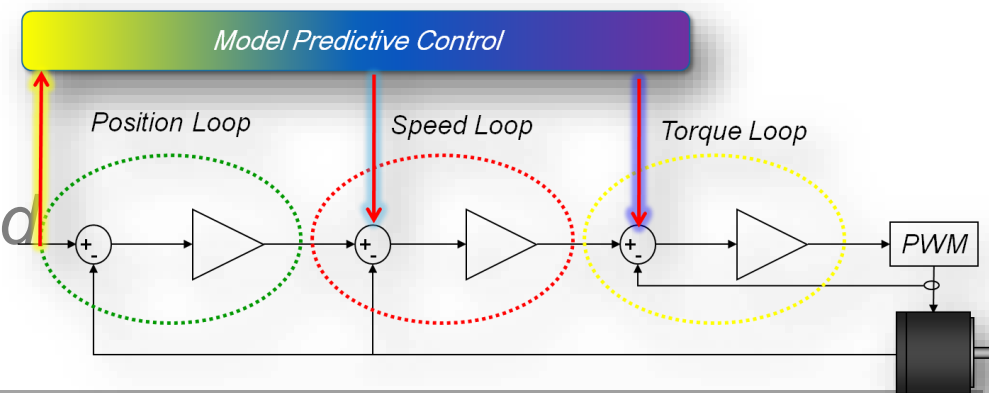
# Advanced Adjustments

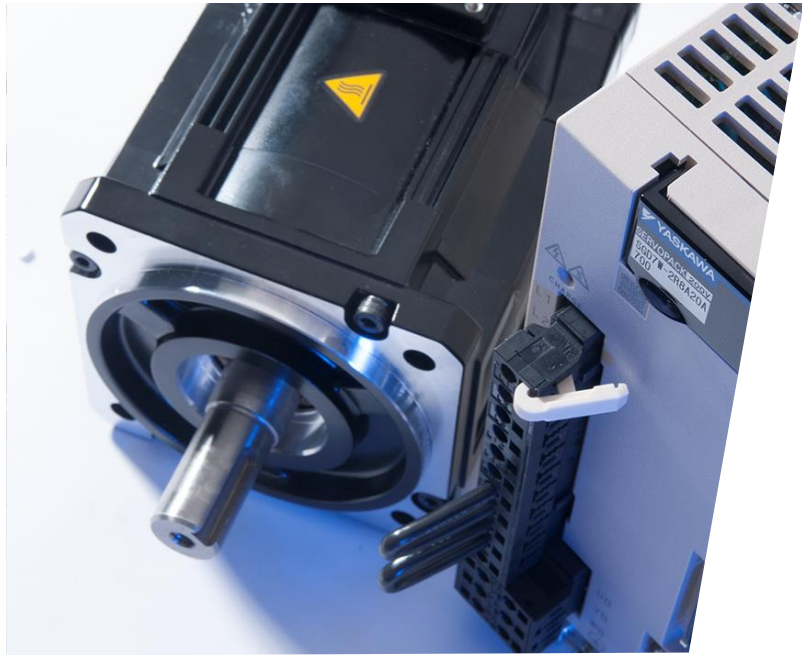
- *Load Level*
  - *Pn170.3*
  - *Higher inertia, increase level*
- *Model Following Control*
  - *Pn140.0*
  - *Improve settling time by increasing gain Pn141*
  - *Set Pn103 =0*
  - *Feedforward Pn109 no effect*
- *Vibration Suppression*
  - *Only if Model Following is enabled*

Pn140.0	Model Following Control Selection	—	0 : Do not use m...
Pn140.1	Vibration Suppression Selection	—	0 : Do not perfor...
Pn140.2	Vibration Suppression Adjustment	—	1 : Adjust vibratio...
Pn140.3	Speed Feedforward (VFF)/Torque F...	—	0 : Do not use m...
Pn141	Model Following Control Gain	0.1/s	500
Pn142	Model Following Control Correction	0.1%	1000
Pn143	Model Following Control Bias in the	0.1%	1000
Pn144	Model Following Control Bias in the	0.1%	1000

If you spend too much time  
adjusting Tuning-Less, you  
will be...

“Tuning-More”



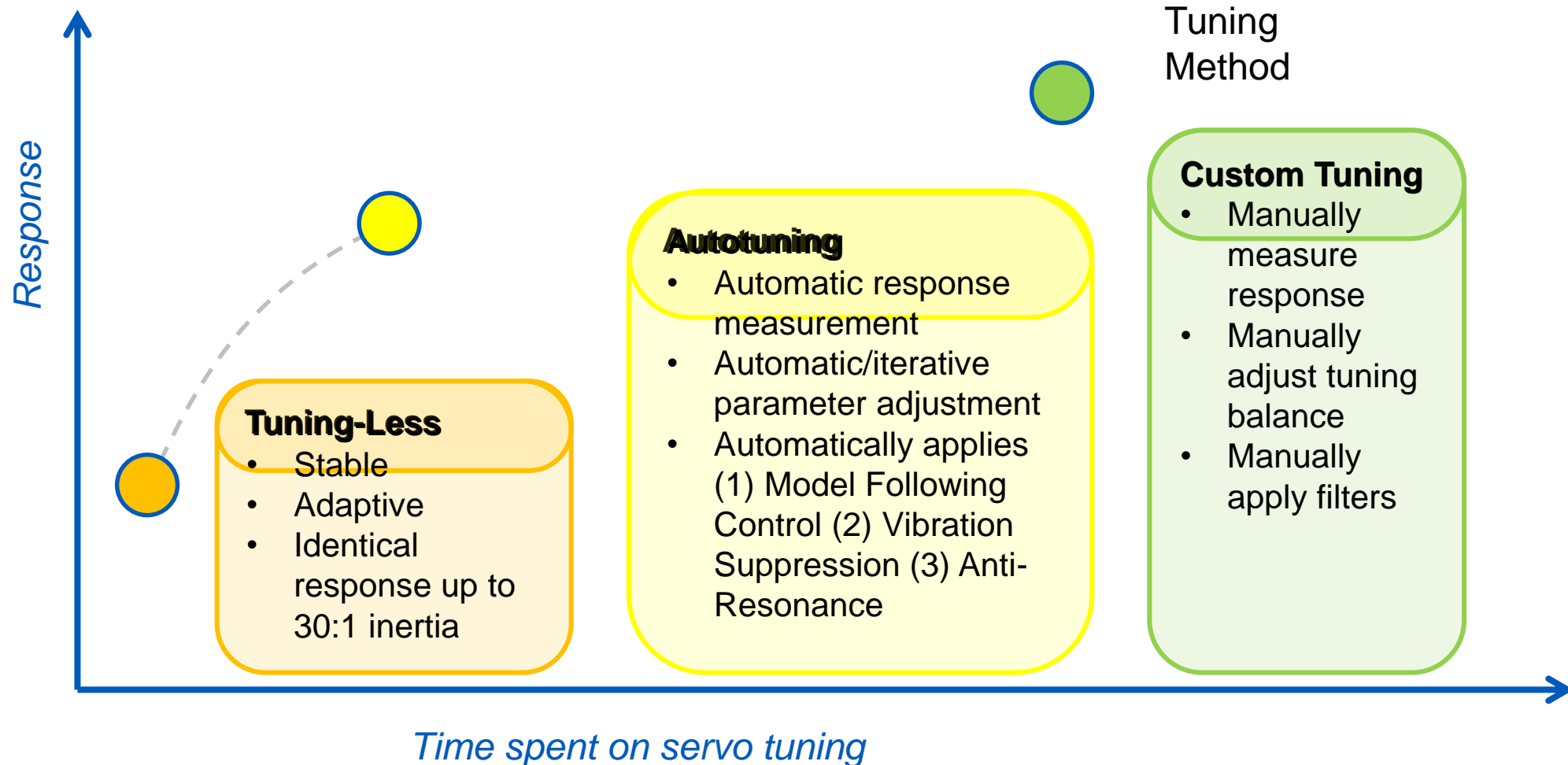


# Sigma-7 Servo Tuning Autotuning

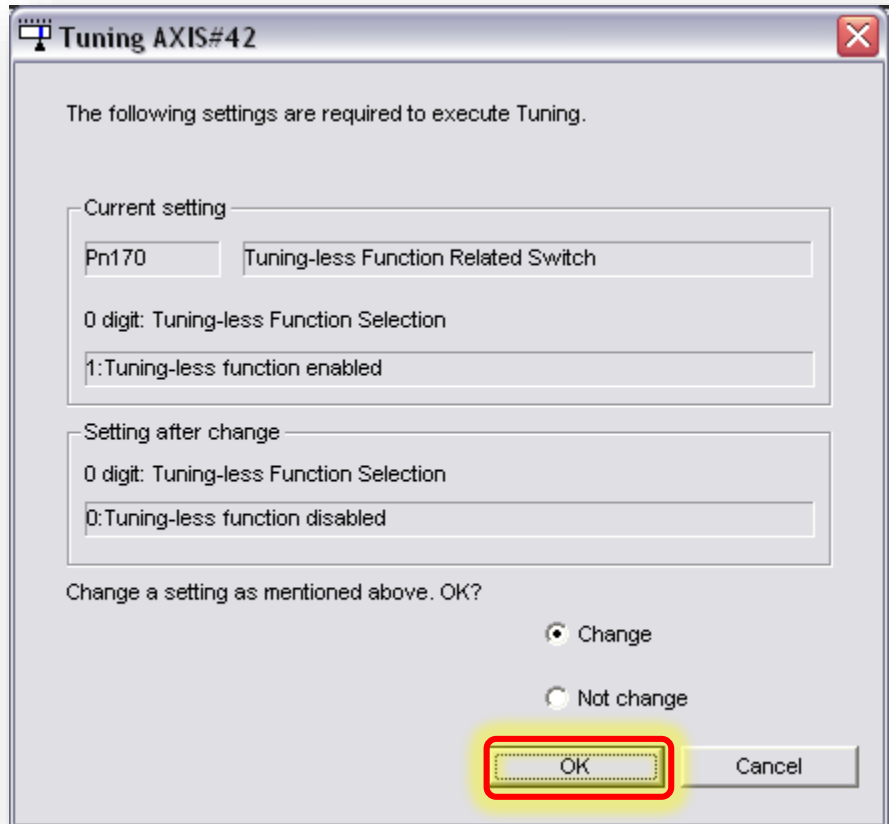
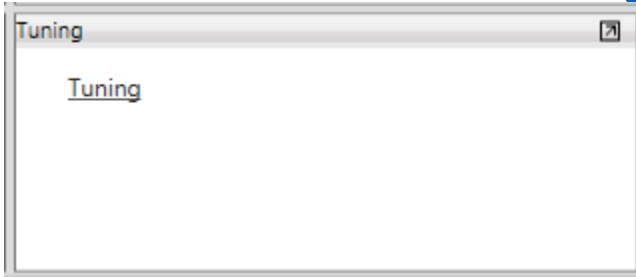
Run the Autotuning function on the Demo X Axis

- *Disable Tuning-Less*
- *Moment of Inertia Ratio*
- *Position Reference*
- *Mode and Mechanism*
- *Execute Autotuning*
- *Troubleshooting*

# Sigma-7 Tuning Methods



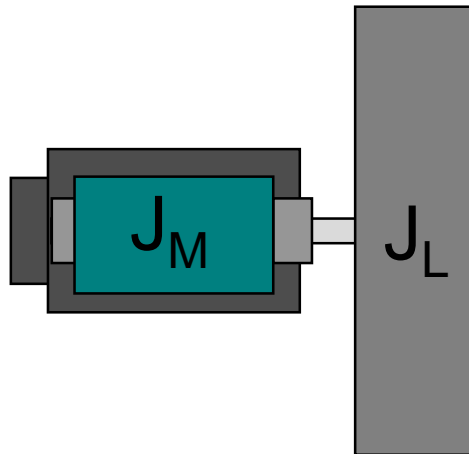
# Disable Tuning-Less



- *Autotuning requires Tuning-Less disabled*
  - *Adaptive tuning is cancelled*
  - *$Pn170.0 = 0$*
  - *Performance may change significantly*

# Moment of Inertia Ratio

- *Identify Pn103*
  - *Tuning-Less disabled*
  - *Pn103 scales system gains*
- *Motor will move*
  - *Stop controller motion*
  - *Servo Off*



$$\text{Inertia Ratio} \frac{J_L}{J_M}$$

**Tuning**

Set the moment of inertia (mass) ratio before executing autotuning. Precautions

Moment of inertia (mass) ratio identification

Pn103 : Moment of Inertia Ratio

Execute.

1878 % Edit

Autotuning

Reference input from host controller

Position reference input

No reference input

Autotuning

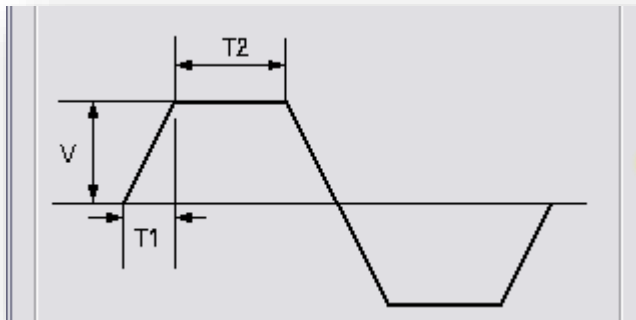
Advanced adjustment Finish



# Moment of Inertia Ratio

## ■ Motion Profile

- Choose motor speed appropriate for mechanism
- It is possible to customize the motion profile
  - » Acceleration
  - » Speed
  - » Distance



Motor will move both directions

Use highest speed and acceleration applicable to the machine

Condition Setting AXIS#

Condition Setting → Reference Transmission → Operation / Measurement → Write Results

Please set the following conditions for Moment of Inertia Identification.

Speed Loop Setting  
 Pn100:Speed Loop Gain [400] [0.1Hz] Edit  
 Pn101:Speed Loop Integral Time Constant [2000] [0.01ms]

Identification start level [300] [%] Edit

Reference Selection: ±1000min-1(2.50 turns MAX)

Detailed Setting (limitation in operation)  
 Acceleration: ±20000.00 [min-1/s] (5000.00 - 47746.48)  
 Speed: ±1000.00 [min-1] (1.15 - 1100.00)  
 Moving distance: ±2.50 [rotation] (0.01 - 2.75)

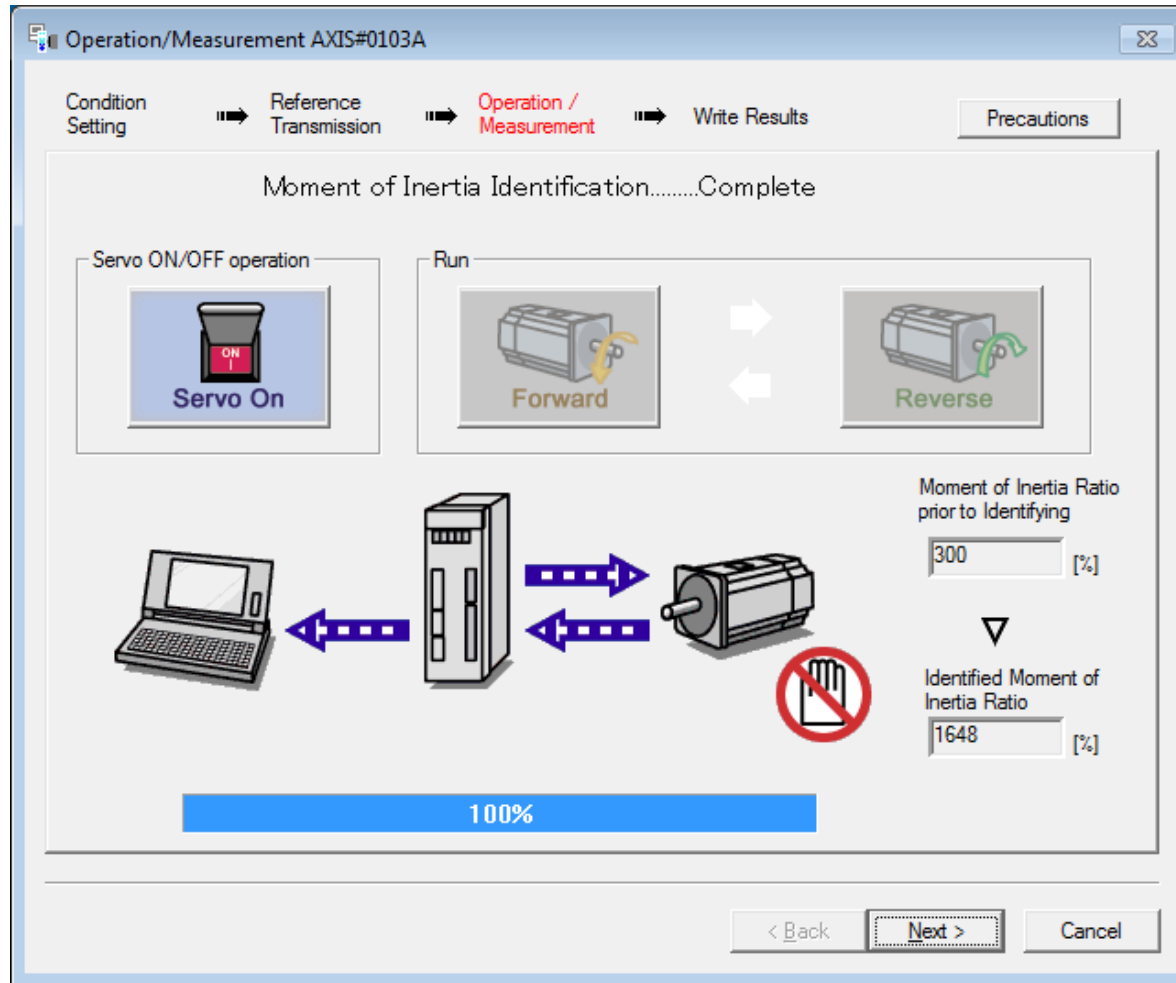
**CAUTION**  
 The Moment of Inertia Ratio can not be identified correctly under the following cases:  
 1. When the torque limit is active  
 Please see the Setting Help in detail.  
 Execute the software reset function, or turn the power off and then on after completion of execution.

Buttons: < Back, Next >, Cancel

Verify distance allowed

# Moment of Inertia Ratio

- Execute the move



## If the measurement fails

1. Change the profile settings from the previous screen, and try again

2. Reduce noise

- Set filters
- Lower Pn100

# Position Reference

## Position Reference Input

- External motion command
- Controller
- Program Jog

## No Reference Input

- Servopack generates motion command
- When no controller is available
- Simple

The image shows two software windows for Yaskawa motor control. The left window, 'Jog Program AXIS#0103A', displays a graph of position over time. The y-axis ranges from -1000 to 4000 [min-1/div] and the x-axis from 0 to 1235 [ms/div]. A red line shows a step function that jumps from 0 to approximately 3000 at 988 ms. To the right of the graph are 'Running Condition' parameters: Pn531: Program Jogging Travel Distance (167772160), Pn533: Program Jogging Movement Speed (3000), Pn534: Program Jogging Acceleration/Deceleration (35), Pn535: Program Jogging Waiting Time (1000), Pn536: Program Jogging Number of Movements (1), and Pn530.0: Program Jogging Operation Pattern (0). A 'Running Information' box at the bottom left shows 'Total Time 1236[ms]' and 'The total amount of movements +167772160[reference units]'. The right window, 'Tuning AXIS#0103A', shows 'Moment of inertia (mass) ratio identification' with 'Pn103: Moment of Inertia Ratio' set to 1648%. Below this is an 'Autotuning' section with 'Reference input from host controller' selected, and 'Position Reference Input' highlighted with a red box. The 'Autotuning' block is also highlighted with a yellow box. Buttons for 'Advanced adjustment' and 'Finish' are at the bottom.

Program Jog is the Position Reference Input

# Advanced Auto-Tuning

## ■ Mode Selection

- 1: Standard
  - » Lowest position error
- 2 & 3: For Positioning
  - » Lowest settling time
  - » Applies “Model Following Control”
  - » Required for Vibration Suppression

## ■ Mechanism Selection

- Balance of torque, speed, position loop bandwidth

## ■ Tuning Parameters

- Starting with default may give a better result

Autotuning - Setting Conditions AXIS#0103A

Set conditions.

Mode selection

2: For positioning

A gain adjustment specialized for positioning will be executed. In addition, the following automatic adjustments can be executed: Model following control, notch filter, anti-resonance control, and vibration suppression.

Mechanism selection

3: Rigid model

Executes adjustment suitable for a high-rigidity mechanism, such as rigid model.

Tuning parameters

Start tuning using the default settings

Next > Cancel

Output Amplitude (dB)

-3 dB

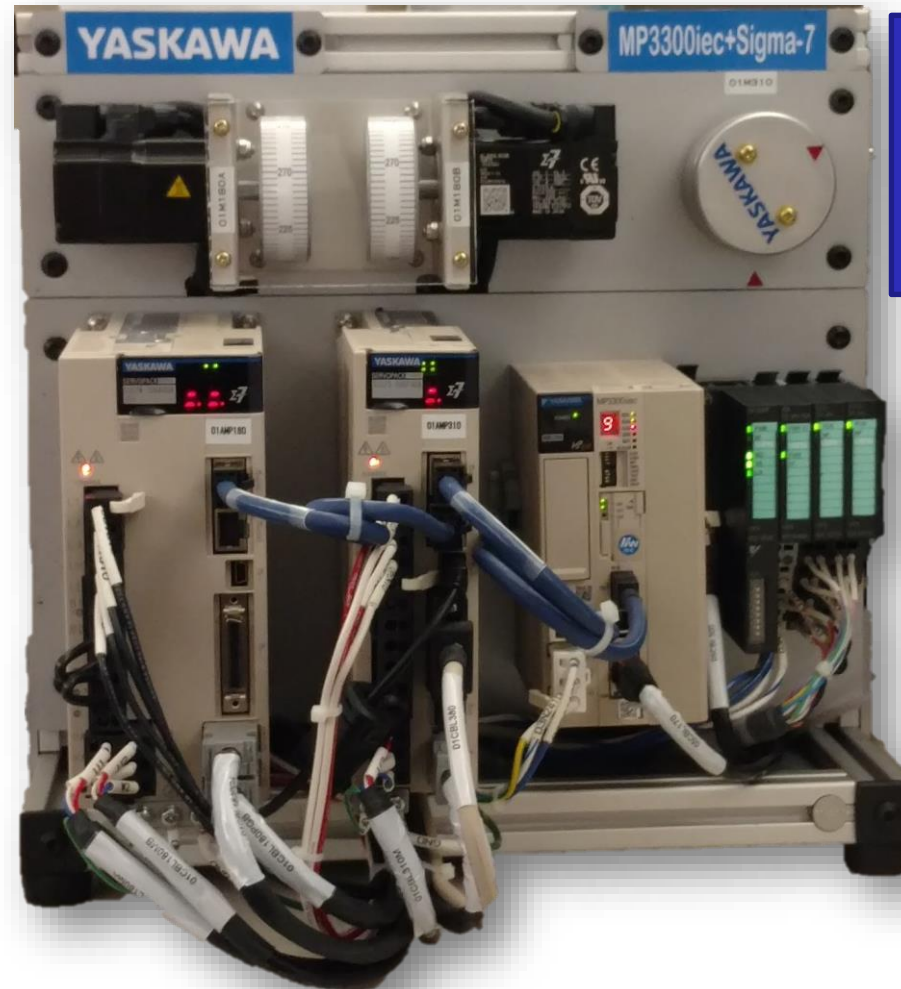
Frequency (Hz)

Position ( $f_p$ ) Speed ( $f_v$ ) Torque ( $f_c$ )

# Target Response

Tune for low position settling time.

Axes synchronized to each other



Tune for lowest position error.

Synchronized to external axis

Typical electronic cam application; rotary knife

# Execute Auto-Tuning

- *Start Program Jog*
- *Start Tuning*

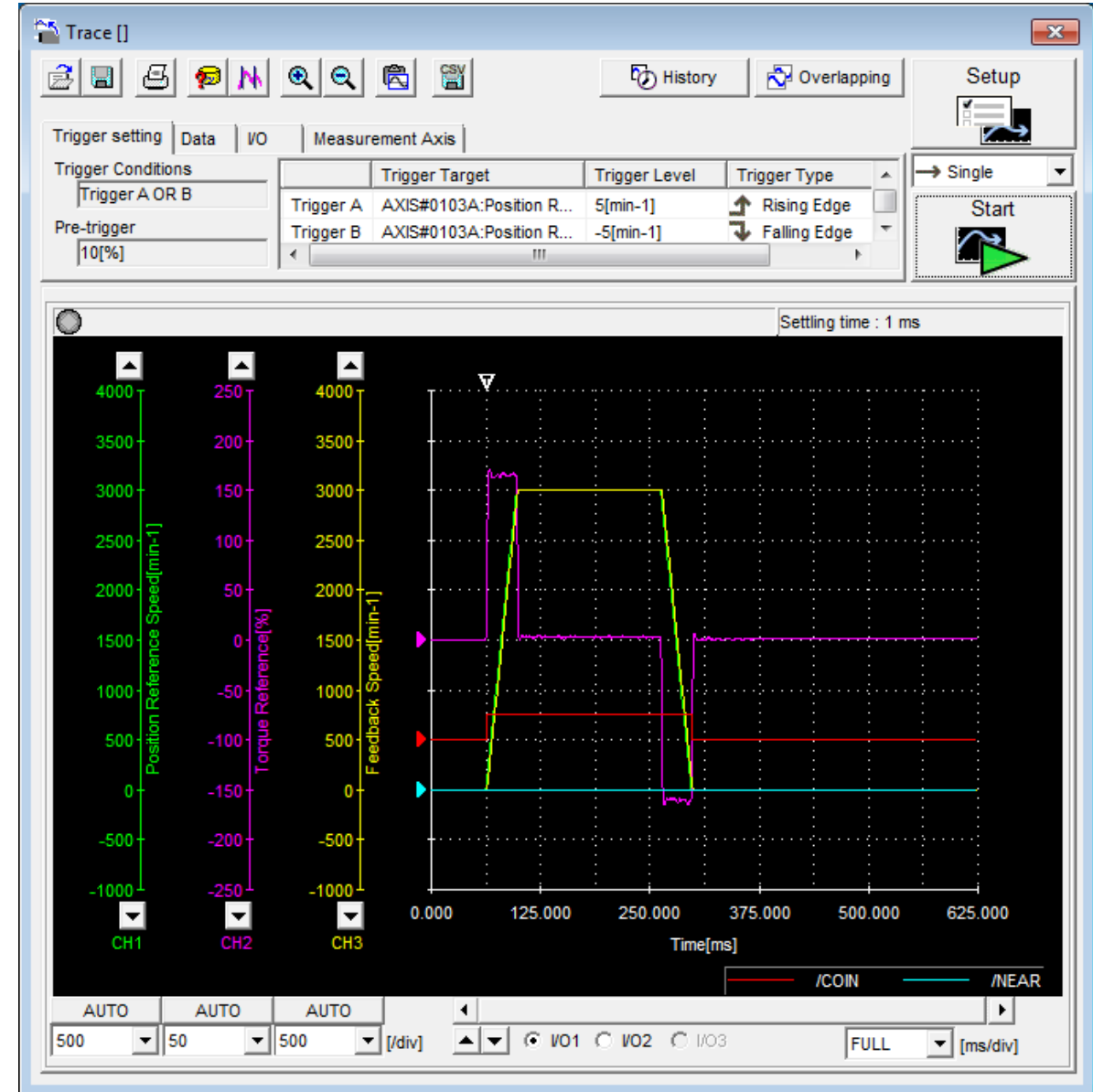
The image shows two windows from the Yaskawa software interface. The left window, titled "Jog Program AXIS#0103A", displays a graph of position (y-axis, -1000 to 4000) versus time (x-axis, 0 to 1235). The graph shows a step function that rises from 0 to approximately 3000 at time 988 and remains constant until time 1235. Below the graph, there are controls for "AUTO" mode and "FULL" resolution. A "Running Information" box at the bottom left shows: Total Time 1236[ms]/[times] and The total amount of movements +167772160[reference units]/[times]. The right window, titled "Autotuning - Automatic setting AXIS#0103A", shows the autotuning process. It includes a vertical progress bar with steps: "Waiting for execution", "Oscillation level measurement", "Gain search behaviour evaluation", and "Tuning completed". A "Cancel" button is visible. Below the progress bar, there are radio buttons for "Notch filter", "Anti-res Adj", and "Vib Suppress". At the bottom, there are buttons for "Precautions", "< Back", "Finish", and "Cancel". The "Mode selection" is set to "2:For positioning" and "Mechanism selection" is set to "3:Rigid model".

# Advanced Auto-Tuning

- Trace and measure the result
- Record in the Tuning Results Table

MP3300iec & Sigma-7 Demo Tuning

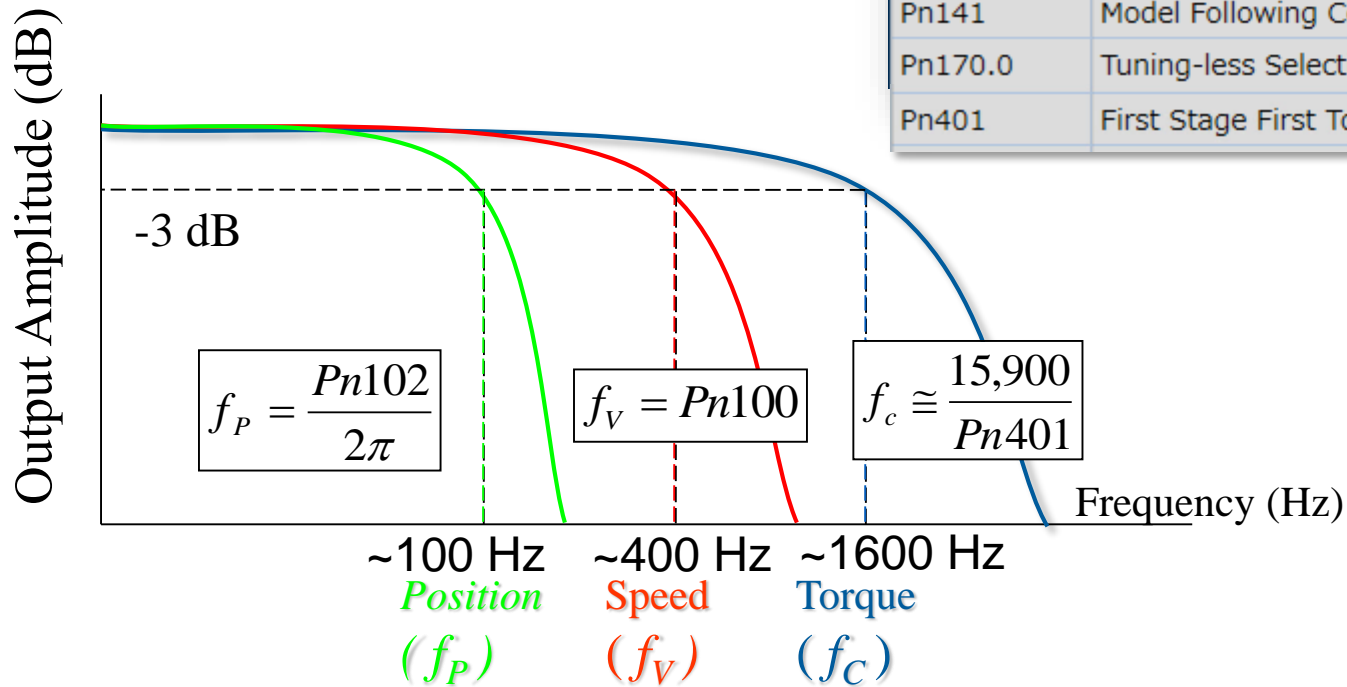
Axis	Tuning Algorithm	Position Settling Time	Maximum Position Error	Torque Ripple / Noise
SGD7W Axis A	Default "Tuning-Less"			
SGD7W Axis A 	Optimized Tuning-Less			
SGD7W Axis A 	<b>Advanced Auto-Tuning</b>			
SGD7W Axis A	Custom Tuning			
SGD7W Axis B	Default "Tuning-Less"			
SGD7W Axis B 	Optimized Tuning-Less			
SGD7W Axis B	Advanced Auto-Tuning			
SGD7W Axis B	Custom Tuning			
SGD7S AxisA	Default "Tuning-Less"			
SGD7S AxisA 	Optimized Tuning-Less			
SGD7S AxisA	Advanced Auto-Tuning			
SGD7S AxisA	Custom Tuning			



# Parameters

- $Pn102$
- $Pn100$
- $Pn401$

No.	Name	Unit	Default Setting	0103-SGD7W-1F Axis A
Pn100	Speed Loop Gain	0.1Hz	400	1212
Pn101	Speed Loop Integral Time Constant	0.01ms	2000	525
Pn102	Position Loop Gain	0.1/s	400	1818
Pn103	Moment of Inertia Ratio	%	100	1593
Pn109	Feedforward	%	0	100
Pn123	Friction Compensation Coefficient	%	0	85
Pn140.0	Model Following Control Selection	–	0 : Do not use mod	1 : Use model fo...
Pn141	Model Following Control Gain	0.1/s	500	6092
Pn170.0	Tuning-less Selection	–	1 : Enable tuning-le	0 : Disable tunin...
Pn401	First Stage First Torque Reference F	0.01ms	100	32

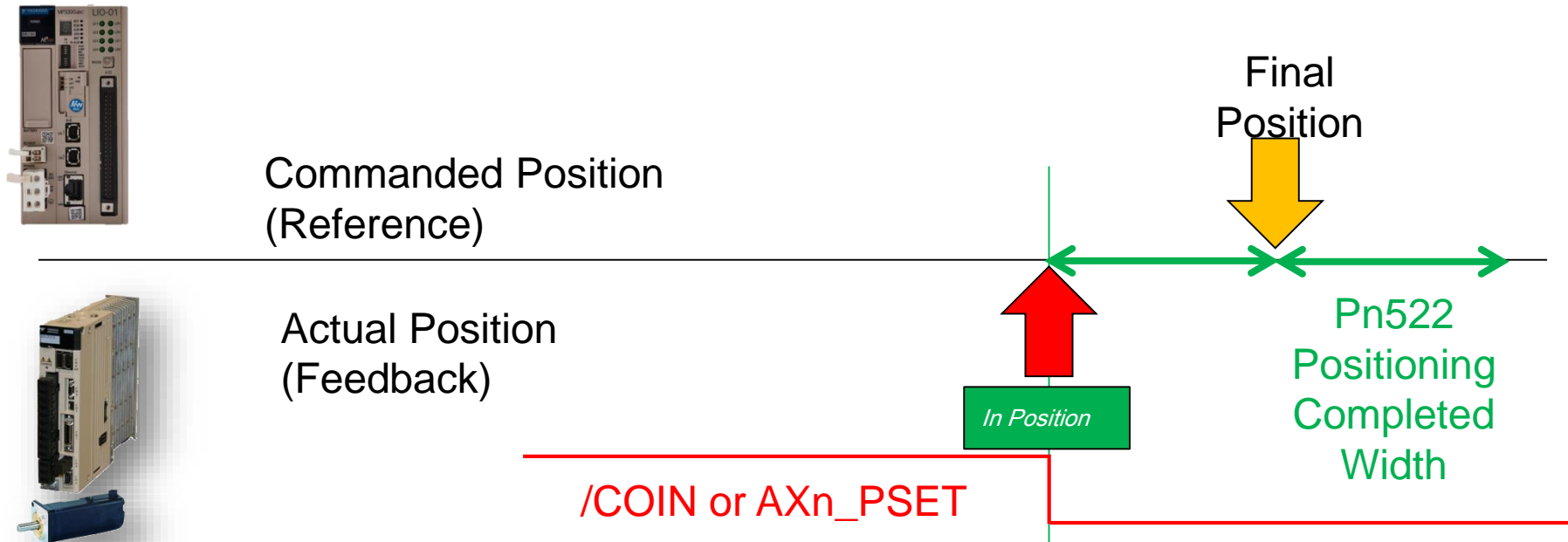




# Troubleshooting

- *Autotuning Fail*
  - */COIN signal must turn on between moves*
  - *Pn522 is too low*
  - *Not enough time between moves*
  - *Mechanical Problem*

- *Poor response*
  - *Pn522 is too low*



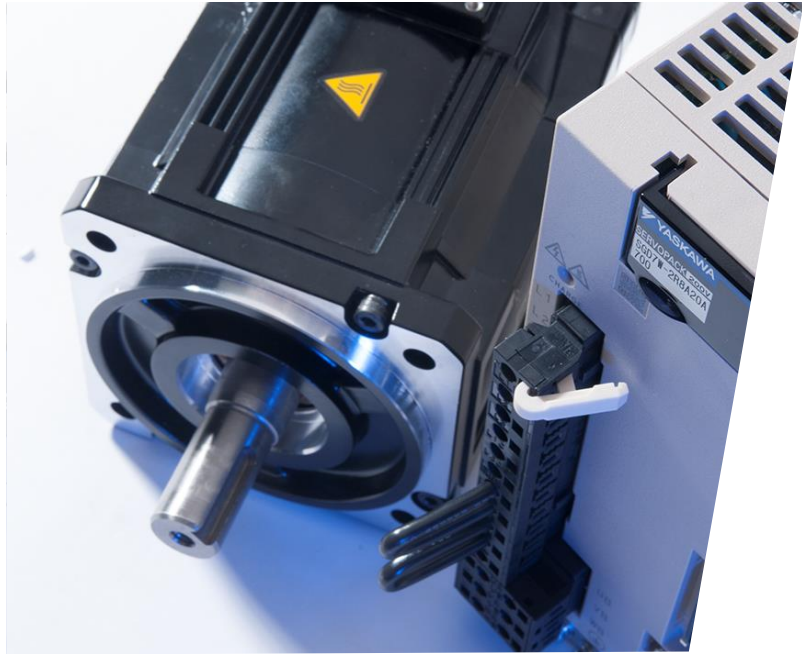
# Exercise

- Autotune the Y axis
  - Mode 2: Position Settling Time

MP3300iec &amp; Sigma-7 Demo Tuning

Axis	Tuning Algorithm	Position Settling Time	Maximum Position Error	Torque Ripple / Noise
SGD7W Axis A	Default "Tuning-Less"			
SGD7W Axis A 	Optimized Tuning-Less			
SGD7W Axis A	Advanced Auto-Tuning			
SGD7W Axis A	Custom Tuning			
SGD7W Axis B	Default "Tuning-Less"			
SGD7W Axis B 	Optimized Tuning-Less			
SGD7W Axis B	Advanced Auto-Tuning			
SGD7W Axis B	Custom Tuning			
SGD7S AxisA	Default "Tuning-Less"			
SGD7S AxisA 	Optimized Tuning-Less			
SGD7S AxisA	Advanced Auto-Tuning			
SGD7S AxisA	Custom Tuning			

- Axis B in SigmaWin+
  - "Axis B" in the menu
  - Trace measurement axis
    - » Trigger on Axis B

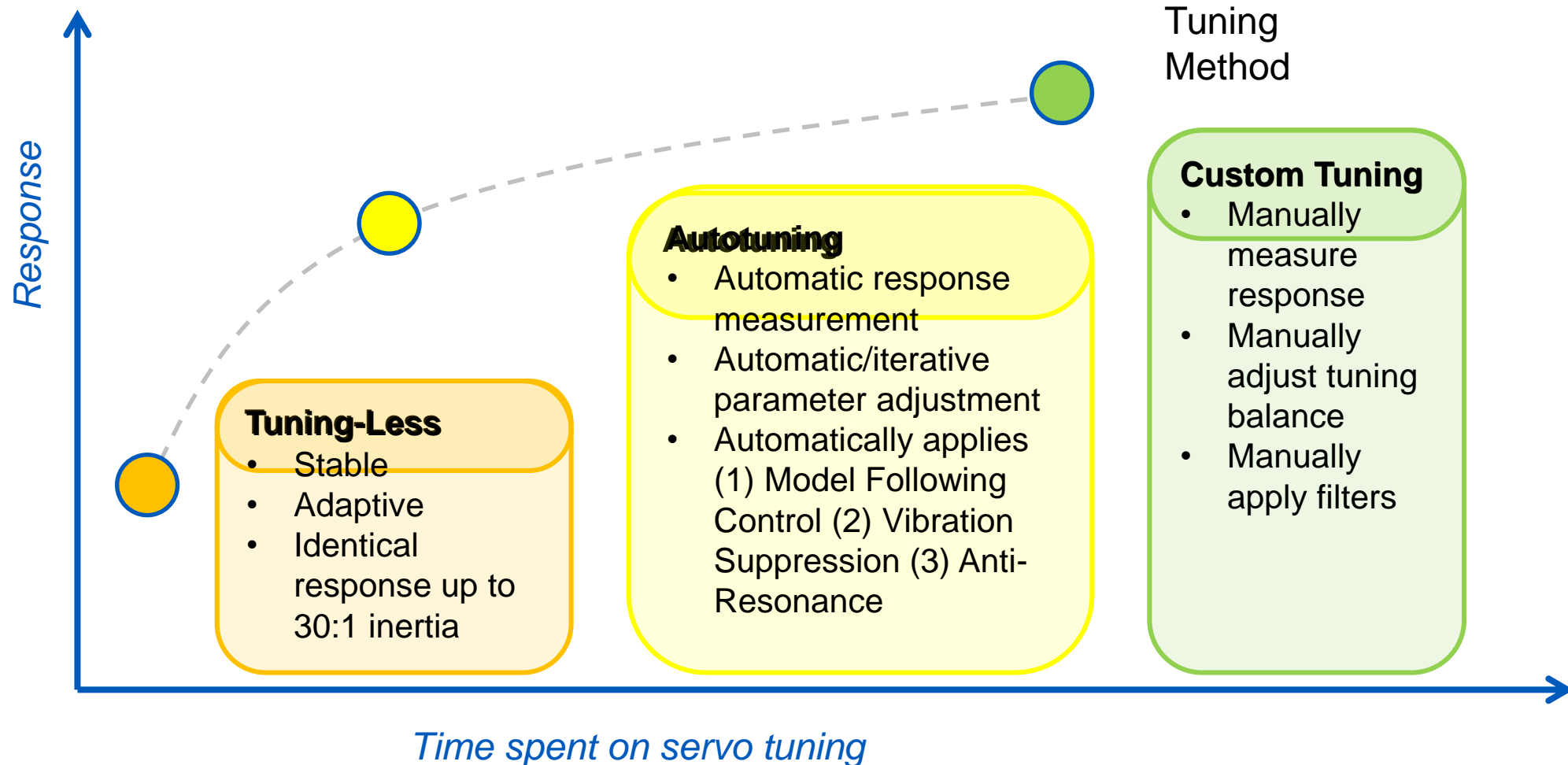


# Sigma-7 Servo Tuning Custom Tuning

Optimize the result of Auto Tuning on the Demo X Axis

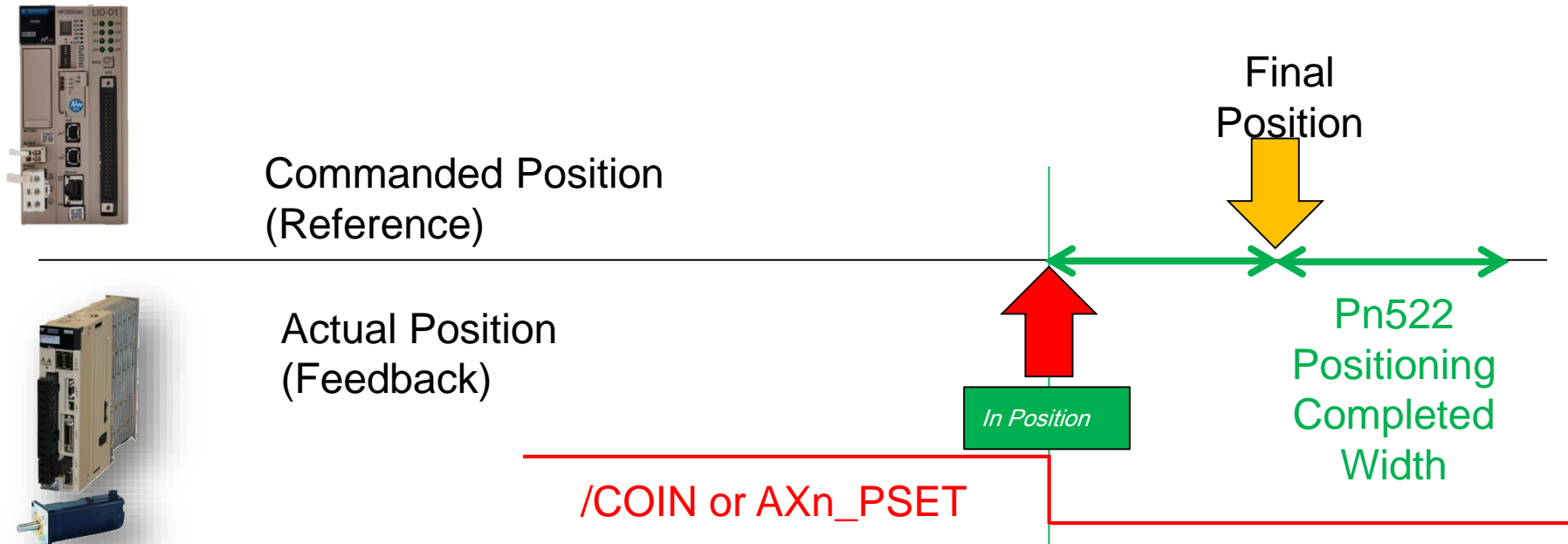
- *Basic Usage*
- *Filters*
- *Model Following Control*
- *Synchronize with MFC*

# Sigma-7 Tuning Methods

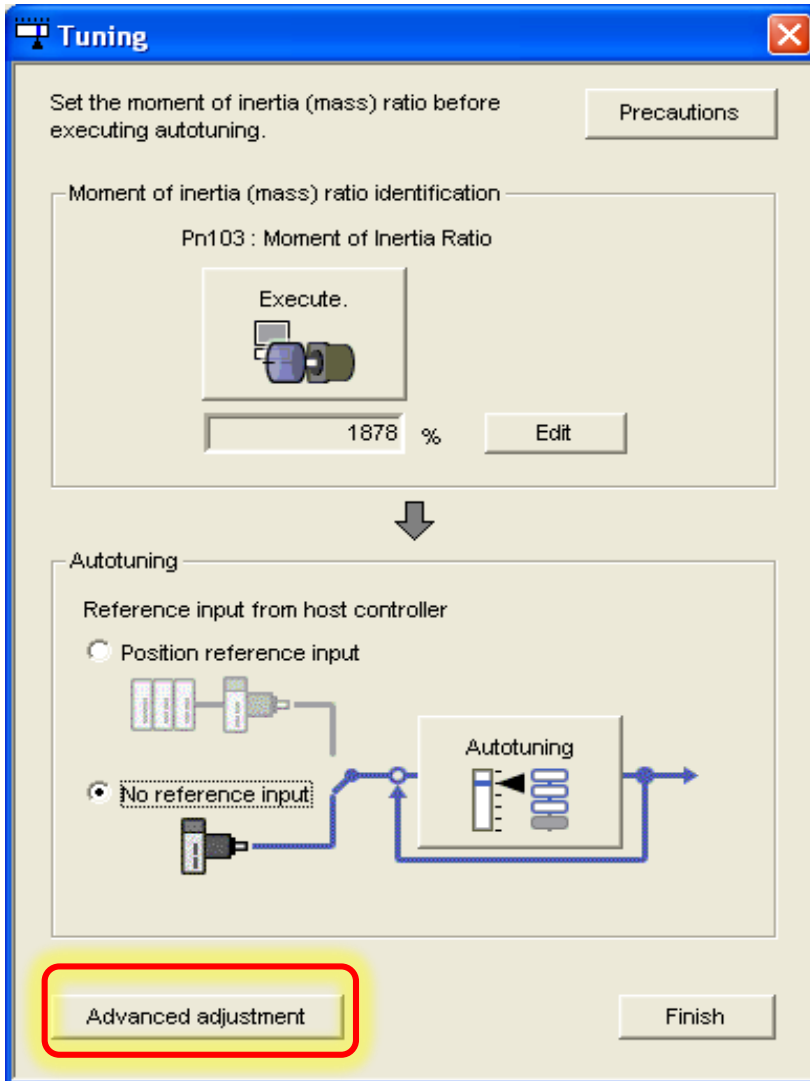


# Positioning Completed Width

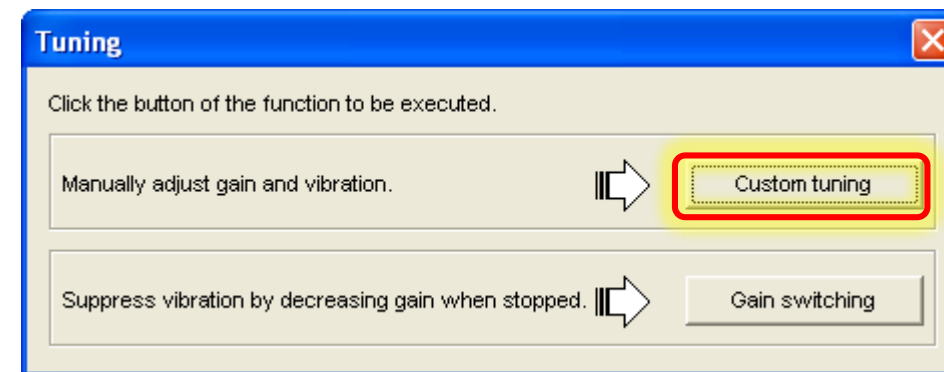
- *Change in Application Requirement*
- *Now: 0.01 [degree]*
  - *Previously 0.1 [degree]*
- *Pn522= 466 [pulse]*



# Basic Usage



- *Use after Autotuning*
- *May be able to improve the response further*



# Basic Usage

- *Increase levels for higher response*
- *Level too high produces noise*
- *Apply filters and increase level*

Pn141	Model Following Control Gain	0.1/s	6297
Pn142	Model Following Control Correction	0.1%	1000
Pn143	Model Following Control Bias in the Forward Direction	0.1%	1000
Pn144	Model Following Control Bias in the Reverse Direction	0.1%	1000
Pn145	Vibration Suppression 1 Frequency A	0.1Hz	500
Pn146	Vibration Suppression 1 Frequency B	0.1Hz	700
Pn147	Model Following Control Speed Feedforward Compensat	0.1%	1000
Pn148	Second Model Following Control Gain	0.1/s	500
Pn149	Second Model Following Control Correction	0.1%	1000
Pn14A	Vibration Suppression 2 Frequency	0.1Hz	800
Pn14B	Vibration Suppression 2 Correction	%	100
Pn14F.0	Model Following Control Type Selection	-	1 : Use model foll...

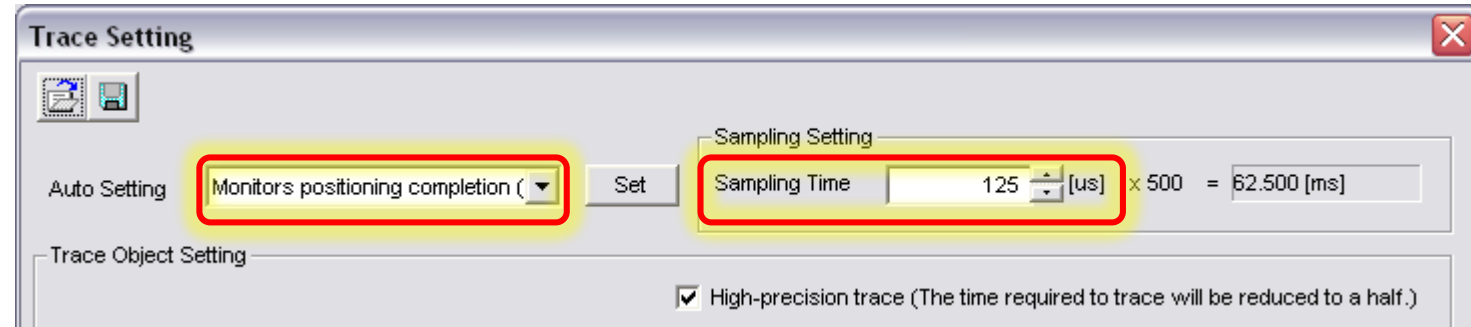
# Basic Usage

## Trace Settings

- Positioning Completion
- Sampling Time low
- Vertical Offset

## Exercise

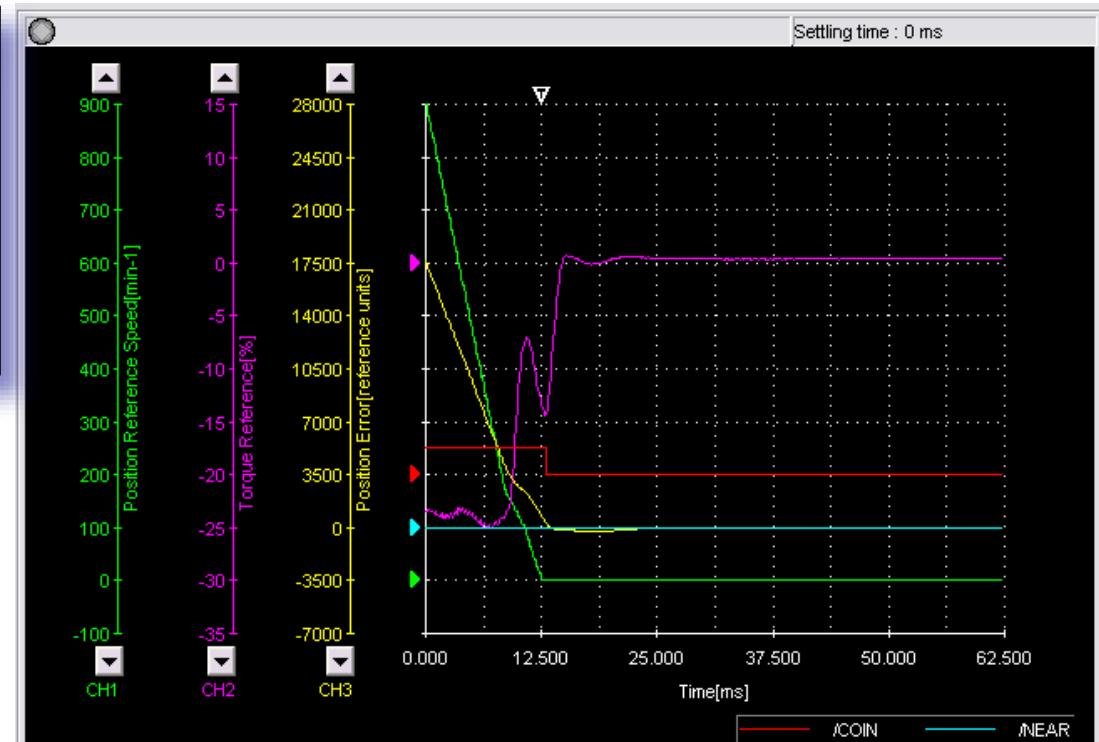
- Pn522=466
- Program Jog
- Adjust Levels



### Positioning Accuracy of 0.01 Degrees

Change /COIN level from 0.1 to 0.01

Pn522 = 4660 → 466

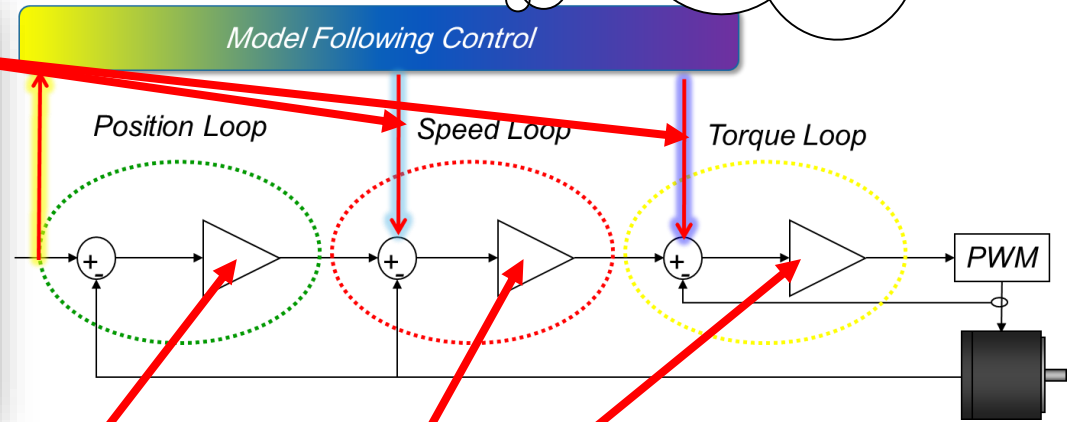
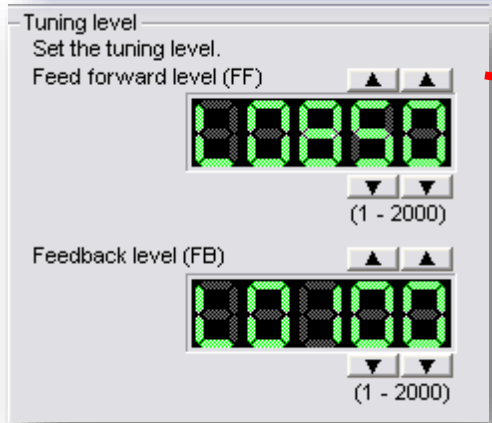




# Model Following Control (MFC)

- Autotuning modes 2 and 3
- Inertia, Friction, Compliance describe the machine
- Predicted torque and speed sent as feed forward
- Find Balance between FF and FB

Feed Forward Level (FF) sets the Model Following Control gain Pn141.



$$\begin{aligned} \Delta U(k) &= \begin{bmatrix} \Delta u_{2M}(k+N_p) \\ \vdots \\ \Delta u_{2M}(k) \end{bmatrix} \\ \Xi(k) &= \begin{bmatrix} HE(k) \\ HA(k)E(k) + HE(k) \\ \vdots \\ \sum_{i=1}^{N_p-1} HA(k)^{i-1}E(k) \\ \vdots \\ HB(k) \quad 0 \quad \dots \quad 0 \\ HA(k)B(k) \quad HB(k) \\ \vdots \\ HA(k)^{N_p-1}B(k) \quad \vdots \quad HB(k) \\ \vdots \\ -1 \quad 0 \quad \dots \quad 0 \end{bmatrix} \end{aligned}$$

Feedback Level (FB) sets the gains and filters for the control loops. Pn100, Pn101, Pn102, Pn401. Error is reduced. Noise can be produced.

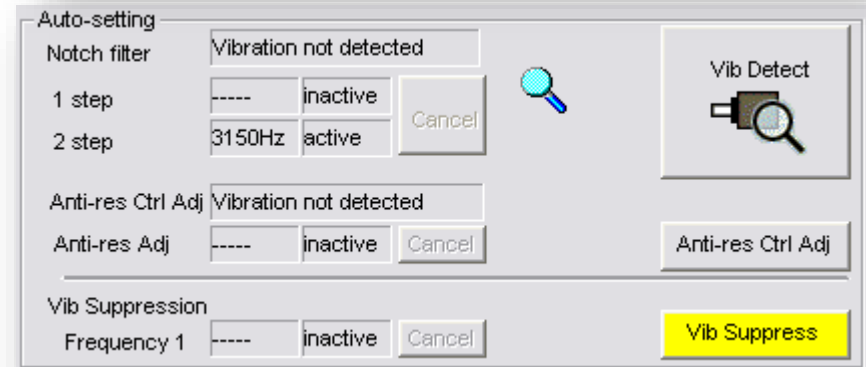
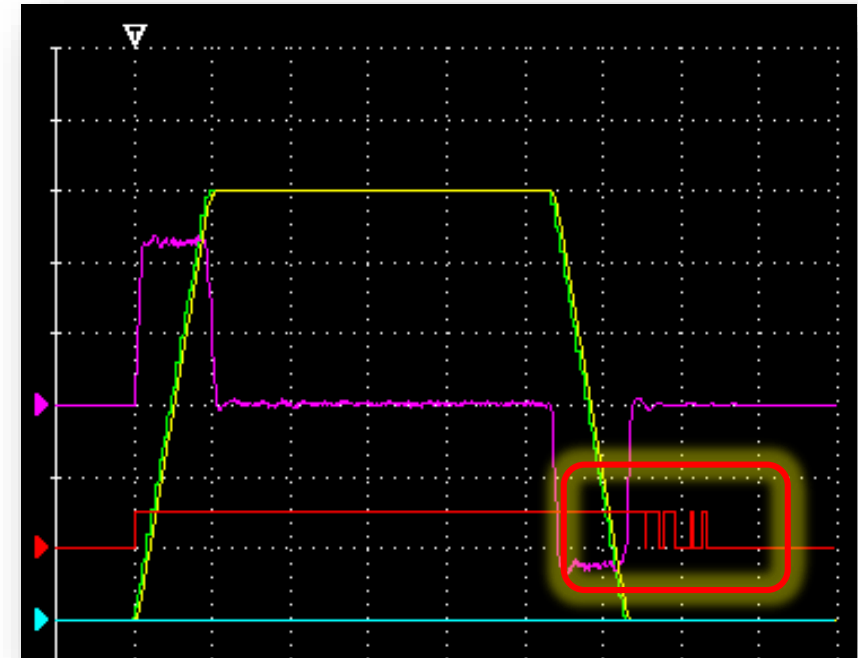
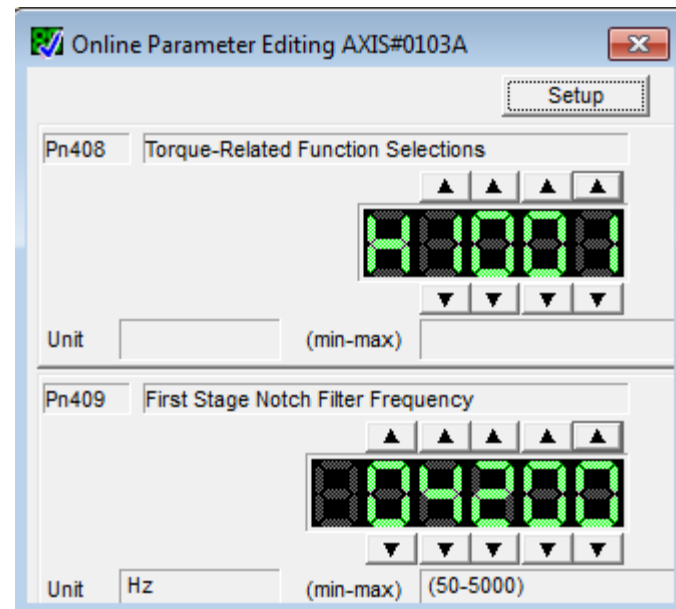
$$f_P = \frac{Pn102}{2\pi}$$

$$f_V = Pn100$$

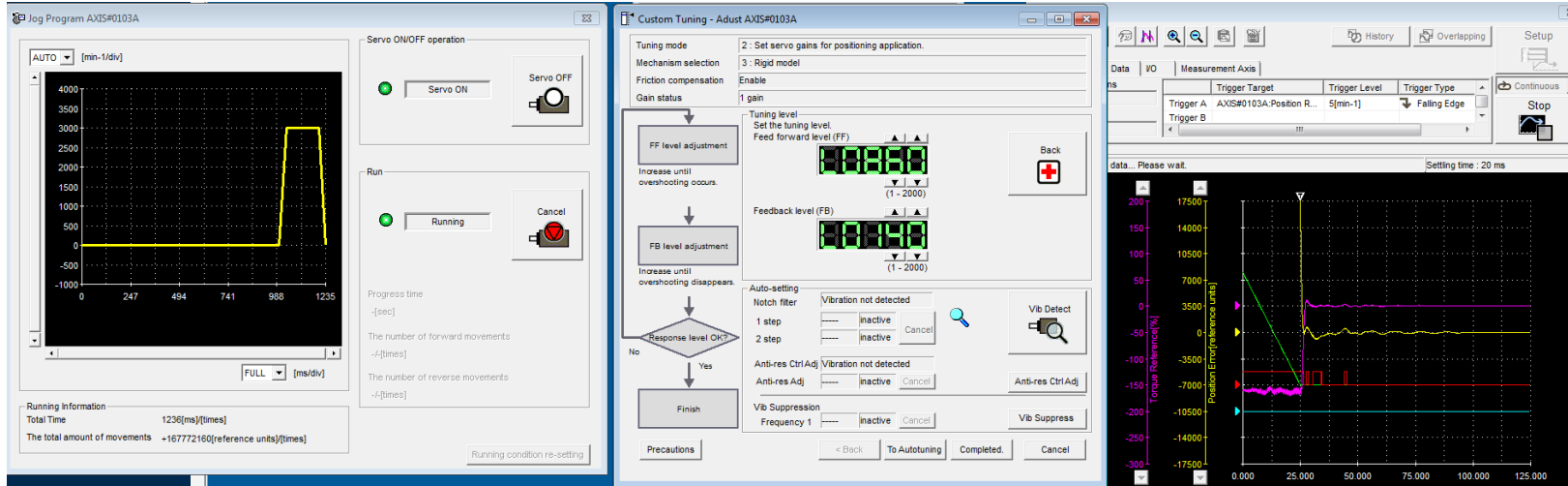
$$f_c \cong \frac{15,900}{Pn401}$$

# Filters

- *Vibration Suppression*
  - *Oscillation outside of the Position Complete Window Pn522 (/COIN) indicates vibration at end of move*
- *Notch Filter*
  - *Online Adjustment*



# Record Result



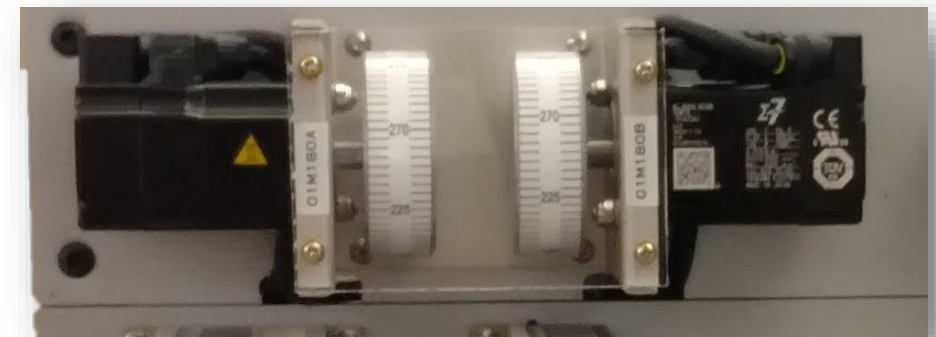
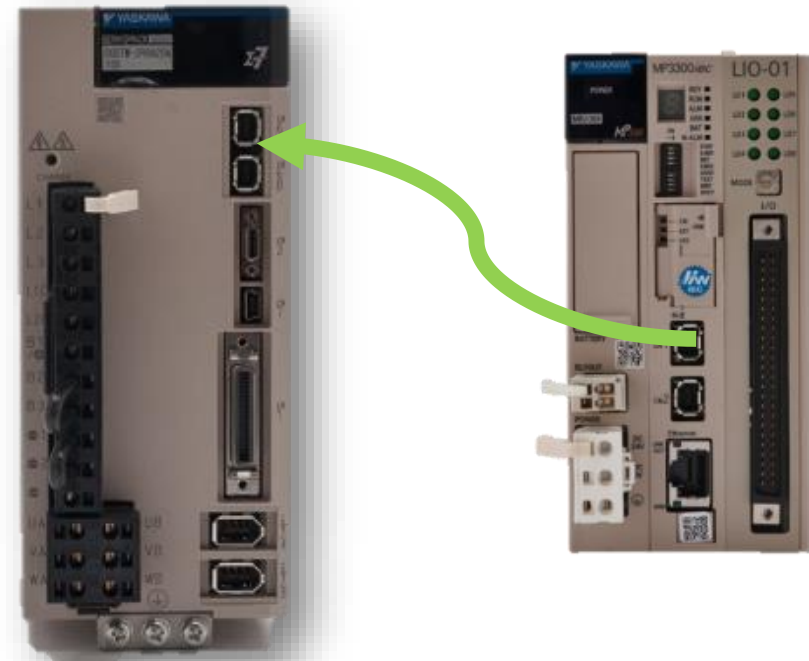
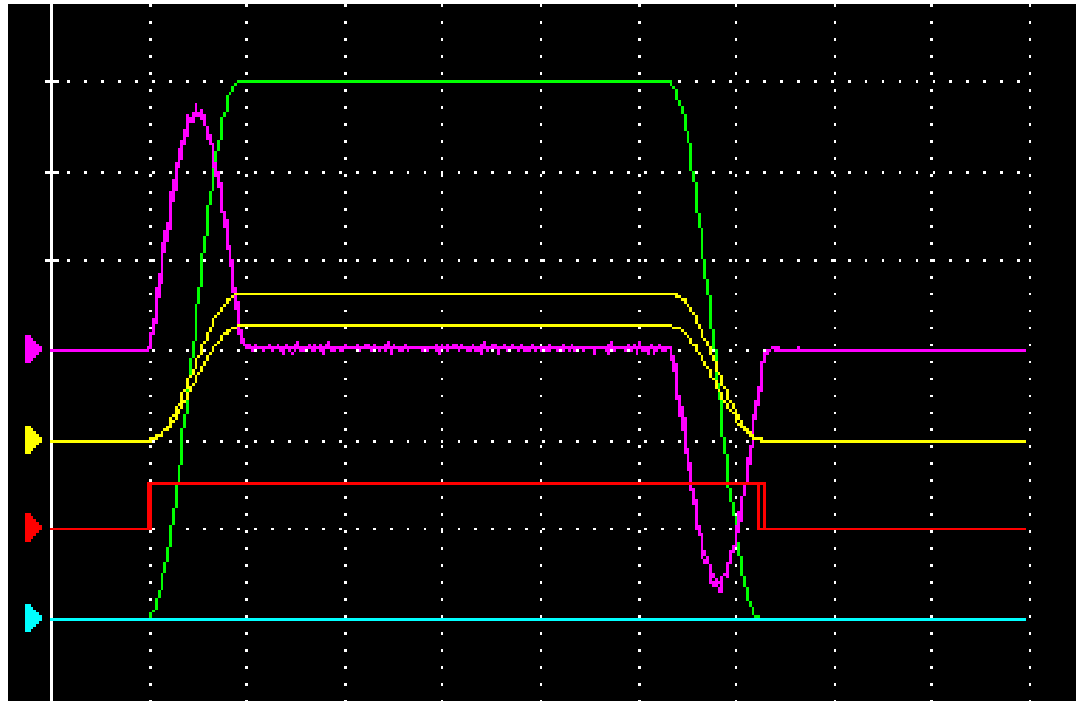
- Measure final result
- Record results in table
- Save Trace
- Save Parameters

MP3300iec & Sigma-7 Demo Tuning

Axis	Tuning Algorithm	Position Settling Time	Maximum Position Error	Torque Ripple / Noise
SGD7W Axis A	Default "Tuning-Less"			
SGD7W Axis A	Optimized Tuning-Less			
SGD7W Axis A	Advanced Auto-Tuning			
SGD7W Axis A	Custom Tuning			
SGD7W Axis B	Default "Tuning-Less"			
SGD7W Axis B	Optimized Tuning-Less			
SGD7W Axis B	Advanced Auto-Tuning			
SGD7W Axis B	Custom Tuning			
SGD7S AxisA	Default "Tuning-Less"			
SGD7S AxisA	Optimized Tuning-Less			
SGD7S AxisA	Advanced Auto-Tuning			
SGD7S AxisA	Custom Tuning			

# Synchronize with MFC

- *Synchronized Command*
- *MFC Gain Pn141 not the same*
- *Response Not Synchronized*



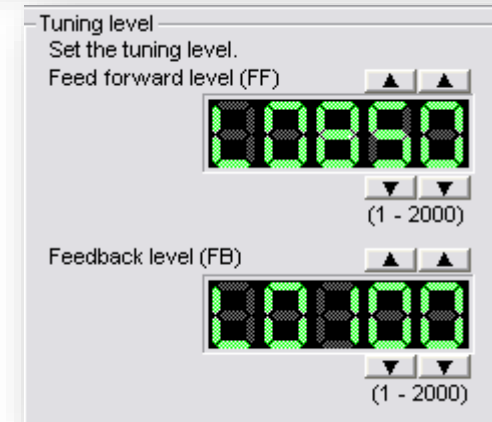
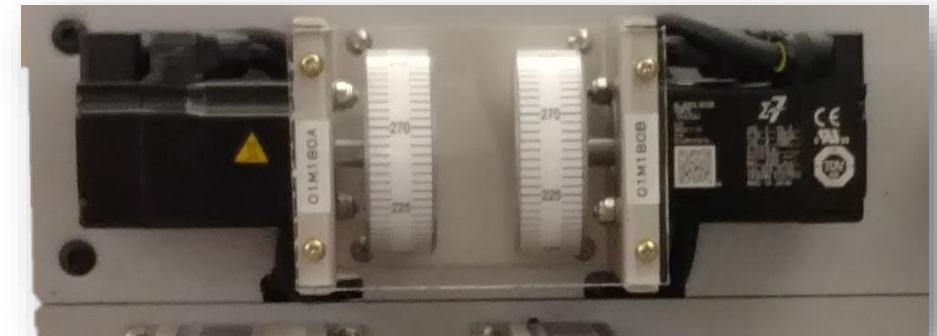
# Synchronize with MFC

- *Repeat Custom Tuning for Y Axis*
  - *Set Feed Forward Level the same as X axis*

If Pn141 (Model Following Control Gain) is the same, then the same command results in the same profile and axes are synchronized even though position error is high

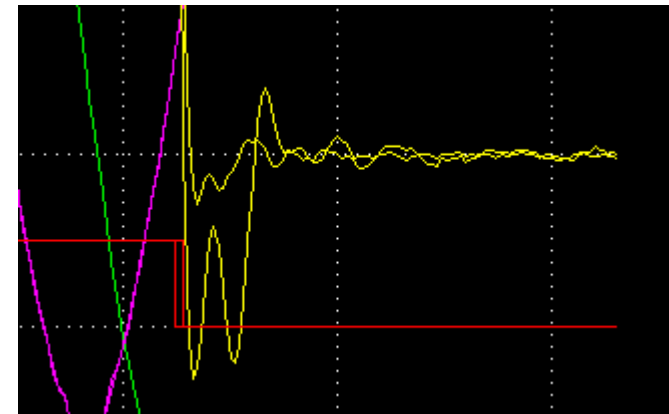
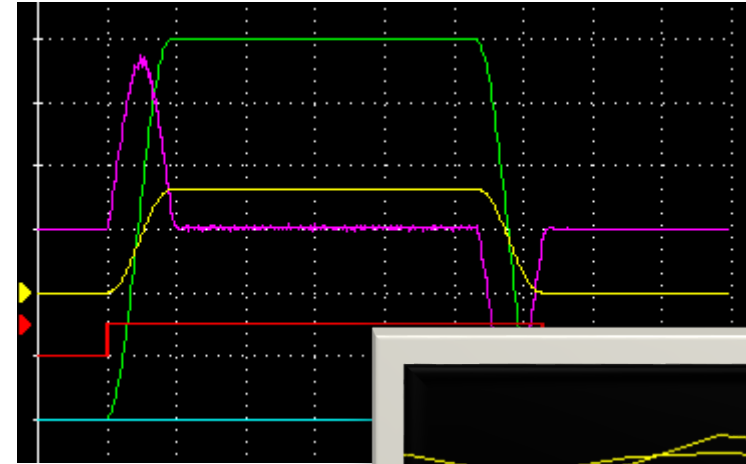
MP3300iec & Sigma-7 Demo Tuning

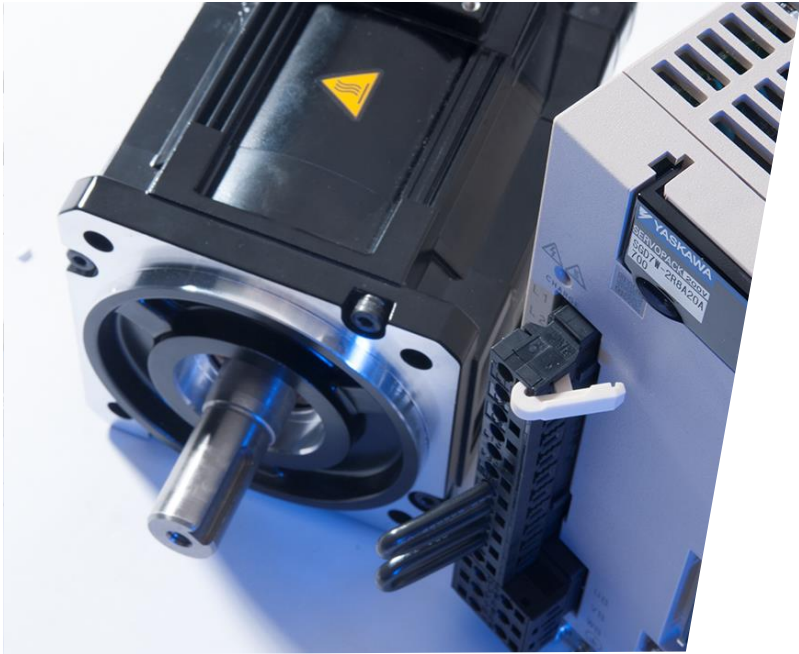
Axis	Tuning Algorithm	Position Settling Time	Maximum Position Error	Torque Ripple / Noise
SGD7W Axis A	Default "Tuning-Less"			
SGD7W Axis A	Optimized Tuning-Less			
SGD7W Axis A	Advanced Auto-Tuning			
SGD7W Axis A	Custom Tuning			
SGD7W Axis B	Default "Tuning-Less"			
SGD7W Axis B	Optimized Tuning-Less			
SGD7W Axis B	Advanced Auto-Tuning			
SGD7W Axis B	Custom Tuning			
SGD7S AxisA	Default "Tuning-Less"			
SGD7S AxisA	Optimized Tuning-Less			
SGD7S AxisA	Advanced Auto-Tuning			
SGD7S AxisA	Custom Tuning			



# Synchronize with MFC

- *Synchronized Command*
- *MFC Gain Pn141 **IS** the same*
- *Response **IS** Synchronized*
- *Feedback Level (FB) affects end of move*





# Sigma-7 Servo Tuning Tuning for Low Position Error

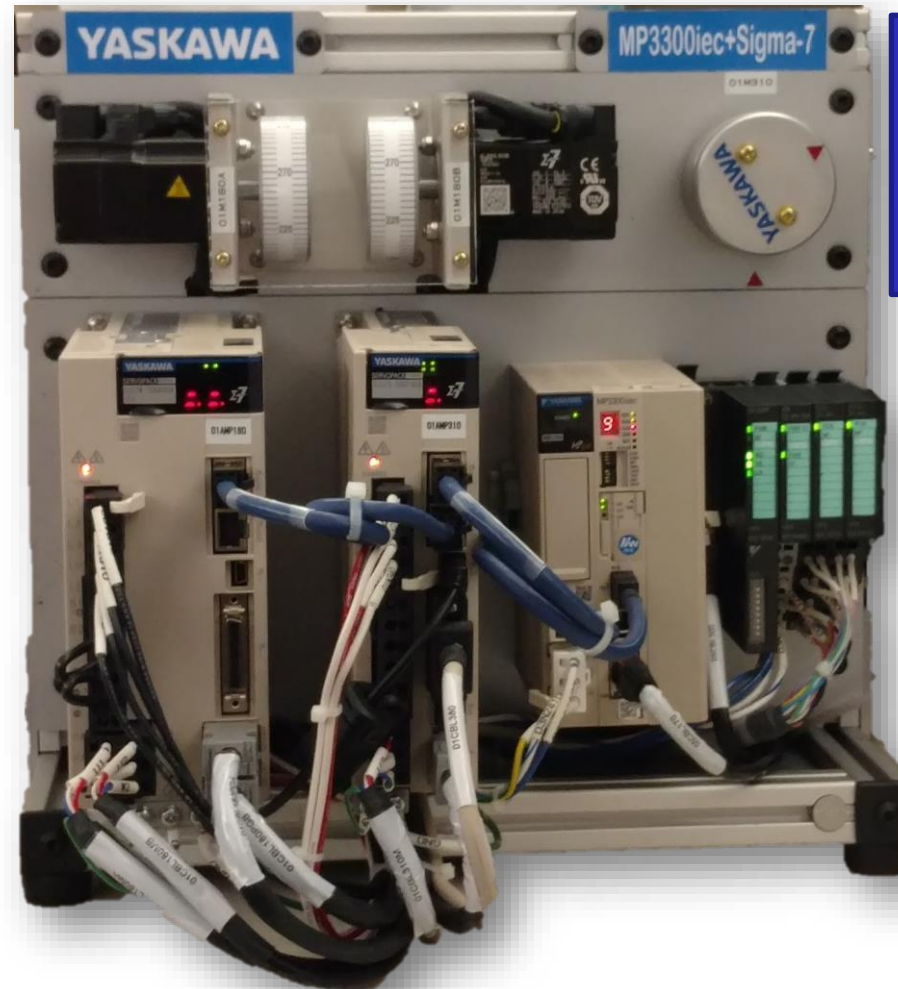
Minimize Position Error on Z-Axis

- *Autotuning Mode 1*
- *100% Feed Forward*
- *Custom Tuning Mode 1*

# Target Response

Tune for low position settling time.

Axes synchronized to each other



Tune for lowest position error.

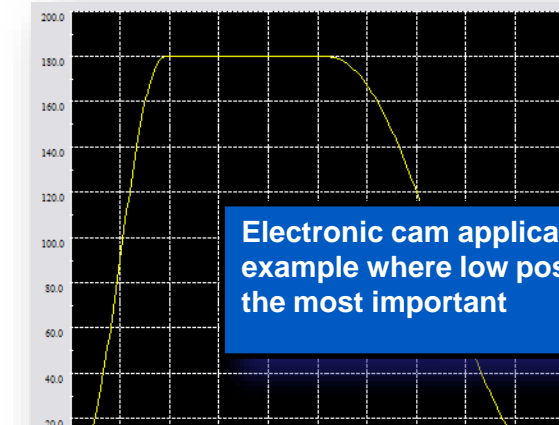
Synchronized to external axis

Electronic cam application; rotary knife




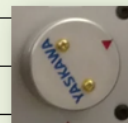
# Process Overview

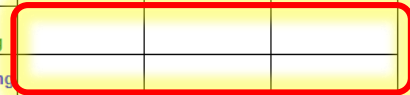
1. *Auto-Tune Mode 1: "Standard"*
2. *Set feed-forward Pn109 = 100*
3. *Custom Tuning Mode 1*



Electronic cam applications are one example where low position error is the most important

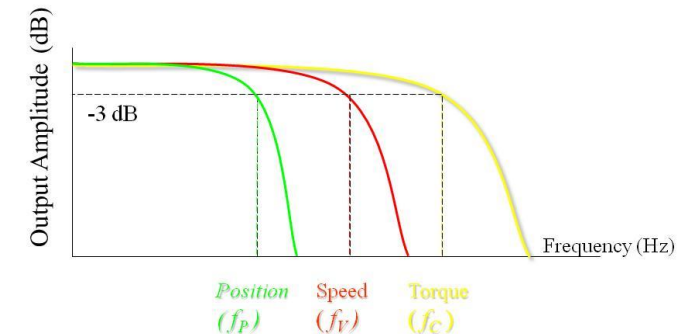
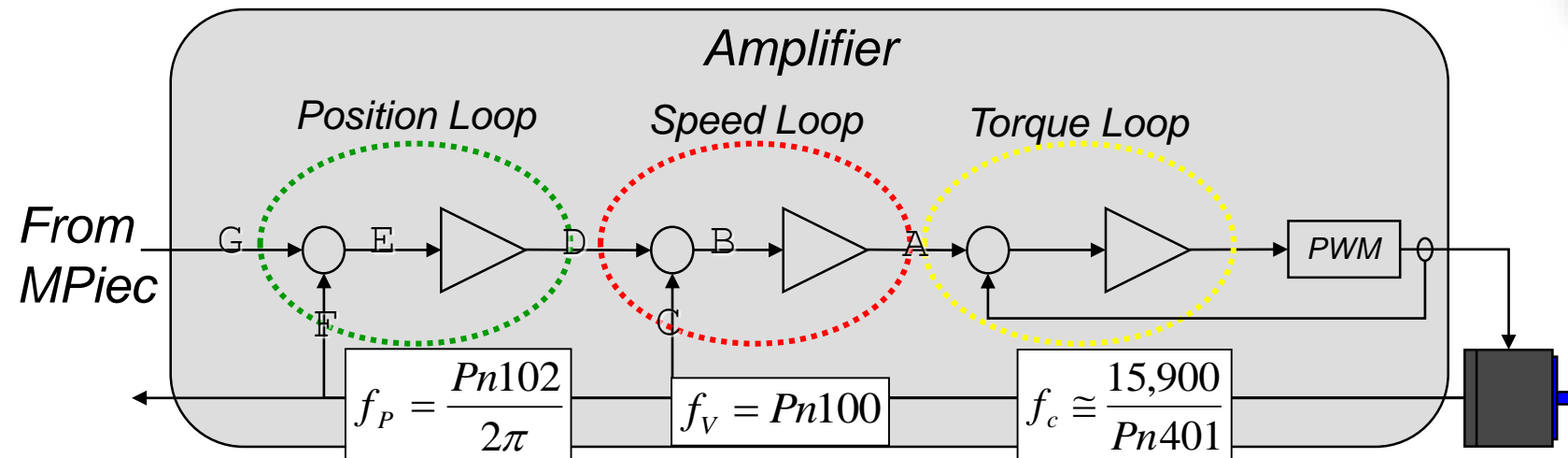
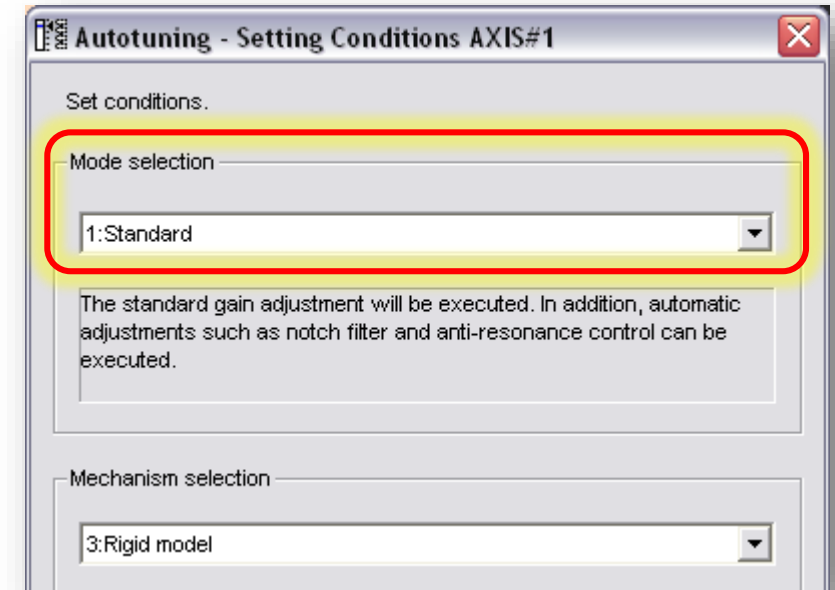
MP3300iec & Sigma-7 Demo Tuning

Axis	Tuning Algorithm	Position Settling Time	Maximum Position Error	Torque Ripple / Noise
SGD7W Axis A	Default "Tuning-Less"			
SGD7W Axis A 	Optimized Tuning-Less			
SGD7W Axis A	Advanced Auto-Tuning			
SGD7W Axis A	Custom Tuning			
SGD7W Axis B	Default "Tuning-Less"			
SGD7W Axis B 	Optimized Tuning-Less			
SGD7W Axis B	Advanced Auto-Tuning			
SGD7W Axis B	Custom Tuning			
SGD7S AxisA	Default "Tuning-Less"			
SGD7S AxisA 	Optimized Tuning-Less			
SGD7S AxisA	Advanced Auto-Tuning			
SGD7S AxisA	Custom Tuning			



# 1. Autotuning, Mode 1: "Standard"

- *Model Following is OFF (Pn140.0=0)*
- *Vibration Suppression NOT available*
- *Bandwidths remain proportional, according to Mechanism Selection*
- *Execute with Feed-forward Pn109=0*



## 2. Feed Forward Pn109=100

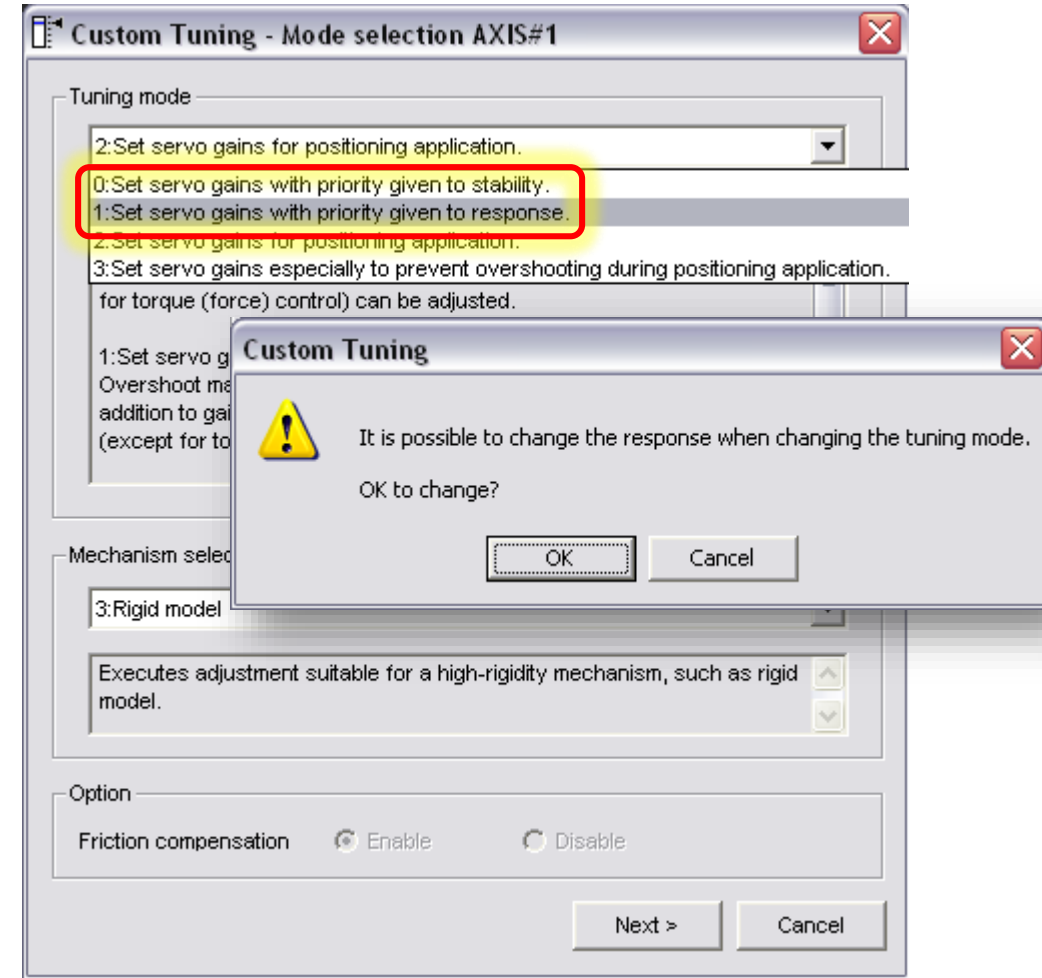
- Position Error near zero at constant speed



## 3. Custom Tuning Mode 1

- *OK to warning*
- *Continuous Trace*
- *Increase Tuning Level*
- *Vibration Sound?*
  - *Adjust Notch Filter Frequency*

Pn409	First Stage Notch Filter Frequency	Hz	5000
Pn40A	First Stage Notch Filter Q Value	0.01	70
Pn40B	First Stage Notch Filter Depth	0.001	0
Pn40C	Second Stage Notch Filter Frequency	Hz	3860
Pn40D	Second Stage Notch Filter Q Value	0.01	70
Pn40E	Second Stage Notch Filter Depth	0.001	0



# Tuning for Low Position Error

- Record Final Result

MP3300iec & Sigma-7 Demo Tuning

Axis	Tuning Algorithm	Position Settling Time	Maximum Position Error	Torque Ripple / Noise
SGD7W Axis A	Default "Tuning-Less"			
SGD7W Axis A	Optimized Tuning-Less			
SGD7W Axis A	Advanced Auto-Tuning			
SGD7W Axis A	Custom Tuning			
SGD7W Axis B	Default "Tuning-Less"			
SGD7W Axis B	Optimized Tuning-Less			
SGD7W Axis B	Advanced Auto-Tuning			
SGD7W Axis B	Custom Tuning			
SGD7S AxisA	Default "Tuning-Less"			
SGD7S AxisA	Optimized Tuning-Less			
SGD7S AxisA	Advanced Auto-Tuning			
SGD7S AxisA	Custom Tuning			

Custom Tuning - Adjust AXIS#0105A

Tuning mode: 1 : Set servo gains with priority given to response.

Mechanism selection: 3 : Rigid model

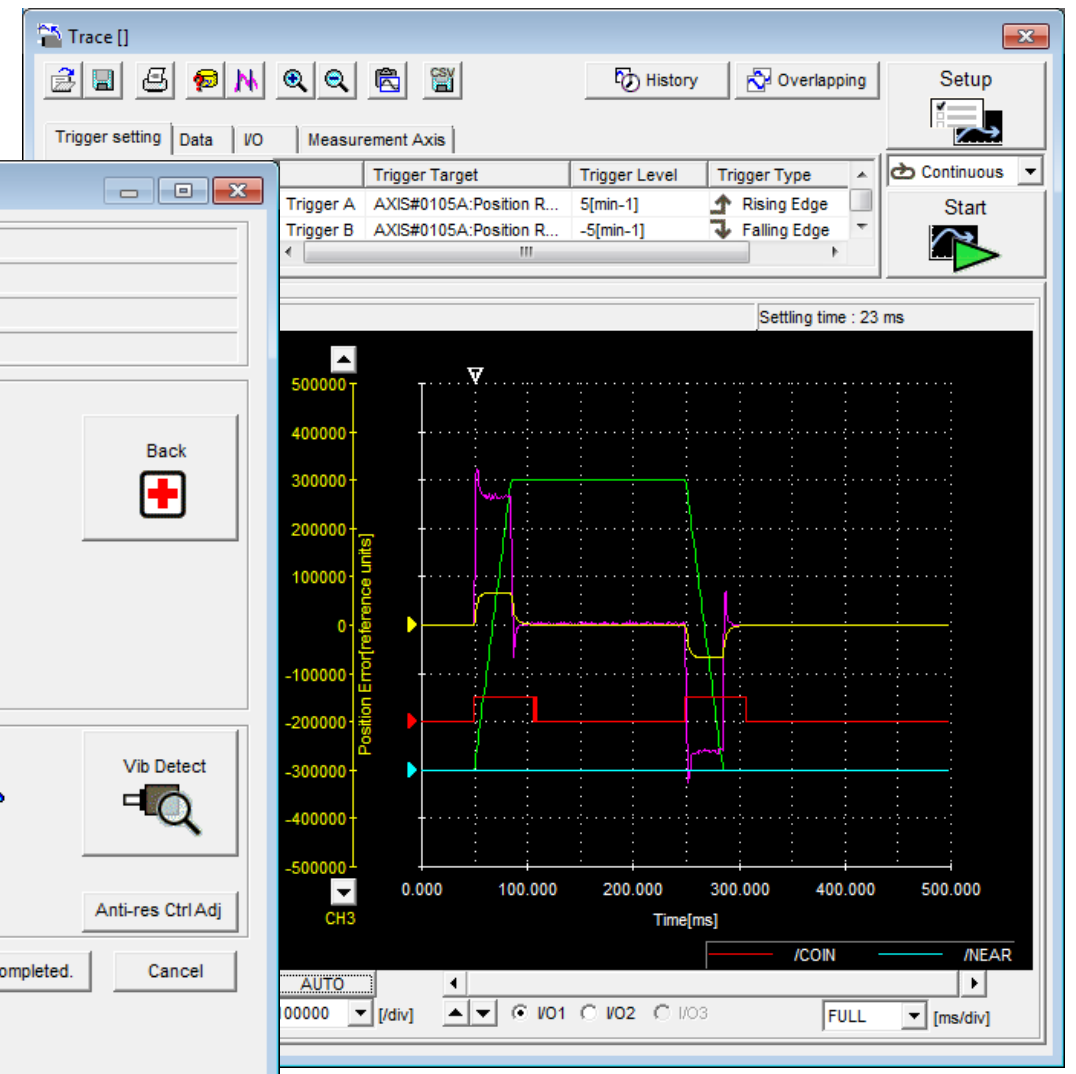
Friction compensation: Enable

Gain status: 1 gain

Tuning level: 0000 (1 - 2000)

Auto-setting: Notch filter (3260Hz active), Anti-res CtrlAdj (inactive)

Buttons: Back, Vib Detect, Anti-res CtrlAdj, < Back, To Autotuning, Completed, Cancel



# Autotuning Modes

Item	Mode 1 (Standard)	Mode 2, 3 (Positioning)
Low Settling Time	Good	<b>BEST</b>
Low Position Error	<b>BEST</b>	OK
Electronic Cam	<b>BEST</b>	Good
Point-To-Point	Good	<b>BEST</b>
Model Following	Not Available	<b>Used</b>
Vibration Suppression	Not Available	<b>Available</b>
Anti-Resonance	<b>Available</b>	<b>Available</b>
Notch Filter	<b>Available</b>	<b>Available</b>
FeedForward Pn109	<b>Used</b>	Not Used
Speed Control Mode	<b>Available</b>	Not Available

Autotuning - Setting Conditions AXIS#0105A

Set conditions.

Mode selection

1:Standard  
 1:Standard  
 2:For positioning  
 3:For positioning especially to prevent overshooting executed.

Mechanism selection

3:Rigid model

Executes adjustment suitable for a high-rigidity mechanism, such as rigid model.

Tuning parameters

Start tuning using the default settings.

Next > Cancel

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