MITSUBISHI ELECTRIC

A700 VFD with SSCNET III

Application Note

Contents

FURTHER READING REFERENCE LIST

- FR-A7NS SSCNET III Communication Function User Manual IB(NA) 0600308ENG-C
- FR-A7AL Orientation Control, Encoder Feedback Control, Vector Control, Position Control, Encoder Pulse Dividing Output Instruction Manual IB_NA_0600310ENG-A
- FR-A700 Precision Synchronous OS Specification SV22Y03QA_QC(E)
- FR-A700 Instruction Manual (Applied), NA Version IB(NA) 0600255ENG-F
- Technical Report:
  Specification of FR-A700 Connection with SV13SV22 for Q172DCPU_Q173DCPU_Q170MCPU
- DeviceList_QD22.XLS (Active Excel spreadsheet from Help files of MTWorks2
- SV13-SV22 Real Mode Manual IB(NA)0300136-B

Chapter 1 A700 VFD On SSCNet III - General Considerations

With the presence of the FR-A7NS card, the Drive will always power up in NET mode.

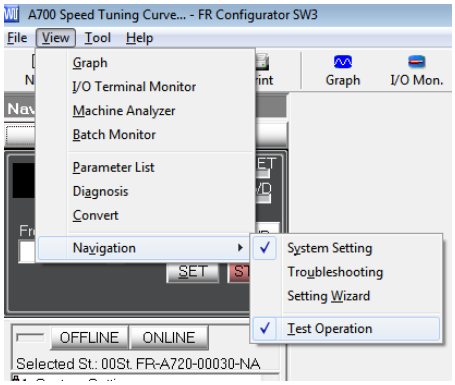
This will prevent typical set up access for Offline Auto Tuning, running in PU mode, or any manual control.

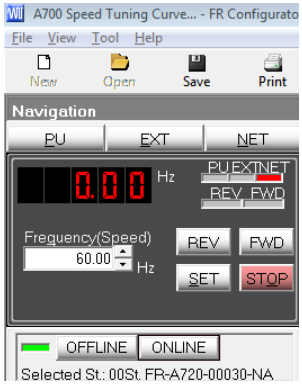
In order to allow the unit to go to PU mode (whether on PU itself or through FR-Configurator) do the following:

- Set pr. 499 to “9999”
- Disconnect the SSCNet (Useful if the control application may have the All Servo ON command active on power up)
- Cycle Power
- Switch to PU mode using the PU controls (if this will not switch make sure drive is in “Stop” mode)

If control and parameter changes are desired to be changed/set from FR-Configurator then:

- Make sure Pr 77 is set to “2” so you can write parameters in any mode
- Set Pr 551 to “3” if using the USB port from FR-Configurator to manually control the drive operation (very convenient if the motor is not visible from the drive panel or nearby the PC location)
- Power Cycle the drive after changing Pr. 551
- Then choose “View/Navigation/Test Operation” to get the control panel on your FR-Configurator screen:





Once the drive is available in PU mode the normal set up and configuration of the drive can be done.

Offline Auto Tuning and any Manual tuning should be done while in this mode.

The drive can also be utilized to jog that axis and verify rotation direction, encoder setting, gear ratios and speed settings desired.

When modifications and settings are complete return the drive to Network control:

- Set Pr. 499 back to “0”
- Set Pr. 77 back to default “0” if desired
- Set Pr. 551 back to the Default “2” (PU is in control when in PU mode)
- Reconnect SSCNet if disconnected
- Power Cycle Drive
- Recommend PCPY be performed at this point to save the parameters in the PU
    - Set “PCPY” to “1”, will flash “PCPY” when complete

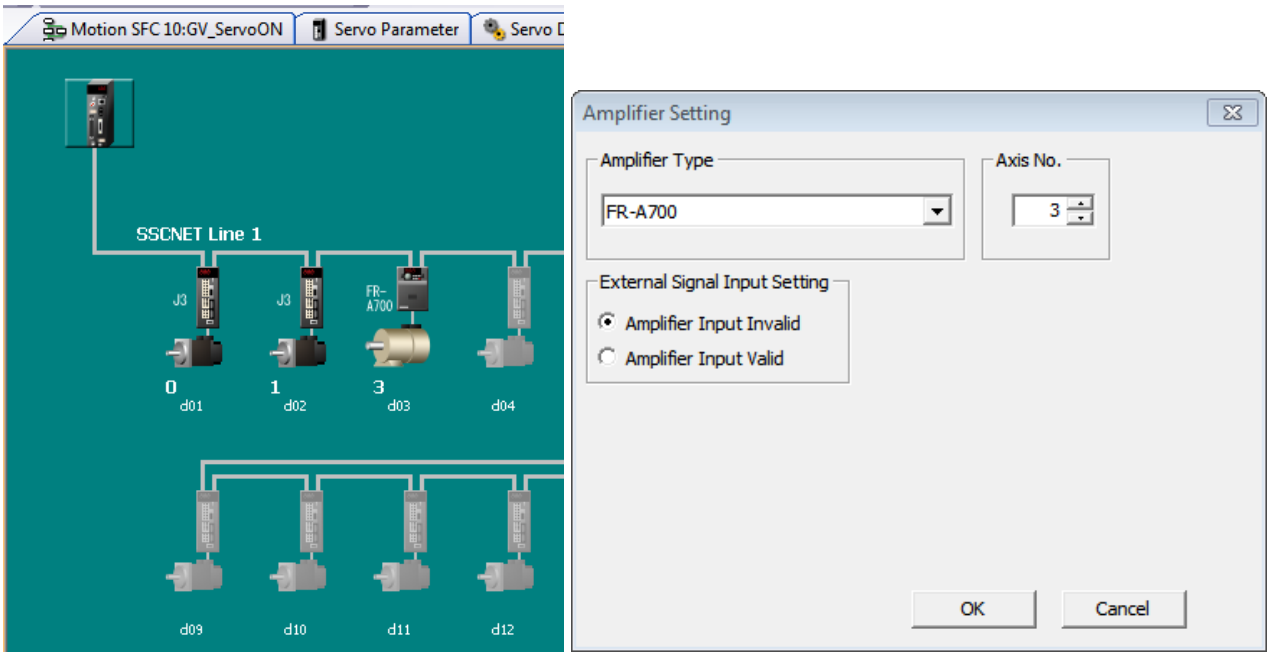
Chapter 2 A700 Motion Control through Q170M/Q173D

2.1 A700 VFD Can be used together with Servo Axes

With the addition of the SSCNet III card, the A700 VFD can be included on the SSCNet bus and operated through the motion controller in a way very similar to the Servos.

The Main difference is that Parameters CANNOT be written across SSCNet III by the Motion Controller.

The two types of Axes – Servo and VFD can also be operated together on the same bus:

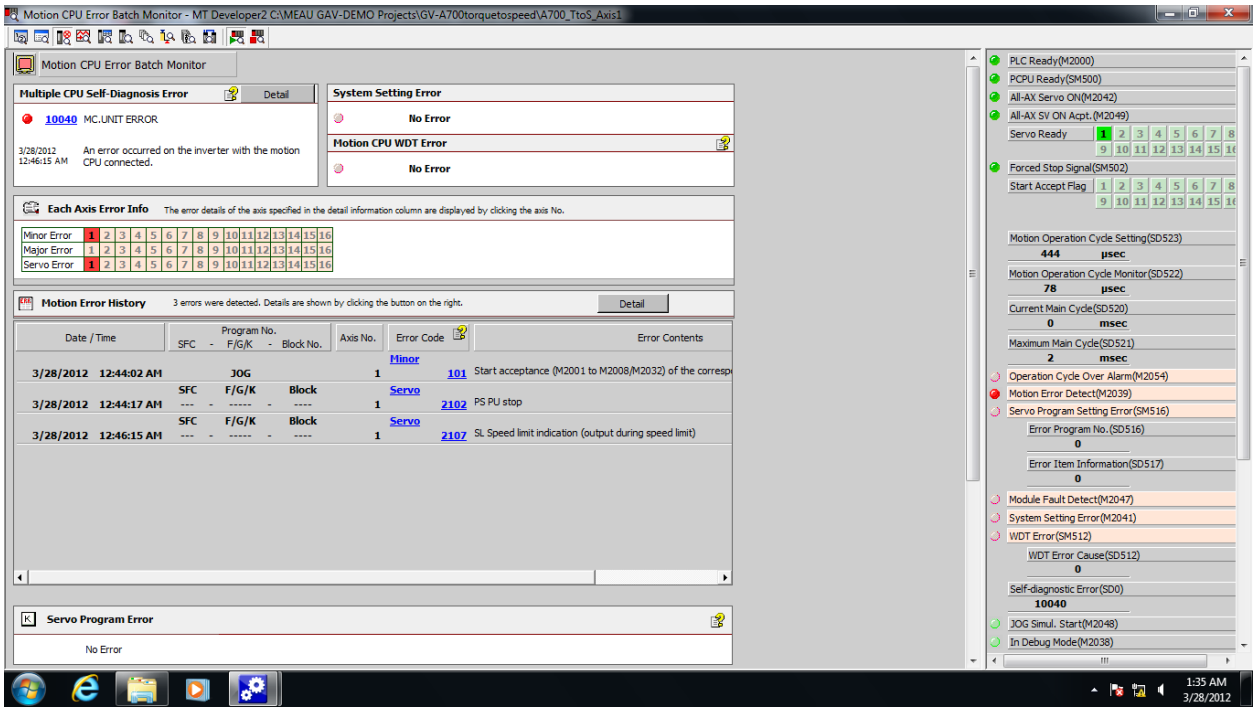


Item	Axis1
Fixed Parameter	**Set the fixed parame**
Unit Setting	3:PLS
Number of Pulses/Rev.	17444[PLS]
Travel Value/Rev.	640000[PLS]
Backlash Compensation	0[PLS]
Upper Stroke Limit	0[PLS]
Lower Stroke Limit	0[PLS]
Command In-position	100[PLS]
Sp. Ctrl. 10x Mult. for Deg.	-
Home Position Return Data	**Set the data to execu**
OPR Direction	1:Forward Direction
OPR Method	2:Data Set Type 1
Home Position Address	0[PLS]
OPR Speed	-
Creep Speed	-
Travel After Dog	-
Parameter Block Setting	-
OPR Retry Function	-
Dwell Time at the OPR Retry	-
Home Position Shift Amount	-
Speed Set at Home Pos. Shift	-
Torque Limit Value at Creep Speed	-
Operation for OPR Incompletion	0:Execute Servo Program
OPR Request Setting in Pulse Conversion Unit	-
Standby Time after Clear Signal Output in Pulse C...	-
JOG Operation Data	**Set the data to execu**
JOG Speed Limit Value	20000[PLS/s]

Item	Block No.1	Block No.2
Parameter Block	**Set the data such as the acceleration/deceler**	
Interpolation Control Unit	3:PLS	3:PLS
Speed Limit Value	**8091798[PLS/s]**	3276803[PLS/s]
Acceleration Time	4000[ms]	10000[ms]
Deceleration Time	4000[ms]	10000[ms]
Rapid Stop Deceleration Time	2000[ms]	2000[ms]
S-curve Ratio	5[%]	5[%]
Torque Limit Value	300[%]	300[%]
Deceleration Process on STOP	0:Deceleration Stop	0:Deceleration Stop
Allowable Error Range for Circular Interpolation	100[PLS]	100[PLS]
Bias Speed at Start	0[PLS/s]	0[PLS/s]
Acceleration/Deceleration System	0:Trapezoid/S-curve	0:Trapezoid/S-curve
Advanced S-curve Acceleration/Decelerat...	**Set the data of advanced S-curve acceleration**	
Acceleration 1 Ratio	-	-
Acceleration 2 Ratio	-	-
Deceleration 1 Ratio	-	-
Deceleration 2 Ratio	-	-

2.2 VFD Error Codes and how to reset

The A700 VFD will properly report back the error codes to the Motion Controller through SSCNet and can be observed in MT Developer 2 using the various Monitor function displays already built in to MT Dev 2.



Those code numbers for the VFD Axes are correct, but the Descriptions provided in the software are those for the Servo Errors only.

In order to properly annunciate the errors, the chart from:

Technical report: Specification of FR-A700 Connection with SV13SV22 for Q172DCPU_Q173DCPU_Q170MCPU

Servo Error Detected signal M2408 + 20n (n = axis number) is ON when a Servo Error occurs.

Servo Errors can be reset by removing the cause and turning on Servo Error Reset command (M3208+20n) then a Reboot as noted in the excerpt from the same technical report below:

(6) VFD Error Detected by FR-A700-□K (Additional Servo Error)

Servo error detection signal (M2408+20n) is on when a VFD error occurs. The servo error is reset by removing the error cause and turning the servo error reset command (M3208+20N) on. Reboot afterward.

2.3 VFD Error Code Definitions in Motion Controller

The Error codes reported in this table to the Motion Controller are the VFD specific errors and will have a different definition than those for the Servo Axis Servo Errors as follows:

(a) Details of VFD Error

See below for the classification of the VFD errors.

Error Codes and Classification

Error Code	Classification
2000-2099	Alarm
2100-2199	Warning

List of VFD Error Codes

Error Code	Communication Status Monitor Display	Abbr. Code	Error Description
2012	OC3	E.OC3	Overcurrent interrupt during deceleration
2015	OV3	E.OV3	Regenerative overcurrent interrupt during deceleration/stop
2016	THM	E.THM	Motor overload interrupt (electronic thermal)
2017	THT	E.THT	VFD overload current (electronic thermal)
2018	IPF	E.IPF	Instantaneous power outage protection
2019	UVT	E.UVT	Undervoltage protection
2020	BE	E.BE	Brake transistor error detection
2022	GF	E.GF	Output side earth overcurrent protection
2022	OHT	E.OHT	External thermal operation
2023	OLT	E.OLT	Motor overload
2024	OPT	E.OPT	Option error
2027	PE	E.PE	Parameter memory unit error
2028	PUE	E.PUE	PU disconnection
2030	CPU	E.CPU	CPU error
2031	ILF	E.ILF	Open-phase at input
2032	FIN	E.FIN	Fin Overheat
2033	OS	E.OS	Overspeed
2034	OSD	E.OSD	Detection of excessive velocity error
2035	ECT	E.ECT	Detection of disconnection
2036	OD	E.OD	Significant position error
2045	P24	E.P24	DC24V power supply output short circuit
2046	CTE	E.CTE	Power short circuit for DC24V
2047	LF	E.LE	Open-phase at output protection
2048	PTC	E.PTC	PTC thermistor
2049	PE2	E.PE2	Memory unit error (MA side)

Error Code	Communication Status Monitor Display	Abbr. Code	Error Description
2050	CDO	E.CDO	Output current detection value over
2051	IOH	E.IOH	Rush resistor overheat
2052	SER	E.SER	Communication error (main unit)
2053	AIE	E.AIE	Analogue input error
2055	USB	E.USB	USB communication error
2056	E.1	E.1	Error 1
2057	E.2	E.2	Error 2
2058	E.3	E.3	Error 3
2061	E.6	E.6	Error 6
2062	E.7	E.7	Error 7
2070	EEP	E.EP	Encoder phase error
2090	OP3	E.OP3	Option slot error (slot 3)
2091	OP3	E.OP3	Option slot error (slot 3)
2092	OP3	E.OP3	Option slot error (slot 3)
2100	OL	OL	Stall prevention (overcurrent)
2101	oL	oL	Stall prevention (overvoltage)
2102	PS	PS	PU stop
2103	RB	RB	Regenerative brake pre-alarm
2104	TH	TH	Electronic thermal pre-alarm
2105	MT	MT	Maintenance signal output
2106	CP	CP	Parameter copy
2107	SL	SL	Speed limit output (output during speed control)
2108	Fn	Fn	Fan failure
2144	Pr	-	Parameter write error
2146	MRS	-	Output stop
2147	EMG	-	Output stop (emergency stop included)

(b) Motion Error History (#8640-8735)

VFD errors are regarded as servo errors. Errors can be determined if detected by a VFD or servo amp, based on the error model in the motion error history. See the table below for the detailed error info in the motion error history.

Motion Error History Detailed Error Information

No.	Signal	Description	
		Motion SFC Control Error	Motion Control Error
+0	Motion SFC Error Program No.	0-255: SCF program No. with an error 1: Error irrelevant to the motion SFC program	-1
+1	Error Type	20: F/FS 21: G 22: K or others (neither F/FS nor G) 23: Motion SFG diagram	3: Minor/serious error 4: Minor/serious error (virtual servo motor axis) (SV22 only) 5: Minor/serious error (synchronous encoder axis) (SV22 only) 6: Error detected by servo amp 7: Servo program setting error 8: Mode selection error (SV22 only) 9: Manual pulsar axis setting error 10: Test mode request error 11: WDT error 13: Self-diagnosis error (error code: under 10000) 14: System setting error 40: Error detected by VFD
+2	Error Program No.	0-4095: Program No. of F/FS, G, and K 0-255: GSUB program No. -1: Irrelevant to F/FS, G, K, and GSUB	Error type is "3", "4," or "7" (display) 0-4095: servo program No. → 0-4095 FFFFH: JOG → 'JOG' FFFEH: manual pulsar → 'MAN' FFFDH: test mode (home return, servo analysis, servo startup) → 'TEST' FF00H: others → blank Error type is other than "3", "4", or "7" -1: irrelevant
+3	Error block No. /Motion SFC List /Line No. /Axis No.	0-8191: Block No. (line No.) of F/FS or G program when Error type is "1" or "2", 0-8188: Line number in the motion SFC list when error type is "-2" -1: Error type "1" or error type is "1" or "2", and irrelevant to the block	1-32: Applicable axis number when error type is "3"-"6" or "40" -1: Others
+4	Error Code	After 16000 (Motion SFC error code)	● Existing error codes (below 16000) when error type is "3"-"6" or "40". ● D9190 storage error code when error type is "7" ● D9193 storage error code when error type is "8" ● -1 when the error type is "9" or "10" ● D9184 storage error code when error type is "11" ● D9196 storage error code when error type is "12 ● SD0 storage error code when error type is "13" or "14"
Snip			

2.4 Trapezoidal and Advanced S-Curve functions in Motion Controller

Both Trapezoidal and Advanced S-Curve functions are available in the Motion controller and can be applied to the VFD Axis.

There are a couple of precautions:

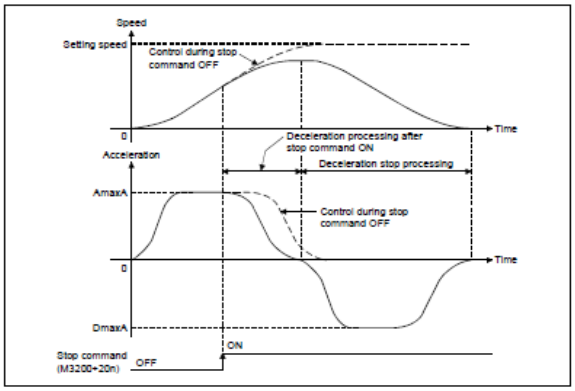
- Trapezoidal S-Curve applies evenly at both Start and End of Acceleration, and to both Acceleration/Deceleration
- Advanced S-Curve can be applied separately at each start and finish of Acceleration and Deceleration
    - Advanced S-Curve use will allow speed to continue to Increase as Acceleration moves to zero by the ratio specified – This can result in a very prolonged, calculable, and notable rise in speed when the Axis stop command has already been issued.
    - This does NOT occur when using Trapezoidal – Acceleration stops immediately and Deceleration begins when the Axis Stop command is issued

4 PARAMETERS FOR POSITIONING CONTROL

[Operation]

(1) Stop processing

When the stop command turns ON during acceleration, the acceleration is decreased until it reaches zero according to acceleration section 2 ratio setting. Therefore, the speed will continue to increase for a while before deceleration stop processing is executed.
(Deceleration is smooth.)



POINTS

When the stop command turns ON during acceleration processing of advanced S-curve acceleration/deceleration, in order to maintain smoothness of acceleration, the speed will continue to increase until acceleration reaches zero.
Use the rapid stop command if an increase in speed is not desired.

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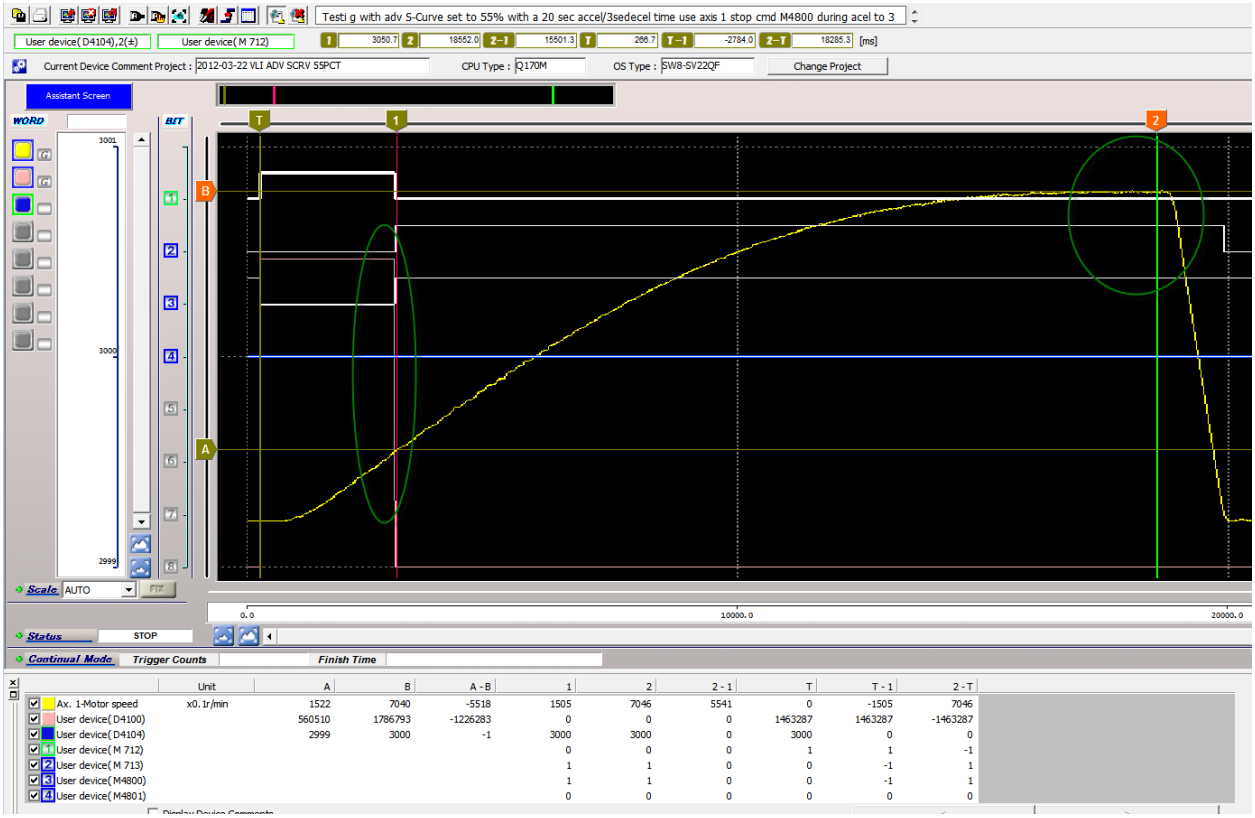
2.5 **Advanced S-Curve Actual Operation**

Here is a graph of an actual 20 sec Acceleration of Axis 1 interrupted by the Axis 1 Stop command approximately 2.7 sec into a 20 sec accel. Cursor 1 is the Axis 1 Stop Command Issued, Cursor 2 where the Deceleration begins (approximately 15.5 sec after Stop Command issued)

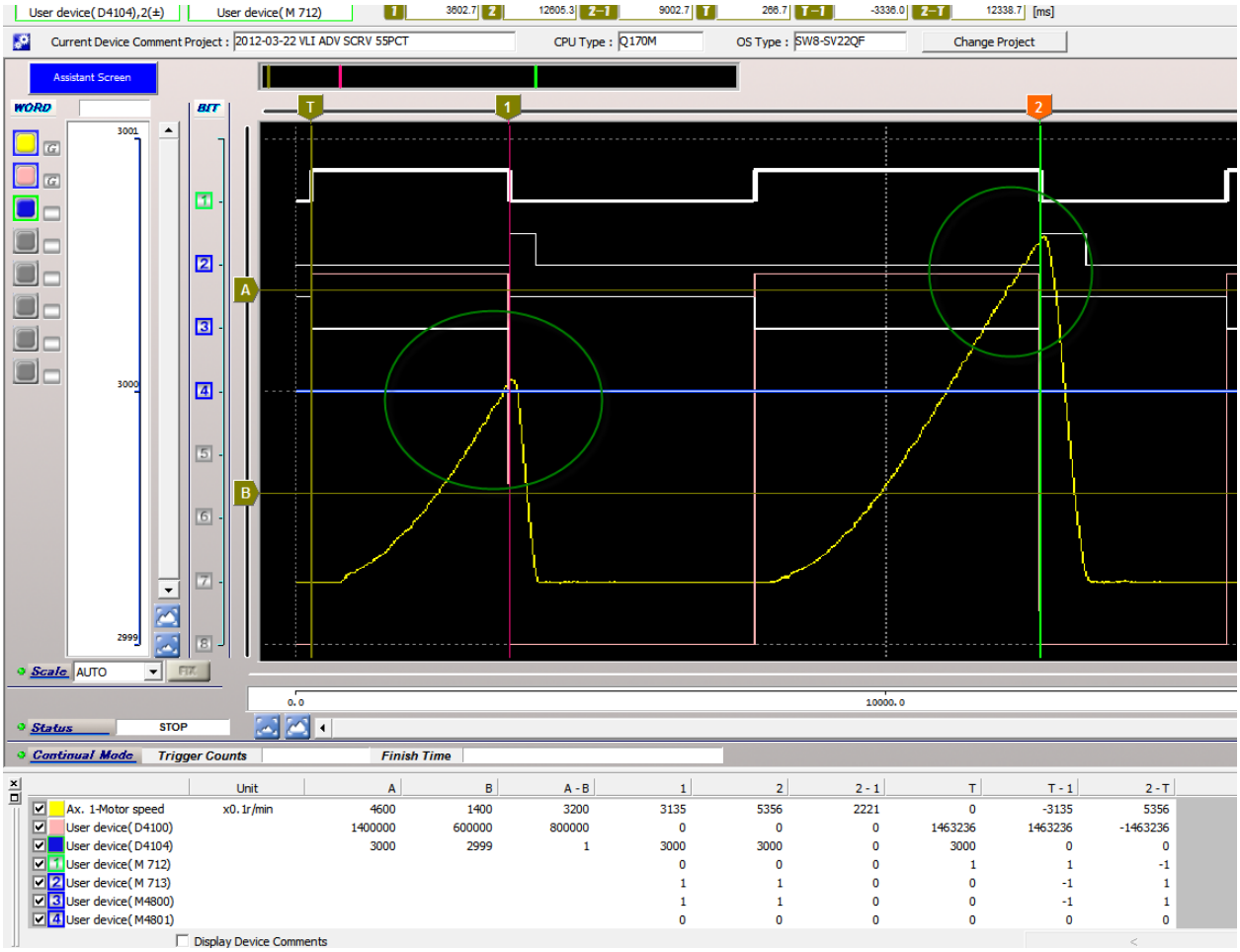
Note: Speed rises from 152.2 rpm to 704 rpm during this interval.



2.6 Trapezoidal S-Curve Actual Operation

Here we used the same machine and motor, with the only change being to use the Trapezoidal S-Curve with the same 20 sec Accel, 3 sec Decel we used on the Advanced S-Curve:

Note the immediate response to the Stop Command – Acceleration is abruptly taken to zero and Deceleration started. This is with the S-Curve set to 100%



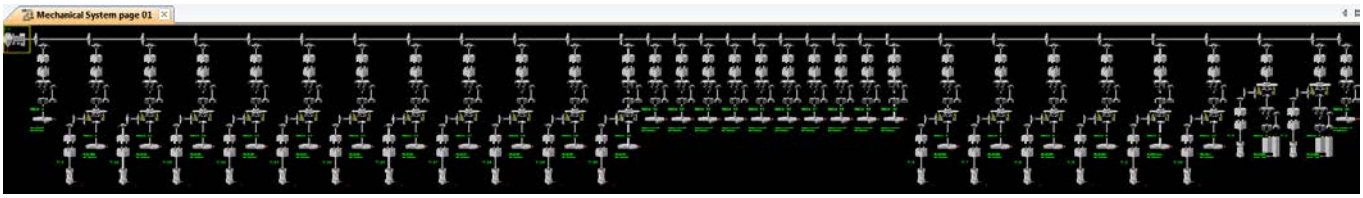
While both are extremely useful, their application is quite different.

Be sure that the appropriate structure is used for the application at hand.

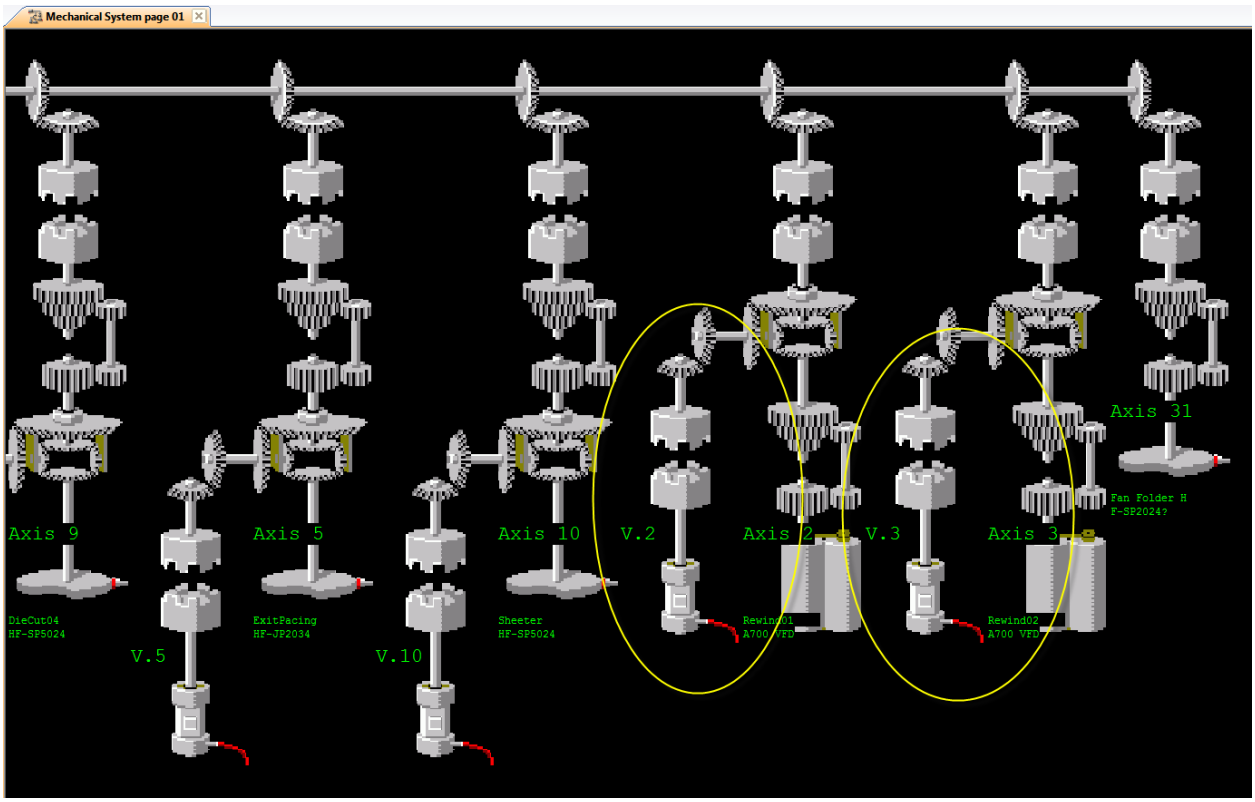
Chapter 3 **A700 with Servo Axes on SSCNet III**

- Servo and VFD axes can be combined on one network as noted before
- VFD Axis can follow Servo Axis and vice-versa: Coordinated motion can be accomplished
- Real and Virtual mode can be utilized for both types of Axes

This is an example from a real application: 29 Axes of Servo with 2 axes of VFD on the same SSCNet III controlled from an IQ PLC with 2 Q173 Motion CPU's

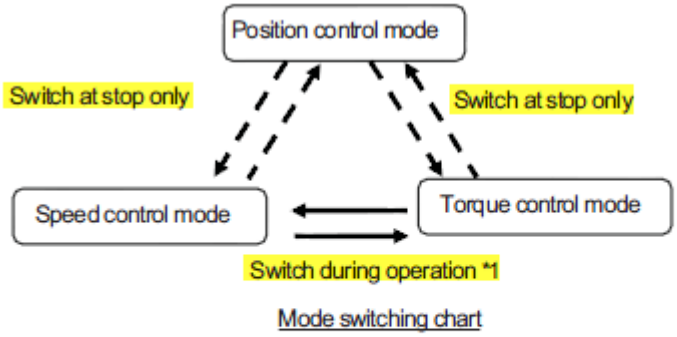


Here is a Detail of the two VFD Axes – Note the Auxiliary Input circled. This is used to add pulse counts to the virtual line-shaft speed command (Speed Limit for those axes in Torque Mode) which will keep the Speed limit above the running speed of the web.



Chapter 4 **A700 Torque/Speed Mode Switching**

Speed and Torque Control can be switched to/from “On the Fly” in either Real or Virtual mode using the SV22Y03 OS – Switching to/from Position Control can only be done at a Stop (graphic taken from the SV22Y03 Specification)

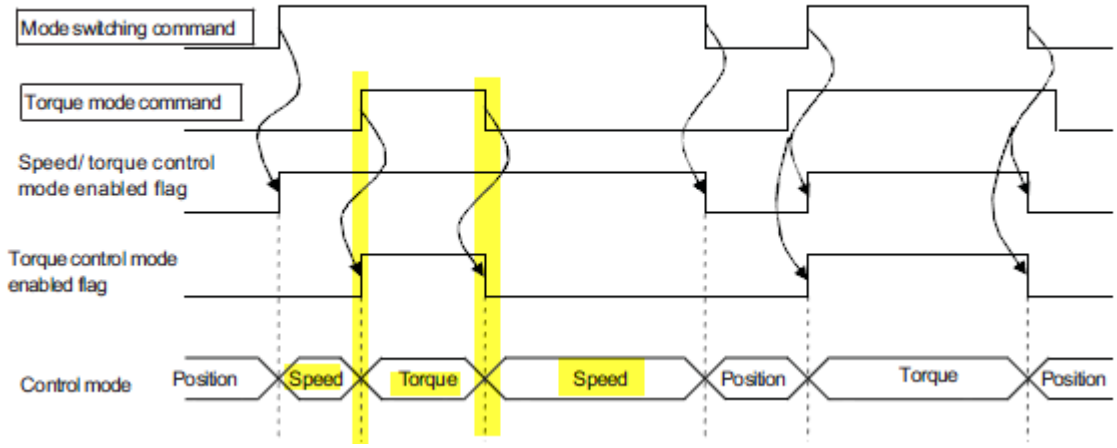


Mode switching chart

*1: Immediately after switching from the speed control to the torque control, the motor speed may be changed for a moment.
Before switching the speed control to the torque control, it is recommended to stop the motor and set the torque command value to 0

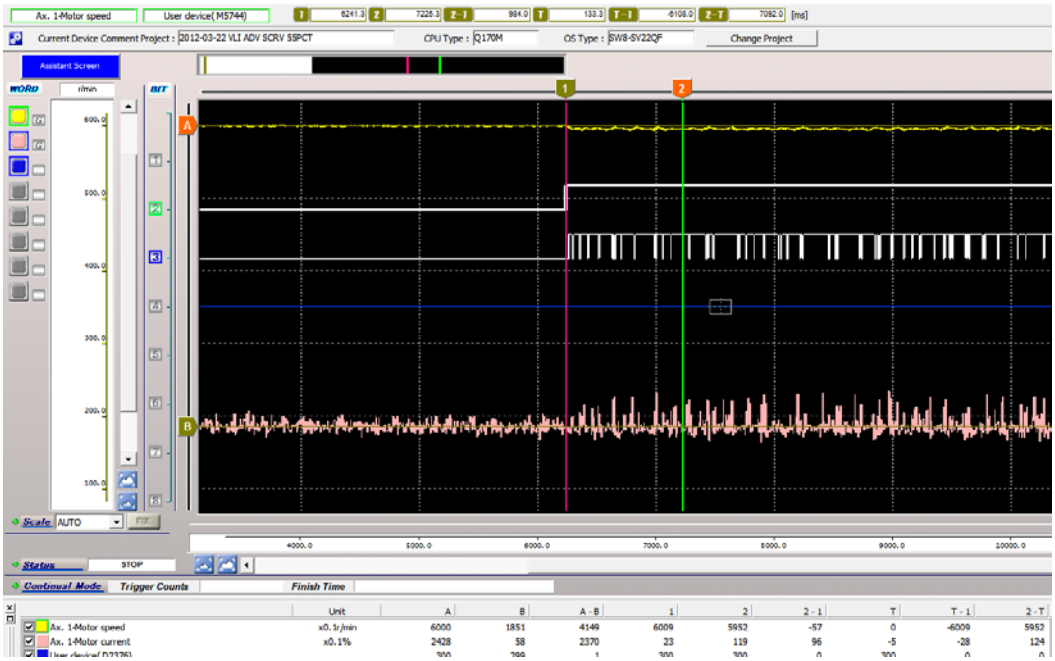
There is no time delay between when switching between Torque/Speed modes (also from the SV22Y03 Specification):

[Mode Switching Timing Chart]



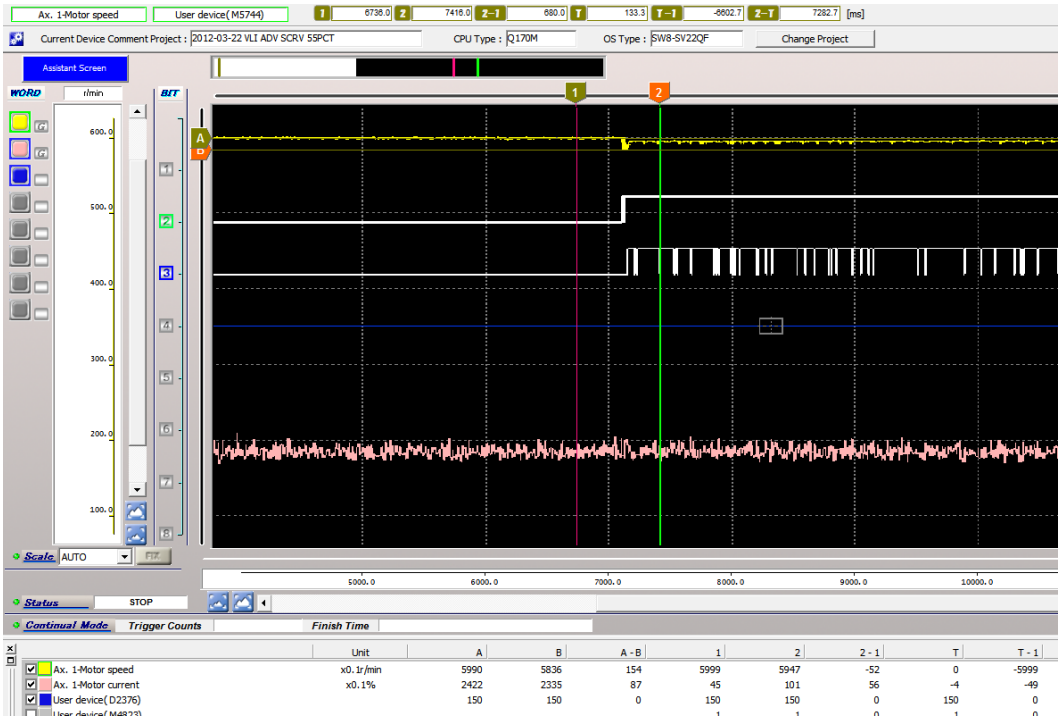
4.1 Speed to Torque Mode Low Torque settings

This is a Motion Graph taken of the motor Speed (Yellow) and Motor Current (Pink) for a drive in Speed mode at 600 rpm, switching to Torque mode with a Speed Limit of 600 rpm, Torque Command Set to 30% (cursor 1 is at the mode change command):

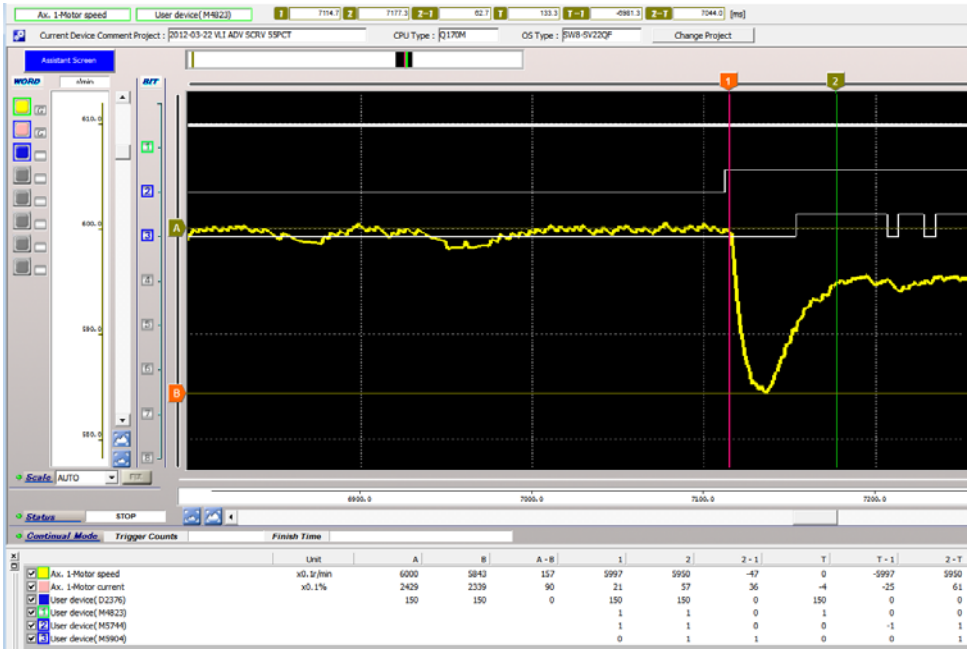


There is little change in speed because there is sufficient Torque available to overcome the inertia of the motor

This is the same change from Speed to Torque Mode at 600 rpm Speed Command/Speed Limit but with Torque Command set down to 15% (Note the slight drop of about 16 rpm in speed after the change):



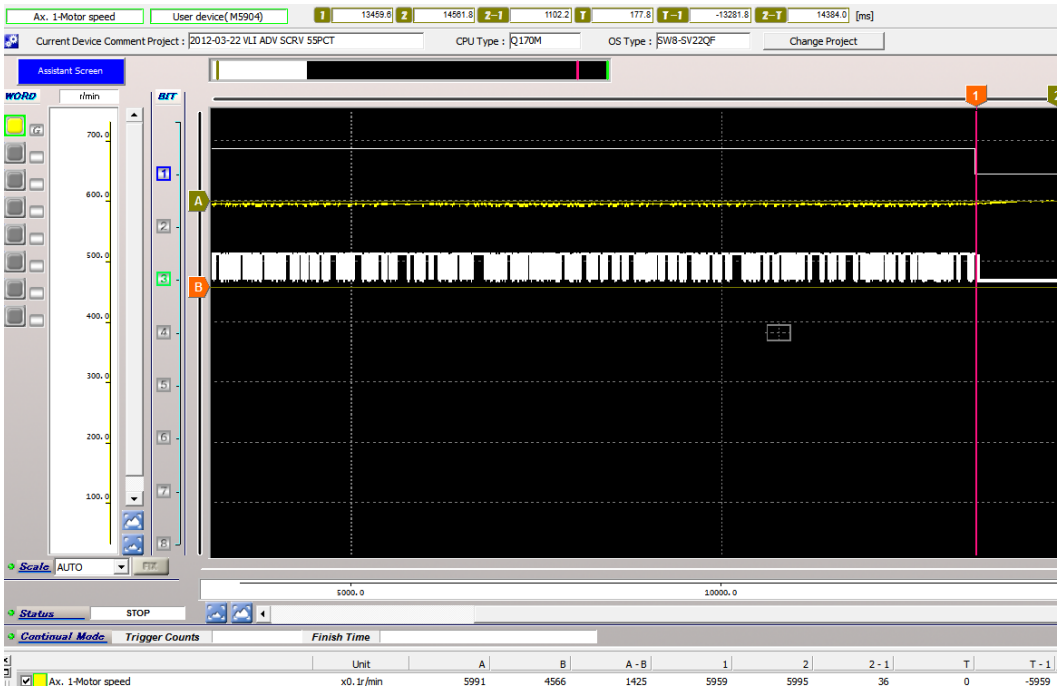
Here is a close up of that drop in speed – notice it only lasted about 65 ms:



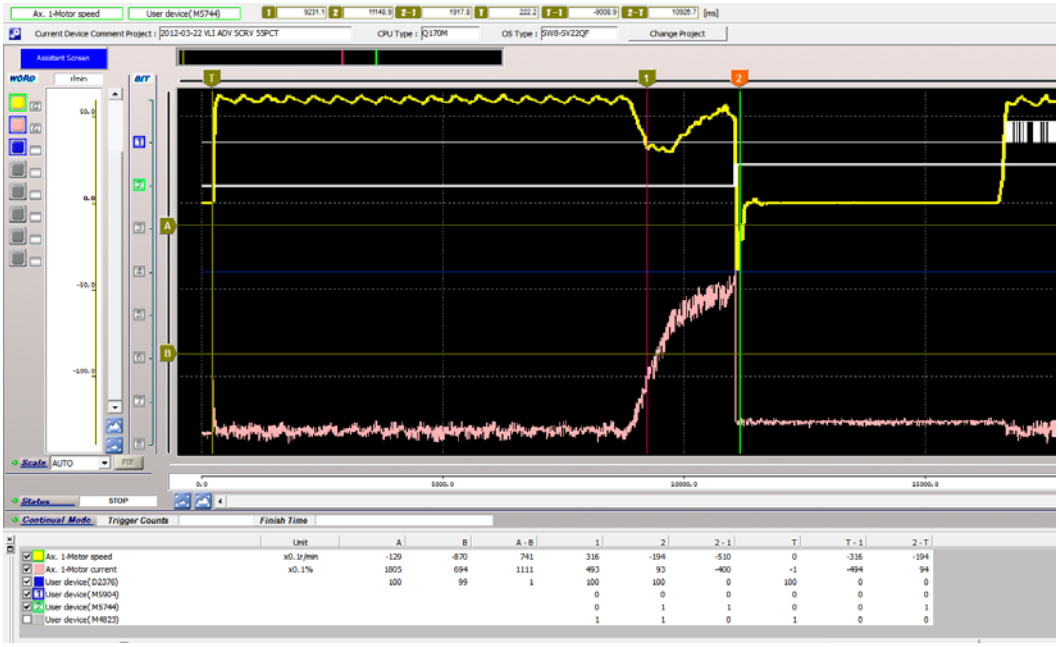
This is the same speed command with Torque Command set to 10% - Note that the speed drop is about 33 rpm and lasts 148 ms:

4.2 **Torque to Speed Mode Switching**

Here is a graph of the same motor switching from Torque Mode to Speed Mode – Note that the speed just increases slightly to the set point smoothly because the full value of Pr 22 (Torque Limit) is available to accelerate the motor:



And here is Speed Mode with a load applied to the shaft, then switched to Torque mode (Torque Command = 10%, Speed Limit/Command set to 600 rpm)



Chapter 5 A700 Torque Mode Tuning Notes

5.1 General Notes on Using Torque Mode

- It is essential that Speed Limit not be reached if Torque Control is critical
  - At Speed Limit, the mode of Operation changes to Speed mode but has the full amount of Pr. 22 available – which can be quite excessive relative to the Torque Setting
  - An Example would be an Unwind application where the Unwind axis Speed limit is dropped below the current Web speed. The Unwind will go to into a speed mode but the torque output will climb as the Unwind fights the Speed controlling axis until the web is damaged
  - This is different from a commanded Speed mode where a device for Torque limit can be set in place of Pr. 22 – which is typically 150-300% to prevent Overcurrent during stopping/starting
- Stopping In Torque Mode: If Web Tension cannot be lost while stopping, the Axis Stop Command must be used (M4800 for Axis 1 for example).
- If Rapid Stop Command is used, the axis will stop as fast as commanded with no torque control and web tension control will be lost
  - This may be acceptable for an Emergency Stop situation depending on the application
  - Some applications with large inertial loads may allow 2 sec to bring the load to a stop which may be attainable using the Axis Stop Command with a Deceleration of 2 seconds as an alternative to Rapid Stop
- Note that use of the Advanced S-Curve in the Motion Parameter Blocks or K-Blocks will extend time to decelerate so Rapid Stop may be required (bypasses use of S-Curve during the stop)

5.2 Notes on Tuning A700 VFD for Torque Mode control

This may have additional reference after meetings prior to Technical Summit:

In running 3 axes of VFD in a Unwind/Rewind application (1 Axis running in Speed/Position mode, the other two in Torque mode) we had an issue with web material “bouncing” in an excessive way causing loss of tension control and affecting roll quality

(See video: Mark Andy VLI Bounce Issue with Inertia Comp OFF_IMG_1037.MOV)

This application had a very high reflected inertia ratio (in the video about 123:1) which makes tuning very difficult.

After exhausting all avenues noted in the manual we attempted the approach recommended by our Senior Field operatives: Tuning in Speed mode from the PU before running Torque mode following these steps:

- Obtain Large Inertial Load (preferably the maximum the system is designed for)
- Calculate the Maximum Speed and the Accel time needed for Example: 40” Max Dia Roll, Max Web Speed 950 ft/min, Accel min = 3 seconds so:

  [(950 ft/min)*(12”/ft)*(Rev/40”*Pi)]*(Gear Ratio)/1750rpm*60Hz = Freq for Top Speed

  {[(950*12)/(40*Pi)]*(1.53)/1750}*60 = 4.76 Hz

- Set A700 into PU mode, set Pr 20 = 4.76Hz (Frequency to attain top Web Speed)
- Set A700 Pr 7/8 (Accel/Decel) to 3 sec (min Accel/Decel time)
- Enable EZ Gain Tuning (Pr. 819 to “1” to enable EZ Gain tuning)
- Set Pr 818 to a high value to begin (15 for our test)
- Graph Motor Speed and Motor Torque on FR-Config Oscilloscope utility
- Start and let roll reach full web surface speed, Stop and Start a few times
- Continue to Stop and Start, Adjusting Pr 818 down until the Speed Curve approaches a smooth ramp up with little or no overshoot and settles quickly
- Turn Off EZ Gain when results are not improved by lowering pr 818
- Read all parameters and make note of new Pr. 880 setting, Pr.820, & Pr 821 settings

- If further adjustment is needed manually, start with Pr 820 Speed P Gain until overshoot minimized
- Then adjust Pr 821 (Speed Integral Gain) until the speed graph settles quickly and with a minimal bounce
- When satisfied, reset Pr 20 to 60 hz, and rest pr. 499 to get unit back in Net Mode, cycle power and run machine to test Torque Mode operation
- Set Pr. 7 and Pr. 8 to 0.1 sec after tuning is complete before going back to torque control
- If needed Torque Mode Gains (Pr. 824 – P Gain, and Pr. 825 I Gain, can be adjusted to refine the torque control.

- Show video of Same Web Material at the same 950 fpm web speed, 3 sec accel, with NO torque parameters tuned off of defaults:

Mark Andy VLI Post Tuning - LabelStock 3s Accel to 950 fpm_Bad Unwind Roll Quality_IMG_1048.MOV

Chapter 6 A700 Parameter/Function Restrictions on SSCNet III

Parameter	Name	Function Validity
239	Multi-speed setting (speed 15)	×
240	Soft-PWM operation selection	○
241	Analog input display unit switchover	×
242	Terminal 1 added compensation amount (terminal 2)	×
243	Terminal 1 added compensation amount (terminal 4)	×
244	Cooling fan operation selection	○
245	Rated slip	×
246	Slip compensation time constant	×
247	Constant-power region slip compensation selection	×
250	Stop selection	×
251	Output phase failure protection selection	○
252	Override bias	×
253	Override gain	×
255	Life alarm status display	○
256	Inrush current limit circuit life display	○
257	Control circuit capacitor life display	○
258	Main circuit capacitor life display	○
259	Main circuit capacitor life measuring	○
260	PWM frequency automatic switchover	○
261	Power failure stop selection	×

Parameter	Name	Function Validity
262	Subtracted frequency at deceleration start	×
263	Subtraction starting frequency	×
264	Power-failure deceleration time 1	×
265	Power-failure deceleration time 2	×
266	Power failure deceleration time switchover frequency	×
267	Terminal 4 input selection	×
268	Monitor decimal digits selection	○
270	Stop-on contact/load torque high-speed frequency control selection	×
271	High-speed setting maximum current	×
272	Middle-speed setting minimum current	×
273	Current averaging range	×
274	Current averaging filter time constant	×
275	Stop-on contact excitation current low-speed multiplying factor	×
276	PWM carrier frequency at stop-on contact	×
278	Brake opening frequency	×
279	Brake opening current	×
280	Brake opening current detection time	×
281	Brake operation time at start	×
282	Brake operation frequency	×

RESTRICTIONS ON THE FUNCTIONS

Parameter	Name	Function Validity
283	Brake operation time at stop	×
284	Deceleration detection function selection	×
285	Overspeed detection frequency (Excessive speed deviation detection frequency)	×
286	Droop gain	○
287	Droop filter time constant	○
288	Droop function activation selection	○
291	Pulse train I/O selection	○ *7
292	Automatic acceleration/deceleration	×
293	Acceleration/deceleration time individual calculation selection	×
294	UV avoidance voltage gain	×
299	Rotation direction detection selection at restarting	×
300	BCD input bias AX	×
301	BCD input gain AX	×
302	BIN input bias AX	×
303	BIN input gain AX	×
304	Digital input and analog input compensation enable/disable selection AX	×
305	Read timing operation selection AX	×
306 *2	Analog output signal selection AY AN	○

Parameter	Name	Function Validity
307	Setting for zero analog output AY AN	○
308	Setting for maximum analog output AY AN	○
309	Analog output signal voltage/current switchover AY AN	○
310	Analog meter voltage output selection AY AN	○
311	Setting for zero analog meter voltage output AY AN	○
312	Setting for maximum analog meter voltage output AY AN	○
313 *2	DO0 output selection AY	○
314 *2	DO1 output selection AY	○
315 *2	DO2 output selection AY	○
316 *2	DO3 output selection AY	○
317 *2	DO4 output selection AY	○
318 *2	DO5 output selection AY	○
319 *2	DO6 output selection AY	○
320 *2	RA1 output selection AR AC	○
321 *2	RA2 output selection AR AC	○
322 *2	RA3 output selection AR	○
323	AM0 0V adjustment AY AN	○

Parameter	Name	Function Validity
324	AM1 0mA adjustment AY AN	○
325 *6	Terminal 40 input selection AN	×
329	Digital input unit selection AX	×
331	RS-485 communication station	×
332	RS-485 communication speed	×
333	RS-485 communication stop bit length	×
334	RS-485 communication parity check selection	×
335	RS-485 communication retry count	×
336	RS-485 communication check time interval	×
337	RS-485 communication waiting time setting	×
338	Communication operation command source	×
339	Communication speed command source	×
340	Communication startup mode selection	×
341	RS-485 communication CR/LF selection	×
342	Communication EEPROM write selection	○ *8
343	Communication error count	×
349	Communication reset selection	×
350	Stop position command selection AP AL	×
351	Orientation speed AP AL	×
352	Creep speed AP AL	×

Parameter	Name	Function Validity
353	Creep switchover position AP AL	×
354	Position loop switchover position AP AL	×
355	DC injection brake start position AP AL	×
356	Internal stop position command AP AL	×
357	Orientation in-position zone AP AL	×
358	Servo torque selection AP AL	×
359	Encoder rotation direction AP AL	○
360	16 bit data selection AP AL	×
361	Position shift AP AL	×
362	Orientation position loop gain AP AL	×
363	Completion signal output delay time AP AL	×
364	Encoder stop check time AP AL	×
365	Orientation limit AP AL	×
366	Recheck time AP AL	×
367	Speed feedback range AP AL	×
368	Feedback gain AP AL	×
369	Number of encoder pulses AP AL	○
374	Overspeed detection level	○
376	Encoder signal loss detection enable/ disable selection AP AL	○

RESTRICTIONS ON THE FUNCTIONS

Parameter	Name	Function Validity
379	SSCNET III rotation direction selection	○
380	Acceleration S-pattern 1	×
381	Deceleration S-pattern 1	×
382	Acceleration S-pattern 2	×
383	Deceleration S-pattern 2	×
384	Input pulse division scaling factor	×
385	Frequency for 0 input pulse	×
386	Frequency for maximum input pulse	×
393	Orientation selection AP AL	×
396	Orientation speed gain (P term) AP AL	×
397	Orientation speed integral time AP AL	×
398	Orientation speed gain (D term) AP AL	×
399	Orientation deceleration ratio AP AL	×
406	High resolution analog input selection AZ	×
407	Motor temperature detection filter AZ	○
408	Motor thermistor selection AZ	○
413	Encoder pulse division ratio AL	○
414 *3	PLC function operation selection	×
415 *3	Inverter operation lock mode setting	×
416 *3	Pre-scale function selection	×
417 *3	Pre-scale setting value	×

Parameter	Name	Function Validity
419	Position command source selection AP AL	×
420	Command pulse scaling factor numerator AP AL	×
421	Command pulse scaling factor denominator AP AL	×
422	Position loop gain AP AL	○
423	Position feed forward gain AP AL	○
424	Position command acceleration/ deceleration time constant AP AL	×
425	Position feed forward command filter AP AL	○
426	In-position width AP AL	○
427	Excessive level error AP AL	○
428	Command pulse selection AP AL	×
429	Clear signal selection AP AL	×
430	Pulse monitor selection AP AL	○
432	Pulse train torque command bias AL	×
433	Pulse train torque command gain AL	×
447	Digital torque command bias AX	×
448	Digital torque command gain AX	×
449	SSCNET III input filter setting	○

Parameter	Name	Function Validity
450	Second applied motor	×
451	Second motor control method selection	×
453	Second motor capacity	×
454	Number of second motor poles	×
455	Second motor excitation current	×
456	Rated second motor voltage	×
457	Rated second motor frequency	×
458	Second motor constant (R1)	×
459	Second motor constant (R2)	×
460	Second motor constant (L1)	×
461	Second motor constant (L2)	×
462	Second motor constant (X)	×
463	Second motor auto tuning setting/status	×
464	Digital position control sudden stop deceleration time AP AL	×
465	First position feed amount lower 4 digits AP AL	×
466	First position feed amount upper 4 digits AP AL	×
467	Second position feed amount lower 4 digits AP AL	×

Parameter	Name	Function Validity
468	Second position feed amount upper 4 digits AP AL	×
469	Third position feed amount lower 4 digits AP AL	×
470	Third position feed amount upper 4 digits AP AL	×
471	Fourth position feed amount lower 4 digits AP AL	×
472	Fourth position feed amount upper 4 digits AP AL	×
473	Fifth position feed amount lower 4 digits AP AL	×
474	Fifth position feed amount upper 4 digits AP AL	×
475	Sixth position feed amount lower 4 digits AP AL	×
476	Sixth position feed amount upper 4 digits AP AL	×
477	Seventh position feed amount lower 4 digits AP AL	×
478	Seventh position feed amount upper 4 digits AP AL	×
479	Eighth position feed amount lower 4 digits AP AL	×

Parameter	Name	Function Validity
480	Eighth position feed amount upper 4 digits AP AL	×
481	Ninth position feed amount lower 4 digits AP AL	×
482	Ninth position feed amount upper 4 digits AP AL	×
483	Tenth position feed amount lower 4 digits AP AL	×
484	Tenth position feed amount upper 4 digits AP AL	×
485	Eleventh position feed amount lower 4 digits AP AL	×
486	Eleventh position feed amount upper 4 digits AP AL	×
487	Twelfth position feed amount lower 4 digits AP AL	×
488	Twelfth position feed amount upper 4 digits AP AL	×
489	Thirteenth position feed amount lower 4 digits AP AL	×
490	Thirteenth position feed amount upper 4 digits AP AL	×
491	Fourteenth position feed amount lower 4 digits AP AL	×

Parameter	Name	Function Validity
492	Fourteenth position feed amount upper 4 digits AP AL	×
493	Fifteenth position feed amount lower 4 digits AP AL	×
494	Fifteenth position feed amount upper 4 digits AP AL	×
495	Remote output selection	○
496	Remote output data 1	○
497	Remote output data 2	○
498 *3	PLC function flash memory clear	×
499	SSCNET III operation selection	○
500	Communication error execution waiting time	×
501	Communication error occurrence count display	×
502	Stop mode selection at communication error	×
503	Maintenance timer	○
504	Maintenance timer alarm output set time	○
505	Speed setting reference	○
506 *3	Parameter 1 for user	×
507 *3	Parameter 2 for user	×
508 *3	Parameter 3 for user	×
509 *3	Parameter 4 for user	×
510 *3	Parameter 5 for user	×

Parameter	Name	Function Validity
511 *3	Parameter 6 for user	×
512 *3	Parameter 7 for user	×
513 *3	Parameter 8 for user	×
514 *3	Parameter 9 for user	×
515 *3	Parameter 10 for user	×
516	S-pattern time at a start of acceleration	×
517	S-pattern time at a completion of acceleration	×
518	S-pattern time at a start of deceleration	×
519	S-pattern time at a completion of deceleration	×
539	Modbus-RTU communication check time interval	×
547	USB communication station number	×
548	USB communication check time interval	×
549	Protocol selection	×
550	NET mode operation command source selection	×
551	PU mode operation command source selection	×
555	Current average time	○
556	Data output mask time	○

Parameter	Name	Function Validity
557	Current average value monitor signal output reference current	○
563	Energization time carrying-over times	○
564	Operating time carrying-over times	○
569	Second motor speed control gain	×
570	Multiple rating setting	○
571	Holding time at a start	×
573 *3	4mA input check selection	×
574	Second motor online auto tuning	×
575	Output interruption detection time	×
576	Output interruption detection level	×
577	Output interruption cancel level	×
592 *4	Traverse function selection	×
593 *4	Maximum amplitude amount	×
594 *4	Amplitude compensation amount during deceleration	×
595 *4	Amplitude compensation amount during acceleration	×
596 *4	Amplitude acceleration time	×
597 *4	Amplitude deceleration time	×
598 *5	Undervoltage level	○
611	Acceleration time at a restart	×
665	Regeneration avoidance frequency gain	×

RESTRICTIONS ON THE FUNCTIONS

Parameter	Name	Function Validity
684	Tuning data increments switchover	○
800	Control method selection	×
802	Pre-excitation selection AP AL	○
803	Constant power range torque characteristic selection	○
804	Torque command source selection	×
805	Torque command value (RAM)	×
806	Torque command value (RAM,EEPROM)	×
807	Speed limit selection	×
808	Forward rotation speed limit	×
809	Reverse rotation speed limit	×
810	Torque limit input method selection	×
811	Set resolution switchover	× *9
812	Torque limit level (regeneration)	×
813	Torque limit level (3rd quadrant)	×
814	Torque limit level (4th quadrant)	×
815	Torque limit level 2	×
816	Torque limit level during acceleration	×
817	Torque limit level during deceleration	×
818	Easy gain tuning response level setting	○
819	Easy gain tuning selection	○
820	Speed control P gain 1	○

Parameter	Name	Function Validity
821	Speed control integral time 1	○
822	Speed setting filter 1	○
823	Speed detection filter 1 AP AL	×
824	Torque control P gain 1	○
825	Torque control integral time 1	○
826	Torque setting filter 1	×
827	Torque detection filter 1	○
828	Model speed control gain	○
829	Number of machine end encoder pulses AL	×
830	Speed control P gain 2	○
831	Speed control integral time 2	○
832	Speed setting filter2	×
833	Speed detection filter 2 AP AL	×
834	Torque control P gain 2	○
835	Torque control integral time 2	○
836	Torque setting filter2	×
837	Torque detection filter 2	×
838	DA1 terminal function selection AZ	○
839	DA1 output filter AZ	○
840	Torque bias selection AP AL	×
841	Torque bias 1 AP AL	×

Parameter	Name	Function Validity
842	Torque bias 2 AP AL	×
843	Torque bias 3 AP AL	×
844	Torque bias filter AP AL	×
845	Torque bias operation time AP AL	×
846	Torque bias balance compensation AP AL	×
847	Fall-time torque bias terminal 1 bias AP AL	×
848	Fall-time torque bias terminal 1 gain AP AL	×
849	Analog input off set adjustment	×
850	Control operation selection	×
853	Speed deviation time AP AL	O
854	Excitation ratio	O
857	DA1-0V adjustment AZ	O
858	Terminal 4 function assignment	×
859	Torque current	O
860	Second motor torque current	×
862	Notch filter time constant	O
863	Notch filter depth	O
864	Torque detection	O
865	Low speed detection	O

Parameter	Name	Function Validity
866	Torque monitoring reference	O
867	AM output filter	O
868	Terminal 1 function assignment	×
869 *4	Current output filter	O
872	Input phase failure protection selection	O
873	Speed limit AP AL	×
874	OLT level setting	O
875	Fault definition	×
877	Speed feed forward control/model adaptive speed control selection	O
878	Speed feed forward filter	O
879	Speed feed forward torque limit	O
880	Load inertia ratio	O
881	Speed feed forward gain	O
882	Regeneration avoidance operation selection	×
883	Regeneration avoidance operation level	×
884	Regeneration avoidance at deceleration detection sensitivity	×
885	Regeneration avoidance compensation frequency limit value	×
886	Regeneration avoidance voltage gain	×
888	Free parameter 1	O

RESTRICTIONS ON THE FUNCTIONS

Parameter	Name	Function Validity
889	Free parameter 2	O
891	Cumulative power monitor digit shifted times	O
892	Load factor	O
893	Energy saving monitor reference (motor capacity)	O
894	Control selection during commercial power-supply operation	O
895	Power saving rate reference value	O
896	Power unit cost	O
897	Power saving monitor average time	O
898	Power saving cumulative monitor clear	O
899	Operation time rate (estimated value)	O
C0(900)	FM terminal calibration *10	O
C1(901)	AM terminal calibration	O
C2(902)	Terminal 2 frequency setting bias frequency	×
C3(902)	Terminal 2 frequency setting bias	×
125(903)	Terminal 2 frequency setting gain frequency	×
C4(903)	Terminal 2 frequency setting gain	×
C5(904)	Terminal 4 frequency setting bias frequency	×
C6(904)	Terminal 4 frequency setting bias	×
126(905)	Terminal 4 frequency setting gain frequency	×
C7(905)	Terminal 4 frequency setting gain	×

Parameter	Name	Function Validity
C8(930) *4	Current output bias signal	×
C9(930) *4	Current output bias current	×
C10(931) *4	Current output gain signal	×
C11(931) *4	Current output gain current	×
C12(917)	Terminal 1 bias frequency (speed)	×
C13(917)	Terminal 1 bias frequency (speed)	×
C14(918)	Terminal 1 gain frequency (speed)	×
C15(918)	Terminal 1 gain (speed)	×
C16(919)	Terminal 1 bias command (torque/ magnetic flux)	×
C17(919)	Terminal 1 bias (torque/magnetic flux)	×
C18(920)	Terminal 1 gain command (torque/ magnetic flux)	×
C19(920)	Terminal 1 gain (torque/magnetic flux)	×
C29(925)	Motor temperature detection calibration (analog input) AZ	O
C30(926)	Terminal 6 bias frequency (speed) AZ	×
C31(926)	Terminal 6 bias (speed) AZ	×
C32(927)	Terminal 6 gain frequency (speed) AZ	×
C33(927)	Terminal 6 gain (speed) AZ	×

Parameter	Name	Function Validity
C34(928)	Terminal 6 bias command (torque) AZ	×
C35(928)	Terminal 6 bias (torque) AZ	×
C36(929)	Terminal 6 gain command (torque) AZ	×
C37(929)	Terminal 6 gain (torque) AZ	×
C38(932)	Terminal 4 bias command (torque/ magnetic flux)	×
C39(932)	Terminal 4 bias (torque/magnetic flux)	×
C40(933)	Terminal 4 gain command (torque/ magnetic flux)	×
C41(933)	Terminal 4 gain (torque/magnetic flux)	×
989	Parameter copy alarm release	○
990	PU buzzer control	○
991	PU contrast adjustment	○

*1 Read and write from communication with PU connector only is enabled.
*2 Some functions of the I/O signals set using these parameters are invalid. Refer to *page 69*.
*3 Setting can be made only for the EC and NA versions.
*4 Setting can be made only for the EC and CH versions.
*5 Setting can be made only for the CH versions.
*6 Setting can be made only for the NA versions.
*7 Note that pulse train input is invalid.
*8 Note that only RS-485 communication from PU port is valid.
*9 Setting increments is always the same. (Note that a value can be displayed.)
*10 When EC or CH version is used, this parameter is "CA terminal function selection".

6.1 A700 Inverter I/O Terminal Function List

RESTRICTIONS ON THE FUNCTIONS

6.3 Inverter I/O Terminal Function List

The following shows ○ : validity, × : invalidity of I/O terminal function during SSCNET III communication operation.
The following symbols are I/O terminal that functions when used with an option.
AY ..... FR-A7AY, AR FR-A7AR

6.3.1 Input terminal function

Setting	Signal Name	Function Name		Function Validity
0	RL	*Pr. 59* = 0 (initial value)	Low-speed operation command	×
		Pr. 59 = 1, 2 *1	Remote setting (setting clear)	×
		Pr. 270 = 1, 3 *2	Stop-on-contact selection 0	×
1	RM	*Pr. 59* = 0 (initial value)	Middle-speed operation command	×
		Pr. 59 = 1, 2 *1	Remote setting (deceleration)	×
2	RH	*Pr. 59* = 0 (initial value)	High-speed operation command	×
		Pr. 59 = 1, 2 *1	Remote setting (acceleration)	×
3	RT	Second function selection		×
		Pr. 270 = 1, 3 *2	Stop-on-contact selection 1	×
4	AU	Terminal 4 input selection		×
5	JOG	Jog operation selection		×

Setting	Signal Name	Function Name	Function Validity
6	CS	Selection of automatic restart after instantaneous power failure, flying start	×
		Commercial power supply-inverter switchover function	×
7	OH	External thermal relay input *3	○
8	REX	15 speed selection (combination with three speeds RL, RM, RH)	×
9	X9	Third function selection	×
10	X10	Inverter operation enable signal (FR-HC, MT-HC, FR-CV connection)	○
11	X11	FR-HC or MT-HC connection, instantaneous power failure detection	○
12	X12	PU operation external interlock	×
13	X13	External DC injection brake operation start *7	×
14	X14	PID control valid terminal	×
15	BRI	Brake opening completion signal	×

Setting	Signal Name	Function Name	Function Validity
16	X16	PU-external operation switchover	×
17	X17	Load pattern selection forward/reverse rotation boost	×
18	X18	V/F switchover (V/F control is exercised when X18 ON)	×
19	X19	Load torque high-speed frequency	×
20	X20	S-shaped acceleration/deceleration C switching terminal	×
22	X22	Orientation command *4	×
23	LX	Pre-excitation/servo on *5	×
24	MRS	Output stop	○
		Commercial power supply-inverter switchover function	×
25	STOP	Start self-holding selection	×
26	MC	Control mode changing	×
27	TL	Torque limit selection	×
28	X28	Start-time tuning start external input	×
37	X37	Traverse function selection *6	×
44	X44	P/PI control switchover	×
50	SQ	Sequence start *7	×
60	STF	Forward rotation command (assigned to STF terminal *(Pr. 178)* only)	Δ *8
61	STR	Reverse rotation command (assigned to STR terminal *(Pr. 179)* only)	Δ *8
62	RES	Inverter reset	○
63	PTC	PTC thermistor input (assigned to AU terminal *(Pr. 184)* only)	○
64	X64	PID forward/reverse action switchover	×
65	X65	PU-NET operation switchover	×
66	X66	External-NET operation switchover	×
67	X67	Command source switchover	×
68	NP	Conditional position pulse train sign	×
69	CLR	Conditional position droop pulse clear	×
70	X70	DC feeding operation permission	○
71	X71	DC feeding cancel	○
74	X74	Magnetic flux decay output shutoff signal	×
76	X76	Proximity dog	○
9999	—	No function	○

RESTRICTIONS ON THE FUNCTIONS

*1 When *Pr. 59 Remote function selection* = "1 or 2", the functions of the RL, RM and RH signals change as listed above.
*2 When *Pr. 270 Stop-on contact/load torque high-speed frequency control selection* = "1 or 3", the functions of the RL and RM signals change as listed above.
*3 The OH signal turns on when the relay contact "opens".
*4 The FR-A7AX (16-bit digital input) is needed to externally input a stop position under orientation control.
*5 Servo ON is made valid during position control under vector control operation.
*6 Setting can be made only for the EC and CH versions.
*7 Setting can be made only for the EC and NA versions.
*8 Although run command is invalid as a start signal since it depends on SSCNET Ⅲ communication, terminal function as upper/lower stroke limit is valid.

RESTRICTIONS ON THE FUNCTIONS

6.3.2 Output terminal function

Setting		Signal Name	Function Name	Function Validity
Positive Logic	Negative Logic			
0	100	RUN	Inverter running *1	○
1	101	SU	Up to frequency *2, 3	×
2	102	IPF	Instantaneous power failure/undervoltage	○
3	103	OL	Overload alarm	○
4	104	FU	Output frequency detection *3	○
5	105	FU2	Second output frequency detection *3	○
6	106	FU3	Third output frequency detection *3	○
7	107	RBP	Regenerative brake prealarm	○
8	108	THP	Electronic thermal relay function prealarm	○
10	110	PU	PU operation mode	×
11	111	RY	Inverter operation ready	○
12	112	Y12	Output current detection	○
13	113	Y13	Zero current detection	○
14	114	FDN	PID lower limit	×
15	115	FUP	PID upper limit	×
16	116	RL	PID forward/reverse rotation output	×
17	—	MC1	Electronic bypass MC1	×
18	—	MC2	Electronic bypass MC2	×
19	—	MC3	Electronic bypass MC3	×
20	120	BOF	Brake opening request	×
25	125	FAN	Fan fault output	○
26	126	FIN	Heatsink overheat pre-alarm	○
27	127	ORA	Orientation in-position	×
28	128	ORM	Orientation error	×
30	130	Y30	Forward rotation output	○
31	131	Y31	Reverse rotation output	○
32	132	Y32	Regenerative status output	○
33	133	RY2	Operation ready 2	○
34	134	LS	Low speed output	○
35	135	TU	Torque detection	○
36	136	Y36	In-position *4	○
39	139	Y39	Start time tuning completion	×
41	141	FB	Speed detection	○
42	142	FB2	Second speed detection	○
43	143	FB3	Third speed detection	○
44	144	RUN2	Inverter running *1	○
45	145	RUN3	Inverter running and start command is on	○
46	146	Y46	During deceleration at occurrence of power failure (retained until release)	×

Setting		Signal Name	Function Name	Function Validity
Positive Logic	Negative Logic			
47	147	PID	During PID control activated	×
64	164	Y64	During retry	×
70	170	SLEEP	PID output interruption	×
84	184	RDY	Position control preparation ready	○
85	185	Y85	DC feeding	○
86	186	Y86	Control circuit capacitor life [AY] [AR]	○
87	187	Y87	Main circuit capacitor life [AY] [AR]	○
88	188	Y88	Cooling fan life [AY] [AR]	○
89	189	Y89	Inrush current limit circuit life [AY] [AR]	○
90	190	Y90	Life alarm	○
91	191	Y91	Alarm output 3 (power-off signal)	○
92	192	Y92	Energy saving average value updated timing	○
93	193	Y93	Current average value monitor signal	○
94	194	ALM2	Alarm output 2 *5	○
95	195	Y95	Maintenance timer signal	○
96	196	REM	Remote output	○
97	197	ER	Minor fault output 2	○
98	198	LF	Minor fault output	○

Setting		Signal Name	Function Name	Function Validity
Positive Logic	Negative Logic			
99	199	ALM	Alarm output	○
9999		—	No function	○

*1 RUN and RUN2 turn on when speed command from SSCNET III is not "0" at turning on the servo during speed control and torque control.
Turning the servo on turns the terminals on during position control.

*2 Note that when the frequency setting is varied using an analog signal or  of the operation panel (FR-DU07), the output of the SU (up to frequency) signal may alternate on and off depending on that varying speed and the timing of the varying speed due to acceleration/deceleration time setting. (The output will not alternate on and off when the acceleration/deceleration time setting is "0s".)

*3 Up to frequency SU, frequency detection FU, FU2, FU3 under encoder feed back control or vector control signals are as below.
SU, FU: Output when the actual speed (frequency) by the encoder feedback signal exceeds detected specification frequency.
FU2, FU3: Output when the inverter output frequency exceeds detected specification frequency.

*4 The signal is on even when the servo is off during SSCNET III communication operation.

*5 When a power supply reset is performed, the alarm output 2 signal (ALM2) turns off as soon as the power supply switches off.

7 PRECAUTIONS

- During SSCNET III communication, the inverter parameter can not be changed from the servo system controller. Note that, even if the mode has changed to SSCNET III operation mode, setting "2" in *Pr.77 Parameter write selection* allows parameter setting change from the PU (FR-DU07/FR-PU07/FR-PU04). In such case, *Pr.CL Parameter clear and ALLC All parameter clear* can not be made.
- The usable encoder pulses are 1000 to 4096 pulses.
- Start and stop commands are given from SSCNET III side and STF signal and STR signal are made invalid. Instead, upper stroke limit signal can be assigned to STF terminal and lower stroke limit signal to STR terminal. (Refer to *page 69* for input terminal function validity/invalidity.)
- Before starting operation, always give the servo ON signal from the host controller to put the motor in the servo lock status, and then start operation.
- Running speed depends on the command from the servo system controller.
(The rotation direction depends on the setting of *Pr. 379 SSCNET III rotation direction selection*.)
- When "0, 10" (droop control is disabled during acceleration/deceleration) is set in *Pr.288 Droop function activation selection*, droop control can not be performed. Set "1, 11" or "2".
(For details, refer to the inverter manual.)
- E.OC3 and E.OV3 are displayed when the inverter stops due to "overcurrent shut-off" or "regenerative overvoltage shut-off" during SSCNET III operation. (For details, refer to the inverter manual.)
- Restrictions of I/O signal *(Refer to page 69)* are the same even when used with other options (FR-A7AX, FR-A7AY, FR-A7AR, etc).
- Offline auto tuning cannot be performed from the servo system controller. Perform it using the PU or the setup software (FR Configurator FR-SW3-SETUP-WE) before starting communication.
- Before shutting off the communication temporarily by resetting the inverter power, disconnecting the SSCNET III cable, or other methods, it is necessary to perform the disconnection/reconnection function for the servo system controller. Refer to "Q173DCPU/Q172DCPU motion controller programming manual (common mode version)" for details.
- When the MRS signal is on, create a motion SFC program that turns on the servo off command of the target shaft. Before resetting the MRS signal (ON to OFF) or turning off the servo off command, make sure that the motor speed is 20r/min or less.

Chapter 7 **Terminology**

Revisions

Original release	5/3/2012