APPLICATION NOTE YASKAWA

Title: Best Practices Using Yaskawa EtherCAT SERVOPACKs	
Product(s): SERVOPACKs with CANopen over EtherCAT	**Doc. No.** AN.MTN.02

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1. About This Document

This document is intended for:

- EtherCAT Master Developers in the planning stages of EtherCAT master development.
- Machine designers migrating designs from analog to EtherCAT servos.

This document guides developers in determining features to implement that are available through the network in the areas of:

- Machine design
- SERVOPACK setup
- Machine manufacturing
- Machine operation
- Machine maintenance

Utilizing SERVOPACK features affects plans for:

- Machine design
- Provisioning SERVOPACKs during machine manufacturing
- End-user machine operation instructions
- Field maintenance procedures

2. Digital Motion Network Advantages

As a digital motion network, EtherCAT enables many additional features and modes of operation relative to legacy analog servo interfaces. If taken advantage of, these features can have a positive impact on all aspects of system design, implementation, and operation:

- Machine design
  - Hardware reduction of I/O devices and wiring
- SERVOPACK setup
  - Parameter Write
  - Tuning
  - Initialization
- Machine manufacturing
  - Automatic setup of SERVOPACK parameters
- Machine operation
  - Synchronized High-resolution absolute position control
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  - Automatic setup of replaced SERVOPACK
  - Total SERVOPACK run time

3. Design: Hardware Reduction

The following hardware simplifications may be possible when utilizing a network:

- Reduction of I/O devices & wiring
- Removal of overtravel limit sensors

3.1. Reduction of I/O Devices & Wiring

Reduction of controller or network I/O devices may possible by using the general-purpose digital input and output signals on the SERVOPACK. In addition, by monitoring SERVOPACK-related signals digitally over the network, hard-wiring SERVOPACK status-related I/O to the controller becomes unnecessary.

- General-purpose input example: Using a controller input module to monitor a machine sensor is not necessary because the sensor may be wired into one of the 7 SGDV SERVOPACK general-purpose inputs, and monitored over the network using CoE object 60FDh "Digital Inputs".
- General-purpose output example: Using a controller output module to set an LED indicator is not necessary because the LED indicator may be wired into one of the 3 SGDV SERVOPACK general-purpose outputs, and set over the network using CoE object 60FEh "Digital Outputs".
- Wiring reduction example, SERVOPACK output: Using a controller input module to monitor the SERVOPACK safety output EDM is not necessary because the SERVOPACK safety input signals HWBB1 and HWBB2 may be monitored over the network.
- Wiring reduction example, SERVOPACK input: Using a controller output module to toggle the Alarm Reset input is not necessary because the CoE function Fault Reset (bit 7 of the Controlword) performs the alarm reset function.

3.2. Removal of Overtravel Limit Sensors

Removal of overtravel limit sensors may be possible by using the "Software Position Limit" (CoE object 607Dh) which stops the processing of a commanded position beyond the set limits.

Using an absolute encoder eliminates the need for homing the axis after the machine is power cycled.

Note: Take appropriate overtravel cautions during machine design.

4. Setup: Tuning

SERVOPACK tuning can be performed over the EtherCAT network in the following manner:

The EtherCAT network can communicate motor feedback position, velocity, and torque data to the controller, where the data can then be recorded or plotted. Most tuning parameters written through the EtherCAT network become enabled immediately, allowing their effect on application performance to be evaluated on-the-fly.

5. Setup: Initialization

Initialization procedures that can be performed over the EtherCAT network include:

- Absolute encoder multiturn reset
  - In analog systems, performing a function using utility software or utilizing the front panel would be required.
- Set home offset
  - In analog systems, home offset would be handled by the controller.
- Additional initialization procedures
  - For SGDV, refer to chapter “Object Dictionary” section “Manufacturer Specific Objects” of Yaskawa.com document number SIEPC72082904.

6. Setup, Manufacturing, Maintenance: SERVOPACK Setup/Parameter Write

By using the controller to write all application parameters over the EtherCAT network during machine start up, manufacturing and maintenance becomes simplified because the need to use special tools and procedures to configure parameters on new SERVOPACK hardware is eliminated.

Writing and enabling parameters over the network provides the following benefits:

- Enable parameters without hardware power cycle
- Multi-node setup from the controller
- Automation of parameter writing

These benefits allow the possibility of:

- An increase in the setup speed
- Servo gain switching during operation for improved performance
- Reduction of necessary manual user steps during machine manufacturing
    - Example: A controller function can automatically write a list of parameters to the SERVOPACK to set up the SERVOPACK during manufacturing.
- Reduction of necessary manual user steps during machine maintenance
    - Example: A controller function can automatically write a list of parameters to the SERVOPACK to set up a SERVOPACK that has replaced a SERVOPACK on the machine.

6.1. Enable Parameters

For parameters that do not become enabled immediately, a restart is required.

- For SGDV SERVOPACKs, refer to Appendix section "SERVOPACK Parameters" of Yaskawa.com document number SIEPC72082904 to determine if the parameter becomes enabled immediately or requires a restart.

The network function "User Parameter Configuration" (CoE object 2700h) performs a soft restart that causes parameter changes to become enabled.

Note: In cases where the requirements to use "User Parameter Configuration" cannot be satisfied (such as the presence of a SERVOPACK alarm), the parameters can be stored to the SERVOPACK using the network function "Store Parameters" (CoE object 1010h), and the SERVOPACK can be restarted using the network function "Adjusting Command" (CoE object 2710h) with the adjustment service "Software Reset".

Refer to "**Appendix B: Software Reset Over EtherCAT**".

The parameters will become enabled after the SERVOPACK completes the software reset.

7. Operation: Synchronized High-Resolution Absolute Position Control

Yaskawa EtherCAT SERVOPACKs can receive absolute position commands every network cycle. This has the following benefits relative to legacy analog command interfaces such as a velocity command voltage or pulse-and-direction signals:

- Synchronization
  - The SERVOPACK is synchronized to all other axes on the network.
- Operation at full bandwidth
  - The SERVOPACK is not limited by low-bandwidth pulse or voltage command signals
- Operation at full resolution of encoder
  - Setting user units to lower resolution to achieve max speed is not necessary.
- Improved positioning
  - Using absolute position commands simplifies the task of the controller, making it unnecessary to send velocity control commands and close a position loop, or send incremental position commands and track/correct absolute position.

8. Operation: Improving Motion Performance

Improving motion performance is possible using the following methods:

- Writing tuning parameters during operation
  - Refer to "**4. Setup: Tuning**".
- Writing performance-related CoE objects during operation
  - Velocity offset CoE object 60B1h (VFF, Velocity Feed Forward)
  - Torque offset CoE object 60B2h (TFF, Velocity Feed Forward)

9. Operation: Dynamic Mode Change

Changing operation mode (CoE object 6060h "Mode of Operation") between position, velocity, and torque during motion operation is possible.

For SGDV, refer to chapter "CiA402 Drive Profile" section "Modes of Operation" of Yaskawa.com document number SIEPC72082904.

10. Operation: Dynamic Stop Types

Changing the stop type (CoE object 605Dh "Halt Option Code") during motion operation is possible.

For SGDV, refer to chapter "Object Dictionary" section "Device Control" of Yaskawa.com document number SIEPC72082904.

11. Operation: Drive-Based Homing

The advantage of drive-based homing is that network delays are removed from the homing function, allowing precise latching of the homing sensor.

For SGDV, refer to chapter “CiA402 Drive Profile” section “Homing” and chapter “Object Dictionary” sections “Device Control” & “Homing Mode” of Yaskawa.com document number SIEPC72082904 for the homing procedure and homing methods.

For SGDV, refer to Yaskawa.com document number MTN-98ML99 for additional details.

For hard stop homing, controller-based homing functions are required, because hard stop homing functions are neither included in the CoE specification nor included in the SERVOPACK specification.

One method to implement controller-based hard homing is as follows:

Example, Hard Stop Homing:

1. Set the “Max Torque” (CoE object 6072h) to a value slightly greater than the torque necessary to move the motor at the hard home speed.
2. In Cyclic Synchronous Position mode (CoE object 6061h = 8), command the speed for hard homing.
3. Monitor the “Position Actual Value” (CoE object 6064h) or “Torque Actual Value” (CoE object 6077h).
4. When the “Position Actual Value” no longer increments as expected, or when “Torque Actual Value” exceeds the expected value, the motor has reached the hard limit.
5. Command a “Target Position” (CoE object 607Ah) a slight value in the reverse direction, to move the motor away from the hard stop.

12. Operation: Latching

The advantage to drive-sided latching is that network delays are removed from the latching function, allowing higher precision latched positions.

Latching on both edges of an input is possible by wring the input into both latch inputs of the SERVOPACK, and then setting the corresponding positive/negative logics on the SERVOPACK (Pn511).

13. Operation: Software Limits

Various limit settings are available to dynamically limit position and torque.

For SGDV, refer to chapter “Operation” section “Limiting Torque” and chapter “Object Dictionary” section “Profile Position Mode” of Yaskawa.com document number SIEPC72082904.

This allows dynamic limit control of applications.

This also allows the possibility of removing limit switches from the machine design.

Refer to “**3.2. Removal of Overtravel Limit Sensors**”.

14. Operation: SERVOPACK I/O

The state of the SERVOPACK inputs is visible on the network, including P-OT, N-OT, and HWBB states.

The state of the SERVOPACK outputs may be set over the network.

This allows dynamic machine reaction based on state, and dynamic control of outputs.

For SGDV, refer to chapter “Object Dictionary” section “Digital Inputs/Outputs” of Yaskawa.com document number SIEPC72082904.

This also allows a reduction of components for machine design.

Refer to “**3.1. Reduction of I/O Devices & Wiring**”.

15. Maintenance: Addressing

The use of SERVOPACK addressing simplifies maintenance in cases of SERVOPACK replacement because addressing forces the data to be communicated to the intended SERVOPACK. This allows the communications cables to be connected to any order of the SERVOPACKs.

For SGDV, refer to chapter “Wiring and Connection” section “Connection Example of EtherCAT Communication” subsection “EtherCAT Secondary Address Settings” of Yaskawa.com document number SIEPC72082904.

16. Maintenance: Error Monitoring & Alarm/Warning Detection

The SERVOPACK's error status and alarm/warning codes may be read though the network though various methods:

- EtherCAT's Emergency Message
- Reading CoE object 603Fh "Error Code"

A controller-sided function may be developed to lookup the alarm code and provide the machine user with the alarm name of the alarm code, as well as the description, cause, investigative action, and corrective action.

For SGDV, refer to chapter "Troubleshooting" of Yaskawa.com document number SIEPC72082904 for alarm and warning tables.

A fault reset may be issued over the network to reset the alarm or warning.

CoE function Fault Reset (bit 7 of the Controlword) performs the alarm/warning reset, as long as the alarm reset is allowed for the alarm.

Note: All warnings may be reset with the CoE Fault Reset function.

For SGDV, refer to chapter "Troubleshooting" of Yaskawa.com document number SIEPC72082904 for indications of which alarms may be reset with Alarm Reset.

17. Maintenance: Total SERVOPACK Run Time

A controller may track the total SERVOPACK run time by recording the duration the SERVOPACK is run.

The total SERVOPACK run time recorded in the controller should be reset when the SERVOPACK is replaced.

To detect when a SERVOPACK has been replaced, a controller function may be implemented to detect the SERVOPACK replacement.

Example:

- Write to a parameter that is not used by the application, during setup of the SERVOPACK, and store to EEPROM by using the "Store Parameters" (CoE object 1010h) function.
- Each time the machine starts up, the controller may read that parameter.
- If the parameter is set, then the SERVOPACK has not been replaced.
- If the parameter is not set, then the SERVOPACK has been replaced.

Appendix A: User’s Manuals, Software, ESI Files

- Sigma-5 User Manual: Setup for Rotary Motors:
  - Yaskawa.com document number SIEPS80000043
- Sigma-5 User Manual: Design and Maintenance - Rotary Motors - Option Command Reference:
  - Yaskawa.com document number SIEPS80000060
- Sigma-5 User Manual: Design and Maintenance - Linear Motors - Option Command Reference:
  - Yaskawa.com document number SIEPS80000066
- Sigma-5 User Manual: EtherCAT (CoE) Network Module:
  - Yaskawa.com document number SIEPC72082904
- Sigma-5 User Manual: Design and Maintenance - Rotary Motors - Analog Voltage and Pulse Train Reference:
  - Yaskawa.com document number SIEPS80000045
  - Use this manual only to reference Pn216 & Pn217 functionality. The command option style amplifier user’s manual states that these parameters are “reserved”. However, the functionality for these parameters exists.
- SigmaWin Plus Software for Sigma Series Servos:
  - Yaskawa.com document number JZSP-WP002
- ESI files:
  - Yaskawa.com document number Yaskawa_CoE_ESI_Files

Appendix B: Software Reset Over EtherCAT

For SGDV, refer to the chapter "Object Dictionary" section "Manufacturer Specific Objects" subsection "SERVOPACK Adjusting Command (2710h)" in Yaskawa.com document number SIEPC72082904.

In addition to the Executable Adjustments listed, "Software Reset" is also available as follows:

Adjustment	Request Code	Preparation before execution	Processing Time	Execution Conditions
Software Reset	2006H	None	5 s max.*	Adjustment is disabled: • While the servo is ON • While Servo-ON has been requested

* Communications to the SERVOPACK will be lost when execution of the "Software Reset" command completes successfully.

In the instructions "How to Send a Command for Adjustment", after step 3 is performed to execute the adjustment "Software Reset", when the slave station receives the command normally, the communications to the SERVOPACK will be lost during the software reset.

Communications will be re-established when the software reset is complete.