Using Induction Motors and Siemens G120 Drives with Fixed Length Actuators and SSI Encoders

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Table of Contents

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Preface

This tech note is focused on the application of using SSI multiturn absolute encoders with the CU250S2 controllers. It assumes that the reader has a working knowledge of commissioning G120 drives. If you need further assistance, please don't hesitate to contact us at C & E.

General Scope

For this discussion, we will consider positioning with an induction motor that causes something to move within a fixed distance or angle of rotation. This can be done by actuators that use gears, belts, ball or roller screws, racks and pinions, etc. The motor causes the actuator to move the load while an absolute multi-turn encoder monitors position. A drive controller turns the motor while monitoring the encoder. When the load approaches the destination, it is slowed down and stopped at the desired point. For this discussion, we are focusing on motion within a fixed range of travel, rather than continuously in one direction.

Why Position using G120 drives with Encoders?

There are various methods for controlling motion of fixed length actuators, ranging from very simple to precision servo controls. Each application should be evaluated to determine what method is the most cost effective over the useful life of the system.

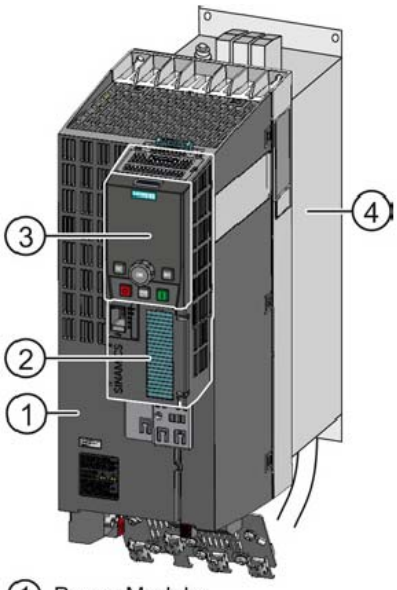
Some critical parameters to be evaluated include the required positioning accuracy and repeatability, the distance and time for each move, the mass of the product and tooling that will be moved, and how much variation there will be in the mass that is moved. Another key factor is whether the positions to be moved to are fixed or if they vary from cycle to cycle or product to product.

One traditional method of position control with induction motors is to use limit, photo, or proximity switches to detect when product is approaching the desired position. The switch triggers the stopping of the motion. This relatively inexpensive approach works reasonably well when the product mass, desired stopping position and speed of the actuator are constants. However, if any of those factors change, then either manual adjustment or additional control logic are required to compensate for the change. Frequently, reliable positioning is unattainable under those circumstances.

Using a G120 drive and an absolute multiturn encoder to monitor and control position not only addresses those problems, but adds flexibility and often increased performance to the solution. By continually monitoring position, the drive controller can adjust for changes in product size and inertia and stop at the desired position with a high level of repeatability. It also provides the capability to move to any position within the range of motion of the actuator upon command, with different speeds and acceleration. This flexibility often yields higher production rates, improved quality, and reduced machine setup and maintenance.

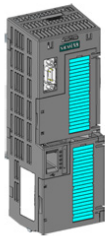
Equipment

The drives that we recommend for this application are Siemens G120 units with CU250S-2 controllers or G120D with CU250D-2 controllers. These high end drives have expanded interfaces including encoder inputs in several formats and connection types. They also have the capability of controlling position and extended safety functions when ordered with the appropriate licenses. They can be ordered with Modbus RTU, Profibus DP, Profinet / Ethernet IP, or CANopen communications to interface with a wide variety of control networks, or operate standalone via hardwired terminals.



1. Power Module
2. Control Unit
3. Intelligent Operator Panel IOP
4. Base components: Filters, reactors or braking resistors

The Control Units CU250S-2 differ with regard to the type of fieldbus.



Designation	Order number	Fieldbus
CU250S-2	6SL3246-0BA22-1BA0	USS, Modbus RTU
CU250S-2 DP	6SL3246-0BA22-1PA0	PROFIBUS DP
CU250S-2 PN	6SL3246-0BA22-1FA0	PROFINET IO, EtherNet/IP
CU250S-2 CAN	6SL3246-0BA22-1CA0	CANopen

The CU250S-2 control modules are matched with PM240-2 power modules sized for motors from 0.5 to 400 HP. Other accessories include Basic or Intelligent Operator Panels, backup memory cards with license files, grounding shields, NEMA 1 enclosures, filters, and braking resistors.

Many types of standard induction motors can be used for these applications, but there are some considerations. The motors must be properly sized for the application so that they run within the rated operating conditions for the specific motor. That must include duty cycle, speed, torque, and importantly cooling. Many induction motors are not designed to run at slow speeds with high torque. This is particularly true of totally enclosed fan cooled (TEFC) motors, but also applies to other configurations as well. We can assist with motor recommendations if you define the required operating conditions.

Encoders should be multi-turn absolute and can have Siemens DriveCLiQ interface or a specific configuration of the SSI protocol. While the use of incremental or single turn encoders is also supported by the CU250S-2 controllers, they require homing to a known reference point on power up. This is often difficult if not impossible with some actuators. This paper is based upon using an Encoder Products A36SB-06MB-1312SIAGV4-AC6 SSI encoder. A link to the data sheet is in the Reference Section. Check with your C & E Motion Specialist before using other encoders, as not all SSI configurations are supported by the G120 units.

The CU250S-2 drive controller uses a DB15 connector for SSI encoder input. The pin out from the drive connector to the encoder is per the following chart.

Function	G120 DB15P pinout X2100	G120D M12-8 pinout X10.	EPC Cable color code	EPC M12 pinout
	1			
Clock +	2	5	Green	3
Clock -	3	6	Yellow	4
Power Supply +	4	2	Brown	2
Power Supply +	5			
	6			
GND	7	7	White (GND) Blue (Preset) Red (Dir)	1 7 8
	8			
	9			
	10			
	11			
	12			
	13			
Data -	14	4	Pink	6
Data +	15	3	Gray	5
	Shield			

Notes:

Preset (establish zero position) and Dir (Direction) must be tied to GND to prevent unexpected changes.

This table includes wiring to the G120D with CU250D-2 controller, which functions like the CU250S-2 but is built to IP67 standards.

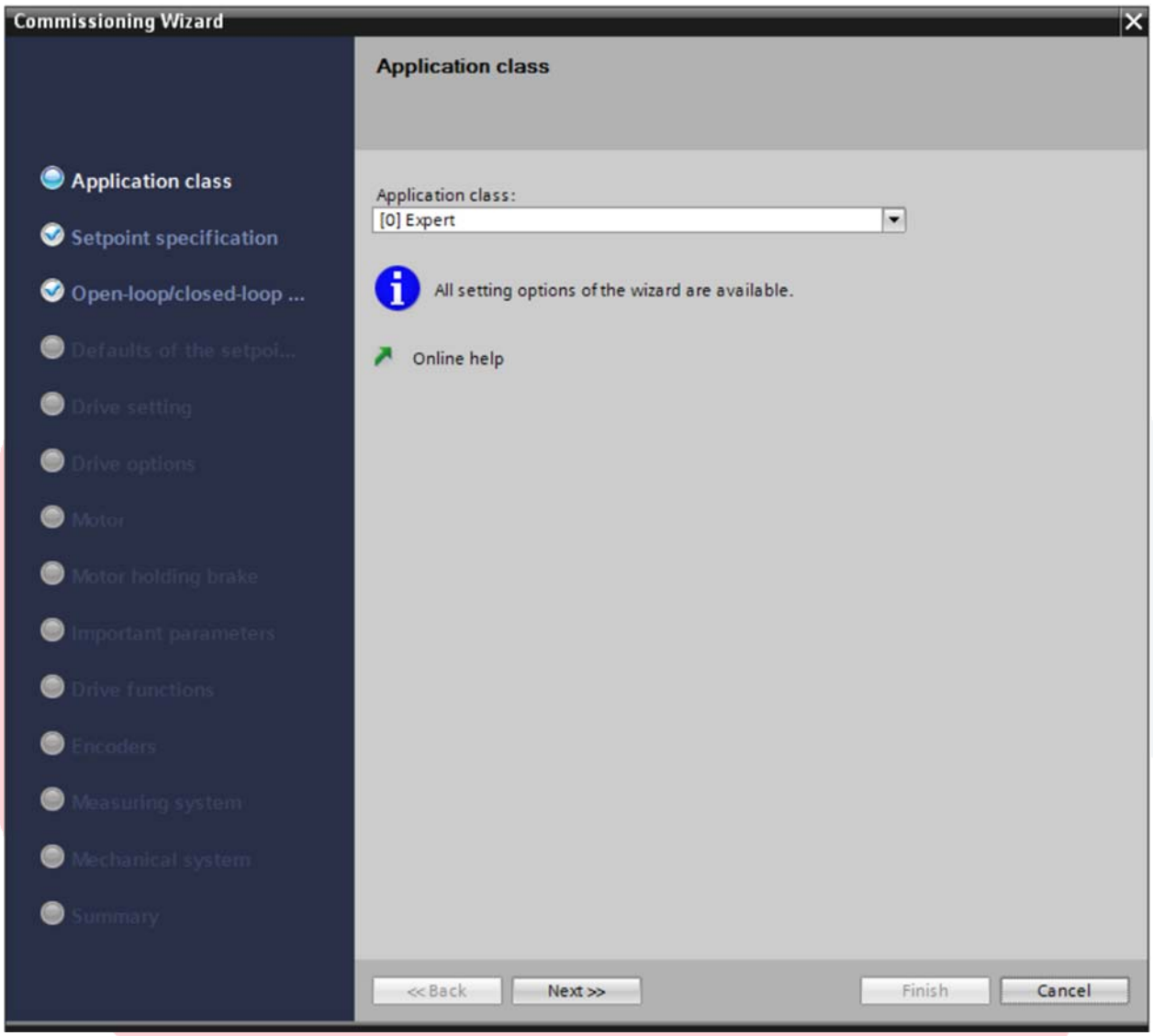
The DB15P (male) connectors are available from many sources.

The M12-8 connectors that we use are Turck BS 8281-0 field installable.

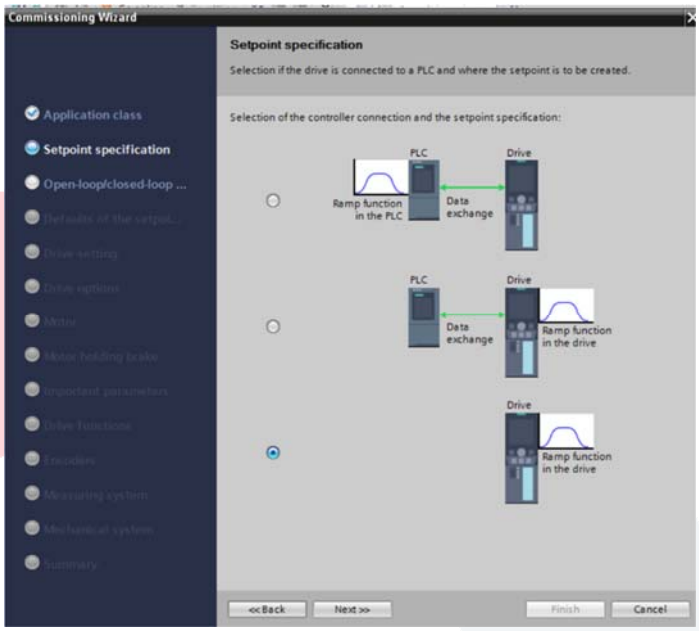
Drive Commissioning

Use the Commissioning Wizard in StartDrive to commission the drive.

Application class: Select [0] Expert, then Next:



Setpoint specification: You must make a fundamental decision as to where the position loop and setpoint are to be handled. If you are closing the position loop in the PLC using Technology Objects, then you should select Ramp function in the PLC and Data exchange to the drive. That is required for synchronized axes and optional for independent axes.

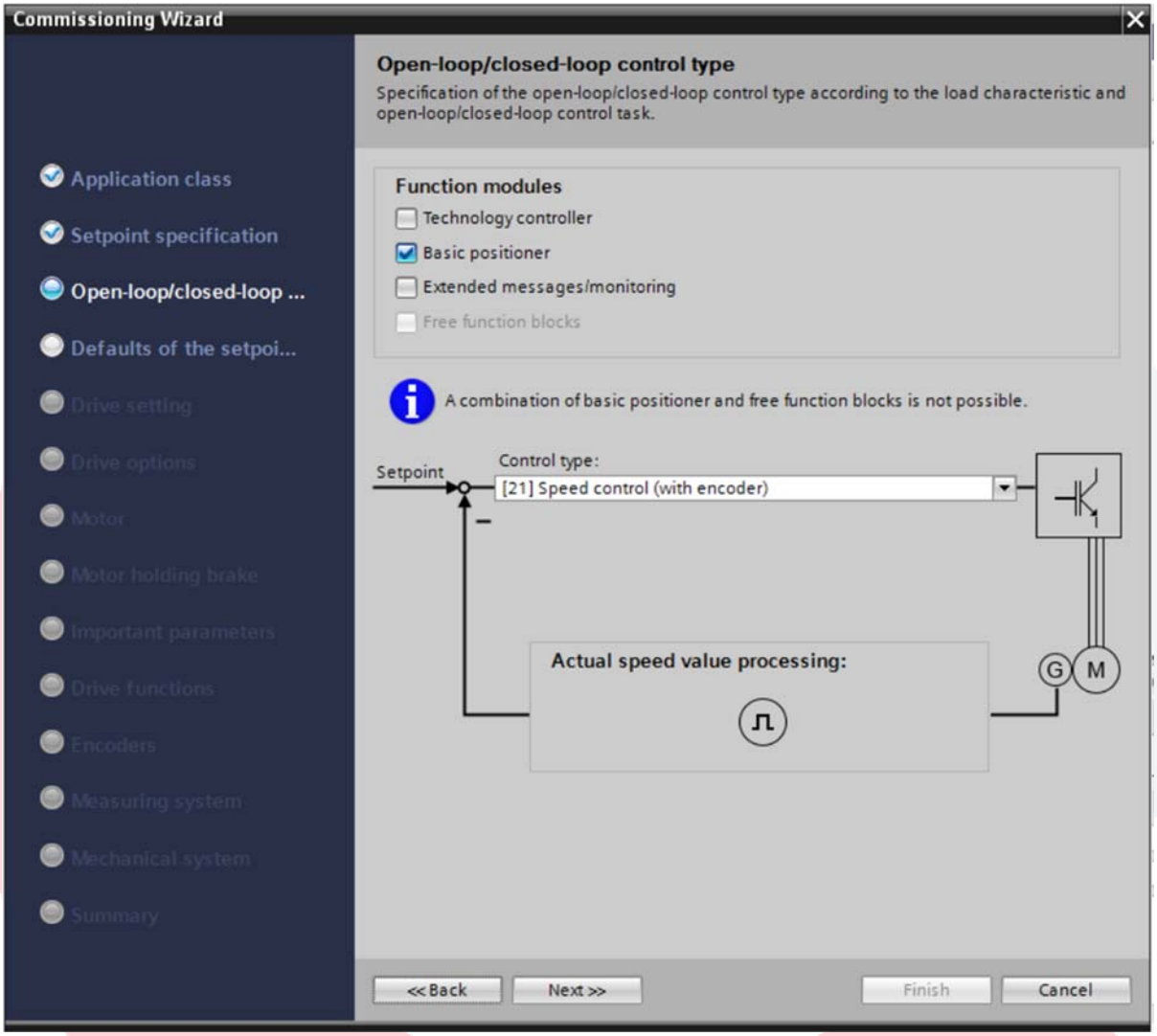


If you plan to use PLC Function Blocks like SINA_Pos or C&E's FB300 to control the position moves in the drive using Basic Positioner, use the center option.

If positioning is to be done completely in the drive, select Ramp function in the drive.

These selections determine if the drive is to be configured to run in speed mode with the PLC controlling when to stop or in Basic Positioner mode where the drive closes the position loop. It also affects the setpoint and command sources and which telegrams can be configured.

Open-loop/closed-loop: If the PLC is controlling the ramp functions, leave Basic positioner unchecked. If the drive is controlling the ramp functions, check Basic positioner. Also select [21] Speed control (with encoder) as the control type. Then click Next,

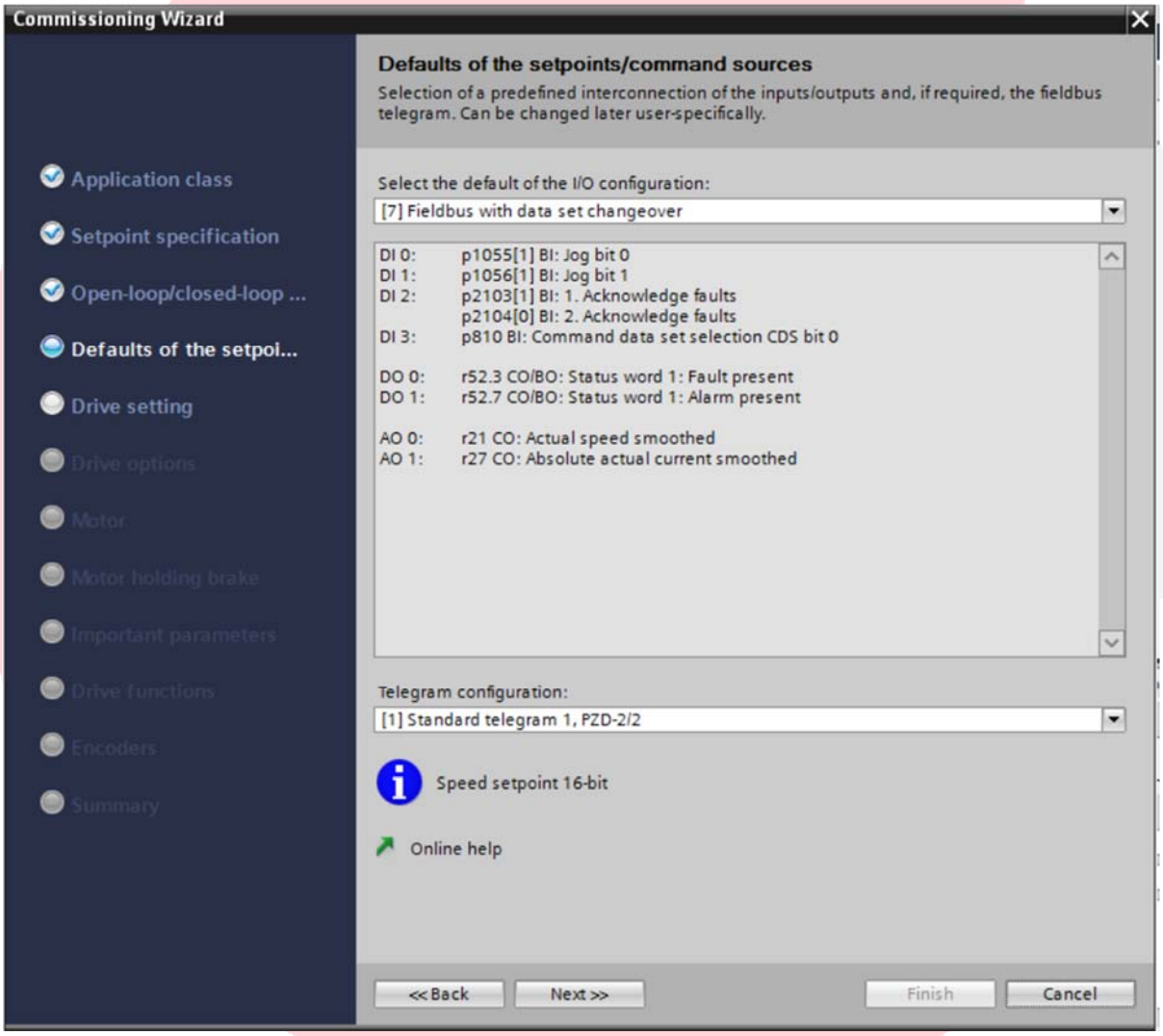


Defaults of the setpoints / command sources:

The configuration options here depend upon what was selected in the Setpoint specification.

If the PLC is selected for Ramp Function and/or Data exchange, then the I/O configuration will be [7] Fieldbus with data set changeover. That sets up the drive with the default control to come from the plc but includes an alternate local control if DI3 is true (On).

If all control is local to the drive and Basic Positioner is selected, then [12] Standard I/O with analog setpoint is the default. That may be changed based upon how you want to wire the control signals. Consult the Commissioning Manual for the options.



If the PLC is controlling Ramp function, then set the Telegram configuration to [1] Standard telegram 1, PXD-2/2.

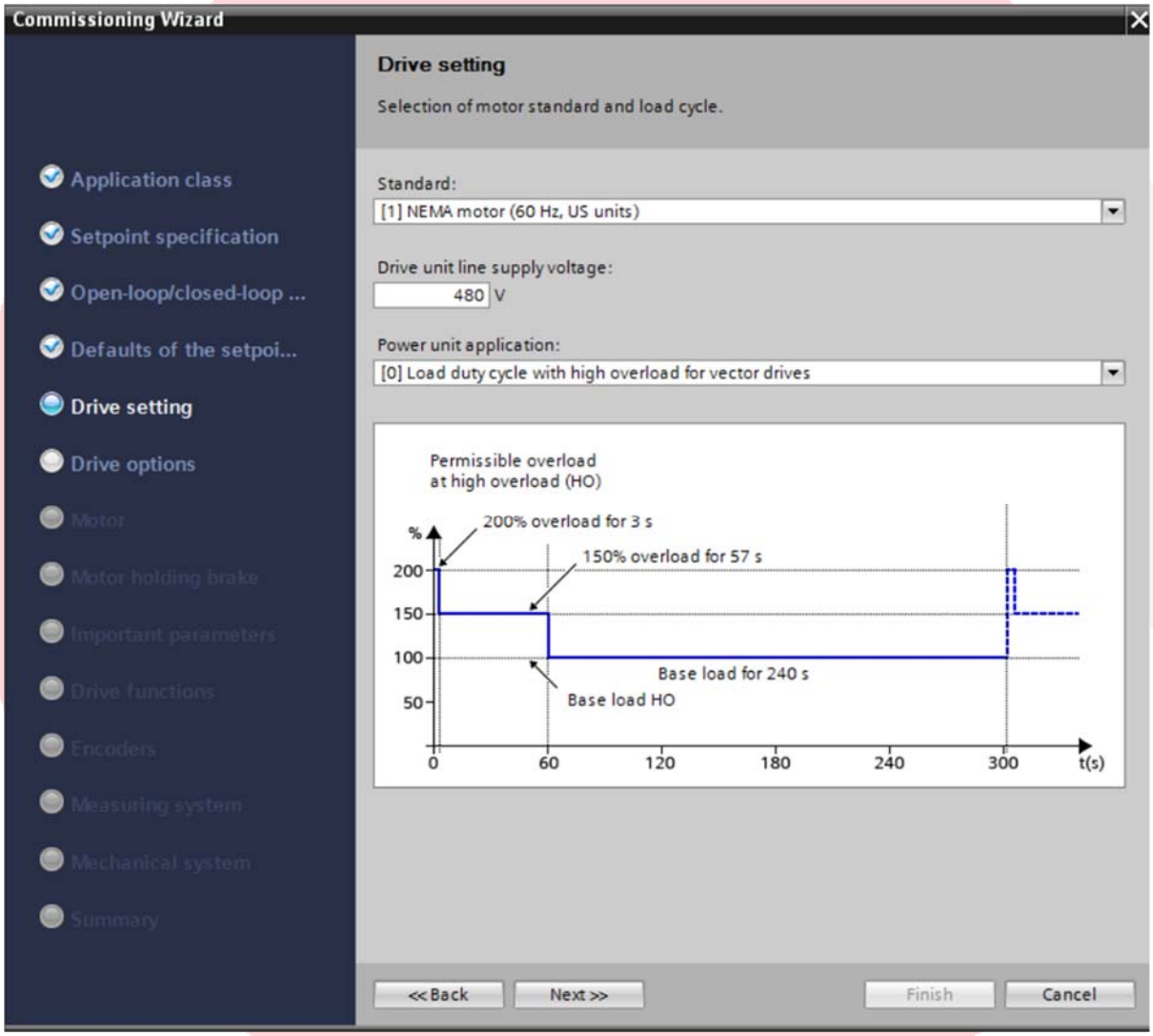
If the PLC is set only for Data Exchange and the drive is in Basic Positioner mode, then set the Telegram configuration to [111] SIEMENS telegram 111, PZD-12/12.

Drive setting:

Standard: Look at the motor nameplate to determine the appropriate selection. [0] IEC-Motor (50 Hz, SI units), [1] NEMA motor 60 Hz, US units) (HP) or [2] NEMA motor (60 Hz, SI units) (Kw).

Drive unit line supply voltage: Set the incoming voltage to the drive.

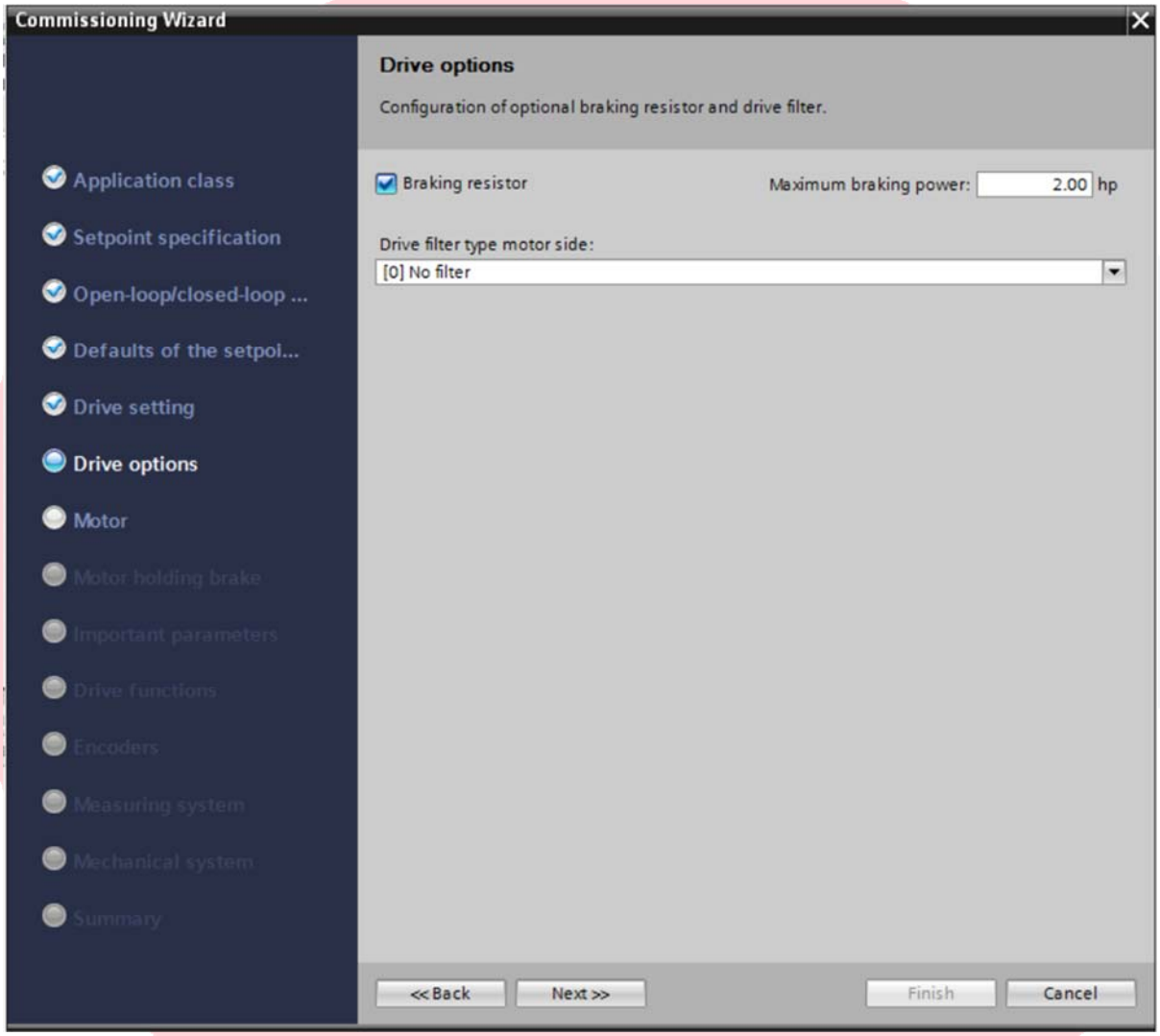
Power unit application: Select the overload setting. This sets limits in the drive based upon current draw and timing to ensure adequate temperature control of the internal components in the drive. Click Next when finished.



Drive Options:

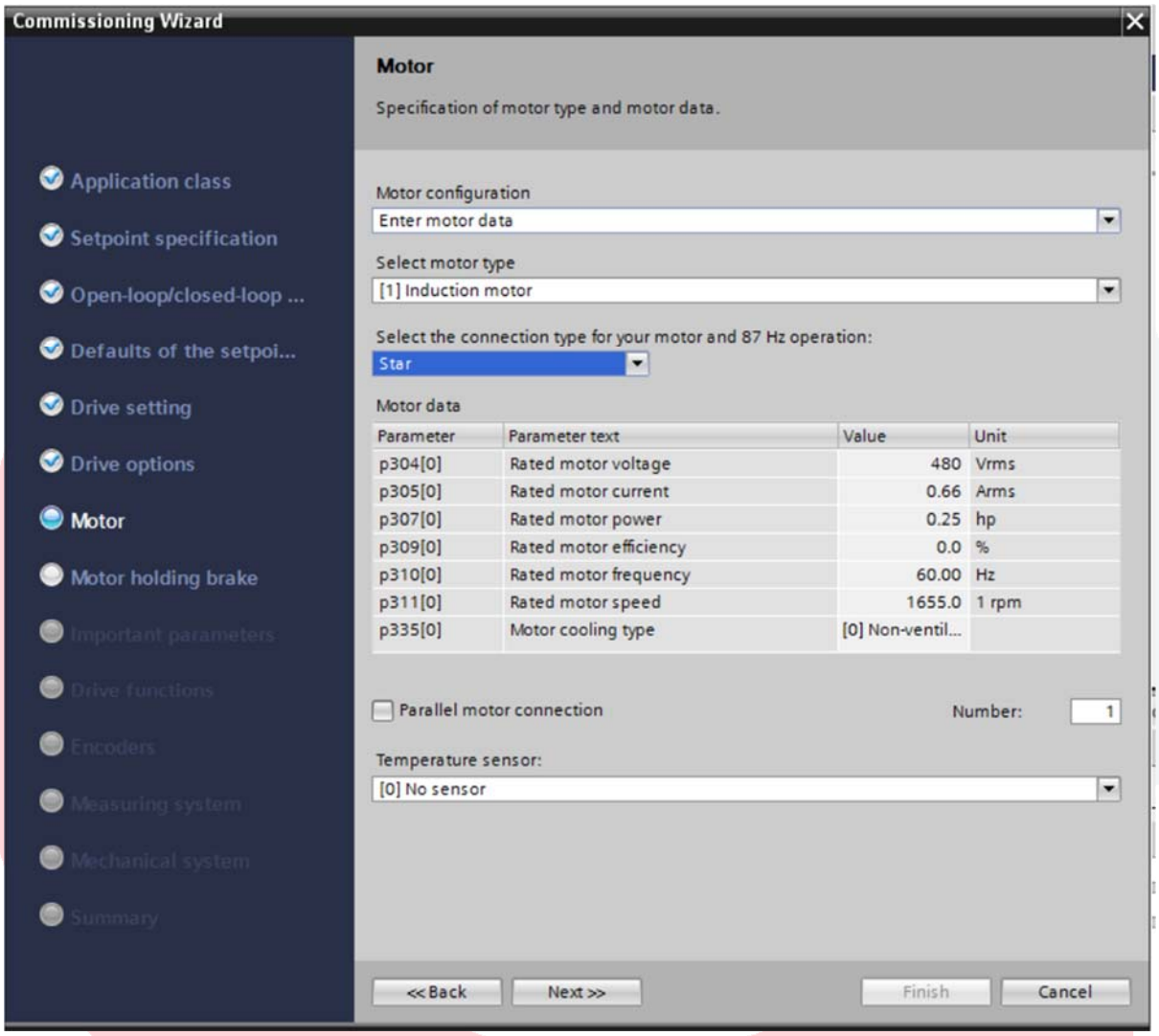
Stopping loads with short deceleration times may require a braking resistor. If used, check the box and enter the maximum braking power per the nameplate.

If an external filter or line reactor is used, select the appropriate entry.



Motor:

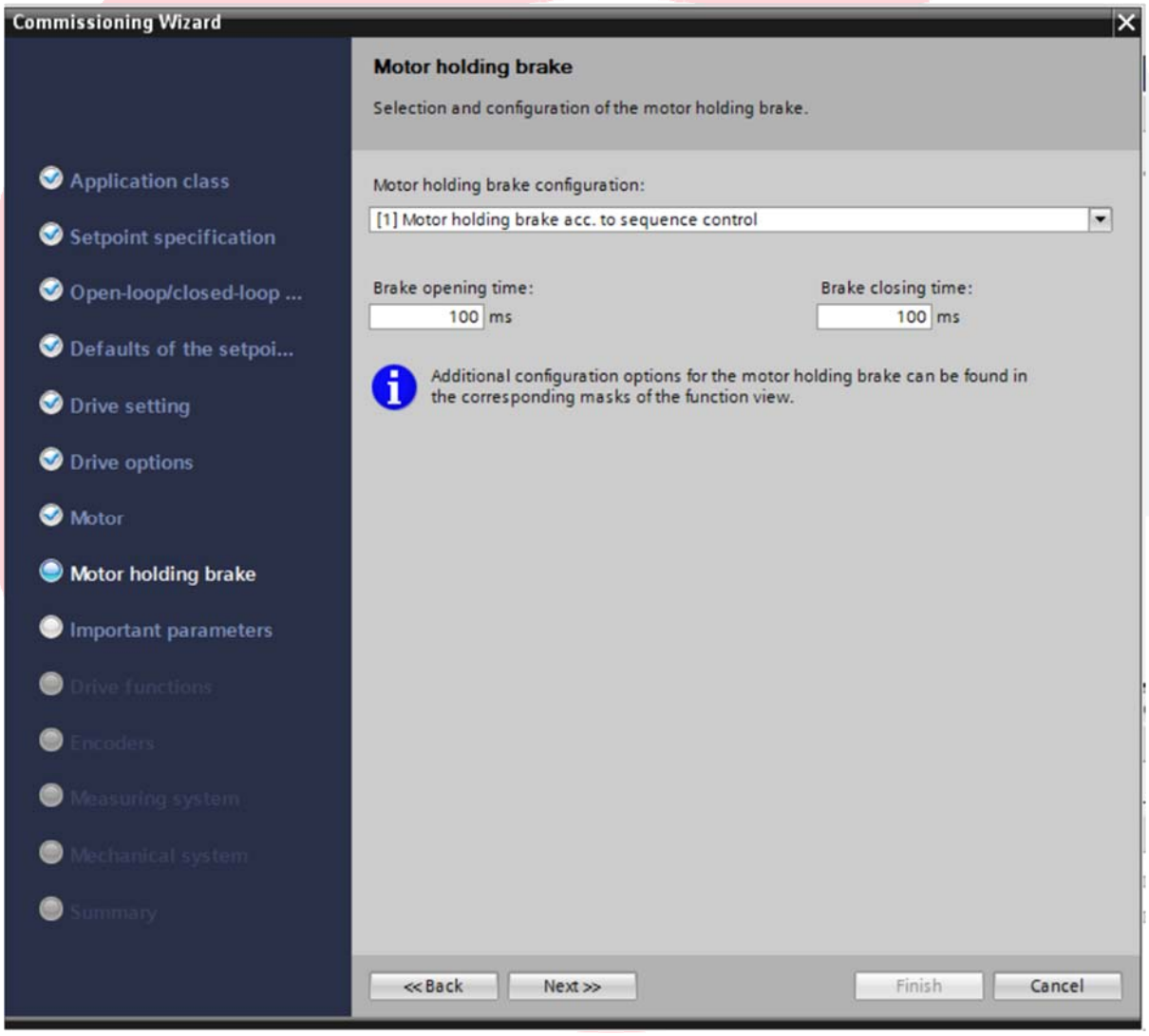
Generally you will be entering motor data for an induction motor. If you have a Siemens motor, then you may be able to select the order number from a list. Once you have entered data in the fields from the motor nameplate, click Next.



Motor Holding Brake:

Holding brakes are electromechanical devices that are released by the drives when motion is enabled. With G120 drives, they are typically interfaced via a 6SL3252-0BB00-0AA0 Brake relay or a 6SL3252-0BB01-0AA0 Safe brake relay actuated directly by the power module. Using mode [1] Motor holding brake acc. to sequence control will delay the opening of the brake slightly after motor power is applied to allow torque to build up so that the load doesn't drop back. In a similar manner, the brake will be closed just before full power is removed from the motor so that it is fully engaged before torque is released.

Option [3] allows for the brake command to be issued from the PLC.



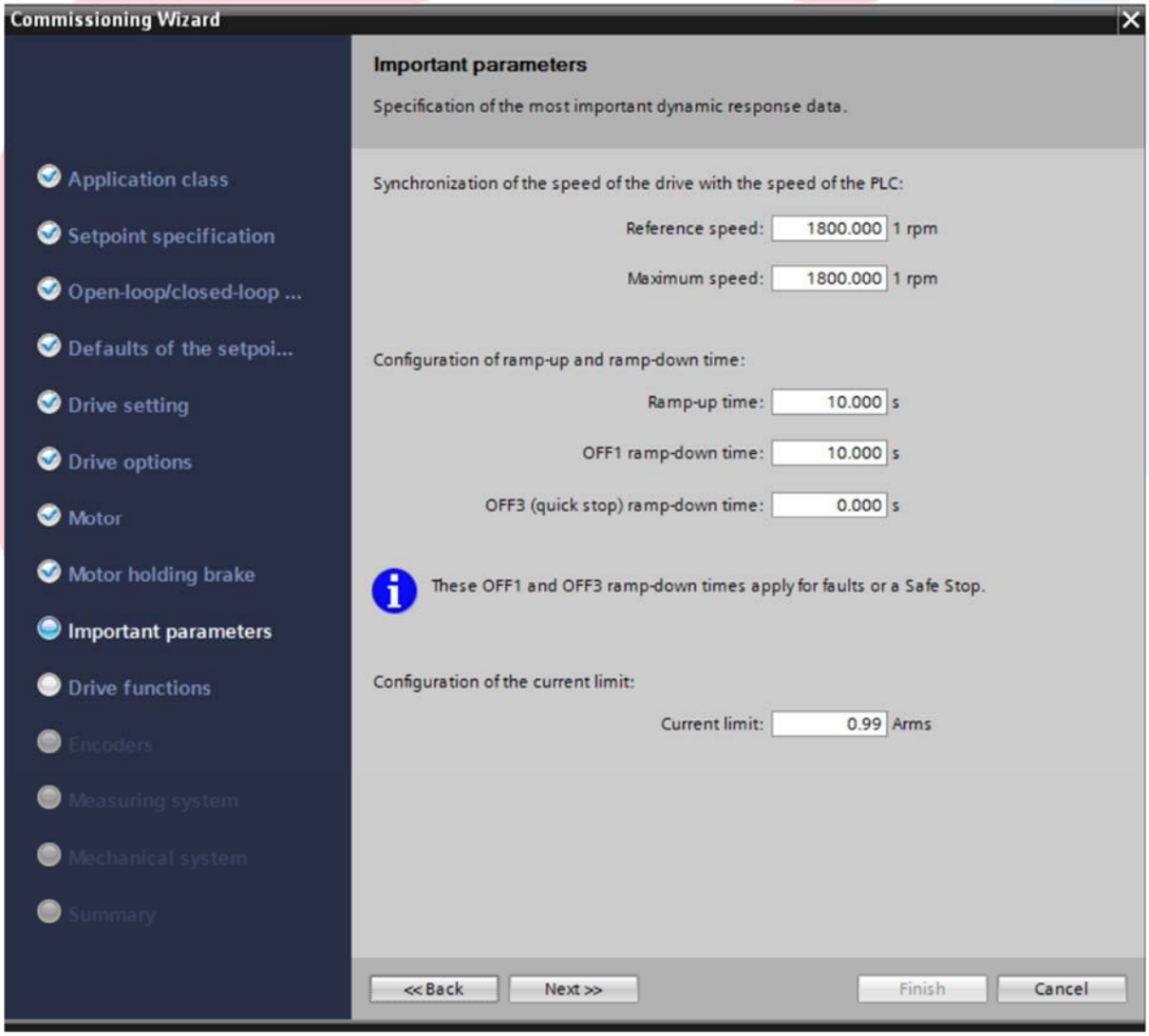
Important parameters:

The Reference speed is used to set the 100% range that is used with telegrams and drive commands to vary frequency set to the motor. Usually the synchronous speed of the motor.

The Maximum speed is used to limit how fast the motor is allowed to run.

The ramp up and down times set the acceleration rates used during normal operation of the drive. The OFF3 (quick stop) time sets how fast the drive will be commanded to stop during emergencies. Note that if there is a mass with a high inertia that must be stopped, the Ramp-down times need to be long enough for the drive and resistors to dissipate the energy.

The Current limit defaults to 150 % of full load amps.



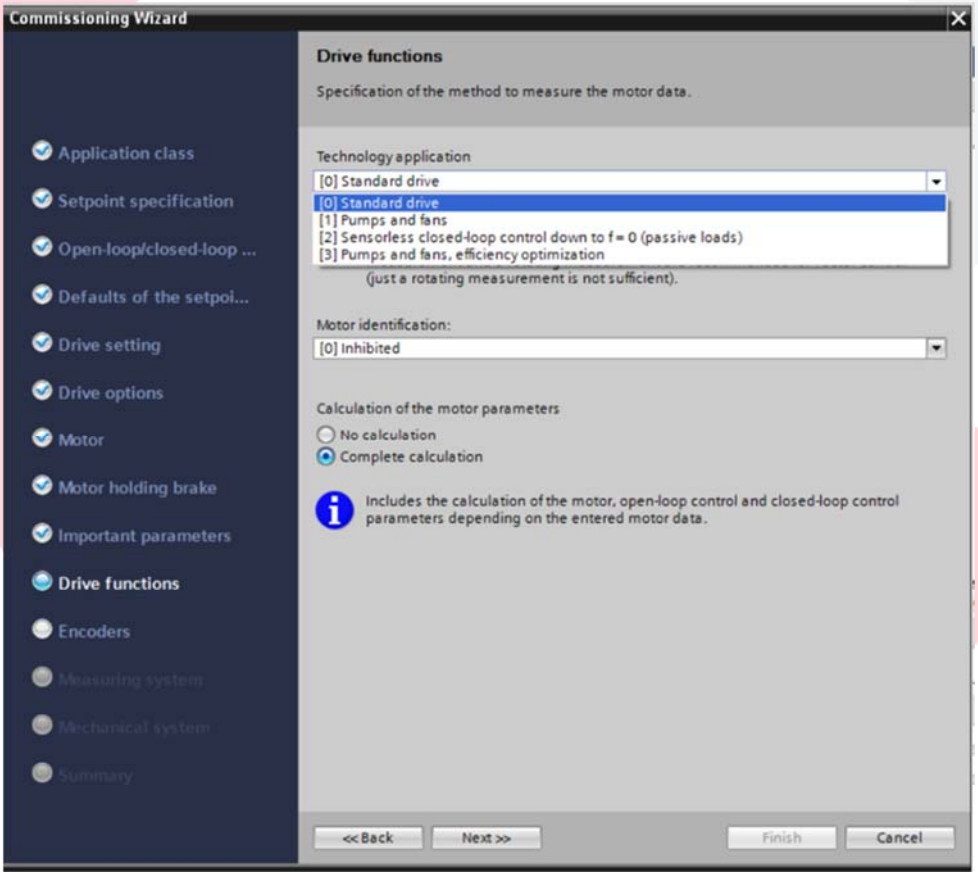
Drive functions:

The Technology application parameter is used to automatically select parameters which apply specifically to certain applications. For example, the output is adjusted to variable torque in the case of pumps and fans. Consult the manuals for details. For positioning, the typical selection is [0] Standard drive.

Motor identification is a one-time measurement of critical motor and cable parameters that are used to determine output values to the motor. For positioning, mode [11] Identify motor data and optimize speed controller, operation is recommended during commissioning, although this may need to be done without the motor connected to the load.

If enabled, a test is performed the first time that the drive is set to run mode during commissioning. The drive will enable and "hum", but the motor will not move during the stationary measurement. The motor will turn during the speed controller optimization. Once the testing is complete, the values must be copied to the drives ROM memory to prevent the test from running at future power on cycles.

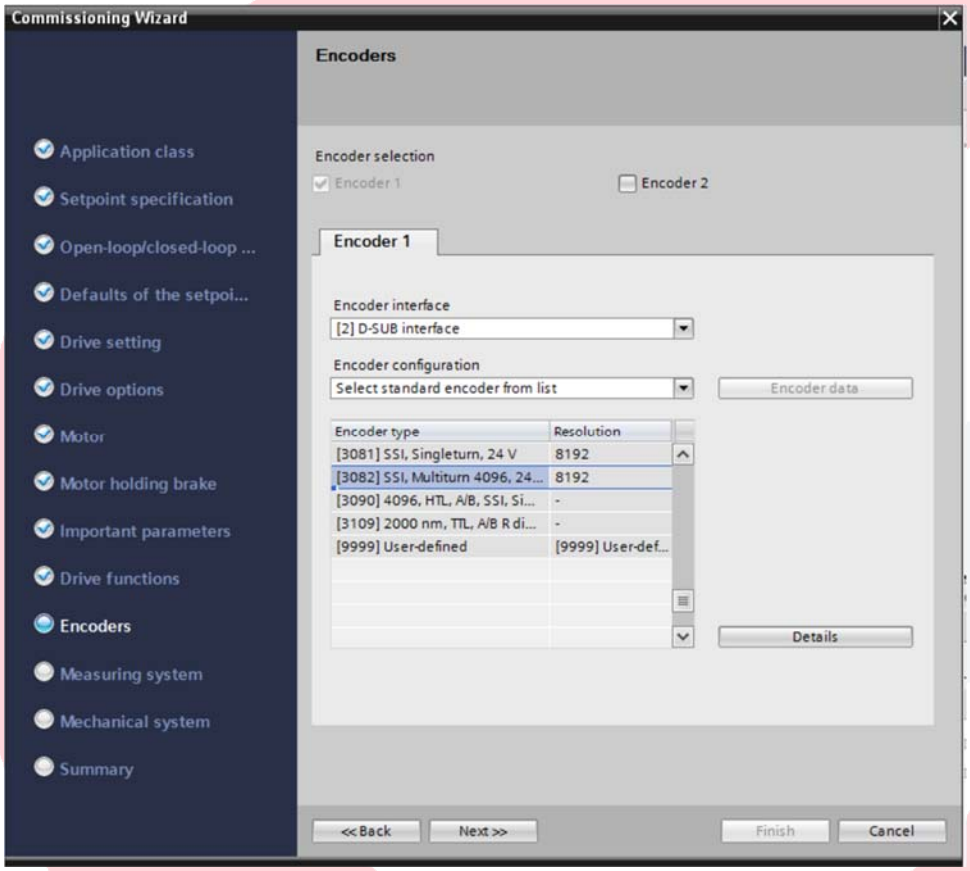
General practice is to set the Motor identification to [0] Inhibited in the Wizard, and then enable it during the online commissioning of the drive. That does require strict attention to commissioning steps, but prevents accidental running of the tests under potential crash conditions.



Encoders:

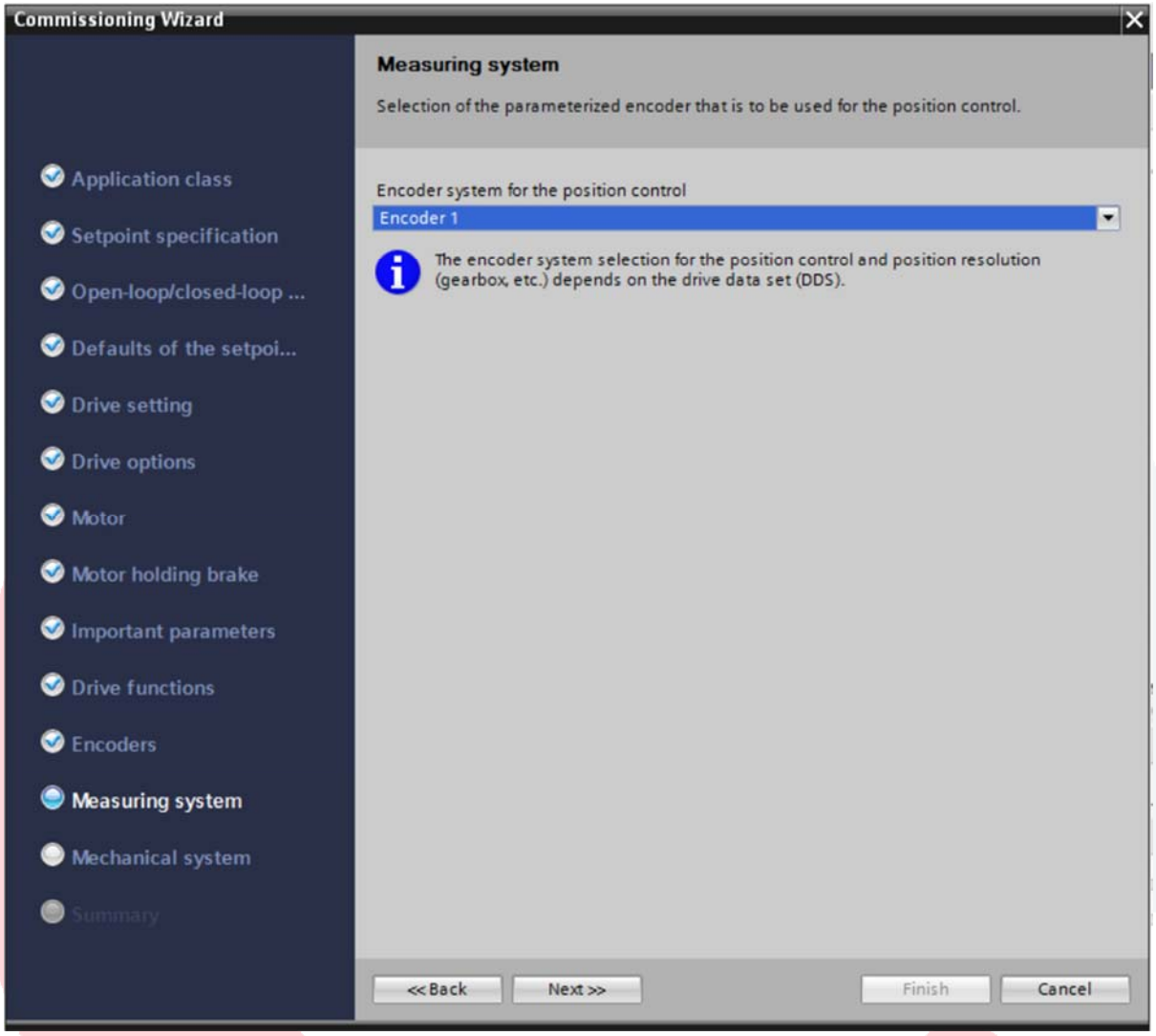
The drives can accommodate up to two encoders. One encoder is always used to measure motor speed. Depending upon mechanics, it can also be used for position. Optionally a second can be used to measure the position. For this discussion, only one encoder is used for both functions, the Encoder Products A36SB-06MB-1312SIAGV4-AC6SSI.

It is interfaced through a D-Sub interface marked X2100 on the drive. The encoder configuration for this unit is [3082] SSI, Multiturn 4096, 24 V, 8192 resolution.



Note: If you receive an error message relating to the fine resolution exceeding 32 bits, reduce the value in G1_XIST2 to lower the resolution.

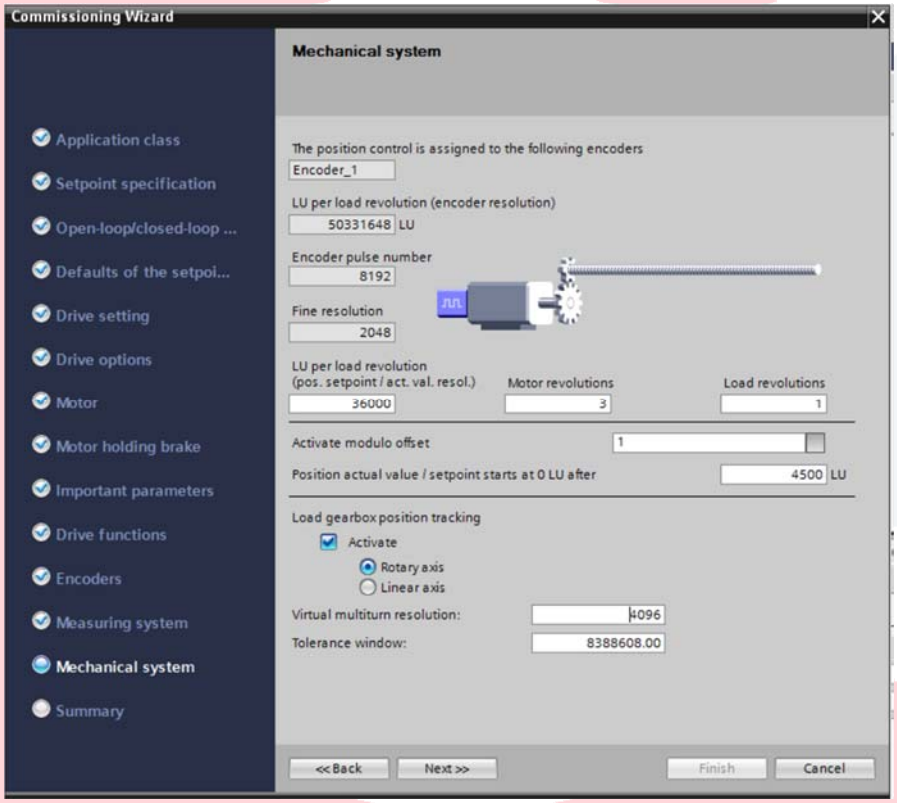
Measuring System:



Mechanical System:

Siemens has a method for defining its measuring system that is different than many of its competitors, but that once understood makes configuration of the system very powerful. The basis of Siemens system is the Load Unit (LU for short). A load unit is an integer that represents the smallest unit of measure in engineering units that the load moves. It is entered into the system as the number of LU's that the load moves in one revolution of the output shaft. For example, if you want to measure the rotation of a turntable in hundredths of degrees, you will enter 36000 LU per revolution (360 degrees/rev times 100 LU's per degree = 36000 LU/rev).

The number of motor revolutions to load revolutions is the gear ratio through the system, in integer format. So if you have a ratio involving decimals, you may need to adjust the scale to get to integer format. Example a ratio of 2.5 / 1 can also be expressed as 25 / 10.



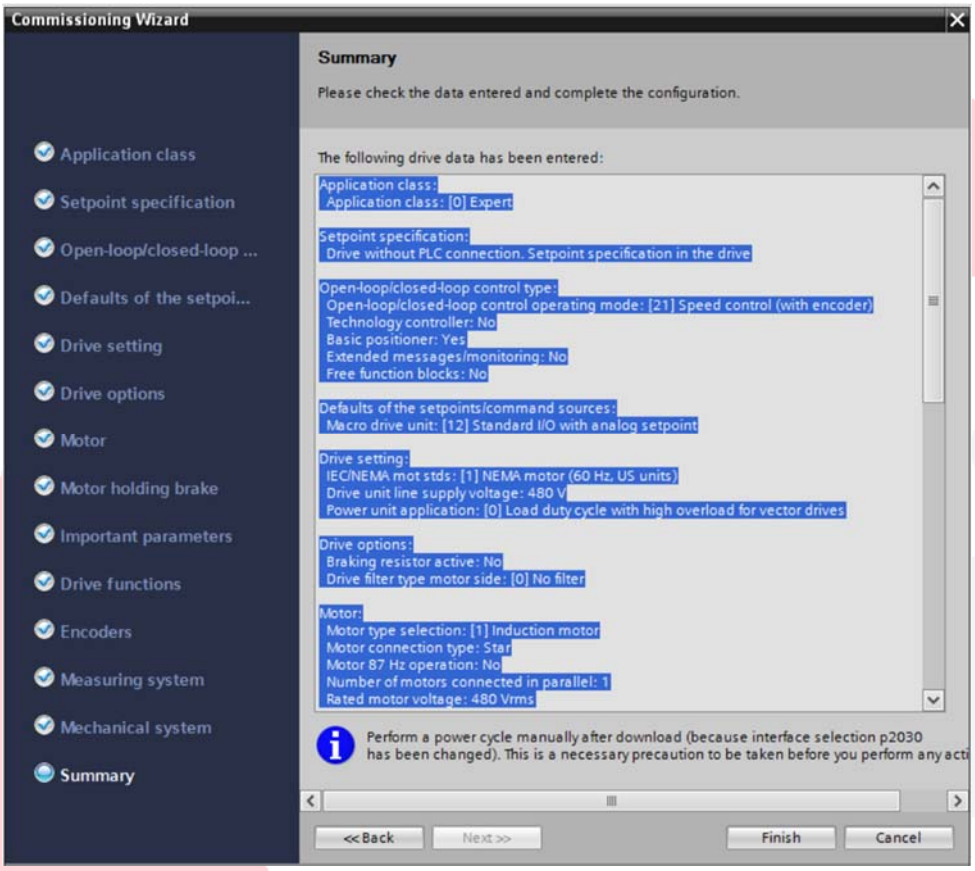
Modulo is a system where the range repeats itself, like a turntable moving in only one direction with stations every 45 degrees. As shown above, enter a "1" to Activate modulo offset and enter 4500 LU's Position actual value / setpoint starts at 0.

Do not use Modulo for a fixed range actuator like a ball screw that moves within a range.

Load gearbox position tracking is used with multiturn encoders. Enter the number of encoder revolutions. The Tolerence window is calculated automatically at one fourth the product of the two encoder resolutions.

Summary

This is a listing of all of the selections that you made during commissioning. If you click in the listing and then press CTRL + A to select all, you can copy the contents and past them into a text document. Then click FINISH and save your work.



Application class:

Application class: [0] Expert

Setpoint specification:

Drive without PLC connection. Setpoint specification in the drive

Open-loop/closed-loop control type:

Open-loop/closed-loop control operating mode: [21] Speed control (with encoder)

Technology controller: No

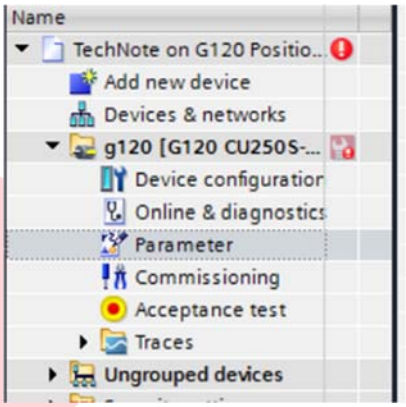
Basic positioner: Yes

Extended messages/monitoring: No

Free function blocks: No

Homing and Setting the Reference Position

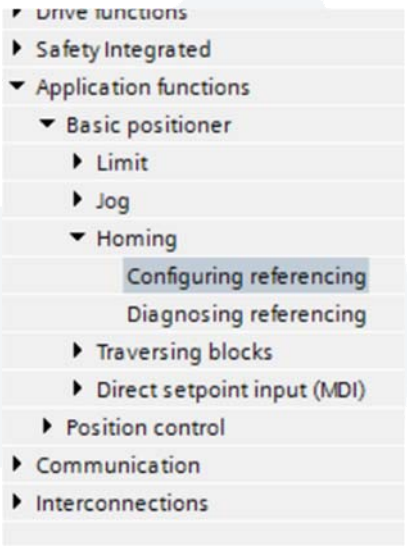
There is one additional step that must be completed during the online commissioning phase: performing the initial absolute encoder adjustment.



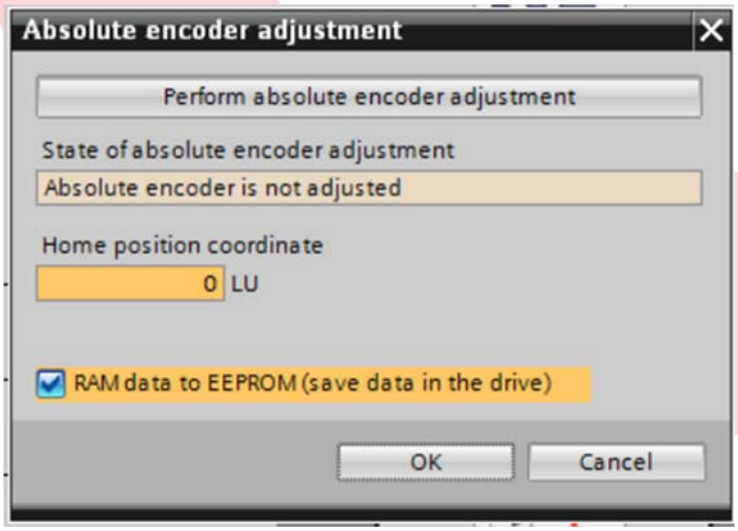
First download the configuration from the previous section to the drive. Then go online.

Double click on the Parameter branch in the project tree to bring up the Parameter window in the Functional view.

Then drill down to the Homing > Configuring referencing screen under the Applications functions > Basic positioner.



In the center of the screen, click on the Active Homing block to bring up the encoder adjustment.



The Home position coordinate is entered as the number of load units in integer format that the current position is from the desired home position coordinate (HPC). If the current position is the home position, enter zero (0). If something else, enter the offset in integer format. Example, if the current position is 100 mm's from the desired home position and there are 1000 LU's per revolution of a ball screw with 10 mm pitch, then the HPC is 10000 LU's.

Check the box to save data in the drive, then OK.

References and Useful Links

G120 CU250S-2 PN Manuals can be found at the Siemens Support Site:

https://support.industry.siemens.com/cs/search?search=CU250S-2%20PN&type=Manual&lc=en-US

Operating Instructions
https://support.industry.siemens.com/cs/document/109757229/sinamics-g120-inverter-with-cu250s-2-control-unit?dti=0&lc=en-WW

Function Manual Basic Positioner
https://support.industry.siemens.com/cs/document/109757593/function-manual-basic-positioner?dti=0&lc=en-WW

List Manual

https://support.industry.siemens.com/cs/document/109751315/sinamics-g120-control-units-cu250s-2?dti=0&lc=en-WW

Getting Started https://support.industry.siemens.com/cs/document/109757229/sinamics-g120-inverter-with-cu250s-2-control-unit?dti=0&lc=en-WW

Application Examples and Guides can be found at the Siemens Applications Site:

https://www.automation.siemens.com/mc-app/sinamics-application-examples/Home/Index?language=en

SINAMICS G: Axis positioning with the 'SINA_POS' block
https://support.industry.siemens.com/cs/document/109736845/sinamics-g%3A-axis-positioning-with-the-sina_pos-block?dti=0&lc=en-WW

SINAMICS G: Guide for Commissioning a Position-Controlled Drive
https://support.industry.siemens.com/cs/document/109479977/sinamics-g:-guide-for-commissioning-a-position-controlled-drive?lc=en-ww

Information on Encoder Products SSI and other encoders can be found at:
http://www.encoder.com/

MODEL A36SB - ABSOLUTE SHAFT ENCODER
http://encoder.com/core/files/encoder/uploads/files/datasheet-a36sb.pdf

Model A36HB - Absolute Hollow Bore encoder
http://encoder.com/core/files/encoder/uploads/files/datasheet-a36hb.pdf

TB-529 *Understanding EPC's SSI Encoders*
http://encoder.com/core/files/encoder/uploads/files/TB-529.pdf

TB-111 *M12 (12 mm) Connector Option*
http://encoder.com/core/files/encoder/uploads/files/TB-111.pdf

Acknowledgments

Screenshots are of StartDrive, Siemens drive commissioning software. All rights reserved.