

SERCOS® III for Hypertherm® CNCs

Field Service Bulletin

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Section 1

SERCOS III Overview


Introduction

SERCOS III is a real-time communication bus for digital servo drives designed for high-speed communications over industrial Ethernet cable. This Field Service Bulletin describes SERCOS III setup for Hypertherm CNCs. In it you will find:

- A SERCOS III overview that applies to all SERCOS III rings supported by Hypertherm CNCs. This section describes general SERCOS III concepts and setup information for all SERCOS III system that are compatible with Hypertherm CNCs, regardless of drive type.
- Concepts and setup information specific to Bosch Rexroth drives. If you have Bosch Rexroth drives, start with Section 1, and then refer to Section 2 to complete your setup.
- Concepts and setup information specific to Kollmorgen AKD® drives. If you have Kollmorgen AKD drives, start with Section 1, and then refer to Section 3 to complete your setup.

Hypertherm CNCs support both SERCOS II (fiber optics) and SERCOS III (Ethernet) communication protocols. See the *Phoenix V9 Series Installation and Setup Manual* (806410) for information on SERCOS II. For more information about the SERCOS standard, see www.sercos.com.


Work in partnership with your drive manufacturer when you size the drives and motors for your cutting machine. Refer to your partner and the drive documentation for technical information about the drives that you need when you set up the Hypertherm CNC to work with the SERCOS ring. Cutting machine specifications and mechanics are beyond the scope of this document.

 Setting up the CNC requires that you have access to the password-protected Machine Setup screen. Contact your table manufacturer or system integrator for assistance with password-protected screens on the CNC.


SERCOS III equipment supported by Hypertherm CNCs

Hypertherm CNCs support the following SERCOS III equipment.

Drives


 All drives in the SERCOS III ring must use the same firmware version.

- **Bosch Rexroth IndraDrive Cs Basic or Economy:** Bosch Rexroth IndraDrive Cs Basic (CSB02.1A) or IndraDrive Cs Economy (CSE) with multi-Ethernet support, drive firmware type MPB, and firmware version 16V24, 17V14 or later, or 18V06 or later. Requires Phoenix 9.73.0 or later.


 We recommend that you don't mix Basic and Economy drives. Phoenix uses a cyclic rate of 1 ms with the Basic drives and a cyclic rate of 2 ms with the Economy drives. But the SERCOS master can only operate with one cyclic rate. So if you mix the Basic and the Economy drives within the ring, then the cyclic rate can only operate at 2 ms, which reduces the performance of the Cs Basic drives.

- **Bosch Rexroth IndraDrive C:** Bosch Rexroth IndraDrive C with drive firmware type MPB and firmware version 18V06 or later. Requires Phoenix 9.73.0 or later.
- **Kollmorgen AKD:** Kollmorgen AKD drives with the part number format AKD-PXXXXX-NBS3-XXXX and firmware version 01-13-05 or later. Requires Phoenix version 9.76.1 or later.

Bus couplers


 The CNC supports one I/O bus coupler on the SERCOS ring. **Make sure you connect the I/O bus coupler as the last device on the ring.**

Beckhoff EK9700 bus coupler and I/O modules

 This equipment requires Phoenix 9.76.0 or later.


Part Number	Description
EK9700	Beckhoff bus coupler
EL1008	8-channel digital input terminal, 24 VDC, 3 ms
EL2008	8-channel digital output terminal 24 VDC, 0.5 A
EL3064	4-channel analog input terminal 0–10 V, single-ended, 12-bit
EL4004	4-channel analog output terminal 0–10 V, 12-bit

Bosch Rexroth fieldbus coupler and I/O modules

 This equipment requires Phoenix 9.73.0 or later.

Part Type	Description
R-IL S3 BK DI8 DO4-PAC	SERCOS III fieldbus coupler, 8 digital inputs, 4 digital outputs, 500 mA, Bosch Rexroth part number R91170875
R-IB IL AO 2/U/BP-PAC	Analog output module, 2 analog outputs, ± 10 V/0-10 V, 2-wire connection
R-IB IL AI 2/SF-PAC	Analog input module, 2 analog inputs: 0 to 20 mA/4 to 20 mA/ ± 20 mA, ± 10 V/0-10 V, 2-wire connection

WAGO® bus coupler and I/O modules

 This equipment requires Phoenix 9.76.0 or later.

Part Number	Description
750-351	SERCOS III bus coupler, 2-port, 100 Mbit/s, digital and analog signals
750-459	4-channel analog input module, ± 10 V/0-10 V (single-ended)
750-530	8-channel digital output module, 24 VDC
750-430	8-channel digital input module, 24 VDC
750-559	4-channel analog output module, ± 10 V/0-10 VDC
750-627	Internal data bus extension end module (for connecting remote I/O modules)
750-628	Internal data bus extension coupler module
750-1500	16-channel digital output module, ribbon cable, high-side switching, 24 VDC
750-1400	16-channel digital input module, ribbon cable, high-side switching, 24 VDC
750-600	End module, no function (physical end cap)

Cables

The SERCOS III ring requires Ethernet Cat5e or Cat6e STP (shielded twisted pair) cables. While the ring can function through a single SERCOS port on the CNC, connecting a second cable to the second SERCOS port provides redundancy.

The following Ethernet Cat5e shielded cables are available from Hypertherm.

Part number	Length
223102	61.0 m (200 feet)
223101	45.5 m (150 feet)
223100	30.5 m (100 feet)
223099	23.0 m (75 feet)
223008	15.0 m (50 feet)
223223	10.5 m (35 feet)
223119	7.5 m (25 feet)
223222	6.0 m (20 feet)
223212	3.0 m (10 feet)
223380	1.5 m (5 feet)
223382	0.6 m (2 feet)
223381	0.3 m (1 feet)

SERCOS III system overview

Figure 1 shows two examples of SERCOS rings. The double ring provides redundancy through two counter-rotating rings so that the system continues to operate if a single cable breaks. Hypertherm CNCs equipped with the SERCOS III master card have two RJ-45 ports, P1 and P2, that allow you to set up the ring topology. The single ring topology, using only P1, is also supported by the CNC but does not provide communication redundancy.


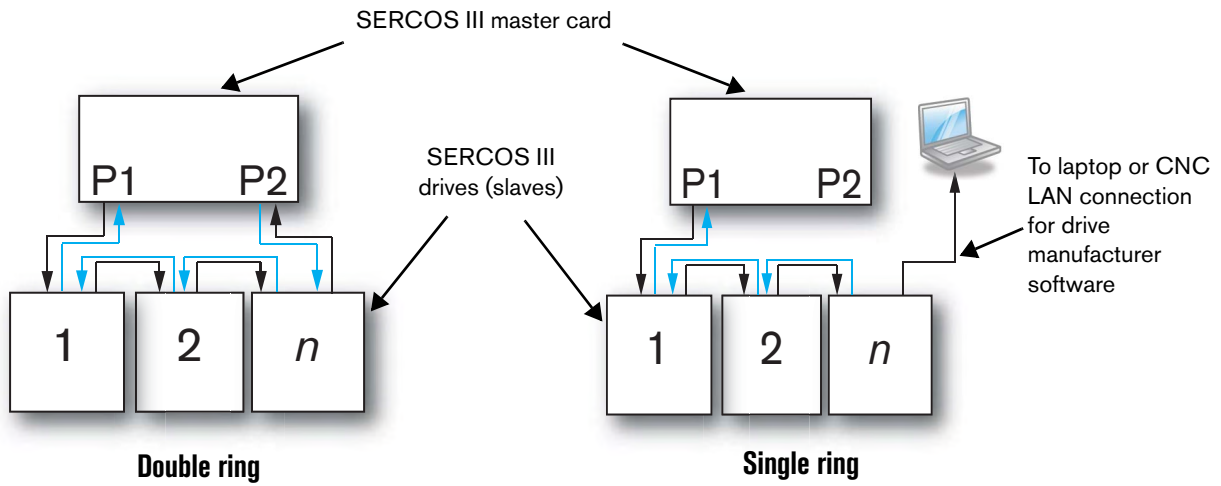

 In this document, the term “SERCOS ring” applies to either a single or double ring.

Figure 1 - Two examples of SERCOS III rings



 The communications between master and slaves, shown with the blue and black lines, take place over a single physical cable.

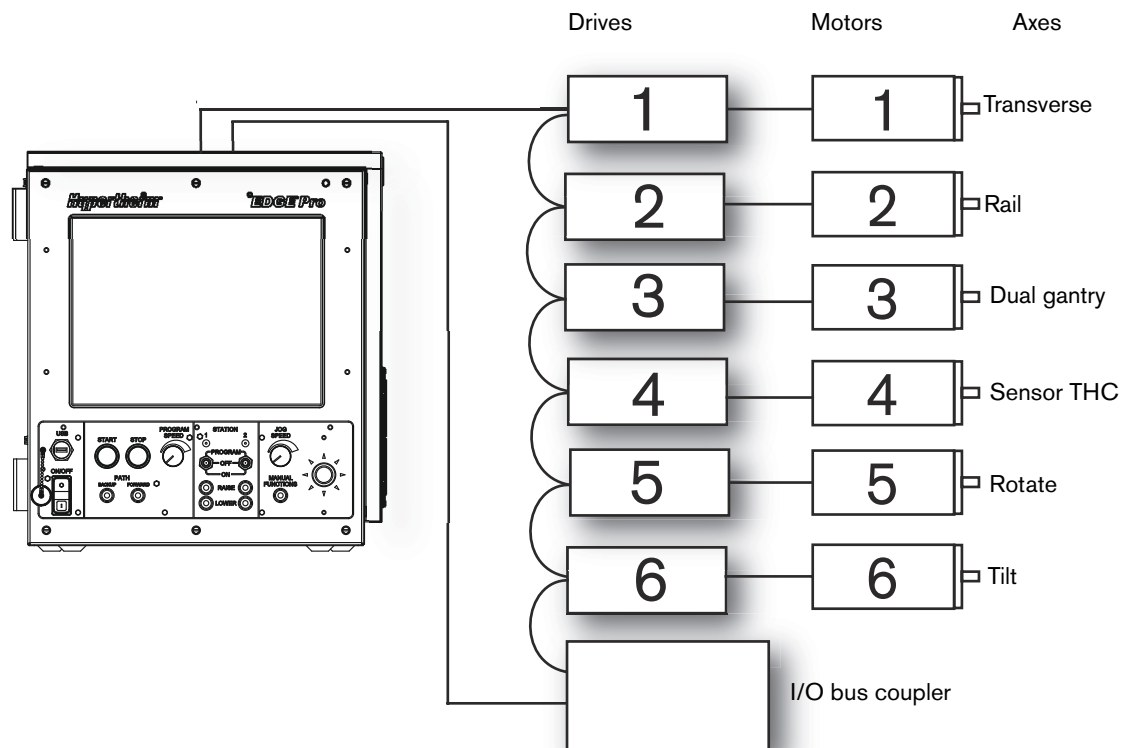
General requirements for SERCOS III


Follow these requirements for ease of setup and best performance:

- Do the installation steps in this order:
 1. Set up the SERCOS ring.
 2. Set up the CNC to communicate with the ring.
 3. Phase up the ring.
- The number of drives in the ring must match the number of axes actively assigned in the Machine Setups screen.
- Do not mix brands or types of drives in the same ring.
- Do not use drives that have different servo loop update rates in the same ring. For example, if one drive uses a 1 ms servo loop update rate, and another drive uses a 2 ms servo loop update rate, the CNC uses the 2 ms servo loop update rate for **all** the drives, which reduces system performance.
- Connect the axis limit switches (also called overtravel switches) to the drive I/O, not to an I/O module.

- Assign overtravel switches in both the CNC and the drive. This makes sure that the CNC is notified of the overtravel condition while allowing the drive to provide the best deceleration of the cutting machine. An exception to this rule is if you are homing to an overtravel switch, in which case the overtravel switch should only be assigned in the CNC.
- Connect the divided arc voltage signal (output) from the VDC3 to the THC drive analog input.

Figure 2 - Example of a SERCOS ring with the drives and axes





 The CNC supports one I/O bus coupler on the SERCOS ring. Connect the I/O bus coupler as the last device on the ring as shown above.


About drive addresses and axis assignments

Hypertherm CNCs are hard-coded with the axis assignments and require that the axis assignment and drive address match. The table below shows the drive addresses that the CNC uses for the 12 axes, and common letter identifiers for the axes.

Drive address	Axis assignment
1	Transverse or Rail (X)
2	Rail or Transverse (Y)
3	Dual Gantry (W)
4	Sensor THC 1 (Z)
5	Rotate 1 (B or C)
6	Tilt 1 (A)
7	Transverse 2
8	Rotate 2
9	Tilt 2
10	Sensor THC 2
11	Sensor THC 3
12	Sensor THC 4

 All cutting machines require both Transverse and Rail axes, but you can assign either to X or Y.

 A Dual Gantry axis is parallel to the Rail axis (think of it as a “Rail 2” axis). The Dual Gantry axis receives the same position command from the CNC as the Rail axis.

 Rotate and Tilt rotary axes are used for bevel cutting.

Special passwords NRT and 1RT (No Rotate Tilt and 1 Rotate Tilt respectively) redirect certain axis assignments to different drive addresses. For example, a 2-station cutting machine on a 6-axis CNC requires the NRT password so that the Transverse 2 and Sensor THC 2 digital signals are output to drive addresses 5 and 6 instead of 7 and 10.

The following tables identify the application, password, and drive addresses for common, supported cutting machine axis configurations. Use these tables to identify the drive address where the CNC will output the axis signals.

5-axis I-cutting on pipe or tube, with Dual Gantry, NRT password

Drive address	Axis assignment
1	Transverse or Rail
2	Rail or Transverse
3	Dual Gantry
4	Sensor THC
5	Transverse 2

6-axis, 2-station, I-cutting on flat plate, with Dual Gantry, NRT password

Drive address	Axis assignment
1	Transverse or Rail
2	Rail or Transverse
3	Dual Gantry
4	Sensor THC
5	Transverse 2
6	Sensor THC 2

6-axis bevel cutting on pipe or tube, no Dual Gantry, 1RT password

Drive address	Axis assignment
1	Transverse or Rail
2	Rail or Transverse
3	Sensor THC
4	Transverse 2
5	Rotate
6	Tilt

7-axis bevel cutting on pipe or tube, with Dual Gantry, 1RT password

Drive address	Axis assignment
1	Transverse or Rail
2	Rail or Transverse
3	Dual Gantry
4	Sensor THC
5	Rotate
6	Tilt
7	Transverse 2

Address the SERCOS III drives

If the drives are in the physical order of the addresses 1 through n , you can set each drive to address 1 and the CNC will address the drives during the first phase-up of the SERCOS ring. Again, this method works **only when the drives are in physical order** in the ring. If the drives are **not** physically in order equal to the axis assignment, you need to manually address each drive according to the tables on the preceding pages.



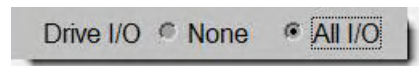
When using the NRT or 1RT password, the CNC redirects the axis signals for Sensor THC, Transverse 2, and Sensor THC 2 to lower-numbered drive addresses. These addresses are not shown on the CNC in the axis setup screens (**Machine Setups > Axes**). See *To check the drive address* on page 20 for information on viewing the drive address using IndraWorks (Bosch Rexroth drives) and WorkBench (Kollmorgen AKD drives).



SERCOS drive addresses are different from IP addresses. Refer to the section of this document that applies to your drive type for more information about IP addresses. For Bosch Rexroth drives, see *Internet Protocol (IP) addresses* on page 25. For Kollmorgen AKD drives, see *Internet Protocol (IP) addresses* on page 47.


Drive I/O

The **All I/O** option for the **Drive I/O** parameter on the SERCOS screen (**Setups > Password > Machine Setups > SERCOS**) controls the use of the drive I/O. Setting the **Drive I/O** parameter to **All I/O** is the recommended setting. The CNC addresses the I/O starting with the first drive in the ring and continuing to the last drive.




Some I/O assignments may have already been made in the drives. The CNC does not reset these assignments. However, if a drive uses an I/O point, set the same I/O point in the CNC to **Spare**. Likewise, when the CNC uses an I/O point, set the same I/O point in the drive to **Not Assigned** or **Off**.

In most cases, you can assign the I/O points in the CNC, not in the drive. An exception to this rule is the assignment of X and Y hardware limit (or overtravel) switches. The drive provides the best deceleration of the cutting machine if an overtravel switch is activated, so assigning the overtravel switches in both the CNC **and** the drive is recommended.

 If you are homing to an overtravel switch, the overtravel switch should only be assigned in the CNC.

The table below shows an example of how the CNC would address the I/O in a SERCOS III ring with 6 drives (each drive with 7 digital inputs, 1 digital output, 1 analog input, 1 analog output) and an I/O module.

 Refer to the section of this document that applies to your drive type for your drive I/O assignments. For Bosch Rexroth drives, see *Drive I/O* on page 26. For Kollmorgen AKD drives, see *Drive I/O* on page 47.

Drive address	Digital inputs	Digital output	Analog input	Analog output
1	1 – 7	1	5	1
2	8 – 14	2	6	2
3	15 – 21	3	7	3
4	22 – 28	4	8	4
5	29 – 35	5	9	5
6	36 – 42	6	10	6
I/O module at address 50: first input or output	43 and above	7 and above	11 and above	7 and above

Analog inputs

The CNC supports 16 analog inputs in the SERCOS ring. Analog inputs 1 through 4 are reserved by the utility board in the CNC for system temperature and program speed and jog speed controls on the operator console. The analog inputs on the SERCOS drives start with analog input 5.

Drive address	Analog input
1	5
2	6
3	7
4	8
5	9
6	10

I/O bus coupler

A compatible I/O bus coupler can be used to handle miscellaneous I/O on the cutting machine. Use the following settings to set up the CNC to use the I/O bus coupler in addition to the drive I/O.



See *SERCOS III equipment supported by Hypertherm CNCs* on page 6 for part numbers of compatible equipment.



The CNC supports one I/O bus coupler on the SERCOS ring. **Make sure you connect the I/O bus coupler as the last device on the ring.**

1. Choose **Setups > Machine Setups > SERCOS**.
2. For **Drive I/O** choose **All I/O**.
3. For **Inline I/O Modules at Address 50** choose **Yes**.

About machine enable/disable inputs

Hypertherm CNCs provide three different inputs to disable the drives in an emergency or urgent stop condition, and to disable and enable the drives before and after a power cycle:

■ Drive Disabled

When this input activates, the CNC turns off the individual drive enable signals and the Drive Enable output after the next update cycle (1 ms). The CNC also clears its internal home reference position; the cutting machine needs to be re-homed before cutting can resume. The CNC displays the status message **Drive Disabled** when this input activates. The Drive Disabled input should be wired into the cutting machine's safety circuit so that it can be deactivated by way of a reset mechanism.

■ Front Panel E-stop

When this input activates, the CNC turns off the individual drive enable signals and the Drive Enable output after the next update cycle (1 ms). The CNC also clears its internal home reference position; the cutting machine needs to be re-homed before cutting can resume. The CNC displays the status message **Emergency Stop Active** when this input activates. The Front Panel E-stop input should be wired into the cutting machine's safety circuit.

■ Fast Stop

Use the Fast Stop input when you want an urgent stop. When this input activates, the CNC decelerates motion using the Fast Deceleration Rate on the Speeds screen, and turns off the individual drive enable signals. One second after Fast Stop activates, the CNC turns off the Drive Enable output, which disables the drives. The CNC retains position information so that you can restart the cutting job after you clear the condition that caused you to stop the system. Fast Stop is often wired to a separate switch on the operator console.



Momentarily pulsing Fast Stop for less than 1 second causes the cutting machine to do a fast deceleration and stop motion but keeps the drives enabled. This allows you to stop the machine without disabling the drives. Check with local safety authorities before using the Fast Stop input in a cutting machine safety circuit.

Enable the cutting machine after a power cycle or stop

After you power up the cutting machine and after an emergency or urgent stop, you need to re-enable the drives. The following is an example sequence of re-enabling the drives. How you re-enable the cutting machine depends on the wiring of the drives, the machine's safety circuit, the machine's reset mechanisms, the disable input assigned in the CNC, and the timing of the CNC's enable logic.

1. Turn on the CNC and wait for the SERCOS ring to phase up. (The state of the machine is: E-stop depressed, no AC power to drives, and disable input active to the CNC.)
2. Deactivate the disable input to the CNC (Drive Disabled, Front Panel E-stop, or Fast Stop). Often this is accomplished by way of a reset mechanism or push-button, depending on the operator console and drive box safety circuit.
3. After the input is deactivated, the CNC attempts to re-enable the drives for up to 2 seconds. After 2 seconds, the CNC stops trying. The drives must be in stand-by mode or the attempt fails after 2 seconds. If the CNC doesn't succeed in re-enabling the drives automatically, you can re-enable the drives manually by pressing the **Setups > Enable Control** soft key.

Drive parameters used by the CNC

The CNC sets very few parameters for the SERCOS drives. The CNC automatically sets the parameters in the table below for the drives when the SERCOS ring phases up. The parameter value shown in the table is the IDN format specified by the SERCOS standard.



If your cutting machine has absolute encoders, see *Parameters for absolute encoders* on page 18.

Parameter	Value
Position polarity	IDN S-0-0055.0.0
Velocity polarity	IDN S-0-0043.0.0
Torque polarity	IDN S-0-0085.0.0
Drive storage mode (Bosch Rexroth drives only)	IDN S-0-0269.0.0

IDN data structure

IDNs follow this format:

15	14	12	11	8	0
X	X	X	X	X	X

- **Bit 15:** 0 = Standard data (normative), 1 = product data (determined by the drive or I/O module manufacturer)
- **Bits 14 – 12:** Parameter set 0 – 7
- **Bits 11 – 0:** Data block number from 0 to 4095

About absolute encoders

Absolute encoders allow the use of stored position information in the motors and drives so that the cutting machine does not require re-homing after a power cycle. Both the motor and drive must support battery backup so that they can store the position information. Hypertherm CNCs support absolute encoders in Bosch Rexroth and Kollmorgen AKD drives.

A cutting machine with absolute encoders should only require homing in the following situations:

- When it is first commissioned
- If any of the motors have been removed from the rack
- If any of the battery backups for the motor encoders fail

Home position in the CNC is the Absolute Home Position plus the Home Offset Distance (if used), which are set in the axis setup screen. When you complete homing the cutting machine, the CNC updates the home position in each drive.



When the CNC updates the home position, it briefly halts the drive (in the case of Bosch Rexroth IndraDrive drives) or turns off the drive enable outputs (in the case of Kollmorgen AKD drives).

Absolute encoder setup

Absolute encoder setup varies depending on whether you have Bosch Rexroth drives or Kollmorgen AKD drives.

- **For Bosch Rexroth drives:** In the IndraWorks Ds software, you can set up Force Absolute Encoder Evaluation in the Motor Encoder screen. This feature lets you set up a monitoring window that looks for a difference in position between the physical position of the axis and the position recorded by the absolute encoder. If the physical position of the axis exceeds this distance, the drive sends an error to the CNC.

To set this up, in the **Motor Encoder** screen, select **Force Absolute Encoder Evaluation** and enter a distance value for the Encoder Monitoring window.

- **For Kollmorgen AKD drives:** In the WorkBench software, enter a valid distance in the **FB1.INITPWINDOW** parameter; for example, 65536 (1 motor revolution at 16-bit resolution, which is recommended).

Parameters for absolute encoders

The CNC also sets the following parameters in the drives for absolute encoders:

Parameter	Value
Position feedback type Note: For Bosch Rexroth drives, set bits 8 and 6 to 1. See <i>IDN data structure</i> on page 17.	IDN S-0-0277.0.0
Position feedback status	IDN S-0-0403.0.0
Set absolute position procedure command	IDN S-0-0447.0.0
Set absolute position control	IDN S-0-0448.0.0

SERCOS Sensor THC setup for plasma cutting machines

The Sensor THC (torch height control) regulates the torch height relative to the workpiece using arc voltage feedback. The Sensor THC requires an independent drive axis that does positioning. The drive for the THC axis is part of the SERCOS ring. The THC drive must operate in Velocity Mode (Operation Mode is set in the drive software).

Sensor THC voltage divider card

Connector J2 on the Sensor THC voltage divider card (VDC3), installed in the plasma system, has connections to the SERCOS drive.

- Analog output from the voltage divider card must be connected to an analog input on a drive, not on an I/O module in an I/O bus coupler. This is because the arc voltage analog input requires the update rate to be 4 ms or faster, but 1 ms is recommended.
- Nozzle Contact Sense and Nozzle Contact Enable both require negative logic. They can connect to the drive or the I/O module.

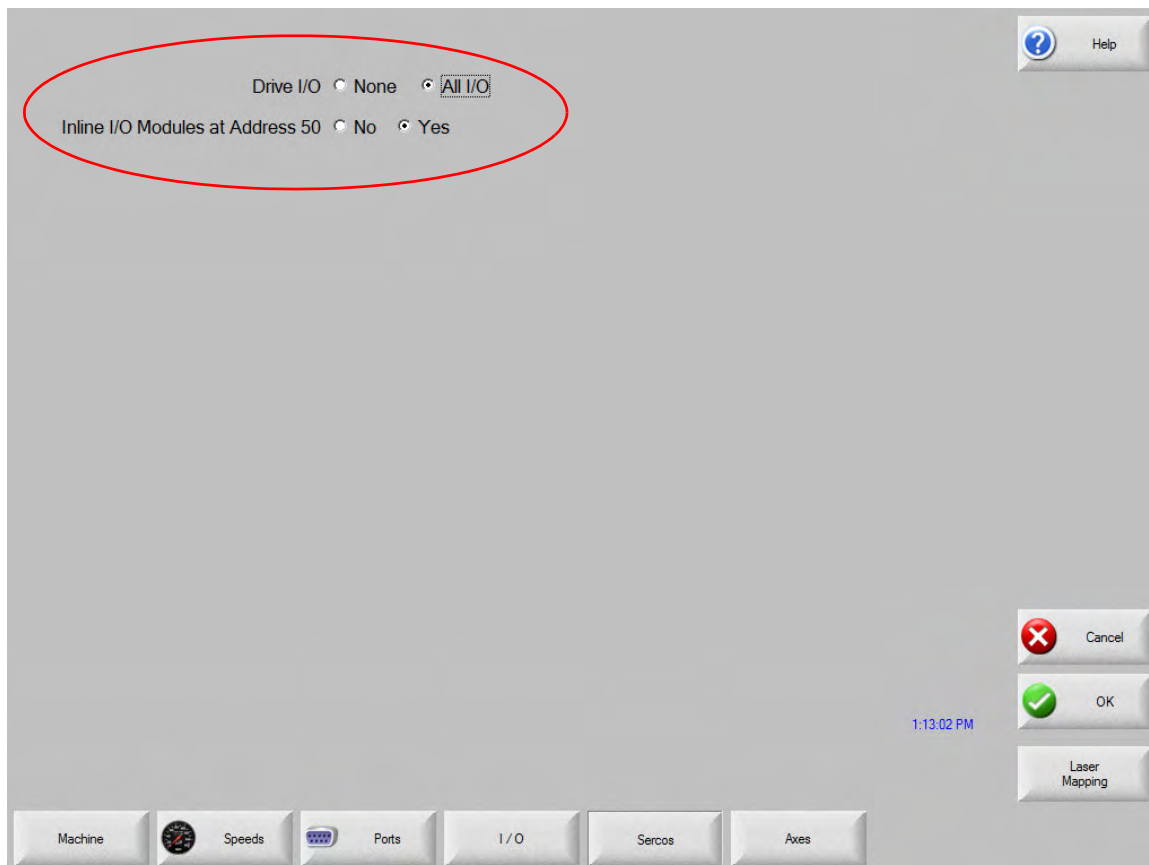
The inputs and signals on J2 are shown in the following table.

VDC3 Pin	VDC3 Signal	Drive I/O
1	24 VDC Common	Not connected
2	+24 VDC	Not connected
3	Nozzle Contact Sense	Negative logic digital input
4	Nozzle Contact Enable	Negative logic digital output
5	24 VDC Common	Not connected
6	Analog Out +	Analog input +
7	Analog Common	Analog common
8	Earth Ground	

Refer to the section of this document that applies to your drive type for specific instructions on connecting the Sensor THC to the drive. For Bosch Rexroth drives, see *Sensor THC connections to the Bosch Rexroth IndraDrive drives* on page 41. For Kollmorgen AKD drives, see *Sensor THC connections to the Kollmorgen AKD drives* on page 60.


SERCOS setup screen

The CNC requires that the drive I/O or bus coupler I/O be enabled. Choose **Setups > Password > Machine Setups > SERCOS** to open the setup screen.



On the setup screen, make the following selections:

- **Drive I/O:** Select **All I/O** to enable the drive I/O (recommended). Select **None** if the drives do not have available I/O or you do not intend to use the drive I/O.
- **Inline I/O Modules at Address 50:** Select **Yes** if you are using an I/O bus coupler to expand the total number of I/O in the SERCOS ring.

 The CNC supports one I/O bus coupler on the SERCOS ring. **Make sure you connect the I/O bus coupler as the last device on the ring.**

Troubleshooting tips

If you have trouble phasing up the SERCOS ring, follow these guidelines to help identify the issue.

- Check the cable type. SERCOS III requires CAT5e shielded cables. Unshielded CAT5 cables are not capable of the faster transmission speeds required for SERCOS III.
- Check the cables from P1 on the CNC to Drive 1, and then from drive to drive. Be sure the cables are properly seated in their connectors on the drives and CNC and that there are no breaks in the cables.
- The CNC supports SERCOS passwords 1SA, 2SA, and so on through 12SA. Use these passwords to troubleshoot or to prevent drives from phasing up. See *Troubleshooting Tips* in the section of this document that applies to your drive type for specific instructions.
- If the CNC is displaying error messages or having difficulty enabling the drives, see *About machine enable/disable inputs* on page 16.

To check the drive address

Depending on your drive type, use one of these procedures to verify the SERCOS drive addresses.

For Bosch Rexroth drives (IndraWorks Ds software)

IndraWorks Ds shows the drive address in the Axis Status screen. Choose **Diagnostics/Service > Axis Status**.



For Kollmorgen AKD drives (WorkBench software)

WorkBench can be configured to display the drive address in the Watch panel. Complete the following steps to enable the Watch panel and add the drive address.

1. In WorkBench, choose **View > Toggle Watch Panel** to display the Watch panel.
2. In the first empty row, click in the **Parameter** column to view the available parameters.

3. Enter the **S3.ADDRESS** parameter to view the drive address in the Watch panel.

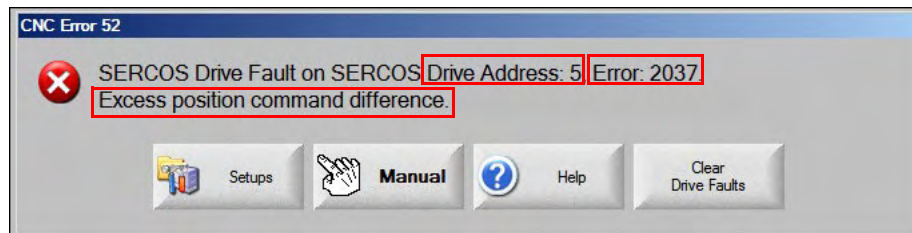
[Add New Kollmorgen Device...](#)

Watch				
Enable	Device	Parameter	Value	Units
<input checked="" type="checkbox"/>	Rail (Online)	PLFB - Position feedback	-669,745.408	Counts16Bit
<input checked="" type="checkbox"/>	Rail (Online)	ILFB - Current feedback	-0.007	Arms
<input checked="" type="checkbox"/>	Rail (Online)	S3.ADDRESS - S3.ADDRESS		1
<input type="checkbox"/>				

SERCOS drive faults

If there is an error, the CNC displays an Error 52 SERCOS Drive Fault window like Figure 3. The window shows the drive address and fault message for the specific drive that has faulted. The drives generate the specific SERCOS error codes that the CNC displays. If one of these errors appears, consult the drive documentation for troubleshooting information.

Figure 3 - SERCOS drive fault error window



Section 2

SERCOS III for Bosch Rexroth Drives

Hypertherm CNCs with Phoenix software version 9.73.0 or later support the SERCOS III interface to the following Bosch Rexroth IndraDrive servo drive amplifiers. For a list of compatible inline I/O bus couplers, see *Bus couplers* on page 6. The IndraWorks Ds software, used to program the Bosch Rexroth drives, is provided on the CNC.

- **Bosch Rexroth IndraDrive Cs Basic or Economy:** Bosch Rexroth IndraDrive Cs Basic (CSB02.1A) or IndraDrive Cs Economy (CSE) with multi-Ethernet support, drive firmware type MPB, and firmware version 16V24, 17V14 or later, or 18V06 or later.



We recommend that you don't mix Basic and Economy drives. Phoenix uses a cyclic rate of 1 ms with the Basic drives and a cyclic rate of 2 ms with the Economy drives. But the SERCOS master can only operate with one cyclic rate. So if you mix the Basic and the Economy drives within the ring, then the cyclic rate can only operate at 2 ms, which reduces the performance of the Cs Basic drives.

- **Bosch Rexroth IndraDrive C:** Bosch Rexroth IndraDrive C with drive firmware type MPB and firmware version 18V06 or later.



All drives in the SERCOS III ring must use the same firmware version.

The IndraDrive drives have the following I/O:

- 7 digital inputs
- 1 digital output
- 1 analog input

Use the following resources to learn more about the Bosch Rexroth IndraDrive drives and the IndraWorks Ds software:

- IndraWorks Ds Help file, provided on the Hypertherm CNC.
- References available on the Bosch Rexroth website at www.boschrexroth.com.

Work in partnership with your Bosch Rexroth representative to size the drives and motors for your cutting machine. Cutting machine specifications and mechanics are beyond the scope of this document.

Launch the IndraWorks Ds software

To launch the software from Phoenix, choose **Setups > Diagnostics > Drives and Motors**.

SERCOS III drive and CNC setup

The following are the basic steps for setting up the SERCOS III drives and the CNC. Complete these steps before phasing up the ring for the first time. The remainder of this section provides additional information on drive addresses, I/O, troubleshooting, and other topics.

Drive settings

Most parameters in the Bosch Rexroth IndraDrive drives can be left at their default settings. Hypertherm CNCs use the parameters listed below. Set the first group of parameters in the drive. The CNC automatically sets the second group of parameters during ring phase-up.

These settings are made in the drive using the IndraWorks Ds software.

1. Select the motor you are using, or configure the drive to automatically detect the motor. This loads the default parameters that are correct for the selected motor and drive combination.
2. **Operation Mode:** For each drive, check the primary operation mode, as follows:

Axis	Type	Operation mode
Linear	Transverse, Rail, Dual Gantry, or Transverse 2	Position Control Lagless, Encoder 1
Torch height control	Sensor THC	Velocity Control
Rotary	A, B, or C axis (Rotate and Tilt axes in Phoenix)	Position Control Lagless, Encoder 1
Pipe	Transverse 2 (Rotating Dual Transverse)	Position Control Lagless, Encoder 1

3. **Master Communication Protocol:** Set to **SERCOS III**.

4. **Drive Address:** The drive address must match the axis number required by the CNC.



You can set all the drive addresses to 1 and allow Phoenix to address the drives. See *About drive addresses and axis assignments* on page 11 to learn more about addressing the axes and drives.

5. **Scaling:** This is similar to the **Encoder Counts per mm (inch)** setting in the CNC. Determine the Encoder Counts for the CNC first, then set the scaling depending on the axis type and machine mechanics.
6. **Bipolar Velocity Limit:** Similar to following error in the CNC, the Bipolar Velocity Limit is the maximum error between the commanded velocity and the actual velocity of the motor. How you set this value depends on your system mechanics. If you set this value too low, it can cause needless faults in the system.
7. **Motor/Encoder:** Use this setting if your drives support absolute encoders. Absolute encoders require battery backup, which is used to save position information. See *About absolute encoders* on page 17.

The following settings are made automatically in the drive by the CNC when you first phase up the ring.


- **Operation Mode:** The operation mode depends on the type of axis as set up in the CNC, and the CNC automatically makes this setting when you first commission the system. See the table on page 24 for the operation modes.
- **Servo Loop Update Rate:** The CNC sets the update rate for all drives to the same value, usually 1 ms.
- **Encoder Polarity:** This parameter sets the positive or negative input direction of the encoder to establish proper counting for positive machine motion.
- **Torque Polarity:** This parameter sets the travel direction of the axis.
- **Drive Storage Mode:** At ring phase-up, this parameter writes all of the drive parameters into the drive RAM instead of the EEPROM, which extends the life of the EEPROM.

CNC settings

1. Choose **Setups > Password > Machine Setups > Axes**. For each axis, the Encoder Counts and Encoder Polarity are the key values for setting up the SERCOS ring:
 - a. Set the desired **Encoder Counts per mm (inch)** for each axis. Encoder Counts per mm (inch) in the CNC must match the scaling units in the drive using the IndraWorks Ds software. Based on your desired encoder counts, you calculate the position resolution for the drives. You set the position resolution and the mechanical characteristics of the cutting machine using the IndraWorks Ds software. For more information and examples, see *Scaling and units settings* on page 28.


We recommend a maximum of 20,000 encoder counts per mm (500,000 encoder counts per inch). For rotary axes, we recommend a maximum of 10,000,000 encoder counts per revolution.
 - b. Set the **Encoder Polarity** for each axis. This sets the positive or negative input direction of the encoder to establish proper counting for positive machine motion. You will need this value for a setting in the SERCOS III drive.
2. In the SERCOS III screen, select whether you will be using drive I/O and/or I/O provided by an I/O bus coupler. **All Drive I/O** is the recommended setting.

Internet Protocol (IP) addresses

 If you want to connect a PC or laptop to the SERCOS ring and use IndraWorks while the ring is running, then you need to assign IP addresses to the SERCOS drives as follows. If you do not want to connect a PC or laptop, you can skip this section.

Each drive in the SERCOS ring must have a unique IP address for communication between the IndraWorks Ds software and the drives. Bosch Rexroth drives default to the IP address of 192.168.0.1. For ease of setup, assign the IP addresses to the SERCOS drives as shown in the following table. The CNC does not use the IP addresses.

IP address	Drive address
192.168.0.1	1
192.168.0.2	2
192.168.0.3	3
192.168.0.4	4
192.168.0.5	5
192.168.0.6	6
192.168.0.7	7
192.168.0.8	8
192.168.0.9	9
192.168.0.10	10

 IP addresses are different from SERCOS drive addresses. See *Address the SERCOS III drives* on page 13 for more information about SERCOS drive addresses.


Drive I/O


The Bosch Rexroth IndraDrive drives each support 7 digital inputs, 1 digital output, and 1 analog output. The CNC automatically sets the **Inline I/O Modules at Address 50** to **Yes** during ring phase-up.

These I/O addresses are specific to the IndraDrive drives. Phoenix addresses the I/O for the drives as shown in the following table, starting with Drive 1 and continuing in drive address order:

Drive address	Digital inputs	Digital output	Analog input
1	1 – 7	1	5
2	8 – 14	2	6
3	15 – 21	3	7
4	22 – 28	4	8
5	29 – 35	5	9
6	36 – 42	6	10
I/O bus coupler at address 50 – first input or output	43	7	11

 Analog inputs 1 – 4 are reserved by the utility card in the CNC.

 The Bosch Rexroth IndraDrive drives require overtravel switches to be wired to drive inputs 4 and 5. On Drive 1, inputs 4 and 5 map to Phoenix inputs 4 and 5. On Drive 2, inputs 4 and 5 map to Phoenix inputs 11 and 12.

 The CNC supports one I/O bus coupler on the SERCOS ring. **Make sure you connect the I/O bus coupler as the last device on the ring.**

SERCOS axis setup screen

Each axis on a SERCOS CNC contains the same parameters as the SERCOS axis setup screen shown below. Complete the following settings in this screen before phasing up the SERCOS ring.

- **SERCOS Drive Address:** The CNC automatically assigns an address to each drive axis. The drives are numbered sequentially and need to match the Master Communication Address set in the drive using the IndraWorks Ds software.
- **Encoder Counts per mm (inch):** Set your desired encoder counts per mm (inch). Based on your desired encoder counts, you calculate the position resolution for the drives. You set the position resolution and the mechanical characteristics of the cutting machine using the IndraWorks Ds software. For more information, see *Scaling and units settings* on page 28.



We recommend a maximum of 20,000 encoder counts per mm (500,000 encoder counts per inch). For rotary axes, we recommend a maximum of 10,000,000 encoder counts per revolution.

- **Encoder Polarity:** This parameter changes the encoder input polarity to establish proper counting for positive machine motion.



The remaining parameters on the SERCOS axis setup screen are common to all axes on the CNC. Refer to the *Phoenix V9 Series Installation and Setup Manual* for information on these parameters.

The screenshot displays the SERCOS axis setup screen with the following parameters and settings:

- SERCOS Drive Address:** 1
- Servo Error Tolerance:** 1 in
- Encoder Counts per in:** 100000
- Encoder Polarity:** ☐ Positive ☒ Negative
- Use Hardware Overtravels:** ☐ No ☒ Yes
- Backlash Compensation:** 0 in
- Fault Ramp Time:** 2 sec
- Home:** to Overtravel Switch
- Absolute Home Position:** -1.969 in
- Home Offset Distance:** 1.969 in
- Home Direction:** ☐ Positive ☒ Negative
- Use Marker Pulse:** ☐ No ☒ Yes
- Use Software Travel Limits:** ☐ No ☐ Fault ☒ Fast Decel
- Maximum Travel Limit:** 61.024 in
- Minimum Travel Limit:** -0.984 in
- Laser Compensation:** ☒ No ☐ Yes


Buttons at the bottom: Rail, Transverse, Dual Gantry, Sensor THC, Rotate, Tilt. Bottom right buttons: Cancel, OK. A timestamp 8:14:51 AM is visible.

Scaling and units settings

This section provides examples of linear, rotary, pipe, and Sensor THC axis mechanics and setups.

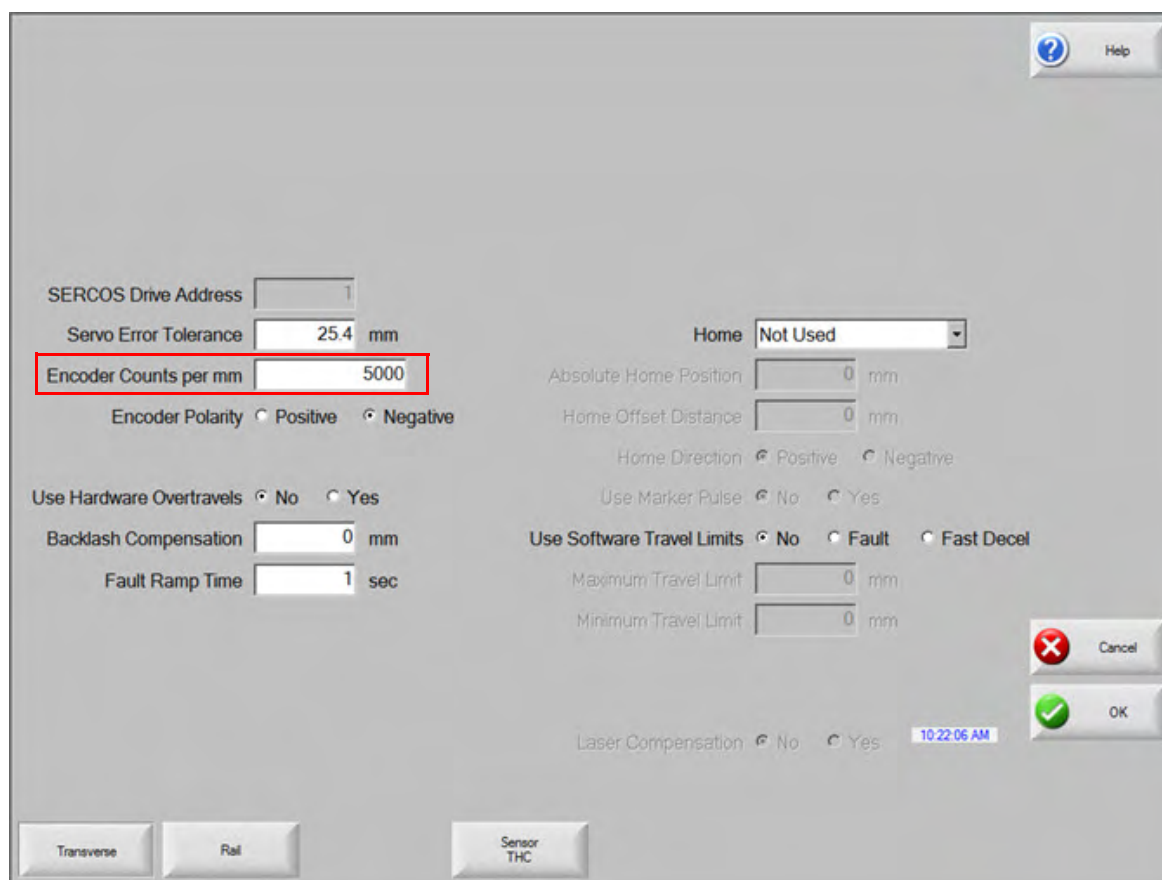
First you enter your desired Encoder Counts per mm (inch) on the SERCOS axis screens on the CNC. Based on your desired encoder counts, you calculate the position resolution for the drives. Then you use the IndraWorks Ds software to program the drives with the mechanical characteristics of the cutting machine.

Linear axis

 Linear axes include Transverse, Rail, Dual Gantry, Transverse 2 (non-rotating), and Sensor THC. For an example of a Sensor THC axis setup, see *Sensor THC axis* on page 38.

In this example, your desired encoder counts are 5,000 counts per millimeter (100,000 counts per inch).

On the SERCOS axis setup screen, set the **Encoder Counts per mm (inch)** to 5,000 counts per millimeter (100,000 counts per inch).






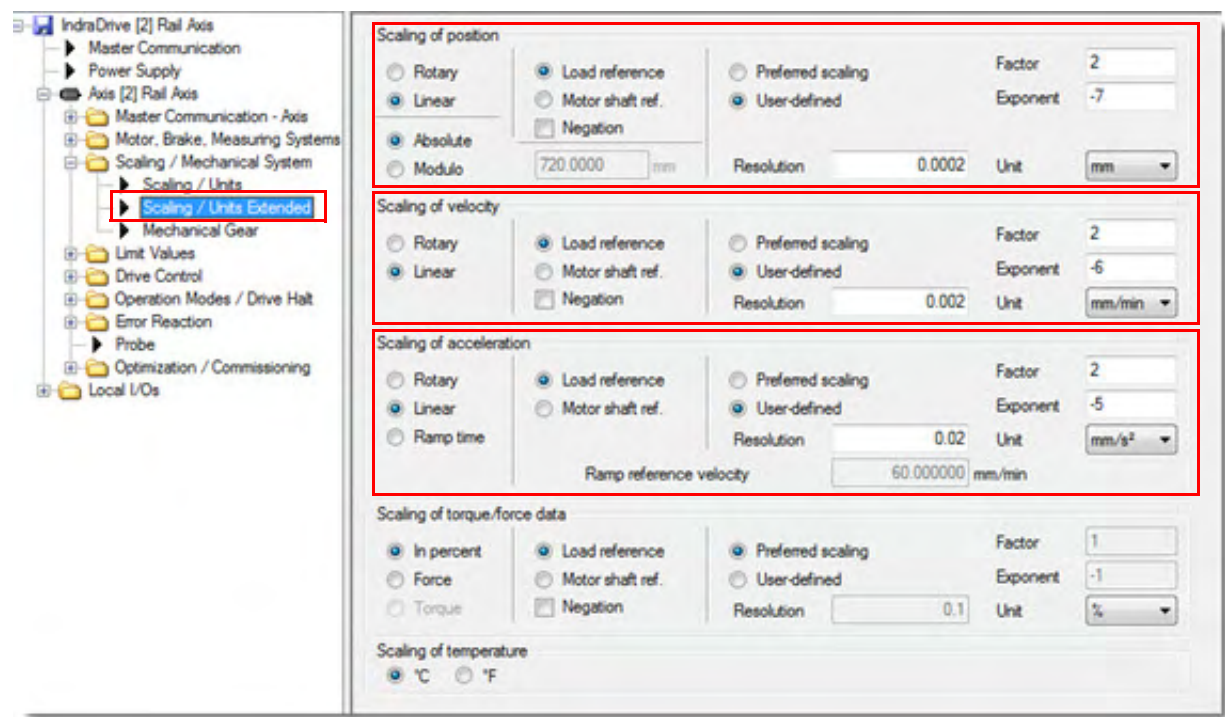
The screenshot shows the SERCOS axis setup screen. The 'Encoder Counts per mm' field is highlighted with a red box and set to 5000. Other fields include SERCOS Drive Address (1), Servo Error Tolerance (25.4 mm), Encoder Polarity (Negative), Home (Not Used), Absolute Home Position (0 mm), Home Offset Distance (0 mm), Home Direction (Positive), Use Marker Pulse (No), Use Software Travel Limits (No), Maximum Travel Limit (0 mm), Minimum Travel Limit (0 mm), Laser Compensation (No), Fault Ramp Time (1 sec), Backlash Compensation (0 mm), and Use Hardware Overtravels (No). Buttons for Transverse, Rail, and Sensor THC are at the bottom.

 The remaining parameters on the SERCOS axis setup screen are common to all axes on the CNC. Refer to the *Phoenix V9 Installation and Setup Manual* for information on all axis parameters.

In IndraWorks, set the following parameters on the **Scaling / Units Extended** screen:

Scaling Parameter	Settings	
Position	<ul style="list-style-type: none"> ■ Linear ■ Absolute ■ Load reference ■ User-defined 	<ul style="list-style-type: none"> ■ Resolution / Unit: 0.0002 mm (0.00001 in. for English) ■ Factor: 2 (1 for English) ■ Exponent: -7 (-5 for English)
Velocity	<ul style="list-style-type: none"> ■ Linear ■ Load reference ■ User-defined 	<ul style="list-style-type: none"> ■ Resolution / Unit: 0.002 mm/min (0.0001 in/min for English) ■ Factor: 2 (1 for English) ■ Exponent: -6 (-4 for English)
Acceleration	<ul style="list-style-type: none"> ■ Linear ■ Load reference ■ User-defined 	<ul style="list-style-type: none"> ■ Resolution / Unit: 0.02 mm/s² (0.001 in/s² for English) ■ Factor: 2 (1 for English) ■ Exponent: -5 (-3 for English)

-  Once you enter Resolution / Unit, IndraWorks calculates Factor and Exponent for you.
-  To determine the position Resolution / Unit, take the inverse (1/X) of the desired encoder counts. For example, if you want 5,000 encoder counts per mm, the position resolution is 0.0002 (1/5,000=0.0002).
-  We recommend you set the velocity resolution to the position resolution multiplied by 10 (0.0002 X 10 = 0.002). We recommend you set the acceleration resolution to the position resolution multiplied by 100 (0.0002 X 100 = 0.02).

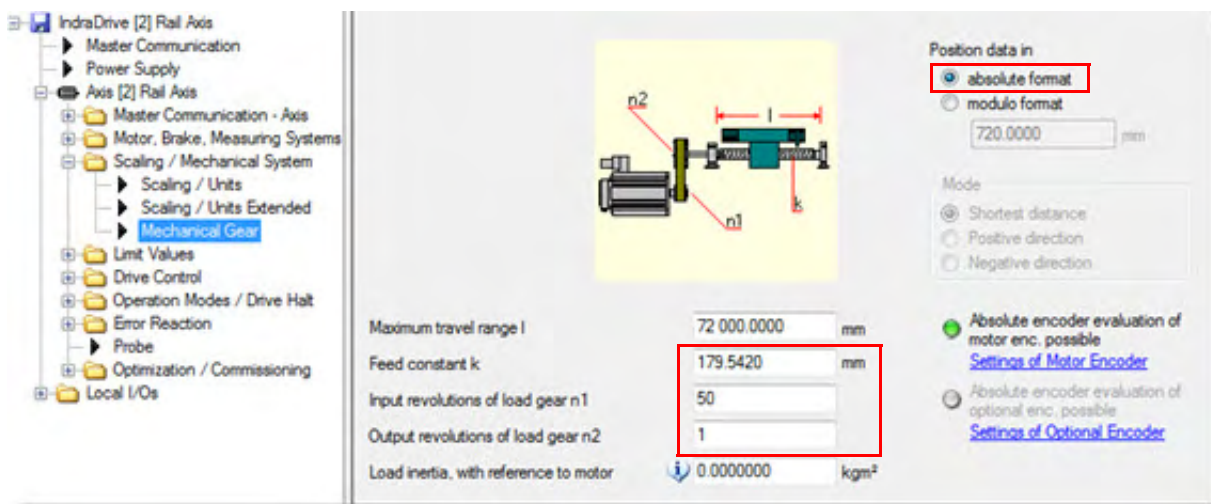


The Transverse axis has the following machine characteristics:


Gear box ratio:	50:1
Rack pitch diameter:	57.15 mm (2.25 inches)

In IndraWorks Ds, set the following parameters in the **Mechanical Gear** screen:

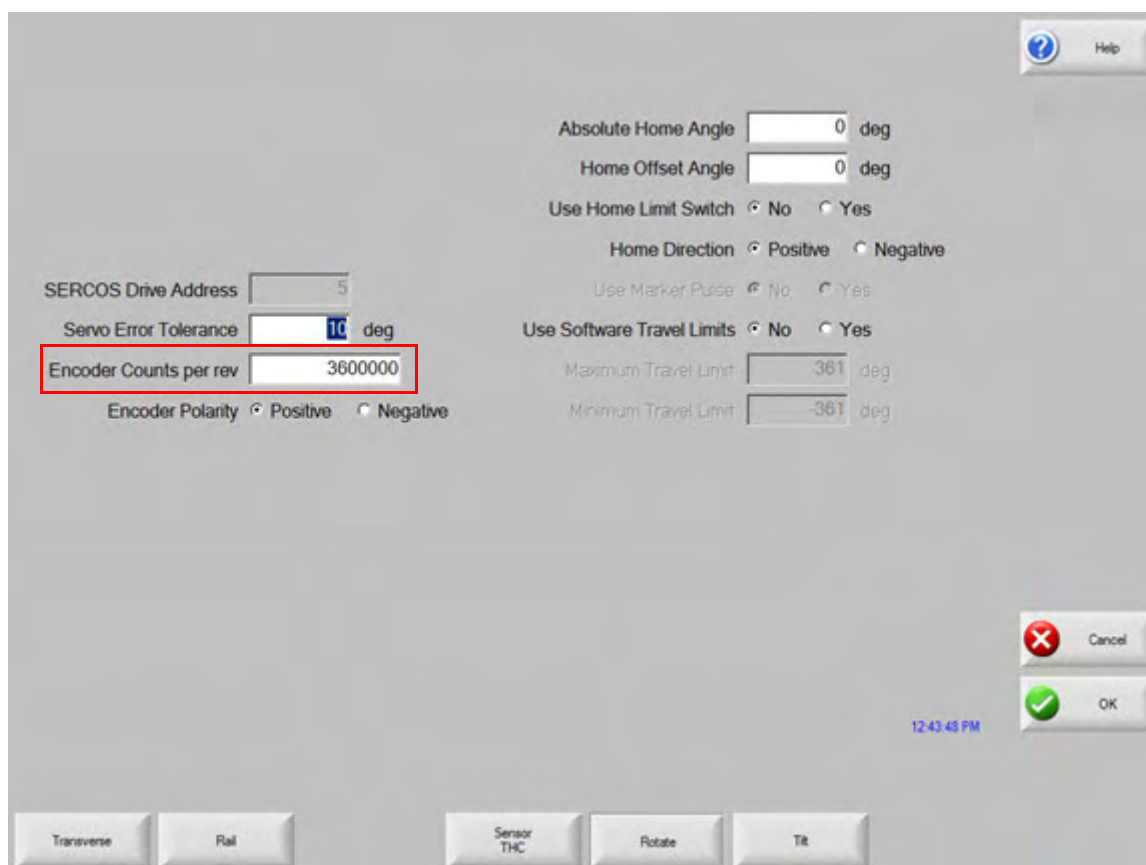
Position data in:	absolute format
Feed constant k:	Pitch diameter X π = feed constant 57.15 mm X 3.14159 = 179.542 mm (2.25 inches X 3.14159 = 7.068 inches)
Input revolutions of load gear n1:	50
Output revolutions of load gear n2:	1



Rotary axis

 Rotary axes are used for bevel cutting and include Rotate, Tilt, and CBH.

In this example, your desired encoder counts per revolution are 3,600,000. On the SERCOS axis setup screen, set the **Encoder Counts per rev** to 3,600,000.





The remaining parameters on the SERCOS axis setup screen are common to all axes on the CNC. Refer to the *Phoenix V9 Installation and Setup Manual* for information on all axis parameters.

In IndraWorks, set the following parameters on the **Scaling / Units Extended** screen:

Scaling Parameter	Settings	
Position	■ Rotary	■ User-defined
	■ Modulo	■ Resolution / Unit: 0.0001 degrees
	■ Load reference	■ Rotational pos. resolution: 3 600 000
Velocity	■ Rotary	■ Resolution / Unit: 0.001 rpm
	■ Load reference	■ Factor: 1
	■ User-defined	■ Exponent: -3
Acceleration	■ Rotary	■ Resolution / Unit: 0.01 rad/s ²
	■ Load reference	■ Factor: 1
	■ User-defined	■ Exponent: -2



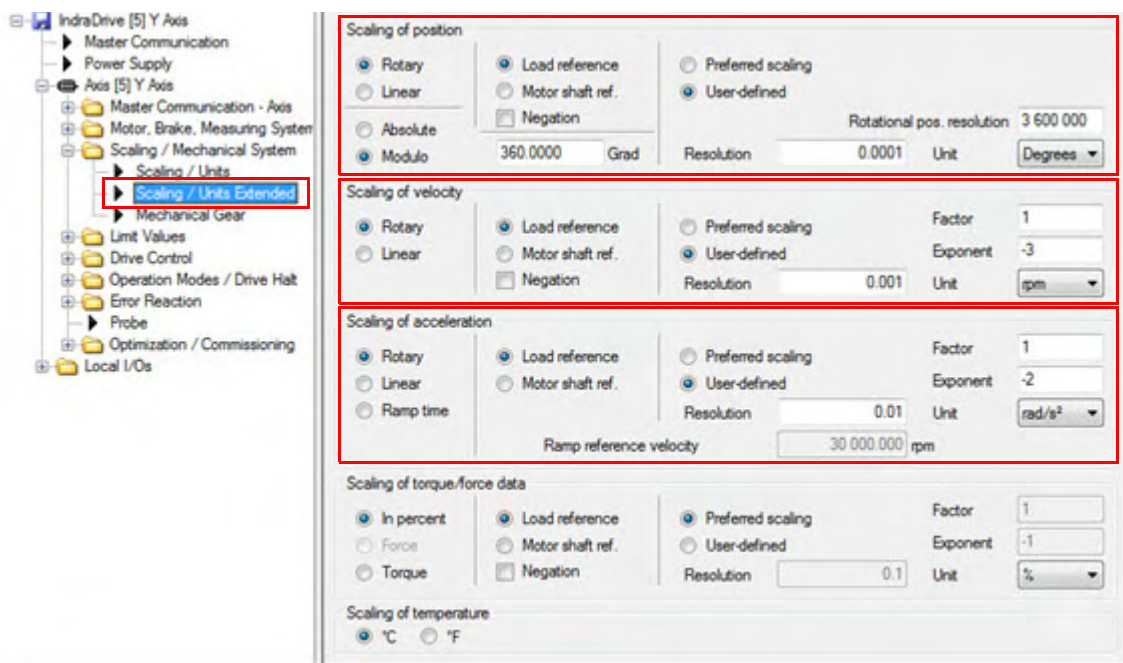
Once you enter Resolution / Unit, IndraWorks calculates Factor and Exponent for you.



To determine the position Resolution / Unit, take the inverse (1/X) of the desired encoder counts, multiplied by 360. For example, if you want 3,600,000 encounter counts per revolution, the user-defined resolution for position is 0.0001 ($1/3,600,000 \times 360 = 0.0001$).



We recommend you set the velocity resolution to the position Resolution / Unit multiplied by 10 ($0.0001 \times 10 = 0.001$). We recommend you set the acceleration resolution to the position resolution multiplied by 100 ($0.0001 \times 100 = 0.01$).

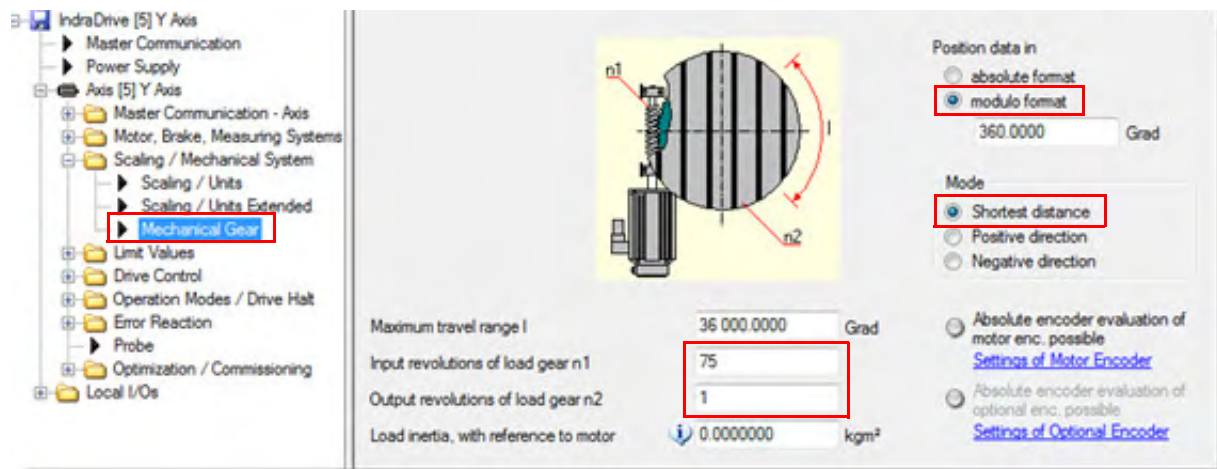


The Rotate axis has the following machine characteristics:

Gear box ratio:	75:1
Mechanics:	Rotary actuator

In IndraWorks Ds, set the following parameters in the **Mechanical Gear** screen:

Position data in:	Modulo format
Mode:	Shortest distance
Input revolutions of load gear n1:	75
Output revolutions of load gear n2:	1



Pipe axis

For pipe and tube cutting, you set up the Transverse 2 (also known as the Dual Transverse) axis as a Pipe (Rotary) axis. This is also referred to as a Rotating Dual Transverse axis.



Set up the Pipe axis as a Rotary axis, but *without* modulo.

In this example, your desired encoder counts per revolution are 3,600,000.

On the SERCOS axis setup screen, set the **Encoder Counts per rev** to 3,600,000.

SERCOS Drive Address

Servo Error Tolerance deg

Encoder Counts per rev

Encoder Polarity ☒ Positive ☐ Negative

Use Hardware Overtravels ☐ No ☒ Yes

Backlash Compensation deg

Fault Ramp Time sec

Minimum Head Spacing deg

Home

Absolute Home Position deg

Home Offset Distance deg

Home Direction ☒ Positive ☐ Negative

Use Marker Pulse ☒ No ☐ Yes

Use Software Travel Limits ☒ No ☐ Fault ☐ Fast Decel

Maximum Travel Limit deg

Minimum Travel Limit deg

Mirrored Marker Offsets ☒ No ☐ Yes

Rotating Transverse ☒ No ☐ Yes

Laser Compensation ☒ No ☐ Yes

2:18:54 PM

Transverse 2 Rotate 2 Ta 2

Cancel OK

Normally the drive address in the CNC needs to match the Master Communication Address set for the drive in IndraWorks Ds. But for a Pipe axis, they might not match.

The remaining parameters on the SERCOS axis setup screen are common to all axes on the CNC. Refer to the *Phoenix V9 Installation and Setup Manual* for information on all axis parameters.

2 – SERCOS III for Bosch Rexroth Drives

In IndraWorks, set the following parameters on the **Scaling / Units Extended** screen:

Scaling Parameter	Settings	
Position	<input checked="" type="checkbox"/> Rotary	<input checked="" type="checkbox"/> User-defined
	<input checked="" type="checkbox"/> Absolute	<input checked="" type="checkbox"/> Resolution / Unit: 0.0001 degrees
	<input checked="" type="checkbox"/> Load reference	<input checked="" type="checkbox"/> Rotational pos. resolution: 3 600 000
Velocity	<input checked="" type="checkbox"/> Rotary	<input checked="" type="checkbox"/> Resolution / Unit: 0.001 rpm
	<input checked="" type="checkbox"/> Load reference	<input checked="" type="checkbox"/> Factor: 1
	<input checked="" type="checkbox"/> User-defined	<input checked="" type="checkbox"/> Exponent: -3
Acceleration	<input checked="" type="checkbox"/> Rotary	<input checked="" type="checkbox"/> Resolution / Unit: 0.01 rad/s ²
	<input checked="" type="checkbox"/> Load reference	<input checked="" type="checkbox"/> Factor: 1
	<input checked="" type="checkbox"/> User-defined	<input checked="" type="checkbox"/> Exponent: -2



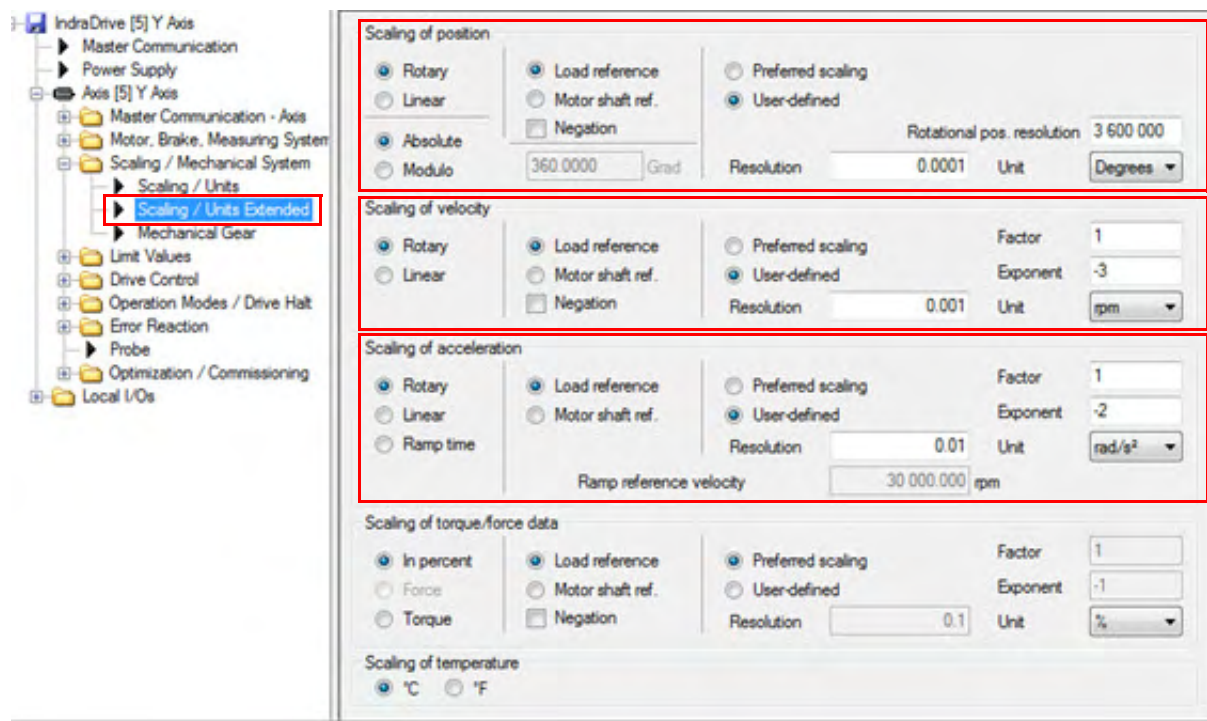
Once you enter Resolution / Unit, IndraWorks calculates Factor and Exponent for you.



To determine the position Resolution / Unit, take the inverse (1/X) of the desired encoder counts, multiplied by 360. For example, if you want 3,600,000 encounter counts per revolution, the user-defined resolution for position is 0.0001 ($1/3,600,000 \times 360 = 0.0001$).



We recommend you set the velocity resolution to the position Resolution / Unit multiplied by 10 ($0.0001 \times 10 = 0.001$). We recommend you set the acceleration resolution to the position resolution multiplied by 100 ($0.0001 \times 100 = 0.01$).

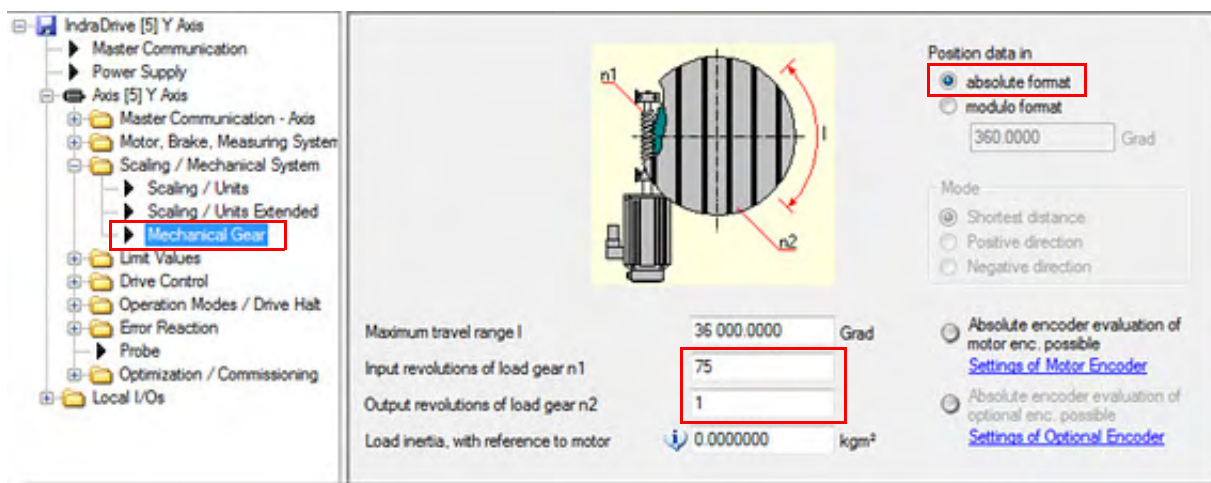


The Pipe axis has the following machine characteristics:

Gear box ratio:	75:1
Mechanics:	Rotary actuator

For this example, in IndraWorks Ds, set the following parameters in the **Mechanical Gear** screen:

Position data in:	absolute format
Input revolutions of load gear n1:	75
Output revolutions of load gear n2:	1



Sensor THC axis

In this example, your desired encoder counts are 800 counts per mm (for English for this example, use 20,000 counts per inch). On the SERCOS axis setup screen, set the **Encoder Counts per mm (inch)** to 800 counts per millimeter (20000 counts per inch).

The screenshot shows the 'Sensor THC Axis Setup' dialog box. The 'Encoder Counts per mm' field is highlighted with a red box and contains the value 800. Other fields include Proportional Gain (25), Feedforward Gain (0), SERCOS Drive Address (4), Voltage Gain (100), Servo Error Tolerance (5 mm), Stall Force Tolerance (1.25 mm), Encoder Polarity (Negative), Slide Length (321.31 mm), Home (to Hard Stop Current Limited), Current Limit (50 %), Home Current Limit (10 %), IHS Current Limit (5 %), Plasma 1, Tracking Mode (Normal), and Average Voltage Over (25 msec). Buttons for Cancel and OK are at the bottom right.



The remaining parameters on the SERCOS axis setup screen are common to all axes on the CNC. Refer to the *Phoenix V9 Installation and Setup Manual* for information on all axis parameters.

In IndraWorks, set the following parameters on the **Scaling / Units Extended** screen:

Scaling Parameter	Settings	
Position	<ul style="list-style-type: none"> ■ Linear ■ Absolute ■ Load reference ■ User-defined 	<ul style="list-style-type: none"> ■ Resolution / Unit: 0.00125 mm (0.00005 in. for English) ■ Factor: 125 (5 for English) ■ Exponent: -8 (-5 for English)
Velocity	<ul style="list-style-type: none"> ■ Linear ■ Load reference ■ User-defined 	<ul style="list-style-type: none"> ■ Resolution / Unit: 0.0125 mm/min (0.0005 in/min for English) ■ Factor: 125 (5 for English) ■ Exponent: -7 (-4 for English)
Acceleration	<ul style="list-style-type: none"> ■ Linear ■ Load reference ■ User-defined 	<ul style="list-style-type: none"> ■ Resolution / Unit: 0.125 mm/s² (0.005 in/s² for English) ■ Factor: 125 (5 for English) ■ Exponent: -6 (-3 for English)



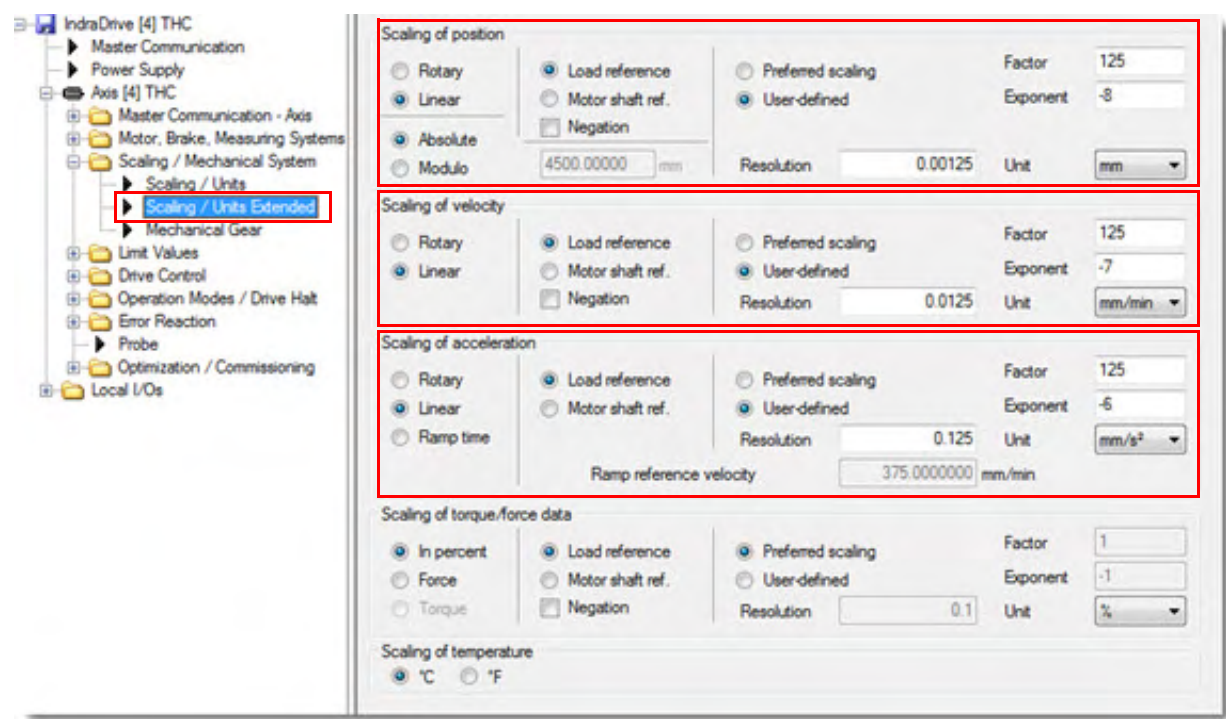
Once you enter Resolution / Unit, IndraWorks calculates Factor and Exponent for you.



To determine the position Resolution / Unit, take the inverse (1/X) of the desired encoder counts. For example, if you want 800 encoder counts per mm, the position resolution is 0.00125 (1/800=0.00125).



We recommend you set the velocity resolution to the position resolution multiplied by 10 (0.00125 X 10 = 0.0125). We recommend you set the acceleration resolution to the position resolution multiplied by 100 (0.00125 X 100 = 0.125).

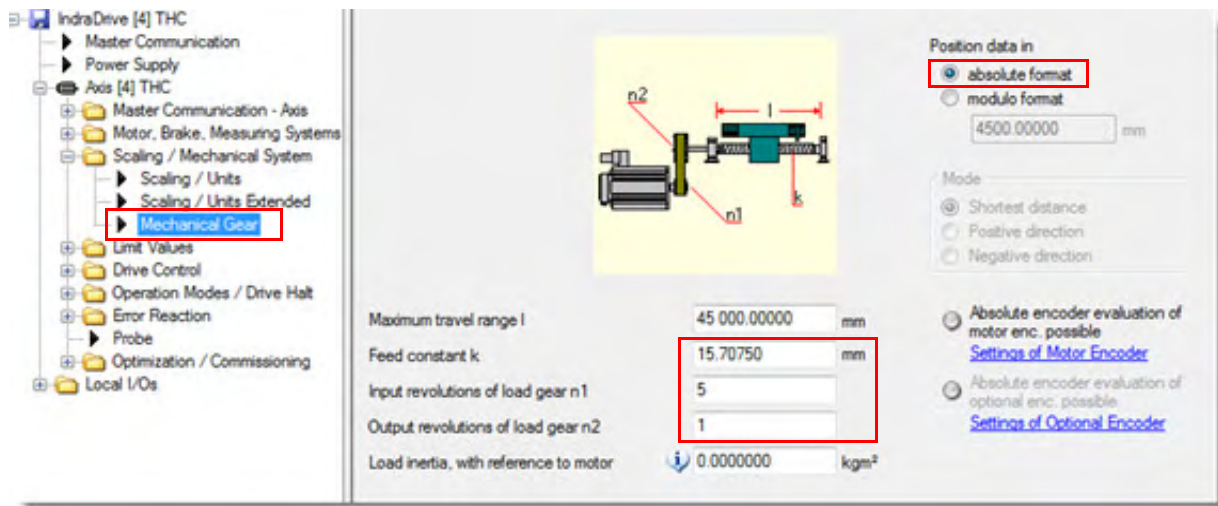


In this example, the Sensor THC axis has the following machine characteristics:

Gear box ratio:	5:1
Lead screw pitch:	5.0 mm/revolution (0.19685 inch/revolution)

In IndraWorks Ds, set the following parameters in the **Mechanical Gear** screen:

Position data in:	absolute format
Feed constant k:	Pitch diameter X π = feed constant 5.0 mm X 3.14159 = 15.70795 mm (0.19685 in. X 3.14159 = 0.61842 inch)
Input revolutions of load gear n1:	5
Output revolutions of load gear n2:	1



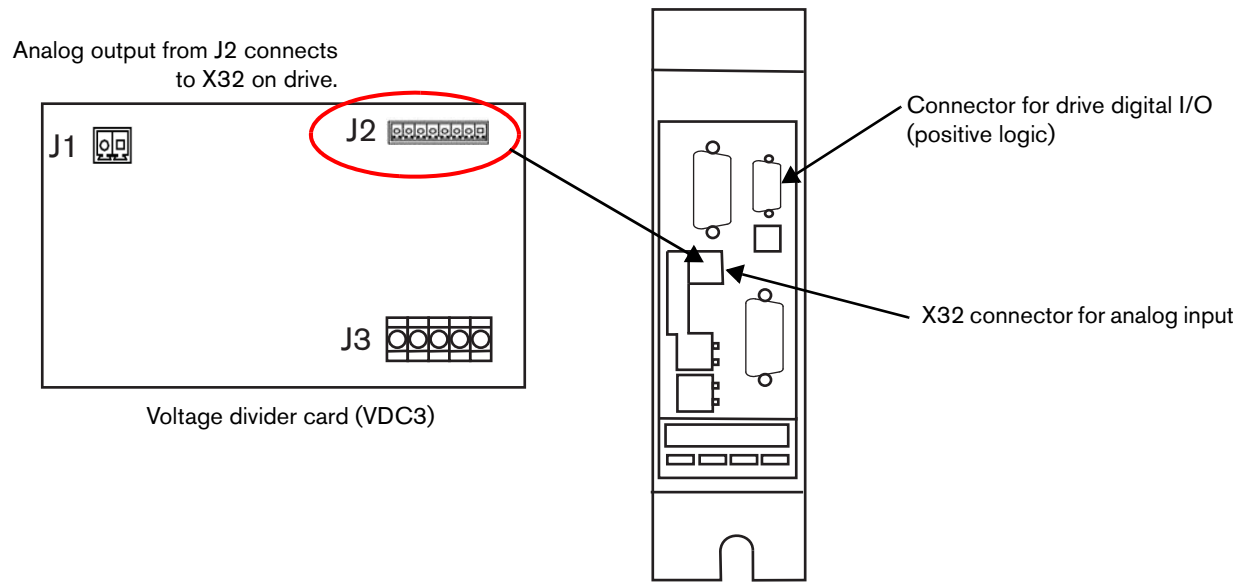
Sensor THC connections to the Bosch Rexroth IndraDrive drives

Connector J2 on the Sensor THC voltage divider card (VDC3), installed in the plasma system, connects to the SERCOS drive.

- Analog output from the voltage divider card must be connected to an analog input on a drive, not on an I/O module in an I/O bus coupler. This is because the arc voltage analog input requires the faster communications speed provided by the drive.
- Nozzle Contact Sense and Nozzle Contact Enable are both negative logic and must be wired to a negative logic input and output.

The inputs and signals on J2 are shown in the following table.

VDC3 Pin	VDC3 Signal	IndraDrive Drive I/O
1	24 VDC Common	Not connected
2	+24 VDC	Not connected
3	Nozzle Contact Sense	Negative logic digital input
4	Nozzle Contact Enable	Negative logic digital output
5	24 VDC Common	Not connected
6	Analog Out +	Analog input + on Bosch Rexroth drive connector X32
7	Analog Common	Analog common on Bosch Rexroth drive connector X32
8	Earth Ground	



Notes:

- The digital I/O for nozzle contact sense should be configured for negative I/O logic on the drive or I/O module.
- Drive I/O is positive logic.
- J1 connects AC power to the VDC3.
- J3 connects to high voltage connections of the plasma supply (Shield, Work, Electrode, Ground).

Troubleshooting tips

- Check the firmware version in IndraWorks Ds. For Bosch Rexroth IndraDrive Cs Basic (CSB02.1A) or IndraDrive Cs Economy (CSE) drives, we require drive firmware type MPB and firmware version 16V24, 17V14 or later, or 18V06 or later. For Bosch Rexroth IndraDrive C drives, we require drive firmware type MPB and firmware version 18V06 or later.
- Each drive has an LCD display that shows messages; for example, when you re-enable the cutting machine after a power cycle or stop:

Drive message	Description
P-1	The drive is ready for phase-up; no fault.
Bb	The ring is phased up but there is no AC power to the drives.
Ab	The ring is phased up with AC power to the drives; stand by.
Af	The drive is enabled.
Ah	The drive is enabled but halted from motion. This is used during absolute homing when a new position reference is assigned.



If one of the drives fails to show one of these messages, or shows a different message, consult the Bosch Rexroth documentation for more information.



For more information about re-enabling the cutting machine after a power cycle or stop, see *Enable the cutting machine after a power cycle or stop* on page 16.

- Correcting Rail or Dual Gantry positions: In a SERCOS III ring with drives using absolute encoders, when you remove a pinion from the drive rack to do maintenance on a Rail or Dual Gantry axis, you must reposition the pinion manually before re-enabling the drives. Absolute encoders remember position and communicate it to the CNC. The CNC will attempt to correct the difference in position between the Rail and Dual Gantry axis. **This motion could cause mechanical damage to the cutting machine.** Contact your table manufacturer or drive supplier for additional assistance in correcting this condition.
- The CNC supports SERCOS passwords 1SA, 2SA, and so on through 12SA. Use these passwords to troubleshoot or to prevent drives from phasing up. To use the SERCOS passwords with the Bosch Rexroth IndraDrive drives, follow these steps:
 1. Disconnect the drives you do not want to phase up from the ring. For example, to phase up only Drive 1, disconnect the cable that connects it to the next drive in the ring before entering the 1SA password. Connect Drive 1 to Drive 2 but disconnect Drive 2 from the ring before entering the 2SA password, and so on.
 2. If your SERCOS ring includes I/O modules, disconnect and disable them before entering the SERCOS passwords. Choose **Setups > Machine Setups > SERCOS** and select **No** for **Inline I/O Modules at Address 50** to disable the I/O modules.
 3. Use the passwords in sequence starting with 1SA.
 4. To start troubleshooting, enter the password **1SA** to phase up only Drive 1. If that is successful, connect Drive 2 and enter the password **2SA** to phase up both Drives 1 and Drive 2, then **3SA** and so on.
 5. When testing is complete, enter the password **SA** or cycle power to the CNC to re-enable all drives in the ring.

Section 3

SERCOS III for Kollmorgen AKD Drives

Hypertherm CNCs support the SERCOS III interface to Kollmorgen AKD servo drive amplifiers. For a list of compatible inline I/O bus couplers, see *Bus couplers* on page 6. The WorkBench software to program Kollmorgen AKD drives is provided on the CNC.

Compatible Kollmorgen AKD drives use the part number format AKD-PXXXXX-**NBS3**-XXXX and firmware version 01-13-05 or later. Phoenix version 9.76.1 or later is also required.

These drives support:

- 7 digital inputs (an additional input is reserved for a dedicated use)
- 2 digital outputs
- 1 analog input
- 1 analog output

Use the following resources to learn more about the Kollmorgen AKD drives and the WorkBench software:

- WorkBench help file (1.8.7.34650), provided on the Hypertherm CNC.
- *AKD™, AKD™ BASIC, AKD™ PDMM Installation Manual* and other references, available on the Kollmorgen website at www.kollmorgen.com.

Work in partnership with your Kollmorgen representative when sizing the drives and motors for your cutting machine. Cutting machine specifications and mechanics are beyond the scope of this document.

Launch the WorkBench software

To launch the software from Phoenix, choose **Setups > Diagnostics > Drives and Motors**.

SERCOS III CNC and drive setup

The following are the basic steps for setting up the Kollmorgen AKD drives with the Hypertherm CNC. Complete these steps before phasing up the ring for the first time. Additional information on drive addresses, I/O, and other topics can be found in the sections following this overview.

CNC settings

1. Assign the axes in the Machine Setups screen. **Encoder Counts per mm (inch)**, **Encoder Polarity**, and **Emulated Counts/motor rev** are the key values for setting up each axis:
 - ❑ For AKD drives, **Emulated Counts/motor rev** is always set to **65536**.
 - ❑ See *Set drive units* on page 48 for examples of calculating encoder counts.
 - ❑ **Encoder Polarity** sets the positive or negative input direction of the encoder to establish proper counting for positive machine motion.
2. In the SERCOS III screen, select whether you will be using drive I/O and/or I/O provided by an I/O bus coupler. The recommended setting is **All Drive I/O**.

Drive settings

Most parameters in the Kollmorgen AKD drive can be left at their default settings. Hypertherm CNCs use the parameters listed below. Set the first group of parameters in the drive. The CNC automatically sets the second group of parameters during ring phase-up.

These settings are made in the drive using the Kollmorgen WorkBench software.

1. After you add a drive, choose **Settings** to expand the tree view of the parameters you can set in the drive.
2. Select the motor connected to the drive from the motor database included with WorkBench. The WorkBench software can also automatically detect many of the compatible motors. After WorkBench identifies the motor, it automatically loads the correct settings and tuning information for the motor.
3. **Operation Mode:** For each drive, choose the operation mode at the top of the WorkBench screen as follows:

Axis	Type	Operation mode
Linear	Transverse, Rail, Dual Gantry, or Transverse 2	Position
Sensor THC	Torch height control	Velocity
Rotary	A, B, or C axis (Rotate and Tilt axes in Phoenix)	Position
Pipe	Transverse 2 (Rotating Dual Transverse)	Position

4. **Communication:** Make sure that **Drive Type** is set to **SERCOS III**.

5. **Drive Address:** The drive address must match the axis number required by the CNC.



You can set all the drive addresses to 1 and allow Phoenix to address the drives. See *About drive addresses and axis assignments* on page 11 to learn more about addressing the axes and drives.


6. **Units:** Set the mechanical dependent units in the WorkBench software, and then enter the **Encoder Counts per mm (inch)** in the CNC. See *Set drive units* on page 48 for instructions.

- 7. Limits:** The motor limits may be set automatically when WorkBench identifies the motor and loads its parameters from the motor database. You can reduce the limits on this screen if needed.


The following settings are made automatically in the drive by the CNC when you first phase up the ring.

- **Operation mode:** The operation mode depends on the type of axis as set up in the CNC, and the CNC automatically makes this setting when you first commission the system. See the table above for the operation modes.
- **Encoder polarity:** This parameter sets the positive or negative input direction of the encoder to establish proper counting for positive machine motion.
- **Drive polarity:** This parameter sets the travel direction of the axis.

Internet Protocol (IP) addresses

 If you want to connect a PC or laptop to the SERCOS ring and use WorkBench while the ring is running, then you need to assign IP addresses to the SERCOS drives as follows. If you do not want to connect a PC or laptop, you can skip this section.

Each drive in the SERCOS ring requires a unique IP address to communicate with the WorkBench software. Kollmorgen AKD drives can be set to have dynamic or static IP addresses. Dynamic IP addresses can be convenient since the network DHCP assigns them automatically. If a network DHCP is not present, the drive assumes an automatic private IP address of 169.254.xxx.xxx. Refer to the Kollmorgen AKD drive installation manual for more information on selecting static or dynamic IP addresses using the rotary switches on the drive. The CNC does not use the IP addresses.

 IP addresses are different from SERCOS drive addresses. See *Address the SERCOS III drives* on page 13 for more information about SERCOS drive addresses.

Drive I/O

The Kollmorgen AKD drives each support 7 digital inputs, 2 digital outputs, 1 analog input, and 1 analog output. A digital input 8 is non-programmable and reserved by the drive for “output stage enable.” Phoenix ignores input 8. The CNC automatically sets the **Inline I/O Modules at Address 50** parameter to **Yes** during phase-up. The CNC then numbers the I/O as shown in the following table:

Drive address	Digital inputs	Digital outputs	Analog inputs	Analog output
1	1 – 7	1 – 2	5	1
2	8 – 14	3 – 4	6	2
3	15 – 21	5 – 6	7	3
4	22 – 28	7 – 8	8	4
5	29 – 35	9 – 10	9	5
6	36 – 42	11 – 12	10	6
I/O bus coupler at address 50, first input or output	43 and above	13 and above	11 and above	7 and above

 The CNC supports one I/O bus coupler on the SERCOS ring. **Make sure you connect the I/O bus coupler as the last device on the ring.**


Set drive units

The CNC commands the Kollmorgen AKD drives every 1 ms. The position information transmitted by the CNC and read by the drives is in encoder counts. The WorkBench software allows you to select meaningful units that match the units that the CNC displays in the Machine Setup screens. Although it is not required that you set these parameters in WorkBench, we strongly recommend that you do. Keeping the WorkBench and Phoenix settings the same makes setup and troubleshooting easier.

The WorkBench software automatically applies these settings to the drive. The unit settings in the drive reflect the last settings made in the Units screen before exiting. However, you can save the settings to non-volatile drive memory by choosing the **Save to Drive** button in the WorkBench toolbar.

The following are examples for selecting units on a linear, rotary, pipe, and THC axis, then setting the **Encoder Counts per mm (inch)** and **Emulated Counts/motor rev** to enter in the axis setup screen in the Phoenix software.


Set units for a linear axis

 Linear axes include Transverse, Rail, Dual Gantry, Transverse 2 (non-rotating), and Sensor THC. For an example of a Sensor THC axis setup, see *Set units for a Sensor THC axis* on page 57.

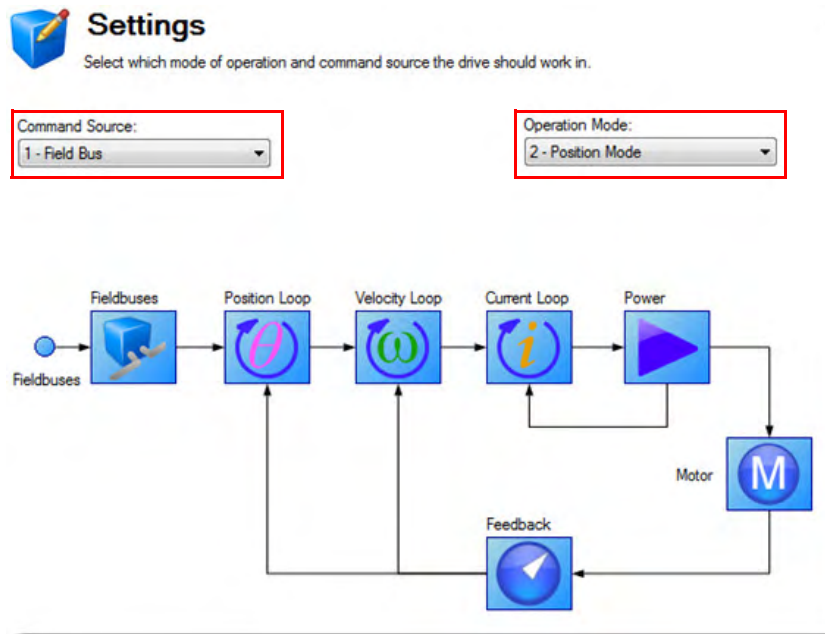
In this example, the Rail axis has the following machine characteristics:

Gear box ratio:	15:1
Belt/Pulley:	1:2
Lead screw pitch:	32 mm/revolution (1.259 inches/revolution)

In WorkBench, set the following parameters in the Settings and Units screens for the Rail axis drive.

 In this example, combine both the gear box ratio and the belt/pulley ratio for a total gear ratio of 15:2.

Select **Field Bus** and **Position Mode** in the **Settings** screen:



Enter the machine characteristics into the **Units** screen:

The **Units** screen allows configuration of units for positions, velocities, and accelerations. It includes a **Select Type of Mechanics** dropdown set to **Lead Screw**. Below this, there are radio buttons for **None**, **Turns** (selected), and **Teeth**. The **Motor** field is set to **15** and the **Load** field is set to **2**. A **Lead** field is set to **32.000 mm**. An illustration of a lead screw mechanism is shown. At the bottom, there are dropdown menus for **Position Unit** (set to **3 - Custom (mechanics dependent)**), **Velocity Unit** (set to **3 - Custom/s (mechanics dependent)**), and **Acceleration Unit** (set to **3 - Custom/s^2 (mechanics dependent)**). The **Custom Position Unit** dropdown is set to **mm**. A **Modbus Unit** link is available, and a **More >>** button is at the bottom.

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On the CNC, enter the **Encoder Counts per mm (inch)** and the **Emulated Counts/motor rev** in the **Machine Setup > Rail** screen:

SERCOS Drive Address: 2

Servo Error Tolerance: 25.4 mm

Encoder Counts per mm: 15360

Encoder Polarity: ☒ Positive ☐ Negative

Emulated Counts/motor rev: 65536

Use Hardware Overtravels: ☐ No ☒ Yes

Backlash Compensation: 0 mm

Fault Ramp Time: 1 sec

Home: to Overtravel Switch

Absolute Home Position: 25.4 mm

Home Offset Distance: 25.4 mm

Home Direction: ☐ Positive ☒ Negative

Use Marker Pulse: ☐ No ☐ Yes

Use Software Travel Limits: ☐ No ☒ Fault ☐ Fast Decel

Maximum Travel Limit: 1778 mm

Minimum Travel Limit: 25.4 mm

Laser Compensation: ☒ No ☐ Yes

8:33:31 AM

Transverse Rail Sensor THC

Cancel OK


Use this formula to calculate the **Encoder Counts per mm (inch)**:

$$\frac{65536 \text{ counts}}{1 \text{ motor revolution}} \times \frac{15 \text{ motor revolutions}}{2 \text{ load revolutions}} \times \frac{1 \text{ load revolution}}{32 \text{ mm}} = 15360 \text{ counts per mm}$$

 For AKD drives, **Emulated Counts/motor rev** is always set to **65536**.

The remaining parameters on the SERCOS axis setup screen are common to all axes on the CNC. Refer to the *Phoenix V9 Installation and Setup Manual* for information on all axis parameters.

Set units for a rotary axis

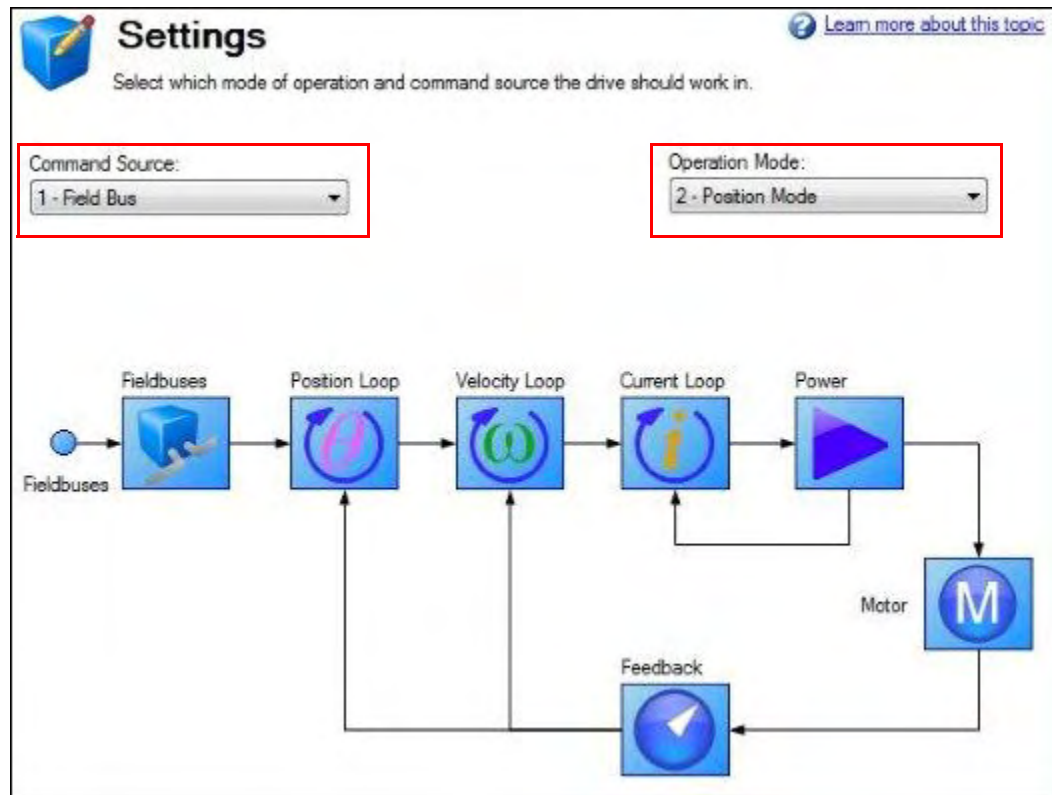
 Rotary axes are used for bevel cutting and include Rotate, Tilt, and CBH.

In this example, the Rotary axis has the following machine characteristics:

Gear box ratio:	102:1
Mechanics:	Disk (Angular)

In WorkBench, set the following parameters in the Settings, Units, and Modulo screens for the Rotary axis drive.

In the **Settings** screen, set **Command Source** and **Operation Mode** as follows:



3 – SERCOS III for Kollmorgen AKD Drives

In the **Units** screen, enter the machine characteristics as follows:

?

Units

Learn more about this topic

You can select the units used for positions, velocities and accelerations.

Select Type of Mechanics:

Disk (Angular)

None

Turns

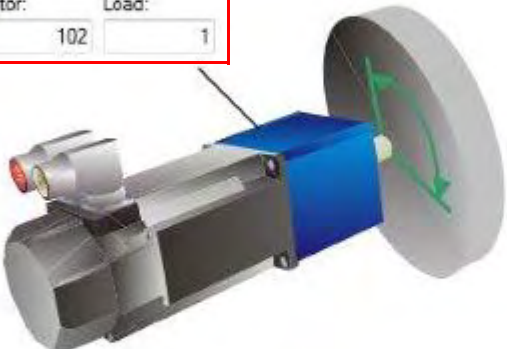
Teeth

Motor:

Load:

102

1



Position Unit:

4 - Counts 16bit (motor shaft)

Velocity Unit:

3 - Custom/s (mechanics dependent)

Acceleration Unit:

3 - Custom/s^2 (mechanics dependent)

Custom Position Unit:

Degree

Modbus Unit:

[Goto Modbus](#)

More >>

On the **Modulo** screen, enable modulo and then enter the **Modulo Range Begin/End** values and **Direction For Absolute Motion Task**.

Modulo

Modulo is used to set a rollover value for the position scale.

Modulo Position:

1 - Enabled

Modulo Range Begin/End:

0.000

Counts 16Bit

Modulo Range Begin/End:

6,684,672.000

Counts 16Bit

Direction For Absolute Motion Task:

3 - Shortest Distance

Position Feedback:

0.000

Counts 16Bit

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Set **Modulo Range Begin** to 0. To determine the **Modulo Range End** setting, use this formula:


$$\frac{65536 \text{ counts}}{1 \text{ motor revolution}} \times \frac{102 \text{ motor revolutions}}{1 \text{ load revolutions}} = 6684672 \text{ counts per revolution}$$

On the CNC in the Rotary axis setup screen, enter the **Encoder Counts per rev** and the **Emulated Counts/motor rev** as follows:

The screenshot shows the SERCOS axis setup screen with the following parameters:

- SERCOS Drive Address: 5
- Servo Error Tolerance: 2 deg
- Encoder Counts per rev: 6684672 (highlighted with a red box)
- Encoder Polarity: Positive (selected)
- Emulated Counts/motor rev: 65536 (highlighted with a red box)
- Absolute Home Angle: 49.171 deg
- Home Offset Angle: 49.171 deg
- Use Home Limit Switch: Yes (selected)
- Home Direction: Positive (selected)
- Use Marker Pulse: No (selected)
- Use Software Travel Limits: No (selected)
- Maximum Travel Limit: 361 deg
- Minimum Travel Limit: -361 deg


Buttons at the bottom include Transverse, Rail, Sensor THC, Rotate, and Tilt. A timestamp of 3:54:28 PM is displayed in the bottom right corner.

 For AKD drives, **Emulated Counts/motor rev** is always set to **65536**.

The remaining parameters on the SERCOS axis setup screen are common to all axes on the CNC. Refer to the *Phoenix V9 Installation and Setup Manual* for information on all axis parameters.

Set units for a pipe axis

For pipe and tube cutting, you set up the Transverse 2 (also known as the Dual Transverse) axis as a Pipe (Rotary) axis. This is also referred to as a Rotating Dual Transverse axis.

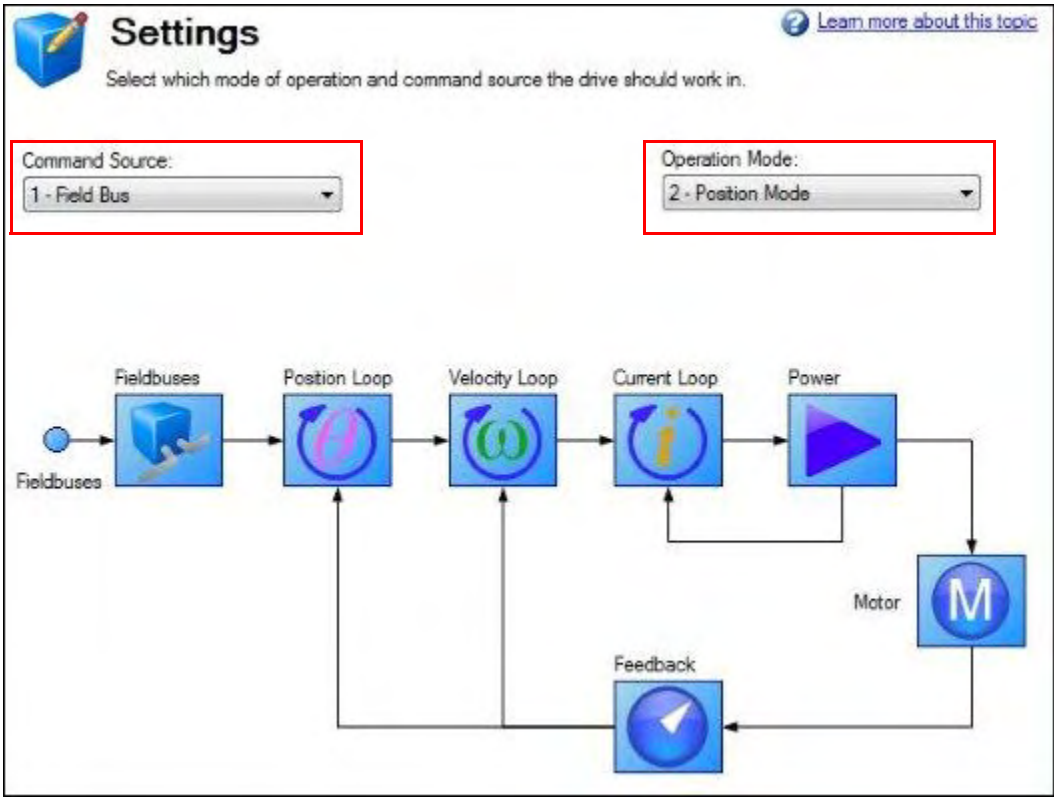
 Set up the Pipe axis as a Rotary axis, but **without** modulo.

In this example, the Pipe axis has the following machine characteristics:

Gear box ratio:	75:1
Mechanics:	Rotary actuator

In WorkBench, set the following parameters in the Settings, Units, and Modulo screens for the Pipe axis drive.

In the **Settings** screen, set **Command Source** and **Operation Mode** as follows:



In the **Units** screen, enter the machine characteristics as follows:

Units

You can select the units used for positions, velocities and accelerations.

Select Type of Mechanics: **Disk (Angular)**

☐ None
☒ Turns
☐ Teeth

Motor: 75 Load:

Position Unit: **4 - Counts 16bit (motor shaft)**

Velocity Unit: 3 - Custom/s (mechanics dependent)

Acceleration Unit: 3 - Custom/s² (mechanics dependent)

Custom Position Unit: **Degree**

Modbus Unit: [Goto Modbus](#)

More >>

On the **Modulo** screen, make sure that modulo is **disabled**.

Modulo

Modulo is used to set a rollover value for the position scale.

Modulo Position: **0 - Disabled**

Modulo Range Begin/End: 0.000 Counts16Bit

Modulo Range End/Begin: -1.000 Counts16Bit

Direction For Absolute Motion Task: 3 - Shortest Distance

Position Feedback: 0.000 Counts16Bit

[Learn more about this topic](#)

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On the CNC in the Rotate axis setup screen, enter the **Encoder Counts per rev** and the **Emulated Counts/motor rev** as follows:

The screenshot shows the 'Rotate' axis setup screen. The 'Encoder Counts per rev' field is set to 4915200 and the 'Emulated Counts/motor rev' field is set to 65536. Both fields are highlighted with red boxes. Other fields include Absolute Home Angle (0 deg), Home Offset Angle (0 deg), Use Home Limit Switch (Yes), Home Direction (Positive), Use Marker Pulse (No), Use Software Travel Limits (Yes), Maximum Travel Limit (361 deg), and Minimum Travel Limit (-361 deg). The bottom of the screen shows buttons for Transverse, Rail, Sensor THC, Rotate, and Tilt.

Use this formula to calculate the **Encoder Count per rev**:

$$\frac{65536 \text{ counts}}{1 \text{ motor revolution}} \times \frac{75 \text{ motor revolutions}}{1 \text{ load revolutions}} = 4915200 \text{ counts per revolution}$$

 For AKD drives, **Emulated Counts/motor rev** is always set to **65536**.

The remaining parameters on the SERCOS axis setup screen are common to all axes on the CNC. Refer to the *Phoenix V9 Installation and Setup Manual* for information on all axis parameters.

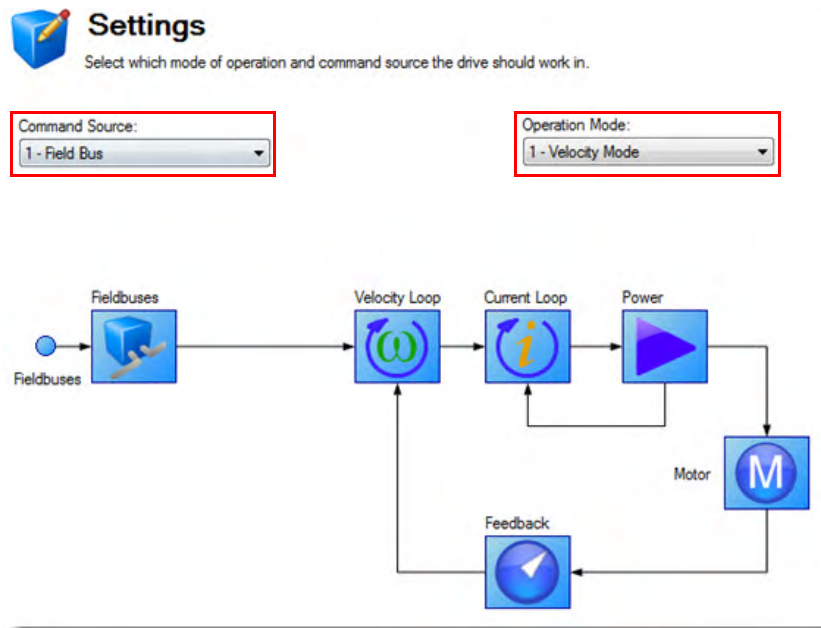
Set units for a Sensor THC axis

In this example, the Sensor THC axis has the following machine characteristic:

Gear box ratio:	5:1
Lead screw pitch:	5.08 mm/revolution (0.20 inches/revolution)

In WorkBench, set the following parameters in the Settings and Units screens for the Sensor THC axis drive.

On the **Settings** screen, set **Command Source** and **Operation Mode** as follows:



Enter the machine characteristics into the **Units** screen:

?

Units

You can select the units used for positions, velocities and accelerations.

Select Type of Mechanics:

Lead Screw

None

Turns

Teeth

Motor:

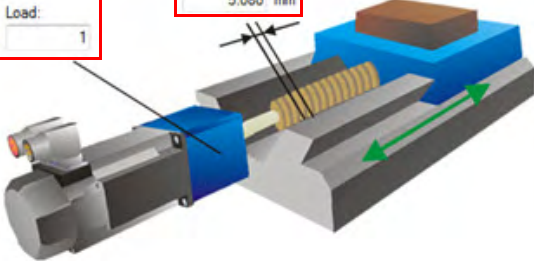
5

Lead:

1

Lead:

5.080 mm



Position Unit:

2 - Degree (motor shaft)

Velocity Unit:

3 - Custom/s (mechanics dependent)

Acceleration Unit:

3 - Custom/s^2 (mechanics dependent)

Custom Position Unit:

mm

Modbus Unit: [Goto Modbus](#)

More >>

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On the CNC, enter the **Encoder Counts per mm (inch)** and the **Emulated Counts/motor rev** in the **Machine Setup > Sensor THC Axis Setup** screen:

Use this formula to calculate the **Encoder Counts per mm (inch)**:

$$\frac{65536 \text{ counts}}{1 \text{ motor revolution}} \times \frac{5 \text{ motor revolutions}}{1 \text{ load revolution}} \times \frac{1 \text{ load revolution}}{5.08 \text{ mm}} = 64503.94 \text{ counts per mm}$$



For AKD drives, **Emulated Counts/motor rev** is always set to **65536**.

The remaining parameters on the SERCOS axis setup screen are common to all axes on the CNC. Refer to the *Phoenix V9 Installation and Setup Manual* for information on all axis parameters.

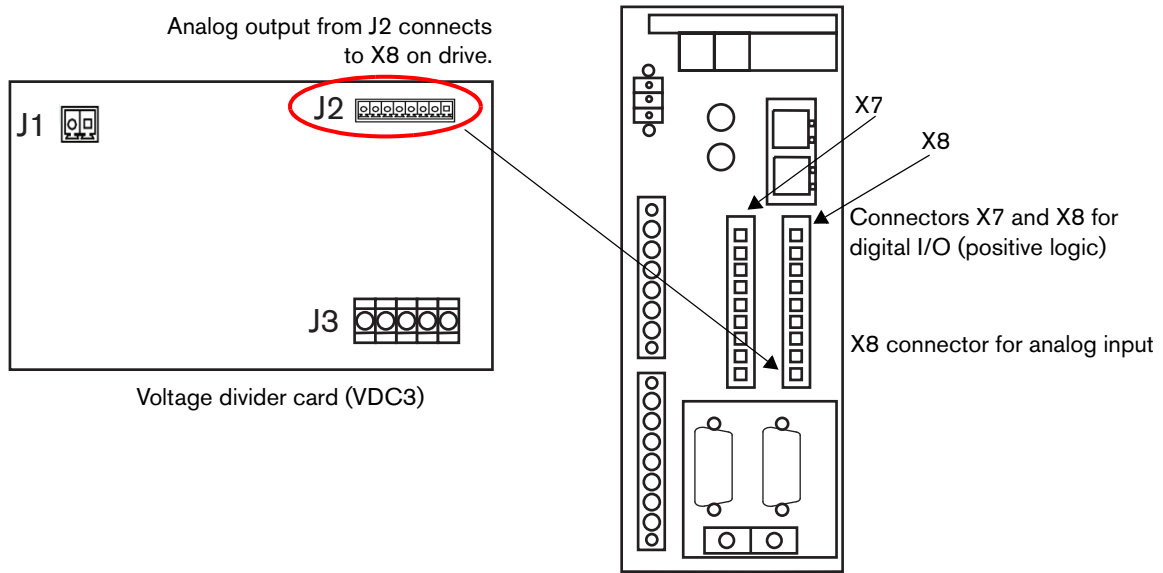
Sensor THC connections to the Kollmorgen AKD drives

Connector J2 on the Sensor THC voltage divider card (VDC3), installed in the plasma system, connects to the SERCOS drive.

- Analog output from the voltage divider card must be connected to an analog input on a drive, not on an I/O module, because the arc voltage analog input requires the faster communications speed the drive provides.
- Nozzle Contact Sense and Nozzle Contact Enable connect to the I/O module. Both require negative logic.

The inputs and signals on J2 are shown in the following table.

VDC3 J2 pin number	VDC3 Signal	AKD Drive I/O
1	24 VDC Common	Not connected
2	+24 VDC	Not connected
3	Nozzle Contact Sense	Negative logic digital input
4	Nozzle Contact Enable	Negative logic digital output
5	24 VDC Common	Not connected
6	Analog Out +	Analog input + on AKD drive connector X8, pin 10
7	Analog Common	Analog common on AKD drive connector X8, pins 7 and 9
8	Earth Ground	



Notes:

- The digital I/O for nozzle contact sense should be configured for negative I/O logic on the drive or I/O module.
- The WorkBench software can set the drive I/O polarity.
- J1 connects AC power to the VDC3.
- J3 connects to high voltage connections on the plasma supply (Shield, Work, Electrode, Ground).

Troubleshooting tips

- Use WorkBench to check the firmware version in the drives. For Phoenix version 9.76.1 or later, we require Kollmorgen AKD drives with the part number format AKD-PXXXXX-NBS3-XXXX and firmware version 01-13-05 or later.
- Each drive has an LED display that shows messages. When the drive initializes, it displays a sequence of characters: -- [] 00 then 01 for a velocity axis, and 02 for a position axis. When the drive is enabled, it displays a dot next to the number: 01. and 02. These are programmable and may differ from what is described here.
- The CNC supports SERCOS passwords, 1SA through 12SA, that can be used for troubleshooting or for preventing drives from phasing up.

Use the passwords in sequence starting with 1SA.

1. To start troubleshooting, enter the password **1SA** to phase up only Drive 1. If Drive 1 phases up successfully, enter the password **2SA** to phase up both Drives 1 and Drive 2, then **3SA** and so on.
2. When testing is complete, enter the password **SA** or cycle power to the CNC to re-enable all drives in the ring.

