IndraDrive Tuning Procedures
Using Indraworks DS 09v12
for IndraDrive Series Servo Drives with Sercos Option

Bosch-Rexroth drives can be tuned in-house or in the field. The following procedures are written for a technician tuning a drive, in-house. Where an asterisk (*) appears, field-tuning procedures deviate from what is written. **Customers attempting to tune a drive unit on-site should use the information following the asterisk.**

CUSTOMERS PLEASE READ THIS PAGE. CRITICAL INFORMATION REGARDING YOUR EQUIPMENT IS CONTAINED IN THIS FIRST PAGE.

1. **Safety precautions must be followed at all times!** Bosch-Rexroth drives have large capacitors inside them that can deliver a high amperage shock to anyone touching the terminals on the drive. These capacitors can remain charged for up to 10 minutes after having power removed. Remove power and lock out incoming line power before touching any of the terminals on the drive. Eye protection should also be worn while working with these units.

2. The power cable that connects the drive to the motor must not be “spliced”, terminated, or otherwise modified. There are important grounding and shielding connections between the motor and the drive that must be maintained for proper operation. Improper connection of this cable will cause catastrophic failures in the motor and the drive. The motor cable must be connected directly from the motor to the drive. Failure to do so will result in damaged equipment.

3. With power removed and locked out, connect the motor power cable to the drive and motor. It is important to attach the three main power wires to the appropriate terminals. These wires are labeled 1, 2, and 3, respectively, and must be connected to the corresponding terminals, A1, A2, and A3. These drives are self-phasing and cannot correctly phase themselves if the power leads are not properly connected.

4. The drive comes with “hose clamps” that can be used to clamp the motor cable to the drive. At the end of the motor cable the cable’s internal shields emerge and are wrapped under copper foil. The motor cable must be clamped to the case of the drive with the copper foil shield making contact to the case of the drive (see the Functional Description section of the drive manual for more details.) Looking at the motor side of the cable, there is a shield wire terminated with a ring connector. This connector must be connected to the case of the motor via the terminals inside the head of the connector plug. There are two terminals in the head, one for the motor cable, and one for the resolver feedback cable. Some motor/cable combinations have screw on connections at the motor. No additional shield terminations need to be made in these cases.

5. The motor cable has four wires for the thermal switch and motor brake that must be connected to the drive and motor. See the Functional Description section of the drive manual for terminal connections.

6. The resolver feedback cable must be connected to the drive and motor. On the drive side, the connector is a DB15 connector. On the motor side, there is a screw on connector.

7. Once all the terminal connections have been made and verified, reapply power and turn the console on. The Drive Should power up to a blinking “RL” on the screen. Press the “Esc” button on the front panel of the drive to clear this as shown below:
The drive will power up through a sequence of diagnostics until an “F2174” error is shown on the screen. This is normal and will be cleared later in this document. Continue to step 8.

Note: If your drive powers up with a red light and a P-1 like shown below:

The XL200 Controller is not talking to the Servo Drive and you may have one of the following conditions:

- Sercos Cable connection issue:
  - Swap the Sercos cables. They may be crossed
  - Verify the connection of your Sercos cables to the XL200 series controller.
Inspection of Sercos Cables:

- inspect the Sercos Cables for damage.

Controller Parameter Issue:

- Check the setting in the XL200 controller for Optical Cable Length. This can be found by holding the setup key while powering up the XL200 Series Controller. Press OK for the Dip Switches. Enter the length of your Sercos Cables.
- Verify the Model of the XL200 Series Controller has the “O” option.

8. Using the interface cable IKB0041, connect the drive to a laptop computer.

9. Start up the Indraworks Ds software and select Serial connection and the appropriate “Com Port”. Press OK.

You should now see your project in the “project tree” located in the upper left hand side of the screen.
You are now on-line with the drive. The XL200 Series Controller has set many of the initial setup parameters in the drive. We need to set some additional parameters based on the machine configuration.
10. We will now adjust some parameters in the drive. Before doing so we must set the drive into Parameterization mode or “PM” by clicking the button on the top of the screen as shown below:

11. Inform the system if there is a Braking Resistor available. Double Click the “Power Supply” text on the left hand side of the screen. The window below will appear. If there is a braking resistor on the system check the box marked “HLB or Braking resistor available on the DC Bus”:
12. Assuming this application is a Die Accelerator or Roll Feed application, we will not need Absolute positioning of the Servo motor. We will need to turn this feature off. To do this:

- Click Motor, Brake, Measuring Systems
- Click Motor Encoder
- Click Settings of Motor Encoder
- Uncheck the box marked Absolute Encoder Evaluation as shown below:
13. Set the Mechanical Gearing of the system. Go there by doing the following:

- Click Scaling/Mechanical System
- Click Mechanical Gear

This is the location in which we tell the controller what is the system is connected to. The screen should look like the below picture:

![Screen shot of IndraWorks DI - Mechanical Gear - Axis [1] Anwendung.png](image)

The above screen is where we tell the drive what our motor is attached to. For the above example I chose to use a ballscrew with a 1” pitch, no gear box. The following applies:

Feed Constant K = Ball screw Pitch
Input Revolutions of Load gear N1 and N2 = gear ratio
If we had another system with the following parameters: Ball screw with a .5” pitch, and 5:1 gear box.

The following would be entered:
14. Set the scaling of the system and set some motion limits. Go there by doing the following:

- Click Limit Values
- Click Motion Limit Values

To scale the system we need to know the maximum FPM of the machine. We will need to convert this value to in/min and add 20% to properly scale the system. For instance, we have a Die Accelerator System that we want to run at a max speed of 150FPM. The following formula would be used:

\[ 150 \text{FPM} \times 12 = 1,800 \text{in/min} \times 1.2 = 2,160 \text{ in/min} \]

Therefore 2,160 in/min would be entered as shown below:

At this time we would also tell the drive if we have Overtravel switches connected and if they are N/O or N/C. The drive should be set to react as a warning as shown above. If you are setting up a Roll Feed System do NOT check the tracel range box above.
15. Set the E-stop Function. Assuming the E-stop signal is being used and is physically wired the below selections can be made. Go there by doing the following:

- Click Error Reaction
- Click E-stop Function

Note: If the E-stop signal is not being utilized simply check “inactive”
16. No adjustments are required for the inputs and outputs of the drive. To be sure they are set correctly check the I/O to the screens below. Go there by:

- Click Local I/O's
- Click I/O X31/X32
17. The commissioning of the drive is complete. We now need to place the drive back into Operating Mode or “OM” at the top of the screen. See below:

The drive should power up to an Ab or bb state. This means the drive is ready for control.
Controller Setup

Now that the initial drive parameters are set, the system is ready for motion.

**De-couple motor from all mechanical connections to die. Should the command signal be out of phase on start-up, the motor will quickly spin out of control in one direction, causing physical harm to equipment and personnel.**

1. The motor should be disconnected from any mechanical structures, gearing or couplings before continuing. Place the motor on the floor and secure the motor so it can’t roll. Most servomotors have enough torque to roll over or even flip in the air, causing damage to the motor or those standing near.

2. The closed-loop AMS controller must now be programmed with the information required to begin testing the servo system. Explanations of these parameters follow.

3. Begin by setting the following parameters to their corresponding “start-up” settings:

<table>
<thead>
<tr>
<th>Jog Select</th>
<th>Die</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loop Gain</td>
<td>5</td>
</tr>
<tr>
<td>Maximum Die Return Velocity</td>
<td>Max. Line Speed + 15fpm</td>
</tr>
<tr>
<td>Minimum Die Return Velocity</td>
<td>1*</td>
</tr>
<tr>
<td>Acceleration</td>
<td>Line Speed in fpm + 10-15</td>
</tr>
<tr>
<td>Return Acceleration</td>
<td>Same as Acceleration</td>
</tr>
<tr>
<td>Minimum Die Distance</td>
<td>See Below</td>
</tr>
<tr>
<td>Maximum Die Distance</td>
<td>Max. Travel Allowed**</td>
</tr>
<tr>
<td>Line Resolution</td>
<td>See Below</td>
</tr>
</tbody>
</table>

**Jog Select:**
The Jog Select parameter allows the operator to switch from jogging the line through the controller to jogging the die. If Line is selected, the controller turns on its Forward and Reverse outputs when the corresponding inputs are activated.

When Die is selected, the controller does not turn on its directional outputs when the jog buttons are pushed. When the controller is configured to jog the die, and a jog input is received, the controller turns on its Drive Enable output and tries to command the drive with the analog signal.

**Loop Gain:**
In simple terms, Loop Gain reflects the responsiveness of the motor. If this number is too low, the motor will be slow and sluggish to respond. If the Loop Gain is set too high, the motor will become “over-stable” and begin to oscillate.

AMS sets the Loop Gain as high as possible without pushing the motor into an “over-stable” state. This is accomplished by increasing the Loop Gain until the motor begins to oscillate, then backing the number down until oscillation goes away.

For most applications, the Loop Gain for a Bosch-Rexroth motor/drive combination should be set around 10-15.

**Maximum Die Return Velocity/Minimum Die Return Velocity:**
When running parts, the AMS controller can calculate the speed at which it needs to bring the die back to the home position in order to achieve the next part. It is
programmed to always try to come back as slowly as possible to save wear and tear on the servo/actuator system*.

The maximum return velocity of the motor should be set high enough so that the controller can bring the die back to the home position before the next cut point is reached. For most applications, adding 10 to 15 feet per minute to the maximum line speed is sufficient.

If the controller is able to achieve the first target, but displays a “Missed Shear” error afterward, increase the Maximum Die Return Velocity to overcome this problem.

Minimum Die Return Velocity should be set as low as possible to extend the life of the mechanical parts on the servo/actuator system. However, should the need arise to bring the die back to the home position faster, the Minimum Die Return Velocity parameter can be set as high as is necessary.

*On Hole Detect models, the controller is not programmed with the part length, so it cannot calculate a return speed. In these cases, the controller will always bring the die back to home at the Maximum Die Return Velocity. Careful consideration should therefore be given when setting the Analog Input scaling of Volts per RPM on controller models with the Hole Detect option.

Acceleration/Return Acceleration:

- Acceleration is the rate at which the controller brings the die up to line velocity. Enter the value calculated for the sizing of the application.

- Return Acceleration should be set high enough for the controller to bring the die up to speed to get back to the home position, but Return Acceleration can usually be set lower to increase the life of the mechanical equipment in the servo/actuator system.
Minimum Die Distance:

Minimum Die Distance is the minimum amount of distance the die must travel at the controller’s programmed Acceleration to reach line velocity. This distance can be calculated by using the following formula:

\[ S_0 = \text{Line Speed in Feet per Minute} \]
\[ S_1 = \text{Line Speed in Inches per Second} \]
\[ D = \text{Total Dwell Time of Press} \]
\[ A = \text{Acceleration} \]
\[ S_0 / 5 = S_1 \]
\[ (S_1)^2 / (2 \times A) = \text{Minimum Die Distance} \]

Every time the controller accelerates the die to line speed to achieve a cut, the die typically overshoots the actual target, initially, and spends a little time trying to compensate for the overshoot. This results in something of a dampening curve. The higher the Acceleration, the longer it takes for the controller to position the die accurately. Increasing the Minimum Die Distance can decrease tolerance problems caused by this overshoot.

Maximum Die Distance:

Depending on the setting of the On Tolerance Error parameter in the AMS controller, this parameter may or may not be critical. If the On Tolerance Error parameter is set to Stop No Cut, the controller will begin calculating its tolerance when the die reaches the Minimum Die Distance, and will not fire the die until it’s in Tolerance. If the controller cannot achieve Tolerance by the programmed Maximum Die Distance, it will not make the cut, but instead will stop the line, bring the die back to the home position, and give the operator an “Out Of Tolerance” error.

If the On Tolerance Error parameter is set to Cut and Stop, the controller will fire the die at the Minimum Die Distance and calculate tolerance error at the end of the Shear Dwell Down time. In this instance, Maximum Die Distance is ignored.

In any case, the controller updates the Lag time of the servo system whenever the die is traveling between the Minimum and Maximum Die Distances.

Line Resolution:

The Line Resolution parameter is the amount of material represented by one pulse from the line encoder. Line Resolution is calculated using the following formula:

\[ P = \text{Model of AMS Encoder or the Pre-Quadrature Pulses per Rev. of a Non-AMS Encoder} \]
\[ D = \text{Diameter of the Measuring Wheel} \]
\[ C = \text{Circumference of the Measuring Wheel} \]
\[ \pi = \text{Pi, a Mathematical Constant Approximately Equal to 3.14} \]
\[ C = \pi \times D \]
\[ \text{Line Resolution} = C / (P \times 4) \]

4. Reset the line/console. The drive should display “Ab” on the digital read out on the firmware module. This indicates the drive is powered up and ready for motion. If the module displays any other code, check the Bosch-Rexroth Functional Description manual for the appropriate firmware version. Call AMS if questions arise. AMS technicians are experts in the use of these drive systems with AMS controllers. Bosch-Rexroth
technicians may not be able to assist in start-ups because they do not know how the AMS controller interfaces with the drive.

5. **For XL Model Controllers**- Enter the controller setup screen Closed Loop Data and select Jog Die Accelerator from the menu. The screen will display a position of 0.000”. Press the Jog Forward button.

**For Mp Model Controllers**- Press the Setup key until the screen displays the option, “Jog Die”. The screen should display a position of 0.000”.

The motor should begin turning. If the motor turns in a controlled manner and in the proper direction, proceed to step 50.

*When any of the DIP-switches on the controller are changed, the power on the controller must be cycled for the change to take effect. Once power has been cycled, the controller will clear its memory, so be sure to record all of the settings from the parameter list, first.*

If the analog command signal is inverted, the motor will “run away”, or spin out of control, in the same direction regardless of which jog button is pushed. In this case, switch the Analog Polarity DIP-switch on the back (or side) of the controller.

If the encoder signals are inverted, the motor will run away, but it will change direction depending on which jog button is pressed. Switch the Encoder Direction DIP-switch on the back (or side) of the controller.

If both the analog command signal and the encoder signals are reversed, the motor will run in control, but move opposite the direction of the jog button pressed. Switch both the Analog Polarity and the Encoder Direction DIP-switches on the back (or side) of the controller.

6. Now that the motor is turning in control and in the proper direction, reconnect the motor to the actuator. This should be done with the power removed from the drive and motor.

*Before moving the die, over-travel limit-switches and the home switch must be in place. Over-travel switches should be part of the E-Stop chain for the machine. Shock absorbers should be mounted at both ends of the travel to maintain the AMS warranty on the actuator and to protect the mechanical equipment from damage. Additional hard, or physical, stops should be added to prevent damage to equipment and personnel.*

7. Press the Manual Shear button to home the die and zero the position reading on the controller. This will move the die to the home switch, bring the die off the switch, then back onto the switch and fire the press. If any Shear Die Distance has been programmed, the die will move to the programmed position before the press fires.

The manual shear button must remain depressed until the AMS controller fires the press, or the process will be aborted. This is a safety feature of the AMS controller.

8. **For XL Model Controllers**- Enter the Setup menu and go to the Closed Loop Data submenu in the AMS controller. Select Die Test from the Closed Loop Data submenu. Enter a test length and a line speed to simulate and press enter to begin the test. The die will begin to simulate production.

**For MP Model Controllers**- Press the Setup key until the option, “Die Test” appears. Enter a test length and a line speed to simulate, and press the enter key to begin the test. The die will begin to simulate production.
It’s usually a good idea to start off at a low speed (10-50 fpm) and work up to a test that will simulate the line at maximum production speed. This will require that the Die Test be halted and restarted for each change in simulated line speed.

9. The AMS Closed-Loop controller performs its main function by accelerating a cutting tool to line speed, matching position and speed of the target, and firing a press to actuate the cutting tool. The AMS controller accomplishes this by using the Acceleration and Minimum Die Distance programmed by the user.

One way to improve tolerance is to increase Minimum Die Distance. This gives the controller more distance to match speed and position of the target. Lowering Acceleration can accomplish the same thing by decreasing the amount of “overshoot” of the die once it has reached line velocity.

Try increasing Minimum Die Distance until it no longer seems to have an effect on the tolerance. At this point, begin increasing Loop Gain. Loop Gain is the final tool in fine-tuning the servo system.

Loop Gain should be increased until the tolerance begins to become more erratic. At this point, the closed-loop is over-stable. Set the gain to a lower, more stable number.