Problem: For new users of an intelligent drive, starting to implement a motion control application can be a quite complex task. You need to know how to hook-up the components of the motion system, to configure them (motor, sensors and drive), test their functionality, identify parameters and tune controllers. Finally, execute a simple movement to validate the basic system functionality and focus on your real motion application.

Solution:

♦ Drive : Technosoft Intelligent Servo Drives IBL2403 / IBL2403-CAN

♦ S/W environment : Technosoft EasyMotion Studio

Description:

This Application Note explains:

- how to perform the basic hardware connections for IBL2403 / IBL2403-CAN and brushless motor with encoder/hall sensors;
- how to create under the 'EasyMotion Studio' a new project/application for motion control with a brushless motor;
- how to configure the components of the motion system: motor, sensors, drive;
- how to test the functionality of the system components;
- how to identify the motor parameters and tune the controllers;
- how to run and use data analysis tools;
- how to save your project/application;
Basic hardware connections

24V Digital I/O connection:

![Diagram of 24V Digital I/O connection](image)

**Figure 1. 24V Digital I/O connection**

**Note1:** In order to use 24V outputs, an external resistor needs to be connected to a supply of \(+V_{DC}\).

**Note2:** The minimum value of external resistors \(R_{\text{min}}\) must be 560 \(\Omega\).
5V Digital I/O connection:

Figure 2. 5V Digital I/O connection
Analog inputs connection:

![Analog Inputs Connection Diagram](image)

**Figure 3. Analog inputs connection**

**Note:** Default input range for analog inputs is 0÷5 V. For a +/-10 V range, please contact Technosoft.

Supply connection:

![Supply Connection Diagram](image)

**Figure 4. Supply connection**
CAUTION ! Before connecting the motor, be sure you have the right application programmed to E2ROM, else you can damage the motor and drive.

At power-on, the TML application is automatically executed. See User Manual, Section 4.16. Special connection on how to disable this feature.
Single-ended encoder connection:

Figure 6. Single-ended encoder connection
Differential encoder connection:

![Differential encoder connection diagram]

**Figure 7.** Differential encoder connection

**Note:** 120-Ω (0.25-W) terminators are required for long encoder cables, or noisy environments.
Hall connection:

![Hall connection diagram](image)

**Figure 8. Hall connection**

Linear Hall connection:

![Linear Hall connection diagram](image)

**Figure 9. Linear Hall connection**
Serial RS-232 connection:

![Diagram of Serial RS-232 connection]

**Figure 10.** Serial RS-232 connection

Special connection (Non-Autorun):

![Diagram of Connection for Non-Autorun]

**Figure 11.** Connection for Non-Autorun

This connection can be used to automatically stop the execution of your application located in E2ROM memory. You need this connection when your application in the E2ROM is corrupted and the RS232 communication is lost.
Project set-up:

1. Create a new project

Launch EasyMotion Studio from Windows Start “Start | Programs | EasyMotion Studio | EasyMotion Studio”. EasyMotion Studio starts with an empty window from where you can create a new project or open a previously created one.

Figure 12. EasyMotion Studio opening screen
Press **New** button to open the “New Project” dialogue. Set the axis number for your first application equal with your drive axis ID. The initial value proposed is 255 which is the default axis ID of the drives. Press **New** button and select your drive type: **IBL2403** or **IBL2403-CAN**, the motor technology: **BRUSHLESS MOTOR** and type of feedback device: **Incremental Encoder** or **Linear Halls**.

![Create a new project in EasyMotion Studio](image)

*Figure 13. Create a new project in EasyMotion Studio*

Validate your selection with a mouse click. EasyMotion Studio opens the **Project** window where on the left side you can see the structure of the project. At beginning both the new project and its first application are named “Untitled”. The application has 2 components: **S** Setup and **M** Motion (program).
2. Establish communication

If you have the drive connected with your PC, now it's time to check the communication. Use menu command **Communication | Setup** to check/change your PC communication settings. Press the **Help** button of the dialogue opened. Here you can find detailed information about how to setup your drive/motor and the connections. Power on the drive/motor and then close the **Communication | Setup** dialogue with **OK**. If the communication is established, EasyMotion Studio displays in the status bar (the bottom line) the text “Online” plus the axis ID of your drive and its firmware version. Otherwise the text displayed is “Offline” and a communication error message tells you the error type. In this case, return to the **Communication | Setup** dialogue, press the Help button and check troubleshoots.

**Note:** When first started, EasyMotion Studio tries to communicate with your drive/motor via RS-232 and COM1 (default communication settings). If your drive/motor is powered and connected to your PC port COM1 via an RS-232 cable, the communication can be automatically established.
3. Motor and drive setup

In the project window left side, select “S Setup”, to access the setup data for your application.

Press View/Modify button This opens 2 setup dialogues: for Motor Setup and for Drive setup through which you can configure and parameterize your Technosoft drive. In the Motor setup dialogue you can introduce the data of your motor and the associated sensors. Data introduction is accompanied by a series of tests having as goal to check the connections to the drive and/or to determine or validate a part of the motor and sensors parameters. In the Drive setup dialogue you can configure and parameterize the drive for your application. In each dialogue you will find a Guideline Assistant, which will guide you through the whole process of introducing and/or checking your data.

3.A. Brushless Motor Setup

Through Motor Setup dialogue you can introduce the data of your motor and the associated sensors. Data introduction is accompanied by a series of tests having as goal to check the connections to the drive and/or to determine or validate a part of the motor and sensors parameters. The key data you need to introduce are the motor Nominal current and Peak current.

CAUTION! Check carefully the motor Nominal current and Peak current values. A part of the tests applies power to the motor. These tests suggest a test current based on the motor nominal current and set the over current protection function of the motor peak current. If these parameters are incorrectly introduced, the tests can damage your motor!

You can introduce your motor and sensors data in 2 ways:

1. Choose a motor from one of the databases available, or
2. Modify the data displayed corresponding to another motor.

In the first case, select first the Database and then the Motor from the list. If your motor is not present, choose another motor, and adjust its data (see second case).

In the second case, you start from an existent motor and modify its data to match yours. When you change the data of an existent motor, the motor name gets the suffix (modified), to suggest you that you may save your motor data in the database User. Press the Save to User Database button to execute this operation. The database switches to User. You may also Delete motors from the User database. Note that you can’t change or delete the motors from the other databases.
### Notes:

1. Your motor and sensors data are automatically saved together with your application setup. Hence, it is not necessary to save them in the User database, unless you want to use them in other applications too.

2. When you select a motor from a database other than User, only those parameters available for the selected motor will be changed. For example, if you choose a motor without an encoder, the encoder data will remain unchanged.

3. When you save a motor in the User database, you attribute it all the parameters from motor dialogue. Therefore, when you select it, it will overwrite all the parameters.
Motor Data. Specify in the “Motor Data” group box the basic data of your brushless motor:

**Step 1.** Check **Nominal current** – the maximum motor current RMS value for continuous operation. This value is used by the tests (to suggest and limit the test current), by the I2t motor protection and one of the start methods.

**Step 2.** Check **Peak current** – the maximum motor current accepted for a short period of time. This value is used as a maximum value for the drive current limit and for the over current and I2t motor protections.

**Step 3.** Run the **Motor Phase Connection Test** to check the physical connection of motor phases to the drive. Press the **Test Phase Connections** button to open the test dialogue. This is a “hot” test, which applies power to the motor. The test applies a positive voltage on one motor phase (A) and the negative half of it on the other two phases (B and C). Consequently, the measured currents on two motor phases must be in relation $I_A = -2*I_B$ (with some degree of approximation). If the test is passed, it validates the physical connection of motor phases to the drive. Test is passed if $I_A \approx -2*I_B \approx $ Test current.

**Figure 15. Motor Phase Connection Test**

**Step 4.** Check **Pole pairs** – the number of motor pole pairs. It is necessary, if the commutation method is sinusoidal, i.e. the brushless motor is seen as a PMSM (Permanent Magnet Synchronous Motor) and is commanded using a vector control algorithm.

Use the **Detect the Number of Pole Pairs** test to determine/check this value. This is a “hot” test, which applies power to the motor. The test requires visual inspection of motor shaft rotation. It
rotates the motor each time you press the “Move” button. The number of times you need to press the button in order to rotate the motor shaft with one complete rotation is equal with the number of motor poles pairs.

In order to perform the test, follow the “Test Procedure” indications.

As the test ends only when you press the “Stop” button, there is no failure message, given by the program for this test.

If the number of poles pairs detected differs from the one set in the Motor Setup dialogue, you’ll be asked to validate the result when test dialogue is closed. If you agree, the newly obtained value will replace the previous parameter.

Step 5. Check the Torque constant – the motor torque constant. This value is used to estimate the total inertia reported to the motor shaft and also for the speed and position controllers tuning.

Step 6. Check Phase resistance (motor+drive) – the motor phase resistance (half of the phase to phase resistance which is measured between 2 motor phases). The value is used for the current controller tuning.

Step 7. Phase inductance (motor+drive) – the motor phase inductance (half of the phase to phase inductance measured between 2 motor phases). The value is used for the current controller tuning.

Press the “Identify Resistance and Inductance” button to automatically detect these parameters. This is a “hot” test, which applies power to the motor. The test applies different patterns of voltages.
to the motor. Based on the current measurements, the two parameters are computed and displayed at the end of the test. If the detected values of the resistance or inductance differ from the ones set in the Motor Setup dialogue, you'll be asked to validate the result when test dialogue is closed. If you agree, the newly obtained values will replace the previous parameters.

Figure 17. Motor Resistance and Inductance Identification Test

Step 8. Check the Motor Inertia. -- the motor inertia. If you do not know this value, check Motor inertia is unknown. You can use the Total Inertia Test accessible from position or speed controller tuning dialogue to identify the total inertia (motor + load) reported to the motor shaft.

Motor Sensors. Specify in the “Motor Sensors” group box what kinds of sensors are mounted on the motor, and their parameters.

Press the Test connection button to check the physical connections between the Incremental Encoder and the drive. This is a “cold” test, which does not apply power to the motor. Only the drive logic supply needs to be powered. The test will visually show the motor shaft movement, as measured from the encoder signals. You need to manually move the motor shaft. No voltage is applied to the motor for this test. If either A or B signals are missing, the motor position indicator will not move on the dialog while you move the motor shaft. If the test is passed, it validates the physical connection of the encoder signals to the drive.
Step 2. Specify the No. of lines / revolution. The position feedback resolution expressed in encoder counts / revolution is 4 times bigger i.e. 4 x No. of lines / revolution. Setting correctly this parameter is essential for correct operation of the motor. If you are not sure about this value, press the Detect number of lines button to open the Encoder Resolution and Direction Test and check it.

This is a “hot” test, which applies power to the motor. The test measures the number of counts from the encoder during one motor shaft mechanical revolution. The measured value is used to estimate the encoder resolution as number of lines per revolution.

In “Position Counter” the value displayed is the exact number of encoder pulses measured during the test. This is 4 times bigger than the number of lines of the encoder. The “Estimated encoder lines / revolution” value is computed as the closest standard encoder value corresponding to the measured number of encoder pulses. Note that the motor movement is done open loop hence it is approximately but not exactly one revolution.

If the number of encoder lines detected differs from the one set in the Motor Setup dialogue, you’ll be asked to validate the result when test dialogue is closed. If you agree, the newly obtained value will replace the previous parameter.
Step 3. Check Hall sensors if your motor includes these sensors else go to Transmission to Load section. Press the Test Connections button to check the physical connection of the three digital Hall signals to the drive and their correct operation. The Hall Signals Connection Test is a "cold" test, which does not apply power to the motor. Only the drive logic supply needs to be powered. You need to manually move the motor shaft. The test will display the motor shaft movement, and fill the 6 commutation sectors, function of the value read from the Hall sensors.

The test is passed if during the motion, transitions are detected on all the three Hall signals. Visually this means to pass through and fill all the 6 commutation sectors.
Step 4. Check the Hall configuration parameter value. Execute Detect Hall Configuration test to establish how the Hall sensors are placed, related with the motor phases. Note that identifying the correct Hall configuration is mandatory for correct operation of the brushless motor using trapezoidal commutation or with sinusoidal commutation and start method using Hall signals. This test must always be executed with a new motor.

This is a “hot” test, which applies power to the motor. The test moves the motor shaft in two specific positions and reads the Hall sensors. Based on this information, and knowing which motor phases were energized in the two positions, the test detects the “Hall Configuration”. In total there are 12 possibilities (6 combinations x 2 polarities), which are numbered from 2 to 13.

If the “Hall Configuration” detected differs from the one set in the Motor Setup dialogue, you’ll be asked to validate the result when test dialogue is closed. If you agree, the newly obtained value will replace the previous parameter.
For configurations with linear Hall sensors:

In configurations with motors equipped with linear Hall sensors execute the Offset Detection Test to determine the linear Hall sensors gains and their offset versus motor phase A. Note that setting the correct values for the linear Hall sensors gains and their offset is mandatory for correct operation.
Transmission to load. In the “Transmission to load” group box set the type and ratio of the transmission between the motor and load.

**Step 1.** At Transmission type select Rotary to rotary for load with rotary motion or Rotary to linear for load with linear motion.

**Step 2.** Set the transmission ratio as the ratio of motor displacement over the load displacement, both values are signed. The transmission ratio is used to translate the position/speed reference from load position/speed units into motor position/speed units. The transmission ratio sign indicates the direction of the load movement: positive – same as the motor’s, negative – reversed to the motor’s.

Press the Ok button to keep the changes done since last entry in the Motor dialogue and go to Drive Setup dialogue. Press the Cancel button to exit without keeping the changes done since last entry in the Motor dialogue and go to Drive Setup dialogue.
### 3.B. Drive Setup

Through the **Drive Setup** dialogue you can configure and parameterize the drive for your application. Use this dialogue only after you have introduced your motor and sensors data in the **Motor Setup** dialogue.

Use the **Guideline Assistant**, and follow the steps described. This will guide you through the whole process of setting up the drive. Use the **Next** button to see the next guideline step and the **Previous** button to return to the previous step.

The drive setup is accompanied by a series of tests having as goal to determine a part of the drive parameters and to validate the overall system behavior. The key data you need to introduce are the drive Power supply and the drive Current limit i.e. the maximum current to be used by the drive (see below for details).

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**CAUTION!** Check carefully the drive Power supply and Current limit as well as the motor Nominal current and Peak current from the **Motor Setup** dialogue. If these parameters are incorrectly introduced, the tests will not work properly and can damage your motor!

---

**Figure 21. The Drive Setup dialogue**
Step 1 Select the drive Control Mode
- **Position** – drive performs position control
- **Speed** – drive performs speed control
- **Torque** – drive performs torque/current control

If your application requires switching between position and speed control, select **Position**, press the **Advanced** button and in the group **Control scheme** choose the option **Close position, speed and control loop**.

**Note:** The default option for position control is to **Close only position and current loop**. In this configuration, the position controller output is a current/torque command and the speed controller is not used.

Step 2 Select the Commutation Method
- **Sinusoidal** – the motor is treated like a PMSM (Permanent magnet synchronous motor) and is vector controlled using a FOC (field oriented control) algorithm. In this mode, the motor works with 3-phase sinusoidal voltages and currents.
- **Trapezoidal** – the motor is controlled as brushless DC using Hall sensors for commutation. In this mode, the motor currents are rectangular and the BEMF voltages are trapezoidal. The trapezoidal mode is possible only if your motor is equipped with digital Hall sensors.

Step 3 Select the motion reference type in the **External reference** group box:
- **Yes** – your drive gets the reference from an external device
- **No** – the reference is set only by the internal reference generator.

Press the **Setup** button to select the reference type and its parameters. Your selection is also shown in the external reference group box.

**Automatically activated after Power On** – after downloading the setup data, the drive starts at power to operate with the selected external reference without any other command. The drive must be set in the AUTORUN mode.

Step 4 Set the Drive operation parameters
- **Power supply** – the supply voltage for the power stage (also named motor supply). Use **Detect** button to measure its actual value as applied to the drive. The supply voltage is used in the current controller(s) tuning.
Current limit – the maximum current used by the drive to control the motor. The current limit must be set bigger than the motor nominal current to allow dynamic moves, but no more than the motor peak current.

Step 5 Set the Current Controller parameters:
- \( K_p \) – proportional term of the PI current controller
- \( K_i \) – integral term of the PI current controller

Press the Tune & Test button to open the Current controller tuning dialogue where you can tune and test the behavior of the current controller. The test has two steps:
- Set-up the test parameters in “Test parameters” tab
- Run the test in “Test” tab

This is a “hot” test, which applies power to the motor. It sets a current reference and during runtime it captures and displays the motor current, current reference and voltage reference values. The test does not move the motor.
Test purpose
Checks current controller step input response.

Test procedure
1. Check/Setup the test parameters below
2. Go to the “Test” tab and press the “Tune” button
3. Set the desired parameters and press the controller
4. Press the “Start” button
5. Wait until the test ends and display the results
6. If needed, change the controller parameters during the test, until you get satisfactory results

<table>
<thead>
<tr>
<th>Test parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Test current</td>
<td>0.58 A</td>
</tr>
<tr>
<td>I protection</td>
<td>3.6 A</td>
</tr>
</tbody>
</table>

![Figure 22 Current controller Tuning Test dialogue](image)

Test Parameters tab

The current reference is a step signal equal with the value set in “Test current” parameter from the “Test Parameters” group box. When entering the dialogue, the program suggests a “Test current” equal with half of the motor nominal current. You may increase this value, up to 90% of the motor nominal current (or drive nominal current if this is smaller).

The “I Protection” parameter sets the over current protection limit. The protection time is set to minimum, i.e. the protection is immediately triggered if the motor current reaches “I Protection” value. The maximum value of “I Protection” is limited to motor peak current (or drive peak current if this is smaller). The “I Protection” parameter must be bigger than the “Test current”
**Test tab**

Check the current controller parameters. In the “**Tuning**” group box you can use the automatic tuning by pressing the “**Tune**” button. This sets the controller parameters according with the pass-band chosen, your motor data and the supply voltage value.

Check “**Use filter on the current controller**” if you want to apply a filter to the current reference. In this case, the input in the current controller is smoothed with a first order digital filter before being used as current controller reference. Set the “**Filter bandwidth**”. This parameter must be correlated with the current controller bandwidth.
For applications with gravitational loads you can add an offset to the current reference to compensate the gravitational force. Check “Compensate for gravitational load” and set the “Offset value”. The maximum value of the offset is limited at motor nominal current.

Press the “Start” button and wait until the test ends and displays the results. If needed, adjust the controller parameters and repeat the test by pressing the Start button again.

Figure 24. Current Controller Tuning Test – Test result

Test validation
The test is validated through visual inspection of the results presented graphically. If the controlled current reaches the reference current with acceptable performances (response time, overshoot, final error), you can validate the controller coefficients, otherwise, change their parameters and execute the test until the results are satisfactory.

Test failure
If the test fails, do the following:
• Check the motor phases connections. Use for example the Motor Phase Connections Test
• Check the encoder connections and counting direction. Use for example the Encoder Resolution and Direction Test
• Check the power supply value. Use for example the Vdc Detection Test
• Check the current controller tuning. Start with a pass band around 2000 rad/s and press the Tune button
• Check “I Protection” level. It should be above the “Test current”
• Check error register MER from the Drive status control panel for other errors

Press the button Ok to save the actual values of the controller parameters and return to the Drive dialogue. Press the button Cancel to leave unchanged the controller parameters and return to the Drive dialogue.

**Step 6.** Set the Speed Controller parameters:

- **Kp** – proportional term of the PI speed controller
- **Ki** – integral term of the PI speed controller
- **Integral limit** – saturation limit for the integral term of the PI speed controller
- **Feedforward** - acceleration feedforward (available only in speed control mode)

Press the Tune & Test button to open the Speed controller tuning dialogue where you can tune the speed controller and test its behavior. The test has two steps:

- Set-up the test parameters in “Test parameters” tab
- Run the test in “Test” tab

This is a “hot” test, which applies power to the motor. It sets a speed reference and during runtime it captures and displays the load speed, speed reference, motor current and current reference values.

**Test Parameters tab**

The “I Protection” parameter sets the over current protection limit. The protection time is set to minimum, i.e. the protection is immediately triggered if the motor current reaches “I Protection” value. The maximum value of “I Protection” is limited to motor peak current (or drive peak current if this is smaller). The “I Protection” parameter must be bigger than the “I limit” value

The “I limit” parameter sets the drive output current limit i.e. the maximum current command allowed during the test.

The “I start” parameter is the value of the current used during the motor start (initial positioning). It is expressed in percentage of the motor nominal current. See the time diagram included in the dialog in order to have a better understanding of the meaning of these parameters.

The test allows you to define a speed profile from the “Test speed profile” group box. When entering the dialog, the program suggests a value for the load “Final speed”. You may change this value, in a specific range, limited by motor maximum accepted speed.
Depending on this value as well as the acceleration and deceleration time intervals “tap” and/or “tan”, you can generate step, ramp or trapezoidal speed profiles. Single or repetitive cycle movements can be selected using the “Multiple Cycle Movement” checkbox.

In order to perform the test, follow the “Test Procedure” indications.

![Speed Controller Tuning Test dialogue](image)

**Test tab**

Check the speed controller parameters. In the “Tuning” group box, verify the ratio (load inertia / motor inertia) or the total inertia. If you are not sure about these values, press “Identify” button to estimate the total inertia via the **Total Inertia Test**. The test identifies the total inertia of the motor, transmission and load, as seen at the motor shaft.

The **Total Inertia Test** is a “hot” test, which applies power to the motor. The test must be executed only after performing the current controller tuning. The test injects a current in the motor and measures its acceleration. Based on these data, and the motor torque constant, computes the total inertia of the system as seen at the motor shaft.
If the total inertia detected differs from the one set in the Drive Setup dialogue, you’ll be asked to validate the result when test dialogue is closed. If you agree, the newly obtained value will replace the previous parameter.

Press the “Tune” button to set the controller parameters according with the pass-band chosen, your motor data and the total inertia value.

You have 2 options to get the test results: as an “On-line plot” or as a “Data logger” plot.

In the “On-line plot” option, the load speed and the speed reference are continuously read from the drive and displayed in a control panel. This option is recommended if you set a repetitive cycle as speed reference and plan to tune the controller on-the-fly while motor is moving.

In the “Data logger” option, the load speed, speed reference, motor current and current reference values are saved in the drive memory, then uploaded and displayed in a data logger window. This procedure provides very precise data that can be analyzed with all the data logger facilities, but can’t be used to tune on-the-fly the controller. Therefore “Data logger” option is recommended more like a checking tool, to validate the tuning done in the “on-line plot” mode.

If you choose “On-line plot”, press the Start button. The test will run until you press the Stop button. You may freeze the control panel operation by pressing the “Pause” button and resume its normal operation with the “Play” button. If you choose “Data logger” press the Start button and wait until the test ends or until the data acquisition memory fills up (the maximum no. of data acquisition points is product specific).
If needed, adjust the controller parameters and repeat the test by pressing the **Start** button again.

**Note:** The controller tuning does not include the acceleration feedforward. Set initially its value to 0, and do the tuning without feedforward. Then, increase gradually the acceleration feedforward and check the speed loop response.

You can change the controller parameters by modifying their value in the corresponding edit boxes or by dragging the associated slider. When using the "on-line plot" mode, you can do this operation on the fly while the motor is moving. The min/max range of a slider is a sub-range of the absolute range, which is between:

- 0 and 2048 for Kp (proportional term) and Ki (integral term)
- 0 and 100 for the Integral limit.
- 0 and 4194300 for the acceleration feedforward
Test validation

The test is validated through visual inspection of the results presented graphically. If the load speed follows the speed reference with acceptable performances (response time, overshoot, steady-state and following error), you can validate the controller coefficients, otherwise, change their parameters and execute the test until the results are satisfactory.

Figure 28 Speed Controller Tuning Test – Test result

Test failure.

If the test fails, do the following:

- Check the motor phases connections. Use for example the Motor Phase Connections Test
- Check the encoder connections and counting direction. Use for example the Encoder Resolution and Direction Test
- Check the current controller tuning. Use for example the Current Controller Tuning Test.
- Check the total inertia value. Use for example the Total Inertia Test
Check the speed controller tuning. Start with a pass band around 150-200 rad/s and press the Tune button
Check “I Protection” level. It should be above the “I limit”
Check error register MER from the Drive status control panel for other errors

Press the button Ok to save the actual values of the controller parameters and return to the Drive dialogue. Press the button Cancel to leave unchanged the controller parameters and return to the Drive dialogue.

Step 7. Set the Speed Controller parameters:
• **Kp** – proportional term of the PID position controller
• **Ki** – integral term of the PID position controller
• **Kd** – derivative term of the PID position controller
• **Kd filter** – filtering coefficient for the derivative term of the PID position controller
• **Integral limit** – saturation limit for the integral term of the PID position controller
• **Feedforward** – acceleration and speed feedforward (speed feedforward is available only if speed loop is closed)
• **Speed limit** – maximum speed command set by the position controller (available only when the speed loop is closed)

Press the Tune & Test button to open the Speed controller tuning dialogue where you can tune the speed controller and test its behavior. The test has two steps:
• Set-up the test parameters in “Test parameters” tab
• Run the test in “Test” tab

This is a “hot” test, which applies power to the motor. It sets a position reference and during runtime it captures and displays the values of the load position and position reference plus:
• The motor current and the current reference, if speed loop is not closed, or
• The load speed and the speed reference, if speed loop is closed

Test Parameters tab
The “I Protection” parameter sets the over current protection limit. The protection time is set to minimum, i.e. the protection is immediately triggered if the motor current reaches “I Protection” value. The maximum value of “I Protection” is limited to motor peak current (or drive peak current if this is smaller). The “I Protection” parameter must be bigger than the “I limit” value

The “I limit” parameter sets the drive output current limit i.e. the maximum current command allowed during the test.

The “I start “parameter is the value of the current used during the motor start (initial positioning). It is expressed in percentage of the motor nominal current. See the time diagram included in the dialogue in order to have a better understanding of the meaning of these parameters.

The test allows you to define a position profile from the “Test position profile” group box. When entering the dialog, the program suggests a value for the “Final position” of the load.
Depending on this value as well as the acceleration and deceleration time intervals “tap” and/or “tan”, you can generate step, ramp or trapezoidal position profiles. Single or repetitive cycle movements can be selected using the “Multiple Cycle Movement” checkbox.

In order to perform the test, follow the “Test Procedure” indications.

![Position Controller Tuning Test](image)

**Test tab**

Check the position controller parameters. If the position control is done without closing the speed loop (see Step 1) the position controller tuning depends on the total inertia of your system. In the “Tuning” group box, verify the ratio (load inertia / motor inertia) or the total inertia. If you are not sure about these values, press “Identify” button to estimate the total inertia via the Total Inertia Test.

The Total Inertia Test is a “hot” test, which applies power to the motor. **The test must be executed only after performing the current controller tuning.** The test injects a current in the...
motor and measures its acceleration. Based on these data, and the motor torque constant, computes the total inertia of the system as seen at the motor shaft.

![Figure 30 Total Inertia Test](image.png)

If the total inertia detected differs from the one set in the Drive Setup dialogue, you'll be asked to validate the result when test dialogue is closed. If you agree, the newly obtained value will replace the previous parameter.

Press the "Tune" button. This sets the controller parameters according with the pass-band chosen, your motor data and the total inertia value.

You have 2 options to get the test results: as an "On-line plot" or as a "Data logger" plot.

In the "On-line plot" option, the load position and the position reference are continuously read from the drive and displayed in a control panel. This option is recommended if you set a repetitive cycle as position reference and plan to tune the controller on-the-fly while motor is moving.

In the "Data logger" option, the values of the load position and position reference plus: either the motor current and the current reference (when position control is done without closing the speed) or the load speed an the speed reference (when position control is done closing the speed loop) are saved in the drive memory, then uploaded and displayed in a data logger window. This procedure provides very precise data that can be analyzed with all the data logger facilities, but can't be used to tune on-the-fly the controller. Therefore "Data logger" option is recommended more like a checking tool, to validate the tuning done in the "on-line plot" mode.

If you choose "On-line plot", press the Start button. The test will run until you press the Stop button. You may freeze the control panel operation by pressing the "Pause" button and resume its
normal operation with the “Play” button. If you choose “Data logger” press the Start button and wait until the test ends or until the data acquisition memory fills up (the maximum no. of data acquisition points is product specific).

If needed, adjust the controller parameters and repeat the test by pressing the Start button again.

You can change the controller parameters by modifying their value in the corresponding edit boxes or by dragging the associated slider. When using the “on-line plot” mode, you can do this operation on the fly while the motor is moving. The min/max range of a slider is a sub-range of the absolute range, which is between:

- 0 and 2048 for Kp (proportional term), Ki (integral term), Kd (derivative term) and the speed feedforward
- 0 and 100 for the Integral limit.
- 0 and 4194300 for the acceleration feedforward

Test validation
The test is validated through visual inspection of the results presented graphically. If the motor position follows the position reference with acceptable performances (response time, overshoot, steady-state and following error), you can validate the controller coefficients, otherwise, change their parameters and execute the test until the results are satisfactory.

![Position Controller Tuning Test](image)

**Figure 32. Position Controller Tuning Test – Test result**

**Test failure**

If the test fails, do the following:

- Check the motor phases connections. Use for example the Motor Phase Connections Test
- Check the encoder connections and counting direction. Use for example the Encoder Resolution and Direction Test
- Check the current controller tuning. Use for example the Current Controller Tuning Test.
- Check the total inertia value. Use for example the Total Inertia Test.
• Check the speed controller tuning if position control is done with speed loop closed. Use for example the Speed Controller Tuning Test. Note that in this case the speed loop pass band must be at least 5 times higher then the position loop bandwidth.

• Check the position controller tuning. If position control is done without speed loop closed, start with a pass band around 100 rad/s and press the Tune button. If the position control is done with speed loop closed, use a pass band at least 5 times lower compared with that set for the speed loop and press the Tune button. For example if the speed loop pass band is 200 rad/s, the position loop pass band must be 20-40 rad/s

• Check “I Protection” level. It should be above the “I limit”

• Check error register MER from the Drive status control panel for other errors

Press the button Ok to save the actual values of the controller parameters and return to the Drive dialogue. Press the button Cancel to leave unchanged the controller parameters and return to the Drive dialogue.

**Step 8.** In the “Protections” group-box, select and parameterize those protections that you want to be activated during the motion. For a first evaluation, use the default settings and selections.

**Step 9.** Specify the Inputs polarity

**Enable** – when this input is active, the drive is enabled. The active level is programmable. To execute the setup tests, the active level must set on: Enabled after power on.

**Limit switch(+/−)** – when any of these 2 inputs is activated, the drive enters in quick stop mode. The active level is programmable. In order to execute the setup tests, these inputs must be set to the inactive level

**Step 10.** Specify the Start mode for motors controlled with sinusoidal commutation

**Move till aligned with phase A** – The motor moves until it is aligned first with phase B, then with phase A. Set up the current to use during the motor start (as percentage of the nominal current) and the time needed to stabilize after the alignment with each phase.

**Direct using Hall sensors** – may be used if the motor is equipped with digital Hall sensors. In this case, the motor starts directly in trapezoidal mode and commutes to sinusoidal mode after the first transition of the Hall sensors.

**Remark:** The start mode selection is needed only if the motor is controlled like a PMSM with sinusoidal commutation

**Step 11.** Set/change axis ID

Select the Axis ID for the drive. Choose H/W (hardware) to read the Axis ID from the hardware switches for axis ID setting. If your drive has no hardware switches for Axis ID, the option H/W sets the default Axis ID which is 255. Choose any other value to impose an Axis ID, regardless of the Axis ID switches. The selected Axis ID will become effective after downloading the setup data and resetting the drive.

**Note:** At power on, the axis ID is set using the following algorithm:

a. With the value read from the EEPROM setup table containing all the setup data
b. If the setup table is invalid, with the last axis ID value read from a valid setup table
c. If there is no axis ID set by a valid setup table, with the value read from the hardware switches/jumpers for axis ID setting

d. If the drive/motor has no hardware switches/jumpers for axis ID setting, with the default axis ID value which is 255.

Press the **Ok** button to keep all the changes regarding the motor and drive setup. Press the **Cancel** button to exit without keeping the changes. Press the **Motor Setup** button to return to Motor Setup dialogue.

### 4. Download the setup to the drive

Press the **Download to Drive/Motor** button to download your setup data in the drive/motor EEPROM memory in the setup table. From now on, at each power-on, the setup data is copied into the drive/motor RAM memory which is used during runtime. It is also possible to save the setup data on your PC and use it in other applications. Note that you can upload the complete setup data from a drive/motor.

To summarize, you can define or change the setup data of an application in the following ways:

- create a new setup data by going through the motor and drive dialogues
- use setup data previously saved in the PC
- upload setup data from a drive/motor EEPROM memory

### 5. Program motion

Programming motion on a Technosoft drive means to create and download a TML (Technosoft Motion Language) program into the drive/motor memory. The TML allows you to:

- Set various motion modes (profiles, PVT, PT, electronic gearing or camming, etc.)
- Change the motion modes and/or the motion parameters
- Execute homing sequences
- Control the program flow through:
  - Conditional jumps and calls of TML functions
  - TML interrupts generated on pre-defined or programmable conditions (protections triggered, transitions on limit switch or capture inputs, etc.)
  - Waits for programmed events to occur
- Handle digital I/O and analogue input signals
- Execute arithmetic and logic operations
- Perform data transfers between axes
• Control motion of an axis from another one via motion commands sent between axes
• Send commands to a group of axes (multicast). This includes the possibility to start simultaneously motion sequences on all the axes from the group
• Synchronize all the axes from a network

In order to help you create a TML program, EasyMotion Studio includes a **Motion Wizard**. This offers you the possibility to program all the motion sequences using high level graphical dialogues which automatically generate the corresponding TML instructions. With Motion Wizard you can develop motion programs using almost all the TML instructions without needing to learn them.

The Motion Wizard is automatically activated when you select “**M** Motion” in the project window left side. When activated, Motion Wizard adds a set of toolbar buttons in the project window just below the title. Each button opens a programming dialogue. When a programming dialogue is closed, the associated TML instructions are automatically generated. Note that, the TML instructions generated are not a simple text included in a file, but a motion object. Therefore with Motion Wizard you define your motion program as a collection of motion objects.

![Figure 33. Main section of the TML program](image)

As a starting point, push for example the left most Motion Wizard button, **Motion – Trapezoidal profiles**. The programming dialogue allows you to program a *position or speed profile* with a trapezoidal shape of the speed, due to a limited acceleration.
Figure 34. Motion – Trapezoidal Profiles dialog

Set a position or speed profile and then press the button. At this point the following operations are done automatically:

- A TML program is created by inserting your motion objects into a predefined template
- The TML program is compiled and downloaded to the drive
- The TML program execution is started

5. Evaluate motion application performances

EasyMotion Studio includes a set of evaluation tools like the Data Logger, the Control Panel and the Command Interpreter which help you to quickly measure and analyze your motion application. Details about the evaluation tools are presented in EasyMotion Studio on-line help.