MotionLab
Software

For support mail to: tech-support@smac-mca.nl

See also our website: www.smac-mca.com

Software Manual

Revision 1.3

www.ingeniamc.com

MotionLab – Software Manual

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Contents

Icons

Icons that the reader may encounter in this manual are shown below, together with their meanings.

Additional information
Provides the user with tips, tricks and other useful data.

Warning
Provides the user with important information. Ignoring this warning may cause the device not to work properly.

Critical warning
Provides the user with critical information. Ignoring this critical warning may cause damage to the device.

1 Introduction

Use MotionLab to configure an Ingenia Digital Servo Drive, as well as connection settings and security options.

MotionLab allows for:

- Detect compatible servo drives connected to the software network.
- Connect to one servo drive, configure, tune and test it.
- Configure and test different motion modes (position, velocity, torque, etc.).
- And many other motion control related features.

1.1 Getting Started

Minimum computer requirements to run MotionLab software are:

- Microsoft Windows OS version 2000, XP, Vista or 7.
- Processor 1GHZ or higher with at least 64Mb of RAM.
- At least 100MB of free disk space.
- USB or Serial COM port for controller serial connection.
- CAN port for CAN connection [optional].

In order to install and run the MotionLab software, you must have Administrator privileges (for installation).

After installing the MotionLab software on your computer, you can run the application from your Start > Programs menu.

To always use the latest version of MotionLab download the software from the Ingenia website.

1.2 Before you begin

In order to ensure successful drive setup, you should verify that the following conditions are met:

- If you are using CANopen networking, be sure that the required CAN board(s) have been successfully installed.
- The system should be properly balanced; that is the motor speed should be 0 when zero current is injected to it.
- The motor axes should be free to move plus or minus several electric poles.
- The encoder and motor should have suitable wiring.

1.3 MotionLab Desktop

Upon accessing the MotionLab software, you will see a set of windows/panes that can be opened and closed, and manipulated as needed. Across the top, as in most Windows applications, is the menu bar, with several movable toolbars beneath it.

1.3.1 MotionLab windows

The following windows provide on-going information as you work in MotionLab:

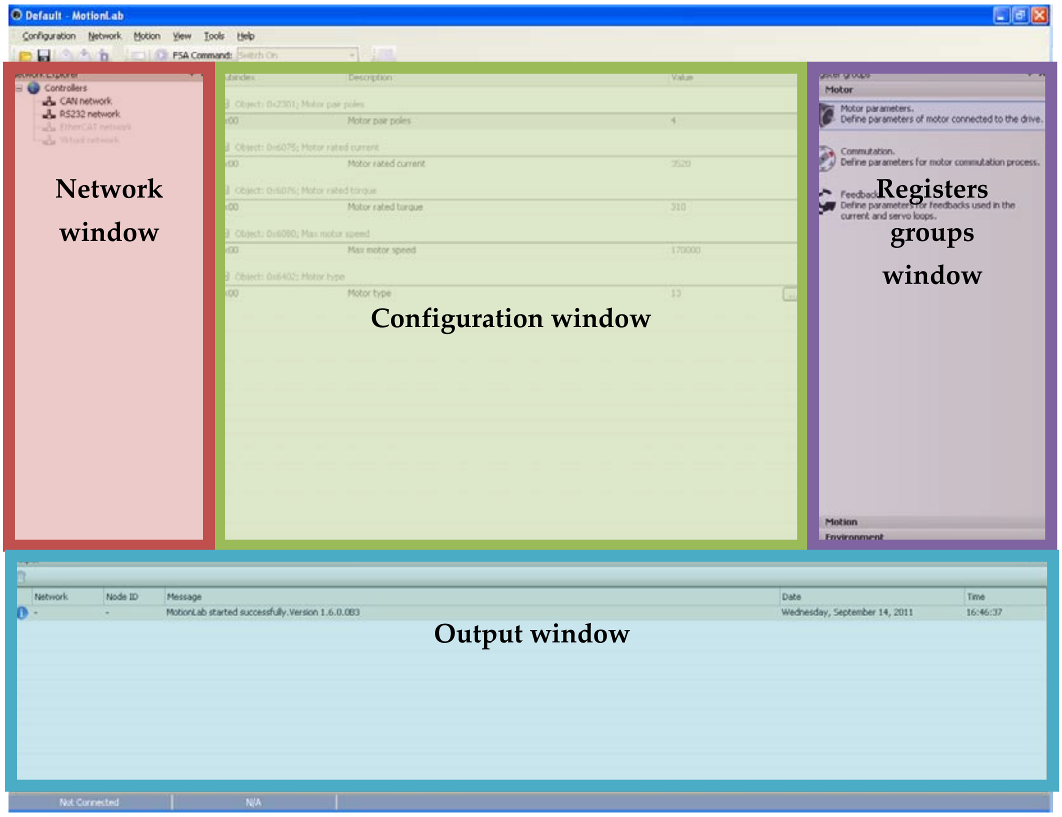

Figure 1: MotionLab windows

- **Configuration window**

This is where the configuration of the drive is edited. For example, when a register category/group is selected, all the registers within that category are displayed in this area.

Several configuration wizards can be accessed from this window by clicking on the [...] button.

- **Network window**

This window displays controllers on the MotionLab networks. From here user can connect/disconnect to digital servo drives.

- **Registers groups window**

This window allows for selecting group of registers to be configured.

- **Output window**

This window displays a list of the most recent system messages concerning communication between the host and the connected drive.

1.3.2 MotionLab toolbars

The three toolbars — **Configuration**, **Control** and **Motion** —contain buttons that enable you to quickly access the most frequently-used tools and options in the MotionLab application.
You can move the toolbars around the desktop and relocate them for your convenience.

Configuration toolbar

The following table describes the function of each button in the Configuration toolbar.

	Open existing configuration file
	Save current configuration to file
	Upload all drive registers
	Download all actual configuration registers to drive
	Download modified configuration registers to drive

Control toolbar

The following table describes the function of each button in the Build toolbar.

	Reset actual fault and Switch on the drive.
	Run selected FSA command
FSA Command: Switch On	Select FSA command

Additional information on Drive Finite State Automaton (FSA) can be found in next chapters of this manual.

Motion toolbar

The following table describes the function of each button in the Motion toolbar.

	Open motion test dialog
	Open homing test dialog

1.3.3 MotionLab Menu Bar

The menu bar along the top of the MotionLab desktop provides access to the full range of tools and options. The main menu options are described in the following table:

Menu	Option > Sub-option	Description
Configuration		Standard Windows options for manipulating configuration files and for

		uploading/downloading drive configurations.
Network	Network Wizard…	Open network wizard dialog
Motion	Test Motion Modes	Open test motion modes dialog
	Test Homing Mode	Open test homing modes dialog
Tools	Options…	Open MotionLab Options dialog
View		Show/Hide MotionLab windows, toolbars and status bar

1.3.4 MotionLab Status Bar

The status bar on the bottom of the desktop contains information on the drive **connection state**, **FSA current status** and **drive error codes**.

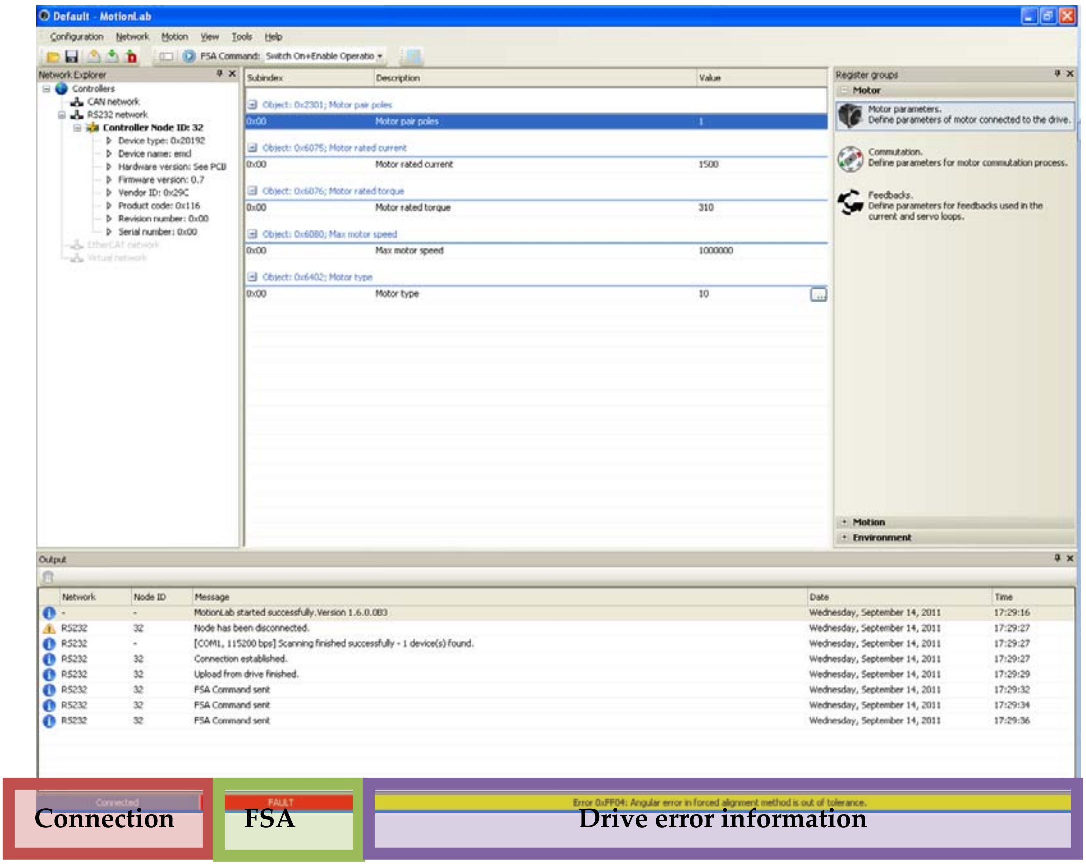

Figure 2: MotionLab status bar

2 Connecting to the Drive

The first thing you need to do in order to work with your drive (configure, tune or test it) is establish a connection with it.

To that end you need to select the network type your drive is plugged in, configure it and start scanning.

Several networks are supported for configuring (RS232, CAN-CANopen, …). Choose the appropriate network for your drive and make sure it is properly powered before to continue.

2.1 Network wizard dialog

The Network wizard dialog pops-up when you first start the MotionLab software or when you select the *Network > Network Wizard* option from the main menu.

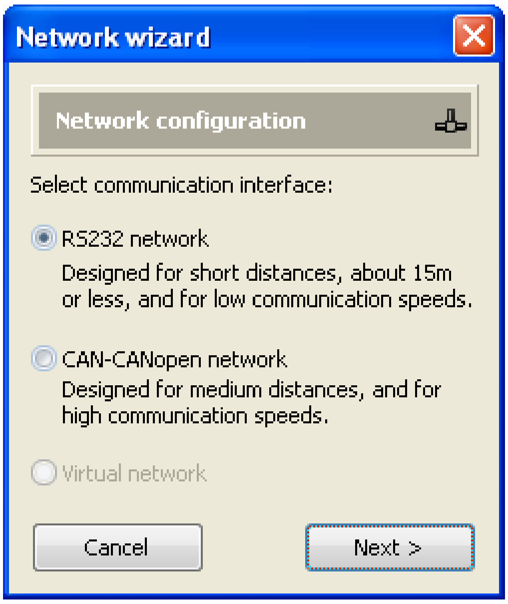

Figure 3: Network wizard dialog

Select the desired communication interface and click on *Next* button to proceed with configuration process.

2.1.1 RS232 network configuration

If RS232 communication interface is selected in *Network wizard dialog*, the following dialog will pop-up.

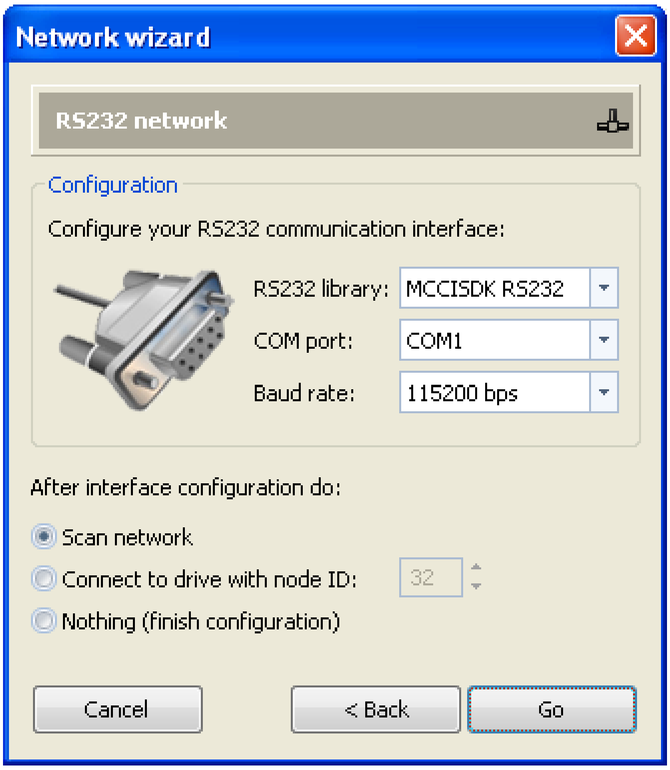

Figure 4: RS232 network configuration

In the RS232 dialog you need to select:

- **RS232 library:** Only 'MCCISDK RS232' option is allowed.
- **COM port:** Selects the serial communication port to which the drive is connected.
- **Baud rate:** Select the communication baud rate.

Then you can specify whether to do one of the following actions:

- **Scan network:** If you just want to scan for Drives connected to the RS232 network.
- **Connect to drive:** If you already know the node ID of the Drive you which to connect with.
- **Nothing:** If you just wanted to configure RS232 network but you do not need to connect to any Drive.

Click on the *Go* button to execute selected action.

The results of the scan/connection process will be displayed at the Output window. Following table summarizes possible scanning errors and their meaning:

Scanning error code	Meaning
-1	Error opening selected communication interface.
-2	Communication errors while detecting connected drives to the network.
-3	Error when releasing communication interface after a scan progress.

2.1.1.1 Considerations on using RS232-USB converters

It is not recommended to use RS232 to USB converters for RS232 communication. However more and more PC/laptop companies are removing serial connectors in favor of multiple USB connectors, so you might be forced to use one of that converters.
If that is the case, please assure that they do not introduce additional delays in transmission/reception of messages.

Contact Ingenia for further information on the recommended RS232-USB converters to use.

Some antivirus software could block the opening of COM port opening.

2.1.2 CAN/CANopen network configuration

If CAN/CANopen communication interface is selected in *Network wizard dialog*, the following dialog will pop-up.

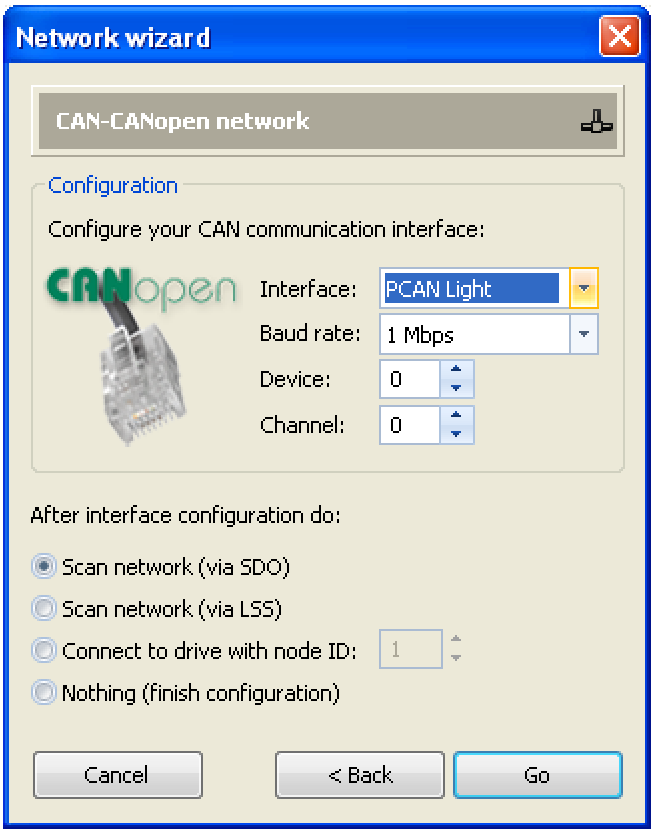

Figure 5: CAN network configuration

In the CAN-CANopen dialog you need to select:

- **Interface:** Select the CAN interface you will use to communicate with the Drive. Supported CAN interfaces are listed in the table below.

Interface name	Manufacturer	Devices supported
IXXAT	IXXAT	USB-to-CAN USB-to-CAN compact
PCAN-Light	Peak-System Technik	PCAN-USB
Kvaser	Kvaser AB	Kvaser USBcan Professional Kvaser Leaf Professional Kvaser Leaf SemiPro Kvaser Leaf Light Kvaser USBcan Rugged Kvaser USBcan II
Vector	Vector Informatik	CANcaseXL CANcardXL

- **Baud rate:** Select the communication baud rate.
- **Device:** Select the device number (zero based) of selected CAN interface.
- **Channel:** Select the channel number (zero based) of selected CAN interface.

Then you can specify whether to do one of the following actions:

- **Scan network (via SDO):** If you just want to scan for Drives connected to the CAN network (via SDO CANopen service).
- **Scan network (via LSS):** If you just want to scan for Drives connected to the CAN network (via LSS CANopen service).
- **Connect to drive:** If you already know the node ID of the Drive you which to connect with.
- **Nothing:** If you just wanted to configure RS232 network but you do not need to connect to any Drive.

Click on the *Go* button to execute selected action.

2.2 Drive connection

Once the network has been successfully scanned the Network Explorer pane automatically shows all drives detected.
You can establish a connection with a controller right-clicking on it in the *Network Explorer pane* and selecting the **Connect** option from the pop-up menu (see Figure 2).

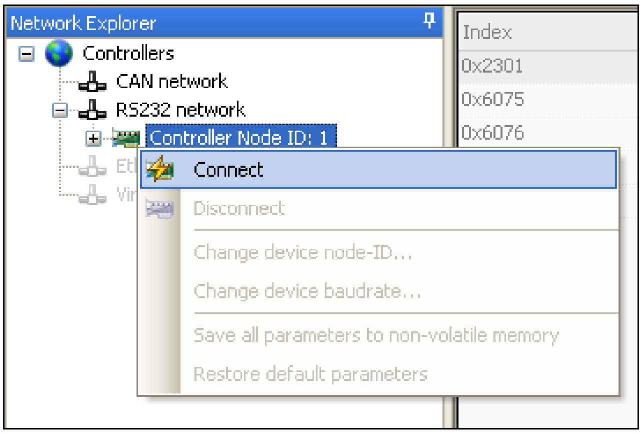

Figure 6: Connect to drive

Keep in mind that only one connection is allowed at a time.

Upon successful completing the connection process, MotionLab will ask you to upload the actual values from drive. Click **Yes** to update local configuration parameters with drive parameters.

You can disconnect from a drive at any time by right-clicking on it in the *Network Explorer pane* and selecting the **Disconnect** option from the pop-up menu.

2.3 Uploading/Downloading drive parameters

Once connected, drive parameters can be uploaded from drive at any time doing one of the following:

- Click the  button in the Configuration toolbar.
- Select **Configuration-Upload from drive** from the MotionLab menu bar.

Alternatively you can also download current configuration to drive doing one of the following:

- Click the  button in the Configuration toolbar.
- Select **Configuration-Download to drive** from the MotionLab menu bar.

You can also download just modified parameters to drive doing one of the following:

- Click the  button in the Configuration toolbar.
- Select **Configuration-Download modified to drive** from the MotionLab menu bar.

3 Drive State

Current state of Servo Drives connected to MotionLab software can be checked at any time in the status bar at the bottom of the desktop.

Transition events to switch from one state to another one can be sent using **Control toolbar** functions.

3.1 Finite state automaton

Ingenia drives fulfill CiA 402DSP CANopen standard for the finite state automaton (FSA) with respect to control of the power stage.

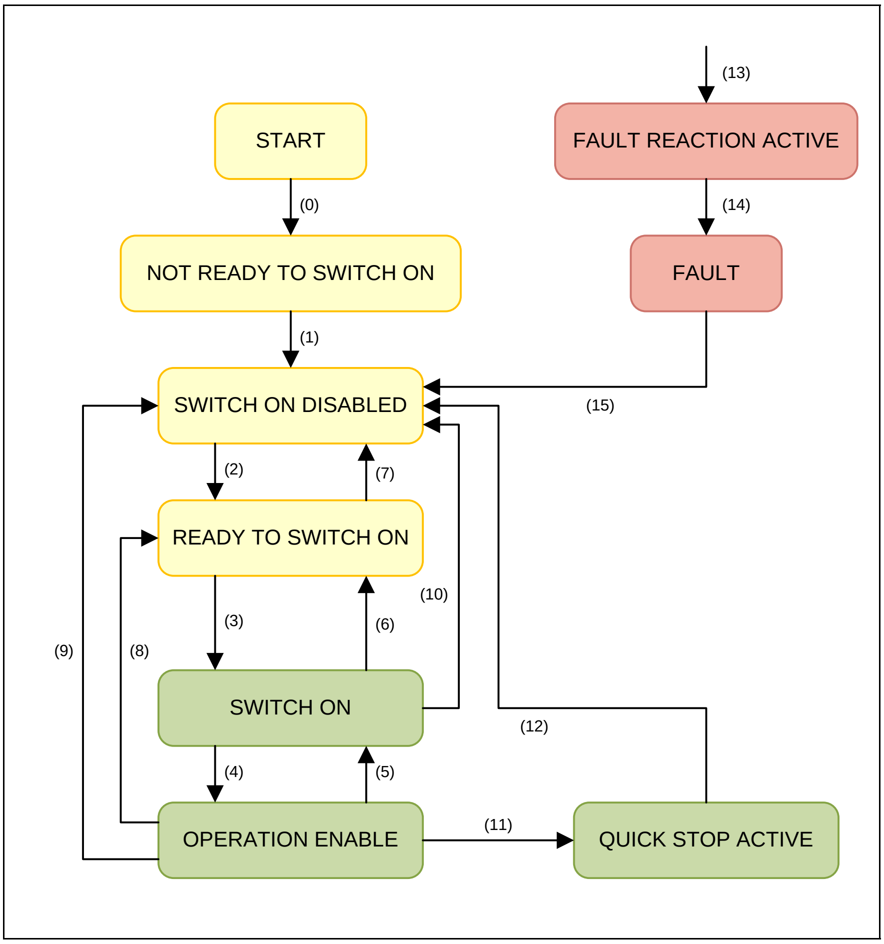

Figure 7: Finite state automaton

Check product manual of your Ingenia Servo Drive to verify FSA supported.

Supported functions in each FSA state are listed in the following table.

Function	FSA states							
	Not Ready to Switch On	Switch on disabled	Ready to switch on	Switched on	Operation enabled	Quick stop active	Fault reaction active	Fault
Brake applied, if present	Yes	Yes	Yes	Yes	Yes/No	Yes/No	Yes/No	Yes
Low-level power applied	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
High-level power applied	Yes/No	Yes/No	Yes/No	Yes	Yes	Yes	Yes	Yes/No
Drive function enabled	No	No	No	No	Yes	Yes	Yes	No
Configuration allowed	Yes	Yes	Yes	Yes	Yes/No	Yes/No	Yes/No	Yes

Events that cause transitions among FSA states are detailed below:

Transition	Event	Action
0	Automatic transition after power-on or reset application.	Drive device self-test and/or self initialization is performed.
1	Automatic transition after initialization.	Communications are activated.
2	*Shutdown command* received from control device or local signal.	None.
3	*Switch on command* received from control device or local signal.	The high-level power is switched on.
4	*Enable operation command* received from control device or local signal.	The drive function is enabled, phasing process is executed and all internal set-points cleared.
5	*Disable operation command* received from control device or local signal.	The drive function is disabled.
6	*Shutdown command* received from control device or local signal.	The high-level power is switched off.
7	*Quick stop* o *disable voltage command* received from control device or local signal.	None.
8	*Shutdown command* received from control device or local signal.	The drive function is disabled, and the high-level power is switched off.
9	*Disable operation command* received from control device or local signal.	The driver function is disabled, and the high-level power is switched off.
10	*Disable voltage* o *quick stop command* received from control device or local signal.	The high-level power is switched off.
11	*Quick stop* received from control device or local signal.	The quick stop function is started.
12	Automatic transition when the *quick stop* function is completed or *disable voltage command* is received from control device.	The drive function is disabled, and the high-level power is switched off.

13	*Fault* signal.	The configured fault reaction function is executed.
14	Automatic transition.	The drive function is disabled, and the high-level power is switched off.
15	*Fault reset command* received from control device or local signal.	A reset of the fault condition is carried out, if no fault exists currently on the drive device; after leaving the Fault state, the Fault reset bit in the controlword is cleared by the control device.

The list of commands that can be sent to switch among FSA states is listed in the table below. All these commands are accessible though the drop-down list of the control toolbar.

Command	**Transitions**
Shutdown	2, 6, 8
Switch on	3
Switch on + enable operation	3+4 (Automatic transition to Enable operation state after executing SWITCHED ON state functionality.)
Disable voltage	7, 9, 10, 12
Quick stop	1, 10, 11
Disable operation	5
Enable operation	4, 16
Fault reset	15

Additional information on Finite state automation for Ingenia Servo Drives can be found on their product manuals.

4 Drive Configuration

In MotionLab you can edit configuration parameters of the connected Servo Drive directly or loading a configuration file.

4.1 Loading/saving configurations

You can load or save configurations at any time. This is very useful when a system has been completely set up and you want to store the parameters to download them to other identical systems.

To load a configuration, you can do one of the following:

- Click the button in the Configuration toolbar.
- Select **Configuration-Load from file** from the MotionLab menu bar.

In the Load dialog box, select the configuration file and click **Load**.

Keep in mind that after loading a configuration the parameters will be just set locally in MotionLab, but not downloaded to the drive. To do that you need to explicitly perform a download to drive operation.

To save a configuration, you can do one of the following:

- Click the button in the Configuration toolbar.
- Select **Configuration-Save to file** from the MotionLab menu bar.

In the Save As dialog box, enter a name for the file, browse to the location at which it should be saved, and click **Save**.

4.2 Drive services

MotionLab uses layer setting services (for CANopen communication) and other Ingenia proprietary services to allow configuration of some base parameters of drives.
The services allowed are described in next subchapters.

4.2.1 Change drive node-ID

To change the drive node number, right-click on the drive tree item of *Network explorer pane* and select the **Change device node-ID** option from the pop-up menu.
The *New node ID* dialog box will pop up (see Figure 8). Enter the new node ID for the drive and click **OK**.

Figure 8: Change node ID

To maintain the new node ID after a system reboot, check the Save to non-volatile memory checkbox.

4.2.2 Change drive baud rate

To change the drive baud rate, right-click on the drive tree item of *Network explorer pane* and select the **Change device baudrate** option from the pop-up menu.
The *Device baudrate* dialog box will pop up (see Figure 9). Enter the new baud rate for the drive and click **OK**.

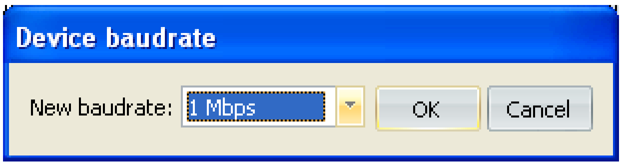

Figure 9: Change baud rate

To apply new baud rate, you will need to save configuration to non-volatile memory, power cycle the drive and reconnect with it using the new baud rate.

4.2.3 Save to non-volatile memory

Some drive parameters can be stored into the non-volatile memory of the MCU. They will be loaded after each new system reset or power cycle.

Refer to the software manual of your drive in order to check which parameters can be stored in the non-volatile memory..

To perform a save to non-volatile memory operation, right-click on the connected drive tree item of *Network explorer pane* and select the **Save all parameters to non-volatile memory** option from the pop-up menu.
Current configured drive parameters will be stored in the non-volatile memory.

4.2.4 Restore default parameters

The default values of parameters can be easily restored at any time by right-clicking on the connected drive tree item of *Network explorer pane* and select the **Restore default parameters** option from the pop-up menu.
New values will be valid after the drive is reset or power cycled.

4.3 Motor configuration

To configure the motor connected to your drive, select the **Motor group** from the *Registers groups pane*. Motor parameters are classified in 3 sub-groups (see Figure 10):

- Motor parameters
- Commutation
- Feedbacks

All of them need to be configured.

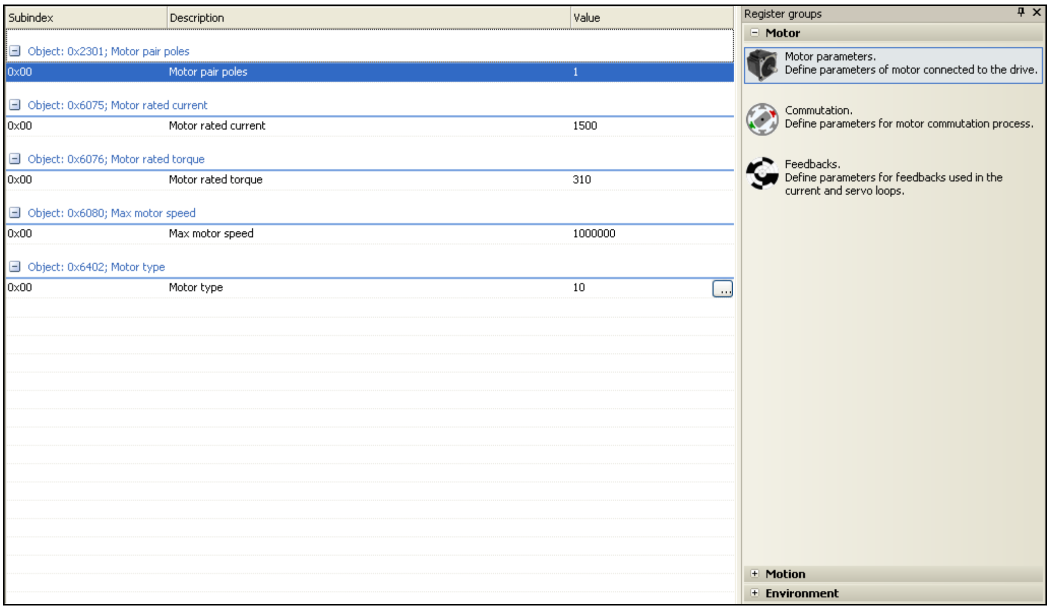

Figure 10: Motor configuration

> Some registers include a "wizard" dialog to set up their value. They will pop up when user click on the [...] button.

> Further information on each register meaning and value can be found on the *Embedded Motion Control Library – Product manual.*

4.3.1 Motor parameters

Motor parameters are:

- **Motor pair poles:** number of pair poles (only used for Sinusoidal BL motors).
- **Stepper parameters:** Stepper specific parameters.
- **I2T parameters:** I2t parameters
- **Motor rated current:** current consumed at rated conditions (in mA).
- **Motor rated torque:** torque at rated operation (in mNm).

Rated torque definition refers to rotating motors. When using linear motors all "torque" objects refer to a "force" instead. In that case the motor rated “force” value shall be entered as multiples of mN (milliNewton).

- **Max motor speed:** maximum allowed speed for the motor in either direction (in inc/s).
- **Motor type:** motor connected to the drive. This parameter includes a wizard that allows for checking proper phase connections.

Motor type	Commutation feedback	Phasing	Control feedback
DC commutator PM	-	-	Encoder
Trapezoidal PM BL	Halls	-	Halls
Sinusoidal PM BL	Encoder	Forced	Encoder
	Digital Halls + Encoder	Halls based	

Depending on the Ingenia Servo Drive, some of the above motor parameters could be not available.

4.3.1 Commutation

Commutation parameters are:

- **Commutation sensor:** Specify the sensor used for **phase commutation** (for brushless motors).
- **Initial angle determination method:** In Permanent magnet synchronous motors the position of the rotor is initially unknown. Phasing is a process that determines the initial angle/position of the rotor. Several initial angle determination methods are available:

- **Forced alignment:** If *force alignment method* is selected for the *Initial angle determination method*, the rotor position will be forced using excitation.
- **Digital Halls transition:** This method determines the position of the rotor detecting the transition of halls sensors.
- **Known alignment:** In some applications it is not mandatory to execute an auto-phase detection process because the initial position is always known. This object is used to specify the initial rotor position of the system.
- **Non-incremental sensor:** To skip initial angle determination method you should select non-incremental sensor used.

- **Forced alignment method:** If *force alignment method* is selected for the *Initial angle determination method*, the rotor position will be forced using excitation. In that case several parameters should be set:
    - **Process time:** determines the duration in milliseconds of the whole process.
    - **Process current:** determines the current used by the process. The value is expressed as per thousand of rated current.
    - **Process tolerance:** determines the maximum tolerated error of expected encoder increments in process. The value is expressed as a percentage.
- **Known alignment method:** If *known alignment method* is selected for the *Initial angle determination method*, this object is used to specify the initial rotor position of the system.

> Remember to apply your setting by clicking on the **download to drive** button.

4.3.1 Feedbacks

Feedback parameters are:

- **Feedback sensors:** Specify the sensors used for each closed loop (torque, velocity, position).
- **Encoder swap mode:** indicates whether to swap or not swap the channels A and B of the quadrature incremental encoder.

> This parameter only applies if *quadrature incremental encoder* is used as a *position feedback sensor*.

- **Position encoder type:** indicated the type of encoder used.

This parameter only applies if *quadrature incremental encoder* is used as a *position feedback sensor*.

- **Digital halls:** configures the polarity and the offset of the Halls sensors used.

This parameter only applies if *Digital Halls* sensors are used as a *position feedback sensor*.

- **Analog halls offsets:** configures analog halls offset.

This parameter only applies if *Analog Halls* are used as a *position feedback sensor*.

- **Analog halls gain:** configures analog halls gain.

This parameter only applies if *Analog Halls* are used as a *position feedback sensor*.

- **Analog input feedback:** configures analog input used as feedback input.

This parameter only applies if *Analog Input* is used as a *position feedback sensor*.

- **DC-Tachometer:** configures the DC tachometer used as velocity feedback sensor.

This parameter only applies if *DC tachometer* is used as a *velocity feedback sensor*.

- **Position encoder resolution**: for your specific drive select the appropriate encoder resolution. The resolution is calculated as the **encoder increments** per **Motor revolutions**.

This parameter only applies if *Incremental encoder* is used as a *position feedback sensor*.

For a correct operation of the system the positive sense of movement based on encoder and hall must match.

Depending on the Ingenia Digital Servo Drive some of the above Feedback objects could not be available.

4.4 Motion parameters

To configure the motion parameters for your drive, select the **Motion group** from the *Register group pane*. Motion parameters are classified in the following sub-groups:

- Servo loops.
- Trajectory generator.
- Homing.
- Torque profiler.
- Motion limits.
- Control functions.

All of them need to be configured.

Further information on each register meaning and value can be found on the *Embedded Motion Control Library – Product manual*.

4.4.1 Servo loops

To proper operate with your servo drive, you will need to adjust the current loop, velocity loop and position loop (depending on the motion mode you are going to use).

To adjust the loops, click on the Servo loops sub-group in the Motion group and then click on the wizard button of any of the loop parameters.

4.4.1.1 Current loop

The current controller must be properly tuned before any other process can be successfully carried out.

Be aware that the motor shaft may move while the current loop is being tuned. Therefore, take the necessary precautions for the unlikely event of an undesired movement.

Theoretical tuning

MotionLab can automatically calculate values for integral and proportional gains of current loop, based on the actual power supply, motor phase resistance and motor phase inductance.

Maximum close loop bandwidth should be set according to mechanical time constant of the system.

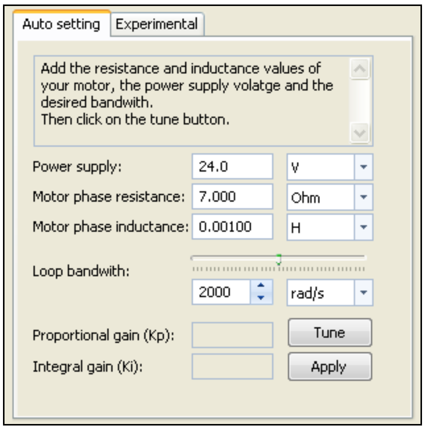

Figure 11: Automatic current tuning dialog

Theoretical tuning is a plant model based tuning method that could be imprecise depending on the linear time invariant behavior of your system.

Theoretical tuning is not ready to work with stepper motors.

Experimental tuning

To experimentally tune the current loop you will need to apply a small-magnitude torque step command to the drive (if necessary increase torque slope register).

To tune the current loop first zero the integral gain and increase proportional constant to get sustained oscillation (not necessary around target command). Use the **Run** button to perform each execution. Results will be displayed in the dialog scope (see Figure 12, Figure 13, Figure 14 and Figure 16).

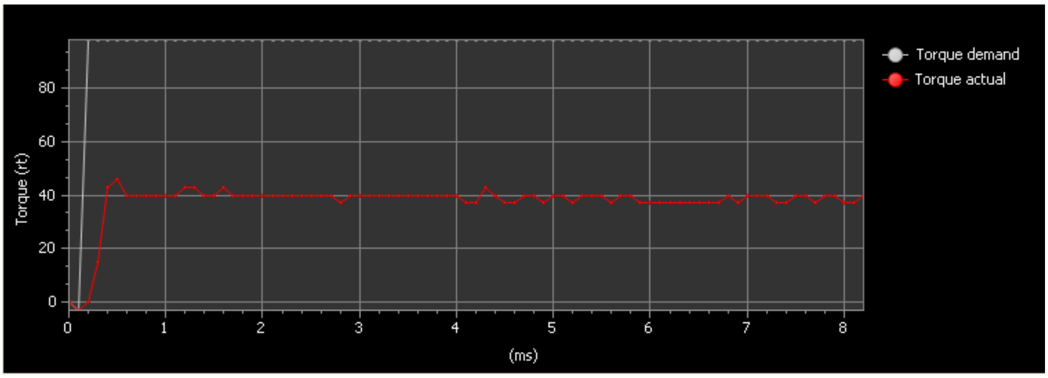

Figure 12: Too low proportional gain

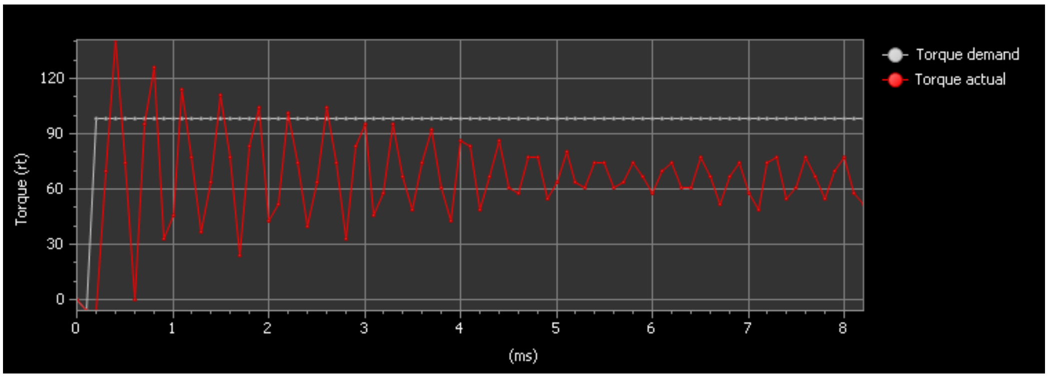

Figure 13: About right proportional gain

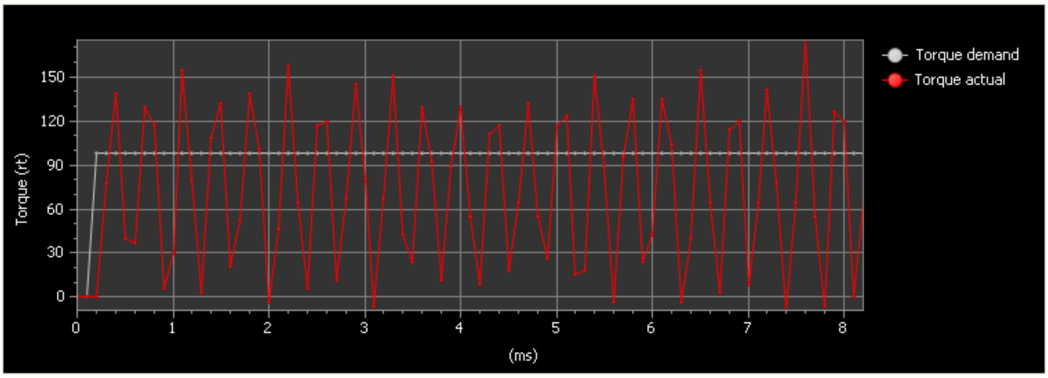

Figure 14: Right proportional gain (constant oscillation)

Approximately measure the period of the oscillation and get the PI parameters though the Ziegler-Nichols calculator.

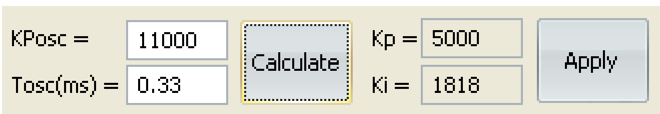

Figure 15: Ziegler-Nichols calculator

Verify proper adjustment with calculated values:

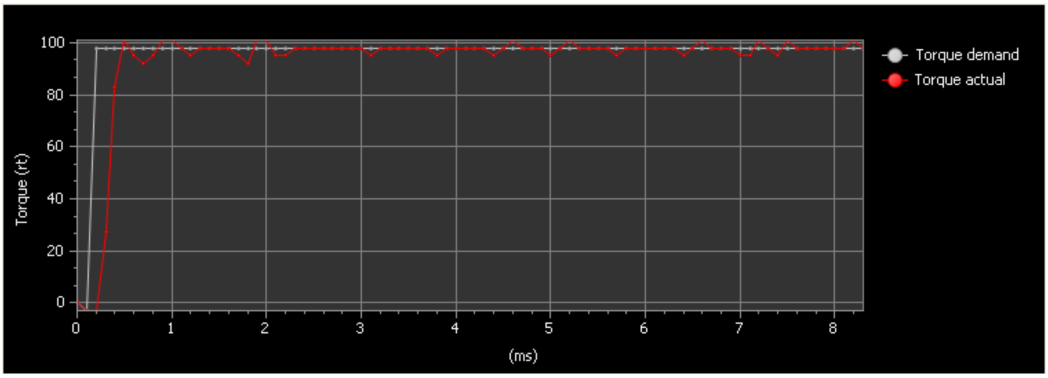

Figure 16: Properly tuned current loop

4.4.1.2 Velocity loop

Theoretical tuning

MotionLab can automatically calculate values for integral and proportional gains of velocity loop, based on some system parameters.

The first parameter that must be set is the type of displacement your system is carrying out: **rotary** or **linear**.

As a good rule of thumb, to maintain phase margin and stability in the speed loop, its maximum bandwidth must be limited to 1/3rd to 1/5th the bandwidth of the current/torque loop.

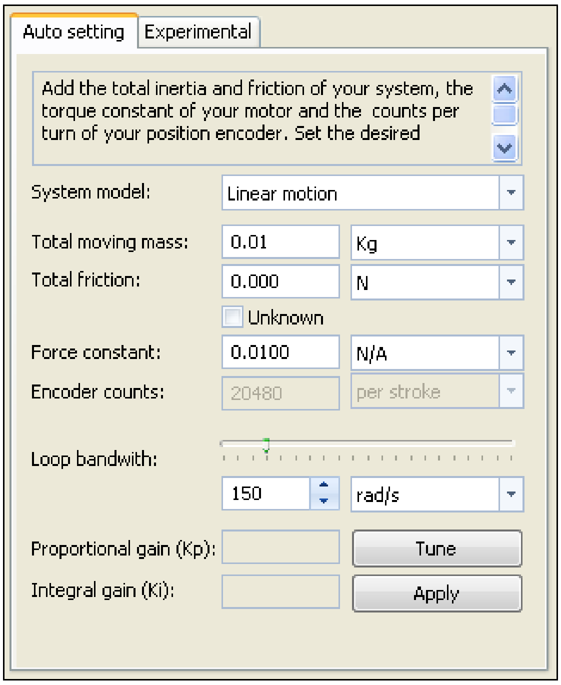

Figure 17: Automatic velocity tuning dialog

Theoretical tuning is a plant model based tuning method that could be imprecise depending on the linear time invariant behavior of your system.

Theoretical tuning is not ready to work with stepper motors.

Experimental tuning

To experimentally tune the velocity loop apply a small-magnitude step command to the drive (**velocity profile parameters**). You should adjust the step to be as large as possible without calling for peak current from the drive. If you ask for too much current, you will saturate the current loops; this makes the loop more difficult to tune correctly. Typical step commands are from 50 RPM to about 500 RPM, depending on the loop speed and the amount of inertia.

Now, adjust the zones one at a time. First, zero the integral zone and tune proportional constant to get a little overshoot or no-overshoot (See Figure 18, Figure 19 and Figure 20).
Next, add integral gain until the overshoot reaches about 10%-15% (See Figure 21).

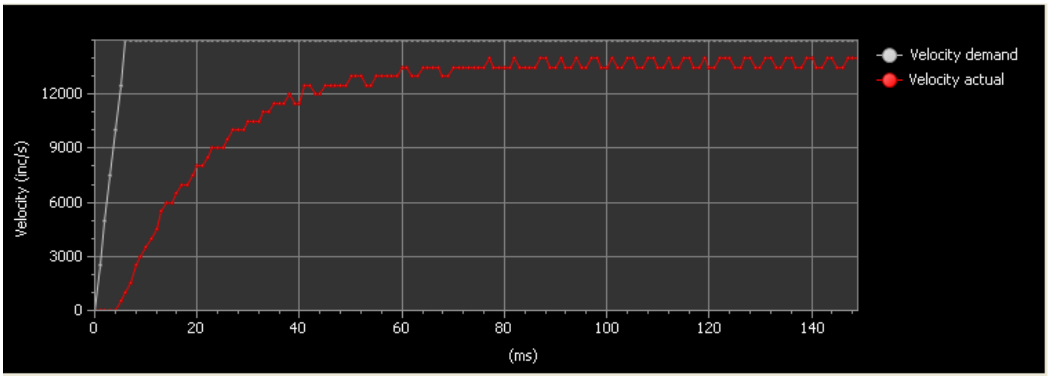

Figure 18: Too low proportional gain

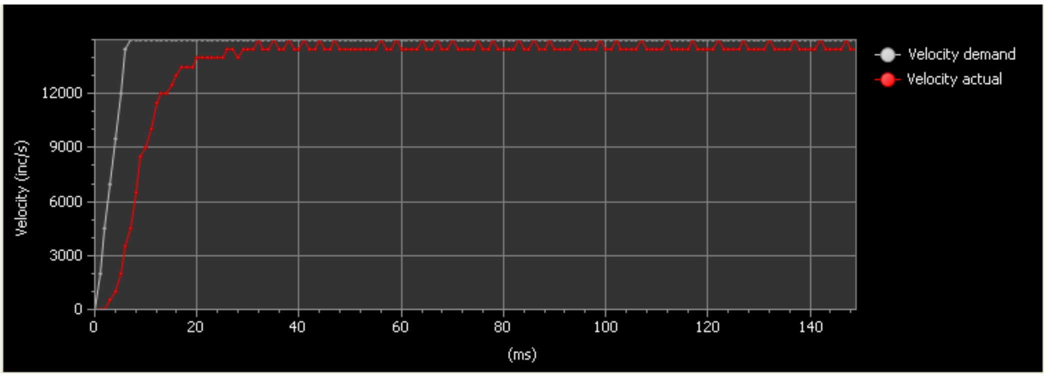

Figure 19: About right proportional gain

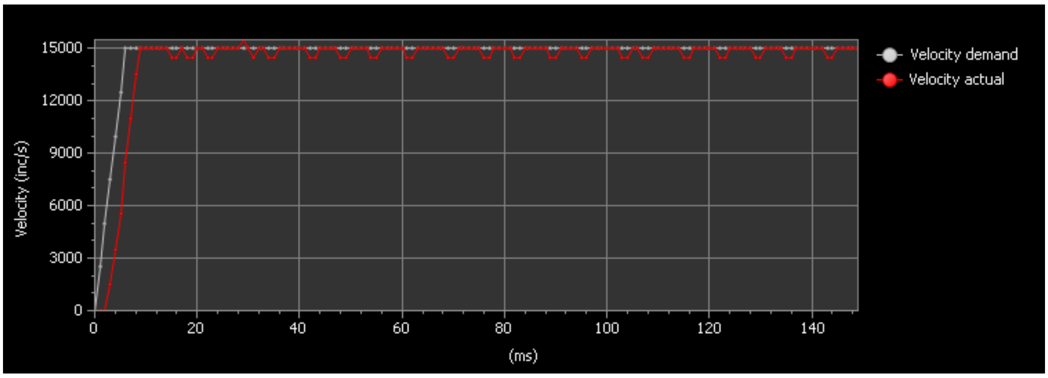

Figure 20: Right proportional gain

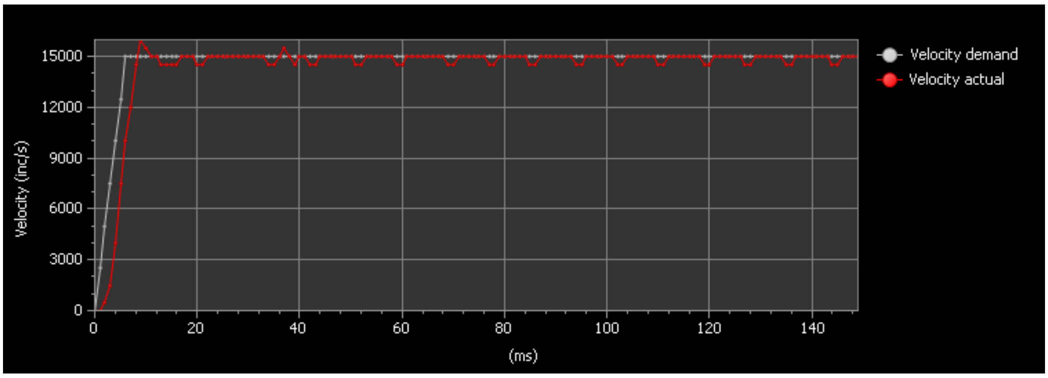

Figure 21: Added integral gain

Some systems may also need to use *derivative* or *acceleration feedforward* gains

Also use integral anti-windup gain if integrator winds-up your system.

Be aware that the motor shaft may move while the velocity loop is being tuned. Therefore, take the necessary precautions for the unlikely event of an undesired movement.

4.4.1.3 Position loop

Theoretical tuning

MotionLab can automatically calculate values for proportional, integral and derivative gains of position loop, based on some system parameters.
The first parameter that must be set is the type of displacement your system is carrying out: **rotary** or **linear**.

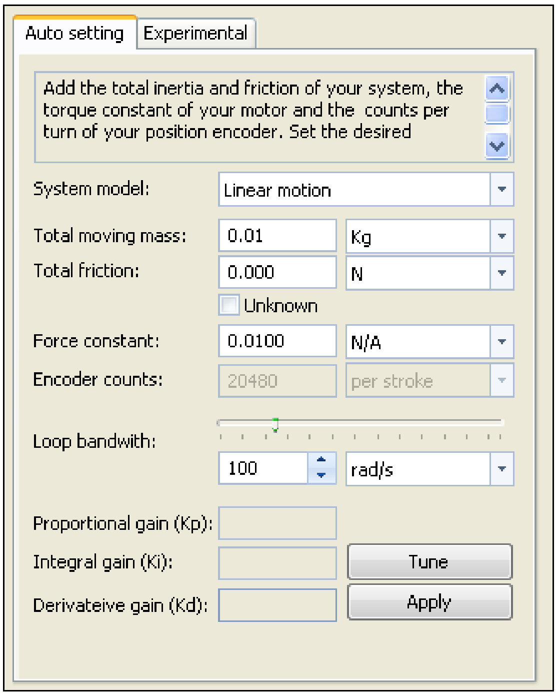

Figure 22: Automatic position tuning dialog

Automatic tuning is a plant model based tuning method that could be imprecise depending on the linear time invariant behavior of your system.

Theoretical tuning is not ready to work with stepper motors.

Experimental tuning

To experimentally tune the position loop of your drive use *tuning in zones* method.

Each of the control loop gains operates in one of the three "frequency zones". The highest frequency zone is covered by the derivative gain. The proportional gain covers the mid-frequency zone and the low frequency zone is covered by integral gain.

<u>Zone 1: Derivative gain</u>

Begin tuning the highest frequency zone. Start by eliminating the lower zones (proportional and integral).

Now set test parameters (**position profile parameters**) to perform a trapezoidal point-to-point move with acceleration and deceleration rates as high as the drive will allow.

If the commanded move puts the current controller in saturation, reduce the peak velocity of the move.

Now, raise the derivative gain as high as possible without generating overshoot in the velocity response and avoiding high frequency noise.

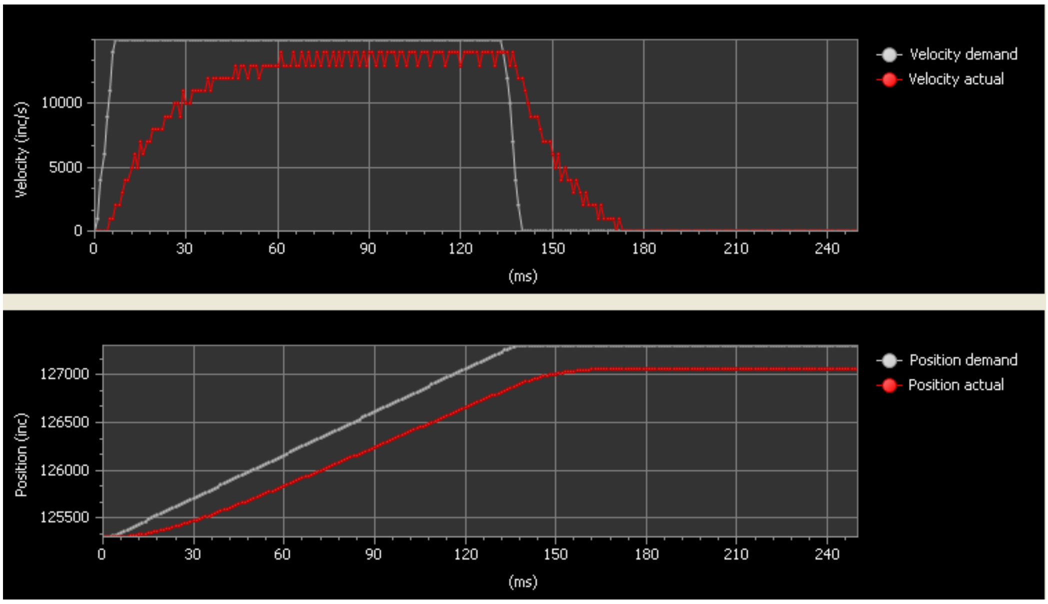

Figure 23: Too low derivate gain

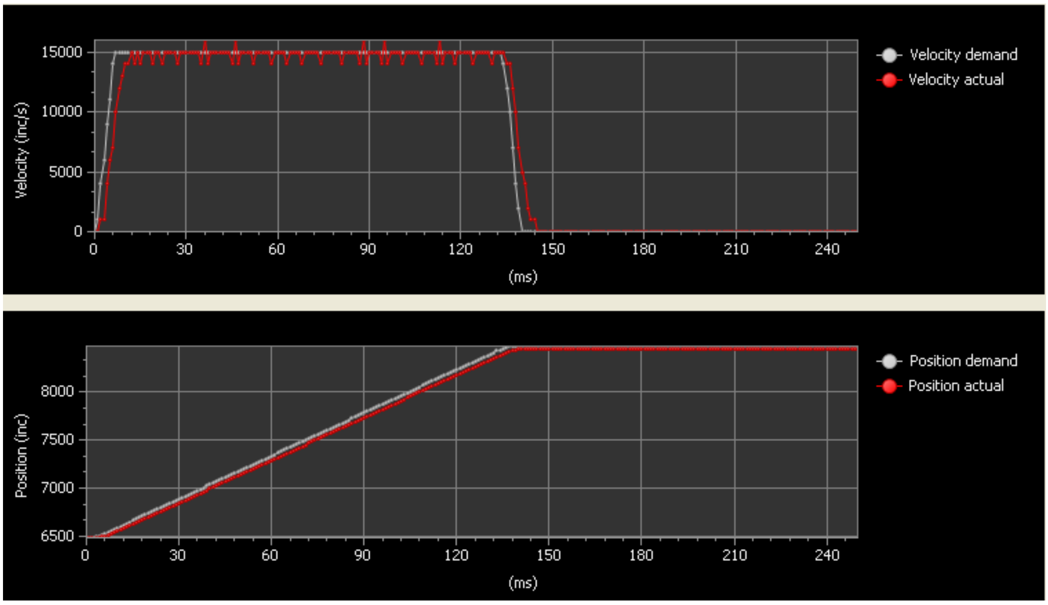

Figure 24: Right derivative gain

Zone 2: Proportional gain

With derivate gain set, tune the proportional gain. To do so, first modify the test parameters (**position profile parameters**); Lower the acceleration and deceleration to the highest rates that will be seen in the application under normal operation.

Now increase proportional gain without generating overshoot.

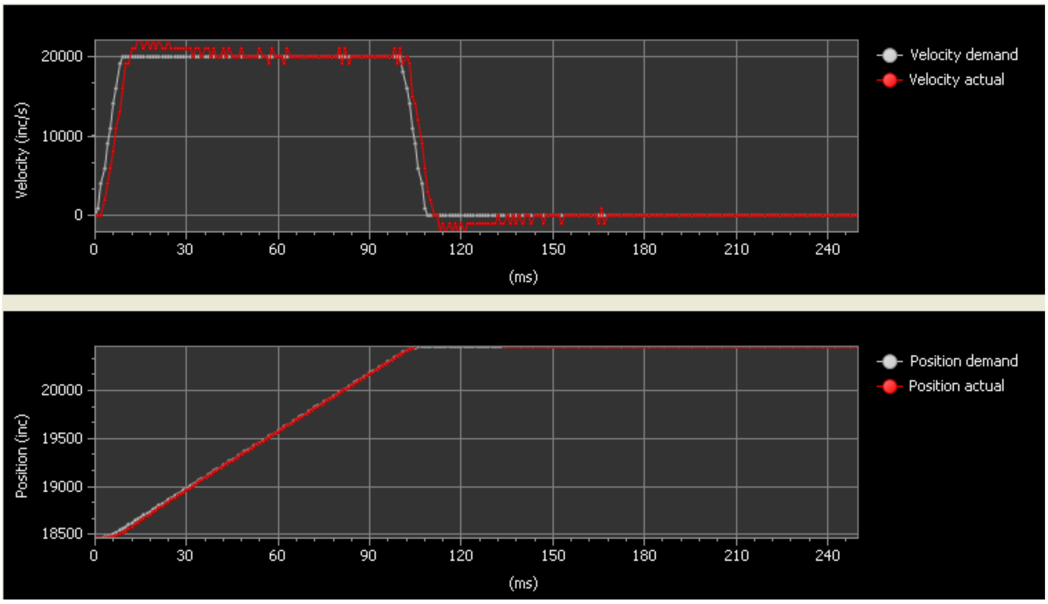

Figure 25: Too much proportional gain

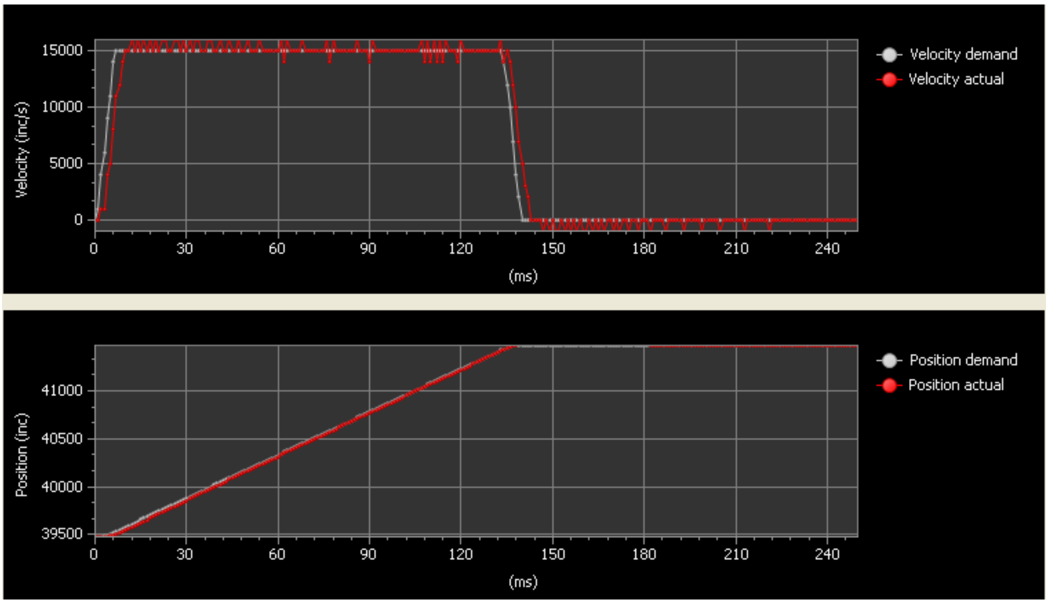

Figure 26: Right proportional gain

<u>Zone 3: Integral gain</u>

Tuning integral gain is difficult because even small amount causes overshoot. Try to increase in order that it generates the minimum overshoot allowed by the application.

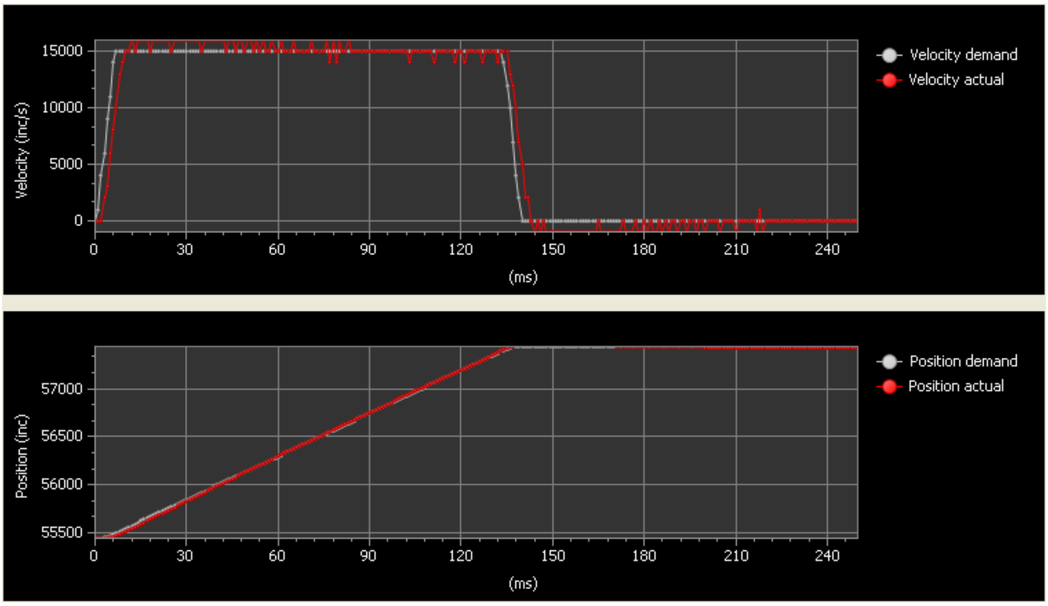

Figure 27: Add integral gain carefully

Be aware that the motor shaft may move while the position loop is being tuned. Therefore, take the necessary precautions for the unlikely event of an undesired movement.

4.4.2 Trajectory generator

The trajectory generator is generating the position/velocity demand values for the position/velocity loops.

Parameters for *trajectory generator* sub-group are:

- **Polarity:** sets the system polarity. The current position/velocity and the target position/velocity will be multiplied internally by 1 or -1, depending on the polarity value. The position polarity bit is used by profile position mode and the velocity polarity bit is used by profiled velocity mode.
- **Max. profile velocity**: this parameter indicates the maximal allowed velocity in either direction during a profiled motion.
- **Profile velocity**: It indicates the desired velocity attained at the end of the acceleration ramp during the profiled motion.
- **Profile acceleration**: It indicates the desired acceleration for the profiled motion.
- **Profile deceleration**: It indicates the desired deceleration for the profiled motion.
- **Quick stop deceleration**: this parameter indicates the deceleration used to stop the motor when the quick stop function is activated.
- **Motion profile type**: this parameter indicates the configured type of motion profile used to perform a profiled motion.

4.4.3 Homing

In positioning systems, it is usually necessary to know the absolute position of the mechanics to assure correct movements. For cost reasons, most of systems do not usually use absolute encoders which provide an absolute reference, and therefore a homing process or search for an absolute reference method is mandatory.

Parameters for *homing* sub-group are:

- **Homing extra parameters**: It contains extra parameters necessary by manufacturer specific Homing methods
- **Home offset**: It indicates the configured difference between the zero position for the application and the machine home position.
- **Homing method:** It indicates the used homing method.
- **Homing speeds:** It indicates the speeds used to locate the switch or mechanical limit and the encoder index pulse.
- **Homing acceleration:** It establishes the acceleration used for all accelerations and decelerations in standard homing methods.

4.4.4 Torque profiler

The torque profiler is generating the torque demand values for the torque loops.

Parameters for *torque profiler* sub-group are:

- **Torque slope**: It indicates the configured rate of change of torque.
- **Torque profile type**: It indicates the configured type of profile used to perform a torque change.

4.4.5 Motion limits

Parameters for *motion limits* sub-group are:

- **System polarity**: It indicates the direction for positive movements and for negative movements. The system polarity is used in all modes. As the direction of torque, velocity and position could be changed it allows reversing the direction of a system without modifying any cabling.
- **Max torque**: It indicates the configured maximum permissible torque in the motor.
- **Max current**: It indicates the configured maximum permissible torque creating current in the motor.
- Position range limit: It contains two parameters, a **minimum position limit** and a **maximum position limit**. These parameters define the absolute position limits for the target and current position.
  Every new target position will be checked and adjusted to the limits established by these values.
- **Torque offset**: this parameter indicates the offset for the torque value. The torque offset is useful to compensate systems with constant loads like vertical mounted systems or springs.
- **Max. acceleration**: this parameter indicates the configured maximal acceleration. It is used to limit the acceleration to an acceptable value in order to prevent the motor and the moved mechanics from being destroyed.
- **Max. deceleration**: this parameter indicates the configured maximal deceleration. It is used to limit the deceleration to an acceptable value in order to prevent the motor and the moved mechanics from being destroyed.
- **Positive torque limit**: this parameter indicates the configured maximum positive torque in the motor.
- **Positive torque limit**: this parameter indicates the configured maximum negative torque in the motor.

4.4.6 Control functions

The position and velocity control functions parameters work in conjunction with position and velocity loops.
The position and velocity loops are powered from the output of the profiler and from the position/velocity detector or feedback output.
The output of the position/velocity loops will be input to the flux-torque or current loop.
Parameters for *control functions* sub-group are:

- **Following error window**: this parameter indicates the configured range of tolerated position values symmetrically to the position demand value.
- **Following error time out**: this parameter indicates the configured time for a following error condition, after that the bit 13 of the *statusword* shall be set to 1.
- **Position window**: this parameter indicates the configured symmetrical range of accepted position relative to the target position. If the actual value of the position encoder is within the position window, this target position shall be regarded as having been reached. As the user mostly prefers to specify the position window in his application in user-defined units, the value is transformed into increments.
- **Position window time**: this parameter indicates the configured time, during which the actual position within the position window is measured.
- **Velocity window**: this parameter indicates the configured symmetrical range of accepted velocity relative to the target velocity. If the actual value of the velocity is within the velocity window, this target velocity shall be regarded as having been reached.
- **Velocity window time**: this parameter indicates the configured time, during which the actual velocity within the velocity window is measured.
- **Velocity threshold**: this parameter indicates the configured zero velocity threshold.
- **Velocity threshold time**: this parameter indicates the configured zero velocity threshold time.

4.4.7 Command sources

Parameters for *Command sources* sub-group are:

- **Command reference source**: The input command source for Ingenia Digital Servo Drives can be provided by one of the following options:
    - **Network**: Ingenia Drives can utilize network communication as a form of input command. Ingenia Drives can provide an input reference command through the CAN and the RS232 interface.
    - **Analog input**: Utilize one of the hardware available analog inputs (+-10V single ended or differential) as a form of input command.

      When using an analog input command source and working in Profile position mode the Position range limit registry will be used as limits of the system. Therefore, the min voltage in the analog input will correspond to a Target position of Min. Position range limit, and the max voltage will correspond to a Max. Position range limit.

      When working in Profile velocity mode the Max motor speed will be used as the maximum value of the system and the same value but with opposite sign for the minimum value of the system.

When working in Profile torque mode the Max torque will be used as the maximum value of the system and the same value but with opposite sign for the minimum value of the system.

- **PWM & Direction**: Choose this mode if you would like to use a PWM input as a form of input command. The PWM goes directly into MCU which calculates the appropriate command for the current, velocity or position loop.
- **Step & Direction**: Choose this mode if you would like to position the motor with step (pulse) & direction signals.
- **Electronic gearing**: Utilize the counts coming from a secondary digital incremental encoder as a form of input command. This command source is normally used to synchronize movements.

- **Electronic gearing command source**: Defines a gear ratio between the movement of the master motor and the slave.

This object only applies if *Electronic gearing is* specified as a *command reference source*.

- **Step & Direction command source**: Defines Step value. Each step or pulse will increase or decrease the position of the motor (depending on the value of direction input) the number of increments indicated by the object Step value.

This object only applies if *Step & Direction is* specified as a *command reference source*.

- **Analog input command source**: Defines which input is used as analog input and which its offset is. It also allows for configuring a deadband of values for the case that analog input is a reference command for Profile velocity mode. If the difference between the value of the input and value of the midpoint of the analog range (2.5V) is smaller than deadband value, the input will be considered null. This characteristic allows reducing sensitivity at low speeds.
  This registry is expressed in percentage of the maximum value, thus if for example the registry takes a value of 10, it will corresponds to 10% of 5V and therefore to a dead zone 0.5V around 2.5V.

This object only applies if *Analog Input is* specified as a *command reference source*.

- **PWM command source**: Defines the PWM mode used:

- PWM & direction (**Dual input mode**): It uses two inputs; one to assign the direction of the movement and another to assign the magnitude. This mode uses the 100% of the PWM range
- PWM (**Single input mode**): It uses only one input to control the direction and the magnitude. This mode uses 50% of the PWM range for each direction.

This object only applies if *PWM command source is* specified as a *command reference source*.

4.5 Environment parameters

To configure the environment parameters for your drive, select the **Environment group** from the *Register group pane*. Environment parameters are classified in 2 sub-groups:

- Inputs & Outputs.
- UART configuration.

All of them need to be configured.

Further information on each register meaning and value can be found on the *Embedded Motion Control Library – Product manual*.

4.5.1 Inputs & Outputs

Parameters for *Inputs & Outputs* sub-group are:

- The **polarity** and **value** for **general digital input/outputs** can be configured. Each of them is a 16bit binary representation which bit meaning depends on the specific Ingenia drive used. Please refer to your hardware manual for further information.
- **Analog output 1 value -10bits-**: this parameter allows setting the output for the 10bit DAC.
- **Analog output 2 value -16bits-**: this parameter allows setting the output for the 16bit DAC.

4.5.2 UART configuration

For Ingenia drives with UART interface, some parameters can be configured.
Parameters for *UART configuration* sub-group are:

- **Daisy chain mode**: this parameter indicates if UART works in daisy chain mode (**Enabled** option) or not (**Disabled** option).
- **Base format**: this parameter configures the format of the value data. Possible values are **Hexadecimal** or **Decimal** base format.
- **Statusword mode**: this parameter modifies the behavior of the statusword notification mechanism.

4.5.3 Fault protections

For Ingenia drives some Fault protections can be configured trough this Regsiters group.

- **Drive temperature**: Defines the limits of temperature accepted by the system. When the actual temperature is out of the defined range an Emergency message is sent.
- **Bus voltage**: Defines the limits of the bus voltage accepted by the system. Depending on the availability of an external shunt the reaction of an out of range situation will be different:
    - Shunt not available: Emergency message is sent.
    - Shunt available: Shunt is activated is voltage is higher than maximum. Emergency message is sent if voltage is below than minimum.
- **Shunt configuration**: Contains all the information needed for external shunt configuration.

  The external shunt is activated when the actual bus voltage is higher than Max user voltage plus hysteresis and is deactivated when the actual bus voltage is lower than Max user voltage minus **hysteresis**.

  The hysteresis is expressed as percentage of max bus voltage.

  The voltage applied to the shunt is modulated with a frequency of 20kHz approximately and the **duty** is user configurable.

> Depending on the Ingenia Digital Servo Drive some of the above Fault protections objects could not be available.

5 Testing Motion

Once the Ingenia Servo Drive has been properly configured, user can test motion modes (using network communication as input command) through the Test Motion Modes Dialog of MotionLab software.

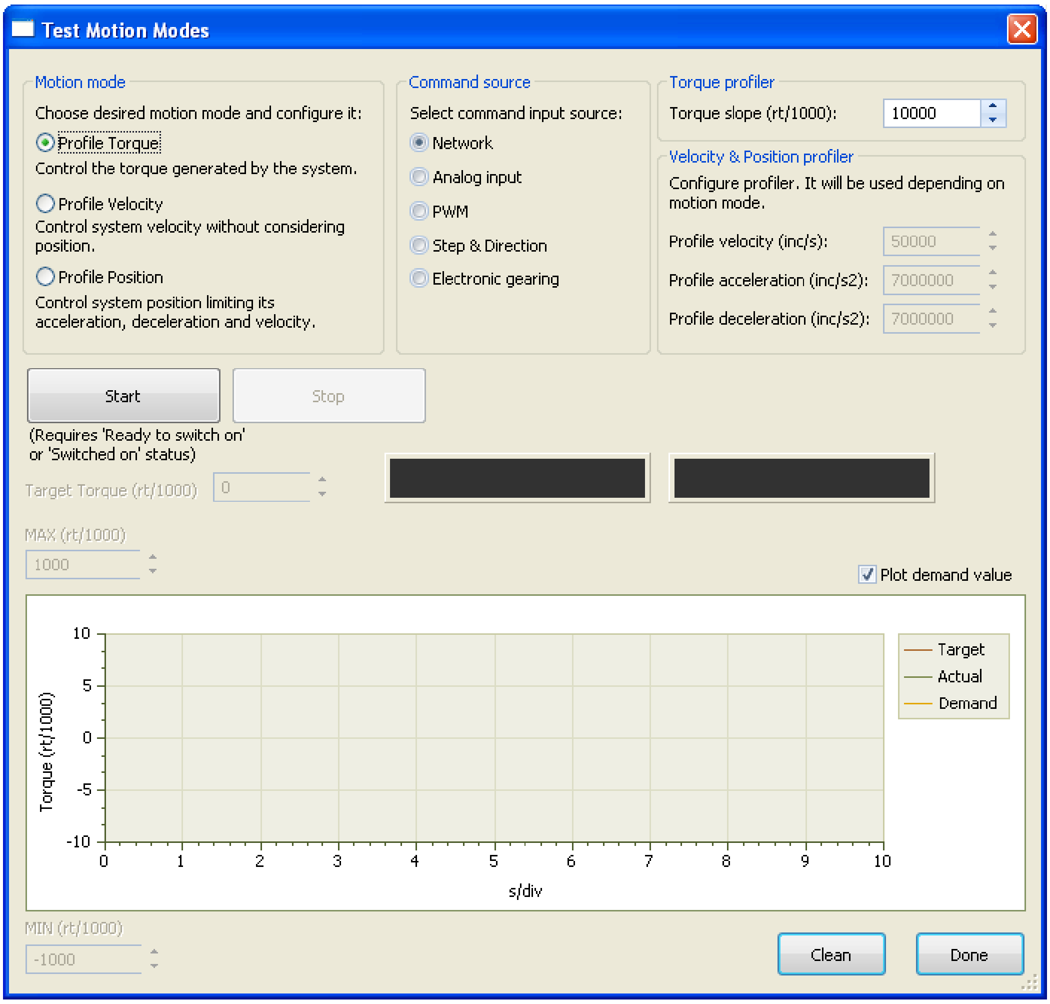

Figure 28: Test Motion Mode Dialog

5.1 Torque profile motion mode

The profile torque operation mode makes it possible to control the torque of the motor according to the parameters set by the user. Movement parameters are profiled according to the torque slope and torque profile type parameters. Values generated at the profiler output are delivered to the torque control function, which converts these values into the corresponding electrical parameters for the motor.

Configuration

The profile torque mode configurable parameters are:

- Max torque

- Max current
- Torque profile type

All of them are accessible in the Motion Parameters *registers groups* pane.

Execution

To perform a profiled torque movement:

1) Click on the **Start** button.
2) Set new **Target torque** and press enter key to start the movement.
3) Repeat step 2 as many times as required.
4) Click on the **Stop** button to exit the profile torque mode.

The target and the actual torque values will be continuously updated and displayed in the chart while profile torque mode is running.

The range of allowed torques is automatically set to max torque.

It is recommended to tune the current loop before executing profiled torque movements.

5.2 Velocity profile motion mode

The profile velocity operation mode makes it possible to control the velocity of the motor according to the parameters set by the user. Movement parameters are profiled according to the profiler configuration. Values generated at the profiler output are delivered to the velocity control function, which converts these values into the corresponding electrical parameters for the motor.

The following diagram shows the internal working of this mode.

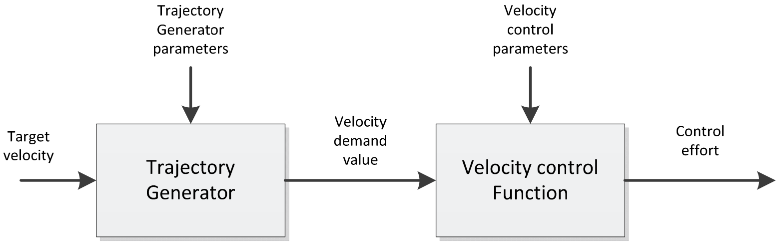

Figure 29: Overall structure for profile velocity mode

Configuration

The profile torque mode configurable parameters are:

- Profile acceleration
- Profile deceleration

Both can be accessed directly in the Motion Test Dialog.

Execution

To perform a profiled velocity movement:

1) Edit the desired profile for the movement (**Profile acceleration** and **Profile deceleration** edit boxes) in the profile configuration.
2) Click on the **Start** button.
3) Set new **Target velocity** and press enter key to start the movement.
4) Repeat step 3 as many times as required.
5) Click on the **Stop** button to exit the profile velocity mode.

The target and the actual velocity values will be continuously updated and displayed and displayed in the chart while profile velocity mode is running.

The range of allowed velocities is automatically set to the minimum value between max motor speed and max profile velocity.

It is recommended to tune the current and velocity loops before executing profiled velocity movements.

5.3 Position profile motion mode

The profile position operating mode permits point-to-point movements whose movement parameters are profiled, depending on the profiler configuration.

The values generated at the profiler output are delivered to the position control function, which converts these values into the corresponding electrical parameters for the motor.

The following diagram shows the internal working of this mode.

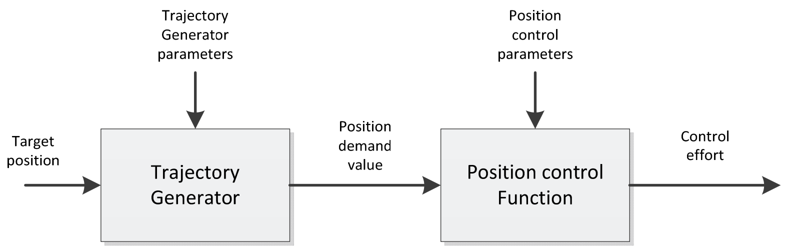

Figure 30: Overall structure for profile position mode

Configuration

The profile position mode configurable parameters are:

- Position range limit (min position range limit and max position range limit)
- Profile velocity
- Profile acceleration
- Profile deceleration

Execution

To perform a profiled position movement:

1) Set the appropriate position limits for your system (**MIN position** and **MAX position** edit boxes).
2) Edit the desired profile for the movement (**Profile velocity**, **Profile acceleration** and **Profile deceleration** edit boxes) in the profile configuration.
3) Click on the **Start** button.
4) Set new **Target position** and press enter key to start the movement.
5) Repeat step 4 as many times as required.
6) Click on the **Stop** button to exit the profile position mode.

The target and the actual position values will be continuously updated and displayed and displayed in the chart while profile position mode is running.

It is recommended to tune the current and position loops before executing profiled velocity movements.

6 Testing Homing

Once the Ingenia Servo Drive has been properly configured, user can test homing mode through the Test Homing Mode Dialog of MotionLab software.

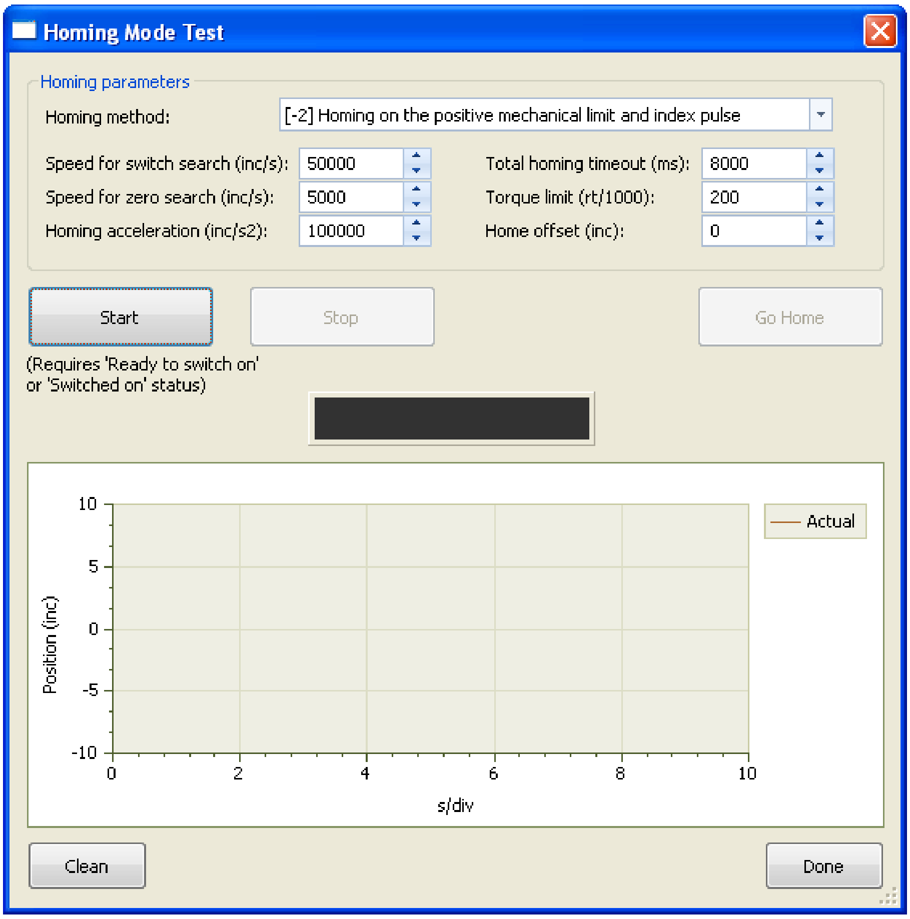

Figure 31: Test Homing Mode Dialog

6.1 Homing mode

In positioning systems, it is usually necessary to know the absolute position of the mechanics to assure correct movements. For cost reasons, most of systems do not usually use absolute encoders which provide an absolute reference, and therefore a homing process or search for an absolute reference method is mandatory.

The Ingenia Servo Drives include various methods of finding Home through limit switches or contacts. Most methods also use the index pulses of incremental encoders to improve detection accuracy.

> It is recommended to tune the current and position loops before executing homing methods.

Configuration

The homing mode configurable parameters are:

- Speed for switch search
- Speed for zero search
- Homing acceleration
- Total homing timeout
- Torque limit
- Home offset

Execution

To perform a homing movement:

1) Set the appropriate homing method.
2) Configure homing parameters.
3) Click on the **Start** button and wait for homing completion.
4) Click on the **Stop** button to stop the homing procedure.