maxon motor

maxon motor control Getting Started EPOS Positioning Controller December 2008 Edition

# **EPOS** 24/1

# **Positioning Controller**

# Documentation Getting Started



maxon document number 573049-09

# 1 Table of contents

1	Table of contents	2
2	Table of figures	3
3	Introduction	4
4	How to use this guide	
5	Safety Instructions	5
6	Installation and Configuration	6
6.1	Step 1: Software Installation	
6.2	Step 2: Minimum External Wiring	
6.2		
6.2		
6.2		11
6.2	.4 EPOS 24/1 for maxon DC/EC motor (Molex connectors) with Hall sensor and digital	
	Encoder	-
6.3	Step 3: System Configuration	15
6.4	Step 4: Regulation Gains Tuning	
6.4	5	
6.4	.2 Auto-tuning of the Current Regulator	23
6.4		
6.4	.4 Auto-tuning of the Position Regulator	27
6.4		
6.4	.6 Save all Regulation Gains	30
7	Conclusion	30

# 2 Table of figures

Figure 1: EPOS 24/1 photo	4
Figure 2: EPOS documentation hierarchy	
Figure 3: EPOS CD-ROM	
Figure 4: Minimum wiring for DC-Motor with integrated motor/encoder ribbon cable	
Figure 5: Minimum wiring for EC 6-Motor	10
Figure 6: Minimum wiring for EC16/EC22-Motor	
Figure 7: Minimum wiring for DC/EC-Motor with Molex connectors	14
Figure 8: Startup wizard dialog for minimum external wiring	15
Figure 9: Startup wizard dialog for setting RS-232 communication	16
Figure 10: Communication settings found	16
Figure 11: Startup wizard dialog for choosing motor type	16
Figure 12: Startup wizard dialog for choosing EC motor pole pairs	
Figure 13: Startup wizard dialog for setting DC motor data	17
Figure 14: Startup wizard dialog for setting EC motor data	
Figure 15: Startup wizard dialog for choosing DC motor position sensor type	
Figure 16: Startup wizard dialog for choosing EC motor position sensor type	
Figure 17: Recommendations for using Hall sensors as position sensors	
Figure 18: Startup wizard dialog for setting DC motor encoder resolution	
Figure 19: Startup wizard dialog for setting EC motor encoder resolution	
Figure 20: Startup wizard configuration summary	
Figure 21: Startup wizard dialog for setting EC motor encoder resolution	
Figure 22: Save & activate the configured parameters	
Figure 23: Confirm parameter activation	
Figure 24: Clear CAN error	
Figure 25: Start regulation tuning	
Figure 26: Auto-tuning of current regulator	
Figure 27: Auto-tuning button	
Figure 28: Confirm motor shaft blocking	
Figure 29: Confirm end of tuning	
Figure 30: Confirm tuning error	
Figure 31: Clear tuning error	
Figure 32: Auto-tuning of velocity regulator	
Figure 33: Auto-tuning button	
Figure 34: Confirm free running of motor	
Figure 35: Confirm end of tuning	
Figure 36: Confirm tuning error	
Figure 37: Clear tuning error	
Figure 38: Auto-tuning of position regulator	
Figure 39: Auto-tuning button	
Figure 40: Confirm free running of motor	
Figure 41: Confirm end of tuning	
Figure 42: Confirm tuning error	
Figure 43: Clear tuning error	
Figure 44: Manual tuning mode	
Figure 45: Manual tuning mode	
Figure 46: Next tuning step	
Figure 47: Save button	
Figure 48: Confirm regulation gains saving	
Figure 49: Confirm saving of all parameters	
rigare for committee an parametere management of the	

# 3 Introduction

This documentation 'Getting Started' provides the first steps in using EPOS positioning controller. It describes the standard procedure when the amplifier is put into operation. The document facilitates the installation and configuration of a basic EPOS 24/1 system.



Figure 1: EPOS 24/1 photo

maxon motor EPOS 24/1 is a small-sized full digital smart motion controller. Due the flexible and high efficient power stage the EPOS 24/1 drives brushed DC motors with digital encoder as well as brushless EC motors with digital Hall sensors and encoder.

The sinusoidal current commutation by space vector control offers to drive brushless EC motors with minimal torque ripple and low noise. The integrated position-, velocity- and current control functionality allows sophisticated positioning applications. It is specially designed being commanded and controlled as a slave node in the CANopen network. In addition the unit can be

operated through any RS-232 communication port. The latest edition of these 'Getting Started', additional documentation and software to the EPOS positioning controller may also be found in the internet under <u>http://www.maxonmotor.com</u> category <Service & Downloads>.

# 4 How to use this guide



# **Getting Started**

# Installation

# Configuration

# Programming

# Application



- Application Notes
- Application Samples



Cable Starting Set



 Hardware Reference



Graphical User Interface





IEC1131 libraries



Specification



Figure 2: EPOS documentation hierarchy

# **5** Safety Instructions



# Skilled Personnel

Installation and starting of the equipment shall only be performed by experienced, skilled personnel.



# Statutory Regulations

The user must ensure that the positioning controller and the components belonging to it are assembled and connected according to local statutory regulations.



# Load Disconnected

For primary operation the motor should be free running, i.e. with the load disconnected.



# Additional Safety Equipment

An electronic apparatus is not fail-safe in principle. Machines and apparatus must therefore be fitted with independent monitoring and safety equipment. If the equipment breaks down, if it is operated incorrectly, if the control unit breaks down or if the cables break, etc., it must be ensured that the drive or the complete apparatus is kept in a safe operating mode.



# Repairs

Repairs may be made by authorized personnel only or by the manufacturer. It is dangerous for the user to open the unit or make repairs to it.

$\underline{\wedge}$

# Danger

Do ensure that during the installation of the EPOS 24/1 no apparatus is connected to the electrical supply. After switching on, do not touch any live parts!



# Max. Supply Voltage

Make sure that the supply voltage is between 9 and 24 VDC. Voltages higher than 27 VDC or of wrong polarity will destroy the unit.



# **Electrostatic Sensitive Device (ESD)**

# 6 Installation and Configuration

# 6.1 Step 1: Software Installation

Install the software from the EPOS CD-ROM. The CD-ROM contains all necessary information and tools for installation and operation of the EPOS controllers (Manuals, Firmware, Tools, and Windows DLLs).



Figure 3: EPOS CD-ROM

The latest edition of the software to the EPOS positioning controller may be downloaded from the internet under <u>http://www.maxonmotor.com</u> category <Service & Downloads>.

Minimum system requirements:

# Windows ME, Windows NT 4.0, Windows 2000, XP 486 processor, 128 MB RAM 200 MB free storage space on hard drive Screen resolution 1024 x 768 pixels at 256 colours

Follow the next instructions to install the whole software on your computer:

### 1. Insert CD-ROM

Insert the EPOS CD-ROM into the CD-ROM drive of your computer.

# 2. Start the installation program 'EPOS\_CD-ROM.exe'

Normally the installation program starts automatically after inserting EPOS CD-ROM. Alternatively, double click the item in the explorer to start the installation program 'EPOS\_CD-ROM.exe'

# 3. Follow the instructions during the installation program

Please read each instruction carefully. During the installation procedure you will be asked for a working directory. (Recommendation: C:\Programme\maxon motor EPOS CD-ROM)

### 4. Check the new shortcuts and items in the start menu

All necessary files are copies to the hard drive 'maxon motor EPOS CD-ROM' item allows accessibility to all 'Contents'. On the desktop, a new shortcut to the 'EPOS\_UserInterface.exe' will be added. Check the new shortcuts in the start menu and on the desktop.

# 5. Modify or remove the EPOS software

To change application features or to uninstall the EPOS software, start the installation program 'EPOS\_CD-ROM.exe' and follow the instructions.

# 6.2 Step 2: Minimum External Wiring

Select the correct EPOS 24/1 variant for minimum wiring:

- EPOS 24/1 order number 280937 see section <u>'6.2.1 EPOS 24/1 for maxon DC motor with integrated motor/encoder ribbon cable</u>'
- EPOS 24/1 order number 317270 see section <u>'6.2.2 EPOS 24/1 for maxon EC 6 motor with Hall sensor and digital MR-Encoder</u>'
- EPOS 24/1 order number 302267 see section '6.2.3 EPOS 24/1 for maxon EC16/EC22 motor with Hall sensor and digital Encoder'
- EPOS 24/1 order number 302287 see section <u>'6.2.4 EPOS 24/1 for maxon DC/EC motor (Molex connectors) with Hall sensor and digital Encoder</u>'

# 6.2.1 EPOS 24/1 for maxon DC motor with integrated motor/encoder ribbon cable

Next option allows hardware installation of EPOS 24/1 for maxon DC motor with integrated motor/encoder ribbon cable (Order No. 280937). Follow the steps and see also <u>figure 4</u>.

# 1. Power Supply Wiring

Connect the power supply (+9 ... +24 VDC) to the EPOS 24/1. The necessary output current is depending on load. (Continuous max. 1 A; acceleration, short-time max. 2 A)

Power SupplyEPOS 24/1 Screw TerminalsPower +Vcc (+9 ... +24 VDC)=> Connector J1 Pin number [13]Power\_Gnd=> Connector J1 Pin number [12]

**Note!** Make sure that the supply voltage is between +9 and +24 VDC. Voltages higher than +27 VDC or of wrong polarity will destroy the unit.

### 2. Connect the motor

Connect the DC-Motor connector to the connector J3 of the EPOS 24/1.

### 3. RS-232 Communication Lines Wiring

Connect the RS-232 communication lines to the EPOS 24/1.

PC Interface 9-pin D-Sub	EPOS 24/1 Screw Terminals
Pin 2 RxD =>	Connector J2 Pin number [4] RS-232 TxD
Pin 3 TxD =>	Connector J2 Pin number [3] RS-232 RxD
Pin 5 Gnd =>	<ul> <li>Connector J2 Pin number [5] Gnd</li> </ul>

Figure 4: Minimum wiring for DC-Motor with integrated motor/encoder ribbon cable

# 6.2.2 EPOS 24/1 for maxon EC 6 motor with Hall sensor and digital MR-Encoder

Install the EPOS 24/1 hardware. Use the maxon cable assemblies below for wiring.

You should have:

EPOS 24/1 positioning controller for

maxon EC 6 motor ..... order number 317270 EPOS cable (included in delivery of 317270) ...... order number 281074 EPOS adapter (included in delivery of 317270) ..... order number 317228

Follow the steps and see also figure 5.

### 1. Power supply wiring

Connect the power supply (+9 ... +24 VDC) to the EPOS 24/1. The necessary output current is depending on load. (Continuous max. 1 A; acceleration, short-time max. 2 A)

### Power Supply

Power Gnd

**EPOS 24/1 Screw Terminals** 

Power +Vcc (+9 ... +24 VDC) => Connector J1 Pin number [13] => Connector J1 Pin number [12]

Note! Make sure that the supply voltage is between +9 and +24 VDC. Voltages higher than +27 VDC or of wrong polarity will destroy the unit.

# 2. Connect maxon motor control Cable

Connect cable (Order No. 281074) to the connector J4 of the EPOS 24/1 (Order No. 317270). On the opposite side connect to the connector J5 of the adapter (Order No. 317228).

# 3. Connect the maxon EC 6 motor

Connect the EC 6 motor flex-print to the connector J7 of the adapter (Order No. 317228). Connect the EC 6 encoder flex-print to the connector J6 of the adapter (Order No. 317228).

### 4. RS-232 Communication Lines Wiring

Connect the RS-232 communication lines to the EPOS 24/1.

#### PC Interface 9-pin D-Sub **EPOS 24/1 Screw Terminals**

Pin 2 RxD	=> Connector J2 Pin number [4] RS-232 TxD
Pin 3 TxD	=> Connector J2 Pin number [3] RS-232 RxD
Pin 5 Gnd	=> Connector J2 Pin number [5] Gnd

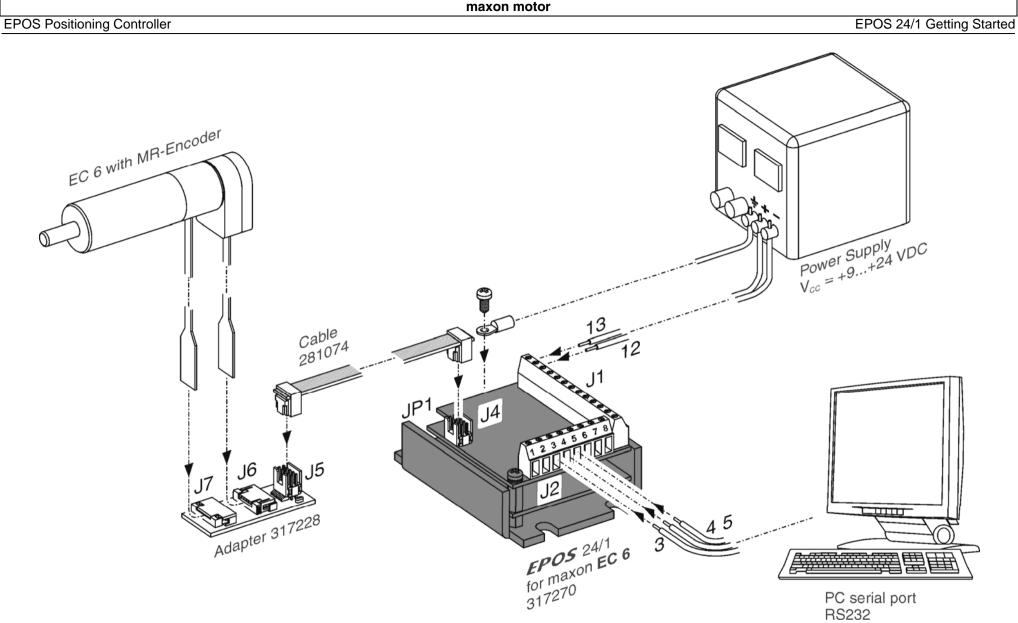


Figure 5: Minimum wiring for EC 6-Motor

	maxon motor
EPOS 24/1 Getting Started	EPOS Positioning Controller

# 6.2.3 EPOS 24/1 for maxon EC16/EC22 motor with Hall sensor and digital Encoder

Next option allows hardware installation of EPOS 24/1 for maxon EC16/EC22 motor (Order No. 302267).

Follow the steps and see also figure 6.

### 1. Power supply wiring

Connect the power supply (+9 ... +24 VDC) to the EPOS 24/1. The necessary output current is depending on load. (Continuous max. 1 A; acceleration, short-time max. 2 A)

Power SupplyEPOS 24/1 Screw TerminalsPower +Vcc (+9 ... +24 VDC)=> Connector J1 Pin number [13]Power\_Gnd=> Connector J1 Pin number [12]

**Note!** Make sure that the supply voltage is between +9 and +24 VDC. Voltages higher than +27 VDC or of wrong polarity will destroy the unit.

# 2. Connect the motor

Connect the EC motor cable to the connector J8 of the EPOS 24/1. Connect the EC encoder cable to the connector J9 of the EPOS 24/1. For extending motor encoder cable, EPOS encoder cable (Order No 275934) can be used.

# 3. RS-232 Communication Lines Wiring

Connect the RS-232 communication lines to the EPOS 24/1.

PC Interface 9-pin D-Sub	EPOS 24/1 Screw Terminals
Pin 2 RxD =>	Connector J2 Pin number [4] RS-232 TxD
Pin 3 TxD =>	Connector J2 Pin number [3] RS-232 RxD
Pin 5 Gnd =>	Connector J2 Pin number [5] Gnd

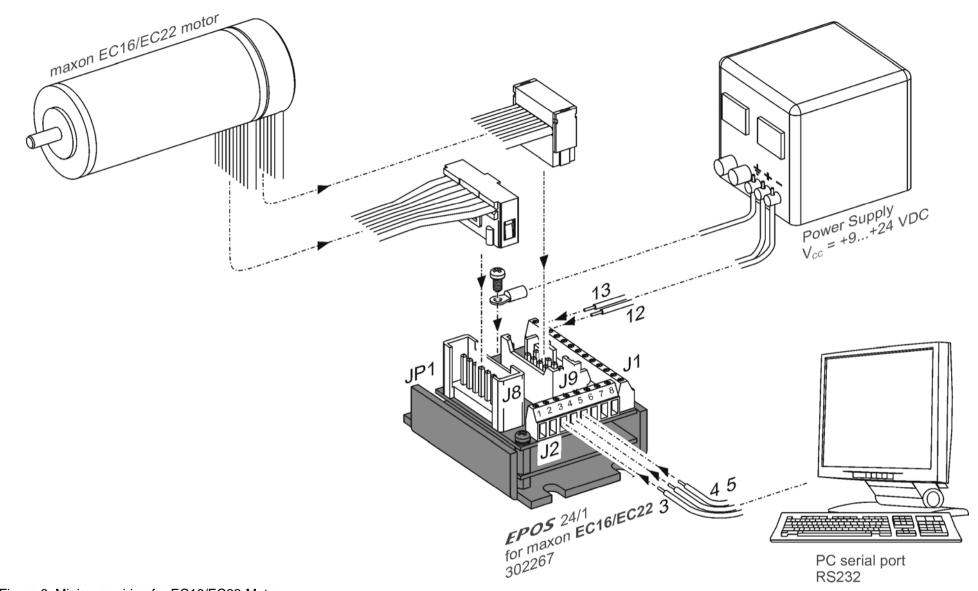


Figure 6: Minimum wiring for EC16/EC22-Motor

# 6.2.4 EPOS 24/1 for maxon DC/EC motor (Molex connectors) with Hall sensor and digital Encoder

Next option allows hardware installation of EPOS 24/1 for maxon DC/EC motor (Order No. 302287). Use the maxon cable assemblies below for wiring.

You should have:

EPOS 24/1 for maxon DC/EC motor ...... order number 302287 EPOS 24/1 EC motor / hall sensor cable (Connector J10)..... order number 302948 or EPOS 24/1 DC motor cable (Connector J10) ..... order number 303490 EPOS encoder cable (Connector J11) ..... order number 275934 EPOS RS232-COM cable (Connector J12) ...... order number 275900 EPOS signal cable (Connector J14) ...... order number 275932

Follow the steps and see also figure 7.

### 1. Power supply wiring

Connect the signal cable (Order No. 275932) to the connector J14 of the EPOS 24/1. On the opposite side connect the red/blue (+Vcc) line and the white/green (Gnd) line to terminal blocks. Connect a power supply (+9 ... +24 VDC) to the opposite side of the terminal blocks. The necessary output current is depending on load. (Continuous max. 1 A; acceleration, short-time max. 2 A)

**Note!** Make sure that the supply voltage is between +9 and +24 VDC. Voltages higher than +27 VDC or of wrong polarity will destroy the unit.

## 2. Connect the motor

### a. EC motor

Connect the EPOS 24/1 EC motor / hall sensor cable (Order No. 302948) to the connector J10 of the EPOS 24/1. On the opposite side connect to terminal blocks. Connect the motor Hall sensor and motor power lines to the opposite side of the terminal blocks.

# b. DC motor

Connect the EPOS 24/1 DC motor cable (Order No. 303490) to the connector J10 of the EPOS 24/1. On the opposite side connect to terminal blocks. Connect the motor power lines to the opposite side of the terminal blocks.

# 3. Connect EPOS encoder cable

Connect the encoder cable (Order No. 275934) to the connector J11 of the EPOS 24/1. On the opposite side connect to the encoder of the motor.

# 4. Connect EPOS RS232-COM cable

Connect the RS232-COM cable (Order No. 275900) to the connector J12 of the EPOS 24/1. On the opposite side connect to a free RS-232 port of your computer.

**Note!** If you do not use the maxon cables, you have to do the wiring using the 'EPOS 24/1 Cable Starting Set' manual.

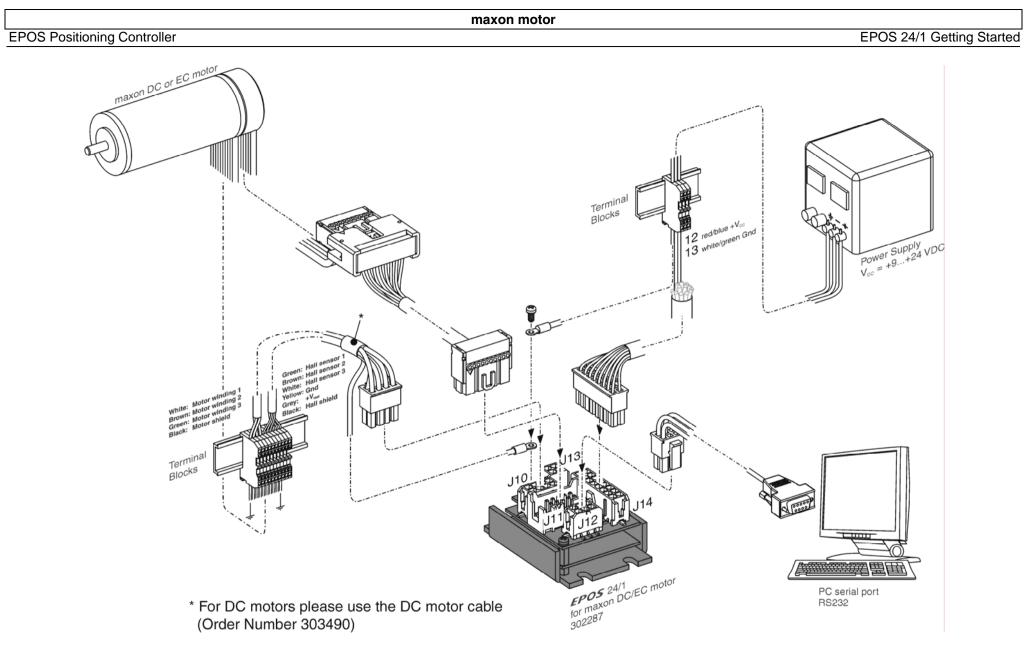


Figure 7: Minimum wiring for DC/EC-Motor with Molex connectors

	maxon motor
EPOS 24/1 Getting Started	EPOS Positioning Controller

# 6.3 Step 3: System Configuration

In this section you will configure the EPOS 24/1 for your drive system.

# Please note:

• The EPOS User Interface provides an online help. It contains all available documentation.

To open online help functions:

- press F1



- or click the right mouse button
- You have to know some technical data about your system. Use the maxon catalogue or the datasheets of the components used.

To configure your drive system:

# 1. Power-up

Switch on the EPOS 24/1 power supply.

2. Start the 'EPOS User Interface' Version 2.00 or higher

Double click on the item 'EPOS UserInterface.exe' on the desktop to start the graphical user interface (GUI). By starting the 'EPOS User Interface' the 'Startup Wizard' will be started automatically.

# 3. 'Startup Wizard' Step 1: Minimum External Wiring

- a) Verify that your hardware installation is correct. Please refer to chapter <u>'6.2 Step 2: Minimum External Wiring'</u>.
- b) If you have already read the 'Getting Started' document, click on the button 'Confirm that you've read the 'Getting Started' document'. Otherwise it is possible to display the document online by clicking on the button 'Show Getting Started'.

Startup Wizard		×
	Step 1: Minimum External Wiring! Please read the 'Getting Started' document for a correct hardware installation! Confirm that you've read the 'Getting Started' document! Show 'Getting Started' INFO: All documentations are available on the internet <a href="http://www.maxormotor.com">http://www.maxormotor.com</a> in the section 'Service'' as ''Download''.	
	< Zurtick Weiter > Abbrec	nen



c) Click on the button 'Weiter' for the next step.

## 4. 'Startup Wizard' Step 2: Communication Setting!

- a) Verify that your RS-232 wiring is correct. <sup>1</sup> Please refer to chapter <u>'6.2 Step 2: Minimum External Wiring'</u>.
- b) Click on the button 'Search Communication Setting' to search the used COM port and the adjusted baudrate automatically.

Startup Wizard		>
	Step 2: Communication Setting!	
	Select the correct communication settings!	
	Communication via 🔿 R\$232 or 🔿 CANopen	
	Interface RS232	
	Serial Port CDM1 🖃	
	Baudrate 38400 💌  😰	
http	NOTE: For a correct wiring of the communication have a look at the document "Getting Started"!	
		-
	<zurück weiter=""> Abbreche</zurück>	n

Figure 9: Startup wizard dialog for setting RS-232 communication

c) If a correct communication setting is found, the following dialog is displayed.

EPOS_Us	erInterface 🔀
i	Correct communication setting found!
V	Port: Com1 Baudrate: 38400 baud
	OK

Figure 10: Communication settings found

- d) Click on the 'OK' button to confirm and accept the values.
- e) Click on the button 'Weiter' for the next step.

# 5. 'Startup Wizard' Step 3: Motor Type

a) Select the used motor type.

Startup Wizard	[Node 1]	×
	Step 3: Motor Type Select the correct motor type I maxon DC motor maxon DC motor maxon EC motor maxon EC motor	
	< Zurück Weiter > Abbrech	ien

Figure 11: Startup wizard dialog for choosing motor type

b) Click on the button 'Weiter' for the next step.

<sup>&</sup>lt;sup>1</sup> It is also possible to run 'EPOS User Interface' via CANopen communication. In this case, a PC CAN- interface card from IXXAT or Vector has to be used. For correct wiring please see 'EPOS 24/1 Hardware Reference' document.

# EPOS 24/1 Getting Started

- 6. 'Startup Wizard' Step 4 for EC motors: Motor Pole Pair
- a) Select the correct number of pole pairs.

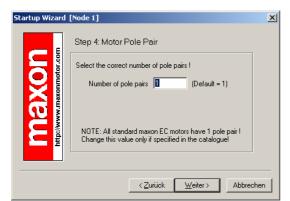


Figure 12: Startup wizard dialog for choosing EC motor pole pairs

b) Click on the button 'Weiter' for the next step.

# 7. 'Startup Wizard' Step 5 for EC motors: Motor Data

- a) Select the maximum permissible speed.
- b) Select the nominal current (maximum continuous current).
- c) Select the thermal time constant of the winding.

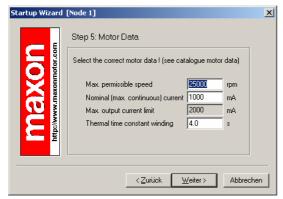


Figure 14: Startup wizard dialog for setting EC motor data

d) Click the button 'Weiter' for the next step.

# 6. 'Startup Wizard' Step 4 for DC motors: Motor Data

- a) Select the maximum permissible speed.
- b) Select the nominal current (maximum continuous current).
- c) Select the thermal time constant of the winding.

Startup Wizard	[Node 1]			x
	Step 4: Motor Data			
<b>C</b>	Select the correct motor data ! (see ca	italogue moto	data)	
	Max. permissible speed	25000	rpm	
i i i i i i i i i i i i i i i i i i i	Nominal (max. continuous) curren	1000	mA	
	Max. output current limit	2000	mA	
	Thermal time constant winding	4.0	s	
htt				
	< <u>Z</u> urück	Weiter >	Abbrech	nen

Figure 13: Startup wizard dialog for setting DC motor data

- d) Click on the button 'Weiter' for the next step.
- 7. 'Startup Wizard' Step 5 for DC motors: Position Sensor Type
- a) Select the used position sensor type

Startup Wizard	[Node 1]	×
Maxon http://www.maxonmotor.com	Step 5: Position Sensor Type Select the correct position sensor I  Sel	
	< <u>Z</u> urück <u>W</u> eiter> Abbrec	hen

Figure 15: Startup wizard dialog for choosing DC motor position sensor type

b) Click the button 'Weiter' for the next step.

- 8. 'Startup Wizard' Step 6 for EC motors: Position Sensor Type
- a) Select the used position sensor type

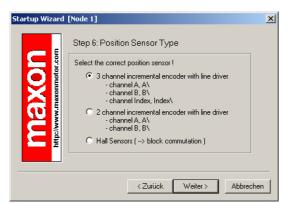


Figure 16: Startup wizard dialog for choosing EC motor position sensor type

- b) Click the button 'Weiter' for the next step.
- c) Important remarks for using Hall sensors: For a proper function of the regulation, please be aware of the following restrictions.

WARNING!	WARNING!	WARNING!	WARNING!
The option 'Hall Ser Only the following a			esolution!
Position Regulation Velocity Regulation Current Regulation	: Velocity hig	her than 1000 i	le pairs and higher) pm (1 pole pair motors)

Figure 17: Recommendations for using Hall sensors as position sensors

d) Please consider this warning carefully before clicking the 'Accept' button for the next step.

- 8. 'Startup Wizard' Step 6 for DC motors: Position Resolution
- a) Enter the resolution of the used encoder

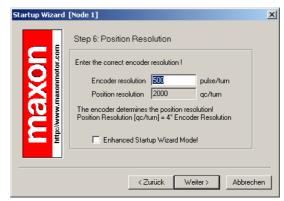


Figure 18: Startup wizard dialog for setting DC motor encoder resolution

b) Click the button 'Weiter' for the next step.

### 9. 'Startup Wizard' Step 7 for EC motors: Position Resolution

a) Enter the resolution of the used encoder

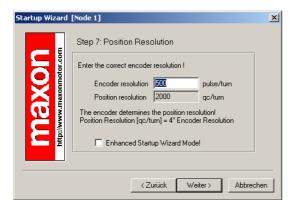


Figure 19: Startup wizard dialog for setting EC motor encoder resolution

b) Click the button 'Weiter' for the next step.

## 9. 'Startup Wizard' Step 7 for DC motors: Summary

- a) A short summary of the most important configuration values is displayed in this window.
- b) If there are any mistakes in the configuration, you can go back and modify the values by clicking on the button 'Zurück'.
- c) If you will not start the startup wizard at the beginning of every EPOS user interface session, you have to deselect the option 'Always start this wizard after program start'.

Startup Wizard	[Node 1]	×
	Step 7: Summary	
	Now you have configured the EPDS I RS232 Baudrate 38400 baud Motor Type maxon DC motor Position Sensor Type 3 channel incremental encoder Position Resolution 2000 qc/turn Always start this wizard after program start.	
	< Zurück Fertig stellen Abbrech	en l

Figure 20: Startup wizard configuration summary

d) If all settings are correct, click the button 'Fertig stellen' to close the startup wizard.

- 10. 'Startup Wizard' Step 8 for EC motors: Summary
- A short summary of the most important configuration values is displayed in this window.
- b) If there are any mistakes in the configuration, you can go back and modify the values by clicking on the button 'Zurück'.
- c) If you will not start the startup wizard at the beginning of every EPOS user interface session, you have to deselect the option 'Always start this wizard after program start'.

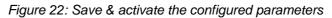


Figure 21: Startup wizard dialog for setting EC motor encoder resolution

d) If all settings are correct, click the button 'Fertig stellen' to close the startup wizard.

# 11. Save and activate parameters





a) Click the button 'Yes' to accept the parameters.



Figure 23: Confirm parameter activation

b) Confirm by clicking the 'OK' button.

## 12. Clear CAN error

Now, the object dictionary will be loaded. In case of not connected CAN communication, the error 'CAN in Error Passive Mode' appears.<sup>1</sup>

a) Click on button 'Clear Errors' to clear the error 'CAN in Passive Error Mode'.

Wizards	Command Ar	nahser					
B	Velocity Mode	Curre	nt Mode Master Encoder Mode	Step Direction Mode	D	ataRecording I/O Monitor	1
P	Object Dictio	_	Device Control Profile Position N	tode Homing Mode	Pro	file Velocity Mode Position	Mode
lartup Wizard							
1000	1	1912		123317	rnor		
1	Objec	t Diction	nary Access	The a	eros	📕 is in fault state 🔤	-
Promotion in the local division of the local	Concession of						
gulation Tuning					Antine	e Object Filter System Parameter	_
-		1	1	112	1.0000		
C3	Index	Subindes	Name	Type	Access		100
<b>N</b>	0x6005	0.60	Max Following Error	Uint32	RW	2000	
ware Download	0x60F6	0x01	Current Regulator P-Gain	Int16	RW	400	
Wgard	0.6076	0x02	Current Regulator I-Gain	Int16	BW	200	
	0x60F9	0x01	Speed Regulator P-Gain	Int16	EW.	400	
	0x60F9	0.02	Speed Regulator I-Gain	Int16	EW.	100	
_Y	0x60FB	0x01	Position Regulator P-Gain	Int16	BW.	150	
~~	0x60FB	0x02	Position Begulator I-Gain	Int16	EW.	10	
Configuration	0.60FB	0.03	Position Regulator D-Gain	Int16	EW	200	
Wizard	D-60FB	0.04	Velocity Feedforward Factor	Lint16	EW.	0	
	Diff. B	0.65	Acceleration Feedforward Factor	Unt16	EW.	0	
	0.6 12	0x00	MotorType	Ulnt16	EW.	10	
	0.640	0x01	Continuous Current Limit	Uint6	EW	1000	
Parameter	0.60	0.02	Output Current Limit	Ulo(15	EW.	2000	
xport/Import	0.6-0	0.03	PolePair Number	Uni8	BW	1	
Appending on	0.6-0	0.03	Maximal Speed in CurrentMode	Unt16	EW.	30000	
<b>A</b>	0.6-0	0:04	Themal Time Constant Winding	Untits	EW	40	
	0.211	0x00			EW.	0	
0	0.2 1		CAN Bitrate	Uint16	EW.	3	
gnostic Wizard		0.00	R5232 Baudrate	Ulnt16		3	
	0.208	0.60	Miscellaneous Configuration	Uint16	RW		
	- 0.2.10	0x01	Encoder Pulse Number	Uint16	RW	500	
# 🖁	0x210	0x02	Position Sensor Type	Uint16	EW.	.1	
4 <u></u>							_
Nocen Wizard	1 ERF. FOL	JNDI Connec	ted EPOS: Set 11 10000 11	duare//ersion: 0x6010 AppN	mber: 0x0	000 AppVersion: 0x0000	
TOPOTI TRADA		1		cription			_
	Clear Errors	1010		In Error Passive Mode			

Figure 24: Clear CAN error

- b) If other errors occurred, please check wiring and startup configuration. For more information's about errors, refer to EPOS firmware documentation.
- c) Your EPOS is now ready for regulation gains tuning.

<sup>&</sup>lt;sup>1</sup> If the 'EPOS User Interface' is communicating via CANopen, this error will not appear.

# 6.4 Step 4: Regulation Gains Tuning

The EPOS 24/1 offers a possibility to perform auto-tuning of the regulation gains. You can tune the current, velocity and position gains on the regulators. The auto-tuning function is a good help, but optimal regulation parameters can't be guaranteed. The auto-tuning is a good starting point for a manual tuning.

The following procedure is recommended for the tuning of the regulation gains.

# 6.4.1 Start the Auto-tuning Tool

a) In the EPOS user interface, double click the button 'Regulation Tuning' to start the auto-tuning tool.

Object Dictionary         Device Costrol         Profile Roution Mode         Profile Value	Viards	Command Ar	10/60011					
Object Dictionary Access         The EPOS in deaded           Index Statings         Name         Type         Active Object File         System Para           Index Statings         Index	📲 L	Velocity Mode			Step Direction Mode	_		UO Monikor
Index         Subinder         Name         Type         Access         Value           be005         0.000         Mediation         Unit2         FW 2000         Mediation	tun afgard	Object Dictio	nary (	Device Control Profile Position Mode	Poming Mode	Profil	le Velocity Mode	Position Mo
Active Object Filter         System Param           Index         Subindex         Name         Type         Active Object Filter         System Param           Weard         0x0055         0x00         Mod Following Ener         Unr022         Rvw         2000           Weard         0x0055         0x00         Mod Following Ener         Unr022         Rvw         2000           Weard         0x0055         0x00         Speed Regulate P Gain         Hr16         Rvw         200           System         0x0059         0x01         Speed Regulate P Gain         Hr16         Rvw         200           Ward         0x0079         0x01         Speed Regulate P Gain         Hr16         Rvw         100           0x0079         0x019         0x019         Postion Regulater I Gain         Hr16         Rvw         10           0x0199         0x019         Postion Regulater I Gain         Hr16         Rvw         10         0x019           0x0190         0x019         Postion Regulater I Gain         Hr16         Rvw         10         0x019         0x0116         0x01         0x0116         0x01         0x0116         0x01         0x01         0x01         0x01         0x0116         0x01		Objec	t Diction	hary Access		POS	in disabled	<b>.</b>
No.         Devided         Deficiency         Unrd2         Hww         2000           Ward         Deficiency	aton Tuning					Active (	Object Filter System	Parameter
Deveload View         DefD/I6 bit 000         0.01         Dument Register PGan         Int/I6 bit 000         Prove 200           Image: Stand Stand Stand View         0.0000         Speed Register PGan         Int/I6 bit 000         Prove 200           Image: Stand Stand Stand View         0.0000         Speed Register PGan         Int/I6 bit 000         Prove 200           Image: Stand Stand Stand View         0.0000         Speed Register PGan         Int/I6 bit 000         Prove 200           Image: Stand Stand Stand View         0.0000         Postion Register PGan         Int/I6 bit 000         Prove 200           Image: Stand Stand Stand View         0.0000         Postion Register PGan         Int/I6 bit 000         Prove 200           Image: Stand Stand Stand Stand Stand Stand View         0.0000         Postion Register PGan Postion Register PGan Stand Stand Stand Stand View         Int/I6 bit 00         Prove 200           Image: Stand Stand Stand Stand Stand Stand View         0.0000         Continues Content Lint         Uint/I6 bit 00         Prove 2000           Image: Stand Stand Stand Stand Content Lint         Uint/I6 bit 00         Prove 2000         DefD/IF bit 00         Postin 000           Image: Stand Stand Stand Content Lint         Uint/I6 bit 00         Postin 000         DefD/IF bit 00         DefD/IF bit 000         DefD/IF bit 00         DefD/IF bit		Index	Subindex	Neme	Type	Access	Value	
Videod         Initia         PW 200           Image: State of the s	<u> </u>	0x60055	0.400	Max Following Error	Uint32	BW	2000	
Wead         D.66/F6         Du/D         Convert Regulator I Gain         Int16         FW         200           Image: State of the st	re Download	0x60F6	0x01	Current Regulator P-Gain	Int16	EW.	400	
Specific solar         Inflig         FW         100           OpSUP9         0402         Specific solar         Inflig         FW         100           Configuration         0407         Probine Replacer Feah         Inflig         FW         100           Configuration         0407         Probine Replacer Feah         Inflig         FW         100           ObSUP9         0402         Probine Replacer Feah         Inflig         FW         100           ObSUP9         0402         Probine Replacer Josan         Lintis         FW         100           ObSUP9         0402         Probine Replacer Josan         Lintis         FW         200           ObSUP9         0404         Velocity Feedbowed Factor         Uint15         FW         0           0-06410         0407         Continuous Cheres Linit         Uint15         FW         100           0-06410         0407         Continuous Cheres Linit         Uint15         FW         1000           0-06410         0407         Continuous Cheres Linit         Uint15         FW         1000           0-06410         0404         Monal Specific Cuentritide         Uint16         FW         20000           0-06410				Current Regulator I-Gain	Int16		200	
Viscal         DisGRPB         Out?         Position Regulator / Gain         Int16         FW         190           Configuration         DisGRPB         Out2         Position Regulator / Gain         Int16         FW         100           Configuration         DisGRPB         Out2         Position Regulator / Gain         Int16         FW         100           ObsGRPB         Out2         Position Regulator / Gain         Int16         FW         200           ObsGRPB         Out2         Position Regulator / Gain         Int16         FW         200           ObsGRPB         Out2         Position Regulator / Gain         Int16         FW         0           ObsGRPB         Out2         Out2         Position Regulator / Gain         Unit16         FW         0           ObsGRPB         Out0         Accelerator Feedforward Factor         Unit16         FW         0           ObsGRPB         Out0         Out0         Continuum Current Intri         Unit16         FW         0           ObsGRPB         Out0         Out0         Continuum Current Intri         Unit16         FW         1000           ObsGRPB         Out0         Out0         Out17         Out0         Unit16         FW <td></td> <td>- 0.60F9</td> <td></td> <td></td> <td>Int16</td> <td></td> <td></td> <td></td>		- 0.60F9			Int16			
Conjectation Ward         DiSIPE DeSIRE         Dod/2         Position Regulator / Gain         Int16         R/W         10           DiSIPE Ward         DiSIPE DeSIRE         Dod/2         Position Regulator / D-Gain         Int16         R/W         200           DiSIPE DeSIRE         Dod/2         Velocity Feedbowed Factor         Uint16         R/W         0           DiSIPE DeSIRE         Dod/2         Dod/3         Model/2         Unint16         R/W         0           DiSIPE DeSIRE         Dod/2         Dod/3         Model/2         Unint16         R/W         0           DiSIPE Desire         Dod/2         Dod/3         Model/2         Unint16         R/W         1000           DiSIPE Desire         Disition         Dod/3         Dod/a         Limit16         R/W         2000           DiSIPE Desire         Disition         Dod/3         Polyan Current Limit         Unint16         R/W         2000           Disition         Disition         Disition         Disition         Disition         R/W         20000           Disition         Disition         Disition         Disition         Disition         Disition         R/W         20000           Disition         Disition	<b>a</b> I				Int/16			
Configuation         DeSCRP         DeSCRP <thdescrp< th=""> <thdescrp< th=""> <thdesc< td=""><td>-Y  </td><td>0x60FB</td><td></td><td>Position Regulator P-Gain</td><td>Int16</td><td>BW</td><td>150</td><td></td></thdesc<></thdescrp<></thdescrp<>	-Y	0x60FB		Position Regulator P-Gain	Int16	BW	150	
World         D0807B         D0807B </td <td>~</td> <td></td> <td></td> <td></td> <td>Int16</td> <td></td> <td></td> <td></td>	~				Int16			
DeG/PB         DeG/PB <thdeg pb<="" th=""> <thdeg pb<="" th=""> <thdeg pb<="" td="" th<=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></thdeg></thdeg></thdeg>								
Image: Constraint Constaint Constaint Constraint Constraint Constraint Constraint Const	weard	0x60FB		Velocity Feedlorward Factor	Ulrit16			
Image: Control (Control (Contro) (Contro) (Control (Control (Control (Control (Control (Control (								
Vermeter         D.6410         D.4/2         D.4/2 <thd.4 2<="" th="">         D.4/2         D.4/2</thd.4>								
Op/Almoint         0x6410         0x63         PolePair Number         Uint8         FW         1           0x6410         0x6410         0x644         Marmal Speech in Current/Hode         Uint16         FW         30000           0x6410         0x645         0x645         Uint16         FW         40           0x6410         0x645         CeVe Binate         Uint16         FW         40           0x4001         0x600         CeVe Binate         Uint16         FW         0	K 2							
Operation         Operation <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td>2000</td><td></td></t<>							2000	
0x6410         0x65         Themal Time Constant Winding         Uint16         FW         40           0x2001         0x00         CAN Bitrate         Uint16         FW         0	cont/limport						1	
0x2001 0x00 CAN Bitrate Uint16 FW 0	<u> </u>							
	0							
	<u>∽</u>							
	ostic Wigard	0x2002	0.400	RS232 Baudrate	Uint16	RW	3	
0x2008 0x00 Miscelaneous Configuration UInt16 FW 0								
0x2210 0x01 Encoder Pulse Number Ulix16 FW 500							500	
Could Decision Sensor Type     Unx16 FW 1		0x2210	0x02	Position Sensor Type	Uint16	EW	. 1	
Commercial NO ERROR Connected EPOS: SoftwareVersion: 0x2022 HardwareVersion: 0x6010 AppNumber: 0x0000 AppVersion: 0x0000	-eee	10 5000			Version: 0.6010 Anoth	mbure 0.00	00 Analiseties: 040	000

Figure 25: Start regulation tuning

# 6.4.2 Auto-tuning of the Current Regulator

EPOS 24/1 Getting Started

In a first step, tune the current regulator.

a) Leave all settings to default values.

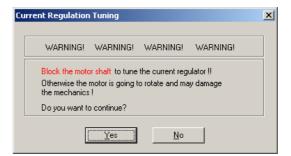
lation Tuning [No	ode 1]						
Regulator to Tube Performance Index Step Type Current Step	Current Step	inor)	rhanced	Cum	ent Step	Current Regulator	Encoder
The <b>EPOS</b>	is disabled !		G		💠 🔄 🗸 🎯	Tuning Mode	uto Tuning 💌
Performance	Index P-Gain	I-Gain		Auto	Name	Value	Delta
1 41	Traden	- drawn			Proportional Gain	400	0
Tuning History					Integral Gain	200	0
			<u>C</u> lose Regula	tion Tunin	e l		

Figure 26: Auto-tuning of current regulator



Figure 27: Auto-tuning button

- b) Click on 'Start Tuning' button to start the auto-tuning.
- c) Block the motor shaft continuously until current regulator autotuning is finished.



*Figure 28: Confirm motor shaft blocking*d) Confirm by clicking on 'Yes' button.

December 2008 Edition / document number 573049-09 / subject to change

**EPOS Positioning Controller** 

e) Now, auto-tuning will start. It is searching suitable regulation gains for current regulation mode automatically. This procedure can take a few minutes. All tuning steps will be displayed for further analysis.

E	nd of Regulation Tuning	x
	End of Regulation Tuning	_
	If the new regulation gains do not meet your regulation requirements, the tuning has to be repeated!	
	Do you want to restart the regulation tuning?	
	Yes No	

Figure 29: Confirm end of tuning

- f) Confirm the end of tuning by clicking on 'No' button.
- g) If an error occurs and the auto-tuning will not start, please confirm and clear the error. Next adjust the starting parameters by referring to chapter <u>6.4.5 'Manual Tuning'</u>. Afterwards start the auto-tuning again.

EPO5_Us	erInterface	×
♪	Device is in Fault St	ate!
	OK	

Figure 30: Confirm tuning error

			/
The <b>EPOS</b> is disabled !	Error Found! Fault State	₿×	- TI

Figure 31: Clear tuning error

maxon motor	
EPOS 24/1 Getting Started	EPOS Positioning Controller

# 6.4.3 Auto-tuning of the Velocity Regulator

Now tune the velocity regulator.

- a) Select the menu item 'Velocity Regulator' in the menu 'Regulator to Tune'.
- b) Leave all other settings to default values.

ation Tuning [Node 1]		
Regulator to Tune Pediotry Hegulator Pediotmanophidex Contern Regulator Contern Regulator Pediotin Regulator Pediotin Velocity Step Profile Velocity Step 1000 rpm Enhan	Profile Generation	Regulator Regulator
The <b>EPOS</b> _ is disabled !	Next Evaluation Setting	ng Mode 🗛 Auto Tuning 💌
Performance Index P-Gain I-Gain	Auto Name	Value Delta
Contraction in a contraction of the contraction of	Proportional Gain	400 0
uning History	☑ Integral Gain	100 0
	Friday	

Figure 32: Auto-tuning of velocity regulator



Figure 33: Auto-tuning button

- c) Click on 'Start Tuning' button to start the auto-tuning.
- d) Be sure the motor shaft is free running.

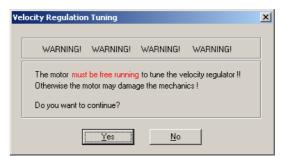


Figure 34: Confirm free running of motore) Confirm by clicking on 'Yes' button.

f) Now, auto-tuning will start. It is searching suitable regulation gains for velocity regulation mode automatically. This procedure can take a few minutes. During this procedure the motor is performing some rotations to both directions. All tuning steps will be displayed and recorded for further analysis.

End of Regulation Tuning	×
End of Regulation Tuning	
If the new regulation gains do not meet your regulation requirements, the tuning has to be repeated!	
Do you want to restart the regulation tuning?	
Yes No	

Figure 35: Confirm end of tuning

- g) Confirm the end of tuning by clicking on 'No' button.
- h) If an error occurs and the auto-tuning will not start, please confirm and clear the error. Next adjust the starting parameters by referring to chapter <u>6.4.5 'Manual Tuning'</u>. Afterwards start the auto-tuning again.



Figure 36: Confirm tuning error

			/
The <b>EPOS</b> is disabled!	Error Found! Fault State	<b>₽</b> ×	ন্থা

Figure 37: Clear tuning error

ma	xon motor
EPOS 24/1 Getting Started	EPOS Positioning Controller

#### Auto-tuning of the Position Regulator 6.4.4

Now tune the position regulator.

a) Select the menu item 'Position Regulator' in the menu 'Regulator to Tune'.

٦

b) Leave all other settings to default values.

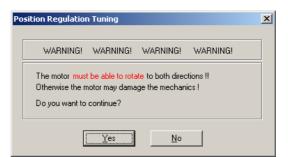
Iation Tuning [Node 1] Regulator to Tune Position Regulator Performance Indue Velocity Regulator Velocity Regulator	Profe	Generator	on Current Regulator	
Step Type Position Regulation Profile Position Step Profile Position Step Profile Position Step				Encoder
The <b>EPOS</b> is disabled		⇔   ⇔   →   ⊛	Tuning Mode Auto	Turing 💌
Performance Index P-Gain I-Gain D-Gain			Value	Delta
renormance moex r-gain I-gain U-gain		Proportional Gain	150	0
		Integral Gain	10	0
Funing History		Differential Gain	200	0
	a hand a sain and an a hand a sain and a sain and a sain a hand a sain a hand a sain a hand a sain a hand a sain			
Performance Index Variation: 0.48%	- Ē	. <b>ii</b> i		.ii.i.i
Close	e Regulation Tunin			

Figure 38: Auto-tuning of position regulator



Figure 39: Auto-tuning button

- c) Click on 'Start Tuning' button to start the auto-tuning.
- d) Be sure the motor shaft is free running.



- Figure 40: Confirm free running of motor
- e) Confirm by clicking on 'Yes' button.

f) Now, auto-tuning will start. It is searching suitable regulation gains for position regulation mode automatically. This procedure can take a few minutes. During this procedure the motor is performing some rotations to both directions. All tuning steps will be displayed and recorded for further analysis.

End of Regulation Tuning	×
End of Regulation Tuning	
If the new regulation gains do not meet your regulation requirements, the tuning has to be repeated!	
Do you want to restart the regulation tuning?	
Yes <u>No</u>	_

Figure 41: Confirm end of tuning

- g) Confirm the end of tuning by clicking on 'No' button.
- h) If an error occurs and the auto-tuning will not start, please confirm and clear the error. Next adjust the starting parameters by referring to chapter <u>6.4.5 'Manual Tuning'</u>. Afterwards start the auto-tuning again.

EPO5_Us	erInterface 🛛 🗙	1
♪	Device is in Fault State!	
	OK	

Figure 42: Confirm tuning error

			/
The <b>EPOS</b> is disabled !	Error Found! Fault State	<b>₽</b> ×	- TI

Figure 43: Clear tuning error

# 6.4.5 Manual Tuning

EPOS 24/1 Getting Started

If the auto-tuning shows an error or the result of the auto-tuning is not sufficient, you have to tune the appropriate regulator manually. You have to start an iterative search of the regulation gains. Change the system parameters manually, start a single step movement and check the recorded data.

Follow the next instructions:

a) Choose the 'Manual Tuning' mode in the regulation tuning screen and start the tuning.



Figure 44: Manual tuning mode

b) Go to the 'Next Evaluation Setting' and change the regulation gains of the appropriate regulator.

out Fu	aluation Setting		
Auto	Name	Value	Delta
2	Proportional Gain	150	0
~	Integral Gain	100	0
~	Differential Gain	200	0

Figure 45: Manual tuning mode

### Hints:

Start values for current and velocity regulator are normally not difficult to find.

For positioning regulator, following rule of thumb will be helpful:

**Start values:** 'Integral Gain' = 0 'Proportional Gain' = 2 x 'Differential Gain'

**Overshoot:** Reduce the 'Proportional Gain' or increase the 'Differential Gain'.

Position Error: Increase the 'Proportional Gain' and the 'Differential Gain'.

**Integral Gain:** Adjust the 'Integral Gain' at the end, if the other two gains are optimized. Increase the 'Integral Gain' until the static position error is small enough.

c) Start a new movement and judge the recorded data.



Nevr Evaluation Setting

Figure 46: Next tuning step

d) Repeat this iteration until all regulation gains are optimized.

# 6.4.6 Save all Regulation Gains

All the regulation gains found by the auto-tuning are stored locally (on your PC) up to now. To take effect permanently you have to store the values on the EPOS.



Figure 47: Save button

a) Click on 'Save button' to save regulation gains.

EPO5_UserInterface						
Do you really want to save the regulation gains						
	<u>la</u> <u>N</u> ein					

Figure 48: Confirm regulation gains saving

b) Confirm the saving of regulation gains by clicking on 'Ja' button.

EPOS_Us	erInterface 🛛 🗙	1
⚠	All Parameters are saved!	
	ОК	

Figure 49: Confirm saving of all parameters

c) Confirm saving of all parameters by clicking on 'OK' button.

# 7 Conclusion

Now the EPOS 24/1 is ready for operation in one of the supported regulation modes!

For further settings and more detailed information's, use online help by pressing F1 or refer to the <u>EPOS 24/1 documentation</u>.