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User Manual

MAC Motors generation III
Integrated Servo Motors

MAC404, 604, 802, 804, 1004, 1202, 1403, 1404
Including options



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Important
User Information



Warning



The MAC series of products are used to control electrical and mechanical components of motion control systems.
You should test your motion system for safety under all potential conditions. Failure to do so can result in damage to equipment and/or serious injury to personnel.

Please contact your nearest JVL representative in case of technical assistance. Your nearest contact can be found on our web site www.jvl.dk

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1 Introduction 3
1.1 Features 4
1.2 Overall description 5
2 Installation 11
2.1 Connector Overview 12
2.2 Status indicators 22
2.3 Power Supply 27
2.4 Control Power Supply 35
2.5 User I/O 36
2.6 Analogue Inputs 41
2.7 User Outputs 44
2.8 Communication interface 47
2.9 EMC considerations 55
3 Basic Motor Operation 59
3.1 Mechanical Homing 60
3.2 Electro Mechanical brake 70
3.3 Invert rotation direction 73
3.4 Rotary table option 74
3.5 Absolute Multi-Turn Encoder 80
3.6 8000-PPR encoder emulation 87
4 Drive Modes 89
4.1 Register units and conversions 90
4.2 Passive mode 91
4.3 Velocity mode 92
4.4 Position mode 94
4.5 Gear Mode 96
4.6 Gear Follow mode 100
4.7 Analogue Velocity mode 102
4.8 Analogue Velocity with dead-band 104
4.9 Analogue Velocity/Gear mode 106
4.10 Velocity-limited Analogue Torque 108
4.11 Analogue Torque mode 110
4.12 Analogue Gear mode 112
4.13 Coil Mode 114
4.14 Analogue bi-position mode 118
4.15 Analogue to Position mode 120
5 Servo Tuning and Motion Performance 123
5.1 Servo filter adjustment 124
5.2 Clear filters on mode change 133
5.3 How to monitor motor torque and load 134
5.4 Advanced 136
6 Inputs and Outputs 145
6.1 Multifunction I/O terminal type 146
6.2 External encoder input filter 147
6.3 Invert external encoder direction 148
6.4 Position capture on analogue input 149
6.5 Fix position capture sample point 150
6.6 Error output: position compare 151
6.7 Dedicated I/O 152
7 Safety, Diagnostics and Error Handling 155
7.1 Error messages and error handling 156
7.2 Safe Torque Off (STO) 174
7.3 Undervoltage Handling 176
7.4 Auto-restart after STO or supply loss 178
7.5 Delayed supply acceptance at startup 179
7.6 Dynamic braking in Passive mode 180
7.7 Active braking on error 181

8 Industrial Ethernet 183
8.1 Industrial Ethernet 184
9 MacTalk Setup Software 185
9.1 Installation of MacTalk 186
9.2 Using MacTalk to setup the motor 190
9.3 MacTalk Scope usage 199
9.4 Message Center 205
9.5 ePLC usage 206
9.6 How to update the motor firmware 230
10 Appendix 231
10.1 Technical Data 232
10.2 Torque Performance Curves 236
10.3 Physical dimensions 240
10.4 Installation Instructions 243
10.5 Emergency stop considerations 247
10.6 Trouble-shooting guide 253
10.7 Registers 254
10.8 Accessories 256
10.9 Vibration and shock certificates 257
10.10 CE Declaration of Conformity 259
10.11 UL Certificate of Compliance 261

1 Introduction

This user manual covers the newest **MAC motor generation III** from JVL.
The motors covered in this user manual are:

MAC404
MAC604
MAC802
MAC804
MAC1004
MAC1202
MAC1403
MAC1404

Please note that this user manual DOES NOT cover the previous MAC motor generations I and II.

1.1 Features



The MAC series of brushless servo motors with integrated electronics represents a major step forward in motion control systems. All of the necessary electronics for a servo system are integrated into the motor itself.
Traditional motor systems typically have the controller and drive electronics placed some distance away from the motor. This increases machine costs and has the negative effect that installation time and costs are a major part of the total expense of building machinery.
The basic idea of the MAC motor is to minimise these costs, but also to make a component that is much better protected against electrical noise which can be a typical problem when using long cables between a controller and motor.
All user inputs and outputs are filtered, which means that the MAC motors will work properly even in an environment with a high level of electrical noise.

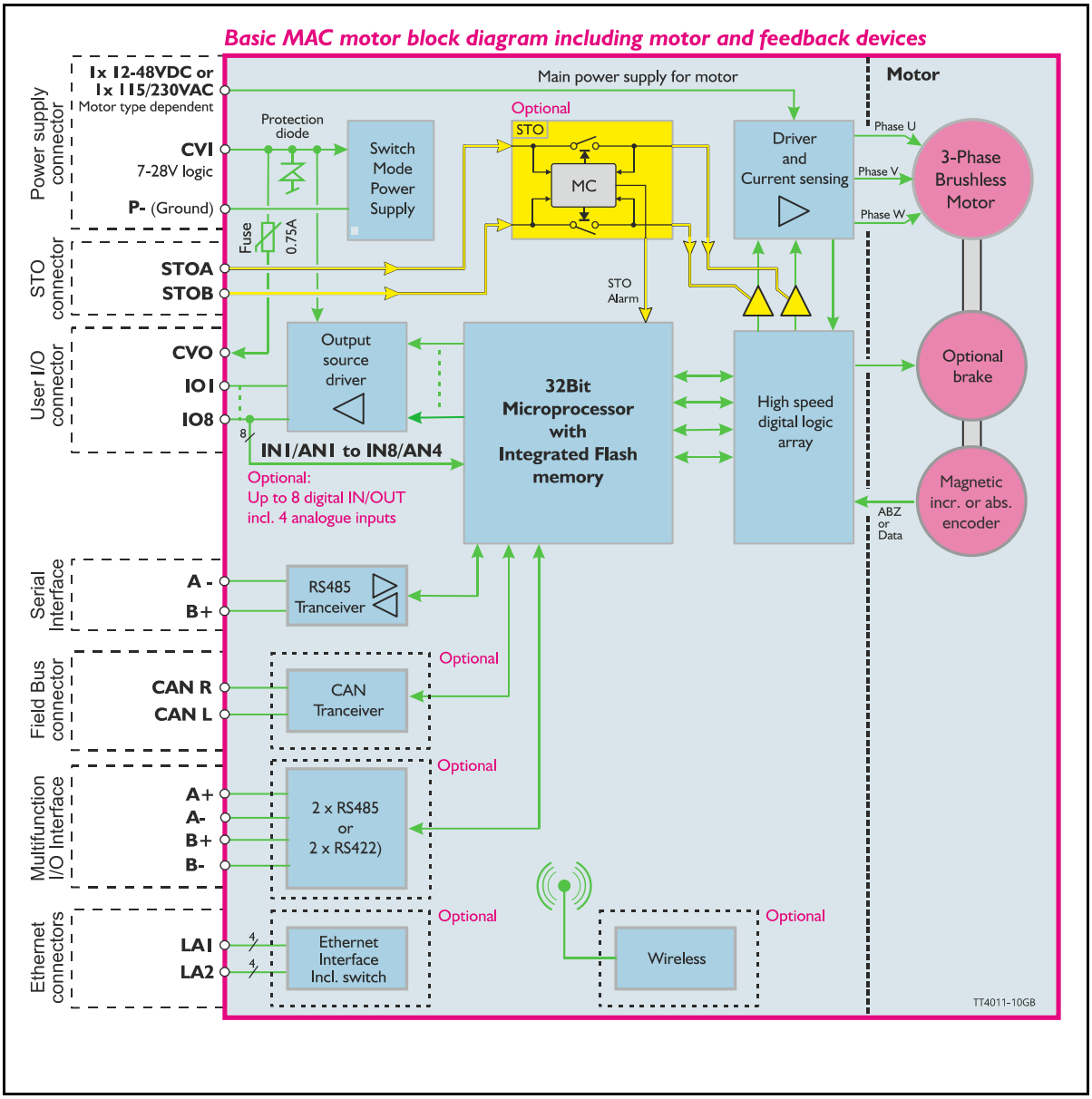
The major advantages are:

- Lower installation costs
- Faster installation
- Quiet and maintenance-free operation
- Replacement for pneumatic solutions
- Replacement for step motors, offering much faster response
- Great flexibility due to many I/O possibilities and many functions.
- Less machine space required.
- Smaller risk of wiring errors.

Main Features:

- Wide variety of connectivity:
  - Industrial Ethernet - 4 protocols
  - CANopen® (planned)
  - ePLC w/graphic programming
  - Custom designed interfaces on request
- Pulse and direction inputs make it possible to replace step motors.
- Quadrature input for gearing applications.
- 0-5V input for controlling speed and torque (0-10V from hardware revision 0.7)
- 2 ch. Quadrature output to master controller when used as driver.
- Accepts position and velocity commands sent via RS485 interface.
- Wide supply voltage range AC or DC
  - DC supplied: 12-48VDC nominal
  - AC supplied: 115 or 230 VAC, 47-63 Hz
- Excellent efficiency compared to step motors.
- IP55 as standard and IP66 also available
- Low cost and high performance make the MAC series ideal for high-volume applications
- Outputs for *In position* and *Error* indication.
- High order digital filter which only needs a single inertia adjustment.
- Standard PAM60 and PAM80 flanges.
- Absolute Multi Turn feedback (optional).
- Easy and simple Windows program - MacTalk available for installation/setup.
- High-efficiency power stage keeps temperature at a low level.
- CE approved. UL pending.

1.2 Overall description



1.2.1 Internal function overview

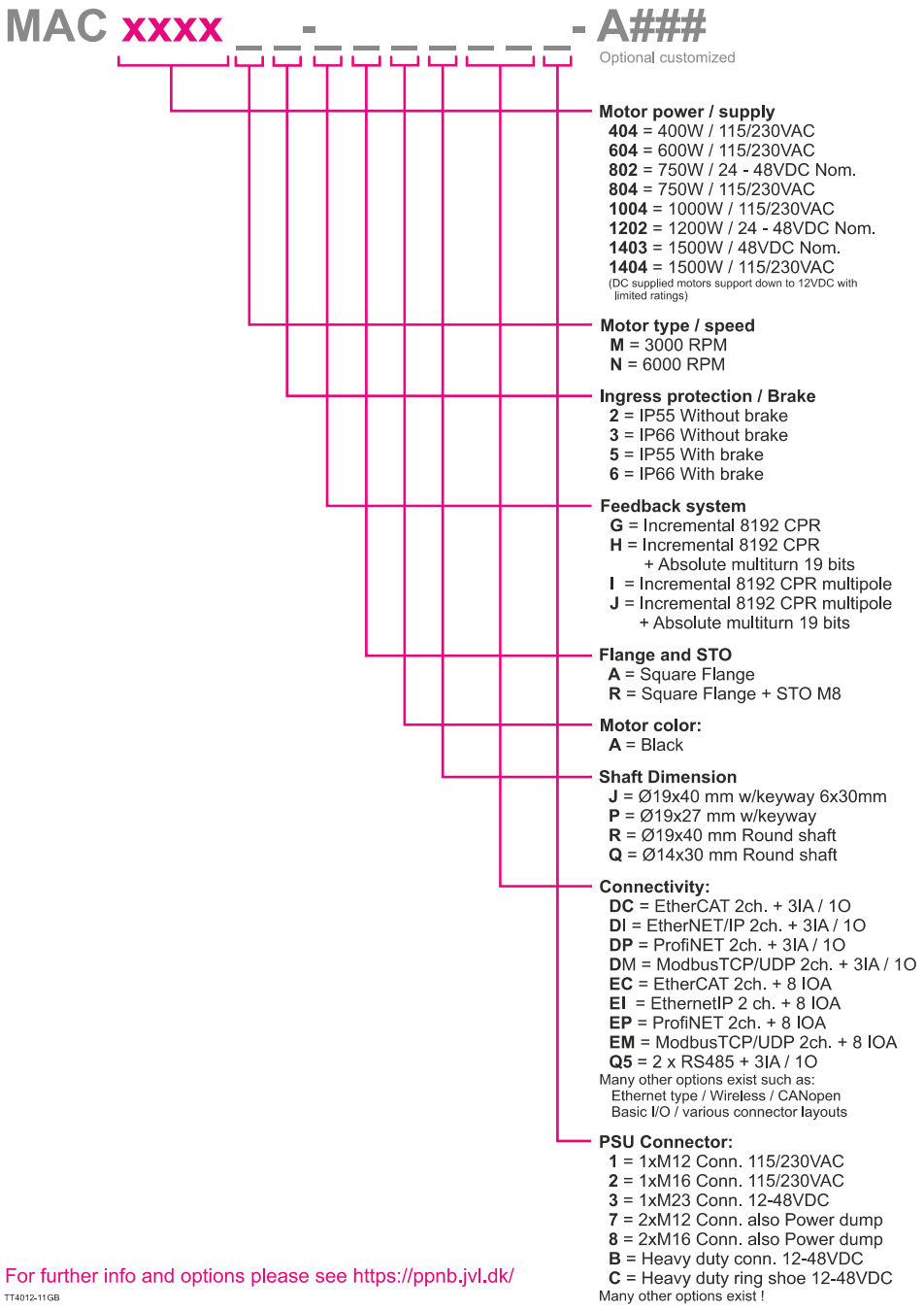
All the internal building blocks of the MAC motor are shown in the illustration above. The central microprocessor takes care of all the processes in the motor via the various I/O blocks such as the serial interface, differential transceiver (Multifunction I/O) and the motor driver sections.

Please note that all MAC motors covered by this user manual have 2 supply inputs. This offers the possibility to remove energy from the motor while keeping the control core active, so that position values and other dynamic parameters remain intact during a power-down situation such as an emergency stop.

1.2 Overall description

1.2.2 Type number nomenclature

Nomenclature for the MAC generation III product family



1.2.3 MAC motor generation III family overview

The MAC generation III is divided into 2 supply groups.

- Low voltage DC 12-48VDC
- High voltage AC 115 and 230VAC

The following motors are available for low voltage DC supply 12-48VDC:

Basic Motor Type	Continuous Torque	Peak Torque	Power (cont.)	Nom. Speed	Flange	Total length
MAC802	**2.39 Nm** (338.5 oz-in)	**7.17 Nm** (1015.4 oz-in)	**750 Watt @24VDC**	**3000 RPM @24VDC**	**PAM80 80x80mm** (3.15" x 3.15")	**Nom. 157.0 mm** (6.18")
MAC1202	**3.82 Nm** (541.0 oz-in)	**11.46 Nm** (1622.9 oz-in)	**1200 Watt @24VDC**	**3000 RPM @24VDC**	**PAM80 80x80mm** (3.15" x 3.15")	**Nom. 190.0 mm** (7.48")
MAC1403	**4.78 Nm** (676.9 oz-in)	**14.33 Nm** (2029.3 oz-in)	**1500 Watt @48VDC**	**3000 RPM @48VDC**	**PAM80 80x80mm** (3.15" x 3.15")	**Nom. 200.0 mm** (7.87")

The following motors are available for high voltage AC supply 115 and 230VAC:

Basic Motor Type	Continuous Torque	Peak Torque	Power (cont.)	Nom. Speed	Flange	Total length
MAC404	**1.27 Nm** (180.3 oz-in)	**3.82 Nm** (540.9 oz-in)	**400 Watt**	**3000 RPM**	**PAM60 60x60mm** (2.36" x 2.36")	**Nom. 170.0 mm** (6.69")
MAC604	**1.91 Nm** (270.5 oz-in)	**5.73 Nm** (811.4 oz-in)	**600 Watt**	**3000 RPM**	**PAM60 60x60mm** (2.36" x 2.36")	**Nom. 187.8 mm** (7.39")
MAC804	**2.39 Nm** (338.5 oz-in)	**7.17 Nm** (1015.4 oz-in)	**750 Watt**	**3000 RPM**	**PAM80 80x80mm** (3.15" x 3.15")	**Nom. 188.0 mm** (7.40")
MAC1004	**3.18 Nm** (450.6 oz-in)	**9.55 Nm** (1352.3 oz-in)	**1000 Watt**	**3000 RPM**	**PAM80 80x80mm** (3.15" x 3.15")	**Nom. 197.6 mm** (7.78")
MAC1404	**4.78 Nm** (676.9 oz-in)	**14.33 Nm** (2029.3 oz-in)	**1500 Watt**	**3000 RPM**	**PAM80 80x80mm** (3.15" x 3.15")	**Nom. 231.0 mm** (9.09")

Please note that the complete MAC motor range spans from 50W up to 4500W in continuous power. Visit www.jvl.dk to see the complete range.

1.2.4 Basic modes/functions in the MAC motor

The MAC motor offers the following basic function modes.

- **Passive Mode**
  The motor will be in a completely passive state, but communication is active and internal registers can be set up.
  See *Passive mode, page 91* for details.

- **Velocity Mode**
  The motor velocity can be controlled using MacTalk software or by sending commands via the serial interface.
  See *Velocity mode, page 92* for details.

- **Position Mode**
  The motor position can be controlled using MacTalk or by sending position commands via the serial interface.
  See *Position mode, page 94* for details.

- **Gear Mode**
  The position of the motor is controlled by the multifunction I/O, which is configured as input. Either a pulse and direction signal can be applied or a quadrature A and B signal from, for example, an incremental encoder.
  This mode is very powerful if the MAC motor is used to upgrade a step motor system or if the motor is used in electronic gear applications such as a flying saw, where an external encoder tracks the position of a moving object.
  See *Gear Mode, page 96* for details.

- **Gear Follow Mode**
  Same mode as Gear mode, except that the input pulses are not buffered, so that control strictly follows the input pulses.
  See *Gear Follow mode, page 100* for details.

- **Analogue Velocity Mode**
  The motor velocity is controlled by the voltage applied at the analogue input (0-10 V, or 0-5 V depending on hardware/firmware version - see *Analogue Inputs, page 41*). This mode can be used in several applications, but typical applications include maintaining an adjustable, constant speed in feeding mechanisms or as a slave driver in multi-axis systems with a master position controller for several axes.

  NOTE: The 0-10V input range requires hardware revision 0.7 or later (earlier revisions: 0-5V). The revision can be read from HW Version (Reg 205) - see the Analogue Inputs section in the Installation chapter. The firmware does not support the 0-10V range yet, up to and including v3.1.3.0.

  See *Analogue Velocity mode, page 102* for details.

- **Analogue Velocity (with deadband) Mode**
  Same function as Analogue Velocity Mode, but a deadband around zero is inserted. The deadband is approx. ±0.31V. This feature is useful if a potentiometer or similar device is used to control the speed of the motor, since the motor will be stationary if the input voltage is almost at zero.
  See *Analogue Velocity with dead-band, page 104* for details.

- **Analogue Velocity/Gear Mode.**
  This mode is similar to Gear mode, but it is possible to increase or decrease the position of the motor by adjusting the voltage applied to the analogue input (0-10 V / 0-5 V, see *Analogue Inputs, page 41*). A typical application is feeding mechanisms that require “on-the-fly” adjustment.

  NOTE: The 0-10V input range requires hardware revision 0.7 or later (earlier revisions: 0-5V). The revision can be read from HW Version (Reg 205) - see the Analogue Inputs section in the Installation chapter. The firmware does not support the 0-10V range yet, up to and including v3.1.3.0.

  See *Analogue Velocity/Gear mode, page 106* for details.

- **Velocity/Analogue Torque Mode**
  The motor torque is fully controlled by the voltage applied at the analogue input (0-10 V / 0-5 V, see *Analogue Inputs, page 41*).

This mode is useful if the motor is used for winding applications where a constant torque is required in the process. Another typical application is as a slave driver in multi-axis systems with a master position controller for several axes. The update frequency is 1000 Hz. Use Analogue Torque (Direct) if a higher bandwidth is required.

NOTE: The 0-10V input range requires hardware revision 0.7 or later (earlier revisions: 0-5V). The revision can be read from HW Version (Reg 205) - see the Analogue Inputs section in the Installation chapter. The firmware does not support the 0-10V range yet, up to and including v3.1.3.0.

See *Velocity-limited Analogue Torque, page 108* for details.

- **Analogue Torque (Direct) Mode**
  Same function as Velocity/Analogue Torque mode, but the top speed and acceleration are NOT controlled - the motor accelerates until the load torque balances the produced torque. Use Velocity/Analogue Torque mode if a speed limit is required.
  See *Analogue Torque mode, page 110* for details.

- **Analogue Gear Mode**
  This mode is somewhat similar to *Gear Mode* or *Analogue Velocity/Gear Mode*. The position of the motor is controlled by the multifunction I/O, which is configured as input. Either a pulse and direction signal can be applied or a quadrature A and B signal from, for example, an incremental encoder.
  The gear ratio specified will determine the basic gear ratio between the applied pulses and the motor movement. The special feature in this mode is that the basic gear ratio can be changed by approx. 2.5% per volt applied to the analogue input.
  For example, +2V will adjust the gear ratio approx. 5% higher.
  A typical application is feeding mechanisms that require "on-the-fly" adjustment.
  See *Analogue Gear mode, page 112* for details.

- **Coil Mode**
  Similar to Gear mode, but the position range can be limited in such a manner that the motor changes direction each time the upper or the lower limit is reached. Both limits can be adjusted. The mode is intended to be used for controlling a wire/cable guide on a winding machine. The guide will follow the position of the coil driven by a "main motor", and using this mode it is possible to position the wire very precisely, regardless of the speed at which the "main motor" is running.
  See *Coil Mode, page 114* for details.

- **Analogue Bi-position Mode**
  The motor will move a certain distance or go to one of 2 positions depending on the voltage at the analogue input. The voltage at the analogue input will be seen as a digital signal, meaning either logic low or logic high.
  The distance or positions can be set up in 2 internal registers and saved permanently in the motor.
  See *Analogue bi-position mode, page 118* for details.

- **Analogue to Position Mode**
  The position of the motor will change proportionally with the voltage at the analogue input, between the zero position and a predefined position.
  A typical application could be controlling a valve position using a voltage or a current control signal.
  See *Analogue to Position mode, page 120* for details.

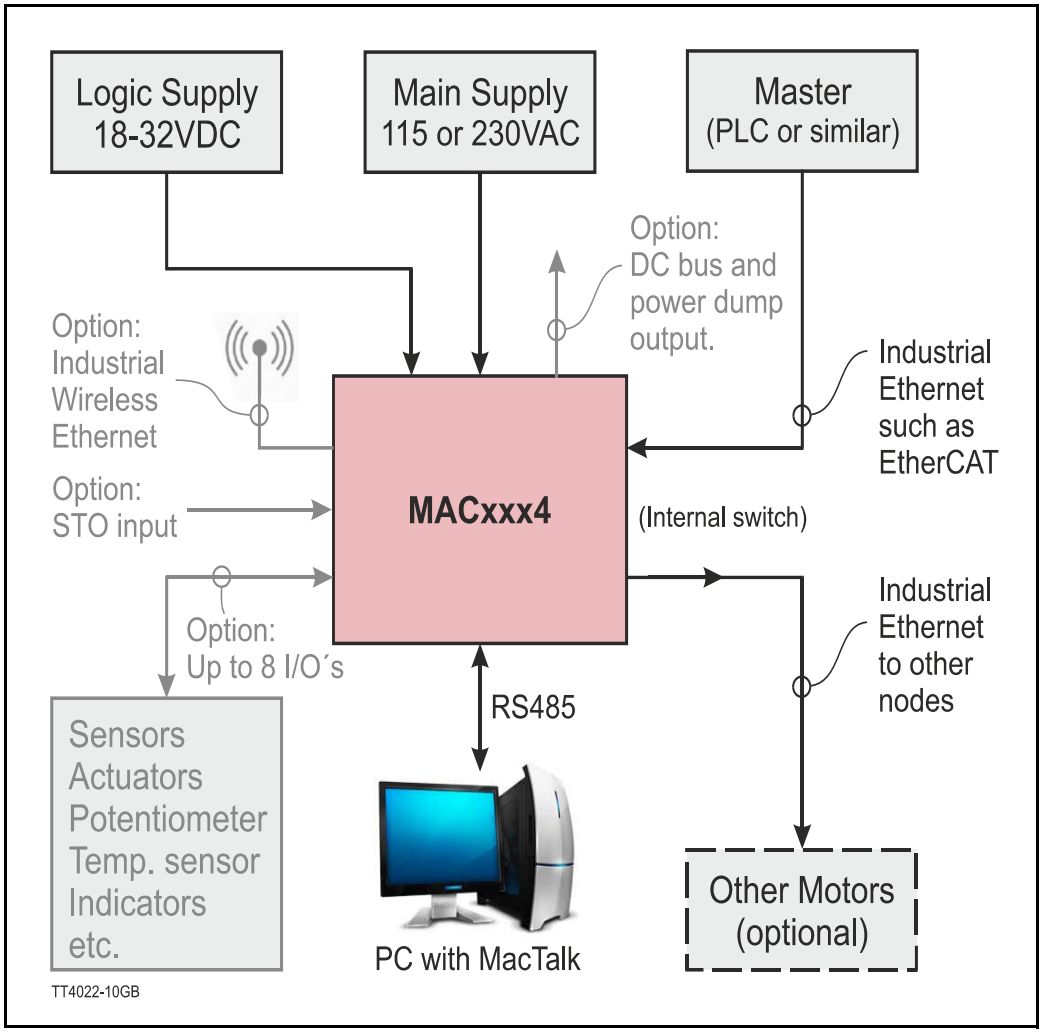
NOTE: All motor registers are documented in detail in the online register overview:
www.jvl.dk/register.html?register=MACmotor

2 Installation

2.1 Connector Overview

Only MACxxx4

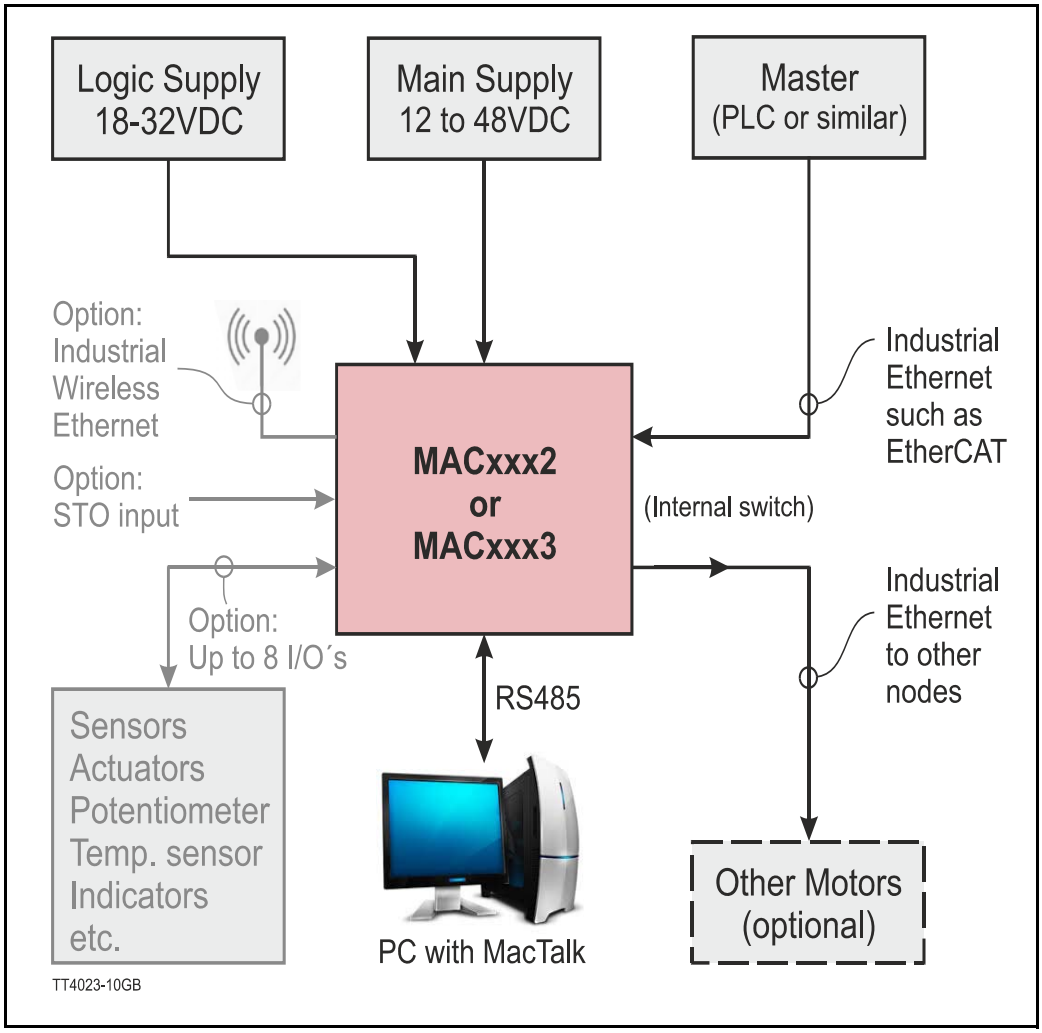
2.1.1 Connector overview (115/230VAC supplied versions)



The block diagram above illustrates all the external connections that are possible at a MAC G3 motor with 115/230VAC supply.
Most of the connections are the same as for the 24/48VDC supplied types except for the main supply itself and the optional "DC bus and power dump output", which is only available at the AC supplied motors.

On the next pages, detailed info about all connectors is presented and how to use them.

2.1.2 Connector overview (24/48VDC supplied versions)



The block diagram above illustrates all the external connections that are possible at a MAC G3 motor with 24/48VDC supply.

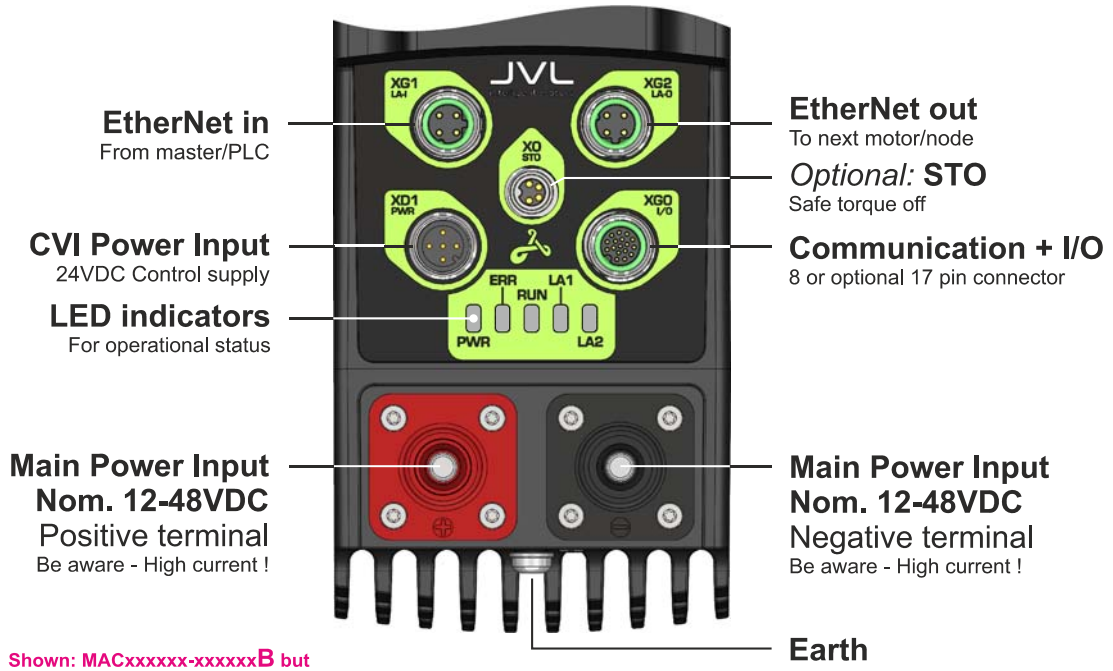
Most of the connections are the same as for the 115/230VAC supplied types except for the main supply voltage, which is nominal 24VDC (MACxxx2) or 48VDC (MACxxx3).

On the next pages, detailed info about all connectors is presented and how to use them.

2.1 Connector Overview

Only MACxxx2/xxx3

2.1.3 Connectors MACxxx2 and 3 (24/48VDC supplied versions)



2.1.4 Connector description including options

The MACxxx2 and MACxxx3 motors offer robust M8, M12 and "heavy duty power" connectors, which make them ideal for automation applications and use in a harsh environment. The connectors offer solid mechanical protection and are easy to operate.
This chapter covers a MAC with all connector options, such as STO (safe torque off) and extended I/O connector.
The following tables give the relevant information about each connector and the pins, wire colours and a short description of the signals available.

Please notice: When connecting a cable to one of the M12 connectors, it must be tightened with 0.6 Nm to prevent ingress of fluids and/or particles in the connector, which can cause malfunction.

The connector layout:

"Main Power Input" - Main power for the motor - Heavy duty connectors				
Signal name	**Description**	**Pin no.**	**JVL Cable**	**Isolation group**
M+	RED terminal - +12-48VDC (positive)	1	WP080x and others	4
M-	BLACK terminal - Ground (negative)	2	WP070x and others	4
Be aware that this is the main supply for the motor and these terminals are isolated from any other connector or terminals at the motor. The current can be up to **60ARMS** (continuously) and up to **200 A** peak during motor acceleration. Be careful when dimensioning the power supply circuit and consult the power supply chapter in this manual for further details.				

(Continued next page)

"LA-I" (XG1) Ethernet In connector - M12 - 4pin female connector "D" coded				
Signal name	**Description**	**Pin no.**	**JVL Cable WI1046-M12 M4TM4TxxT**	**Isolation group (See note)**
Tx0_P	Ethernet Transmit channel 0 - positive terminal	1	-	2
Rx0_P	Ethernet Receive channel 0 - positive terminal	2	-	2
Tx0_N	Ethernet Transmit channel 0 - negative terminal	3	-	2
Rx0_N	Ethernet Receive channel 0 - negative terminal	4	-	2
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

"LA-O" (XG2) Ethernet Out connector M12 - 4 pin female connector "D" coded				
Signal name	**Description**	**Pin no.**	**JVL Cable WI1046-M12 M4TM4TxxT**	**Isolation group (see note)**
Tx1_P	Ethernet Transmit channel 1 - positive terminal	1	-	3
Rx1_P	Ethernet Receive channel 1 - positive terminal	2	-	3
Tx1_N	Ethernet Transmit channel 1 - negative terminal	3	-	3
Rx1_N	Ethernet Receive channel 1 - negative terminal	4	-	3
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

"PWR" (XD10) - Power input. M12 - 5pin male connector				
Signal name	**Description**	**Pin no.**	**JVL Cable WI1000-M12F5TxxN**	**Isolation group**
-	Not used	1	Brown	1
-	Not used	2	White	1
P-	Main supply ground. Connect with pin 5 *	3	Blue	1
CVI	Control and user output supply +18-32VDC. **DO NOT connect >30V to this terminal!**	4	Black	1
P-	Main supply ground. Connect with pin 3 *	5	Grey	1
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

2.1.5 Connector option - "STO"

If the motor is called MACxxxxx-x**R**xxxxx, it contains the STO function and has the M8 STO connector included. The table below describes the connections.

"STO" (X0) connector M8 - 4 pin male connector				
Signal name	**Description**	**Pin no.**	**JVL Cable WI1010-M08M4TxxP**	**Isolation group (see note)**
STOA	STO channel A	1	Brown	1
GND	Ground for the STO signals	2	Inner screen	1
STOB	STO channel B	3	Black	1
24V out	DO NOT CONNECT !	4	(does not exist)	1
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

2.1.6 Connector option I/O - 8 pin connector

If the motor is called MACxxxxx-xxxx**D**xx or MACxxxxx-xxxx**Q**Ax, it contains the basic I/O connector with RS485 communication and a small portion of I/O's in an 8 pin M12 connector. The table below describes the connections.

"I/O" (XG0) - RS485 + I/O connector - M12 - 8pin female connector.				
Signal name	**Description**	**Pin no.**	**JVL Cable WI1000-M12 M8T**xx**N**	**Isolation group (See note)**
IN1	Digital input 1 (24V) or analogue input 0-5V (see section 2.6)	1	White	1
IN2	Digital input 2 (24V) or analogue input 0-5V (see section 2.6)	2	Brown	1
OUT1	Digital output max. 300mA. Supplied from CVO.	3	Green	1
GND	Ground intended to be used together with the other signals in this connector	4	Yellow	1
RS485: B0-	RS485 MacTalk interface. Leave open if unused	5	Grey	1
RS485: A0+	RS485 MacTalk interface. Leave open if unused	6	Pink	1
IN3	Digital input 3 (24V) or analogue input 0-5V (see section 2.6)	7	Blue	1
CVO	Supply output. Connected internally to the **CVI** terminal in the PWR connector. Max 700 mA. **DO NOT connect >30V to this terminal!**	8	Red	1
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

2.1.7 Connector option I/O - 17 pin connector

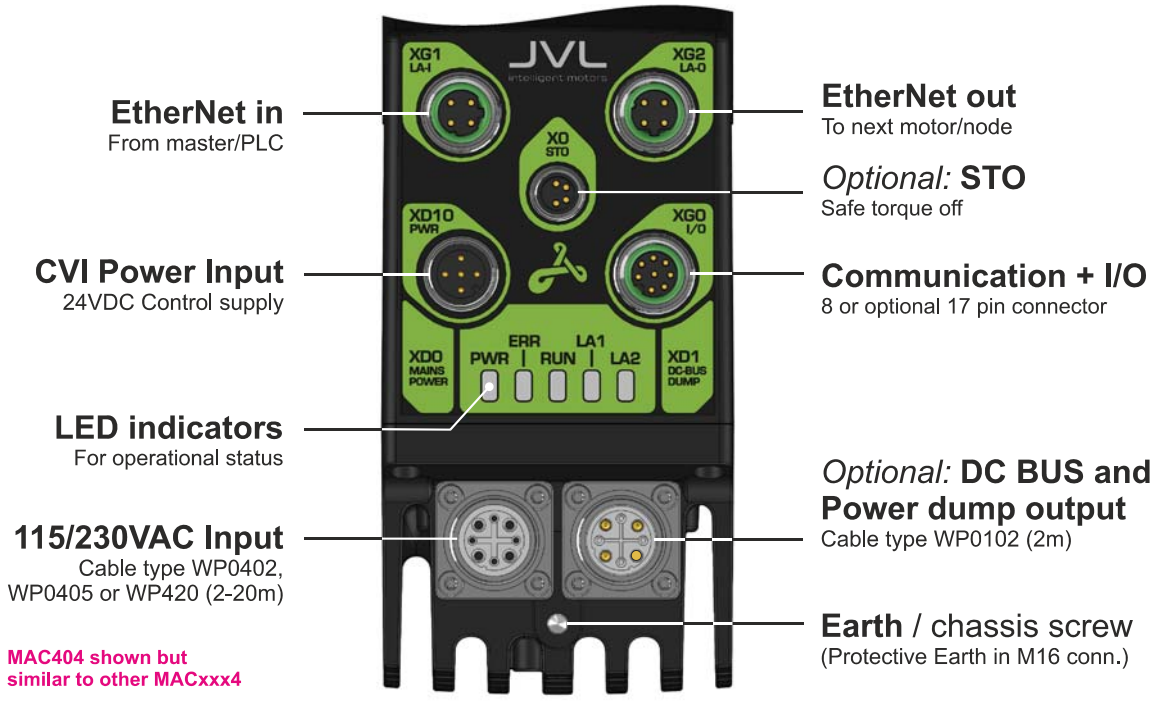
If the motor is called MACxxxxx-xxxx**E**xx or MACxxxxx-xxxx**Q**5x, it contains the extended I/O connector with RS485 communication in a 17 pin M12 connector. The table below describes the connections.

"I/O" (XG0) RS485 + I/O connector - M12 - 17pin female connector				
Signal name	**Description**	**Pin no.**	**JVL Cable WI1009M12 M17TxxN**	**Isolation group (see note)**
IO1	I/O channel 1. Can be used as digital input or digital output 350mA (24V) or analogue input 0-5V*.	1	Brown	1
GND	Ground intended to be used together with the other signals in this connector	2	Blue	1
IO2	I/O channel 1. Can be used as digital input or digital output 350mA (24V) or analogue input 0-5V*.	3	White	1
IO3	I/O channel 1. Can be used as digital input or digital output 350mA (24V) or analogue input 0-5V*.	4	Green	1
RS422: B1-	RS422 I/O terminal B-	5	Pink	1
IO4	I/O channel 1. Can be used as digital input or digital output 350mA (24V) or analogue input 0-5V*.	6	Yellow	1
RS422: A1-	RS422 I/O terminal A-	7	Black	1
RS422: B1+	RS422 I/O terminal B+	8	Grey	1
CVO	Supply output. Connected internally to the **CVI** terminal in the PWR connector. **DO NOT connect >30V to this terminal!**	9	Red	1
RS422: A1+	RS422 I/O terminal A+	10	Violet	1
IO5	I/O channel 5. Can be used as input or output 350mA	11	Grey/pink	1
IO6	I/O channel 6. Can be used as input or output 350mA	12	Red/blue	1
IO7	I/O channel 7. Can be used as input or output 350mA	13	White/Green	1
IO8	I/O channel 8. Can be used as input or output 350mA	14	Brown/Green	1
RS485: B0-	RS485 MacTalk interface. Leave open if unused	15	White/Yellow	1
GND	Ground intended to be used together with the other signals in this connector	16	Yellow/brown	1
RS485: A0+	RS485 MacTalk interface. Leave open if unused	17	White/grey	1
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

* If hardware version 0.7 or newer the analogue input is 0-10V. See also section 2.6.

2.1 Connector Overview

2.1.8 Connectors MACxxx4 (115/230VAC supplied versions)



2.1.9 Connector description including options

The MAC motors offer robust M8, M12 and M16 connectors, which make them ideal for automation applications and use in a harsh environment. The connectors offer solid mechanical protection and are easy to operate.
This chapter covers a MAC with all connector options, such as STO (safe torque off), extended I/O connector and optional M16 connector for external DC bus and/or power dump.
The following tables give the relevant information about each connector and the pins, wire colours and a short description of the signals available.

Please notice: When connecting a cable to one of the M12 connectors, it must be tightened with 0.6 Nm to prevent ingress of fluids and/or particles in the connector, which can cause malfunction.
The connector layout:

"PWR" (XD10) - Power input. M12 - 5pin male connector				
Signal name	**Description**	**Pin no.**	**JVL Cable WI1000-M12F5TxxN**	**Isolation group**
-	Not used	1	Brown	1
-	Not used	2	White	1
P-	Main supply ground. Connect with pin 5 *	3	Blue	1
CVI	Control and user output supply +18-32VDC. **DO NOT connect >30V to this terminal!**	4	Black	1
P-	Main supply ground. Connect with pin 3 *	5	Grey	1
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

(Continued next page)

"LA-I" (XG1) Ethernet In connector - M12 - 4pin female connector "D" coded				
Signal name	**Description**	**Pin no.**	**JVL Cable WI1046-M12 M4TM4TxxT**	**Isolation group (See note)**
Tx0_P	Ethernet Transmit channel 0 - positive terminal	1	-	2
Rx0_P	Ethernet Receive channel 0 - positive terminal	2	-	2
Tx0_N	Ethernet Transmit channel 0 - negative terminal	3	-	2
Rx0_N	Ethernet Receive channel 0 - negative terminal	4	-	2
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

"LA-O" (XG2) Ethernet Out connector M12 - 4 pin female connector "D" coded				
Signal name	**Description**	**Pin no.**	**JVL Cable WI1046-M12 M4TM4TxxT**	**Isolation group (see note)**
Tx1_P	Ethernet Transmit channel 1 - positive terminal	1	-	3
Rx1_P	Ethernet Receive channel 1 - positive terminal	2	-	3
Tx1_N	Ethernet Transmit channel 1 - negative terminal	3	-	3
Rx1_N	Ethernet Receive channel 1 - negative terminal	4	-	3
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

"MAINS POWER" (XD0) connector M16 - 4 pin male connector				
Signal name	**Description**	**Pin no.**	**JVL Cable WP0402**	**Isolation group (see note)**
Neutral	Neutral used for 115 or 230VAC phase input	A	Blue	4
L1	115VAC supply input	B	Red	4
L2	230VAC supply input	C	Brown	4
PE (Earth)	Protective earth terminal	Earth	Green/Yellow	4
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

2.1.10 Connector option - "STO"

If the motor is called MACxxxxx-x**R**xxxxx, it contains the STO function and has the M8 STO connector included. The table below describes the connections.

"STO" (X0) connector M8 - 4 pin male connector				
Signal name	**Description**	**Pin no.**	**JVL Cable WI1010-M08M4TxxP**	**Isolation group (see note)**
STOA	STO channel A	1	Brown	1
GND	Ground for the STO signals	2	Inner screen	1
STOB	STO channel B	3	Black	1
24V out	DO NOT CONNECT !	4	(does not exist)	1
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

2.1.11 Connector option I/O - 8 pin connector

If the motor is called MACxxxxx-xxxx**D**xx or MACxxxxx-xxxx**Q**Ax, it contains the basic I/O connector with RS485 communication and a small portion of I/O's in an 8 pin M12 connector. The table below describes the connections.

"I/O" (XG0) - RS485 + I/O connector - M12 - 8pin female connector.				
Signal name	**Description**	**Pin no.**	**JVL Cable WI1000-M12 M8TxxN**	**Isolation group (See note)**
IN1	Digital input 1 (24V) or analogue input 0-5V (see section 2.6)	1	White	1
IN2	Digital input 2 (24V) or analogue input 0-5V (see section 2.6)	2	Brown	1
OUT1	Digital output max. 300mA. Supplied from CVO.	3	Green	1
GND	Ground intended to be used together with the other signals in this connector	4	Yellow	1
RS485: B0-	RS485 MacTalk interface. Leave open if unused	5	Grey	1
RS485: A0+	RS485 MacTalk interface. Leave open if unused	6	Pink	1
IN3	Digital input 3 (24V) or analogue input 0-5V (see section 2.6)	7	Blue	1
CVO	Supply output. Connected internally to the **CVI** terminal in the PWR connector. Max 700 mA. **DO NOT connect >30V to this terminal!**	8	Red	1
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

2.1.12 Connector option I/O - 17 pin connector

If the motor is called MACxxxxx-xxxx**E**xx or MACxxxxx-xxxx**Q**5x, it contains the extended I/O connector with RS485 communication in a 17 pin M12 connector. The table below describes the connections.

"I/O" (XG0) RS485 + I/O connector - M12 - 17pin female connector				
Signal name	**Description**	**Pin no.**	**JVL Cable WI1009M12 M17TxxN**	**Isolation group (see note)**
IO1	I/O channel 1. Can be used as digital input or digital output 350mA (24V) or analogue input 0-5V*.	1	Brown	1
GND	Ground intended to be used together with the other signals in this connector	2	Blue	1
IO2	I/O channel 1. Can be used as digital input or digital output 350mA (24V) or analogue input 0-5V*.	3	White	1
IO3	I/O channel 1. Can be used as digital input or digital output 350mA (24V) or analogue input 0-5V*.	4	Green	1
RS422: B1-	RS422 I/O terminal B-	5	Pink	1
IO4	I/O channel 1. Can be used as digital input or digital output 350mA (24V) or analogue input 0-5V*.	6	Yellow	1
RS422: A1-	RS422 I/O terminal A-	7	Black	1
RS422: B1+	RS422 I/O terminal B+	8	Grey	1
CVO	Supply output. Connected internally to the **CVI** terminal in the PWR connector. **DO NOT connect >30V to this terminal!**	9	Red	1
RS422: A1+	RS422 I/O terminal A+	10	Violet	1
IO5	I/O channel 5. Can be used as input or output 350mA	11	Grey/pink	1
IO6	I/O channel 6. Can be used as input or output 350mA	12	Red/blue	1
IO7	I/O channel 7. Can be used as input or output 350mA	13	White/Green	1
IO8	I/O channel 8. Can be used as input or output 350mA	14	Brown/Green	1
RS485: B0-	RS485 MacTalk interface. Leave open if unused	15	White/Yellow	1
GND	Ground intended to be used together with the other signals in this connector	16	Yellow/brown	1
RS485: A0+	RS485 MacTalk interface. Leave open if unused	17	White/grey	1
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

* If hardware version 0.7 or newer the analogue input is 0-10V. See also section 2.6.

2.1.13 Connector option DC-BUS/DUMP

If the motor is called MACxxxxx-xxxxxx**8**, it contains the extra and optional connector for external DC bus and power dump resistor. The table below describes the connections.

"DC-BUS/DUMP" (XD1) connector M16 - 4 pin female connector				
Signal name	**Description**	**Pin no.**	**JVL Cable WP0402**	**Isolation group (see note)**
BO	Internal DC bus output	A	White	4
PD	Output to external power dump resistor	B	Yellow	4
CM	DC bus common (high voltage ground)	C	Brown	4
PE (Earth)	Protective earth terminal	Earth	Green/Yellow	4
Connector housing/metal is connected to earth and for JVL supplied cables also to the cable screen.				

NOTE: The term "Isolation group" in all the tables indicates which terminals/circuits are galvanically connected to each other. In other words, group 1, 2, 3 and 4 are all fully independently isolated from each other. Group 5 corresponds to the housing of the motor, which may also be connected to earth via the DC or AC input supply. Group 5 is isolated from all electrical circuitry inside the motor.

2.2 Status indicators

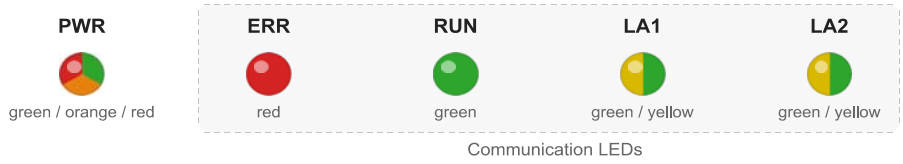
2.2.1 LED Status indicators

The motor signals its operating state through 5 LEDs on the motor itself.
Reading the LEDs is the quickest way to establish what the motor is doing before you connect a PC or a controller.
All five indicators are present on every motor. What the four communication LEDs show depends on the protocol in use.

- PWR (green/orange/red): power and overall motor status.
- ERR (red): EtherCAT error indication. Off means no EtherCAT error is present. On other Ethernet protocols this LED is used differently, e.g. as CIP Module Status on EtherNet/IP.
- RUN (green): protocol state indication.
- LA1 (green/yellow): link and activity on the first Ethernet port.
- LA2 (green/yellow): link and activity on the second Ethernet port.

The PWR LED is described in detail in *Power / status LED (PWR), page 23*, and the four communication LEDs in *Industrial Ethernet, page 25*.

Status indicators - all five LEDs



LED	Colours	What it reports
PWR	green, orange, red	Power and overall motor status
ERR	red	Protocol error. Off means no error
RUN	green	Protocol state
LA1	green, yellow	Link and activity, Ethernet port 1
LA2	green, yellow	Link and activity, Ethernet port 2

TT4095-17GB

All five LEDs are present on every motor. The blink patterns and the complete state lists are in the figures that follow.
The ERR and RUN states given in this manual are the EtherCAT states. Source: LED_description_MACG3_MISG3 v0.2.

All LED tables in this section use the same set of blink patterns:

- Constant: the LED is on continuously.
- Blinking: 200 ms on, 200 ms off (2.5 Hz).
- Single flash: 200 ms on, followed by 1 s off.
- Double flash: two pulses of 200 ms, followed by 1 s off.
- Flickering: rapid on/off at approximately 50 ms (10 Hz).

Only the combinations listed in the tables are used. The PWR LED can physically produce other combinations of colour and pattern, but they are not used by the current firmware and carry no meaning. If you observe a pattern that is not in the tables, note exactly what you saw and contact JVL rather than trying to interpret it.

2.2 Status indicators

2.2.2 Power / status LED (PWR)

PWR (power / status) LED TT4084-10GB

LED	Pattern	Description	Action
	(off)	CVI is missing	Connect CVI
		CVI is applied and sufficient	-
		P+ is missing or voltage is too low	Connect or increase P+
		CVI applied but too low	Increase CVI voltage
		Identify device (from PLC or tool)	-
		Firmware is missing	Connect MacTalk, update firmware
		A warning is present	-
		Firmware update in progress	-
		An error is present	Clear the error

Pattern key: solid = constant | dashes = blinking (200 ms on/off, 2.5 Hz) | dots = flickering (approx. 50 ms, 10 Hz).

A warning shown here excludes P+ and CVI warnings, which have their own constant-colour rows above. When several conditions are present at once, only one is shown - see the priority figure. Source: LED_description_MACG3_MISG3 v0.2.

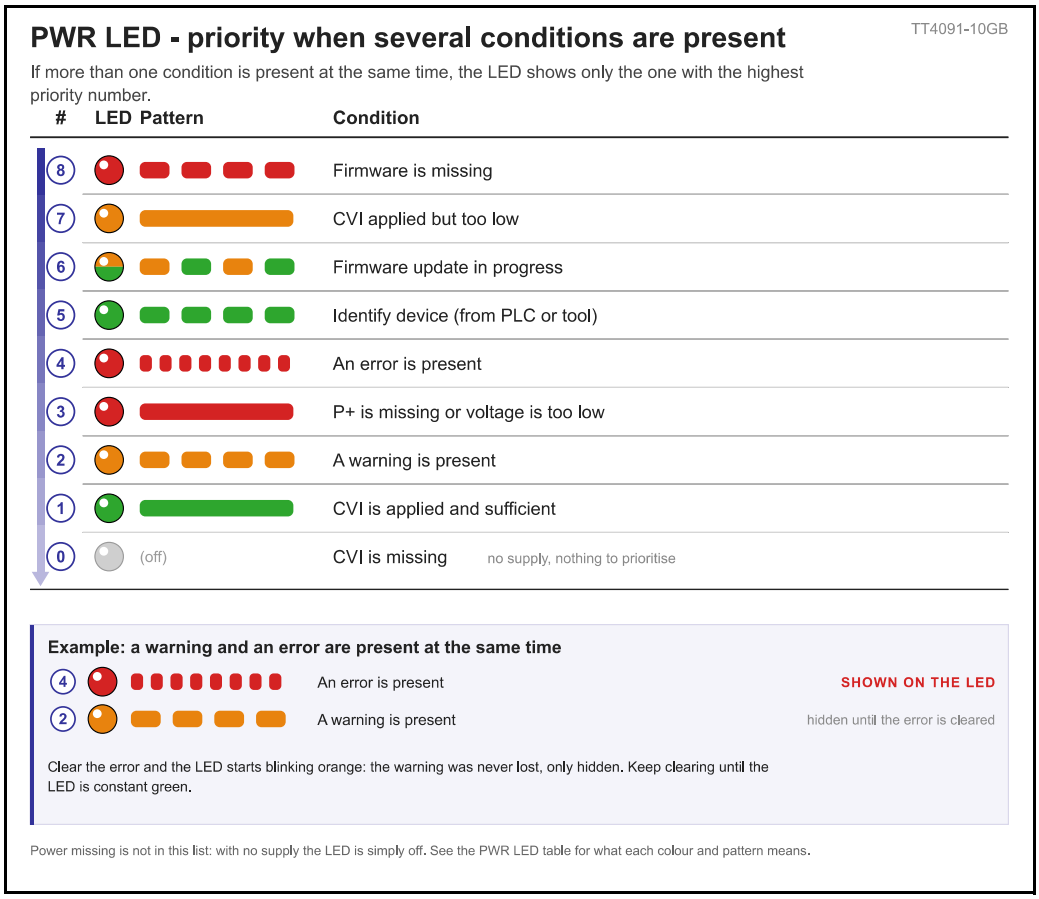
The PWR LED is a multi-colour indicator that reports the overall condition of the motor. As a rule:

- Green indicates power applied and normal operation.
- Orange indicates information or a warning. The pattern decides which: a constant orange LED means the control voltage (CVI) is applied but too low, whereas a blinking orange LED means a warning is present.
- Red indicates a fault that prevents normal operation.

Note in particular that a constant red LED means control power (CVI) is applied but the main supply (P+) is missing or too low, whereas a flickering red LED means an error is active. For the error itself, and for how to read and clear it, see chapter 7, Safety, Diagnostics and Error Handling.

2.2.2.1 Priority when several conditions are present

A motor can have several conditions at once. The LED cannot show them all, so it shows the one highest in the list below and keeps the rest in reserve. Clear the one you see, and the next one appears.



For the errors and warnings themselves, and for how to read and clear them, see *Safety, Diagnostics and Error Handling, page 155*.

2.2.3 Communication LEDs

Motors fitted with a fieldbus interface have additional LEDs that report the state of the bus and of the physical connection. These LEDs are independent of the PWR LED, which keeps the meaning given in the previous section whichever bus is fitted.

The sections below describe the communication LEDs for each bus family. Only the section that matches the interface ordered with the motor applies.

2.2.3.1 Industrial Ethernet

Communication LEDs - EtherCAT (ERR, RUN) and Ethernet ports (LA1/LA2) TT4085-11GB

LED	Pattern	Meaning
ERR (Red)		
off	(off)	No EtherCAT error
constant		Critical communication or controller error
blinking		General configuration error
single flash		Local error
double flash		Process-data / EtherCAT watchdog timeout
flickering		Booting error
RUN (Green)		
off	(off)	Device state = INIT
constant		Device state = Operational
blinking		Device state = Pre-Operational
single flash		Device state = Safe-Operational
flickering		Booting - not yet in INIT
LA1 / LA2 (Green/Yellow)		
off	(off)	No valid Ethernet connection
constant		Ethernet connected
flickering		Link / activity

blinking=200ms on/off (2.5Hz) | single flash=200ms on+1s off | double flash=2x200ms+1s off | flickering=approx.50ms (10Hz). Source: LED_description_MACG3_MISG3.

This section applies to motors with an Industrial Ethernet interface, that is EtherCAT, EtherNet/IP, PROFINET and Modbus TCP.

Four communication LEDs are fitted. The states listed below and in the table are those of EtherCAT; see LB0077 Ethernet G3 NetX for the equivalents on EtherNet/IP, PROFINET and Modbus TCP.

- ERR (red): EtherCAT error indication. Off means no EtherCAT error is present. On other Ethernet protocols this LED is used differently, e.g. as CIP Module Status on EtherNet/IP.
- RUN (green): EtherCAT device state, from INIT through Pre-Operational and Safe-Operational to Operational.
- LA1 (green/yellow): link and activity on the first Ethernet port.
- LA2 (green/yellow): link and activity on the second Ethernet port.

The port LEDs LA1 and LA2 behave the same way for all Ethernet protocols: off means no valid connection on that port, constant means a link is established, and flickering means traffic is passing.

The ERR and RUN states shown in the table apply to EtherCAT. These two LEDs are driven by the protocol firmware itself, so their meaning follows the standard for the protocol the motor was ordered with:

- EtherCAT: as shown in the table above.
- EtherNet/IP: the two LEDs are the Module Status and Network Status indicators defined by ODVA. They are steady green in normal operation, so a lit LED here is not by itself a fault indication.
- PROFINET: the two LEDs follow the PROFINET diagnostic indicators.
- Modbus TCP/UDP: Modbus runs alongside the real-time protocol rather than instead of it. The LEDs continue to show the state of the protocol the motor was ordered with, and Modbus traffic does not change them.

For Ethernet configuration and diagnostics, see the separate manual LB0077 Ethernet G3 NetX.
If a port LED stays off, check the cable and the connector before investigating the protocol state. A bus that never leaves the initial state usually points to a configuration mismatch with the controller rather than to a fault in the motor.

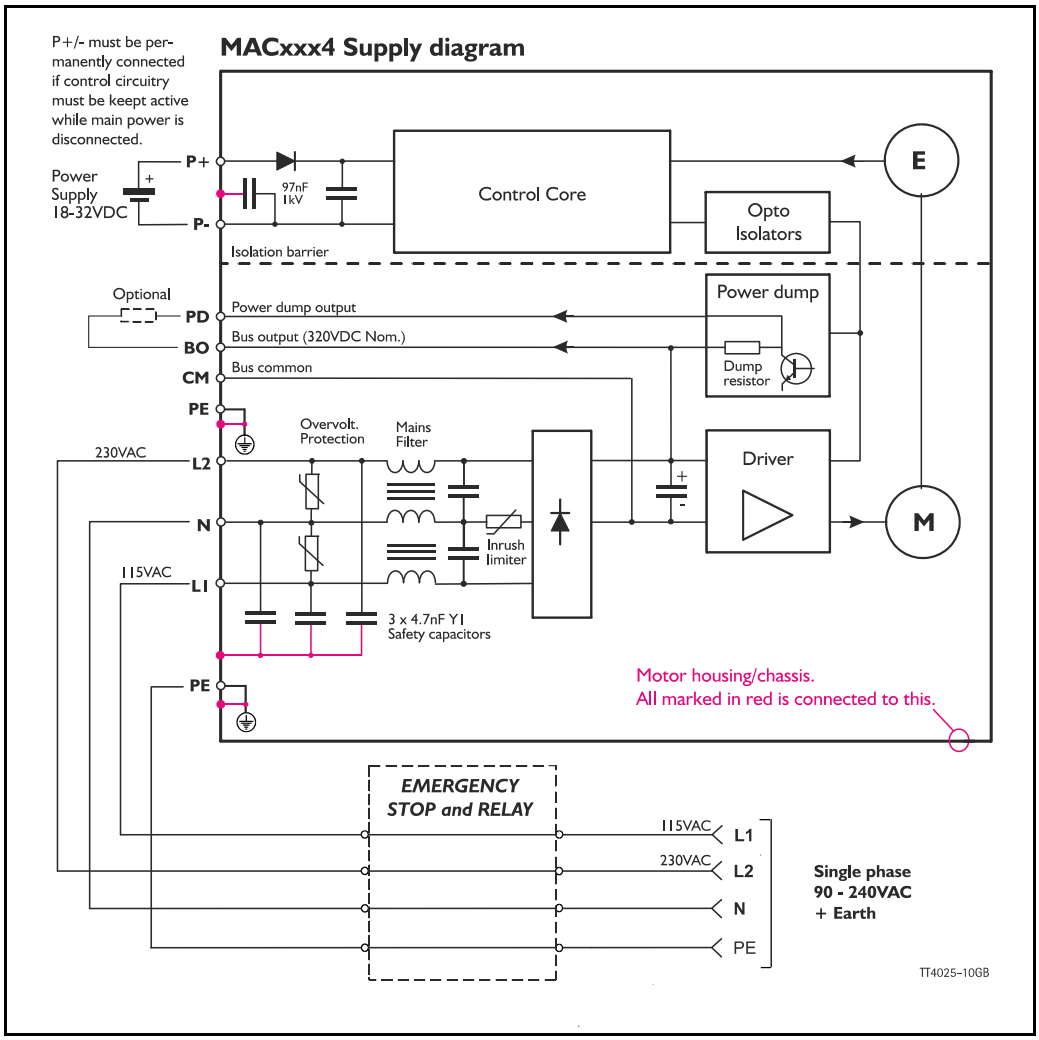
2.3 Power Supply

Only MACxxx4

2.3.1 Power supply circuitry (115/230VAC supplied versions)

The supply at the MACxxx4 motors is split into 2 individual circuits with full galvanic isolation between the circuits.

The control circuitry requires a voltage in the range 18 to 32VDC, and the power circuitry must be supplied with 90 to 240VAC. Having 2 independent supply circuits offers the feature that the supply voltage for the power circuitry (90-240VAC) can be removed for safety reasons, while the control circuitry can continue operating and thus keep the position counter updated and keep other vital functions such as communication active.

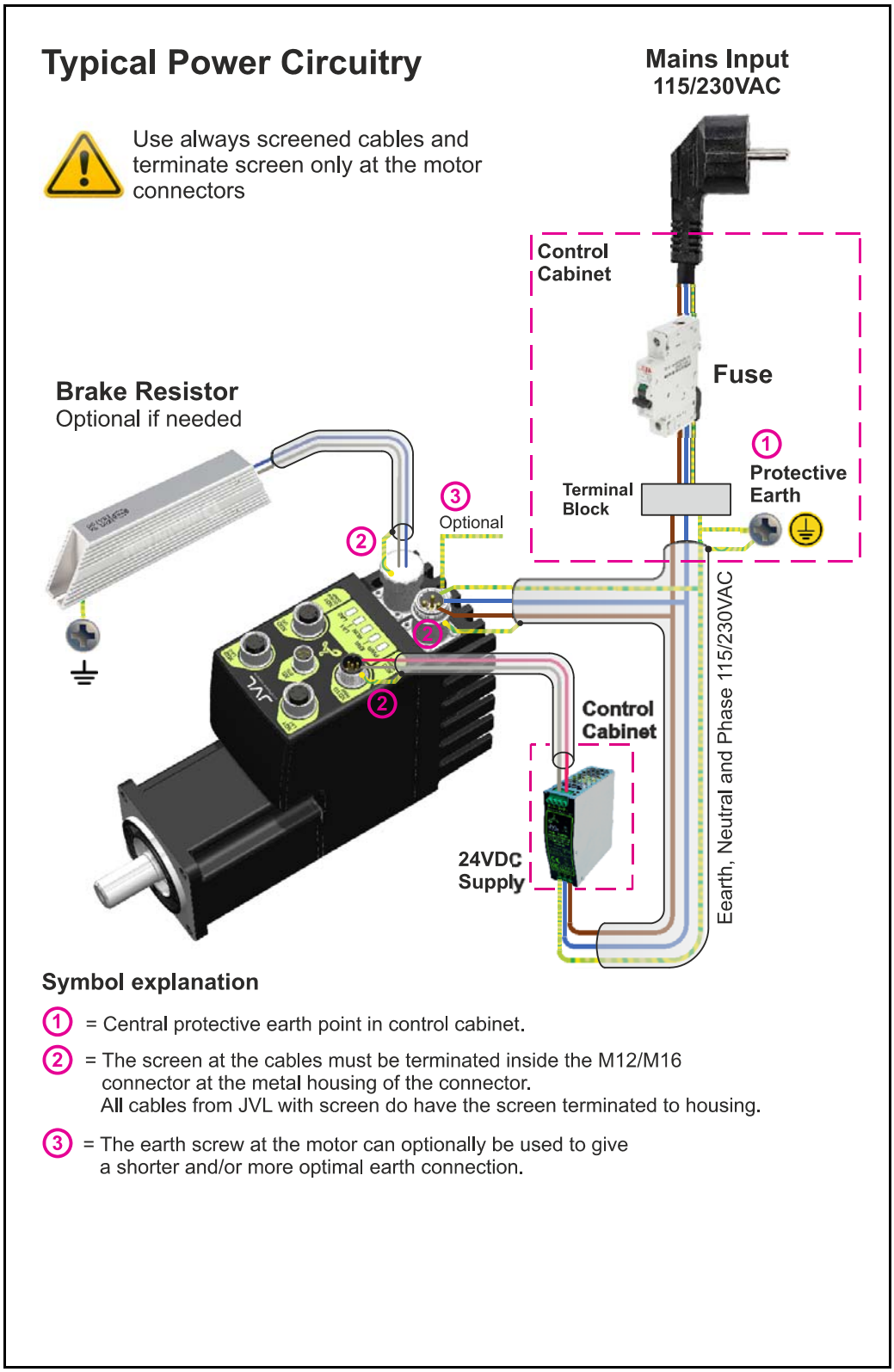


The circuit above is shown with an emergency relay (box), which can be omitted if the application does not require this safety feature. Examples of Emergency stop and relay are shown. *See "Emergency stop" on page 247.*

The internal power dump is intended to cover 90% of all applications, but if the error message 'Overvoltage on bus' or 'Regenerative overload' is reported, an external power dump resistor must be connected between the terminals *PD* and *BO*.

2.3.2 How to connect power supply and related components

Below is shown how to connect the MAC motor to the mains supply and also how to connect the control voltage 24V and an optional brake resistor if needed.



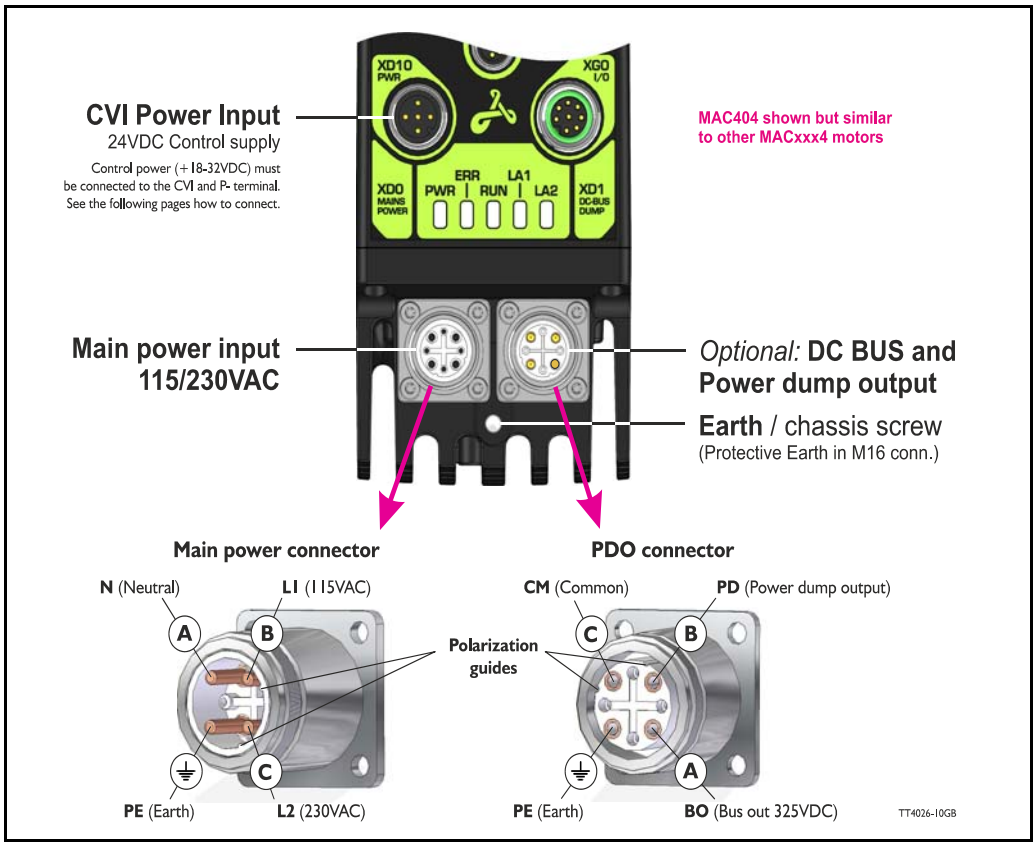
Symbol explanation

1. = Central protective earth point in control cabinet.
2. = The screen at the cables must be terminated inside the M12/M16 connector at the metal housing of the connector. All cables from JVL with screen do have the screen terminated to housing.
3. = The earth screw at the motor can optionally be used to give a shorter and/or more optimal earth connection.

2.3 Power Supply

2.3.3 Power connectors at the motor (115/230VAC supplied versions)

The power supply needed for the MACxxx4 motors is separated into 2 circuits.
The control power nom. 24VDC and the 115/230VAC main supply.
The following pages describe how to connect the main supply 115/230VAC. See the following pages for how to connect the 24VDC control power.



Main power connector terminal descriptions:

L1	115VAC input (phase)	WARNING: Please be aware that high voltage is present also when the terminal is unconnected!
L2	230VAC input (phase)	WARNING: Please be aware that high voltage is present also when the terminal is unconnected!
N	115/230VAC input (neutral).	
PE	Earth must be used with power input terminals L1, L2 and N.	

PDO connector terminal descriptions (optional connector):

PD	Power dump out - see also *Connecting an external power dump resistor, page 31*.
BO	Bus output (nom. 325VDC).
CM	Common. Ground for the internal DC-bus.
PE	Earth must be used with the DC-bus and the PD terminals.

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NOTE: Please use screened cables only. The screen must be connected to the metal connector housing, which is also internally connected to the earth terminal.

2.3 Power Supply

Only MACxxx4



2.3.4 MACxxx4 Grounding

Make sure that the machine part on which the MACxxx4 is mounted is properly grounded to the main part (body) of the machine in order to avoid major ground/earth currents flowing through the motor and causing interference to other signal groups.

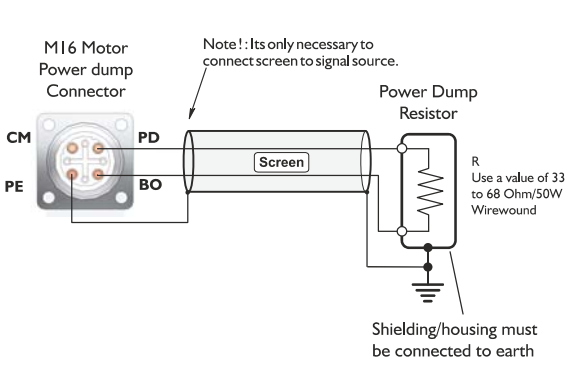
The 115/230VAC power supply connector contains a protective earth connection, but if needed, the designated earth screw placed near the power connector can also be used.

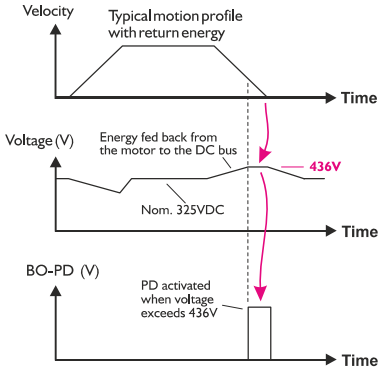
2.3.5 Emergency stop

Please consult the chapter: *Emergency stop considerations, page 247*.

2.3.6 Connecting an external power dump resistor

External power dump connection.
Only MACxxx4 motors with 115/230VAC supply





Terminal description for the "Dump" connector.
CM = Common. Is internally connected to the ground of the DC bus. Is only intended to be used if multiple motors share DC-bus.
BO = Bus output. The internal DC bus is connected to this terminal.
PD = Power Dump output. Behind this terminal is placed a switch (IGBT transistor) which connect the terminal to the internal bus ground if the voltage become higher than 436VDC.

If the return energy is too high and the used power dump resistor is not able to keep down the voltage below **467V** the motor will report an overvoltage error and go in passive mode in order to protect it self.

TT4024-10GB

The internal power dump can absorb the following:

Motor size	Max. continuous power	Peak power	Motor types
400 - 600W	4W	1460W	MAC404 and MAC604
750 - 1500W	10W	1460W	MAC804, 1004 and 1404

The above values are considered as appropriate for most applications.
However, should a situation occur in which the connected load inertia is too large or the deceleration too fast, the internal power dump will not be able to absorb all the returned energy and will report the error message "regenerative overload".
In this situation the only possible solutions are as follows:

1. Decrease the acceleration/deceleration parameter.
2. Lower the attached load inertia.
3. Connect an external power resistor.

The drawing above shows how to connect an external power resistor. A wirewound type is recommended since it will be able to absorb higher peak power than other types of resistors. Do not use a film based resistor since it will not be able to absorb higher peak power than the nominal rating, which is typically very low.

Warnings: Ensure that the resistor value is between 33 and 68 Ohm/50W since the output otherwise can be damaged. Also avoid short-circuit of the output.



CAUTION - Risk of electric shock. Disconnect all power and wait 5 min. before servicing

2.3.7 Sizing the external pre-fuse (115/230VAC supplied versions)

Below is the recommended sizing of the pre-fuse connected in the power supply line before the motor.

Motor size	Fuse size when supply 115VAC	Fuse size when supply 230VAC	Motor type
400W	T10A	T6.3A	MAC404
600W	T15A	T8A	MAC604
750W	T15A	T10A	MAC804
1000W	T15A	T10A	MAC1004
1500W	T20A	T12A	MAC1404

Melt type fuses recommended:
For **115V** supply voltage:
To meet UL requirements, the prefuse must be a class RK5, such as the type FRN-R-xx from the manufacturer Cooper Bussmann Inc. The rating must be according to the table above.

For **230V** supply voltage:
Melt fuse: type gG, Do or Dz in the phase line. Rated for 600V/150kA. The rating must be according to the table above.

Automatic fuses recommended:
If an automatic fuse is used for either 115 or 230VAC, then choose "Class D". The rating must be according to the table above.

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In general, it must be verified that the fuse can withstand the motor drawing up to 300% peak power for short periods, which stresses the fuse and can reduce its lifetime over time. Therefore, in general, use only slow acting fuses, which are robust to short overloads.

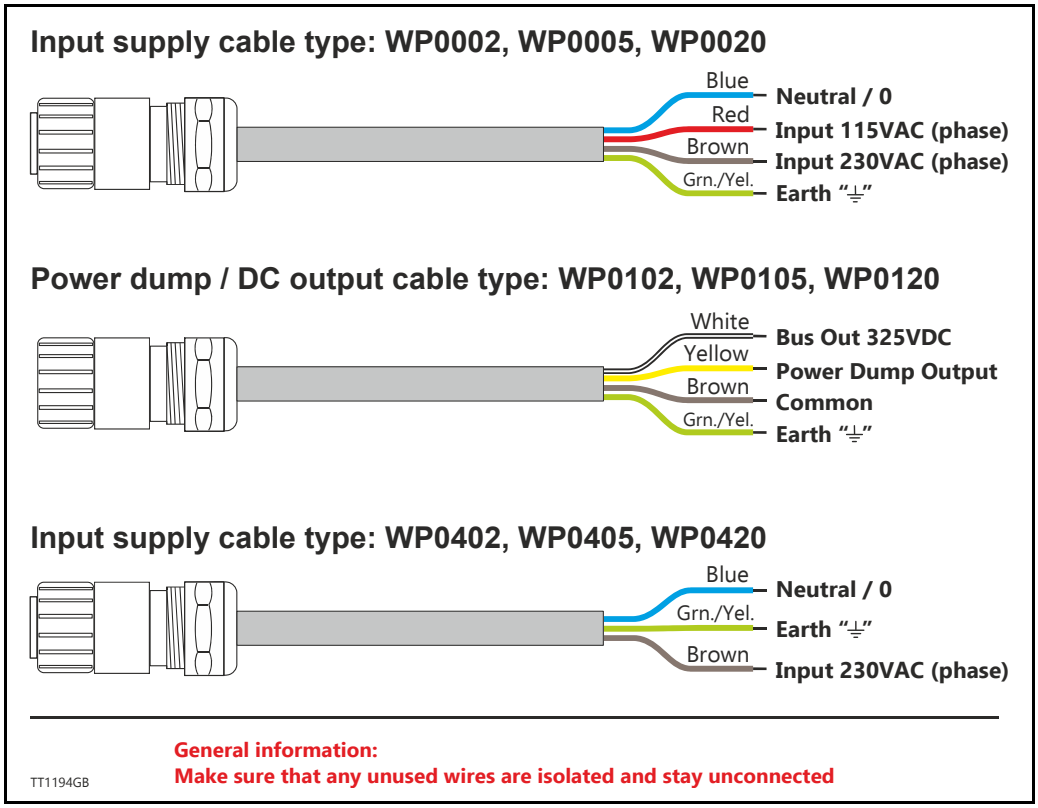
2.3 Power Supply

2.3.8 Power cable accessories (115/230VAC supplied versions)

The following standard cables can be supplied by JVL:

JVL no.	Type	Description
WP0002	MACxxx4	115/230VAC power cable 2 m. Straight M16 conn and free end. Female
WP0005	MACxxx4	115/230VAC power cable 5 m. Straight M16 conn and free end. Female
WP0020	MACxxx4	115/230VAC power cable 20 m. Straight M16 conn and free end. Female
WP0102	MACxxx4	Brake resistor cable 2 m. Straight M16 conn and free end. Male
WP0105	MACxxx4	Brake resistor cable 5 m. Straight M16 conn and free end. Male
WP0120	MACxxx4	Brake resistor cable 20 m. Straight M16 conn and free end. Male
WP0402	MACxxx4	230V power cable with earth 2m. Straight M16 conn and free end. Female
WP0405	MACxxx4	230V power cable with earth 5m. Straight M16 conn and free end. Female
WP0420	MACxxx4	230V power cable with earth 20m. Straight M16 conn and free end. Female

Please use the illustration below when connecting the cables.
Warning: Please notice that it can be fatal to connect 230V to the 115V input.



2.3.9 Power connector parts (115/230VAC supplied versions)

Manufacturer: Hummel AG - Germany.
General web: http://www.hummel-group.com
US web: http://www.sealconusa.com

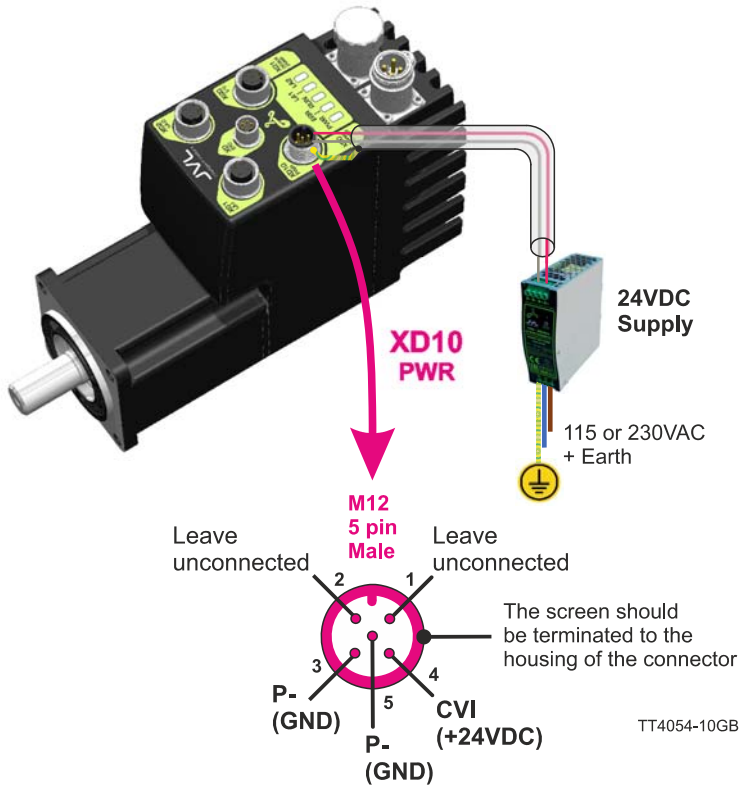
Used for	Part description	Hummel part no.	JVL part no.
Power 115/230VAC	Connector kit with all necessary connector parts. Contains: 1pcs. WG0227 4pcs. WG0229, 1pcs. WG0230		MAC400-CONKIT1-PWR
Brake resistor/DC bus	Connector kit with all necessary connector parts. Contains: 1pcs. WG0226 4pcs. WG0228, 1pcs. WG0230		MAC400-CONKIT1-DCPD
Individual connector components:			
Power 115/230VAC	M16 Female conn insert nylon Accepts 3 + PE crimp sockets **Use 1 pcs. per connector.**	7003.9431.02	WG0227
Power 115/230VAC	M16 Crimp socket (female) Accepts 0.34 to 1.5mm² wires / AWG16 to AWG22. **Use 4 pcs. per connector.**	7010.9816.02	WG0229
Power 115/230VAC	M16 Straight metal housing Accepts cable with outer dia. 5.0 to 9.0mm / 0.2" to 0.53" **Use 1 pcs. per connector.**	7810.4000.00	WG0230
Power 115/230VAC	Optional - same as above but 90 degree housing.	7830.4000.00	WG0231
Brake resistor/DC bus	M16 Male conn insert nylon. Accepts 3 + PE crimp pins. **Use 1 pcs. per connector.**	7003.9431.01	WG0226
Brake resistor/DC bus	M16 Crimp pin (male) Accepts 0.34 to 1.5mm² wires / AWG16 to AWG22. **Use 4 pcs. per connector.**	7010.9816.01	WG0228
Brake resistor/DC bus	M16 Straight metal housing Accepts cable with outer dia. 5.0 to 9.0mm / 0.2" to 0.53" **Use 1 pcs. per connector.**	7810.4000.00	WG0230
Brake resistor/DC bus	Optional - same as above but 90 degree housing.	7830.4000.00	WG0231
Brake resistor/DC bus	Metal protection cap. Mounted if connector is not in use	7010.9001.62	WG0224
-	Crimp tool	7.000.900.904	Not for sale

2.4 Control Power Supply

2.4.1 How to connect the control voltage input

Besides the main power to the motor in the form of 115/230VAC or 12-48VDC (depending on the type of motor), it is always necessary also to connect control power (CVI).

CVI The control voltage input is supplying all the internal control circuits, including the microprocessor, encoder and user I/O circuitry. The voltage needed must be in the range 18-32 VDC, which also supports 24 V battery driven applications. Supply current is below 250 mA (voltage dependent and no user outputs activated).



MAC404 Is shown but the control power connector XD10 is placed similar at all MAC generation III motors

2.4.2 CVI supply Precautions

The CVI supply is not critical since the supply current is quite small (<250 mA). Only make sure that the voltage stays at 24 VDC nominal and does not exceed 32 VDC.

NOTE: The motor monitors the control voltage. If it drops below approximately 12.35 V, the output stage is locked and the error 'Control voltage unstable' is reported, so the motor cannot run on a control supply below the specified range.

Warning: A supply voltage at CVI higher than 35VDC will cause permanent damage.

2.5 User I/O

Option !

2.5.1 How to see which I/O options exist

The MAC motor offers an optional number of I/O's covering up to 8 I/O's, where each I/O terminal can be used as either a digital input or a digital output. 4 of the I/O's can also be used as analogue inputs 0-5VDC (see section 2.6).

Different options exist depending on the motor type number.
The table below shows which options are available.

Extract from nomenclature for the MAC generation III product family



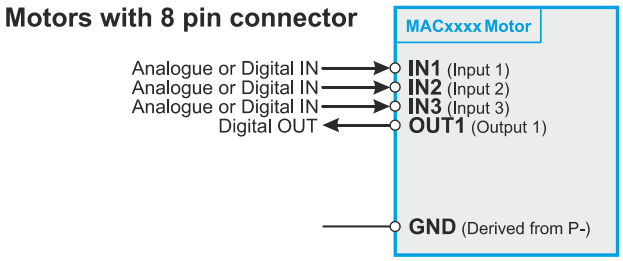
Type of I/O‹s and connectors available

	Digital IN	Digital OUT	Analog IN	Connector type
D_	3	1	3	8 pin M12 A-coded
E_	8	8	4	17 pin M12 A-coded
QA	8	8	4	17 pin M12 A-coded
Q5	3	1	3	8 pin M12 A-coded
W_	8	8	4	17 pin M12 A-coded

TT4045-10GB

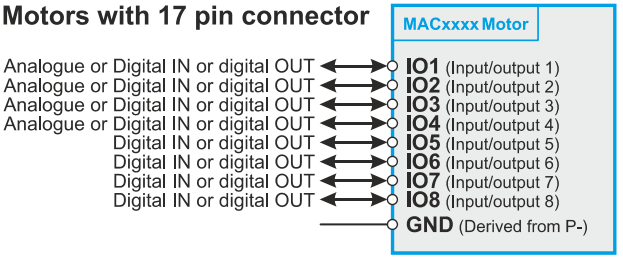
Examples:

A motor type **MAC404M2-HAAQDC2** offers:



TT4047-10GB

A motor type **MAC404M5-HRAMEC2** offers:



TT4046-10GB

2.5.2 Digital User Inputs

If a MAC motor is equipped with digital user inputs, this chapter describes how to use the inputs.
Please also see *How to see which I/O options exist, page 36.*

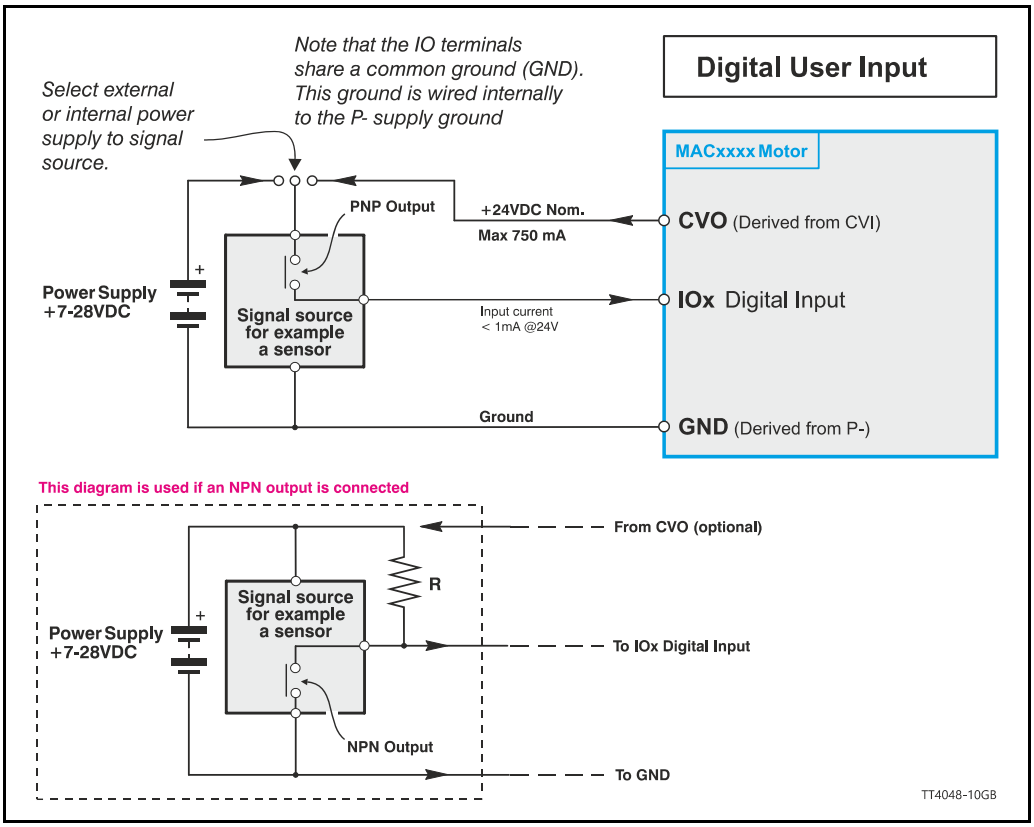
The physical layout of the connectors where the I/O's are present can be seen in chapter *Connector Overview, page 12.*

Depending on the actual I/O option for the motor, it may have 3 or 8 digital inputs.

The inputs offer the following main features:

- Inputs are TTL to 30 VDC compliant. Trigger levels LTL = 2.3 V and UTL = 2.65 V.
- High input impedance (>10 kOhm).
- No galvanic isolation but very robust against noise and spikes/surges.
- Zero search input can be selected to any input.
- Limit switch inputs.

The diagram below illustrates how to connect an external device to the input.



2.5.3 General input description

The motor is optionally equipped with a number of digital inputs. Each input can be used for a variety of purposes depending on the actual application. Each of the inputs can be read/detected from the actual ePLC program that has been downloaded to the motor or via serial commands over the Modbus interface or optionally Ethernet interface.

The Inputs are not optically isolated from other circuitry in the control section (low voltage) of the motor.
All of the Inputs have a common ground terminal, denoted GND. Each Input can operate with voltages in the range 5 (TTL) to 30VDC. Note that the Inputs should normally be connected to a PNP output since a positive current must be applied for an input to be activated.
Note that CVO (control voltage output) is internally connected to the CVI supply terminal in the PWR connector. This provides the facility that local sensors can be supplied directly from the controller. CVO is internally fused to a maximum allowable current of 700 mA.

2.5.4 Connection of NPN Output

If an Input is connected to an NPN output, a Pull-Up resistor must be connected between the Input and the + supply. See also the illustration above.

The value of the resistance used depends on the supply voltage. The following resistances are recommended:

Supply Voltage	Recommended Resistance R
5-12VDC	1kOhm / 0.25W
12-18VDC	2.2kOhm / 0.25W
18-24VDC	3.3kOhm / 0.25W
24-28VDC	4.7kOhm / 0.25W

2.5.5 User-controlled In-Position output

By default the In-Position output reflects the motor's automatic in-position status.
If your application needs to control this output manually (for example from an Ethernet interface write or an ePLC program), set bit 8 (mask 0x100) in Register 39, HW_SETUP (HW Setup).
When bit 8 is set, the output no longer follows the in-position status. Instead it follows bit 0 of Register 207, USEROUTVAL (Basic motor output 1 + 2):

Register 39 - HW Setup (HW_SETUP)

TT4056-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit 8: User-controlled In-Position output (HW_SETUP_USER_INPOS)

Value	Function / Influence
0 (default)	In-Position output reflects the motor's automatic in-position status.
1	In-Position output is controlled by bit 0 of Register 207 (USEROUTVAL).

Bit 31 - 9 and Bit 7 - 0: Is used for other purposes - do not overwrite these bits

Basic motor output 1 + 2 (Reg 207) can be written directly over the fieldbus, or set and cleared from an ePLC program. The output is mapped to physical output channels via Register 110. The polarity can be inverted with bit 10 (HW_SETUP_INV_INPOS_OUT) of HW Setup (Reg 39).

NOTE: The equivalent feature for the Error output is bit 9 (HW_SETUP_USER_ER-

ROR), which redirects that output to bit 1 of Basic motor output 1 + 2 (Reg 207).

2.5.6 Inverting the In-Position output

When the In-Position signal has been mapped to one or more digital outputs (see Register 110), its active level can be inverted using bit 10 (mask 0x400) of Register 39, HW_SETUP (HW Setup):

Register 39 - HW Setup (HW_SETUP)

TT4058-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	**10**	9	8	7	6	5	4	3	2	1	0

Bit 10: Invert In-Position output (HW_SETUP_INV_INPOS_OUT)

Value	Function / Influence
0 (default)	In-Position output active high: output high when motor is in position.
1	In-Position output active low: output high when motor is NOT in position.

Bit 31 - 11 and Bit 9 - 0: Is used for other purposes - do not overwrite these bits

Use this option when the controller or PLC receiving the In-Position signal expects the opposite active level, so the polarity can be matched in software instead of changing the wiring.

NOTE: The corresponding Error output inversion is controlled by bit 11 of HW Setup (Reg 39) (HW_SETUP_INV_ERROR_OUT).

2.5.7 Inverting the Error output

By default the Error output is active high: the output is driven high when the motor is in an error state. Set bit 11 (mask 0x800) in Register 39, HW_SETUP (HW Setup) to invert the polarity to active low — useful when the receiving PLC or safety circuit expects a normally-high "healthy" signal, so a broken wire or loss of power is also detected as a fault.

Register 39 - HW Setup (HW_SETUP)

TT4059-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	**11**	10	9	8	7	6	5	4	3	2	1	0

Bit 11: Invert Error output polarity (HW_SETUP_INV_ERROR_OUT)

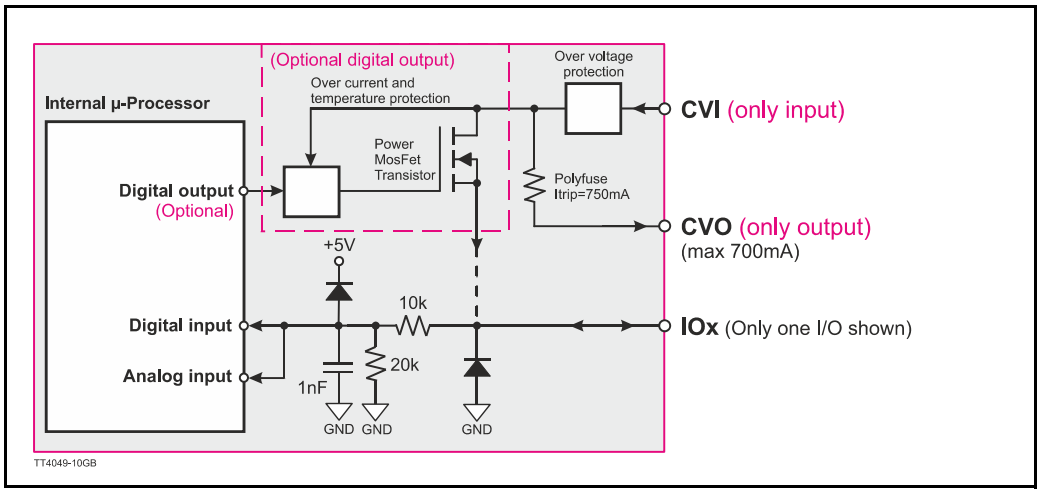
Value	Function / Influence
0 (default)	Error output active high: output high when error is present.
1	Error output active low: output high when no error is present.

Bit 31 - 12 and Bit 10 - 0: Is used for other purposes - do not overwrite these bits

NOTE: Bit 11 is evaluated continuously by the firmware, so a change takes effect immediately. Perform Save in Motor to keep the setting after a power cycle.

2.5.8 Internal circuitry behind the input and output terminal

Input/output functional diagram:



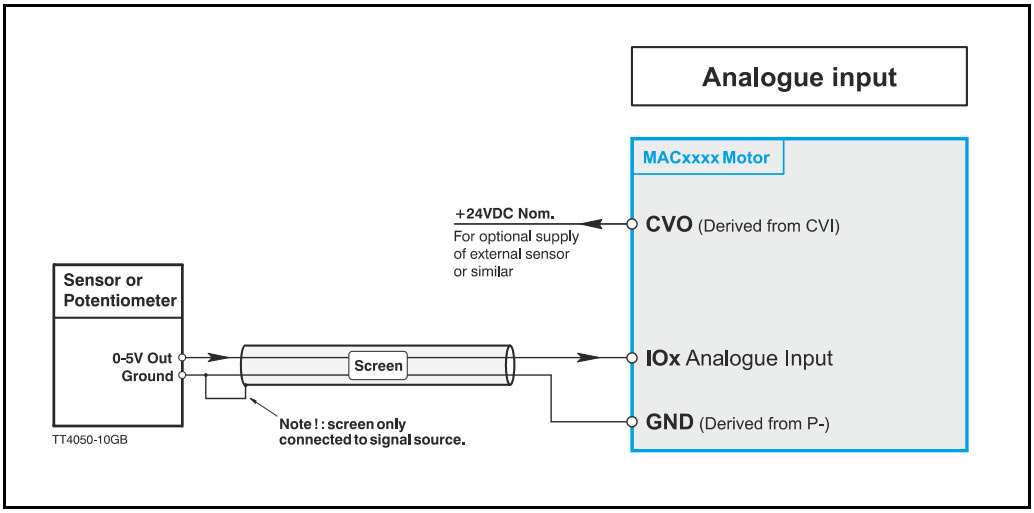
The I/O terminal is well protected with clamping diodes, fuse and high frequency filter to withstand exposure of electrical noise and other typical disturbances in an industrial environment.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

See also *Multifunction I/O terminal type, page 146* and *Dedicated I/O, page 152*.

2.6 Analogue Inputs

Option !



2.6.1 General

Analogue input range 0-5V / 0-10V - hardware revision dependent:
On motors with hardware revision 0.7 or later - fitted with the corresponding revised internal flex cables - the analogue inputs measure 0-10V. Motors with earlier hardware revisions measure 0-5V.

NOTE: firmware versions up to and including v3.1.1.0 do not yet support the 0-10V range. As of firmware v3.1.3.0 this is still the case, so 0-10V operation requires both hardware revision 0.7 or later and a future firmware release.

The hardware revision is stated on the motor type label (QR code) and can also be read in Register 205, HW_VERSION (HW Version), bits [7:0]: [7:4] = major, [3:0] = minor (e.g. 0x07 = revision 0.7).
The Analogue Inputs are used, for example, when the motor is operated as a stand-alone unit. In this kind of application it can be an advantage to use a potentiometer, joystick or other device for adjusting speed, position, acceleration, etc.

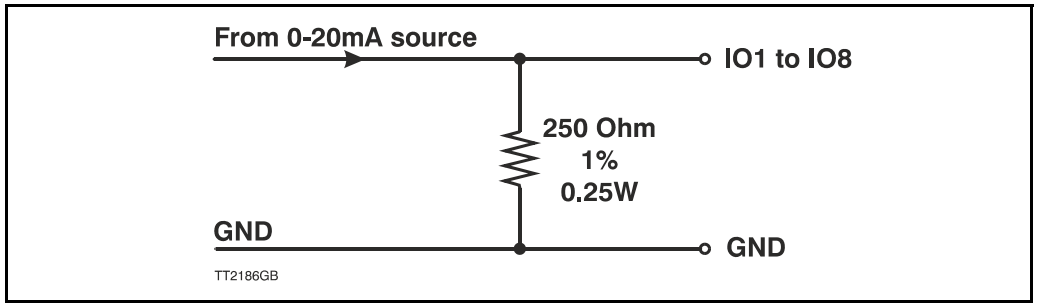
In these modes of operation, the motor is controlled to produce a velocity or position, etc., which is determined by, and proportional to, the voltage applied to the Analogue Input.
The Analogue Inputs share a common ground with the GND terminal and are not optically isolated from all other inputs and outputs. The Analogue Inputs are protected against voltage overload up to 30V peak and have a built-in filter which removes input signal noise.
Always use shielded cable to connect the source used to control an Analogue Input since the motor, etc., can easily interfere with the analogue signal and cause instability.
The controller is equipped with 4 analogue inputs, Analog input 1 to 4 (Reg 216, 218, 220 and 260), each converted by an analogue-to-digital converter (ADC) with a resolution of 12 bit.
The converter result is scaled before it is stored in the register:

- 5.00 V at the terminal gives 1024 counts in the register, i.e. 204.8 counts per volt.
- The internal divider passes two thirds of the input voltage on to the converter, so the register value saturates at 1536 counts, corresponding to 7.5 V at the terminal.
- The input impedance to GND is 30 kOhm, formed by the 20 kOhm / 10 kOhm divider.

2.6 Analogue Inputs

Option !

In order to use the Analogue Inputs as 0-20 mA inputs, a 250 Ω, 1% resistor must be connected between the analogue input and GND.



Please notice: The number of I/O terminals available may differ depending on which motor type and connector configuration you are using. Please consult the chapter *How to see which I/O options exist, page 36*.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

Selecting which analogue input controls the motor
The analogue operating modes, Sensor Homing and Analogue bi-position mode all read a single register, Analogue input (Reg 170). Register 222, IOSETUP (Analog input selector), bits 0-3 select which physical input is copied into it, and which offset register is added:

- Value 0, the factory default, uses Analog input 1 with Analogue input offset (Reg 171).
- Value 1 uses Analog input 1 with Analog input 1 offset (Reg 217).
- Value 2 uses Analog input 2 with Analog input 2 offset (Reg 219).
- Value 3 uses Analog input 3 with Analog input 3 offset (Reg 221).

In MacTalk the selector is the Analog input selection field, which offers Analog input 1 (Reg 216), Analog input 2 (Reg 218) and Analog input 3 (Reg 220). Analog input 1 to 4 (Reg 216, 218, 220 and 260) are always updated with their own raw readings no matter how the Analog input selector (Reg 222) is set, so the inputs that are not selected can still be read from a fieldbus or from an ePLC program. Remember to perform Save in Motor after changing the Analog input selector (Reg 222).

Digital filtering of the analogue input
The filter mentioned above is a hardware filter. In addition, the value that ends up in Analog input (Reg 170) passes through two digital filter stages, both of which are switched off by the factory defaults. In MacTalk they are found in the Analog input filter setting group.

Register 227, AIFILT_MAXSLOPE (Analog input filter slope), limits how many counts the value is allowed to change from one sample to the next. The default is 65535, which is far more than the input range, so no limiting takes place.

Register 228, AIFILT_FILTFACT (Analog input filter factor), applies an exponential low-pass filter in which each sample contributes 1/2 ^ N of the new value, where N is the value of the register. The default is 0, which makes the filter pass the input straight through. A value of 10, for example, takes 1/1024 of the new reading and 1023/1024 of the previous filtered value.

The input is sampled once per servo sample period, that is 1000 times per second at the factory default sample time of 1.0 ms, divided by Register 157, OUTLOOPDIV (Sample time divider).

NOTE: Bit 18 in Register 236, SETUP_BITS (Setup Bits special), stops the firmware from updating Analogue input (Reg 170) and removes the write protection on that register. An application can then write the value itself, for example to test an analogue operating mode without a signal connected.

See also *Position capture on analogue input, page 149*.

2.6.2 Analogue input used as a digital input

In some modes of operation the analogue input is evaluated as a digital signal instead of as a proportional reference. A voltage above the threshold is read as logic high (active) and a voltage below it as logic low (passive). The threshold depends on the function:

- Sensor homing (Homing mode Sensor type 1 and Sensor type 2): 4.5 V, i.e. Analogue input (Reg 170) >= 920 counts.
- Analogue bi-position mode (mode 20): 1.88 V on the way up and 0.63 V on the way down, i.e. Analogue input (Reg 170) >= 384 counts and below 128 counts. The two levels form a hysteresis.
- Position capture on an analogue input: 5.00 V, i.e. Analog input 1 (Reg 216) > 1024 counts. The same level applies to Analog input 2 (Reg 218) when capture is armed on analogue input 2.

Register 41, T_HOME (Home torque), also affects the polarity in sensor homing: the firmware evaluates the sensor as the exclusive OR of Analogue input (Reg 170) above 4.5 V and a negative Home torque (Reg 41). A negative homing torque therefore inverts the polarity, so that a voltage below 4.5 V becomes the active level.

Changing the threshold

In these modes the offset register is always added to the measured value before the comparison, so the physical trigger voltage becomes the threshold minus the offset. Example: to move the sensor homing threshold from 4.5 V down to 3.0 V, write 4.5 V - 3.0 V = 1.5 V = 307 counts to the offset register.

Register 222, IOSETUP (Analog input selector), bits 0-3 select both which physical input is copied into Analogue input (Reg 170) and which offset register is added: value 0 = analogue input 1 with Analogue input offset (Reg 171), value 1 = analogue input 1 with Analog input 1 offset (Reg 217), value 2 = analogue input 2 with Analog input 2 offset (Reg 219) and value 3 = analogue input 3 with Analog input 3 offset (Reg 221). Position capture does not use Analogue input (Reg 170): it compares Analog input 1 (Reg 216) and Analog input 2 (Reg 218) directly, each with its own offset register.

2.7 User Outputs

Option !

2.7.1 User outputs

If a MAC motor is equipped with digital user output(s), this chapter describes how to use the output(s).
Please also see *How to see which I/O options exist, page 36*.

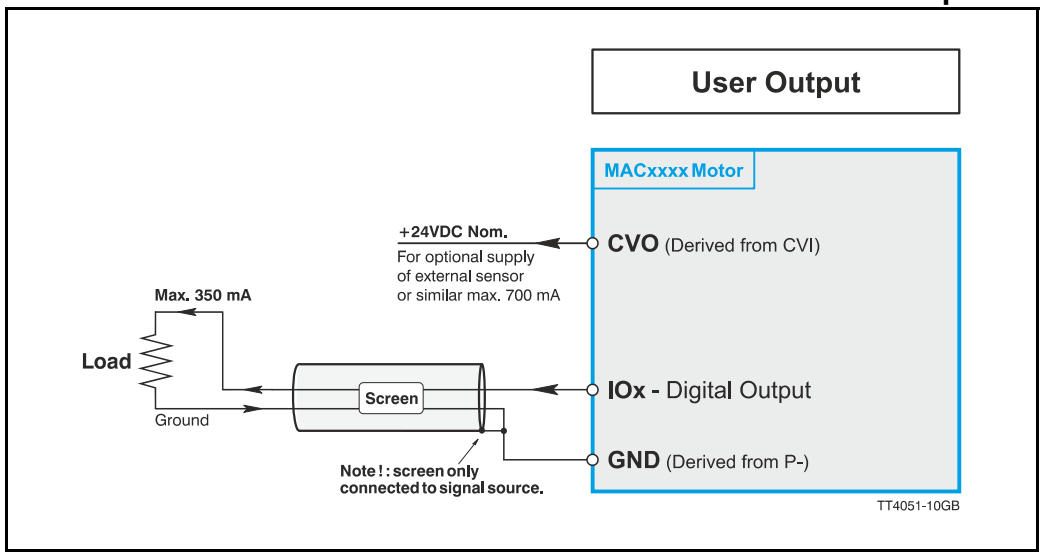
The physical layout of the connectors where the I/O's are present can be seen in chapter *Connector Overview, page 12*.

Depending on the actual I/O option for the motor, it may have 1 or 8 digital outputs.

The output(s) offer the following main features:

- Over current and over temperature protected.
- Short-circuit-to-ground protection that shuts down the affected outputs until the short circuit is removed - see the description
- Protected to handle heavy inductive loads.
- No galvanic isolation but very robust against noise and spikes/surges.
- Output current up to 350mA per output.
- The Outputs are Source outputs and 18-32VDC compliant.
- Optional *"In Position"* and *"Error"* signals can be selected to be on any outputs 1 to 8.

The illustration below shows how to connect an external load to an output.



2.7 User Outputs

Option !

2.7.2 General

The motor is equipped with 1 or 8 digital outputs (depending on which option).
Each output can be used for a variety of purposes depending on the motor's basic mode of operation. The Outputs are not galvanically isolated from other circuitry in the motor. The output circuitry is powered from the control voltage supply terminal CVI.

The output circuitry operates with voltages in the range 18-32 VDC.
Each of the I/O channels 1-8 can supply a continuous current up to 350 mA. The dedicated OUT1 on the 8-pin I/O connector is limited to 300 mA (supplied from CVO).
The outputs are all source drivers, i.e. if a given output is activated, contact is made between the control voltage (CVI) and the respective output terminal. See above illustration.

2.7.3 Overload of User Outputs

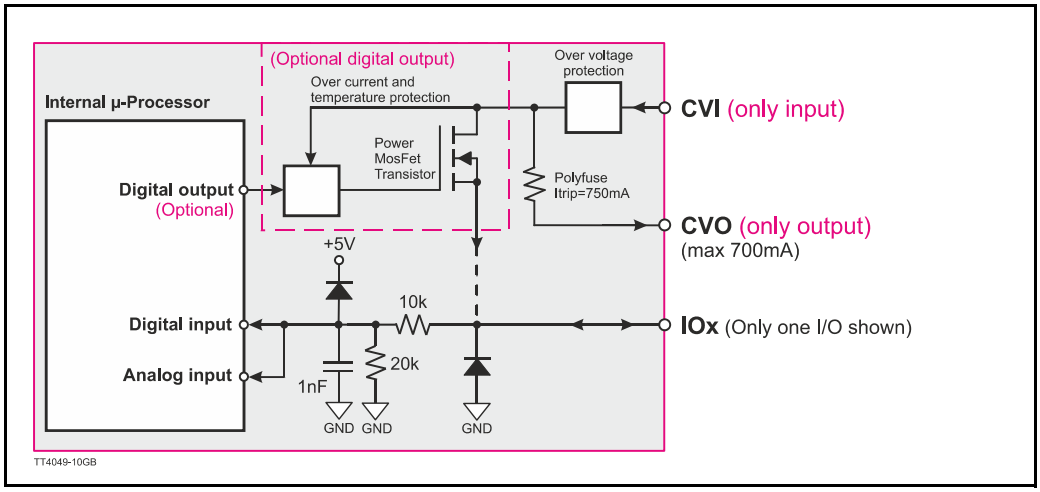
All of the outputs are short-circuit protected: the output driver automatically disconnects the affected output(s) in the event of a short circuit and resumes normal operation when the short circuit has been removed. The output will first function normally again when the short-circuit has been removed.

NOTE: Do not connect a voltage greater than 32 VDC to the CVI terminal as the output circuitry may be seriously damaged and the unit will require factory repair.

If one or more outputs are short-circuited, the output driver disconnects the affected output by itself. The motor and a running ePLC program are not stopped, and the condition is not reported in a register on the MAC G3.

2.7.4 Internal circuitry behind the input and output terminal

Input/output functional diagram:



The I/O terminal is well protected with clamping diodes, fuse and high frequency filter to withstand exposure of electrical noise and other typical disturbances in an industrial environment.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

See also *Error output: position compare, page 151* and *Dedicated I/O, page 152*.

2.8 Communication interface

2.8.1 Serial interfaces

The controller optionally offers two serial interfaces:

- RS485 (Balanced interface - 2 wire) for up to 32 units in multi-axis applications and Modbus communication. (Standard)
- Optional: Ethernet interface for Industrial Ethernet protocols such as EtherNet/IP, EtherCAT, PROFINET (including the PROFIdrive profile) and others. See also *Industrial Ethernet, page 183*

Ethernet and RS485 can be used at the same time.



Please notice: The number of I/O terminals available may differ depending on which motor type and connector configuration you are using. Please consult the chapter *Connector Overview, page 12*.

2.8 Communication interface

2.8.2 RS485 Interface

2.8.2.1 RS485 - General description

The RS485 interface offers more noise immune communication compared to a USB or RS232 interface. Up to 32 motors can be connected to the same interface bus.

When connecting the RS485 interface to a central controller, the following rules must be followed:

1 Use twisted pair cable.

2 Use shielded cable.

3 Make sure that the GND is also connected.

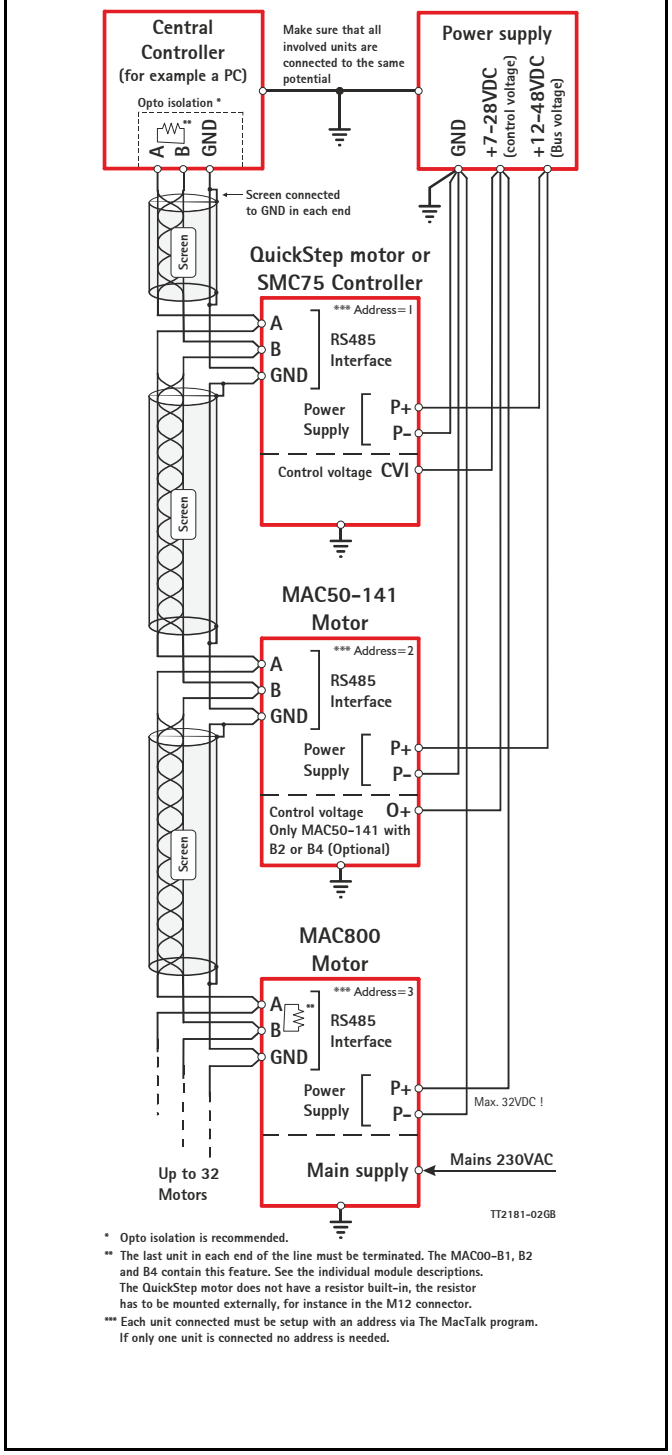
4 Ensure that all units have a proper connection to safety ground (earth) in order to refer to the same potential.

5 The last unit at each end of the network must be terminated with a 120 Ohm resistor between A and B.

6 Ensure that the supply lines are made individually in order to reduce the voltage drop between the motors.

7 Central Controller RS485 interface:
If available, it is strongly recommended that a type with optical isolation is used.

RS485 network with 1 x QuickStep, 1 x MAC140 and 1 x MAC800 mounted with MAC00-B1, B2 or B4 modules.



* Opto isolation is recommended.

** The last unit in each end of the line must be terminated. The MAC00-B1, B2 and B4 contain this feature. See the individual module descriptions. The QuickStep motor does not have a resistor built-in, the resistor has to be mounted externally, for instance in the M12 connector.

*** Each unit connected must be setup with an address via The MacTalk program. If only one unit is connected no address is needed.

The default configuration:
Data bits = 8
Baud rate = 115200
Stop bit = 1
Parity = None

USB to RS485 converter:
www.jvl.dk/1387/rs485-usb-m12m5m8m17

2.8.2.2 RS485 serial frame format

Register 213, UART1_SETUP (UART1: Setup serial RS422/MF1), configures the serial port on the multifunction I/O terminals (A1+/A1-, B1+/B1-), which carries Modbus and SerialGear communication when HW Setup (Reg 39) bits 0-1 select serial mode (the default). It does not affect the B0-/A0+ RS485 MacTalk port. By default (value 0x300B27) the port uses 8-O-1 framing (8 data bits, odd parity, 1 stop bit) at 1 Mbaud with the JVL Module Modbus protocol. Bits 11-13 select the parity and bits 14-15 select the stop bits.

Bits 11-13 (UARTX_PARITY_MASK): 0 = even parity; 1 = odd parity (default, 8-O-1); 2-7 = no parity. **NOTE:** when the protocol field (bits 4-7) selects JVL Module Modbus (protocol 2), the firmware always uses odd parity regardless of this field.

Bits 14-15 (UARTX_STOPBITS_MASK): 0 = 1 stop bit (default); 1 = 1 stop bit (1.5 stop bits is not supported); 2 = 2 stop bits; 3 = reserved (1 stop bit).

Register 213 - UART1: Setup serial RS422/MF1 (UART1_SETUP)

TT4071-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bits 11-13: RS485 parity (UARTX_PARITY_MASK)

Value	Function / Influence
0 (default)	No parity: 8N1 frame format.
1	Odd parity: 8O1 frame format.
2	Even parity: 8E1 frame format.

Bit 31 - 14 and Bit 10 - 0: Is used for other purposes - do not overwrite these bits

Register 213 - UART1: Setup serial RS422/MF1 (UART1_SETUP)

TT4072-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bits 14-15: RS485 stop bits (UARTX_STOPBITS_MASK)

Value	Function / Influence
0 (default)	1 stop bit.
1	2 stop bits.

Bit 31 - 16 and Bit 13 - 0: Is used for other purposes - do not overwrite these bits

NOTE: After changing the frame format, perform Save in Motor and reset the motor. All devices on the RS485 network must use the same frame format.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

2.8.3 SerialGear master/slave role

The MAC motor can operate in a SerialGear network where one master motor transmits position data to one or more slave motors over the RS485 link. Bits 24-25 (UARTX_OPT_SM_MASK) of Register 213, UART1_SETUP (UART1: Setup serial RS422/MF1) select the role.

Value 0 (default): Standard Modbus slave. The motor waits passively for commands from an external Modbus master.

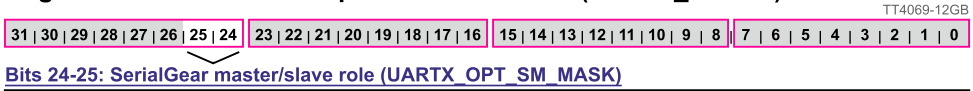
Value 1: SerialGear slave. The motor follows position telegrams from the SerialGear master and raises a Modbus communication error if no telegram is received within the timeout period.

Value 2: SerialGear master. The motor transmits its Actual position (Reg 10) to the slave and monitors the slave's error status.

Value 3: RxP master. The embedded ePLC/eRxP program acts as the Modbus master.

Register 213 - UART1: Setup serial RS422/MF1 (UART1_SETUP)

TT4069-12GB



Bits 24-25: SerialGear master/slave role (UARTX_OPT_SM_MASK)

Value	Function / Influence
0 (default)	Standard Modbus slave: passive, waits for commands from an external master.
1	SerialGear slave: follows master position telegrams; raises Modbus Com. Error on timeout.
2	SerialGear master: sends actual position to the slave; monitors slave error status.
3	RxP master: embedded ePLC/eRxP program acts as the Modbus master.

Bit 31 - 26 and Bit 23 - 0: Is used for other purposes - do not overwrite these bits

NOTE: After changing bits 24-25, perform Save in Motor and reset the motor. The SerialGear master data content can be extended with bits 8-10 of Register 236, SETUP_BITS (Setup Bits special); see sections on ZUP_Px_OFFSET, ZUP_PSOLL_PAIR, and ZUP_VSOLL_PAIR.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

2.8.4 SerialGear master data options

When Register 213, UART1_SETUP (UART1: Setup serial RS422/MF1), bits 24-25 are set to SerialGear master mode (value 2), three bits in Register 236, SETUP_BITS (Setup Bits special), control what position and velocity data the master transmits to the slave.

Bit 8 (ZUP_Px_OFFSET, mask 0x100): By default the master sends the Actual position (Reg 10). When set, the master sends the Actual position (Reg 10) plus Position Reg 6 (Reg 59) instead, allowing the slave's mechanical zero to be offset from the master's.

Bit 9 (ZUP_PSOLL_PAIR, mask 0x200): When set, the master transmits the position set-point, Requested position (Reg 3), instead of the Actual position (Reg 10). The slave then follows the master's demanded position (feed-forward), which can reduce tracking error in high-dynamic systems.

Bit 10 (ZUP_VSOLL_PAIR, mask 0x400): When set, the master transmits the velocity setpoint, Velocity (Reg 5), instead of a position. The telegram then carries only this single value, which is written to the slave's Velocity (Reg 5); bits 8 and 9 have no effect while bit 10 is set.

Register 236 - Setup Bits special (SETUP_BITS)

TT4081-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit 8: SerialGear master sends position offset (ZUP_Px_OFFSET)

Value	Function / Influence
0 (default)	SerialGear master transmits actual position P_IST to slave.
1	SerialGear master transmits P_IST + POS5 (position offset) to slave.

Bit 31 - 9 and Bit 7 - 0: Is used for other purposes - do not overwrite these bits

Register 236 - Setup Bits special (SETUP_BITS)

TT4082-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit 9: SerialGear master sends P_SOLL (ZUP_PSOLL_PAIR)

Value	Function / Influence
0 (default)	SerialGear master transmits actual position P_IST to slave.
1	SerialGear master transmits position setpoint P_SOLL instead of P_IST.

Bit 31 - 10 and Bit 8 - 0: Is used for other purposes - do not overwrite these bits

Register 236 - Setup Bits special (SETUP_BITS)

TT4083-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit 10: SerialGear master sends V_SOLL (ZUP_VSOLL_PAIR)

Value	Function / Influence
0 (default)	SerialGear master transmits position data only to slave.
1	SerialGear master also transmits velocity setpoint V_SOLL (feed-forward).

Bit 31 - 11 and Bit 9 - 0: Is used for other purposes - do not overwrite these bits

NOTE: These bits have no effect unless SerialGear master mode is active, i.e. UART1: Setup serial RS422/MF1 (Reg 213) bits 24-25 = 2. Set the relevant bits in Setup Bits special (Reg 236), then perform Save in Motor and reset the motor.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

2.8.5 FastMac commands

A FastMac command is a single-byte command (value 0-127) that makes the motor activate a set of pre-loaded registers or execute a small built-in function. The command set originates from the FastMac protocol used between the interface modules and the basic motor on previous MAC motor generations. The MAC G3 has no interface modules and no FastMac serial channel, but the command set is fully supported and offers a very fast way to trigger movements with a single register write.
The command value is interpreted as follows:
Values 0-95: Bits 6-5 select the operating mode and the remaining bits select and activate one of the pre-loaded registers. Activating for example P4 in Position mode copies P4 to Requested position (Reg 3) and starts the movement.

Register selection (command values 0-95)
The command value is the sum of a mode offset and a register index N. The mode offset is 0 for Passive, 32 for Velocity and 64 for Position mode, and N (0-31) selects the register:

- N = 0-7: Position Reg 1 to Position Reg 8 (Reg 49-63, in steps of two) - shown as P1-P8 in MacTalk. The selected position is copied to Requested position (Reg 3) at once, so the movement starts immediately.
- N = 8-15: Velocity Reg 1 to Velocity Reg 8 (Reg 65-72) - V1-V8.
- N = 16-19: Acceleration Reg 1 to Acceleration Reg 4 (Reg 73-76) - A1-A4.
- N = 20-23: Torque Reg 1 to Torque Reg 4 (Reg 77-80) - T1-T4.
- N = 24-27: Load Reg 1 to Load Reg 4 (Reg 81-84) - L1-L4.
- N = 28-31: In position window 1 to In position window 4 (Reg 85-88) - Z1-Z4.

Example: command value 32 + 9 = 41 - written as 169 to Special Command (Reg 211) - selects Velocity mode and makes Velocity Reg 2 (Reg 66), shown as V2 in MacTalk, the active velocity.

Special commands (command values 96-127)
Command values 96-127 execute a built-in function instead of activating a register. N below is the command number, i.e. the command value minus 96, and the value in brackets is what must be written to Special Command (Reg 211):

- N = 1 (225): Clear the error bits in Error status (Reg 35).
- N = 2 (226): Requested position (Reg 3) = 0 and clear the In Position status.
- N = 3 (227): Actual position (Reg 10) = 0.
- N = 4 (228): P_FNC (Reg 8) = 0 and clear the In Position status.
- N = 5 (229): Velocity (Reg 5) = 0.
- N = 6 (230): Torque (Reg 7) = 0.
- N = 7 (231): Clear the In Position, Accelerating and Decelerating status bits.
- N = 8 and 9 (232 and 233): Start a relative movement of Position Reg 7 (Reg 61) or Position Reg 8 (Reg 63) counts using P_FNC (Reg 8). P_FNC (Reg 8) is loaded with

the actual Follow error (Reg 20) minus the selected position.

- N = 12-15 (236-239): Activate register set 1-4. The position, velocity, acceleration, torque, load and in-position window register with the same index are loaded together, and the movement starts.
- N = 16 (240): Start a homing sequence. The mode number in Home mode (Reg 42) bits 8-15 is copied to Operating mode (Reg 2). Nothing happens if that field is zero.
- N = 17 and 18 (241 and 242): Requested position (Reg 3) = Actual position (Reg 10) + Position Reg 7 (Reg 61) or + Position Reg 8 (Reg 63).
- N = 20 (244): Use absolute positioning.
- N = 21 (245): Use relative positioning via Requested position (Reg 3).
- N = 22 (246): Use relative positioning via P_FNC (Reg 8).
- N = 23 (247): Synchronise the position absolutely - Actual position (Reg 10) and Requested position (Reg 3) are both set to Resynchronize position (Reg 4).
- N = 24 (248): Synchronise the position relatively - Actual position (Reg 10) and Requested position (Reg 3) are both increased by Resynchronize position (Reg 4).

The remaining command numbers - 0, 10, 11, 19 and 25-31 - are either no operation or belong to the FastMac serial channel, which the MAC G3 does not have. The special commands affected by the high-resolution mode are listed in the Servo Tuning chapter.
A FastMac command is executed on the MAC G3 in one of two ways:
By writing the command value + 128 to Register 211, COMMAND_REG (Special Command). This works from any interface that can write registers: MacTalk, RS485, Modbus or industrial Ethernet. Example: writing 248 (128 + 120) to Special Command (Reg 211) executes FastMac command 120.
From an ePLC program, using the Send FastMac command instruction - see the MacTalk chapter.

2.8.6 Register equivalents of the MacTalk buttons

The buttons that are used most often in MacTalk are all implemented as writes to Register 211, COMMAND_REG (Special Command). They can therefore be reproduced from a PLC, from an industrial Ethernet master or from an ePLC program, without MacTalk being connected:

- Reset Motor: write 1 to Special Command (Reg 211). The motor performs an immediate and unconditional CPU reset. Any setup change that has not been saved to flash memory is lost.
- Save in Motor: write 2 to Special Command (Reg 211). The setup registers are saved to flash memory. The command is only accepted when Operating mode (Reg 2) is 0 (Passive mode) or 15 (Safe mode). In any other mode it is silently ignored - nothing is saved and no error is flagged. When the save has completed, the motor resets automatically.
- Clear Errors: write 225 to Special Command (Reg 211). This is FastMac special command 1 described above. Only the error bits in Error status (Reg 35) are cleared - the status and control bits in the same register are left untouched. Errors that are still present are set again immediately.
- Start Homing: write 240 to Special Command (Reg 211). This is FastMac special command 16 described above. The motor starts the Homing mode selected by bits 15:8 of Home mode (Reg 42), and nothing happens if that field is zero. See Homing configuration via motor registers in the Basic Motor Operation chapter.

To save a setup reliably, first set Operating mode (Reg 2) to 0 to place the motor in Pas-

sive mode, then write 2 to Special Command (Reg 211). Allow the motor to complete its automatic reset and to start up again before communication is resumed.

NOTE: Errors must not be cleared by writing 0 to Error status (Reg 35). That register also holds status and control bits - for example bit 14, which disables the software position limits - so writing zero to the whole register clears those bits as well.

2.9 EMC considerations

2.9.1 EMC considerations

The MAC family of motors eliminates the traditional problems with noise from long motor cables that emit noise and feedback cables that are sensitive to noise from external sources.
However, it is still necessary to be aware of noise problems with communications cables and the 8 general-purpose inputs and outputs.
Whenever a digital signal changes level quickly, a noise spike is generated, and is transferred to the other wires in the same cable, and to a lesser degree to wires in other cables located close to the cable with the switching signal. A typical example is when a digital output from the MAC motor changes from low to high to drive a relay. If this digital output signal is transmitted in a multi-wire cable together with the RS485 signals, there is a high risk that the RS485 signal will be affected to the extent that the communication will fail, and require software retries.
If communication is used during operation, and operation includes either digital input signals or digital output signals, some precautions must be taken to avoid noise problems.
The following sections describe a number of measures which can be taken to solve noise problems. In most installations, no special measures will be required, but if noise problems are experienced – and/or must be avoided – it is highly recommended the instructions below are followed.

2.9.2 Use short cables

The shorter a cable is, the fewer noise problems it will induce. Be sure to keep the cables as short as possible. Instead of curling up the cables, cut them off at the minimum required length.

2.9.3 Use separate cables

Avoid running digital signals in the same multi-wire cables as RS485 communication signals.
On some models of the MAC motors, the same connector contains both RS485 signals and I/O signals – typically the I/Os 1-4.
In many applications, far from all inputs and outputs are used. If only up to four I/Os are required, consider using only I/Os 5-8 which are typically available via another connector on the motor.

2.9.4 Use filters

If more than 4 I/Os are needed, consider using I/Os 1-4 for inputs and I/Os 5-8 for outputs. It is normally possible to install a hardware filter on the digital input signals before they enter the cable. With such a (good) filter, noise on the RS485 signals will not be a problem.
It is also possible to use filters on the outputs, but it is more difficult. It can be done by using short cables from the motor to the filters, and then using longer cables from the filters to the output targets. It may be easier to use a short cable from the motor to a splitter box, and then split the I/Os in one cable and the RS485 signals in another cable.

2.9 EMC considerations

2.9.5 Use termination (resistors) on the RS485 signals

RS485 is typically used to connect a single master PC or PLC to one or more motors in a chain. Both ends of the chain must have a 120 Ohms termination resistor connected between the A+ and B- signals. There is typically a terminating resistor in the master PC or PLC, but there is no termination inside the motors. Therefore, an external resistor must be connected at the end of the cable out of the last motor in the chain. If the last motor has no connection cable, a connector with a resistor soldered between the A+ and B- pins should be used.

As an alternative, a connector with a short cable can be used with the resistor soldered between the two wires carrying A- and B+.
Use individually shielded cables.

In some installations, it will be necessary to have RS485 signals in the same multi-wire cables as fast-switching digital signals. In addition to keeping cable lengths to a minimum and using termination resistors, high-quality cables, where each wire is shielded from the other wires in the cable, should be used. This is typically done using a metal foil wrapped around each wire. These types of cables are more expensive, but the overall cost and noise immunity requirements may justify the solution instead of splitting cables.

2.9.6 Use simple shielding

Using cables with only a single shield shared by all the signal wires will also improve noise problems to some degree, but will not guarantee completely stable operation for mixed signal cables. If a cable carries only RS485 or only digital I/O, this simple and inexpensive form of shielding is recommended.

2.9.7 Checking for disturbed communication

An EMC test can disturb communication without stopping the motor. A disturbance that costs only a few retries leaves no lasting trace in the motor status, so a motor that keeps running through an exposure is not by itself proof that its communication was undisturbed. The motor does count communication errors, however, and those counters can be read out before and after each exposure.
Read the counters immediately before the exposure starts, read them again as soon as it ends, and use the difference between the two readings. Only the difference means anything. The counters are cumulative and are not reset when the motor starts up, so their absolute values say nothing about the test.
Eleven counters are relevant, and the table below is the whole list. The last column names the connector whose cable to check when a counter has moved, by the designations used in the connector overview.

Counter	Register	What it counts	Cable to check
Serial interface com. errors	208	Errors in the MacTalk telegram	XG0 (I/O): pair, screen, termination
Modbus frmn/Par. err. cnt.	240	Framing, overrun, parity	XG0 (I/O)
ModBus CRC err. cnt.	241	Failed Modbus checksum	XG0 (I/O)
Serial 1	18221	Checksum, serial interface	XG0 (I/O)
Ethernet 1	18222	Frame errors on Ethernet	XG1 (LA-I), XG2 (LA-O): cable, screen, switch
internal a	18216	Internal communication	Any cable, earth included
internal b	18218	Internal communication	Any cable, earth included
internal c	18219	Internal communication	Any cable, earth included
internal d	18220	Internal communication	Any cable, earth included
internal e	245	Internal communication	Any cable, earth included

(Continued)

Counter	Register	What it counts	Cable to check
internal f	18217	Internal communication, firmware update	Any cable, earth included

NOTE: Of the counters in the table, only the first three are named in MacTalk. The others are read by number through a register interface. Note in particular that MacTalk shows a register named SPI CRC error count at 16423: that address is unused in current firmware and always reads zero, while the counter that works is 18216.

2.9.7.1 Which cable to look at first

The last column of the table says which cable to look at. One case is not in the table at all: a disturbance on the encoder link. No counter covers it on the MAC G3, so it shows up as a position error or a follow error instead. Neither communication cable is involved - look at the encoder cable and its screening.
If the cables in the last column have been checked and a counter still rises, contact JVL support. Send the counter readings from before and after the exposure, the event log, and the motor type. With those, the counter can be traced to the link it belongs to and a more precise diagnosis can be given than the table allows.

NOTE: ModBus CRC err. cnt. (Reg 241) is a single counter shared by more than one protocol and by more than one serial channel. It cannot distinguish a Modbus RTU CRC16 failure from an OMRON XOR FCS failure, and it cannot distinguish one serial channel from another. A rising value therefore shows that telegrams were corrupted, but not on which link.

NOTE: The two Modbus counters do not cover the same telegrams. When the motor works as a Modbus slave, Modbus frmn/Par. err. cnt. (Reg 240) counts only errors on telegrams addressed to this motor or sent as a broadcast, and it does not cover every serial channel on the motor. ModBus CRC err. cnt. (Reg 241) is not filtered by address. The two counters will therefore not move by the same amount, and a difference between them is not in itself a sign of a fault.

The counters give totals; the event log gives times. The motor keeps an event log in non-volatile memory holding 512 entries, each stamped with a 40-bit time stamp. The log survives a power cycle, and it can be read in MacTalk or transferred from the motor as file 158.
Because every entry is time stamped, the log shows when a fault occurred and not merely how many faults there were in total. That is what ties a fault to a particular exposure step in the test, and it is worth reading the log even when the counters have moved by only a few counts. See also *Event log, page 170*.

NOTE: The error counters and the event log are separate mechanisms. A corrupted telegram increments a counter, but does not by itself create an entry in the event log. Read both.

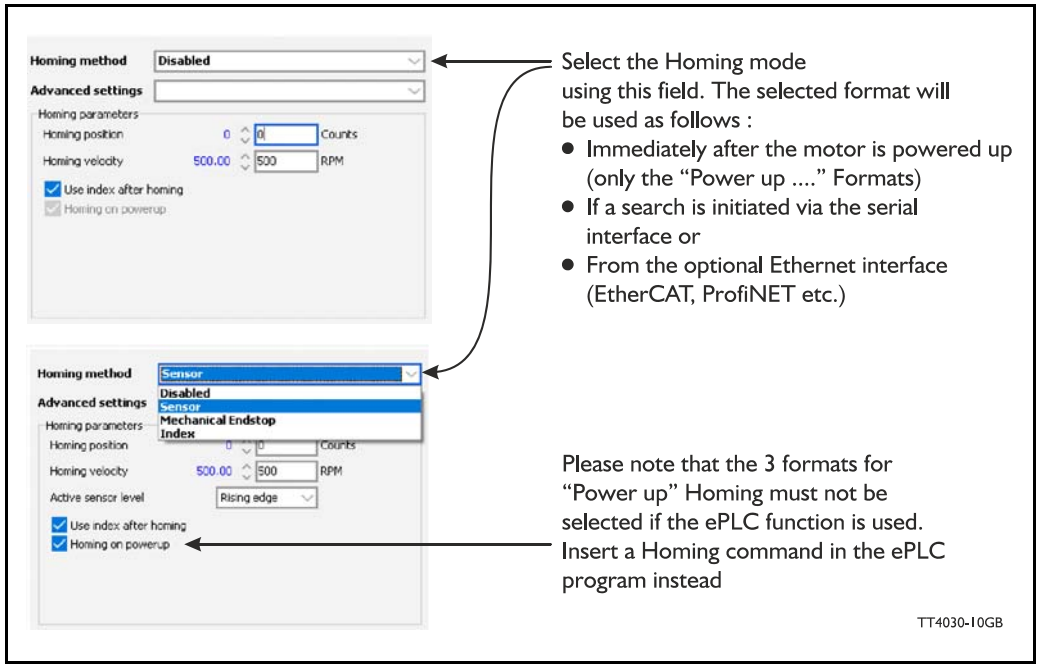
2.9 EMC considerations

3 Basic Motor Operation

3.1 Mechanical Homing

3.1.1 Mechanical Homing modes

Every positioning system needs a way to establish a mechanical zero position, either after power-up or at specific times during operation. For this purpose, the MAC motor offers 5 different *Homing* modes, selected in the MacTalk main window or by a command on one of the serial interfaces.
Each of the 5 *Homing* modes can also be started automatically at power-up, or triggered by a command during normal operation.



The Homing method field offers four choices, which are refined by the Advanced settings field. This gives the following combinations:

Homing method	Precision	Ext. sensor needed
Disabled (no *Homing*)	-	-
Mechanical Endstop	Low	No
Sensor (Unidirectional)	Medium	Yes
Sensor (Bidirectional)	High	Yes
Index (Standard)	High	No
Index (Quick)	Medium	No

The fields on the Homing page have the following functions.
Homing method
Selects the basic Homing method: Disabled, Sensor, Mechanical Endstop or Index. Together with the Advanced settings field it determines the mode number that is written to Operating mode (Reg 2) when a Homing is started: Mechanical Endstop uses mode 12, Sensor uses mode 13 (unidirectional) or mode 14 (bidirectional), and Index uses mode 25 or mode 26.
Advanced settings
Refines the selected Homing method. For Mechanical Endstop the choices are Forward and Reverse. For Sensor they are Unidirectional Forward, Unidirectional Reverse, Bidirectional Forward and Bidirectional Reverse. For Index the field selects which of the two

index variants is used, see Index Homing later in this section. The direction is stored in the motor as the sign of Home velocity (Reg 40): a negative value searches in the reverse direction.

Active sensor level
Only present when the Homing method is Sensor. It selects which polarity of the zero sensor signal is treated as an activation. In the motor, the polarity is stored as the sign of Home torque (Reg 41): the sensor is regarded as activated when the voltage on the analogue input is above 4.5 V, and this evaluation is inverted when Home torque is negative.

Homing parameters
Homing position (Counts) is the position value that is assigned to the zero point when it has been found. It is stored in Home offset (Reg 38), see Making a Zero point offset later in this section. Homing velocity (RPM) is the velocity used during the search and is stored in Home velocity (Reg 40). Homing torque (%) is stored in Home torque (Reg 41) and is used as the torque limit that defines the mechanical stop when the Homing method is Mechanical Endstop.

Use index after homing
When this box is checked, the motor finds the internal encoder index position after the Homing has been completed and uses it as the zero point. See Find index position after Homing later in this section.

Homing on powerup
When this box is checked, the mode number of the selected Homing is stored in bits 0-7 of Home mode (Reg 42), and the motor enters that Homing mode automatically after every power-up instead of its normal start-up mode. When the box is not checked, bits 0-7 are zero and the motor starts up in the normal start-up mode. The mode number used when a Homing is started by a command on one of the serial interfaces is held in bits 8-15 of the same register.

3.1.2 Overall Homing mode descriptions

Disabled (default)
The *Homing* is disabled.

Mechanical Endstop
The *Homing* function searches for the zero position until a mechanical "collision" occurs. The point at which the motor torque is equal to the specified value of the *Homing* torque (Reg 41) is defined as the zero position.

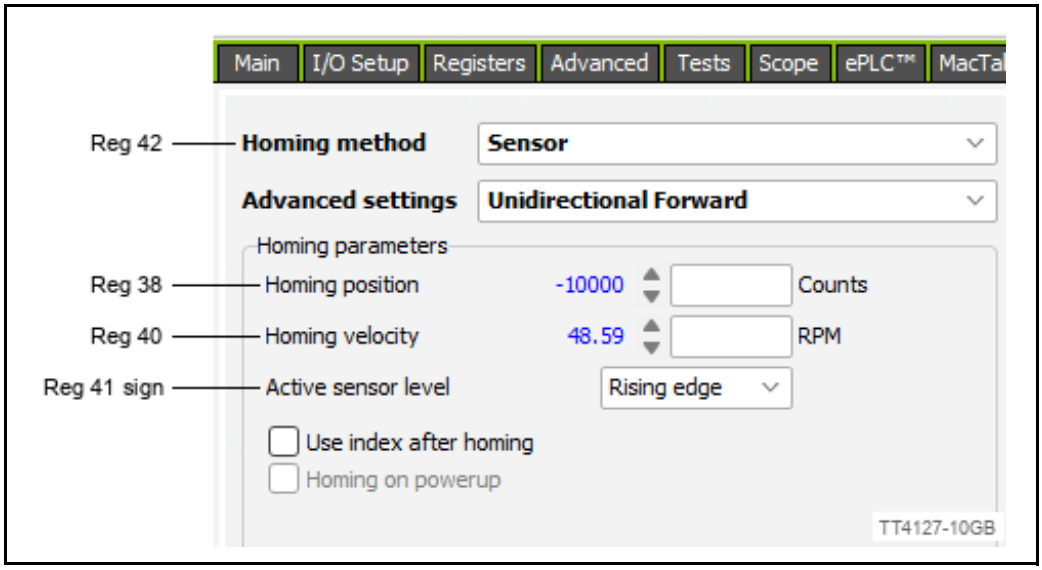
Sensor
The Homing function seeks the zero position until an external sensor is activated. The point at which the sensor is activated is defined as zero.

Index
The *Homing* function will move up to 1.5 motor revolutions and detect where the internal encoder index pulse occurs. The position where the index pulse was found is defined as zero. 4 different setting possibilities: *Standard Forward/Reverse* and *Quick Forward/Reverse*. *Standard* is more precise but slower than *Quick*.

The following sections explain in detail the functionality of the fundamental *Homing modes in detail.*

3.1.3 Starting a Homing

If the *Homing* mode is set to *Disabled,* no *Homing* is done at any time.

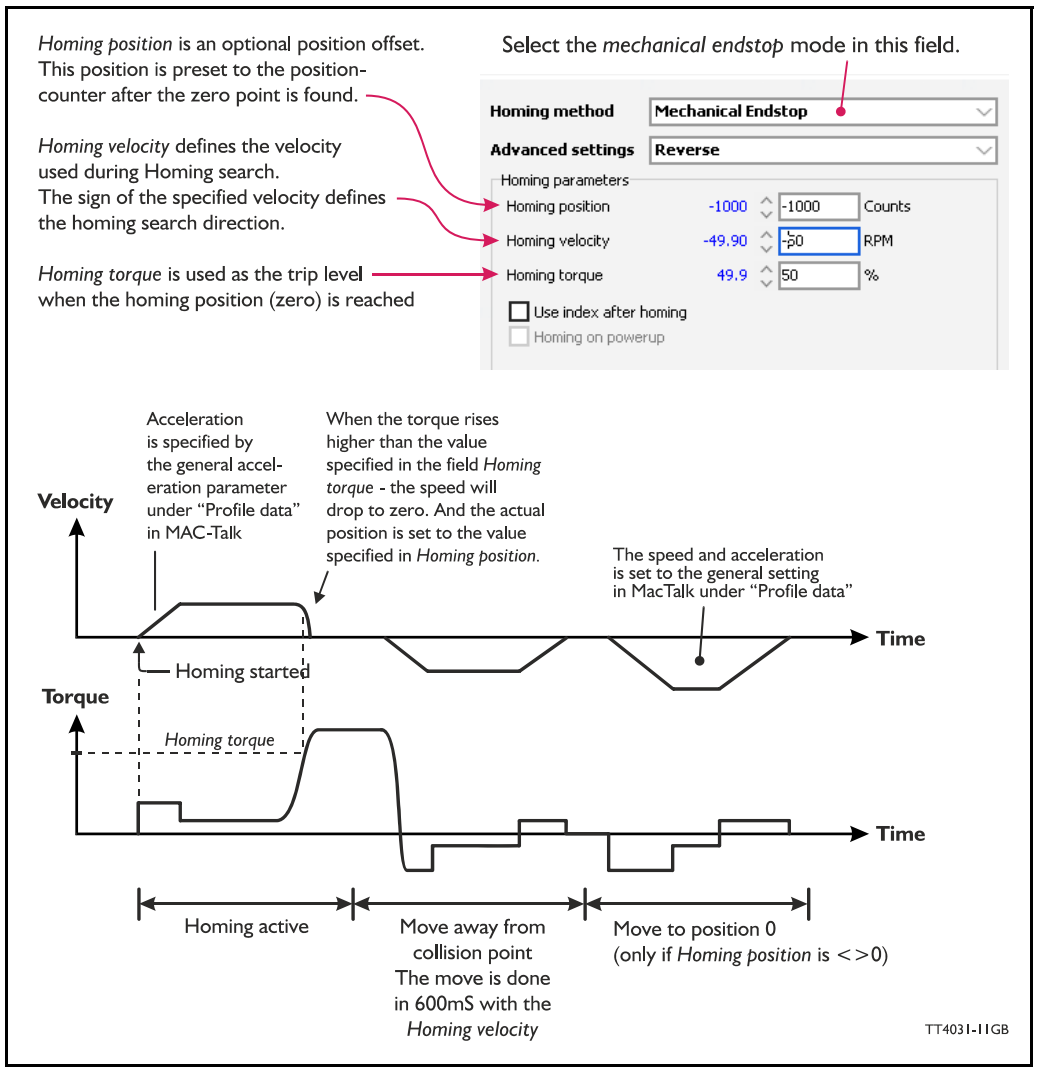


If Homing on powerup is selected, the Homing mode will be executed every time the MAC motor is restarted / power cycled.
The Homing can also be initiated by clicking on the Start Homing button on the *Homing page*.
A similar button is present on the *Tests* page.
The same command is available from any register interface - see *Homing configuration via motor registers, page 66*.
For more details, see the individual detailed Homing descriptions on the next pages.

3.1 Mechanical Homing

3.1.4 Mechanical Endstop

Mechanical Endstop is carried out according to the following illustration.



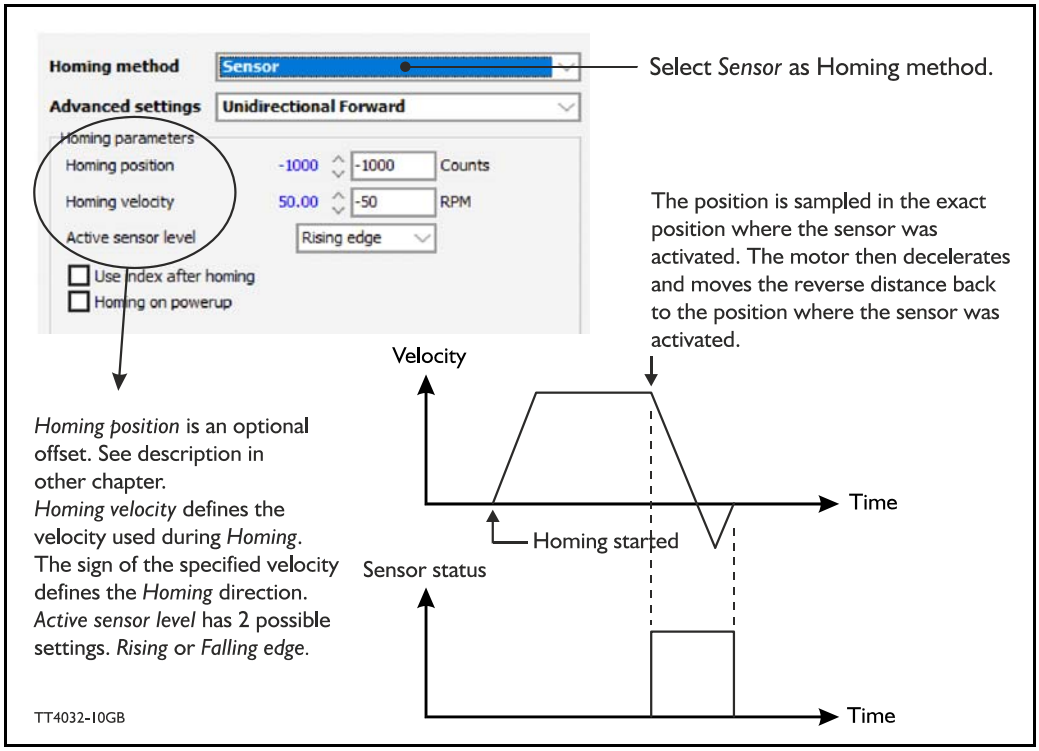
The *Homing* method using a *Mechanical Endstop* as a reference is a cheap, simple way to find the mechanical zero position, but please be aware of the following critical points.

- Make sure that the *Homing torque* (Reg 41) is set to a proper value higher than the mechanical friction in the system in order to avoid a faulty zero point being found. It is a good idea to let the motor run in Velocity mode at the velocity that will be used for Homing, and observe the actual motor torque. This value can be observed in the status area on the right side of the main window. Set the *Homing torque* to a value 10-20% higher than the actual torque observed during this procedure.

- To improve the repeatability precision of the zero point, make sure that the mechanical "collision" point is as stiff and well-defined as possible.

3.1.5 Sensor Homing

Homing using *Sensor* is carried out according to the following illustration.



The Zero sensor must be connected to one of the analogue inputs (AIN), which during *Homing* functions as a digital input.
For connection information and electrical specification, see *Analogue Inputs, page 41*.

Unidirectional and bidirectional Sensor Homing
Unidirectional Sensor Homing runs the motor at Home velocity (Reg 40) until the Zero sensor becomes active. At that moment the motor stops and the position counter is set to zero, so the zero point is the point at which the sensor activated.

Bidirectional Sensor Homing uses the opposite sensor edge instead. When the sensor becomes active, the motor reverses at a much lower speed, one sixty-fourth of Home velocity plus one count per sample, and continues until the sensor becomes inactive again. The zero point is that deactivation point. Because the sensor edge is left at a very low speed, it is far more repeatable than the activation edge reached at full Homing velocity, so bidirectional Homing gives a better zero point than unidirectional Homing at the cost of a longer Homing time.

Both variants handle a sensor that is already active when the Homing starts. The motor then first runs in the opposite direction until the sensor becomes inactive, and only then begins the actual search in the selected direction. No special preparation of the mechanics is needed before a Homing is started. MacTalk still refers to the two variants as Sensor type 1 (unidirectional) and Sensor type 2 (bidirectional) in the tooltip for the Advanced settings field, and earlier manuals used those names throughout. Note also that several MacTalk field labels still use the older wording: Zero search position, Zero search velocity and Zero search torque are the fields for Home offset (Reg 38), Home velocity (Reg 40) and Home torque (Reg 41), and the checkbox for the index feature is labelled Use index after zero search.

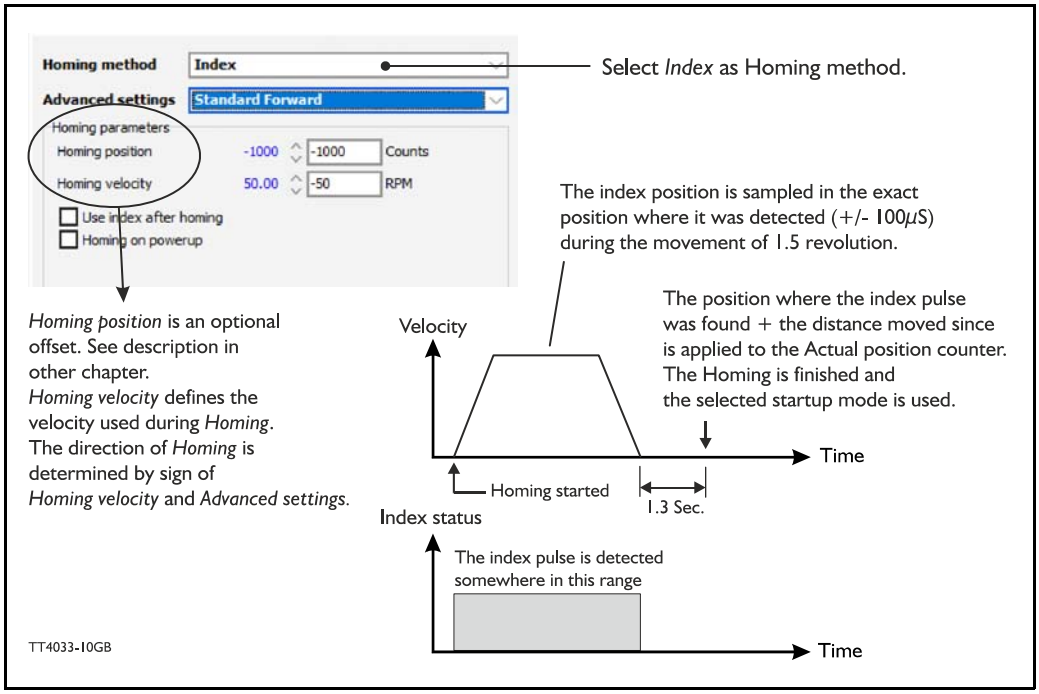
(continued)
In both variants the final zero point is the average of 32 position samples taken after a settling time of 1000 servo cycles, approximately 1 second at the factory default sample time, with Register 38, P_HOME (Home offset) added.

3.1.6 Index Homing

The motor also offers one unique point per motor revolution, called the index point. On the MAC G3 this is not a separate pulse output from the encoder. It is the fixed zero position of the encoder's absolute single-turn measurement, and the present single-turn position is available in Register 209, INDEX_IST (Single turn position), which counts from 0 to 8191 over one mechanical revolution. For applications where the working range is always less than or equal to one revolution, this point can be used as the mechanical zero. This avoids having any external sensors involved, which simplifies the mechanics and the cabling.

This Homing mode has four possible settings: Standard Forward, Standard Reverse, *Quick Forward or Quick Reverse*. Standard mode is slower but much more precise, since the index position is measured while the motor is stationary and averaged over 32 samples. It will, however, need a few seconds to complete, depending on the *Homing* speed and the overall acceleration used.

When the *Index Homing* is carried out, the motor will, in Standard mode, move exactly 1.5 revolutions in total. A pause of approx. 1 second (1024 servo cycles) is then used to stabilize the motor position and to do various calculations.
In Quick mode, the motor stops as soon as the index pulse is found, and no pause is used.



3.1.7 Homing configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, Profibus, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Start the *Index Homing* Standard:
Write the decimal value 25 into Register 2, MODE_REG (Operating mode). This will immediately start the *Homing*. The value is expressed in 32 bits unsigned.

Start the *Index Homing* Quick:
Write the decimal value 26 into Operating mode (Reg 2). This will immediately start the *Homing*. The value is expressed in 32 bits unsigned.

Set the Homing velocity:
Write the velocity value into Register 40, V_HOME (Home velocity). Notice that the sign will determine the *Homing* direction.
A velocity expressed as 100 RPM must be written as 218 (1 RPM = 2.18 at the factory default sample time and resolution). The value is expressed in 32 bits signed.

For setting the *Homing* position in Home offset (Reg 38), see *Making a Zero point offset, page 67*

Select the Homing mode and start a Homing on command:
Register 42, HOME_MODE (Home mode) holds two independent mode numbers in its lower two bytes. Bits 7:0 select the Homing mode that the motor enters automatically every time it starts up; when this field is zero, the motor starts up in the mode held by Register 37, START_MODE (Start mode) instead. Bits 15:8 select the Homing mode that is executed when a Start Homing command is received.

To issue that command, write 240 to Register 211, COMMAND_REG (Special Command). The motor copies the mode number from bits 15:8 of Home mode (Reg 42) into Operating mode (Reg 2), and the Homing starts immediately. Nothing happens if bits 15:8 are zero. This command is the register equivalent of the Start Homing button in MacTalk.

Both fields use the same mode numbers as Operating mode (Reg 2): 12 for Mechanical Endstop, 13 for Sensor (unidirectional), 14 for Sensor (bidirectional), 25 for Index Homing Standard and 26 for Index Homing Quick. Writing one of these values directly to Operating mode (Reg 2), as described above, starts the Homing immediately without using Home mode (Reg 42) at all.

Detect that a Homing has finished:
When a Homing sequence has completed, the motor sets bit 16 in Home mode (Reg 42) and bit 18, Homing done, in Error status (Reg 35). Both bits are cleared again when a new Homing is started, and after a reset or a power cycle, so either of them can be polled to detect that a commanded Homing has actually finished.

3.1.8 Making a Zero point offset

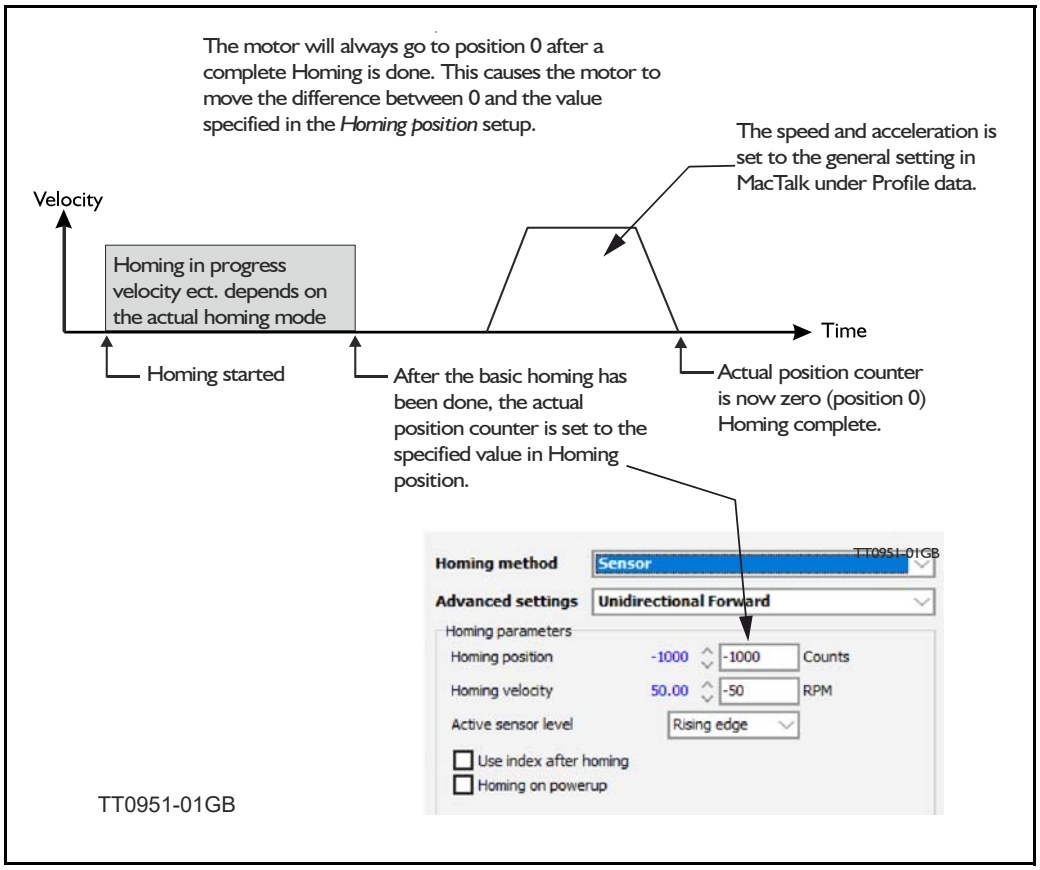
In all *Homing* modes, the zero point can optionally be placed somewhere other than the physical reference point (endstop, sensor or index). The offset is entered in the "Homing position" field (Reg 38): when the reference point is found, the position counter (Reg 10) is set to this value instead of 0.
When is it useful to use the zero point offset?

- When the working range should use convenient, positive positions (0 to +n). Without an offset, this is not always possible: the reference point, and thereby position 0, may be far from the working range or in the middle of it.
- When the motor should automatically move to a defined start position after a power-up *Homing*.

The offset value must be specified in the "*Homing* position" field.
The complete *Homing* sequence is then performed in the following order:

1. The *Homing* is started either automatically (power up) or initiated by command from the interface.
2. The basic *Homing* is completed, and the position counter is set to the value specified in the *Homing position* field.
3. If the Homing position value is different from position 0, the motor will now move to position 0.
4. The *Homing* is now completed, and the motor will switch to normal operation, which means the mode selected in the "Startup mode" field in the main window.

The illustration below shows the complete cycle.

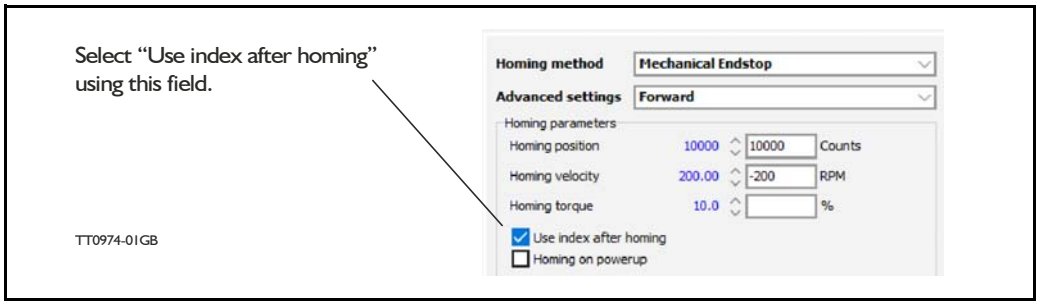


3.1.9 Find index position after Homing

The motor offers one unique point per revolution, called the index point. It is generated from the absolute single-turn encoder at its fixed zero position and is therefore always the same physical position.
By enabling the Use index after homing feature, an extra precise zero point can be defined.

NOTE: The zero point is refined by calculation on the absolute single-turn position, not by searching for a pulse. The feature therefore works on every motor type covered by this manual, including the types with the absolute multi-turn encoder.

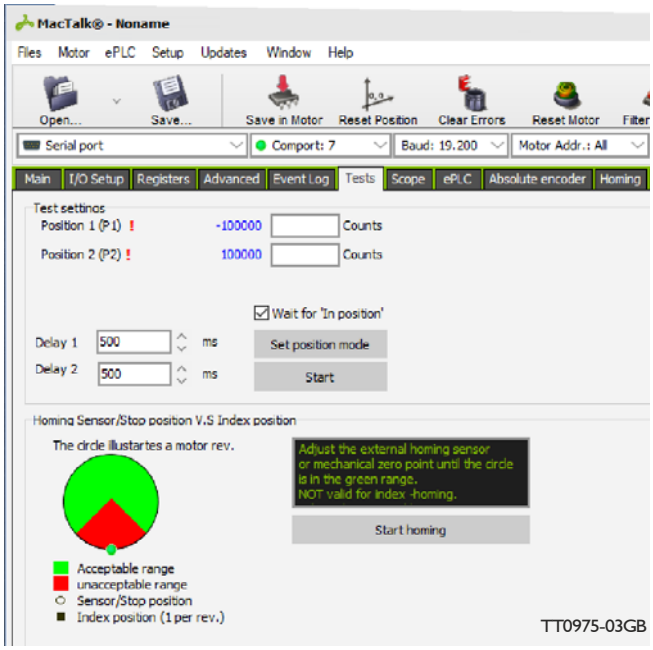
When the Zero sensor or the mechanical end stop is reached, the motor records the single-turn position at that instant. At the end of the Homing sequence the recorded value is applied to the calculated zero point, which moves the reference from the exact point where the sensor happened to trigger to a fixed point within that revolution. The repeatability of the zero point is therefore set by the encoder rather than by the sensor.
This feature is intended to be used if the external sensor does not offer the desired precision. The feature can be used after each of the basic *Homing* modes, including the *Mechanical End stop Homing* mode.
Enable the *Use index after homing* feature in the *Homing* window.



When the feature is selected, it is very important that the external *Homing* sensor is adjusted to the correct position range with a certain margin to the index point to ensure the same index is always found during every *Homing*. If the external sensor is activated too close to the index point, small variations can cause the *Homing* to finalize with reference to the index point of the neighbouring revolution, which in practice constitutes an error of one full motor revolution. Adjustment of the *Homing* point must be done regardless of which of the *Homing* methods is selected.

3.1 Mechanical Homing

The illustration below shows the MacTalk ***Tests*** tab, which must be used for adjusting the *Homing* point.



NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

3.2 Electro Mechanical brake

Only MACxxxx-y5-zzzzzzz and MACxxxx-y6-zzzzzzz

This section is only for MAC motors with the -5 or -6 brake option.
The motors will have the number MACxxxx-y**5-zzzzzzz or MACxxxx-y6-zzzzzzz.**

3.2.1 Brake Introduction

The motor can be equipped with an electro-mechanical brake to hold the position in Passive mode and power-off situations where the motor has no torque. This is often desired to keep mechanics in position, for example if it's a vertical movement.
The brake control always ensures that the brake is activated (holds the motor) if a situation occurs where the motor is not powered and therefore can slip away from the desired position.
No involvement from the user's side is needed to activate and de-activate the brake.

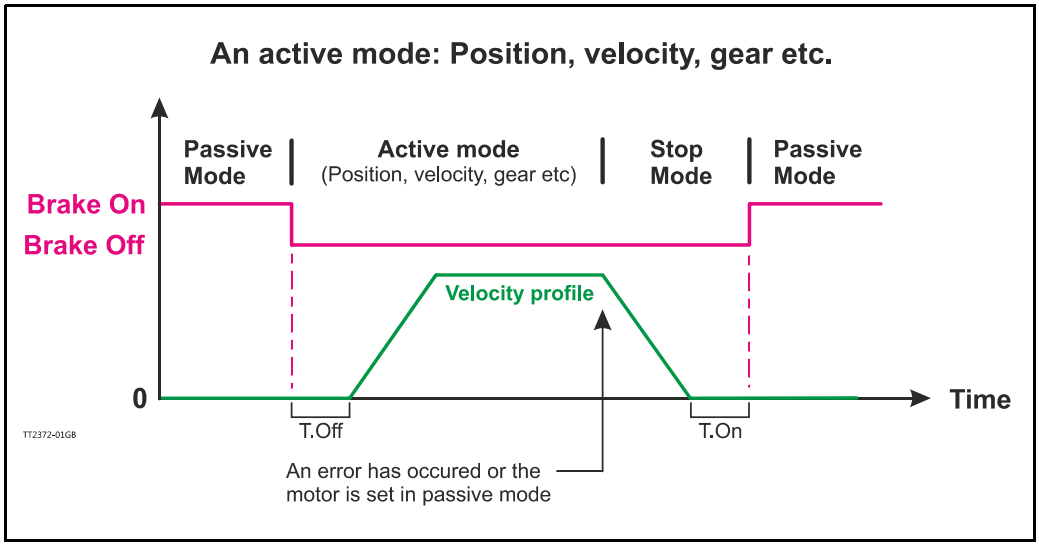
3.2.2 Brake timing

The brake is always engaged in Passive mode because the motor has zero torque. When changing to an active mode, the standby current is applied and the brake is released. Since the brake requires a few milliseconds to fully release, there will be a short delay before the motor can move.

From firmware version 3.1, the brake engage and release delays are configurable.

Register 287, BRAKE_TIME_MS (Brake On Time) controls the engage delay — the time the firmware waits after the motor has decelerated to standstill before the brake is allowed to grip.

Register 288, UNBRAKE_TIME_MS (Brake Off Time) controls the release delay — the time the firmware waits after applying standby current before the motor is allowed to move. Values are given in milliseconds, up to a maximum of 1000 ms. The defaults are measured per rotor size: MAC404 and MAC604 use 64 ms engage and 78 ms release, while MAC802, MAC804, MAC1004, MAC1202, MAC1403 and MAC1404 use 74 ms engage and 66 ms release. The measured times are multiplied by a safety factor - 1.3 on engage and 1.6 on release - so a loaded vertical axis cannot sag before the brake has gripped. Shortening them removes that margin. Changes take effect immediately, but remember to save the settings permanently (Save in Motor); otherwise they are lost at the next power-off.



3.2.3 Brake Power Save

From firmware version 3.1.2.0 the motor reduces the power to the brake coil once the brake has been released. A motor with a brake runs warmer than the same motor without one, and at high load or in a warm environment that extra heat can reduce the duty cycle the motor can sustain.
When the brake is released, full power is applied for 2 seconds so that the brake opens reliably. After the 2 seconds the power is reduced to a holding level, by default 62.5 %. Holding the brake open takes less power than opening it, so the reduction lowers the dissipation in the brake coil and therefore the heat added to the motor. Measured on a MAC1202, the brake current falls from 0.51 A at full power to 0.19 A at the default setting.
The 2 seconds are fixed and cannot be changed. The holding level is set with bits 31-29 in Register 236, SETUP_BITS (Setup Bits special). The field is a signed three-bit value, so the order is not sequential:

Register 236 - Setup Bits special (SETUP_BITS)



Bit 31 - 29: Brake holding power, applied 2 seconds after the brake is released

Value	Function / Influence
0 (default)	62.5 % holding power
1	75 %
2	87.5 %
3	100 % - the power is not reduced, Brake Power Save is off
4	12.5 %
5	25 %
6	37.5 %
7	50 %

The value is a signed three-bit field, so the order is not sequential.
The other bits of Register 236 are used for other purposes - do not overwrite them. TT4104-11GB

Setting the field to 3 switches the function off. The default is 0 because these bits were previously reserved and read as zero, so Brake Power Save is active after a firmware update without any change from the user.
The percentage applies to the power the motor uses to release the brake, which is already compensated for the actual control voltage (CVI). The brake therefore sees the same holding level whether CVI is 18 or 32 V. The value is a PWM duty ratio, not a regulated voltage.
CAUTION: Do not reduce the holding power further than the application allows. If the holding power is too low, vibration or mechanical shock can let the brake plate make contact. That gives mechanical drag and can, in the worst case, brake the motor during operation. The default of 62.5 % is chosen conservatively to keep a margin for reliable release. There is no setting for 0 %, since that would let the brake fall.
Example: a MAC1404 with a brake drives a vertical axis in a cabinet at 40 °C, and the motor reaches its thermal limit during long cycles. Setting bits 31-29 to 7 lowers the holding power to 50 %, which roughly halves the brake current again. Verify on the machine that the brake still releases reliably under vibration before putting the setting into production.

The setting takes effect immediately, but remember to save the settings permanently (Save in Motor); otherwise they are lost at the next power-off.

Only MACxxxx-y5-zzzzzzz and MACxxxx-y6-zzzzzzz

3.2.4 Brake register

Setting bit 7 in Register 36, CNTRL_BITS (Control bits) makes it possible to disable the brake, so that the motor can run freely regardless of which mode or condition the motor is in.

External brake: if an external brake is fitted, set bit 8 (mask 0x100) in Register 246, SETUP2_BITS (Scope/Samp.bits). Output OUT1 then follows the internal brake output, so the external brake engages and releases with the same timing as the built-in brake, using Brake On Time (Reg 287) and Brake Off Time (Reg 288), and no ePLC program is needed. Note that OUT1 cannot be used as the In-Position output while this bit is set.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

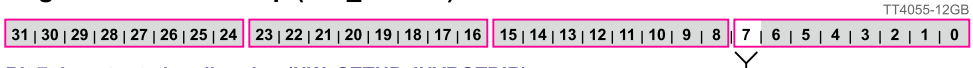
3.3 Invert rotation direction

By default, a positive value of Requested position (Reg 3) or Velocity (Reg 5) rotates the motor shaft in the clockwise direction (as seen from the shaft end). If the mechanical installation requires the opposite convention, the positive direction can be reversed without changing the sign of every set point, gear ratio or homing velocity.

Set bit 7 (mask 0x80) in Register 39, HW_SETUP (HW Setup). When set, the motor inverts the commanded torque and the measured velocity and position feedback together, so a positive command turns the shaft counter-clockwise. Index-based homing is adjusted automatically so the zero point is found correctly in the reversed direction.

Register 39 - HW Setup (HW_SETUP)

TT4055-12GB



Bit 7: Invert rotation direction (HW_SETUP_INVROTDIR)

Value	Function / Influence
0 (default)	Positive direction = clockwise (seen from shaft end).
1	Positive direction = counter-clockwise (direction inverted).

Bit 31 - 8 and Bit 6 - 0: Is used for other purposes - do not overwrite these bits

NOTE: HW Setup (Reg 39) is read once at power-up/reset. After changing bit 7 (for example via the register view in MacTalk), reset or power-cycle the motor for the new direction to take effect.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

3.4 Rotary table option

3.4.1 General description

The Rotary table option, also sometimes called Dividing head, Indexing table or turntable option, makes the motor work in three different ways that limit Actual position (Reg 10) and Requested position (Reg 3) to a smaller position range than normal. This is useful for supporting some mechanical systems.

One of the strong features of this is the motor's ability to calculate the shortest movement to a new target position automatically.
The option can also be used to have the motor always move in the same direction for any target position value, even if the new target position value is below the old position. In this case, the motor will turn in the configured CW or CCW direction until it reaches the new, lower target position.
The actual position will not overflow even when always running in the same direction for any length of time.

The general idea is to define a range of positions by a Minimum and a Maximum value that can be freely selected within the normal position range of the motor (-67 million counts to +67 million counts). Whenever the actual position exceeds the maximum, it will wrap around and continue from the minimum position while still running in the same direction.

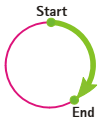
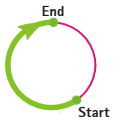
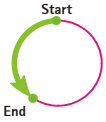
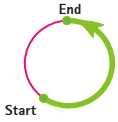
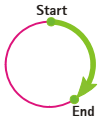
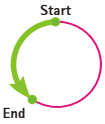
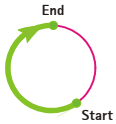
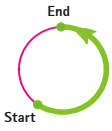
Also, when moving below the minimum position, it will wrap around and continue to count down from the maximum position.

During operation, the motor's main operation mode is usually set to Position mode with Operating mode (Reg 2) set to 2, and the motor is commanded to a new target position by writing a new value to Register 3, P_SOLL (Requested position). See also - *Modes other than Position mode, page 79*.

The value written to Requested position (Reg 3) should be within the rotary table position range. If the value is outside the working range specified by *"Turn table pos. min."* or *"Turn table pos. max"*, it will be clipped to be within the values specified by *"Turn table pos. min."* or *"Turn table pos. max"*. To make a full turn in CW or CCW mode, a multiturn operation is supported - see the following illustration. The registers normally used for software position limits are used to define the rotary table working range in rotary table operation.

3.4 Rotary table option

The 5 operation options for the Rotary Table operation are shown in the following scheme:

Basic setup: Working range min./max= 0 to 7999 counts equal to one revolution. Examples based on MAC800	**Situation 1**	**Situation 2**
1 Singleturn CW rotation	 Setup : Start position 0 Target postion = 3000	 Setup : Start position 3000 Target postion = 0
2 Singleturn CCW rotation	 Setup : Start position 0 Target postion = 5000	 Setup : Start position 5000 Target postion = 0
3 Shortest path	 Setup : Start position 0 Target postion = 3000	 Setup : Start position 0 Target postion = 5000
4 Multiturn CW rotation	 Setup: Start position 0 Target postion = 19000 Result: P_SOLL = 3000 since the remainder after 19000 / 8000 is 3000.	 Setup : Start position 3000 Target postion = -1000 Result: Actual position (P_SOLL) =0 since the value is limited to the working range minimum
5 Multiturn CCW rotation	 Setup : Start position 5000 Target postion = 12345 Result: Actual position (P_SOLL) = 7999 since the value is imited against the working range maximum	 Setup: Start position 0 Target postion = -21000 Result: P_SOLL = 5000 since the remainder after 21000 / 8000 is 5000. TT1186GB

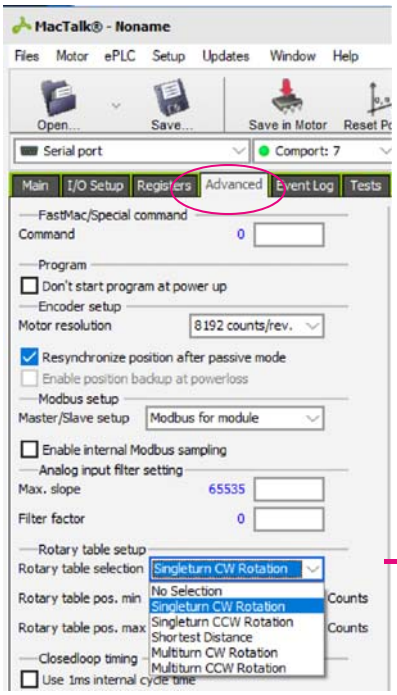
Note 1: In general, Actual position (P_SOLL) will be modified to be within the valid rotary table position working range if a value outside this range is written to the Actual position register (P_SOLL).

Note 2: When using the multiturn options (4 and 5) the position is limited as follows:
- Multiturn CW rotation (4). Values below working range minimum are limited to the minimum.
- Multiturn CCW rotation (5). Values above working range maximum are limited to the maximum.

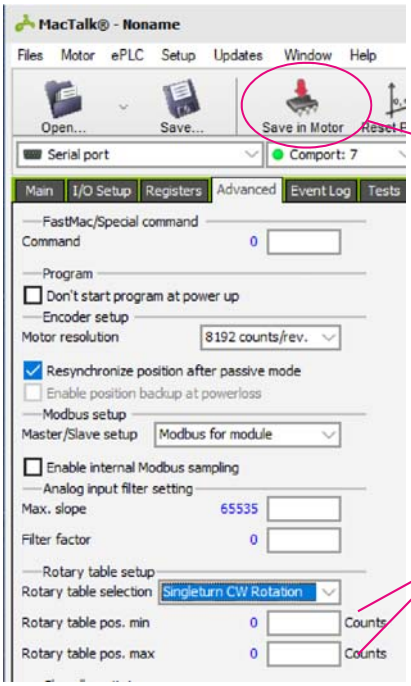
3.4 Rotary table option

3.4.2 Configuration via MacTalk

When using MacTalk for configuration, the following parameters are used:



The desired *Rotary table selection* is selected here at the *Advanced* tab.



After the setup is done please remember to save it in the permanent memory by pressing the *Save in Motor* button.

The working range can be defined here after selecting the type of turn table mode. Minimum is the lowest position possible to reach and maximum is the highest position that can be reached. Both in encoder counts. Both values are refering to the zero position found during the optional *Homing* or alternatively the zero point defined if using an absolute multiturn encoder.

TT1185-01GB

3.4.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, Profibus, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.
The main rotary table operation is selected by bits 24 and 25 in Register 39, HW_SETUP (HW Setup), and the option to support multi-turn rotary table operation is selected by bit 26 in the same register.

Register 28, MIN_P_IST (Minimum position)

Holds the minimum position for the rotary table working range.

Register 30, MAX_P_IST (Maximum position)

Holds the maximum position for the rotary table working range.
Note that the firmware automatically swaps the min. and max. values if the minimum is larger than the maximum.

Register 39, HW_SETUP (HW Setup)

Bits 24, 25 and 26 only. The value of bits 25 and 24 defines the rotary table options:

Bit 26	Bit 25	Bit 24	Operation selected
0	0	0	No Rotary table operation (normal motor operation with full position range)
0	0	1	Singleturn CW rotation.
0	1	0	Singleturn CCW rotation.
0	1	1	Shortest path rotary table operation.
1	0	0	Not used.
1	0	1	Multiturn CW rotation
1	1	0	Multiturn CCW rotation
1	1	1	Not used.

Bit 26 in HW Setup (Reg 39) selects the multi-turn operation. This bit is used only with the CW and CCW operations and allows complete turns to end at the same mechanical position as they started from by specifying a target position in Requested position (Reg 3) that lies outside the rotary table position range. For instance, if the working range is 0 - 8191 (a range of 8192 valid positions, one full motor shaft revolution on the MAC G3 motors) and the current target position is at 3000, writing 11192 (3000 + 8192) will make the motor perform exactly one full turn and leave both Requested position (Reg 3) and Actual Position Rotary Table Offset (Reg 25) at 3000 afterwards.

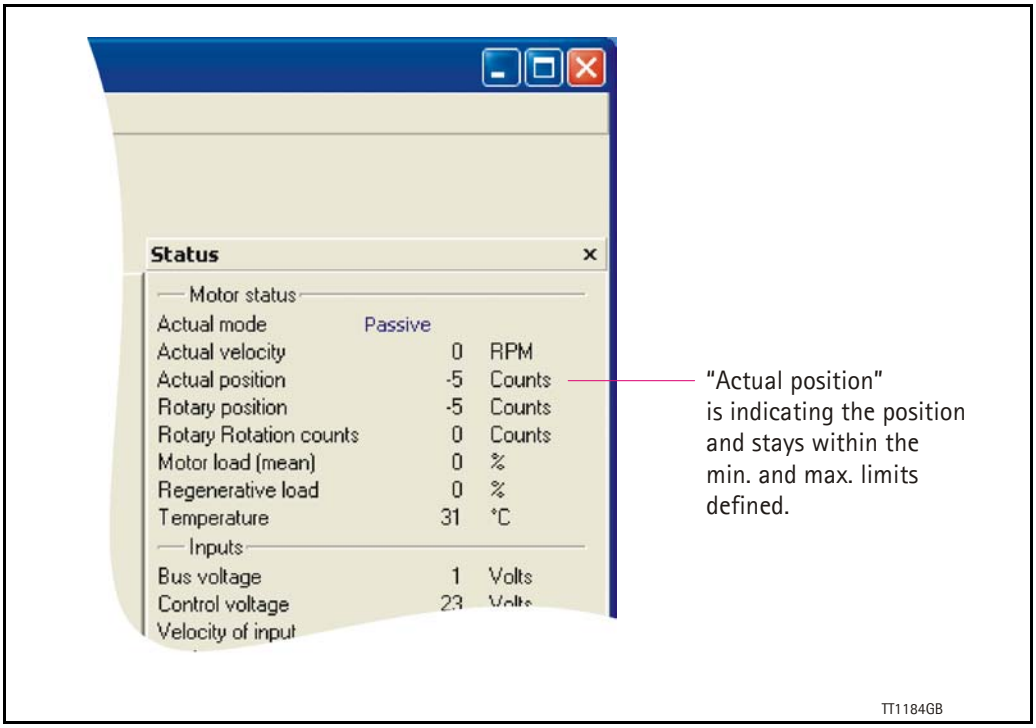
In general, Requested position (Reg 3) will be modified to be within the valid rotary table position working range if a value outside this range is written to Requested position (Reg 3).

Important: Please remember to save the setup in permanent memory (Save in Motor) before the setup is applied and used by the motor.

3.4 Rotary table option

3.4.4 Status read out via MacTalk

When status read out is done via the MacTalk program, data is presented as follows:



3.4.5 Status read out via motor registers

When status read out is done by channels other than MacTalk, such as Ethernet, CAN-open etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 25, P_IST_TURNTAB (Actual Position Rotary Table Offset)

Holds the actual position within the rotary table working range.

Register 27, TURNTAB_COUNT (Rotary Table Wrap Around Counter)

Is a counter that keeps track of wrap-arounds since the last reset of the motor. This register can be written to another value by the user at any time.

Register 10, P_IST (Actual position)

Is still the 'real' actual position 'inside' the motor but should generally not be used in rotary table operation. Actual position (Reg 10) will be modified by the firmware as a result of writes to the Requested position register (Reg 3).

3.4 Rotary table option

3.4.6 Rotary table notes

- Start up positions.
Normally, the motors will start up with a zero value in Actual position (Reg 10) and Requested position (Reg 3) when using a standard encoder or with the position read from an absolute encoder, possibly offset by the Abs Enc. offset register (Reg 225).
In case the rotary table position range does not include the start up value, the start up value is modified by adding or subtracting N times the number of valid positions in the rotary table position range until it is inside this range.

- Valid position range.
Whenever the motor needs to perform a wrap-around, it moves the value of Actual position (Reg 10) outside the valid rotary table position range.

For normal operation, without multi-turn:
When operation *"Singleturn CW rotation"* is selected, Actual position (Reg 10) can temporarily be moved up to one full working range below Minimum position (Reg 28).
When operation *"Singleturn CCW rotation"* is selected, Actual position (Reg 10) can temporarily be moved up to one full working range above Maximum position (Reg 30).

With Shortest Path, Actual position (Reg 10) can be moved either one full working range above Maximum position (Reg 30) or below Minimum position (Reg 28).
When set up for operation as either *"Multiturn CW rotation"* or *"Multiturn CCW rotation"*, the number of ranges Actual position (Reg 10) can temporarily move outside the working range depends on the value written to Requested position (Reg 3) and will be the number of full turns required plus one.
This is important to keep in mind if it causes Actual position (Reg 10) to exceed the motor's absolute position working range of -67 million to +67 million.

- Modes other than Position mode
With rotary table operation activated, main motor modes other than Position mode also work slightly differently.

The software position limits do not cause the motor to go into Passive mode if/when Actual position (Reg 10) exceeds any of these limits: with rotary table operation active, Minimum position (Reg 28) and Maximum position (Reg 30) define the rotary table working range instead, and the normal position limit supervision is disabled. This applies to the hardware position limit inputs (Reg 210) as well: while rotary table operation is active, neither the software limits nor the hardware limit inputs stop the motor.

Actual Position Rotary Table Offset (Reg 25) is still updated to show the actual position relative to the rotary table position range - even while Actual position (Reg 10) gets outside Minimum position (Reg 28) or Maximum position (Reg 30).

One common way to do manual adjustment of the motor is to make a JOG function by using Velocity mode. After a JOG function Actual position (Reg 10) may be left outside the rotary table position range, so switching back to Position mode may cause the motor to move 'unexpectedly'. It is generally recommended to set the maximum velocity in Velocity (Reg 5) to zero when exiting a JOG operation and update Actual position (Reg 10) and Requested position (Reg 3) to desired values before setting Velocity (Reg 5) back to a non-zero value.

NOTE: All motor registers are documented in detail in the online register overview:
www.jvl.dk/register.html?register=MACmotor

3.5 Absolute Multi-Turn Encoder

Only MACxxxx-yy-Hzzzzzz and MACxxxx-yy-Jzzzzzz

3.5.1 Introduction

The Absolute Multi Turn encoder is an **option** for the MAC404, MAC604, MAC802, MAC804, MAC1004, MAC1202, MAC1403 and MAC1404 motors.

The option offers the advantage that once the mechanical zero point is defined, there will be no need for any *Homing* or initialization sequence after power up, since the motor always knows where it is with reference to the original defined zero point regardless of whether power has been removed for a shorter or longer time.

Please notice that **ONLY MAC motors with the "H" or "J" extension contain this feature** (MACxxxx-yy-Hzzzzzz or MACxxxx-yy-Jzzzzzz).

The built-in Multi Turn Encoder uses an energy harvesting technology with the advantage that no battery is used to hold the position after power off. A battery needs replacement after a certain operating time or a certain number of charge/discharge cycles. In other words, the technology used in the MAC motors is a maintenance-free solution.

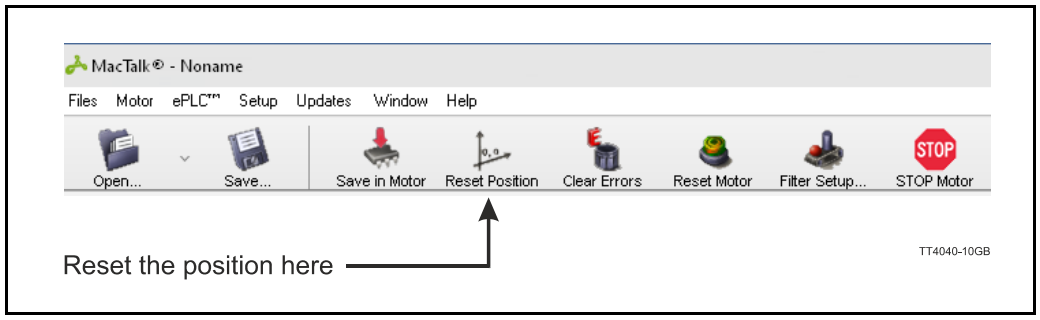
3.5.2 Absolute Multi Turn encoder resolution

The total position range for the encoder is 32 bits, which include single and multi-turn information. This gives:

13 bits single turn information = 8192 counts per revolution and
19 bits multi-turn information = ±262144 revolutions.

3.5.3 How to setup the mechanical zero point

When the mechanical system is at the desired "0" point position (Home), the position counter can be reset to 0 by using the "Reset Position" button in the MacTalk program.



Procedure for adjusting the zero point:

1. Mount the motor in the application and move it to the intended mechanical zero position where the Actual position register (Reg 10) should be 0.

2. Press the *"Reset Position"* button to reset the *"Actual position"* (Reg 10). The actual position counter is now saved permanently to this new position (0).

3.5 Absolute Multi-Turn Encoder

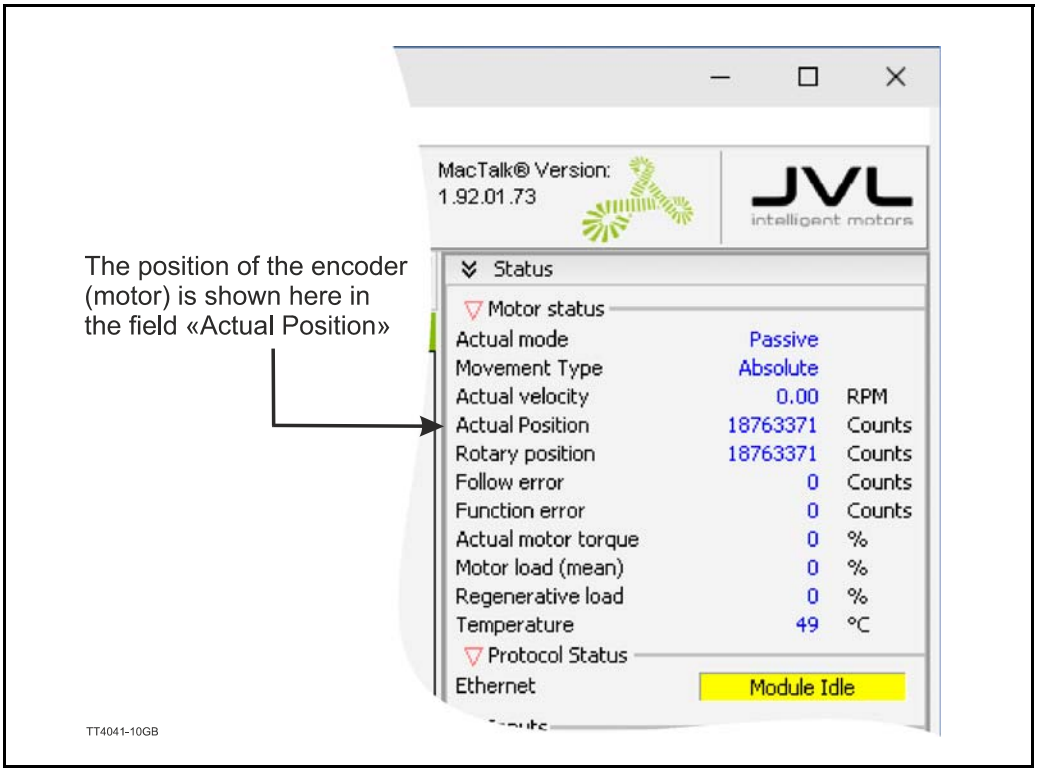
Only MACxxxx-yy-Hzzzzzz and MACxxxx-yy-Jzzzzzz

3.5.4 How to read out the actual position

The actual encoder (motor) position is always available in the main tab of MacTalk. See below.

The motor keeps the multi-turn position without Save in Motor. It writes the position to a non-volatile FRAM memory by itself approximately every 100 milliseconds, alternating between two checksum-protected copies so that a power loss during a write cannot destroy both. At the next start-up the motor reads the stored value back and combines it with the absolute reading from the encoder.

This means that Save in Motor is not needed to preserve the position, but also that the stored value can be up to a few hundred milliseconds old. If the shaft is turned during that window and the control voltage disappears at the same moment, the motor may start up with a position that is off by the distance moved in that interval. Encoders with the Wiegand option are not affected, because they count revolutions without power and the motor recovers the movement at start-up.



3.5 Absolute Multi-Turn Encoder

Only MACxxxx-yy-Hzzzzzz and MACxxxx-yy-Jzzzzzz

3.5.5 Resetting or presetting the position when NOT using MacTalk

The procedure for resetting or presetting the *"Actual position"* (Reg 10) counter is as follows.

When the configuration is done by channels other than MacTalk, such as over Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

3.5 Absolute Multi-Turn Encoder

Only MACxxxx-yy-Hzzzzzz and MACxxxx-yy-Jzzzzzz

The *"Actual Position"* register (Reg 10) is available as follows.

Register 10, P_IST (Actual position).

The register is a read and write register, which means that it can also be overwritten with a new value that will be also remembered after power has been removed from the motor.



Please notice: Do not write to Actual position (Reg 10) during motor movement, since it can cause the value in the position counter to be very imprecise and accumulate an unintended deviation in position.

A safer alternative is to let the firmware perform the write. Write the new position to Register 4, P_NEW (Resynchronize position) and then either write 247 to Register 211, COMMAND_REG (Special Command), or set bit 6 in Register 36, CNTRL_BITS (Control bits) while leaving bit 8 cleared. The motor then sets both the actual position (Reg 10) and the requested position (Reg 3) to the value in Resynchronize position (Reg 4) in the same control cycle, updates the internal function position P_FNC (Reg 8) accordingly, and re-evaluates the Rotary table position range if that option is enabled.

Bit 6 is the trigger, and the motor clears it again when the synchronisation has been carried out. Bit 8 only selects between absolute (bit 8 = 0) and relative (bit 8 = 1) synchronisation, and the motor does not clear it, so it must be cleared explicitly before an absolute synchronisation is triggered. The relative variant, which adds Resynchronize position (Reg 4) to the present position instead of replacing it, is described in Extended encoder operation - endless relative moves later in this section.

3.5.6 Extended encoder operation - endless relative moves

In some applications, the motor keeps moving in one direction with a certain length per move.
Since the position counter (Reg 10) has a limited working range, this kind of operation will sooner or later cause an overflow/wrap around situation.

To avoid the overflow/wrap around situation, the actual motor position can be offset via a command. This offset can be done at any time without losing any position information.

This feature is very helpful since the position counter will stay inside the working range.

Follow this setup sequence for doing a relative position offset:

1. To specify the offset distance, write the desired offset distance (counts) to Register 4, P_NEW (Resynchronize position).

2. To actually offset the position value, one of the following actions can be done:
   - Write 248 to Register 211, COMMAND_REG (Special Command) or alternatively...
   - Set bits 6 and 8 in Register 36, CNTRL_BITS (Control bits) without changing the other bits.

This will add the value given in point 1 above to both Actual position (Reg 10) and Requested position (Reg 3).

To actually perform a relative movement, there are two safe options and one not so safe/ precise.

Option 1, relative moves using Requested position (Reg 3).

1. Prepare for relative movement using Register 3, P_SOLL (Requested position) by executing FastMac command 117 (96+21). This only has to be done once after start up. It selects what will happen when a position register, one of P1 through P8 (Reg 49-63), is activated by a FastMac command.
2. Prepare the relative distance to move by writing it to one of the general purpose P1 through P8 position registers.
3. Execute a FastMac command that 'activates' the Px register. FastMac commands can be sent from MacTalk (see Send FastMac command in the MacTalk chapter) or from any register interface such as RS485 or Ethernet - see the FastMac commands section in the Installation chapter.

This type of relative movement will set Requested position (Reg 3) = Actual position (Reg 10) + Px in a safe way that avoids the type of error described in option 3 below. Note that Requested position (Reg 3) and Actual position (Reg 10) will sooner or later exceed the operating range if this method is used repeatedly, so you will need to use the relative position offset method described for the absolute encoder in Extended Encoder operation.

Option 2, relative moves using P_FNC (Reg 8).

1. Prepare for relative movements using Register 8, P_FNC by executing FastMac command 118 (96+22). This only has to be done once after start up. It selects what will happen when a position register, one of P1 through P8, is activated by a FastMac command.
2. Prepare the relative distance to move by writing it to one of the general purpose P1 through P8 position registers.
3. Execute a FastMac command that 'activates' the Px register. FastMac commands can be sent from MacTalk (see Send FastMac command in the MacTalk chapter) or from any register interface such as RS485 or Ethernet - see the FastMac commands section in the Installation chapter.

This type of relative movement will not change Requested position (Reg 3), so no wrap-around handling is needed.

Option 3 (the unprecise one):

Write a value to Requested position (Reg 3) that is the actual position (Reg 10) plus/minus the distance to move. This is unsafe/inaccurate because the actual position may have changed in the time it took to read the value, do the calculation and write back the new target position. This may still work on some applications, or even be desirable, but note that a position error might accumulate over time.

In some applications, it may be useful to prepare several position distances in the different P1 through P8 registers, and then activate them using different FastMac commands.

3.5.7 ePLC programming - Resetting or presetting to new position

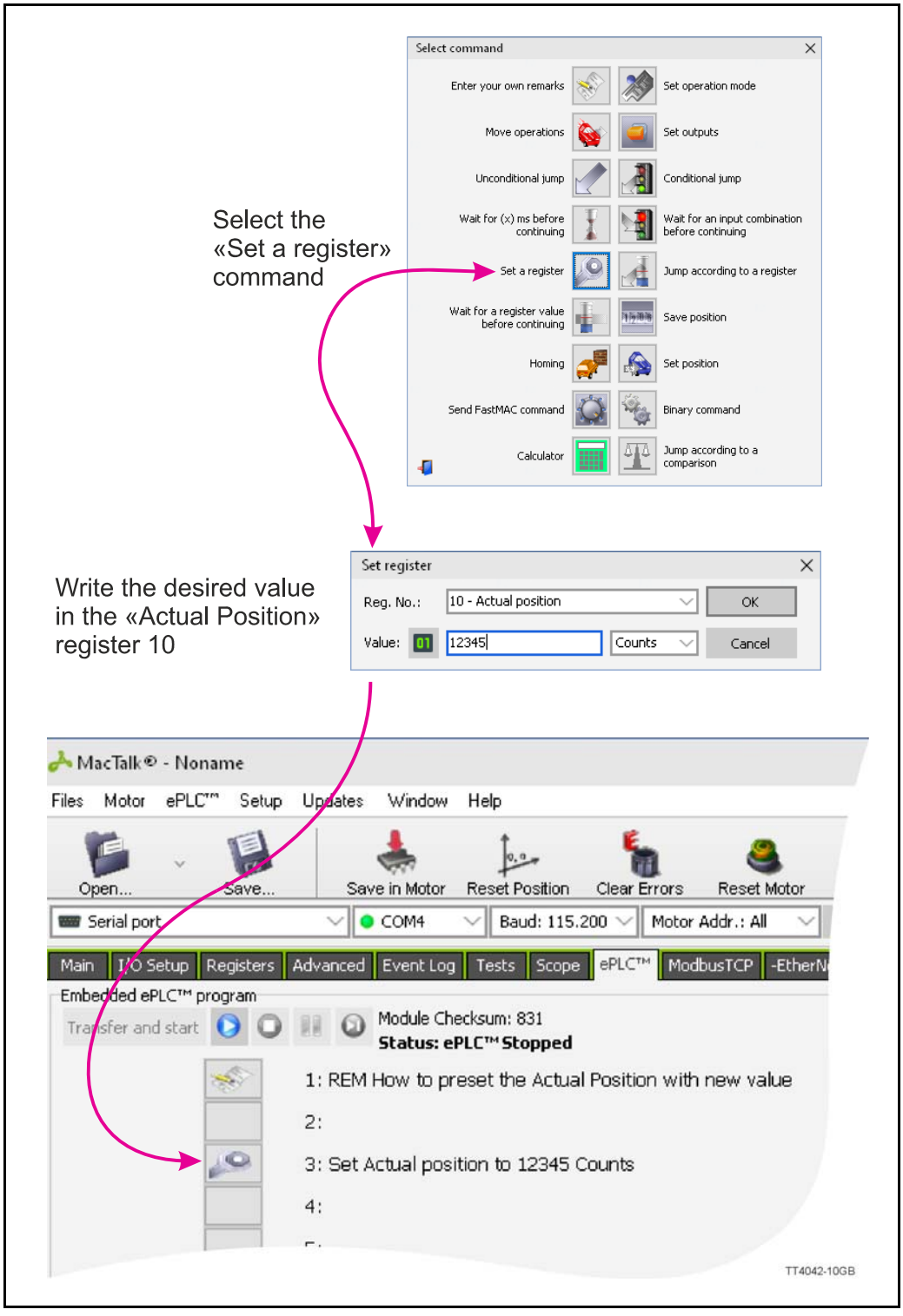
If an ePLC program is resetting the encoder zero point or another position must be preset into the register, it can be done as follows.

1. Select the “Set a register” command
2. Select register 10 - “Actual Position” and type the desired new value
3. Press OK, and the command will be inserted in the ePLC program, ready for execution.

(continued next page)

3.5 Absolute Multi-Turn Encoder

Only MACxxxx-yy-Hzzzzzz and MACxxxx-yy-Jzzzzzz



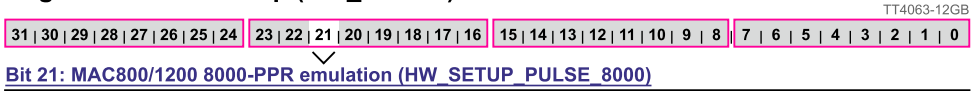
NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

3.6 8000-PPR encoder emulation

G3 motors use a native encoder resolution of 8192 pulses per revolution (PPR). The older MAC800, 1000 and MAC1200 motors were fitted with an 8000 PPR encoder. Applications written for those motors assume 8000 counts per revolution.
To ease migration of such an application onto a G3 motor without recalculating gear ratios, velocity and acceleration scaling, and servo-filter tuning, set bit 21 (mask 0x200000) in Register 39, HW_SETUP (HW Setup). The firmware then rescales the encoder feedback by the factor 8000 / 8192 (= 125 / 128), so position, actual velocity and the internal over-speed limits are reported and evaluated as for an 8000 PPR encoder.

Register 39 - HW Setup (HW_SETUP)

TT4063-12GB



Bit 21: MAC800/1200 8000-PPR emulation (HW_SETUP_PULSE_8000)

Value	Function / Influence
0 (default)	Normal operation: native 8192 PPR encoder resolution.
1	8000 PPR emulation: feedback rescaled 8000/8192 for MAC800/1200 application compatibility.

Bit 31 - 22 and Bit 20 - 0: Is used for other purposes - do not overwrite these bits

NOTE: Set or clear this bit only in Passive mode. After changing the bit, perform Save in Motor and reset the motor. The value is latched at start-up; changing it while the motor is in an active mode can corrupt the reported position.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

3.6 8000-PPR encoder emulation

4 Drive Modes

4.1 Register units and conversions

The drive modes are configured through a small set of motor registers. All registers hold integer values in the motor's internal units. This section defines the conversions between register values and physical units. The complete register list is available at www.jvl.dk/register.html?register=MACmotor.

All registers can be written from any control channel: MacTalk, the serial interface, or industrial Ethernet. For the Ethernet protocols (EtherCAT, PROFINET, EtherNet/IP, Modbus TCP etc.), see the Ethernet user manual, LB0077.

Positions

Requested position (Reg 3), Actual position (Reg 10), P1-P6 (Reg 49-59) etc. are measured in encoder counts. One motor shaft revolution is 8192 counts, or 8000 counts if bit 21 in HW Setup (Reg 39) is set for MAC800 compatibility.

Register 5, V_SOLL (Velocity)

The conversion depends on the motor resolution and on the sample time, which is selected by bit 13 in Setup Bits special (Reg 236): 1 = 1.0 ms, the MAC G3 factory default; 0 = 1.3 ms. The factors are:
1.3 ms, 8000 counts/rev.: Velocity (Reg 5) = rpm x 2.7733
1.3 ms, 8192 counts/rev.: Velocity (Reg 5) = rpm x 2.8399
1.0 ms, 8000 counts/rev.: Velocity (Reg 5) = rpm x 2.1333
1.0 ms, 8192 counts/rev. (factory default): Velocity (Reg 5) = rpm x 2.1845
Example: at the factory defaults, Velocity (Reg 5) = 277 gives approx. 127 rpm. Writing 500 to Velocity (Reg 5) gives 500 / 2.1845 = approx. 229 rpm.

Register 6, A_SOLL (Acceleration)

At the factory defaults, one count equals 457.8 rpm/s (1.3 ms sample time: 270.9 rpm/s).

Register 7, T_SOLL (Torque)

341 counts equal 100% of the rated torque; the full range 0-1023 corresponds to 0-300%. Default is 1023 (300%).

Register 170, ANINP (Analogue input)

2048 counts equal 10.00 V (204.8 counts per volt). The input can be zero-adjusted with Analogue input offset (Reg 171). On the MAC G3 the input is unipolar: 5.00 V corresponds to 1024 counts and the reading saturates at 1536 counts (7.5 V), so negative values can only be produced through a negative value in Analogue input offset (Reg 171).
The physical input range depends on the hardware revision: 0-5 V (0-1024 counts), or 0-10 V from hardware revision 0.7 combined with a firmware later than 3.1.1.0 - see *Analogue Inputs, page 41*.
If bit 18 (ZUP_USER_ANINP) is set in Setup Bits special (Reg 236), the firmware stops updating Analogue input (Reg 170) from the physical input, and Analogue input (Reg 170) can instead be written directly from any interface. The analogue modes can then be used as register-controlled modes without any analogue wiring.

If Sample time divider (Reg 157) is set above 1, multiply the velocity factor by that divider and the acceleration factor by the square of that divider.

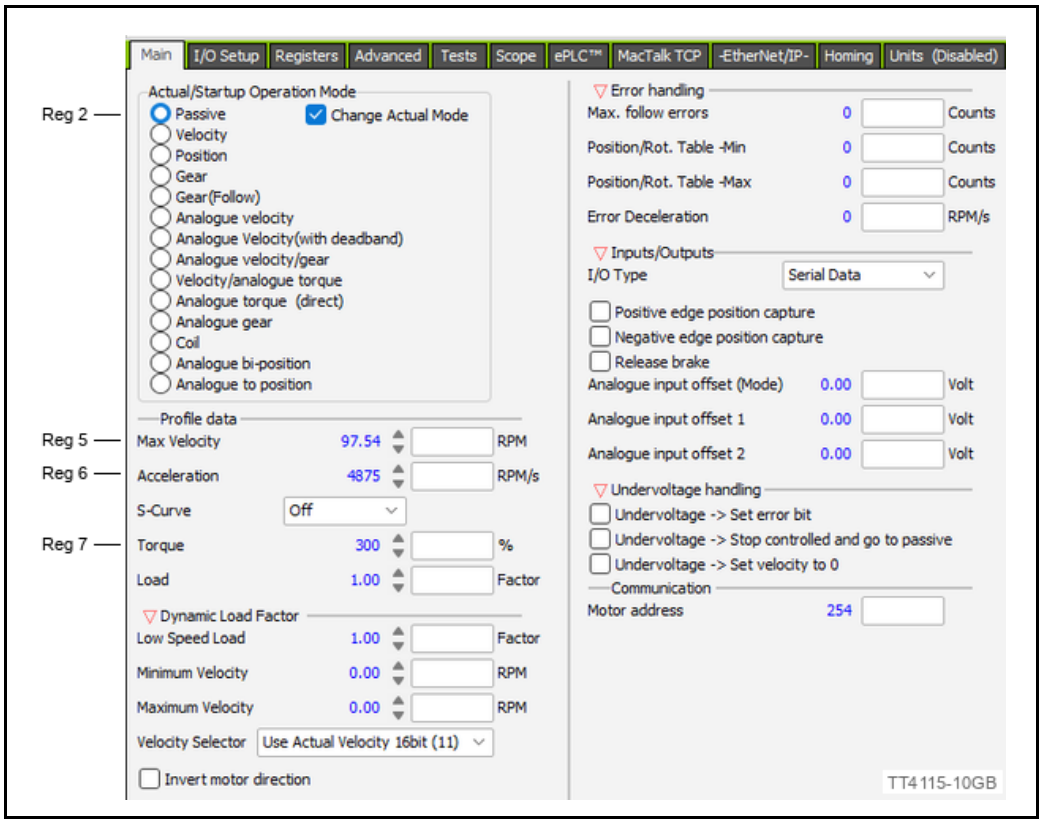
4.2 Passive mode

4.2.1 Passive mode (mode 0) - overall description

In Passive mode the motor shaft is not controlled by the drive. No torque is produced, and the axis can be moved freely by hand or by external mechanics.
In this state the power stage is switched off, so no current flows in the motor windings. The shaft can be turned freely by external forces.
The encoder is still active, so the actual position is updated and can be read out at any time - even while the axis is being moved externally.
Passive mode is typically used when the axis must be released, for example during manual adjustment of the machine, or as a neutral state to switch to before changing between operating modes.
Note that a braking function can be active in Passive mode. See *Dynamic braking in Passive mode, page 180* and *In-Position output in Passive, page 153* for supplementary functions related to Passive mode.

4.2.2 Configuration via MacTalk

The mode is selected in the Startup mode field in MacTalk, or by writing 0 to the operating mode register (Reg 2).



4.2.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 2, MODE_REG (Operating mode)

Write 0 to set the motor to Passive mode.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

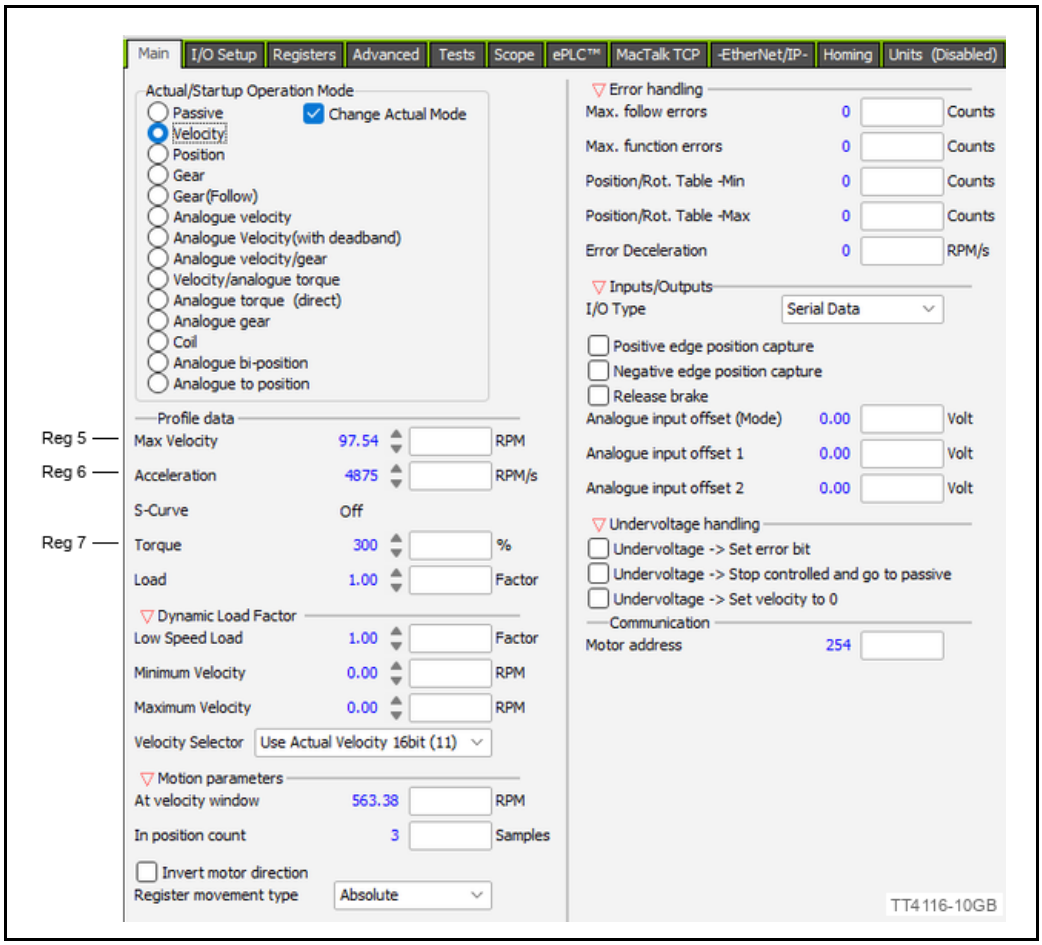
4.3 Velocity mode

4.3.1 Velocity mode (mode 1) - overall description

In Velocity mode the motor runs at a constant velocity determined by Velocity (Reg 5), without violating the maximum torque or the acceleration programmed in Acceleration (Reg 6).
The velocity can be changed at any time by writing a new value to Velocity (Reg 5) - the motor then ramps to the new velocity using the programmed acceleration. The sign of Velocity (Reg 5) determines the direction of rotation, and the value 0 stops the motor with a controlled ramp.
Velocity mode is typically used for simple transport applications such as conveyor belts, mixers and pumps, where a fixed and repeatable speed is required.

4.3.2 Configuration via MacTalk

The mode is selected in the Startup mode field in MacTalk, or by writing 1 to the operating mode register (Reg 2).



Velocity Desired velocity (Reg 5). The sign selects the direction of rotation, and the value 0 stops the motor with a controlled ramp.

Acceleration Acceleration (Reg 6) used when ramping to a new velocity.

Torque The maximum torque can be limited in the range 0-300% (Reg 7).

4.3.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 5, V_SOLL (Velocity)
Desired velocity. The sign selects the direction.

Register 6, A_SOLL (Acceleration)
Acceleration used when ramping to a new velocity.

Register 2, MODE_REG (Operating mode)
Write 1 to start Velocity mode. The motor immediately ramps to the value in Velocity (Reg 5).

Set Velocity (Reg 5) and Acceleration (Reg 6) before writing Operating mode (Reg 2). Velocity (Reg 5) can be rewritten at any time - the motor then ramps to the new velocity, limited by Acceleration (Reg 6).

See also *Register units and conversions, page 90*.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

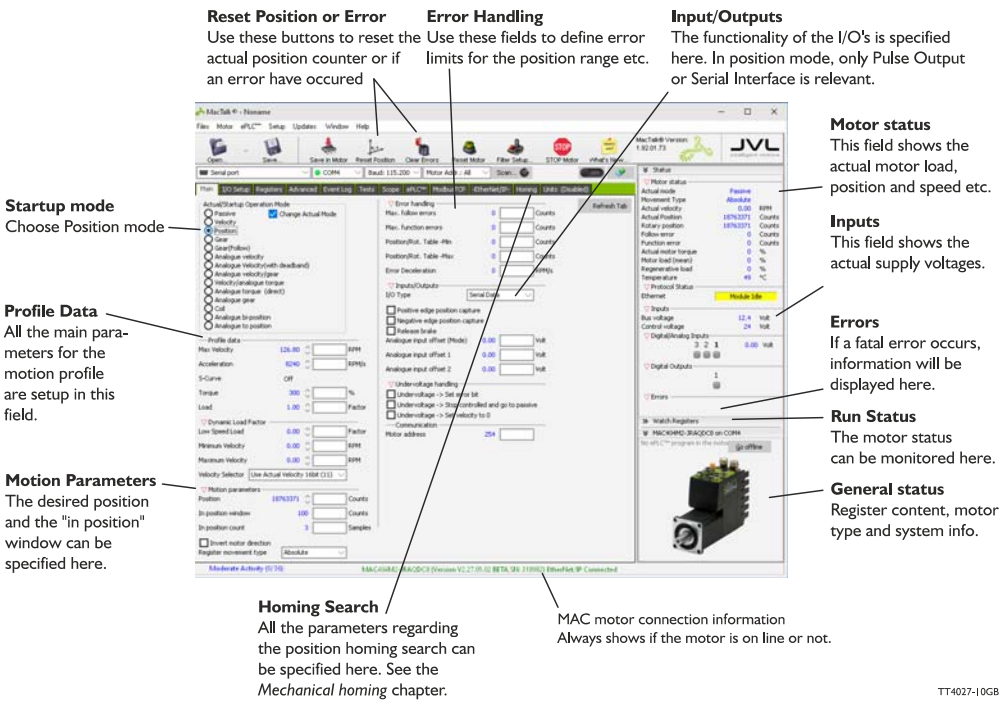
4.4 Position mode

4.4.1 Position mode (mode 2) - overall description

Follow the description below to set up the MAC motor in Position mode.

4.4.2 Configuration via MacTalk

The MacTalk program is used to set up the motor initially. During normal operation, positioning commands can either be given through MacTalk or via one of the serial interfaces. The main window in MacTalk is as follows when Position mode is selected.



Startup Mode Select Position mode in this field.

Reset Position The counter, which keeps track of the actual position, can be reset using this button.

Profile data The target position (Reg 3), maximum velocity (Reg 5) and acceleration/deceleration (Reg 6) of the movement are set here. The target position can be changed at any time, even during a movement - the motor then moves toward the new target.

Error Handling Worst case limits for the position range can be set up here. Please consult *Error messages and error handling, page 156* for details.

Input/Outputs The multifunction I/O terminals can be defined here. In Position mode, these terminals can either work as a quadrature output from the internal encoder or as a serial RS422 interface for commands sent from a master controller. See also the *User I/O, page 36*.

Motor Status The actual mode, speed, position, position error, load torque, load current, and regenerative energy (returned energy from the motor) can be monitored here.

Inputs The supply voltage can be measured here.

4.4.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 3, P_SOLL (Requested position)
Target position in encoder counts. The motor moves toward Requested position (Reg 3) whenever it differs from the actual position. Requested position (Reg 3) can be rewritten at any time, even during a movement.

Register 5, V_SOLL (Velocity)
Maximum velocity of the movement.

Register 6, A_SOLL (Acceleration)
Acceleration and deceleration of the movement.

Register 10, P_IST (Actual position)
Actual position (read out).

Register 2, MODE_REG (Operating mode)
Write 2 to enter Position mode.

See also *Register units and conversions, page 90*.

4.5 Gear Mode

4.5.1 Gear Mode (mode 3) - overall description

In Gear mode, the motor follows a pulse signal applied to the Multifunction I/O terminals. The ratio between the incoming pulses and the motor movement can be adjusted to a desired value. The ratio is set as two integer registers (Input/Output), allowing a very wide range of ratios. Typically, this mode is used if the MAC motor is incorporated into an application where movement needs to be synchronised with an external movement. Another typical application is the replacement of step motors, since the MAC motor in Gear Mode can work like a step motor using pulse and direction.

4.5.2 Configuration via MacTalk

The following setup must be done to operate in Gear mode (listed according to importance).

Startup Mode Select Gear Mode in this field.

Gear Factor This field defines the ratio between incoming pulses and the motor movement. If the preferred motor direction needs to be reversed, the sign in the "output" field must be inverted. Example: 1024 must be -1024 to reverse the direction of movement. The two fields are Gear input factor (Reg 15) and Gear output factor (Reg 14).

Input/Outputs The multifunction I/O terminals must be set to "pulse input" since gear mode uses the incoming pulses at this input to control the motor movement. Also, the "Input type" must be selected. Choose "Quadrature" if an incremental encoder is connected or "pulse-direction" if it is a step motor signal. See also *User I/O, page 36*.

Profile data In Gear mode, motor movement is fundamentally controlled from the external signal source, but via the 4 parameters specified in the "Profile data" field, it is possible to add limitations to speed, etc.

Velocity

The velocity field can be used to limit the maximum speed of the motor. Example - if an external encoder is producing a frequency which theoretically should give a MAC motor speed of 10000 RPM, the speed can be limited to 4000 RPM (max. allowed speed for the MAC). Without this limit, the motor would become unstable and go into an error state after some time, since it is not able to run at 10000 RPM. Note that no pulses are lost if the velocity is limited. They are simply remembered and used when the input frequency falls to a level at which the motor is able to follow.

Acceleration

The acceleration parameter can be useful in systems in which the signal source instantaneously applies a high frequency without any acceleration. Under this condition, the MAC motor will take care of making a controlled acceleration and deceleration. Note that no pulses are lost if the acceleration is limited. They are simply remembered and used when motor velocity reaches a level corresponding to the input frequency.

Torque

The maximum torque can be limited in the range 0-300%. 300% corresponds to the rated peak torque of the MAC motor used.

(continued)

Load
The Load parameter is the overall gain in the position/velocity filter and ensures that the motor is stable with the actual mechanical inertia used in the application. See also *Servo filter adjustment, page 124* for further details.

Error Handling Worst case limits for the position range and follow error (maximum position error) can be set up here. Please consult *Error messages and error handling, page 156* for details.

Motor Status The actual mode, speed, position, position error, load torque, load current, and regenerative energy (energy returned from the motor) can be monitored here.

Inputs The supply voltages can be measured here.

Homing In typical Gear mode applications, the motor moves relative to its starting position, without any absolute zero point, but for applications that require a specific mechanical zero position, the general *Homing* in the MAC motor can be used. Please consult the chapter *Mechanical Homing, page 60*.

Example 1: **Encoder (quadrature) input.**
An external encoder feeds the MAC motor. The I/O type is set to "Pulse input" and "Input type" is set to "Quadrature" in order to decode the encoder signal. The encoder is connected to the A and B terminals (Multifunction I/O's). See also *User I/O, page 36*.
The resolution of the external encoder is 500 ppr (pulses per rev.).
The MAC motors have 2048 ppr (8192 counts/rev).
If this application requires that the MAC motor rotates 1 rev. each time the external encoder has rotated 1 rev., the *Input* parameter is set to 500 (external encoder) and the *Output* parameter is set to 2048. Now the ratio between the external encoder and the MAC motor will be 1:1. Ensure the "Profile data" is set to proper values in order not to limit motor operation unintentionally.

Example 2: **Pulse and direction input.**
A step motor system is replaced by a MAC motor, meaning that the MAC motor receives a pulse and direction signal, which is a very common signal format in step motor applications.
The I/O type is set to "Pulse input" and "Input type" is set to "Pulse-direction" in order to decode the input signal. The pulse signal is connected to the A terminals (Multifunction I/O) and the direction signal is connected to the B terminals (Multifunction I/O's).
See also *User I/O, page 36*.
The MAC motor is replacing a step motor system with 400 steps per revolution, which means that when the pulse source produces 400 pulses, it expects the MAC motor to rotate one revolution.
The MAC motors have 8192 cpr. If this application requires that the MAC motor rotates 1 revolution each time 400 pulses are received, the *Input* parameter is set to 800, since the MAC motor detects on both the rising and falling edge of the input signal.
The *Output* parameter is set to 8192, since the number of counts (edges) on the internal encoder is 8192. Now the MAC motor will move 1 revolution if 400 pulses are applied to the pulse input. Ensure the "Profile data" is set to proper values in order not to limit motor operation unintentionally. The following table can be used as a guide for setting up typical gear ratios:

Pulse and direction gear ratio setup - "Commonly used ratios"		
Applied number of pulses per MAC motor revolution.	**Input register GEARF2 (Reg 15)**	**Output register GEARF1 (Reg 14)**
200	400	8192
400	800	8192
500	1000	8192
800	1600	8192
1000	2000	8192
4096	8192	8192
8192 (Same as motor resolution)	16384	8192

4.5.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 14, GEARF1 (Gear output factor)
Gear output factor (the Output field in MacTalk): the motor moves the number of encoder counts held in Gear output factor (Reg 14) for every number of counts held in Gear input factor (Reg 15) received on the pulse inputs. A negative value reverses the direction.

Register 15, GEARF2 (Gear input factor)
Gear input factor (the Input field in MacTalk).

Register 5, V_SOLL (Velocity)
Maximum velocity used when catching up.

Register 6, A_SOLL (Acceleration)
Maximum acceleration.

Register 2, MODE_REG (Operating mode)
Write 3 to enter Gear mode.

The gear is exact: division remainders are carried over, so no input pulses are lost. If the input runs faster than Velocity (Reg 5) allows, the surplus is remembered and executed afterwards.
Read out: Ext. encoder velocity (Reg 163); Ext. encoder velocity, geared (Reg 164); and Not executed geared pulses (Reg 165).

See also *Register units and conversions, page 90*.

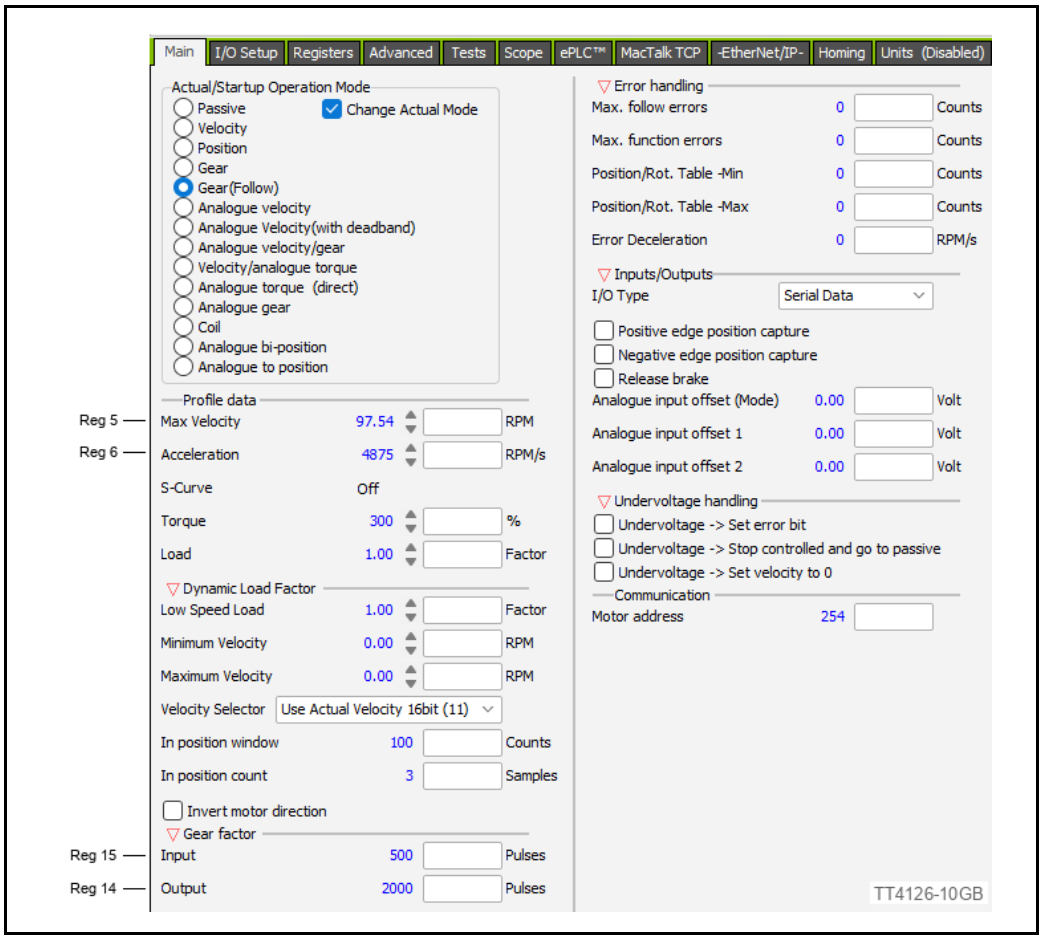
4.6 Gear Follow mode

4.6.1 Gear Follow mode (mode 24) - overall description

Gear Follow mode works as Gear Mode (mode 3): the motor follows the external encoder/pulse input with the gear ratio programmed in Gear output factor (Reg 14) and Gear input factor (Reg 15). The difference lies in how closely the motor follows the input. In Gear Mode the motor always keeps a safe deceleration distance, so it can stop without overshooting if the input pulses stop suddenly. In Gear Follow mode this distance is not used - the motor follows the input directly with minimum lag, but it will overshoot if the pulse input stops abruptly.
Use Gear Follow mode when tight, low-lag tracking of the master is more important than overshoot protection - and Gear Mode when the axis must never overshoot.

4.6.2 Configuration via MacTalk

The mode is selected in the Startup mode field in MacTalk, or by writing 24 to the operating mode register (Reg 2).



The setup in MacTalk is identical to Gear Mode - gear factor, input type and profile data are configured in the same fields. See *Gear Mode, page 96*.

Gear Factor The gear ratio between the master pulse input and the motor movement, set as Gear output factor (Reg 14) divided by Gear input factor (Reg 15) - the same fields as in Gear Mode.

Velocity Maximum velocity during the follow movement (Reg 5).

Acceleration Maximum acceleration (Reg 6). In this mode the effective acceleration limit is at least Velocity (Reg 5) / 4, to keep the follow error low.

4.6.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 14, GEARF1 (Gear output factor) / Register 15, GEARF2 (Gear input factor)
Gear factors as in Gear mode (mode 3).

Register 5, V_SOLL (Velocity)
Maximum velocity.

Register 6, A_SOLL (Acceleration)
Maximum acceleration. In this mode the effective acceleration limit is at least Velocity (Reg 5) / 4, to keep the follow error low.

Register 2, MODE_REG (Operating mode)
Write 24 to enter gear follow mode.

Unlike Gear mode, the motor follows the input directly, without the overshoot-safe deceleration profile: the follow error is minimal, but the motor will overshoot if the input pulses stop abruptly.

See also *Register units and conversions, page 90*.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

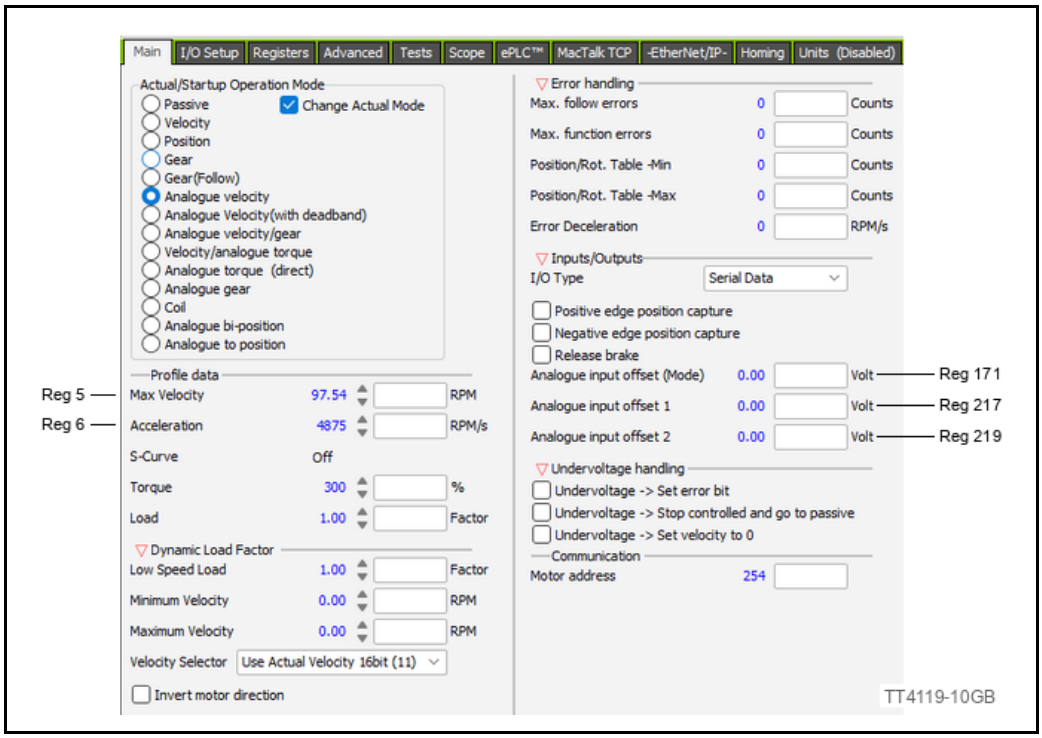
4.7 Analogue Velocity mode

4.7.1 Analogue Velocity mode (mode 5) - overall description

In Analogue Velocity mode the motor velocity is controlled by the voltage applied to the analogue input.
Full analogue input gives the velocity programmed in Velocity (Reg 5), and the velocity scales proportionally with the input voltage. When the input changes, the velocity change is limited by Acceleration (Reg 6).
Note that a small offset or noise on the analogue signal around 0 V will make the motor creep slowly. If this is a problem, use Analogue Velocity with dead-band (mode 16), which ignores small input voltages.

4.7.2 Configuration via MacTalk

The mode is selected in the Startup mode field in MacTalk, or by writing 5 to the operating mode register (Reg 2).



Velocity Use this field to set the velocity at full analogue input (Reg 5). The velocity scales proportionally with the input voltage. The analogue input itself is unipolar (0-10 V / 0-5 V - see Register 170, ANINP above); to run the motor in reverse, set a negative value in Analogue input offset (Reg 171), which is added to the physical reading. Note: on the previous generation (G2), this input was bipolar and reversed direction directly on a negative voltage - that is no longer the case.

Acceleration Acceleration (Reg 6) used to follow changes of the input.

Analogue input offset
Zero-adjusts the analogue input, so that the motor stands still at the intended input voltage. Which of the three offset fields is in force is decided by the Analog input selector (Reg 222): the factory default uses Analogue input offset (Reg 171), and the two other fields are Analog input 1 offset (Reg 217) and Analog input 2 offset (Reg 219).

4.7.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 5, V_SOLL (Velocity)

Velocity at full analogue input. The velocity command is Analogue input (Reg 170) x Velocity (Reg 5) / 2048: 10 V gives the full value in Velocity (Reg 5), 5 V gives half of that value. Reverse direction requires a negative value in Analogue input offset (Reg 171) - see above.

Register 6, A_SOLL (Acceleration)

Acceleration used to follow changes of the input.

Register 171, ANINP_OFFSET (Analogue input offset)

Zero-point adjustment of the analogue input.

Register 2, MODE_REG (Operating mode)

Write 5 to enter analogue Velocity mode.

See also *Register units and conversions, page 90*.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

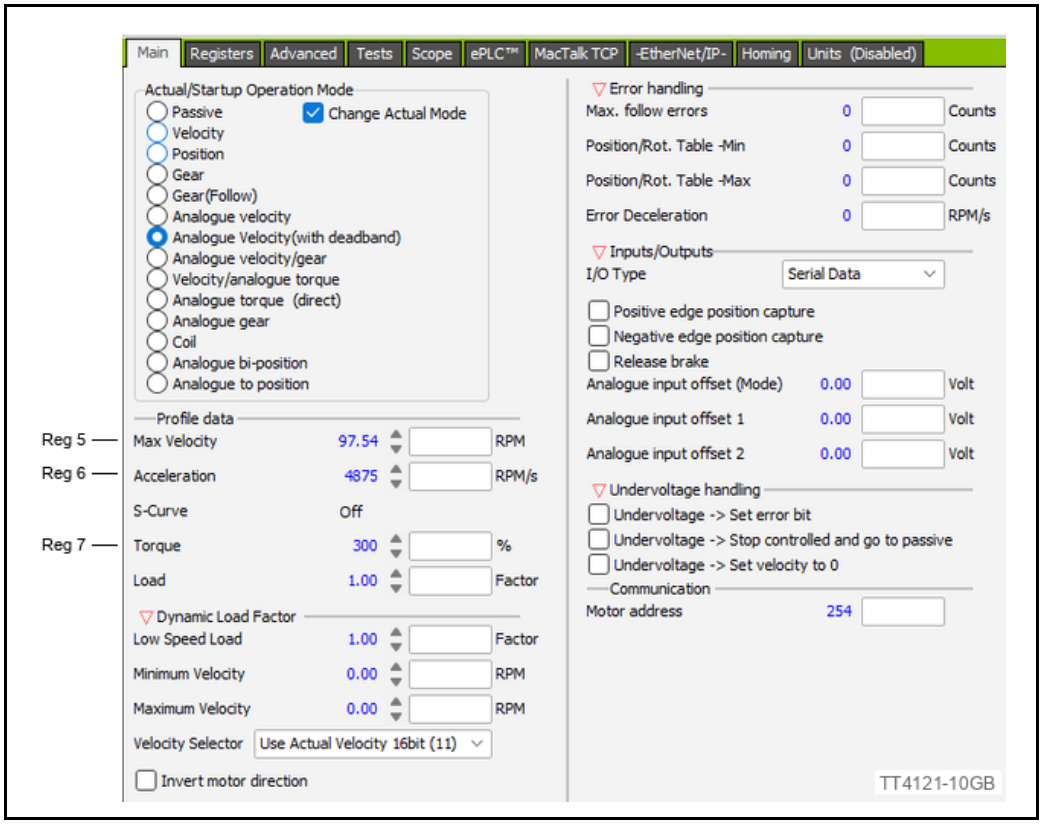
4.8 Analogue Velocity with dead-band

4.8.1 Analogue Velocity with dead-band (mode 16) - overall description

Analogue Velocity with dead-band mode works as Analogue Velocity mode (mode 5), but with a dead-band added around 0 V on the analogue input.
Input voltages inside the dead-band (up to approx. 3% of full scale) give zero velocity. This prevents the motor from creeping due to noise or a small offset on the analogue signal when the commanded velocity is zero.
Outside the dead-band the velocity scales with the input voltage up to the value in Velocity (Reg 5) at full input, and velocity changes are limited by Acceleration (Reg 6).

4.8.2 Configuration via MacTalk

The mode is selected in the Startup mode field in MacTalk, or by writing 16 to the operating mode register (Reg 2).



Velocity Velocity at full analogue input (Reg 5), as in Analogue Velocity mode (mode 5). Input voltages inside the dead-band (up to approx. 3% of full scale) give zero velocity.

Acceleration Acceleration (Reg 6) used to follow changes of the input.

Torque The maximum torque the drive is allowed to use, 0-300% of rated torque (Reg 7). The motor uses up to this torque to follow the velocity given by the analogue input.

4.8 Analogue Velocity with dead-band

4.8.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 5, V_SOLL (Velocity)
Velocity at full analogue input, as in mode 5.

Register 6, A_SOLL (Acceleration)
Acceleration used to follow changes of the input.

Register 171, ANINP_OFFSET (Analogue input offset)
Zero-point adjustment of the analogue input.

Register 2, MODE_REG (Operating mode)
Write 16 to enter analogue velocity with dead-band mode.

Input values within +/-64 counts (approx. 0.31 V) give zero velocity. Outside the dead-band the range is rescaled by 33/32, so full input still gives the full value in Velocity (Reg 5).

See also *Register units and conversions, page 90*.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

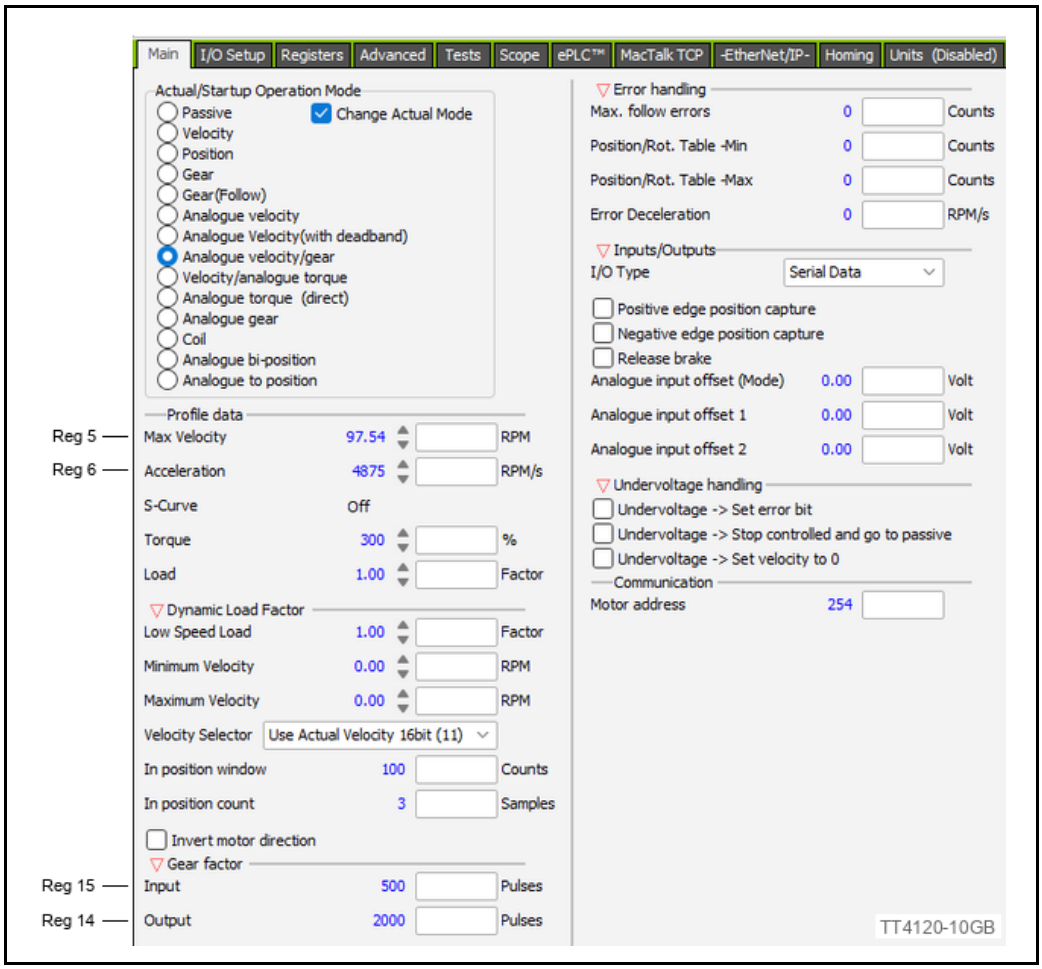
4.9 Analogue Velocity/Gear mode

4.9.1 Analogue Velocity/Gear mode (mode 6) - overall description

In Analogue Velocity/Gear mode the motor follows the external encoder/pulse input with the gear ratio programmed in Gear output factor (Reg 14) and Gear input factor (Reg 15), as in Gear Mode (mode 3). In addition, a velocity offset proportional to the voltage on the analogue input is added to the gear velocity.
This makes it possible to synchronise the motor to a master axis and at the same time make fine speed corrections with an analogue signal - for example for draw or tension trimming between two driven rollers.
The total velocity is limited by Velocity (Reg 5), and velocity changes are limited by Acceleration (Reg 6).

4.9.2 Configuration via MacTalk

The mode is selected in the Startup mode field in MacTalk, or by writing 6 to the operating mode register (Reg 2).



Gear Factor The motor follows the external encoder/pulse input with this gear ratio, as in Gear Mode (mode 3). The two fields are Gear input factor (Reg 15) and Gear output factor (Reg 14).

Velocity The total velocity (the gear velocity plus the analogue offset) is limited to this value (Reg 5).

Acceleration Velocity changes are limited by this acceleration (Reg 6).

4.9 Analogue Velocity/Gear mode

4.9.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 14, GEARF1 (Gear output factor) /
Register 15, GEARF2 (Gear input factor)
Gear factors as in Gear mode (mode 3).

Register 5, V_SOLL (Velocity)
Symmetrical velocity limit.

Register 6, A_SOLL (Acceleration)
Acceleration limit.

Register 2, MODE_REG (Operating mode)
Write 6 to enter analogue velocity/gear mode.

The analogue input adds a velocity offset of 13 x Analogue input (Reg 170) / 32 counts to the geared velocity - at full input (10 V) approximately 380 rpm at the factory defaults (approx. 300 rpm with the 1.3 ms sample time). This mode follows the input velocity; it is not position-locked like Gear mode.

See also *Register units and conversions, page 90*.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

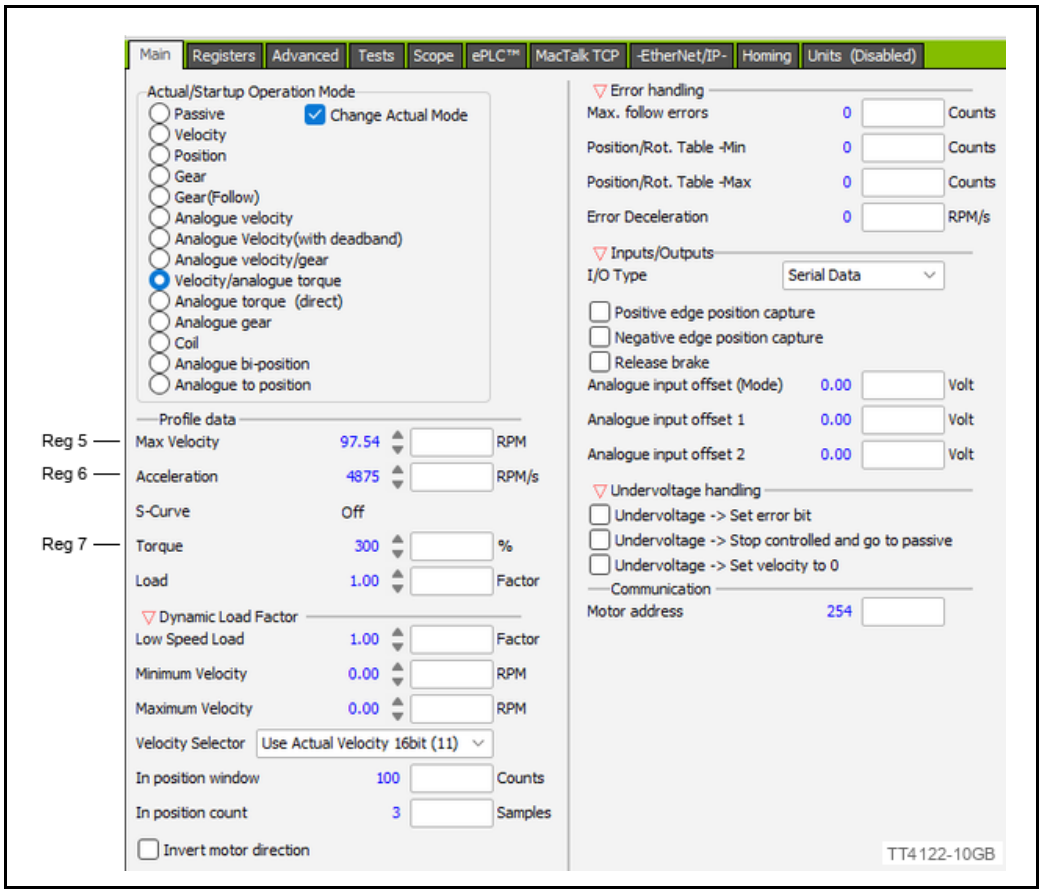
4.10 Velocity-limited Analogue Torque

4.10.1 Velocity-limited Analogue Torque (mode 17) - overall description

Velocity-limited Analogue Torque mode works as Analogue Torque mode (mode 4): the motor torque is controlled by the analogue input, scaled by Torque (Reg 7). Unlike mode 4, the sign of the analogue input is ignored - the direction of rotation is determined by the sign of Velocity (Reg 5).
In addition, the velocity is limited to the value in Velocity (Reg 5). If the load torque disappears, the motor will not run away, but will only accelerate up to the programmed velocity limit.
This mode is typically used in tension-control and winding applications, where a break in the material would otherwise cause the motor to speed up uncontrollably.

4.10.2 Configuration via MacTalk

The mode is selected in the Startup mode field in MacTalk, or by writing 17 to the operating mode register (Reg 2).



Torque Use this field to set the torque at full analogue input, 0-300% (Reg 7). The torque scales proportionally with the input voltage. The sign of the analogue input is ignored.

Velocity The velocity is limited to this value (Reg 5) - if the load torque disappears, the motor only accelerates up to this limit. The sign determines the direction of rotation.

Acceleration Acceleration (Reg 6) used when ramping the velocity.

4.10 Velocity-limited Analogue Torque

4.10.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 5, V_SOLL (Velocity)
The motor runs at this velocity, ramped by Acceleration (Reg 6), as in Velocity mode.

Register 6, A_SOLL (Acceleration)
Acceleration used when ramping the velocity.

Register 7, T_SOLL (Torque)
Torque limit scale: the torque is limited to the absolute value of Analogue input (Reg 170) x Torque (Reg 7) / 2048, from zero at 0 V to Torque (Reg 7) at 10 V.

Register 2, MODE_REG (Operating mode)
Write 17 to enter velocity-limited Analogue Torque mode.

See also *Register units and conversions, page 90*.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

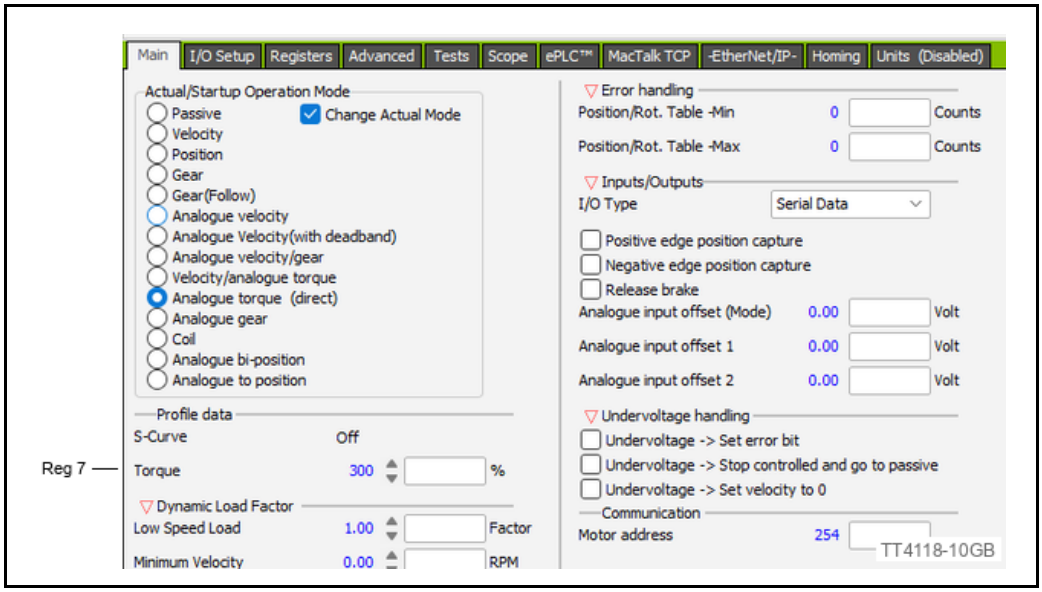
4.11 Analogue Torque mode

4.11.1 Analogue Torque mode (mode 4) - overall description

In Analogue Torque mode the motor torque is controlled directly by the voltage applied to the analogue input. All the analogue operating modes read the same register, Analogue input (Reg 170), and Analog input selector (Reg 222) decides which physical input is copied into it - see Selecting which analogue input controls the motor in the Installation chapter. Unless that register has been changed, the modes follow Analog input 1.
Torque (Reg 7) defines the torque delivered at full analogue input. The torque scales proportionally with the input voltage, so half input gives half of the programmed torque.
The velocity is not controlled in this mode - the motor accelerates until the load torque balances the produced torque. If a velocity limit is required, use Velocity-limited Analogue Torque (mode 17) instead.
Analogue Torque mode is typically used in winding and tension-control applications.

4.11.2 Configuration via MacTalk

The mode is selected in the Startup mode field in MacTalk, or by writing 4 to the operating mode register (Reg 2).



Torque Use this field to set the torque delivered at full analogue input, 0-300% of rated torque (Reg 7). The torque scales proportionally with the input voltage, so half input gives half of the programmed torque. Negative input gives torque in the opposite direction.

4.11 Analogue Torque mode

4.11.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 7, T_SOLL (Torque)

Torque at full analogue input. The torque command is Analogue input (Reg 170) x Torque (Reg 7) / 2048, scaling linearly from zero at 0 V to Torque (Reg 7) at full scale. Torque in the opposite direction requires a negative value in Analogue input offset (Reg 171) - see Register 170/171 above.

Register 171, ANINP_OFFSET (Analogue input offset)

Zero-point adjustment of the analogue input.

Register 2, MODE_REG (Operating mode)

Write 4 to enter Analogue Torque mode.

Read out: Actual torque (Reg 169) and Analogue input (Reg 170).

See also *Register units and conversions, page 90*.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

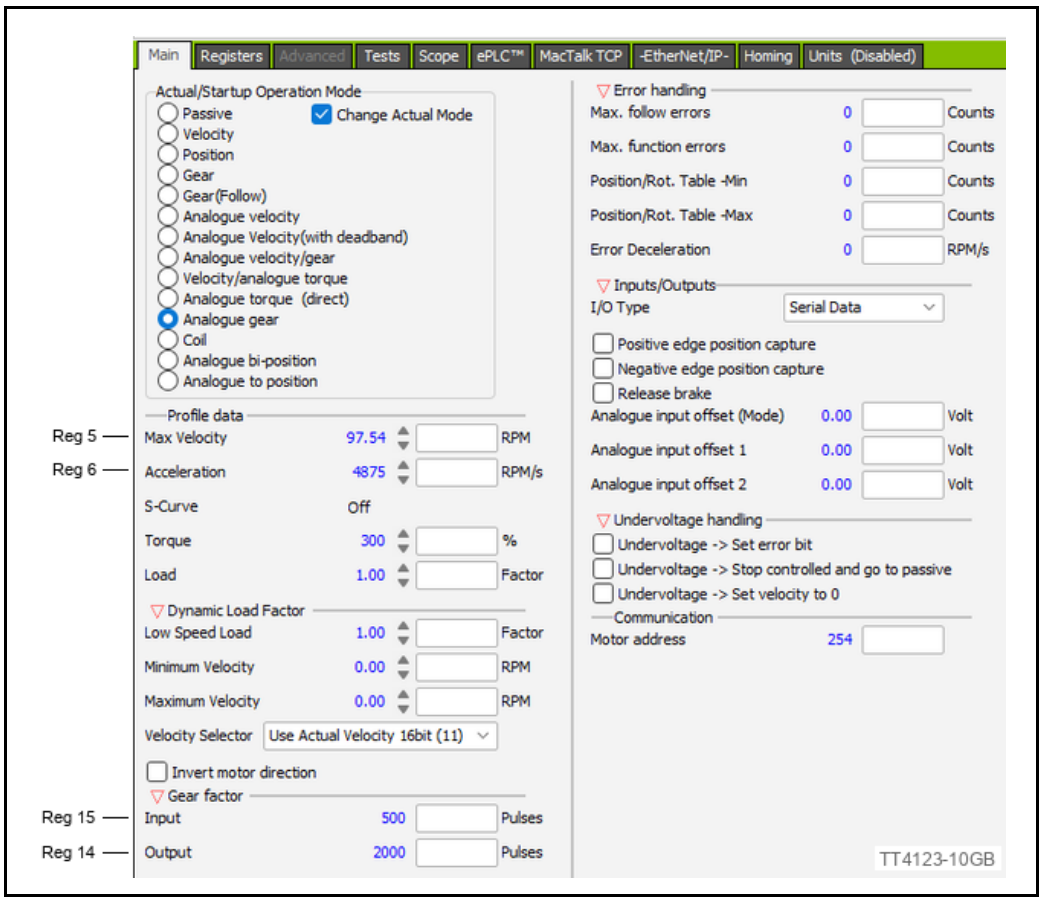
4.12 Analogue Gear mode

4.12.1 Analogue Gear mode (mode 18) - overall description

In Analogue Gear mode the motor follows the external encoder/pulse input as in Gear Mode (mode 3), but the gear ratio is continuously adjusted by the analogue input.
The basic ratio is programmed in Gear output factor (Reg 14) and Gear input factor (Reg 15). The analogue input then trims this ratio proportionally - at full analogue input the ratio is changed by up to approx. 25%.
This is useful in applications where two axes run synchronised and the ratio between them must be fine-adjusted during operation, for example to control material tension or stretch.
The velocity is limited by Velocity (Reg 5), and velocity changes are limited by Acceleration (Reg 6).

4.12.2 Configuration via MacTalk

The mode is selected in the Startup mode field in MacTalk, or by writing 18 to the operating mode register (Reg 2).



Gear Factor The basic gear ratio between the external pulse input and the motor movement, set with Gear input factor (Reg 15) and Gear output factor (Reg 14). The analogue input trims this ratio proportionally - at full analogue input the ratio is changed by up to approx. 25%.

Velocity Maximum velocity (Reg 5).

Acceleration Maximum acceleration (Reg 6).

4.12 Analogue Gear mode

4.12.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 14, GEARF1 (Gear output factor) /
Register 15, GEARF2 (Gear input factor)
Gear factors as in Gear mode (mode 3).

Register 5, V_SOLL (Velocity)
Maximum velocity.

Register 6, A_SOLL (Acceleration)
Maximum acceleration.

Register 2, MODE_REG (Operating mode)
Write 18 to enter analogue Gear mode.

The analogue input trims the gear ratio. The effective ratio is:

Gear output factor (Reg 14) / Gear input factor (Reg 15) x (1 + Analogue input (Reg 170) / 8192)

At full analogue input the ratio is therefore adjusted by up to 25 % upwards.
To trim the ratio in both directions, shift the zero point with Analogue input offset (Reg 171), or write Analogue input (Reg 170) directly.
The mode is position-locked, as Gear mode is.

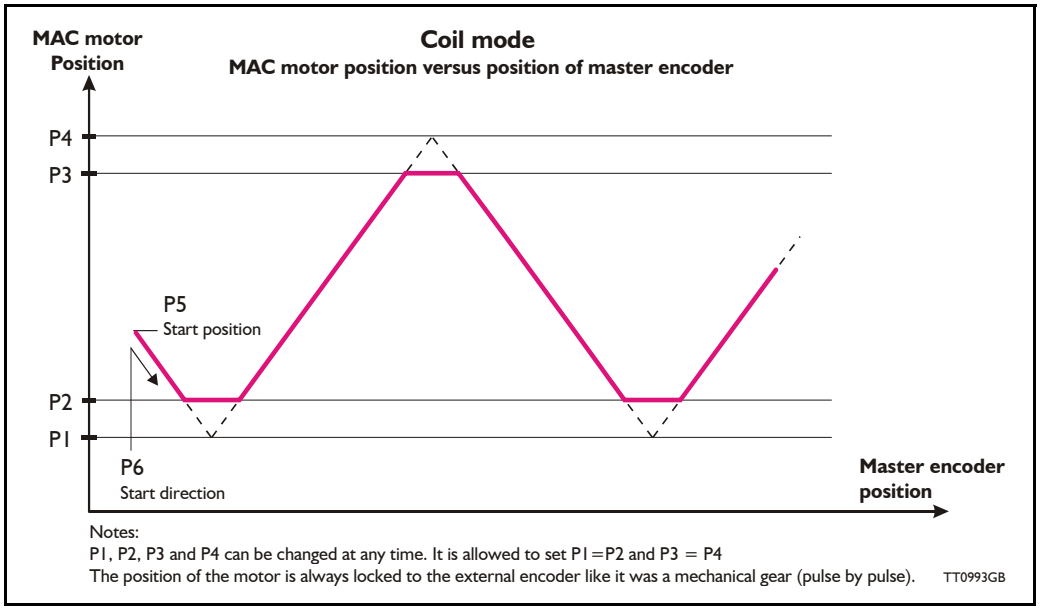
See also *Register units and conversions, page 90*.

NOTE: All motor registers are documented in detail in the online register overview:
www.jvl.dk/register.html?register=MACmotor

4.13 Coil Mode

4.13.1 Coil Mode (mode 19) - overall description

The Coil Mode is similar to gear mode, but the position range can be limited in such a manner that the motor changes direction every time 2 predefined limits (upper and lower) are reached. Both limits are fully adjustable. The mode is intended to be used for controlling a wire/cable guider on a winding machine. The guide will follow the position of the coil driven by a "main motor" as if it were mechanically connected by a transmission, and by using this mode, it is possible to steer the wire to the desired position at the coil, even when the "main motor" changes speed. Since Coil Mode is very similar to Gear mode, it is recommended that the Gear mode setup instructions are followed before using the additional features described in this section. See *Gear Mode, page 96*.



When the thread is thick compared to the coil and there are only a few windings per layer, it is preferable to stop the traverse motion at the edges while one winding is coiled on top of the previous one. Therefore, the edges can be cut off at the positions given by registers P2 (Reg 51) and P3 (Reg 53), as shown in the illustration above.

When starting a new coil, you must specify the starting position and the starting direction of the MAC motor to achieve repeatability. With a positive starting direction (P6 bit 0 = 0) the traverse starts from the left cut-off position P2; with a negative starting direction (P6 bit 0 = 1) it starts from the right cut-off position P3. Register P5 (Reg 57) holds a reposition target that can be commanded during operation.

A typical setup could be:

P1 (Reg 49) = 10000 Left position limit of basic function
P2 (Reg 51) = 12000 Left cut off position
P3 (Reg 53) = 58000 Right cut off position
P4 (Reg 55) = 60000 Right position limit of basic function
P5 (Reg 57) = 12000 Reposition target (optional)
P6 (Reg 59) = 0 Start traversing right (positive direction, from P2)

Repositioning to the P5 target is initiated by setting the analogue input (AIN) high. When the input is set low again, the MAC motor resumes the normal coiling function.

The rules for setting up P1 - P6 are:

P1 <= P2 <= P3 <= P4
P1 <= P5 <= P4
P6 bit 0 = 0 (positive direction) or 1 (negative direction)

4.13.2 The gear ratio in Coil mode

The gearing ratio must be specified in the exact same manner as Gear mode, using the Input and Output registers. See *Gear Mode (mode 3) - overall description, page 96*.

4.13.3 Initiating Homing in Coil mode

The MAC motor can be set up to make an initiating *Homing* at power up. When using the sensor *Homing* modes, the *Homing* function uses the analogue input as zero sensor input, and the coiling function uses the signal to sense the 'go to start position command'. Still, the two signals can be coupled in parallel to the input, provided the *Homing* sensor is only activated outside the normal working area (normally open).

In conjunction with the above setup for registers P1...P6 (Reg 49-59), the setup for the *Homing* could therefore be:

Homing type (Reg 42):"Sensor 1"
Homing velocity (Reg 40):-100
Homing position (Reg 38):-2000
Start mode: Coil Mode

When the power-up *Homing has finished*, you must give the MAC motor an initial start position command before starting the first coil process.

4.13.4 Filter setup in Coil mode

Recommended filter setting for this application (using the filter selector).
Please note that the filter setting can also depend on other factors such as the inertia, friction etc. in the actual system.

Current filter: Medium or high.
Position filter: x-y coordinate = 3, 3 (fast, almost hard)
Follow error type: Static, degree = 75%

Remember to fine-tune the Load (Reg 13) factor on the MacTalk main tab.

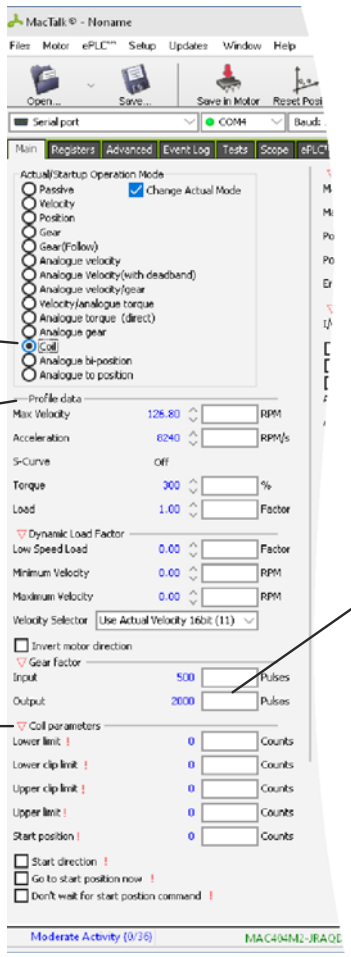
Other settings (recommended):

- Max velocity: Set limit higher than the normal speed used
- Acceleration: Set high value (example 300000 RPM/sec)
- Torque: 300%
- Gear factor: Set value
- Follow error: 0
- Function error: 0

4.13.5 Register overview in MacTalk

The following screen is shown in MacTalk when selecting Coil Mode.

Main parameters used in coil mode



Startup mode
Choose "Coil mode"

Profile Data
All these parameters can be used to limit the motion. For example the maximum torque or velocity.

Coil mode parameters
Set P1 to P6 in this field according to the description in this chapter.
Also start direction and how to start is set here

Gear factor
The ratio between the incomming pulses and the actual motor movement is specified here.

TT4029-10GB

The general setup, such as selecting maximum velocity, gear ratio and input type setup, is similar to Gear Mode. Only the Coil Mode parameters differ from Gear Mode.
For details of the overall setup, please see *Gear Mode, page 96*.

NOTE: All motor registers are documented in detail in the online register overview:
www.jvl.dk/register.html?register=MACmotor

4.13.6 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 49, POS0 (Position Reg 1)
Lower (left) turn point: the traverse reverses direction here.

Register 51, POS1 (Position Reg 2)
Left cut-off: lower limit for the commanded position. Also the start position when the start direction is positive.

Register 53, POS2 (Position Reg 3)
Right cut-off: upper limit for the commanded position. Also the start position when the start direction is negative.

Register 55, POS3 (Position Reg 4)
Upper (right) turn point.

Register 57, POS4 (Position Reg 5)
Reposition target used with the reposition command.

Register 59, POS5 (Position Reg 6)
Command register: bit 0 = start direction (1 = negative), bit 1 = reposition command, bit 2 = power-up command. Bit 3 is set by the firmware as acknowledgement. Bit 4 makes the power-up command automatic: if Start mode (Reg 37) is 19 and bit 4 is set when the motor starts up, the firmware sets bit 2 itself, so the coiling starts without any command from the outside. Position Reg 6 (Reg 59) is a parameter register that is saved in flash memory, so this applies at every power-up.

Register 14, GEARF1 (Gear output factor) /
Register 15, GEARF2 (Gear input factor)
Traverse movement per count on the spindle (pulse) input.

Register 5, V_SOLL (Velocity)
Maximum traverse velocity.

Register 6, A_SOLL (Acceleration)
Acceleration of the traverse movement.

Register 2, MODE_REG (Operating mode)
Write 19 to enter Coil mode.

An analogue input above 256 counts (approx. 1.25 V) also triggers the reposition command.

See also *Register units and conversions, page 90*.

4.14 Analogue bi-position mode

4.14.1 Analogue Bi-position Mode (mode 20) - overall description

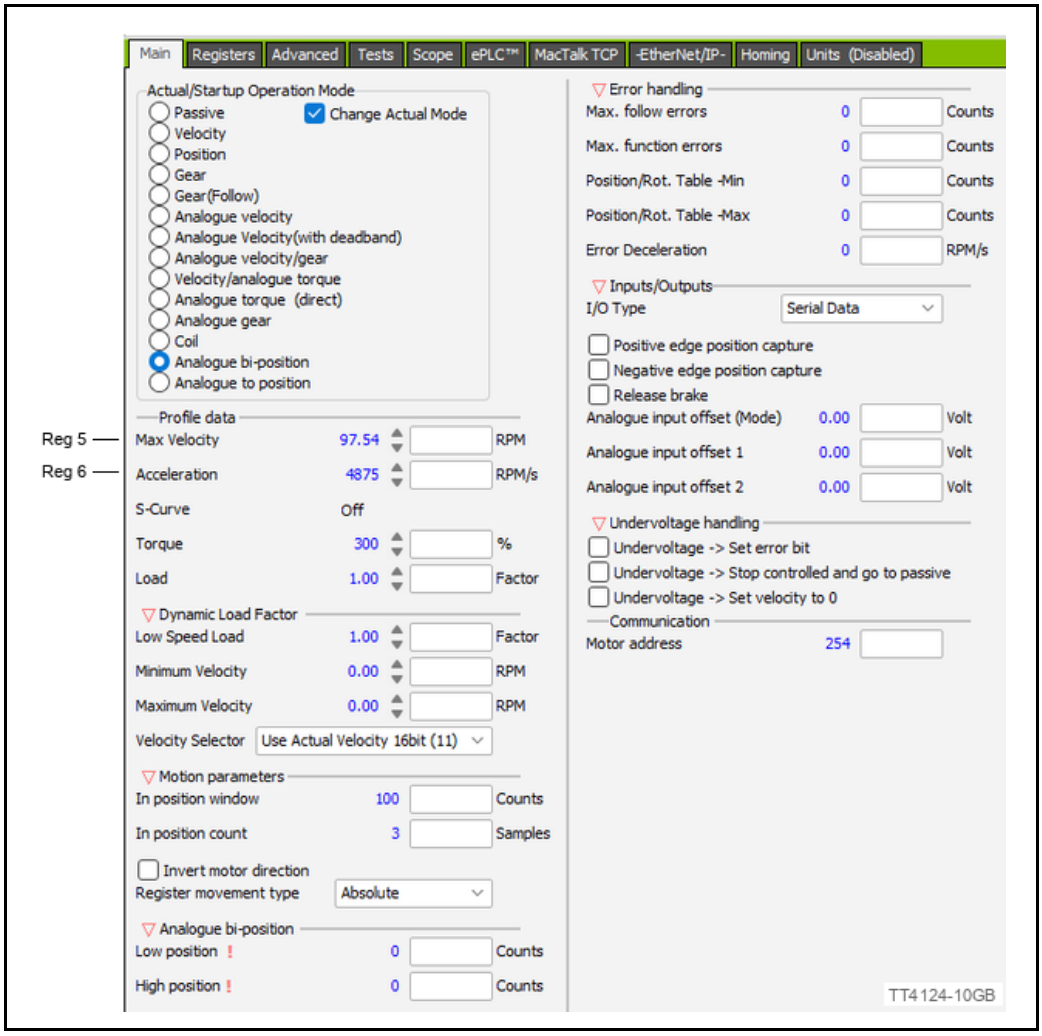
For simple positioning purposes, the basic MAC motor offers Analogue bi-position mode, which works as follows:

The motor will move a certain distance or go to one of 2 positions depending on the voltage at the analogue input. The voltage at the analogue input is interpreted as a digital signal - either logic low or logic high.
The distance or positions can be set up in 2 internal registers and saved permanently in the motor.

Concerning the trigger level at the input and how to change it, see the Analogue Inputs section in the Installation chapter.

4.14.2 Configuration via MacTalk

The mode is selected in the Startup mode field in MacTalk, and the two positions are entered as Position 1 (Reg 49) and Position 2 (Reg 51).



Velocity Maximum velocity of the movements (Reg 5).

Acceleration Acceleration of the movements (Reg 6).

4.14 Analogue bi-position mode

4.14.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 49, POS0 (Position Reg 1)
First target position, selected when the analogue input is below 128 counts (approx. 0.63 V).

Register 51, POS1 (Position Reg 2)
Second target position, selected when the input is above 384 counts (approx. 1.88 V). Between the two levels the motor keeps its present target (hysteresis).

Register 5, V_SOLL (Velocity)
Maximum velocity of the movements.

Register 6, A_SOLL (Acceleration)
Acceleration of the movements.

Register 36, CNTRL_BITS (Control bits)
Options for relative positioning - see the online register overview.

Register 2, MODE_REG (Operating mode)
Write 20 to enter analogue bi-position mode.

See also *Register units and conversions, page 90*.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

4.15 Analogue to Position mode

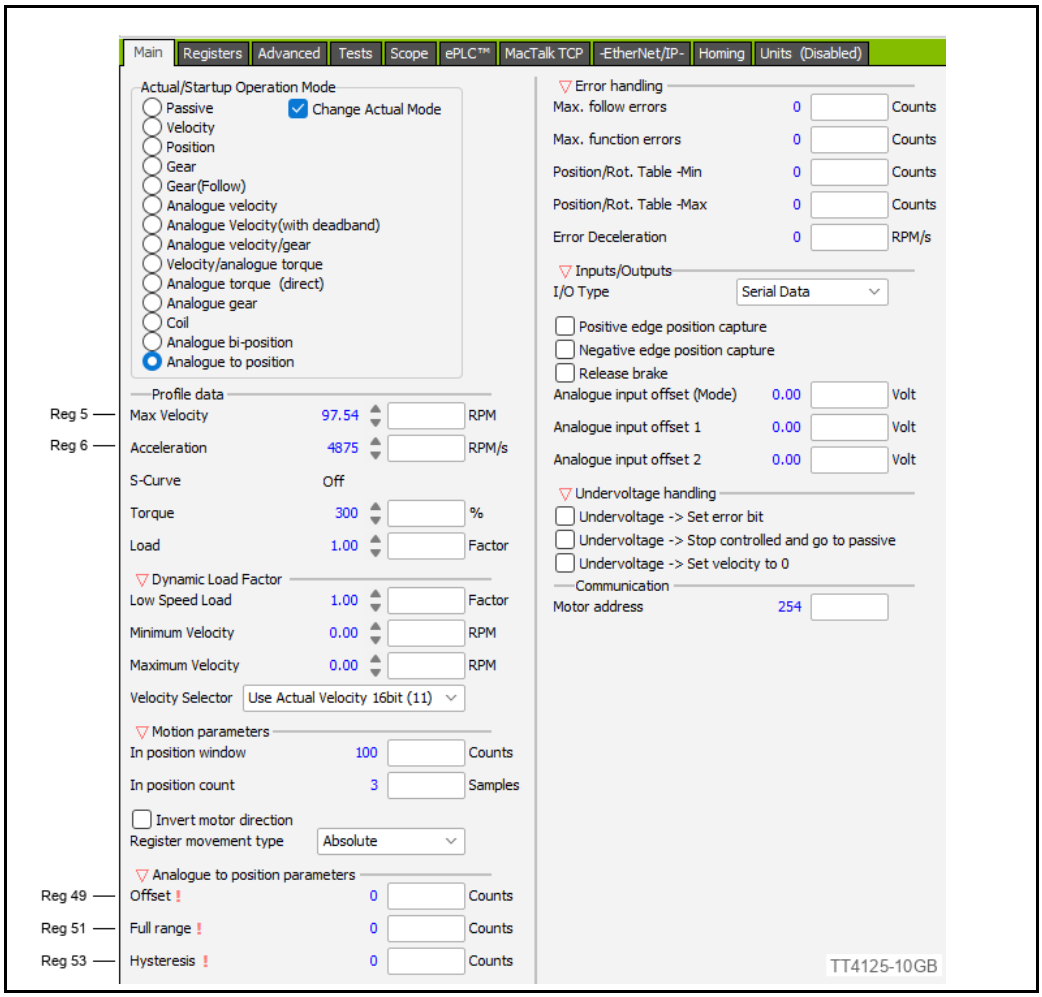
4.15.1 Analogue to Position mode (mode 21) - overall description

In Analogue to Position mode the motor position follows the voltage applied to the analogue input.
The distance the motor moves at full analogue input is defined by the Full range setting (Reg 51; the distance spans 64 x the register value, in encoder counts). The absolute position at 0V input is defined by the Offset register (Reg 49). The motor moves with the normal position profile, so the velocity and acceleration are limited by Velocity (Reg 5) and Acceleration (Reg 6).
To filter away noise on the input signal, the Hysteresis register (Reg 53) can be used: the motor does not move unless the input voltage changes by more than the value corresponding to the programmed number of counts.
Example: the desired working range is 5000 counts, and an offset of 1000 counts from the mechanical zero point is wanted. The Offset register is then set to 1000 counts and the Full range register to 5000 counts. If the motor should ignore input changes smaller than 50 counts, the Hysteresis register is set to 50 counts.
If the application requires a specific mechanical zero position, use the general Homing function before entering this mode. See *Mechanical Homing, page 60*.

4.15 Analogue to Position mode

4.15.2 Configuration via MacTalk

The mode is selected in the Startup mode field in MacTalk, or by writing 21 to the operating mode register (Reg 2).



Offset The absolute position at 0 V input, in encoder counts (Reg 49). On the Registers tab in MacTalk the same register is called Position 1 (P1).

Full range The distance the motor moves at full analogue input, in encoder counts (Reg 51), called Position 2 (P2) on the Registers tab.

Hysteresis The motor does not move unless the input voltage changes by more than the value corresponding to the programmed number of counts (Reg 53), called Position 3 (P3) on the Registers tab. Use this to suppress hunting caused by noise on the input.

Velocity Maximum velocity of the movement (Reg 5).

Acceleration Acceleration of the movement (Reg 6).

4.15 Analogue to Position mode

4.15.3 Configuration via motor registers

When the configuration is done by channels other than MacTalk, such as Ethernet, CANopen etc., or just a simple interface connection to the basic motor, the following description must be followed.

Register 49, POS0 (Position Reg 1)
Position at 0 V input (offset).

Register 51, POS1 (Position Reg 2)
Gain: the target position is Position Reg 1 (Reg 49) plus Analogue input (Reg 170) x Position Reg 2 (Reg 51) / 32. The full input range (10 V = 2048 counts) then spans 64 counts for each unit in Position Reg 2 (Reg 51) - this is the Full range in MacTalk.

Register 53, POS2 (Position Reg 3)
Hysteresis: the target only follows the input when the change exceeds the number of counts in Position Reg 3 (Reg 53). Use this to suppress hunting caused by noise on the input.

Register 5, V_SOLL (Velocity)
Maximum velocity of the movement.

Register 6, A_SOLL (Acceleration)
Acceleration of the movement.

Register 2, MODE_REG (Operating mode)
Write 21 to enter analogue to Position mode.

See also *Register units and conversions, page 90*.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

5 Servo Tuning and Motion Performance

5.1 Servo filter adjustment

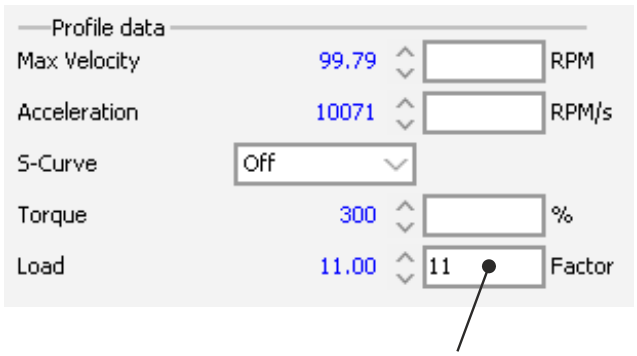
A detailed step-by-step guide to servo filter adjustment is available online: Servo Filter adjustment guide - EN - MAC Tuning Manual - www.jvl.dk/416/user-manuals

5.1.1 Servo filter adjustment

The MAC motor contains a higher-order digital filter regulation core. The purpose of the filter is to ensure that the desired speed, torque and/or position are achieved, and secondly that stability is obtained.
The motor's default setting (when delivered) is normally appropriate for most applications. The only necessary adjustment is the *LOAD* parameter, which is available via the *Main* setup in the MacTalk software. For more demanding applications, the *Filter selector* can be used.

5.1.2 Adjusting the LOAD parameter

The LOAD parameter must be increased proportionally to the inertia of the payload in the system. The default value of the LOAD parameter is 1.0000.
The proper LOAD value must be determined as follows:
LOAD=(Motor inertia+Load inertia)/Motor inertia.



Adjust **Load** according to the attached inertia.

Example:
A system uses a MAC1004. The MAC1004 has a motor inertia of 1.8kg/cm² (according to data in appendix).
If the inertia of the payload attached to the motor is 18kg/cm² (motor intertia x 10) the Load needs to be adjusted to LOAD=(Motor inertia+Load inertia)/Motor inertia
LOAD=(1.8 + 18) / 1.8 = **11**

TT4035-10GB

If the load inertia is not fully known, it is highly recommended to slowly increase the LOAD parameter until the motor starts to be unstable and noisy. Then decrease the value by 20-30% to obtain a certain safety margin. Remember to save the adjustment permanently in the motor by pressing the "Save in Motor" button.

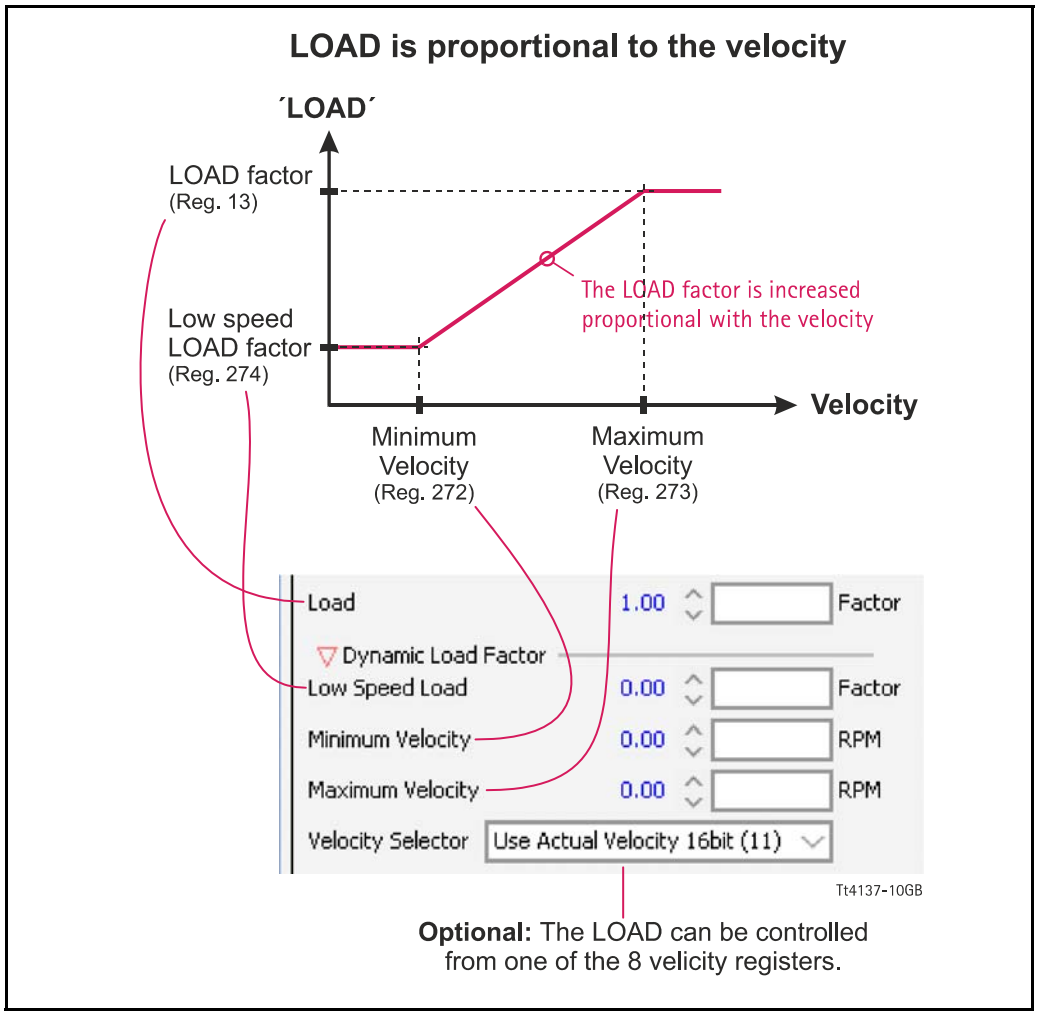
5.1 Servo filter adjustment

5.1.3 Exceptions when adjusting LOAD

Precautions must be taken if the transmission from the motor to the load is elastic or involves a certain amount of backlash. A typical situation where precautions must be taken is when using a belt drive actuator, since the motor's force may have to be transmitted through a gear, for example, and then through the belt before it finally reaches the payload. This “transmission chain” is typically very elastic and the gear will contain a certain amount of backlash.
The main problem is that the motor does not directly “see“ the final payload.
When the motor starts to rotate, it will not “sense” the payload before the backlash distance is passed and the belt is tightened. It is therefore not a linear system, and the LOAD cannot be increased as much as in theory.

5.1.4 Velocity-dependent LOAD factor

The elastic transmission described above can often be handled by letting the motor use two different LOAD factors:
A low factor while the motor is standing still or running slowly, and the normal factor when it runs at higher speed.
This is typically useful with long toothed belts, where the motor only sees the full load inertia once the belt has been tightened. The motor performs the adjustment itself from the actual velocity, and the load factor is recalculated in every cycle of the outer control loop.



5.1.5 Velocity-dependent LOAD factor - detailed

Five registers control the function:

- **Register 274, KVOUT_LO (Low Speed Factor)** is the load factor used at low velocity. The function is switched off when this register is 0, which is the default, and also if it is negative or larger than 100.0000. The motor then uses the Load value alone, exactly as described in the previous sections.

- **Register 272, KVOUT_MIN_VEL (Minimum Velocity)** and **Register 273, KVOUT_MAX_VEL (Maximum Velocity)** are the two velocity limits. The motor uses the absolute values of both limits and of the velocity, so the function works in both directions of rotation.

- **Register 275, KVOUT_SELECT (Velocity Selector)** selects which velocity is evaluated. 0, which is the default, uses Actual Velocity 16bit (Reg 11), while 1 to 8 use Velocity Reg 1 to Velocity Reg 8 (Reg 65 to Reg 72). Values above 8 are treated as 0.

- **Register 13, KVOUT_HI (Load)** is the normal LOAD parameter described in the previous sections. It is the load factor used at high velocity.

At velocities up to and including Minimum Velocity (Reg 272) the motor uses Low Speed Factor (Reg 274), and at velocities at or above Maximum Velocity (Reg 273) it uses Load (Reg 13).

Between the two limits the load factor is interpolated linearly between Low Speed Factor (Reg 274) and Load (Reg 13). If Maximum Velocity (Reg 273) is set equal to or lower than Minimum Velocity (Reg 272), no interpolation takes place and the motor switches directly between the two factors at the limit. If both limits are left at 0, Low Speed Factor (Reg 274) is used only while the shaft is completely stopped.
Low Speed Factor (Reg 274) and Load (Reg 13) use the same scaling as the LOAD parameter, where 65536 corresponds to a load factor of 1.0000. Minimum Velocity (Reg 272) and Maximum Velocity (Reg 273) use the same unit as the velocity register selected by Velocity Selector (Reg 275).
If Minimum Velocity (Reg 272) is written as a negative value, the motor also writes the resulting load factor to Load Reg 4 (Reg 84) each time it is calculated. The absolute value is still used as the velocity limit, so the only extra effect is this diagnostic output, which can be recorded with the Scope function while tuning. Note that any value already held in Load Reg 4 (Reg 84) is overwritten.
The velocity-dependent adjustment is not used in Velocity-limited Analogue Torque mode (mode 17), where the load factor is always taken from Load (Reg 13).
In MacTalk the four registers appear on the Main tab, in the Dynamic Load Factor group, listed top to bottom in this order: Low Speed Load (Reg 274), Minimum Velocity (Reg 272), Maximum Velocity (Reg 273) and Velocity Selector (Reg 275). The fifth, Load (Reg 13), is the ordinary Load field described earlier. Remember to perform Save in Motor to retain the setting.

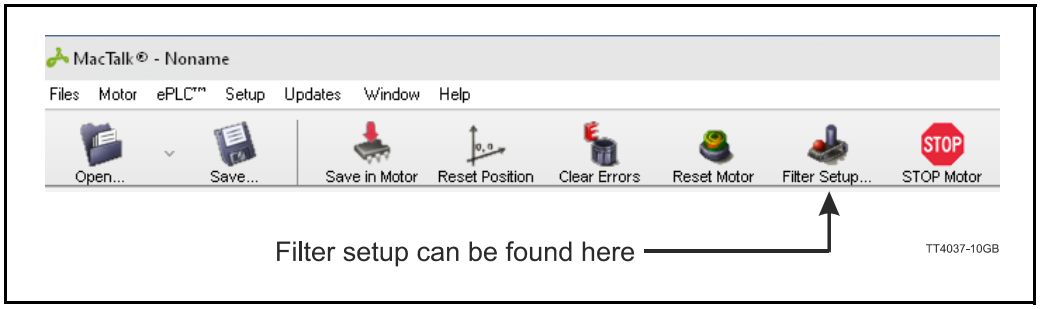
NOTE: the Invert motor direction checkbox shown just below this group belongs to a different function - it is bit 7 of Register 39, HW_SETUP, described in *Invert rotation direction, page 73*.

5.1.6 Filter selector basics

If the desired motor response cannot be achieved using only the LOAD parameter, the filter selector can be used.

5.1 Servo filter adjustment

The filter selector can be found in the MacTalk upper toolbar.

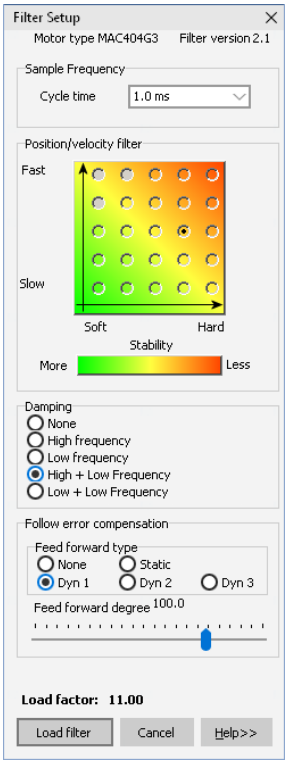


Using the Filter selector, the "personality" of the motor response can be optimised to specific applications. The following overall behaviour can be adjusted:

- Follow error during movement and/or when the motor is stationary.
- Stability with a high load inertia.
- Stability if the load inertia changes during operation.
- Motor noise

The function and options in the filter selector are the same for the complete MAC motor range MAC404, 604, 802, 804, 1004, 1202, 1403 and 1404.

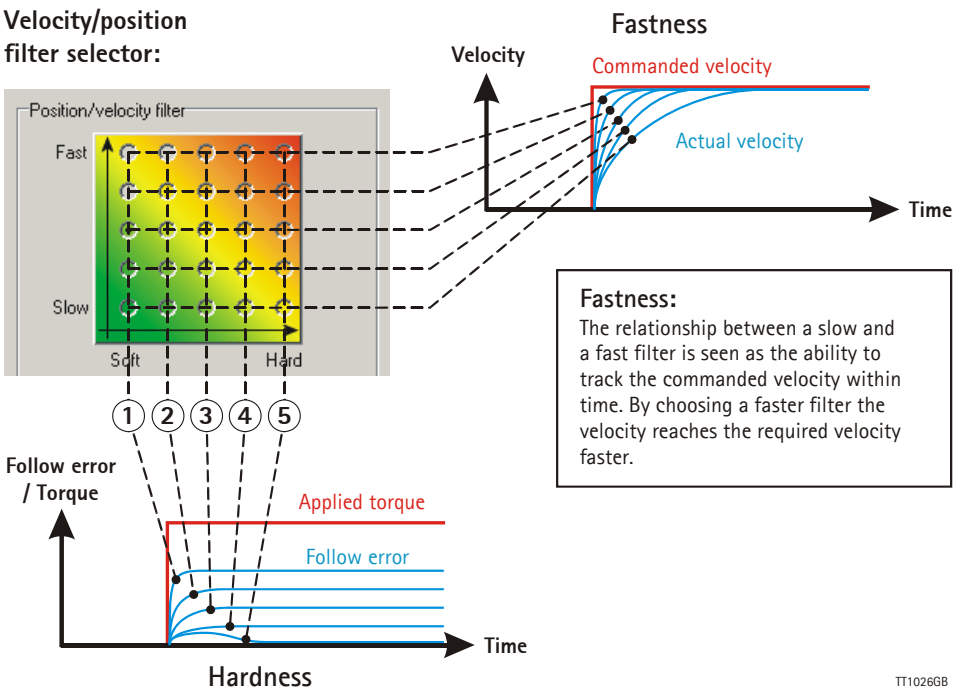
Filter setup dialog:



5.1.7 Adjusting the Position/Velocity filter

The Position/Velocity filter is the main filter which sets up the main response performance of the motor.

5.1 Servo filter adjustment



Fastness:
The relationship between a slow and a fast filter is seen as the ability to track the commanded velocity within time. By choosing a faster filter the velocity reaches the required velocity faster.

Hardness:
The follow error is decreased by choosing a harder filter but the stability is also decreased.
The 5 levels of hardness will affect the motor torque in the following manner.
In case of certain follow error the torque is integrated up to 300% (full torque).

300% motor torque is produced when these follow errors are present:
Column 1 : Follow error of 8000 counts
Column 2 : Follow error of 2000 counts
Column 3 : Follow error of 500 counts
Column 4 : Follow error of 125 counts
Column 5 : Follow error of 1 count (no error is accepted)

5.1.8 Damping

In almost any application it can be useful to damp (suppress) certain oscillations.
The damping selector can be used for this purpose.
The following damping types are available:

- **None**
  Damping feature is disabled.

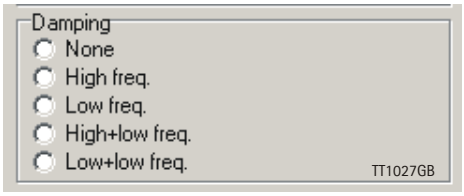
- **Low frequency**
  When selecting *Low frequency*, oscillations caused by a poor mechanical transmission can be reduced. Poor mechanical transmission means backlash in the coupling or elastic toothbelts, etc. The filter becomes more tolerant to variations in the inertia, which normally can cause the motor to become unstable.

- **High frequency**
  When selecting *High frequency,* oscillations at higher frequencies will be reduced. This can typically occur if the filter starts to oscillate at a frequency related to the sample frequency. Often this can be heard as an audible noise.

- **High+Low frequency**
  This is a combination of High and Low frequency settings.

- **Low+Low frequency**
  This setting is similar to Low frequency but adds extra tolerance to variations in the inertia.

Damping selector:



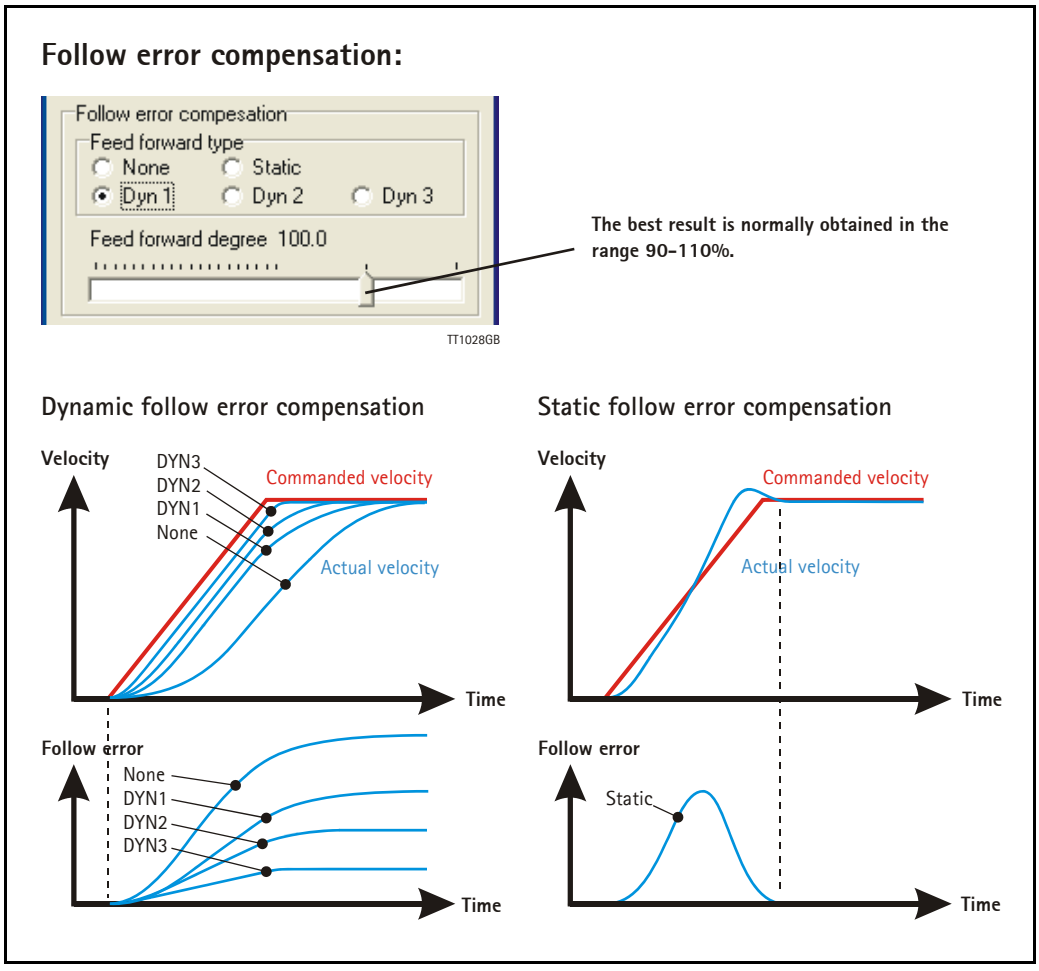
5.1 Servo filter adjustment

5.1.9 Follow error compensation

This feature makes it possible to achieve a minimum position error during movement (dynamically). The 2 main types are:

- **Static**
  Will reduce follow error at constant speed, which can be useful for electronic gear applications since the motor will follow exactly what is demanded without any position error.

- **Dynamic**
  Will reduce follow error during acceleration or deceleration (speed changes). This feature is intended to be used for applications which require that a commanded speed or target position is reached as fast as possible but without any overshoots etc. The Dynamic compensation provides 3 levels (Dyn 1 to 3). Using a higher Dyn number increases the filter order, and better performance may be possible, depending on the actual application.



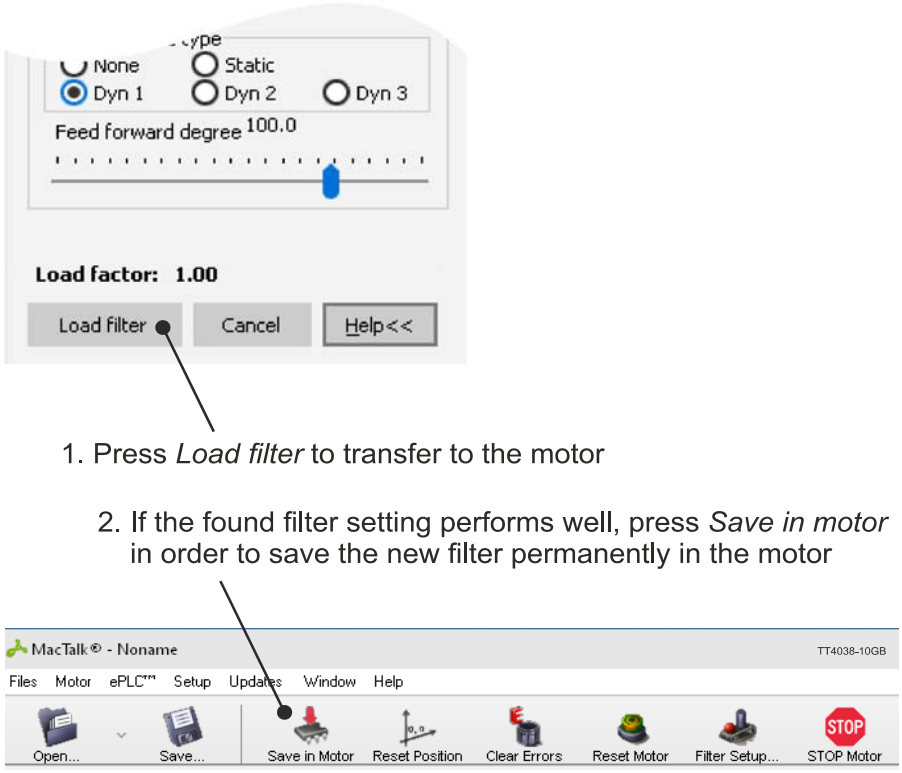
Please note that if one of the 5 slowest main filters has been chosen, the dynamic compensation level Dyn 3 is NOT available.

5.1 Servo filter adjustment

5.1.10 Transferring and saving the filter

After setting the filter choices, the filter can be transferred to the motor.

Transferring and saving the filter setting:



The complete setup including the filter configuration can also be saved to and later re-called from file by using the *Open* and *Save* buttons in the toolbar.

5.1 Servo filter adjustment

5.1.11 Additional adjustment

Now the desired filter is set up in the motor, and the performance can be tested. Further improvement may be required, and typically it may be necessary to experiment in order to obtain an optimum result.
Please note that the LOAD parameter must still be used to adjust the inertia ratio between the motor and load. See also *Adjusting the LOAD parameter, page 124*.

5.2 Clear filters on mode change

By default, the outer control-loop filters keep their internal state - including any accumulated integrator value - when the motor switches between active operating modes. This section describes the register bit that controls whether the filters are reset instead.

Bit 20 (ZUP_CLR_MODECHANGE) in Register 236, SETUP_BITS (Setup Bits special), controls whether the outer control-loop filters are reset when the motor transitions between active operating modes.
Normally, the filters (including integrators in the position controller) retain their accumulated state across a mode transition, which can cause an unwanted transient in some applications. Setting bit 20 = 1 clears the filters on every active-to-active mode transition, so the new mode starts from a clean initial state. Set bit 20 (mask 0x100000) in Setup Bits special (Reg 236), then perform Save in Motor.

Register 236 - Setup Bits special (SETUP_BITS)

TT4079-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit 20: Clear outer-loop filters on mode change (ZUP_CLR_MODECHANGE)

Value	Function / Influence
0 (default)	Outer-loop filters retain their state when changing between active modes.
1	Outer-loop filters are cleared on each active-to-active mode transition.

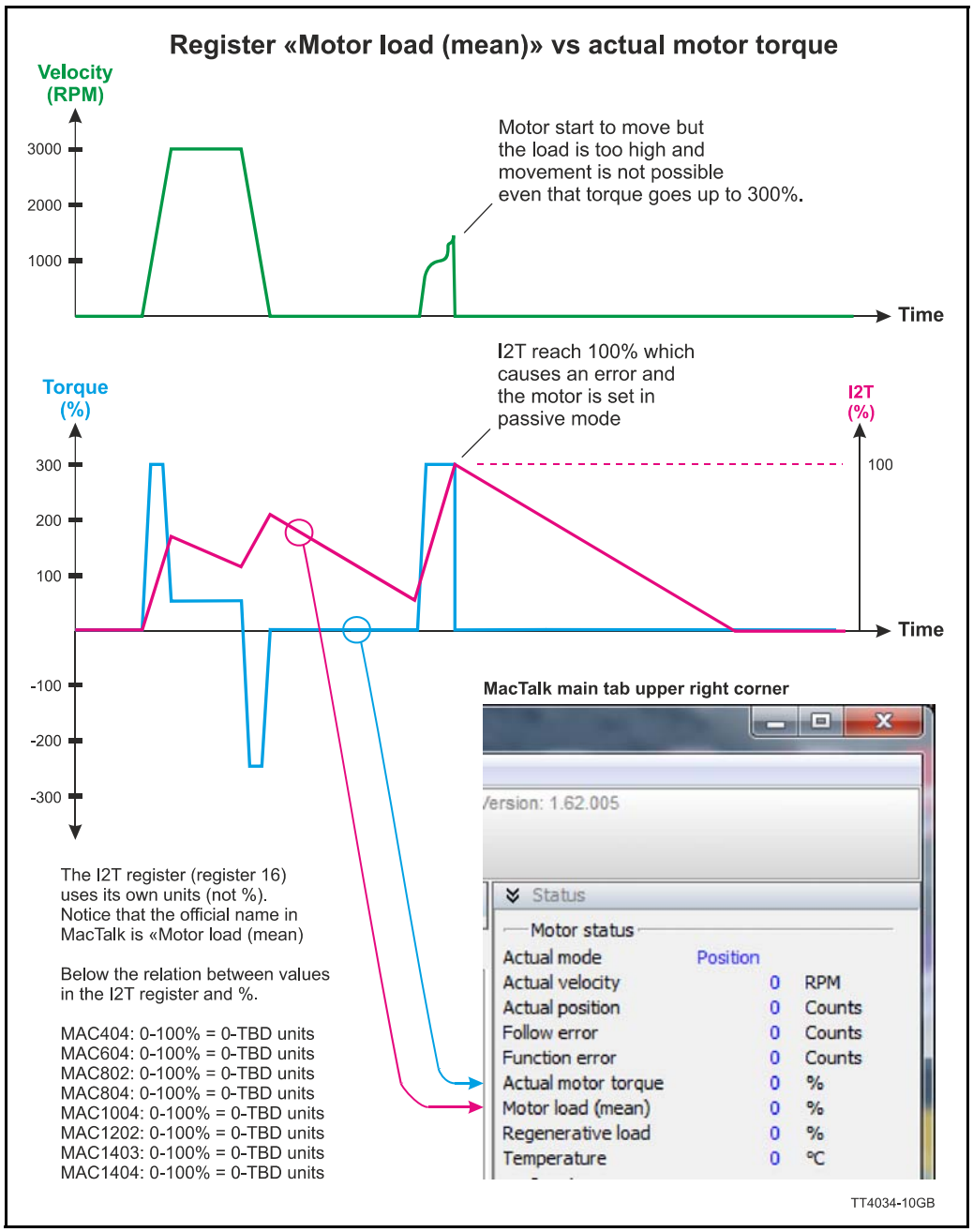
Bit 31 - 21 and Bit 19 - 0: Is used for other purposes - do not overwrite these bits

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

5.3 How to monitor motor torque and load

5.3.1 Monitoring motor torque and load

All the MAC motors contain a register that is continuously updated with the actual motor load integrated over some time.
The register is Register 16, I2T - the melt integral. Its name in MacTalk is “Motor load (mean)”.
The motor can produce up to 300% torque as long as Motor load (mean) (Reg 16) does not reach 100%. If it reaches 100%, the motor will go into Passive mode, and an overload error is reported. Motor load (mean) (Reg 16) can also be useful to monitor the load over time to see if the mechanics start to have an unintended higher friction compared to the installation date.



5.3 How to monitor motor torque and load

Motor load (mean) (Reg 16) and Motor load max (Reg 17) are raw counter values, not percentages. The percentage shown in MacTalk is the ratio between the two, so 100% means that Motor load (mean) (Reg 16) has reached the value held in Motor load max (Reg 17). The limit is therefore model-dependent: every MAC G3 model has its own default value for Motor load max (Reg 17), matched to the thermal capacity of that motor. The motor recalculates the load every 0.2 seconds, independently of the selected sample time. Two independent thermal models are maintained, one for the power transistors in the drive and one for the stator windings, each with its own set of accumulation and decay coefficients. Motor load (mean) (Reg 16) always shows the higher of the two. This is why a short current peak and a long, moderate load can both reach the limit, but at very different rates.
The contribution to the load also depends on the velocity. The same current contributes approximately 90% as much at standstill as it does at 3000 RPM, so a stalled motor builds up the calculated load slightly more slowly than the same current does at nominal speed. After a reset or a power-up, Motor load (mean) (Reg 16) does not start at 0 but at approximately 75% of Motor load max (Reg 17). This is deliberate: a motor that was already warm when it was reset must not be able to be put straight back to full work without the overload protection noticing. The pre-load is applied to the winding model, which is the slower of the two to decay, so the value can take some time to fall back to the actual load.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

5.4 Advanced

5.4.1 High resolution velocity - introduction

This feature offers the possibility to obtain 2 things:

1. The motor velocity and acceleration can be set with a 64 times higher resolution than normal.
2. The positioning range is expanded to full 32 bits. (This is already the default with the standard G3 scaling.)

5.4.2 Function description

Traditionally, the JVL MAC motors have used an internal resolution 16 times higher than the physical encoder resolution of 8000/8192 pulses per revolution.
This allows the user to select target/maximum velocity and acceleration with a 16 times higher resolution.
However, some applications need an even higher resolution than the default resolution for the motors.

This feature offers 1024 times higher velocity resolution than the physical encoder.
This can be accomplished by setting a bit in Setup Bits special (Reg 236).
This will have the following effects:

1. The Velocity registers get a 64 times higher resolution.
2. The Acceleration registers get a 64 times higher resolution.
3. The valid position ranges in Position and Gear modes are expanded, in the G2-compatibility scaling, from +/-134 million counts to +/-2147 million counts. (With the standard G3 scaling, the full range is already available.)
4. The internal Position registers get a 64 times higher scaling.
5. The internal Position registers change from 32 bit to 64 bit.

The following paragraphs list more details, including all registers affected.
The scaling of the Actual velocity (Reg 12) and Actual position (Reg 10) registers is NOT changed and has the same resolution regardless of whether the high resolution velocity is enabled or not.

To get an idea of the improvement in resolution, the following two tables show how many RPM one count in the Target Velocity registers means for supported sample times and encoder resolutions. Values are in RPM per count:

The formula is RPM/Count = (sample_frequency_in_Hz * 60) / (encoder_resolution * (1024 or 16)).

Classic resolution (default):

Sample time	**Sample frequency**	**Encoder resolution** (RPM/count)	
		Encoder used 8000 CPR	Encoder used 8192 CPR
1.0 ms	1000 Hz	0.468750000	0.457763671
1.3 ms	769.23 Hz	0.360576562	0.352125901
2.0 ms	500 Hz	0.23437500	0.228881835
2.6 ms	384.61 Hz	0.180288281	0.176062950

NOTE: Only the previous generation MAC800-1200 in some versions were available with an 8000 CPR encoder. All generation III motors have 8192 CPR encoders.

High resolution:

Sample time	Sample frequency	Encoder resolution (RPM/count)	
		Encoder used 8000 CPR	Encoder used 8192 CPR
1.0 ms	1000 Hz	0.007324218	0.007152557
1.3 ms	769.23 Hz	0.005634014	0.005501967
2.0 ms	500 Hz	0.003662109	0.003576278
2.6 ms	384.61 Hz	0.002817007	0.002750983

NOTE: Only the previous generation MAC800-1200 in some versions were available with an 8000 CPR encoder.

All generation III motors have 8192 CPR encoders.

5.4.2.1 How to enable high resolution velocity

Register 236 - Setup Bits special (SETUP_BITS)

TT4097-11GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit 26: Enable/disable high resolution velocity

Value	Function / Influence
0 (default)	High resolution velocity disabled - normal motor function
1	High resolution velocity enabled

Bit 31 - 27 and Bit 25 - 0: Is used for other purposes - do not overwrite these bits

The general, simple way of using this option is to set bit-26 (value 0x4000000) in Register 236, SETUP_BITS (Setup Bits special), and then Save in Motor.
After a following reset, the target velocity and acceleration registers then work with 64x higher resolution compared to the default resolution.

For example, to set a velocity of 3000 RPM using a sample time of 1.0 ms and an encoder resolution of 8192 CPR, set Register 5, V_SOLL (Velocity), to 3000/0.0071526 = 419430 counts.

It is strongly recommended to keep the bit either set or cleared during the entire operation in the application.
If the bit changes when the motor is in an active mode, this will result in corrupted positions. However, it is possible to change the bit without saving to flash or performing a reset. This should ONLY be done when the motor is in Passive mode.
One of the consequences of using high-resolution velocity and acceleration is that the internal position Register 8, P_FNC, becomes a 64-bit value, and will occupy both register numbers 8 and 9. Index Offset (Reg 9) is then moved to Register 276, INDEX_OFFSET_HIRES. It is recommended to avoid writing directly to P_FNC (Reg 8) when in high-resolution mode, but instead set it indirectly through FastMac commands and Control Bits that calculate it from other registers, like Register 4, P_NEW (Resynchronize position). P_FNC (Reg 8) is primarily used in relative movements.
Please be aware of marginal rounding differences between the classic and high-resolution modes. This can mean some applications must be fine-tuned to reach the same maximum velocity and acceleration.
The following registers are influenced by bit-26 in Register 236, SETUP_BITS (Setup Bits special):

The table below shows all the registers that are relevant for high resolution velocity.

Register number	Short name	MacTalk name	Description, when in high-resolution mode:
5	V_SOLL	Max Velocity	Scaled 64 times higher
6	A_SOLL	Acceleration	Scaled 64 times higher
8	P_FNC	Internal Position	64-bit, Scaled 64 times higher – low word
9	P_FNC_HI	Internal Position	64-bit, Scaled 64 times higher – high word
9	INDEX_ OFFSET	Index position	Moved to register 276 in high-resolution mode
28	MIN_P_IST	Position/ Rot.table -Min	Unchanged scaling, operation range 64x higher
30	MAX_P_IST	Position/ Rot.table – Max	Unchanged scaling, operation range 64x higher
32	ACC_EMERG	Error Deceleration	Scaled 64 times higher
40	V_HOME	Homing Velocity	Scaled 64 times higher
43	P_REG_P	-	Activated Px register can use full range
44	V_REG_P	-	Activated Vx register must be scaled 64x higher
45	A_REG_P	-	Activated Ax register must be scaled 64x higher
49,51,53, 55, 57,59, 61,63	POS0-POS7	P1–P8	Unchanged scaling, operation range 64x higher
65-72	VEL0-VEL7	V1-V8	Activated register must be scaled 64x higher
73-76	ACC0-ACC3	A1-A4	Activated register must be scaled 64x higher
165	G_FNC	-	64-bit, Scaled 64 times higher – low word
236	SETUP_ BITS	<various checkmarks>	Bit-26, value 0x4000000 selects high-res mode.
276	INDEX_ OFFSET_HIRES	Index position	Moved from Register 9 in high-res mode,
277	G_FNC_HI	-	64-bit, Scaled 64 times higher – high word

Operations where the scaling of one or more of the changed registers is used:

Relative positioning and FastMac commands
Relative position using P_FNC

NOTE: the FastMac command numbers below are the numbers within the special-command group (0-31). To execute one of them via Register 211, COMMAND_REG (Special Command), write 224 + the number (128 + 96 + the number) - see the FastMac commands section in the Installation chapter.

FastMac command 04: P_FNC (Reg 8) = 0
FastMac command 08: P_FNC (Reg 8) = [Follow error (Reg 20) - P7 (Reg 61)] * 1 (* 16 in G2-compatibility scaling; * 1024 in high-resolution mode)
FastMac command 09: P_FNC (Reg 8) = [Follow error (Reg 20) - P8 (Reg 63)] * 1 (* 16 in G2-compatibility scaling; * 1024 in high-resolution mode)

FastMac commands 12, 13, 14, 15: Activate four sets of P, V, A, T, L, Z registers.
FastMac command 22: Relative position using P_FNC (Reg 8)
FastMac command 17: Relative position offset P7
FastMac command 18: Relative position offset P8
FastMac command 23: Synchronize positions using Resynchronize position (Reg 4), absolute

FastMac command 24: Synchronize positions using Resynchronize position (Reg 4), relative

Operating modes
Velocity mode
Position mode
Gear Position mode
Analogue Velocity mode
Stop mode (entered automatically before changing to Passive mode)

Analogue Velocity with dead-band mode
Velocity limited Analogue Torque mode
Analogue Gear mode
Coil mode
Analogue bi-position mode
Analogue-to-position mode
Gear Follow mode

Homing modes
Sensor based Homing modes
Torque based Homing modes
Index Homing mode 1 (slow, high precision)
Index Homing mode 2 (fast, lower precision)

Rotary table operations
All Rotary Table operations

Position synchronization and status
Synchronize Positions (manually)
Synchronize Positions, manually, using Resynchronize position (Reg 4)
In-Position status bit calculation (also at-velocity status bit calculation)

5.4.3 On-the-fly unit scaling

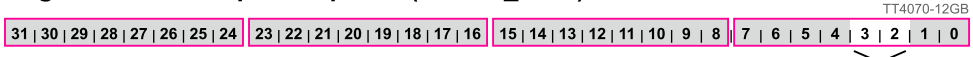
On-the-fly unit scaling is a user-defined, custom conversion of register values. For each register, a conversion factor can be set up so that the register is read and written in the user's own engineering units - for example, velocity in RPM instead of the internal counts/sample value.
The conversion factors are configured in MacTalk under Parameters > Advanced > Unit Scaling and are stored in the motor. When enabled, the motor converts the values on the communication channel during each read and write operation; the internal register values are unchanged, and channels without scaling still access the raw values.

Three independent channels can be enabled in Register 236, SETUP_BITS (Setup Bits special):

Bit 2 (mask 0x04): Apply on-the-fly scaling to Modbus register read/write.
Bit 3 (mask 0x08): Apply on-the-fly scaling to MacTalk register read/write. This bit is normally enabled by MacTalk when unit scaling is used (the firmware default is off).
Bit 4 (mask 0x10): Apply on-the-fly scaling to ePLC program register read/write.

Register 236 - Setup Bits special (SETUP_BITS)

TT4070-12GB



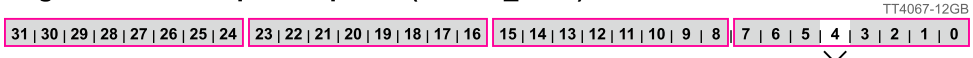
Bits 2-3: On-the-fly unit scaling channels (SETUP_BITS)

Value	Function / Influence
Bit 2	Apply on-the-fly unit scaling to Modbus register read/write.
Bit 3	Apply on-the-fly unit scaling to MacTalk register read/write. Set by default.

Bit 31 - 5 and Bit 1 - 0: Is used for other purposes - do not overwrite these bits
Bit 4: ePLC unit scaling - see the next figure

Register 236 - Setup Bits special (SETUP_BITS)

TT4067-12GB



Bit 4: ePLC on-the-fly unit scaling (ZUP_NANOPLC_SCALE)

Value	Function / Influence
0 (default)	ePLC register accesses use raw internal firmware values.
1	ePLC register reads/writes go through the unit-scaling tables (engineering units).

Bit 31 - 5 and Bit 3 - 0: Is used for other purposes - do not overwrite these bits

NOTE:

Bit 4 (ZUP_NANOPLC_SCALE) affects only register accesses made from within a running ePLC program. When set, a register read/write inside the program operates in scaled engineering units. When clear (the default), ePLC register accesses use the raw internal values. To enable, set bit 4 in Setup Bits special (Reg 236), then perform Save in Motor.

5.4.4 Raise speed-error limit

Each MAC motor has a built-in over-speed monitor. If the measured velocity, Actual velocity (Reg 12), exceeds an internal limit, the motor stops with a speed error. By default, this limit is set at or slightly above the motor's normal maximum speed.

For applications that must run close to the motor's top speed without triggering spurious speed errors, the limit can be raised by setting bit 5 (mask 0x20) in Register 236, SETUP_BITS (Setup Bits special). The change takes effect immediately; perform Save in Motor to retain it after a reset. Approximate limits by model: MAC404: 4300 RPM (default) / 5000 RPM (raised); MAC604/804/1004/1404: 3600 RPM (default) / 4000 RPM (raised); MAC802/1202/1403: approx. 4000 RPM (bit 5 has no effect on these models).

Register 236 - Setup Bits special (SETUP_BITS)

TT4064-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit 5: Raise speed-error limit (ZUP_HIGHER_MAX_SPEED)

Value	Function / Influence
0 (default)	Speed-error limit = normal maximum speed.
1	Limit raised: MAC404 ~5000 RPM; MAC604/804/1004/1404 ~4000 RPM; MACx02 no change.

Bit 31 - 6 and Bit 4 - 0: Is used for other purposes - do not overwrite these bits

NOTE: This bit only moves the speed-error threshold. It does not change the motor's ratings, does not raise any speed setpoint or command limit, and does not affect the internal critical-overspeed PWM-lock protection.

5.4.5 Noise Reduction

5.4.5.1 Introduction

Noise Reduction reduces the audible noise of the motor, for applications where quiet operation is required.

By default, the current controller is tuned for maximum dynamic response, so the motor movement is controlled fast and precisely.
This aggressive current control is the main source of the audible noise from the motor.

Activating Noise Reduction reduces the current-controller response, and thereby the noise, in 15 selectable levels. The trade-off is reduced efficiency and peak torque, most noticeable at higher velocities.
The dynamic response of the motor is correspondingly slower. This is normally acceptable if Noise Reduction is enabled only while the motor is at standstill.

The feature is available on all MAC G3 motors:



MAC404 to MAC1404 and MAC802, MAC1202, MAC1403.
The following are NOT supported: MAC050-141 Gen.1., MAC400 and MAC800.

5.4.5.2 How to enable Noise Reduction

The internal Register 246, SETUP2_BITS (Scope/Samp.bits), bits 7:4, is used to enable and adjust the degree of noise reduction.
Please note that the other bits in this 32 bit register are used for other purposes, so avoid overwriting these, since this can cause unexpected behaviour of the motor.
The Noise Reduction setup is saved similarly to other registers by using “Save in Motor”.

Register 246 - Scope/Samp.bits (SETUP2_BITS)

TT4096-11GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

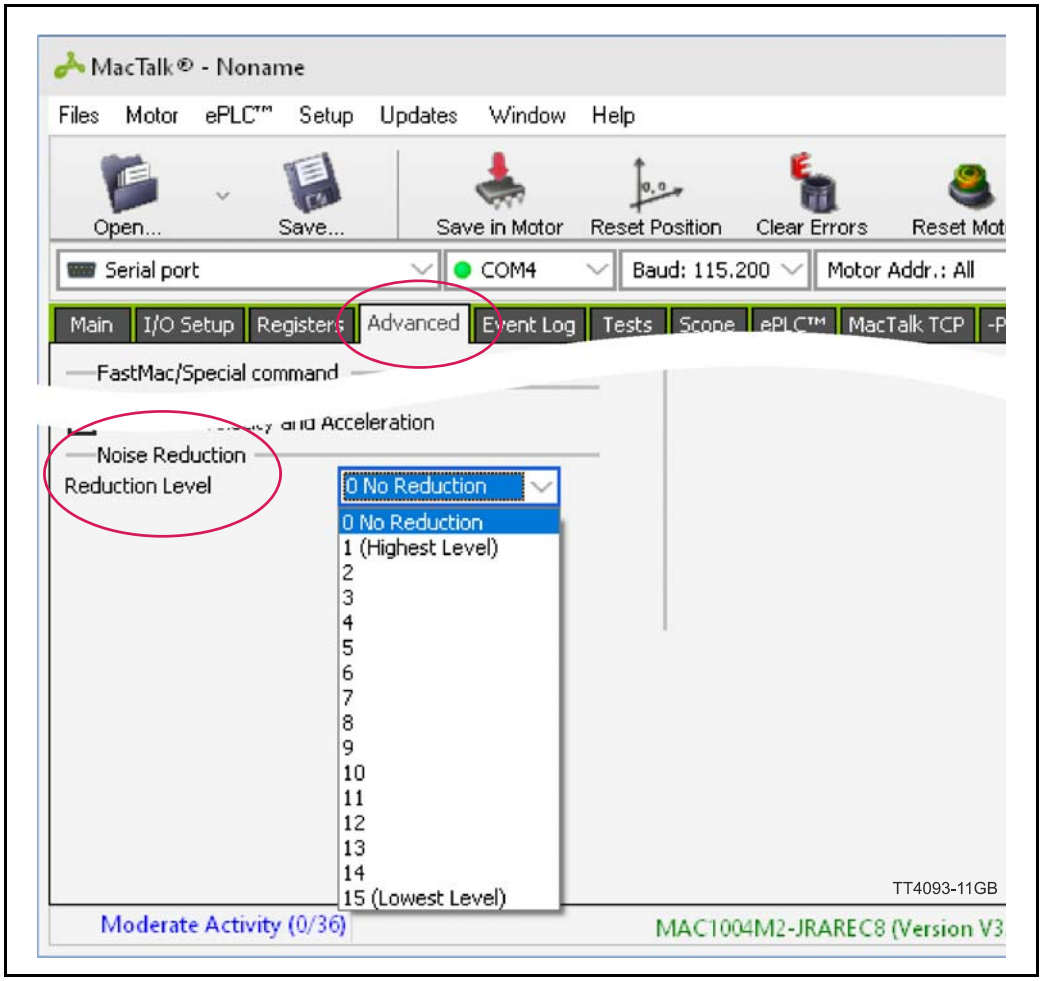
Bit 7 - 4: Silence degree

Value (hex)	Function / Influence
0 (default)	Silence mode disabled - normal motor function
1	Silence mode enabled level 1 - Minimum noise reduction
2	Silence mode enabled level 2
3	Silence mode enabled level 3
4	Silence mode enabled level 4
5	Silence mode enabled level 5
6	Silence mode enabled level 6
7	Silence mode enabled level 7
8	Silence mode enabled level 8
9	Silence mode enabled level 9
A	Silence mode enabled level 10
B	Silence mode enabled level 11
C	Silence mode enabled level 12
D	Silence mode enabled level 13
E	Silence mode enabled level 14
F	Silence mode enabled level 15 - Maximum noise reduction

Bit 31 - 8 and Bit 3 - 0: Is used for other purposes - do not overwrite these bits

The noise reduction level can also be set from MacTalk: use the Noise Reduction control on the Advanced tab.
In MacTalk the field is called Reduction Level on the Advanced tab, and the level chosen there is written into bits 7:4, so the register value is the level multiplied by 16: level 1 gives 16, level 8 gives 128 and level 15 gives 240. Level 1 changes the current-controller coefficients the least and level 15 the most, so level 15 gives the quietest operation and the slowest dynamic response. The two ends are labelled 1 (Highest Level) and 15 (Lowest Level) in MacTalk, which refers to the response level and not to the amount of noise reduction.

(continued next page)



5.4.6 Always-on cooling fan

On motors fitted with a cooling fan (Option), the fan is normally controlled automatically: it switches on when the internal temperature rises above approximately 75% of the maximum allowed temperature and switches off again when the temperature has dropped approx. 2 °C below that threshold. Set bit 18 (mask 0x40000) in Register 39, HW_SETUP (HW Setup), to force the fan to run continuously regardless of temperature:

Register 39 - HW Setup (HW_SETUP)

TT4060-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit 18: Always-on cooling fan (HW_SETUP_ALWAYS_COOL)

Value	Function / Influence
0 (default)	Fan controlled automatically by temperature.
1	Fan runs continuously (always on).

Bit 31 - 19 and Bit 17 - 0: Is used for other purposes - do not overwrite these bits

NOTE: Use continuous cooling in applications with high ambient temperature, restricted airflow, or sustained high load, where keeping the power stage cool at all times reduces the risk of a Temperature too high error. This setting has no effect on motors

without a cooling fan, and does not disable the over-temperature protection - the motor still faults if the maximum temperature is exceeded.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

6 Inputs and Outputs

6.1 Multifunction I/O terminal type

The MAC motor has a pair of multifunction I/O channels (A and B) that can be configured for different signal roles. Bits 0-1 (HW_SETUP_DIRAWR / HW_SETUP_DIRBWR) of Register 39, HW_SETUP (HW Setup), select the operating mode.

Value	Function
0 (bits 0-1 = 00)	Pulse input. The terminals accept an external encoder or pulse/direction signal for gear synchronisation.
1 (bits 0-1 = 01, default)	Serial data. RS485/Modbus is active.
2 (bits 0-1 = 10)	Reserved. Do not use.
3 (bits 0-1 = 11)	Pulse output. The internal encoder A/B signals are driven out on the terminals.

Register 39 - HW Setup (HW_SETUP)

TT4068-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

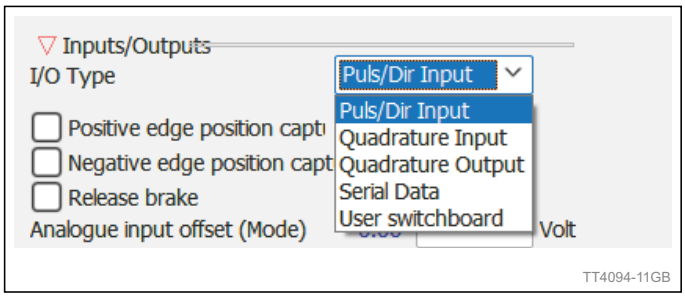
Bits 0-1: Multifunction I/O type (HW_SETUP_DIRAWR / HW_SETUP_DIRBWR)

Value	Function / Influence
00	Pulse input: terminals accept external encoder or pulse/direction signal.
01 (default)	Serial data: RS485/Modbus is active on the terminals.
10	Reserved: keeps existing I/O configuration; do not use.
11	Pulse output: internal encoder A/B signals driven out on the terminals.

Bit 31 - 2: Is used for other purposes - do not overwrite these bits

NOTE: HW Setup (Reg 39) bits 0-1 are read only at power-up/reset. After changing them, perform Save in Motor and reset the motor for the new setting to take effect.

In MacTalk, the I/O type is selected with the I/O Type field on the Main tab, in the Inputs/Outputs group:



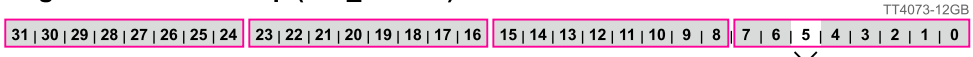
NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

6.2 External encoder input filter

Bit 5 (HW_SETUP_NOFILT) in Register 39, HW_SETUP (HW Setup), controls the input filter on the external encoder inputs (multifunction I/O).
By default, a low-pass filter is active that limits the signal frequency to approximately 1 MHz, rejecting cable noise and spikes. Setting bit 5 = 1 disables the 1 MHz limit; the input is then sampled at the full FPGA clock rate. This is only necessary for very fast encoders (high resolution at high speed) where the 1 MHz limit would clip the signal. Set bit 5 (mask 0x20) in HW Setup (Reg 39), then perform Save in Motor.

Register 39 - HW Setup (HW_SETUP)

TT4073-12GB



Bit 5: Ext-encoder input filter (HW_SETUP_NOFILT)

Value	Function / Influence
0 (default)	Input filter active: external encoder signal filtered at 1 MHz (noise rejection).
1	Input filter off: signal sampled at 8 MHz (for high-speed encoders).

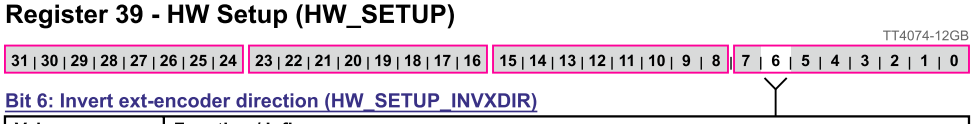
Bit 31 - 6 and Bit 4 - 0: Is used for other purposes - do not overwrite these bits

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

6.3 Invert external encoder direction

Bit 6 (HW_SETUP_INVXDIR) in Register 39, HW_SETUP (HW Setup), inverts the counting direction of the external encoder input (eQEP2).
By default, an increasing encoder signal counts in the positive direction. Setting bit 6 = 1 inverts the sign internally, without requiring physical swapping of the A and B cables. This is an alternative to negating the gear factor. Set bit 6 (mask 0x40) in HW Setup (Reg 39), then perform Save in Motor.

Register 39 - HW Setup (HW_SETUP)



Bit 6: Invert ext-encoder direction (HW_SETUP_INVXDIR)

Value	Function / Influence
0 (default)	External encoder counts in the normal direction.
1	External encoder counting direction is inverted.

Bit 31 - 7 and Bit 5 - 0: Is used for other purposes - do not overwrite these bits

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

6.4 Position capture on analogue input

The motor can latch its actual position the instant Analog input 1 (Reg 216) or Analog input 2 (Reg 218) crosses a +5.0 V threshold. This is useful for marking the position of an external event, for example a product sensor or a registration mark, and provides approximately 50 µs resolution.
Capture on analogue input 1 is armed by setting the relevant bit in Register 39, HW_SETUP (HW Setup). When the threshold is crossed, the firmware copies the current value of Fast act. pos. 100uS (Reg 229) into the result register and automatically clears the arming bit. Re-arm the bit before the next capture event.
Bit 19 (mask 0x80000): arm capture on Analog input 1 (Reg 216) rising above +5.00 V. Result stored in Register 63, POS7 (Position Reg 8).
Bit 20 (mask 0x100000): arm capture on Analog input 1 (Reg 216) falling below +5.00 V. Result stored in Register 64, CAPCOM7.

Capture on analogue input 2 is armed from Register 246, SETUP2_BITS (Scope/Samp.bits) instead:
Bit 1 (mask 0x02): arm capture on Analog input 2 (Reg 218) rising above +5.00 V. The captured position is stored in Register 59, POS5 (Position Reg 6).
Bit 2 (mask 0x04): arm capture on Analog input 2 (Reg 218) falling below +5.00 V. The captured position is stored in Register 60, CAPCOM5.

On both inputs the +5.00 V threshold is shifted by the offset register belonging to the input, Analog input 1 offset (Reg 217) or Analog input 2 offset (Reg 219), because the offset is always added to the measured value before the comparison.

Register 39 - HW Setup (HW_SETUP)

TT4061-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
												↓																			

Bit 19: Rising-edge capture (HW_SETUP_POSITION_CAPTURE_UP)

Value	Function / Influence
0 (default)	Position capture on rising ANINP1 edge disabled.
1	Capture P_QUICK to POS7 (Reg 63) when ANINP1 rises above +5.00 V.

Bit 31 - 20 and Bit 18 - 0: Is used for other purposes - do not overwrite these bits

Register 39 - HW Setup (HW_SETUP)

TT4062-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
											↓																				

Bit 20: Falling-edge capture (HW_SETUP_POSITION_CAPTURE_DN)

Value	Function / Influence
0 (default)	Position capture on falling ANINP1 edge disabled.
1	Capture P_QUICK to CAPCOM7 (Reg 64) when ANINP1 falls below +5.00 V.

Bit 31 - 21 and Bit 19 - 0: Is used for other purposes - do not overwrite these bits

NOTE: By default, the capture fires on a level (signal is above/below the threshold). To require an actual edge transition on both inputs, set bit 3 (mask 0x08) of Scope/Samp.bits (Reg 246). Capture can also be armed or cleared on-the-fly by writing to Register 211, COMMAND_REG (Special Command): 0x1041 = arm rising on Analog input 1 (Reg 216), 0x1042 = arm falling on Analog input 1, 0x1043 = arm rising on Analog input 2 (Reg 218), 0x1044 = arm falling on Analog input 2. Writing 0x1040 disables and de-arms all four capture options.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

6.5 Fix position capture sample point

Bit 29 (HW_SETUP_CAPTURE_NO_JITTER) in Register 39, HW_SETUP (HW Setup), significantly reduces timing jitter on the high-speed position capture triggered by Analog input 1 (Reg 216); see the Position capture section.
The high-speed capture samples Fast act. pos. 100uS (Reg 229) at 50 μs intervals; the sample point normally varies slightly within each timeslice. Setting bit 29 = 1 fixes the sample point to the same moment every timeslice, significantly reducing this jitter. The trade-off is a small reduction in the ePLC execution budget.

Register 39 - HW Setup (HW_SETUP)

TT4076-12GB



Bit 29: Fix position capture sample point (HW_SETUP_CAPTURE_NO_JITTER)

Value	Function / Influence
0 (default)	Position capture timing follows the standard timeslice schedule.
1	Fixed capture sample point each timeslice; eliminates jitter (reduces ePLC budget).

Bit 31 - 30 and Bit 28 - 0: Is used for other purposes - do not overwrite these bits

NOTE: Use this bit only in applications where precise capture timing is critical, such as cam synchronisation, and accept the reduced ePLC capacity. Set bit 29 (mask 0x20000000) in HW Setup (Reg 39), then perform Save in Motor.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

6.6 Error output: position compare

Bit 14 (HW_SETUP_CMP_ERROR_OUT) in Register 39, HW_SETUP (HW Setup), re-assigns the Error output from motor fault status to a position comparator output. When bit 14 = 1, the Error output becomes active (driven high; inverted if bit 11, HW_-SETUP_INV_ERROR_OUT, is set) when Actual position (Reg 10) is greater than or equal to CAPCOM0 (Reg 50). This functions as a hardware comparator trigger that can be used for synchronisation or triggering in position-controlled applications.

Register 39 - HW Setup (HW_SETUP)

TT4075-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit 14: Error output = position compare (HW_SETUP_CMP_ERROR_OUT)

Value	Function / Influence
0 (default)	Error output reflects the normal motor error status.
1	Error output driven by position compare: active when P_IST >= CAPCOM0.

Bit 31 - 15 and Bit 13 - 0: Is used for other purposes - do not overwrite these bits

NOTE: When bit 14 is set, motor faults are no longer signalled on the Error output. The output is dedicated to the position compare function regardless of the motor error state. Set bit 14 (mask 0x4000) in HW Setup (Reg 39), then perform Save in Motor.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

6.7.1 User-controlled Error output

By default, the Error output reflects the motor's internal error status. If your application needs to control this output manually, for example from a fieldbus write or an ePLC program, set bit 9 (mask 0x200) in Register 39, HW_SETUP (HW Setup).

When bit 9 is set, the output no longer follows the error status. Instead, it follows bit 1 of Register 207, USEROUTVAL (Basic motor output 1 + 2): when bit 1 = 1, the output is driven active (inverted if HW Setup (Reg 39) bit 11 is set).

Register 39 - HW Setup (HW_SETUP)

TT4057-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit 9: User-controlled Error output (HW_SETUP_USER_ERROR)

Value	Function / Influence
0 (default)	Error output reflects the motor's automatic error status.
1	Error output is controlled by bit 1 of Register 207 (USEROUTVAL).

Bit 31 - 10 and Bit 8 - 0: Is used for other purposes - do not overwrite these bits

NOTE: Bit 9 is evaluated continuously by the firmware, so a change takes effect immediately; perform Save in Motor to keep the setting after a power cycle. Basic motor output 1 + 2 (Reg 207) can be written directly over the fieldbus, or set and cleared from an ePLC program.

Mapping the In-Position and Error signals to physical outputs

The MAC G3 has no dedicated In-Position or Error output pins. Each of the two signals instead has a bit mask that selects which of the digital output channels follow it. Register 110, MAC00_5, is the mask for the In-Position signal, and Register 111, MAC00_6, is the mask for the Error signal. A set bit forces the corresponding output to follow the signal, while a cleared bit leaves that output under normal user control.

Both masks are evaluated on every update of the digital outputs, so a change takes effect immediately and does not require a reset. The active level of either signal can be inverted with bit 10 and bit 11 of Register 39, HW_SETUP (HW Setup).

NOTE: If both bit 9 and bit 14 of HW Setup (Reg 39) are set, bit 9 takes precedence and the position comparator has no effect on the Error output. Bit 11 inverts the result in all three cases.

6.7.2 In-Position output in Passive

Bit 19 (ZUP_INPOS_PASSIVE) in Register 236, SETUP_BITS (Setup Bits special), determines whether the In-Position output is updated while the motor is in Passive mode. By default, the In-Position output (OUT1/InPos) is deasserted automatically when the motor enters Passive mode. Setting bit 19 = 1 causes the firmware to continue evaluating the live position window and updating the output - the motor is passive, but the In-Position signal still reflects whether the actual position is within the configured window. When bit 19 is set, the In-Position status can also be read directly from bit 4 of Register 35, ERR_STAT (Error status). Set bit 19 (mask 0x80000) in Setup Bits special (Reg 236), then perform Save in Motor.

Register 236 - Setup Bits special (SETUP_BITS)

TT4078-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit 19: In-Position output in Passive mode (ZUP_INPOS_PASSIVE)

Value	Function / Influence
0 (default)	In-Position output is cleared when the motor is in Passive mode.
1	In-Position output reflects live position window status in Passive mode.

Bit 31 - 20 and Bit 18 - 0: Is used for other purposes - do not overwrite these bits

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

6.7 Dedicated I/O

7 Safety, Diagnostics and Error Handling

7.1 Error messages and error handling

7.1.1 Error messages and error handling

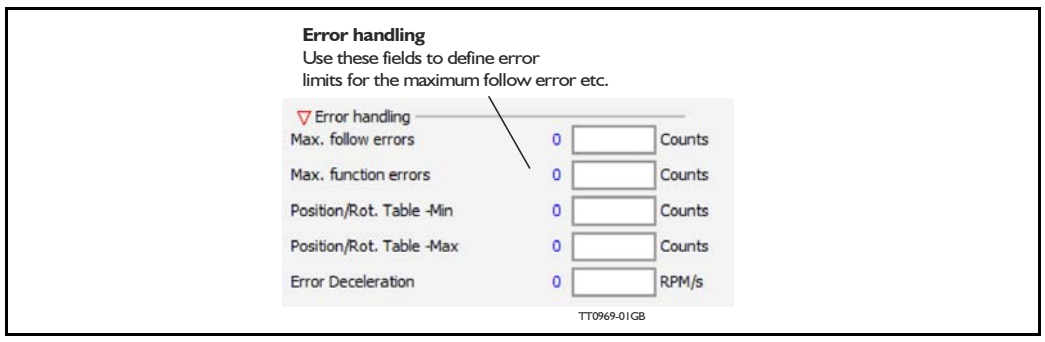
The MAC motor incorporates 5 fundamental parameters used for protection-related purposes. They all have effect regardless of the operation mode the motor is set up to use.

Follow error max (Reg 22)
It is possible to define the maximum allowable difference between the actual position of the motor and the desired position. Depending on the setting of the servo filter etc., this position difference will change. For protection, it can be useful to define that the difference is not allowed to exceed, for example, 500 counts. The motor normally has a resolution of 8192 counts per revolution, but 8000 counts per revolution if bit 21 of HW Setup (Reg 39) is set for compatibility with earlier MAC800 systems. In MacTalk the setting is the Motor resolution field, which offers 8192 counts/rev. and 8000 Counts/rev. If a mechanical collision occurs, the position difference will typically be exceeded and cause a follow error, making the motor passive with no further movement. The default is 0, meaning that the feature is disabled.

Function error max (Reg 26)
Similar to Follow Error, but the number of difference counts is only measured from the point where the peak torque is reached, making it impossible for the motor to follow the commanded movement. Default is 0, meaning that the feature is disabled.

Minimum position (Reg 28) and Maximum position (Reg 30)
A software-based replacement for the physical limit switches. Minimum position (Reg 28) and Maximum position (Reg 30) define the legal travel range, and the motor cannot move outside it: as soon as the actual position passes one of the limits (a tolerance of 25 counts is allowed), the motor sets the error 'Position Limit Exceeded' and is switched to Stop mode, so the movement is stopped at the limit instead of continuing. The function is only active when at least one of the two registers differs from 0; with both registers set to 0 the feature is disabled. The error is cleared automatically when the position is back inside the legal range, and it can be temporarily overridden so that the motor can be driven free of a limit. See Error message 'Position Limit Exceeded' later in this chapter for the error details.

Error deceleration (Reg 32)
If an unrecoverable error occurs, it can be expedient to use a controlled deceleration instead of a sudden stop. If the inertia in the system is high and the mechanical parts are weak, a sudden stop can cause damage and unintended behaviour. When an error switches the motor to Stop mode, the motor therefore does not brake abruptly: the velocity is ramped down to zero with the deceleration defined by Error deceleration (Reg 32). If the register is left at 0, the ramp uses Acceleration (Reg 6) instead, so the stop is still controlled - a value of 0 does not disable the function.



7.1 Error messages and error handling

7.1.2 Monitoring errors and warnings

When using the MacTalk PC-program, any error or warning is shown in the 'Status' field on the main tab.

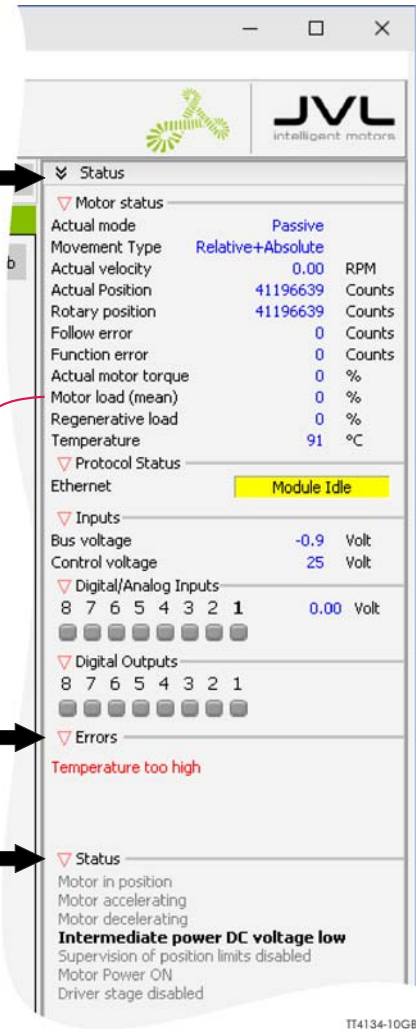
General error, warning and status area at the main screen

In this area actual values for the motor operation is monitored continously. Most of these monitored values will trip a corresponding error message.

Example :
The value 'Motor load (mean)' indicate the long term load at the motor. If the value goes above 99% the motor will shut down and the error message 'Overload' will be shown.

Actual error(s) are shown here if any

Warnings and status information are presented here



7.1 Error messages and error handling

7.1.3 Error message 'Overload'

The following list shows the possible error messages, the cause of the error and possible actions to prevent the error from happening.
Each error can also be monitored by reading Error status (Reg 35). The register can be read from any control channel: MacTalk, the serial interface, or industrial Ethernet. For the Ethernet protocols (EtherCAT, PROFINET, EtherNet/IP, Modbus TCP etc.), see the Ethernet user manual, LB0077. Over the serial interface the register can also be read from software packages such as the OCX driver or MacRegIO.

Message no. / Message	**I / 'Overload'**
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	The calculated accumulated load of the motor and electronics is above the limit set by Motor load max (Reg 17). The actual level of losses can be observed in the 'Motor load (mean)' field (Reg 16) (see the screen dump above). For a description of how the load is calculated, see Monitoring motor torque and load in the Servo Tuning and Motion Performance chapter.
Possible cause of this error	The motor has been loaded above the maximum continuous torque rating for too long a time, causing a critical internal temperature.
Solutions to avoid error	- Reduce average motor load. - Reduce the speed and/or acceleration. - Adjust servo filter to a stable behaviour during any event. - Make sure that the supply voltage is at the specified level.
How to return to normal operation	- Reset the motor, clear the error bit(s) in ERR_STAT (Reg 35) or cycle the power. - Clearing the error bit only has an effect once Motor load (mean) (Reg 16) has fallen back below Motor load max (Reg 17). As long as the accumulated load is still above the limit, the motor sets the error and forces passive mode again at the next load calculation, i.e. every 0.2 seconds, so the motor must be allowed to cool down first. - After a reset or a power cycle the accumulated load is preloaded to approximately 75% of Motor load max (Reg 17), so that a motor that was hot before the reset cannot immediately be put back to full work. During normal operation the value settles at the actual load within a few seconds.
Error bit / Firmware name	Bit 0 / 'I2T_ERR'

7.1 Error messages and error handling

7.1.4 Error message 'Follow Error'

Message no. / Message	**2 / 'Follow error'**
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	The actual difference between the actual motor position and the intended position is higher than the value specified in the 'Maximum follow error' field (Reg 22) in MacTalk.
Possible cause of this error	The motor has been applied too high a load or the 'maximum follow error' value has been set at an unrealistically low value in regard to the actual hardness of the servo filter.
Solutions to avoid error	- Increase the 'Maximum follow error' value. - Adjust the servo filter hardness to a more aggressive value. - Make sure that the torque setting is not limiting the motor movement. - Set the 'Maximum follow error' to 0 (default) which will disable the detection of this error type.
How to return to normal operation	- Reset the motor, clear the error bit(s) in ERR_STAT (Reg 35) or cycle the power.
Error bit / Firmware name	Bit 1/ 'FLW_ERR'

7.1.5 Error message 'Function Error'

Message no. / Message	**3 / 'Function error'**
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	If the actual load torque of the motor gets higher than the specified torque setting permits, it will cause the motor to slip away from where it is supposed to be. If the number of motor counts missing in this situation gets higher than the value specified in the 'Maximum function error' field (Reg 26) in MacTalk, it will trigger the 'function error'. If the actual motor torque never reaches the value specified in the 'torque' field (Reg 7), this error will never be triggered. The above condition is valid when the motor is operated in Position mode, Bi-position mode, or Analogue to position mode.
Possible cause of this error	The motor has been applied too high a load or the 'maximum function error' value has been set at an unrealistically low value in regard to the 'torque' setting.
Solutions to avoid error	- Increase the 'Maximum function error' value. - Adjust the servo filter hardness to a more aggressive value. - Make sure that the torque setting is not limiting the motor movement. - Set the 'Maximum function error' to 0 (default) which will disable the detection of this error type.
How to return to normal operation	- Reset the motor, clear the error bit(s) in ERR_STAT (Reg 35) or cycle the power.
Error bit / Firmware name	Bit 2 / 'FNC_ERR'

7.1 Error messages and error handling

7.1.6 Error message 'Regenerative overload'

Message no. / Message	4 / 'Regenerative overload'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	The amount of power dissipated in the motor's built-in power dump (braking) resistor is above the safe limit. This error is tripped if the 'Regenerative load' (Reg 18) is >99%. The regenerative load value can be monitored in the 'Motor status field'.
Possible cause of this error	The returned amount of energy from the motor has been too high. This can typically happen if: - The motor decelerates a large load inertia too fast. - The motor is forced backwards. - The servo filter or 'Load' parameter is not adjusted to a stable motor operation and the motor tends to oscillate causing energy to flow forward and backward from/to the motor. In all situations the motor will start to work as a generator that generates energy backward into the drive electronics.
Solutions to avoid error	- Decrease the load inertia. - Decrease the top speed and/or the acceleration value. - Make sure that the supply voltage is within nominal range in order to leave extra capacity at the internal capacitors.
How to return to normal operation	- Reset the motor, clear the error bit(s) in ERR_STAT (Reg 35) or cycle the power.
Error bit / Firmware name	Bit 3 / 'UIT_ERR'

Error message 5, 6 and 7 do not exist since bits are used for other status purposes

7.1.7 Error message 'Position Limit Exceeded'

Message no. / Message	8 / 'Position Limit Exceeded'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	The actual position of the motor is outside the value(s) specified in the 'position limit min.' (Reg 28) or 'position limit max.' (Reg 30) specified in the 'error handling' area of the main tab in MacTalk.
Possible cause of this error	The motor has been commanded outside the value(s) specified in the 'position limit min.' (Reg 28) or 'position limit max.' (Reg 30) registers. Be aware that the error can happen even if the motor is in passive mode and the motor is forced outside this range.
Solutions to avoid error	- Set the position limits described above to more realistic values. - Make sure that the position limits also cover worst case situations such as position overshoot (if using a soft filter).
How to return to normal operation	- Reset the motor, clear the error bit(s) in ERR_STAT (Reg 35) or cycle the power.
Error bit / Firmware name	Bit 7 / 'PLIM_ERR'

7.1 Error messages and error handling

7.1.8 Error message 'Temperature too high'

Message no. / Message	9 / 'Temperature too high'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	The temperature has been higher than 95°C (203°F) which is not allowed. The limit is set by DEGCMAX (Reg 31); the default is 95°C.
Possible cause of this error	- The ambient temperature is higher than allowed - max is +40°C/104°F. - The motor is built into an environment where it cannot dissipate enough heat. - The motor is not mounted on a proper mechanical structure where heat can be dissipated.
Solutions to avoid error	- Take precautions to decrease the surrounding ambient temperature. - Lower the speed and/or load on the motor.
How to return to normal operation	- Reset the motor, clear the error bit(s) in ERR_STAT (Reg 35) or cycle the power.
Error bit / Firmware name	Bit 8 / 'DEGC_ERR'

7.1.9 Error message 'Low AC-voltage'

Message no. / Message	10 / 'Low AC-voltage'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	The mains supply is not connected or the mains voltage is too low. **NOTE:** this error bit is only set when 'Undervoltage -> Set error bit' is enabled (default Off); otherwise only status bit 10 is raised. See the Undervoltage Handling section.
Possible cause of this error	- The mains supply is not connected correctly. - The external fuse has blown.
Solutions to avoid error	- Make sure that the external fuse is OK and that the mains supply is connected correctly according to the chapter *Power Supply, page 27*.
How to return to normal operation	- Reset the motor, clear the error bit(s) in ERR_STAT (Reg 35) or cycle the power. See also the chapter *Undervoltage Handling, page 176*.
Error bit / Firmware name	Bit 9 / 'UV_ERR'

Error message 11 do not exist since bits are used for other status purposes.

7.1 Error messages and error handling

7.1.10 Error message 'Overvoltage on bus'

Message no. / Message	12 / 'Overvoltage on bus'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	The internal bus-voltage has been higher than approx. 467VDC (DC models MAC802, 1202 and 1403: 63VDC) which is not allowed in order to prevent damage to the motor.
Possible cause of this error	- The internal brake resistor is not sufficient to handle the amount of returned energy from the motor. Use an external resistor or if already present lower the value of the resistor. - The mains supply voltage is too high.
Solutions to avoid error	- Make sure that the mains voltage is within specified voltage range. - If this error only happens during a motor movement the error can probably be avoided by connecting an external power dump resistor or decrease the ohmic value if a resistor is already present. See also *Connecting an external power dump resistor, page 31*.
How to return to normal operation	- Reset the motor, clear the error bit(s) in ERR_STAT (Reg 35) or cycle the power.
Error bit / Firmware name	Bit 11 / 'OV_ERR'

7.1.11 Error message 'Peak error, motor overcurrent'

Message no. / Message	13 / 'Peak error, motor overcurrent'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	The motor phase current has been measured to be Out of Range and the motor driver is shut down to prevent permanent failure. Please note that this message is only available in MAC404, 604, 802, 804, 1004, 1202, 1403 and MAC1404.
Possible cause of this error	- The servo filter (control loop) is unstable. - The motor has been physically blocked. - The motor has been running into a sudden mechanical collision. - The actual AC supply voltage is too low to run the motor at the actual speed.
Solutions to avoid error	- Make sure that the servo filter is not set at an extreme unrealistic setting compared to the nature of the actual load. See also *Servo filter adjustment, page 124*. - Avoid the motor meeting a mechanical collision or an extreme overload situation during normal operation.
How to return to normal operation	- This error type cannot be reset by software. Cycle the control voltage (24VDC).
Error bit / Firmware name	Bit 12 / 'IPEAK_ERR'

7.1 Error messages and error handling

7.1.12 Error message 'Overspeed'

Message no. / Message	14 / 'Overspeed'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	The actual velocity (speed) has been higher than allowed.
Possible cause of this error	- Velocity too high. - The servo filter is not stiff enough and speed may overshoot during start and/or stop or when sudden load changes happen. This error is triggered at 4300 RPM (MAC404), 3600 RPM (MAC604, 804 and 1004) and 4000 RPM (MAC802, 1202 and 1403).
Solutions to avoid error	- Make sure that the velocity setting is within specified range (0-3000 RPM nominal). - Make sure that the servo filter is set to a stable setting in order to avoid overshoots during acceleration or similar. See also *Servo filter adjustment, page 124*.
How to return to normal operation	- Reset the motor, clear the error bit(s) in ERR_STAT (Reg 35) or cycle the power.
Error bit / Firmware name	Bit 13 / 'SPEED_ERR'

Error message 15 do not exist since bits are used for other status purposes.

7.1.13 Error message 'Internal Encoder error'

Message no. / Message	16 / 'Internal Encoder error'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	A general encoder/feedback error has been detected. The specific cause is reported in ERR_INFO (Reg 242) - see the section on error status registers and error information.
Possible cause of this error	The cause depends on the ERR_INFO (Reg 242) code - for example excessive electrical speed (ERR_INFO = 2) or a hardware/feedback fault. Read ERR_INFO to identify the specific cause.
Solutions to avoid error	Act according to the ERR_INFO (Reg 242) cause: for excessive speed, reduce the commanded velocity and acceleration; for a hardware or feedback fault, contact JVL.
How to return to normal operation	Cycle the 24 VDC control voltage, or reset the motor. This error locks the output stage, so clearing the error bit in ERR_STAT (Reg 35) is not sufficient on its own. Cycle the power. If a genuine hardware fault is indicated, return the motor for service.
Error bit / Firmware name	Bit 15 / 'INDEX_ERR'

7.1 Error messages and error handling

7.1.14 Error message 'Invalid Filter settings'

Message no. / Message	17 / 'Invalid Filter settings'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	The servo filter settings are not within valid ranges.
Possible cause of this error	- The setup file used has been corrupted. - The setup file used is an old type not compatible with the actual motor version.
Solutions to avoid error	- Select a new filter or contact JVL.
How to return to normal operation	- Correct the servo filter setting. This error also locks the output stage, so the motor must be reset, or the 24 VDC control voltage cycled, before it can run again - clearing the error bit is not sufficient. See also *Servo filter adjustment, page 124*. - Cycle the 24VDC power.
Error bit / Firmware name	Bit 16 / 'OLDFILTERR'

7.1.15 Error message 'Control voltage unstable'

Message no. / Message	18 / 'Control voltage unstable'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	The control voltage (24VDC at the P+ and P- terminals) has been unstable and detected outside the specified voltage range for too long a time.
Possible cause of this error	- The control voltage has been detected outside the nominal voltage range. - The voltage has been applied too slowly with variations.
Solutions to avoid error	- Make sure that the voltage is stable in the specified voltage interval. - Make sure that the voltage is applied in less than 500 ms.
How to return to normal operation	- Cycle the 24VDC power. A reset will not clear the error.
Error bit / Firmware name	Bit 17 / 'U24V_ERR'

Error messages 19 and 20 do not exist.

7.1 Error messages and error handling

7.1.16 Error message 'PWM Locked'

Message no. / Message	21 / 'PWM Locked'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	An unrecoverable error has occurred and the motor output driver is shut down in order to prevent any further damage. This error always takes place in combination with one or more other errors. These errors can be one of the following: - *"Peak error, motor over current" (Bit 12). The motor current has been* significantly higher than allowed during normal operation. - *"Internal Encoder Error"* (Bit 15). The internal encoder has a fault. - *"Invalid Filter settings"* (Bit 16). The actual filter used is an old version or corrupted because wrong values have been transferred to the motor. - *"Control voltage unstable"* (Bit 17). The 24V control voltage has been unstable.-Critical overspeed (approx. 10000 RPM, ERR_INFO (Reg 242) code 44).- A lock initiated by the FPGA supervision (error bit 28 is then set as well).
Possible cause of this error	This error is always followed by other error messages. See individual description of these errors. See also error condition above.
Solutions to avoid error	- See other error messages that follow this error.
How to return to normal operation	- This error type cannot be reset by software. Cycle the control voltage (24VDC).
Error bit / Firmware name	Bit 20 / 'PWM_LOCKED'

7.1.17 Error message 'Modbus Com. Error'

Message no. / Message	22 / 'Modbus Com. Error'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	Modbus communication has not been possible due to a communication error.
Possible cause of this error	- The motor is set up as master but it has not been possible to reach a slave motor. - The motor is set up as a slave but does not receive any position information.
Solutions to avoid error	- If the actual system is a master/slave configuration, make sure that a slave motor is present. - Make sure that the cabling is made in a proper manner with twisted pair wires and screened cable. - Make sure that the opposite unit in the communication system uses the same parameters (baud rate etc.) - Adjust the time out register, COMM_ALIVE_TIMER (Reg 270).
How to return to normal operation	- The error is cleared if error free communication is re-established but the desired operation mode must be selected again. - Try to save actual settings and restart the motor by a reset or cycle the power (24VDC).
Error bit / Firmware name	Bit 21 / 'COMM_ERR'

Error message 23 do not exist since bits are used for other status purposes

7.1 Error messages and error handling

7.1.18 Error message 'Slave Error'

Message no. / Message	24 / 'Slave Error'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	- Modbus communication with a slave motor has not been possible due to a communication error. - A connected slave motor has discovered an error. See the slave motor's ERR_STAT (Reg 35).
Possible cause of this error	- The motor is set up as master but it has not been possible to reach a slave motor. - A connected slave motor has discovered an error. See the slave motor's ERR_STAT (Reg 35).
Solutions to avoid error	- If the actual system is a master/slave configuration make sure that a slave motor is present. - Make sure that the cabling is made in a proper manner with twisted pair wires and screened cable. - Make sure that the opposite unit in the communication system uses the same parameters (baud rate etc.)
How to return to normal operation	- Reset the motor, clear the error bit(s) in ERR_STAT (Reg 35) or cycle the 24VDC power.
Error bit / Firmware name	Bit 23 / 'SLAVE_ERR'

Error message 25 do not exist since bits are used for other status purposes

7.1.19 Error message 'Initialization error'

Message no. / Message	26 / 'Initialization error'
Type / Motor action	Unrecoverable error / Motor is set in passive mode.
Error condition	The power-up initialization did not complete correctly.
Possible cause of this error	- The motor shaft was rotated or moved during power-up while the encoder was being initialized.- The encoder did not respond correctly during startup.- Invalid production data stored in the motor.
Solutions to avoid error	- Make sure that the motor shaft is at standstill during power-up.- Cycle the power. If the error persists, contact your JVL distributor.
How to return to normal operation	- Reset the motor, clear the error bit(s) in ERR_STAT (Reg 35) or cycle the power.
Error bit / Firmware name	Bit 25 / 'INIT_ERR'

7.1 Error messages and error handling

7.1.20 Error message 'Safe torque off STO'

Message no. / Message	**28 / 'Safe torque off STO'**
Type / Motor action	Alarm / Motor is set in passive mode.
Error condition	The STO (Safe Torque Off) circuit was activated while the motor was in an active mode.
Possible cause of this error	- The STO input was de-energized (the safety circuit opened) during operation.
Solutions to avoid error	- Restore the STO supply before switching the motor to an active mode. See the Safe Torque Off (STO) section in this chapter.
How to return to normal operation	- Reset the motor, clear the error bit(s) in ERR_STAT (Reg 35) or cycle the power.
Error bit / Firmware name	Bit 27 / 'STO_ALARM_ERR'

7.1 Error messages and error handling

7.1.21 Error status registers and error info

In addition to the error messages described above, the motor reports errors through related registers. Register 35, ERR_STAT (Error status) and Register 235, ERR_STAT_2 (Error Status register 2) indicate which error has occurred - one bit per category. Register 242, ERR_INFO (Error Info - Special) gives the specific cause as a numeric code. Where relevant, Register 243, ERR_VALUE (Error value - Special) holds an associated measured value (speed, current, voltage or temperature). The tables below list the bits of Error Status register 2 (Reg 235) and the codes of Error Info - Special (Reg 242); motor-type-dependent trip levels are collected in the per-model over-speed trip table.

Error Status register 2 (Reg 235) - error bits:

Bit	Firmware name	Description
0	ENCODER_ERR	An encoder/feedback error was detected. See ERR_INFO (Reg 242) for the specific cause.
1	ENCODER_SYNC_LOST	After a critical overspeed (approx. 10000 RPM), encoder synchronization was lost. Power-cycle the motor to recover.
2	HW_OC_ERR	The hardware over-current detector has triggered (trip level set in the gate driver). Power-cycle to clear; check load and wiring.
3	IX_OFFSET	The current-measurement offset reached its limit, typically a missing current-sensor signal (hardware fault).
4	INNERLOOP_TIMEOUT	The internal control loop exceeded its time budget.

Bits 5-31: reserved.

Error Info - Special (Reg 242) - error codes:

Code	Firmware name	Description
0	—	No error information.
1	LATE_PWM	PWM values were delivered too late to the FPGA.
2	HISPEED	Overspeed detected in the fast PWM loop. (Customer-relevant overspeed limits are codes 4 and 44.)
3	MISS_INDEX	Encoder count too large.
4	HISPEED_SLOW	Motor speed exceeded the maximum-speed limit for the motor type - see the per-model over-speed trip table below.
5	IA	Phase-A current exceeded the over-current limit (set per motor type — see the motor datasheet).
6	IB	Phase-B current exceeded the over-current limit (set per motor type — see the motor datasheet).
7	IC	Phase-C current exceeded the over-current limit (set per motor type — see the motor datasheet).
8	ICNT	The current loop was saturated (output clipped) for too long.
9	FPGA_INDEX	The FPGA detected an encoder index error more than 4 times in a row.
10	ADC_INIT	The initial ADC conversion did not complete (internal +5 V supply is possibly missing).

7.1 Error messages and error handling

11	PROD_VERS	The 125 kHz signal does not match the hardware version.
12	ENC_OVER_35RPM	Encoder velocity during startup over 35 RPM (or encoder invalid response).
13	CAI_TAIL	Index error detected in the inner-loop calculation.
15	DMA_AREA	The combined size of DMA data is too large for the available memory windows.
20	STO_SENSEA	STO-A input below threshold (approx. 17 V).
21	STO_SENSEB	STO-B input below threshold (approx. 17 V).
22	STO_ALARM	STO ALARM input active.
23	BISS	BiSS encoder error.
24	PRODUCTIONDATA	Production-data header not found.
25	MOTORTYPE	Unknown motor type.
26	FPGA	FPGA failed to load.
27	ENCODER	Encoder initialization failed.
28	INVALID_ENCTYPE	Invalid encoder type detected.
29	HW_OC_LATCH	The hardware over-current detector latched (trip level set in the gate driver). Power-cycle to clear.
32	I2C	I2C error during startup.
33	IX_OFFSET	The current-measurement offset reached its limit, typically a missing current-sensor signal.
34	TEMPERATURE_DRV	Driver/power-stage over-temperature (>= 100 °C).
35	TEMPERATURE_MAIN	Mainboard over-temperature (above the limit in DEGCMAX (Reg 31), default approx. 95 °C).
36	MU_ERR_CHIP_STATUS	Encoder chip status indicates an error.
37	MU_ERR_WRITE_TO_CHIP	Error writing to the encoder chip.
38	MHM_REGISTER_MISMATCH	Multiturn registers could not be verified.
39	MHM_MT_INTERFACE_ERR	Multiturn interface error (possibly mis-configured Wiegand).
40	MHM_GEN_ERROR_1	Multiturn generic error.
41	FPGA_PWM_PROTECT	FPGA PWM protection error.
42	ADC_IA	Phase-A current-measurement ADC out of range (measurement-circuit fault).
43	ADC_IB	Phase-B current-measurement ADC out of range (measurement-circuit fault).
44	CRITICAL_OVERSPEED	Critical overspeed (approx. 10000 RPM); PWM is locked and encoder synchronization is lost. Restart (power-cycle) to recover.
45	24V_LOW	Control supply voltage too low (approx. 12.4 V).
46	OVERVOLT_INL	DC-bus over-voltage (approx. 467 V on AC models, approx. 63 V on DC models).
47	OVERVOLT_OTL	DC-bus over-voltage (outer-loop path; same limits as code 46).

Codes 14, 16-19, 30, 31 and 48+ are not defined in the current firmware.

Per-model over-speed trip (code 4):

Motor	Group	Max-speed trip (code 4), RPM
MAC404	AC	4300
MAC604	AC	3600
MAC802	DC	4000
MAC804	AC	3600
MAC1004	AC	3600
MAC1202	DC	4000
MAC1403	DC	4000
MAC1404	AC	3600

Over-speed RPM = limit / 8192 counts/rev / cycle-time (default 1.0 ms) x 60; the rated max speed is ~3000-3600 RPM, and the protection trips just above. MAC1404 has no dedicated firmware value of its own and uses the same limit as MAC1004.

Raising the maximum speed limit
Bit 5 in Register 236, SETUP_BITS (Setup Bits special), raises the trip level. The limit then becomes 5000 RPM for MAC404 and 4000 RPM for MAC604, MAC804, MAC1004 and MAC1404. For MAC802, MAC1202 and MAC1403 the raised level is the same as the normal one, so the bit has no useful effect on those models. The firmware documentation notes that the raised limit is intended for special short-run applications only; the motors are not rated for continuous operation above their normal maximum speed.

The trip level is also scaled by the sample time, by bit 21 of Register 39, HW_SETUP (HW Setup), and by Register 157, OUTLOOPDIV (Sample time divider), so the figures above apply at the factory default settings. The critical overspeed protection at approximately 10000 RPM is not affected by bit 5 and cannot be raised.

Error messages that do not exist on the MAC G3
Error message 23 does not exist. Bit 22, Current loop error, reports that less than 2 mA was measured on a 4-20 mA current-loop input for more than 100 ms. That input belongs to an expansion module that the MAC G3 does not have, so the motor never sets the bit.

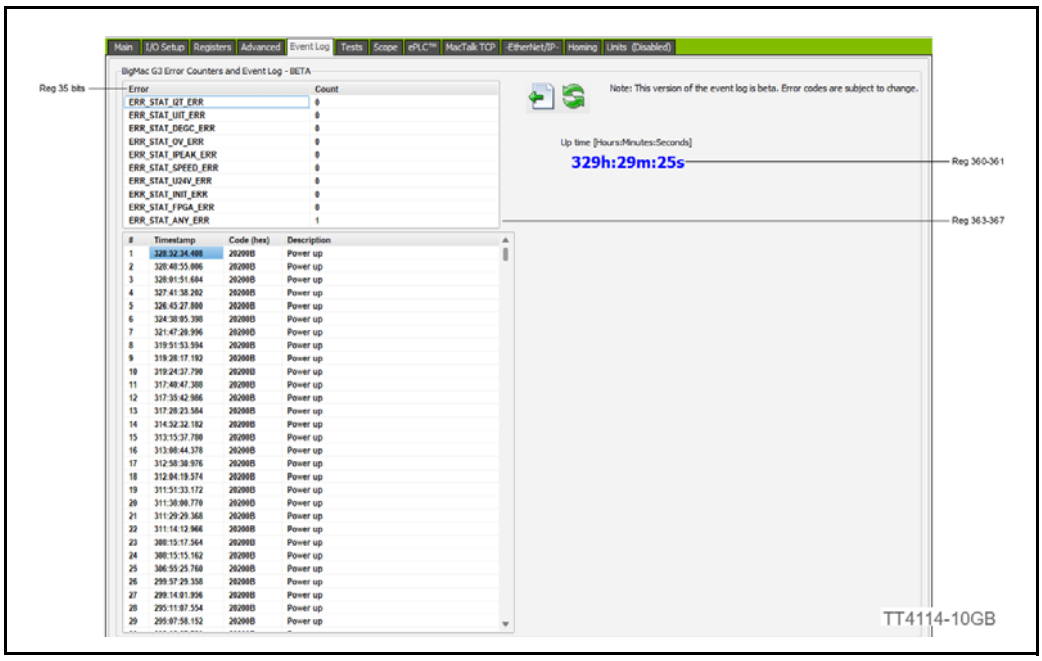
Error message 29 is reported as an FPGA error. Bit 28 is set when the processor and the FPGA disagree about the state of the PWM output stage, typically because the FPGA locked the output on its own without the processor requesting it; error bit 20, PWM locked, is then set at the same time. The error cannot be cleared from software. Remove and re-apply the control voltage, and contact JVL if it returns.

Phase over-current (codes 5/6/7): the limit is set per motor type. A per-model ampere figure is not published here - the firmware current constants do not convert reliably to physical amps (per-model calibration), and rated/peak current depends on the supply voltage (DC models: 24-48 VDC). For the rated and peak current per model, see the JVL product page and the motor datasheet: https://www.jvl.dk/1369/mac802-1202-1403

7.1.22 Event log

The motor maintains a non-volatile event log that records errors, warnings and status changes, and is retained across power cycles. It is a circular buffer of up to 512 entries;

when full, the oldest entries are overwritten.
Each entry stores a time stamp together with a diagnostic code that identifies the event. The diagnostic codes correspond to the error and status conditions described in the registers above: Error status (Reg 35), Error Status register 2 (Reg 235) and Error Info - Special (Reg 242).
The event log can be read in MacTalk or transferred from the motor as a file, file number 158. The motor also keeps persistent counters of how many times each error has occurred; these survive power cycles and firmware updates.



These counters cover the following error types (corresponding to the error bits in *Error status registers and error info, page 168*):

Counter	Increments when
I2T (thermal overload)	The I2T thermal-load limit is exceeded
UIT (voltage-time load)	The UIT load limit is exceeded
Over-temperature	The board temperature is too high
Mains over-voltage	The supply voltage is too high
Peak current	The peak current is exceeded
Over-speed	The speed limit is exceeded
Control under-voltage	The internal / 24 V control voltage is too low
Initialization	A start-up / initialization error occurs
FPGA	An FPGA error occurs
Any error (total)	Any error occurs (summary counter)

In MacTalk the counters are shown on the Event Log tab, together with the motor total on-time.
Write 4199 (0x1067) to Register 211, COMMAND_REG (Special Command). The motor then copies its diagnostic block into Register 360 to Register 369. No unlock is needed.

Register 360 and Register 361 hold the motor total on-time in milliseconds as one 64-bit value, with the low half in Register 360. MacTalk shows it as Up time.

Register 362 holds the index of the next log entry and the total number of entries recorded.

Register 363 to Register 367 hold the ten counters, two per register and in the order of the table above: the first of each pair in bits 15:0, the second in bits 31:16.
The counters can only be cleared with a JVL service command.

7.1.23 Status LED indicators

The motor has a multi-colour PWR LED, plus communication LEDs on models with a fieldbus interface. Every LED state and blink pattern is described in *Status indicators, page 22*, together with what each pattern means and what to do about it.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

7.1 Error messages and error handl

Only MACxxxx-yy-zRzzzzz

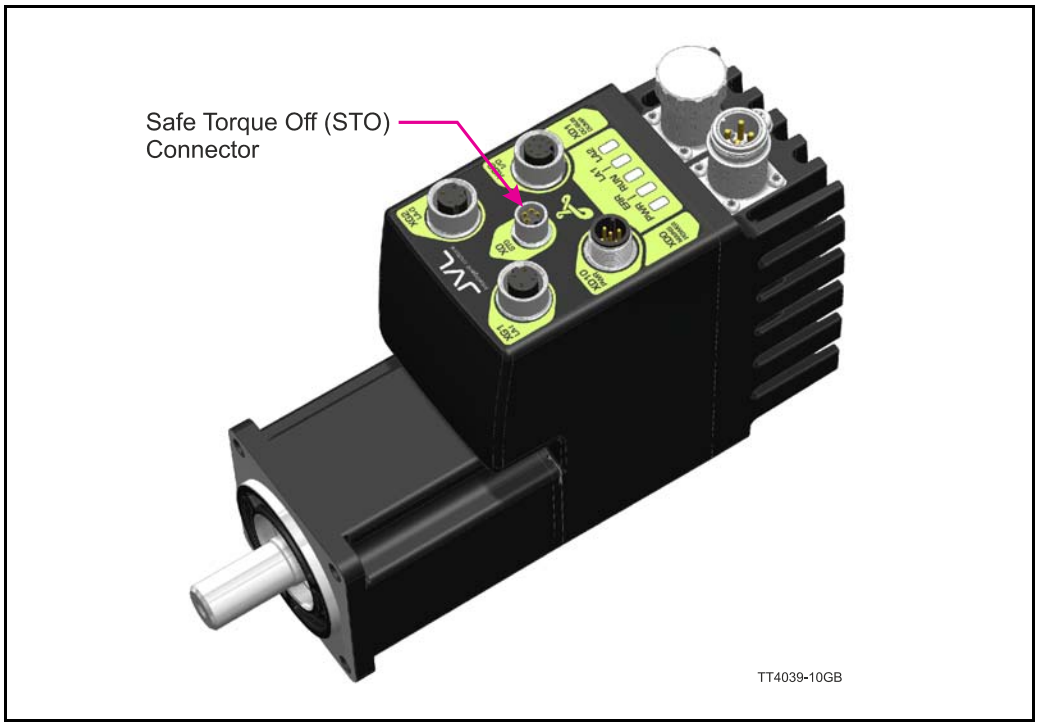
7.2 Safe Torque Off (STO)

Only MACxxxx-yy-zRzzzzz

7.2.1 Introduction to the STO function

The STO function can be used for disabling the energy to the motor. The motor will thereby be set in a state where it produces no torque.
The STO function has its own input connector mounted at the top of the motor.
It is a 2 input system (redundant), and it is required that both inputs are activated (applied with a voltage) before the motor is energized and can operate normally.
The STO option is available on MAC404, 604, 802, 804, 1004, 1202, 1403, and 1404.

The STO input connector is placed as shown below. The illustration is based on the MAC404 motor, but the STO connector is placed similarly on the other MAC motors mentioned above.



Important general information:

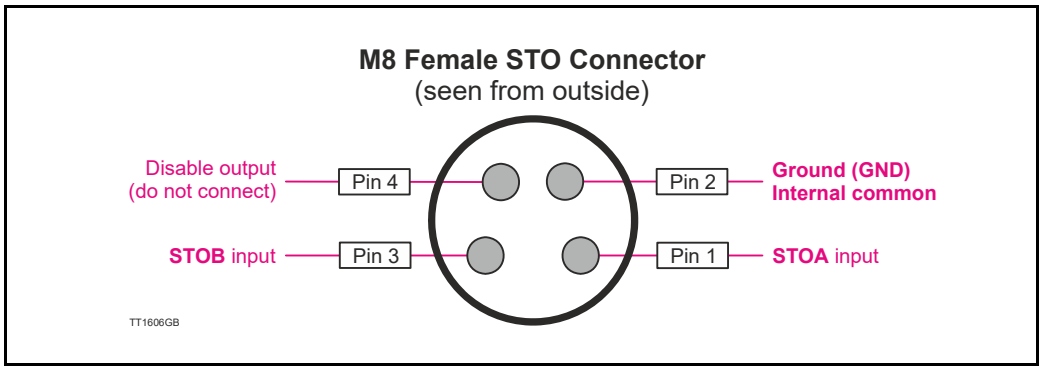
- The STO function is not approved by any third party laboratory (only pending)
- Please note that removing the energy from the motor by use of the STO function does not necessarily stop the motor rotation, since any attached load inertia will keep the motor moving until the energy is dissipated.
- The person that installs and services the motor must have a general knowledge concerning electrical equipment and safety functions.
- The STO function is considered as functional and reliable for 20 years.

7.2 Safe Torque Off (STO)

7.2.2 How to connect and use the STO function

The STO connector is a 4-pin M8 female.

The STO connector contains the 2 enable inputs STOA and STOB. Both inputs must be supplied with nominal +24VDC in order to energize the motor and make any motor movement possible.
If either of the two inputs is not supplied with +24VDC, the internal STO circuit will immediately remove the energy from the motor.
The illustration below shows the pin-out of the connector.



7.2.3 Disabling the STO function

If the STO function is not needed, the plug JVL type ***WI1010-M08M4STO*** must be inserted in the STO connector.
Requiring this external plug to disable the STO function ensures a high safety level and prevents any misunderstanding about whether the STO function is active.

7.2.4 STO cabling

JVL offers a standard 5m long cable with a 4-pin M8 connector at one end and flying leads at the other end.
The part no. is WI1010-M08M4T05P.

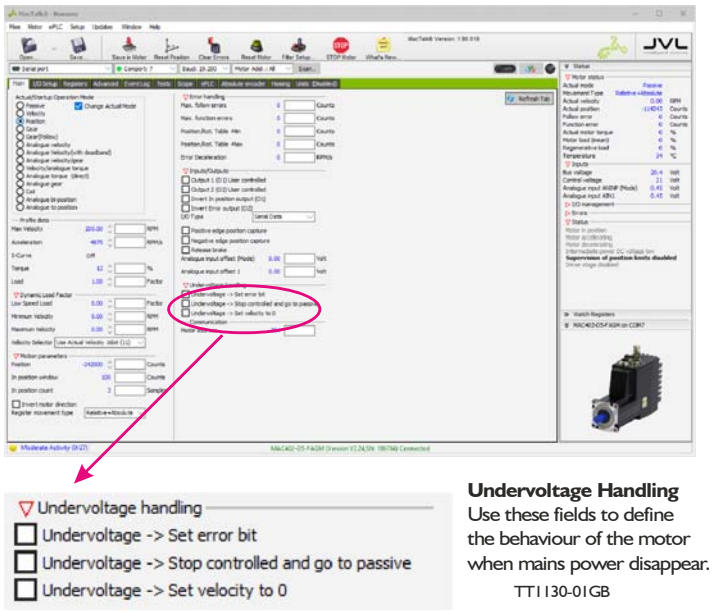
7.2.5 Behaviour of the motor operation if STO is activated

When one or both of the STO signals are removed, it will force the motor into passive mode and an STO error will be shown.

The motor will be forced into passive mode (motor not energized) fully independently of any software function or operation mode it was in just before the STO signal(s) were removed.

STO activation is reported in software by error bit 27, STO_ALARM_ERR, in Register 35, ERR_STAT (Error status), and by STO INPUTS (Reg 238). Note that the DC-bus voltage readout, Bus voltage (Reg 198), keeps showing the actual measured bus voltage; the fixed 100 VDC indication used on earlier MAC generations does not apply to MAC generation III.

7.3 Undervoltage Handling



Undervoltage Handling
Use these fields to define the behaviour of the motor when mains power disappear.

TT1130-01GB

7.3.1 Undervoltage handling

The MAC motor offers the possibility to define the behaviour during and after the mains-voltage disappears. This situation could for example be during an emergency stop which causes the mains supply to be cut while the control voltage is still applied to the motor.

The DC-supplied models have no mains input
MAC802, MAC1202 and MAC1403 are supplied directly with DC, so there is no mains voltage for the motor to watch. On those models the undervoltage handling monitors the DC bus voltage itself, Bus voltage (Reg 198), instead. The options described below work in exactly the same way; only the source of the measurement differs.

The detection thresholds also differ. On the AC-supplied models the motor reports undervoltage when the bus falls to about 78 V and requires about 97 V before it will leave the undervoltage state again. On the DC-supplied models the corresponding levels are about 7 V and 8 V.

NOTE: These are the levels at which the motor detects and clears an undervoltage condition. They are not an operating range. The DC models still require the supply voltage stated in the technical data, and running them near the detection threshold leaves no headroom for the current the motor draws under load.

3 options exist:

7.3.2 Undervoltage -> Set error bit

Default = Off.
If this option is selected, an undervoltage will be handled like an error situation, and the corresponding error bit will be set. The motor is stopped using the "Error deceleration" (Reg 32) before the motor is switched to passive mode, like any other error situation. When the main power is re-applied, the motor will stay in passive mode and report an undervoltage error. To get the motor back in normal operation, the error must be cleared and an operation mode must be selected.
If this function is activated, it will have first priority, and the error deceleration will be used, unlike the 2 other options "Undervoltage -> Stop controlled and go to passive" and "Undervoltage -> Set velocity to 0", which both use normal deceleration.

7.3.3 Undervoltage -> Stop controlled and go to passive

Default = Off
This option makes the motor decelerate according to the normal Acceleration parameter (Reg 6) and go to passive mode when the mains power is removed. When main power is re-applied, the motor stays in passive mode. To get the motor back in normal operation, an operation mode must be selected.

7.3.4 Undervoltage -> Set velocity to 0

Default = Off.
This option simply sets the velocity to 0, causing the motor to decelerate and stay stationary (except in "torque direct mode") when mains power is removed. The velocity setting will stay at 0 also after the main power is re-applied. A velocity value (>0RPM) must be written into the Velocity register (Reg 5) to get the motor moving again.

NOTE: In Analogue Torque mode (mode 4) the undervoltage options above have no effect. If an undervoltage is detected in that mode, the motor is always set to Passive mode, regardless of the settings in Register 23, UV_HANDLE (Main Supply Voltage Error Bits).

NOTE: All motor registers are documented in detail in the online register overview:
www.jvl.dk/register.html?register=MACmotor

7.4 Auto-restart after STO or supply loss

By default, when the STO condition is removed (both STOA and STOB are re-applied with +24 VDC), the motor stays in Passive mode and must be re-enabled by the controller writing a new operating mode. If you want the motor to re-enter its operating mode automatically, set bit 24 (mask 0x1000000) in Register 236, SETUP_BITS (Setup Bits special), and perform Save in Motor.
When bit 24 is set, after the STO condition has been removed and has stayed removed for approximately 20 ms, the firmware automatically copies Register 37, START_MODE (Start mode), into Register 2, MODE_REG (Operating mode), returning the motor to the operating mode defined in Start mode (Reg 37). The same bit also affects recovery from a mains/AC undervoltage event: if bit 24 is set together with bit 25 (ZUP_DELAYED_AC_OK), the motor resumes the mode it was in before the undervoltage occurred; otherwise it resumes the mode given by Start mode (Reg 37).

Register 236 - Setup Bits special (SETUP_BITS)

TT4066-12GB

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
							▼																								

Bit 24: Auto-restart after STO/AC returns (ZUP_AUTO_START_MODE)

Value	Function / Influence
0 (default)	Motor stays in Passive after STO is removed. Controller must re-enable.
1	Motor automatically resumes START_MODE approx. 20 ms after STO inputs are re-applied.

Bit 31 - 25 and Bit 23 - 0: Is used for other purposes - do not overwrite these bits

WARNING: With bit 24 set, the motor can start moving on its own as soon as the STO inputs are re-applied or mains power returns, without any command from the controller. Only enable automatic restart where an unexpected, automatic start of motion is safe for the machine and personnel.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

7.5 Delayed supply acceptance at startup

Bit 25 (ZUP_DELAYED_AC_OK) in Register 236, SETUP_BITS (Setup Bits special), allows the mains AC supply to be applied after the 24 V control supply during power-up. Normally the motor expects AC to already be present when 24 V is applied. If AC arrives too late during startup, an undervoltage fault is generated. In many cabinet designs the 24 V and AC contactors switch with different delays. Setting bit 25 = 1 tells the firmware to accept AC arriving after 24 V at power-up without raising a fault. Set bit 25 (mask 0x2000000) in Setup Bits special (Reg 236), then perform Save in Motor.

Register 236 - Setup Bits special (SETUP_BITS)

TT4080-12GB



Bit 25: Delayed AC acceptance at startup (ZUP_DELAYED_AC_OK)

Value	Function / Influence
0 (default)	AC mains must be present at power-up; late AC triggers an undervoltage error.
1	AC mains may arrive after 24V power-up without triggering an undervoltage error.

Bit 31 - 26 and Bit 24 - 0: Is used for other purposes - do not overwrite these bits

NOTE: This bit only affects the power-up sequence. Undervoltage monitoring remains active during normal operation - if AC is lost while the motor is running, an undervoltage fault will still be raised regardless of this bit. Bit 25 combines with bit 24 (ZUP_AUTO_START_MODE): when both bits are set, the motor resumes the operating mode it was in before an undervoltage event, rather than falling back to Start mode (Reg 37).

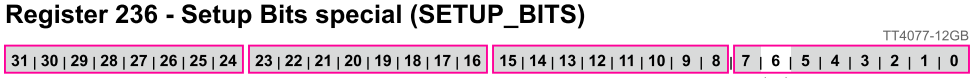
NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor.

7.6 Dynamic braking in Passive mode

Bit 6 (ZUP_PWM0_IN_PASSIVE) in Register 236, SETUP_BITS (Setup Bits special), enables electrical braking whenever the motor enters Passive mode.
When bit 6 = 1, the motor windings are short-circuited at 50 % PWM duty cycle each time the motor is in Passive mode, producing a braking torque that decelerates the motor faster than free coasting. This is distinct from bit 21 (ZUP_PWM0_ON_ERROR), which only activates braking when a fault has driven the motor into Passive mode. Set bit 6 (mask 0x40) in Setup Bits special (Reg 236), then perform Save in Motor.

Register 236 - Setup Bits special (SETUP_BITS)

TT4077-12GB



Bit 6: Dynamic braking in Passive mode (ZUP_PWM0_IN_PASSIVE)

Value	Function / Influence
0 (default)	No dynamic braking in Passive mode; motor coasts freely.
1	Dynamic braking active in Passive mode: windings short-circuited at 50% PWM.

Bit 31 - 7 and Bit 5 - 0: Is used for other purposes - do not overwrite these bits

NOTE: Do not set both bit 6 and bit 21 simultaneously. Bit 6 = braking whenever in Passive mode; bit 21 = braking only when a fault is present in Passive mode.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

7.7 Active braking on error

Register 236, SETUP_BITS (Setup Bits special), bit 21 (mask 0x200000), enables electrical braking of the motor while it is in Passive mode and an error is present.
When bit 21 = 1 and an error has been latched, the three PWM outputs are kept active at 50 % duty cycle, short-circuiting the motor windings. This produces a braking torque that decelerates the motor faster than free coasting. The feature is automatically suppressed for peak-current (IPEAK), overvoltage (OV) and regenerative-overload (UIT) errors to protect the power bridge and brake resistor.

Register 236 - Setup Bits special (SETUP_BITS)

TT4065-12GB



Bit 21: Dynamic braking on error in Passive mode (ZUP_PWM0_ON_ERROR)

Value	Function / Influence
0 (default)	Motor free-wheels when entering Passive mode on error.
1	Motor applies dynamic braking (50% PWM short) when in Passive with an error latched.

Bit 31 - 22 and Bit 20 - 0: Is used for other purposes - do not overwrite these bits

NOTE: This electrical braking is distinct from dynamic braking while in Passive mode regardless of error state, which is controlled separately by bit 6 (ZUP_PWM0_IN_PASSIVE) of Setup Bits special (Reg 236). Set bit 21 (mask 0x200000) in the same register, then perform Save in Motor.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

7.7 Active braking on error

8 Industrial Ethernet

8.1 Industrial Ethernet

8.1.1 Industrial Ethernet documentation

The documentation for the industrial Ethernet interface is very extensive and has therefore been placed as a separate user manual, **LB0077**.

The complete user manual, LB0077 Ethernet G3 NetX, can be downloaded using this link: www.jvl.dk/416/user-manuals

The following Ethernet protocols are available:

EtherCAT
- JVL drive profile available on MAC (8 x 32 bit cyclic read/write registers)

EthernetIP
- JVL drive profile available on MAC (8 x 32 bit cyclic read/write registers)

ModbusTCP/UDP
- JVL drive profile available on MAC (8 x 32 bit cyclic read/write registers)

PROFInet
- JVL drive profile available on MAC (8 x 32 bit cyclic read/write registers)
- PROFIdrive standard telegram 1, 2 and 3 supported
- PROFIdrive Application Class 1 supported (Real Time)
- PROFIdrive Application Class 4 supported (Real Time + Isochronous Real Time)

Soon also available:
- **POWERLINK**

The Ethernet module has registers of its own in addition to the motor registers, and MacTalk lists them alongside. One that is useful on its own is Register 16517, Temperature CPU A - the internal temperature of CPU A, the processor handling Ethernet communication. It is read only and given in thousandths of a degree Celsius, so a reading of 42500 means 42.5 °C. The remaining module registers are described in LB0077.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

9 MacTalk Setup Software

9.1 Installation of MacTalk

9.1.1 Obtain the latest version of MacTalk

MacTalk is available for online purchase at:
https://www.jvl.dk/523/software-mac-motor
You will receive the MacTalk SW along with a license.

9.1.2 Installation of MacTalk

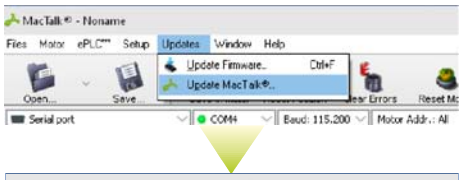
Once you have obtained the MacTalk software / commissioning tool, it is time for installation. This is done by running the downloaded MacTalk Setup file.
Ex. *MAC_TALK_1_90_019_INSTALL.zip*

9.1 Installation of MacTalk

9.1.3 Update MacTalk version

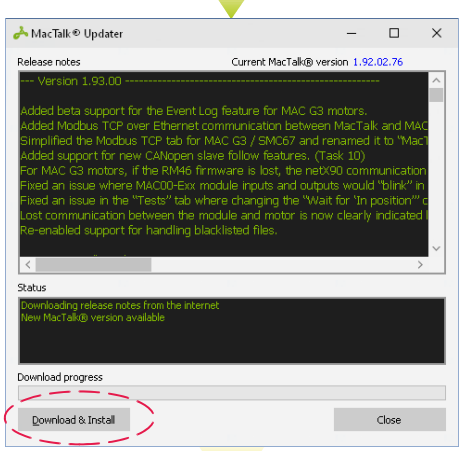
MacTalk can be updated directly from the internet at any time. It is recommended always to use the latest version of MacTalk since it supports the latest features, and bugs may have been found and corrected. Below it is shown how to update MacTalk.

Step 1
Choose the *Update MacTalk* in the *Updates* menu.



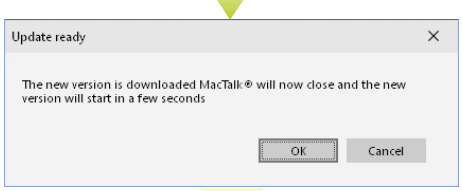
Step 2
MacTalk will now check if newer version exist on the JVL server. If a newer version exist it will automatically be downloaded and the release notes can be seen in the window.

Press the *Download & Install* button to download the selected latest MacTalk.
The new version is now located in the same directory as the MacTalk which was installed in the first place.
The old version is automatically deleted.
Notice that the old version can be recovered by entering the update process again !.



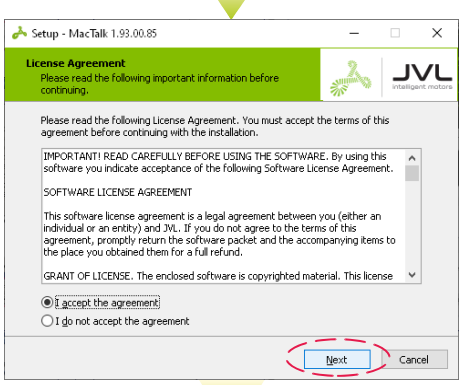
Step 3
The Download is now in progress.
Please wait for a short while.

Step 4
When the download process is finished, the status shows "*Update ready*".
Press "*OK*" to start the installation of the new version of MacTalk.



Step 5
When the download process is finished, a License Agreement shows up.

Press "*I accept the agreement*" and "*Next*" to start the installation of the new version of MacTalk.



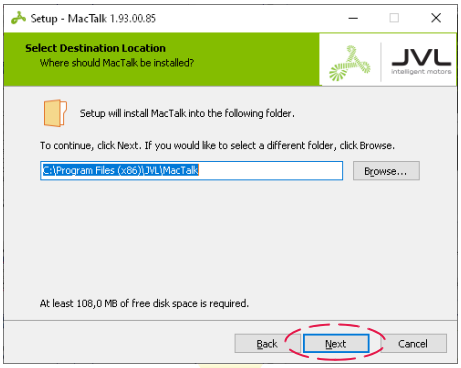
Continued at next page

TT4131-10GB

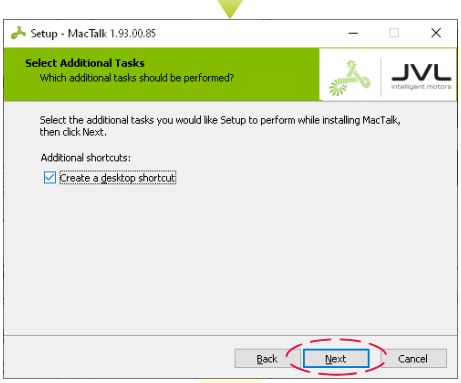
9.1 Installation of MacTalk

MacTalk closes automatically once the update is confirmed, and the installer for the new version starts, as shown below.

Step 6
Now the directory acn be choosen where MacTalk must be installed.
Use the default directory if no other wishes.
Push *Next* to proceed.

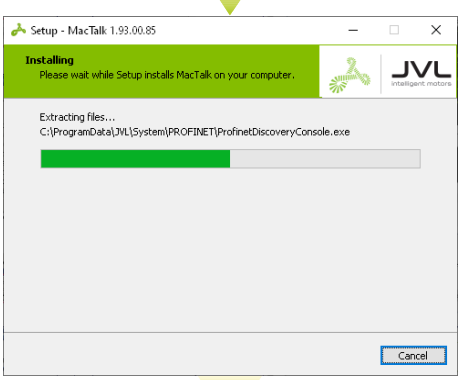


Step 7
Select *Create a desktop* shortcut if needed and press *Next* to proceed.

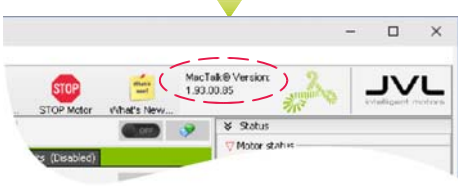


Step 8
Now MacTalk is finally getting installed.

It may take a short while.



Step 9
Finally the old MacTalk version shut down and the new version will open.
In the upper corner of the main screen the version number for the new MacTalk is shown.



The update is finished !

TT4132-10GB

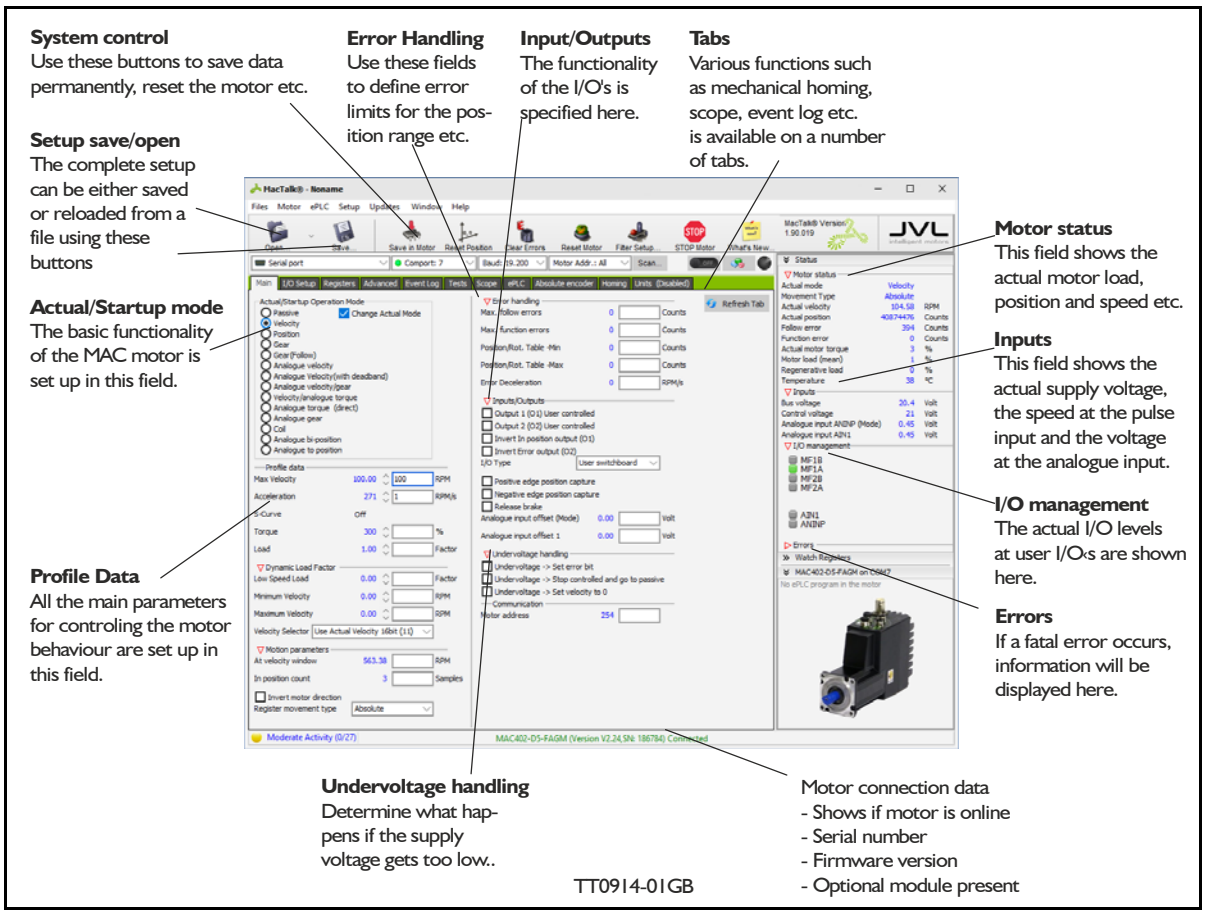
Once the installation completes, MacTalk restarts automatically with the new version.

9.1 Installation of MacTalk

9.1.4 Uninstallation of MacTalk

Uninstallation of MacTalk SW can either be done by running unins000.exe in the MacTalk installation folder (Ex. C:\Program Files (x86)\JVL\MacTalk\unins000.exe) or the usual Windows method: Settings -> Apps -> Select MacTalk 1.90.019 and click on the Uninstall button.

9.2 Using MacTalk to setup the motor



9.2.1 MacTalk introduction

The MacTalk software is the main interface for setting up the MAC motor for a specific application.
The program offers the following features:

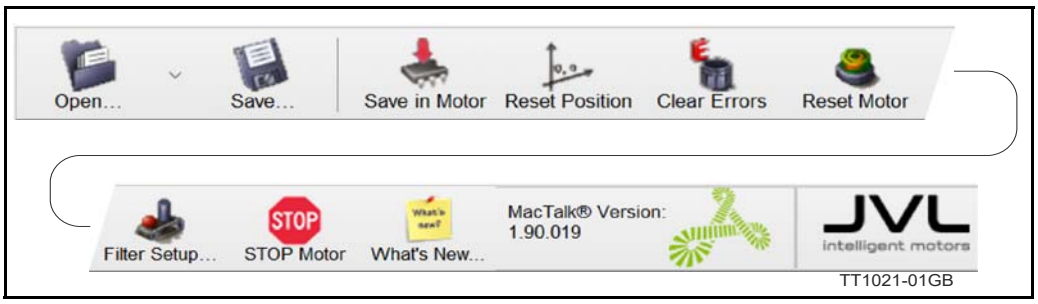
- Choice of the operating mode of the MAC motor.
- Changing main parameters such as speed, motor torque, Homing type, etc.
- Monitoring the actual motor parameters in real time, such as motor load, supply voltage, voltage at the analogue input, etc.
- Changing protection limits such as position limits, maximum position error.
- Determining what should happen if the supply voltage gets too low.
- Saving all current parameters to file.
- Restoring all parameters from file.
- Saving all parameters permanently in the motor.
- Updating the motor firmware or MacTalk software from the internet or a file.

The main window of the program changes according to the selected mode, thus only showing the relevant parameters for operation in the selected mode.
The following pages describe the actual window for each mode and how the parameters affect the MAC motor operation.

9.2.2 Toolbar description

The toolbar at the top of the MacTalk window contains the most commonly used features.

9.2 Using MacTalk to setup the motor



[Open...]
Opens a setup file and downloads the setup to the motor. If no motor is connected, the setup is shown in MacTalk and can be edited and saved again.

[Save...]
Saves the actual setup from the motor to a file. If no motor is connected, the actual off-line settings (including the ePLC program) will be saved.

[Save in Motor]
The complete current setup of the basic motor will be saved permanently in flash memory in the motor. If the motor is powered down or reset, the saved setup will be used.

[Reset Position]
For motors with an absolute encoder, *Abs Enc. offset* (Reg 225) is set to the absolute encoder position multiplied by -1, making the *Actual position* (Reg 10) zero.
If saved in the motor, then the *Actual position* will be zero.
The content of the position counter can be monitored on the right side of the main screen as *Actual position*.

[Clear Errors]
Clears all the errors (if any). Please note that if an error is still present, the motor will remain in the actual error state.

[Reset Motor]
Resets the motor. Same as doing a power off / on operation.

[Filter Setup...]
Short-cut to the servo filter setup screen.

[STOP Motor]
Stops the motor immediately using a controlled deceleration ramp and puts the motor into passive mode. If an active ePLC program is running, this is stopped as well.
This button should be considered a functional stop button and is available also by using the keyboard short-cut CTRL+F8.

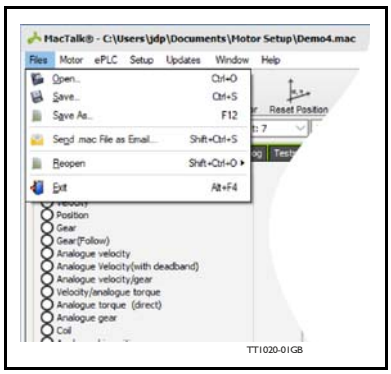
Warning! Do not consider this button as an appropriate Emergency stop.
Always fit Emergency stop circuitry to your motor setup.

[What's New...]
Shows what has been added or changed since the last MacTalk® version.

9.2 Using MacTalk to setup the motor

9.2.3 Saving or opening a setup file to/from file

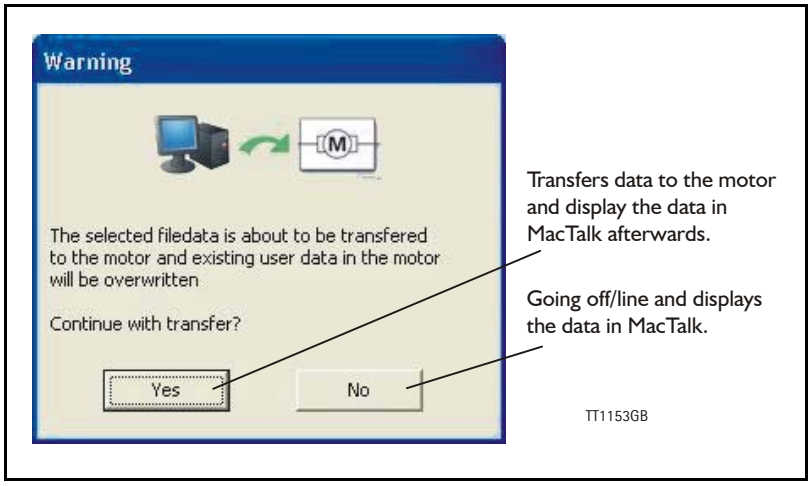
The complete motor setup can be saved to file, or retrieved from file, and transferred to the motor. The setup files can be saved anywhere on any media. Saving and opening a file over a network drive is also possible.
The setup files use the extension *.MAC*. By default, the setup files are saved in the same directory where MacTalk itself is also installed. Other directories can be selected.



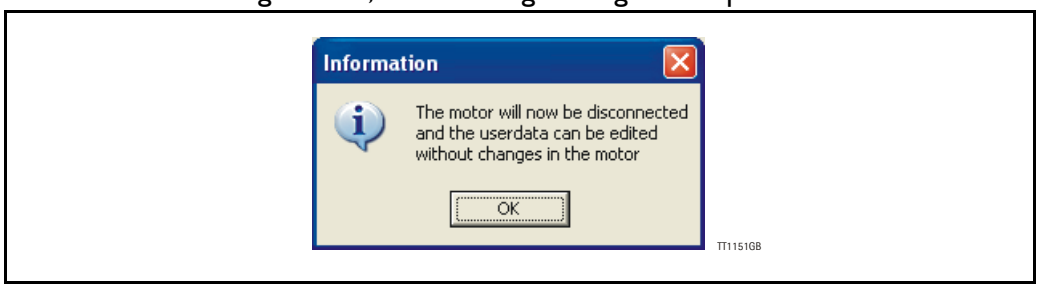
From file to motor.
Use *Open* to select a file containing the desired motor setup. When opening the file, the setup will simultaneously be sent to the motor.
Remember to use the *Save in Motor* button if the setup must be permanently saved in the motor.

From motor to file.
Use Save or Save as to save the actual setup in a motor as a setup file. Make sure that the motor is on-line with MacTalk, otherwise only the MacTalk default setup is saved.

In the case where a motor is present and a file is opened, the user is prompted to keep the connection or to go offline and display the file content. The following message box appears.



If the user decides to go offline, the following message box is presented.

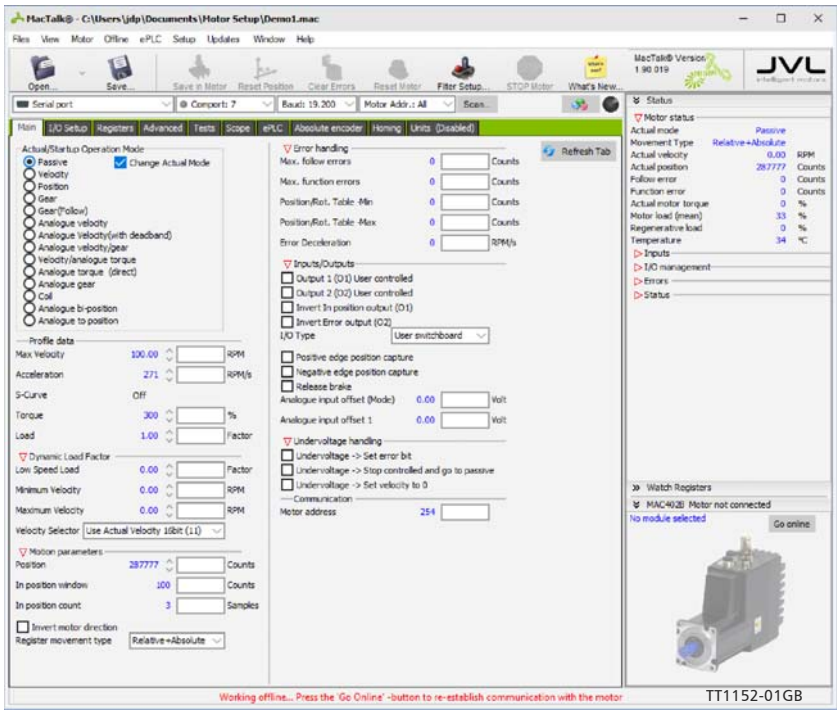


Pressing "OK" disconnects the motor from the PC application, and all data can be edited without any interruption in the motor. The following MacTalk view is presented.

9.2 Using MacTalk to setup the motor

9.2.4 Working offline

As seen in the bottom info line, the motor is disconnected and the file data is currently present in MacTalk. To re-establish communication with the motor, simply press the Go Online button, and if any data has been changed, a warning box appears enabling the user to save current data before re-establishing communication with the motor, as this will overwrite existing data in MacTalk.



If data is changed in MacTalk, the user is warned that current data in MacTalk may be overwritten and needs to be saved. The following warning message box appears.



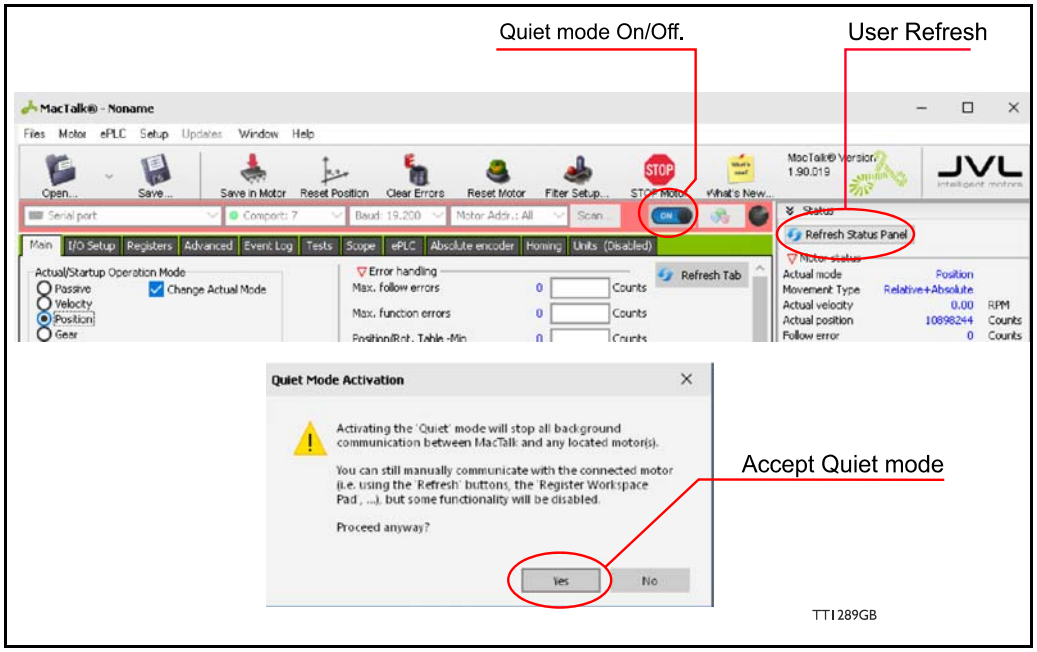
Choosing "No" will immediately upload all motor data; pressing "Yes" will save all data to the open file.

9.2.5 MacTalk in "Quiet" mode

When "Quiet" mode is activated, all live communication with the motor stops. It does

9.2 Using MacTalk to setup the motor

not mean that it is not connected, but simply that values are not refreshed without user refresh/request.
All setup changes made in the setup will be communicated to the motor, and the setup result will be read and presented in MacTalk.

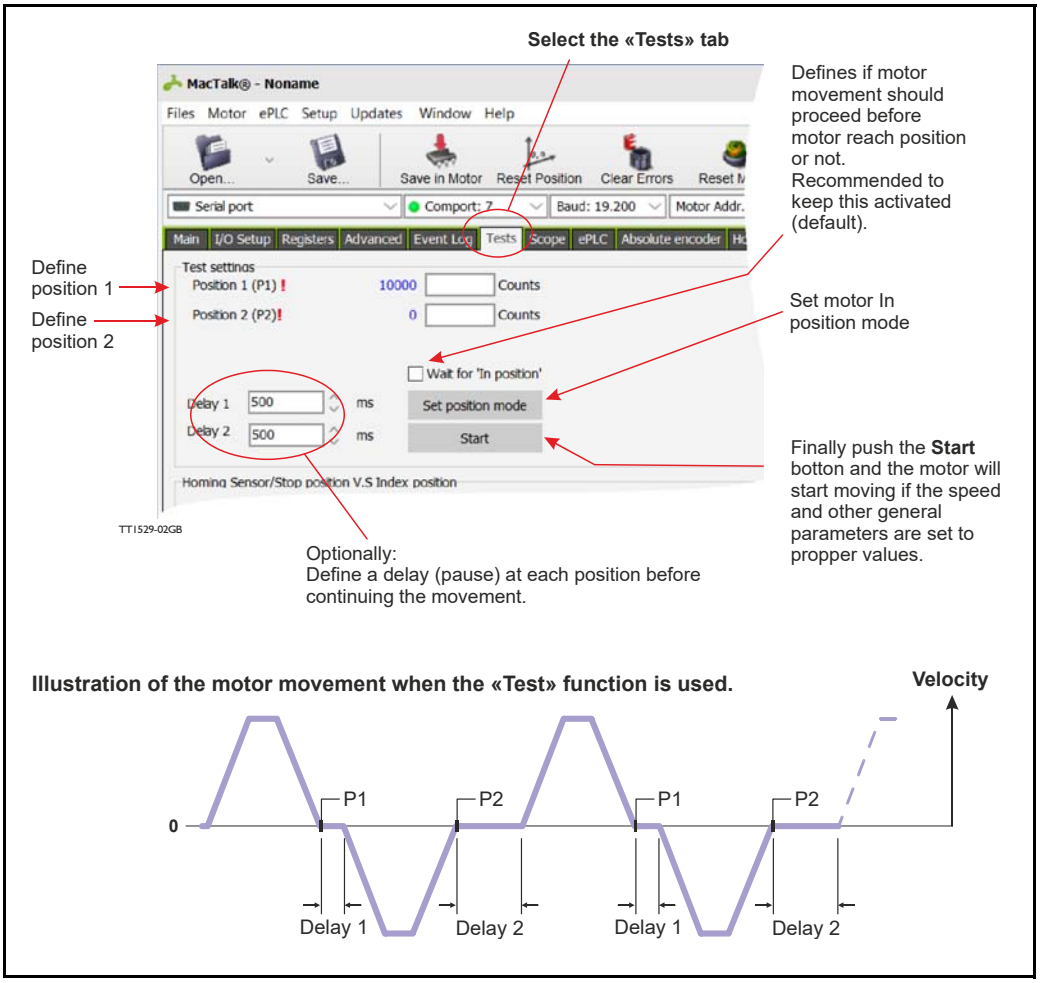


Background functionality, such as overload protection, is still active in the motor.
The internal ePLC program will also continue to run.

9.2 Using MacTalk to setup the motor

9.2.6 Motor "TEST" function

When setting up a servo system, it is convenient to test that the motor movement is stable and smooth.
For this purpose, the TEST tab can be used.
On this tab, it is possible to set up the motor in position mode and define 2 positions between which the motor can move cyclically. A delay between each motion can also be defined.
The speed and acceleration used during this process are the general parameters defined on the Main tab. All parameters can be changed dynamically during operation.



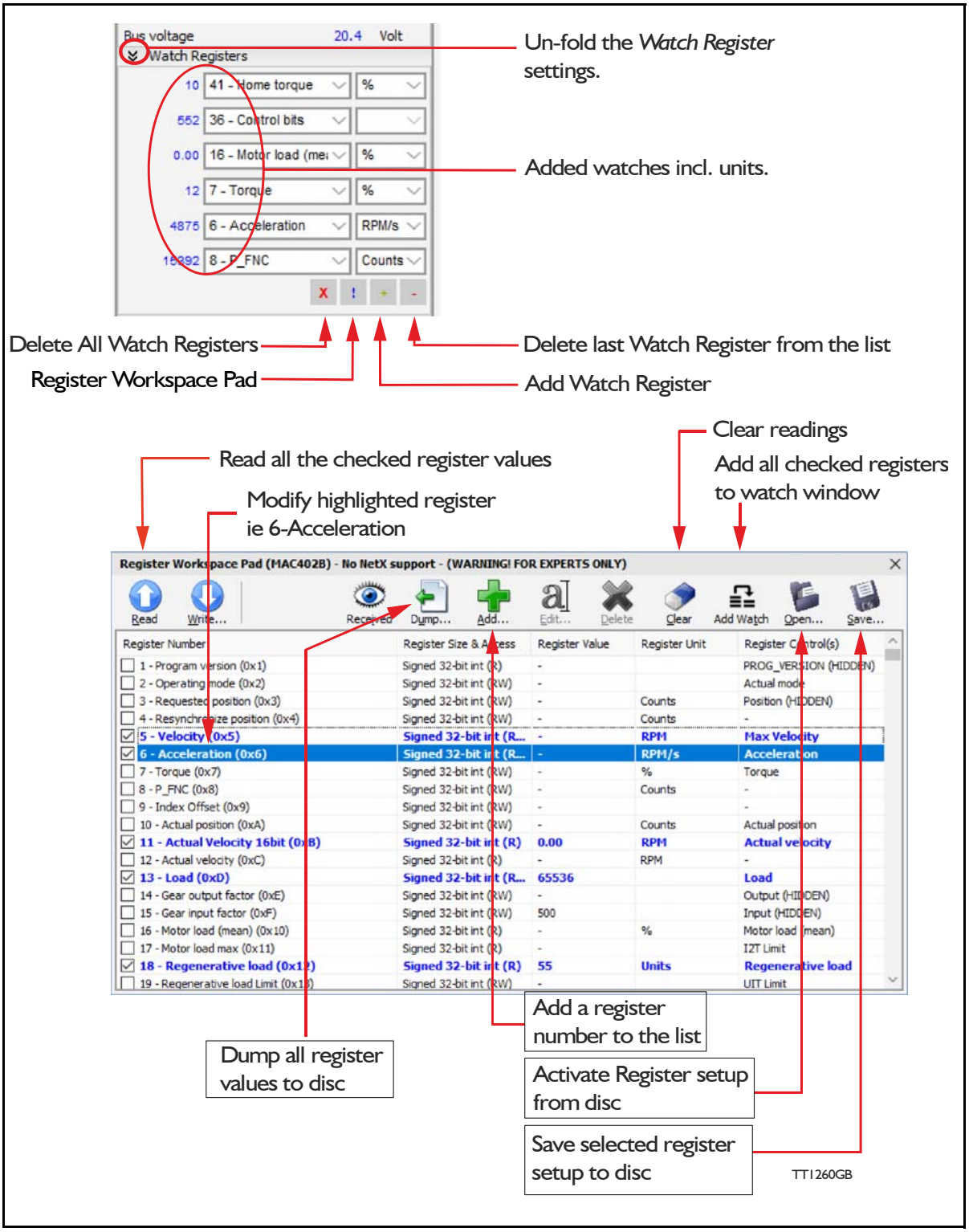
Please notice that the movement is fully controlled by MacTalk.
If the communication cable is unplugged, the movement will stop at the last demanded position. Also, some slight timing variations may exist depending on the Windows operating system and which other applications are running on the PC at the same time.

Important: Make sure that no other communication takes place when using the Test function, since it may interrupt the function of the test.

9.2 Using MacTalk to setup the motor

9.2.7 Watch registers

Watch Registers are mainly used to extend the presentation of register values, but also to examine register values during e.g. running ePLC programs.
Watch register setup can be saved as separate files, which can be reloaded after restart. These files are independent of the usual motor configuration.



9.2 Using MacTalk to setup the motor

9.2.8 Register Workspace Pad

The *Register Workspace Pad* is activated via the **[!]** button in the *Watch Registers* window, from the Window menu, or with the keyboard shortcut Shift+Ctrl+F8. See figure on the previous page.

The *Register Workspace Pad* presents all the defined registers in the motor. All these registers can be selected and added to the *Watch Registers* window.

[Add...]
Enables adding non-predefined motor registers.
Beware of the limitation of these registers. If the register number is larger than 511, it will not be part of the normal MacTalk® configuration. It is, however, possible to save the *Watch Registers* via the **[Save...]** button and later use **[Open...]** to reinsert the register set.

[Read...]
Reads and presents all the selected motor registers.

[Write...]
Opens a dialogue where the highlighted motor register is presented for writing. The keyboard shortcut Ctrl+w opens the same dialogue. For obvious reasons, only Writeable registers will change their values. The write dialogue makes it straightforward to alter a Decimal/Binary register value.
An underlying calculator can be used for simple calculations such as + - * /, but also for more complex arithmetic: left/right rotation and many other operations.

[Dump...]
Creates a file containing all register values read from the motor. The file is a plain ASCII file and looks more or less like the Register Workspace Pad content.

[Edit...] and **[Delete]**
Only valid for user-defined registers.

[Clear]
Clears the content of all register values (not the register selection).

[Add Watch]
Adds all the selected registers to the *Watch Registers* window.

[Open...]
Opens a previously saved register selection list.

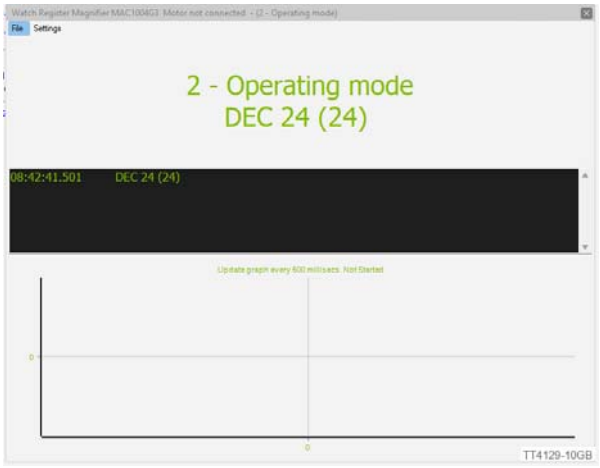
[Save...]
Saves a register selection list including the user-added registers.

[Received]
Presents all register values received since the start of MacTalk®.

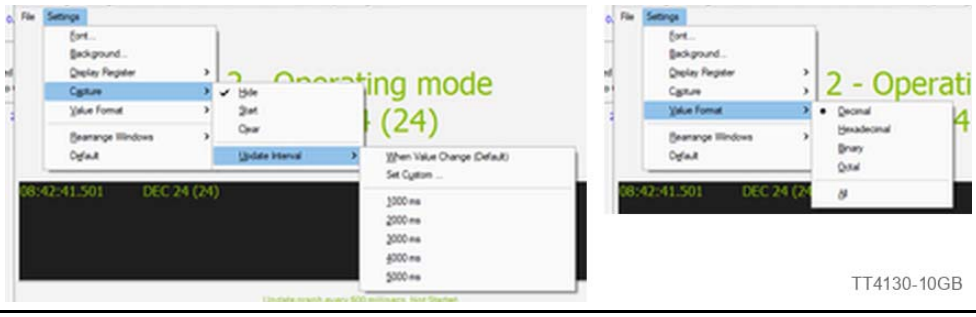
9.2 Using MacTalk to setup the motor

9.2.9 Watch register value

Via double-clicking on the value in the watch window, a Watch Register Magnifier pops up.



This window shows the actual value of the register. Settings->Value Format selects how it is shown: Decimal, Hexadecimal, Binary, Octal, or All, which shows every format at once.
Via Settings->Capture->Start it is possible to follow the value of the register in a graphical representation.
The graph is drawn from the samples, and that is what makes the window useful for more than reading a value: a temperature that rises slowly, an external input that changes while a fault is being traced, or any other register that has to be followed over time.
Settings->Capture->Update Interval decides when a sample is taken: When Value Change (Default) samples only when the register changes, or a fixed interval of 1000, 2000, 3000, 4000 or 5000 ms can be chosen. Set Custom... takes any other interval. The interval in use is written under the graph.



Captured data can be saved to a file (Text or CSV) via *File->Save Captured as...*
When more than one magnifier window is open, Settings->Rearrange Windows arranges them: Stack places them on top of each other, Tile side by side.

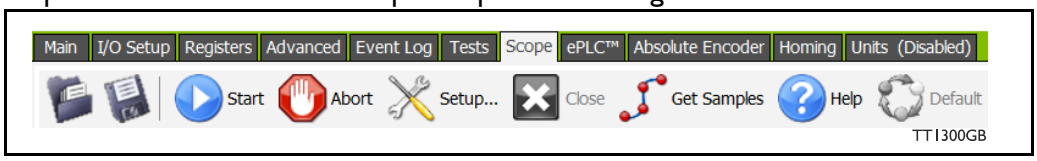
NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

9.3 MacTalk Scope usage

9.3.1 Scope buttons

The Scope function is an 8/4 channel oscilloscope, which is a very good and necessary function for testing a new application or finding errors in an existing system.
The Setup has to be selected to set up the Scope function correctly before use. Almost all registers in the MAC motors can be chosen for viewing and many different trigger functions can be selected. Saving and loading scope recorded data is possible.

Scope buttons to control the Scope setup and recording.



9.3.2 Scope Sample view



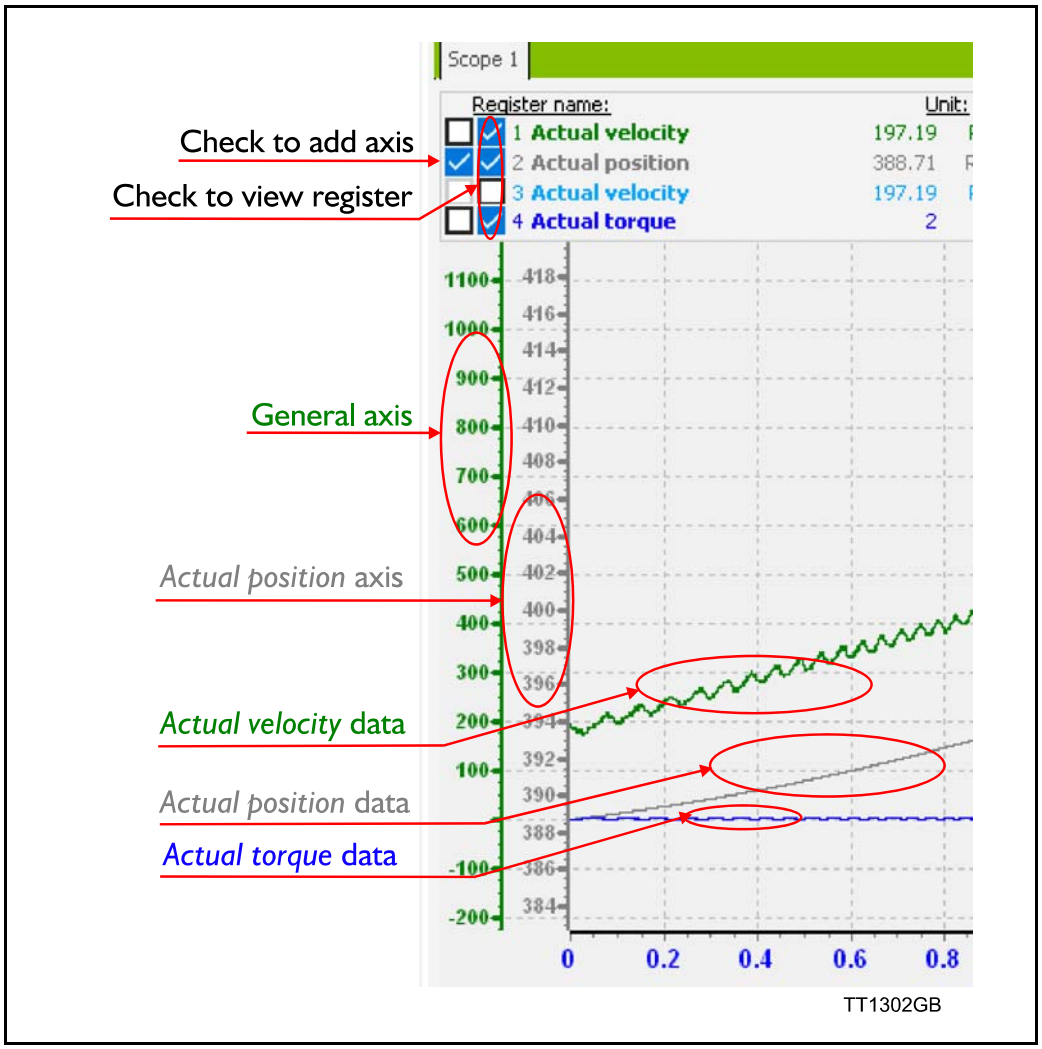
Zoom and Pan are possible to examine specific data.
Zoom: Click, hold and drag the left mouse button to the right downwards. The selected rectangle will be the zoomed view.
Pan: The zoomed view can be panned in all directions: Click and hold the right mouse button while moving the view area.
To restore the entire scope data view: Click, hold and drag the left mouse button upwards to the left.

The **Default** icon can also be used. All settings will return to the default view of data.

Different colours can be applied to the graph data and scales. Double-click on the 'Register name' and select the preferred colour.

9.3 MacTalk Scope usage

In Scope Sample view, it is possible to select which of the sampled register values to show or hide. The ***General scale*** will adapt to the sampled data.
It is also possible to show or hide scales for each sampled register.



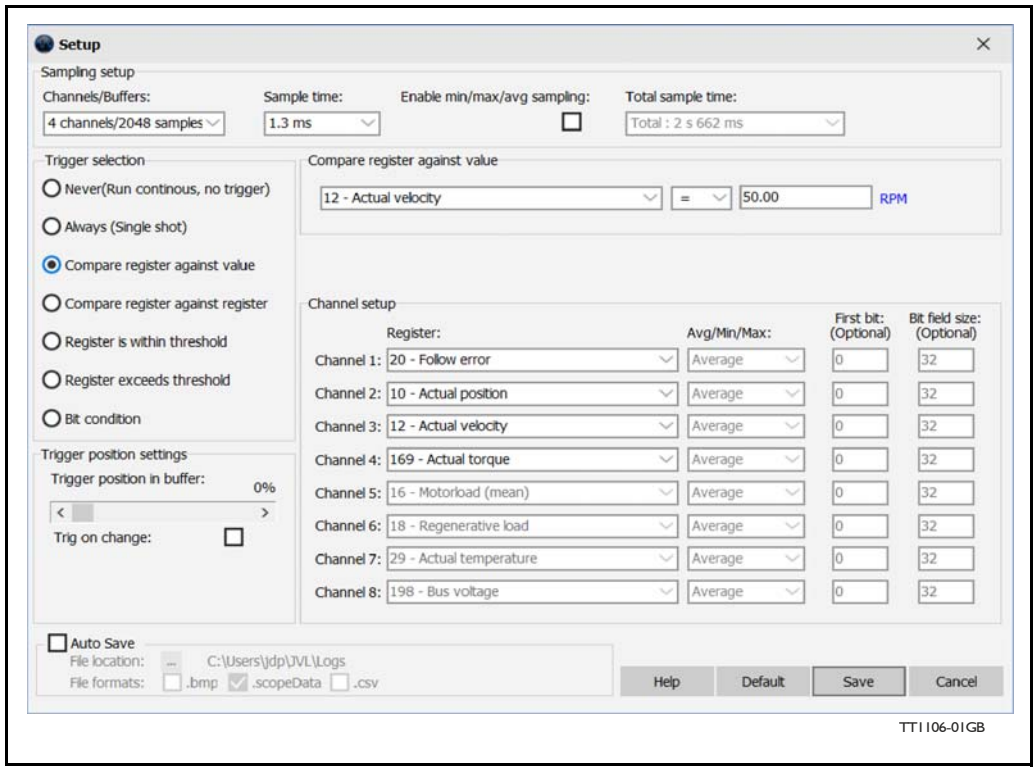
Note that for the Actual torque (Reg 169) values it is very hard to see any variation. In this specific case, it would be a good idea to add a scale for ***Actual torque***.

9.3 MacTalk Scope usage

9.3.3 Sampling Setup

In Sampling setup, it is possible to select between recording of 4 or 8 register values. Along with the channel count, it is possible to choose different sample counts (512, 1024 and 2048 samples).
Selection of sample time impacts the total sample time along with the number of channels and samples. You can select 100 μs or 1.3 ms.
If extended recording time is preferred, you can do so by activating ***Enable min/max/avg sampling*** and selecting the desired ***Total sample time***.

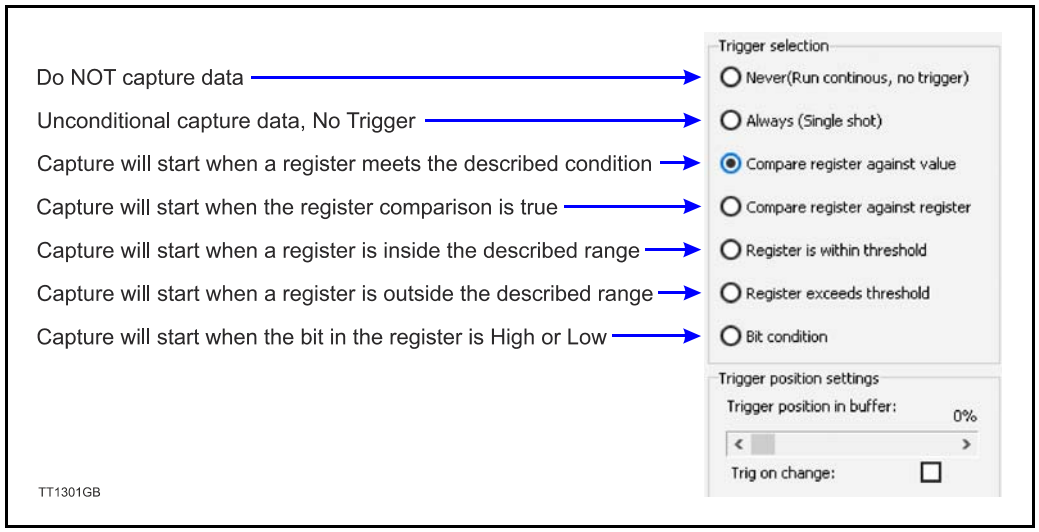
The entire scope setup is part of the general setup and will be saved along with all other motor setup.



When saving scope data using the ***MacTalk® Scope Data Format*** (.scopeData), you will be able to reload the recording back into MacTalk.
Reloaded scope data can still be saved as .CSV or .BMP, if needed.

9.3.4 Scope trigger setup

The scope trigger is rather complex with many possible configurations.
First, you have to make a trigger selection.



Never (Run continuous, no trigger):
The default mode where no data is captured.
The purpose of this mode is to be able to load previous scope data for preview.

Always (Single shot):
Capture data directly after Start without any trigger condition.

Compare register against value:
Capture will start when a register value meets the described condition.
Possible comparison selection is: '=', '!=', '>', '>=', '<' or '<='.
A typical scenario: Trigger recording of data when the Actual velocity (Reg 12) exceeds 1000rpm.

Compare register against register:
Same as above, but where the value is the contents of another register.
Possible comparison selection is: '=', '!=', '>', '>=', '<' or '<='.
A typical scenario: Trigger recording of data when the *Regenerative load = Regenerative load limit*.

Register is within threshold:
Capture will start when a register value meets the described condition.
A typical scenario: Trigger recording of data when the Actual velocity (Reg 12) is inside the range 900rpm to 1000rpm.

Register exceeds threshold:
Capture will start when a register value meets the described condition.
A typical scenario: Trigger recording of data when the Actual velocity (Reg 12) is outside the range 900rpm to 1000rpm.

Bit condition:
Capture will start when a bit in a register changes to High or Low.
A typical scenario: Trigger recording of data when Error status (Reg 35) Bit 24 is set or reset.

9.3.5 Trigger position setting

Trigger position in buffer can be selected from 0% to 100%.
0% means that the data recorded starts exactly at the trigger condition.
If you want to record data prior to the trigger point, then you need to select a higher percentage.
100% means that all data is prior to the trigger point.
NB! If the trigger condition occurs before the buffer is full, the available data will be presented.

9.3.6 Trig on change

When selected, the trigger point will occur when the value crosses the threshold coming from the non-triggering side.
Ex. Trigger point is *Actual velocity* (Reg 12) > 600rpm
Motor is running at 700rpm when scope is started.
Now the trigger is not armed until the Actual velocity has been below 600rpm.
Subsequently, the trigger will be activated when the *Actual velocity* again rises beyond 600rpm.

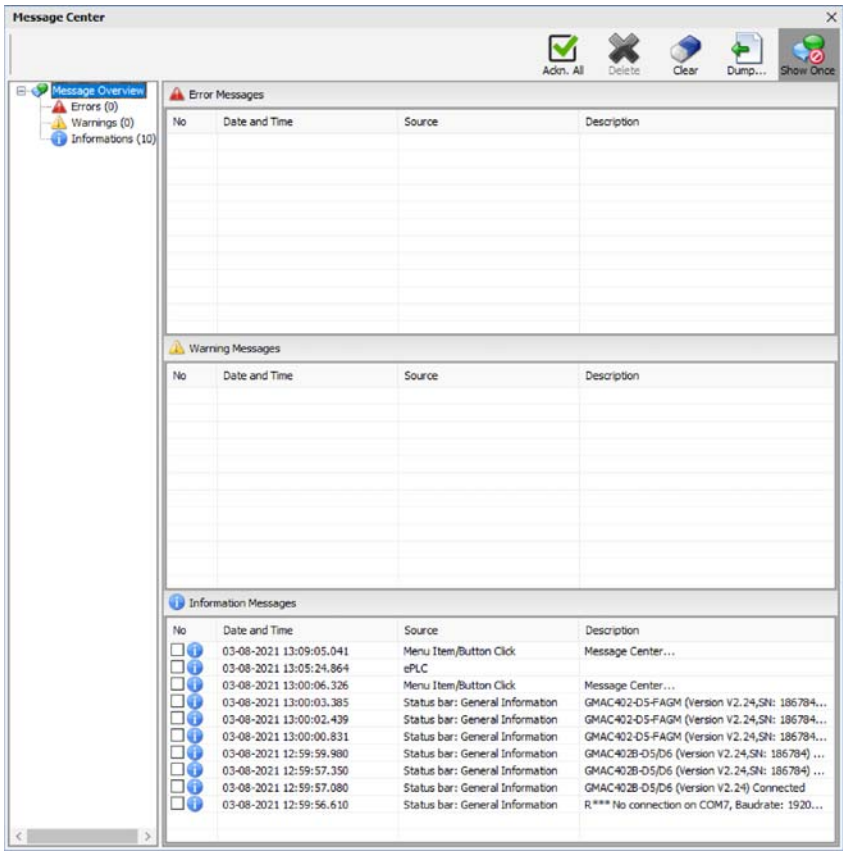
If unchecked, the trigger is based on a static value evaluation.

NOTE: All motor registers are documented in detail in the online register overview:
www.jvl.dk/register.html?register=MACmotor

9.3 MacTalk Scope usage

9.4 Message Center

The Message Center can be accessed via a click on the Icon, Window -> Message Center or via keyboard short-cut Shift+Ctrl+F9.
Message Center records 3 types of events: Errors, Warnings and Information.
Information entries are mainly user interactions, but also events occurring during execution of ePLC programs.
The idea behind the Message Center is to track what happened prior to a Warning or an Error.
This enables the user to create flawless ePLC programs and valid motor setup.



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9.5 ePLC usage

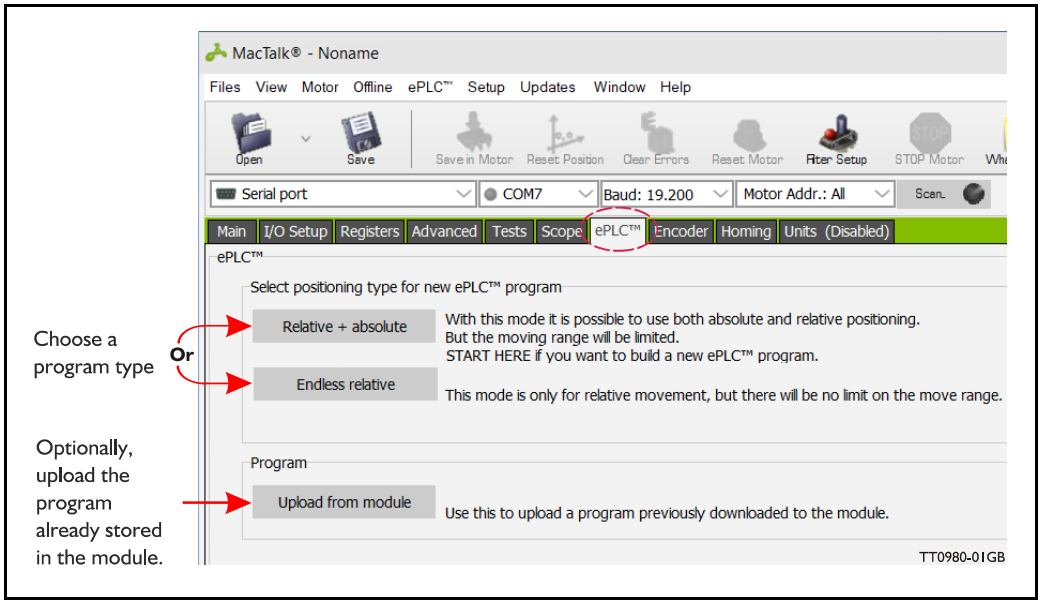
9.5.1 Introduction to ePLC

Using the ePLC functionality in a MAC motor, almost any kind of program can be created using a set of user-friendly icons.
To create a program, first of all it must be determined whether the application requires that the motor always stays within the allowed position range, which is +/- 67,108,863 counts, or if the application requires that the motor mostly moves in only one direction, meaning that sooner or later it will pass the maximum limit of counts mentioned above.

Typical applications for the two program types are:

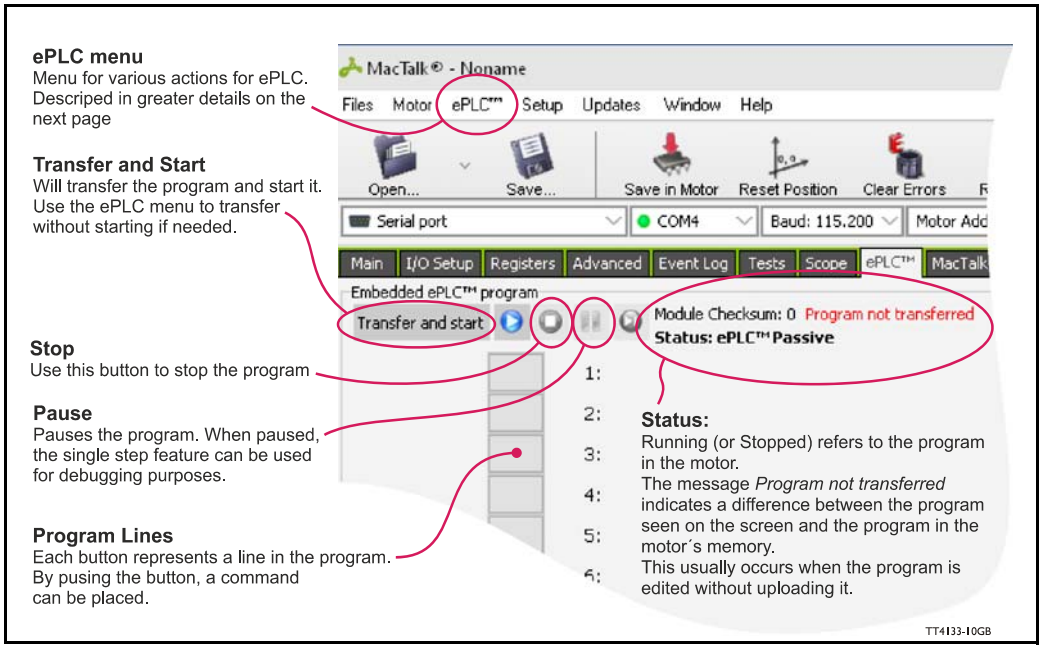
Relative + Absolute	XY tables Pick and place robots Valve actuators
Endless relative	Dispensers for film, labels etc. Dosing pumps Turntables Torque-controlled screw machines

Select the program positioning type when creating a new program in the ePLC tab, or choose to upload the program stored in the motor.



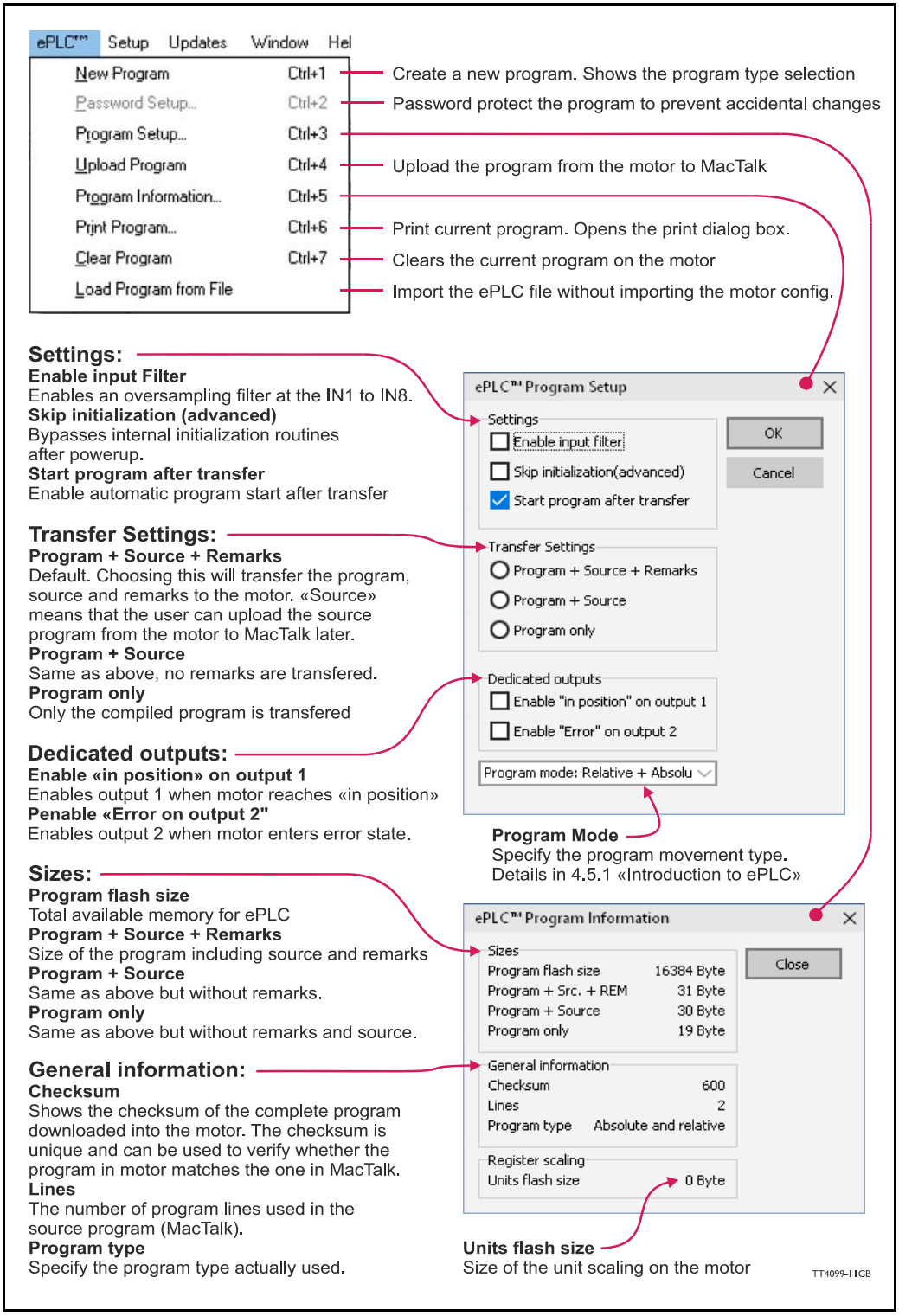
9.5.2 ePLC Main window

The main window for creating a new program or editing a program is shown below:



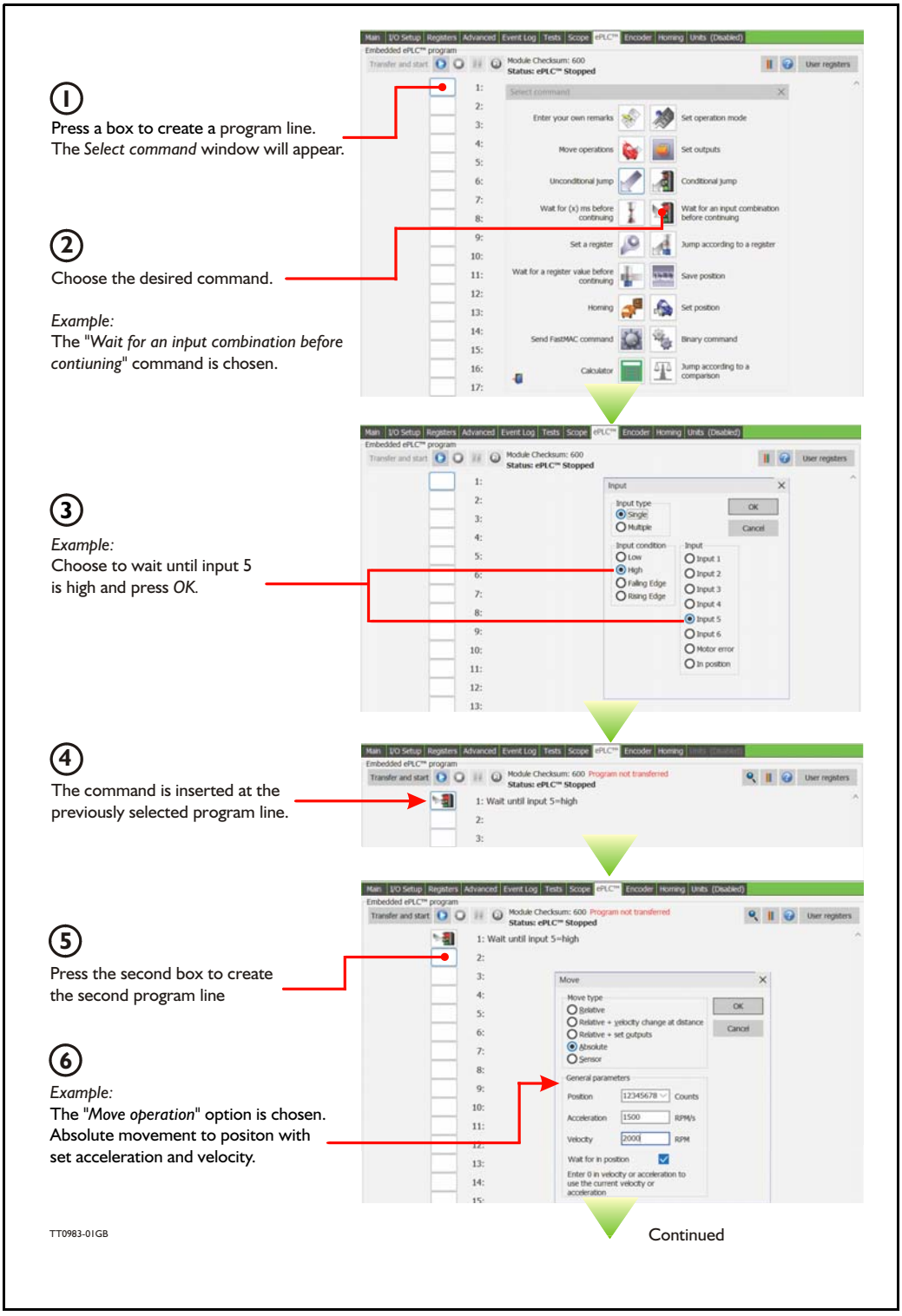
9.5.3 ePLC menu

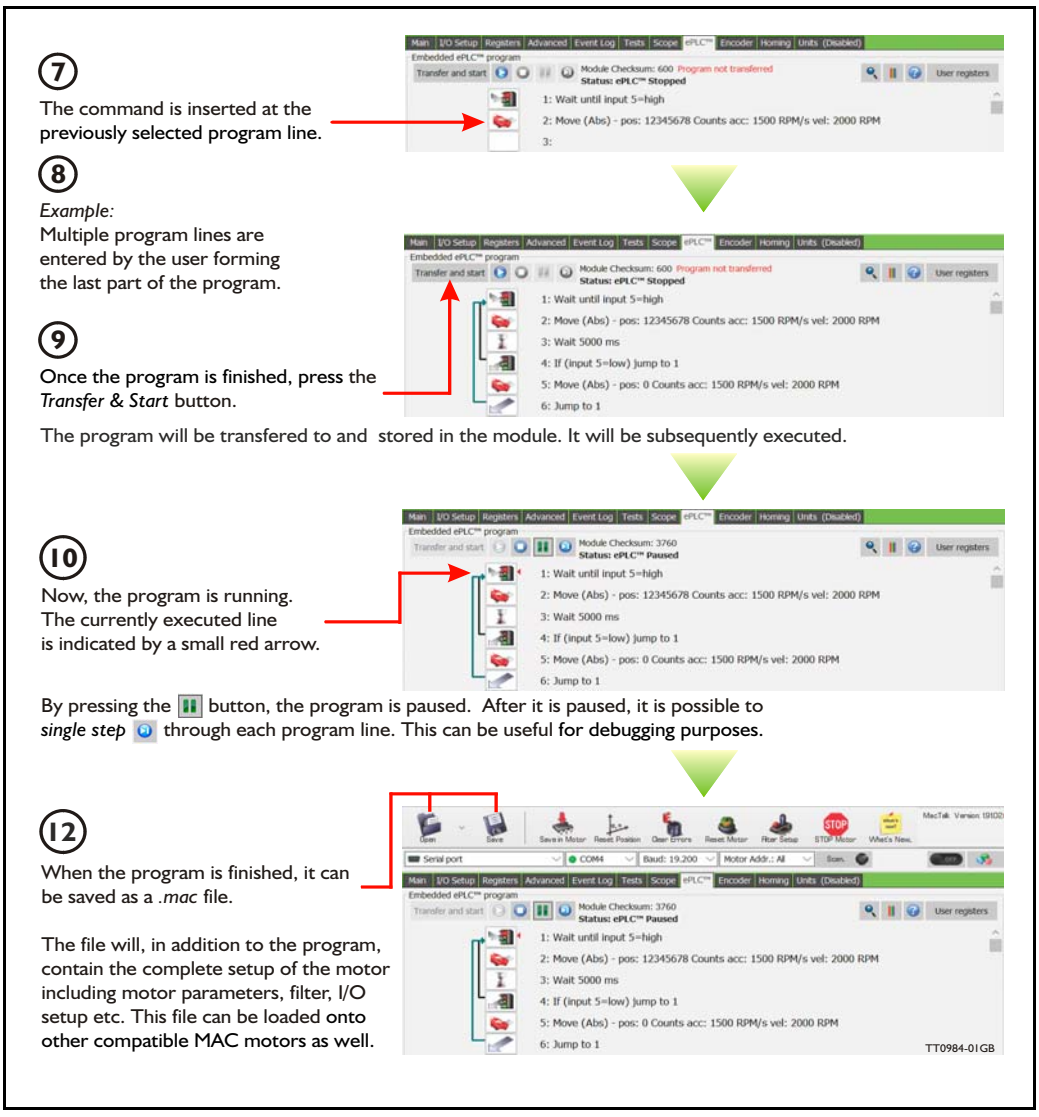
The ePLC menu, found in the menu bar, contains the following options:



9.5.4 How to build a program

When choosing *New program* in the ePLC menu or entering the ePLC tab for the first time, a program can be built. Press the button at line 1, and a window will appear.





9.5.5 General programming tips

When a program is built and saved, the following tips may be useful to ensure that the program behaves as expected.

1. When transferring the program to the motor, it is saved permanently in the memory. The program will be executed each time the motor is switched on.

2. Before making a program, ensure that the basic parameters for controlling acceleration, torque, safety limits, etc. are set to the desired values. When saving the program as a file, all these basic parameters will be saved together with the program as a complete motor setup.

3. A program line can be edited by double-clicking the command text.

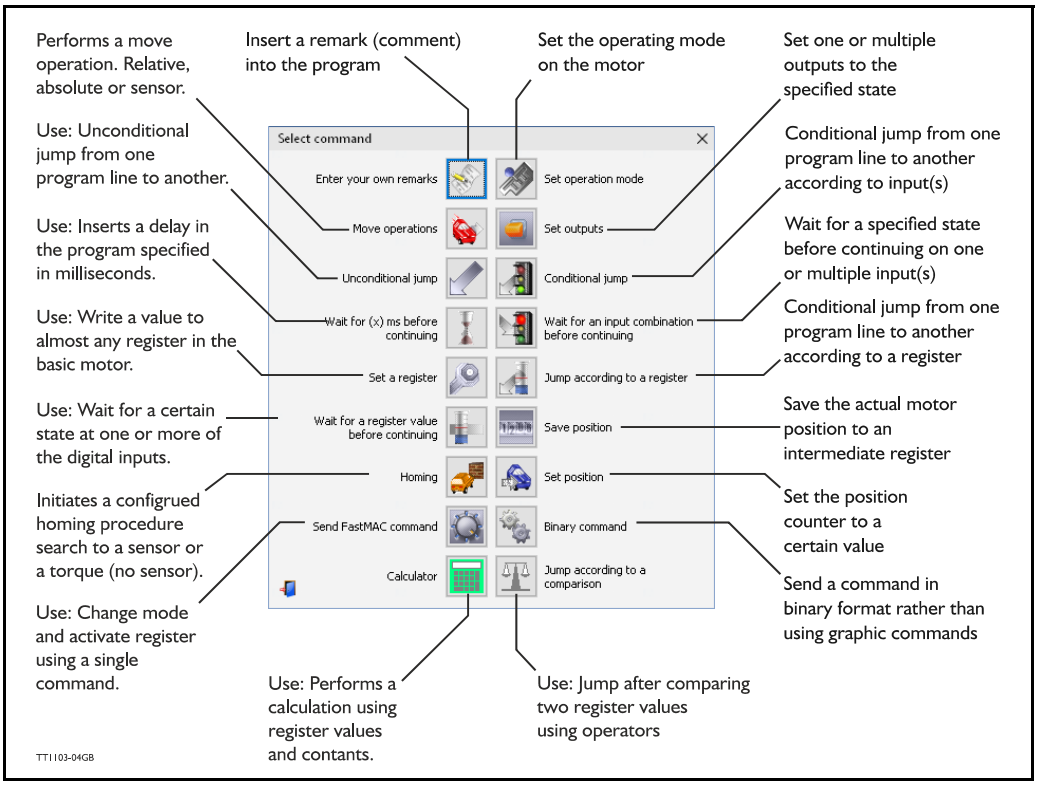
4. When the cursor is placed on top of the command icon, a menu can be called up with a right-click. Here, it is possible to edit, insert, remove, copy, paste and more.

9.5.6 "Select command" window overview

Pressing any empty line in the ePLC tab opens the "Select command" window, the command toolbox. The toolbox comprises 18 different command icons used when creating programs.

The commands give easy access to the most commonly used functions in the motor. Some functions are deceptively simple. For example, the "Set register value" or "Wait for register value before continuing" gives direct access to over 50 registers in the MAC motor. In total, the command toolbox is very powerful since most of a typical program can be built using the simple command icons. The remaining part is obtained by accessing the motor registers.

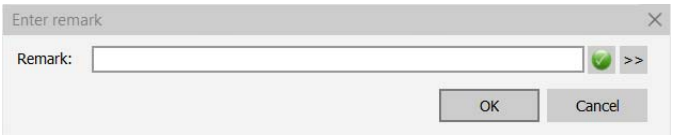
A short description of all command icons can be found below. For more detailed descriptions of the commands, see the following section.



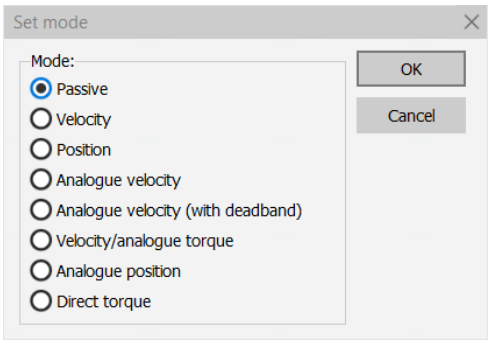
9.5.7 ePLC command descriptions

In the following section, detailed descriptions of each command available in the "Select command" window are given. Each subsection is labelled after the command's name and will show the icon, dialog box and a short description of the function.

9.5.7.1 Enter your own remarks

Icon:	
Dialogue:	
Function:	Inserts a remark/comment in the source code. The program line will not be executed. This can be especially useful if other users are involved in using the program, or if the program is worked on infrequently.

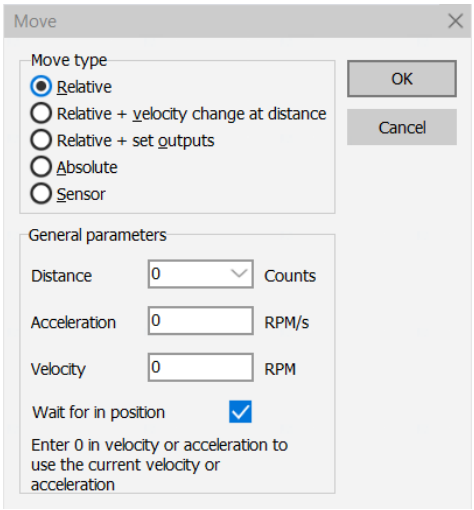
9.5.8 Set operation mode

Icon:	
Dialogue:	
Function:	Sets the operating mode of the motor to the specified mode. This allows using different operating modes in different parts of the program, or in conjunction with jumps. For a detailed description of the individual operating modes, see *Position mode, page 94* to *Analogue bi-position mode, page 118*.

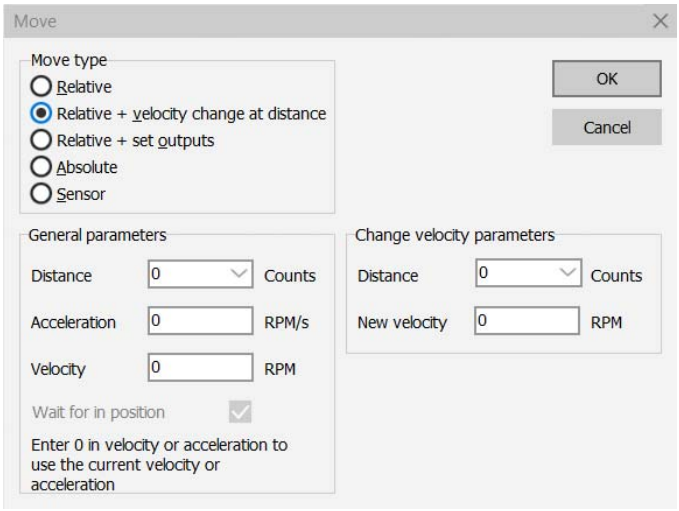
9.5.9 Move operations

Icon:	
Function:	The *Move* command offers a great deal of flexibility, with five different movement types. Each type will be described in its own section.

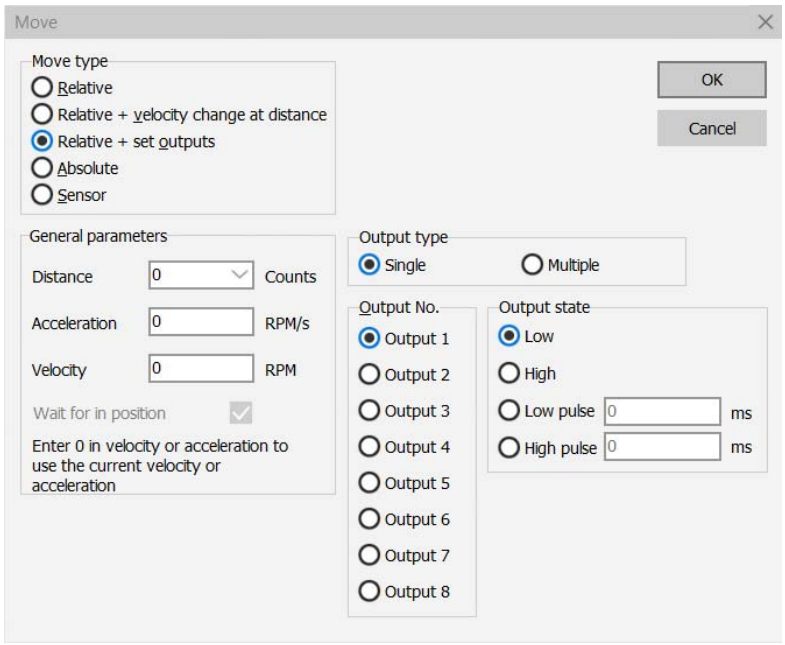
9.5.10 Move Relative

Icon:	
Dialogue:	
Function:	Moves the motor relative to its current position. The distance is measured in encoder counts, and can either be entered directly, or taken from three memory registers (P1-P3, Reg 49-53) in the motor. For further information on using these memory registers, refer to the sections on the “Save position” and “Set position” commands. Note that if a velocity and/or acceleration is specified in the command, Velocity (Reg 5) and/or Acceleration (Reg 6) will be overwritten with the entered value. P1 (Reg 49) is always overwritten by this command. If the “Wait for in position” option is checked, the program will wait until the motor has finished the movement before proceeding to the next program line. If this option is not checked, the program will start the movement, then immediately start executing the next command. The motor will still finish the movement on its own unless it is given instructions to stop or move elsewhere.

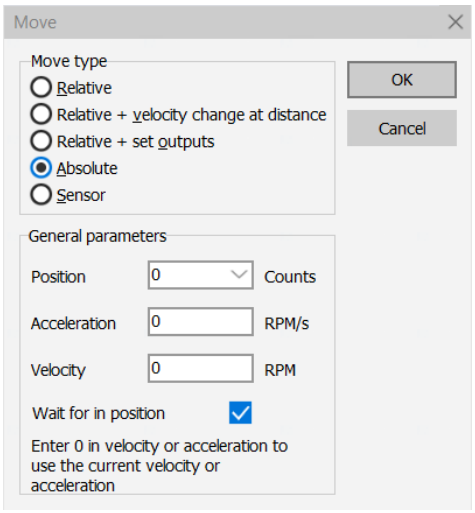
9.5.11 Move (Relative + velocity change at a distance)

Icon:	
Dialogue:	
Function:	Performs a motor movement relative to the current position, but changes the velocity after a specified distance. The *"General parameters"* distance is the total distance moved, whereas the speed is changed after moving the *"Change velocity parameters"* distance. Therefore, the latter value must be smaller than the former. The distance is measured in encoder counts, and can either be entered directly, or taken from three memory registers (P1-P3, Reg 49-53) in the motor. For further information on using these memory registers, refer to the sections on the "Save position" and "Set position" commands. Note that if a velocity and/or acceleration is specified in the command, Velocity (Reg 5) and/or Acceleration (Reg 6) will be overwritten with the entered value. P1 (Reg 49) is always overwritten by this command. This command always causes the program to wait until the movement is finished before executing the next command.

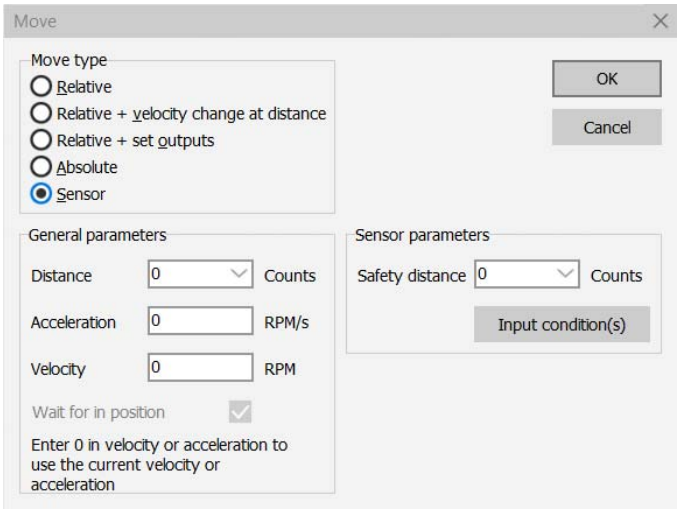
9.5.12 Move (Relative + set outputs)

Icon:	
Dialogue:	
Function:	Performs a motor movement relative to the current position, and sets one or more outputs on when the operation is completed. The distance is measured in encoder counts, and can either be entered directly, or taken from three memory registers (P1-P3, Reg 49-53) in the motor. For further information on using these memory registers, refer to the sections on the “Save position” and “Set position” commands. Note that if a velocity and/or acceleration is specified in the command, Velocity (Reg 5) and/or Acceleration (Reg 6) will be overwritten with the entered value. P1 (Reg 49) is always overwritten by this command. This command always causes the program to wait until the movement is finished before executing the next command.

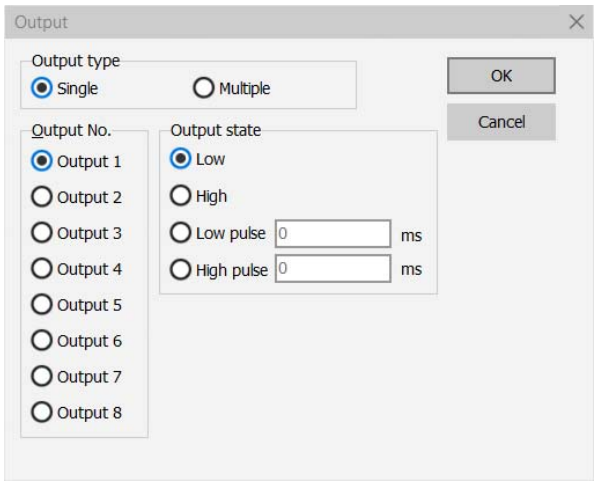
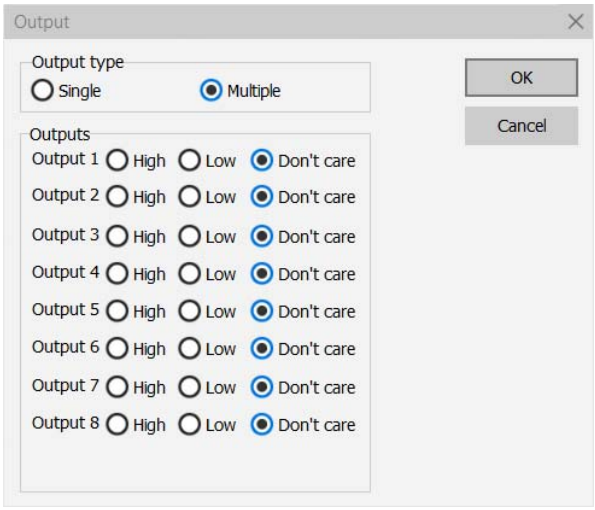
9.5.13 Move (Absolute)

Icon:	
Dialogue:	
Function:	Moves to an absolute (non-relative) position. The motor will move to the exact position specified. The position is measured in encoder counts, and can either be entered directly, or taken from three memory registers (P1-P3, Reg 49-53) in the motor. For further information on using these memory registers, refer to the sections on the “Save position” and “Set position” commands. Note that if a velocity and/or acceleration is specified in the command, Velocity (Reg 5) and/or Acceleration (Reg 6) will be overwritten with the entered value. P1 (Reg 49) is always overwritten by this command. If the “Wait for in position” option is checked, the program will wait until the motor has finished the movement before proceeding to the next program line. If this option is not checked, the program will start the movement, then immediately start executing the next command. The motor will still finish the movement on its own unless it is given instructions to stop or move elsewhere.

9.5.14 Move (Sensor)

Icon:	
Dialogue:	
Function:	Performs a movement in the direction specified by using a positive or negative velocity value. The motor moves until an input condition is satisfied, then moves the distance specified before stopping. The motor will not move farther than the safety distance specified regardless of whether the input condition is satisfied. The distance is measured in encoder counts, and can either be entered directly, or taken from three memory registers (P1-P3, Reg 49-53) in the motor. For further information on using these memory registers, refer to the sections on the “Save position” and “Set position” commands. Note that if a velocity and/or acceleration is specified in the command, Velocity (Reg 5) and/or Acceleration (Reg 6) will be overwritten with the entered value. P1 (Reg 49) is always overwritten by this command. This command always causes the program to wait until the movement is finished before executing the next command.

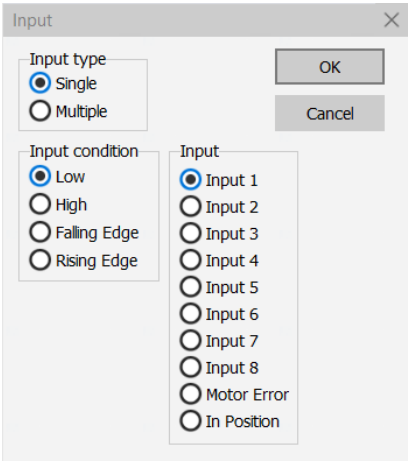
9.5.15 Set outputs

Icon:	
Dialogue:	 
Function:	Sets one or more outputs. When setting a single output, it is possible to specify the length (in milliseconds) of a low/ high pulse. When setting multiple outputs, it is possible to set the state for each output. “Don’t care” leaves the output in its current state.

9.5.16 Unconditional jump

Icon:	
Function:	Jumps to another line in the program. After selecting this command, the user must select the destination line. The source line (the line in which this command is placed) is indicated in a text box next to the cursor. The next line that is clicked on will become the jump destination.

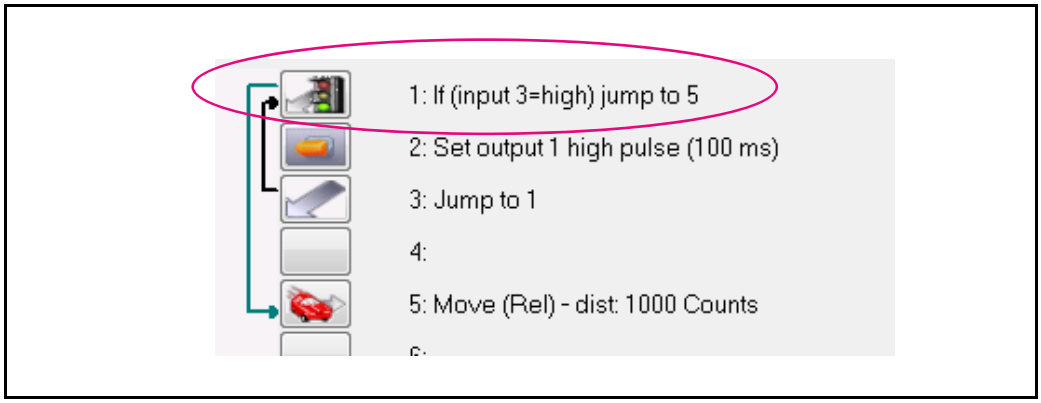
9.5.17 Conditional jump (single input)

Icon:	
Dialogue:	
Function:	Jumps to the specified line in the program if the specified input condition is met. If the condition is not met, the program proceeds to execute the next line in the program. When “Single” is selected as the “Input type”, the command can use four states to trigger the jump: The input is low, the input is high, the input transitioned to low (falling edge), or the input transitioned to high (rising edge). In case an input transition is selected, the transition is latched by the firmware and detected the next time the command executes, no matter when it occurred. After selecting the input condition, the user must select the destination line. The source line (the line in which this command is placed) is indicated in a text box next to the cursor. The next line that is clicked on will become the jump destination.

Examples are given on the following page.

Conditional jump example 1 - Jump controlled by an input level
In the program example below, the command is used in line 1. The program will jump to line 5 if *input 3* is active (supplied with voltage).

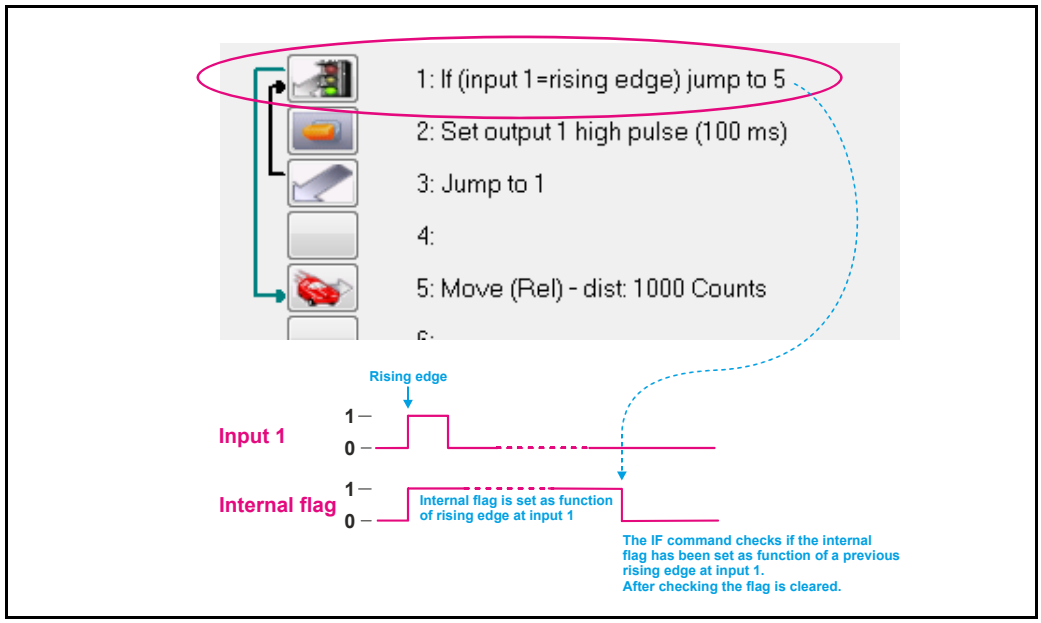
If *input 3* is not active at the time of execution, the program proceeds to line 2.



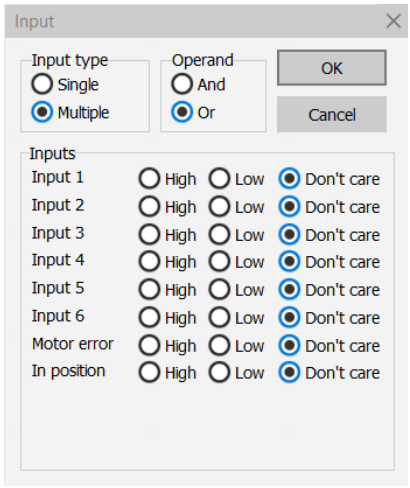
Conditional jump example 2 - Jump controlled by input transition
In the program example below, the command is used in line 1. The program will jump to line 5 if *input 3* has shifted from inactive (0) to active (1).

The function uses an internal flag, which is set whenever a rising edge (latched change from inactive to active) has been detected.

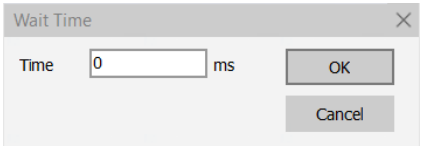
If no shift is detected, the program proceeds to line 2.



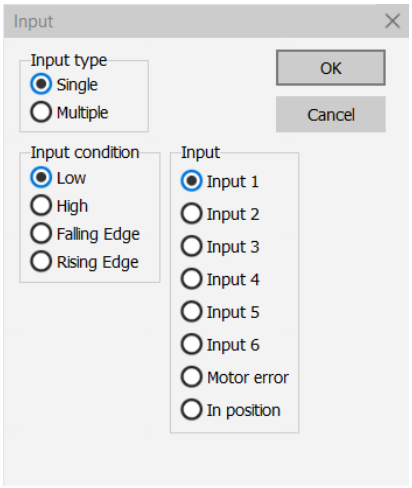
9.5.18 Conditional jump (multiple input)

Icon:	
Dialogue:	
Function:	Jumps to the specified line in the program if the specified input condition is met. If the condition is not met, the program proceeds to execute the next line in the program. When "Multiple" is selected as the "Input type", multiple inputs can trigger the jump depending on its/their state(s); high or low. The "Don't care" option will ignore the state of the input. If the "Operand" setting is set to "And", all inputs must match the chosen state. If set to "Or", the jump is triggered if any input matches the chosen state. After selecting the input condition, the user must select the destination line. The source line (the line in which this command is placed) is indicated in a text box next to the cursor. The next line that is clicked on will become the jump destination.

9.5.19 Wait for (x) ms before continuing

Icon:	
Dialogue:	
Function:	Pauses the program for the specified time (indicated in milliseconds) before continuing. Value range: 0 to 32767 ms. **NOTE:** This command overwrites the "Timer 1" register.

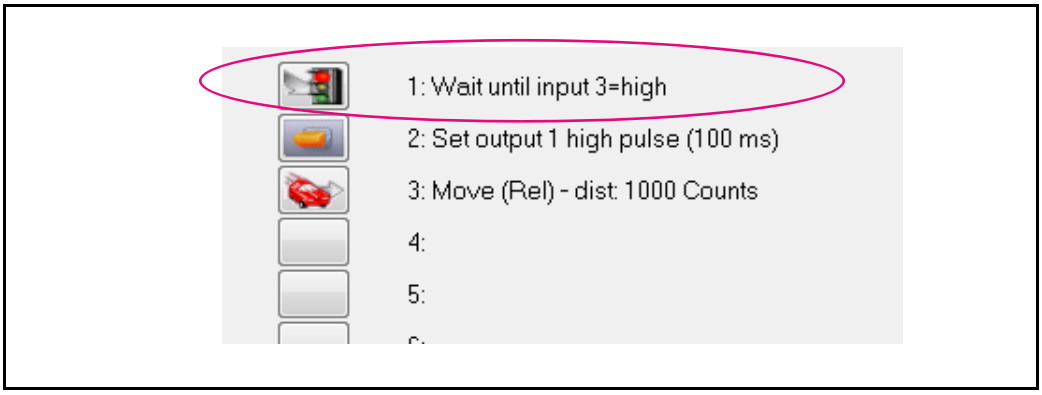
9.5.20 Wait for an input combination before continuing (single input)

Icon:	
Dialogue:	
Function:	Waits for a specified input condition to occur. The next line in the program will not be executed until the input condition has been met. When “Single” is selected as the “Input type”, the command can wait for one of four states: The input is low, the input is high, the input transitioned to low (falling edge), or the input transitioned to high (rising edge). In case an input transition is selected, the transition is latched by the firmware and detected the next time the command executes, no matter when it occurred. The inputs are sampled every 50 microseconds.

Examples are given on the following page.

Conditional wait example 1 - Wait for input level
In the program example below, the command is used in line 1.
The program will wait until *input 3* is active (supplied with voltage).

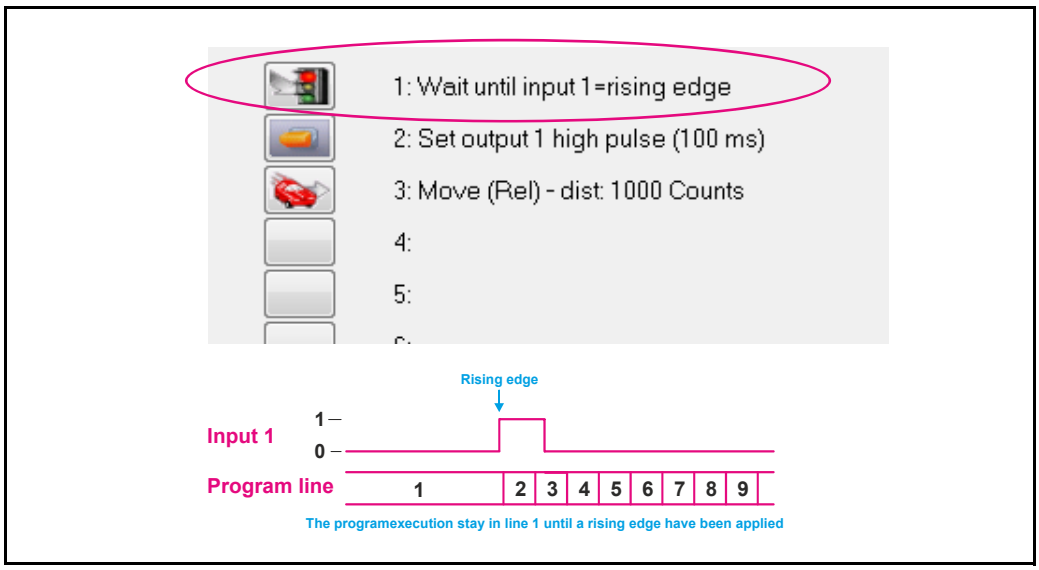
If *input 3* is not active at the time of execution, the program stays on line 1 until it becomes active.



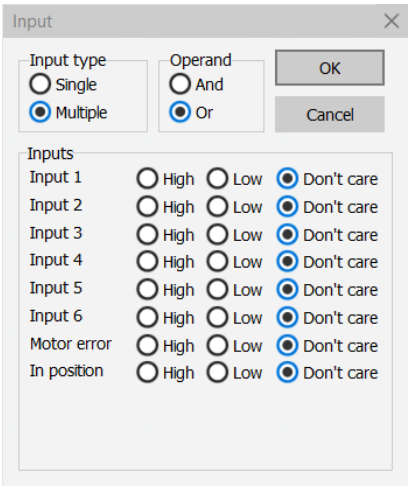
Conditional wait example 2 - Wait for input transition
In the program example below, the command is used in line 1. The program will stall until input 1 has shifted from inactive (0) to active (1).

The function uses an internal flag, which is set whenever a rising edge (latched change from inactive to active) has been detected.

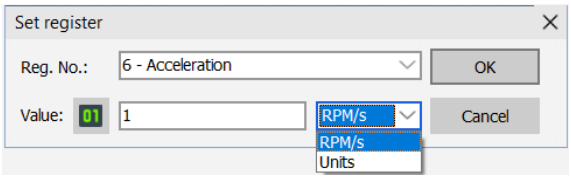
If no shift is detected, the program continues to wait.



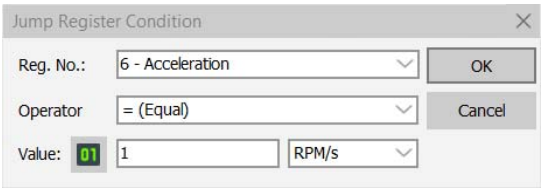
9.5.21 Wait for an input combination before continuing (multiple inputs)

Icon:	
Dialogue:	
Function:	Waits for the specified input state(s) to occur. The next line in the program will not be executed until the input conditions have been met. When “Multiple” is selected as the “Input type”, multiple inputs can end the wait depending on its/their state(s); high or low. The “Don’t care” option will ignore the state of the input. If the “Operand” setting is set to “And”, all inputs must match the chosen state. If set to “Or”, the wait ends if any input matches the chosen state. The inputs are sampled every 50 microseconds.

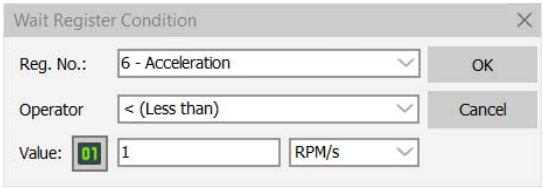
9.5.22 Set register value

Icon:	
Dialogue:	
Function:	Sets a chosen register to a specified value. The register can be selected from a list of user-accessible registers. The value can be entered as MacTalk units (e.g. RPM, RPM/s, etc.) or native motor units (e.g. counts, units etc.) by choosing the desired option in the drop-down menu.

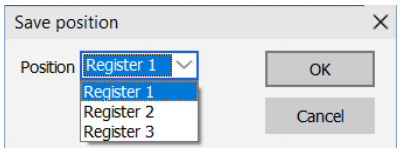
9.5.23 Jump according to a register

Icon:	
Dialogue:	
Function:	Jumps to the specified line in the program if the specified register condition is met. If the condition is not met, the program proceeds to execute the next line in the program. The condition is set up by choosing a register, an operator and a value. The register can be selected from a list of user-accessible registers. The operator is chosen from the drop-down menu and includes options such as equal (=), less than (<), less than or equal (<=) and not equal (<>). The value can be entered as MacTalk units (e.g. RPM, RPM/s, etc.) or native motor units (e.g. counts, units etc.) by choosing the desired option in the drop-down menu. After selecting the input condition, the user must select the destination line. The source line (the line in which this command is placed) is indicated in a text box next to the cursor. The next line that is clicked on will become the jump destination.

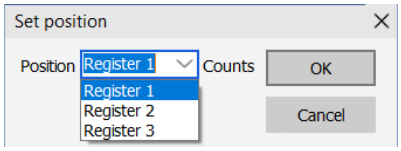
9.5.24 Wait for register value before continuing

Icon:	
Dialogue:	
Function:	Waits until the specified register condition is met. The next line in the program will not be executed until the register condition has been met. The condition is set up by choosing a register, an operator and a value. The register can be selected from a list of user-accessible registers. The operator is chosen from the drop-down menu and includes options such as equal (=), less than (<), less than or equal (<=) and not equal (<>). The value can be entered as MacTalk units (e.g. RPM, RPM/s, etc.) or native motor units (e.g. counts, units etc.) by choosing the desired option in the drop-down menu.

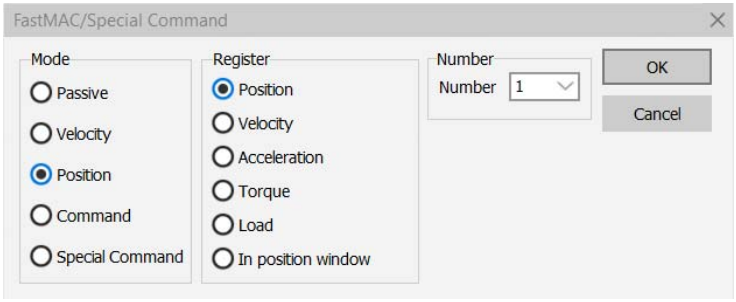
9.5.25 Save position

Icon:	
Dialogue:	
Function:	Saves the current position, *Actual position* (Reg 10), in one of three dedicated position registers: Position Reg 1 (Reg 49), Position Reg 2 (Reg 51) or Position Reg 3 (Reg 53). Register x = Actual position. The saved position(s) may be used in move commands, or in the *"Set position"* command.

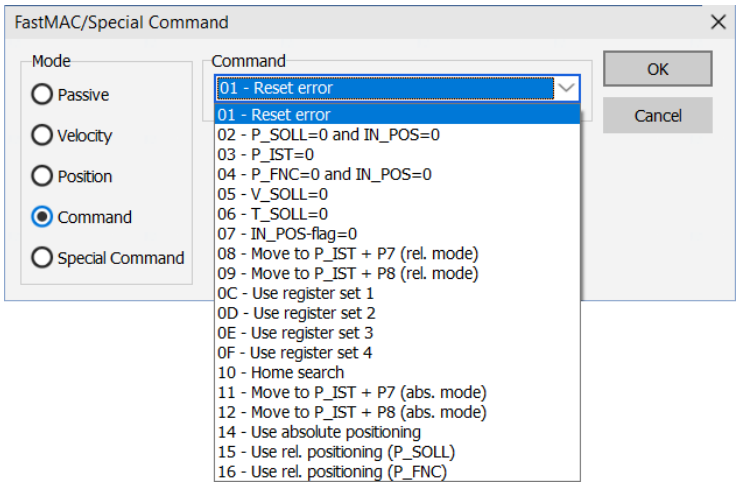
9.5.26 Set position

Icon:	
Dialogue:	
Function:	Sets the current position, Actual position (Reg 10), to one of the three dedicated position registers: Position Reg 1 (Reg 49), Position Reg 2 (Reg 51) or Position Reg 3 (Reg 53). Actual position = Register x This command is the inverse of the "Save position" command.

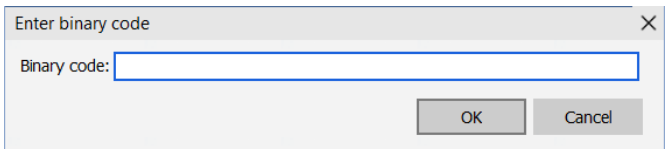
9.5.27 Send FastMAC command (change mode and activate register)

Icon:	
Dialogue:	
Function:	FastMAC commands allow the user to accomplish several tasks. Here, the mode changing and register activation functionality is explained. When *"Passive"*, *"Velocity"*, or *"Position"* mode is chosen, the command allows the user to set mode and change a register to a value from a user register using a single command. The execution time is lower compared to using multiple commands to accomplish the same task. By choosing a *Mode*, *Register* and *Number*, the motor can be set into a mode with the chosen register set to the chosen value. The user registers are registers 49-88 and can be found in the *"Registers"* tab of MacTalk, where their value can also be set. For example, the command in the picture shown above will set the motor to Position mode and set Requested position (Reg 3) to the value written in Position Reg 1 (Reg 49).

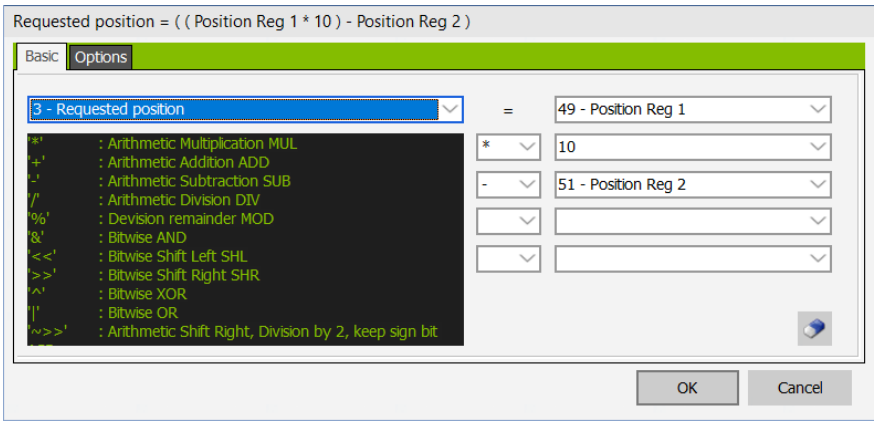
9.5.28 Send FastMac command (command)

Icon:	
Dialogue:	
Function:	FastMAC commands allow the user to accomplish several tasks. Here, the command sending functionality is explained. When *"Command"* or *"Special command"* mode is chosen, the motor does not change mode but can be ordered to carry out various operations. Among these commands are the reset error command, activating homing, synchronizing position and activating user register sets (e.g. setting the requested position to Position Reg 1 (Reg 49), velocity to Velocity Reg 1 (Reg 65), acceleration to Acceleration Reg 1 (Reg 73), torque to Torque Reg 1 (Reg 77), load to Load Reg 1 (Reg 81) and in-position window to In position window 1 (Reg 85) if set 1 is chosen).

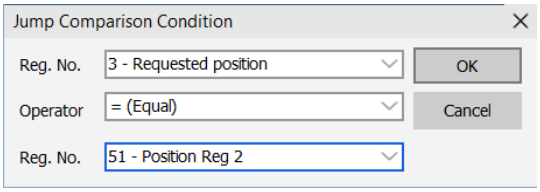
9.5.29 Binary command

Icon:	
Dialogue:	
Function:	**For advanced users only.** Allows the user to send special binary commands. All commands configured in the ePLC are sent to the motor in a compact binary format which is then interpreted by the motor. This command allows the user to send any command to the motor in binary code. This is only to be used under special circumstances where the user has needs that are not covered by the other commands. In this case, contact JVL for assistance.

9.5.30 Calculator (basic)

Icon:	
Dialogue:	
Function:	Performs calculations using register values and/or number values using 11 different operators. The result of the calculation is stored in the chosen register, marked in blue in the picture. The title bar of the window shows the resulting expression. In the “Options” tab, it is possible to switch between “Numbered list with long MacTalk names” and “Simple list with short firmware names”. This allows the user to switch between MacTalk and firmware nomenclature for the register names. For example, the user can switch between using “3 - Requested position” and “P_SOLL”, which are the two names for Requested position (Reg 3). **NOTE:** The values stored in registers using this command use native motor units. For example, velocity is stored in the native motor unit (16 x counts per sample) rather than RPM. Conversion is automatically performed in other commands such as “*Set a register*”, “*Jump according to a register*” and “*Wait for register value before continuing*”.

9.5.31 Jump according to a comparison

Icon:	
Dialogue:	
Function:	Jumps to the specified line in the program if the comparison condition is met. If the condition is not met, the program proceeds to execute the next line in the program. The condition is set up by choosing a register, an operator and another register. The register can be selected from a list of user-accessible registers. The operator is chosen from the drop-down menu and includes options such as equal (=), less than (<), less than or equal (<=) and not equal (<>). The command uses native motor units (for example 16 x counts per sample rather than RPM for velocities). Therefore, it is recommended to compare registers with the same units. After selecting the input condition, the user must select the destination line. The source line (the line in which this command is placed) is indicated in a text box next to the cursor. The next line that is clicked on will become the jump destination.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

9.6 How to update the motor firmware

The firmware in the motor can be updated directly from the internet at any time by using MacTalk.
It is recommended always to use the latest version of the firmware available for the actual MAC motor used since it will contain the latest features, and bugs may have been found and corrected. Below is shown how to make an update of the firmware.

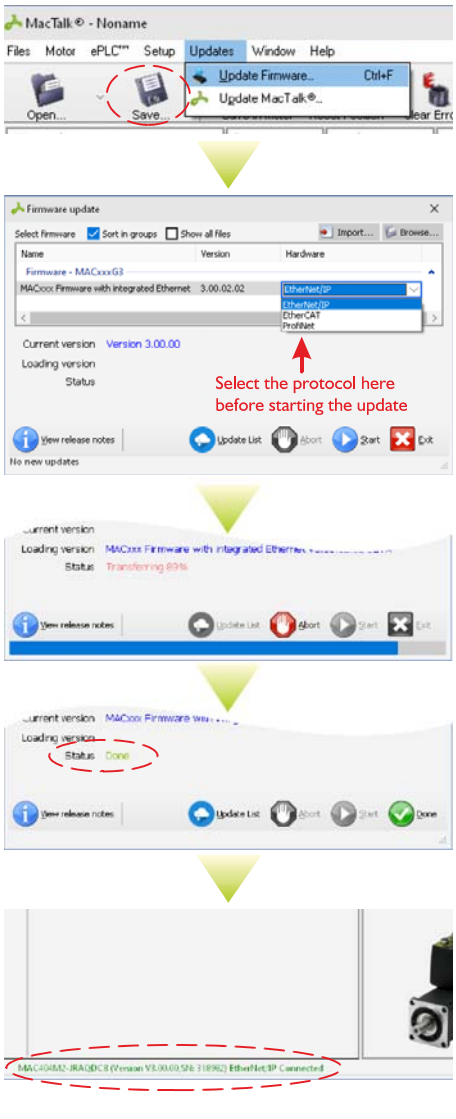
Step 1
The firmware update will erase the existing user setup of the motor. Use the Save button to save the existing setup before updating the motor. Then choose the *Update Firmware* in the *Updates* menu.

Step 2
The first list shown is only the newest firmwares related to the actual motor connected.
If the Ethernet option is present a list of protocols is also shown. Choose the right protocol from list.
To see all files also older versions enable the checkbox *"Show all files"*.
Select the right firmware, «Firmware MACxxxG3».
Press *Start* to download the selected firmware.
The progress counter will now rise from 0 to 100%.

Step 3
When the download process is finished, the status shows *"Done"*.

Step 4
The on-line information shown in the lower right side of the MacTalk main window will now show the complete type of firmware and version.

The firmware update is now fully completed. Please remember that the settings of the motor is set back to default. But can be reinstalled by opening the user setup file made initially in this update sequence.



TT4044-10GB

Hint!: Some older products may not start after pushing the "start" button shown above. If this is the case, simply switch off power, wait 5 seconds and re-apply power. The update should now start.

10 Appendix

10.1 Technical Data

10.1.1 Generic technical data for all MAC motors generation III

Type of product	
Technology and concept	AC-servomotor (Brushless) with built-in magnetic encoder, and 3 phase servo amplifier/controller
Communication	
Basic Communication (all models)	Purpose: Monitoring, setup and dynamic change of internal parameters during motor operation. Interface type 2 wire RS485 Modbus 115.2 kbit/s (115.2 kBaud). Address range 1-254.
Industrial Ethernet - (optional)	Available now: EthernetIP, ProfiNET, EtherCAT, ModbusTCP. Upcoming: POWERLINK.
Control Modes	
Modes available	Position mode, Velocity mode, Homing mode, Gear mode (follow ext. Encoder), Torque mode, Various modes controlled by analogue input or external I/O's. Please see Mode descriptions in another chapter in this user manual.
Feedback / resolution:	
Internal incremental Encoder resolution	8192 counts per motor revolution. Higher resolutions may be possible on request.
Absolute Multiturn Encoder (optional)	Resolution ±262144 revolutions.
Encoder Technology	Magnetic and energy harvesting (no battery or mechanics = long lifetime)
Servo regulator	
Regulator Technology	Filter 6th order filter with only one inertia load factor parameter to be adjusted depending on load inertia
Sample rate (Update frequency)	Default 1.0 ms (1000 Hz) and optionally 1.3 ms, 2.0 ms or 2.6 ms
Amplifier Control System	Sinusoidal current PWM control. Sampling rate 10kHz and PWM switching frequency 10kHz.
Safety functions (optional)	
Type of safety and level	STO input (physical input) according to SIL3 - TÜV certification pending. Support for functional safety protocols: PROFIsafe - in development / CIPsafety - planned / FSoE - planned. Various FuSa functions in development for release in 2026 such as **"Stopping functions"**: STO, SS1-t, SS2-t. **"Monitoring functions"**: SS1-r, SOS, SS2-r, SLS, SSM, SDI, SLP. **"Output functions"**: SBC. All meet SIL3 / PLe.
Digital resolutions and ranges	
Positioning	Position range ±2.147.483.648 (±2^31) counts (default). ±134.217.728 (±2^27) counts if the G2-compatibility x16 scaling is enabled
Velocity	Speed range Nominal ±3000 RPM. The overspeed protection limit is motor-type dependent (3600-4300 RPM) - see the individual motor data tables. The internal unit corresponds to (factory default): **0.45776 RPM** (1.0ms sample rate) and **0.35211 RPM** (1.3ms sample rate). If "high resolution mode" is activated the internal unit for velocity is as follows: **0.0071526 RPM** (1.0ms sample rate) and **0.0055018 RPM** (1.3ms sample rate) Accuracy: ±0.005% (±50ppm) at ambient temperature 0-40°C. Velocity dependency of supply voltage fluctuations = ±0.0% (no influence)
Acceleration Range	Default: **458 - 732422 RPM/s** (1.0ms sample rate) and **271 - 433353 RPM/s** (1.3ms sample rate) If "high resolution mode" is activated the range is **7.15 - 732422 RPM/s** (1.0ms sample rate) and **4.23 - 433353 RPM/s** (1.3ms sample rate).
Motor Torque	Resolution when internally controlled = 10 bit = 1024 steps (0-300% torque). Resolution if controlled from Analogue input. 10bit (no sign). Sign can be introduced by adding a value in the input offset register, ANINP_OFFSET (Reg 171). Scale: Torque set to 100% = Nominal motor load. 300% = Full motor peak torque (highest possible torque that can be produced). Torque control accuracy ≤10% @ 20°C (Reproducibility)
Digital I/O's (optional)	
Purpose and function	Can be used in general for digital signals in or out such as external sensors or activating external solenoids etc.
Number of I/O's	Up to 8 I/O (incl. 4 analogue inputs). Each can be either input or output
Input activation level	When a given I/O is used as digital input: Logic low = max. 2.5V / Logic high = min. 2.6V
Output current	When a given I/O is used as digital output: Output current up to 350 mA per output at 24V. Short circuit protected.
Multifunction I/O's (optional)	
Purpose and function	Dual RS422 port can be used as input for external encoder, or output from internal encoder, or data communication.
Max. frequency/data rate	Input frequency 0-8 MHz (8 Mbit/sec). 0-1 MHz (1 Mbit/sec.) with input filter.
Analogue Inputs (optional)	
Purpose and function	Can be set up to control velocity, torque or any other internal parameter in the motor.
Number of inputs	Up to 4 inputs. Notice that these are sharing terminals with the up to 8 digital I/O's.
Resolution	12-bit ADC. Register scaling 204.8 counts/V (5.00 V = 1024 counts), i.e. 10 bits over the specified 0.00-5.00 V range. The converter saturates at 1536 counts (7.5 V). Not galvanically isolated.
Input voltage range	Nom. input voltage IN1 to IN4 (option dependent). Voltage range 0.00 to 5.00 VDC (unipolar). Protected against voltage overload up to 30 V peak.
Input offset and impedance	Offset typical ±50mV and input impedance to ground = 30kOhm @0-5V (see *Analogue Inputs, page 41*)
Various	
Electromechanical brake (optional)	The brake is activated automatically when the motor is passive or unable to hold the shaft in position e.g. in case of an error.
Default rotation direction	Positive direction -> Motor shaft rotates clockwise (Seen from shaft end). Can be inverted by motor parameter.
Protective functions	Error trace back, Overload (I^2T) - Load exceeds maximum for too long a time, Follow error, function error, regenerative overload (over voltage), position limit exceeded. Abnormality in flash memory, under voltage, over current, temperature too high, and many others.
LED Indicators (all motor types)	The motor is equipped with 5 Bi-colour LED's: See LED chapter for explanation. LED function depends on installed motor options
Leakage current to earth	Leakage current to earth: Less than 3 mA @ 50/60 Hz
Protection Class	IP55 (standard) or IP66 (extended)
Homing Methods	1: Automatic *Homing* with sensor connected to input (2 formats) 2: Mechanical *Homing* without sensor. (Torque controlled)
Certifications and approvals	Conforms to CE regulations - find EU - Declaration of Conformity in the appendix of the user manual. UL File: Pending
Usage / Storage Temperature and Humidity	Ambient 0 to +40°C (32-104°F)/ Storage (power not applied): -20 to +85°C. (-4 to 185°F). Humidity Max. 90% non-condensing. Temperature shut down and error message generated at 95°C (203°F).

Data in red are under evaluation by JVL's R&D department.

10.1 Technical Data

10.1.2 Individual technical data for each motor size/type

Below are data tables for each individual type and motor size in the MAC motor family generation III.

Data for only MAC404			
Motor data	Motor sub types	**MAC404-M2 to M3** (w/o brake)	**MAC404-M5 to M6** (w/brake)
	Rated output @3000 RPM cont. in rated temp. range	400 W	
	Rated Torque RMS / Peak Torque	1.27 Nm / 3.8 Nm	
	Inertia (kg/cm²)	0.52 kg/cm²	0.54 kg/cm²
	Maximum radial / axial force at motor shaft	Fr 245 / Fa 74 N	
	Length	170 mm ±2 mm	206 mm ±2 mm
	Weight	2 kg	2.4 kg
	Electrical / Mechanical motor time constant	2.03 / 1.23 ms	2.03 / 1.26 ms
Pre-fuse	Recommended rating of the connected pre-fuse in supply	T6.3A@230VAC or T10A@115VAC; if automatic, use class D	
Brake resistor	Regenerative power dump (brake resistor circuit)	Internal 4W average / External output 25A peak	
Brake (optional)	Integrated electromagnetic safety brake	**NO**	**YES** - Holding torque >2 Nm
	Backlash (when brake is activated)	(not relevant)	< ±0.5 degree
	Audible brake noise level (measured at 30 cm distance)	(not relevant)	TBD dB(A)
	Timing: release and activate time	(not relevant)	50 / 20 ms.
Speed range	0-3000RPM with nom. torque. (maximum 4000RPM short-term). Speed protection trips at >4300RPM and the motor will shut down.		
Input power supply	115 or 230VAC (±10%), 47-63Hz for main power circuit. 18-32VDC for control circuit. Inrush current < 5A at 115/230VAC. Consumption at 115-230VAC up to 470W average. See also the power supply chapter, page 27, in this user manual. Control circuitry consumption (typical): MAC404M2 or M3 (wo/brake) = Typical 0.22A @ 24VDC(5.3W). Control circuitry consumption (typical): MAC404M5 or M6 (w/brake) = Typical 0.54A @ 24VDC(13W).		
Flange and shaft	Front flange: 60x60mm. Shaft diameter Ø14mm - see also the chapter "Physical dimensions" in this user manual		

Data for only MAC604			
Motor data	Motor sub types	**MAC604-M2 to M3** (w/o brake)	**MAC604-M5 to M6** (w/brake)
	Rated output @3000 RPM cont. in rated temp. range	600 W	
	Rated Torque RMS / Peak Torque	1.91 Nm / 5.73 Nm	
	Inertia (kg/cm²)	0.84 kg/cm²	0.86 kg/cm²
	Maximum radial / axial force at motor shaft	Fr 245 / Fa 74 N	
	Length	188 mm ±2 mm	224 mm ±2 mm
	Weight	TBD kg	TBD kg
	Electrical / Mechanical motor time constant	4.86 / 1.10 ms	4.86 / 1.15 ms
Pre-fuse	Recommended rating of the connected pre-fuse in supply	T8A@230VAC or T15A@115VAC; if automatic, use class D	
Brake resistor	Regenerative power dump (brake resistor circuit)	Internal 4W average / External output 25A peak	
Brake (optional)	Integrated electromagnetic safety brake	**NO**	**YES** - Holding torque >2 Nm
	Backlash (when brake is activated)	(not relevant)	< ±0.5 degree
	Audible brake noise level (measured at 30 cm distance)	(not relevant)	TBD dB(A)
	Timing: release and activate time	(not relevant)	50 / 20 ms.
Speed range	0-3000RPM with nom. torque. (maximum 3400RPM short-term). Speed protection trips at >3600RPM and the motor will shut down.		
Input power supply	115 or 230VAC (±10%), 47-63Hz for main power circuit. 18-32VDC for control circuit. Inrush current < 5A at 115/230VAC. Consumption at 115-230VAC up to 705W average. See also the power supply chapter, page 27, in this user manual. Control circuitry consumption (typical): MAC604M2 or M3 (wo/brake) = Typical 0.22A @ 24VDC(5.3W). Control circuitry consumption (typical): MAC604M5 or M6 (w/brake) = Typical 0.54A @ 24VDC(13W).		
Flange and shaft	Front flange: 60x60mm. Shaft diameter Ø14mm - see also the chapter "Physical dimensions" in this user manual		

Data for only MAC802			
Motor data	Motor sub types	**MAC802-M2 to M3** (w/o brake)	**MAC802-M5 to M6** (w/brake)
	Rated output @3000 RPM cont. in rated temp. range	750 W	
	Rated Torque RMS / Peak Torque	2.39 Nm / 7.17 Nm	
	Inertia (kg/cm²)	1.36 kg/cm²	TBD kg/cm²
	Maximum radial / axial force at motor shaft	Fr 392 / Fa 147 N	
	Length	157 mm ±2 mm	TBD mm ±2 mm
	Weight	TBD kg	TBD kg
	Electrical / Mechanical motor time constant	2.03 / 1.23 ms	2.03 / 1.26 ms
Pre-fuse	Recommended rating of the connected pre-fuse in supply	T80A@24VDC; if automatic, use class D	
Brake resistor	No internal brake resistor	Use external brake resistor device if needed	
Brake (optional)	Integrated electromagnetic safety brake	**NO**	**YES**
	Backlash (when brake is activated)	(not relevant)	< ±1 degree
	Audible brake noise level (measured at 30 cm distance)	(not relevant)	TBD dB(A)
Speed range	0-3000RPM with nom. torque. (maximum 3400RPM short-term). Speed protection trips at >4000RPM and the motor will shut down.		
Input power supply	12-48VDC for main power circuit. **≥24VDC** is mandatory to run nominal speed and power. Maximum speed will be proportionally reduced with a supply lower than 24VDC. Secondary supply 18-32VDC for the control circuit (terminal CVI). Consumption at 24VDC up to 880W average. See also the power supply chapter, page 27, in this user manual. Control circuitry consumption (typical): MAC802M2 or M3 (wo/brake) = Typical 0.22A @ 24VDC(5.3W). Control circuitry consumption (typical): MAC802M5 or M6 (w/brake) = Typical 0.54A @ 24VDC(13W).		
Flange and shaft	Front: 80x80mm. Shaft diameter Ø19mm - see also the chapter "Physical dimensions" in this user manual		

Data for only MAC804			
Motor data	Motor sub types	**MAC804-M2 to M3** (w/o brake)	**MAC804-M5 to M6** (w/brake)
	Rated output @3000 RPM cont. in rated temp. range	750 W	
	Rated Torque RMS / Peak Torque	2.39 Nm / 7.17 Nm	
	Inertia (kg/cm²)	1.63 kg/cm²	1.73 kg/cm²
	Maximum radial / axial force at motor shaft	Fr 392 / Fa 147 N	
	Length	188 mm ±2 mm	227 mm ±2 mm
	Weight	TBD kg	TBD kg
	Electrical / Mechanical motor time constant	4.6 / 0.96 ms	4.6 / 1.02 ms
Pre-fuse	Recommended rating of the connected pre-fuse in supply	T10A@230VAC or T15A@115VAC; if automatic, use class D	
Brake resistor	Regenerative power dump (brake resistor circuit)	Internal 10W average / External output 40A peak	
Brake (optional)	Integrated electromagnetic safety brake	**NO**	**YES**
	Backlash (when brake is activated)	(not relevant)	< ±1 degree
	Audible brake noise level (measured at 30 cm distance)	(not relevant)	TBD dB(A)
Speed range	0-3000RPM with nom. torque. (maximum 3400RPM short-term). Speed protection trips at >3600RPM and the motor will shut down.		
Input power supply	115 or 230VAC (±10%), 47-63Hz for main power circuit. 18-32VDC for control circuit. Inrush current < 5A at 115/230VAC. Consumption at 115-230VAC up to 880W average. See also the power supply chapter, page 27, in this user manual. Control circuitry consumption (typical): MAC804M2 or M3 (wo/brake) = Typical 0.22A @ 24VDC(5.3W). Control circuitry consumption (typical): MAC804M5 or M6 (w/brake) = Typical 0.54A @ 24VDC(13W).		
Flange and shaft	Front flange: 80x80mm. Shaft diameter Ø19mm - see also the chapter "Physical dimensions" in this user manual		

Data for only MAC1004			
Motor data	Motor sub types	**MAC1004-M2 to M3** (w/o brake)	**MAC1004-M5 to M6** (w/brake)
	Rated output @3000 RPM cont. in rated temp. range	1000 W	
	Rated Torque RMS / Peak Torque	3.18 Nm / 9.55 Nm	
	Inertia (kg/cm²)	1.81kg/cm²	
	Maximum radial / axial force at motor shaft	Fr 392 / Fa 147 N	
	Length	198 mm ±2 mm	
	Weight	3.8 kg	
	Electrical / Mechanical motor time constant	4.44 / 0.94 ms	
Pre-fuse	Recommended rating of the connected pre-fuse in supply	T10A@230VAC or T15A@115VAC; if automatic, use class D	
Brake resistor	Regenerative power dump (brake resistor circuit)	Internal 10W average External output 40A peak	
Brake (optional)	Integrated electromagnetic safety brake	**NO**	
	Backlash (when brake is activated)	(not relevant)	
	Audible brake noise level (measured at 30 cm distance)	(not relevant)	
Speed range	0-3000RPM with nom. torque. (maximum 3400RPM short-term). Speed protection trips at >3600RPM and the motor will shut down.		
Input power supply	115 or 230VAC (±10%), 47-63Hz for main power circuit. 18-32VDC for control circuit. Inrush current < 5A at 115/230VAC. Consumption at 115-230VAC up to 1175W average. See also the power supply chapter, page 27, in this user manual. Control circuitry consumption (typical): MAC1004M2 or M3 (wo/brake) = Typical 0.22A @ 24VDC(5.3W). Control circuitry consumption (typical): MAC1004M5 or M6 (w/brake) = Typical 0.54A @ 24VDC(13W).		
Flange and shaft	Front flange: 80x80mm. Shaft diameter Ø19mm - see also the chapter "Physical dimensions" in this user manual		

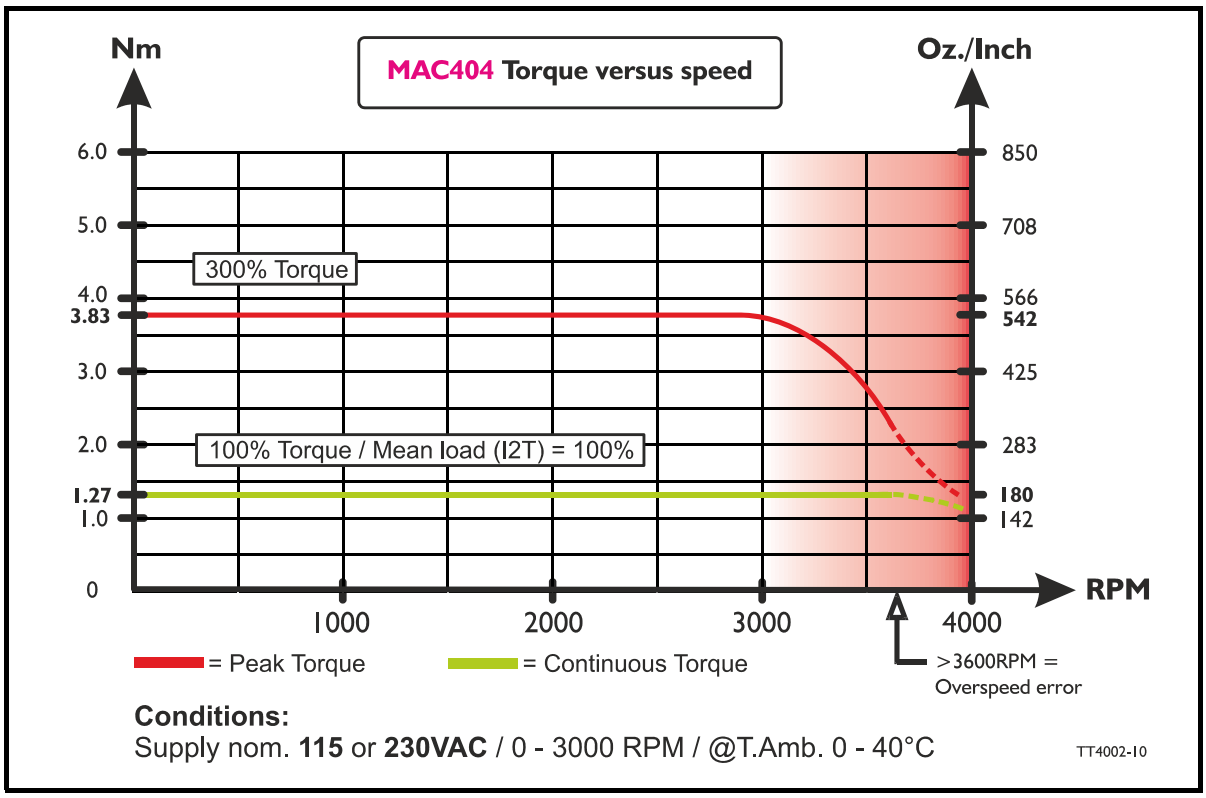
Data for only MAC1202			
Motor data	Motor sub types	**MAC1202-M2 to M3** (w/o brake)	**MAC1202-M5 to M6** (w/brake)
	Rated output @3000 RPM cont. in rated temp. range	1200 W	
	Rated Torque RMS / Peak Torque	3.82 Nm / 11.46 Nm	
	Inertia (kg/cm²)	2.47 kg/cm²	TBD kg/cm²
	Maximum radial / axial force at motor shaft	Fr 392 / Fa 147 N	
	Length	190 mm ±2 mm	224 mm ±2 mm
	Weight	TBD kg	TBD kg
	Electrical / Mechanical motor time constant	9.2 / 0.96ms	9.2 / TBD ms
Pre-fuse	Recommended rating of the connected pre-fuse in supply	T100A@24VDC; if automatic, use class D	
Brake resistor	No internal brake resistor or circuitry	Use external brake resistor device if needed	
Brake (optional)	Integrated electromagnetic safety brake	**NO**	**YES**
	Backlash (when brake is activated)	(not relevant)	< ±1 degree
	Audible brake noise level (measured at 30 cm distance)	(not relevant)	TBD dB(A)
Speed range	0-3000RPM with nom. torque. (maximum 3400RPM short-term). Speed protection trips at >4000RPM and the motor will shut down.		
Input power supply	12-48VDC for main power circuit. **≥24VDC** is mandatory to run nominal speed and power. Maximum speed will be proportionally reduced with a supply lower than 24VDC. Secondary supply 18-32VDC for the control circuit (terminal CVI). Consumption at 24VDC up to 1400W average. See also the power supply chapter, page 27, in this user manual. Control circuitry consumption (typical): MAC1202M2 or M3 (wo/brake) = Typical 0.22A @ 24VDC(5.3W). Control circuitry consumption (typical): MAC1202M5 or M6 (w/brake) = Typical 0.54A @ 24VDC(13W).		
Flange and shaft	Front: 80x80mm. Shaft diameter Ø19mm - see also the chapter "Physical dimensions" in this user manual		

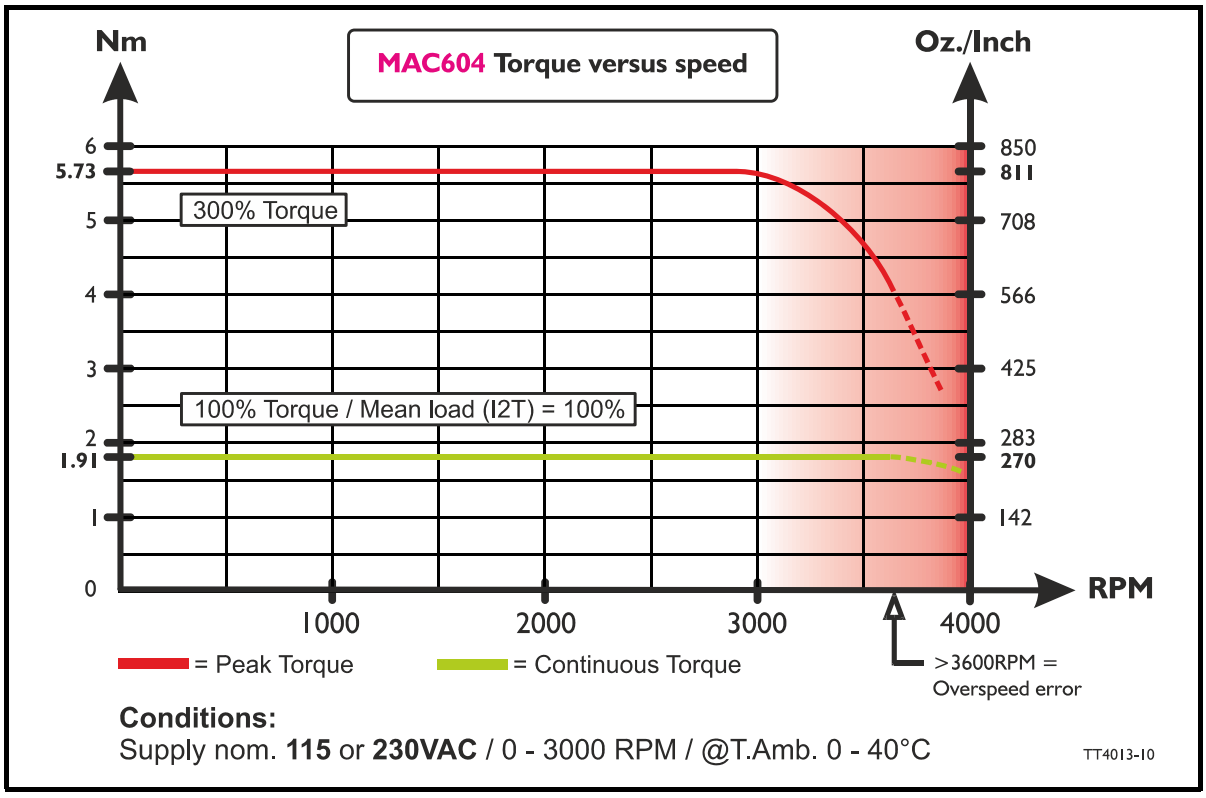
10.1 Technical Data

Data for only MAC1403			
Motor data	Motor sub types	**MAC1403-M2 to M3** (w/o brake)	**MAC1403-M5 to M6** (w/brake)
	Rated output @3000 RPM cont. in rated temp. range	1500 W	
	Rated Torque RMS / Peak Torque	4.78 Nm / 14.33 Nm	
	Inertia (kg/cm²)	3.15 kg/cm²	3.25 kg/cm²
	Maximum radial / axial force at motor shaft	Fr 392 / Fa 147 N	
	Length	200 mm ±2 mm	237 mm ±2 mm
	Weight	4.0 kg	5.1 kg
	Electrical / Mechanical motor time constant	10.3 / 0.85ms	10.3 / TBD ms
Pre-fuse	Recommended rating of the connected pre-fuse in supply	T50A@48VDC; if automatic, use class D	
Brake resistor	No internal brake resistor or circuitry	Use external brake resistor device if needed	
Brake (optional)	Integrated electromagnetic safety brake	**NO**	**YES**
	Backlash (when brake is activated)	(not relevant)	< ±1 degree
	Audible brake noise level (measured at 30 cm distance)	(not relevant)	TBD dB(A)
Speed range	0-3000RPM with nom. torque. (maximum 3400RPM short-term). Speed protection trips at >4000RPM and the motor will shut down.		
Input power supply	12-48VDC for main power circuit. **48VDC** is mandatory to run nominal speed and power. Maximum speed will be proportionally reduced with a supply lower than 48VDC. Secondary supply 18-32VDC for the control circuit (terminal CVI). Consumption at 48VDC up to 1760W average. See also the power supply chapter, page 27, in this user manual. Control circuitry consumption (typical): MAC1403M2 or M3 (wo/brake) = Typical 0.22A @ 24VDC(5.3W). Control circuitry consumption (typical): MAC1403M5 or M6 (w/brake) = Typical 0.54A @ 24VDC(13W).		
Flange and shaft	Front: 80x80mm. Shaft diameter Ø19mm - see also the chapter "Physical dimensions" in this user manual		

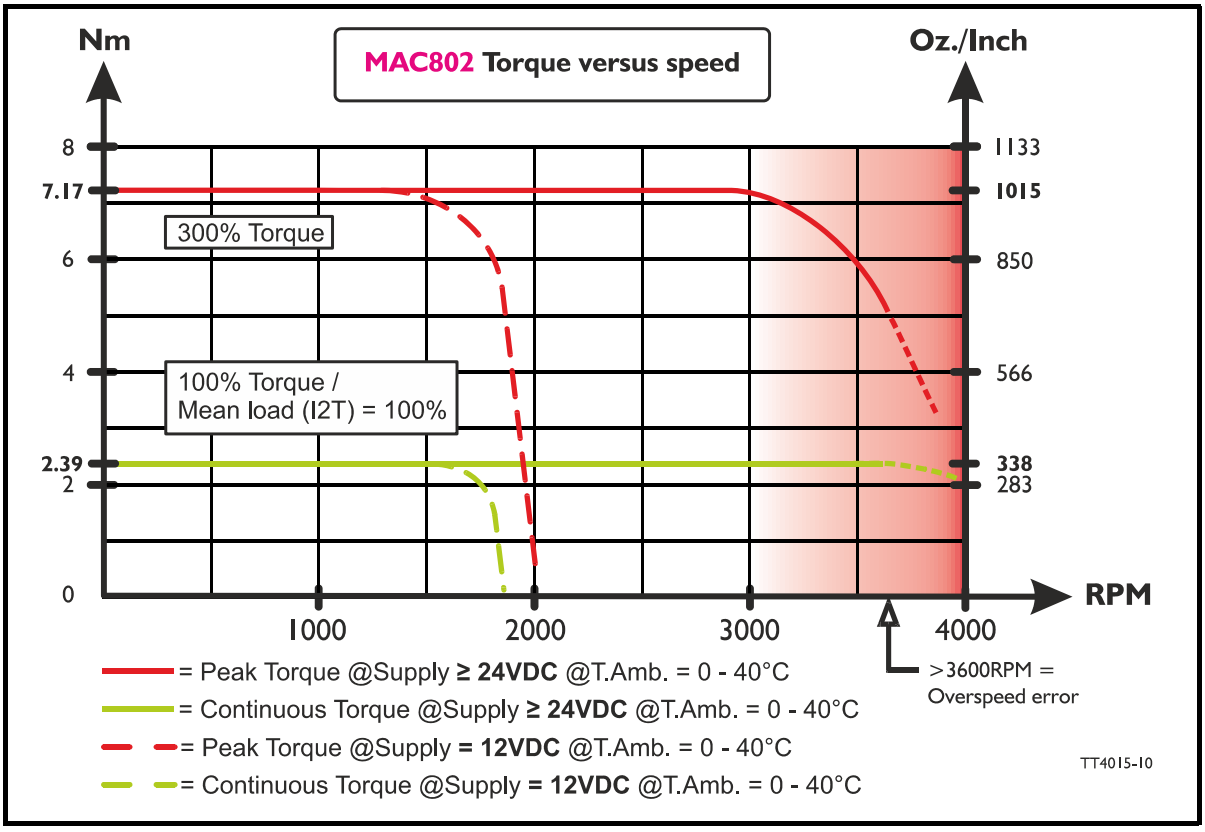
Data for only MAC1404			
Motor data	Motor sub types	**MAC1404-M2 to M3** (w/o brake)	**MAC1404-M5 to M6** (w/brake)
	Rated output @3000 RPM cont. in rated temp. range	1500 W	
	Rated Torque RMS / Peak Torque	4.78 Nm / 14.33 Nm	
	Inertia (kg/cm²)	3.15 kg/cm²	3.25kg/cm²
	Maximum radial / axial force at motor shaft	Fr 335 N/ Fa 167 N	
	Length	231 mm ±2 mm	268 mm ±2 mm
	Weight	TBD kg	TBD kg
	Electrical / Mechanical motor time constant	7.44 / 0.76 ms	7.44 / 0.78 ms
Pre-fuse	Recommended rating of the connected pre-fuse in supply	T12A@230VAC or T20A@115VAC; if automatic, use class D	
Brake resistor	Regenerative power dump (brake resistor circuit)	Internal 10W average / External output 40A peak	
Brake (optional)	Integrated electromagnetic safety brake	**NO**	**YES**
	Backlash (when brake is activated)	(not relevant)	< ±1 degree
	Audible brake noise level (measured at 30 cm distance)	(not relevant)	TBD dB(A)
Speed range	0-3000RPM with nom. torque. (maximum 3400RPM short-term). Speed protection trips at >3600RPM and the motor will shut down.		
Input power supply	115 or 230VAC (±10%), 47-63Hz for main power circuit. 18-32VDC for control circuit. Inrush current < 5A at 115/230VAC. Consumption at 115-230VAC up to 1760W average. See also the power supply chapter, page 27, in this user manual. Control circuitry consumption (typical): MAC1404M2 or M3 (wo/brake) = Typical 0.22A @ 24VDC(5.3W). Control circuitry consumption (typical): MAC1404M5 or M6 (w/brake) = Typical 0.54A @ 24VDC(13W).		
Flange and shaft	Front: 80x80mm. Shaft diameter Ø19mm - see also the chapter "Physical dimensions" in this user manual		

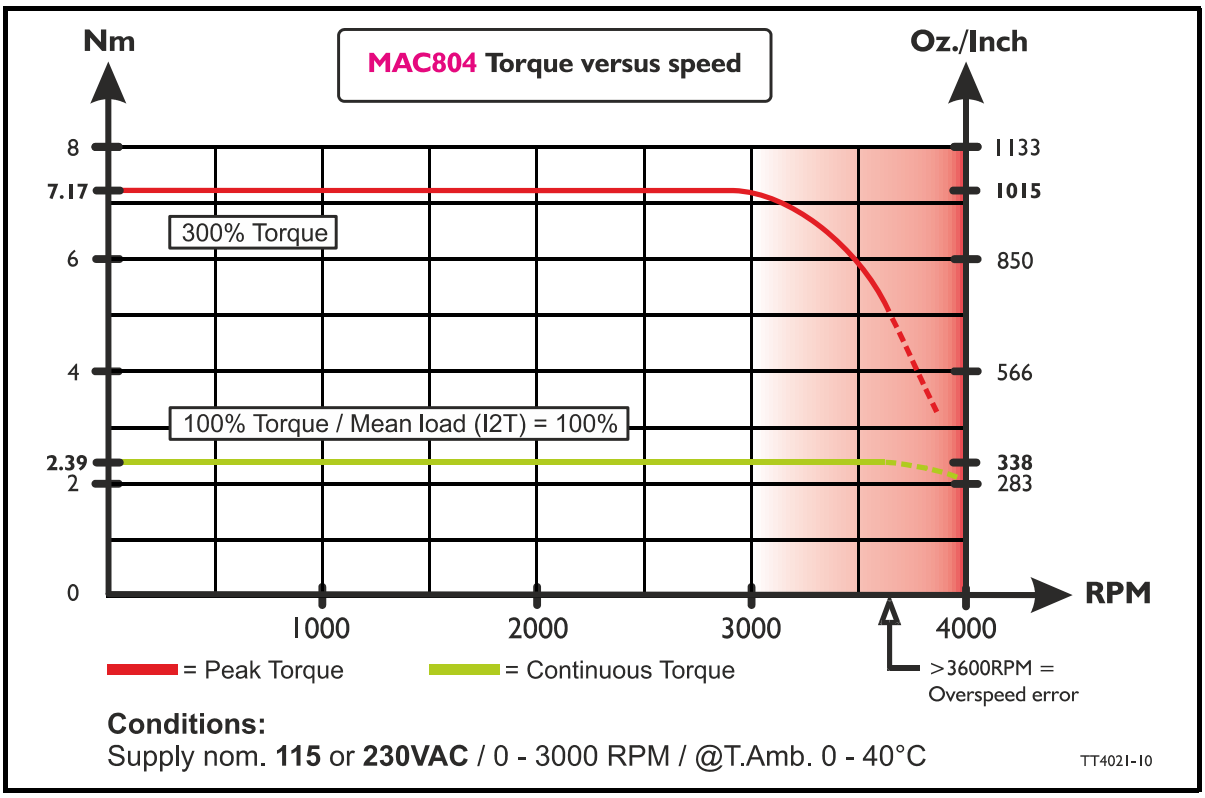
10.2 Torque Performance Curves



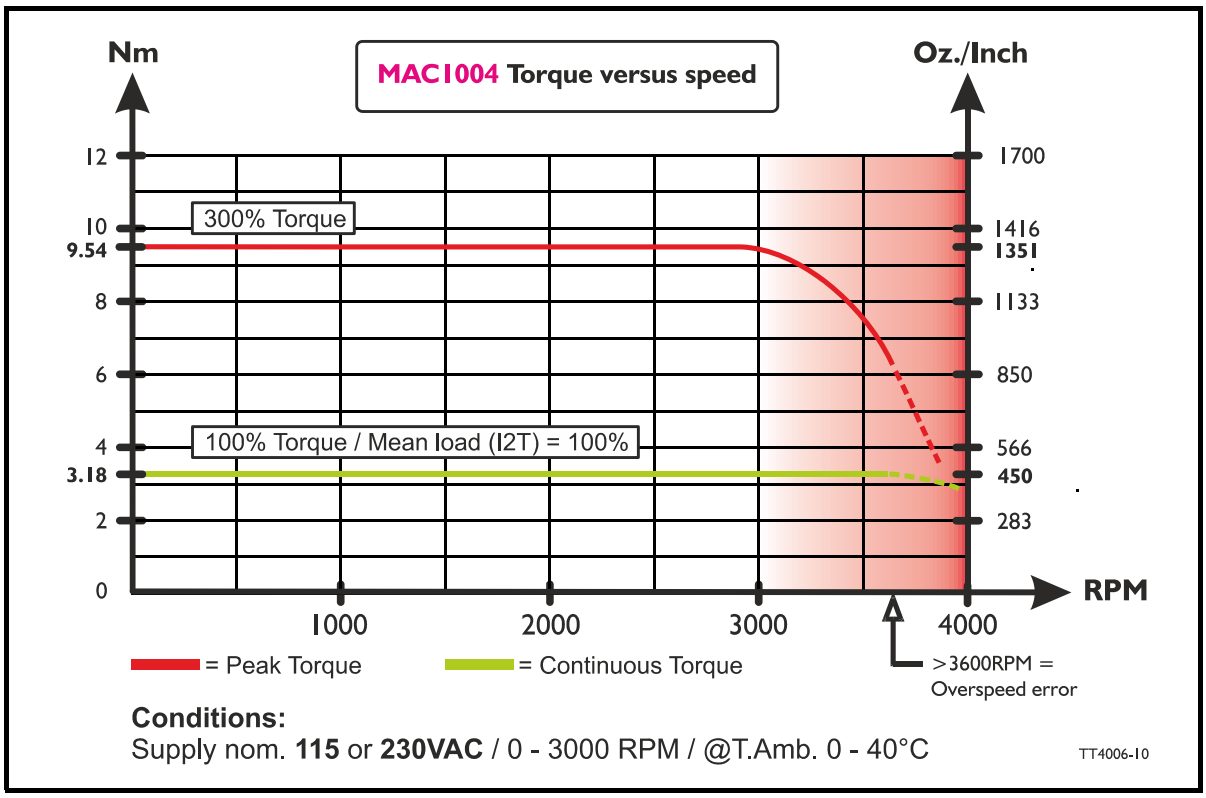


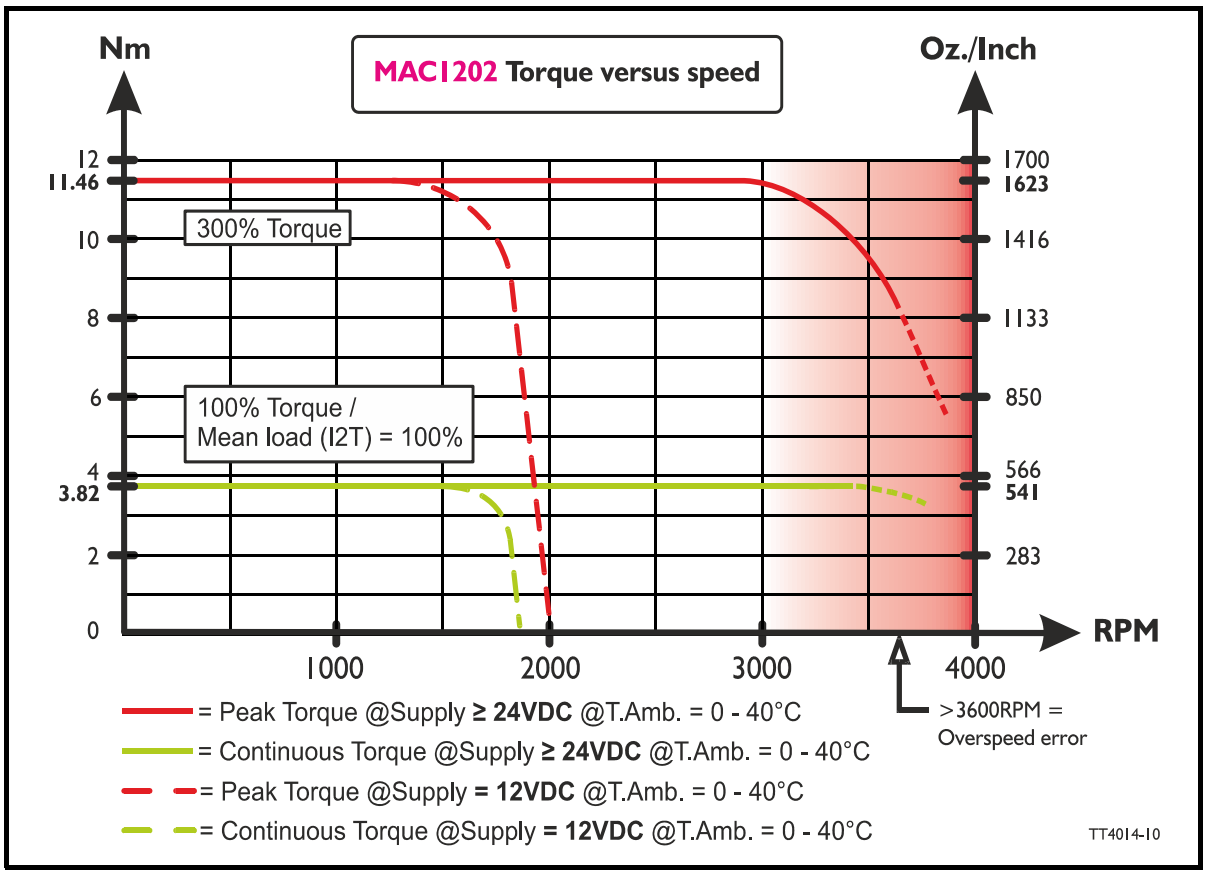
10.2 Torque Performance Curves



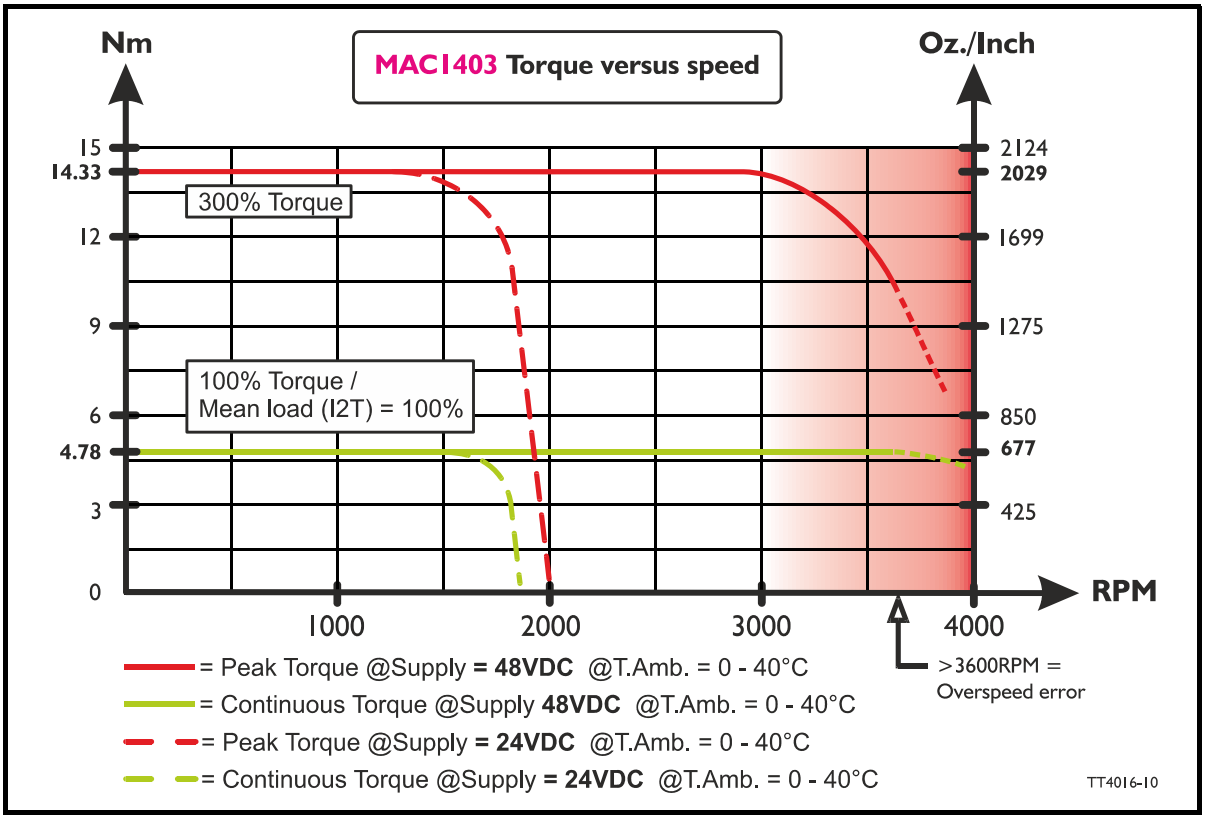


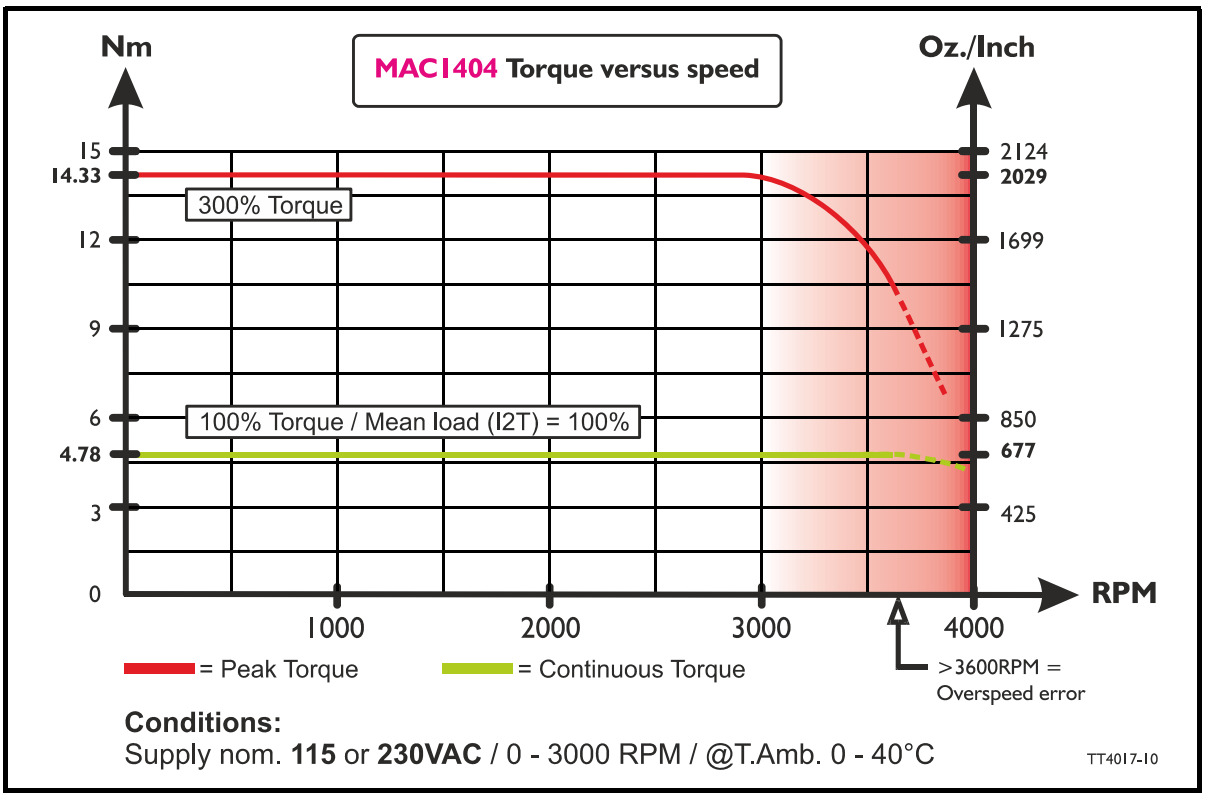
10.2 Torque Performance Curves





10.2 Torque Performance Curves

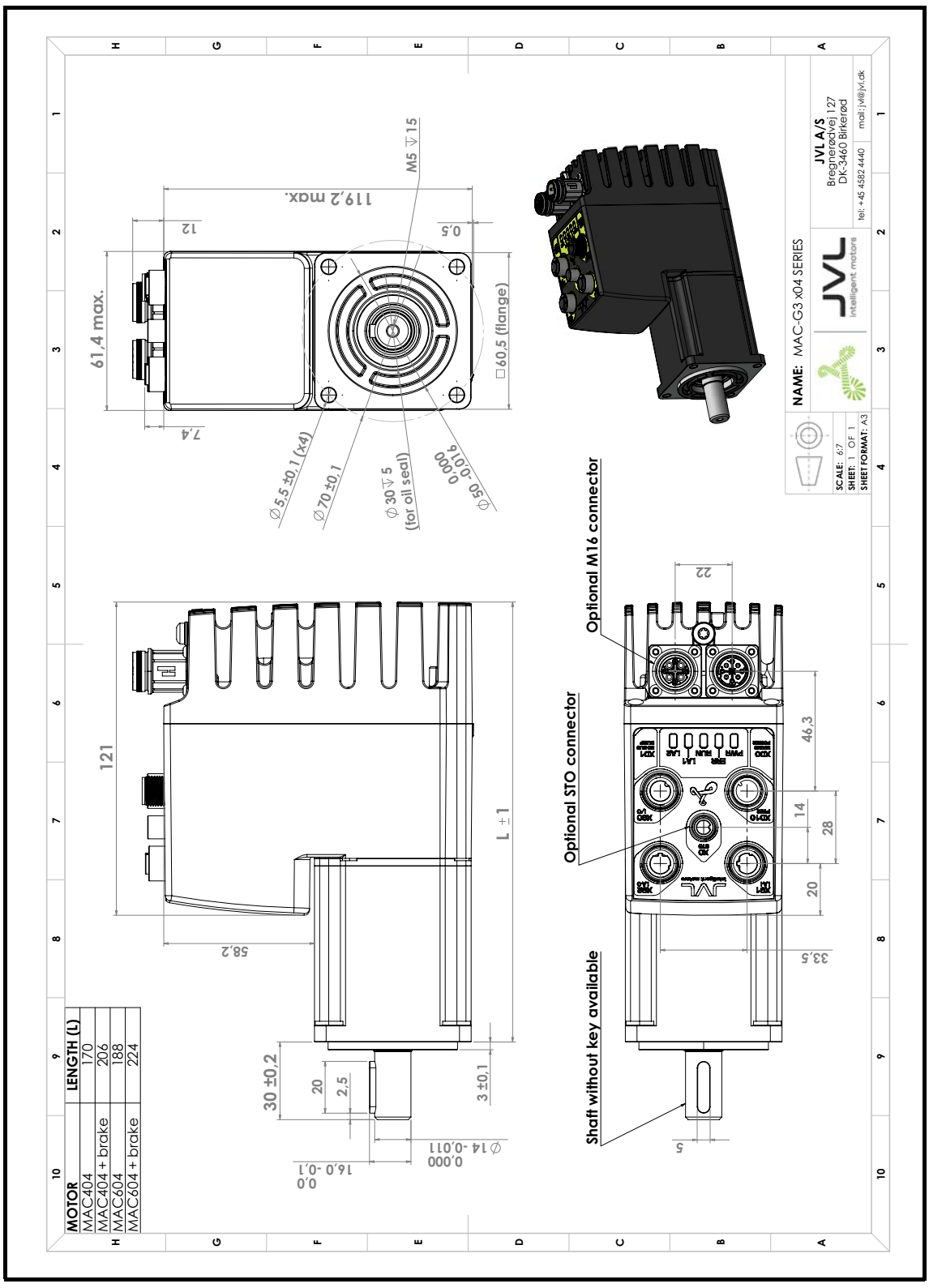




10.3 Physical dimensions

Only MAC404 and 604

10.3.1 MAC404 and MAC604 - Physical dimensions

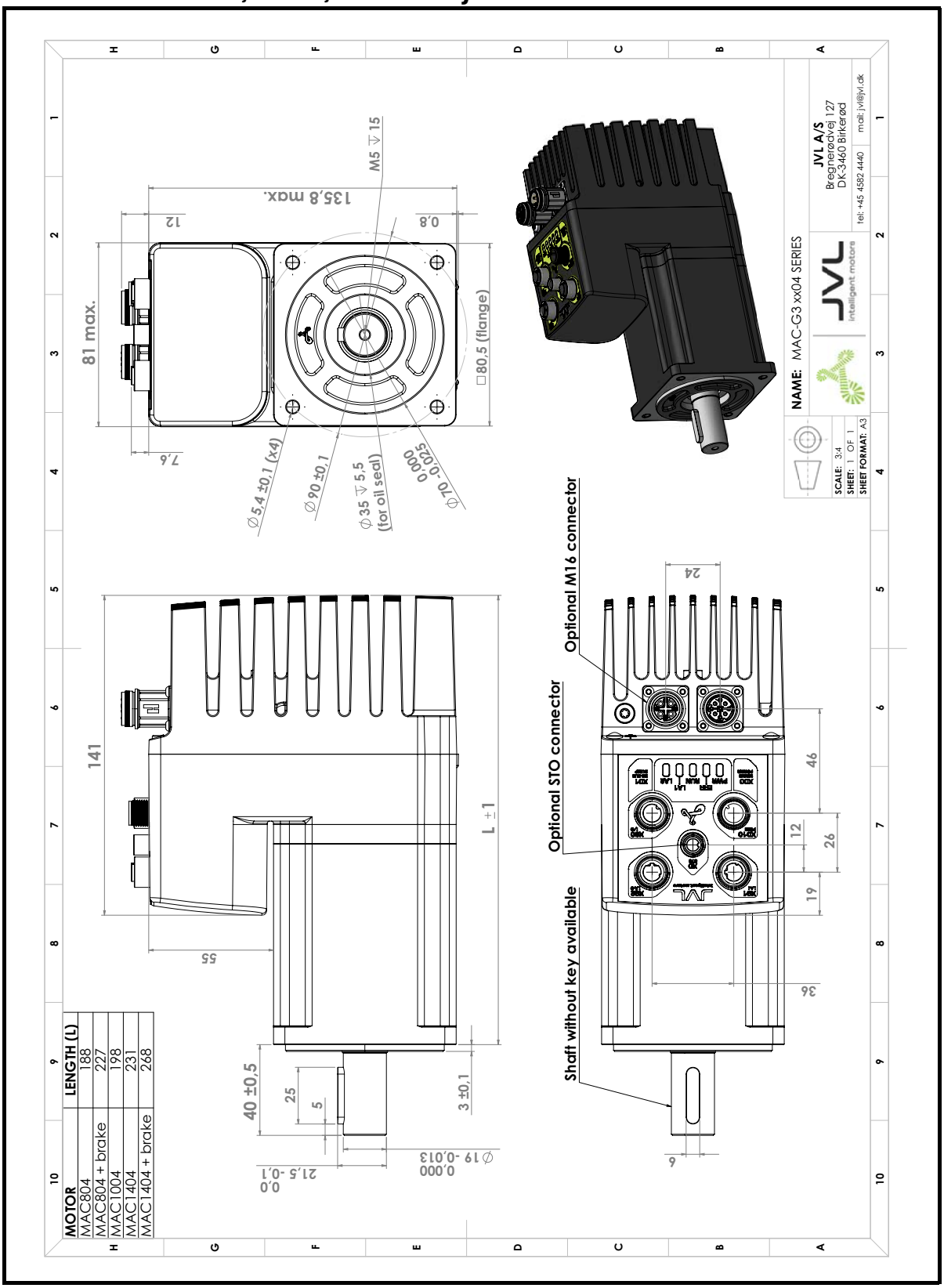


Download CAD drawings from www.jvl.dk/1081/cad-files

10.3 Physical dimensions

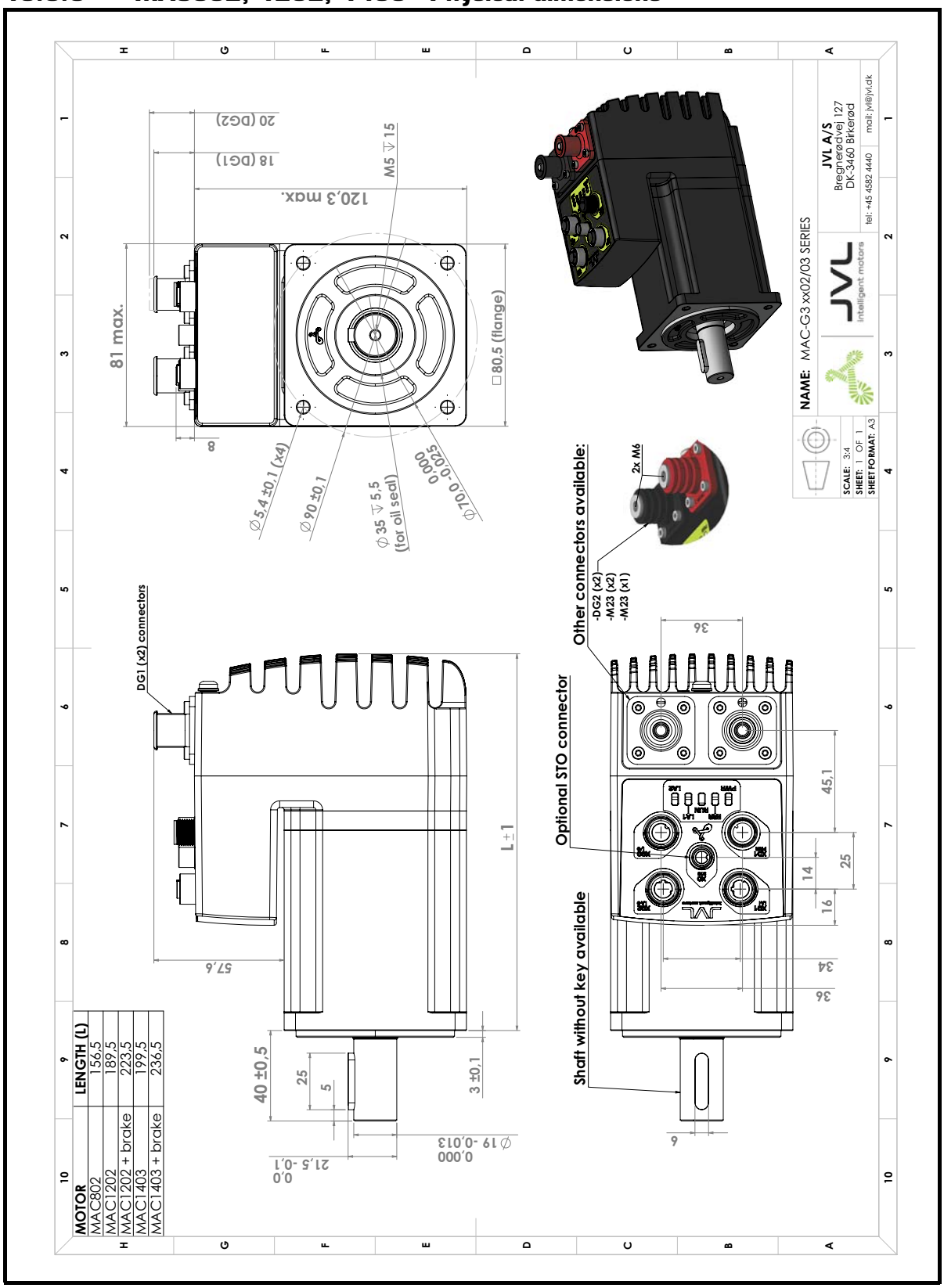
Only MAC08xx and 1xxx

10.3.2 MAC804, 1004, 1404 - Physical dimensions



Download CAD drawings from www.jvl.dk/1081/cad-files

10.3.3 MAC802, 1202, 1403 - Physical dimensions



Download CAD drawings from www.jvl.dk/1081/cad-files

10.4 Installation Instructions

10.4.1 Mounting a gear or a brake at the motor

When a gear or a brake is to be mounted on the front end of a motor, it is very important that this is done in the right way, since a wrong way of mounting may severely reduce the lifetime and performance of the motor and the gear/brake.
Please follow this instruction step by step to ensure that the mounting is done correctly.

1 Step 1 - Make sure that the shaft collar is oriented correctly in order to assure that the right tension around the motor shaft is possible.
Hint: Tighten the shaft collar gently just to keep it in the right position.

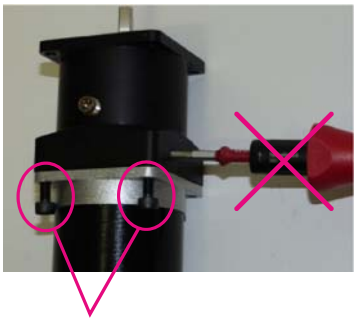


The inner and outer slit is NOT aligned. Make sure they are aligned as shown at right illustration



The inner and outer slit is aligned as they should.

2 Step 2 - Mount the gear or brake at the motor but make sure to fasten the 4 shaft bolt first before fastening the shaft collar.
Its recommended to use Locktite 278 in the threats to make sure that the bolts stay in place.



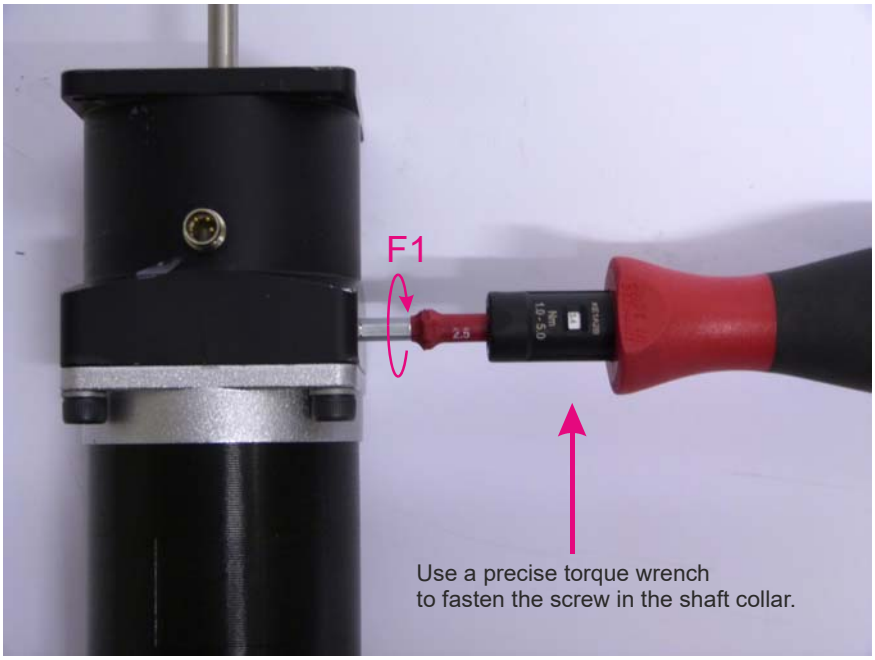
Do NOT tighten the shaft collar before the flange bolts are tightend



Flange bolts properly mounted and tightend.

TT1536-01GB

3 Step 3 - Final stage. Fasten the shaft collar with a torque of according to the scheme below.
Please notice that it can be fatal not to use the specified torque since the shaft may slip over time and cause a position offset.



Gears (Product type to be mounted)

Series	Used with motor type	Tool	Torque (F1)
HTRG05	MAC050 to MAC141 (Ø6.35 shaft)	Hex size 3	5Nm
HTRG05	MIS230-233 (Ø6.35 shaft)	Hex size 3	5Nm
HTRG06	MAC050 to MAC141 (Ø6.35 shaft)	Hex size 3	5Nm
HTRG06	MAC400-402 (Ø14 shaft)	Hex size 3	11Nm
HTRG08	MIS340-341 (Ø9.53 shaft)	Hex size 4	5Nm
HTRG08	MIS342 (Ø14 shaft)	Hex size 5	8Nm
HTRG08	MAC800 (Ø19 shaft)	Hex size 5	11Nm
HTRG10	MAC800 (Ø19 shaft)	Hex size 5	11Nm

Brakes (Product type to be mounted)

Series	Used with motor type	Tool	Torque (F1)
MAB23x	MAC050 to MAC141 (Ø6.35 shaft)	Hex size 2.5	2Nm
MAB23x	MIS230-233 (Ø6.35 shaft)	Hex size 2.5	2Nm
MAB34x	MIS340-341 (Ø9.53 shaft)	Hex size 3	5Nm
			TT1537-01GB

10.4 Installation Instructions

10.4.2 Operation at higher altitudes

Since the air density at higher altitudes is lower, it becomes more difficult for the motor to dissipate the heat losses to the surrounding air.

If the motor is installed at an altitude above 1000m (3281ft), the output power must be de-rated as shown in the table below.

Derating of MAC or MIS motors as function of altitude									
Height above sea level (m)	=< 1000	1500	2000	2500	3000	3500	4000	4500	5000
Height above sea level (ft)	=< 3281	4921	6562	8202	9843	11483	13123	14764	16404
Power rating %	100	96	92	88	84	80	76	72	68

Example:
A MAC404 motor with a nominal power rating of 400W is operating at an altitude of 2500m above sea level.
The power rating at this level is 88%, which means that the nominal power is de-rated to 352W.

Since the heat dissipation in the motor and electronics is primarily influenced by the actual torque, it is recommended to lower the torque to keep within the maximum power. The speed can be kept at the nominal value.

10.4.3 Precautions when installing IPx5/x6/x7 motors

When installing MAC motors with a higher ingress protection (IPx5/x6/x7), a few rules must be respected in order to ensure no ingress over time.

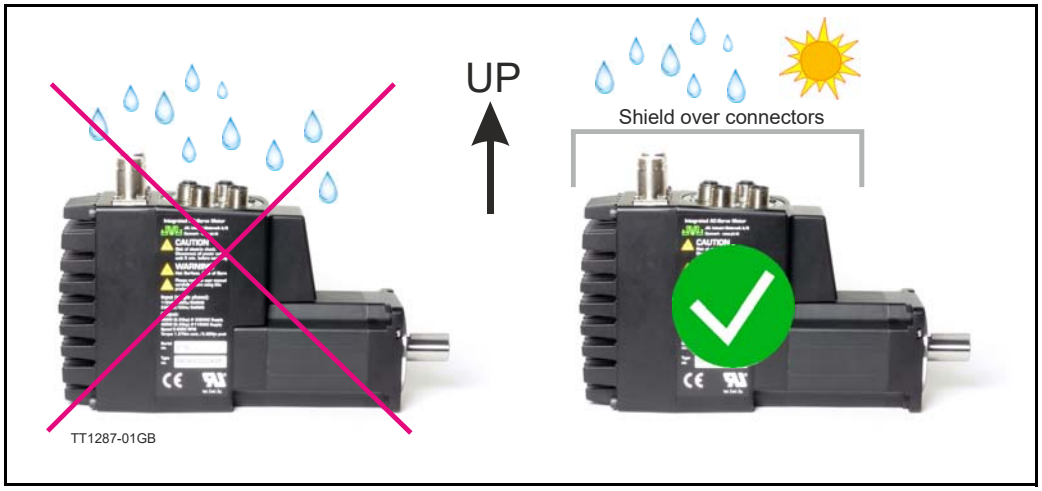


Please notice:
The MAC products are not covered by the warranty if the following rules and guidance are not fully followed.

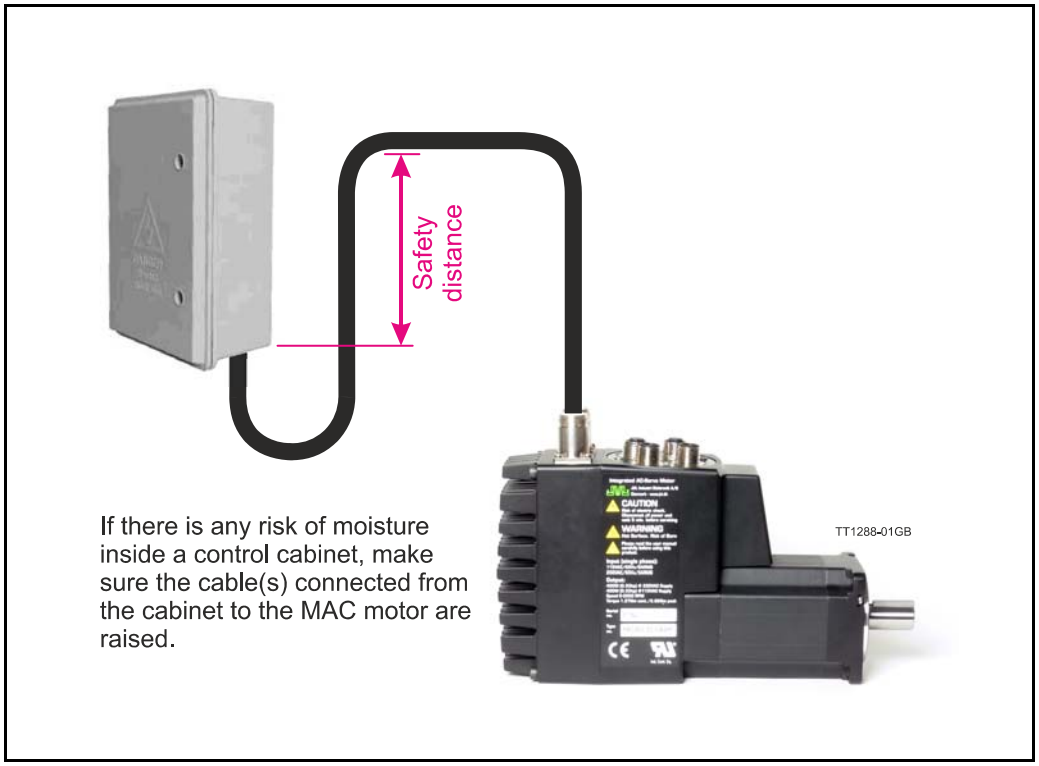
Rule 1 - Connectors
Make sure to tighten all connectors with a sufficiently high torque to make sure that no moisture/liquids can find a way inside the connector.
All circular connectors at the motors, including cables with matching connectors offered by JVL, are guaranteed to be IP67 or higher, but under the condition that they are tightened with a sufficiently high torque.

Make sure to use protective caps at unused connectors. Also make sure that the protective caps are tightened properly.

Rule 2 - Motor mounting orientation in IPx5/x6/x7 applications
It's not recommended to mount the motor with the connectors pointing upwards, since they will be more exposed to moisture that accumulates at the surface and around the connectors and can leak inside the motor over time.
If the actual application requires this mounting orientation, please add a shield/cover over the motor to protect the connectors. Also avoid direct sunlight if mounted outside in open air.



Rule 3 - Cable placement.
In certain environments where the temperature changes fast and often, it may be a problem that moisture condenses inside the cabinet.
Always consider if condensation of moisture or even liquid can be present in the cabinet or similar enclosure from which the cables for the MAC motor are drawn.
If this is considered to be a risk, then always make sure that the cable is routed as shown below, with a point higher than the cabinet bottom, before it connects to the motor to prevent moisture or liquid from flowing inside the cable to the motor connectors.



10.5 Emergency stop considerations

10.5.1 Emergency stop

Fundamental considerations regarding the safety of machines:

In the construction of machines there are several basic requirements that a machine manufacturer or producer must fulfil. It is the machine manufacturer's responsibility to ensure that applicable regulations are fulfilled.

The following presents a broad overview of the applicable regulations in Europe (the EEC). If a machine manufacturer markets its products in other countries, it is the manufacturer's responsibility to ensure compliance with local national regulations.
It cannot therefore be assumed that a machine that is produced in accordance with European requirements will automatically also comply with regulations that are applicable in other markets, even though these are acknowledged in several countries.
The most important European regulation in this context is the Machinery Directive, which in Denmark is implemented via the Danish Working Environment Authority's Executive Order no. 561.

This Executive Order prescribes requirements to ensure that machines are safe, that a technical dossier including a health and safety risk analysis is prepared, and that the machine is supplied together with instructions for use, an EC declaration of conformity and furthermore that the machine is CE marked.
The Essential Health and Safety Requirements are specified in the Directive's appendix 1. To ensure compliance with these requirements, it is advantageous to use various standards, which are described later.

Overall, the most important requirement is to fulfil the Machinery Directive's requirements regarding safety integration, which in brief can be described as follows:

-**1st priority:** The machine's construction must ensure that it is not dangerous.

Example:
The machine construction is such that it is not possible to come into contact with rotating parts or other potentially dangerous components, either during operation, set-up or maintenance.

-**2nd priority**: In cases where it is not always possible to achieve a construction that does not present a potential hazard, additional protective measures must be incorporated to eliminate risk.

Example:
No direct access to rotating or other potentially hazardous parts and components is possible without the removal of a screen, guard, protective cover or other means of protection.

-**3rd priority**: To the extent where a machine construction and the built-in safety measures still leave some potential risk, clear warnings of hazard must be given using signs on the machine itself, and by information in the operation manual and by training if necessary.

It is the risk evaluation of the machine that determines what is necessary to fulfil the essential health and safety requirements of the Machinery Directive and thus also which protective measures are required.
It is also the risk assessment that determines whether an emergency stop function is required.

10.5 Emergency stop considerations

An emergency stop may be omitted only in cases where it is completely evident that an emergency stop would not prevent an injury, minimise an injury or stop an injury.
In practice, this means that essentially all machines must incorporate an emergency stop function.

It must be emphasised that a machine's emergency stop function is NOT a preventive measure, but is regarded as a supplementary measure. This means that the protective measures that must be implemented as a result of the machine's risk assessment cannot be replaced by an emergency stop function.

The protective measures required must be implemented such that they are reliable, i.e. not themselves prone to error or failure. The extent to which this is required depends on the risk that the actual protective measure is designed to eliminate, i.e. the greater the hazard, the more secure and reliable the protective measure.

Protective measures and the emergency stop function are often implemented using the machine's electrical control system.

For guidelines on how the control system's safety related components can be implemented, related standards can be used.

10.5 Emergency stop considerations

10.5.2 EN 60204-1

DS/EN 60204-1 is applicable for the general requirements of a machine's electrical systems.
This standard defines several stop categories, paragraph 9.2.2 Stop functions in DS/EN 60204-1

There are three categories of stop function as follows:

-Stop category 0: stopping by immediate removal of power to the machine actuators (i.e. an uncontrolled stop – paragraph 3.56 in DS/EN 60204-1).

-Stop category 1: a controlled stop (paragraph 3.11 in DS/EN60204-1) with power available to the machine actuators to achieve the stop and then removal of power when the stop is achieved.

-Stop category 2: a controlled stop with power left available to the machine actuators.

Requirements are given that a stop function must be incorporated (paragraph 9.2.5.3 Stop in DS/EN 60204-1)

Stop category 0 and/or category 1 and/or category 2 stop functions shall be provided as indicated by the risk assessment and the functional requirements of the machine (paragraph 4.1 in DS/EN 60204-1).

NOTE: The supply disconnecting device (paragraph 5.3 in DS/EN 60204-1) when operated achieves a stop category 0. Stop functions shall override related start functions (see §9.2.5.2 in DS/EN 60204-1).

Similarly, requirements are specified for the implementation of an emergency stop function:

Paragraph 9.2.5.4.2 Emergency stop (DS/EN 60204-1)

Principles for the design of emergency stop equipment, including functional aspects, are given in ISO 13850.
The emergency stop shall function either as a category 0 or as a category 1 stop (paragraph 9.2.2 in DS/EN 60204-1). The choice of the stop category of the emergency stop depends on the results of a risk assessment of the machine.
In addition to the requirements for stop functions (paragraph 9.2.5.3 in DS/EN 60204-1), the emergency stop function has the following requirements:

-it shall override all other functions and operations in all modes.
-power to the machine actuators that can cause a hazardous situation(s) shall be either removed immediately (category 0 stop) or shall be controlled in such a way to stop the hazardous motion as quickly as possible (stop category 1) without creating other hazards.
-reset shall not initiate a restart.

Considerations are also given regarding the safety and reliability of control circuits:

10.5 Emergency stop considerations

10.5.3 Control functions in the event of failure

Where failures or disturbances in the electrical equipment can cause a hazardous situation or damage to the machine or to the work in progress, appropriate measures shall be taken to minimise the probability of the occurrence of such failure or disturbances. The required measures and the extent to which they are implemented, either individually or in combination, depend on the level of risk associated with the respective application (paragraph 4.1 in DS/EN 60204-1).
The electrical control circuits shall have an appropriate level of safety performance that has been determined from the risk assessment at the machine. The requirements of IEC 62061 and/or ISO 13849-1:1999, ISO 13849-2:2003 shall apply.

Measures to reduce those risks include, but are not limited to:

-Protective devices on the machine (for example, interlocks, guards, trip devices),
-Protective interlocking of the electrical circuit,
-use of proven circuit techniques and components (paragraph 9.4.2.1 in DS/EN 60204-1)
-provision of partial or complete redundancy (paragraph 9.4.2.2 in DS/EN 60204-1) or diversity (paragraph 9.4.2.3 in DS/EN 60204-1),
-Provision for functional tests (paragraph 9.4.2.4 in DS/EN 60204-1).

As noted, reference is made to several other standards, which describe how safety related parts of the control system can be implemented.

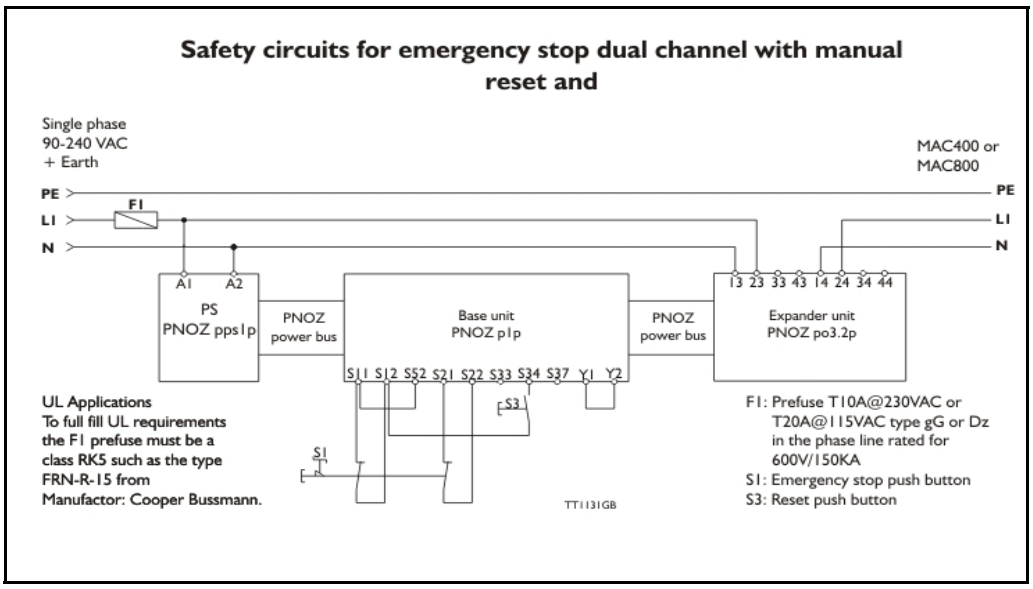
In practice, DS/EN 954-1 can be used, although this has since been superseded by DS/EN ISO 13849-1. The principles of both standards are the same: to first determine the required level of safety and reliability of the control circuits and thereafter design the safety related components of the control system to achieve the required level.

In DS/EN 954-1, the architecture of the safety related circuits is used exclusively as the goal for the level of safety. The standard prescribes 5 categories: B, 1, 2, 3, and 4, where B represents the lowest level and 4 the highest.
DS/EN ISO 13849-1 utilises another criterion for safety level called "Performance level" - PL – in which both the architecture and the component's failure rate are included. 5 PL levels are defined: a, b, c, d, and e, where a represents the lowest level and e the highest. If DS/EN ISO 13849-1 is used, information regarding the components' failure rates (MTTF – mean time to failure) must be obtained from the component manufacturer.

For a more detailed description of the principles and requirements above, see the relevant standards.

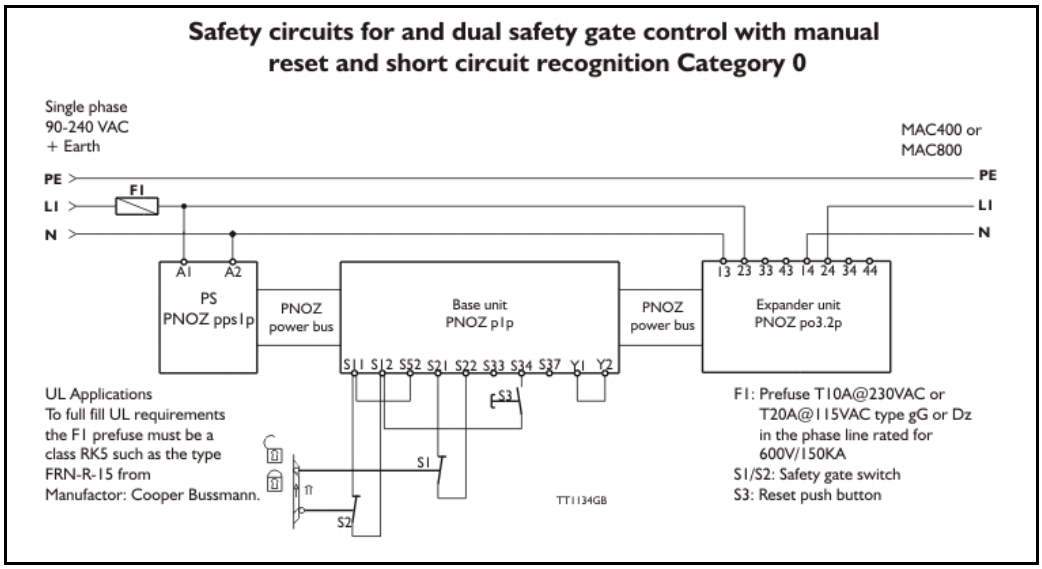
The following drawings illustrate examples of the design of safety circuits for an emergency stop and enclosure system, stop category 0, which fulfils the requirements of category 4 in accordance with DS/EN 954-1.

10.5 Emergency stop considerations



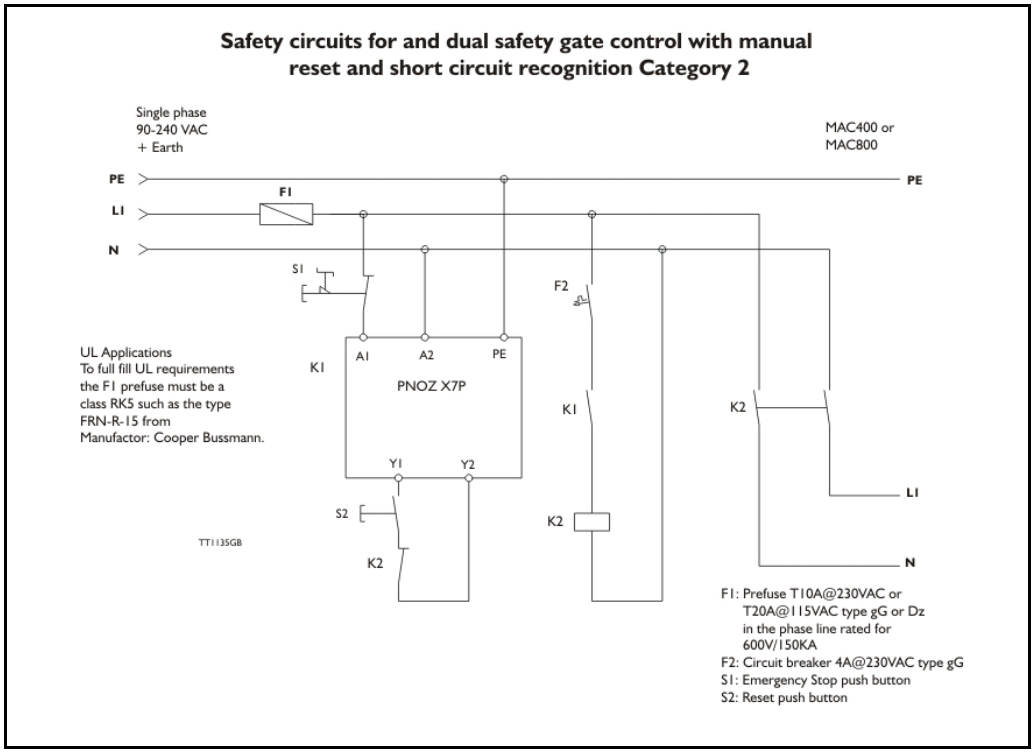
The achievable PL level in accordance with DS/EN ISO 13849 will depend on the MTTF of the components used; using the solutions shown, typically a minimum PL level d would be achieved.

The enclosure system shown utilises a manual reset, which is a requirement if personnel may be located inside the enclosure. If this is not the case, an automatic reset can be used.



In the case of rotating parts in particular, it may be necessary to take component run-down into account, and therefore it is essential to ensure that access cannot be obtained to hazardous areas until the rotating part has come to a standstill. Alternatively, the enclosure can be equipped with an electro-mechanical lock that only allows the enclosure to be opened when the rotational movement has stopped. The latter solution must be implemented with the same levels of safety as those prescribed by the machine's risk assessment of the guard device implemented.

10.5 Emergency stop considerations



The examples shown are implemented using equipment from the company Pilz, and have been chosen to provide as simple cabling as possible. Other components and solutions can of course be used.

In the construction of the machine and its safety control systems, efforts should always be made to achieve solutions that keep the safety requirements placed on the control system as low as possible, in accordance with the principles of safety integration mentioned above.

10.6 Trouble-shooting guide

Trouble-shooting is covered by the separate guide LA0023 - Troubleshooting for MIS and MAC - which is continuously updated with the most recent known issues and their solutions.

Download the guide from the JVL website: Trouble-shooting guide LA0023 - www.jvl.dk/416/user-manuals

10.7 Registers

10.7.1 Internal registers in the MAC motors

www.jvl.dk/register.html?register=MACmotor

In order to control the operation of the motor, a large number of registers exist. These are accessible via the serial communication channels or via the built-in industrial Ethernet interface.

MacTalk also has access to most of these registers. MacTalk offers a more user-friendly and easy-to-understand interface.

It may, however, be necessary to access the registers directly, for example in systems using one of the industrial Ethernet protocols. For this purpose, one can use the register list.

NOTE: All motor registers are documented in detail in the online register overview: www.jvl.dk/register.html?register=MACmotor

10.7 Registers

10.8 Accessories

The following accessories are available for the MAC motor series.

Accessories:

Built in brake	Gear	Junction box	Test box	
IP Protection option: 5 and 6	HTRG08..P701..	WI1302-2AM17T01NMB	PA0162	
				
	see assembly order codes here			

Commissioning

Communication software	USB to RS485 / RS422 / RS232 converter			
MacTalk	RS485-USB-M12M5M8M17			
				
	USB to M12 5pin / 8 pin / 17 pin male			

Communication Cables

Logic Power	Ethernet	Ethernet daisychain	I/O	
WI1000-M12F5TxxN	WI1046-M12M4TxxTRJ45	WI1046-M12M4TM4TxxT	WI1009-M12M17TxxN	
				
xx: available options are 05 and 20 (meter)	xx: available options are 05 and 20 (meter)	xx: available options are 05 and 20 (meter)	For 17 pin connector	

Power supply

Switch Mode Power Supply [P+]	Motor Power 230VAC	Power Dump Cables		
PSU024-0120S1X2AAD1A	WP0402	WP0102		
				
	2 meter default, other lengths are available	2 meter default, other lengths are available		

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Please see www.jvl.dk using this link: www.jvl.dk/1365/mac804-1004-1404

10.9 Vibration and shock certificates

10.9.1 Vibration test at MAC404 and 1004

4 Test and results

4.1 Vibration - Sinusoidal

Test Method & specification

IEC 60068-2-6:2007, Test Fc: Vibration (sinusoidal).

Severity

Frequency range	:	2 - 500 Hz		
Frequency / amplitude	:	2 – 25 Hz	:	±1.6 mm
		25 - 500 Hz	:	±4.0 g
Sweep rate	:	Max. 1 octave/min.		
Number of sweeps	:	10 sweep cycles per axis.		
Number of axes	:	3 mutually perpendicular		

Procedure

The test object is energised and in normal operational mode during the exposure.

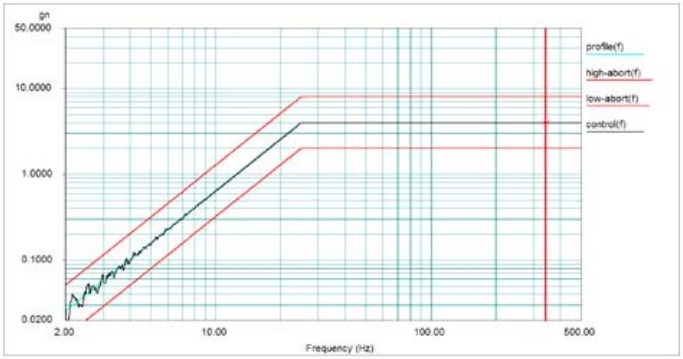
A visual inspection is performed after the exposure.

Accelerometers are placed on the test objects in order to measure the response of the test objects.

Results

No malfunction was observed during the exposure and the function of the test objects was OK during and after the exposure. No mechanical damages were observed during the visual inspection performed after the exposure.

Exposure curves and photos of the test setup are enclosed below





Curve 1 *Sweep, Z-axis. Similar in all axes and all sweeps.*

10.9 Vibration and shock certificates

10.9.2 Shock test at MAC404 and 1004

4.2 Shock

Test method & specification

IEC 60068-2-27:2008, Test Ea: Shock.

Severity

Pulse shape	:	Half-sine
Peak acceleration	:	15 g
Pulse duration	:	30 ms
Shocks per direction	:	1000
Number of directions	:	6 (± x, ± y, ± z)

Procedure

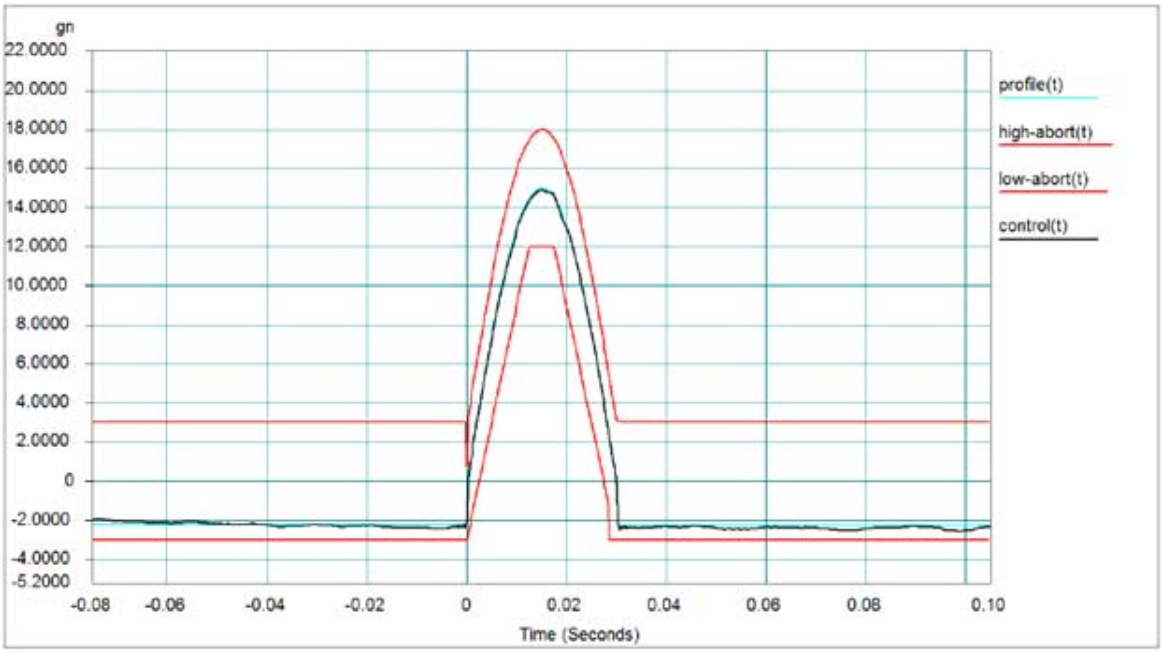
The test object is energised and in normal operational mode during the exposures. A functional test is performed after the exposure.

A visual inspection is performed after the exposure.

Results

No malfunction was observed during the exposure and the function of the test objects was OK during and after the exposure. No mechanical damages were observed during the visual inspection performed after the exposure.

Exposure curves are enclosed below. For photos of the test setup, see section 4.1.



Curve 14 Positive shock, e.g. z-axis, similar in all axes.

10.10 CE Declaration of Conformity

EU - Declaration of Conformity

Manufacturer

Company Name:	JVL A/S
Address:	Bregnerødvej 127, DK-3460 Birkerød Denmark
Telephone:	+45 45 82 44 40
E-mail:	jvl@jvl.dk
Web:	www.jvl.dk

Hereby declares declares, under our sole responsibility, that:

Product

No.:	MAC802, 1202, 1403
Name:	Integrated AC Servo Motor
Type:	Series M1 to M9 with power conn. type 0 to 9
Sub-types:	With connectivity Ex, Qx og Dx and/or STO

- is in conformity with:

DIRECTIVE 2014/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility

and

DIRECTIVE 2014/35/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits

- is manufactured in accordance with the following standards:

EN 61800-3:2004 with A1:2012 - Adjustable Speed Electrical Power Drive Systems - Part 3: EMC requirements and specific test methods

EN 61800-5-1:2007 with A1:2017 and A11:2021 - Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy

Birkerød 16.th. July 2025

Bo V. Jessen
Technical Director
JVL A/S

LX0070-01GB

10.10 CE Declaration of Conformity

EU - Declaration of Conformity

Manufacturer

Company Name:	JVL A/S
Address:	Bregnerødvej 127, DK-3460 Birkerød Denmark
Telephone:	+45 45 82 44 40
E-mail:	jvl@jvl.dk
Web:	www.jvl.dk

Hereby declares declares, under our sole responsibility, that:

Product

No.:	MAC404, 604, 804, 1004, 1504
Name:	Integrated AC Servo Motor
Type:	Series M1 to M9 with power conn. type 0 to 9
Sub-types:	With connectivity Ex, Qx og Dx and/or STO

- is in conformity with:

DIRECTIVE 2014/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility

and

DIRECTIVE 2014/35/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits

- is manufactured in accordance with the following standards:

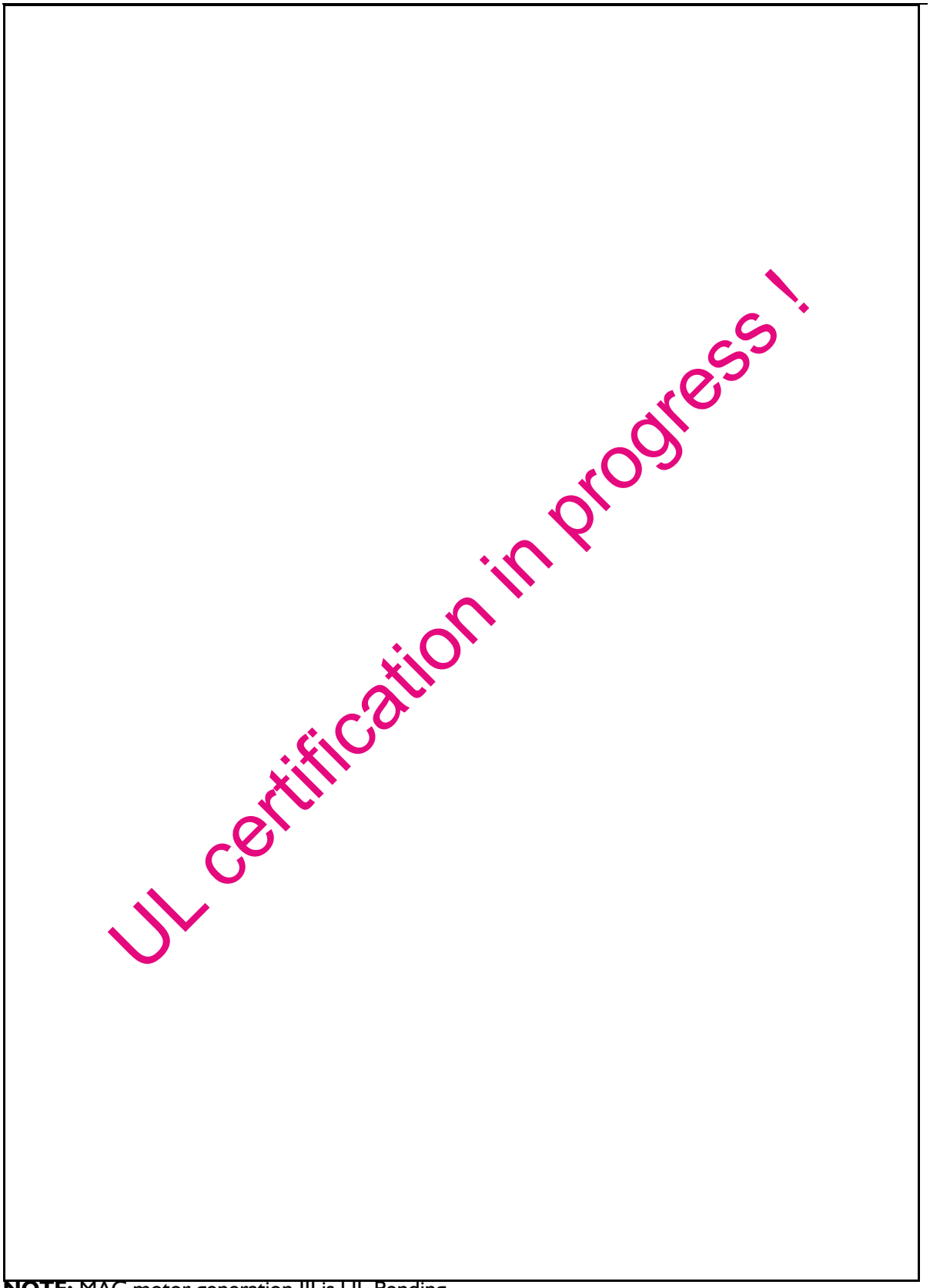
EN 61800-3:2004 with A1:2012 - Adjustable Speed Electrical Power Drive Systems - Part 3: EMC requirements and specific test methods
EN 61800-5-1:2007 with A1:2017 and A11:2021 - Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy

Birkerød 16.th. July 2025

Bo V. Jessen
Technical Director
JVL A/S

LX0065-02GB

10.11 UL Certificate of Compliance



NOTE: MAC motor generation III is UL Pending.