TECHLINE®
IMPROVING FLEXIBILITY

Modbus TCP/IP
User Manual v1.0

LINAK®
WE IMPROVE YOUR LIFE

Contents

Preface

Dear User,

We are delighted that you have chosen a LINAK® product.

LINAK systems are high-tech products based on many years of experience in the manufacturing and development of actuators, electric control boxes, controls, batteries, accessories and chargers.

This User Manual does not address the end user. It is intended as a source of information for the equipment or system manufacturer only, and it will tell you how to install, use and maintain your LINAK electronics. The manufacturer of the end product has the responsibility to provide a User Manual, where relevant safety information from this manual is passed on to the end user.

We are convinced that your LINAK product/system will give you many years of problem-free operation.

Before our products leave the factory, they undergo full function and quality testing. Should you, nevertheless, experience problems with your product/system, you are always welcome to contact your supplier.

LINAK subsidiaries and some distributors situated all over the world have authorised service centres, which are always ready to help you. Locate your local contact information on the back page.

LINAK provides a warranty on all products. (See warranty section)

This warranty, however, is subject to correct use in accordance with the specifications, maintenance being done correctly, and any repairs being carried out at a service centre, which is authorised to repair LINAK products.

Changes in installation and use of LINAK systems can affect their operation and durability. The products may only be opened by authorised personnel.

This User Manual has been written based on the present technical knowledge. LINAK reserves the right to carry out technical modifications and keeps the associated information updated.

LINAK A/S

LINAK® application policy

The purpose of the application policy is to define areas of responsibilities in relation to applying a LINAK product defined as hardware, software, technical advice, et cetera related to an existing or a new customer application.

LINAK products as defined above are applicable for a wide range of applications within Medical, Furniture, Desk, and Industry areas. Yet, LINAK cannot know all the conditions under which LINAK products will be installed, used, and operated, as each individual application is unique.

The suitability and functionality of the LINAK product and its performance under varying conditions (application, vibration, load, humidity, temperature, frequency, et cetera) can only be verified by testing, and shall ultimately be the responsibility of the LINAK customer using any LINAK product.

LINAK shall be responsible solely that LINAK products comply with the specifications set out by LINAK and it shall be the responsibility of the LINAK customer to ensure that the specific LINAK product can be used for the application in question.

About LINAK® Modbus TCP/IP actuators

Summary

This document describes the capabilities of LINAK TECHLINE® Modbus TCP/IP components and the requirements for controlling these. It specifies the technologies involved, the environmental data specification and the functional description. In addition to full position control, the Modbus TCP/IP actuator can provide feedback information about the position, service data and full diagnostics. It also provides system identification data and information about actual current at runtime.

LINAK TECHLINE Modbus TCP/IP actuators are primarily designed with focus on industrial automation according to the following documents:

- Modbus Messaging on TCP/IP Implementation Guide V1.0b
- Modbus Application Protocol V1.1b3

The communication protocol relies on the IEEE 802.3-2018 Ethernet standard. The contents of this document assume that the reader is familiar with this standard.

Commands

Run in/out

Inwards and outwards movement is performed by sending the proper packages. In Service mode, movement is achieved by using the LINAK® Actuator Connect™ PC software or by applying the proper signals to the manual run wires. When using manual run, a start-up delay of up to 200 ms must be expected during the initial run due to safety measures.

Position

Max./min. position: Stroke length

Level setting steps: 0.1 mm

- Load, ramping and specific actuator spindle and gear type should be taken into account in regards to accuracy
- The Position SetPoint can be set dynamically, meaning that it can be done while the actuator is in motion
- If the new SetPoint involves a change in running direction, the ramps will follow the pre-set ramp time

Maximum current in/out

Applying a current limit will induce a degree of mechanical overload protection to the installation.

Max. current limit: Fixed limit*

Level setting steps: 0.25 A

*The custom current limit setting cannot overrule the fixed factory setting, which ensures partial protection of the electronics and mechanics. For further details, see the section: "Internal Monitoring"

Speed control

The speed is controlled using Pulse Width Modulation (PWM).

Min. PWM duty cycle: 0%
Max. PWM duty cycle: 100%
Level setting steps: 0.5%

The ramp up and ramp down time ensures a smoother operation. Its duration depends on the speed with which the actuator runs; for example, if the actuator runs with 50% speed, the ramp time will be 50% of the ramp time for full speed, as displayed in Figure 1.

The speed setting can be changed dynamically during operation.

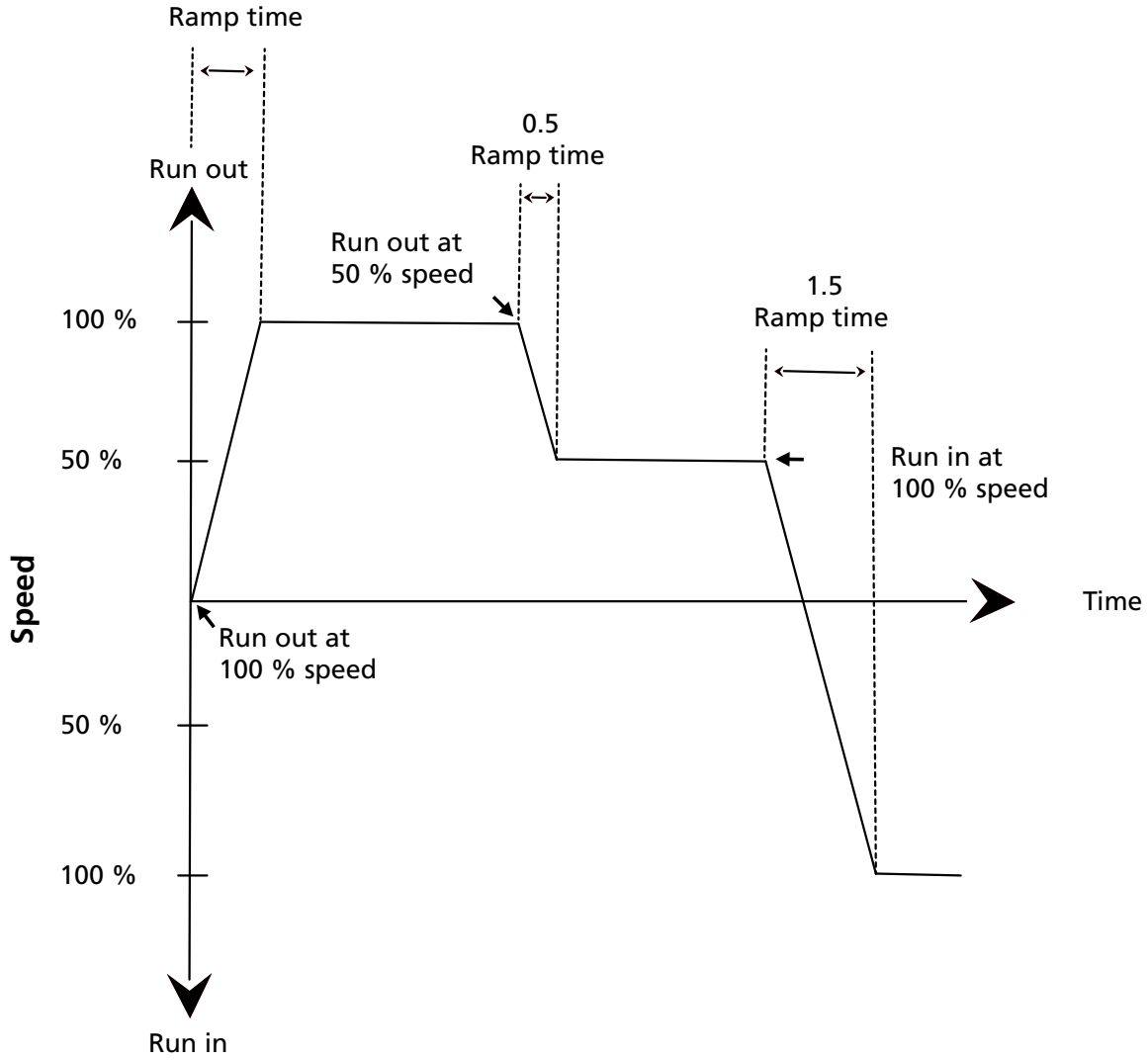

Figure 1. Speed Control Graphics

Internal monitoring

A number of parameters are monitored during operation to prevent overloading the electronics and to minimise the risk of mechanical damage.

Voltage

The supply voltage level is monitored in order to maintain a safe operation and to protect the circuitry.

Overvoltage

If the voltage rises above the set limit, the system will enter overvoltage protection mode and shut down.

Temperature

Two temperature monitoring circuits are in place to measure the absolute temperature of the board and the centre temperature of the H-bridge.

H-bridge

The H-bridge conditions are monitored at all times. Several conditions are required in order to run.

Among these are:

- Correct voltage supplies
- Heartbeat safety signal
- Correct temperatures
- No errors

Parameters

In addition to the immediate monitoring, a number of parameters are stored for long-term evaluation.

These include:

- Number of starts in either direction
- Reason for last stop
- Total running time
- Under- and overvoltage
- Maximum current
- Number of current overloads in either direction

These parameters will help an engineer sort out potential issues. By considering a combination of parameter values, the lifetime load can indicate a possible failure before it happens and thereby prevent downtime.

The current limiting algorithm

Current regulation involves limiting the current consumption of a device to a set limit. In this implementation, the motor supply voltage is controlled using the PWM regulator, which also controls the current through the motor. This keeps it at the set limit, which can either be set by a customer for a specific application or by LINAK®.

If the actuator's current consumption rises above the set limit, the actuator regulates the consumption and tries to keep it below the limit by reducing the PWM, which also reduces the speed accordingly. The actuator regulates continuously until it is mechanically blocked and stops moving - this block is determined by monitoring the Hall feedback signal. If there are no changes to the Hall feedback signal during the set timeframe, the integrated contoller will cut power to the H-bridge motor circuit.

If the actuator is stopped due to the above-mentioned criteria, it automatically drives slightly in the opposite direction to reduce the torque in a blocking situation.

This is visualised in the figure below:

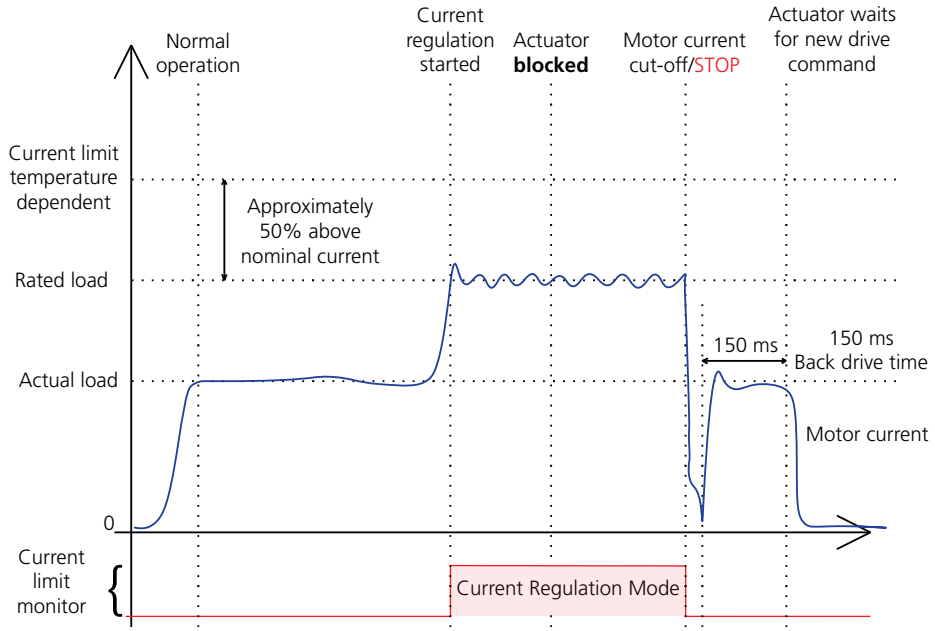

Figure 2. Summary of the Operating Principles of the Current Regulation Algorithm

During cold temperatures (below -20°C), the internal friction of the actuator increases sharply due to reduced grease viscosity, which necessitates the use of a higher current limit. In order to keep the current consumption close to this set limit, the PWM is iteratively increased or reduced. When the PWM regulator goes active, it is reported as "regulation mode". This information is used by the current limit monitor.

Register overview

Command details

Index	Subindex	Data type	Access	Name	Details	Unit	Description
0x2001	8193	UINT8	RW	Communication Heartbeat Counter	0-255		Without regular updates, the actuator will stop*
0x2002	8194	UINT16	RW	Position	0–64255	0.1 mm/bit	Run to position
					64256	Command	Clear error register
					64257	Command	Run out
					64258	Command	Run in
					64259	Command	Stop
					64260	Command	Recovery run out
					64261	Command	Recovery run in
					64262–65535	Reserved	Invalid value, the actuator will not run
0x2003	8195	UINT8	RW	Current	0–250	0.25 A/bit	Maximum current limit
					251	Command	Use default current value
					252–255	Reserved	Invalid value, the actuator will not run
0x2004	8196	UINT8	RW	Speed	0–200	0.5% /bit	Speed to use
					201–250		Use 100% speed
					251	Command	Use default speed value
					252–255	Reserved	Invalid value, the actuator will not run
0x2005	8197	UINT8	RW	Soft Start	0–250	0.05 s/bit	Start ramping time
					251	Command	Use default soft start value
					252–255	Reserved	Invalid value, the actuator will not run
0x2006	8198	UINT8	RW	Soft Stop	0–250	0.05 s/bit	Stop ramping time
					251	Command	Use default soft stop value
					252–255	Reserved	Invalid value, the actuator will not run

Table 1. Command Details

* These should be incremented at least every 500 ms

Configuration parameters

Index	Subindex	Data type	Access	Name	Details	Unit	Description
0x4001	16385	UINT8	RW	Current Limit Out		0.25 A/bit	
0x4002	16386	UINT8	RW	Current Limit In		0.25 A/bit	
0x4003	16387	UINT16	RW	Soft Start Time Out		1 ms/bit	
0x4004	16388	UINT16	RW	Soft Start Time In		1 ms/bit	
0x4005	16389	UINT16	RW	Soft Stop Time Out		1 ms/bit	
0x4006	16390	UINT16	RW	Soft Stop Time In		1 ms/bit	
0x4007	16391	UINT8	RW	Maximum Speed	0-200	0.5% /bit	
					201-255	100%	
0x4008	16392	UINT16	RW	Virtual EOS Out Position		0.1 mm/bit	
0x4009	16393	UINT16	RW	Virtual EOS In Position		0.1 mm/bit	

Table 2. Configuration Parameters

Default product parameters

LC3 IC

Overcurrent	20 A
Soft stop / Soft start time	1500 ms

Table 3. Default Product Parameters

Feedback status details

Index	Subindex	Data type	Access	Name	Details	Unit	Description
0x2101	8449	UINT16	R	Position	0–64255	0.1 mm/bit	Position of the actuator piston
					64256–65023	Reserved	
					65024		Position lost
					65025–65535	Reserved	
0x2102	8450	UINT8	R	Current	0		Not running
					1–250	0.25 A/bit	Measured motor current
					251–253	Reserved	
					254		Fault in current measurement circuit
					255	Reserved	
0x2103	8451	UINT8	R	Status Flags			8-bit independent status bit-indicators
					b0		EOS in
					b1		EOS out
					b2		Overcurrent
					b3		Running out
					b4		Running in
					b5		Heartbeat needed
					b6–b7	Reserved	
0x2104	8452	UINT8	R	Error Code			8-bit error code indicating the currently active error of highest priority
					0		No error
					1		Need stop command
					2		Hall error
					3		Overvoltage
					4		Undervoltage
					5		Failed to maintain heartbeat
					7		Temperature error
					8		Heartbeat error (internal)
					9		SMPS error (internal)
					10		Current measurement (internal)
					11		Parallel arbitration in progress
					254		Internal fault (not specified)
					255		External fault (not specified)
0x2105	8453	UINT16	R	Speed	0–65535	0.1 mm/s /bit	
0x2106	8454	UINT8	R	Input State	b0–b1	25% /bit	Input 1 level
					b2–b3	25% /bit	Input 2 level
					b4–b5	25% /bit	Input 3 level
					b6-b7	Reserved	Always set

Table 4. Feedback Status Details

Service data

Index	Subindex	Data type	Access	Name	Details	Unit	Description
0x400A	16394	UINT32	R	UIN		8 number format	
0x400C	16396	UINT32	R	SW Variant		SWxxxxxxxVx-x	Software number (e.g. 1050000)
0x400E	16398	UINT32	R	SW Version Major		SWxxxxxxxVx-x	
0x4010	16400	UINT32	R	SW Version Minor		SWxxxxxxxVx-x	
0x4012	16402	UINT32	R	Config. Production Order Number			
0x4014	16404	UINT32	R	Production Date		yyyymmdd	
0x4016	16406	UINT8	R	Maximum Current Seen		0.25 A/bit	
0x4017	16407	UINT8	R	Maximum FET Temperature Seen		1 °C /bit - 40	
0x4018	16408	UINT8	R	Maximum Ambient Temperature Seen		1 °C /bit - 40	
0x4019	16409	UINT8	R	Minimum Ambient Temperature Seen		1 °C /bit - 40	
0x401A	16410	UINT32	R	Current Usage Over Time		1 As/bit	
0x401C	16412	UINT32	R	Runtime		1 s/bit	
0x401E	16414	UINT8	R	Number of Stops Due to Overvoltage			
0x401F	16415	UINT8	R	Number of Stops Due to FET Over Temperature			
0x4020	16416	UINT8	R	Number of Stops Due to Ambient Over Temperature			
0x4021	16417	UINT8	R	Number of Stops Due to Low Voltage			
0x4022	16418	UINT8	R	Number of Stops Due to Hall Errors			
0x4023	16419	UINT8	R	Number of Stops Due to EOS Switch Errors			
0x4024	16420	UINT8	R	LINAK Current Overload Out Stops			
0x4025	16421	UINT8	R	LINAK Current Overload in Stops			
0x4026	16422	UINT8	R	Resettable Custom Current Overload Out Stops			
0x4027	16423	UINT8	R	Resettable Custom Current Overload in Stops			
0x4028	16424	UINT16	R	Communication Errors			
0x4029	16425	UINT32	R	Number of EOS Out			
0x402B	16427	UINT32	R	Number of EOS In			
0x402D	16429	UINT32	R	Number of Starts Out			
0x402F	16431	UINT32	R	Number of Starts In			
0x4031	16433	UINT32	R	Total Piston Distance		5 m/bit	
0x4033	16435	UINT16	R	Last Stop Reason ID 0			Stop reason ID
0x4034	16436	UINT8	R	Last Stop Count ID 0			Number of consecutive stop reasons of the same type
0x4035	16437	UINT32	R	Last Stop Powered Time ID 0		1 s/bit	Powered time when the last stop occurred
0x4037	16439	UINT16	R	Last Stop Reason ID 1			Stop reason ID
0x4038	16440	UINT8	R	Last Stop Count ID 1			Number of consecutive stop reasons of the same type
0x4039	16441	UINT32	R	Last Stop Powered Time ID 1		1 s/bit	Powered time when the last stop occurred
0x403B	16443	UINT16	R	Last Stop Reason ID 2			Stop reason ID
0x403C	16444	UINT8	R	Last Stop Count ID 2			Number of consecutive stop reasons of the same type

Index	Subindex	Data type	Access	Name	Details	Unit	Description
0x403D	16445	UINT32	R	Last Stop Powered Time ID 2		1 s/bit	Powered time when the last stop occurred
0x403F	16447	UINT16	R	Last Stop Reason ID 3			Stop reason ID
0x4040	16448	UINT8	R	Last Stop Count ID 3			Number of consecutive stop reasons of the same type
0x4041	16449	UINT32	R	Last Stop Powered Time ID 3		1 s/bit	Powered time when the last stop occurred
0x4043	16451	UINT16	R	Last Stop Reason ID 4			Stop reason ID
0x4044	16452	UINT8	R	Last Stop Count ID 4			Number of consecutive stop reasons of the same type
0x4045	16453	UINT32	R	Last Stop Powered Time ID 4		1 s/bit	Powered time when the last stop occurred
0x4047	16455	UINT32	R	Total Corrected Distance		1 mm/bit	
0x4049	16457	UINT8	R	FET Temperature		1 °C /bit - 40	
0x404A	16458	UINT8	R	Ambient Temperature		1 °C /bit - 40	
0x404B	16459	UINT32	R	Stroke Length		0.1 mm/bit	
0x404D	16461	UINT32	R	Zero Point Offset		0.1 mm/bit	
0x404F	16463	UINT32	R	Actuator PO Number			

Table 5. Service Data Objects

Power supply

Supply voltage

The Modbus TCP/IP actuator will be available in two supply voltage ranges: 24 V DC and 48 V DC. The accepted supply voltage range is specified for the two versions as shown below.

Supply Voltage	V_{MIN}	V_{TYP}	V_{MAX}	Reference	Note
24 V	18 V	24 V	32 V	ISO 16750-2:2012 - Code H	Motor running
	10 V	24 V	39 V	ISO 16750-2:2012 - Code E	Motor not running TCP/IP communication possible
48 V	36 V	48 V	58 V	ISO 21780 / VDA320	Motor running
	10 V	48 V	60 V	ISO 21780 / VDA320	Motor not running TCP/IP communication possible

Table 6. Voltage Supply Levels

Split supply

Split supply consists of a common GND, a control supply and a motor supply. This approach is used to maintain power on the intelligent part of the actuator. In case the main supply is disconnected, split supply allows the processor to still know the actuator's current position and communicate with an external control box. The main supply may be disconnected for reasons related to safety, maintenance or installation.

Power loss

In case of power loss, the actuator position and other important data is saved by the on-board microcontroller.

Actuator Connect™ interface

The column/actuator must have a valid IP address and port number. The default values are as follows:

- IP address: 192.168.1.10
- Port number: 502
- Subnetmask: 255.255.255.0
- Gateway: 192.168.1.1

The network settings can be changed using the LINAK® service tool Actuator Connect. Via this tool it is also possible to access historical and service usage data.

The configuration cable with item no. 0367996 is required in order to use Actuator Connect. This cable must be connected to the 6-pin and 9-pin connector on the actuator side. On the opposite side, power must be applied to the flying leads, and the USB connector must be inserted into your PC.

Installing LINAK® Modbus TCP/IP actuators

This section will assist you in the installation of the LINAK Modbus TCP/IP actuator by going through parameters and procedures necessary for a successful implementation. These include:

- Connections
- Electrical installation
- Starting procedures

Connections

The tables below define the wire connections to the LINAK TECHLINE Modbus TCP/IP actuators. The colours are consistent with all LINAK TECHLINE Modbus TCP/IP actuators.

Power connector - 6-pin mini-fit

LINAK Cable	Description
Brown	+ Motor power supply (24/48 V DC)
Blue	- Common GND

Table 7. Colour of Power Wires.

Communication connector - 9-pin micro-fit

LINAK Cable	Description
Red	Manual run out
Black	Manual run in
Green	Not used
Yellow	Not used
Orange	+ Control power supply (24/48 V DC)
Light Blue	Not used
Violet	Service interface
White	Not used
Grey	Not used

Table 8. Colour of Communication Wires.

The product manual can be accessed here: Product Manual (LC3 IC) - to be added

Cables are supplied with flying leads by default.

Electrical installation

The physical layer conforms to the IEEE 802.3-2018 standard with communication speeds of 10 Mbps and 100 Mbps, respectively. Cable length is reduced to ≤ 100 m without repeater, as determined by IEEE 802.3-2018.

Connection diagram

LC3 XXX XXX F700 00 XXXX X X 3 1 4 - X H 0 (ELEVATE™ Modbus)

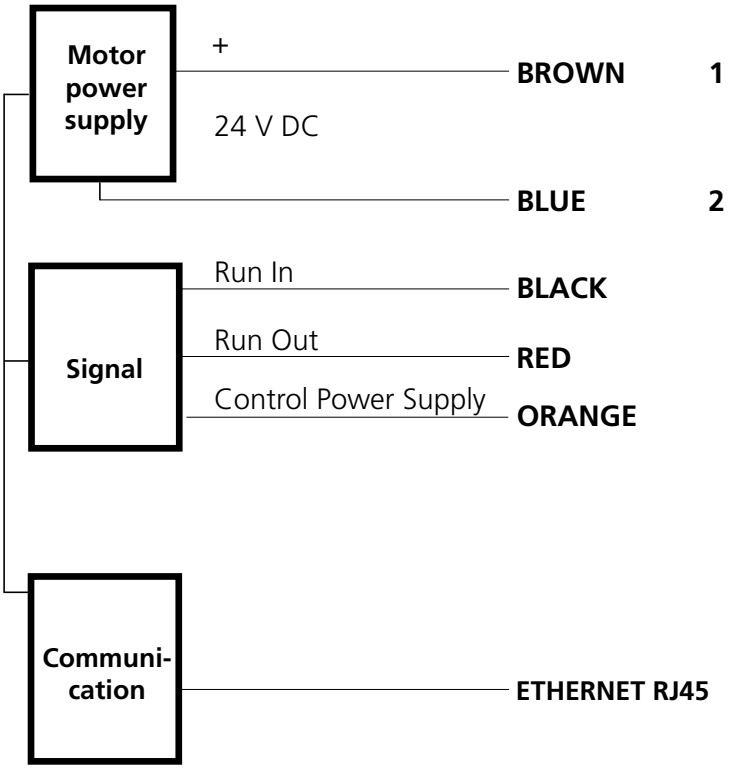

Figure 3. Connection Diagram

Connector options

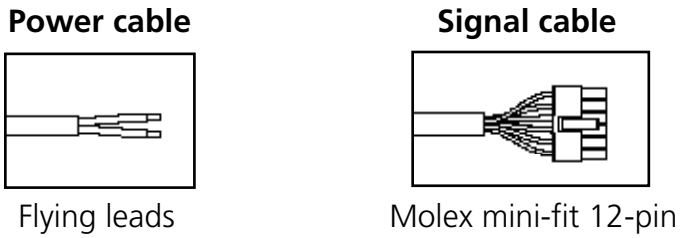

Figure 4. Connector options

Please be aware that if the power supply is not properly connected, you might damage the actuator!

Starting procedures

Follow the procedure below for successful communication startup:

1. Apply power to the actuator using the Blue (common GND), Brown (motor supply, Vcc) and Orange (control supply, Vcc) wires.
2. Increment the value of the "Communication Heartbeat Counter" register periodically.
   2.1. Value of register ranges from 0-255.
   2.2. Must be updated in periods no longer than 500 ms.
   2.3. If not updated within the 500 ms, the actuator will stop, and the "Error Code" register will read a value of 5.
3. Set the "Current" command register.
4. Set the "Speed" command register.
5. Set the "Soft Start" command register.
6. Set the "Soft Stop" command register.
7. Send a stop command.
   7.1. To send a stop command, set the "Position" register.
8. Read the "Error Code" register. It must be 0.
   8.1. If there are errors, check the source of error by reading the value of the register.
   8.2. Once the error is fixed, send a clear error command.
9. Send a run in or a run out command.
   9.1. To run in/out, set the "Position" register.
10. If a change of running direction is desired, first send a stop command before running in the opposite direction.

If the actuator is not running, check Table 9: "Error Codes" for possible solutions

Troubleshooting

The following table further elaborates the error codes mentioned in Table 4: Feedback Status Details.

Error		Description
0	No error	Normal operation.
1	Need stop command	**Reason:** For safety reasons, it is required to send a 'Stop command' after power-up of the actuator. **Solution:** Send a 'Stop command'. 0xFB03 in Index 0x2002.
2	Hall error	**Reason:** The hall sensor positioning is not responding as expected. **Solution:** Send the 'Clear error' command or alternatively perform a power cycle of the actuator.
3	Overvoltage	**Reason:** The supply voltage to the actuator is above the allowed limit. **Solution:** Lower the voltage to continue operation (See section: Power Supply)
4	Undervoltage	**Reason:** The supply voltage to the actuator is below the allowed limit. **Solution:** Raise the voltage to continue operation (See section: Power Supply)
5	Failed to maintain heartbeat	**Reason:** For safety reasons, it is required to update the heartbeat counter value. **Solution:** Send incrementing value to 0x2001 at least every 500 ms.
7	Temperature error	**Reason:** The actuator has reached a temperature above the limit required to protect the unit. **Solution:** Have the actuator cool off to a suitable level.
8	Heartbeat error (internal)	**Reason:** The internal self-check has triggered an unexpected result. **Solution:** Re-power the actuator to continue normal operation. If the error persists, contact your local LINAK® supplier.
9	SMPS error (internal)	
10	Current measurement (internal)	
11	Parallel arbitration in progress	
254	Internal fault (not specified)	
255	External fault (not specified)	

Table 9. Error Codes

Environmental EMC performance

The Electromagnetic Compatibility tests performed on the LINAK® Modbus TCP/IP actuator comply with the TECHLINE® Electrical Test Specification.

Norm/Standard	Test description
IEC 61000-6-4:2019	Conducted emission
IEC 61000-6-4:2019	Radiated emission
IEC 61000-6-2:2019	ESD immunity
IEC 61000-6-2:2019	Interference fields immunity test
IEC 61000-6-2:2019	Power frequency magnetic field
IEC 61000-6-2:2019	Burst transients
IEC 61000-6-2:2019	Surge transients

Table 10. LINAK TECHLINE EMC Test Overview

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