

# MANUAL

## Thyristor motor controller Classic Q1 4 Quadrant circular current-free

Part 1	Power structure	Q1
Part 2	Analog control electronics	REG-xx



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## 1 Basic information

### 1.1 Safety regulations

**In principle electronic equipment is not fault proof!**

## Caution - High voltage

### Shock hazard! / Danger to life!



Before installation or commissioning begins, this manual must be thoroughly read and understood by the skilled technical staff involved. If any uncertainty arises, the manufacturer or dealer should be contacted.

The devices are power electric parts (EB) used for regulating the energy flow in high-voltage systems.  
**Protection rating IP00.**

**The control and power connections may be voltage-carrying without the axis operating!**

**Measure the voltage prior to any disassembly!**



## 2.2 Regulations and guidelines

The devices and their associated components can only be installed and switched on where the local regulations and technical standards have been strictly adhered to.

EU Guidelines	2004/108/EG, 2006/95/EG, 2006/42/EG EN 60204-1, EN292, EN50178, EN60439-1, EN61800-3, ECE-R100 ISO 6469, ISO 26262, ISO 16750, ISO 20653, ISO12100
IEC/UL:	IEC 61508, IEC364, IEC664, UL508C, UL840
VDE Regulations/TÜV Regulations:	VDE100, VDE110, VDE160
Regulations of the statutory accident insurance and prevention institution:	VGB4

## **The user must ensure that in the event of:**

- device failure
- incorrect operation
- loss of regulation or control

the axis will be safely de-activated.

It must also be ensured that the vehicles, machines, equipment, or vehicles are fitted with device independent monitoring and safety features.

Unearthed systems (e.g. vehicles) must be protected by means of independent insulation monitors.

Man as well as property must not be exposed to danger at any time!



### **Assembly**

- should only be carried out when all voltages have been removed and the units are secured
- should only be carried out by suitably trained personnel

### **Installation**

- should only be carried out when all voltages have been removed and the units are secured
- should only be carried out by suitably trained personnel for electricians
- should only be carried out in accordance with health and safety guidelines

### **Adjustments and programming**

- should only be carried out by suitably trained personnel with knowledge in electronic drives and their software
- should only be carried out in accordance with the programming advice
- should only be carried out in accordance with safety guidelines

### **CE**

When mounting the units into vehicles, machines, and installations the proper operation of the units may not be started until it is ensured that the machine, the installation, or the vehicle comply with the regulations of the EC machinery directive 2006/42/EG, the EMC guideline 2004/108/EG, and the guideline ECE-R100.

On the described installation and test conditions (see chapter 'CE notes') it is adhered to the EC guideline 2004/108/EG including the EMC standards EN61000-2 and EN61000-4.

A manufacturer's declaration can be requested.

The manufacturer of the machine or installation is responsible for observing the threshold values demanded by the EMC laws.

### **QS**

Test results are archived with the device serial number by the manufacturer for a period of 5 years. The test protocols can be asked for.

## 1.2 General information and features

**This manual description of the basic unit is only valid in connection with the manual for the control electronics (e.g. REGxx).**



### Build

- Switch cabinet built-in devices
- Acc. to the VDE, DIN, and EG regulations
- Standard control electronics REG
- Basic device as intrinsically safe power section with current controller
- Uncontrolled field supply unit
- Optional units

### Galvanic isolation between

- Power section and housing
- Power section and control electronics

The distances of air gaps and leakage paths adhere to the VDE standards (>8mm).

### Components

- Completely isolated thyristor modules, comfortably over-dimensioned
- Only components customary in trade and industrially standardized
- LED displays
- Precision trimming potentiometer for precise adjustment
- Dip-switch for the system setting

### Features

- ✓ Series Classic Q1
- ✓ Thyristor controller for dc motors
- ✓ Power range 2.7 to 12 KW
- ✓ Driving and braking in all 4 quadrants
- ✓ Energy feedback
- ✓ Intrinsically safe power section
- ✓ Fast analog current control
- ✓ Circular current-free double bridge circuit
- ✓ Optional uncontrolled field rectifier
- ✓ 26-pole interface
- ✓ Features of the control electronics used:
- ✓ see MANUAL REGxx or third-party product
- ✓ Optional units
- ✓ Min. torque-free break 10ms
- ✓ PI-setting by means of two 4-position switches
- ✓ The control electronics is plugged to the front side and readily accessible
- ✓ Connecting terminals are used as far as possible
- ✓ Heavy current connections must be connected via power terminals
- ✓ The output stage is a counter-parallel double bridge circuit

### Application

- ✓ DC motors for circular current-free 4Q operation

## 1.3 Technical data

### Q1 230/180-x

Power connection:	200 ... 250 V~
Auxiliary voltage connection:	200 ... 250 V~
Output voltage:	$\pm 180 \text{ V}^=$
Cooling:	self cooling

Q1 230/180			15	25	40
Input current		A~	16.5	27.5	44
Output current	- peak 5s	A <sup>=</sup>	30	50	80
	- continuous	A <sup>=</sup>	15	25	40
Electric power		kW	2.7	4.5	7.2
Dimensions		mm	200x240x100	200x240x100	200x240x127
Weight		kg			
Fuses (fast acting)	Input	A	20	30	50
	Output	A	35	50	63
Mains choke		Type	K78-16	K84-25	K84-50
		mH	1.2	0.7	0.5
Motor choke		Type	EI 135A-16	EI 135B-24	EI 150B-40
		mH	33	16	7

### Q1 400/300-x

Power connection:	360 ... 440 V~
Auxiliary voltage connection:	360 ... 440 V~
Output voltage:	max. $\pm 300 \text{ V}^=$
Cooling:	self cooling

Q1 400/300			15	25	40
Input current		A~	16.5	27.5	44
Output current	- peak 5s	A <sup>=</sup>	30	50	80
	- continuous	A <sup>=</sup>	15	25	40
Electric power		kW	4.5	7.5	12.0
Dimensions		mm	200x240x100	200x240x100	200x240x127
Weight		kg			
Fuses (fast acting)	Input	A	20	30	50
	Output	A	35	50	63
Mains choke		Type	K78-16	K84-25	K84-50
		mH	1.2	0.7	0.5
Motor choke		Type	EI 135B-16	EI 150C-24	UI 120B-40
		mH	45	30	15

(Inductivity for larger armature circuits on request)

## Basic information

### 1.4 Specifications

#### Common specification

Mains frequency	50 or 60 Hz $\pm 5$ %
Protection rating	IP 00
Format	VDE 0100 group C / VDE 0160
Humidity rating	Class F acc. to DIN 40040
Site of installation	< 1000m above sea level
Operating temperature range	0 ... 45°C
Extended operating range	up to 60°C reduced by 2%/°C
Storage temperature range	-30°C to + 80°C

#### Amplification

Input signal	0... $\pm 10$ V <sup>=</sup>
Output	0... $\pm 200$ % type current

<b>Enable</b>	> + 10 Volt
---------------	-------------

#### Current control loop circuit

Control precision	$\pm 2$ %
Control range	1:50
Over-current limiting	10 Sec. 200 % type current

#### Speed control loop circuit (see MANUAL REG)

Control precision (without actual value error)	$\pm 0.1$ %
Control range	> 1:300

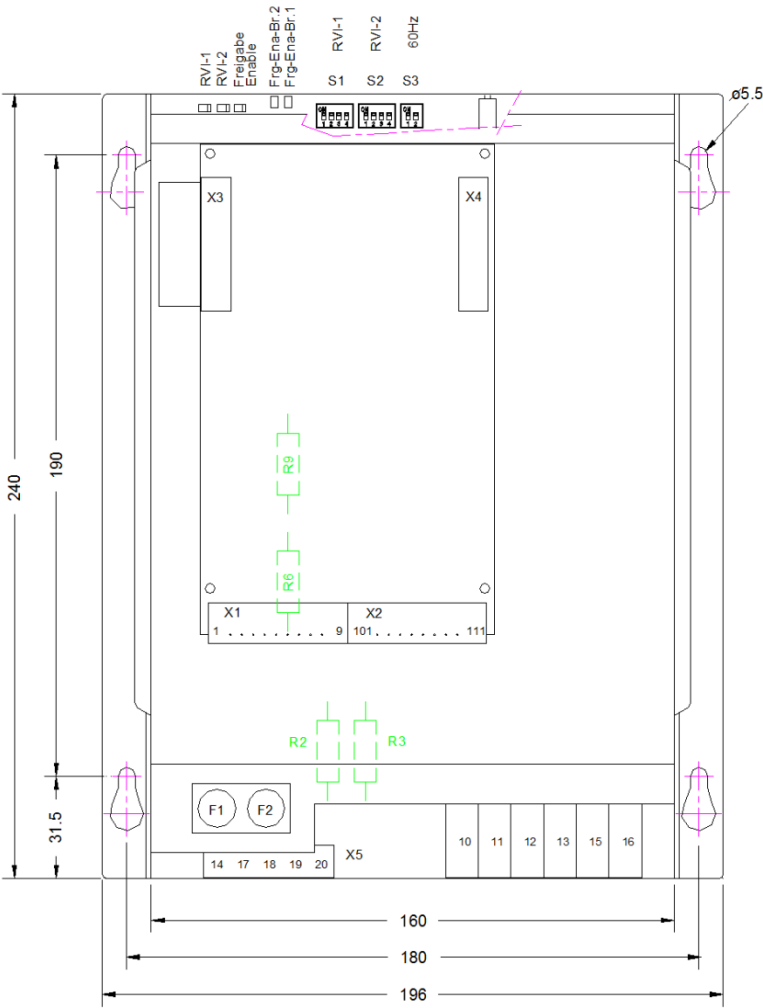
### 1.5 Interfaces

#### Interface control electronics X3

Function		Connector no.
+ 24 V	$\pm 10$ %	X3: 1 and 2
+ 15 V	$\pm 2$ %	X3: 3 and 4
- 24 V	$\pm 10$ %	X3: 5 and 6
- 15 V	$\pm 2$ %	X3: 7 and 8
Device zero GND	0	X3: 9, 10, 11, 12, 13, 14
I – command value (GND)	0	X3: 15
I – command value (signal)	+10 V <sup>=</sup>	X3: 16
Current controller enable	+10 V <sup>=</sup>	X3: 17
Disable 1	+10 V <sup>=</sup>	X3: 18
Disable 2	+10 V <sup>=</sup>	X3: 19
Not connected	not connected	X3: 20
I (current) actual	$\pm 5$ V <sup>=</sup>	X3: 21
Over-current power section	+10 V <sup>=</sup>	X3: 22
Ignition angle 1	+ 10 V <sup>=</sup>	X3: 23
Ignition angle 2	+10 V <sup>=</sup>	X3: 24
Drive ready BTB	+10 V <sup>=</sup>	X3: 25
Not connected	not connected	X3: 26

2 Mechanical installation

2.1 Mounting



2-1 ED-Q1-Maßbild-M006-2

Adjustments

Switch S1	PI circuitry
Switch S2	PI circuitry
Switch S3	60 Hz setting

Current controller RVI-1
Current controller RVI-2
Contact 1,2 to ON

LED displays

Enable	Enable	green	enabled
Current command value			
Current controller	RVI-1	green	control active
Current controller	RVI-2	green	control active
The luminous intensity depends on the trigger angle.			
Disable logic	Bridge 1	green	Bridge 1 enabled
Disable logic	Bridge 2	green	Bridge 2 enabled





## 2.2 Transformer choke

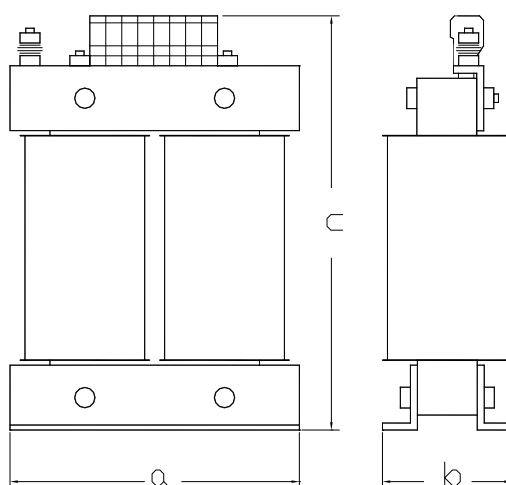
Rated current Q1-x-x-		15	25	40
<b>Auto-transformer</b>	Type	TU4/70 UI120-B	TU5/50 UI150-A	TU5/70 UI150-B
Dimensions a b c	mm	160x145x205	200x130x255	200x155x255
Weight	kg	16	21	28

<b>Mains choke</b>	Typ	K78-16	K84-25	K84-50
Dimensions a b c	mm	72x90x120	72x95x122	72x95x122
Weight	kg	1.5	1.8	1.8

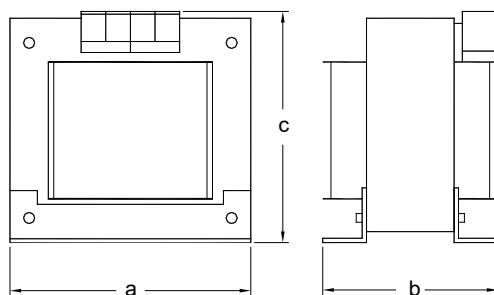
<b>Motor choke 180 V</b>	Typ	EI 135A-16	EI 135B-24	UI 150B-40
	mH	33	16	7
Dimensions a b c	mm	115x120x145	115x130x145	128x132x185
Weight	kg	7	8,2	10,6

<b>Motor choke 300 V</b>	Typ	EI 135B-16	UI 150C-24	UI 120B-40
	mH	45	30	15
Dimensions a b c	mm	115x130x143	128x142x185	160x150x270
Weight	kg	8,2	12,10	16

Model UI

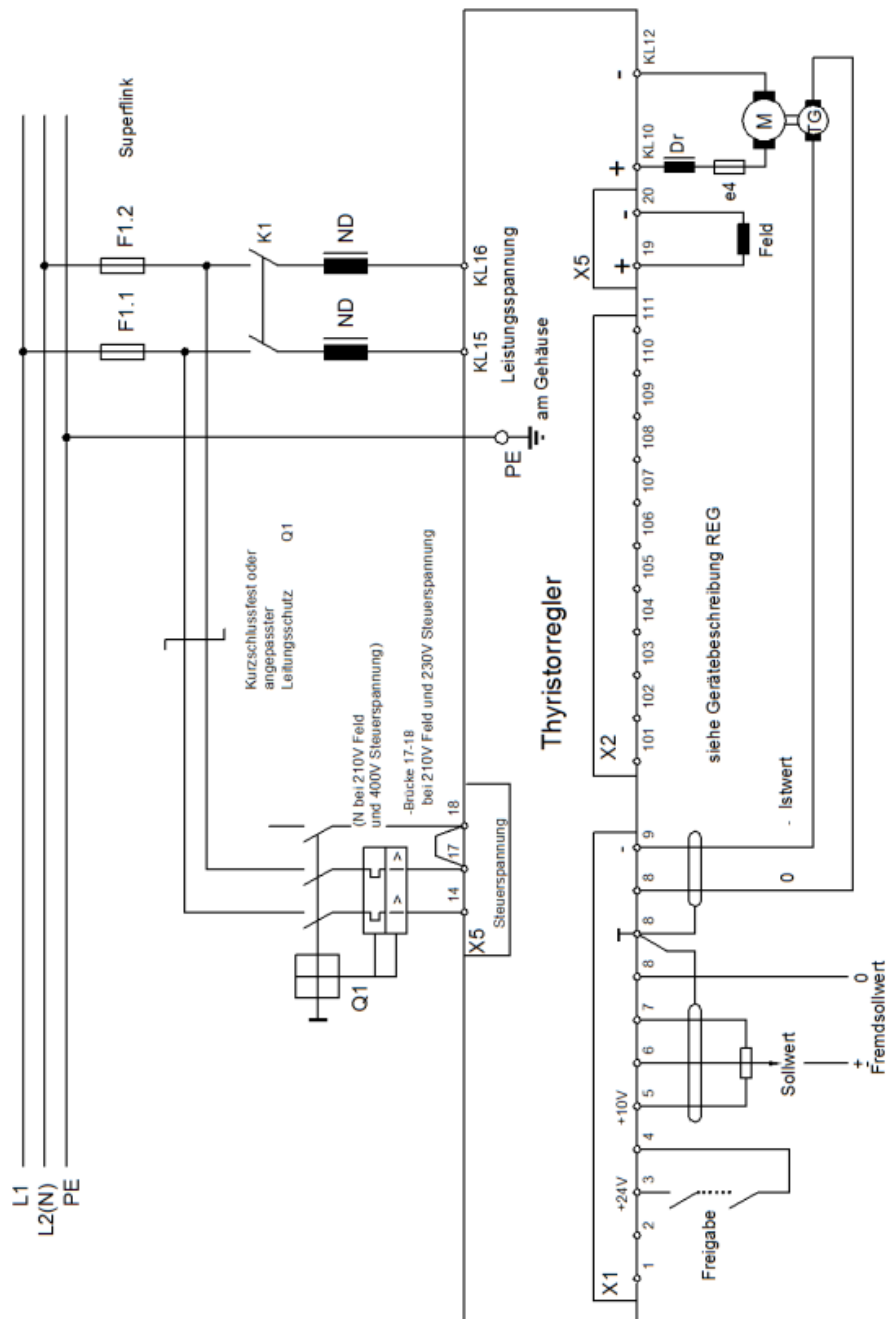


Model K, EI



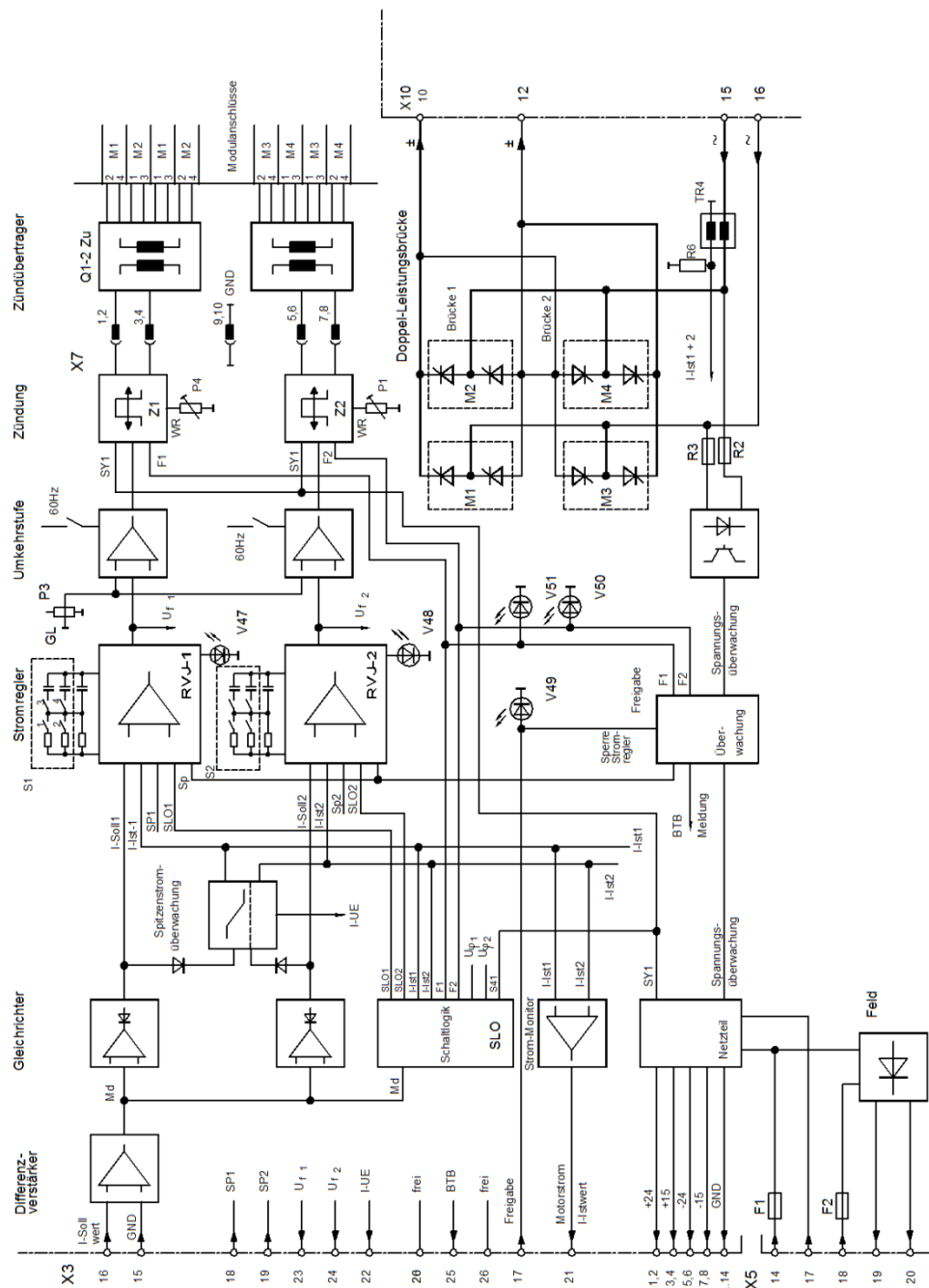
## 3 Electrical installation

### 3.1 Connection diagram



3-1 Q1-Anschlussplan-A016-2

## 3.2 Circuit diagram



3-2 Q1-Schaltplan-S068-1

## 3.3 Important CE notes

The devices adhere to the EU guidelines 89/336/EEG of the technical EMC standards EN 61000-2 and 61000-4 provided that the following conditions are observed.

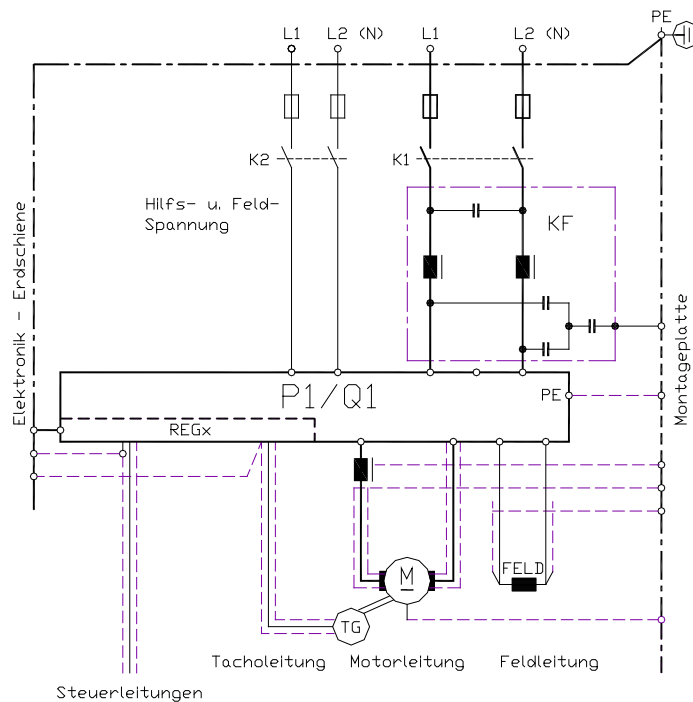
- The device, the power choke, and the filter capacitors are mounted on a 500x500x2mm mounting plate.
- The mounting plate must be connected to ground using a 10mm<sup>2</sup> wire.
- The motor housing must be connected to ground using a 10mm<sup>2</sup> wire.
- The device ground X1:8 must be connected to the mounting plate using a 2.5mm<sup>2</sup> wire.
- Device PE screw must be connected to the mounting plate using a 4mm<sup>2</sup> wire, l = 50mm.

### Two-phase connection

Mains choke type:	see techn. data
Filter capacitors:	0.5 µF/600 V~ 2 x 1µF (x) + 2 x 0.5µF (y)
Conductor length between device and mains choke	<250 mm

### Motor connection:

Motor conductors:	l = 1.5 m, shielded
Tacho and all control conductors shielded	l = 1.5 m, shielded
Shielding connected to PE	



KF = Kommutierungsdrössel mit Filterkondensatoren

3-3 Q1-A-EMV-1

## 3.4 Connections

The order of the connections to the connector no. or the connection terminals is obligatory.  
The input and output conductors may be altered or supplemented in accordance with the electrical standards. All further advice is non-obligatory.

### Adhere to:

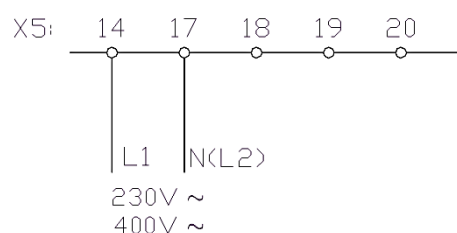
- Connections and operating instructions
- Local regulations
- EU guideline 89/392/EWG
- VDE and TÜV regulations and Trade body guidelines

The controllers are delivered with an auxiliary voltage input for 230 or 400V~.

The current consumption is 0.1 A.

The fuses F1 and F2 are rated for field current (2.5 A f).

Auxiliary voltage and field supply are both connected to the plug-in terminal X5.



The phase position of the auxiliary voltage and the power supply voltage must correspond to each other.

X5:14 corresponds to terminal 15 and X5:17 corresponds to terminal 16.

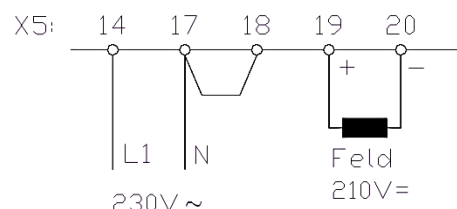
3-4 Q1-Q2-Hilfsspannung-1

### Field voltage

230 V~ connection equal to 210 V=

400 V~ connection equal to 360 V= or

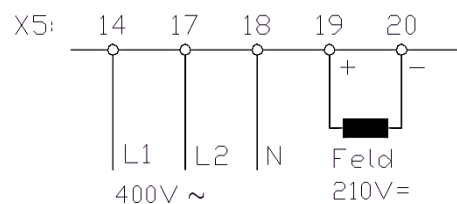
210 V= to N across terminal X5:18



3-5 Q1-Q2-Feld230-210-1

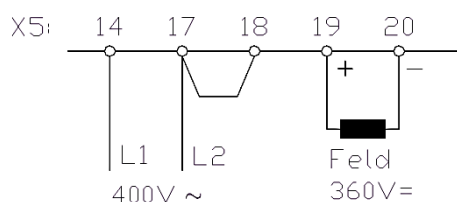
The max. field current is 1.5 A.

The field current is not monitored.



3-6 Q1-Q2-Feld-400-210-1

In case the field fuse F1 fails the device is switched off.



3-7 Q1-Q2-Feld400-360-1

### Note:

**Observe the type plate / control voltage XXX**



## 3.5 Power connections

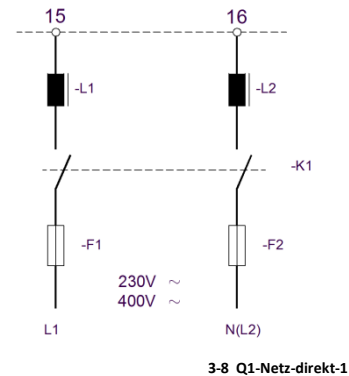
### Direct power connection:

The power connections must be protected by means of fast acting fuses.

The power choke inductance must be  $>200\mu\text{H}$ .

The phases of the power connection and the auxiliary voltage **must be** equal.

There is an internal watchdog for the power connection.  
If the power supply or the fuses fail, the device switches off and the BTB contact opens.

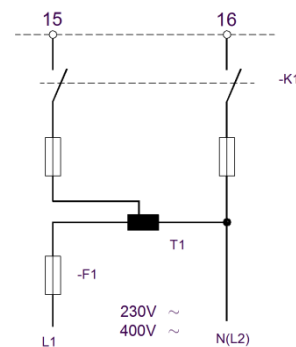


### Power connection via an auto-transformer:

Usually an auto-transformer is used.

The transformer performance is determined by the permanent current and the secondary voltage.

Fast acting fuses F must be installed between the transformer and the control unit.



The fuses are monitored concerning failure via the mains monitoring system.

The phases of the transformer voltage and the auxiliary voltage **must be** equal.

The contactor contacts before the transformer must be rated according to the starting current of the transformer.

Protect the transformer by means of slow fuses.

### Important:

For transformer secondary voltages  $< 230 \text{ V} \sim$  the resistors R2 and R3 of the power section must be adapted in the factory.


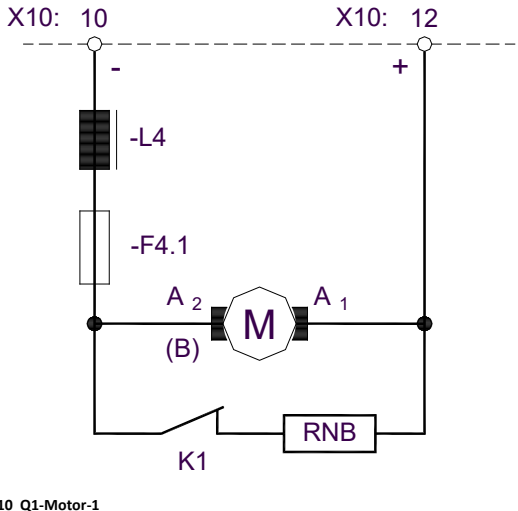


### Specification on order: Transformer voltage

### Operation with a 60Hz current supply:

When operating with a mains frequency of 60Hz the contacts 1 and 2 of the DIP-switch S3 must be set to ON.

## 3.6 Motor connection

Connection for a positive command value			
Motor –	Terminal	X10:12	
Motor +	Terminal	X10:10	
<b>Note:</b> Armature choke inductance: $L \text{ [mH]} = U_A / I_A \times 2.4$ Motor conductors must be shielded. Dynamic over-current: The rated current of the choke must be mind. 0.7 times the set peak current so that the choke does not reach the saturation range.			
			

Conductor cross-section (minimal)				
Type current	A	15	25	40
Mains power supply	mm <sup>2</sup>	1.5	2.5	4
Motor connection	mm <sup>2</sup>	1.5	2.5	4

A fuse F must be installed in the armature circuit. This fuse must be monitored and in case of failure the control unit must be disconnected from the power supply.

### Switching in the armature circuit

- DC circuit disconnected from the mains
- Enable disabled

### Caution:

In case of incorrect switching >>> switch-off arc  
 Mains failure– Brake resistor  
 Break contact of the mains contactor K1  
 Dimension  
 Resistance RNB = max. armature voltage/2x type current

**Braking effect only when the field is excited!**

### Important:

The power lines must be shielded and laid separately from the control lines!  
 Electromagnetic interferences >>> see CE notes





## 3.7 Actual value connection I

### Tacho control

Suitable actual value encoders

- DC tacho generators
- Brushless tachogenerators with evaluation electronics
- Incremental encoder with evaluation electronics

**Note:** AC or three-phase current tachos with rectification are not suitable.

Connection

Tacho line shielded, connect the shield to the device.

Tacho lines must be laid separately from the power lines (EMC).

Control electronics (**adhere to MANUAL REG**)

For a positive command value

Positive tacho

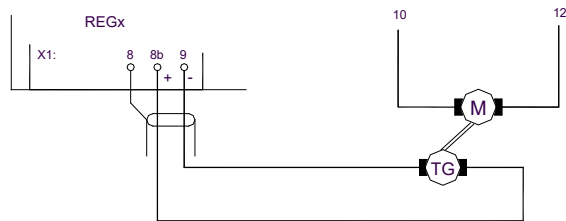
X 1:8b

Negative tacho

X 1:9

Shield

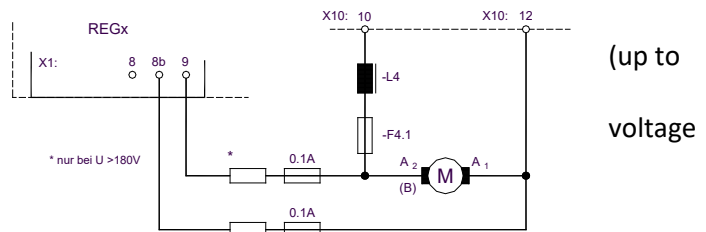
X 1:8



3-11 Q1-Tachoregelung-1

### Armature voltage control

For 4Q control with a small control range 1:50) and low demands on accuracy and dynamics it is possible to use the armature as actual value signal.



3-12 Q1-Ankerspannungsregelung-1

### Ground-referenced actual value

Fuses 2 x 0.1A directly at the tap of the armature voltage

Armature voltage >180 V= additional resistors

Use the (manufacturer) EXZU-UA1 device.

**Note:** adhere to the MANUAL REG

A potential-free armature voltage control is possible by using the Unitek unit QTV 2-3.



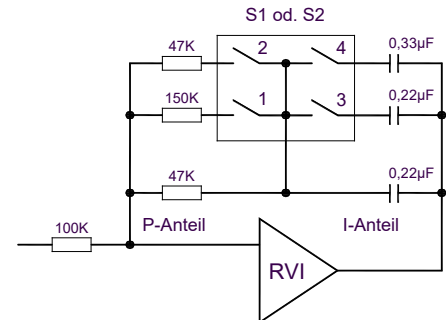
## 4 Settings

### 4.1 Control parameters of the current controller

- The current control characteristics of the power sections can adjusted.
- The PI characteristics of the controller RVI-1 is set by the 4-position DIP switch S1.
- The PI characteristics of RVI-2 is set by switch S2.
- All switches are closed on delivery of the devices.
- This corresponds to the position for the lowest armature circuit inductance.
- The proportional amplification can be changed via the contacts 1 and 2.
- The integral time constant can be changed via the contacts 3 and 4



4-2 Q1-Q2-Schalter-Strom-1



4-1 Q1-Q2-PI-Strom-1

#### Note:

Any current controller optimization must be checked by means of an oscilloscope.

Measuring point X2 : 111 (REG) against GND

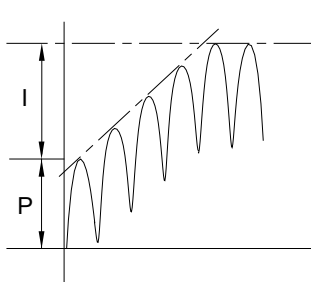
Measured values:

$\pm 2.5 V_{eff}$  according to type current

$\pm 5 V_{eff}$  according to peak current



Oscillogram - current adjustment (measured across REG - X2 : 111)



4-3 Q1-Q2-Oszillogramm-Strom-1

Fig. 1  
Optimal adjustment

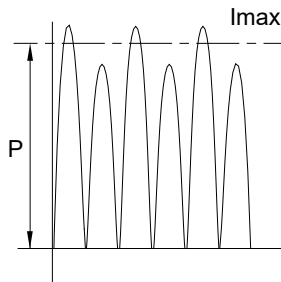


Fig. 2  
Amplification too high

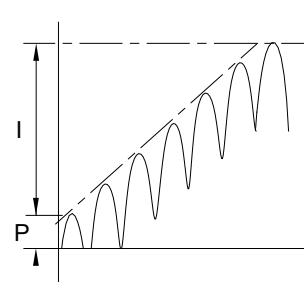


Fig. 3  
Low P-amplification

Some important functions are indicated by LEDs.

Current controller enable (enable) and current command value directions (RVI-1 or RVI-2).

The green LEDs indicate the active states.

## 4.2 Signals

BTB signal	X3:25	>+10 V
Error	X3:25	<+10 V

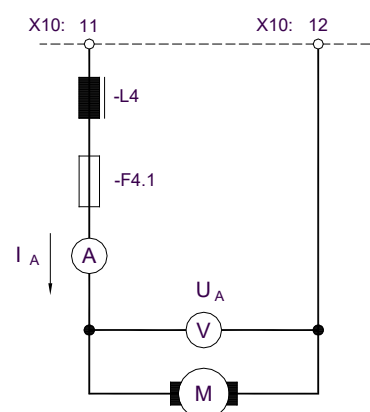
### Errors

Voltage error	24V, 15V, -15V
Input fuse defective / undervoltage	

In case of errors or failure the power section is immediately internally disabled without delay.

### Power measurements

Measuring instruments	Multimeter for current and voltage Shunt or clamp-on ammeter = ~
Measuring errors	Mean value >>> Effective value corresponding to the form factor approx. 1 to 5%



4-4 Q1-Motor-Mess-1

### Measured values with a positive command value

Voltage:	X10:10 negative	X10:12 positive
	Max. 0.75 x power supply voltage with 400 V~	>>> 300 V <sup>=</sup>
Current:	Ammeter in the motor circuit	
	5s 200%, continuously 110% type current	



### Measured values on REGxxx (selectable - see MANUAL REGxx)

Speed	X2:109	±5 V or ±10 V	for ±100% speed
Current	X2:111	±5 V or ±10 V	for ±100% type current

## 4.3 Commissioning Q1 x/x-x with REGxx

**Check the connections prior to any commissioning.  
Observe the type plate!**

### Basic power connections Q1

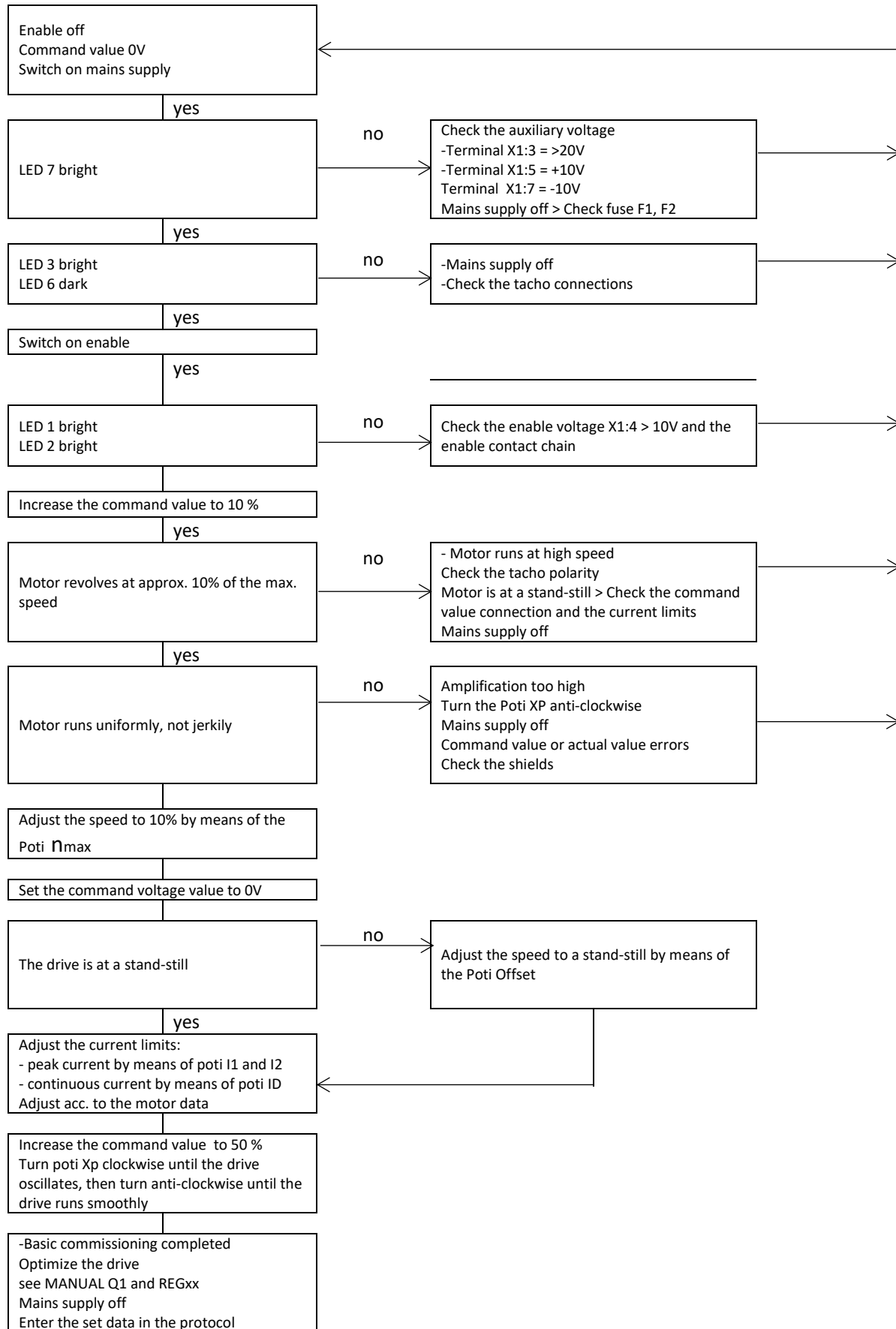
Mains connection	Power	Terminal	X10:15, X10:16
Mains connection	Auxiliary voltage	Terminal	X5:14, X5:17
	Field	Terminal	X5:18
Mains connection	A1/A2	Terminal	X10:10, X10:12
Motor connection	F1/F2	Terminal	X5:19, X5:20
Field connection	PE	Earth screws PE on the housing	

### Basic control connections REGxx


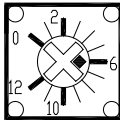
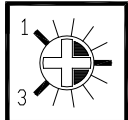
Enable	Contact between X1:3 and X1:4		
Command value	Signal X1:6	GND X1:8a	
Actual value	Signal X1:9	GND X1:8b	
Shields	X1:8		

### Control electronics REGxx

Switch	S4	P-ampl.	Position 4
Switch	S5	I-comp.	Position 4
Switch	S8	D-ampl.	Position 8
Switch	S9	Actual value	Position 8
Potentiometer	I1	Peak current	10%
Potentiometer	I2	Peak current	10%
Potentiometer	ID	Continuous current	100%
Potentiometer	XP	Amplification	50%
Potentiometer	INT	Integrator	Left full scale
Potentiometer	nmax	Speed	Left full scale
Potentiometer	Offset	Offset	50%



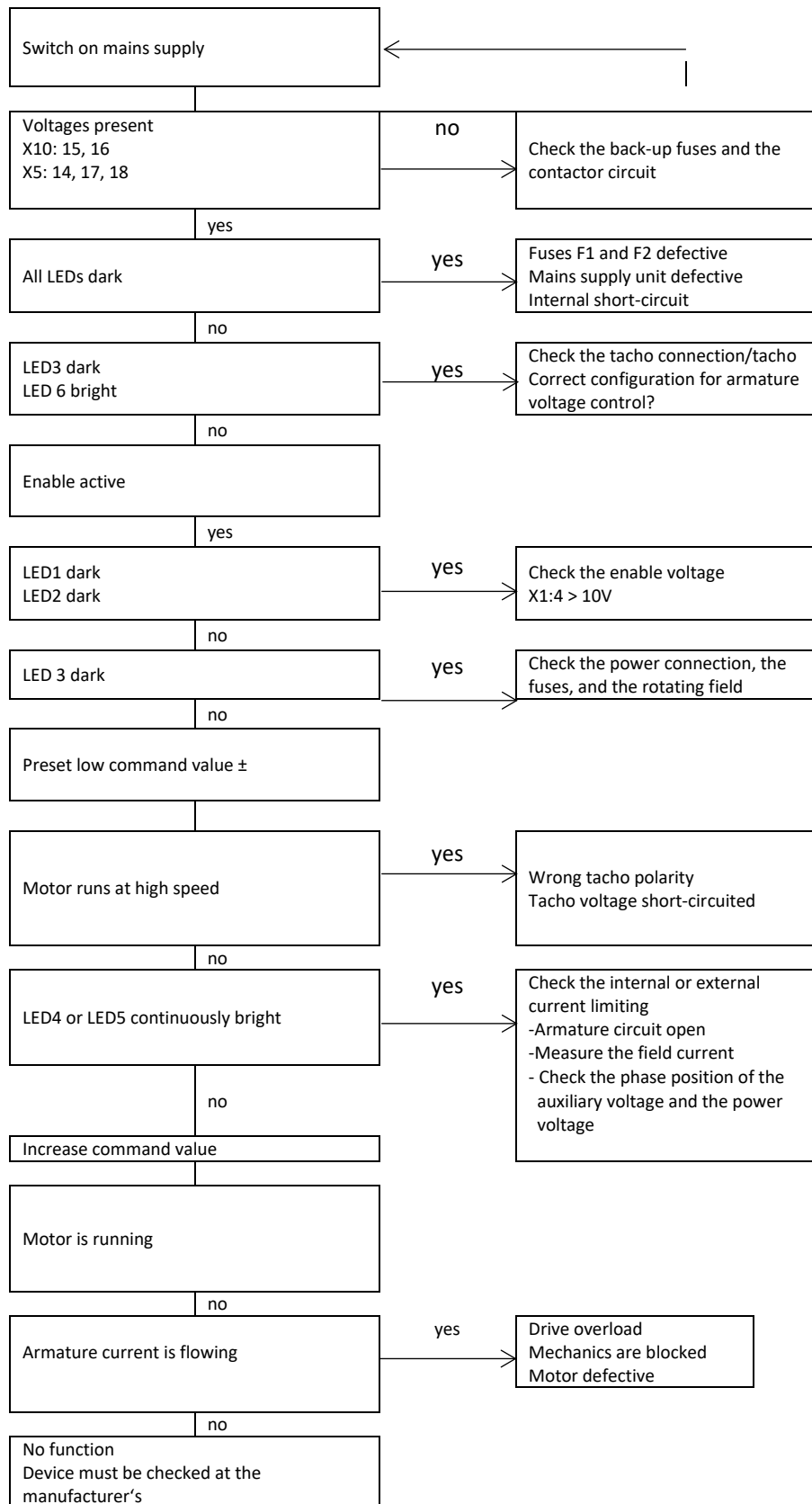
## 4.4 Protocol (commissioning)

<b>Customer</b>				<b>Machine no.</b>	
<b>Device</b>				<b>Serial no.</b>	
<b>Control voltage</b>	[V~]				
<b>Power supply voltage</b>	[V~]				
<b>Field voltage</b>	[V=]				
<b>Inputs REGxx</b>					
Enable	Contact?	Voltage [V=]			
Command value	Type	Voltage [V=]			
Command value supplement	Type	Voltage [V=]			
Current command value	I <sub>max1</sub> external	Voltage [V=]			
Current command value	I <sub>max2</sub> external	Voltage [V=]			
<b>Speed controller REGxx settings</b>					
<b>Switch position</b>					
Tacho adjustment		S9			 REG5 - Schotax 1
P-term		S4	Position		
I-term		S5	Position		
D-term		S8	Position		
<b>Poti positions</b>					
Speed	n <sub>max</sub>	P4	Position		 REG5 - Poti 1
Peak current	I <sub>max1</sub>	P5	Position		
Peak current	I <sub>max2</sub>	P6	Position		
Continuous current	I <sub>D</sub>	P7	Position		
Integrator	INT	P1	Position		 REG5 - Poti 2
Amplification	Xp	P3	Position		
IxR compensation		P2	Position		
<b>DIP switch</b>					
ON	No.				
OFF	No.				

<b>Current controller setting</b>			
P-amplification S1 / S2 - contact 1 and 2	DIP-switch	S1 and S2	
I-component S1 / S2 – contact 3 and 4			
50/60 Hz	DIP-switch S3		
	1+2 ON (60Hz)	1+2 OFF (50Hz)	
<b>Measured values Qxx-REGxx</b>			
Armature voltage	max.	[V=]	
Armature current	peak	[A=]	
Armature current	continuous	[A=]	
Tacho voltage	max.	[V=]	
Acceleration	X4:16	[V/ms]	
Integrator	X4:14	[V/ms]	
<b>Motor data</b>			
Type plate data			
Manufacturer			
Type		Serial no.	
Motor voltage [V=]		Motor current[A=]	
Field voltage [V=]		Field current [A=]	
Tacho voltage [V/min <sup>-1</sup> ]		Tacho type	
Brake [V]		Fan [V]	
Rated speed [U/min]			

## 5 Troubleshooting

### 5.1 Troubleshooting





## 5.2 Functional errors

Functional errors	
Error	Cause
Motor is not running	Incorrect mains supply connection or motor connection Fuses are tripped Missing enable or command value Current limit too low Missing BTB
Motor is running at high speed	Wrong polarity of the actual value (tacho armature voltage) Values of the tacho switch S9 too low Command value too high for armature voltage control Field current too low The fuse of the armature voltage feedback are tripped
Motor is not running smoothly	Mechanical tacho failure Tacho fault Speed controller amplification too high or too low Incorrect PID parameter Command value fault Current controller amplification too high or too low
Motor has no torque	-Current limits too low -Field current too low/motor demagnetized -Mechanical overload of the drive