

MANUAL

Classic Q2 4 Quadrant Circular Current Thyristor Motor Controller

Part 1	Thyristor Motor Controller	Q2
Part 2	Analog Control Electronics	REG-xx



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2 Basic information

2.1 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: Regulations of the statutory accident insurance and prevention institution:	VDE100, VDE110, VDE160 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.

2.3 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. REG).



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
- Optional 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 Q2
- ✓ Thyristor controller for dc motors
- ✓ Power range 0.9 to 5.25 KW
- ✓ Driving and braking in all 4 quadrants
- ✓ Energy feedback
- ✓ Intrinsically safe power section
- ✓ Fast analog current control
- ✓ Circular current 2-phase double centre-point circuit
- ✓ Optional uncontrolled field rectifier
- ✓ 26-pole interface
- ✓ Features of the control electronics used:
see MANUAL REGxx or third-party product
- ✓ Optional units

Application

- ✓ DC motors for circular current 4Q operation

2.4 Technical data

Q2 220/160-x

Power connection:	2x100 ... 2x240 V~
Auxiliary voltage connection:	200 ... 250 V~ or 360 ... 440 V~
Output voltage	max. $\pm 175 V^{\bar{}}$
Cooling:	self cooling

Q2 220/160			10	20	30
Input current		A~	6	12	16
Output current	- peak 5s	A $^{\bar{}}$	20	40	60
	- continuous	A $^{\bar{}}$	10	20	30
Electric power		kW	1.6	3.2	4.8
Fuses (fast acting)	Input	A	10	20	35
	Output	A			
Mains autotransformer		Type	UI 120-A	UI 150-B	UI 180-B
Mains isolating transformer		Type	UI 150-A	UI 180-B	UI 210-B
Armature choke		Type	EI 120A-12	EI 135B-24	UI 120B-40
		mH	49	16	7
Dimensions		mm	200x240x100	200x240x100	200x240x127
Weight		kg	2.85	2.85	

2.5 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... $\pm 10 V^{\bar{}}$
Output	0... $\pm 200\%$ type current

Enable > + 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

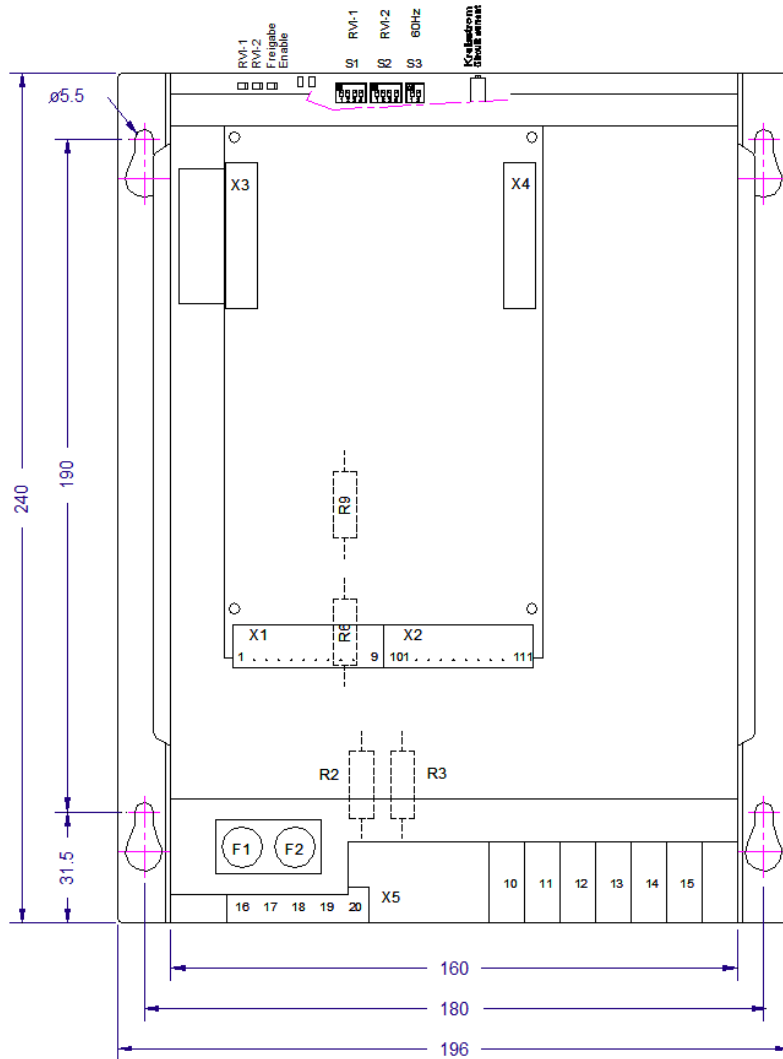
2.6 Interfaces

Interface between the power electronics and the control electronics connector X3 internal

Function		Connector no.
+ 24V	±10 %	X3: 1 and 2
+ 15V	±2 %	X3: 3 and 4
- 24V	±10 %	X3: 5 and 6
- 15V	±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 [±]	X3: 16
Current controller enable	+10 V [±]	X3: 17
Disable 1	+10 V [±]	X3: 18
Disable 2	+10 V [±]	X3: 19
Not connected	not connected	X3: 20
I (current) actual	± 5 V [±]	X3: 21
Over-current power section	+10 V [±]	X3: 22
Ignition angle 1	+10 V [±]	X3: 23
Ignition angle 2	+10 V [±]	X3: 24
Drive ready BTB	+10 V [±]	X3: 25
Not connected	not connected	X3: 26

3 Mechanical installation

3.1 Mounting



3-1 Q1-Q2-Maßbild-M009

Adjustments current controller

Switch S1	PI circuitry	Current controller RVI-1
Switch S2	PI circuitry	Current controller RVI-2
Poti P2	Circular current	increasing when turning counter-clockwise

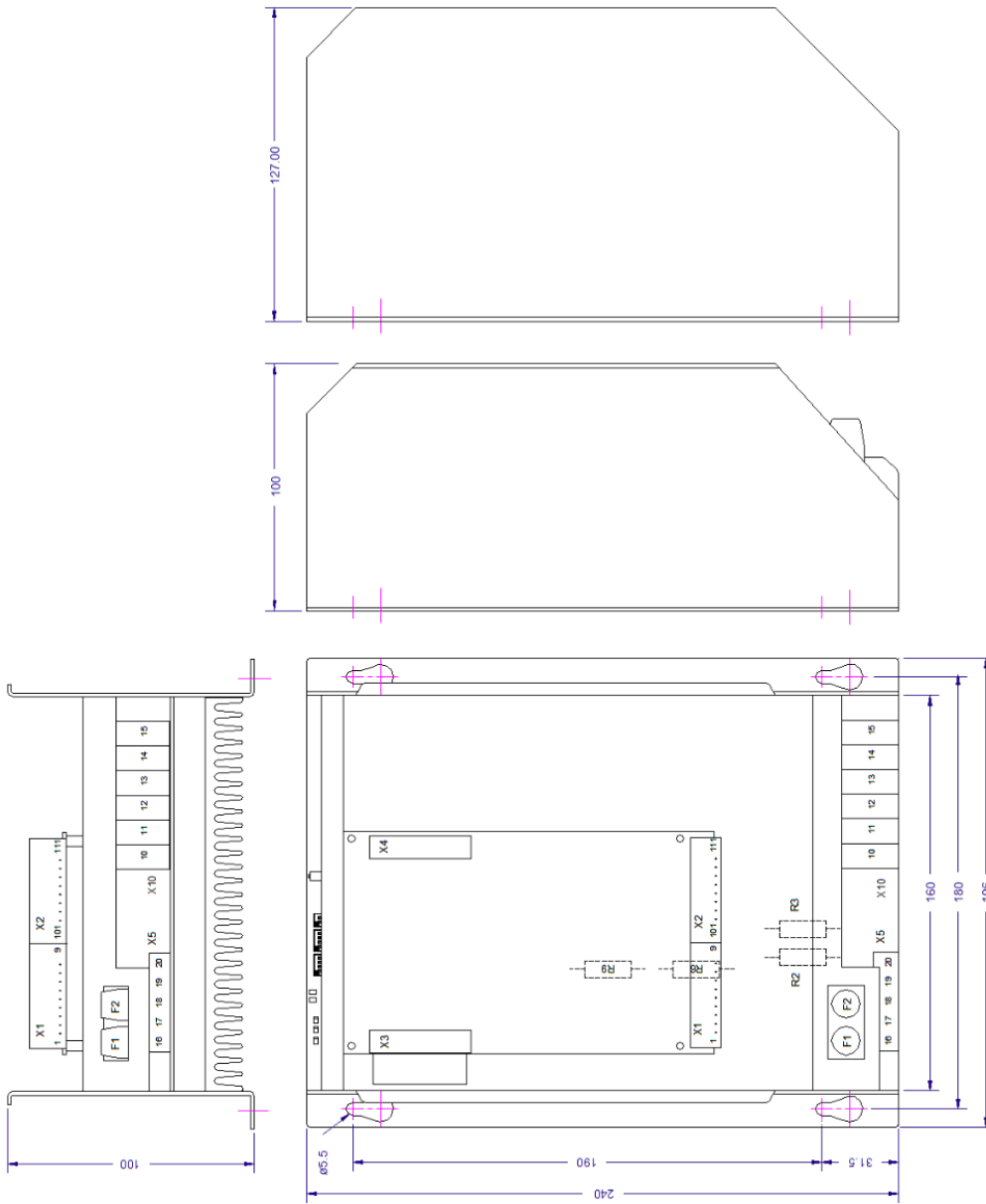
LED – displays - power section

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.	

DIP-switch S3 - power section

Contact 1 and 2	OFF = 50 Hz	ON = 60 Hz
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Dimensions



3-2 Q1-Q2-Maßbild-M009-3

3.2 Transformer choke

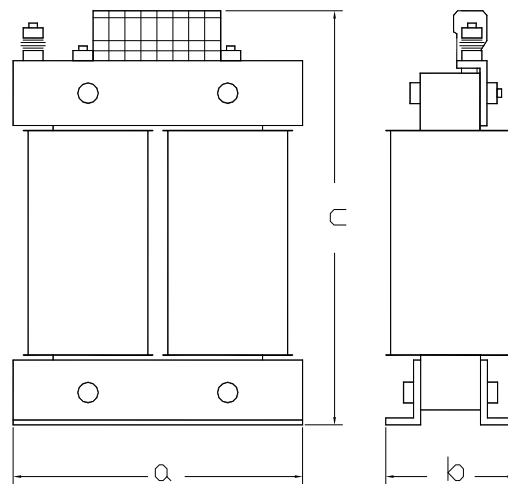
Transformer and choke Q2

Rated current Q2-220-160-		10	20	30
Mains autotransformer	Type	UI 120-A	UI 150-B	UI 180-B
Dimensions a b c	mm	160x135x210	200x145x270	240x190x320
Weight	kg	13	35	44

Mains isolating transformer	Type	UI 150-A	UI 150-C	UI 180-C
Dimensions a b c	mm	200x130x270	200x190x270	240x205x320
Weight	kg	30	39	51

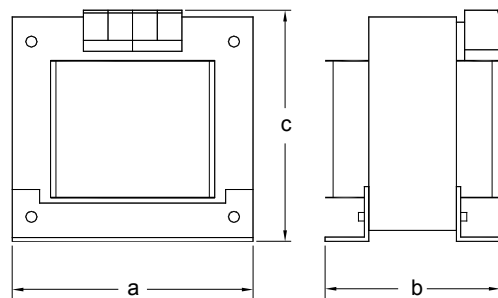
Circular current choke	Type	EI 120A-12	EI 135B-24	UI 120B-40
	mH	49	16	7
Dimensions a b c	mm	102x102x130	115x130x145	160x150x210
Weight	kg	4.3	8.2	16

UI-core



3-3 V256-Trafo VDE-0550

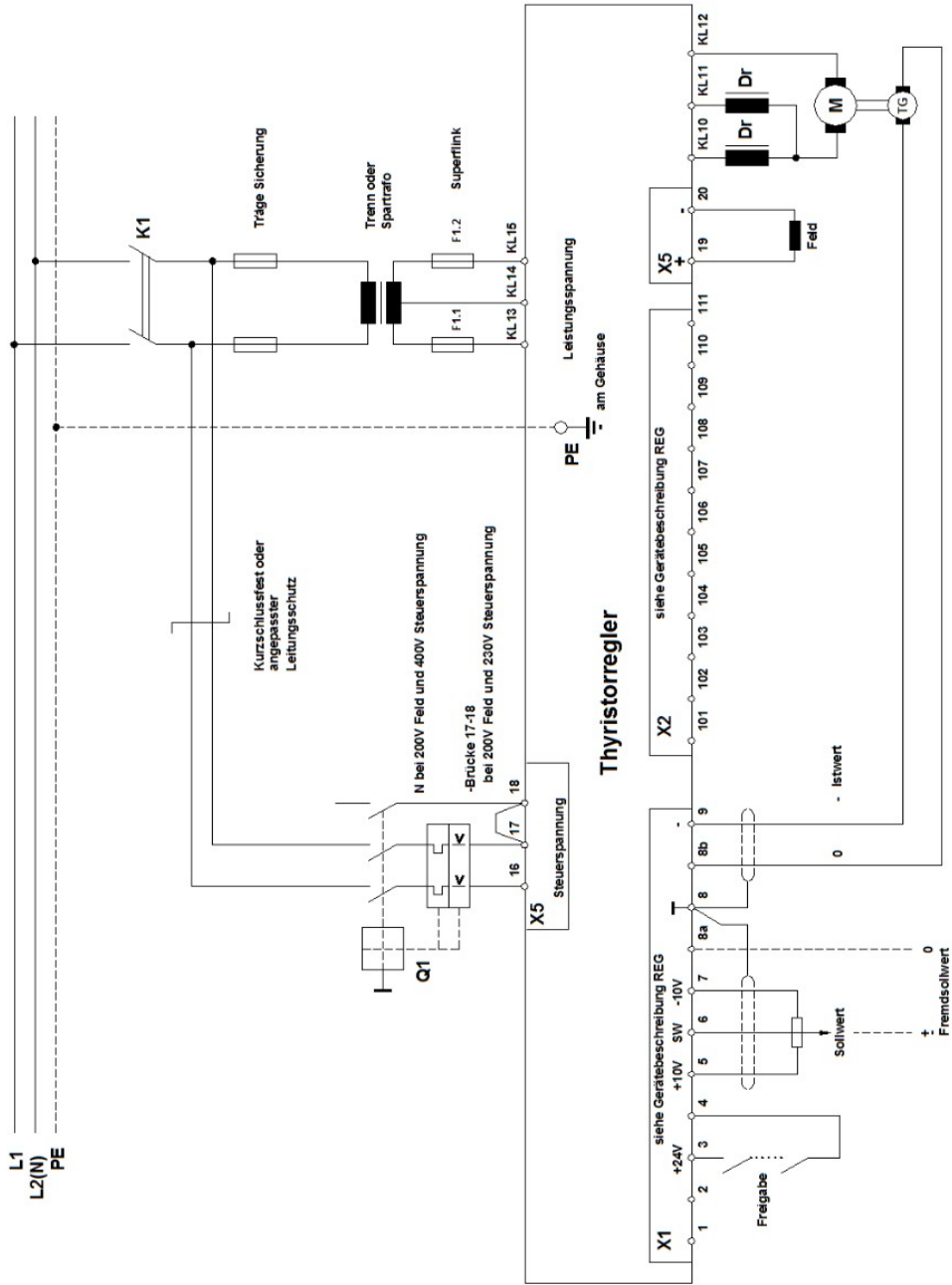
EI core



3-4 V255-Steuer-Trafo

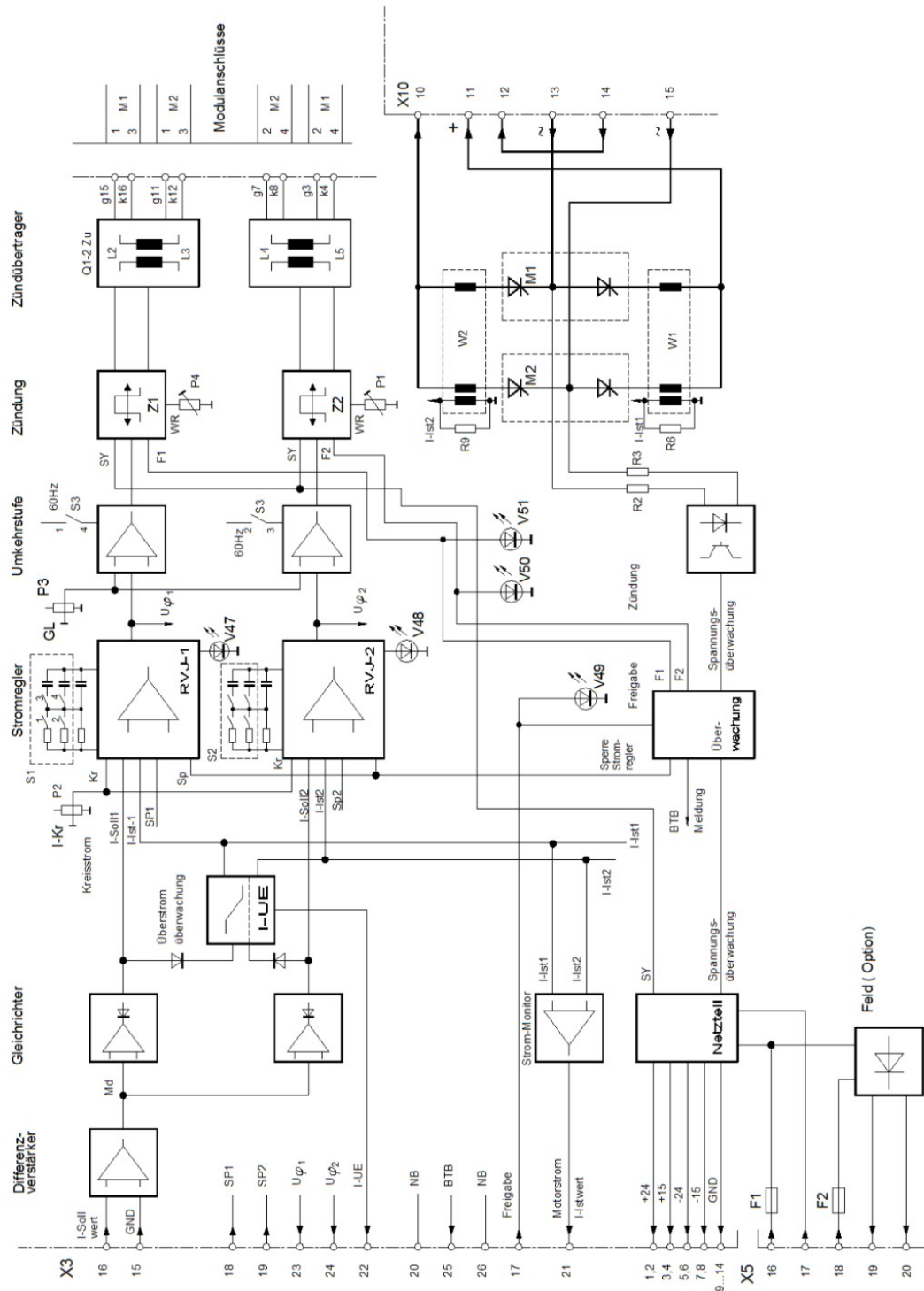
4 Electrical installation

4.1 Connection diagram



4-1 Q2-Anschlussplan-A017.2

4.2 Circuit diagram



4-2 Q2-Schaltplan-S069-2

4.3 Important CE notes

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

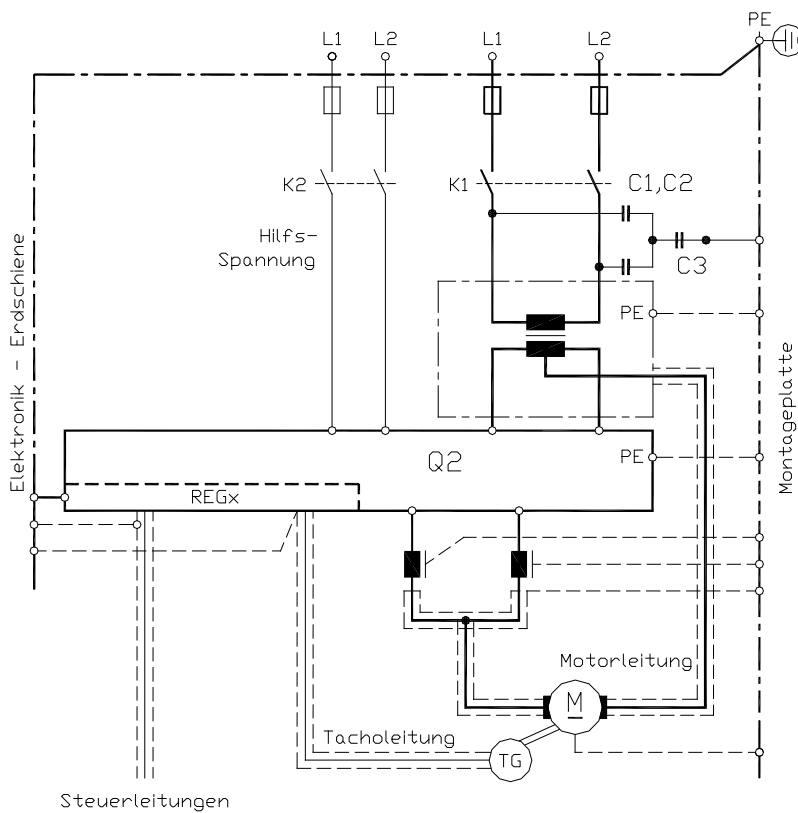
- The device, the power choke, and the filter capacitors are mounted on a 500x500x2mm mounting plate.
- The mounting plate must be connected to ground using a 10mm² wire.
- The motor housing must be connected to ground using a 10mm² wire.
- The device ground X1:8 must be connected to the mounting plate using a 2.5mm² wire.
- Device PE screw must be connected to the mounting plate using a 4mm² wire, l = 50mm.

Two-phase connection

Mains transformer:	rf. to techn. data
Filter capacitors:	2 x 1 μ F(x) + 0.5 x 1 μ F(y)
Conductor length between device and mains transformer	<250mm

Motor connection:

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



4-3 Q2-EMV-1267-1

4.4 Mains connection

Note:

The order of the connections to the connector no. or the connection terminals is obligatory. All further advice is non-obligatory.

The input and output conductors may be altered or supplemented in accordance with the electrical standards

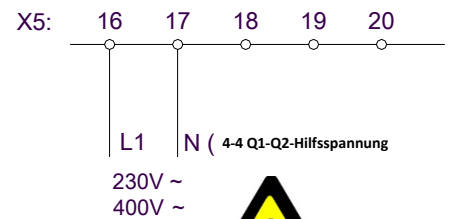


Auxiliary voltage, control voltage

The controllers are delivered with an auxiliary voltage input for 230 or 400V~ (**please observe the type plate**).

The current consumption is 0.1 A.

For Q2 without field option only the fuse F1 (0.8 AT) is installed.



Important note:

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

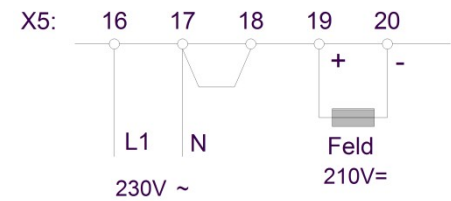
X5:16 corresponds to terminal 13 and X5:17 corresponds to terminal 15.



Field option

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

The auxiliary voltage and the field supply are combined across the plug-in terminal X5.



4-5 Q1-Q2-Feld230-210

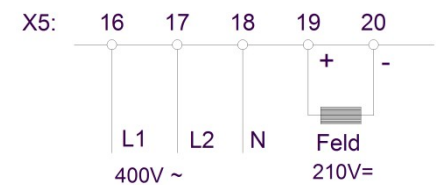
Constant field

Connection

Plug-in terminal strip input	X5:16, X5:17 field
Negative field	X5:20
Positive field	X5:19

Voltages

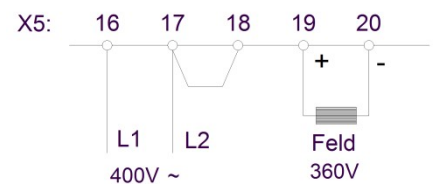
Supply voltage	230 V~
Field voltage	210 V ⁻
Supply voltage	400 V~
Field voltage	210 V ⁻ or 360 V ⁻



4-6 Q1-Q2-Feld400-210

Fuses

Field current	max. 1.5 A
Internal fuses	2 x 2.5 AF
Connection cross-section	min. 0.5 mm ²
External fuses	Conductor protection min. 10 A



4-7 Q1-Q2-Feld-400-360

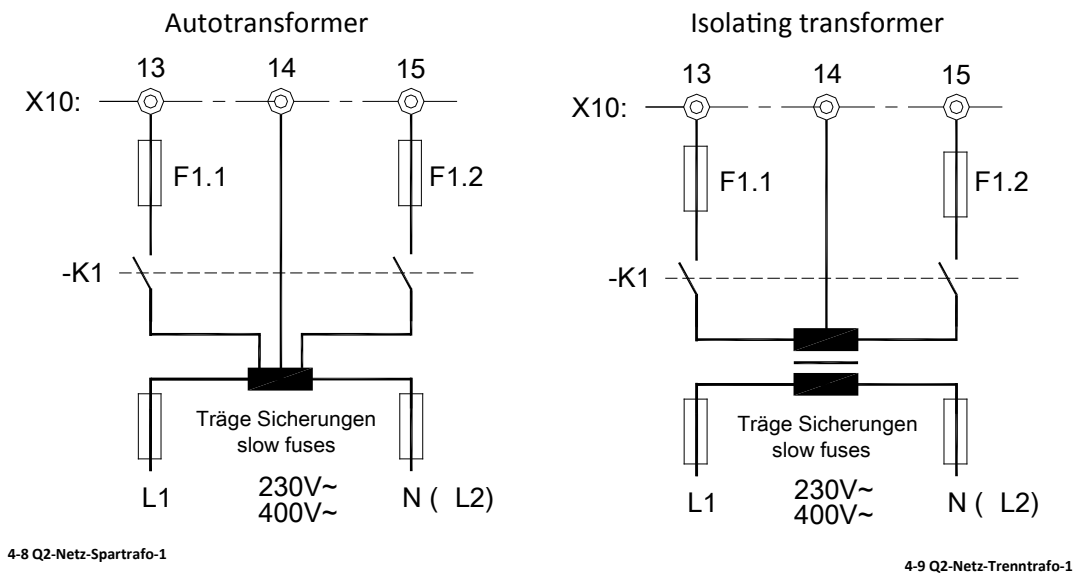
In case the field fuse F1 fails the device is switched off.

4.5 Power supply connection via transformer

- Always use either an isolating transformer or an autotransformer
- Always use an isolating transformer for motors with a weak voltage tolerance or for armature voltage control
- The transformer power is determined by the continuous current and the secondary voltage
- Over-dimension the transformer by 1.5 (dc load)

For 100% ED the transformer power is:
 $P_{Tr.} [VA] = \text{secondary voltage} \times \text{continuous current} \times 1.5$

The transformers recommended in the technical data are rated for 60% ED.



- Use superfast-acting fuses F1.1/F1.2 between the transformer and the control unit
- The fuses are monitored concerning failure via the mains monitoring system
- The connector 14 is not monitored
- The phases of the transformer voltage and the auxiliary voltage across X5 must be equal
- The contactor contacts before the transformer must be rated according to the starting current
- Protect the transformer by means of slow fuses

Important:

For transformer secondary voltages < 220 V~ the resistors R2 and R3 of the power section must be adapted in the factory.

Specification on order: "Transformer voltage"

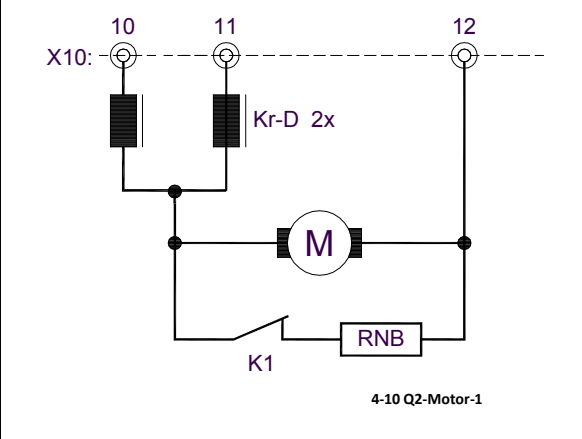
Operation with a 60Hz current supply:

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



4.6 Motor connection

Connection for a positive command value		
Motor –	Terminal	10
Motor +	Terminal	12
<p>Rating for the circular current choke:</p> $L \text{ [mH]} = U_A / I_A \times 2.4$ <p>Motor conductors must be shielded.</p>		



Conductor cross-section (minimal)			
Type current	A	10	20 -3 0
Mains power supply	mm ²	1.5	1.5 – 2.5
Motor connection	mm ²	1.5	1.5 – 2.5

Switching in the armature circuit

- DC circuit disconnected from the mains
- Enable disabled

Caution:

In case of incorrect switching >>> switch-off arc across the switch contacts

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



4.7 Actual value connection

Tacho control

4Q control with a wide control range and good dynamics

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.

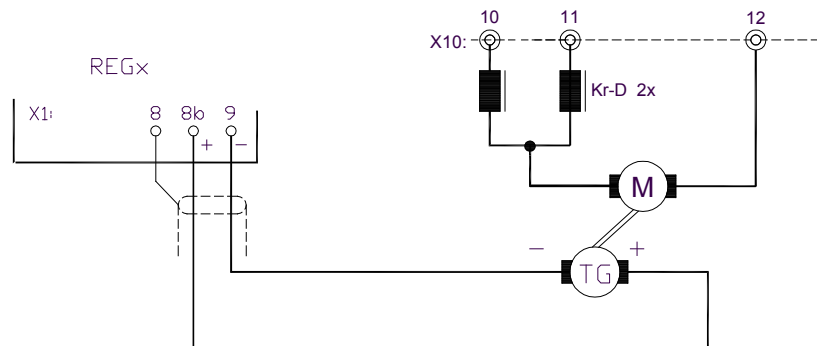
Tacho lines must be laid separately from the power lines (EMV).

For a positive command value

positive tacho X 1:8b

negative tacho X 1:9

Shield X 1:8



4-11 Q2-Tachoregelung-1

Armature voltage control

4Q control with a small control range and bad dynamics

Mains supply via an isolating transformer!

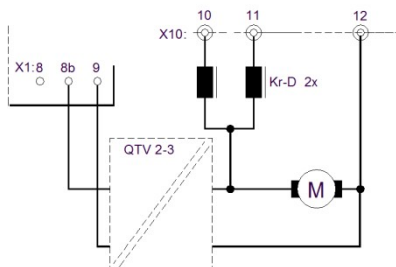
Ground-referenced actual value

Fuses 2 x 0.1 A / 500 V

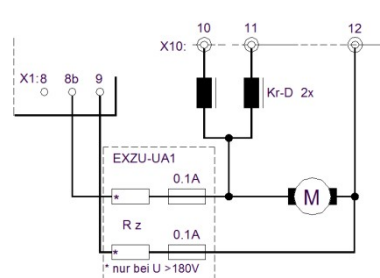
Armature voltage >180V

directly at the tap of the armature voltage

Directly use additional resistors Rz or EXZU-UA1 (manufacturer).



4-13 ED-Q2-Ankerspannung-2-1



4-12 ED-Q2-Ankerspannung-1

Note: Observe the MANUAL REG.

A potential-free armature voltage control is possible by using the QTV 2-3 (manufacturer).



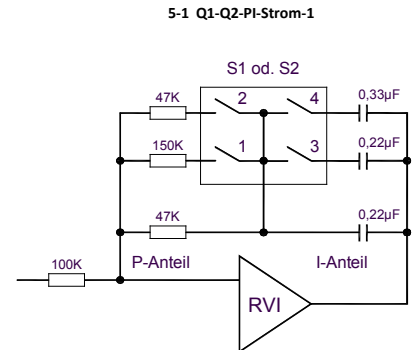
Settings

5 Settings

5.1 Control parameters of the current controller

Optimization of the current controller

- Oscilloscope at the actual current value X3:21
- Current command value step $\pm 1V$ X3:16
- Increase the current command value by 1V-steps to $\pm 10V$
- P-amplification via the DIP-switches S1 and S2 / Contact 1 and 2
- Optimal setting fig. 1
- Setting not permissible fig. 2
- Integral term with via the DIP-switch S1 and S2 / Contact 3 and 4



Oscillogram - current adjustment

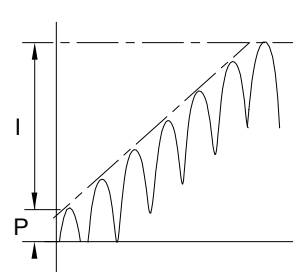
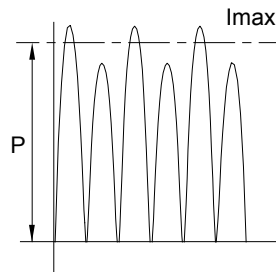
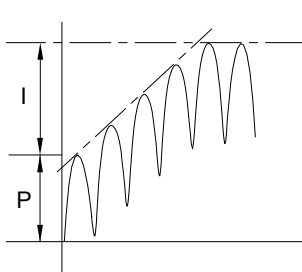


Fig. 1
Optimal adjustment

Fig. 2
Amplification too high

Fig. 3
Low P-amplification

Note:

Current controller optimization only with oscillographical control

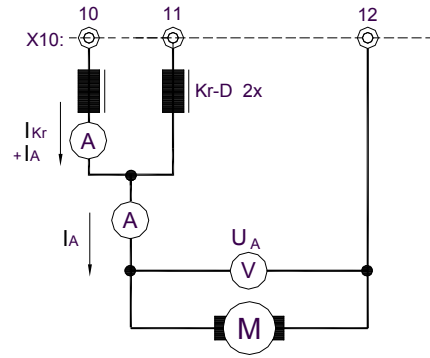


5.2 Signals

BTB signal	X3:25	>+10 V
Error	X3:25	<+2 V

Power measurements

Measuring instruments	Multimeter for current and voltage Shunt or clamp-on ammeter = ~
Measuring error	Mean value >>> Effective value corresponding to the form factor approx. 1 to 5%
Measured values	In the choke circuit = circular current + armature current In the motor circuit = motor voltage and motor current
Polarity	X10:12 is positive against the choke centre point
positive command value	



5-4 Q2-Motor-Mess-1

Measured values on the control electronics REGxx (see MANUAL REG)

Speed	X2:109	±5V or ±10V	for ±100% speed
Current	X2:111	±5V or ±10V	for ±200% current
GND	X2:104		

5.3 Commissioning Q2 x/x-x with REG

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

Basic power connections Q2

Mains connection	Power	Terminal	13, 14, 15
Mains connection	Auxiliary voltage, control voltage	Terminal	16, 17

Observe the phase position between power and control voltage.

Mains connection	Field	Terminal	16,17,18
Motor connection	A1/A2	Terminal	10, 11, 12
Field connection	F1/F2	Terminal	19, 20

Protective conductor	PE	Earth screws PE on the housing
----------------------	----	--------------------------------

The operation without protective conductor PE is forbidden.

Basic control connections REG

Observe the MANUAL REG

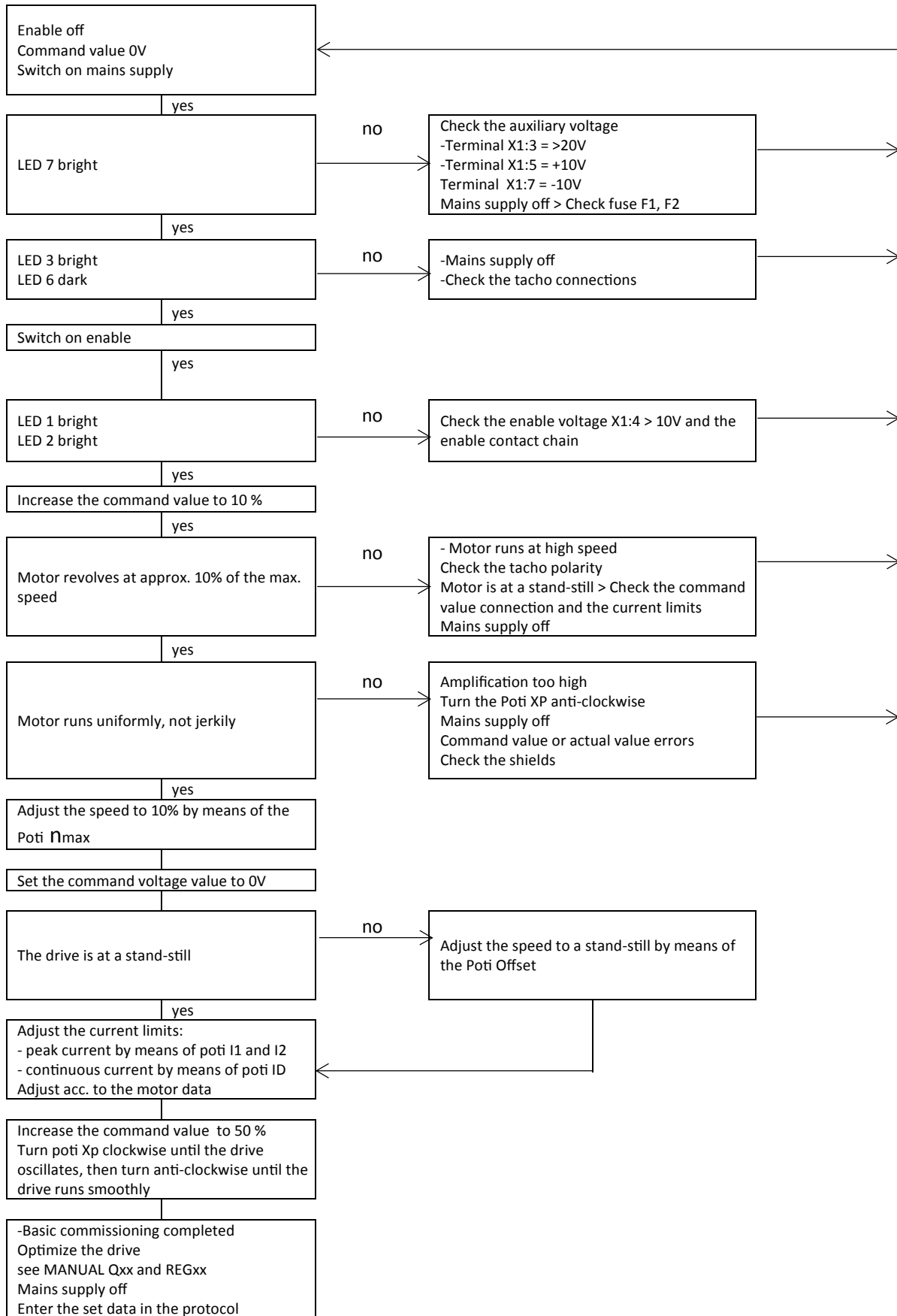
Enable	Contact between X1:3 and X1:4
Command value	Signal X1:6 GND X1:8a
Actual value	Signal X1:9 GND X1:8b
Shields	X1:8

Control electronics REG

Observe the MANUAL REG


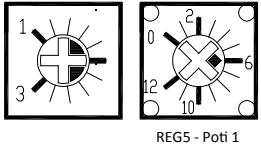
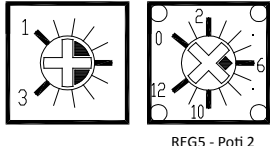
Switch	S4	P-amplif.	Position 4
Switch	S5	I-part	Position 4
Switch	S8	D-amplif.	Position 8
Switch	S9	Actual value	Position 8
Potentiometer	I1	Peak current	10%
Potentiometer	I2	Peak current	10%
Potentiometer	ID	Continuous current	100%
Potentiometer	XP	Amplification	50%
Potentiometer	INT	Integrator	Left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

Settings



Settings

5.4 Protocol (commissioning)

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

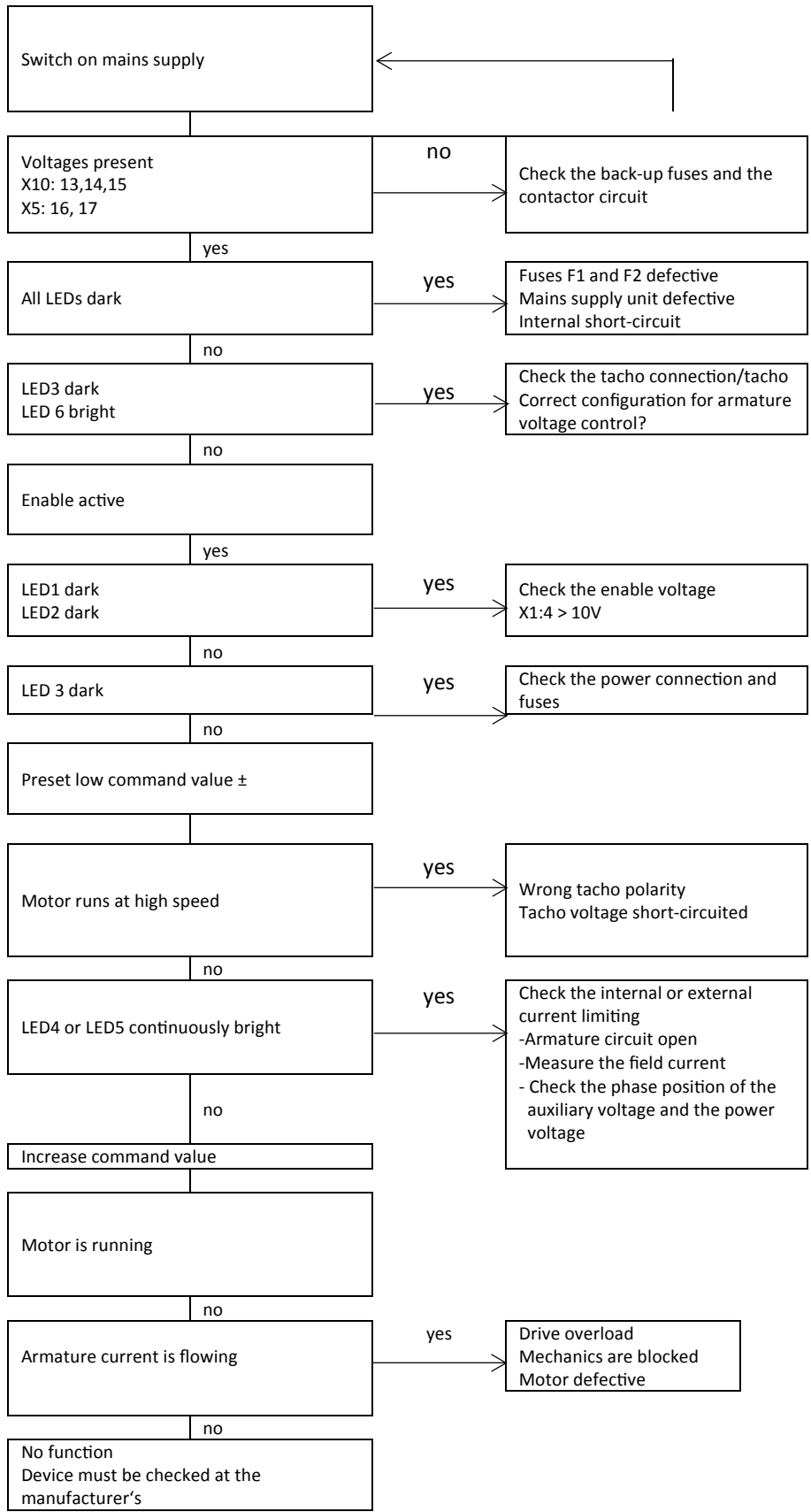
Settings

Current controller settings			
P-amplification S1 / S2 - contact 1 and 2	DIP-switch	S1 and S2	
I-part S1 / S2 – contact 3 and 4			
50/60 Hz	DIP-switch S3		
	1+2 ON (60Hz)	1+2 OFF (50Hz)	
Measured values Qxx-REGxx			
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]	
Motor data			
Type plate data			
Manufacturer			
Type		Serial no.	
Motor voltage [V=]		Motor current[A=]	
Field voltage [V=]		Field current [A=]	
Tacho voltage [V/min ⁻¹]		Tacho type	
Brake [V]		Fan [V]	
Rated speed [U/min]			

Troubleshooting

6 Troubleshooting

6.1 Troubleshooting



6.2 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

7 Guarantee

7.1 Guarantee

We guarantee that the device is free from material and production defects. Test results are recorded and archived with the serial number.

The guarantee time begins from the time the device is shipped, and lasts one year. WE undertakes no guarantee for devices which have been modified for special applications.

During the warranty period, we will, at its option, either repair or replace products that prove to be defective, this includes guaranteed functional attributes. We specifically disclaim the implied warranties or merchantability and fitness for a particular purpose. For warranty service or repair, this product must be returned to a service facility designated by us.

For products returned to us for warranty service, the Buyer shall prepay shipping charges to us and we shall pay shipping charges to return the product to the Buyer.

However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to us from another country.

The foregoing warranty shall not apply to defects resulting from:

- * improper or inadequate repairs effected by the Buyer or a third party,
- * non-observance of the manual which is included in all consignments,
- * non-observance of the electrical standards and regulations
- * improper maintenance
- * acts of nature

All further claims on transformation, diminution, and replacement of any kind of damage, especially damage, which does not affect our device, cannot be considered. Follow-on damage within the machine or system, which may arise due to malfunction or defect in the device cannot be claimed.

This limitation does not affect the product liability laws as applied in the place of manufacture (i. e. Germany).

We reserve the right to change any information included in this MANUAL.

All connection circuitry described is meant for general information purposes and is not mandatory.

The local legal regulations, and those of the Standards Authorities have to be adhered to. We do not assume any liability, expressively or inherently, for the information contained in this MANUAL, for the functioning of the device or its suitability for any specific application.

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The onus is on the reader to verify that the information here is current.