MANUAL

Battery- Motor-Controller
BAMO A1, A2-x-10 - 40
for DC-Motors

BAMO A1, A2 10-40A

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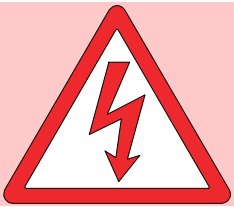
Version
2023/V1

Contents

Electronic equipment is not fault proof. This fact should be borne in mind for all possible operating conditions.

ATTENTION - Direct voltage
160V DC



Before installation or commissioning begins, this manual must be thoroughly read and understood by the technical staff involved.
If any uncertainty arises, the manufacturer or dealer should be contacted.
The device BAMO- series is power electric parts used for regulating energy flow.
Protection rating IP00.
Connections only to a battery or galvanic isolated direct voltage. (See page 8)

Standards and guidelines
The device and its associated components can only be installed and switched on where the local regulations and technical standards have been strictly adhered to:

EU Guidelines	89/392/EWG, 84/528/EWG, 86/663/EWG, 72/23/EWG EN60204, EN50178, EN60439-1, EN60146, EN61800-3
IEC/UL	IEC364, IEC 664, UL508C, UL840
VDE Regulations	VDE100, VDE110, VDE160
TÜV Regulations	
Trade body guidelines	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 machine or equipment are fitted with device independent monitoring and safety features.

Setting adjustments

- should only be carried out by suitably trained personnel
- should only be carried out in accordance with health and safety guidelines

Assembly
- should only be carried out when all voltages have been removed.

QS
Test results are archived with the device serial number by the manufacturer.

CE
The device adheres to the following: Guideline EU 89/336/EWG. EMC standards EN61000-2 and EN61000-4.

General Information

The battery motor controller BAMO-Ax-xx forms together with the low voltage DC-motor a propulsion unit distingushed by its high control range.
With a DC-motor the current is proportional to the torque and the voltage is proportional to the speed.
Current and voltage are measured precisely.
The analogue circuits of the servo driveare simply constructed.
The speed actual value is generated from armature voltage or from the DC-tachogenerator.
The speed and the current controller are designed as P-I-controller.
In version BAMO-A2 (4Q) the brake energy is refeeded to the battery.

Application

for all kinds of machines or vehicles up to 6 kW battery feeded drive power especially for
- a great controller range
- a high efficiency
- small motor dimensions
- a even and smooth travel

for speed or torque regulation or
combined speed-torque regulation with or without superposed position controller.

For use in

battery powered vehicles like cleaning machines, el. boats,
fork-lift trucks, transport systems,
Solar- or wind powered installations,
and many other battery powered machines and installations

Construction:

Cubicle-mount unit in IP23 according to the VDE- DIN- and EU- regulations.
Standard analogue regulation electronics.
Power electronics with IGBT-power semiconductors,generous dimensioning.

Characteristics:

* Battery supply or galvanic isolated direct voltage (Page 8)
* Differential comm. value inputs
* Speed and torque regulation
* Static and dynamic current limit
* Current comm. value output
* Enable logic, quick stop
* Temperature control for motor and device

Technical Data

Power connection

Type BAMO A1, A2	10 - 40	10 - 40
Battery voltage	12, 36V	48 to 160V
direkt current bus mains (galvanicisolated)	12, 36V	48 to 160V
	Page 8	
Output voltage 0.8xUB	max. 30 V	max. 150V
Auxiliary voltage	24V= ±10%, max. 0.5A, Waviness <20% GND = -UB	

Spezifications

Device BAMO A1, A2-x-		10	25	40
Output current steady max.	A=	10	25	40
peak max. (5s)	A=	20	50	80
el. power max.	W	1500	3750	6000
fuses quick	AF		40	80
cooling	60%ED	convect	convect	head sink
cooling	100%ED	convect	head sink	head sink
Dimensions	BxHxT	see Page 6,7		
Weight	Kg	0.50	1.6	1.6
Weight with cooler	Kg	/	2.2	2.2

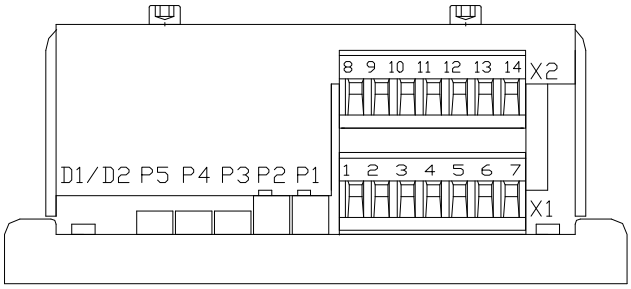
Common specifications

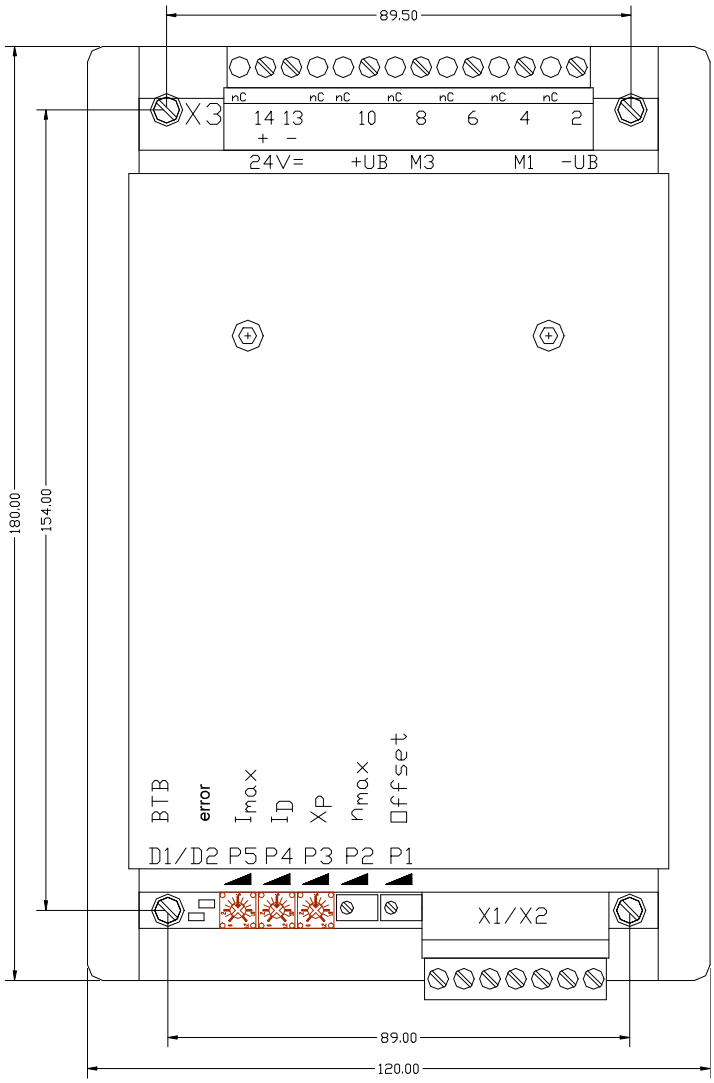
protection standard		IP 00
device layout		VDE 0100 group C VDE 0160
humidity stress		class F accordig to DIN 40040
set up hight		< 1000m over NN
operating range		0 ... 45°C
extended operating range		up to 60°C red. 2%/°C
bearing range		-30°C up to + 80°C
speed controller		
control accuracy	no act.value error	± 0,5%
control range		1: 1000
temeperature observation		80°C

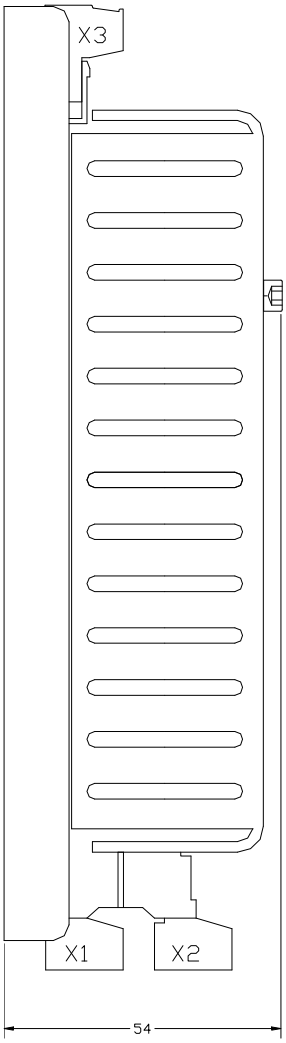
Versions

BAMO A1-xx	1 Quadrant- controller	propeling in rotation direction
BAMO A2-xx	4 Quadrant- controller	propeling and breaking in both rotation directions,energy rear feed (see connect. advice page 8)

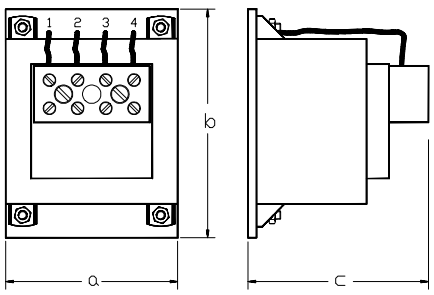
Dimensions BAMO A1, A2-x-10



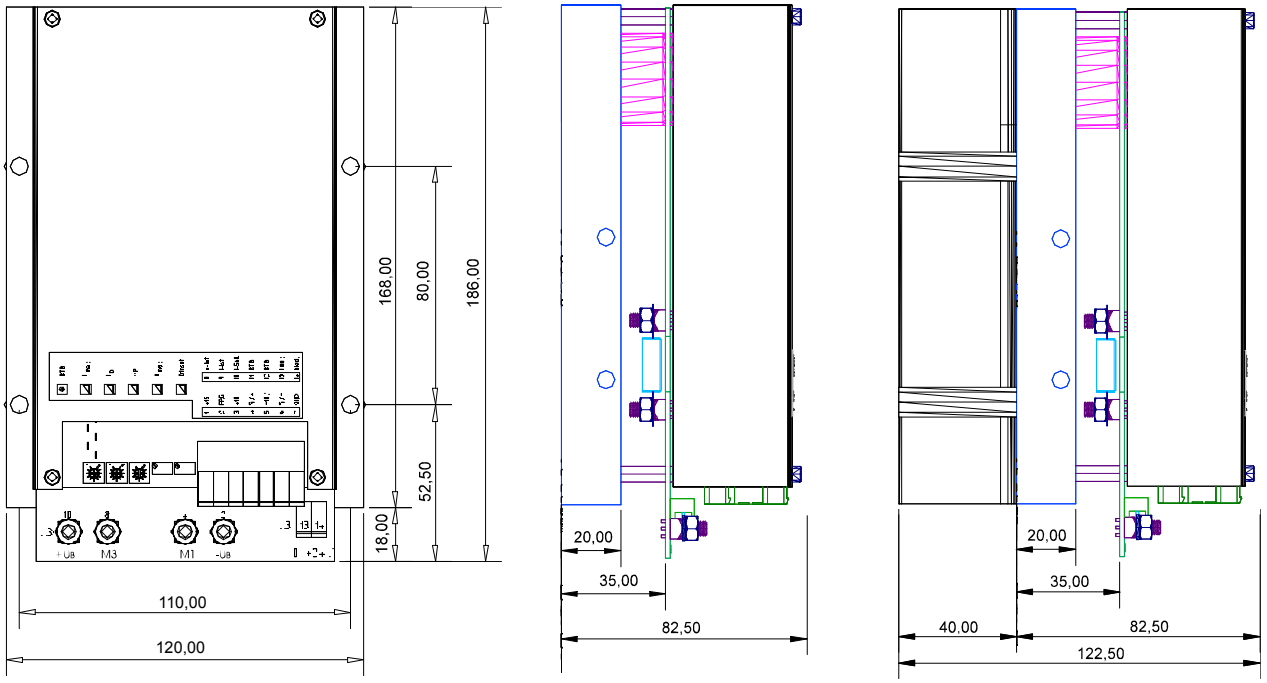


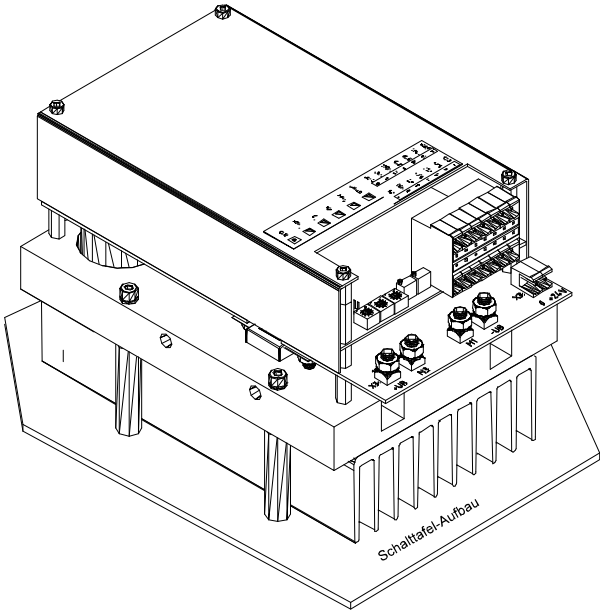


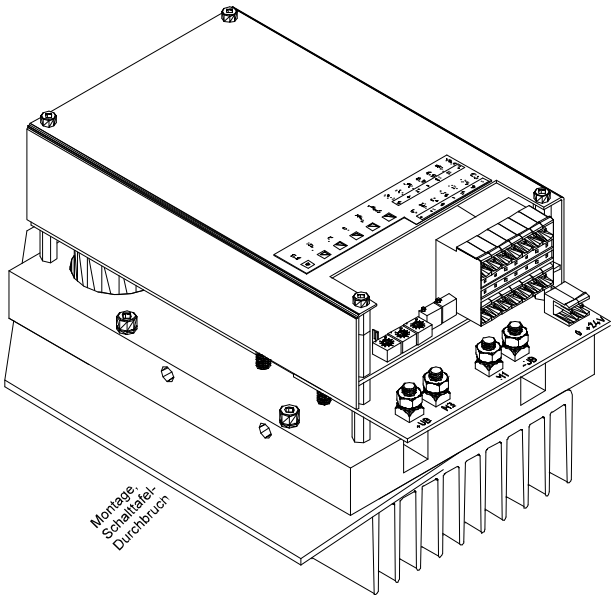
Choke Type	Current A	Induct. mH	Dimensions a /b /c mm	Weight kg
2M7-12	12	1.5	80x 105x 86	1.4
2EI105-20	20	1	90x92x115	3.1
2EI135-40	40	0.7	115x120x145	7



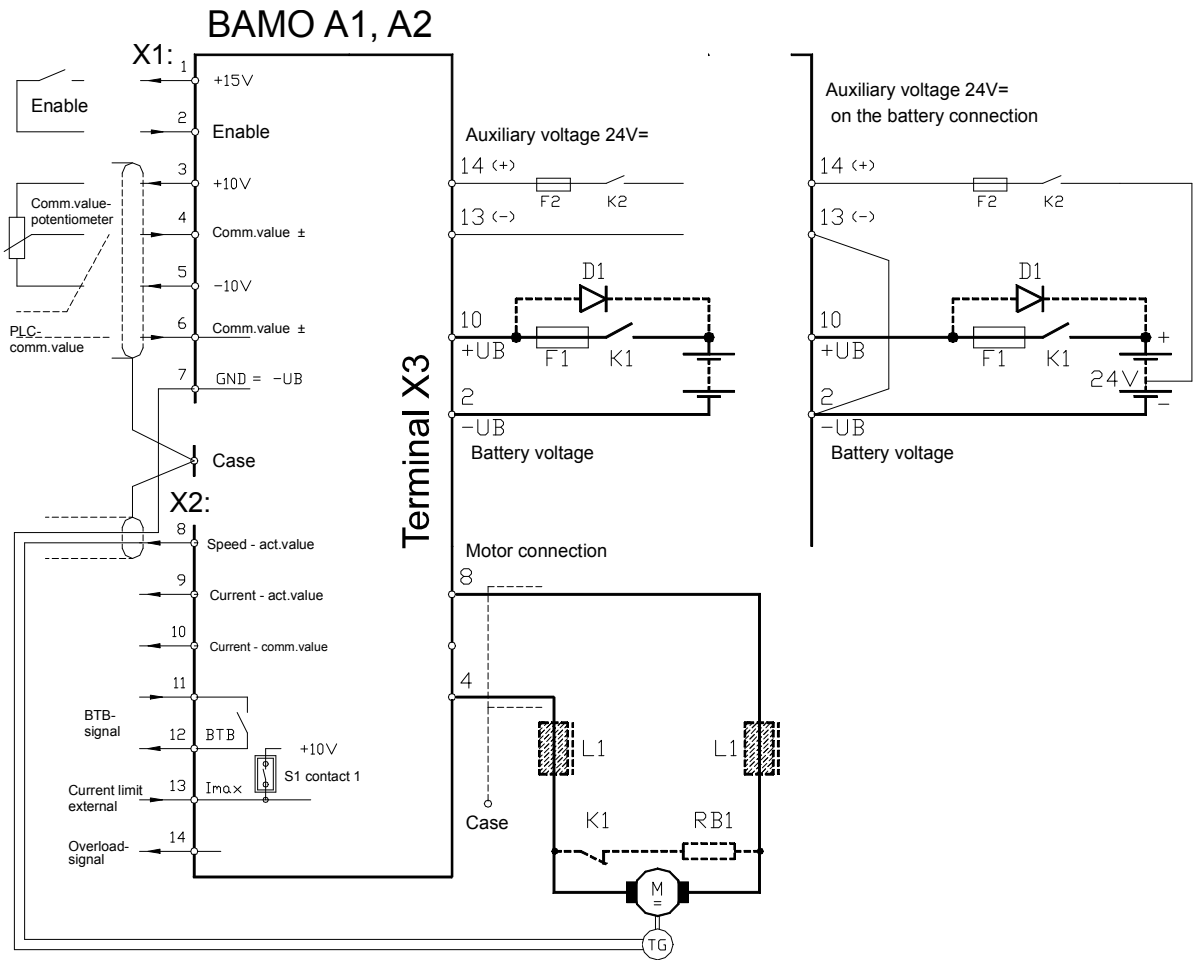
Dimensions BAMO A1, A2-x-25, 40







Bolts : 10x40mm



Notice:

Power connection X3:2 (-UB) , X3:10 (+UB)

Connection polarity >>> no protection against mixing up the contacts
when the connection is wrong the output stage can be distroyed!

The power connection must not be devided during braking! If nessesary built in reverse-current-protection-diode D1. On-stage current = device peek current

Connection to Direct voltage bus or Power supply unit

Make sure that the overvoltage in the buffer circuit is limitated to 20% during braking. Small ResisTor of the source or ballast circuit.

If the ResisTor of the motor is very small the fast rising of the buffer voltage circuit can demage the semi-conductors. In normal case the device is switched to error by the overvoltage observation.

Auxiliary voltage connection X3:13, X3:14

Safe against mixing up the contacts. The connection can be switched seperated from the power connection.

Notice the tolerance and the residual ripple of the voltage.

Motor connection X3:4 (M1),X3:8 (M3)

The motor connections can be exchanged.In case of EMC-problems use chokes and shielded line.

Brakong resistor RB1 and DC-contactor K1 as resistor brake with type A1 or as battery failure brake with type A2

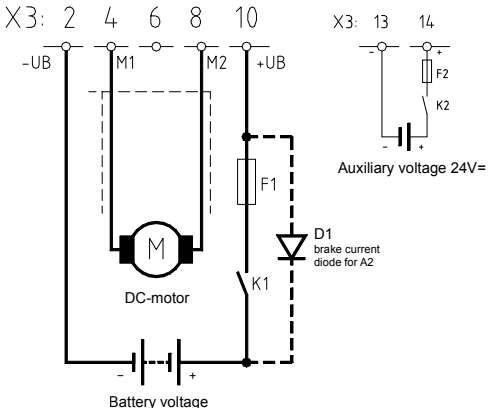
Control connections see special advices.

Caution:

The connection advices concerning the individual attachment of the connections to the plug numbers or terminals are binding.
All further advices to this are not binding.
The input and output lines can be altered or completed in consideration of the electrical regulations.

Notice:
- connection and operation advices
- local technical regulations
- EU-machine regulation 89/392/EWG,84/528/EWG, 86/663/EWG
- VDE and TÜV regulation
- CE-advice, EMC

Connection



Caution:
Risk off distruction by overvoltage in buffer circuit

Using BAMO-A2-36 the batterie voltage
(U_B+ X3:10, U_B- X3:2)
must be applicated to the device 10s before switching on and 10s after switching off enable to limitate a possible occuring brake voltage by the battery everse current protection diode D1 against uncontrolled disconnecting the battery voltage while braking.

If using a DC-Bus notice advices on page 10.

Connection lines

dimensioning	**at A**	**10**	**25**	**40**
Battery connection	mm²	2.5	4	6
Motor connection	mm²	2.5	4	6
Power fuse F1	A	16	35	50

Auxiliary voltage line	mm²	0.5
Line fuse F2	AF	1

Caution : Battery lines < 2m
with longer lines = use a one step strengther cross section!
with battery lines >5m install booster capacitors

The connecting advices are for general information and without obligation

Notice:
- Connecting- and operating instructions
- Local regulations
- EU-machine regulation
- VDE and TÜV regulation

pin-No. terminal block
X1: 1 up to X1:7 and X2 : 8 up to X2 : 14

Signal lines

Shielded and seperated from power lines.
comm. values paired twisted and shielded.

Logical connections

Relay with gold contacts or reed relays. Contact current 6mA.

Enable -internal logical voltage

- internal logical voltage	X1:1	+15V/10mA
- contact chain between	X1:1 and	X1:2

Enable -external logical voltage

- enable voltage +10 … +30V	X1:2
- GND	X1:7

Switch on enable

- comm. value and speed controller are enabled immediately.

Switch off enable

- Command value and speed controller quick stop
- comm. value >>> is switched internally immediately to 0
- after 2 seconds >>> speed controller is locked.

Caution:

Make sure that the battery voltage is connected to the device at least for 10 seconds after switching off the enable.

Auxiliary voltage connection

- Direct voltage 24V= ±10%
- Power requirements 0.5A, with cooling 0.8A

Comm. value-speed

voltage source for comm. values ±10V, 10mA

+10V	X1:3
-10V	X1:5
GND	X1:7

comm. value input

- comm. value input maximum ±10V=
- differential input
- input resistor 50 kΩ
- relay contacts: gold- or reed contacts

Caution
comm. value lines paired twisted and shielded. Screen connection one-sided.

Connection :

comm. value voltage with internal supply

command value	X1:4 (signal) X1:7 (GND)
bridge	X1:6 — X1:7

External comm. value voltage PLC/CNC

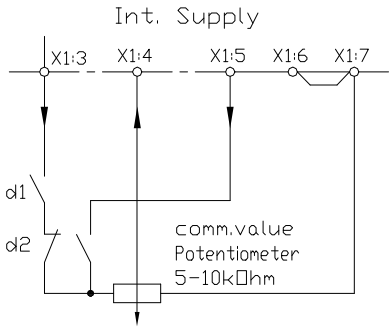
command value	X1:4 (signal) X1:6 (GND)

External command value current PLC/CNC

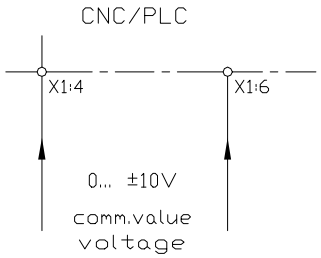
Resistor for command value current 0 ... ± 20mA >>> R-comm.v. = 500Ω

command value current	X1:4 (signal) X1:6 (GND)

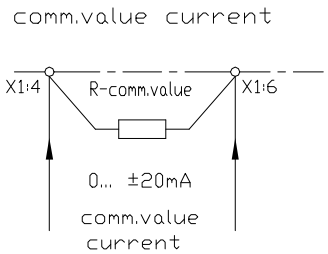
int. supply



CNC/PLC



comm. value current



With A1(1Q) only positiove command value

leave out d2 and connection X1:5 is not coated

Caution:
do not use a command value current between 4 and 20mA

External current limitation

voltage source for external current limit

+10V/10mA	X1:13
GND	X1:7

Current limit- input

maximum input voltage +10V
input resistor 10 kΩ
internal attenuation with potentiometer I_{max}
relay contacts: gold- or reed contacts
switch S1, contact 2 = OFF

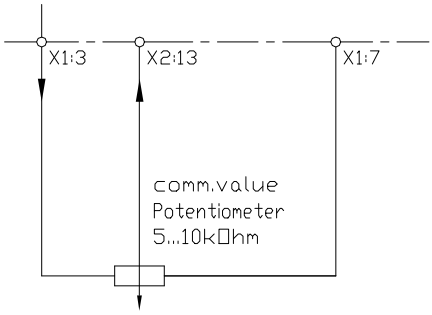
Connection

current limit	X2:13	(signal)
	X1:7	(GND)

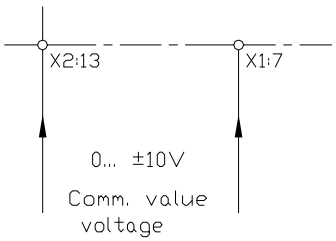
RANGE

0 … + 5V	>>> 0 up to 100% device rated current
0 … +10V	>>> 0 up to 200% device rated current
internal over current control	>>> max. 5 s.

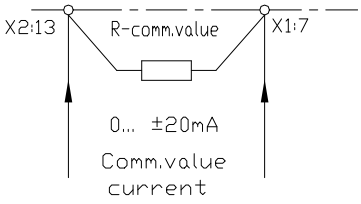
Int.supply



CNC/PLC



comm. value current



Caution:
in case of internal current limit adjustment

switch S1 >>> contact 2 = ON
(see page 15)

Ready for operation signal BTB

Relay RL1

signal contact X2:11 - X2:12
contact values max. 48V; 0,5A

The ready for operation signal (BTB) shows the CNC/PLC that the drive is ready for operation.
Switch BTB- signals of several axes in one row.

delay after switching on mains >>> max. 1sec.

Function	Indication	BTB-Relais
ready for operation	LED green bright	contact closed
not ready f. operation	LED glims green	contact open
error	LED red bright	contact open

BTB turns off with		error
overtemperature		not stored
overvoltage		stored
short-circuit, line-to-earth-fault		stored
voltage error		not stored

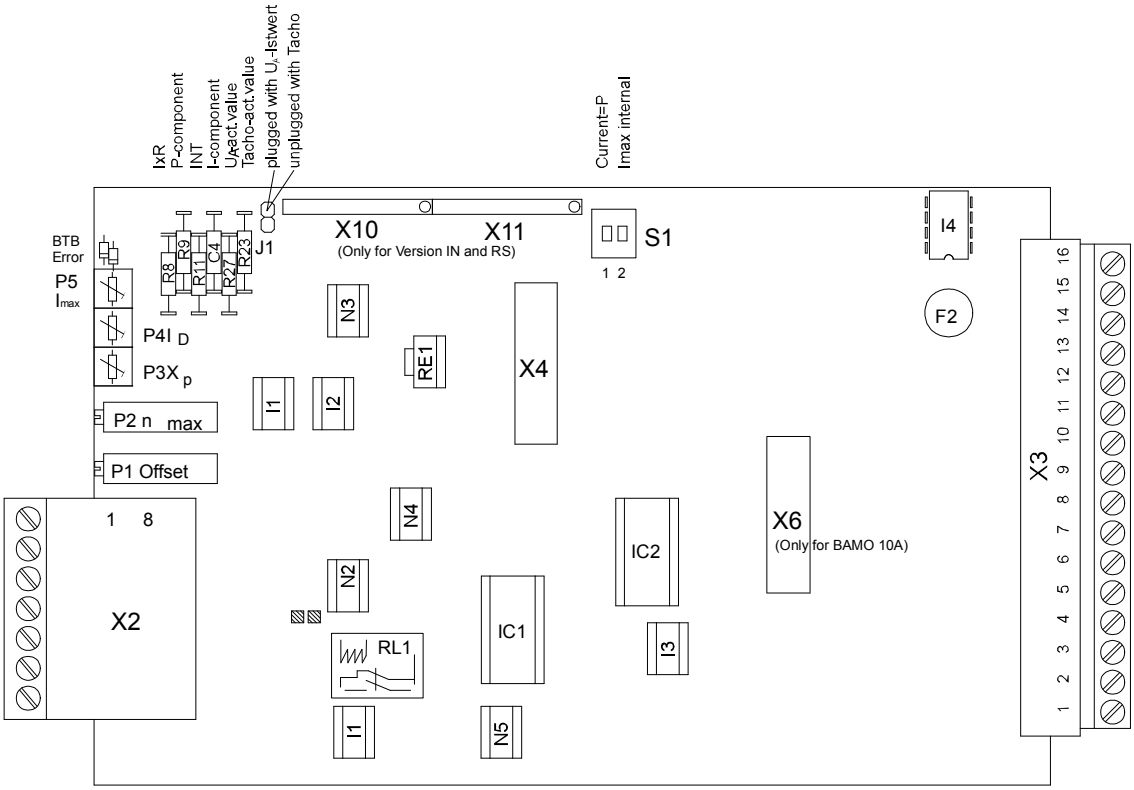
Caution:
Use BTB-contact always with CNC/PLC - control or with emergency-stop circuit !
Self-starting possible!
fault memory
-is not effective with all faults !

Signal blocked		
current demand	normal	overload
output X2:14	>+12V	<+2V
Analogue measuring outputs		
Function	motor current indication	speed- indication
connection	X2:9 - X1:7	X2:8 - X1:7
measuring value	5.0V = peak current 2.5V = rated curret	
measuring speed		± tacho voltage before divider
output Resistor	1 kΩ	4.7 kΩ

Plug-Clamp-No.

Control Connections		
Function		**Clamp-number**
Voltage +15 V/10mA	(for enable)	X1:1
Enable +10 to up +30V	Enable - input	X1:2
Comm.value supply +	Voltage +10V/10mA	X1:3
Command value +	Comm.value - input +	X1:4
Command value supply -	Voltage -10V/10mA	X1:5
Command value -	Command value output	X1:6
GND		X1:7
Speed actual value	Tacho connection	X2:8
Current actual value	measuring output	X2:9
Current command value	measuring output	X2:10
BTB contact	ready for operation	X2:11
BTB contact	ready for operation	X2:12
Current limit external	current limit output	X2:13
Blocked	output	X2:14
Power Connections		
Function		**Clamp-number**
Battery -	- U_B	X3:2
Motor 1	M1	X3:4
Motor 2	M2	X3:8
Battery +	+ U_B	X3:10
Auxiliary voltage		**Clamp-number**
GND -24V		X3:13
+ 24V		X3:14

Component overview



Indications

	D1 green	BTB
	D2 red	fault

Poti

	P5	I_{max}
	P4	I_D
	P3	Xp
	P2	n_{max}
	P1	Offset

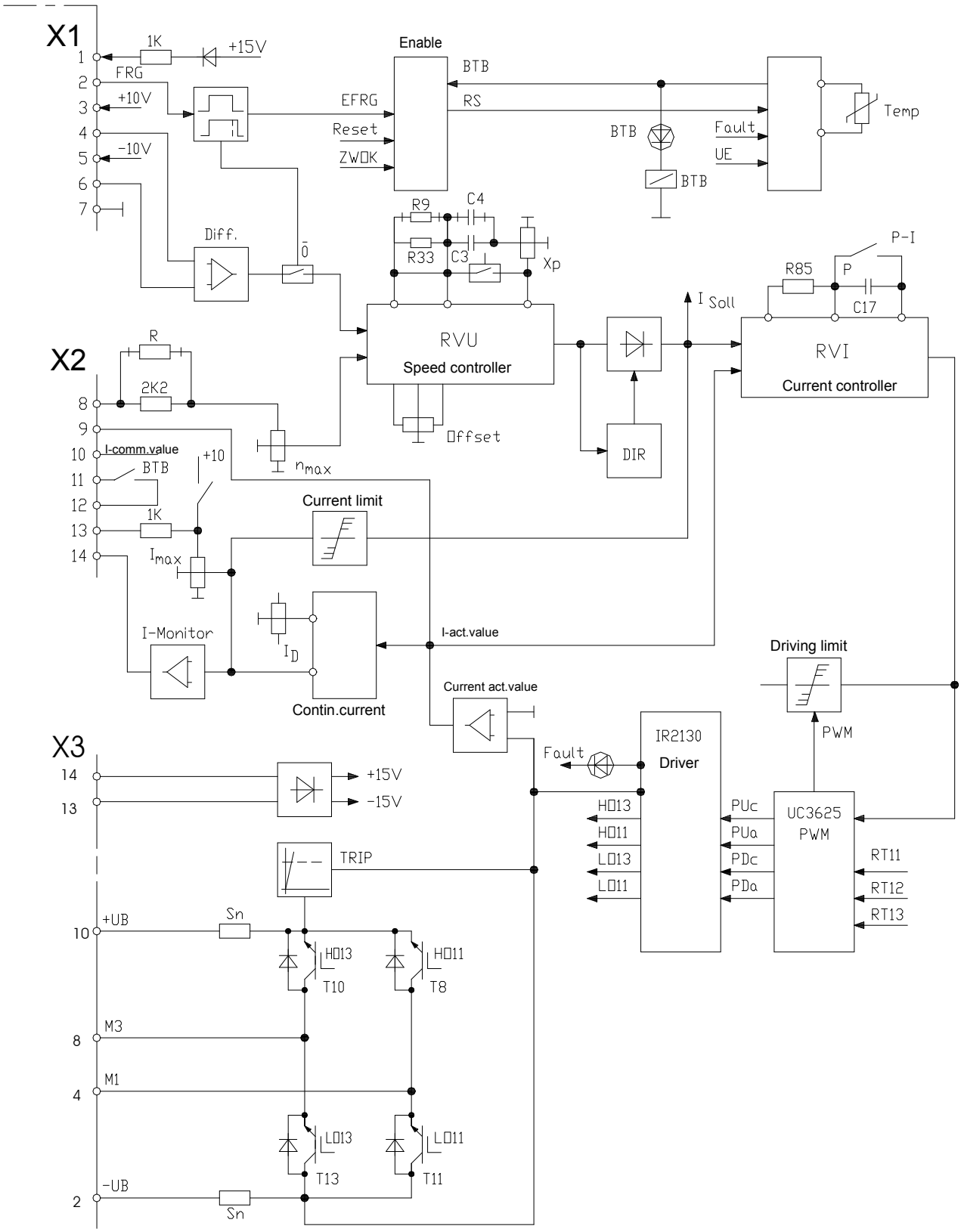
Jumper/Switch

J1	armature voltage control
S1 cont.1	current controller
S2 cont.2	current limit internal

Clamps

X1:1	+15V
X1:2	enable
X1:3	+10V
X1:4	com.value+ (-)
X1:5	-10V
X1:6	com.value - (+)
X1:7	GND
X2:8	n-act.value
X2:9	I-act.value
X2:10	I-com.value
X2:11-12	BTB-contact
X2:13	ext.current limit
X2:14	blocked

Circuit diagram



Function	Poti	Switch	Jumper	Component
Act.value balance DC-Tacho	P2 (n_{max})		J1 offen	R23
Act.value balance armature voltage control	P2 (n_{max})		J1 gesteckt	R27
IxR - compensation				R8
Current limit internal	P5 (I_{max})	S1-2 ON		
Current limit external	P5 (I_{max})	S1-2 OFF		
Continuous current	P4 (ID)			
Amplification P-component	P3 (XP)			R9
Amplification I-component				C4
Integrator				R11
Zero balance	P1 (Offset)			

Switch S1

Function	contact	ON	OFF	
Current limit	2	internal	external	
Current amplification	1	P	PI	

LED- indication

Function	colour	Indication	LED No.	
BTB	green	bright	D1	
Temperatur error	green	low	D1	
error	red	bright	D2	

Signal outputs

Function	description	Clamp- number
Speed	n-actual value	X2:8
Current	I-actual value	X2:9
Current com.value	I-command value	X2:10
blocked	>10V/6mA	X2:14
BTB - contact	BTB/error	X2:11 , X2:12

Adjustment
- only by qualified personnel
- adhered to safety regulations
- notice adjusting sequence

Presettings	Adjust with
Actual value	Tacho coarse adjustment R23
Internal/external current limit	Switch S1, contact 2
Current regulator P- PI	Switch S1, contact 1

Optimization	Adjust with
Act.value adjustment	n_{max} adjustment
Cuirrent controller	Switch S1, contact 1 (default setup = ON)
Current limit	I_{max}, I_D-adjustment
Speed controller	X_P-adjustment, variable components
Zero point	Offset adjustment
Path-/position controller	in CNC\SP

Caution:

control systems have to be optimized from inside to outside.
Sequence :

Current controller determinated by the load circuit time constants
(motor circuit inductance and motor circuit Resistor)
optimized in factory, changing P/PI-amplification with S1

Speed controller determinated by the drive (inertial moment, frictional moment)
optimize to dynamic of the drive

Position controller optimize in the contol (CNC\PLC)

Measuring values		
Measuring value	**max.value**	**Measuring point**
Nominal value	± 10V	X1:4
Speed act.value before divider	± 150V	X2:8
Current act.value unipolar	+ 5V	X2:9
Current com.value unipolar	- 10V	X2:10

Command value		
Function	**max. value**	**connection**
input signal	±10V	
input GND	X1:4	X1:6

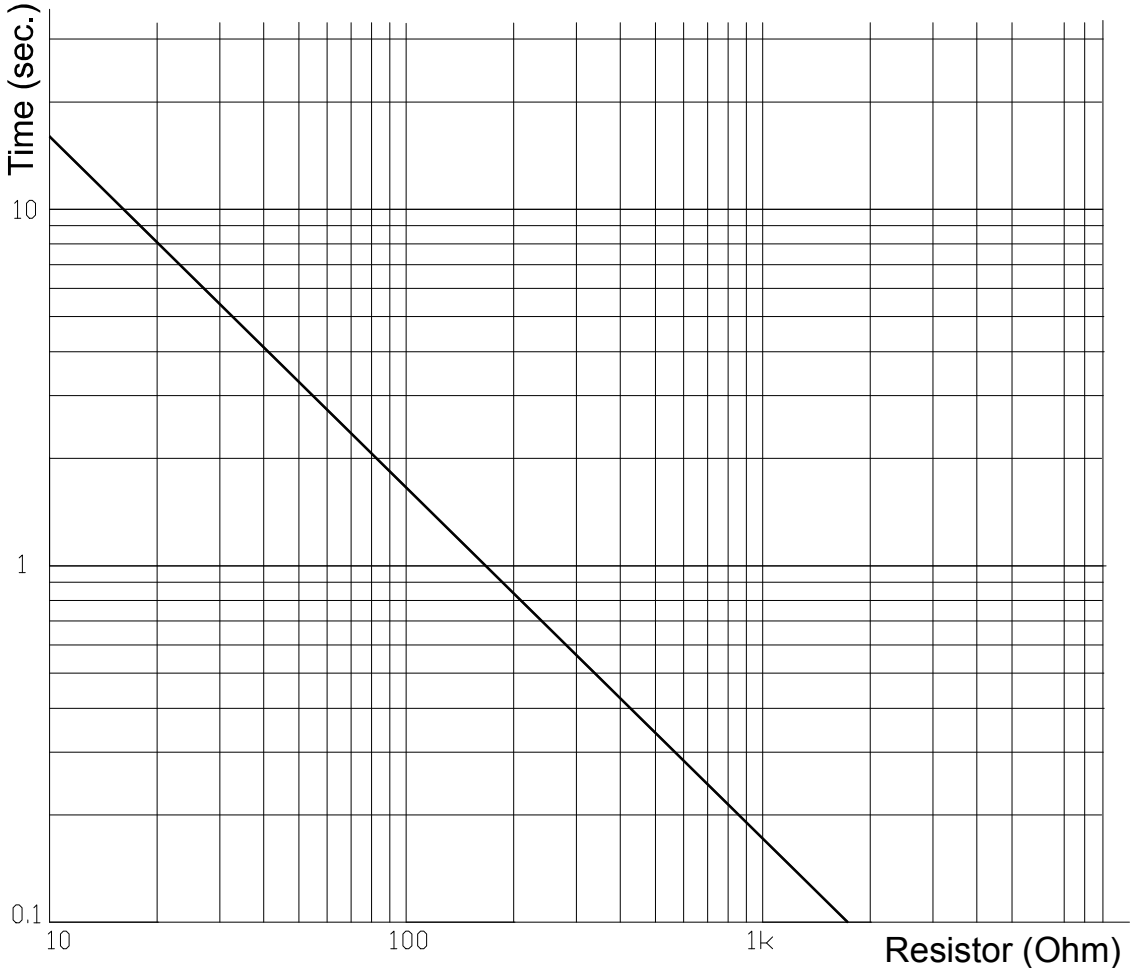
Differential input >>> signal- and GND-connection exchangeable
External Supply >>> Bridge X1:6 and X1:7, GND connected to X1:7

Command value as current signal
command value from external currnet source 0 bis ± 20mA
external burden resistor for command value 0 bis max. ±10V

Command value resistor R-Soll[Ω]=command value voltage/command value current (max. 500Ω)

Caution:
do not use command value current between 4 and 20mA
With A1x only positve command value

Command value - Integrator
Linear - Integrator
Time adjustment with resistor R11



Speed- Actual Value

BAMO - A1x (1Q) DC- or AC-tachogenerator with rectifer
BAMO - A2x (4Q) only DC-tachogenerator

Tacho-Connection

Jumper J1	= no plugged
Input X1:7	= tacho (GND)
Input X2: 8	= tacho (Signal)
PE-Bolt	= shielding

com. value input X1: 4 positive >>> tacho input X2: 8 positive

Tacho Voltage
at maximum speed
limit >>> minimum 5V=, maximum 160V=

Coarse adjustment
with resistor R23

Tacho-voltage-range

without R23		>>>	15V	= up to 160V=
with R23	1kΩ	>>>	5V	= up to 55V=

Armature voltage regulation with IxR -compensation
internal feed back
Coarse adjustment
Voltage range resistor R27
IxR compensation
Motor resistor resistor R8

Speed - fine adjustment

with potentiometer n_{max} (P2)

Command value from potentiometer:
with 1V com. value adjust to 10% of max. speed
with 10V com. value fine adjust to 100% (max. speed)

Command value from CNC\PLC:
with 0.8V command value adjust to 10% of maximum speed

Changing direction of rotation

change motor- **and** tacho-connection
with armature voltage regulation change only motor-connection.

Current limitation

peak current	range 0 up to 200% com. current reset time max. 5 sec.	poti I_{max} (P5)
steady current	range 5 up to 100% com. current	poti I_D (P4)

Internally resetting current limits		
Current limit	**Function**	**Limit**
overload	time	continous current
signal to X2:14	blocked	

Peak current internal current limit (default setup)		
adjustment	**switch**	**poti**
I_{max}	S1, contact 2=ON	I_{max1} (P5)
External current limit		
adjustment	**input**	**switch**	**poti**
I_{max}	X2:13 0 ... +10V	S1, contact 2=OFF	I_{max1} (P5)
The external current limit can internally be reduced with I_{max}- potentiometer.			
Constant current			
adjust motor protection for both torque directions on motor com. current with potentiometer I_D (P4)			

Measure adjustment values

- do not connect motor
- predetermine com. value and enable >>> switch off/on

Measuring value current com.value X2:10 (5V= rated current)		
com. value	measuring value I_{max} (ca.2sec.)	measuring value I_D
+5V	0 up to max.10V	0.25 up to max. 5V
- 5V	0 up to max.10V	0.25 up to max. 5V
Measuring value current actual value X2:9		
Current actual values	measuring value I_{max} (ca.2sec.)	measuring value I_D
±	0 upto+5V	0.12 up to+2.5V

Caution:

for exact torque control:

-PI-current control switching necessary

-manufacturers adjustment is P-control

-change from P- to PI-control in current controller

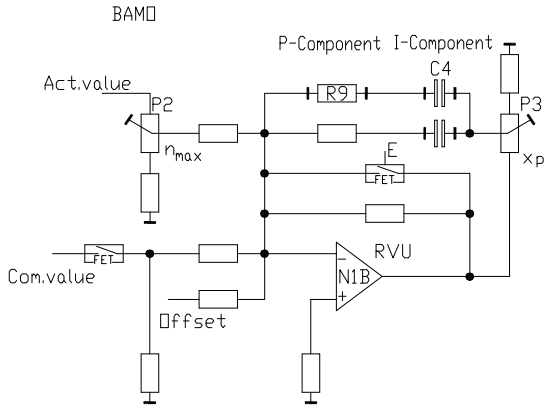
-switch S1, contact 1 = OFF

Speed Controller Switching

- variable components R9, C4
- amplification potentiometer P3 (XP)
- in case of changing devices >>> take over adjustment values.

Basic setup (values of solded components)

P- component = 390kOhm decrease with R9 (47Ohm up to 220kOhm)
I - component = 22nF increase with C4 (0.1µF uo to 1µF)
- amplification potentiometer XP to 50%



- optimal for most drives.

Adjustment without measuring instruments

connect motor,

com. value	= 0
XP	= 50%
R,C	= basical values

enable drive,
-turn potentiometer XP clockwise until drive swings
-turn potentiometer XP anticlockwise until the swinging is dying-out,
-turn XP-potentiometer further 2 positions anticlockwise.

Drive behaviour:	
amplification too low	**amplification too high**
long oscillations 1... 0.1Hz	short oscillations 30 … 200Hz
long overshoots	vibrates during acceleration
overruns target position	vibrates during braking and in position

Caution:
in case of operating with CNC\PLC
- in case of maximum speed
- adjust com. value speed with Poti nmax from 8 up to 9V

Basic setup

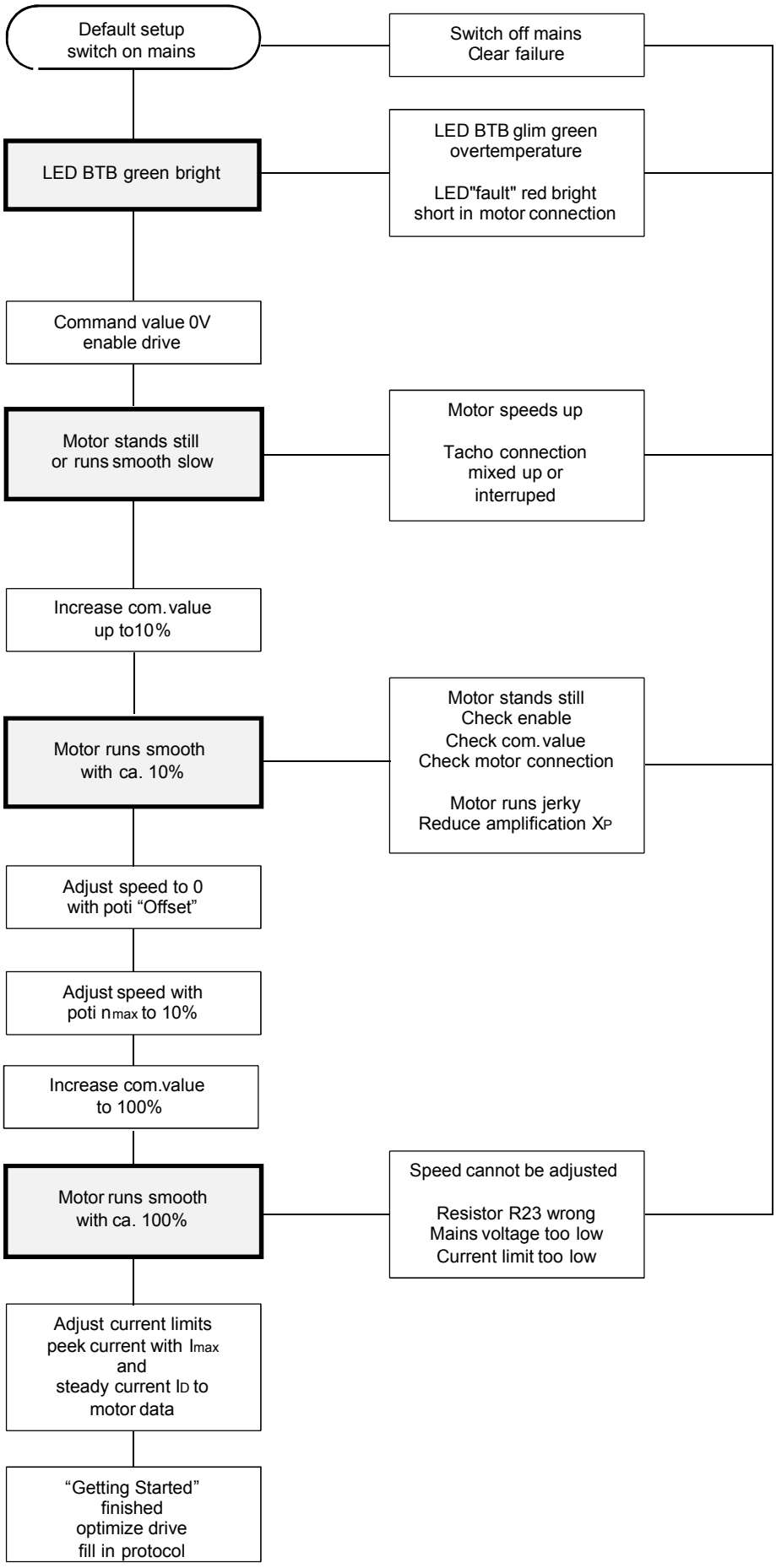
Check connections before getting started

Connection	Voltage	Clamps
Battery connection	max.36V oder max.160V	X3: 2, X3:10
Auxiliary voltage	24V= ± 10%	X3:13, X3:14
Motor connection	max. 30V oder max. 150V	X3: 4, X3:8
Notice connection advice		

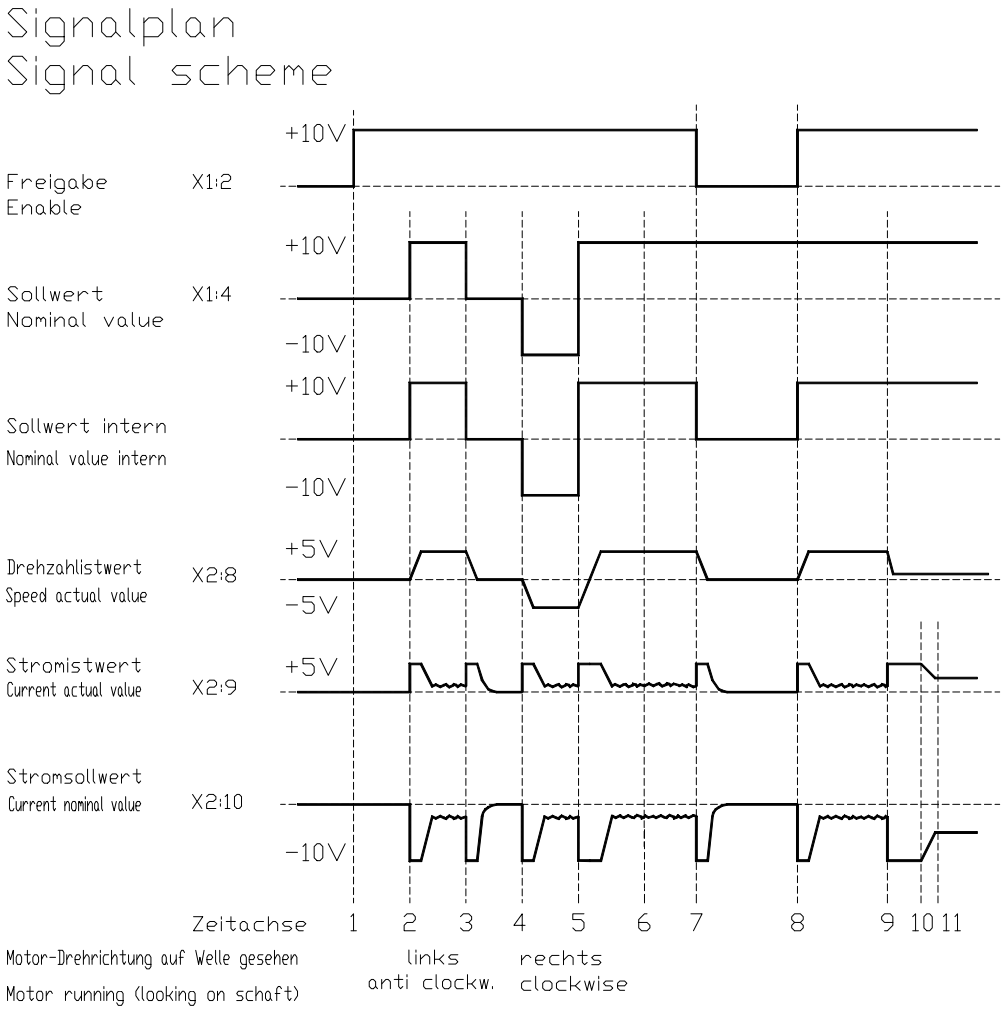
Basic connections-power supply	
Battery	2x power supply connection, Polarity please note!
Motor	2x Motor connection

Basic connection-control connections		
Auxiliary voltage	24V= ± 10%	X3:13, X3:14
BTB	Contact between	X2:11, X2:12
enable	Contact between	X1: 1, X1: 2
com. value (PLC)	Differental input ± 10V	X1: 4, X1: 6
com. value with internal poti-supply		bridge X1:6-X1:7
A1 (1Quadr.)	Positiv 10V	X1:3 (GND X1:7)
A2 (4Quadr.)	Positiv 10V	X1:3
	Negativ 10V	X1:5
com. value	± 10V	X1:4
Actual value - tacho	± 160V	X2:8 (GND X1:7)
Armature voltage regulation no actual value connection. Jumper J1 unplugged!		

Default setup for first getting started		
Function	**Potentiometer**	**adjustment**
peek current	I_{max}	20%
steady current	I_D	100%
amplification	X_P	10%
speed	n_{max}	0%
Zero point	Offset	50%
	Switch / contact	
Current controller PI	S1 K1	ON
Current limit internal	S1 K2	ON


Default setup
switch on mains
Switch off mains
Clear failure
LED BTB green bright
LED BTB glim green
overtemperature
LED"fault" red bright
short in motor connection
Command value 0V
enable drive
Motor stands still
or runs smooth slow
Motor speeds up
Tacho connection
mixed up or
interruped
Increase com. value
up to10%
Motor runs smooth
with ca. 10%
Motor stands still
Check enable
Check com. value
Check motor connection
Motor runs jerky
Reduce amplification XP
Adjust speed to 0
with poti “Offset”
Adjust speed with
poti nmax to 10%
Increase com.value
to 100%
Motor runs smooth
with ca. 100%
Speed cannot be adjusted
Resistor R23 wrong
Mains voltage too low
Current limit too low
Adjust current limits
peek current with Imax
and
steady current ID to
motor data
“Getting Started”
finished
optimize drive
fill in protocol

Faults	
Fault	**Causes**
LED bright red	Overtemperature Short in motor connection Output stage fault Overvoltage
Motor stands still no torque	Enable missed Current limit I_{max} anti-clockwise stop Motor connection interruped
Motor speeds up	Tachometer polarity wrong Tachometer connection interruped
Motor runs jerky	Amplification X_P too high. com. value faults
Drive switches to fault LED red bright	Overtemperature, phase- or earth-short. BTB-fault Ocoarse adjustment with resistorutput stage fault
Speed can't be adjusted with poti n_{max}	Jumper J1 wrong R23 wrong command value wrong



Time axis		
1	Enable on	Motor stands still with torque
2	Command value positive	Motor accelerates
3	Command value 0V	Motor deccelerates
4	Command value negative	Motor accelerates
5	Command value positive	Motor deccelerates and accelerates
6	Speed constant	Motor runs with load current
7	Enable off	Motor deccelerates, device is locked after 5s.
8	Enable on	Motor accelerates
9	Overload	Speed brakes down, current increases to maximum peek current
10	Overload >3s	Current is reduced to steady current
11	Steady current limit	

Commissioning protocol					
Customer			Machinen-No.		
Device			Series-No.		
Connection					
Battery voltage [V=]			Auxiliary voltage [V=]		
fuse [A]			Fuse [A]		
Input					
enable	contact	PLC/CNC	voltage [V=]		
com. value	Poti	PLC/CNC	voltage [V=]		
Current com. value	Poti ext.	PLC/CNC	voltage [V=]		
Actual value adjustment					
Tacho	V=/1000UPM		R23 [kΩ]		
Armature voltage	V=/1000UPM		R27 [kΩ]		
IxR-comp.			R8 [kΩ]		
Adjutment current controller					
Switch	S1-cont.1 ON = P		S1-cont.1 OFF = PI		
Switch	S1-cont.2 ON = internal		S1-cont.2 OFF = current limit external		
Adjustment speed controller					
P-component	R9[kΩ]		I-component	C4 [nF]	
Potentiometer - positions					
peek current	I_{max} P5	position			
Steady current	I_D P4	position			
amplification	X_P P3	position			
speed	n_{max} P2	position			
Zero point	Offset P1	position			
Measuring values					
Motor voltage	max. [V=]				
Tachovoltage	max. [V=]				
Motor current	peek [A=]		steady [A=]		
Motor data					
Producer			Type		
Series-No.		Motor voltage		Motor current	
Tacho voltage		Brake		fan	