Socapel ST1

A Digital Motion Controller

User's Manual

Ordering Number: 024.8080.D

Rev. February 1997

This upgraded and improved version replaces all the previous. We reserve the right to amend this document without prior notice and decline all responsibilities for eventual errors.

Atlas Copco Controls SA
En Montillier 4
CH-1303 PENTHAZ
Switzerland

Doc. No. 024.8080.D

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1. INTRODUCTION

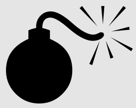
1.1. GENERAL DESCRIPTION

Associated to three-phase AC synchronous (DC brushless) or asynchronous (induction) motors, the ST1 digital motion controllers with integrated power sections are used for controlling the moving parts of all kinds of industrial machines.

1.2. SAFETY CONSIDERATIONS

The ST1 products are using electrical voltages which may be dangerous to humans.

Servicing and Maintenance require thus sufficiently trained persons, according to local laws.



While servicing ST1 devices, handling mistakes may result in uncontrolled movements of machine parts and thus be dangerous to humans and dangerous toward the machine and the environment.

Servicing and Maintenance personal must thus always refer to the machine manufacturer's instructions first.

1.3. USING THIS DOCUMENT

This document provides for summarized information to the machine designer.

It also informs the machine End User about the ST1 products maintenance and servicing, but should only be used then as a complement to the machine manufacturer's instructions.

For more information please refer to the detailed documentation. The latest issue of ACC document 080.8010 "Technical Documentation of SOCAPEL's Products" lists all the documents which are available (also available in German and in French) and their part numbers.

1.4. MANUFACTURER'S DECLARATION TO E. U. DIRECTIVES

Each ST1 and BA4 is delivered with a Declaration of Conformity as the following example:

MANUFACTURER'S DECLARATION

(according to the directive 89/392/EEC regarding machinery, annex II B)

SOCAPEL Deutschland GmbH declares under her sole responsibility that the product

Type ST1/25-310

Part Number 024.7751.B

to which this declaration relates, according to the

Directive 89/392/EEC regarding Machinery
as well as 91/268/EEC, 93/44/EEC and 93/68/EEC

Article 4, paragraph 2

is intended to be incorporated into machinery or assembled with other machinery to constitute machinery covered by the here above mentioned Directive.

Putting this product into service is prohibited until the machinery into which it is to be incorporated has been declared in conformity with the provisions of this Directive.

The manufacturer : Socapel SA
En Montillier 4
CH-1303 Penthaz
Switzerland

The Community established representative : Socapel Deutschland GmbH
Zähringerstrasse 23
D-77652 Offenburg
Germany

SOCAPEL SA and SOCAPEL Deutschland GmbH are determined to provide before January 1, 1996 a "CE" declaration of conformity to the EMC and to the Low-Voltage Directives for their products.

Penthaz, September 2, 1994

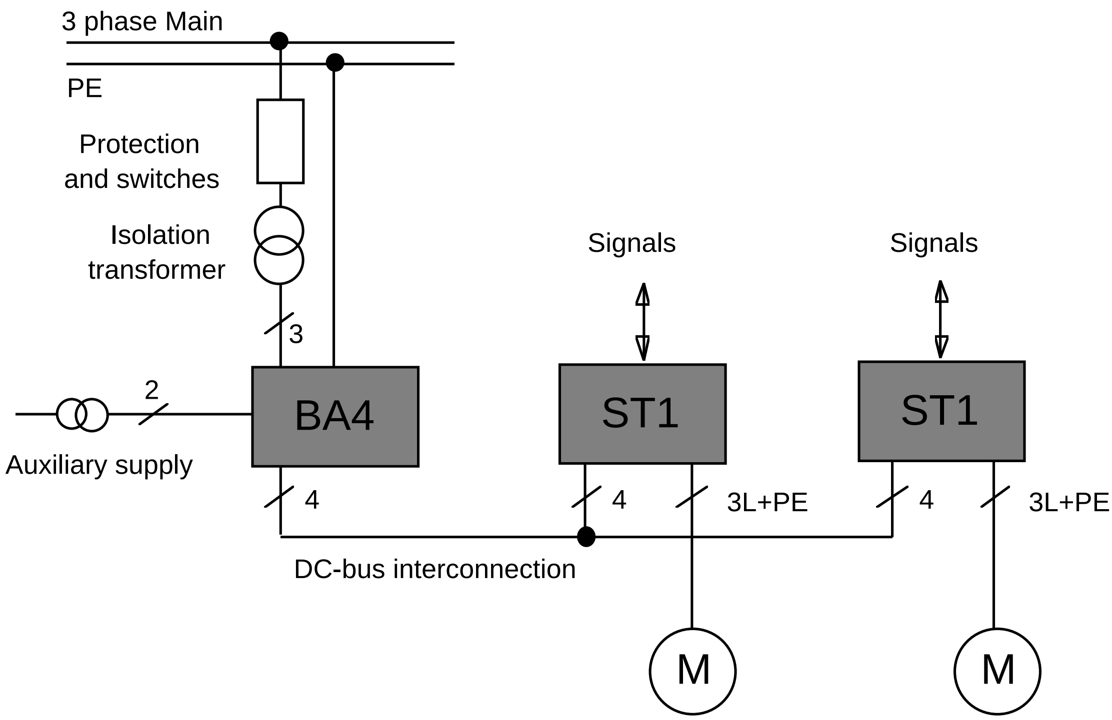
Bernard Jaquet
Director of SOCAPEL Deutschland GmbH
General Director of SOCAPEL SA

(signature)

2. PRODUCT DESCRIPTION

2.1. HARDWARE CONCEPT

A ST1 drive system is made out of one BA4 Supply Unit and several ST1 Drive Units (one for each motor). This concept is optimal for multiaxis application, but can also be used for single-axis machines.

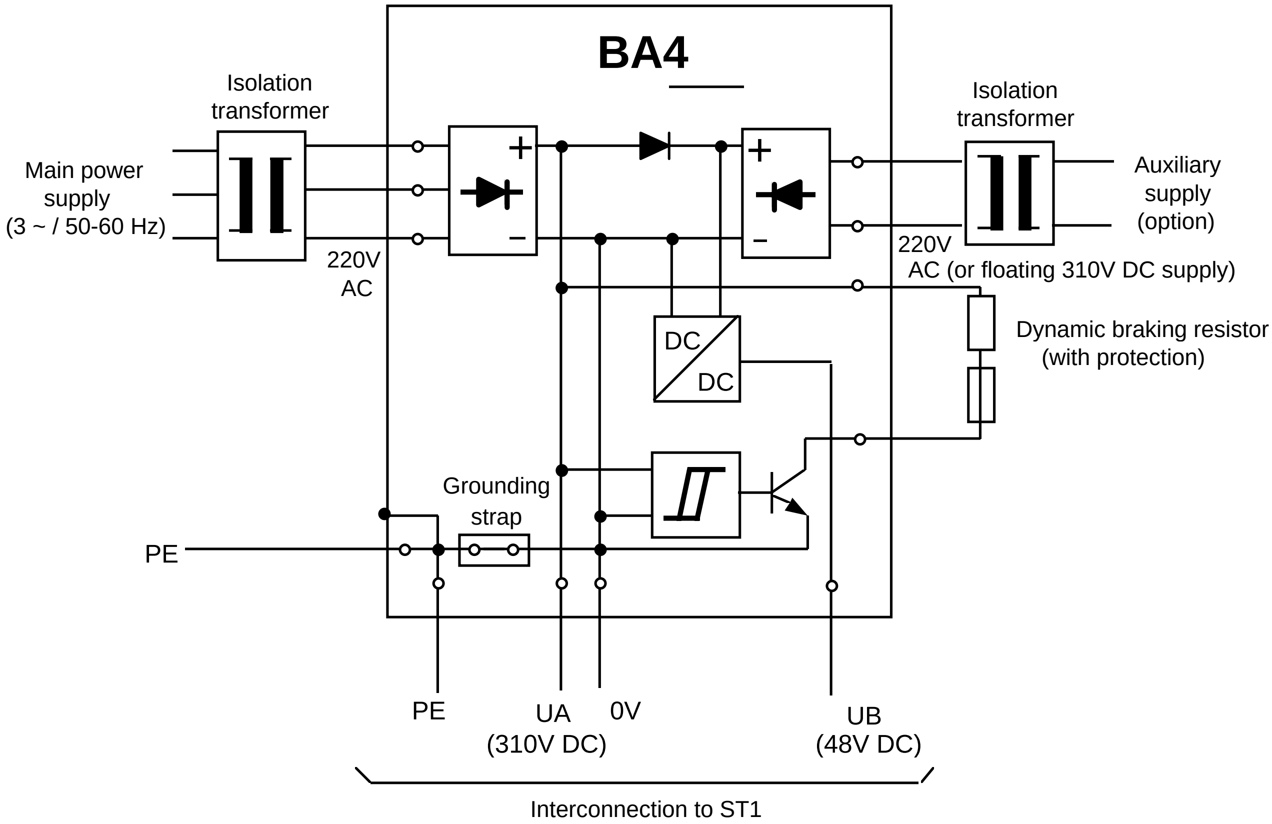


DISTANCE LIMITS

The BA4 and ST1 units should be assembled as close as possible to each other. The whole extend of the DC bus should not exceed 1 meter, or 2 meters if the BA4 is in the middle. Should longer distances be required, than additional, isolated 48 VDC supplies might be needed.

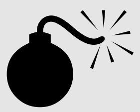
The distance between any ST1 unit and its motor has been tested up to 100 meters. Distances up to 200 meters are assumed to be possible but may produce an additional resolver reading inaccuracy.

2.2. BA4 SUPPLY UNITS



In order to protect the lower edges of all BA4 and ST1 units, it is necessary to attach one "IP20 protection set" p/n 024.7820 below each unit once the wiring is realized.

Forgetting or removing this protection produces a potential danger as one of the DC-bus terminal is at a 310 VDC potential.



Normally, the negative rail of the DC-bus "0V" is grounded thanks to the built-in grounding strap. **All BA4 Supply Units must be used together with an isolation transformer** (one floating secondary for each BA4).

Exceptionally, some BA4 Supply Units may be used together with an autotransformer. Then, the negative rail of the DC-bus "0V" may not be grounded and the grounding strap must be removed. Check then that the supply "neutral" is properly grounded.

TECHNICAL DATA

Main supply	**BA4/30-50**	**BA4/60-80**
Three-phase supply voltage (nominal) :	220 VAC	220 VAC
Tolerances :	140 to 250 VAC	140 to 250 VAC
DC bus voltage (nominal) :	310 VDC	310 VDC
Cont. power output :	8 kW	16 kW
Max. input surge current :	225 A_{rms}	600 A_{rms}
Auxiliary supply voltage :	200 to 380 VDC	200 to 380 VDC
or : (floating AC-current only)	140 to 270 VAC	140 to 270 VAC

48 VDC auxiliary supply

Auxiliary DC voltage output:	48 VDC	48 VDC
Current available for ST1's :	4.8 A	10 A

Dynamic braking resistor chopper

Switch-on threshold :	355 VDC ± 1 %	355 VDC ± 1 %
Peak braking power :	17 kW	28 kW
Max. braking resistor current :	50 A	80 A
Min. braking resistor value :	7.9 ½ ± 10 %	4.9 ½ ± 10 %

Power dissipation (typical)

No load power dissipation (dissipated in the housing) :	20 W	20 W
Additional dissipation at full load (mounting plate) rectifier : shunt regulation :	90 W 40 W	150 W 80 W

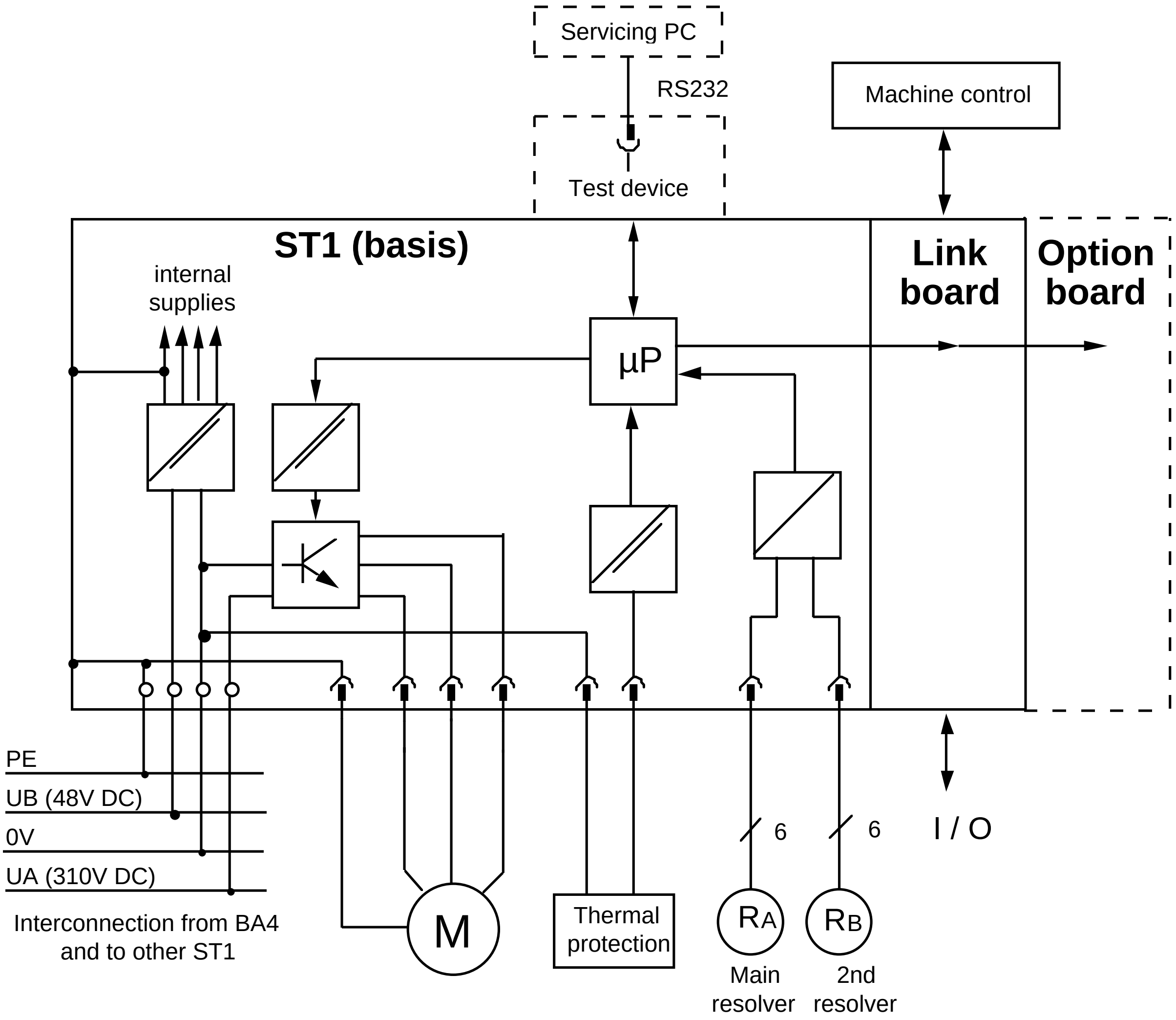
General data information

Weight	4.5 kg 10 lbs	6.5 kg 14 lbs

Ambient operating temperature : 0 to 50 °C (0 to +122 °F)
Storage temperature : -25 to 70 °C (-13 to +158 °F)
Maximum relative humidity : 95 % (without condensing)

For outlines, connector position and markings please refer to chapter 7.

2.3. ST1 DRIVE UNITS



Please note that each ST1 must always be fitted with a link board as required by the application.

It has moreover to be fitted with the proper firmware and the application depending configuration. Refer to § 2.4 bellow.

In order to protect the lower edges of all BA4 and ST1 units, it is necessary to attach one "IP20 protection set" p/n 024.7820 below each unit once the wiring is realized.

Removing this protection produces a potential danger as one of the DC-bus terminal is at a 310 VDC potential.

TECHNICAL DATA

Positioning resolution :	25,736 increments per resolver revolution
Position measurement accuracy : (not including resolver accuracy)	± 1/8500 rev. (± 2.5 arc. min.)
Speed range :	± 0 to 22,500 rpm
Cycle time :	0.33 ms
Velocity signal bandwidth :	up to 600 Hz
Current loop bandwidth :	>1000 Hz

Power stage	ST1/10	ST1/25	ST1/80	ST1/140
DC bus voltage	up to 360 VDC	up to 360 VDC	up to 360 VDC	up to 360 VDC
Max. RMS output current (I_{rms})	7 A	18 A	56 A	100 A
Switching frequency	9.8 kHz	9.8 kHz	9.8 kHz	9.8 kHz
Auxiliary supply voltage (± 1 %)	48 VDC	48 VDC	48 VDC	48 VDC
Max. consumption at 48 VDC	0.8 A	0.8 A	2 A	0.8 A
Min. load inductance	3mH	1.2 mH	0.4 mH	0.2 mH
Optimal load inductance	11...43 mH	4.6...18 mH	1.8...8.2 mH	0.4...1.5 mH

Power dissipation (typical)

No load power dissipation (dissipated in the housing)	40 W	40 W	50 W	50 W
Additional dissipation at max. load (through mounting plate)	70 W	180 W	600 W	930 W

General data information

Weight	6 kg 13 lbs	6 kg 13 lbs	8 kg 18 lbs	16 kg 35 lbs

Ambient operating temperature :	0 to 50 °C (0 to +122 °F)
Storage temperature :	-25 to 70 °C (-13 to +158 °F)
Maximum relative humidity :	95 % (without condensing)

For outlines, connector position and markings please refer to chapter 7.

2.4. ST1 SOFTWARE

APPLICATION SOFTWARE

All ST1 Drive Units are now fitted with a non volatile EEPROM for memorizing the appropriate software. This software is supplied separately as a PC-file on a 3.5" floppy, which has to be downloaded using the maintenance PC or the operation serial link.
Elder ST1 Drive Units were fitted with an EPROM as software memory, which had to be plugged-on.

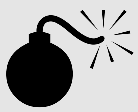
CONFIGURATION (PARAMETERS)

The Drive configuration is also memorized within a non volatile EEPROM, and can also be download using the same links. Single parameter changes are possible.

CONFIGURATION (SEQUENCER AND CAM-SHAFT)

If the LIO Link Board is used, a sequence program and in some cases a cam-shaft table are memorized in a similar way into an EEPROM non volatile memory. They are also downloadable.

FOR MORE INFORMATION ABOUT…	**REFER TO DOCUMENT (latest edition)…**
program (software, firmware):	p/n 024.8072 "Software Versions" p/n 024.8008 "basic software" or 024.8068 "software for synchronization"
parameter:	§ 3.4 of this document p/n 024.8008 or 024.8068 "basic software"
sequencer:	p/n 024.8020.A "LIO link board"
cam-shaft table:	p/n 024.8088 "cam-shaft function"
downloading from servicing PC:	p/n 024.8038 "Socasin Expert"
downloading from operation link:	p/n 024.8068.A "basic software", §10.9



The ST1 Drive Unit operation depends from the software and the configuration which were loaded.
Using for any application a software or a configuration file which correspond to another application may lead to incorrect operation and damage the motor and the machine.

2.5. SERVICING TOOLS

The PC-DOS software "The SOCASIN Expert" (p/n 024.7101 or 024.7102) , which includes the corresponding documentation (p/n 024.8038), provides for a comprehensive interface between the user and the ST1 Drive Units.

Following devices are necessary:

- Test Device p/n 024.7701.B
- PC (refer to document p/n 024.8038 "Socasin Expert" for more information)
- Cable p/n 024.7059
- Multimeter
- (digital storage) oscilloscope

2.6. ACCESSORIES

2.6.1. MOTORS

ACC provides for several ranges of motors which differ by their technology, their data and their price-to-performance ratio:

BAUTZ motors:	Permanent-magnet, synchronous servo-motors 0.4 to 20 Nm rated torque range
FLENDER-ATB-LOHER motors:	Asynchronous (induction) servo-motors 0.4 to 30 kW rated power range Gear-fitted motors also available
RAGONOT motors:	Permanent-magnet, synchronous servo-motors 0.6 to 30 Nm rated torque range
SEM motors:	Permanent-magnet, synchronous servo-motors 0.4 to 60 Nm rated torque range
others:	in preparation

These motors have been tested together with ST1 Drive Units, their assembly and particularly their built-in resolver comply with ACC specifications. Using motors made by other manufactures is generally possible, but requires previously some sample-tests to be performed by ACC. Ask for more information.

> **!** Using motors without previous acceptance by ACC may result in incorrect operation or poor performances.

2.6.2. POWER TRANSFORMERS

ACC provides also for power transformers for supplying ST1 systems. Their main data are:

Nominal Power:	0.85, 2.0, 4.0, 7.0, 12, 18 or 22 kVA
Primary Voltage:	400 VAC (50 or 60 Hz, three-phase) several adjustment terminal configurations
Secondary Voltage:	220 VAC at rated load 228 VAC max. at no load

Other transformers can also be supplied. Ask ACC for additional information.

> **The no-load secondary voltage must be lower or equal to 228 VAC**, when the primary voltage is at its nominal value (i.e. 400 VAC) in order to allow a +10% main voltage change.

> **!** **Use isolation transformers only.**
>
> Autotransformers may be used for special applications, but the ST1 system specifications are no more guaranted by ACC. Refer to §2.2.

2.6.3. Connector Sets

The ST1 Drive Units are supplied with the mating motor and thermoswitch plugs.
All other mating plugs are supplied separately as connector sets. Refer to price list for part numbers. The user may also order these connectors anywhere else; he is then responsible for their compatibility.
Connector sets are available as:

- Resolver-to-ST1 connector set
- Link board connector set
- Option board connector set
- Motor connectors

When using the 2nd. resolver input, the "2 resolver adapter" (p/n 024.7063) should be used.
Pre-confectioned fiber-optic cables are also available in different lengths as follow:

- LPO and PAM interconnection
- OM and OS interconnection

2.6.4. Cooling Heatsinks

(text to be added in a next edition)

2.6.5. Dynamic Braking Resistors

ACC suggests the use of following power resistors for Dynamic Braking (see §3.2.5). They are IP40 protected and may be assembled on the roof of the enclosure for getting rid in an easier way of their thermal load. The dimensions of these resistors are shown in §7.5.

				BA4 / 30-50-310			
		BA4 / 60-80-310					
		P_{inst}=20...25 kW		P_{inst}=12...16 kW		P_{inst}=8...10 kW	
Type	P_W	R(Ohms)	Ref. ACC	R(Ohms)	Ref. ACC	R(Ohms)	Ref. ACC
FWA 40-150	120	5.1	231.1051	8.8	231.1053	12.0	231.1055
FWA 40-200	180	5.8	231.1086	9.6	231.1088	12.8	231.1089
FWA 40-300	300	5.1	231.1119	9.5	231.1122	12.0	231.1123
FWA 40-400	400	5.0	231.1153	8.6	231.1156	13.2	231.1158
FWA 60-300	450	5.3	231.1189	8.9	231.1192	13.5	231.1194
FWA 60-400	600	5.3	231.1223	8.6	231.1226	12.5	231.1228
FWA 60-500	800	5.1	231.1258	7.9	231.1260	13.2	231.1263

Type	P_W	R(Ohms)	Ref. ACC	R(Ohms)	Ref. ACC	R(Ohms)	Ref. ACC
FWDA 40-150	240	5.1	231.2154	8.5	231.2157	12.5	231.2159
FWDA 40-200	360	6.4	231.2189	8.7	231.2191	12.5	231.2193
FWDA 40-300	600	6.0	231.2238	10.2	231.2242	12.0	231.2244
FWDA 40-400	800	5.2	231.2319	8.4	231.2327	14.5	231.2335
FWDA 60-300	900	5.5	231.2384	8.5	231.2386	15.0	231.2388
FWDA 60-400	1200	5.1	231.2429	9.5	231.2435	12.0	231.2437
FWDA 60-500	1600	5.5	231.2506	9.0	231.2514	12.0	231.2522

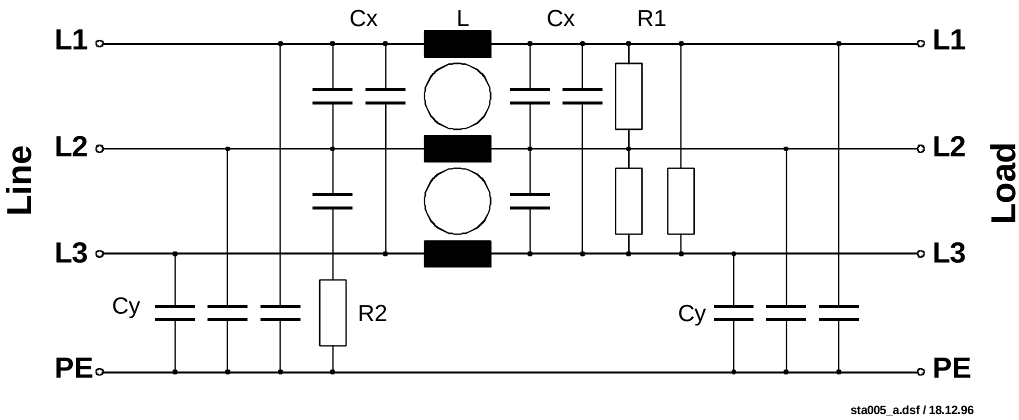
Type	P_W	R(Ohms)	Ref. ACC	R(Ohms)	Ref. ACC	R)Ohms)	Ref. ACC
FWTA 40-150	340	5.7	231.3657	8.3	231.3659	13.3	231.3000
FWTA 40-200	540	5.8	231.3691	8.3	231.3693	12.3	231.3095
FWTA 40-300	900	5.2	231.3740	8.0	231.3744	13.3	231.3750
FWTA 40-400	1200	5.6	231.3827	9.7	231.3835	13.0	231.3843
FWTA 60-300	1350	5.7	231.3886	10.0	231.3888	13.7	231.3890
FWTA 60-400	1800	5.1	231.3933	8.0	231.3937	14.0	231.3941
FWTA 60-500	2400	5.3	231.4014	8.0	231.4022	13.3	231.4030

2.6.6. EMC Filters

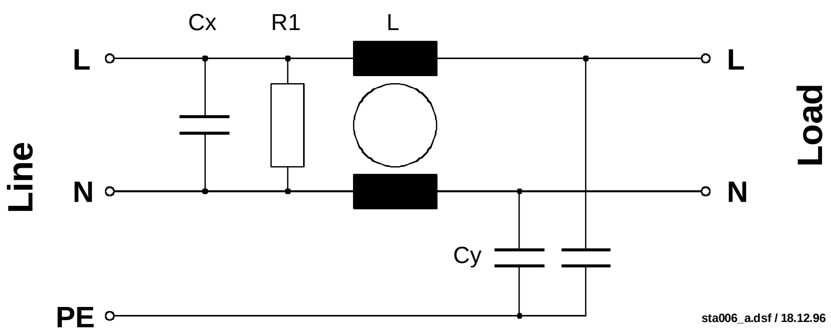
EMC filters shall be chosen so that national electrical regulations are fulfilled in the country where the system is to be used. The filters used shall be tested to comply with the EMC regulations. ACC SA recommends the filters listed in below. Other filters will be added in a next issue of this manual.

Type	Rated current at 40°C [A_{rms}]	Leakage curr. (At 400V,50Hz) max [mA]	Losses [W]	L [mH]	ΣCx [µF]	ΣCy [µF]	R1 [MΩ]	R2 [MΩ]	p/n	Recommended for FA4
FN351-25/33	25	160	8	2.2	4.4	1.8	1.5	1.1	410.0125	BA4 / 30-50-310
FN351-50/33	50	175	11	0.8	4.4	2	1.5	1.1	410.0129	BA4 / 60-80-310
FN2010-3/6	3	0.4		2.5	0.1	4.7	1		410.0031	Auxiliary supply of all BA4

FN351:



FN2010



3. APPLICATION DESIGN CHECK-LIST

3.1. MECHANICAL AND STRUCTURAL DESIGN

3.1.1. DRIVE AND CONTROL CONCEPT

a) Determine which machine moving parts are to be fitted with electrical motors and which kinds of gearings are to be used.

b) Determine which motors are to be fitted with AC servo-motors and to be driven by ST1 units.

c) Determine also the safety requirements and the way each axis is to be mechanically protected.

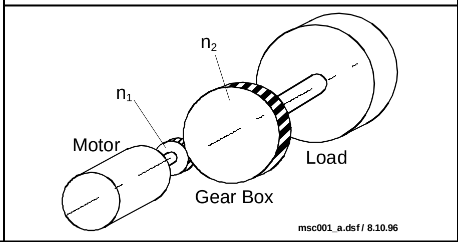
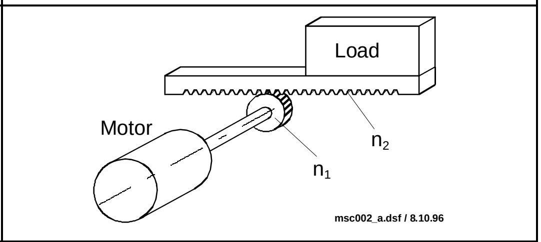
d) Determine the coordination (or synchronisation) relations between the axes and the relations toward other equipments: actuators, sensors, graphical interactivity, etc.

e) Determine the machine control concept and how the different equipment communicate.

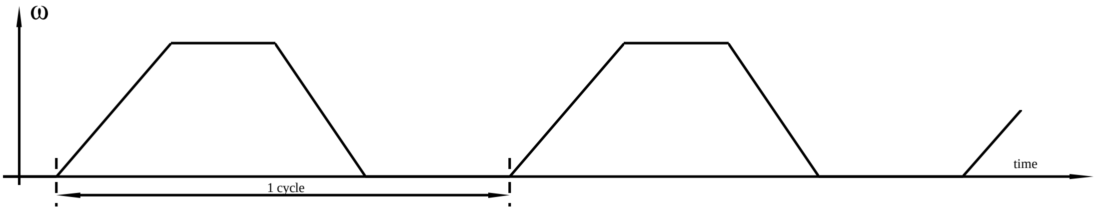
f) Don't forget that machine design is an itterative process, and that detailed design may require reconsidering concept decisions and machine requirements.

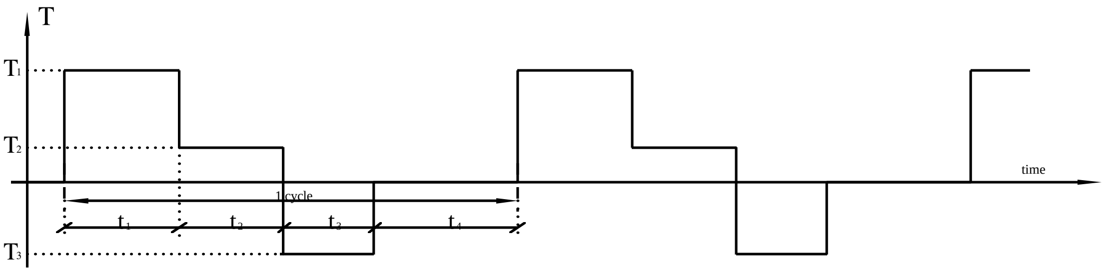
3.1.2. MOTOR AND GEARING SELECTION

a) Investigate the mechanical load for each axis (inertia, friction, erratic forces or torques, etc.).
Here are some helpful formulae:
As a first approximation: $T_{mot}\left[Nm\right] = \sum J\Big|_{mot}\left[kgm^2\right] \cdot \alpha_{motz}\left[rad / s^2\right] + \sum T_{load}\Big|_{mot}\left[Nm\right]$

	ROTARY MOTION	**LINEAR MOTION**
		
Coupling	Gear ratio: i	Pitch: $h\left[m\right]$
Speed	$\omega_{mot}\left[rad / s\right] = \omega_{load}\left[rad / s\right] \cdot i$ $\omega\left[rad / s\right] = n\left[rpm\right] \cdot \frac{\pi}{30}$	$\omega_{mot}\left[rad / s\right] = \frac{2\pi \cdot v_{load}\left[m / s\right]}{h\left[m\right]}$
Acceleration	$\alpha_{mot}\left[rad / s^2\right] = \alpha_{load}\left[rad / s^2\right] \cdot i$	$\alpha_{mot}\left[rad / s^2\right] = \frac{2\pi \cdot \alpha_{load}\left[m / s^2\right]}{h\left[m\right]}$
Torque	$T_{load}\Big\|_{mot}\left[Nm\right] = \frac{T_{load}\left[Nm\right]}{i}$	$T_{load}\Big\|_{mot}\left[Nm\right] = F_{load}\left[N\right] \cdot \frac{h\left[m\right]}{2\pi}$
Inertia	$J_{load}\Big\|_{mot}\left[kgm^2\right] = \frac{J_{load}\left[kgm^3\right]}{i^2}$	$J_{load}\Big\|_{mot}\left[kgm^2\right] = m_{load}\left[kg\right] \cdot \left(\frac{h\left[m\right]}{2\pi}\right)$

b) Define the dynamic requirements (worst-case and average movement cycles) and represent them if possible in terms of equivalent trapeze-looking velocity profiles.





c) Choose the motor and gearing ratio from the inertia and temperature points of view.

This choice may be done using the motor selection tool which is available together with "The SOCASIN Expert" software (p/n 024.7101 or 024.7102, release 1.5) and runs under Microsoft EXCEL.

d) Select the winding (or K_t) option in order to reach the peak velocity and peak torque as required. This choice may be done using ACC's motor selection guides.

In most applications, consider that the motor must be able to reach this working condition at 170 V_{rms} phase-to-phase voltage. The difference between this voltage and the BA4 input rated voltage (220 V_{rms}) provides for enough security toward main voltage lowering (down to -10%), the voltage drops both within the transformer, the rectifier and the power electronics.

! Always consider that these choices which are based mostly on machine modelling have to be confirmed by comprehensive machine prototype testings.

3.2. POWER HARDWARE DESIGN

3.2.1. ST1 UNITS SELECTION

a) Select the ST1 Drive Unit depending on the peak current that the selected motor needs for delivering the peak torque.

b) Estimate for each axis the output current rms value (average time τ adjusted to a typical machine cycle).

$$I_{rms} \approx \frac{1}{k_T} \cdot T_{rms} = \frac{1}{k_T}\sqrt{\frac{1}{\tau} \cdot \int_t^{t+\tau} T^2 dt}$$

This is the general form which becomes for a trapeze looking velocity profile:

$$I_{rms} \approx \frac{1}{k_T}\sqrt{\frac{T_1^2 \cdot t_1 + T_2^2 \cdot t_2 + ... + T_n^2 \cdot t_n}{t_1 + t_2 + ... + t_n}}$$

In exemple for the profile shown on page 16:

$$I_{rms} \approx \frac{1}{k_T}\sqrt{\frac{T_1^2 \cdot t_1 + T_2^2 \cdot t_2 + T_3^2 \cdot t_3}{t_1 + t_2 + t_3 + t_4}}$$

c) If this rms current is close to the peak current, the ST1 cooling design (§3.2.8 below) may show that the next larger ST1 size has to be chosen instead.

d) Check that the motor inductance (stray inductance for induction motors) fits to the ST1 "optimal load inductance" (refer to § 2.3 "technical data").

3.2.2. BA4 UNITS SELECTION

a) Estimate for each axis the peak value both of the positive (acceleration) and the negative (deceleration) power which are required.

The positive peak power must be devided by the motor efficiency (the electrical power need from the main is higher than the motor shaft output power).

$$P_{pos_{peak}} = \frac{1}{\eta} \cdot T_{pos_{\max}} \cdot \omega_{pos_{\max}} \, or \, \frac{1}{\eta} \cdot T_{neg_{\max}} \cdot \omega_{neg_{\max}}$$

The negative peak power must be multiplied by the motor efficiency (the electrical power returned to the DC bus is lower than the motor shaft input power).

$$P_{neg_{peak}} = \left| \eta \cdot T_{neg_{\max}} \cdot \omega_{pos_{\max}} \right| \quad or \quad \left| \eta \cdot T_{pos_{\max}} \cdot \omega_{neg_{\max}} \right|$$

The formulae above are true for trapeze profile point-to-point movements. An axis which follows a cam-shaft profile requires generally smaller peak powers, which are reached when the products $\omega \cdot d\omega / dt$ are maximum (positive) and minimum (negative).

b) Considering all the axes and their individual movement cycles within the whole machine cycle, estimate for the whole machine (or for each group of ST1 Units if several BA4 Supply Units are to be used) the peak positive and the peak negative powers. Assuming that all axes accelerate and decelerate together at the same time is the worst case condition. More accurate figures may be computed if that is not the case.

$$P_{accel_{peak}} \leq \sum_{All\ Axes} P_{pos_{peak}} \qquad P_{decel_{peak}} \leq \sum_{All\ Axes} P_{neg_{peak}}$$

c) Estimate in the same way as "a" for each axis the average values of both the positive and negative power which is required for each axis.

At constant speed: $P_{cst.speed} = \frac{1}{\eta} \cdot T_{cst} \cdot \omega_{cst}$

While accelerating: $P_{acc_{average}} = \frac{1}{\eta} \cdot \frac{T_{acc} \cdot \omega_{\max}}{2}$

While decelerating: $P_{dec_{average}} = \eta \cdot \frac{T_{dec} \cdot \omega_{\max}}{2} \quad (negative)$

Average positive power: $P_{pos_{average}} = \frac{P_{cst.speed\,1} \cdot t_1 + P_{cst.speed\,2} \cdot t_2 + ... + P_{acc_{average}} \cdot t_{acc}}{\tau_{full\ cycle}}$

Average negative power: $P_{neg_{average}} = \left| \frac{P_{dec_{average}} \cdot t_{dec}}{\tau_{full\ cycle}} \right|$

d) Estimate also in the same way as "b" for the whole machine the average positive and negative powers for all axes together.

e) Select the smallest BA4 Supply Unit that yet fits to the "machine" power values above.

f) Check that this BA4 size meets the 48 VDC auxiliary supply requirement of all ST1 units.

3.2.3. POWER TRANSFORMER SELECTION

a) Select the smallest power transformer whose power rating yet is larger than the average positive power required for all axes. Refer to §2.6.2 for the list of ACC standard transformers.

b) Make sure that the peak positive power of the machine is not more than about 4 times the transformer rated power, in order to limit its voltage drop.

3.2.4. POWER TRANSFORMER AND BA4 PROTECTION

a) Select the protective elements (fuses, etc.) according to the rated primary current of the Power Transformer.

b) Check that this protective elements meet the standard requirements for short-circuit protection coordination.

c) Several ACC's standard Power Transformers are fitted with thermal protection switches which take care of the secondary wiring protection. If such a thermal protection is not available, then fuses (or alike) are also necessary on the transformer secondary side.

d) If the Power Transformer power rating is larger than 2 kVA (BA4/30-50-310) or 4.5kVA (BA4/60-80-310), an external in-rush current limitation is necessary. Refer to the figure of § 8.1.

3.2.5. DYNAMIC BRAKING RESISTOR SELECTION

a) The average negative power ($P_{neg.\ average}$) gives you the power of the resistor (P_W in table §2.6.5).

b) Choose the ohmic value considering the BA4 Unit size and the peak negative power ($P_{neg.peak}$, $P_{inst.}$ in the table §2.6.5) of the machine.

3.2.6. DYNAMIC BRAKING RESISTOR PROTECTION

a) Estimate the max. continuous DC current that the Resistor stands under 360 VDC:

$$I_{\max}[A] = \frac{P_{resistor\ rating}[W]}{360[V]}$$

b) Select a thermal relay which can be adjusted to this current. Its signalling contact has to be used for switching-off the main power supply to the BA4 Unit.See figure of § 8.1.

3.2.7. EMERGENCY BRAKE RESISTORS SELECTION

a) Take the motor speed constant and its maximum speed and calculate the corresponding V_M (effective voltage <u>between</u> phases).

b) From the maximum torque or the demagnetisation determin the maximum braking current I_M (effective current in a phase).

c) Calculate the ohmic value of the resistor: $R_{EBR} = \frac{V_M}{I_M \cdot \sqrt{3}} - \frac{R_{mot}}{2}$

$R_{mot.}$: Interphase motor's resistance.

d) Caluculate its power value: $P_{R_{EBR}} \approx 1/60 \cdot J \cdot \omega^2$

J: System inertia and ω:Motor speed [rad/s].

This approximation is valid up to two emergency braking per minute.

For more details, refer to the latest edition of document p/n 024.8028 "The Motor" (§3.2) .

3.2.8. COOLING THE BA4 AND ST1 UNITS

Refer to the latest edition of document p/n 024.8054 "Thermal Dimensioning".

3.3. DEFINING THE ST1 PARAMETERS

Once the proper software has been chosen (refer to §2.4), each ST1 has to be configured. It means that several application dependent settings have to be defined and loaded as parameters.
The following tables shows which parameters are concerned depending on the application, and in which document additional information can be found. The shaded ones have absolutely to be defined even for a preliminary test; the others can be used for enhanced performance.
All parameters which are not concerned for an application should remain unchanged at their "default value".

3.3.1. ST1 PARAMETERS NECESSARY FOR ALL APPLICATIONS

	Motor	🖫 **= Refer to ACC's motor libraries** (024.8038.C)	
🖫	**NPPOL**	Motor pole nb. / Resolver pole nb. ratio	024.8068.A §7.3.3
🖫	**KTINV**	Motor torque constant	024.8068.A §7.4.3
🖫	**KIGLIN**	= 0 (synchr. mot.) or dlip adjustment (ind. mot.)	024.8068.A §7.4.4
🖫	**IMAGNN**	Magentizing current (induction motor only)	024.8068.A §7.4.5
🖫	**VITN**	Nominal Velocity (induction motor only)	024.8068.A §7.4.6
🖫	**VITMAX**	Peak velocity	024.8068.A §7.4.7
🖫	**COUMA**	Peak torque	024.8068.A §7.4.8
🖫	**CURES**	Resolver Supply	024.8068.A §7.3.1
	COULIM	Temporary reduced peak torque	024.8068.A §7.5.14
	CDEPHA	Angle offset between motor and resolver	024.8068.A §7.4.2

Status & Safety	**Refer also to § 6.2 for the meaning of all status bits**	
CMASKU	Power stage desabling mask (Stop 0)	024.8068.A §6.3
CMASKA	Controlled stop (Stop 2)	024.8068.A §6.3
CMASKS	Mask for status signalling to host	024.8068.A §6.3

Pos./Vel. Contr.		
KPOS	Position controller P gain (or vel. contr. I gain)	024.8068.A §7.5.4
KVIT	Position controller D gain (or vel. contr. P gain)	024.8068.A §7.5.5
KTEGR	Position controller I gain	024.8068.A §7.5.6
DPOMA	Position lag measurement limit	024.8068.A §7.5.11
SEUIL1	Position lag warning threshold	024.8068.A §7.5.12
INERT	Feed-forward inertia modelisation	024.8068.A §7.5.7
FVISC	Feed-forward viscosity modelisation	024.8068.A §7.5.8
FSEC	Feed-forward dry friction modelisation	024.8068.A §7.5.9
FEXT	Feed-forward weight modelisation (cst. torque)	024.8068.A §7.5.10

Test Board		
CADBIN	Variable selection for igital output	024.8068.A §7.7.2
CMPBIN	Test device enable and disable	024.8068.A §7.7.2
CADMA1	Variable selection for analog output #1	024.8068.A §7.7.3
CMPMA1	Gain selection for analog output #1	024.8068.A §7.7.3
CADMA2	Variable selection for analog output #2	024.8068.A §7.7.4
CMPMA2	Gain selection for analog output #2	024.8068.A §7.7.4

3.3.2. LPO Link Board (PAM) specific Parameters

Length Units		
CKA	Acceleration range and Motion reversal	024.8068.A §8.4.3
CKAINV	Inverse of CKA	024.8068.A §8.4.3
CKV	Velocity range	024.8068.A §8.4.4
CKR	1st. conversion cste. for position set values	024.8068.A §8.4.13
CKH	2nd. conversion cste. for position set values	024.8068.A §8.4.13

Velocity Profile		
CVP	Required travel speed for moves	024.8068.A §8.4.6
CA1	Required acceleration	024.8068.A §8.4.8
CA2	Required deceleration	024.8068.A §8.4.8
ASTOP	Specific deceleration for stops	024.8068.A §8.4.9
PHIL1	"Left" limit for absolut position	024.8068.A §7.8.2
PHIL2	"Right" limit for absolut position	024.8068.A §7.8.3

3.3.3. LIO Link Board specific Parameters

Length Units		
CKA	Acceleration range and Motion reversal	024.8068.A §8.4.3
CKAINV	Inverse of CKA	024.8068.A §8.4.3
CKV	Velocity range	024.8068.A §8.4.4
CKR	1st. conversion cste. for position set values	024.8068.A §8.4.13
CKH	2nd. conversion cste. for position set values	024.8068.A §8.4.13

Velocity Profile		
CVP	Required travel speed for moves	024.8068.A §8.4.6
CA1	Required acceleration	024.8068.A §8.4.8
CA2	Required deceleration	024.8068.A §8.4.8
ASTOP	Specific deceleration for stops	024.8068.A §8.4.9
PHIL1	"Left" limit for absolut position	024.8068.A §7.8.2
PHIL2	"Right" limit for absolut position	024.8068.A §7.8.3

Serial Link		
LSMR1	Transmission type	024.8020.A §5.2.1
LSMR2	Baudrate selection	024.8020.A §5.2.2
ADAXE	Peripheral address	024.8020.A §5.2.3
TIMOUT	Time-out	024.8020.A §5.2.4
ENDBYT	Answer terminating byte	024.8020.A §5.2.5

Sequencer	(LIO board only)	
CINACL	Initial input active level mask	024.8020.A §5.3.1
CINMAS	Initial input validation mask	024.8020.A §5.3.2
ZMANAL	Dead-band for output OUT6 (motor speed = 0)	024.8020.A §5.3.3

3.3.4. LS Link Board specific Parameters

Length Units		
CKA	Acceleration range and Motion reversal	024.8068.A §8.4.3
CKAINV	Inverse of CKA	024.8068.A §8.4.3
CKV	Velocity range	024.8068.A §8.4.4
CKR	1st. conversion cste. for position set values	024.8068.A §8.4.13
CKH	2nd. conversion cste. for position set values	024.8068.A §8.4.13

Velocity Profile		
CVP	Required travel speed for moves	024.8068.A §8.4.6
CA1	Required acceleration	024.8068.A §8.4.8
CA2	Required deceleration	024.8068.A §8.4.8
ASTOP	Specific deceleration for stops	024.8068.A §8.4.9
PHIL1	"Left" limit for absolut position	024.8068.A §7.8.2
PHIL2	"Right" limit for absolut position	024.8068.A §7.8.3

Serial Link		
LSMR1	Transmission type	024.8012 §5.2
LSMR2	Baudrate selection	024.8012 §5.3
ADAXE	Peripheral address	024.8012 §5.4
TIMOUT	Time-out	024.8012 §5.5
ENDBYT	Answer terminating byte	024.8012 §5.6

3.3.5. LA Link Board specific Parameters

Analog Input		
COEPOS	Input gain for use as position set value	024.8016 §4.2
COEVIT	Input gain for use as velocity set value	024.8016 §4.3
COEACC	Input gain for use as torque set value	024.8016 §4.4
MGAIN	Input gain mode	024.8016 §3.4
ZMANAL	Analog input dead-band	024.8016 §3.5
DIFANA	Slew-rate limitation	024.8016 §3.6
INERT	Scale factor for use as torque set value	024.8016 §4.4
DECZER	Input offset for use as position set value	024.8016 §4.2

3.3.6. Parameters for Optional Functions

Potentiometer	(using 2nd. resolver input)	
COEPOT	Input gain for potentiometer	024.8068.A §8.12.4
OFPOT	Input offset for potentiometer	024.8068.A §8.12.2
PILTPOT	Input filter for potentiometer	024.8068.A §8.12.3
ZMPOT	Input dead-band for potentiometer	024.8068.A §8.12.5
MRATE	Operating mode for vel. and accel. modulation	024.8068.A §8.4.10
SRATE	Synchro. mode for vel. and accel. modulation	024.8068.A §8.4.10

Master Axis	(only with OM Optional Board)	
COMOS	Selection and scaling of master value to transmit	024.8068.A §8.11.2

Slave Axis	(only with OS Optional Board)	
COMOS	Operating mode of slave axis	024.8068.A §8.11.2
CKM	1st. conversion constant for master-slave ratio	024.8068.A §8.5.2
CKS	2nd. conversion constant for master-slave ratio	024.8068.A §8.5.2
CRANS	Scale factor for master-slave ratio	024.8068.A §8.5.2
CKMS	Approximative master-slave ratio	024.8068.A §8.5.2
CSCAN	Master-slave delay compensation	024.8068.A §8.6.2
MRATE	Operating mode for vel. and accel. modulation	024.8068.A §8.4.10
SRATE	Synchro. mode for vel. and accel. modulation	024.8068.A §8.4.10

Slave Axis	(only with OEI Optional Board)	
CKM	1st. conversion constant for master-slave ratio	024.8068.A §8.5.2
CKS	2nd. conversion constant for master-slave ratio	024.8068.A §8.5.2
CRANS	Scale factor for master-slave ratio	024.8068.A §8.5.2
CKMS	Approximative master-slave ratio	024.8068.A §8.5.2
CSCAN	Master-slave delay compensation	024.8068.A §8.6.2
NIMPEI	Encoder resolution	024.8068.A §8.5.7
FILTEI	Encoder filter	024.8068.A §8.5.4
ACCLIM	Acceleration limitation	024.8068.A §8.5.5
PISTEI	Encoder zero channel enable	024.8068.A §8.5.6
MRATE	Operating mode for vel. and accel. modulation	024.8068.A §8.4.10
SRATE	Synchro. mode for vel. and accel. modulation	024.8068.A §8.4.10

Slave Axis	(only using a Second Resolver as Master)	
CKM	1st. conversion constant for master-slave ratio	024.8068.A §8.5.2
CKS	2nd. conversion constant for master-slave ratio	024.8068.A §8.5.2
CRANS	Scale factor for master-slave ratio	024.8068.A §8.5.2
CKMS	Approximative master-slave ratio	024.8068.A §8.5.2
CSCAN	Master-slave delay compensation	024.8068.A §8.6.2
MRATE	Operating mode for vel. and accel. modulation	024.8068.A §8.4.10
SRATE	Synchro. mode for vel. and accel. modulation	024.8068.A §8.4.10

Cam-Shaft		
CLGCAM	Cam length	024.8088 §4.2.1
CNBREP	Number of steps with repetitive velocity	024.8088 §5.2.1
CSTCAM	Cam start-point pointer	024.8088 §5.2.2
CRCAM	Cam output scale factor	024.8088 §5.3.1
OFCAM	Cam input offset	024.8088 §5.2.3
CKM	1st. conversion constant for master-slave ratio	024.8088.A §4.2.2
CKS	2nd. conversion constant for master-slave ratio	024.8088.A §4.2.2
CRANS	Scale factor for master-slave ratio	024.8088.A §4.2.2
CKMS	Approximative master-slave ratio	024.8088.A §4.2.2
COMOS	Reference transmitter	024.8088.A §7.2
CSCAN	Master-slave delay compensation	024.8068.A §8.6.2

! When the cam-shaft function is used in a master-slave application, parameters CKM, CKS, CRANS and CKMS have to be determined according to the specific document 024.8088 "ST1-Cam-Shaft Function" and not according to the general document 024.8068.A "Software for the synchronization of axes.

4. APPLICATION TESTING

4.1. FRONT-PANEL DISPLAYS

The front-panel display shows a 7-segment sign and a decimal point. Its reading is to be interpreted as follow:

Display	Validity	Signification
dark	all versions	Auxiliary supply is missing
any, dot alight	all versions	Auxiliary supply is ok and CPU is running In order to make sure that the dot is alight and not half-alight, depress the reset button and release after 1 second; the dot should show different brilliancy.
any, dot half alight	all versions	Auxiliary supply is ok, but CPU is not running or software is not available. (see the remark above about dot alight or half alight)
0	all versions	The power stage has been disabled as the result of an external command and not because of a fault
1	all versions	Power stage has been enabled
b	downloadable software	No firmware available; boot program only is running
7	boot software	Reboot after completion of software download
8	all versions	Unit is ready; user's initial parameter values are active
9	all versions	Unit is ready; default parameter values are active
A	all versions	Power stage has been desabled; Auxiliary supply missing
C	all versions	Power stage has been desabled; Resolver failure
d	all versions	Power stage has been desabled; Internal supply failure
E	boot software	Parameter memory IC or jumper not ok or bad memory type
H	boot software	Memory overrun while downloading a software, or Checksum error after software download
L	all versions except LA	Power stage has been desabled; out of position end limits
n	boot software	Internal hardware error
o	all versions except LA	Power stage has been desabled; refer to CMASKU parameter setting
P	all versions	Power stage has been desabled; DC-bus overvoltage
r	all versions except LA	Power stage fault test has been completed successfully
S	all versions	Power stage has been desabled; output had a short-circuit
‾	PAM with new ASIC	CRC Ring. A CRC error has been detected.
=	PAM with new ASIC	Fail Ring. A ring error has occured.
≡	PAM with new ASIC	Carrier Fail.A CRC error has been detected by another ST1.
┘	PAM with new ASIC	No frame received during 50 ms.

BA4 LED's:

GREEN	Auxiliary supply OK
RED	Temperature to high
YELLOW	DC bus high

4.2. STATUS INDICATORS FOR REMOTE DIAGNOSIS

Status indicators or flags are grouped within 6 bytes (3 words). They read as follow:

msb							lsb	msb							lsb
#7	#6	#5	#4	#3	#2	#1	#0	#7	#6	#5	#4	#3	#2	#1	#0
STATA								STATB							
STAT1															

msb							lsb	msb							lsb
#7	#6	#5	#4	#3	#2	#1	#0	#7	#6	#5	#4	#3	#2	#1	#0
STATC								STATD							
STAT2															

msb							lsb	msb							lsb
#7	#6	#5	#4	#3	#2	#1	#0	#7	#6	#5	#4	#3	#2	#1	#0
STATE								STATF							
STAT3 (not available in several versions)															

4.2.1. STATA

The STATA byte provides essential information on the status of the ST1 digital motion controller and its software.

Bit 7 (latched) signals that the power stage has been disabled as a result of a fault. Normal disabling will not have any effect on this bit.

Bit 6 (latched) informs that there has been a change in the two bytes of the STATC and STATD status as a function of the mask MASKS. .

Bit 5 indicates whether the real position is less than ("1") or greater than ("0") the value set by the instruction SPWARN.

Bit 4 signals that the position lag (variable DPOS) is greater than ("1") or less than ("0") the value set by the parameter SEUIL1. It provides an overall functional control of the axis, allowing the disclosure of any occurrence of excessive friction or a cable rupture, for example. It is resumed under the memorized format in STATD. In certain versions of the software, velocity lag DVIT is monitored instead of the position lag if parameter KTEGR = 32,768 (hexa : 8000).

Bit 3 signals that the move requested by an instruction ERMOV, ERUN, START, STOP etc. is in progress. The bit is set to "1" when one of the above instructions is received and returns to "0" when the corresponding move is finished.

Bit 2 is used by those software versions which require computation time between the receipt of a move order and the execution of it. It is set to "1" when the computation is finished, which means that a START order will follow immediately. It returns to "0" as soon as the move has started

Bits 1 and 0 give information about the status of the motor speed during the execution of a move of the axis :

Bit 1	*Bit 0*	*Meaning*
0	*0*	*Stop (reference speed zero)*
0	*1*	*Acceleration*
1	*1*	*At speed (reference speed not zero)*
1	*0*	*Deceleration*

4.2.2. STATB

The STATB byte indicates such faults which have immediately resulted in the disabling of the power stage. It allows you to find the reasons for an undesired stop of the axis.

Bit 7 (latched) indicates the amplifier has been disabled due to a failure in the resolver feedback signal.

Bit 6 (latched) indicates that the DC bus voltage UA has exceeded its upper limit.

Bit 5 (latched) indicates that a saturation fault in the power transistors is the source of the disabling. Possible causes : short circuit or overload.

Bit 4 (latched) signals that an internal failure in the auxiliary voltage is the source of the disabling.

Bit 3 (latched) indicates that a momentary interruption of the auxiliary supply is the source of the disabling.

Bit 0 indicates that the boot program is running .

4.2.3. STATC

The effects of the bits of variable STATC depend on the masks. The listing which accompanies every software version, shows all bits having really a meaning. All the other bits remain set to "0".

Bit 7 (latched) indicates that a not valid instruction code has been received.

Bit 6 (latched) indicates that implausible instruction code or data has been received.

Bit 5 (latched) reserved.

Bit 4 (latched) indicates after powering up or resetting that the present link card is not compatible with the present software version, or that the card is missing. Afterwards, it indicates a serial link transmission failure.

Bit 3 is "1" as long as the SAVE routine is in progress, which saves all parameter actual values into the EEPROM parameter memory. It returns to "0" as soon as saving has been completed.

Bit 2 indicates that the master shaft has overrun the limit of one period, or that the zero track of an incremental encoder has been detected.

Bit 1 reproduces the state of input No. 2 of some link cards. If the entry is open (no current, zero voltage), the bit is at 1. If the entry is fed, it is at 0.
While downloading a software bit 1 indicates that the EEPROM memory filling is under way.

Bit 0 depends on the state of input No. 1 of some link cards, as bit 1.
While downloading a software bit 0 indicates that the checksum computation is under way.

4.2.4. STATD

The effects of the bits of variable STATD depend on the masks as STATC. The listing which accompanies every software version, shows all bits having really a meaning. All other bits remain set to "0".

Bit 7 (latched) indicates excessive motor temperature, or that the corresponding input of the ST1 digital motion controller is not connected.

Bit 6 (latched) indicates that the internal overheating protection circuitry is active and reducing the current to the motor.

Bit 5 (latched) is a latched copy of bit 4 of STATA.

Bit 4 (latched) indicates that the real position has exceeded (even if only briefly) the limits set by parameters PHIL1/PHIL2.

Bit 3 (latched) indicates that the ST1 digital motion controller has initiated a STOP procedure.

Bit 2 (latched) indicates a failure of the optional board.

Bit 1 (latched) is used to determine if the microprocessorhas been reinitialized ("RESET") or not. The validity of the position measurement (number of turns) and the other variables depends on it. After each restart of the microprocessor, this bit is worth 1. It is put back to 0 by one of the initialization commands of status and particularly when the power stage is enabled. Then, it can only go back to 1 with a new restart of the microprocessor.

Bit 0 indicates if the power stage is enabled ("0"), or disabled ("1").

4.2.5. STATE

Bit 7 indicates that a motor speed has exceeded the limit set by the parameter VITMAX.

4.2.6. STATF

This status is only used by the PAM version ***

Bit 5 **(CRC NODE)** indicates that ST1 has detected a CRC error in a tram destinated to it.

Bit 4 **(NO TRAM)** indicates that any tram is arrived for 50 ms.

Bit 3 **(CARRIER FAIL)** indicates that a CRC error has been detected by a ST1 upstream in the ring.

Bit 2 **(FAIL RING)** indicates a ring error.

Bit 1 **(CRC RING)** indicates that the ST1 has detected a CRC error in a tram destinated to another ST1.

Bit 0 **(COUNT)** indicates that more than two commands have been sent to the ST1 during one PAM cycle.

4.3. TEST DEVICE

The test device allows you to measure variables in digital (8 bits) or in analog (2 channels) form.

4.3.1. DIGITAL MEASURING

Two parameters are necessary to define which variables you want to measure:

CADBIN: is the address of the variable to be monitored digitally. Default value 128 (hexa:80): STATA

CMPBIN: specifies which part of the variable has to be monitored:
0 to disable the measuring (also the two analog channels).
16 (Hexa:10) for the most significant byte.
4096 (Hexa:1000) for the least significant byte.

4.3.2. ANALOG MEASURING

As for the digital, two parameters (for each channel) have to be set to define a variable analog measuring:

CADMA1: (CADMA2) is the address of the variable to be monitored on pin A1 (respectively pin A2)

CMPMA1: (CMPMA2) is the scale factor for the A1 (respectively A2) analog output. It could be set according to the following table:

Speed variable		Position variable		Torquee variable	
CMPMAx	[t/min/V]	**CMPMA**x	[deg/V]	**CMPMA**x	[Nm/V]
72 (Hexa:48)	2000	144 (Hexa:90)	2	82 (Hexa:52)	5
144 (Hexa:90)	1000	288 (Hexa:120)	1	205 (Hexa:CD)	2
288 (Hexa:120)	500	722 (Hexa:2D2)	0.5	410 (Hexa:19A)	1
722 (Hexa:2D2)	200	1444 (Hexa:5A4)	0.2	820 (Hexa:334)	0.5
1444 (Hexa:5A4)	100	2888 (Hexa:B48)	0.1	1444 (Hexa:5A4)	0.2

Intermediate value are allowed. The relation between output voltage and value (in internal units) is:

$$U_{OUT} = val \cdot \frac{CMPMAx}{4096} \cdot 0.078$$

Address of the most important variables:

		Address	
PHIB	: actual angular position of the resolver	37	Hexa: 25
PHIREB	: angular reference position of the resolver	50	Hexa: 32
DPOS	: angular position lag	53	Hexa: 35
VIRB	: actual angular speed of the resolver	41	Hexa: 29
VIREFB	: set angular speed of the resolver	47	Hexa: 2F
COCOU	: required motor torque	55	Hexa: 37
DVIT	: angular speed lag	52	Hexa: 34

The addresses of the other variables could be found in the variable list furnished with each ST1 software.

ATTENTION! *In both cases (digital and analog) the **CMPBIN** parameter must different of zero to enable any measuring.*

4.4. PUTTING INTO SERVICE

Text to be added in a next edition.

5. PREVENTIVE MAINTENANCE

The ST1 digital Drive Units provide the user with plenty of informations which may be used for preventive maintenance of the machine (refer to § 6.2 for the list of all status flags). The most obvious one is the motor torque which can be required i.e. every time the axis is running at constant speed, and which can help the machine control equipement to detect an unnormal load increase. It is also possible to monitor the ST1 heatsink temperature in order to warn the machine user that the heatsink has to be cleaned-up.

It is absolutely necessary to protect the ST1 and BA4 units agains dust and moisture. Be sure that the cubicles are hermetically closed, and that the cooling air filters (if any) be regularly cleaned-up and replaced.

Should the air humidity be high and the temperature be suddenly lowered, then a risk of water condensation appears, which is not allowed.

The units themselves require no preventive maintenance actions as long as they are used within their operating ranges.

6. TROUBLE-SHOOTING

(text to be added in a next edition)

7. EMC

7.1. GENERAL

Mounting ST1 into cabinets for driving machines has to take care about different points. One of these is the EMC (ElectroMagnetic Compatibility). The EMC is the capability of a part of a system to work without perturbing (emission) - and being perturbed by (immunity) - the rest of the system with electromagnetic phenomena.

Electromagnetic interference are propagated by four different ways:

- Galvanic coupling
- Capacitive coupling
- Inductive coupling
- Radiated electromagnetic field

EMC protection and insulation/safety requirements can have common aspects, such as earthing and protection against overvoltages and lightning. It is important to bear in mind that the safety aspects procedures for personnel protection take precedence over EMC protection procedures.

Safety must always prevail, so that in such cases alternate EMC-related measures must be sought.

Motor cable shields may carry strong, capacitively induced high-frequency currents. These currents are normally routed to the earth and thus produce no particular danger.

Should the user fail to connect these motor cable shields to earth, than a voltage may appear at places which are normally not IP20 protected, and which is dangerous to humans.

It is recommended to design a **meshed earthing network** throughout the machine and even throughout the building where it is used. Each room of the building should have earthing network conductors to allow bonding of apparatus or systems, cable trays, structures, etc. **Earth loops are not only allowed; they are effective mitigation measures against interference**.

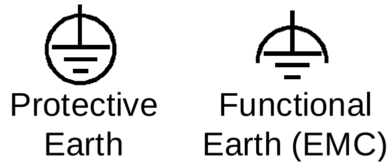
Refer also to IEC 1000-5-2 "Installation and mitigation guidelines, Earthing and cabling" (for the moment it is only available as a commitee draft 77B/168/CDV dated October 1995). This standard is still under study and subject to change, but pro vides for very valuable information.

7.2. CABINET DESIGN

The goal while building a cabinet is to reduce as much as possible all electromagnetic propagation ways. To do that, there are some rules to follow. The first and most important is:

Regarding EMC, GROUNDING is not only connecting a wire to the ground. As the perturbations are high frequency, current is concentrate at the periphery of the conductor. So to have **good EMC grounding** connection, one must use **conductors with flat section** (e.g. flat braided wire) and **large contact area**.

In the schematics we have then the two following signs (ref. IEC617-2 and EN61131-2):



Then more particular rules have to be followed:

a) The cabinet must be perturbations proof. It must be build of five plane l inked together as the longest **electrical connection interruption do not exceed 5cm**. It means that the connection could be done either by soldering or screwing the planes each 5cm. If the screwing solution is chosen, it prohibits naturally **any paint or other insulating material between the planes**. The connection of the sixth plane closing the cabinet (the door) must be also done without interruption longer than 5 cm. It can be done with a **conductive joint**.

b) The **control cabinet and the machine** on which the motor are used must be linked with a **good electrical connection** (e.g. a ground plane or a metallic conduit in which the cables are).Refer to IEC 1000-5-2 guideline (Oct. 1995: commitee draft 77B/168/CDV).

c) The **power and the control devices** must be placed in two **different areas** which are minimum 30 cm apart.

d) **The back plane must not be painted** to be used as ground plane on which all the devices must be mounted with good electrical connection.

e) The **contact area** between devices and the ground plane **must be as large as possible**.

f) If not shielded, **power and the control cables** must be **minimum 30 cm apart**. They must be **as close as possible to the ground plane** in order to reduce the area of the loop they make with the latter.

g) Power cables must not cross the control area and control cables must not cross power area.

h) The **sensitive cables** as well as the **perturbed cables must be shielded**. In addition the sensitive cables have to be twisted pairs

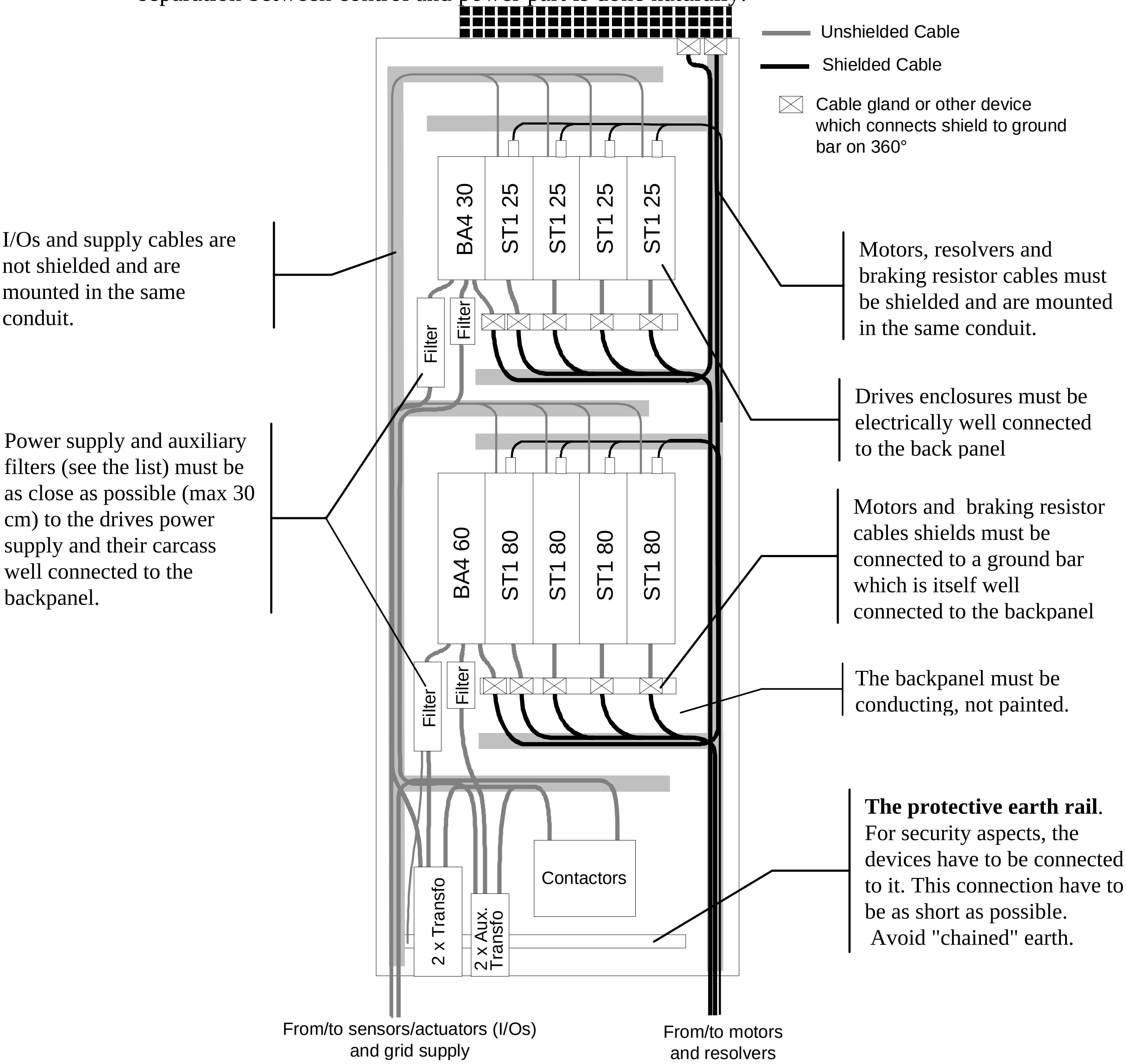
i) When shielded cables are used, the shield must not be twisted and connected to a terminal (pig tail) but **a clamp, with 360° contact on the shield, must fix the cable on a ground bar** which must be itself directly connected to the ground plane with large section. **or directly on the device** it must be connected to.

ii) One EMC filter must be used for each BA4 unit. Please refer to paragraphs 2.6.6 and 8.6 for filter selection and outlines.

7.3. CABINETS CONFIGURATION

7.3.1. EXAMPLE 1

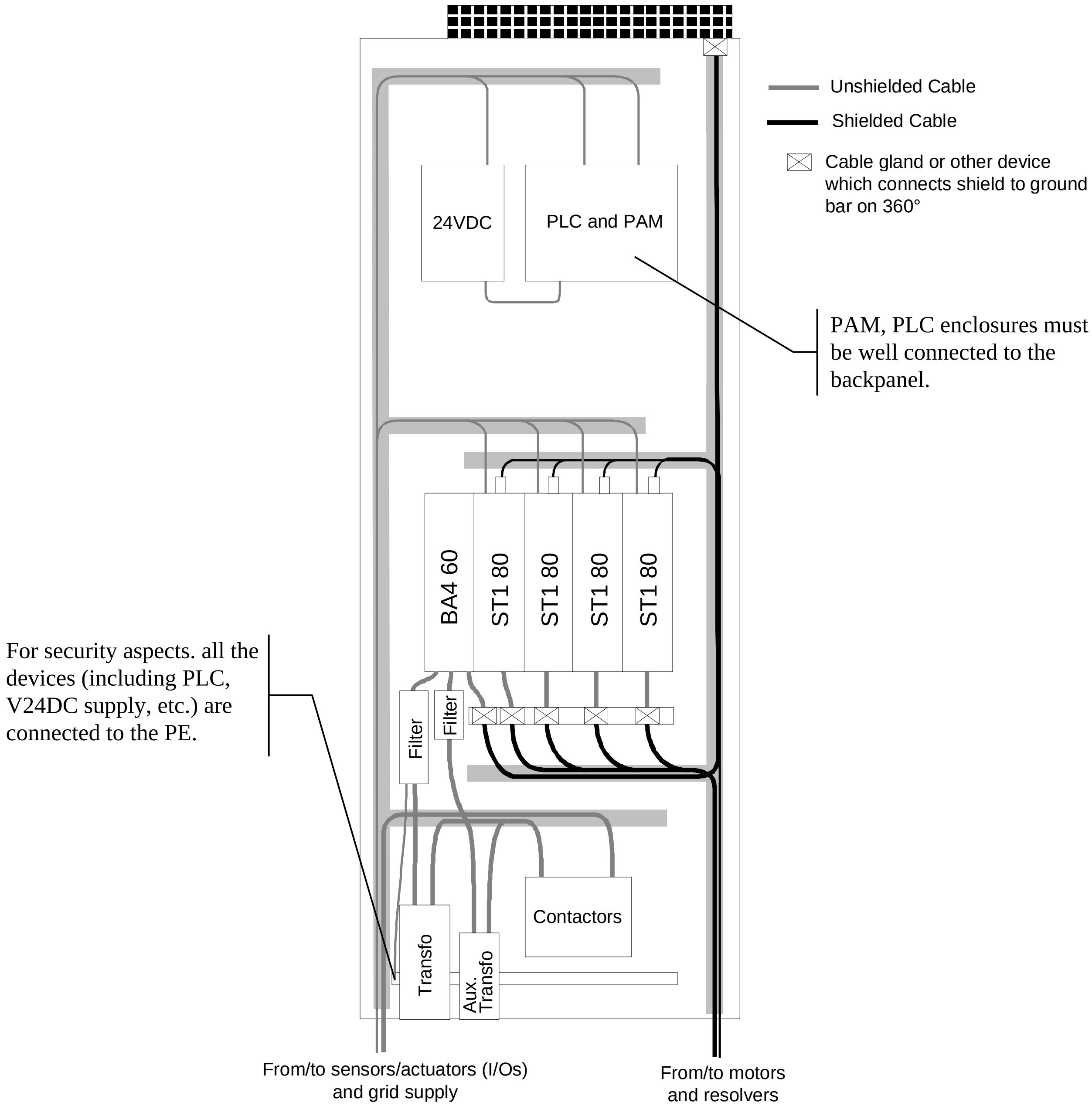
This first example shows a cabinets in which two rows of drives are mounted. The control part (PLC and PAM) are then mounted in another cabinet. The advantage is that the separation between control and power part is done naturally.



All the devices enclosures must be well connected to the metallic backpanel which acts as functional reference ground (which is different than Protective Earth even if both are connected...).
Inside the cabinets, all the cables must be as close as possible to the backpanel.

7.3.2. EXAMPLE 2

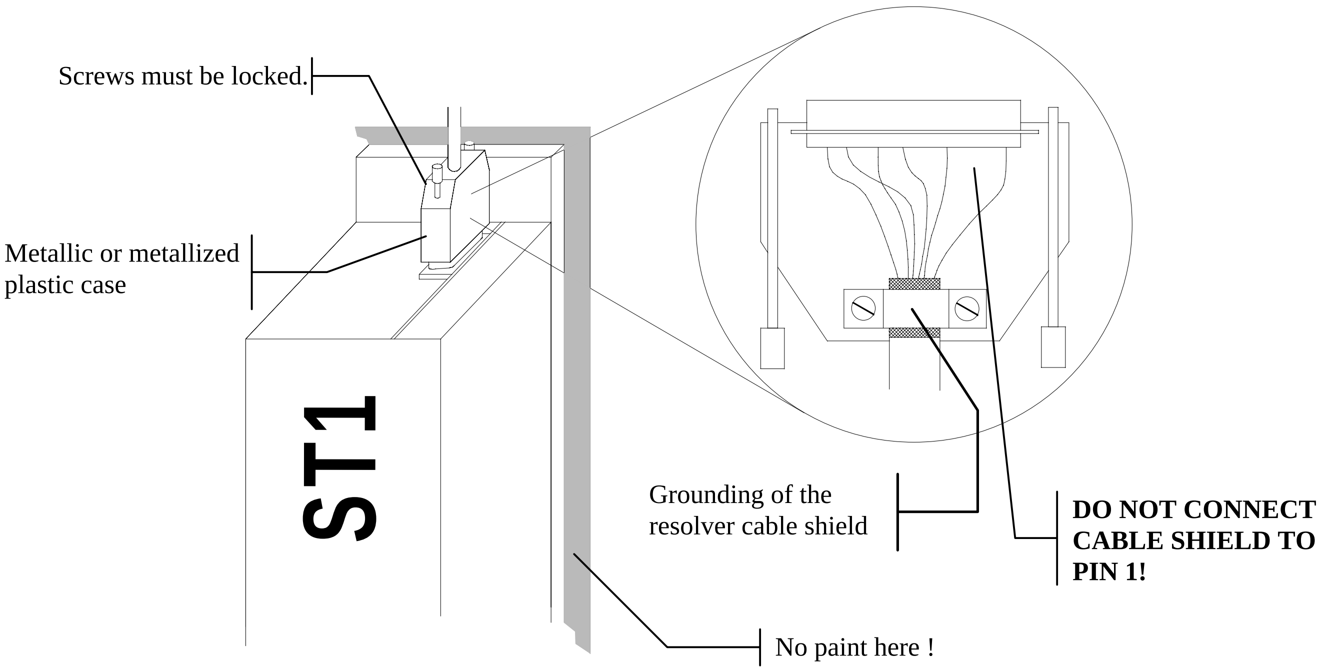
In that case only few drives are used so the control part (PLC and PAM) can be mounted in the same cabinet.



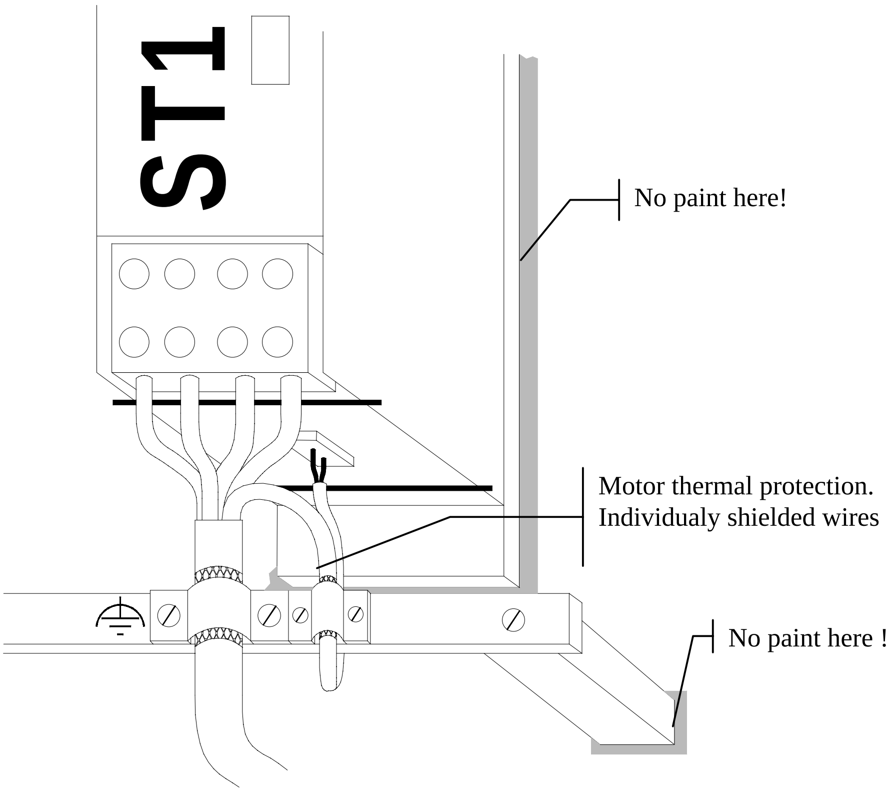
All remarks mentioned for the first example are valid too.

7.4. Details

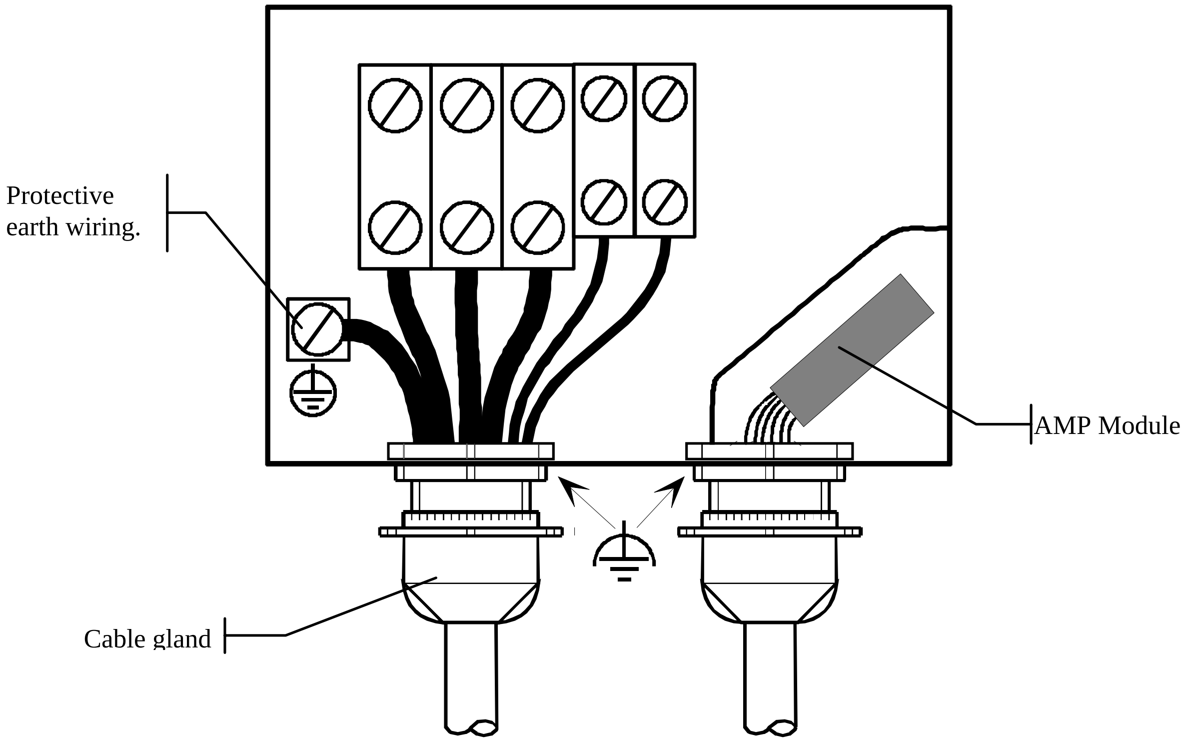
7.4.1. Resolver's Cable Wiring (ST1 side)



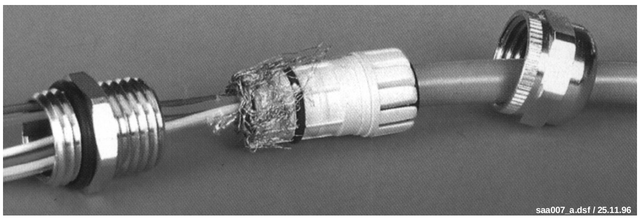
7.4.2. Motor's Cable(s) wiring (ST1 side)



7.4.3. MOTOR AND RESOLVER CABLE WIRING (MOTOR SIDE)

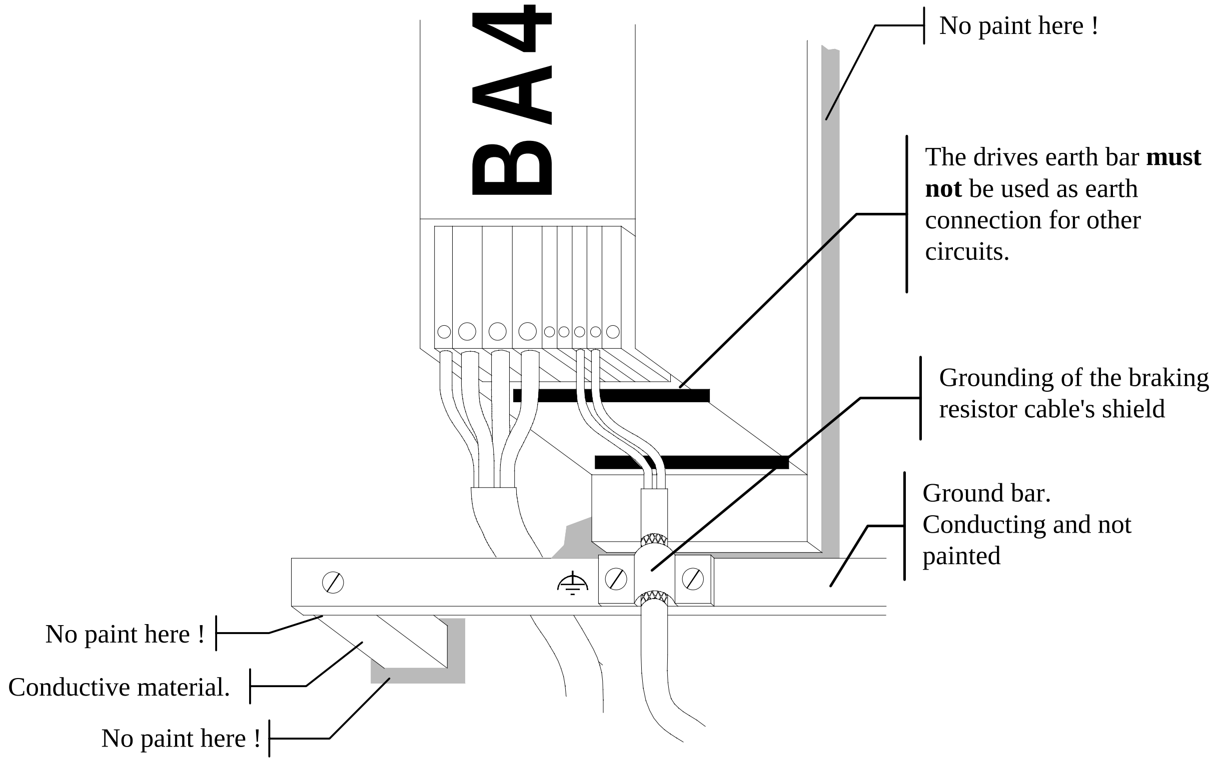


Shield grounding in the cable glands must be done as follow:

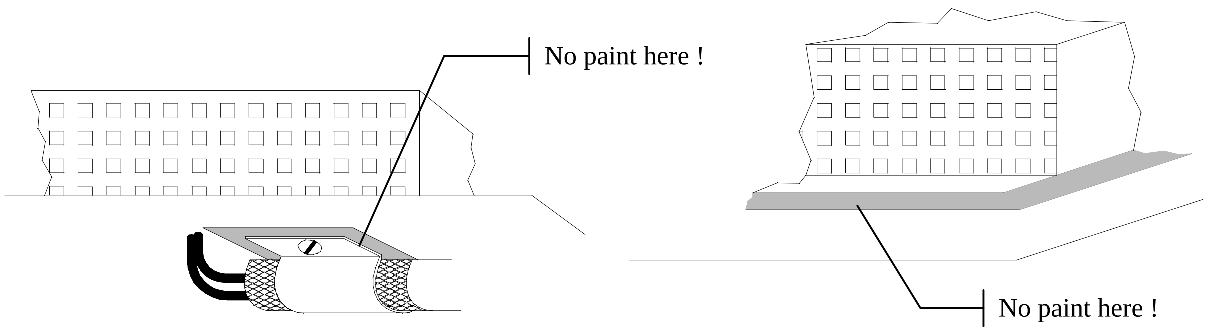


If relevant, plugs with same shield grounding system must be used. The connectors on motor side must then be metallic.

7.4.4. SUPPLY'S AND BRAKING RESISTOR'S CABLE WIRING (BA4 SIDE)

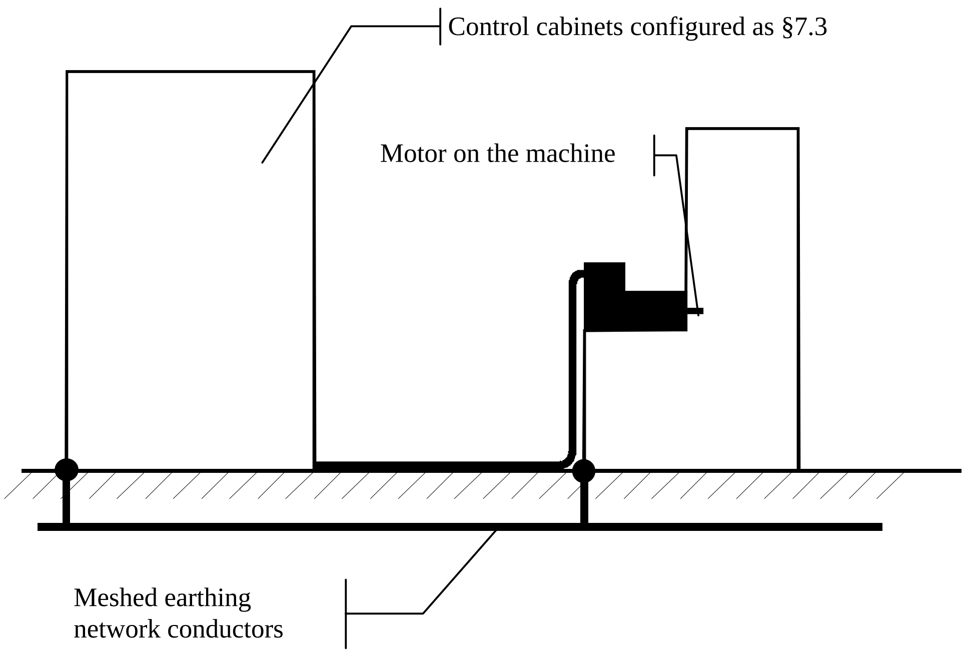


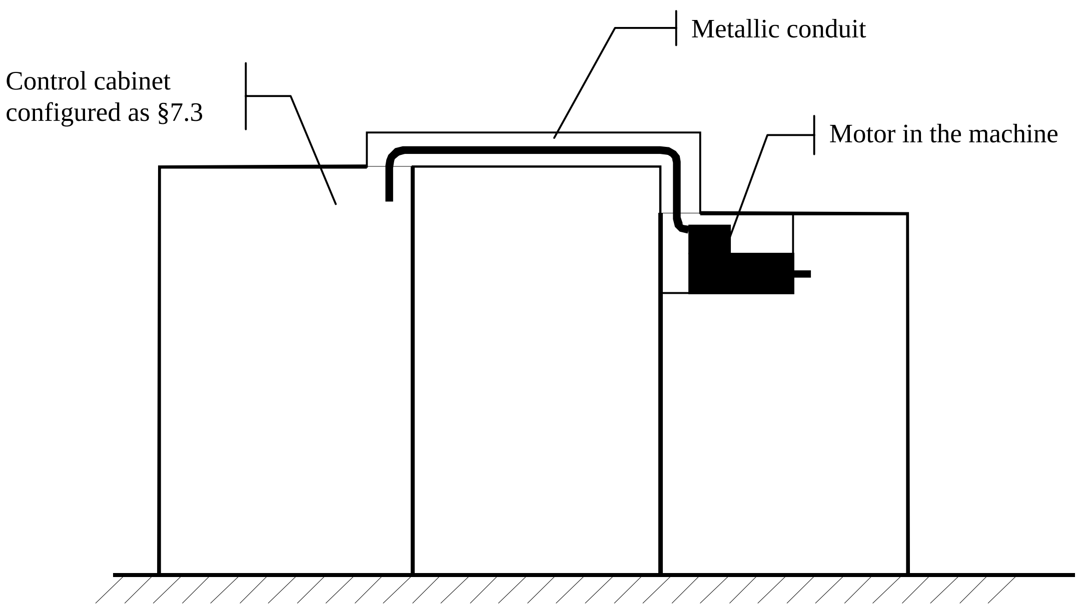
7.4.5. BRAKING RESISTOR'S CABLE WIRING (RESISTOR SIDE)



7.4.6. CONNECTION BETWEEN CONTROL CABINETS AND THE MACHINE

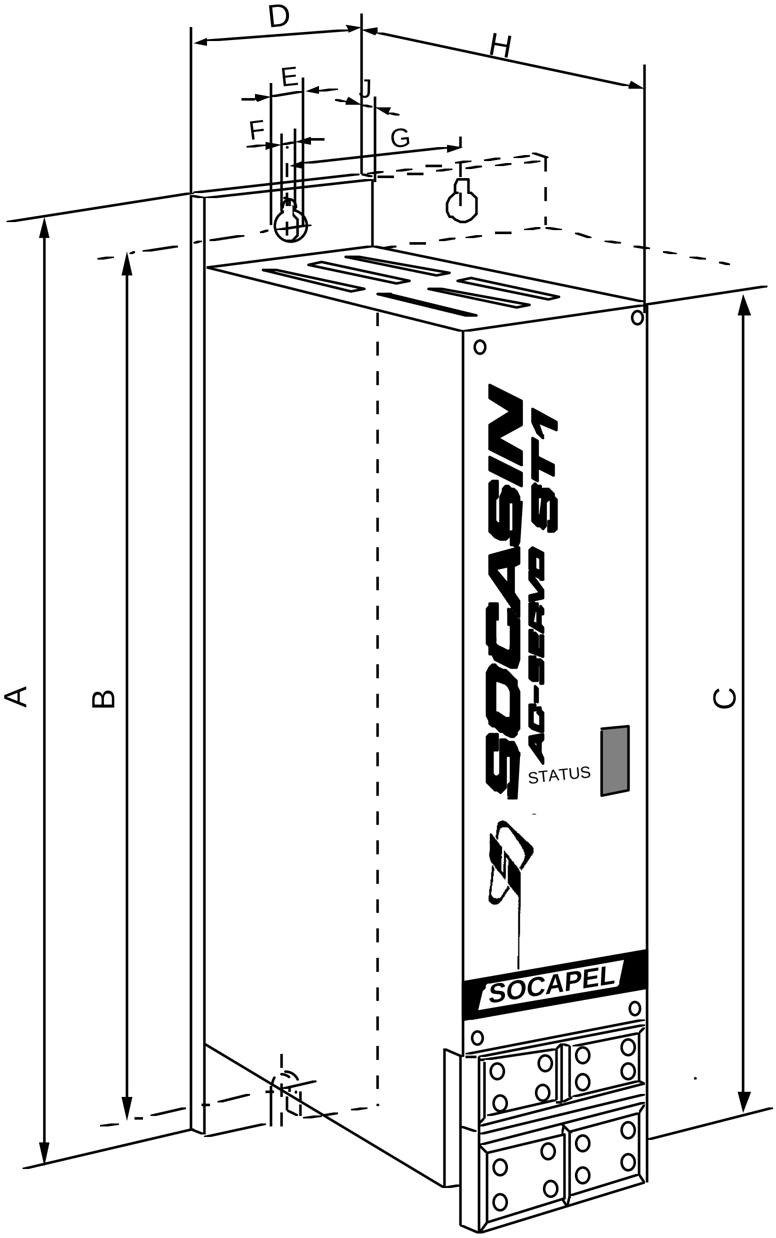
To improve electromagnetic compatibility, it is recommended to connect machine on which motors are mounted to control cabinet in which drives are mounted.
This can be done either connecting the machine and the cabinet to the meshed earthing network of the building or connecting machine and cabinet with a metallic conduit into which motors and resolvers cables run through.





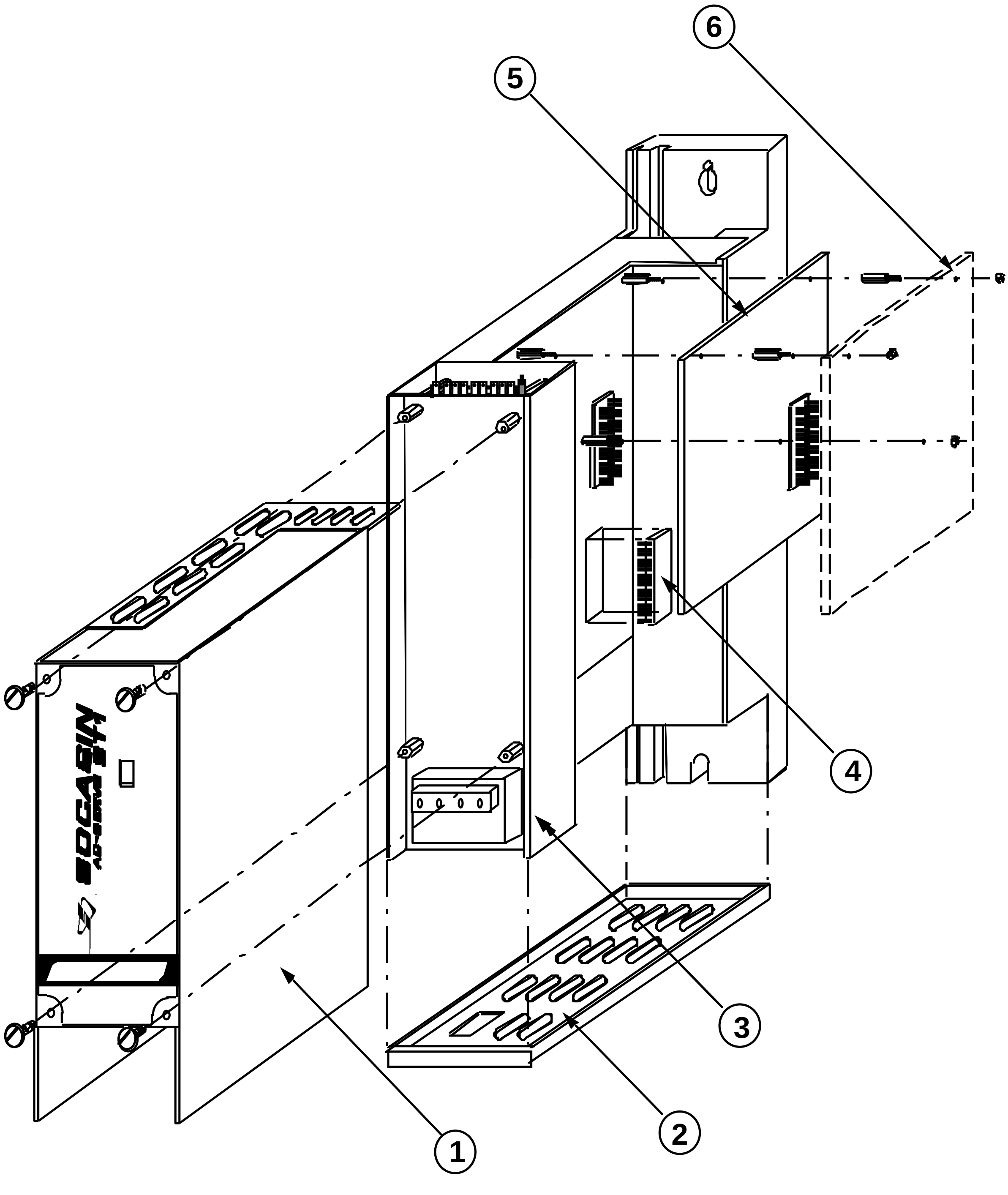
8. Outlines

8.1. BA4 and ST1 Outlines



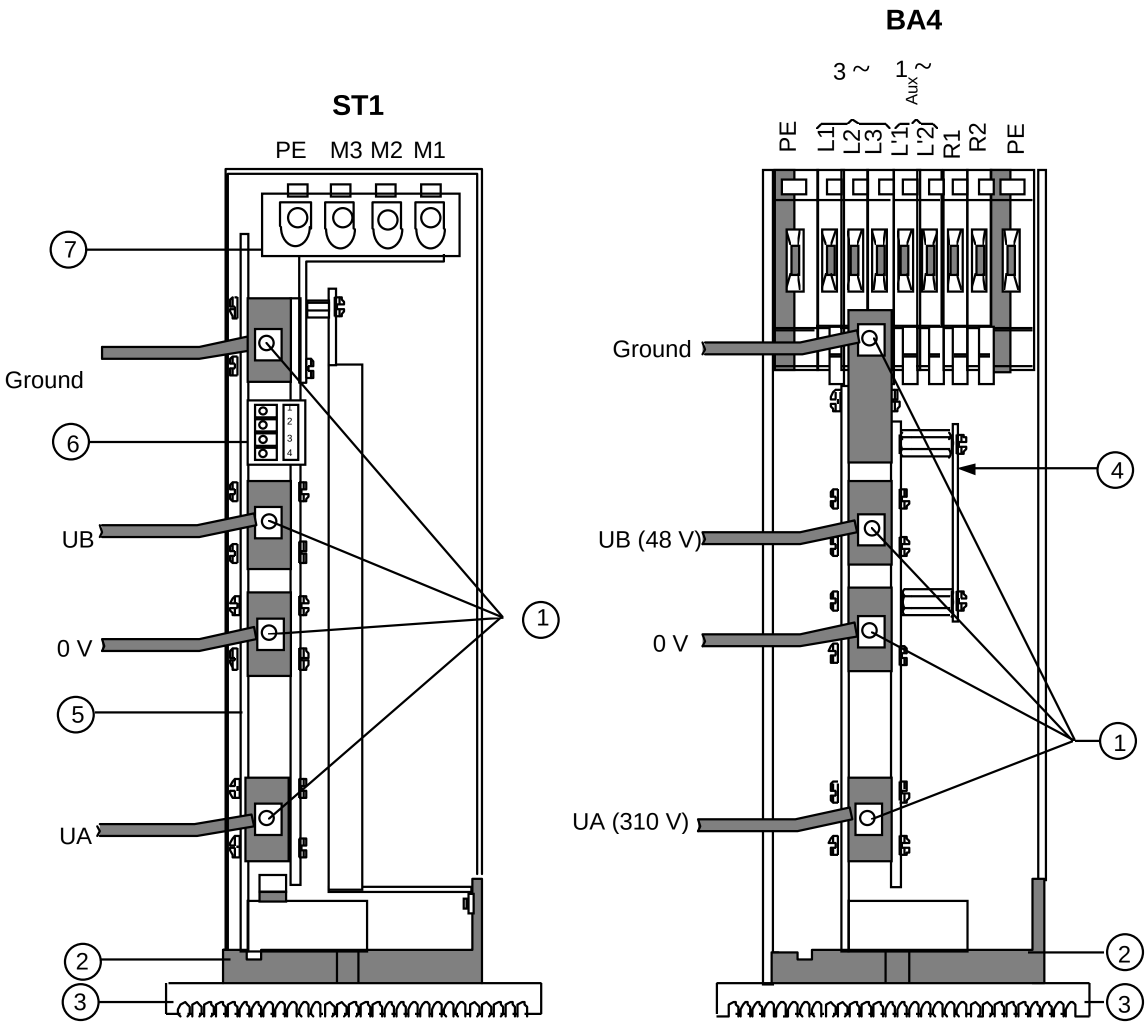
	A	B	C	D	E	F	G	H	J
ST1/10-310	332	311	283	86	18	9	-	281	13
ST1/25-310	332	311	283	86	18	9	-	281	13
ST1/80-310	420	400	371	86	18	9	-	281	13
ST1/140-310	420	400	379	174	18	9	88	285	18
BA4/30-50-310	332	311	283	86	18	9	-	281	13
BA4/60-80-310	420	400	371	86	18	9	-	281	13

8.2. ST1 LINK AND OPTION BOARD ASSEMBLY



1 : Cover (delivered with basic module)
2 : IP20 protection set
3 : ST1 basic module
4 : Sofwtare and parameter EPROMs refer to doc. 024.8008 or 024.8068 for detailed description)
5 : Link board L... (several types)
6 : Option board O... (several types)

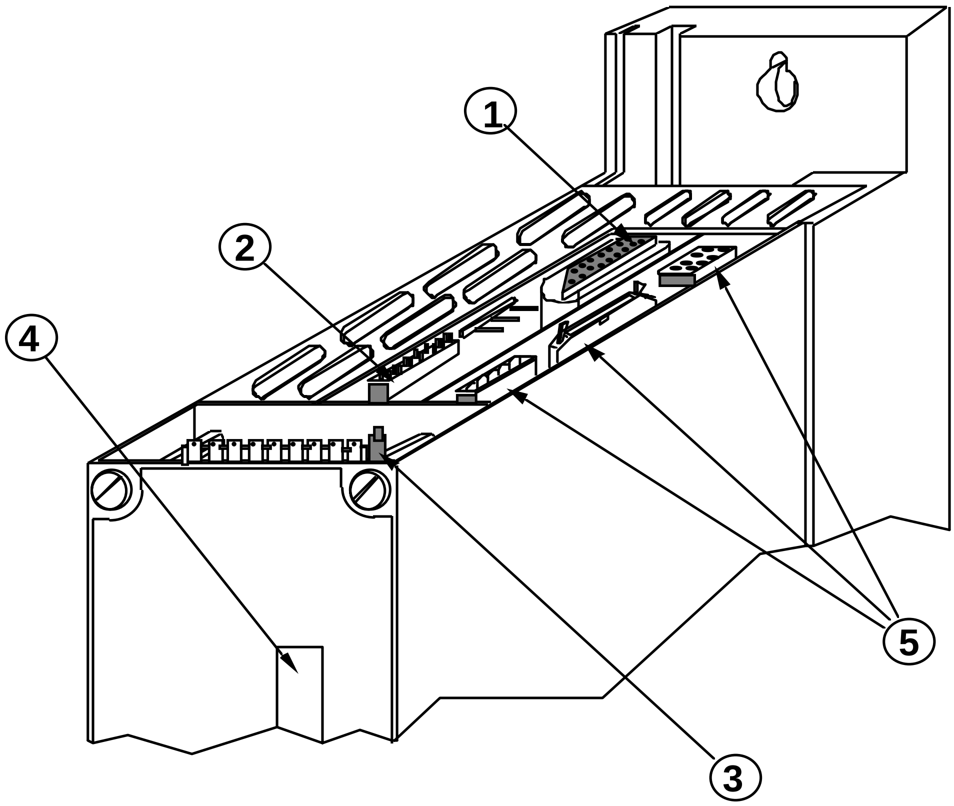
8.3. ST1 AND BA4 BOTTOM VIEW



1 : Power connection (DC-bus)
2 : Support
3 . Cooler
4 : Grounding strap
5 : Power board
6 : Thermal connection of the motor (X3 connector)
7 : Power connection of the motor (X2 connector)

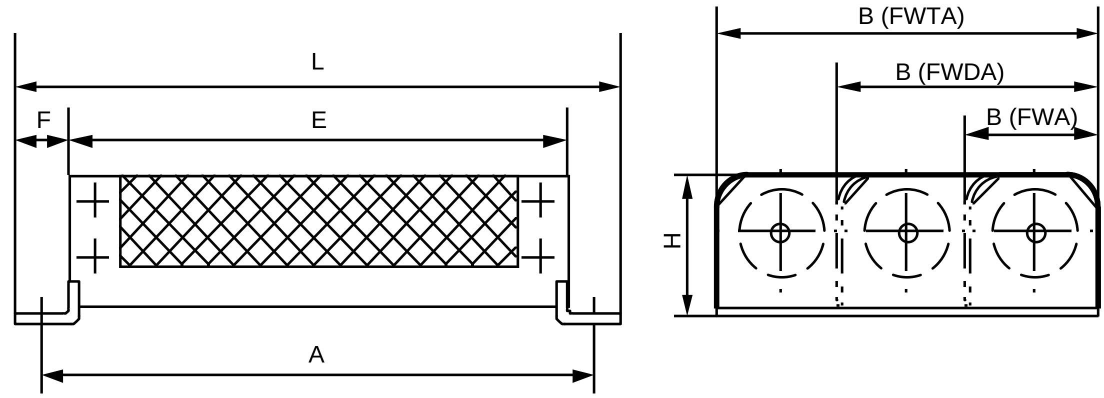
!	In ST1/80, connector X3 (point 6) is mounted 180° rotated, but pinout remains the same (see §9.2). It means that cables are compatible with every ST1.

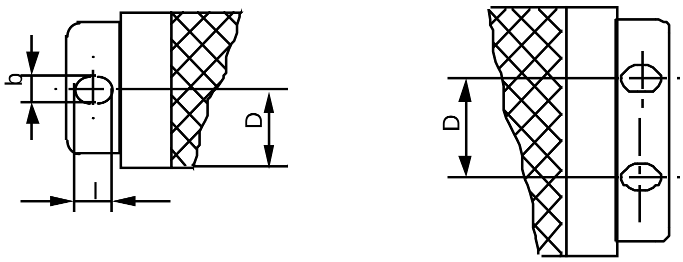
8.4. ST1 UPPER VIEW



1 : Resolver connection (X24)
2 : Test device connection
3 . "Reset" push-button
4 : 7-segment display
5 : Link board connectors(i.e. LIO board)

8.5. DYNAMIC BRAKING RESISTORS





FWDA / FWTA

FWA

Type	L	B	H	A	D	E	F	b x l
FWA 40-150	200	60	85	180	30	154	23	5.5x9
FWA 40-200	250	60	85	230	30	204	23	5.5x9
FWA 40-300	350	60	85	330	30	304	23	5.5x9
FWA 40-400	450	60	85	430	30	404	23	5.5x9
FWA 60-300	350	80	116	330	40	304	23	6.5x9
FWA 60-400	450	80	116	430	40	404	23	6.5x9
FWA 60-500	550	80	116	530	40	504	23	6.5x9

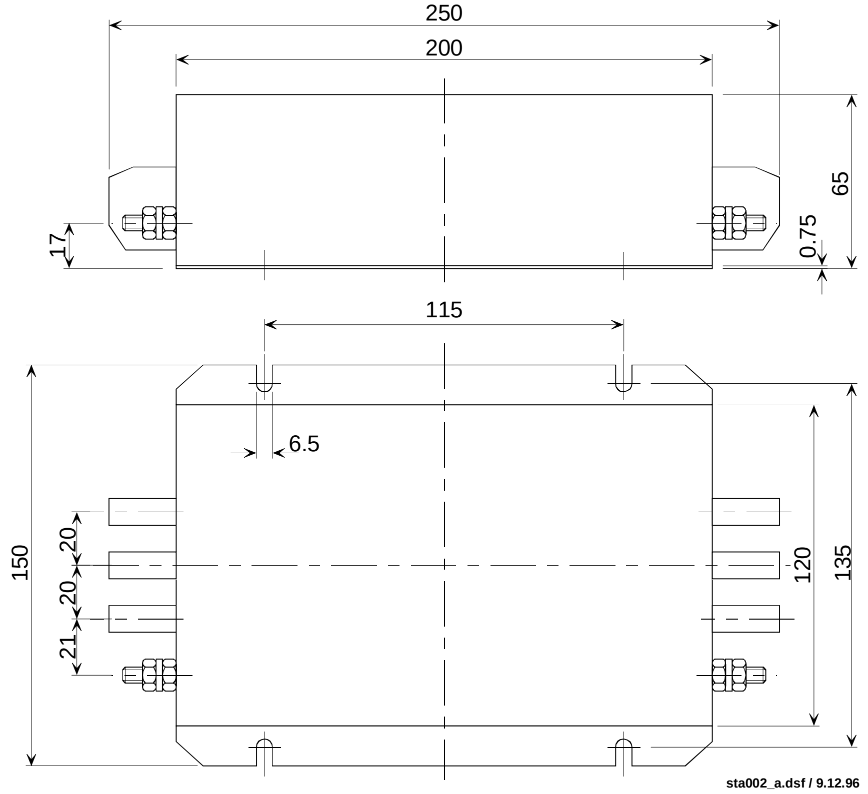
Type	L	B	H	A	D	E	F	b x l
FWDA 40-150	200	130	85	180	60	154	23	5.5x9
FWDA 40-200	250	130	85	230	60	204	23	5.5x9
FWDA 40-300	350	130	85	330	60	304	23	5.5x9
FWDA 40-400	450	130	85	430	60	404	23	5.5x9
FWDA 60-300	350	180	116	330	90	304	23	6.5x9
FWDA 60-400	450	180	116	430	90	404	23	6.5x9
FWDA 60-500	550	180	116	530	90	504	23	6.5x9

Type	L	B	H	A	D	E	F	b x l
FWTA 40-150	200	190	85	180	120	154	23	5.5x9
FWTA 40-200	250	190	85	230	120	204	23	5.5x9
FWTA 40-300	350	190	85	330	120	304	23	5.5x9
FWTA 40-400	450	190	85	430	120	404	23	5.5x9
FWTA 60-300	350	270	116	330	180	304	23	6.5x9
FWTA 60-400	450	270	116	430	180	404	23	6.5x9
FWTA 60-500	550	270	116	530	180	504	23	6.5x9

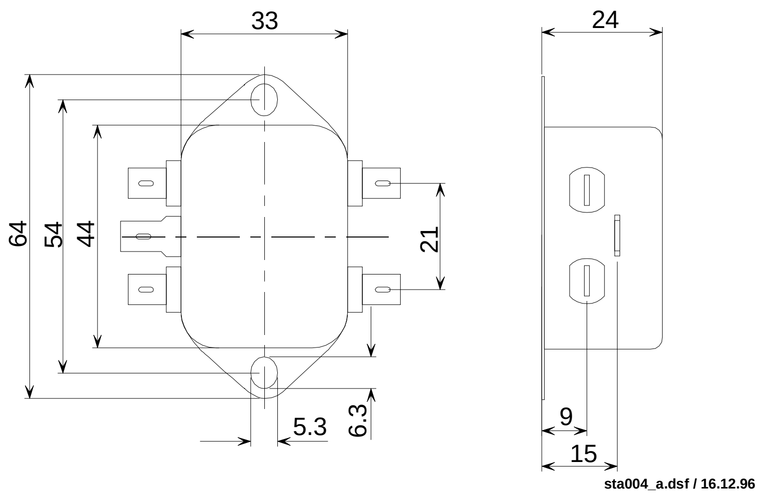
Refer to the §3.2.5 for rating and to §2.6.5 for their normalized values.

8.6. EMC FILTERS

FN351-25/33 and FN351-50/33:

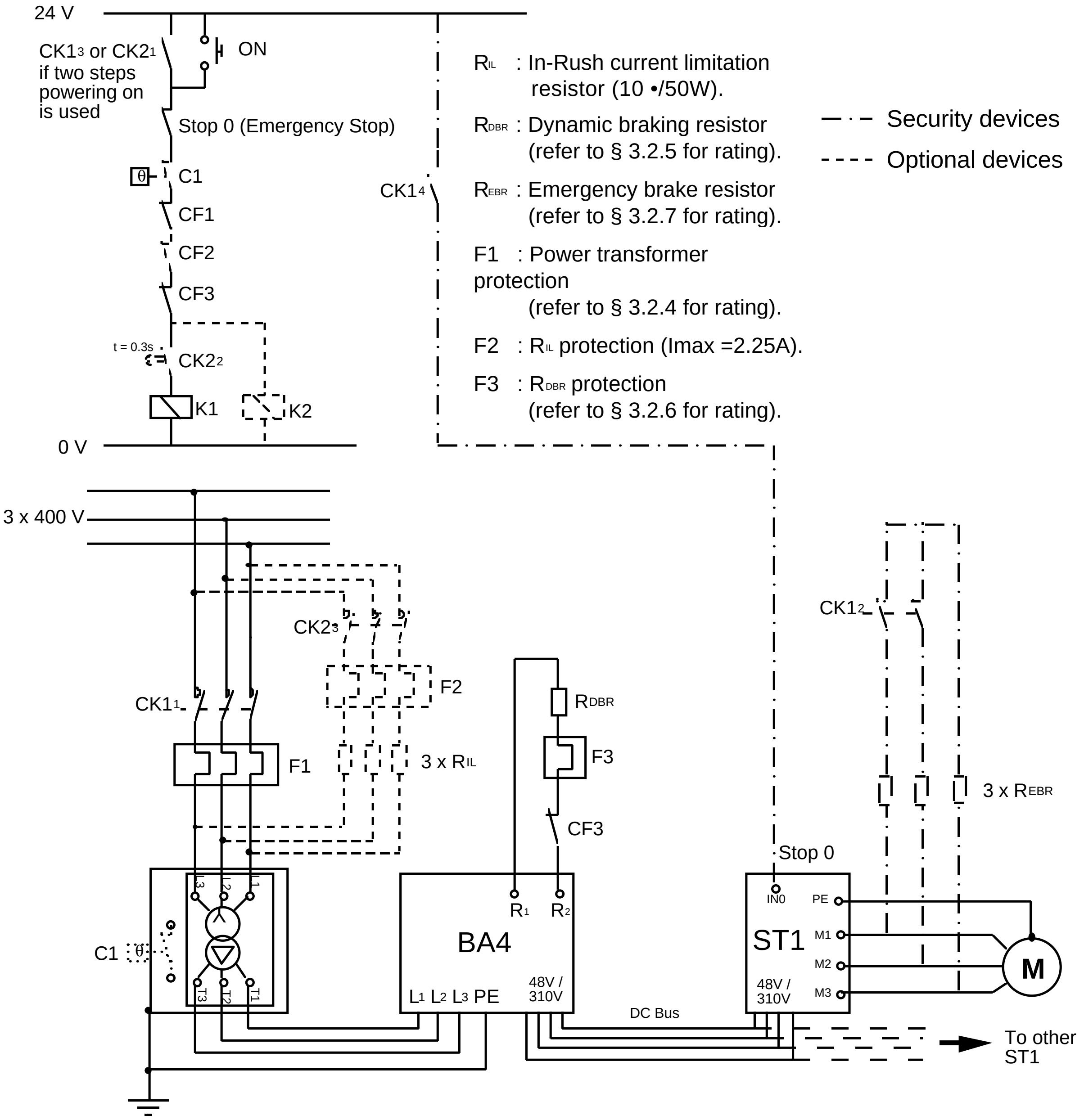


FN 2010-3-6:



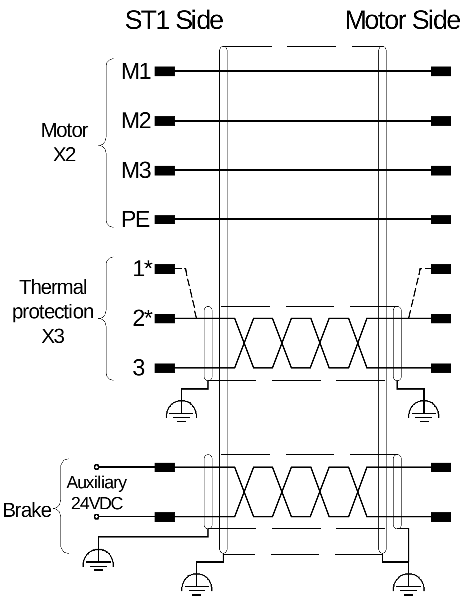
9. WIRING DIAGRAMS

9.1. POWER WIRING AND SAFETY DEVICES



Two steps powering on (optional):
As soon as ON button is pressed, K2 is supplied. So $CK2_1$ (self-standing) and $CK2_3$ (supplying the transfo) are closed.
After 0.3 s, $CK2_2$ is closed, so K1 is supplied. Thus, $CK1_1$ is closed (supplying the transfo) and $CK1_2$ is opened (disconnecting the Emergency brake resistors).
Safety devices:
As soon as a problem occurs (Stop0, Current to high in the transfo or in the Dynamic braking resistor, temperature to high in the transfo), K1 and K2 are no longer supplied thanks to Stop 0, C1, CF1, CF2, CF3. So the system is powered down (thanks to $CK1_1$ and $CK2_3$) and the motors are shorted and then stopped (thanks to $CK1_2$).

9.2. MOTOR WIRING



* pin 1 is for PTC interface
pin 2 for temperature switch

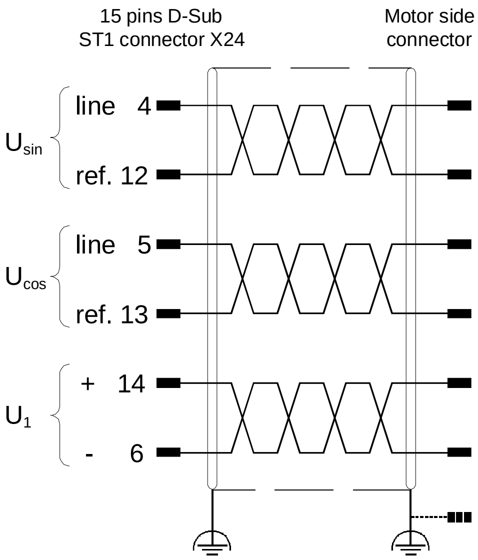
BAUTZ			SEM				Ragonot	ATB
...M506	M713...	Terminal Box	HD70	HD92[1]	HD115 HD142	Terminal Box[2]		
1	1	1	1	B	A	U	U	U
3	2	2	2	G	B	V	V	V
4	3	3	3	A	G	W	W	W
2	⏚	PE	⏚	H	H	GND	T	
								T1
A	5	5	4	C	C	K1	C	
B	7	6	5	D	D	K2	D	T3
C	4	7		E	E	B1	A	
D	6	8		F	F	B2	B	

1: Must have CDEPHA parameter set to 10992 (hexa: 2AAA)
2: only HD115, HD142 and BMR 190

For shield connection, see §7.4

9.3. RESOLVER WIRING

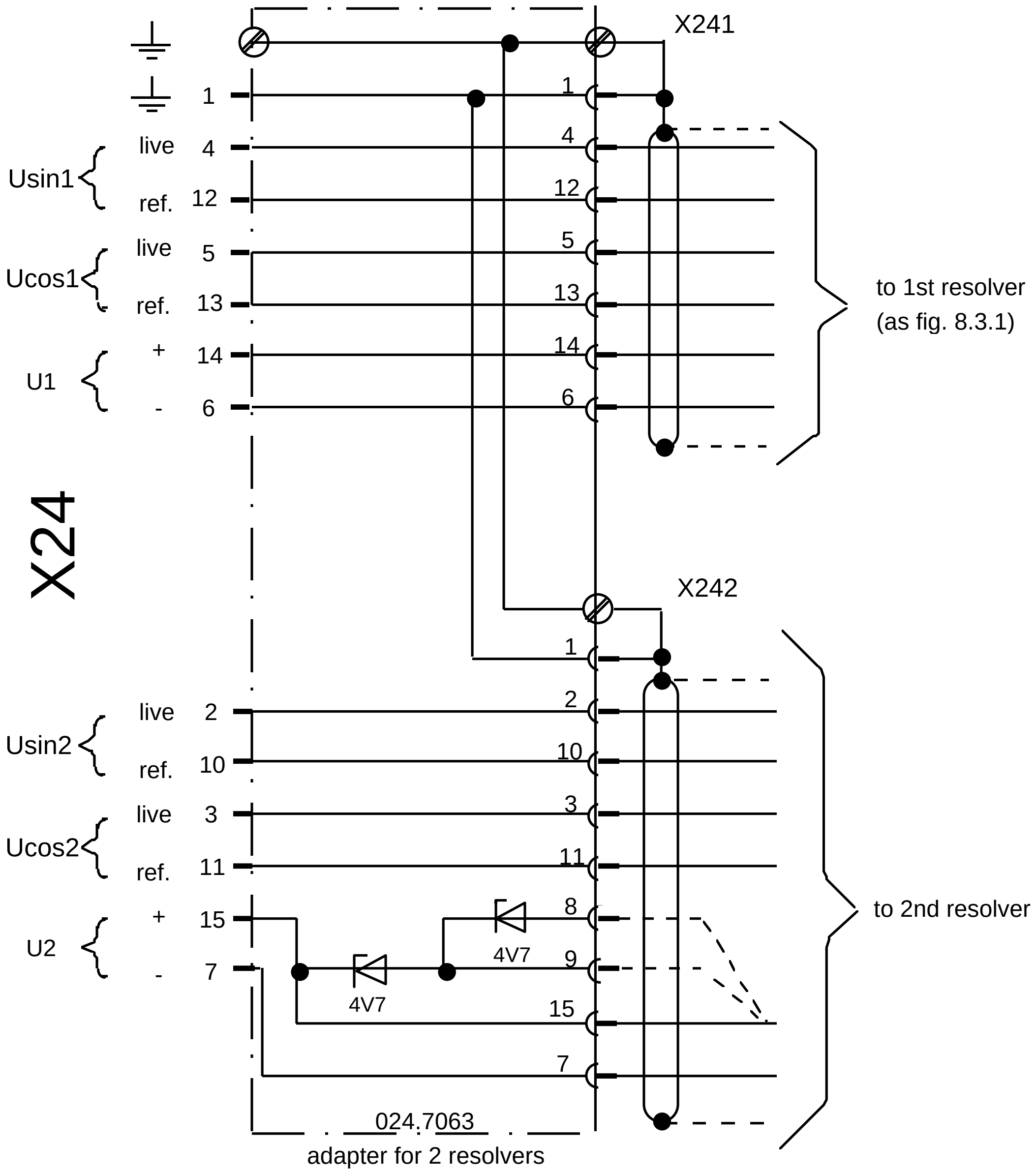
9.3.1. SINGLE RESOLVER WIRING



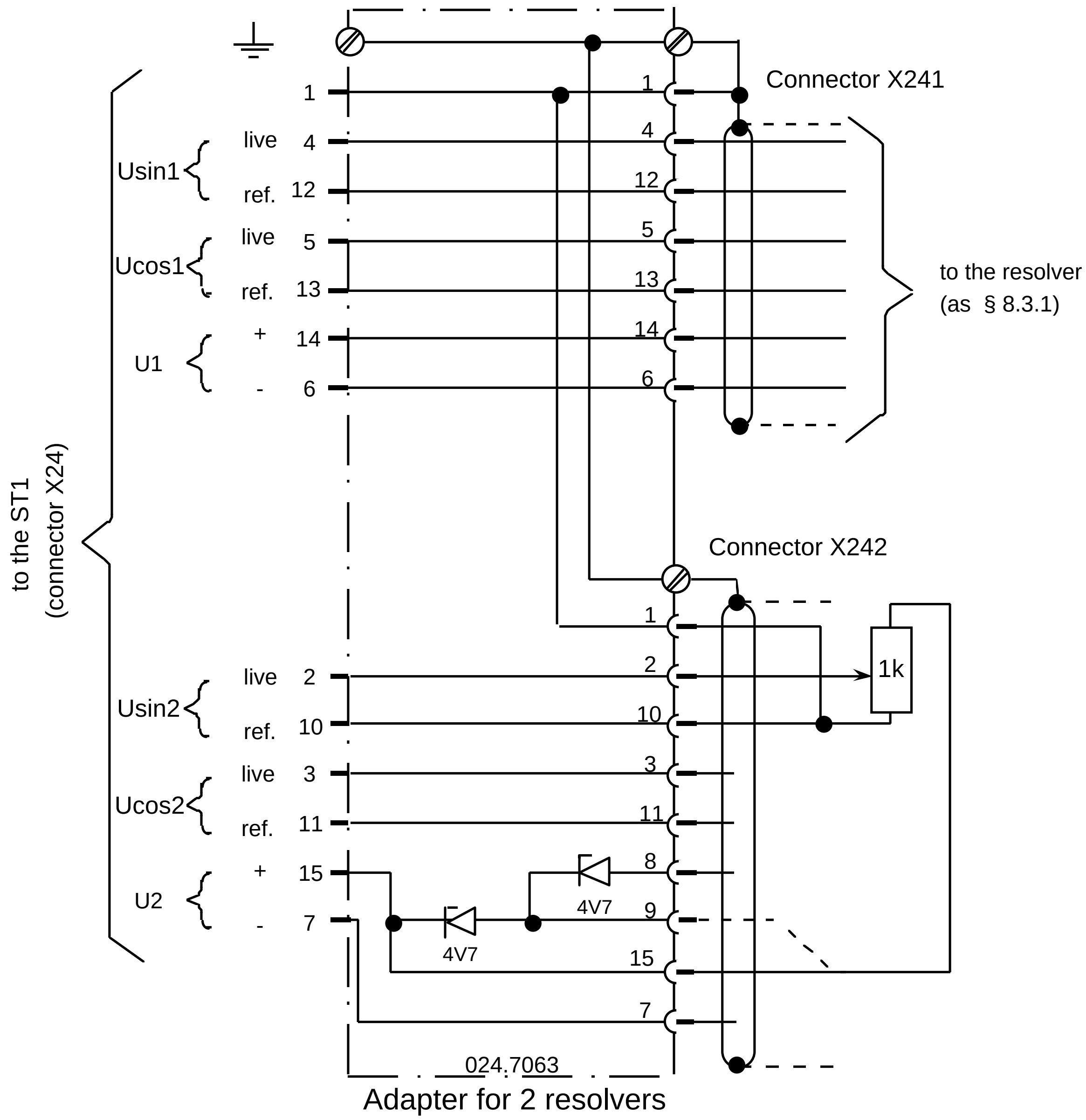
BAUTZ	SEM		Ragonot	ATB
	HD70	Other		
3	3	P	S1	5
4	4	D	S3	4
1	6	C	S2	7
2	5	E	S4	6
5	2	B	R3	1
6	1	A	R1	2
12	9	J	T	9

For shield connection, see §7.4.

9.3.2. WIRING A SECOND RESOLVERS



9.3.3. WIRING A RESOLVER AND A POTENTIOMETER

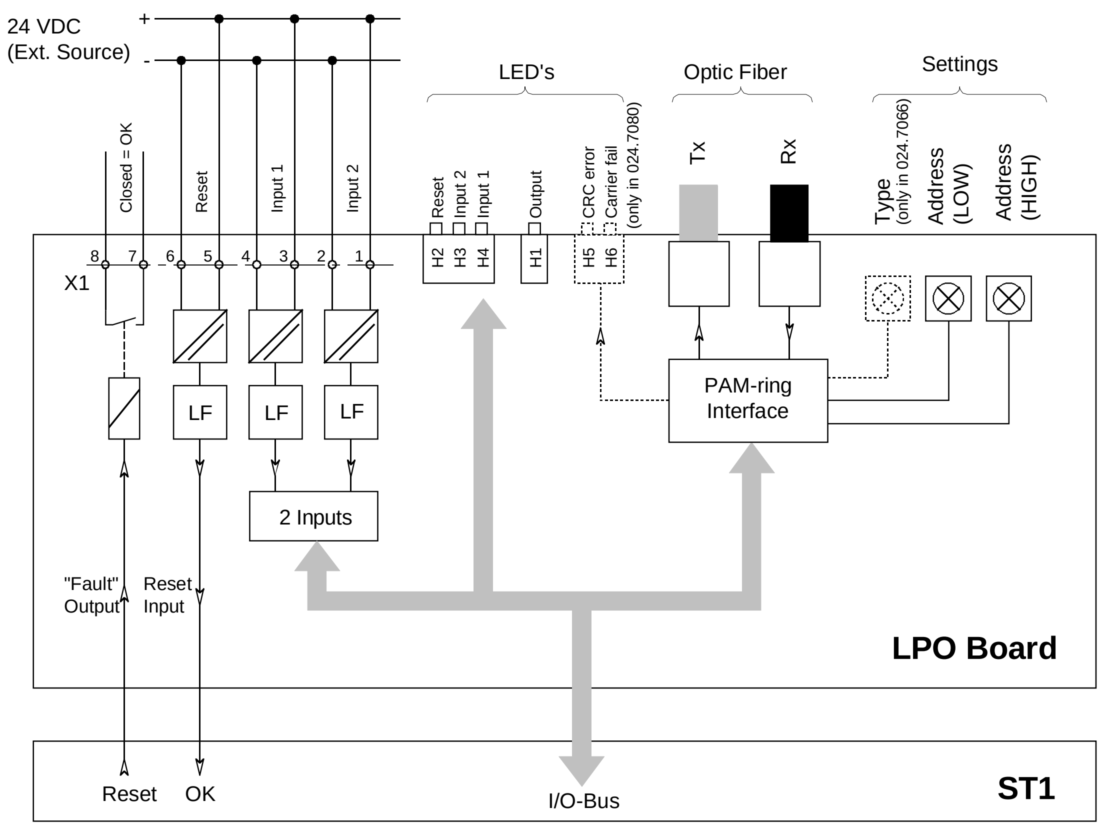


Feeding the potentiometer via pin 9 instead of pin 14 brings better use of potentiometer range (0..10V).
A voltage source (i.e. CNC analog output) may be connected in the same way, using pin # 1, 2 and 10 and leaving pin # 15 (+ 15V) open. In that case, you have to know that the input inpedance is about 5k½. It means that, by 10 V, the input current will be 2 mA.
It is also possible to wire both the resolver and the potentiometer to the ST1 using a single plug. Refer to document 024.8068.A § 8.12.1.

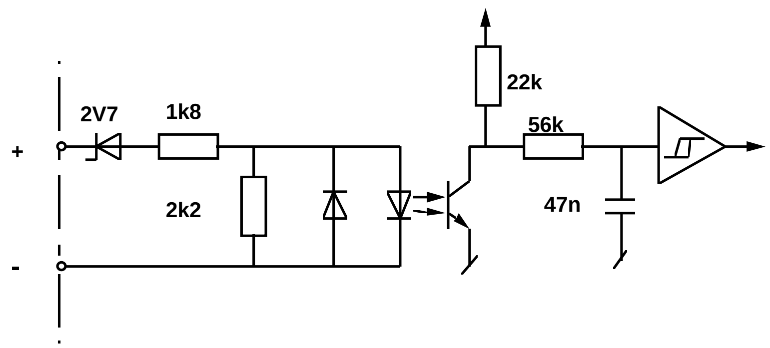
9.4. LPO LINK BOARD WIRING

(Part number 024.7066 / 024.7080 / 024.7082)

9.4.1. FUNCTIONAL DIAGRAM



9.4.2. BINARY INPUTS SCHEMATICS



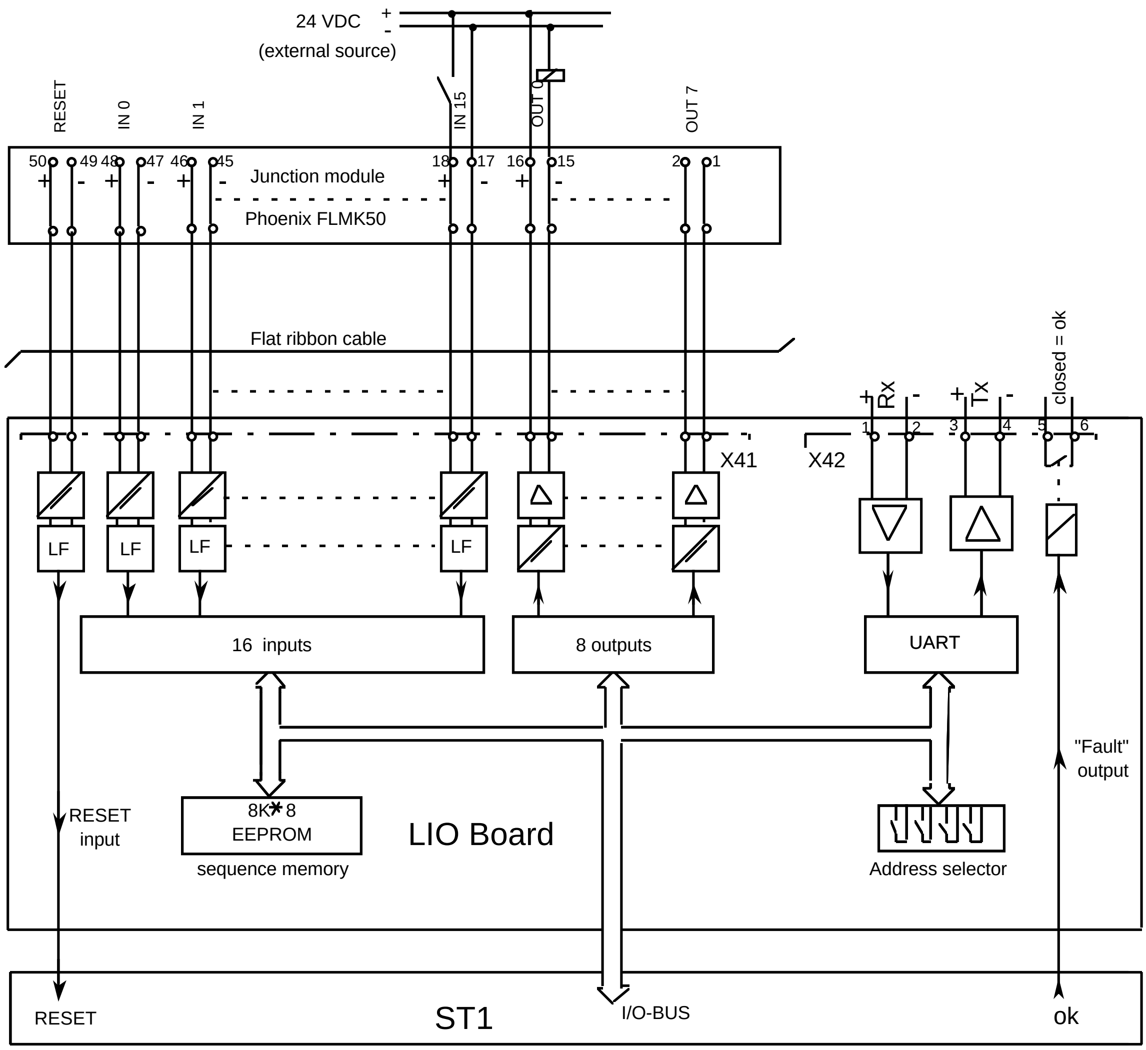
Delays due to the RC filter:

	Reset	Inputs
Raising edge	4.2 ms	4.2 ms
Falling edge	2.1 ms	2.1 ms

9.5. LIO LINK BOARD WIRING

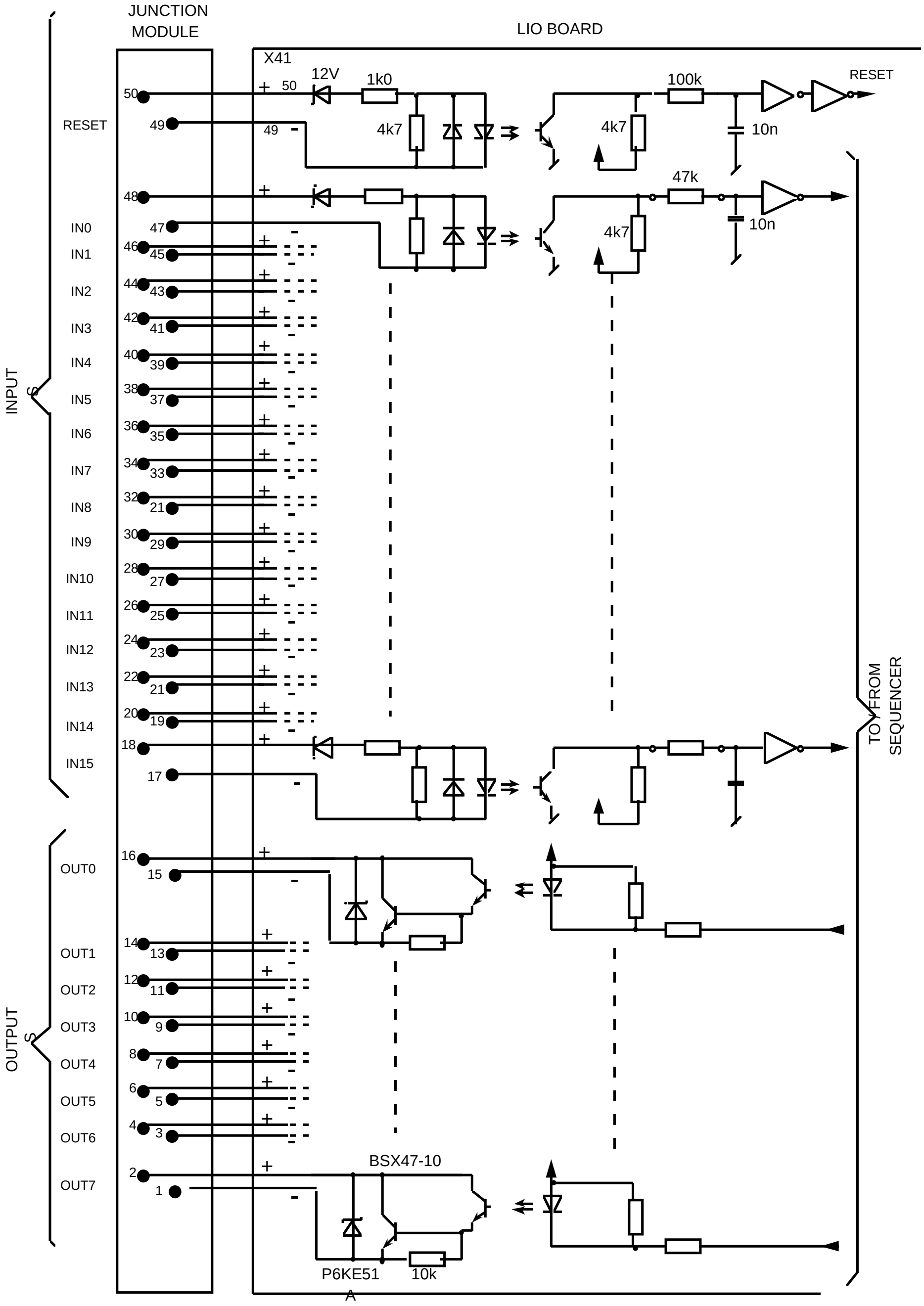
(Part number 024.7040)

9.5.1. FUNCTIONAL DIAGRAM



	Inputs	Outputs	Relay
Current	typ. 10 mA @ 24 VDC	max. 100 mA	max.2 A
Voltage	HIGH +19..+30 VDC LOW -16..+5 VDC	admissible when "open": -0.3..+43 VDC	cutting capacity: DC: 150 VDC/35 W AC: 125 V_{RMS}/60 VA

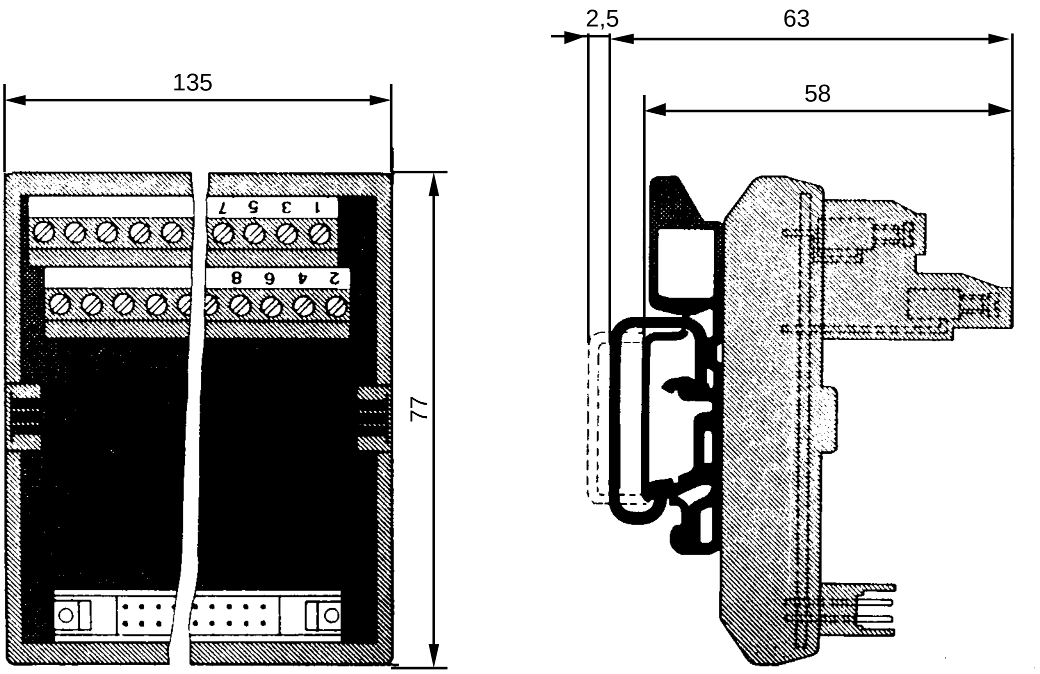
9.5.2. BINARY INPUTS AND OUTPUTS SCHEMATICS

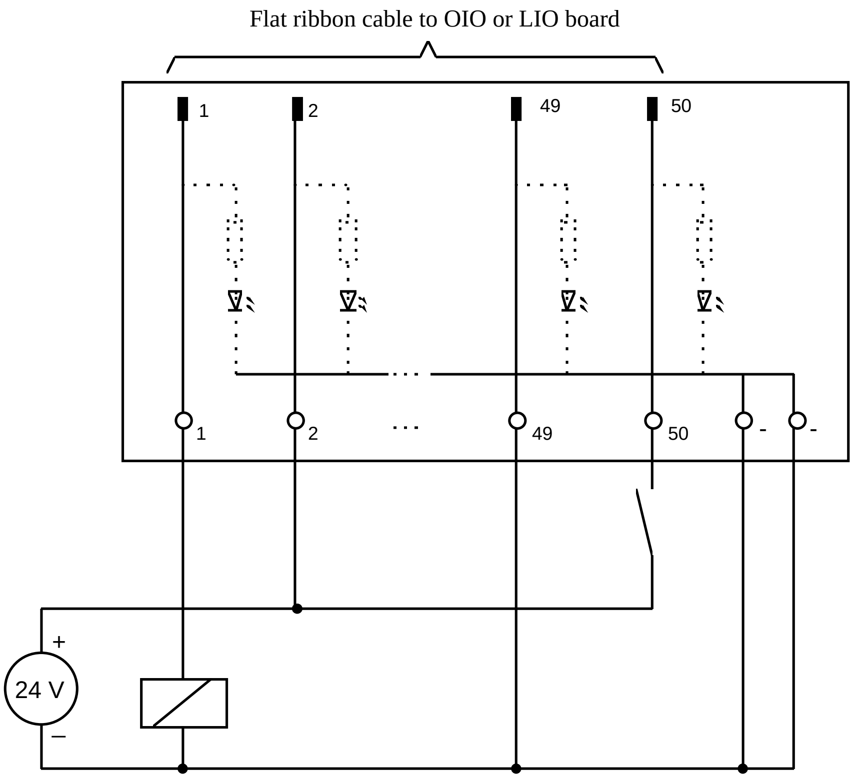


Delays due to the RC filter:

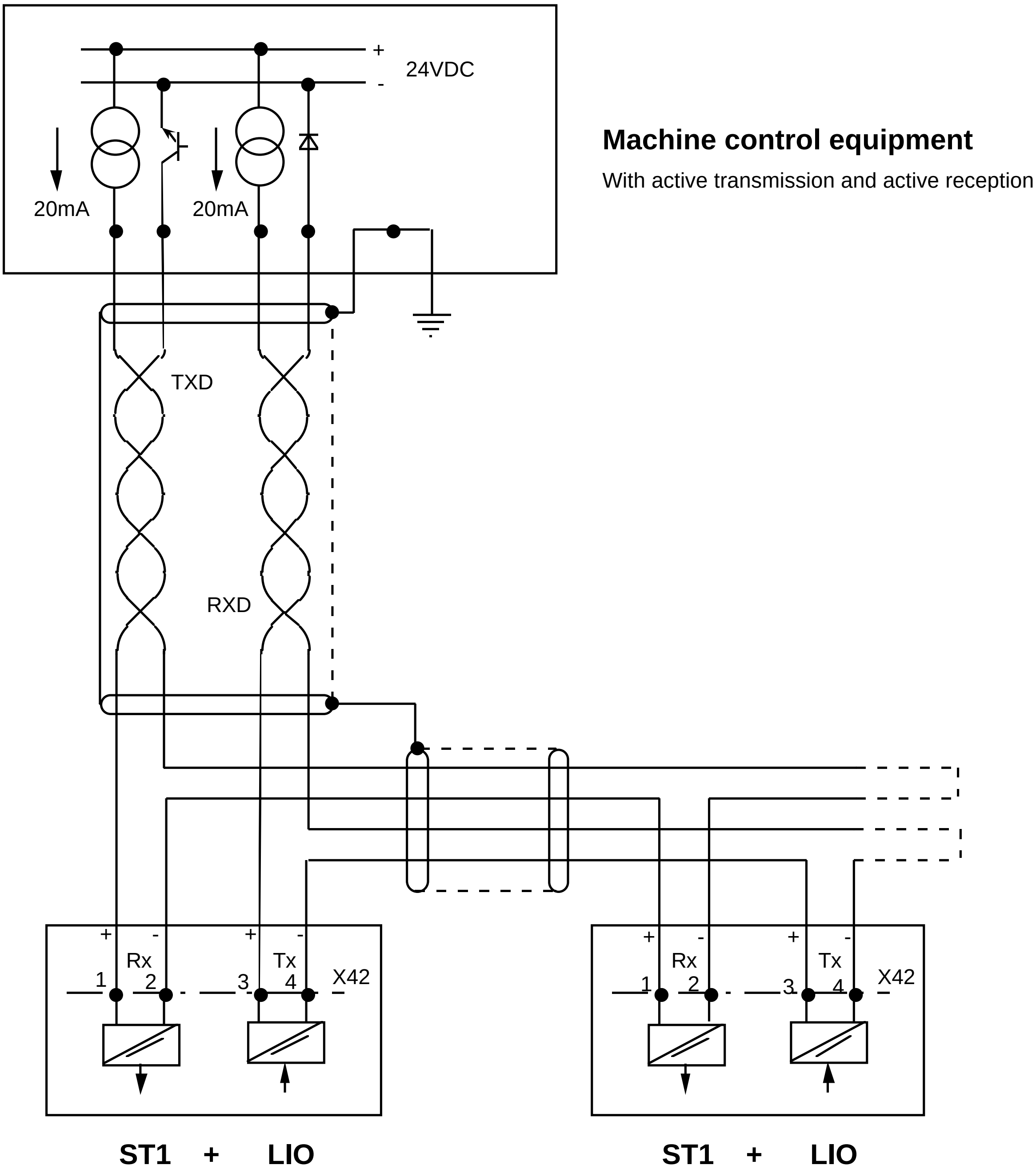
	Reset	Inputs
Raising edge	1.2 ms	0.6 ms
Falling edge	0.8 ms	0.4 ms

9.5.3. JUNCTION MODULE OUTLINES AND SCHEMATICS





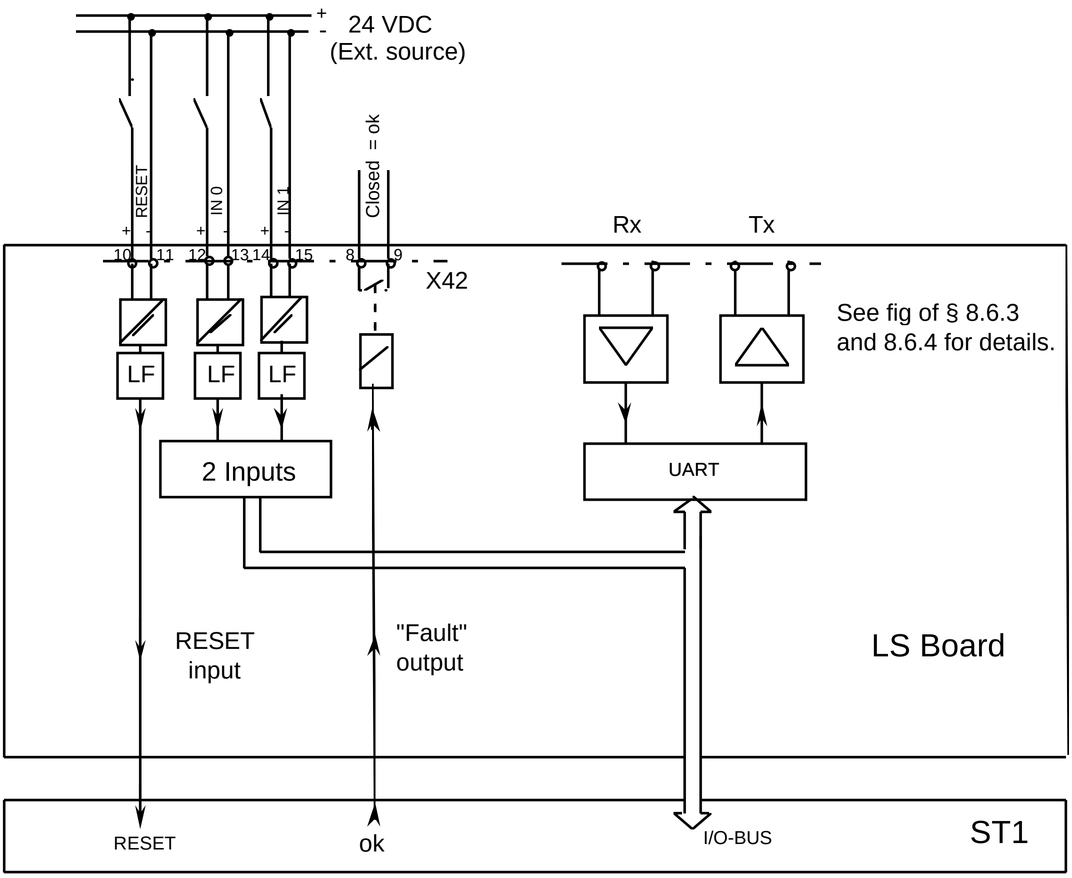
9.5.4. Serial Link Wiring



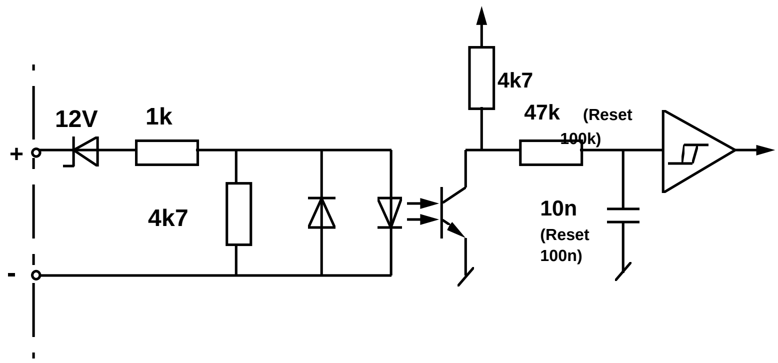
9.6. LS LINK BOARD WIRING

(Part number 024.7025 / 024.7026)

9.6.1. FUNCTIONAL DIAGRAM



9.6.2. BINARY INPUTS SCHEMATICS

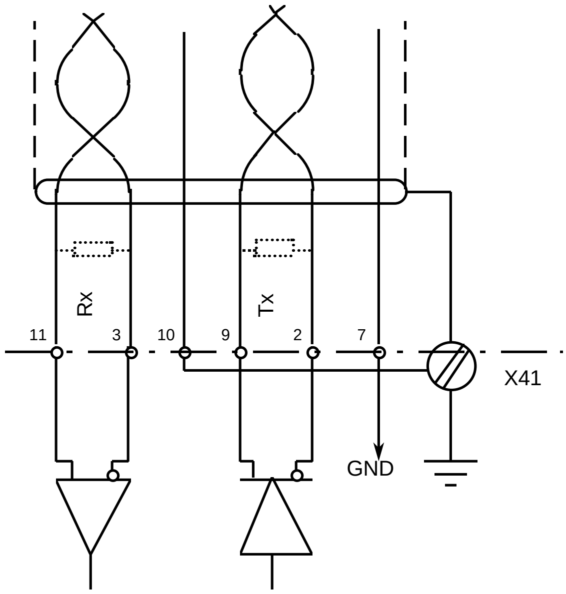


Delay due to the RC filter:

	Reset	Inputs
Raising edge	12 ms	0.6 ms
Falling edge	8.2 ms	0.4 ms

9.6.3. RS485 SERIAL LINK

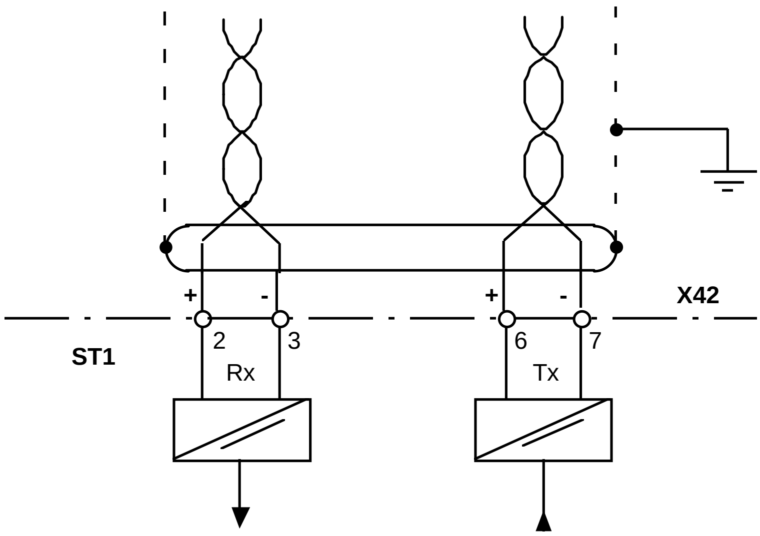
(Part number 024.7025)



Each line pair (TXD and RXD) must be "terminated" by a 100½ resistor (to be mounted within plugs at both cable and on the receiver side)

9.6.4. MA (TTY) SERIAL LINK

(Part number 024.7026)

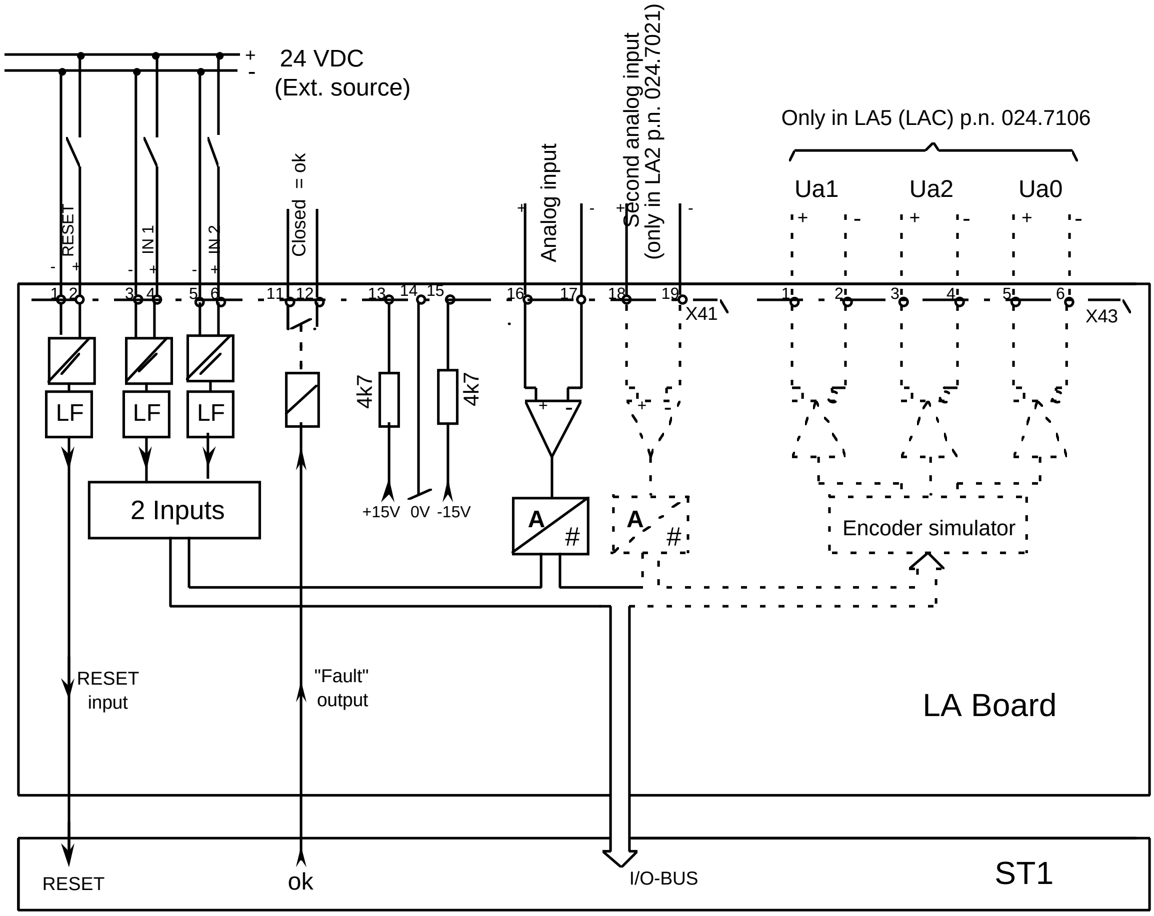


In that case, The same connector (X42) is used for the serial link and for the direct inputs and outputs.
Refer to §8.5.2 for "chaining" several ST1 on a single line.

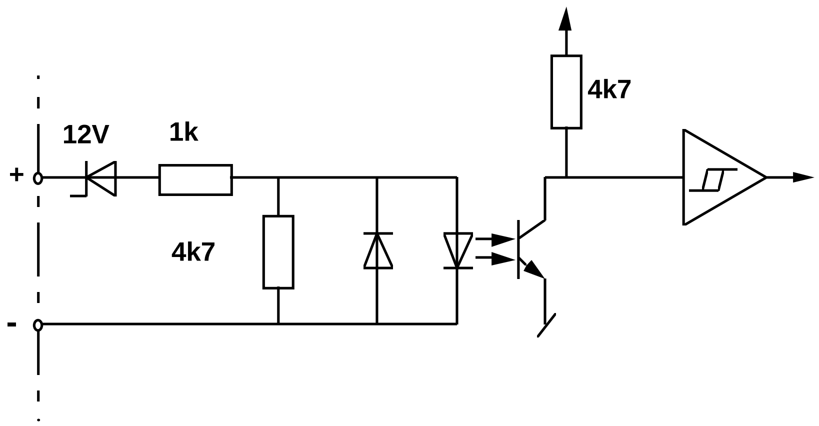
9.7. LA Link Board Wiring

(Part number 024.7015 / 024.7018 / 024.7019 / 024.7021 / 024.7106)

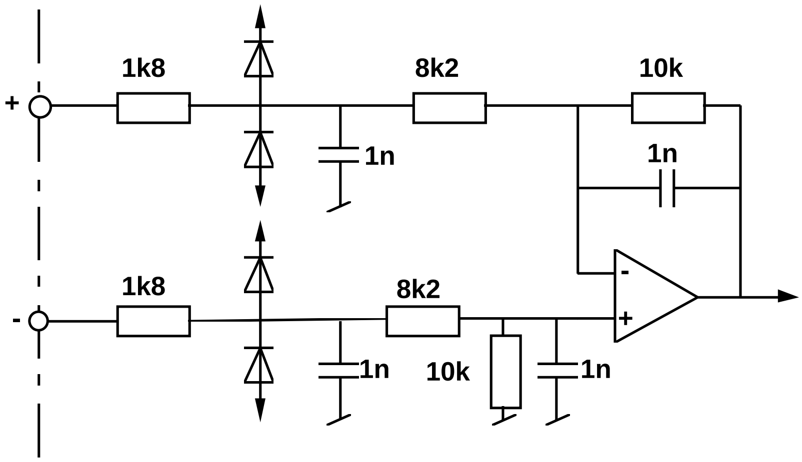
9.7.1. Functional Diagram



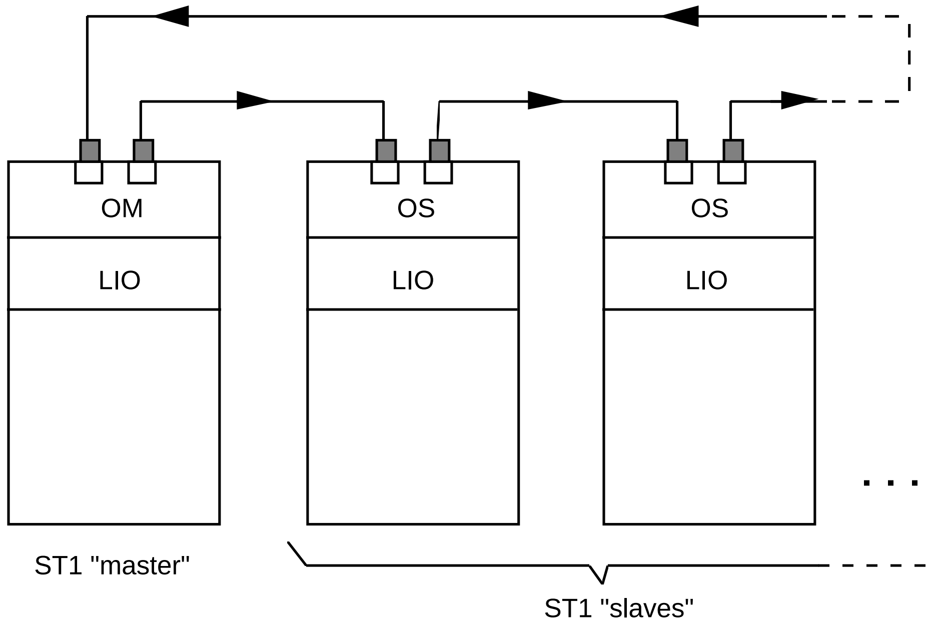
9.7.2. Binary Input(s) Schematics



9.7.3. ANALOG INPUT SCHEMATICS



9.8. OM AND OS OPTIONAL BOARD WIRING



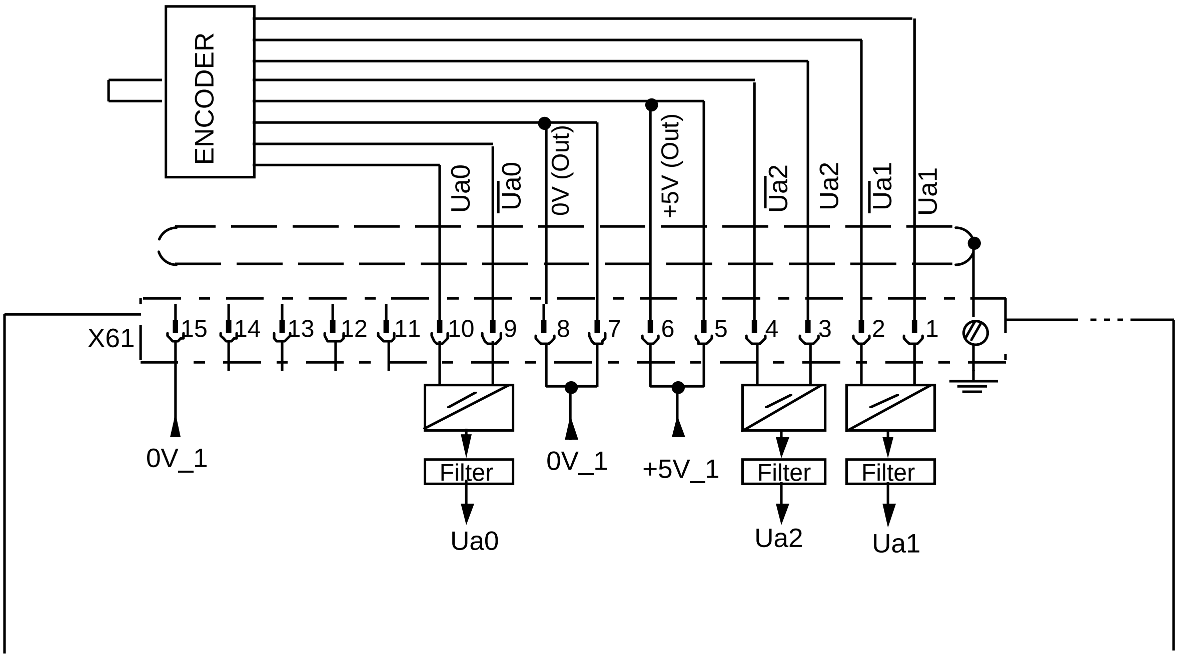
Refer to document 024.8034 for optic fiber cable confection.

9.9. OEI OPTIONAL BOARD WIRING

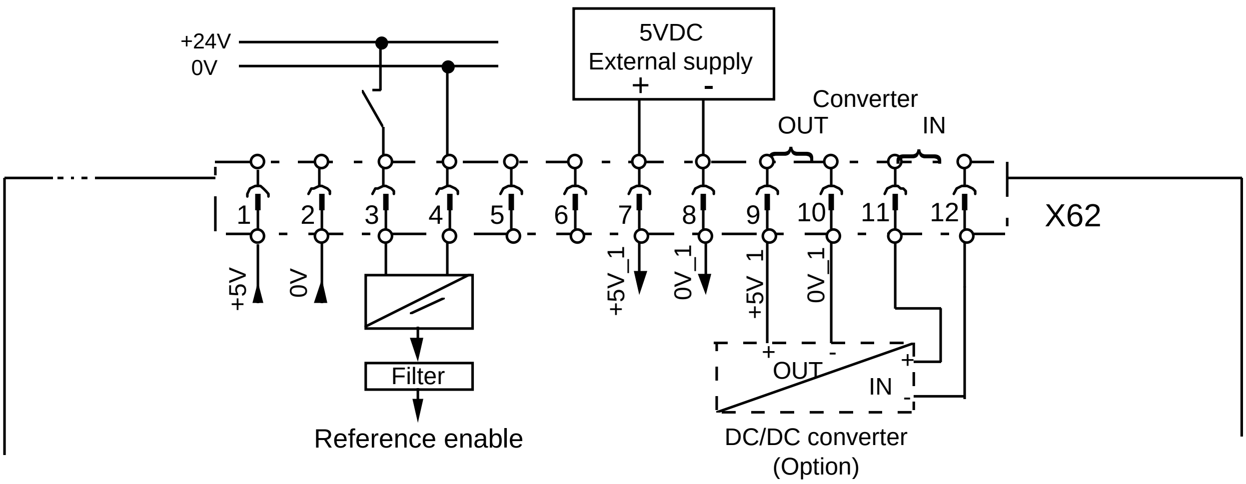
(Part number 024.7045)

9.9.1. WIRING DIAGRAM

Encoder connector (X61):

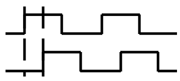
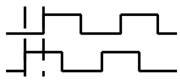
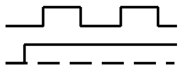
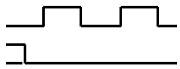
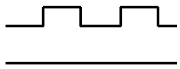
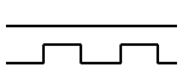


"Power" connector (X62):



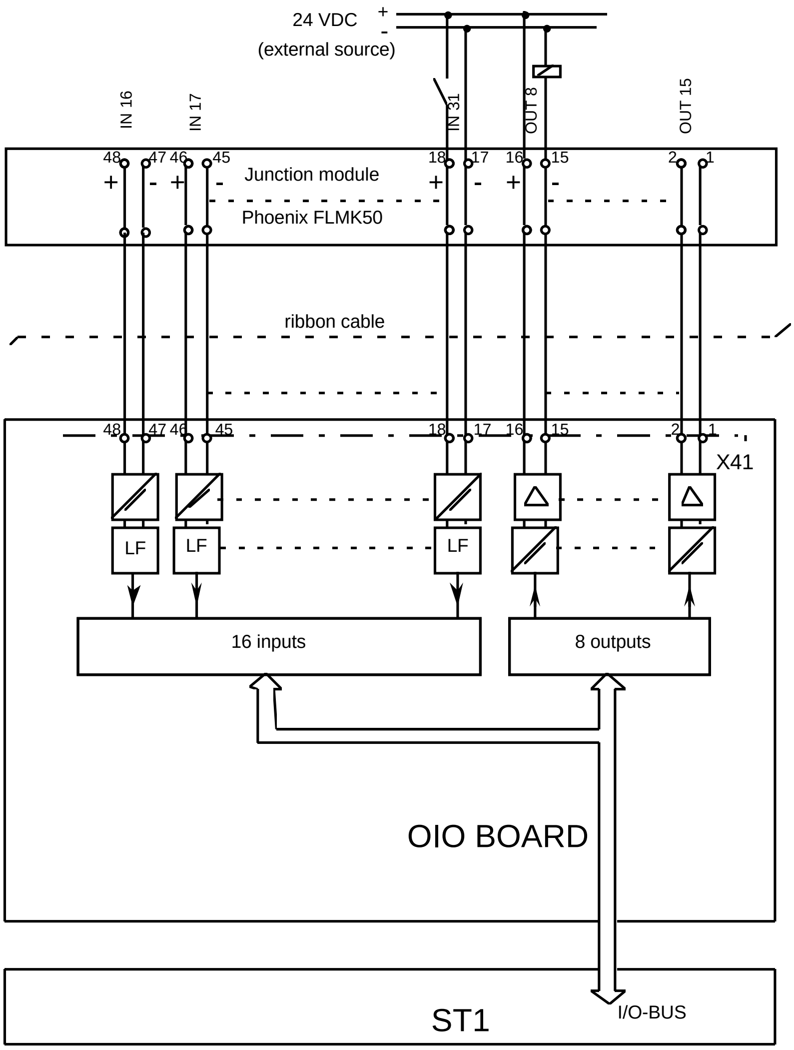
9.9.2. INCREMENTAL INPUT TYPES

The OEI Option Board is available in 3 different hardware versions depending on the application, and more particularly the kind of incremental input it has to interface. Actually, the only difference resides within a programmable IC and can also be checked reading the tag on it.

Part Number (PAL tag)	**Typical Use**	**Input Signals at X61**		**Resolution**
		Counting Up	**Counting Down**	
024.7111 = old 024.7045 ("Filtre V2")	Incremental Encoder (quadrature signals)			4 x Line Count
024.7112 ("Filtre V3")	Step-Motor Input (1 pulse and 1 direction input)			4 x Line Count
024.7113 ("Filtre V4")	Step-Motor Input (1 input for pulses up and 1 for pulses down)			2 x Line Count

9.10. OIO OPTIONAL BOARD WIRING

(Part number 024.7047)



Refer to § 8.5 (LIO Link Board) for detailed schematics.