• 15W0102B500 •

SINUS PENTA
PENTA MARINE
IRIS BLUE
SOLARDRIVE PLUS

USER MANUAL
- Motor Drives Accessories -

Issued on 12/01/2024
R.03

English

• This manual is integrant and essential to the product. Carefully read the instructions contained herein as they provide important hints for use and maintenance safety.
• This device is to be used only for the purposes it has been designed to. Other uses should be considered improper and dangerous. The manufacturer is not responsible for possible damages caused by improper, erroneous and irrational uses.
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REVISION INDEX

The following subjects covered in this User Manual (ID number **15W0102B500**, revision R.02) have been added, changed or suppressed with respect to the previous version of this User Manual (ID number **15W0102B500,** revision R.01).

B40 Series Board for CANopen® added.
Note about maximum Output Frequency in Applying the Inductor to the Inverter added.
Warning W004 removed from list in Alarm ID and Type of fault on BU600.

SANTERNO USER MANUALS MENTIONED IN THIS GUIDE

The following Santerno User Manuals are mentioned throughout this User Manual:

	User Manual Part Number			
User Manual	**Sinus Penta**	**Penta Marine**	**Iris Blue**	**Solardrive Plus**
Programming Guide	**15R0102B200** SINUS PENTA Programming Guide	**15R0102B200** SINUS PENTA Programming Guide	**15R1102B200** IRIS BLUE Programming Guide	**15P00SDB100** SOLARDRIVE PLUS Installation and Programming Guide
Installation Guide	**15P0102B1** SINUS PENTA Installation Guide	**15P0102B1** SINUS PENTA Installation Guide	**15P1102B100** IRIS BLUE Installation Guide	**15P00SDB100** SOLARDRIVE PLUS Installation and Programming Guide
Guide to the Regenerative Application	**15Q0102B00** SINUS PENTA – Guide to the Regenerative Application	**15Q0102B00** SINUS PENTA – Guide to the Regenerative Application	N/A	N/A
Guide to the Synchronous Motor Application	**15Q0102B200** SINUS PENTA – Guide to the Synchronous Motor Application	**15Q0102B200** SINUS PENTA - Guide to the Synchronous Motor Application	N/A	N/A
PROFIdrive COMMUNICATIONS BOARD – Installation and Programming Guide	**15G0010B1** PROFIdrive COMMUNICATIONS BOARD – Installation and Programming Guide	**15G0010B1** PROFIdrive COMMUNICATIONS BOARD - Installation and Programming Guide	**15G0010B1** PROFIdrive COMMUNICATIONS BOARD - Installation and Programming Guide	**15G0010B1** PROFIdrive COMMUNICATIONS BOARD - Installation and Programming Guide
BRIDGE MINI – User Manual	**15P4600B100** BRIDGE MINI – User Manual	**15P4600B100** BRIDGE MINI – User Manual	**15P4600B100** BRIDGE MINI – User Manual	**15P4600B100** BRIDGE MINI – User Manual
Sine Filters – User Manual	**15N0040B100** Sine Filters – User Manual	**15N0040B100** Sine Filters – User Manual	**15N0040B100** Sine Filters – User Manual	**15N0040B100** Sine Filters – User Manual
Assembly Instructions for Through-panel Kit S22	**15W0102B100** SINUS PENTA - Assembly Instructions for Through-panel Kit S22	**15W0102B100** SINUS PENTA - Assembly Instructions for Through-panel Kit S22	N/A	**15W0102B100** SINUS PENTA - Assembly Instructions for Through-panel Kit S22

	User Manual Part Number			
User Manual	**Sinus Penta**	**Penta Marine**	**Iris Blue**	**Solardrive Plus**
Assembly Instructions for Through-panel Kit S32	**15W0102B200** SINUS PENTA - Assembly Instructions for Through-panel Kit S32	**15W0102B200** SINUS PENTA - Assembly Instructions for Through-panel Kit S32	N/A	**15W0102B200** SINUS PENTA - Assembly Instructions for Through-panel Kit S32
Safe Torque Off Function – Application Manual	**15W0102B300** Safe Torque Off Function – Application Manual	**15W0102B300** Safe Torque Off Function – Application Manual	**15W0102B300** Safe Torque Off Function – Application Manual	**15W0102B300** Safe Torque Off Function – Application Manual
AC/DC Units	**15P0102B300** AC/DC UNIT 465 – AC/DC UNIT 1050	**15P0102B300** AC/DC UNIT 465 – AC/DC UNIT 1050	N/A	N/A
RemoteDrive	**15J0901B100** RemoteDrive and IrisControl - User Manual	**15J0901B100** RemoteDrive and IrisControl - User Manual	**15J0901B100** RemoteDrive and IrisControl - User Manual	N/A
BU600 – Programming Guide	**15R0102B500** BU600 – Programming Guide	**15R0102B500** BU600 – Programming Guide	N/A	N/A

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1. OVERVIEW

This manual covers the specifications and installation instructions for the option boards and external accessories available for the following products manufactured by Santerno:

- Sinus Penta
- Penta Marine
- Iris Blue
- Solardrive Plus

The accessory-product compatibility is stated in the Compatibility Table at the beginning of each section in this manual.

2. POWER SUPPLY UNIT SU465

Product-Accessory Compatibility		
Product	**Power Supply Unit SU465**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	-	
Solardrive Plus	-	

Table 1: Product – Power Supply Unit SU465 compatibility

The SU465 power supply unit is typically combined with an inverter to create 12-pulse or 18-pulse configurations, in order to reduce the harmonic content towards the power supply grid.

The SU465 must be installed next to the inverter and is to be connected as described in the following sections.

The same supply unit may also be used as a stand-alone supply unit. Please refer to the specific manual AC/DC Units.

The SU465 is an Open Type device featuring IP00 degree of protection suitable for installation inside a cabinet featuring at least IP3X degree of protection.

2.1. Delivery Check

Make sure that the equipment is not damaged and that it complies with the equipment you ordered by referring to the nameplate located on the inverter front part. The inverter nameplate is described below. If the equipment is damaged, contact the supplier or the insurance company concerned. If the equipment does not comply with the one you ordered, please contact the supplier as soon as possible.

If the equipment is stored before being started, make sure that the ambient conditions do not exceed the acceptable ratings (temperature: –25 °C to +70 °C; relative humidity <95%, no condensation). The equipment guarantee covers any manufacturing defect. The manufacturer has no responsibility for possible damages occurred when shipping or unpacking the inverter. The manufacturer is not responsible for possible damages or faults caused by improper and irrational uses; wrong installation; improper conditions of temperature, humidity, or the use of corrosive substances. The manufacturer is not responsible for possible faults due to the inverter operation at values exceeding the inverter ratings and is not responsible for consequential and accidental damages. The equipment is covered by 2-year guarantee starting from the date of delivery.

2.2. Transporting, handling and unpacking the SU465

For instructions on how to transport, handle and unpack the product, please refer to the general instructions given in the Transport and Handling and Unpacking sections in the Installation Guide.

2.3. Installing and Operating the SU465

Please refer to the general instructions given in section Installing and Operating the Equipment in the Installation Guide.

2.4. SU465 Nameplate

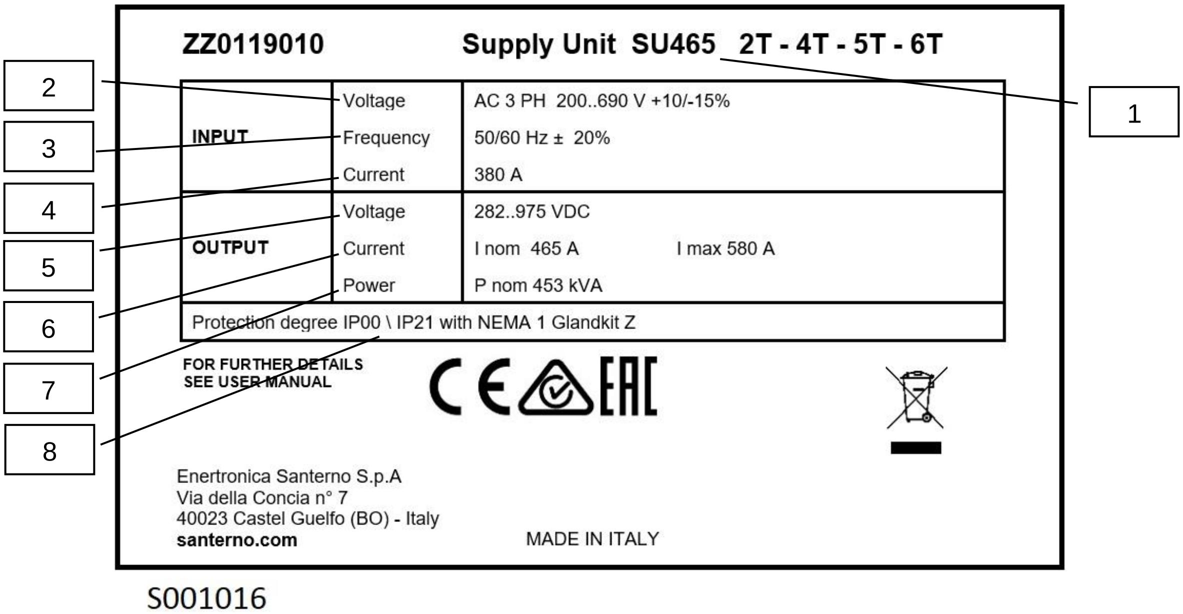


Figure 1: Nameplate for SU465

1.	Model:	SU465
2.	Input voltage:	200-690 Vac
3.	Input frequency:	50-60 Hz
4.	Input current:	380 A nominal current
5.	Output voltage:	282-975 Vdc
6.	Output current:	465 A nominal 580 A maximum
7.	Nominal power:	453 kVA
8.	Degree of protection:	IP00 / IP21

2.5. SU465 Operating Mode

The SU465 may operate as follows:

- As the unique supply unit for one or more conversion units:

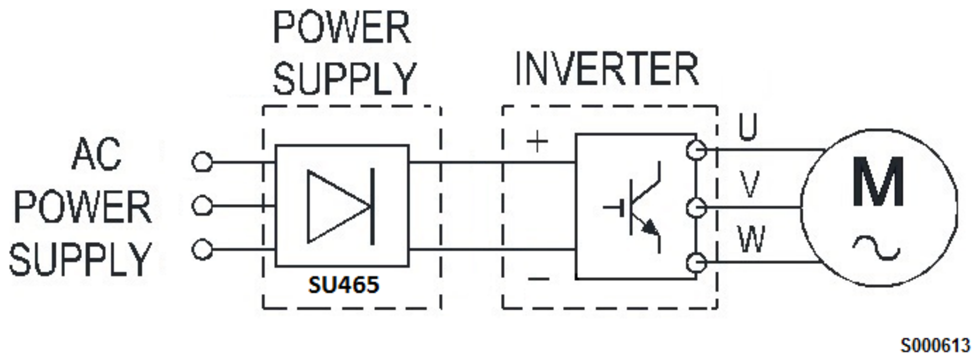


Figure 2: The SU465 as a supply unit of a conversion unit

- In parallel to a converter in the 12-pulse or 18-pulse configurations (these solutions reduce the harmonic contents to the power supply mains); for example, in a 12-pulse connection:

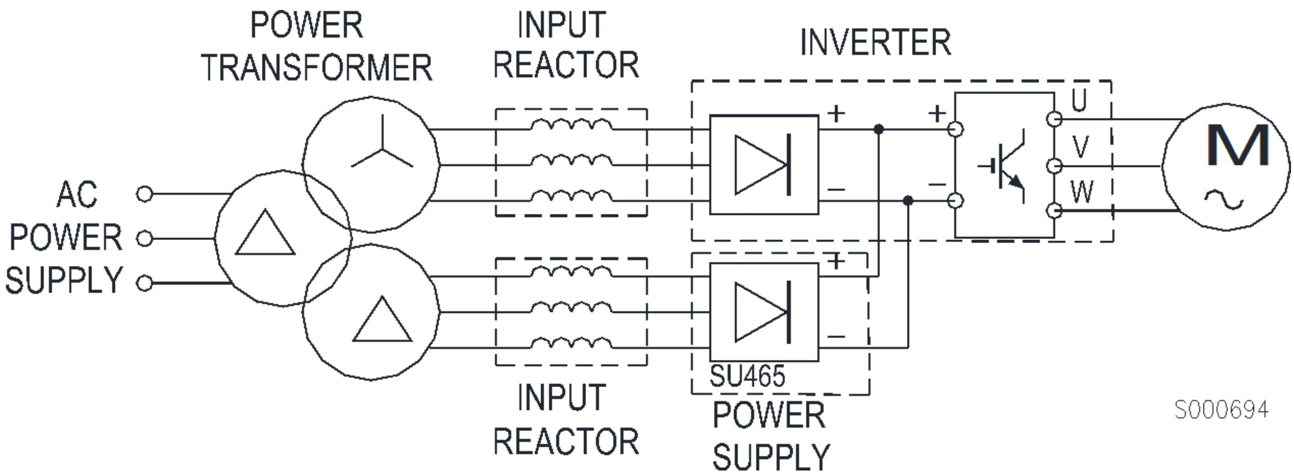


Figure 3: The SU465 in 12-pulse configuration

Possible combinations of inverters and SU465 Supply Units are:

Frame size	12-pulse		18-pulse	
S41 / S51 / S42 / S52	1 SU465	see 2.11	2 SU465	see 2.11.2
2x S41 / 2x S51 / 2x S42 / 2x S52	-	-	1 SU465	see 2.11.4
3x S51 / 3x S52	1 SU465	see 2.11.3	-	-

2.5.1. SU465 Operation in parallel to a converter

In this configuration the SU465 Supply Unit is directly controlled by the inverter.
In particular, the following functions

- Phase detection and measurement
- Heatsink overtemperature measurement and alarm
- Precharge control

are performed by the driver board of the inverter.

2.5.2. System Requirements

As the input current is automatically controlled, the system must meet the following requirements:

- Provide the drive and the supply unit with line inductors as detailed in section Input inductors to be Applied to the Drive and the SU465
- The three-phase transformer must be:
  - Symmetrical
  - The short-circuit current must be Vsc>4%
  - The secondary output voltages must range:
    - Within 5% of relative variation at full load
    - Within 0.5% under no-load conditions
- Wiring to the transformer, the supply unit and the drive shall be as close as possible in terms of cable length and cable cross-section.

2.6. Technical Specifications

Electrical specifications:

Overvoltage category III (according to EN 61800-5-1)

MODEL	Rated input current (A)	Supply voltage (Vac)	Rated output current (A)	Maximum output current (A)	Output voltage (Vdc)	Dissipated power (at rated current) (W)
SU465	380	200-690	465	580	282-975	1160

Mechanical specifications:

MODEL	Degree of protection	Sound pressure (dB)
SU465	IP00 (*)	57

(*) NEMA1 when using the special optional kit

2.7. Installing the SU465

2.7.1. Environmental Requirements for the SU465 Installation, Storage and Transport

Maximum surrounding air temperature	–10 to +40 °C with no derating from +40 °C to +55 °C with 2% derating of the rated current for each degree beyond +40 °C
Ambient temperatures for storage and transport	–25 °C to +70 °C.
Installation environment	Pollution degree 2 or better (according to EN 61800-5-1). Do not install in direct sunlight and in places exposed to conductive dust, corrosive gases, vibrations, water sprinkling or dripping (depending on IP ratings); do not install in salty environments.
Altitude	Max. altitude for installation 2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A. Above 1000 m, derate the rated current by 1% every 100 m.
Operating ambient humidity	From 5% to 95%, from 1 g/m³ to 29g/m³, non-condensing and non-freezing (class 3K3 according to EN 61800-5-1).
Storage ambient humidity	From 5% to 95%, from 1 g/m³ to 29 g/m³, non-condensing and non-freezing (class 1K3 according to EN 61800-5-1).
Ambient humidity during transport	Max. 95%, up to 60 g/m³; condensation may appear when the equipment is not running (class 2K3 according to EN 61800-5-1).
Storage and operating atmospheric pressure	From 86 to 106 kPa (classes 3K3 and 1K4 according to EN 61800-5-1).
Atmospheric pressure during transport	From 70 to 106 kPa (class 2K3 according to EN 61800-5-1).

CAUTION Ambient conditions strongly affect the inverter life. Do not install the equipment in places that do not have the above-mentioned ambient conditions.

2.7.2. Mounting the SU465

The SU465 must be installed on the left of the drive in upright position inside a cabinet. The mechanical dimensions and fixing points are given in the figures below.

If the braking unit or an additional supply unit is installed, those units may be installed side by side.

The minimum allowable side clearance is 150 mm and 100 mm top and bottom.

Dimensions (mm)			Fixing point distance (mm)				Type of screws	Weight (kg)
W	H	D	X	Y	D1	D2	M8-M10	36.6
257	550	398.5	170	515	12	6		

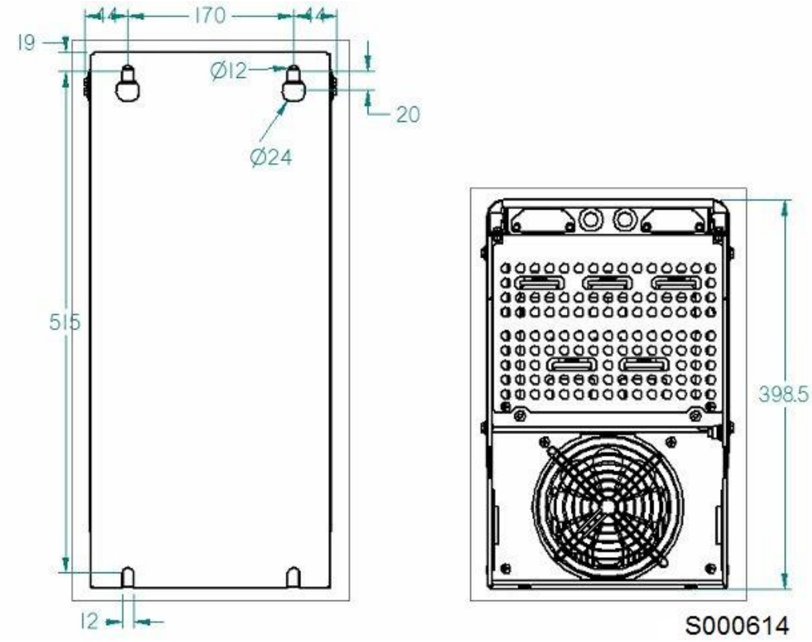


Figure 4: Dimensions and fixing points for the SU465

2.7.3. IP21 Kit

The SU465 may be provided with a special safety kit against top-down water dripping to get IP21 degree of protection. Consequently, the side dimensions become 30 mm.

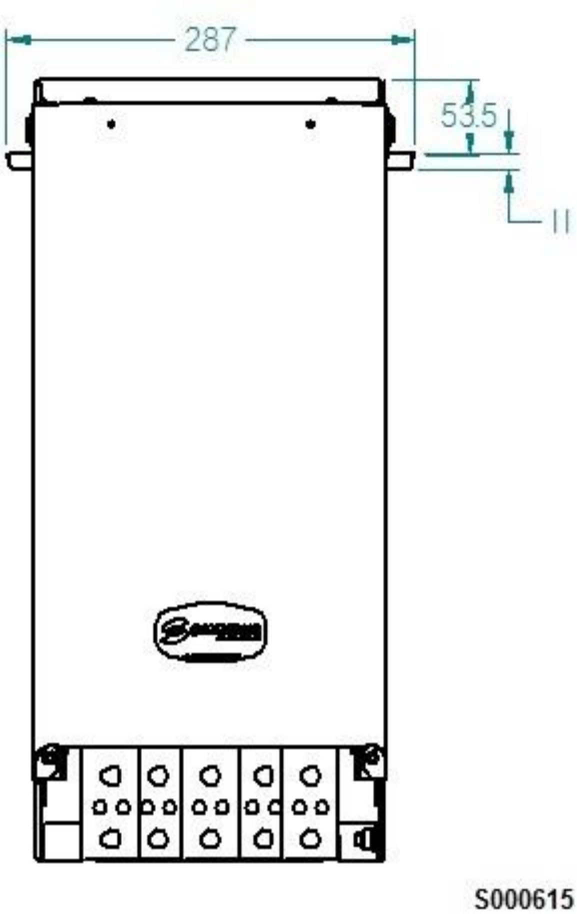


Figure 5: Overall dimensions when using IP21 kit

2.7.4. Through-panel Kit

The supply unit may be provided with the special through-panel kit for the segregation of the air flows.

Dimensions (mm)			Fixing point distance (mm)				Type of screws	Weight (kg)
W	H	D	X	Y	X1	Y1	M8-M10	2
325	683	398.5	250	650	293	400		

Part Number
ZZ0119280

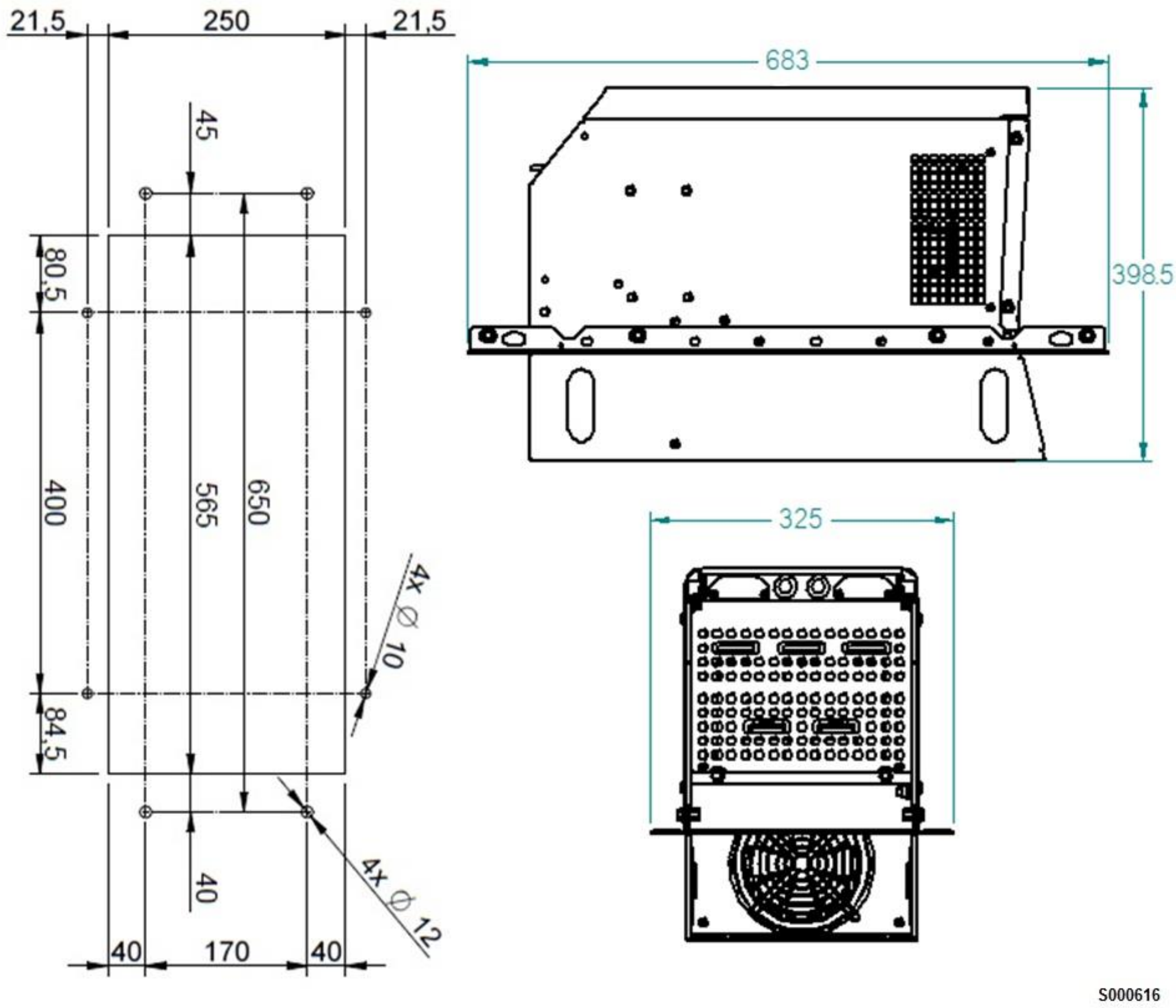


Figure 6: Dimensions and fixing points when using the through-panel kit for the SU465

2.7.5. NEMA1 Kit

The SU465 may be provided with the special NEMA1 kit against accidental contacts.

This optional kit is to be installed directly on the supply unit case and provides protection against accidental contacts with the power terminals in the supply unit.

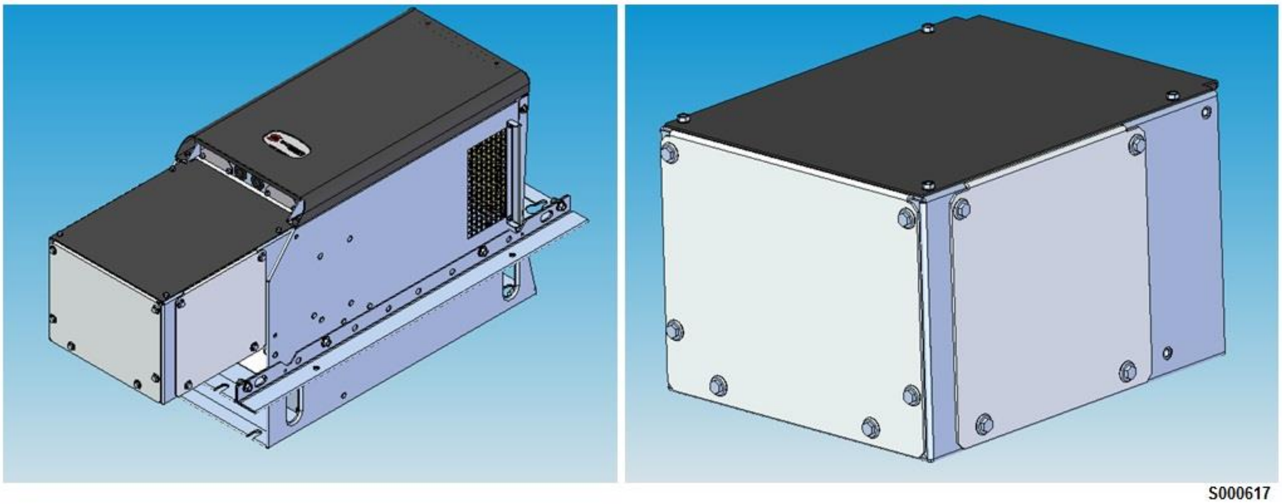


Figure 7: NEMA1 kit and kit installation on the SU465

Part Number
ZZ0119270

The NEMA1 kit is provided with N.3 removable plates that may be drilled to suit the installer's needs in terms of cable paths to the mains and the unit to be power supplied.

The installer is responsible for the utilization of safe materials able to preserve the equipment's degree of protection. It is recommended that the cables do not enter into contact with sharp metal parts that may jeopardize isolation.

Kit dimensions (mm)			SU465 length + NEMA1 kit	Type of screws for mounting	Weight (kg)
W	H	D	H	M8	3.4
187	298	248	765		

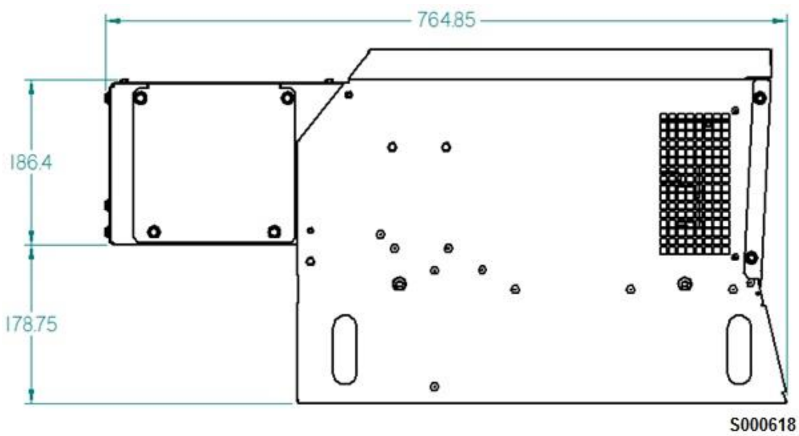


Figure 8: Overall dimensions when installing the NEMA1 kit

2.7.6. Power Terminals and Signal Terminals Layout

Power Wiring

The SU465 is to be connected to the drive as follows:

Decisive voltage class C according to EN 61800-5-1

Terminal	Type	Tightening Torque (Nm)	Connection cable cross-section mm^2 (AWG/kcmils)	NOTES
R	Bar	30	240 (500kcmils)	To be connected to phase R of the transformer
S	Bar	30	240 (500kcmils)	To be connected to phase S of the transformer
T	Bar	30	240 (500kcmils)	To be connected to phase T of the transformer
+	Bar	30	240 (500kcmils)	To be connected to terminal 47/+ of the drive
–	Bar	30	240 (500kcmils)	To be connected to terminal 49/– of the drive

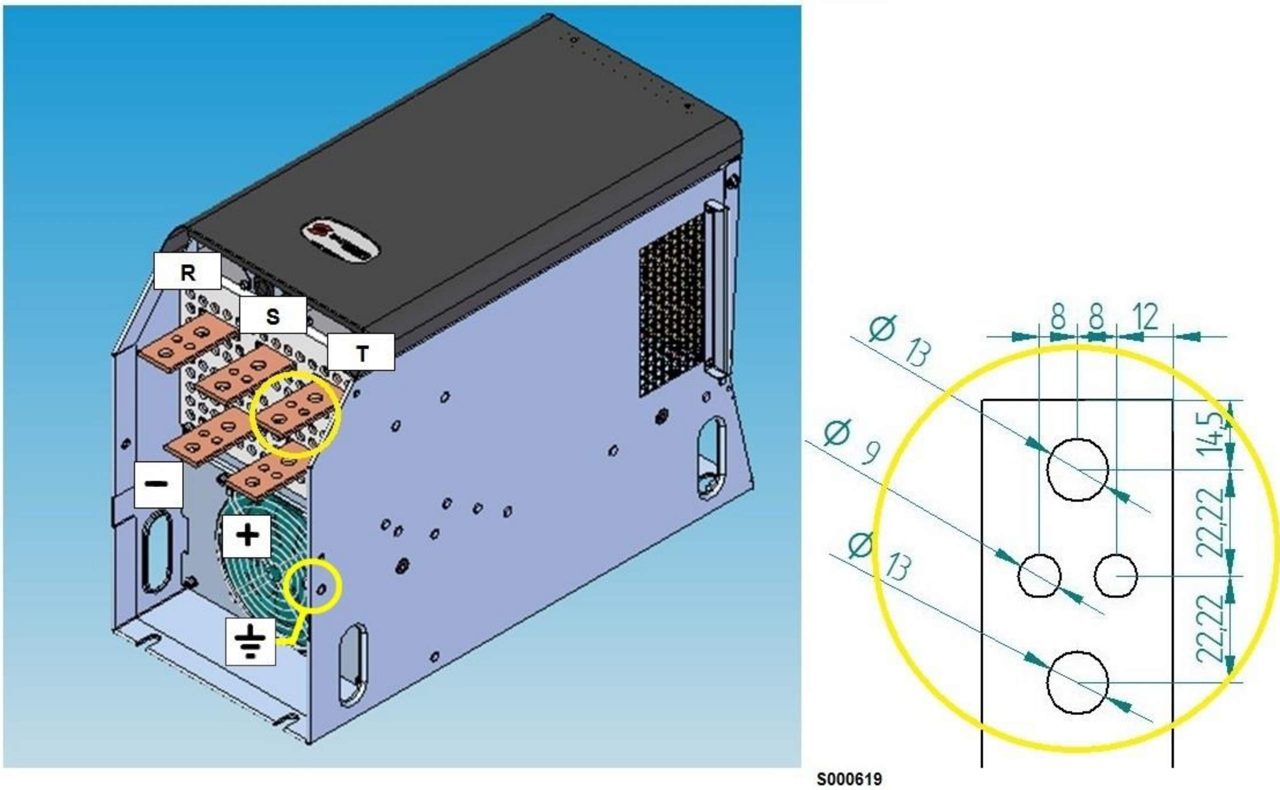


Figure 9: Power terminals

CAUTION When the SU465 is used as a parallel rectifier, bars **47/D** and **47/+** in drives are to be short-circuited.

CAUTION When the SU465 is used as a supply unit, bars **47/D** and **47/+** in the drive are to be disconnected by removing the default bridge.

DANGER DUAL POWER SUPPLY: The SU465 module may be both AC supplied (input) and DC supplied (output) thanks to the parallel connection to the drive. Disconnect both sources (input AC power supply and parallel connection to the drive) before operating on the equipment.

S000625

DANGER Once both AC power supply and DC power supply have been isolated, wait at least 20 minutes before operating on the DC-links to give the capacitors time to discharge.

2.7.7. Signal Connections

Each supply unit is provided with two DB9 connectors for the connection of the control signals. By way of connector CN1, located on the left side if seen frontally (see Figure 11), the device receives the control signals from the drive to be power supplied. Connector CN2 features a similar signal set for the cascade connection of an additional supply unit.

Connector CN1 – Connect terminal board M1 to the drive via a shielded DB9 cable, AWG26, provided with male DB9 terminal on the drive side and female DB9 terminal on the SU465.

Decisive voltage class A according to EN 61800-5-1

N.	Name	Description	I/Os	NOTES
1	**12PHU**	12-ph UNIT FITTED	0-24 V	+24 V: available 0 V: n/available
2	**PREC_M**	Thyristor firing precharge (master)	0-24 V	+24 V: firing failed 0 V: firing successful
3	**Vrs**	Vrs phase readout	±5 V analog	Vrs/200 for 2T-4T Vrs/250 for 5T-6T
4	**Vst**	Vst phase readout	±5 V analog	Vst/200 for 2T-4T Vst/250 for 5T-6T
5	**VBOK**	ON/OFF command for thyristor firing	0-24 V	+24 V for thyristor firing
6	**+24V**	24Vdc power supply	20 W (in common with the drive 24 V power supply)	
7	**0V**	0V	Control board zero volt	
8	**PT_M**	Thermoswitch (master)	0-24 V	+24 V: thermoswitch open 0 V: thermoswitch OK
9	**NTC_M**	NTC readout (master)		NTC 10k polarized at 5 V with 6k81

Connector CN2 – If required, connect terminal board M2 to the additional shielded DB9 connector, at least AWG26, with a male DB9 connector on the first SU465 and a DB9 female on the second SU465.

Decisive voltage class A according to EN 61800-5-1

N.	Name	Description	I/Os	NOTES
1	**18PHU**	18-ph UNIT FITTED	0-24 V	+24 V: available 0 V: n/available
2	**PREC_S**	Thyristor firing precharge (slave)	0-24 V	+24 V: firing failed 0 V: firing successful
3	**-**			Not connected
4	**-**			Not connected
5	**VBOK**	ON/OFF command for thyristor firing	0-24 V	+24 V for thyristor firing
6	**+24V**	24 Vdc power supply	20 W (in common with the drive 24 V power supply)	
7	**0V**	0 V	Control board zero volt	
8	**PT_S**	Thermoswitch (slave)	0-24 V	+24 V: thermoswitch open 0 V: thermoswitch OK
9	**NTC_S**	NTC readout (slave)		NTC 10k polarized at 5 V with 6k81

CAUTION In the event of an 18-pulse or more connection, an external 24V supply unit connected to pins 6 and 7 is required. 20 W power is required for each additional unit.

The connection in parallel of one or more supply units requires configuring the ES840/1 control board by changing the default settings of special-purpose jumpers.

Settings of jumpers J1..J6 are given in the table below, based on the position of the supply unit in the device chain (first position, intermediate position, end position).

	SU465 in first position	SU465 in intermediate position	SU465 in end position
J1	ON	ON	ON
J2	ON	ON	ON
J3	OFF	OFF	ON
J4	OFF	OFF	ON
J5	ON	OFF	OFF
J6	ON	OFF	OFF

The configuration of jumpers J7-J8, instead, depends on the operating voltage of the SU465.

	2T-4T	5T-6T
J7	1-2	2-3
J8	1-2	2-3

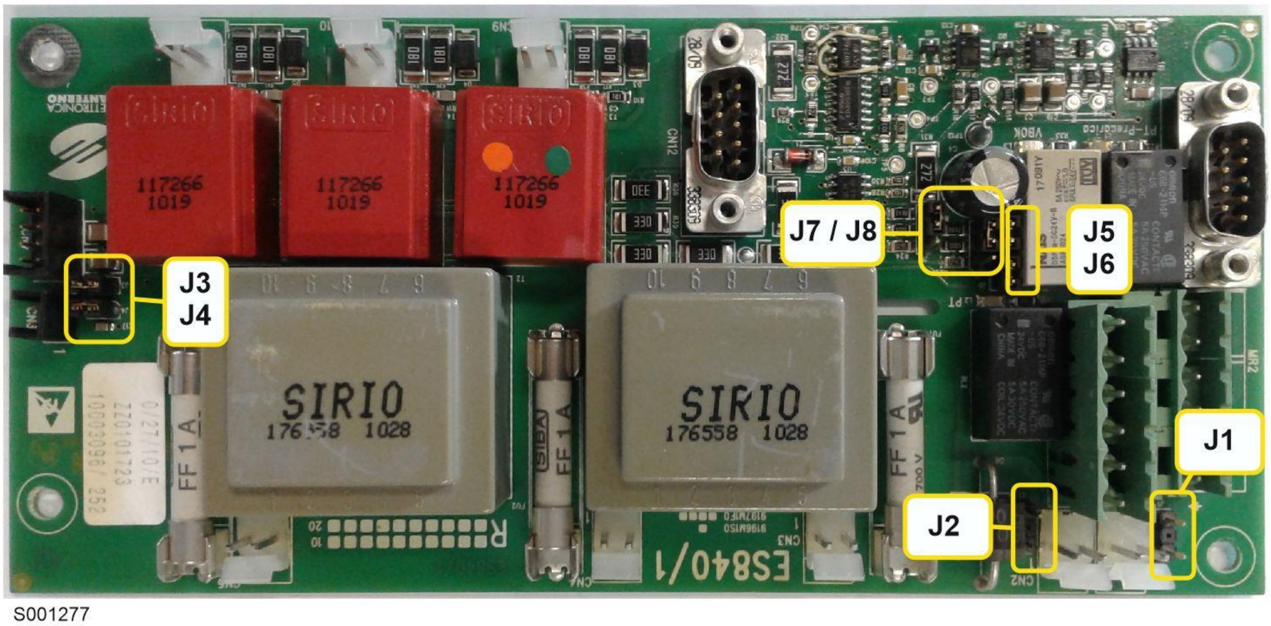


Figure 10: Position of the jumpers in the ES840/1 board

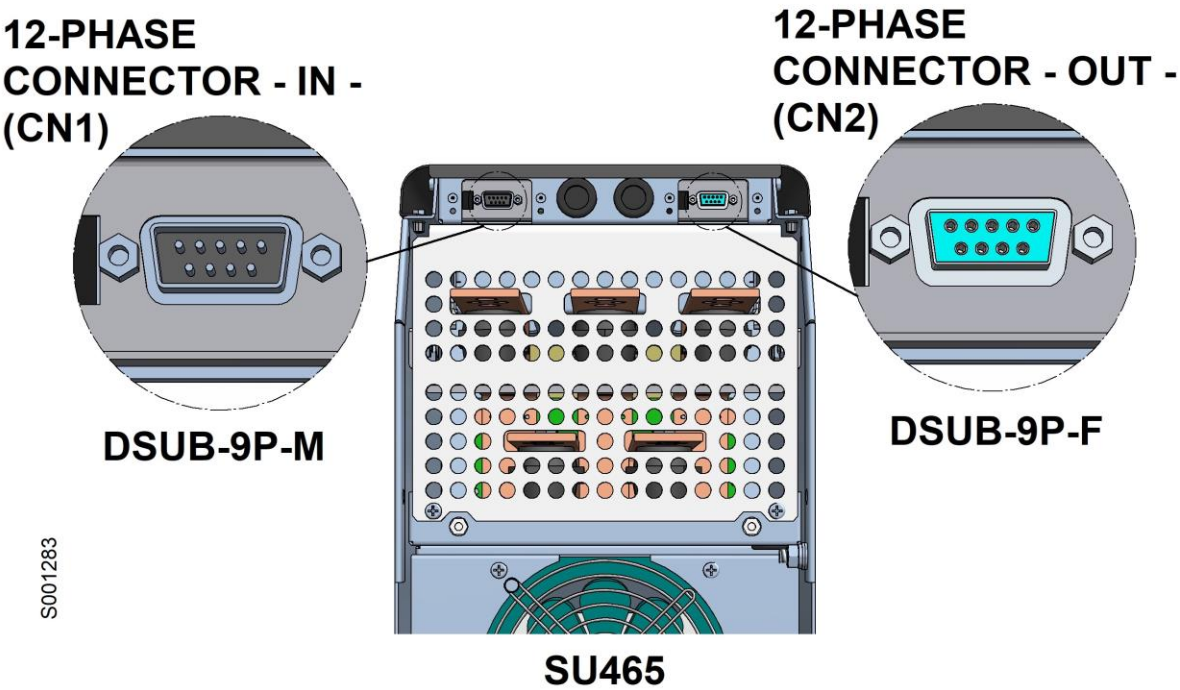


Figure 11: Signal connectors on SU465

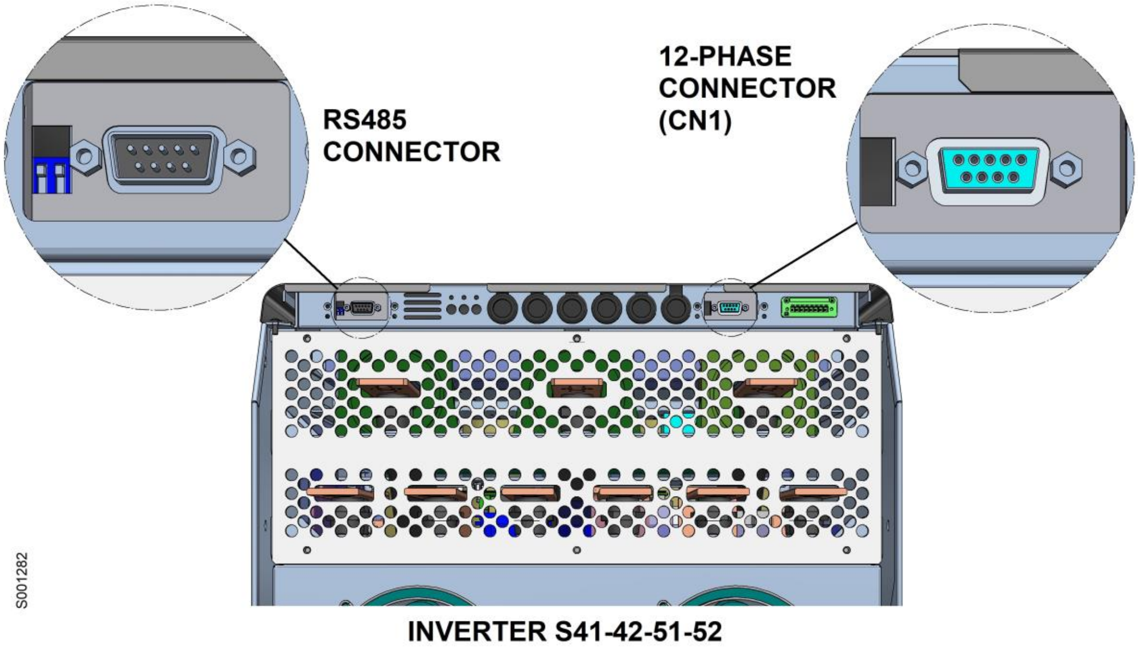


Figure 12: Signal connectors on S41..52 inverters

Figure 13: Example of a 9-pin shielded cable for signal connection

2.7.8. Wiring the SU465

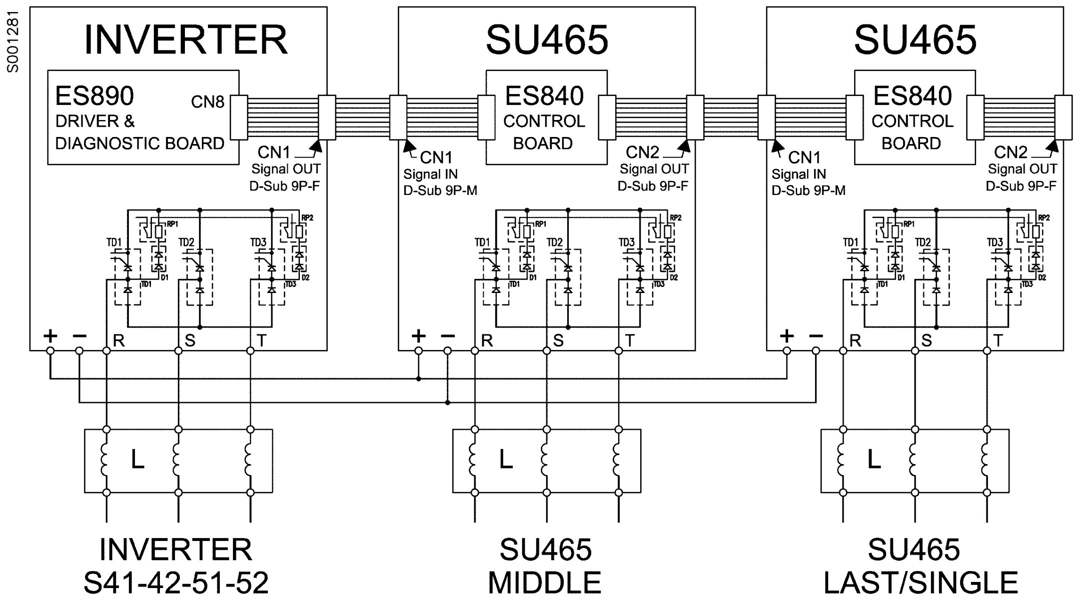


Figure 14: S41..52 inverters with one SU465 (12-pulse) or two SU465 (18-pulse)

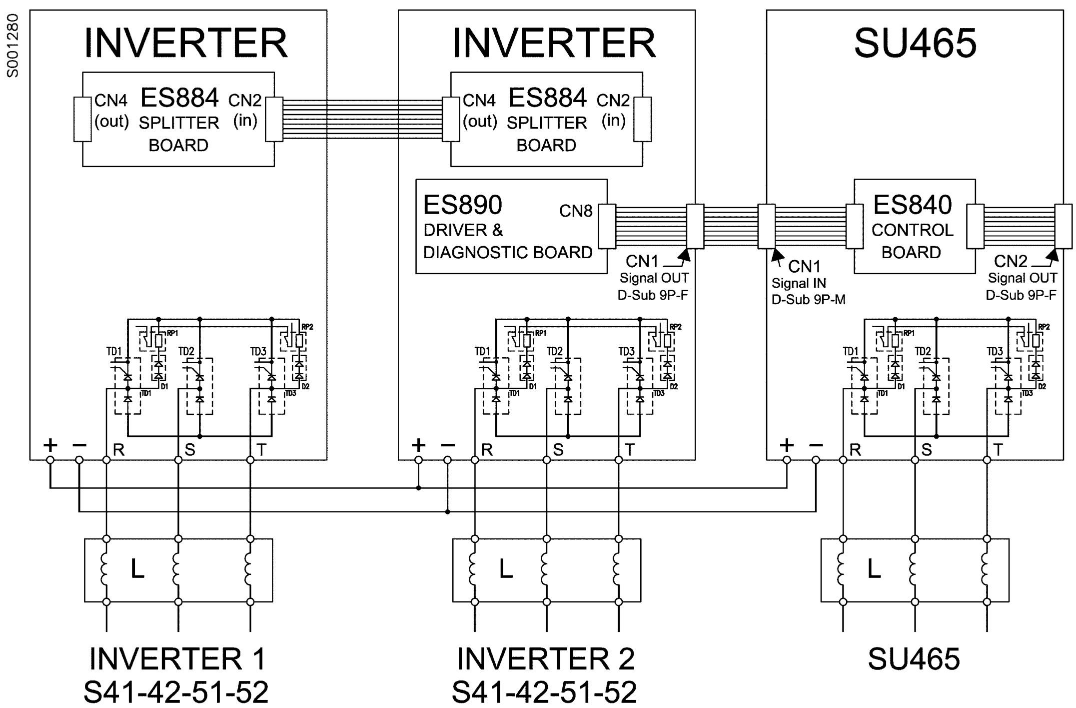


Figure 15: 2xS41..52 inverters with one SU465 (18-pulse)

2.8. Cross-sections of the Power Cables and Sizes of the Protective Devices when the SU465 is Installed

The minimum requirements of the inverter cables and the protective devices needed to protect the system against short-circuits are given in the tables below. It is however recommended that the applicable regulations in force be observed; also check if voltage drops occur for cable links longer than 100 m.

For the largest inverter sizes, special links with multiple conductors are provided for each phase. For example, 2x150 in the column relating to the cable cross-section means that two 150 mm^2 parallel conductors are required for each phase.

Multiple conductors shall have the same length and must run parallel to each other, thus ensuring even current delivery at any frequency value. Paths having the same length but a different shape deliver uneven current at high frequency.

Also, do not exceed the tightening torque for the terminals to the bar connections. For connections to bars, the tightening torque relates to the bolt tightening the cable lug to the copper bar. The cross-section values given in the tables below apply to copper cables.

The links between the motor and the drive must have the same lengths and must follow the same paths. Use 3-phase cables where possible.

Dimensioning depends on the configuration of the SU465 (12-pulse connection or power supply unit – rectifier).

Voltage Class	Size	Drive Model	Rated Inverter Current	Tightening Torque	Cable Cross-section to Mains and Motor Side	Fast Fuses (700V) + Disc. Switch	Magnetic Circuit Breaker	AC1 Contactor
			A	Nm	mm^2 (AWG/kcmils)	A	A	A
2T-4T	S41	**0180**	150	10	95 (4/0AWG)	200	160	160
		0202	175	10	95 (4/0AWG)	250	200	250
		0217	190	10	120 (250kcmils)	250	250	250
		0260	225	10	120 (250kcmils)	315	400	275
2T-4T	S51	**0313**	240	10	120 (250kcmils)	400	400	275
		0367	275	25-30	150 (300kcmils)	400	400	400
		0402	340	25-30	240 (500kcmils)	500	400	450
5T-6T	S42	**0181**	155	30	95 (4/0AWG)	200	200	250
		0201	165	30	95 (4/0AWG)	200	200	250
		0218	180	30	120 (250kcmils)	250	250	250
		0259	200	30	120 (250kcmils)	250	250	250
5T-6T	S52	**0290**	225	30	150 (300kcmils)	315	400	275
		0314	250	30	185 (400kcmils)	400	400	400
		0368	280	30	240 (500kcmils)	400	400	400
		0401	320	30	240 (500kcmils)	450	400	450

NOTE [*] These rated current values apply to the 12-pulse configuration only; configurations other than the 12-pulse configuration have different rated current values.

2.9. Earth Bonding of the SU465

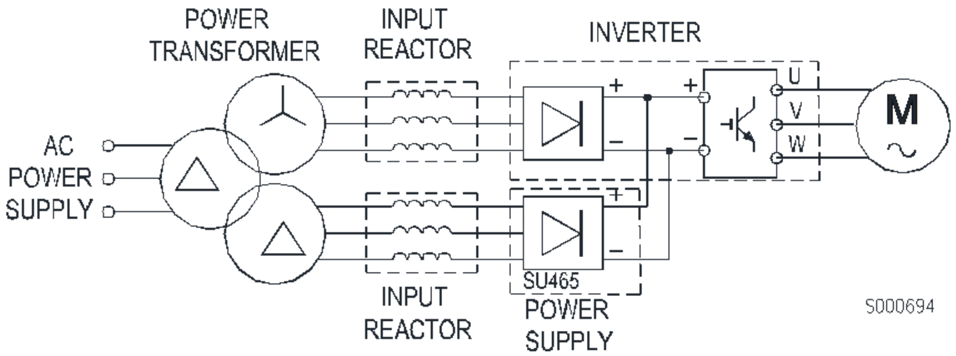
For the earth bonding of the SU465 and the transformer for the 12-pulse application, please refer to the general instructions given in section Inverter and Motor Ground Connection in the Installation Guide.

2.10. Scheduled Maintenance of the SU465

For the SU465 scheduled maintenance, please refer to the general instructions given in section Inverter Scheduled Maintenance in the Installation Guide.

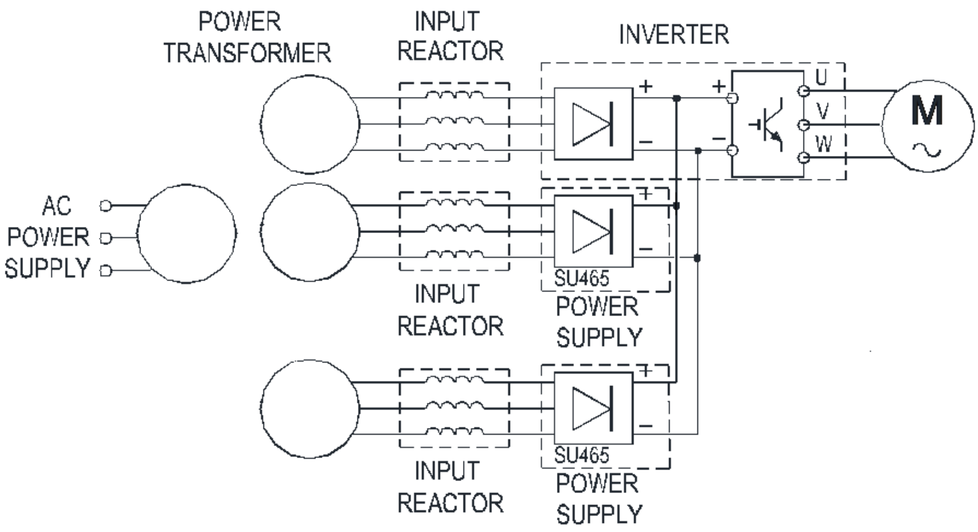
2.11. Input inductors to be Applied to the Drive and the SU465

2.11.1. S41/S51/S42/S52 models in the 12-pulse Connection



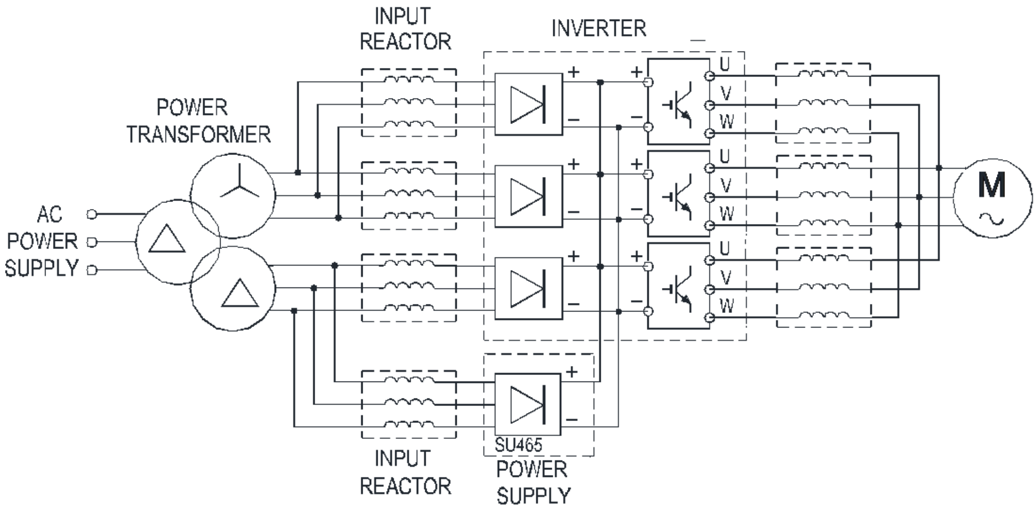
Voltage Class	Drive Size	Drive Model	INPUT THREE-PHASE AC INDUCTOR
2T-4T	S41	0180	IM0126244 0.09mH–252Arms
		0202	
		0217	
		0260	
2T-4T	S51	0313	IM0126282 0.063mH–360Arms
		0367	
		0402	
5T-6T	S42	0181	IM0127274 0.12mH–325Arms
		0201	
		0218	
		0259	
5T-6T	S52	0290	IM0127330 0.096mH–415Arms
		0314	
		0368	
		0401	

2.11.2. S41/S51/S42/S52 models in the 18-pulse Connection



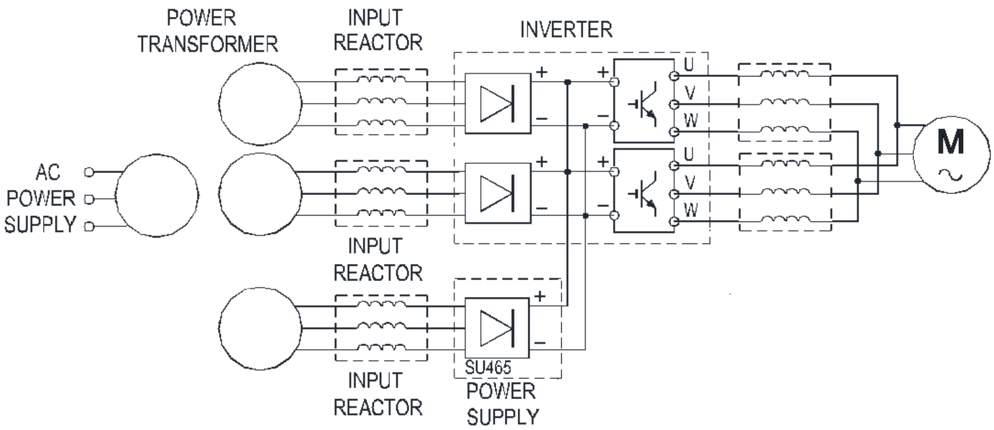
Voltage Class	Drive Size	Drive Model	INPUT THREE-PHASE AC INDUCTOR
2T-4T	S41	**0180**	IM0126204 0.16mH–145Arms
		0202	
		0217	IM0126244 0.09mH–252Arms
		0260	
2T-4T	S51	**0313**	
		0367	
		0402	
5T-6T	S42	**0181**	IM0127202 0.29mH–140Arms
		0201	
		0218	IM0127227 0.19mH–210Arms
		0259	
5T-6T	S52	**0290**	
		0314	
		0368	IM0127274 0.12mH–325Arms
		0401	

2.11.3. 3xS51/3x52 models in the 12-pulse Connection



Voltage Class	Drive Size	Drive Model	INPUT THREE-PHASE AC INDUCTOR
4T	**3xS51**	0850	IM0126332 0.050mH–455Arms
		0965	
		1129	
5T-6T	**3xS52**	0960	IM0127330 0.096mH–415Arms
		1128	

2.11.4. 2xS41/2xS42/2xS51/2x52 models in the 18-pulse Connection



Voltage Class	Drive Size	Drive Model	INPUT THREE-PHASE AC INDUCTOR
2T-4T	**2xS41**	0523	IM0126282 0.063mH–360Arms
4T	**2xS51**	0599	IM0126332 0.050mH–455Arms
		0749	
		0832	
5T-6T	**2xS42**	0459	IM0127274 0.12mH–325Arms
5T-6T	**2xS52**	0526	IM0127330 0.096mH–415Arms
		0600	
		0750	
		0828	

3. RESISTIVE BRAKING

Product-Accessory Compatibility		
Product	**Power Supply Unit SU465**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	-	
Solardrive Plus	-	

Table 2: Product – Resistive braking compatibility

When a large braking torque is required or the load connected to the motor is pulled (as for instance in lifting applications), the power regenerated by the motor is to be dissipated. This can be obtained in two ways:

- by dissipating energy to braking resistors (in that case a braking module is required); or
- by powering the inverter via the DC-bus using a system able to deliver energy to the mains. Both solutions are available.

Both solutions are available: The first solution is described below; for the second solution, please refer to the technical documentation pertaining to the Regenerative Inverter (see the Guide to the Regenerative Application).

From size S05 to size S32, the products are supplied with a built-in braking module. The braking resistor is to be connected outside the inverter to terminal B and terminal + (see Power Terminals for S05-S52 in the Installation Guide); properly set the parameters relating to the inverter braking (see the product's Programming Guide). External braking units are used for greater sizes; please refer to the relevant sections in this manual also for the description of the suitable braking resistors.

When choosing the braking resistor, consider the following:

- drive supply voltage (voltage class),
- the braking resistor Ohm value
- the rated power of the resistor.

The voltage class and the Ohm value determine the instant power dissipated in the braking resistor and are relating to the motor power (see note below); the rated power determines the mean power to be dissipated in the braking resistor and is relating to the duty cycle of the equipment, i.e. to the resistor activation time in respect to the duty cycle full time (the duty cycle of the resistor is equal to the motor braking time divided by the equipment duty cycle).
It is not possible to connect resistors with a Ohm value lower than the min. value acknowledged by the inverter.

NOTE The braking power required to reduce the speed of a rotating body is proportional to the total moment of inertia of the rotating mass, to the speed variation, to the absolute speed and is inversely proportional to the deceleration time required.

The following pages contain application tables stating the resistors to be used depending on the inverter model, the application requirements and the supply voltage.

NOTE The braking resistor power is given as an approximate empirical value; the correct dimensioning of the braking resistor is based on the equipment duty cycle and the power regenerated during the braking stage.

3.1 Braking Resistors to be Supplied to the Drives Equipped with Internal Braking Unit

	NOTE	The wire cross-sections given in the table relate to one wire per braking resistor.
	NOTE	The Part Numbers of the braking resistors in the tables are given in the Available Braking Resistors section.
	HOT SURFACE	The braking resistor case may reach 200 °C based on the operating cycle.
	CAUTION	The cables of the braking resistors shall have insulation features and heat-resistance features suitable for the application. The minimum rated voltage of the cables must be 450/700 V for 2T inverters, 0.6/1 kV for 4T/5T/6T inverters.
	CAUTION	The power dissipated by the braking resistors may be the same as the rated power of the connected motor multiplied by the braking duty-cycle; use a proper air-cooling system. Do not install braking resistors near heat-sensitive equipment or objects.
	CAUTION	Do not connect to the inverter any braking resistor with an Ohm value lower than the value given in the tables.
	CAUTION	Never exceed the maximum operating time of the resistor as given in the Available Braking Resistors section.

3.1.1. Applications with DUTY CYCLE 10% - Class 2T

Size	Model	BRAKING RESISTORS					
		Min. Applicable Resistor (Ω)	Type	Degree of Protection	Type of Connection	Value (Ω)	Wire cross-section mm² (AWG)
S05	**0007**	25.0	56Ω-350W	IP55	A	56	2.5(14)
	0008	25.0	2*56Ω-350W	IP55	B	28	2.5(14)
	0010	25.0	2*56Ω-350W	IP55	B	28	2.5(14)
	0013	18.0	2*56Ω-350W	IP55	B	28	2.5(14)
	0015	18.0	2*56Ω-350W	IP55	B	28	2.5(14)
	0016	18.0	3*56Ω-350W	IP55	B	18.7	2.5(14)
	0020	18.0	3*56Ω-350W	IP55	B	18.7	2.5(14)
S12	**0023**	15.0	15Ω-1100W	IP55	A	15	4(12)
	0033	10.0	10Ω-1500W	IP54	A	10	4(12)
	0037	10.0	10Ω-1500W	IP54	A	10	4(12)
S15	**0040**	7.5	2*15Ω-1100W	IP55	A	7.5	4(12)
	0049	5.0	5Ω-4000W	IP20	A	5.0	10(8)
S20	**0060**	5.0	5Ω-4000W	IP20	A	5.0	10(8)
	0067	5.0	5Ω-4000W	IP20	A	5.0	10(8)
	0074	4.2	5Ω-4000W	IP20	A	5.0	10(8)
	0086	4.2	5Ω-4000W	IP20	A	5.0	10(8)
S30	**0113**	3.0	3.3Ω-8000W	IP20	A	3.3	10(8)
	0129	3.0	3.3Ω-8000W	IP20	A	3.3	10(8)
	0150	2.5	3.3Ω-8000W	IP20	A	3.3	10(8)
	0162	2.5	3.3Ω-8000W	IP20	A	3.3	10(8)

3.1.2. Applications with DUTY CYCLE 20% - Class 2T

Size	Model	BRAKING RESISTORS					
		Min. Applicable Resistor (Ω)	Type	Degree of Protection	Type of Connection	Value (Ω)	Wire cross-section mm² (AWG)
S05	**0007**	25.0	2*100Ω-350W	IP55	B	50	2.5(14)
	0008	25.0	2*56Ω-350W	IP55	B	28	2.5(14)
	0010	25.0	2*56Ω-350W	IP55	B	28	2.5(14)
	0013	18.0	4*100Ω-350W	IP55	B	25	2.5(14)
	0015	18.0	4*100Ω-350W	IP55	B	25	2.5(14)
	0016	18.0	25Ω-1800W	IP54	A	25	2.5(14)
	0020	18.0	25Ω-1800W	IP54	A	25	2.5(14)
S12	**0023**	15.0	15Ω-2200W	IP54	A	15	4(12)
	0033	10.0	2*25Ω-1800W	IP54	B	12.5	2.5(14)
	0037	10.0	2*25Ω-1800W	IP54	B	12.5	2.5(14)
S15	**0040**	7.5	2*15Ω-2200W	IP54	B	7.5	2.5(14)
	0049	5	5Ω-4000W	IP20	A	5	6(10)
S20	**0060**	5.0	5Ω-8000W	IP20	A	5	10(8)
	0067	5.0	5Ω-8000W	IP20	A	5	10(8)
	0074	4.2	5Ω-8000W	IP20	A	5	10(8)
	0086	4.2	5Ω-8000W	IP20	A	5	10(8)
S30	**0113**	3.0	3.3Ω-12000W	IP20	A	3.3	16(6)
	0129	3.0	3.3Ω-12000W	IP20	A	3.3	16(6)
	0150	2.5	3.3Ω-12000W	IP20	A	3.3	16(6)
	0162	2.5	3.3Ω-12000W	IP20	A	3.3	16(6)

3.1.3. Applications with DUTY CYCLE 50% - Class 2T

Size	Model	BRAKING RESISTORS					
		Min. Applicable Resistor (Ω)	Type	Degree of Protection	Type of Connection	Value (Ω)	Wire cross-section mm² (AWG)
S05	**0007**	25.0	50Ω-1100W	IP55	A	50	2.5(14)
	0008	25.0	25Ω-1800W	IP54	A	25	2.5(14)
	0010	25.0	25Ω-1800W	IP54	A	25	2.5(14)
	0013	18.0	25Ω-4000W	IP20	A	25	2.5(14)
	0015	18.0	25Ω-4000W	IP20	A	25	2.5(14)
	0016	18.0	25Ω-4000W	IP20	A	25	2.5(14)
	0020	18.0	20Ω-4000W	IP20	A	20	4(12)
S12	**0023**	15.0	20Ω-4000W	IP20	A	20	6(10)
	0033	10.0	10Ω-8000W	IP20	A	10	10(8)
	0037	10.0	10Ω-8000W	IP20	A	10	10(8)
S15	**0040**	6.6	6.6Ω-12000W	IP20	A	6.6	16(6)
	0049	6.6	6.6Ω-12000W	IP20	A	6.6	16(6)
S20	**0060**	5.0	6.6Ω-12000W	IP20	A	6.6	16(6)
	0067	5.0	2*10Ω-8000W	IP20	B	5	10(8)
	0074	4.2	2*10Ω-8000W	IP20	B	5	10(8)
	0086	4.2	2*10Ω-8000W	IP20	B	5	10(8)
S30	**0113**	3.0	2*6.6Ω-12000W	IP20	B	3.3	16(6)
	0129	3.0	2*6.6Ω-12000W	IP20	B	3.3	16(6)
	0150	2.5	3*10Ω-12000W	IP20	B	3.3	10(8)
	0162	2.5	3*10Ω-12000W	IP20	B	3.3	10(8)

Type of connection:

A - One resistor
B - Two or multiple parallel-connected resistors

CAUTION

The cable cross-sections given in the table relate to the cable connecting each individual braking resistor. For example, if a braking resistor is connected to N.2 parallel-connected resistors, the cable cross-section in the table is the one for each resistor connected to the braking unit.

3.1.4. Applications with DUTY CYCLE 10% - Class 4T

Size	Model	BRAKING RESISTORS					
		Min. Applicable Resistor (Ω)	Type	Degree of Protection	Type of Connection	Value (Ω)	Wire cross-section mm^2 (AWG)
S05	0005	50	75Ω-550W	IP33	A	75	2.5(14)
	0007	50	75Ω-550W	IP33	A	75	2.5(14)
	0009	50	50Ω-1100W	IP55	A	50	2.5(14)
	0011	50	50Ω-1100W	IP55	A	50	2.5(14)
	0014	50	50Ω-1100W	IP55	A	50	2.5(14)
S12	0016	40	50Ω-1500W	IP54	A	50	2.5(14)
	0017	40	50Ω-1500W	IP54	A	50	2.5(14)
	0020	40	50Ω-1500W	IP54	A	50	2.5(14)
	0025	20	25Ω-1800W	IP54	A	25	4(12)
	0030	20	25Ω-1800W	IP54	A	25	4(12)
	0034	20	20Ω-4000W	IP20	A	20	4(12)
	0036	20	20Ω-4000W	IP20	A	20	4(12)
S15	0040	15	15Ω-4000W	IP20	A	15	6(10)
	0049	10	15Ω-4000W	IP20	A	15	6(10)
S20	0060	10	10Ω-8000W	IP20	A	10	10(8)
	0067	10	10Ω-8000W	IP20	A	10	10(8)
	0074	7.5	10Ω-8000W	IP20	A	10	10(8)
	0086	7.5	10Ω-8000W	IP20	A	10	10(8)
S30	0113	6	6.6Ω-12000W	IP20	A	6.6	10(8)
	0129	6	6.6Ω-12000W	IP20	A	6.6	10(8)
	0150	5	5Ω-16000W	IP20	A	5	16(6)
	0162	5	5Ω-16000W	IP20	A	5	16(6)

Type of connection:

A - One resistor

3.1.5. Applications with DUTY CYCLE 20% - Class 4T

Size	Model	BRAKING RESISTORS					
		Min. Applicable Resistor (Ω)	Type	Degree of Protection	Type of Connection	Value (Ω)	Wire cross-section mm² (AWG)
S05	**0005**	50	50Ω-1100W	IP55	A	50	2.5(14)
	0007	50	50Ω-1100W	IP55	A	50	2.5(14)
	0009	50	50Ω-1100W	IP55	A	50	2.5(14)
	0011	50	50Ω-1500W	IP54	A	50	2.5(14)
	0014	50	50Ω-1500W	IP54	A	50	2.5(14)
S12	**0016**	40	50Ω-2200W	IP54	A	50	2.5(14)
	0017	40	50Ω-2200W	IP54	A	50	2.5(14)
	0020	40	50Ω-4000W	IP20	A	50	2.5(14)
	0025	20	25Ω-4000W	IP20	A	25	6(10)
	0030	20	25Ω-4000W	IP20	A	25	6(10)
	0034	20	20Ω-4000W	IP20	A	20	6(10)
	0036	20	20Ω-4000W	IP20	A	20	6(10)
S15	**0040**	15	15Ω-8000W	IP23	A	15	10(8)
	0049	10	10Ω-12000W	IP20	A	10	10(8)
S20	**0060**	10	10Ω-12000W	IP20	A	10	16(6)
	0067	10	10Ω-12000W	IP20	A	10	16(6)
	0074	7.5	10Ω-16000W	IP23	A	10	16(6)
	0086	7.5	10Ω-16000W	IP23	A	10	16(6)
S30	**0113**	6	2*3.3Ω-8000W	IP20	C	6.6	16(6)
	0129	6	2*3.3Ω-8000W	IP20	C	6.6	16(6)
	0150	5	2*10Ω-12000W	IP20	B	5	16(6)
	0162	5	2*10Ω-12000W	IP20	B	5	16(6)

Type of connection:

A - One resistor
B - Two or multiple parallel-connected resistors
C - Two series-connected resistors

3.1.6. Applications with DUTY CYCLE 50% - Class 4T

Size	Model	BRAKING RESISTORS					
		Min. Applicable Resistor (Ω)	Type	Degree of Protection	Type of Connection	Value (Ω)	Wire cross-section mm^2 (AWG)
S05	**0005**	50	50Ω-4000W	IP23	A	50	4(12)
	0007	50	50Ω-4000W	IP23	A	50	4(12)
	0009	50	50Ω-4000W	IP23	A	50	4(12)
	0011	50	50Ω-4000W	IP23	A	50	4(12)
	0014	50	50Ω-4000W	IP23	A	50	4(12)
S12	**0016**	40	50Ω-8000W	IP23	A	50	4(12)
	0017	40	50Ω-8000W	IP23	A	50	4(12)
	0020	40	50Ω-8000W	IP23	A	50	4(12)
	0025	20	20Ω-12000W	IP23	A	20	10(8)
	0030	20	20Ω-12000W	IP23	A	20	10(8)
	0034	20	20Ω-16000W	IP23	A	20	10(8)
	0036	20	20Ω-16000W	IP23	A	20	10(8)
S15	**0040**	15	15Ω-24000W	IP23	A	15	16(6)
	0049	10	15Ω-24000W	IP23	A	15	16(6)
S20	**0060**	10	10Ω-24000W	IP23	A	10	16(6)
	0067	10	10Ω-24000W	IP23	A	10	16(6)
	0074	7.5	2*15Ω-24000W	IP23	B	7.5	16(6)
	0086	7.5	2*15Ω-24000W	IP23	B	7.5	16(6)
S30	**0113**	6	6Ω-64000W	IP23	A	6	35(2)
	0129	6	6Ω-64000W	IP23	A	6	35(2)
	0150	5	5Ω-64000W	IP23	A	5	50(1/0)
	0162	5	5Ω-64000W	IP23	A	5	50(1/0)

Type of connection:

A - One resistor
B - Two or multiple parallel-connected resistors

3.1.7. Applications with DUTY CYCLE 10% - Class 5T

Size	Model	BRAKING RESISTOR					
		Min. Applicable Resistor (Ω)	Type	Degree of Protection	Type of Connection	Value (Ω)	Wire cross-section mm^2 (AWG)
S14	**0003**	120	250Ω-1100W	IP55	A	250	10(8)
	0004	120	180Ω-1100W	IP55	A	180	10(8)
	0006	60	120Ω-1800W	IP55	A	120	10(8)
	0012	60	100Ω-2200W	IP55	A	100	10(8)
	0018	60	82Ω-4000W	IP20	A	82	10(8)
	0019	40	60Ω-4000W	IP20	A	60	10(8)
	0021	40	45Ω-4000W	IP23	A	45	10(8)
	0022	25	45Ω-4000W	IP23	A	45	10(8)
	0024	25	30Ω-4000W	IP23	A	30	10(8)
	0032	20	22Ω-8000W	IP23	A	22	10(8)
S22	**0042**	12	22Ω-8000W	IP23	A	22	10(8)
	0051	12	18Ω-8000W	IP23	A	18	10(8)
	0062	12	15Ω-12000W	IP23	A	15	10(8)
	0069	12	12Ω-12000W	IP23	A	12	10(8)
S32	**0076**	8	10Ω-12000W	IP23	A	10	16(6)
	0088	8	8.2Ω-16000W	IP23	A	8.2	16(6)
	0131	5	6.6Ω-24000W	IP23	A	6.6	16(6)
	0164	5	5Ω-24000W	IP23	A	5	16(6)

Type of connection:

A - One resistor

3.1.8. Applications with DUTY CYCLE 20% - Class 5T

Size	Model	BRAKING RESISTOR					
		Min. Applicable Resistor (Ω)	Type	Degree of Protection	Type of Connection	Value (Ω)	Wire cross-section mm^2 (AWG)
S14	**0003**	120	250Ω-1500W	IP55	A	250	10(8)
	0004	120	180Ω-1500W	IP55	A	180	10(8)
	0006	60	120Ω-4000W	IP20	A	120	10(8)
	0012	60	100Ω-4000W	IP20	A	100	10(8)
	0018	60	82Ω-4000W	IP23	A	82	10(8)
	0019	40	60Ω-4000W	IP23	A	60	10(8)
	0021	40	45Ω-8000W	IP20	A	45	10(8)
	0022	25	45Ω-8000W	IP23	A	45	10(8)
	0024	25	30Ω-8000W	IP23	A	30	10(8)
	0032	20	22Ω-12000W	IP23	A	22	10(8)
S22	**0042**	12	22Ω-12000W	IP23	A	22	10(8)
	0051	12	18Ω-12000W	IP23	A	18	10(8)
	0062	12	15Ω-16000W	IP23	A	15	10(8)
	0069	12	12Ω-16000W	IP23	A	12	10(8)
S32	**0076**	8	10Ω-24000W	IP23	A	10	16(6)
	0088	8	8.2Ω-24000W	IP23	A	8.2	16(6)
	0131	5	6.6Ω-32000W	IP23	A	6.6	25(3)
	0164	5	5Ω-48000W	IP23	A	5	25(3)

Type of connection:

A - One resistor

3.1.9. Applications with DUTY CYCLE 50% - Class 5T

Size	Model	BRAKING RESISTOR					
		Min. Applicable Resistor (Ω)	Type	Degree of Protection	Type of Connection	Value (Ω)	Wire cross-section mm^2 (AWG)
S14	**0003**	120	250Ω-2200W	IP55	A	250	16(6)
	0004	120	180Ω-4000W	IP20	A	180	16(6)
	0006	60	120Ω-4000W	IP23	A	120	16(6)
	0012	60	100Ω-4000W	IP23	A	100	16(6)
	0018	60	82Ω-8000W	IP20	A	82	16(6)
	0019	40	60Ω-8000W	IP23	A	60	16(6)
	0021	40	45Ω-12000W	IP20	A	45	16(6)
	0022	25	45Ω-12000W	IP23	A	45	16(6)
	0024	25	30Ω-16000W	IP23	A	30	16(6)
	0032	20	22Ω-16000W	IP23	A	22	16(6)
S22	**0042**	12	22Ω-24000W	IP23	A	22	16(6)
	0051	12	18Ω-24000W	IP23	A	18	16(6)
	0062	12	15Ω-32000W	IP23	A	15	16(6)
	0069	12	12Ω-48000W	IP23	A	12	16(6)
S32	**0076**	8	10Ω-48000W	IP23	A	10	25(3)
	0088	8	8.2Ω-64000W	IP23	A	8.2	25(3)
	0131	5	6.6Ω-64000W	IP23	A	6.6	50(1/0)
	0164	5	2x10Ω-48000W	IP23	B	5	50(1/0)

Type of connection:

A - One resistor
B - Two series-connected resistors

3.1.10. Applications with DUTY CYCLE 10% - Class 6T

Size	Model	BRAKING RESISTOR					
		Min. Applicable Resistor (Ω)	Type	Degree of Protection	Type of Connection	Value (Ω)	Wire cross-section mm^2 (AWG)
S14	**0003**	150	250Ω-1500W	IP55	A	250	10(8)
	0004	150	180Ω-2200W	IP55	A	180	10(8)
	0006	80	150Ω-2200W	IP55	A	150	10(8)
	0012	80	120Ω-4000W	IP20	A	120	10(8)
	0018	80	82Ω-4000W	IP20	A	82	10(8)
	0019	50	60Ω-4000W	IP23	A	60	10(8)
	0021	50	60Ω-4000W	IP23	A	60	10(8)
	0022	30	45Ω-4000W	IP23	A	45	10(8)
	0024	30	30Ω-8000W	IP23	A	30	10(8)
	0032	25	30Ω-8000W	IP23	A	30	10(8)
S22	**0042**	15	22Ω-8000W	IP23	A	22	10(8)
	0051	15	18Ω-12000W	IP23	A	18	10(8)
	0062	15	15Ω-12000W	IP23	A	15	10(8)
	0069	15	15Ω-12000W	IP23	A	15	10(8)
S32	**0076**	10	10Ω-16000W	IP23	A	10	16(6)
	0088	10	10Ω-24000W	IP23	A	10	16(6)
	0131	6	6.6Ω-24000W	IP23	A	6.6	16(6)
	0164	6	6Ω-32000W	IP23	A	6	16(6)

Type of connection:

A - One resistor

3.1.11. Applications with DUTY CYCLE 20% - Class 6T

Size	Model	BRAKING RESISTOR					
		Min. Applicable Resistor (Ω)	Type	Degree of Protection	Type of Connection	Value (Ω)	Wire cross-section mm^2 (AWG)
S14	**0003**	150	250Ω-2200W	IP55	A	250	10(8)
	0004	150	180Ω-4000W	IP20	A	180	10(8)
	0006	80	150Ω-4000W	IP20	A	150	10(8)
	0012	80	120Ω-4000W	IP23	A	120	10(8)
	0018	80	82Ω-4000W	IP23	A	82	10(8)
	0019	50	60Ω-4000W	IP23	A	60	10(8)
	0021	50	60Ω-8000W	IP23	A	60	10(8)
	0022	30	45Ω-8000W	IP23	A	45	10(8)
	0024	30	30Ω-8000W	IP23	A	30	10(8)
	0032	25	30Ω-12000W	IP23	A	30	10(8)
S22	**0042**	15	22Ω-12000W	IP23	A	22	10(8)
	0051	15	18Ω-16000W	IP23	A	18	10(8)
	0062	15	15Ω-16000W	IP23	A	15	10(8)
	0069	15	15Ω-16000W	IP23	A	15	10(8)
S32	**0076**	10	10Ω-24000W	IP23	A	10	16(6)
	0088	10	10Ω-32000W	IP23	A	10	16(6)
	0131	6	6.6Ω-48000W	IP23	A	6.6	25(3)
	0164	6	6Ω-48000W	IP23	A	6	25(3)

Type of connection:

A - One resistor

3.1.12. Applications with DUTY CYCLE 50% - Class 6T

Size	Model	BRAKING RESISTOR					
		Min. Applicable Resistor (Ω)	Type	Degree of Protection	Type of Connection	Value (Ω)	Wire cross-section mm^2 (AWG)
S14	**0003**	150	250Ω-4000W	IP20	A	250	16(6)
	0004	150	180Ω-4000W	IP23	A	180	16(6)
	0006	80	150Ω-4000W	IP23	A	150	16(6)
	0012	80	120Ω-8000W	IP20	A	120	16(6)
	0018	80	82Ω-8000W	IP23	A	82	16(6)
	0019	50	60Ω-8000W	IP23	A	60	16(6)
	0021	50	60Ω-12000W	IP23	A	60	16(6)
	0022	30	45Ω-16000W	IP23	A	45	16(6)
	0024	30	30Ω-16000W	IP23	A	30	16(6)
	0032	25	30Ω-24000W	IP23	A	30	16(6)
S22	**0042**	15	22Ω-24000W	IP23	A	22	16(6)
	0051	15	18Ω-32000W	IP23	A	18	16(6)
	0062	15	15Ω-48000W	IP23	A	15	16(6)
	0069	15	15Ω-48000W	IP23	A	15	16(6)
S32	**0076**	10	10Ω-64000W	IP23	A	10	25(3)
	0088	10	10Ω-64000W	IP23	A	10	25(3)
	0131	6	2x3Ω-48000W	IP23	C	6	50(1/0)
	0164	6	2x3Ω-48000W	IP23	C	6	50(1/0)

Type of connection:

A - One resistor
C - Two series-connected resistors

3.2. Braking Unit (BU200 2T-4T) for S41-S51 and S60-S60P

An external braking unit is available for 2T-4T inverters of frame sizes from S41 to S60P.

The BU200 is an Open Type Equipment – degree of protection IP00 – that can be installed inside another enclosure featuring degree of protection IP3X as a minimum requirement.

Transporting, handling and unpacking the braking unit is covered in the general instructions given in the "Transport and Handling" and "Unpacking"sections in the Installation Guide.

3.2.1. Delivery Check

Make sure that the equipment is not damaged and it complies with the equipment you ordered by referring to its front nameplate (see figure below).
If the equipment is damaged, contact the supplier or the insurance company concerned.
If the equipment does not comply with the one you ordered, please contact the supplier as soon as possible.
If the equipment is stored before being started, make sure that temperatures range from –25 °C ÷ +70 °C and that relative humidity is <95% (non-condensing).
The equipment guarantee covers any manufacturing defect. The manufacturer has no responsibility for possible damages due to the equipment transportation or unpacking. The manufacturer is not responsible for possible damages or faults caused by improper and irrational uses; wrong installation; improper conditions of temperature, humidity, or the use of corrosive substances. The manufacturer is not responsible for possible faults due to the equipment operation at values exceeding the equipment ratings and is not responsible for consequential and accidental damages.
The braking unit BU200 is covered by a two-year guarantee starting from the date of delivery.

3.2.1.1. Nameplate for BU200 2T-4T

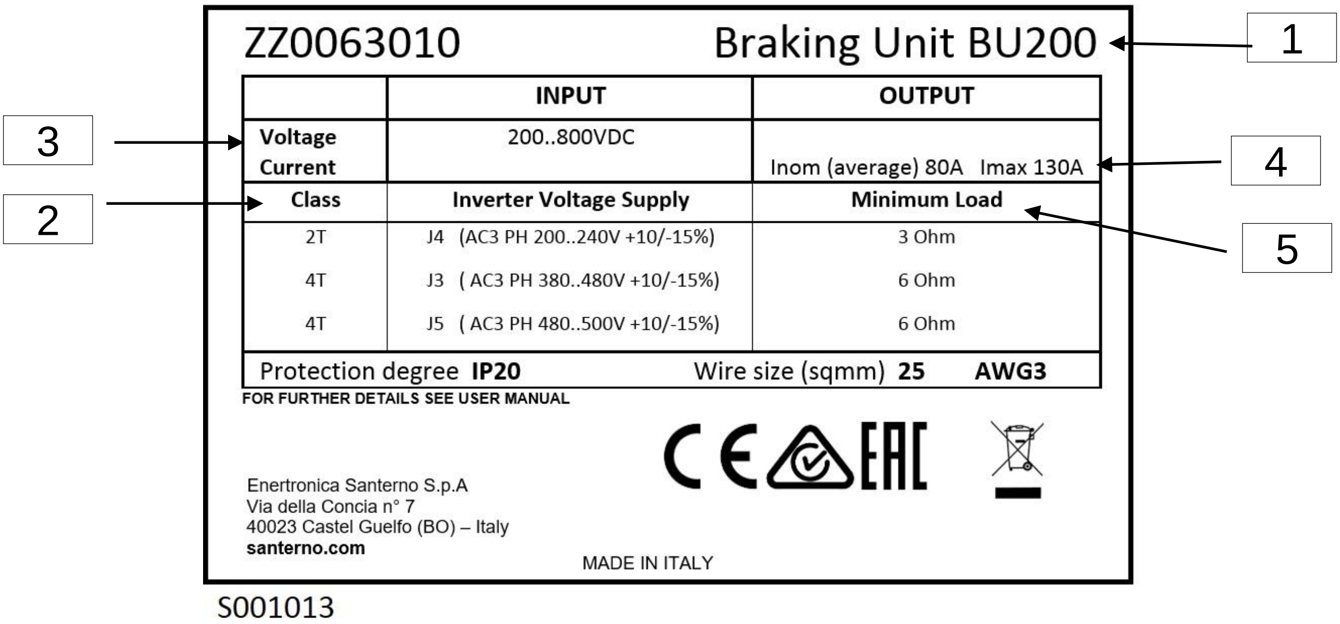


Figure 16: Nameplate for BU200 2T-4T

Numbered items in the figure above:

1.	Model:	BU200 – braking unit 2T-4T
2.	Voltage class:	List of applicable voltage classes
3.	Supply ratings:	200÷800 Vdc (DC supply voltage produced by the inverter terminals)
4.	Output current:	80A (average) – continuous average current in output cables 130A (max.) – max. current in output cables (may be held for the time given in column “Max. Duration of Continuous Operation” in the resistors tables below)
5.	Min. load:	Minimum value of the resistor to be connected to the output terminals (see application tables below)

3.2.2. Operation

The basic size of the braking unit can be used with a braking resistor avoiding exceeding a max. instant current of 130 A, corresponding to a maximum braking power of approx. 97.5 kW (class 4T) and to an average power of 60 kW (class 4T). For applications requiring higher braking power values, multiple braking units can be parallel-connected in order to obtain a greater braking power based on the number of braking units.
To ensure that the overall braking power is evenly distributed to all braking units, configure one braking unit in MASTER mode and the remaining braking units in SLAVE mode, and connect the output signal of the MASTER unit (terminal 8 in connector M1) to the forcing input for all SLAVE braking units (terminal 4 in connector M1).

3.2.3. Configuration Jumpers

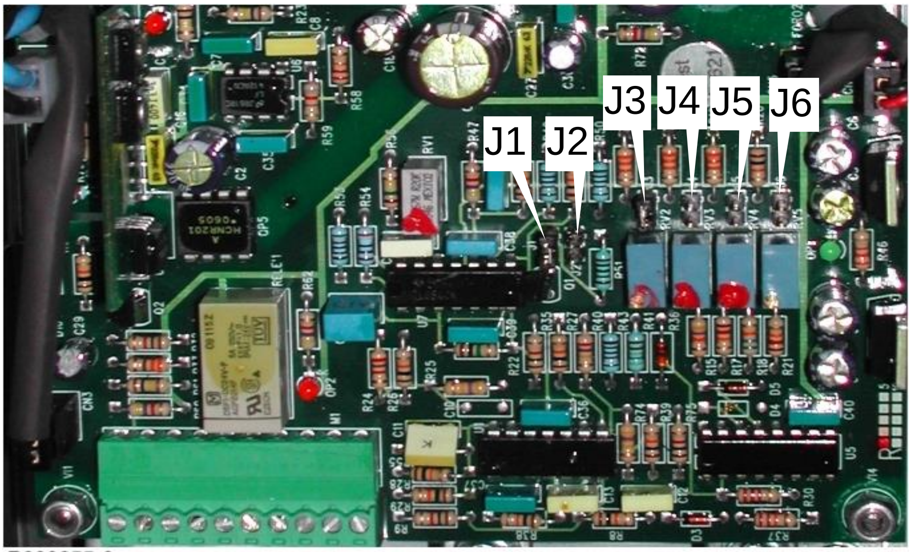
Jumpers located on the control board for BU200 are used for the configuration of the braking unit.
Their positions and functions are as follows:

Jumper	Function
J1	If on, it configures the SLAVE operating mode
J2	If on, it configures the MASTER operating mode

NOTE Either one of the two jumpers must always be “on”. Avoid enabling both jumpers at a time.

Jumper	Function
J3	To be activated for class 4T inverters and mains voltage [380 Vac to 480 Vac]
J4	To be activated for class 2T inverters and mains voltage [200 Vac to 240 Vac]
J5	To be activated for class 4T inverters and mains voltage [481 Vac to 500 Vac]
J6	To be activated for special adjustment requirements

NOTE One of the four jumpers must always be “ON”. Avoid enabling two or more jumpers at a time.



P000655-0

Figure 17: Positions of BU200 configuration jumpers

DANGER Before changing jumper positions, remove voltage from the equipment and wait at least 20 minutes.

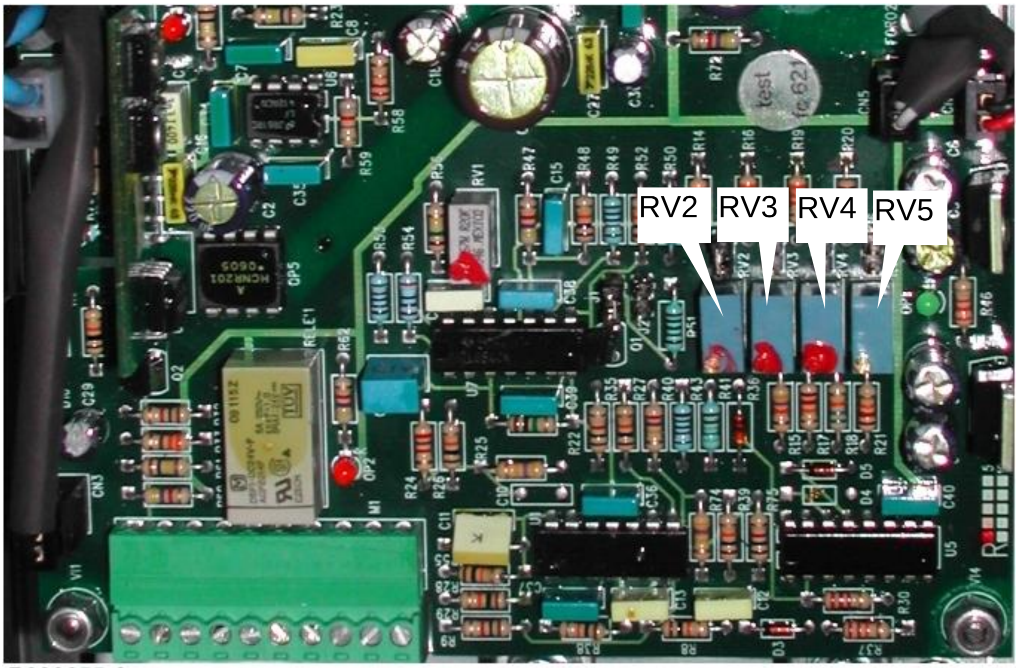
CAUTION **Never** set jumpers to a voltage value lower than the inverter supply voltage. This will avoid continuous activation of the braking unit.

3.2.4. Adjusting Trimmers

Four trimmers are installed on the inverter control board. Depending on the jumper configuration, each trimmer allows the fine-tuning of the braking unit voltage threshold trip.
Jumper-trimmer matching is as follows:

Mains voltage [Vac]	Jumper	Trimmer	Minimum braking voltage [Vdc]	Rated braking voltage [Vdc]	Maximum braking voltage [Vdc]
200÷240 (2T)	J4	RV3	339	364	426
380÷480 (4T)	J3	RV2	700	764	826
481÷500 (4T)	J5	RV4	730	783	861
230÷500	J6	RV5	464	650	810

CAUTION The maximum values in the table above are theoretical values for special applications only. Their use must be authorized by Enertronica Santerno S.p.A.. For standard applications, never change the factory-set rated value.



P000655-0

Figure 18: Positions of BU200 adjusting trimmers

3.2.5. Indicator LEDs

The indicator LEDs below are located on the front part of the braking units:

OK LED Normally “on”; the equipment is running smoothly. This LED turns off due to overcurrent or power circuit failure.

B LED Normally off”; this LED turns on when the braking unit activates.

TMAX LED Normally “off”; this LED turns on when the thermoswitch located on the heat sink of the braking unit trips; if overtemperature protection trips, the equipment is locked until temperature drops below the alarm threshold.

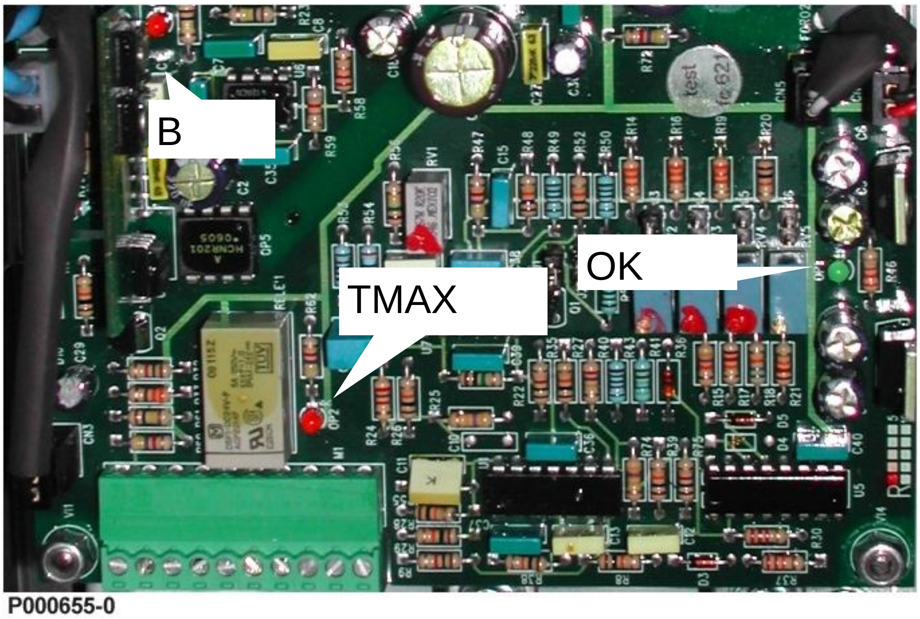


Figure 19: Position of the Indicator LEDs

3.2.6. Ratings

SIZE	Max. Braking Current (A)	Average Braking Current (A)	Sound Pressure (dB)	INVERTER SUPPLY VOLTAGE and JUMPER POSITIONS		
				200-240Vac (class 2T)	380-480Vac (class 4T)	481-500Vac (class 4T)
				J4	J3	J5
				MIN. BRAKING RESISTOR (Ω)		
BU200	130	80	55	3	6	6

3.2.7. Installing the BU200

3.2.7.1. Environmental Requirements for the BU200 Installation, Storage and Transport

Maximum surrounding air temperature	–10 to +40 °C with no derating from +40 °C to +55 °C with a 2% derating of the rated current for each degree beyond +40 °C.
Ambient temperatures for storage and transport	–25°C to +70 °C.
Installation environment	Pollution degree 2 or better (according to EN 61800-5-1). Do not install in direct sunlight and in places exposed to conductive dust, corrosive gases, vibrations, water sprinkling or dripping (depending on IP ratings); do not install in salty environments.
Altitude	Max. altitude for installation 2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A. Above 1000 m, derate the rated current by 1% every 100 m.
Operating ambient humidity	From 5% to 95%, from 1 g/m^3 to 29 g/m^3, non-condensing and non-freezing (class 3K3 according to EN 61800-5-1).
Storage ambient humidity	From 5% to 95%, from 1 g/m^3 to 29 g/m^3, non-condensing and non-freezing (class 1K3 according to EN 61800-5-1).
Ambient humidity during transport	Max. 95%, up to 60 g/m^3; condensation may appear when the equipment is not running (class 2K3 according to EN 61800-5-1).
Storage and operating atmospheric pressure	From 86 to 106 kPa (classes 3K3 and 1K4 according to EN 61800-5-1).
Atmospheric pressure during transport	From 70 to 106 kPa (class 2K3 according to EN 61800-5-1).

CAUTION Ambient conditions strongly affect the inverter life. Do not install the equipment in places that do not have the above-mentioned ambient conditions.

3.2.7.2. Cooling System and Dissipated Power

The braking unit is provided with a heat sink reaching a max. temperature of 80 °C.
Make sure that the bearing surface for the braking unit is capable of withstanding high temperatures. Max. dissipated power is approx. 150 W and depends on the braking cycle required for the operating conditions of the load connected to the motor.

CAUTION The max. temperature alarm for the braking unit shall be used as a digital signal to control the inverter stop.

3.2.7.3. Mounting

- The braking unit (BU200) must be installed in an upright position inside a cabinet;
- Make sure to allow a min. clearance of 5 cm on both types and 10 cm on top and bottom; use cable-glands to maintain IP20 rating;
- Fix the BU200 with four MA4 screws.

Dimensions (mm)			Distance between fixing points (mm)		Type of screws	Weight (kg)
W	H	D	X	Y	M4	4
139	247	196	120	237		

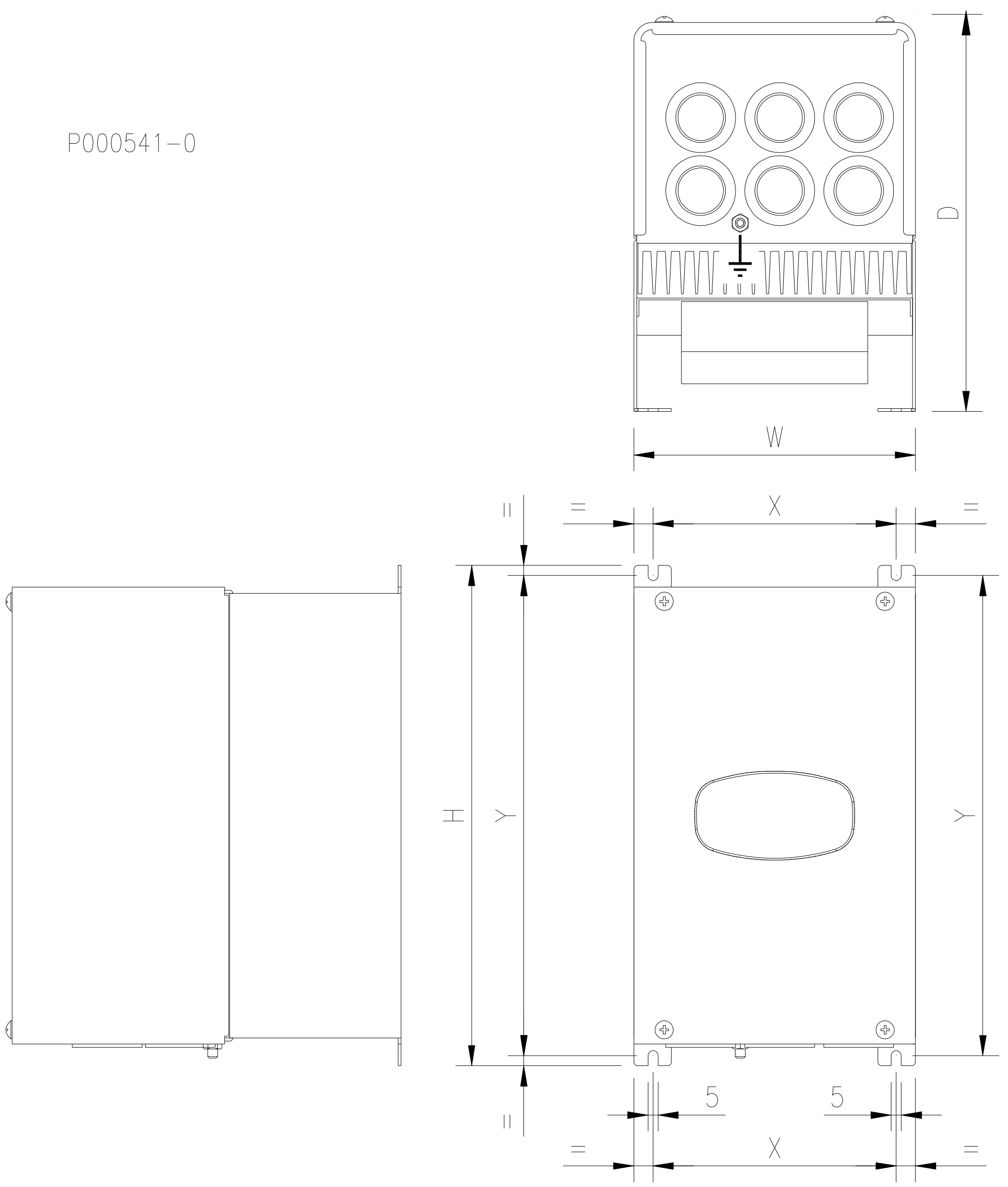


Figure 20: Dimensions and fixing points of BU200

3.2.7.4. Lay-Out of Power Terminals and Signal Terminals

Remove the cover of the braking unit to gain access to its terminal blocks. Just loosen the four fixing screws of the cover located on the front side and on the bottom side of the braking unit.
Loosen the fastening screws to slide off the cover from above.
Power terminals consist of copper bars, that can be reached through the three front holes.

Decisive voltage class C according to EN 61800-5-1

Terminal	N.	Type of terminal	Cable cross-section (mm^2)	Connection
+	20	Copper bar	25	Inverter DC side connected to terminal +
B	21	Copper bar	See Resistors table	Connection to braking resistor
–	22	Copper bar	25	Inverter DC side connected to terminal –

Terminal block M1:
Decisive voltage class A according to EN 61800-5-1

N.	Name	Description	Notes	Features	Cable cross-section (mm^2)
M1: 1		Not used			
M1: 2	0VE	Signal zero volt		Control board zero volt	0.5÷1
M1: 3	Vin	Modulation input (0÷10 V)	To be used for special applications	Rin=10 kΩ	0.5÷1
M1: 4	Sin	Logic input for signal sent from Master	The SLAVE brakes if a signal > 6 V is sent	Max. 30 V	0.5÷1
M1: 8	Mout	Digital output for Slave command signal	High level output when the Master is braking	PNP output (0-15 V)	0.5÷1
M1: 9		Not used			
M1:10		Not used			

Decisive voltage class C according to EN 61800-5-1

M1: 5	RL-NO	NO contact of “thermoswitch on” relay	The relay energizes when an overtemperature alarm trips for BU200	250 Vac, 5A 30 Vdc, 5A	0.5÷1
M1: 6	RL-C	Common of the contact of “thermoswitch on” relay			0.5÷1
M1: 7	RL-NC	NC contact of “thermoswitch on” relay			0.5÷1

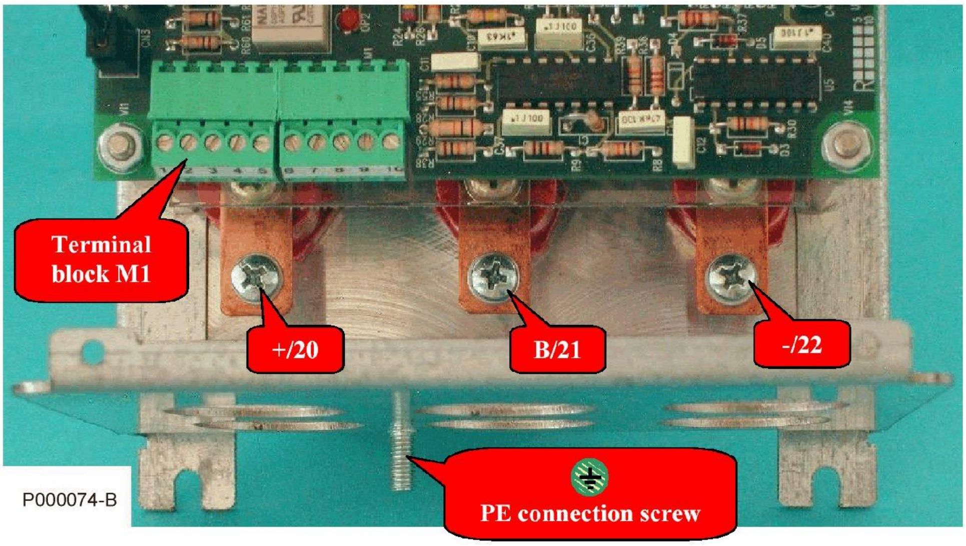


Figure 21: Terminals in BU200

3.2.7.5. Wiring

The braking unit must be connected to the inverter and the braking resistor.
The braking unit is connected directly to the inverter terminals (or copper bars for sizes greater than S32) of the DC voltage output, while the braking resistor must be connected to the inverter on one side and to the braking unit on the other side.
The wiring diagram is shown in the figure below:

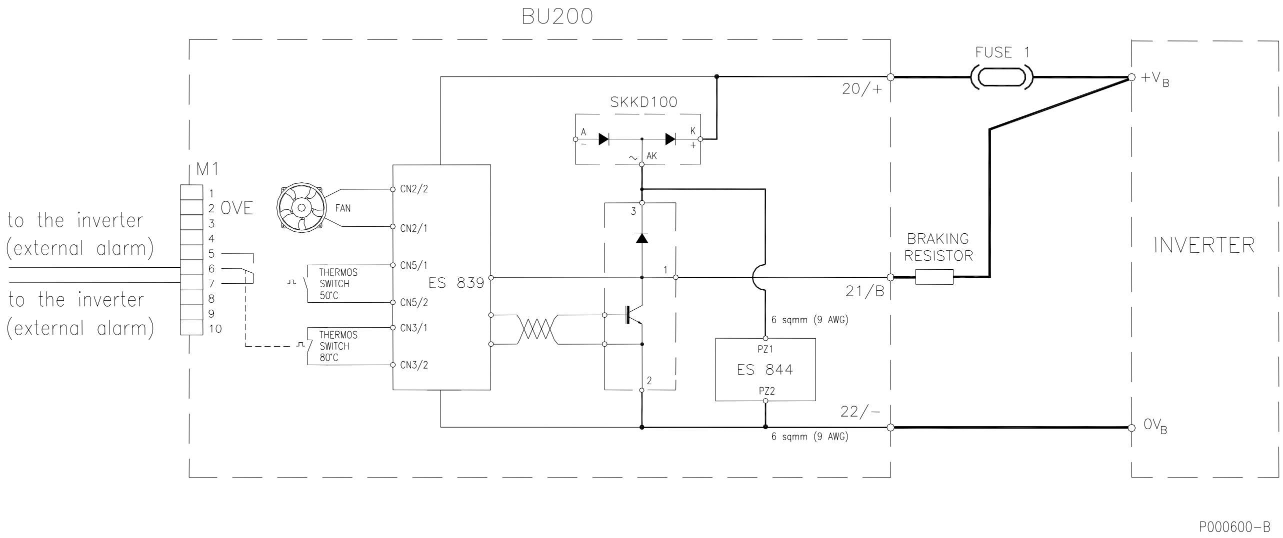


Figure 22: Connecting one BU200 to the inverter

NOTE The braking resistor must be connected between terminal **B** of BU200 and terminal **+** of the inverter. In that way, no sudden variation in braking current occurs in the supply line between the inverter and BU200. In order to minimize electromagnetic radiated emissions when BU200 is operating, the loop obtained from the wiring connecting terminal **+** of the inverter, the braking resistor, terminals **B** and **–** of BU200 and terminal **–** of the inverter should be as short as possible.

NOTE We recommend installing a 50A fuse with DC voltage of at least 700 Vdc (type URDC SIBA series, NH1 fuse) provided with a safety contact.

CAUTION Link the safety contact of the fuse being used with the external alarm of BU200.

3.2.7.6. Master – Slave Connection

The Master-Slave connection must be used when multiple braking units are connected to the same inverter. An additional connection must be done between the Master output signal (terminal 8 in M1) and the Slave input signal (terminal 4 in M1); zero volt of the signal connector in the Master module (terminal 2 in M1) must be connected to zero volt of the signal connector in the Slave module (terminal 2 in M1).
The connection of more than two modules must always be done by configuring one module like a master and the other modules like slaves. Use configuration jumpers accordingly.
The max. temperature alarm of the braking unit must be used as a digital signal to control the inverter stop. All contacts (voltage-free contacts) in all braking modules may be series-connected as shown in the diagram below:

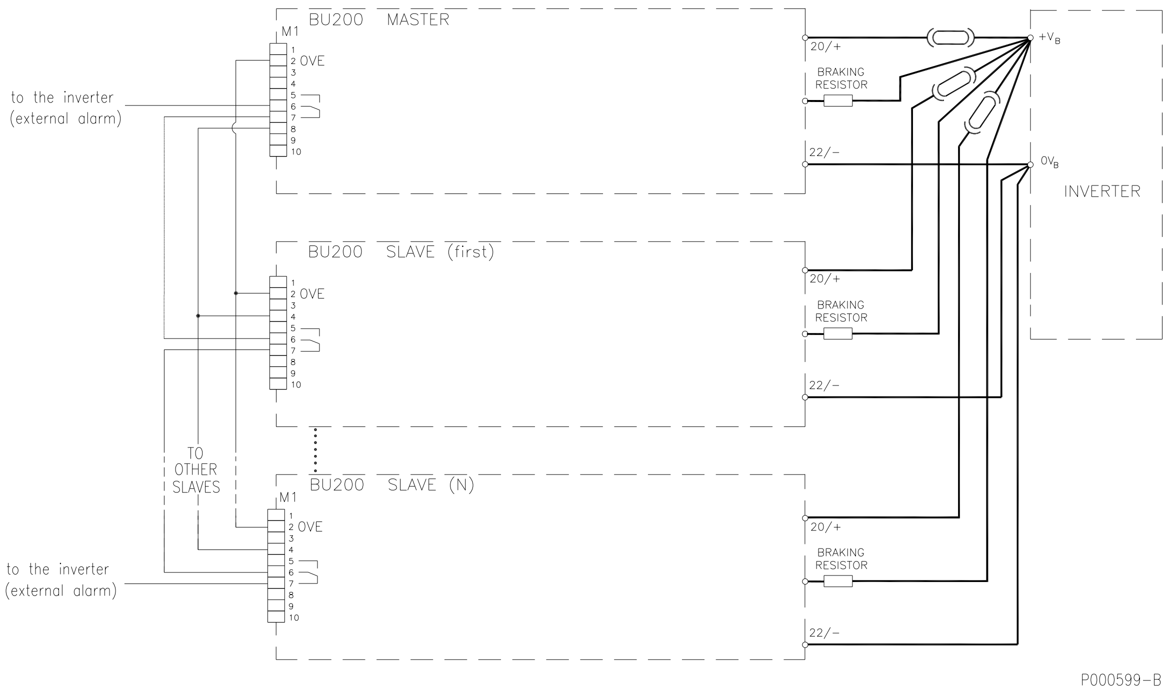


Figure 23: Master – Slave multiple connection

NOTE NEVER connect signal zero volt (terminal 2 in M1) to zero volt of the inverter power supply voltage (–).

NOTE We recommend installing a 50A fuse with DC current of at least 700 Vdc (type URDC SIBA series, NH1 fuse) provided with a safety contact.

CAUTION Link the safety contact of the fuse being used with the external alarm of BU200.

3.2.8. Earth Bonding of the BU200

For the earth bonding of the BU200, please refer to the general instructions given in section Inverter and Motor Ground Connection in the Installation Guide.

3.2.9. Scheduled Maintenance of the BU200

For the scheduled maintenance of the BU200, please refer to the general instructions given in section Inverter Scheduled Maintenance in the Installation Guide.

DANGER Once power supply has been cut off from the drive connected to the BU200, wait at least 20 minutes before operating on the DC circuits to give the capacitors time to discharge.

3.2.10. Braking Resistors for BU200 2T

Refer to the tables below for the connection of the braking resistors.

NOTE The wire cross-sections given in the table relate to one wire per braking resistor.

NOTE The Part Numbers of the braking resistors in the tables are given in the Available Braking Resistors section.

HOT SURFACE The braking resistor case may reach 200 °C based on the operating cycle.

CAUTION The cables of the braking resistors shall have insulation features and heat-resistance features suitable for the application. The minimum rated voltage of the cables must be 450/700 V.

CAUTION The power dissipated by the braking resistors may be the same as the rated power of the connected motor multiplied by the braking duty-cycle; use a proper air-cooling system. Do not install braking resistors near heat-sensitive equipment or objects.

CAUTION Do not connect to the inverter any braking resistor with an Ohm value lower than the value given in the tables.

CAUTION Never exceed the maximum operating time of the resistor as given in the Available Braking Resistors section.

3.2.10.1. Applications with DUTY CYCLE 10% - Class 2T

Size	Drive Model	Braking Unit	Braking Resistors						
			Resistors to be used				Type of connection	Value (Ω)	Wire Cross-section mm^2 (AWG/kcmils)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S41	**0180**	2	2	3.3	8	IP20	M	1.65	10(8)
	0202	2	2	3.3	8	IP20	M	1.65	10(8)
	0217	3	3	3.3	8	IP20	N	1.1	10(8)
	0260	3	3	3.3	8	IP20	N	1.1	10(8)
S51	**0313**	4	4	3.3	8	IP20	O	0.82	10(8)
	0367	5	5	3.3	8	IP20	P	0.66	10(8)
	0402	5	5	3.3	8	IP20	P	0.66	10(8)
S60	**0457**	6	6	3.3	8	IP20	Q	0.55	10(8)
	0524	6	6	3.3	8	IP20	Q	0.55	10(8)

3.2.10.2. Applications with DUTY CYCLE 20% - Class 2T

Size	Drive Model	Braking Unit	Braking Resistors							
			Resistors to be used				Type of connection	Value (Ω)	Wire Cross-section mm^2 (AWG/kcmils)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S41	0180	2	2	3.3	8	IP20	M	1.65	16(6)
	0202	2	2	3.3	8	IP20	M	1.65	16(6)
	0217	3	3	3.3	12	IP20	N	1.1	16(6)
	0260	3	3	3.3	12	IP20	N	1.1	16(6)
S51	0313	4	4	3.3	12	IP20	O	0.82	16(6)
	0367	5	5	3.3	12	IP20	P	0.66	16(6)
	0402	5	5	3.3	12	IP20	P	0.66	16(6)
S60	0457	6	6	3.3	12	IP20	Q	0.55	16(6)
	0524	6	6	3.3	12	IP20	Q	0.55	16(6)

3.2.10.3. Applications with DUTY CYCLE 50% - Class 2T

Size	Drive Model	Braking Unit	Braking Resistors						
			Resistors to be used				Type of connection	Value (Ω)	Wire Cross-section mm^2 (AWG/kcmils)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S41	0180	2	4	6.6	12	IP20	V	1.65	25(4)
	0202	2	4	6.6	12	IP20	V	1.65	25(4)
	0217	3	6	6.6	12	IP20	X	1.1	25(4)
	0260	3	6	6.6	12	IP20	X	1.1	25(4)
S51	0313	4	8	6.6	12	IP20	Y	0.82	25(4)
	0367	5	10	6.6	12	IP20	W	0.66	25(4)
	0402	5	10	6.6	12	IP20	W	0.66	25(4)
S60	0457	6	12	6.6	12	IP20	Z	0.55	25(4)
	0524	6	12	6.6	12	IP20	Z	0.55	25(4)

M-Two units, each of them including a braking module connected to its braking resistor

N-Three units, each of them including a braking module connected to its braking resistor

O-Four units, each of them including a braking module connected to its braking resistor

P-Five units, each of them including a braking module connected to its braking resistor

Q-Six units, each of them including a braking module connected to its braking resistor

V-Two units, each of them including a braking module connected to two parallel-connected braking resistors

X-Three units, each of them including a braking module connected to two parallel-connected braking resistors

Y-Four units, each of them including a braking module connected to two parallel-connected braking resistors

W-Five units, each of them including a braking module connected to two parallel-connected braking resistors

Z-Six units, each of them including a braking module connected to two parallel-connected braking resistors

⚠ **CAUTION**

The cable cross-sections given in the table relate to the cable connecting each individual braking resistor. For example, if a braking resistor is connected to N.2 parallel-connected resistors, the cable cross-section in the table is the one for each resistor connected to the braking unit.

3.2.11. Braking Resistors for BU200 4T

	NOTE	The wire cross-sections given in the table relate to one wire per braking resistor.
	NOTE	The Part Numbers of the braking resistors in the tables are given in the Available Braking Resistors section.
	CAUTION	The cables of the braking resistors shall have insulation features and heat-resistance features suitable for the application. The minimum rated voltage of the cables must be 0.6/1 kV.
	HOT SURFACE	Based on the functioning cycle, the surface of the braking resistors may reach 200 °C.
	CAUTION	The power dissipated by the braking resistors may be the same as the rated power of the connected motor multiplied by the braking duty-cycle; use a proper air-cooling system. Do not install braking resistors near heat-sensitive equipment or objects.
	CAUTION	Do not connect to the inverter any braking resistor with an Ohm value lower than the value given in the tables.
	CAUTION	Never exceed the maximum operating time of the resistor as given in the Available Braking Resistors section.

3.2.11.1. Applications with DUTY CYCLE 10% - Class 4T

Size	**Drive Model**	**Braking Unit**	**Braking Resistors**						
			Resistors to be used				**Type of Connection**	**Value (Ω)**	**Wire Cross-section mm² (AWG/kcmils)**
		Q.ty	**Q.ty**	**Recommended Value (Ω)**	**Power (kW)**	**Degree of Protection**			
S41	**0180**	2	2	6.6	12	IP20	M	3.3	16(6)
	0202	2	2	6.6	12	IP20	M	3.3	16(6)
	0217	3	3	6.6	12	IP20	N	2.2	16(6)
	0260	3	3	6.6	12	IP20	N	2.2	16(6)
S51	**0313**	3	3	6.6	12	IP20	N	2.2	16(6)
	0367	4	4	6.6	12	IP20	O	1.65	16(6)
	0402	4	4	6.6	12	IP20	O	1.65	16(6)
S60	**0457**	4	4	6.6	12	IP20	O	1.65	16(6)
	0524	5	5	6.6	12	IP20	P	1.32	16(6)
S60P	**0598P**	6	6	6.6	12	IP20	Q	1.1	16(6)

3.2.11.2. Applications with DUTY CYCLE 20% - Class 4T

Size	Drive Model	Braking Unit	Braking Resistors						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm² (AWG/kcmils)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S41	0180	2	2	6.6	24	IP23	M	3.3	16(6)
	0202	2	2	6.6	24	IP23	M	3.3	16(6)
	0217	3	3	6.6	24	IP23	N	2.2	16(6)
	0260	3	3	6.6	24	IP23	N	2.2	16(6)
S51	0313	3	3	6.6	24	IP23	N	2.2	16(6)
	0367	4	4	6.6	24	IP23	O	1.65	16(6)
	0402	4	4	6.6	24	IP23	O	1.65	16(6)
S60	0457	4	4	6.6	24	IP23	O	1.65	16(6)
	0524	5	5	6.6	24	IP23	P	1.32	16(6)
S60P	0598P	6	6	6.6	24	IP23	Q	1.1	16(6)

3.2.11.3. Applications with DUTY CYCLE 50% - Class 4T

Size	Drive Model	Braking Unit	Braking Resistors						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm² (AWG or kcmils)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S41	0180	3	3	10	24	IP23	N	3.3	16(6)
	0202	3	3	10	24	IP23	N	3.3	16(6)
	0217	4	4	10	24	IP23	O	2.5	16(6)
	0260	4	4	10	24	IP23	O	2.5	16(6)
S51	0313	5	5	10	24	IP23	P	2.0	16(6)
	0367	6	6	10	24	IP23	Q	1.7	16(6)
	0402	7	7	10	24	IP23	R	1.4	16(6)
S60	0457	7	7	10	24	IP23	R	1.4	16(6)
	0524	8	8	10	24	IP23	S	1.25	16(6)
S60P	0598P	8	8	10	24	IP23	S	1.25	16(6)

M-Two units, each of them including a braking module connected to its braking resistor
N-Three units, each of them including a braking module connected to its braking resistor
O-Four units, each of them including a braking module connected to its braking resistor
P-Five units, each of them including a braking module connected to its braking resistor
Q-Six units, each of them including a braking module connected to its braking resistor
R-Seven units, each of them including a braking module connected to its braking resistor
S-Eight units, each of them including a braking module connected to its braking resistor

CAUTION

The cable cross-sections given in the table relate to the cable connecting each individual braking resistor. For example, if a braking resistor is connected to N.2 parallel-connected resistors, the cable cross-section in the table is the one for each resistor connected to the braking unit.

3.3. Braking Units for S41..S52 and Their Parallel Configuration and Drives S60-S60P (BU600 4T-5T-6T)

The BU600 4T-5T-6T braking unit is available for the following sizes:

- S41 / S42 / S51 / S52;
- Parallel configuration of S43 (2 x S41) / S53 (2 x S51) / S55 (3 x S51) / S44 (2 x S42) / S54 (2 x S52) / S56 (3 x S52);
- S60 / S60P.

The BU600 may also be used as a stand-alone braking unit to be connected to a suitable DC BUS.

The BU600 is an Open Type Equipment – degree of protection IP00 – that can be installed inside another enclosure featuring degree of protection IP3X as a minimum requirement.
Transporting, handling and unpacking the braking unit is covered in the general instructions given in the "Transport and Handling" and "Unpacking" sections in the Installation Guide.

3.3.1. Delivery Check

Make sure that the equipment is not damaged and that it complies with the equipment you ordered by referring to the nameplate located on the inverter front part (see figure below). If the equipment is damaged, contact the supplier or the insurance company concerned. If the equipment does not comply with the one you ordered, please contact the supplier as soon as possible.
If the equipment is stored before being started, make sure that temperatures range from –25 °C to +70 °C and that relative humidity is <95% (non-condensing).
The equipment guarantee covers any manufacturing defect. The manufacturer has no responsibility for possible damages occurred while shipping or unpacking the equipment. The manufacturer is not responsible for possible damages or faults caused by improper and irrational uses; wrong installation; improper conditions of temperature, humidity, or the use of corrosive substances. The manufacturer is not responsible for possible faults due to the equipment operation at values exceeding the equipment ratings. The manufacturer is not responsible for consequential and accidental damages.
The braking unit is covered by a two-year guarantee starting from the date of delivery.

3.3.1.1. Nameplate for BU600 4T-5T-6T

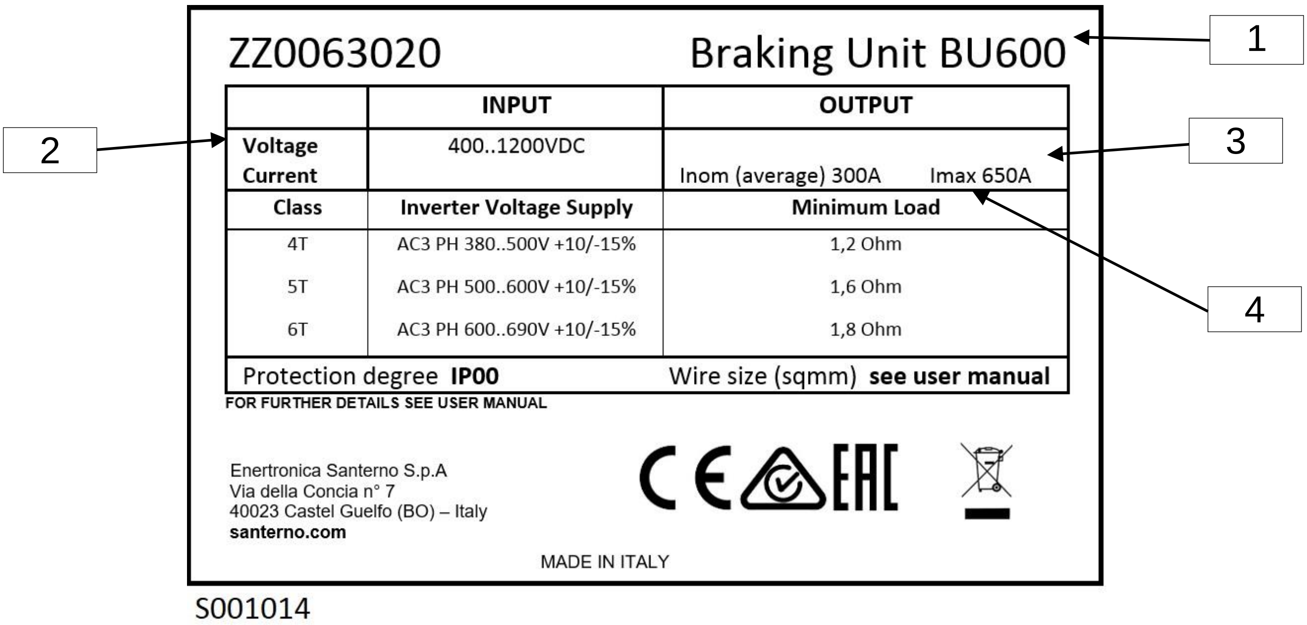


Figure 24: Nameplate for BU600 4T-5T-6T

1.	Model:	BU600 – Braking module 4T-5T-6T
2.	Supply ratings:	DC supply voltage deriving directly from the inverter terminals or the DC Bus connected to the BU600)
3.	Output current:	300A (average) – continuous average current in output cables 600A (max.) – max. current in output cables (may be held for all the time given in column “Max. Duration of Continuous Operation” in the resistors tables below)
4.	Min. load:	Minimum value of the resistor to be connected to the output terminals (see application tables below)

3.3.2. Operating Mode of the BU600 Connected to Drives S41..S52 and their Configuration in Parallel

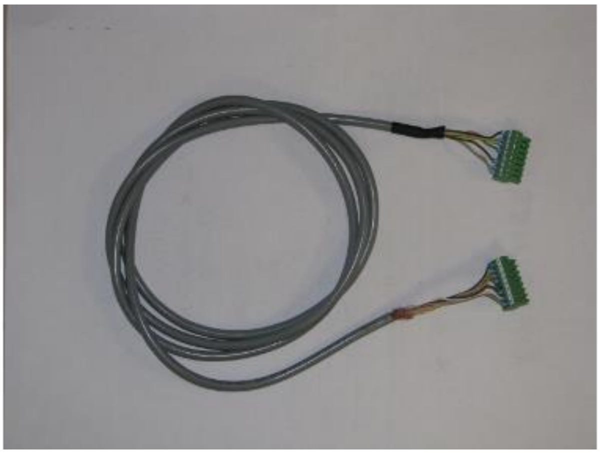
As a factory setting, the braking module is powered and controlled directly by the inverter (parameter P200=2:Slave) [*].

NOTE As a factory setting, the signals on terminal M1 of the braking module are to be connected to the signals on the BRAKE connector of the inverter using the cable supplied.

[*] NOTE If this factory setting it so be changed, alter parameter P200 from the RemoteDrive (see BU600 – Programming Guide).

S000135

Figure 25: **BRAKE connector supplied with the drive**



S000136

Figure 26: Cable connecting the drive to braking unit BU600

3.3.3. Operating Mode of the BU600 when Connected to S60 and S60P Drives or a DC-BUS Made UP of Sinus Penta /Penta Marine Drives from Different Sizes

The braking unit operates independently, i.e. it is not powered and controlled by the drive.

NOTE In order to make the braking unit operate independently, access the RemoteDrive and change parameter **P200** from 2:Slave to 1:Master; also, change parameters **P201** and **P202** based on the voltage class of the connected drive (see BU600 – Programming Guide).
This voltage class is 4T for S60 and S60P drives.

NOTE The cable supplied is not required.

Parameters **P201** and **P202** are to be changed in case of applications that for 4T class drives require rated drive supply voltage exceeding 480Vac or that are power supplied by the DC bus from the Regenerative drive. In any case, braking voltage and hysteresis must be consistent with drive parameter **C008** (see the Programming Guide).

Sinus Penta / Penta Marine Parameter	**BU600 Parameters**			
C008	**P001 Voltage Class**	**P200 Operating Mode**	**P201 Braking voltage (V)**	**P202 Hysteresis (V)**
0: [200 ÷ 240] V 1: 2T Regen.	Not considered	---------------	--------------------	-------------------
2: [380 ÷ 480] V 3: [481 ÷ 500] V 4: 4T Regen.	4T	0: Master+Slave 1: Master 2: Slave (default)	764.6 (default)	5 (default)
5: [500 ÷ 575] V 6: 5T Regen.	5T	0: Master+Slave 1: Master 2: Slave (default)	956.2 (default)	10 (default)
7: [575 ÷ 690] V 8: 6T Regen	6T	0: Master+Slave 1: Master 2: Slave (default)	1103.2 (default)	10 (default)

3.3.4. BU600 Used as a General-purpose Braking Unit to be Connected to a DC-Bus

The BU600 may be used in all applications featuring a DC-Bus from which energy is to be taken during particular working conditions (presence of alternating loads, electric traction, lifting, etc..). This operating mode is available, but is to be authorized by Enertronica Santerno S.p.A..

3.3.5. Diagnostics

The following diagnostic LEDs are provided:

S000134

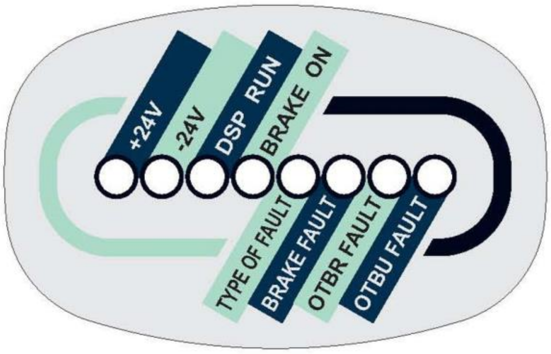


Figure 27: Diagnostic LEDs

+24V, –24V: Both **"**ON" when the braking unit is powered on
DSP RUN [*]: "ON" when the on-board microcontroller is on
BRAKE ON: "ON" when the braking IGBT is ON
TYPE OF FAULT [*]: Coding of the active fault indicated by the flashing LED. Please refer to the BU600 – Programming Guide.
BRAKE FAULT: "ON" together with one of **TYPE OF FAULT**, **OTBR FAULT** and **OTBU FAULT** when a fault occurs.
It turns off only when the RESET input in terminal board M2 is activated.
OTBR FAULT: Thermoswitch tripped ("ON" in conjunction with **BRAKE FAULT**). Alarm ID = A006.
It turns off when the fault condition is reset.
OTBU FAULT: IGBT thermal protection tripped ("ON" in conjunction with **BRAKE FAULT**). Alarm ID = A003.
It turns off when the fault condition is reset.

[*] NOTE This function is available from software version 1.000.

Event	Description	Alarm ID	Flashing	OFF
Alarm	User alarm	A001	Always on	
Alarm	Checksum Fault	A002	Always on	
Alarm	Watchdog Fault	A013	Always on	
Alarm	Brake short circuit	A011	1 blink at 1 Hz	4.5 s
Alarm	IGBT fault	A004	2 blinks at 1 Hz	4.5 s
Alarm	HW Overcurrent	A005	3 blinks at 1 Hz	4.5 s
Alarm	Overvoltage	A012	4 blinks at 1 Hz	4.5 s
Alarm	Driver board overtemperature	A008	5 blinks at 1 Hz	4.5 s
Alarm	DSP overtemperature	A009	5 blinks at 1 Hz	4.5 s
Alarm	DC Link Undervoltage	A007	6 blinks at 1 Hz	4.5 s
Warning	Fan1 inactive	W001	7 blinks at 1 Hz	4.5 s
Warning	Fan2 inactive	W002	8 blinks at 1 Hz	4.5 s
Warning	Heatsink overheated	W003	9 blinks at 1 Hz	4.5 s

Table 3: Alarm ID and Type of fault on BU600 with the TYPE OF FAULT LED

3.3.6. Specifications

MODEL	Max. Braking Current (A)	Average Braking Current (A)	Drive Supply Voltage	Min. Braking Resistor (Ω)	Power Dissipated (at Average Braking Current) (W)	Sound Pressure (dB)
BU600 4T	650	300	380-500 Vac	1.2	700	60
BU600 5T	650	300	500-600 Vac	1.6	700	60
BU600 6T	600	300	600-690 Vac	1.8	700	60

3.3.7. Installing the BU600

3.3.7.1. Environmental Requirements for the BU600 Installation, Storage and Transport

Maximum surrounding air temperature	–10 to +40 °C with no derating From +40 °C to +55 °C with a 2% derating of the rated current for each degree beyond +40 °C.
Ambient temperatures for storage and transport	–25 °C to +70 °C
Installation environment	Pollution degree 2 or better (according to EN 61800-5-1). Do not install in direct sunlight and in places exposed to conductive dust, corrosive gases, vibrations, water sprinkling or dripping; do not install in salty environments.
Altitude	Max. altitude for installation 2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A. Above 1000 m, derate the rated current by 1% every 100 m.
Operating ambient humidity	From 5% to 95%, from 1 g/m³ to 29 g/m³, non-condensing and non-freezing (class 3K3 according to EN 61800-5-1).
Storage ambient humidity	From 5% to 95%, from 1 g/m³ to 29 g/m³, non-condensing and non-freezing (class 1K3 according to EN 61800-5-1).
Ambient humidity during transport	Max. 95%, up to 60 g/m³; condensation may appear when the equipment is not running (class 2K3 according to EN 61800-5-1).
Storage and operating atmospheric pressure	From 86 to 106 kPa (classes 3K3 and 1K4 according to EN 61800-5-1).
Atmospheric pressure during transport	From 70 to 106 kPa (class 2K3 according to EN 61800-5-1).

CAUTION Ambient conditions strongly affect the inverter life. Do not install the equipment in places that do not have the above-mentioned ambient conditions.

3.3.7.2. Mounting the Braking Unit

The braking unit BU600 must be installed in upright position inside a cabinet. Its overall dimensions and fixing points are given in the figure below.

Dimensions (mm)			Fixing Points (mm)				Type of Screws	Weight (kg)
W	H	D	X	Y	D1	D2	M8-M10	72
248	881.5	399	170	845	12	24		

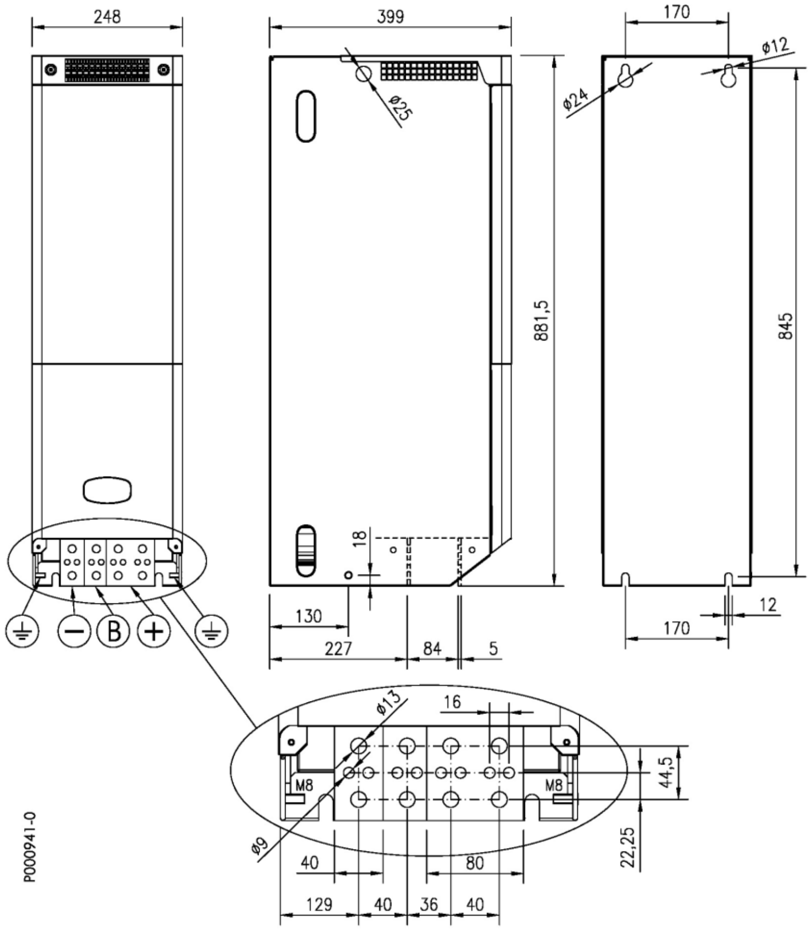


Figure 28: Dimensions and fixing points of braking unit BU600

The location of the BU600 units inside the cabinet is dependent on the number of BUs to be installed.
A general criterion is to try to shorten the DC-bus connections as much as possible and to balance power absorption from the BU600 units and the relative braking resistors.

- N.1 BU600 connected to S41, S42, S51, S52, S43 (2 x S41), S44 (2 x S42), S53 (2 x S51) up to size 0749 included, S60 and S60P

It is recommended that the BU600 is installed on the left of the drives.

- N.2 BU600 units connected to S53 (2 x S51) from 0832 included, S55 (3 x S51), S54 (2 x S52) and to S56 (3 x S52) up to size 0960 included

Recommended installation:
The first BU600 on the left of the drives, and the second BU600 between the two drives for the sizes that require two drives;
The first BU600 on the left of the drives, and the second BU600 between the second and the third drive for the sizes that require three drives.

- N.3 BU600 connected to S56 (3 x S52) size 1120:

Recommended installation:
The first BU600 on the left of the drives, the second BU600 between the first and the second drive, the third BU600 between the second and the third drive.

3.3.7.3. Lay-Out of Power Terminals and Signal Terminals

Power connections

Link the braking module to the inverter and to the braking resistor as described below.

Decisive voltage class C according to EN 61800-5-1

Terminal	Type	Tightening Torque (Nm)	Connection Bar Cross-section mm^2 (AWG/kcmils)	NOTES
+	Bus bar	30	240 (500kcmils)	To be connected to terminal 47/+ of the inverter and to one terminal of the braking resistor
B	Bus bar	30	See Resistors Table	To be connected to the remaining terminal of the braking resistor
–	Bus bar	30	240 (500kcmils)	To be connected to terminal 49/– of the inverter

Table 4: BU600 Power terminals

Figure 29: Power terminals

Signal connections

Terminals M1 – Connect to the inverter using the cable supplied.

Terminal board specifications

Cable cross-section fitting the terminal mm² (AWG)	Tightening torque (Nm)
0.25÷1.5 (24-16)	0.22-0.25

Decisive voltage class A according to EN 61800-5-1

N.	Name	Description	I/O Features	Slave connected to S41, S42, S51, S52	Master connected to S60-S60P or a general-purpose DC-bus	Slave connected to another BU600
1	**BRAKE**	Braking unit command signal	0-24V (active at +24V)	To be connected to the brake terminals of the inverter using the cable supplied	Do not connect	To be connected to terminal 5 in the Master BU600
2	**0V**	Ground	0V		To be connected to terminal 2 in another BU600 (if any) operating in parallel	To be connected to terminal 2 in the Master BU600
3	**BRERR**	Braking unit tripped	0-24V (to +24V with braking unit tripped)		To be used by a controller (if any) of the application	To be used by a controller (if any) of the application
4	**BU_PRES**	Braking unit present and ready to operate	0-24V (to +24V with braking unit present and ready to operate)			
5	**SLAVE**	Braking in progress	0-24V (to +24V with BU600 that is braking)		To be connected to terminal 1 in another BU600 (if any) operating in parallel	To be connected to terminal 1 in another BU600 (if any) operating in parallel
6	**0V**	Ground	0V	Ground	Ground	Ground
7	**CANL**	Unavailable	-	-	-	-
8	**CANH**		-	-	-	-

Terminals M2
Decisive voltage class A according to EN 61800-5-1

N.	Name	Description	I/O Features	NOTES	Cable Cross-section Fitting the Terminal mm² (AWG)	Tightening Torque (Nm)
9	**24VE**	Auxiliary 24V voltage generated internally to the braking module	24V 100mA	Available to send the Reset signal	0.25÷1.5 (24-16)	0.22-0.25
10	**RESET**	Braking module fault reset command	0-24V (active at 24V)	To be connected to +24VE by means of a push-button for fault reset	0.25÷1.5 (24-16)	0.22-0.25
11	**24VE**	Auxiliary 24V voltage generated internally to the braking module	24V 10mA	To be connected to the thermoswitch in the braking resistor [*]	0.25÷1.5 (24-16)	0.22-0.25
12	**PTR**	Input for the braking resistor thermoswitch	0-24V (with +24V braking resistor OK)	To be connected to the thermoswitch in the braking resistor [*]	0.25÷1.5 (24-16)	0.22-0.25

[*] NOTE If more than one braking resistor is connected to the BU600, all the thermoswitches are to be series-connected. The thermoswitches are to be normally closed.

Terminals M3 (functions available from SW version 1.000)
Decisive voltage class C according to EN 61800-5-1

N.	Name	Description	I/O Features	NOTES	Cable Cross-section Fitting the Terminal mm² (AWG/kcmils)	Tightening Torque (Nm)
13	**RL1-NC**	Braking unit present and ready to operate	6A/250Vac 6A/30Vdc	Relay energized with braking unit present and ready to operate. The relay reproduces the status of terminal 4 in M1.	0.2÷2.5 (24-14)	0.5-0.6
14	**RL1-C**					
15	**RL1-NO**					

Terminals M4 (functions available from SW version 1.000)
Decisive voltage class C according to EN 61800-5-1

N.	Name	Description	I/O Features	NOTES	Cable Cross-section Fitting the Terminal mm² (AWG/kcmils)	Tightening Torque (Nm)
16	**RL2-NO**	Braking unit tripped [*]	6A/250Vac 6A/30Vdc	Relay energized with braking unit tripped. The relay reproduces the status of terminal 3 in M1. It is recommended to use this relay to protect the braking resistors in case of BU600 failure.	0.2÷2.5 (24-14)	0.5-0.6
17	**RL2-C**					
18	**RL2-NC**					

[*] NOTE As factory default, the relay energizes only if alarm **A011** (Braking Unit Short-circuit) has tripped. See BU600 – Programming Guide.
Set **P103** = 1 to energize the relay in case of any alarm.

Serial port
Decisive voltage class A according to EN 61800-5-1

The BU600 features RS-485 serial interface; for details on serial communications, please refer to the Serial Communications section in this manual and to the BU600 – Programming Guide.

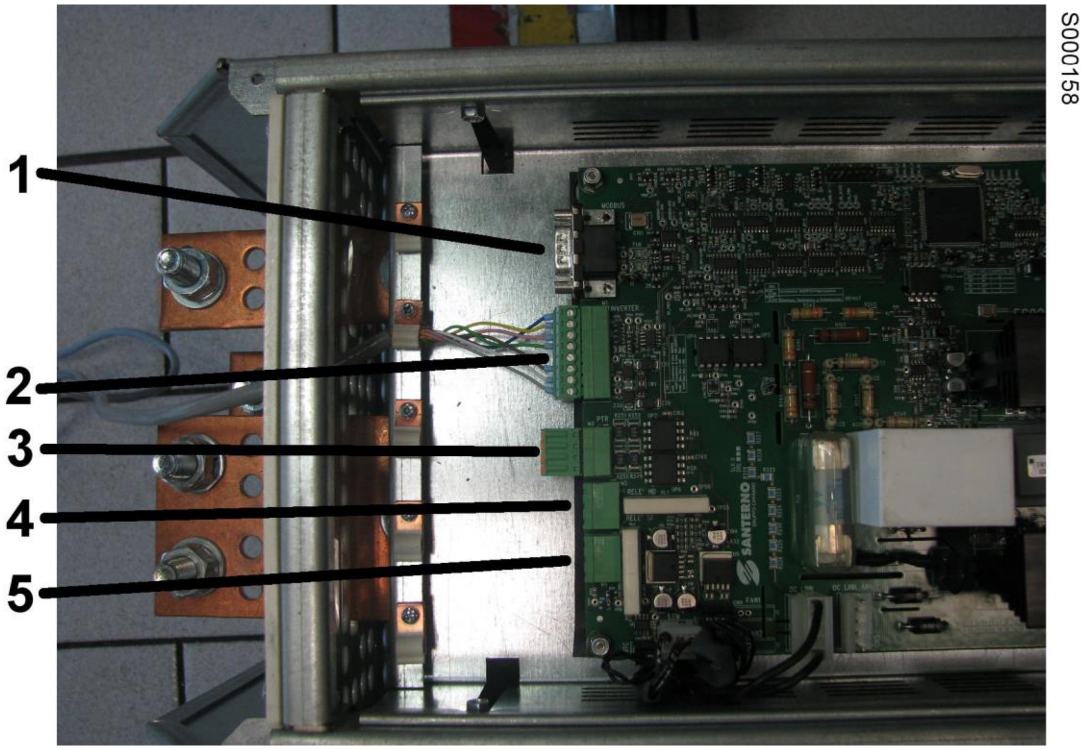


Figure 30: Signal terminals in the BU600

1. Serial port [*]
2. M1 - BRAKE terminals
3. M2 - Reset signal
4. M3 - BU detecting relay [*]
5. M4 - Alarm relay [*]

NOTE [*] Functions available from SW version 1.000.

3.3.7.4. Wiring Diagram of a BU600 Operating as a Slave

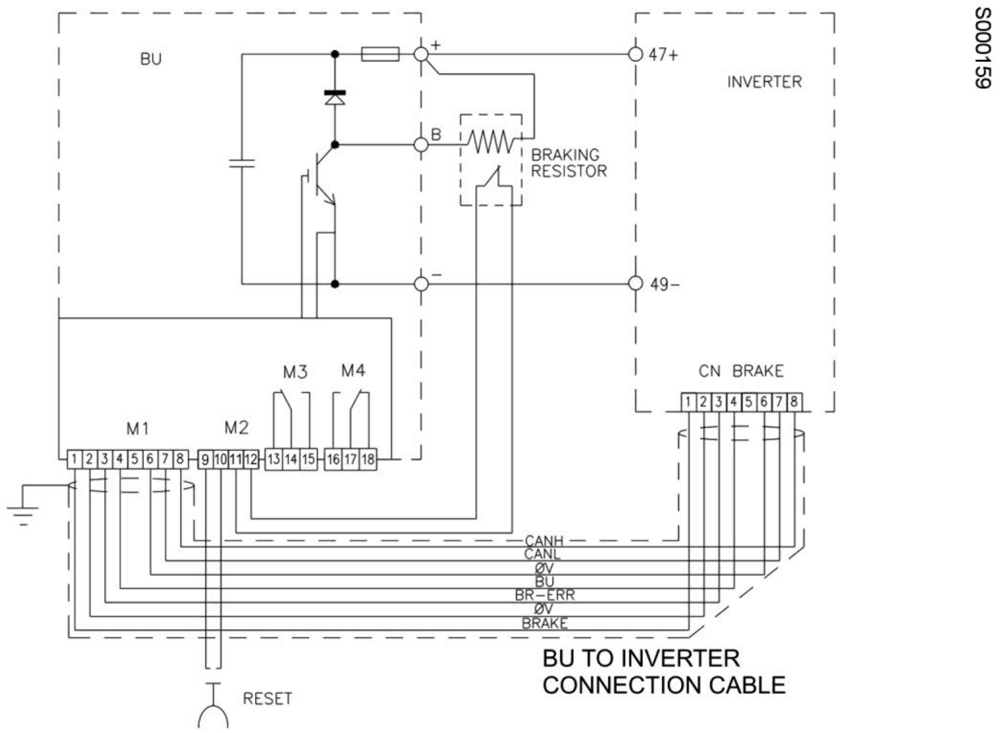


Figure 31: Wiring diagram of a single drive with braking unit BU600

3.3.7.5. Wiring Diagram of Two BU600 Operating as Slaves

Figure 32 and Figure 33 show the wiring diagram and the location of N.2 BU600 4T operating as slaves for SINUS PENTA/PENTA MARINE S51 drives operating in parallel.

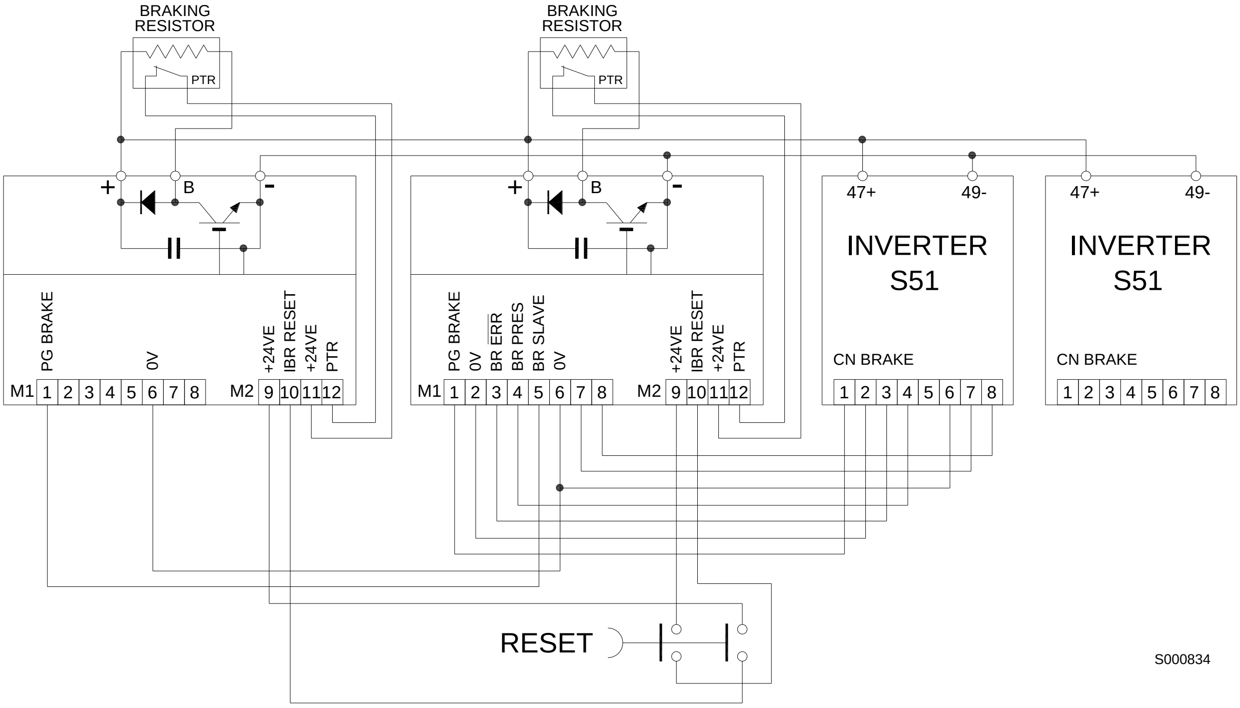


Figure 32: Signal connections of two BU600 operating as slaves

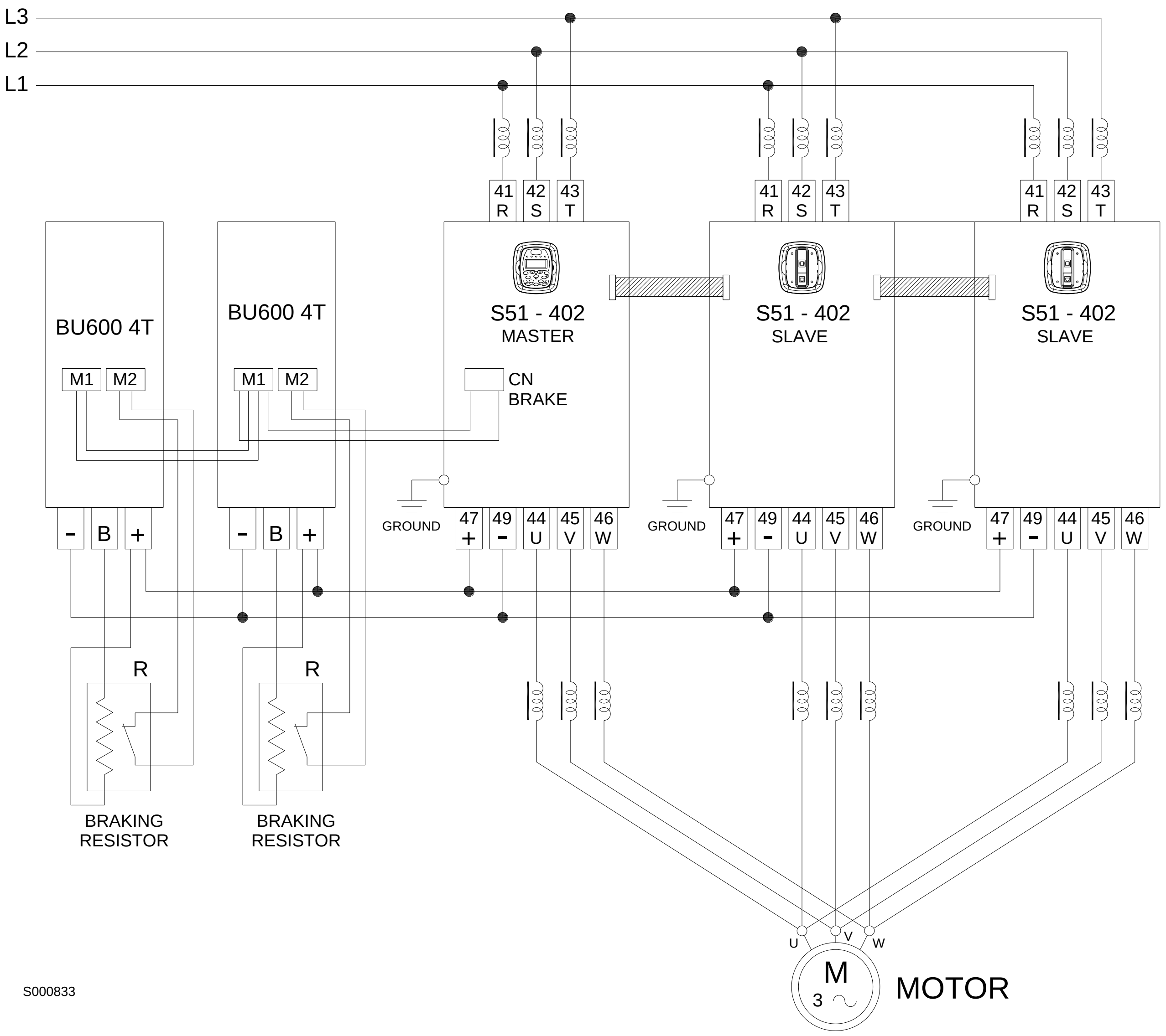


Figure 33: Power connections and layout of two BU600 operating as slaves

3.3.8. Earth Bonding of the BU600

For the earth bonding of the BU600, please refer to the general instructions given in section Inverter and Motor Ground Connection in the Installation Guide.

3.3.9. Protecting the Braking Resistors

Based on their power and energy ratings, the braking resistors are capable of withstanding a maximum allowable power-on time and a given duty cycle. When operating as slaves, in order not to overload the resistors, the maximum allowable power-on time and a given duty cycle are to be set for the drive controlling braking cycle (see the Available Braking Resistors section and the Programming Guide).

This solution might not be sufficient to protect the braking resistors. The following actions are therefore required:

- Always connect the braking resistor thermoswitch to prevent overheating from occurring due to poor air circulation or wrong setting of the maximum duty cycle parameter;
- Use the safety relay to cut off the power supply to the DC-bus connected to the braking module. Should a short-circuit occur in the braking module, the braking resistors and the relevant connection cables are always live on the DC bus, thus leading to melting risk.

DANGER

Should a short-circuit occur in the braking module, the braking resistors and the relevant connection cables are always live on the DC bus, thus leading to melting risk and fire risk.
Always make sure that a method to cut off power supply from the DC bus is available in case of short-circuit of the braking module.

3.3.10. Scheduled Maintenance of the BU600

For the scheduled maintenance of the BU600, please refer to the general instructions given in section Inverter and Motor Ground Connection in the Installation Guide.

DANGER

Once power supply has been cut off from the drive connected to the BU600, wait at least 20 minutes before operating on the DC circuits to give the capacitors time to discharge.

3.3.11. Braking Resistors to be Applied to BU600 4T

NOTE The wire cross-sections given in the table relate to one wire per braking resistor.

NOTE The Part Numbers of the braking resistors in the tables are given in the Available Braking Resistors section.

HOT SURFACE The braking resistor case may reach 200 °C based on the operating cycle.

CAUTION The cables of the braking resistors shall have insulation features and heat-resistance features suitable for the application. The minimum rated voltage of the cables must be 0.6/1 kV.

CAUTION The power dissipated by the braking resistors may be the same as the rated power of the connected motor multiplied by the braking duty-cycle; use a proper air-cooling system. Do not install braking resistors near heat-sensitive equipment or objects.

CAUTION Do not connect to the inverter any braking resistor with an Ohm value lower than the value given in the tables.

CAUTION Never exceed the maximum operating time of the resistor as given in the Available Braking Resistors section.

3.3.11.1. Applications with DUTY CYCLE 10% - Class 4T

DRIVE SIZE	Drive Model	Braking Unit	Braking Resistors						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm^2 (AWG)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S41	**0180**	1	1	3.6	16	IP23	A	3.6	25(4)
	0202	1	1	3.0	24	IP23	A	3.0	25(4)
	0217	1	1	2.4	24	IP23	A	2.4	35(3)
	0260	1	1	2.4	32	IP23	A	2.4	35(3)
S51	**0313**	1	1	1.8	32	IP23	A	1.8	50(1/0)
	0367	1	1	1.8	32	IP23	A	1.8	50(1/0)
	0402	1	1	1.4	48	IP23	A	1.4	70(2/0)
S60	**0457**	1	1	1.4	48	IP23	A	1.4	70(2/0)
	0524	1	1	1.2	48	IP23	A	1.2	95(3/0)
S60P	**0598P**	1	1	1.2	64	IP23	A	1.2	95(3/0)
S43 (2 x S41)	**0523**	1	1	1.2	48	IP23	A	1.2	95(3/0)
S53 (2 x S51)	**0599**	1	1	1.2	64	IP23	A	1.2	95(3/0)
	0749	1	1	1.2	64	IP23	A	1.2	95(3/0)
	0832	2	2	1.6	48	IP23	A	0.8	70(1/0)
S55 (3 x S51)	**0850**	2	2	1.4	48	IP23	A	0.7	70(2/0)
	0965	2	2	1.2	48	IP23	A	0.6	95(3/0)
	1129	2	2	1.2	64	IP23	A	0.6	95(3/0)

3.3.11.2. *Applications with DUTY CYCLE 20% - Class 4T*

DRIVE SIZE	Drive Model	Braking Unit	Braking Resistors						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm^2 (AWG)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S41	0180	1	1	3.6	32	IP23	A	3.6	16(6)
	0202	1	1	3.0	48	IP23	A	3.0	25(3)
	0217	1	1	2.4	48	IP23	A	2.4	50(1/0)
	0260	1	1	2.4	64	IP23	A	2.4	50(1/0)
S51	0313	1	1	1.8	64	IP23	A	1.8	95(3/0)
	0367	1	1	1.8	64	IP23	A	1.8	95(3/0)
	0402	1	2	2.8	48	IP23	B	1.4	50(1)
S60	0457	1	2	2.8	48	IP23	B	1.4	50(1)
	0524	1	2	2.4	48	IP23	A	1.2	50(1/0)
S60P	0598P	1	2	2.4	64	IP23	A	1.2	50(1/0)
S43 (2 x S41)	0523	1	2	2.4	48	IP23	A	1.2	50(1/0)
S53 (2 x S51)	0599	1	2	2.4	64	IP23	A	1.2	50(1/0)
	0749	1	2	2.4	64	IP23	A	1.2	50(1/0)
	0832	2	4	3.6	32	IP23	B	0.9	25(3)
S55 (3 x S51)	0850	2	4	2.8	48	IP23	B	0.7	50(1)
	0965	2	4	2.4	48	IP23	B	0.6	50(1/0)
	1129	2	4	2.4	48	IP23	B	0.6	50(1/0)

3.3.11.3. *Applications with DUTY CYCLE 50% - Class 4T*

DRIVE SIZE	Drive Model	Braking Unit	Braking Resistors						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm^2 (AWG)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S41	0180	1	2	6.6	48	IP23	B	3.3	25(3)
	0202	1	2	6.0	64	IP23	B	3.0	35(2)
	0217	1	2	5.0	64	IP23	B	2.5	35(2)
	0260	1	2	5.0	64	IP23	B	2.5	35(2)
S51	0313	1	3	0.6	48	IP23	C	1.8	240(350)
	0367	1	3	0.6	64	IP23	C	1.8	240(350)
	0402	1	4	1.4	64	IP23	D	1.4	95(3/0)
S60	0457	1	4	1.4	64	IP23	D	1.4	95(3/0)
	0524	1	4	1.2	64	IP23	D	1.2	120(4/0)
S60P	0598P	1	4	1.2	64	IP23	D	1.2	120(4/0)
S43 (2 x S41)	0523	1	4	1.2	64	IP23	D	1.2	120(4/0)
S53 (2 x S51)	0599	1	4	1.2	64	IP23	D	1.2	120(4/0)
	0749	1	4	1.2	64	IP23	D	1.2	120(4/0)
	0832	2	6	5.0	64	IP23	B	0.83	35(2)
S55 (3 x S51)	0850	2	6	4.2	64	IP23	B	0.7	50(1)
	0965	2	8	1.2	64	IP23	D	0.6	120(4/0)
	1129	2	8	1.2	64	IP23	D	0.6	120(4/0)

Type of connection:

A - One resistor only
B - Two or more parallel-connected resistors
C - Two or more series-connected resistors
D - Four resistors (parallel connection of two series of two resistors)

CAUTION

The wire cross-sections given in the table relate to one wire per braking resistor. For example, if two resistors are connected in parallel to a braking unit, the cross-section in the table is related to the cable connecting each resistor to the module. In case of a different wiring diagram, the cross-section is to be recalculated based on the RMS of the current flowing in the cable.

NOTE

If the BU600 is connected to parallel-connected inverters (2 x S41, 2 x S51 and 3 x S51), the number of BUs required and given in the table is the total number of BUs, *not* the number of BUs for each individual inverter in the parallel-connected configuration.

3.3.12. Braking Resistors to be Applied to BU600 5T-6T

NOTE	The wire cross-sections given in the table relate to one wire per braking resistor.
NOTE	The Part Numbers of the braking resistors in the tables are given in the Available Braking Resistors section.
HOT SURFACE	The braking resistor case may reach 200 °C based on the operating cycle.
CAUTION	The cables of the braking resistors shall have insulation features and heat-resistance features suitable for the application. The minimum rated voltage of the cables must be 0.6/1 kV.
CAUTION	The power dissipated by the braking resistors may be the same as the rated power of the connected motor multiplied by the braking duty-cycle; use a proper air-cooling system. Do not install braking resistors near heat-sensitive equipment or objects.
CAUTION	Do not connect to the inverter any braking resistor with an Ohm value lower than the value given in the tables.
CAUTION	Never exceed the maximum operating time of the resistor as given in the Available Braking Resistors section.

3.3.12.1. Applications with DUTY CYCLE 10% - Class 5T

DRIVE SIZE	Drive Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm² (AWG)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S42	**0181**	1	1	4.2	32	IP23	A	4.2	25(3)
	0201	1	1	3.6	32	IP23	A	3.6	35(2)
	0218	1	1	3.6	32	IP23	A	3.6	35(2)
	0259	1	1	3.0	32	IP23	A	3.0	35(2)
S52	**0290**	1	1	3.0	32	IP23	A	3.0	70(2/0)
	0314	1	1	2.4	48	IP23	A	2.4	70(2/0)
	0368	1	1	2.4	48	IP23	A	2.4	70(2/0)
	0401	1	1	1.8	64	IP23	A	1.8	95(3/0)
S44 (2xS42)	**0459**	1	1	1.6	64	IP23	A	1.6	95(3/0)
S54 (2xS52)	**0526**	2	2	2.8	48	IP23	A	1.4	35(2)
	0600	2	2	2.4	48	IP23	A	1.2	50(1)
	0750	2	2	2.1	48	IP23	A	1.05	70(1/0)
	0828	2	2	1.8	48	IP23	A	0.9	70(2/0)
S56 (3xS52)	**0960**	2	2	1.6	64	IP23	A	0.8	95(3/0)
	1128	3	3	1.8	64	IP23	A	0.8	70(2/0)

3.3.12.2. Applications with DUTY CYCLE 50% - Class 5T

DRIVE SIZE	Drive Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm² (AWG)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S42	**0181**	1	4	4.2	32	IP23	D	4.2	35(2)
	0201	1	4	3.6	48	IP23	D	3.6	50(1/0)
	0218	1	4	3.6	48	IP23	D	3.6	50(1/0)
	0259	1	4	3.0	48	IP23	D	3.0	70(2/0)
S52	**0290**	1	4	2.4	48	IP23	D	2.4	70(2/0)
	0314	1	4	2.4	48	IP23	D	2.4	70(2/0)
	0368	1	4	2.4	64	IP23	D	2.4	70(2/0)
	0401	1	4	1.8	64	IP23	D	1.8	95(4/0)
S44 (2xS42)	**0459**	1	6	2.4	48	IP23	E	1.6	50(1/0)
S54 (2xS52)	**0526**	2	6	8.2	64	IP23	B	1.37	70(2/0)
	0600	2	6	6.6	64	IP23	B	1.1	35/(3)
	0750	2	8	2.1	64	IP23	C	1.05	70(2/0)
	0828	2	8	1.8	64	IP23	C	0.9	95(3/0)
S56 (3xS52)	**0960**	2	10	0.3	64	IP23	C	0.75	2x120/(2x4/0)
	1128	3	12	1.8	64	IP23	D	0.6	95(3/0)

Type of connection:

A - One resistor per braking unit
B - Two or more parallel-connected resistors per braking unit
C - Two or more series-connected resistors per braking unit
D - For resistors per braking unit (parallel connection of two series of two resistors)
E - Six resistors per braking unit (parallel connection of three series of two resistors)
G - Six resistors (parallel connection of two series of three resistors) per braking unit

CAUTION

The wire cross-sections given in the table relate to one wire per braking resistor. For example, if two resistors are connected in parallel to a braking unit, the cross-section in the table is related to the cable connecting each resistor to the module. In case of a different wiring diagram, the cross-section is to be recalculated based on the RMS of the current flowing in the cable.

NOTE

If the BU600 is connected to parallel-connected inverters (2 x S44, 2 x S52 and 3 x S52), the number of BUs required and given in the table is the total number of BUs, *not* the number of BUs for each individual inverter in the parallel-connected configuration.

3.3.12.3. Applications with DUTY CYCLE 10% - Class 6T

DRIVE SIZE	Drive Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm² (AWG)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S42	**0181**	1	1	5.0	32	IP23	A	5.0	25(3)
	0201	1	1	3.6	32	IP23	A	3.6	35(2)
	0218	1	1	3.6	32	IP23	A	3.6	35(2)
	0259	1	1	3.6	48	IP23	A	3.6	70(2/0)
S52	**0290**	1	1	3.0	48	IP23	A	3.0	70(2/0)
	0314	1	1	2.4	48	IP23	A	2.4	70(2/0)
	0368	1	1	2.4	64	IP23	A	2.4	95(4/0)
	0401	1	1	1.8	64	IP23	A	1.8	120(250)
S44 (2xS42)	**0459**	1	2	3.6	48	IP23	B	1.8	35(3)
S54 (2xS52)	**0526**	2	2	2.8	48	IP23	A	1.4	50(1)
	0600	2	2	2.8	48	IP23	A	1.4	50(1)
	0750	2	2	2.4	48	IP23	A	1.2	70(1/0)
	0828	2	2	1.8	64	IP23	A	0.9	95/(3/0)
S56 (3xS52)	**0960**	2	2	1.8	64	IP23	A	0.9	95(3/0)
	1128	3	3	2.1	64	IP23	A	0.7	70(2/0)

3.3.12.4. *Applications with DUTY CYCLE 20% - Class 6T*

SIZE	Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm^2 (AWG)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S42	**0181**	1	1	5.0	48	IP23	A	4.2	50(1/0)
	0201	1	1	3.6	64	IP23	A	3.6	50(1/0)
	0218	1	1	3.6	64	IP23	A	3.6	50(1/0)
	0259	1	2	6.6	48	IP23	B	3.3	25(3)
S52	**0290**	1	2	6.0	48	IP23	B	3.0	35(2)
	0314	1	2	5.0	48	IP23	B	2.5	35(2)
	0368	1	2	5.0	64	IP23	B	2.5	50(1/0)
	0401	1	2	3.6	64	IP23	B	1.8	70(2/0)
S44 (2xS42)	**0459**	1	2	3.6	64	IP23	B	1.8	50(1)
S54 (2xS52)	**0526**	2	2	2.8	64	IP23	A	1.4	70(2/0)
	0600	2	4	1.4	48	IP23	C	1.4	70(2/0)
	0750	2	4	1.2	48	IP23	C	1.2	95(4/0)
	0828	2	4	3.6	64	IP23	B	0.9	50(1/0)
S56 (3xS52)	**0960**	2	4	3.6	64	IP23	B	0.9	50(1/0)
	1128	3	6	4.2	64	IP23	B	0.7	95(4/0)

3.3.12.5. Applications with DUTY CYCLE 50% - Class 6T

SIZE	Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm² (AWG)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S42	**0181**	1	4	5	32	IP23	D	5.0	25(3)
	0201	1	4	3.6	48	IP23	D	3.6	70(2/0)
	0218	1	4	3.6	48	IP23	D	3.6	70(2/0)
	0259	1	4	3.6	48	IP23	D	3.6	70(2/0)
S52	**0290**	1	4	2.8	64	IP23	D	2.8	70(2/0)
	0314	1	4	2.4	64	IP23	D	2.4	70(2/0)
	0368	1	4	2.4	64	IP23	D	2.4	120(250)
	0401	1	4	1.8	64	IP23	D	1.8	120(250)
S44 (2xS42)	**0459**	1	2	1.2	64	IP23	G	1.8	95(4/0)
S54 (2xS52)	**0526**	2	8	2.8	64	IP23	D	1.4	50(1/0)
	0600	2	8	2.8	64	IP23	D	1.4	50(1/0)
	0750	2	8	2.4	64	IP23	D	1.2	70(2/0)
	0828	2	8	1.8	64	IP23	D	0.9	95(4/0)
S56 (3xS52)	**0960**	2	12	2.8	64	IP23	E	0.93	50(1/0)
	1128	3	15	10	64	IP23	B	0.66	95(3/0)

Type of connection:

A - One resistor per braking unit
B - Two or more parallel-connected resistors per braking unit
C - Two or more series-connected resistors per braking unit
D - Four resistors per braking unit (parallel connection of two series of two resistors)
E - Six resistors per braking unit (parallel connection of three series of two resistors)
G - Six resistors (parallel connection of two series of three resistors) per braking unit

CAUTION

The wire cross-sections given in the table relate to one wire per braking resistor. For example, if two resistors are connected in parallel to a braking unit, the cross-section in the table is related to the cable connecting each resistor to the module. In case of a different wiring diagram, the cross-section is to be recalculated based on the RMS of the current flowing in the cable.

NOTE

If the BU600 is connected to parallel-connected inverters (2 x S44, 2 x S52 and 3 x S52), the number of BUs required and given in the table is the total number of BUs, *not* the number of BUs for each individual inverter in the parallel-connected configuration.

3.3.13. Serial Communications

3.3.13.1. General Information

The BU600 may be connected via serial link to external devices, thus enabling both reading and writing all parameters normally accessed through the display/keypad. Two-wire RS485 is used, which ensures better immunity against disturbance even on long cable paths, thus reducing communication errors.

The BU600 typically behaves as a slave device (i.e. it only answers to queries sent by another device). A master device (typically a computer) is then needed to start serial communications.
This may be done directly or in a multidrop network of converters featuring a master device (see Figure 34).

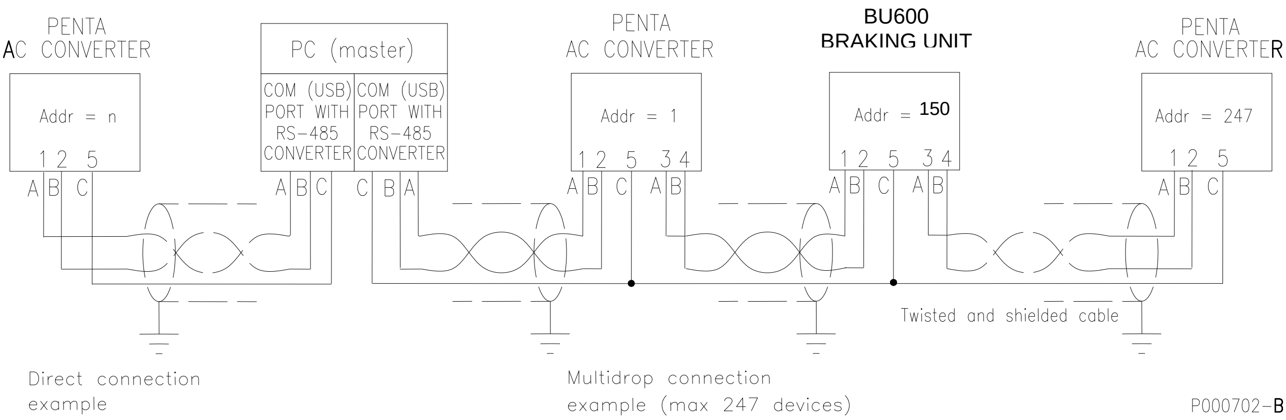


Figure 34: Example of direct and multidrop connection

The BU600 is provided with a connector equipped with N.2 pins for each signal of the RS485 pair: this makes multidrop wiring easier without having to connect two conductors to the same pin and avoids adopting star topology that is not recommended for this type of bus.

Enertronica Santerno S.p.A. also supplies the RemoteDrive software package allowing controlling the drive through a computer connected via serial link.
The RemoteDrive offers the following functionality: image copy, keypad emulation, oscilloscope functions and multifunction tester, data logger, history data table compiler, parameter setting and data reception–transmission–storage from and to a computer, scan function for the automatic detection of the connected inverters (up to 247 connected inverters). Please refer to the RemoteDrive and IrisControl - User Manual).

3.3.13.2. Direct Connection

Electrical standard RS485 may be connected directly to the computer if this is provided with a special port of this type. In case your computer is provided with a serial port RS232-C or a USB port, a RS232-C/ RS485 converter or a USB/RS485 converter is required.
Enertronica Santerno S.p.A. may supply both converters as optional components.
Logic “1” (normally called a MARK) means that terminal TX/RX A is positive in respect to terminal TX/RX B (vice versa for logic “0”, normally called a SPACE).

3.3.13.3. Multidrop Network Connection

The BU600 may be connected to a network through electrical standard RS485, allowing a bus-type control of each device; up to 247 inverters may be interconnected depending on the link length and baud rate.
Each inverter has its own identification number, which can be set in the Serial Network menu as a unique code in the network connected to the PC.

3.3.13.4. Connection

For the connection to the serial link, use the 9-pin, male D connector (see Figure 30).
The D connector pins are the following.

Decisive voltage class A according to EN 61800-5-1

PIN	FUNCTION
1 – 3	(TX/RX A) Differential input/output A (bidirectional) according to standard RS485. Positive polarity in respect to pins 2 – 4 for one MARK. Signal D1 according to MODBUS-IDA association.
2 – 4	(TX/RX B) Differential input/output B (bidirectional) according to standard RS485. Negative polarity in respect to pins 1 – 3 for one MARK. Signal D0 according to MODBUS-IDA association.
5 - 7 – 8	(GND) control board zero volt. Common according to MODBUS-IDA association.
6	(VTEST) Auxiliary supply input (see Auxiliary Power Supply)
9	Not connected

The metal frame of the D connector is connected to the metal frame of the BU600, so it is grounded. Connect the cable braiding of the shielded twisted pair date cable to the ground by using the copper cable lug (see Figure 30). To avoid obtaining too high common voltage for RS485 driver of the master or the multidrop-connected devices, connect together terminals GND (if any) for all devices. This ensures equipotentiality for all signal circuits, thus providing the best operating conditions for RS485 drivers; however, if the devices are connected to each other with analog interfaces, this can create ground loops. If disturbance occurs when communication interfaces and analog interface operate at a time, use optional, galvanically isolated RS485 communications interface.

The MODBUS-IDA association (www.modbus.org) defines the type of wiring for MODBUS communications via serial link RS485, adopted by the BU600, as a “2-wire cable”. The following specifications are recommended:

Type of cable	Shielded cable composed of balanced D1/D0 pair + common conductor (“Common”)
Min. cross-section of conductors	AWG24 corresponding to 0.25 mm^2. For long cable length, larger cross-sections up to 0.75 mm^2 are recommended.
Max. length	500 metres (based on the max. distance between two stations)
Characteristic impedance	Better if exceeding 100 Ω (120 Ω is typically recommended)
Standard colours	Yellow/brown for D1/D0 pair, grey for “Common” signal

The figure below shows the reference wiring diagram recommended from the MODBUS-IDA association for the connection of “2-wire” devices.

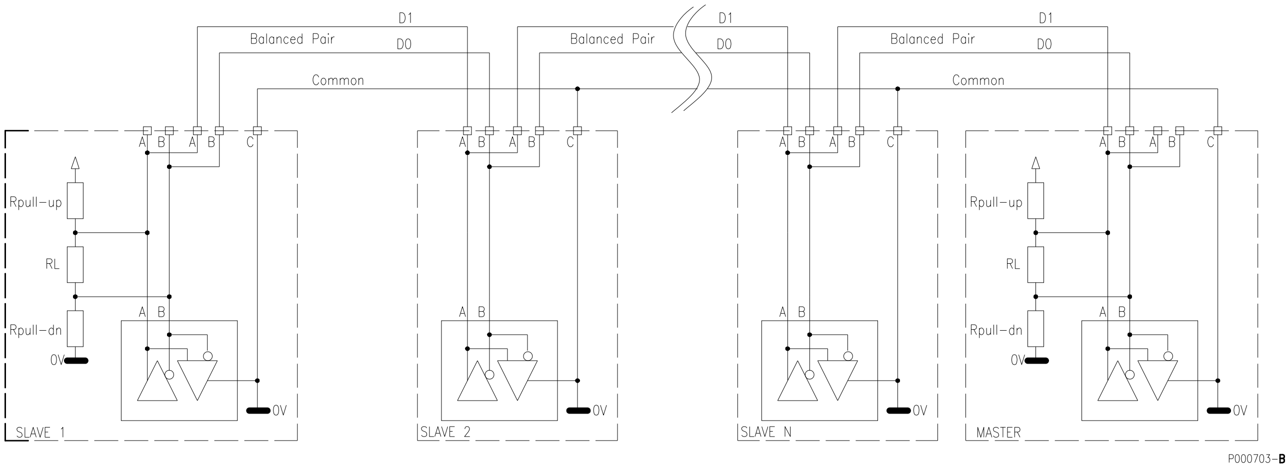


Figure 35: Recommended wiring diagram for “2-wire” MODBUS connection

Note that the network comprising the termination resistor and the polarization resistors is integrated into the inverter and can be activated via appropriate DIP-switches. Figure 35 shows the termination network in the devices at both ends of the chain. The terminator must be inserted in those devices only.

NOTE

Four-pair data transfer cables of Category 5 are normally used for serial links. Although their usage is not recommended, cables of Category 5 can be used for short cable paths. Note that the colours of such cables are different from the colours defined by MODBUS-IDA association. One pair is used for D1/D0 signals, one pair is used as a “Common” conductor, while the remaining two pairs must not be connected to any other device, or must be connected to the “Common”.

NOTE

All devices connected to the communication multidrop network should be grounded to the same conductor to minimize any difference of ground potentials between devices that can affect communication.

NOTE

The common terminal for the supply of the inverter control board is isolated from grounding. If one or multiple inverters are connected to a communication device with a grounded common (typically a computer), a low-impedance path between control boards and grounding occurs. High-frequency disturbance could come from the inverter power components and interfere with the communication device operation.

If this happens, provide the communication device with a galvanically isolated interface, type RS485/RS232.

3.3.13.5. *Line Terminators*

Provide a linear wiring (not a star wiring) for RS485 multidrop line. To do so, two pins for each line signal are provided on the inverter connector. The incoming line may be connected to pins 1 and 2, whereas the outgoing line may be connected to pins 3 and 4.
The first device in the multidrop connection will have only one outgoing line, while the last device will have only one incoming line. The line terminator is to be installed on the first device and the last device.
The first and the last device in the network feature only one outcoming line and one incoming line respectively. The line terminator is to be installed on the first device and the last device. The line terminator of the BU600 is selected via the DIP-switch SW2 on the control board by setting selectors 1 and 2 to ON.

NOTE

Communication does not take place or is adversely affected if multidrop terminators are not properly set, especially in case of high baud rate. If more than two terminators are fitted, some drivers can enter the protection mode due to thermal overload, thus stopping dialoguing with some of the connected devices.

3.3.14. Auxiliary Power Supply

The VTEST auxiliary supply pin is located on the serial port connector. The BU600 control board activates when 9VDC voltage (in respect to GND) is delivered to the VTEST input. This allows doing the following:

1) read and write the parameters with no need to apply DC power supply;
2) keep the control board “on” in case of mains loss (backup power supply).

The auxiliary supply input features are the following:

Features	Min.	Type	Max.	Unit of m.
Auxiliary supply voltage	7.5	9	12	Vdc
Absorbed current		1.1	1.8	A
“Inrush” current at power on			3	A

CAUTION

The power supply unit voltage and current delivery capacity must meet the requirements of the test supply. Lower ratings than the supply test can cause the control board failure and the irreparable loss of the user-defined parameters. On the other hand, higher ratings can cause irreparable damage to the inverter control board. Switching power supply units installed in the control board are characterized by strong “inrush” current at power on. Make sure that the power supply unit being used is capable of delivering such current ratings.

Enertronica Santerno S.p.A. provides a suitable power supply unit as an option; see ES914 Power Supply Unit Board.

3.4. Braking Unit BU1440 for Modular Inverters (BU1440 4T and BU1440 5T-6T)

A braking unit to be applied to modular inverters only is available. The inverter size must be equal to or larger than S65.
The BU1440 is an UL Open Type Equipment – degree of protection IP00 – that can be installed inside another enclosure featuring degree of protection IP3X as a minimum requirement.
Transporting, handling and unpacking the braking unit is covered in the general instructions given in the “Transport and Handling” and “Unpacking”sections in the Installation Guide.

3.4.1. Delivery Check

Make sure that the equipment is not damaged and that it complies with the equipment you ordered by referring to the nameplate located on the inverter front part (see figure below). If the equipment is damaged, contact the supplier or the insurance company concerned. If the equipment does not comply with the one you ordered, please contact the supplier as soon as possible.
If the equipment is stored before being started, make sure that temperatures range from –25 °C to +70 °C and that relative humidity is <95% (non-condensing).
The equipment guarantee covers any manufacturing defect. The manufacturer has no responsibility for possible damages occurred while shipping or unpacking the equipment. The manufacturer is not responsible for possible damages or faults caused by improper and irrational uses; wrong installation; improper conditions of temperature, humidity, or the use of corrosive substances. The manufacturer is not responsible for possible faults due to the equipment operation at values exceeding the equipment ratings. The manufacturer is not responsible for consequential and accidental damages.
The braking unit is covered by a 12-month guarantee starting from the date of delivery.

3.4.1.1. Nameplate for BU1440 4T

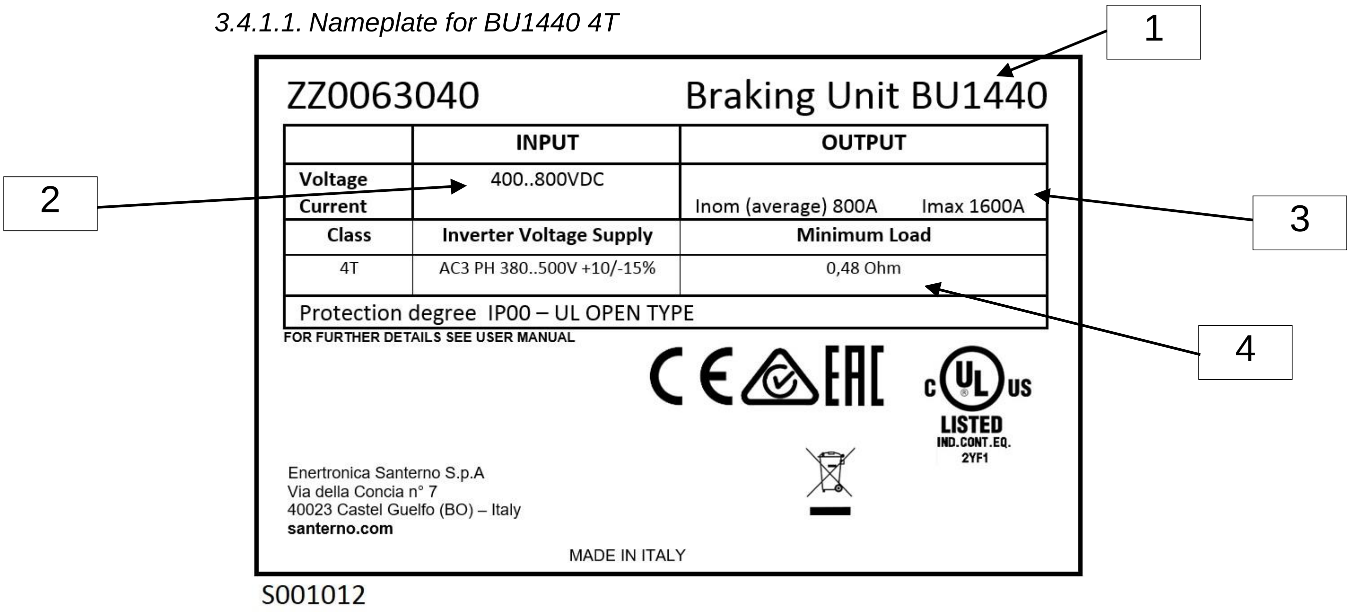


Figure 36: Nameplate for BU1440 4T

1.	Model:	BU1440 – Braking module 4T or 5T-6T
2.	Supply ratings:	DC supply voltage deriving directly from the inverter terminals: 400 to 800 Vdc for BU1440 4T; 800÷1200 Vdc for BU1440 5T-6T (*)
3.	Output current:	800A (average) – continuous average current in output cables 1600A (max.) – max. current in output cables (may be held for all the time given in column “Max. Duration of Continuous Operation” in the resistors tables below)
4.	Min. load:	Minimum value of the resistor to be connected to the output terminals (see application tables below)

3.4.2. Operation

Each size of the braking unit can be used with a braking resistor avoiding exceeding the max. instant current stated in its specifications.
The braking unit is controlled directly by the control unit. Braking units cannot be parallel-connected when applied to modular inverters.

3.4.3. Ratings

SIZE	Max. braking current (A)	Average braking current (A)	Inverter supply voltage	Min. braking resistor (Ω)	Dissipated power (at average braking current) (W)	Sound Pressure (dB)
BU1440-4T	1600	800	380-500 Vac	0.48	1800	65
BU1440-5T	1600	800	500-600 Vac	0.58	2100	65
BU1440-6T	1600	800	600-690 Vac	0.69	2200	65

AUXILIARY INPUT (Fans supply)

AC Voltage	Frequency	Current consumption
230 V	50-60 Hz	1.48 Arms

3.4.4. Installing the BU1440

3.4.4.1. Environmental Requirements for the BU1440 Installation, Storage and Transport

Maximum surrounding air temperature	–10 to +40 °C with no derating From +40 °C to +55 °C with a 2% derating of the rated current for each degree beyond +40 °C.
Ambient temperatures for storage and transport	–25 °C to +70 °C
Installation environment	Pollution degree 2 or better (according to EN 61800-5-1 and UL 508C Open Type Equipment). Do not install in direct sunlight and in places exposed to conductive dust, corrosive gases, vibrations, water sprinkling or dripping; do not install in salty environments.
Altitude	Max. altitude for installation 2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A. Above 1000 m, derate the rated current by 1% every 100 m.
Operating ambient humidity	From 5% to 95%, from 1 g/m^3 to 29 g/m^3, non-condensing and non-freezing (class 3K3 according to EN 61800-5-1).
Storage ambient humidity	From 5% to 95%, from 1 g/m^3 to 29 g/m^3, non-condensing and non-freezing (class 1K3 according to EN 61800-5-1).
Ambient humidity during transport	Max. 95%, up to 60 g/m^3; condensation may appear when the equipment is not running (class 2K3 according to EN 61800-5-1).
Storage and operating atmospheric pressure	From 86 to 106 kPa (classes 3K3 and 1K4 according to EN 61800-5-1).
Atmospheric pressure during transport	From 70 to 106 kPa (class 2K3 according to EN 61800-5-1).

CAUTION Ambient conditions strongly affect the inverter life. Do not install the equipment in places that do not have the above-mentioned ambient conditions.

3.4.4.2. Mounting the Braking Unit

Install braking unit BU1440 for modular inverters in an upright position inside a cabinet, next to the other inverter modules. Its overall dimensions are the same as those of an inverter arm. For more details, please refer to the paragraph relating to the mechanical installation of the modular inverter in the Installation Guide.

Dimensions (mm)			Fixing points (mm)				Screws	Weight (kg)
W	H	D	X	Y	D1	D2	M10	110
230	1400	480	120	237	11	25		

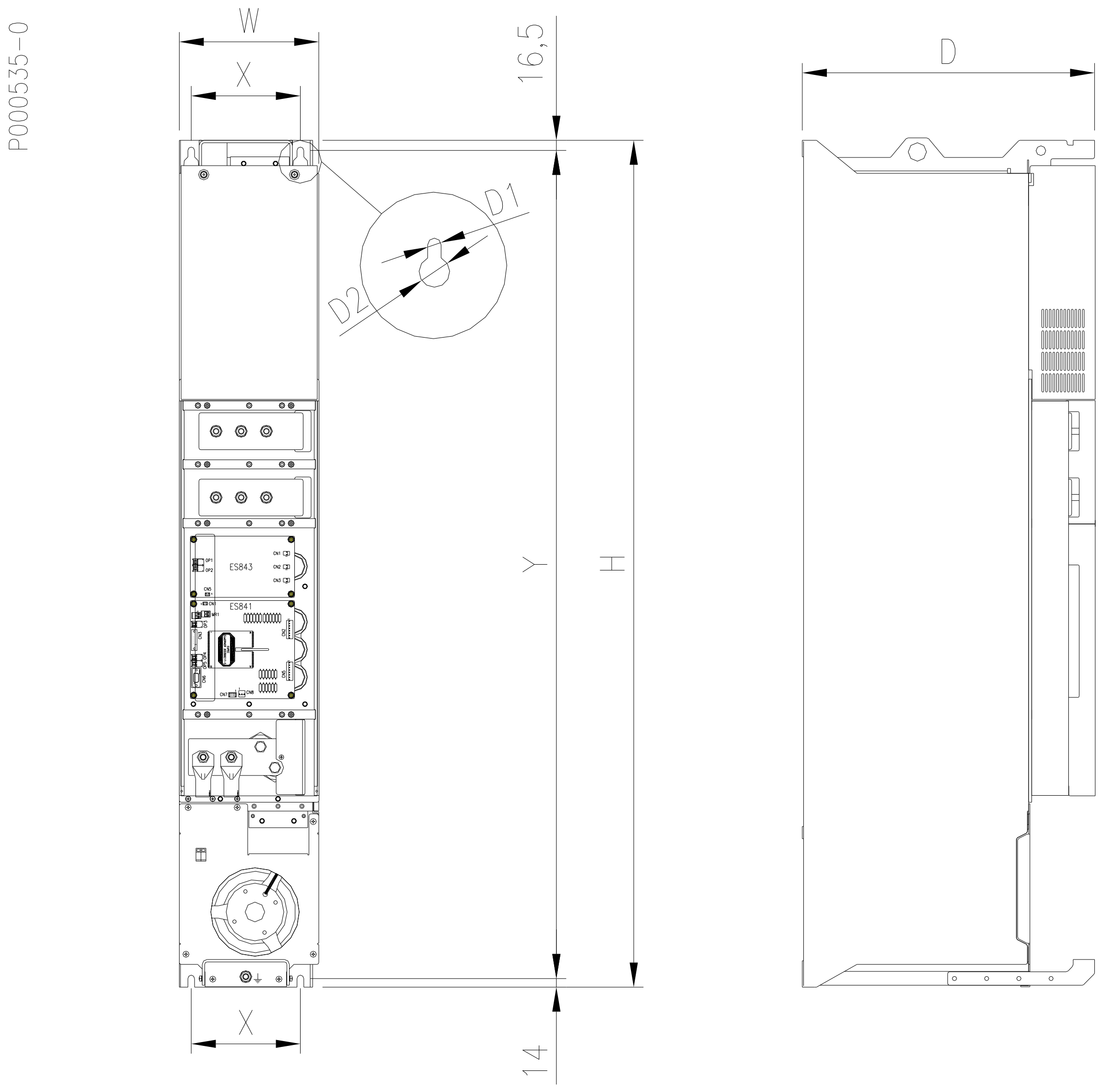


Figure 37: Dimensions and fixing points of BU1440

3.4.4.3. Wiring Diagram

Power connections

The braking unit must be connected to the inverter and the braking resistor.
The connection to the inverter is direct through 60*10mm copper plates connecting the different inverter modules. The braking resistor is connected to the + bar and to the braking unit.
Also connect the single-phase 230Vac supply of the cooling fan.

Decisive voltage class C according to EN 61800-5-1

Terminal	Type	Tightening Torque (Nm)	Connection cable cross-section mm^2 (AWG/kcmils)	NOTES
+	Bar	30	600 mm^2	To be connected to bus bar + of the drive
–	Bar			To be connected to bus bar – of the drive
+	Cord	30	See sections 3.4.7 and 3.4.8	To be connected to Braking Resistor
B	Cord			To be connected to Braking Resistor
61	Wire	0.6-0.8	1 mm^2 (AWG18)	To be connected to 230 Vac supply
62	Wire			To be connected to 230 Vac supply

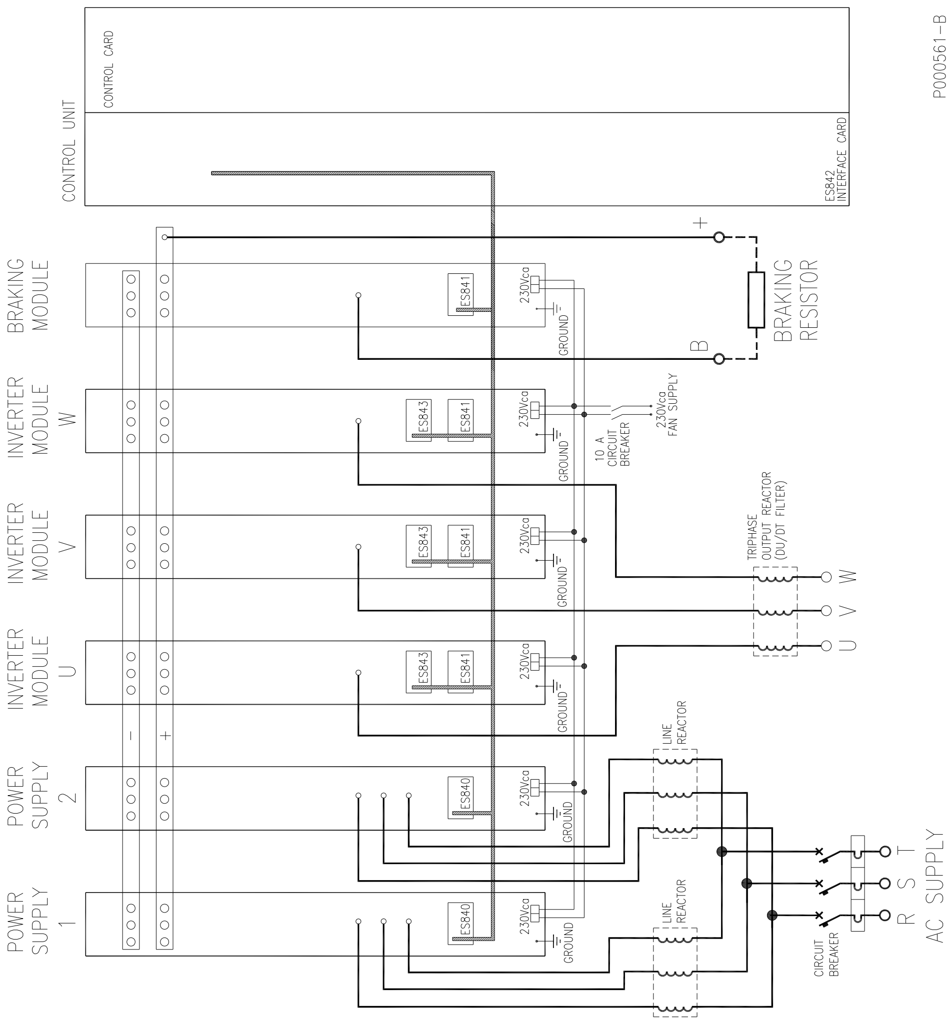


Figure 38: External power connections for modular inverters S65-S70 provided with BU1440

NOTE Power supply unit n.2 (power supply 2) is available for size S70.

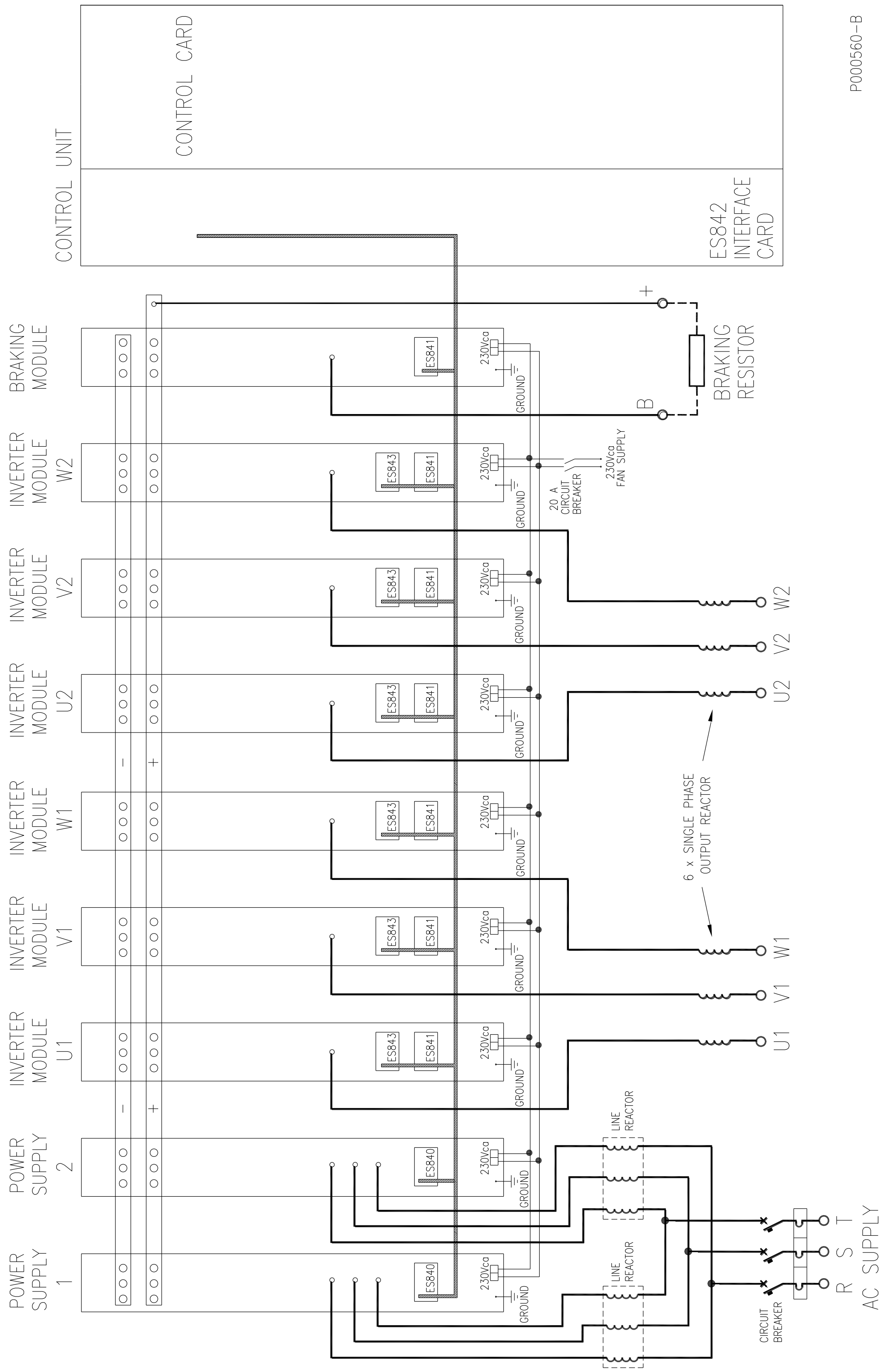


Figure 39: External power connections for modular inverters S75-S80 provided with BU1440

NOTE Power supply unit n. 3 is available for size S80.

Signal connections

CAUTION Make sure that the control device is properly set-up when using the braking arm. When ordering the inverter, always state the inverter configuration you want to obtain.

Because the braking arm is controlled directly by the control device, the following wiring is required:

- connect +24V supply of gate unit ES841 of the braking unit through a pair of unipolar wires (AWG17-18 – 1 mm^2)
- connect braking IGBT to the fault IGBT signal through 2 optical fibres (diameter: 1mm) made of plastic (typical attenuation coefficient: 0.22 dB/m) provided with Agilent HFBR-4503/4513 connectors.

The wiring diagram is as follows:

Signal	Type of wiring	Wire marking	Component	Board	Connector	Component	Board	Connector
+24VD Driver board ES841 power supply	Unipolar wire 1 mm^2	24V-GB	Phase W	ES841	MR1-3	Braking unit	ES841	MR1-1
0VD Driver board ES841 power supply	Unipolar wire 1 mm^2		Phase W	ES841	MR1-4	Braking unit	ES841	MR1-2
Brake IGBT command	Single optical fibre	G-B	Control unit	ES842	OP-4	Braking unit	ES841	OP5
Brake IGBT fault	Single optical fibre	FA-B	Control unit	ES842	OP-3	Braking unit	ES841	OP3

CAUTION Do not remove the cap of connector OP4 in ES841 control board of the the braking module.

Figure 40: ES841 Unit gate board for the braking unit

1. OP1: Green LED – Board OK
2. MR1: 24V gate unit supply
3. OP2: Red LED - Board faulty[*]
4. OP3: IGBT Fault [*]
5. OP4-OP5: IGBT gate commands. OP4 MUST BE SEALED – DO NOT CONNECT
6. CN3: MUST NOT BE CONNECTED

NOTE [*] The “IGBT Fault” signal, if the OP2 LED remains OFF, indicates that the thermoswitch has tripped.

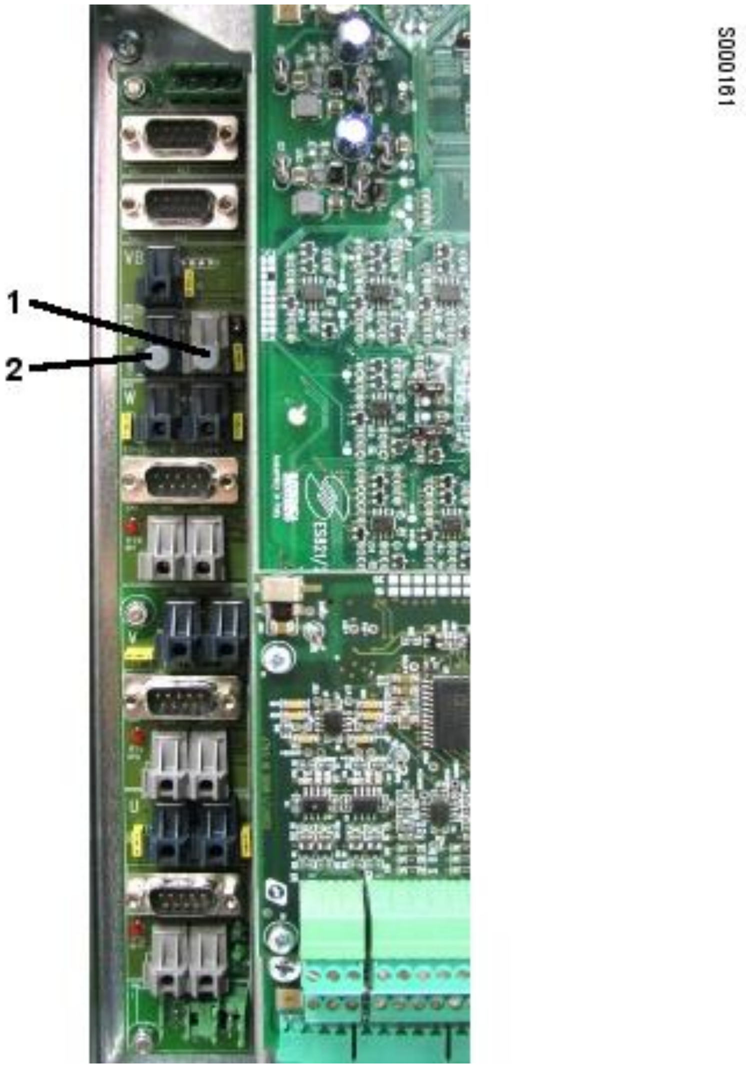


Figure 41: **Connection points on ES842 for the braking unit optical fibres**

7. OP4: Gate command for IGBT Brake
8. OP3: IGBT Fault Signal

The figure below shows the internal wiring of inverters S65-S70 provided with a braking unit.

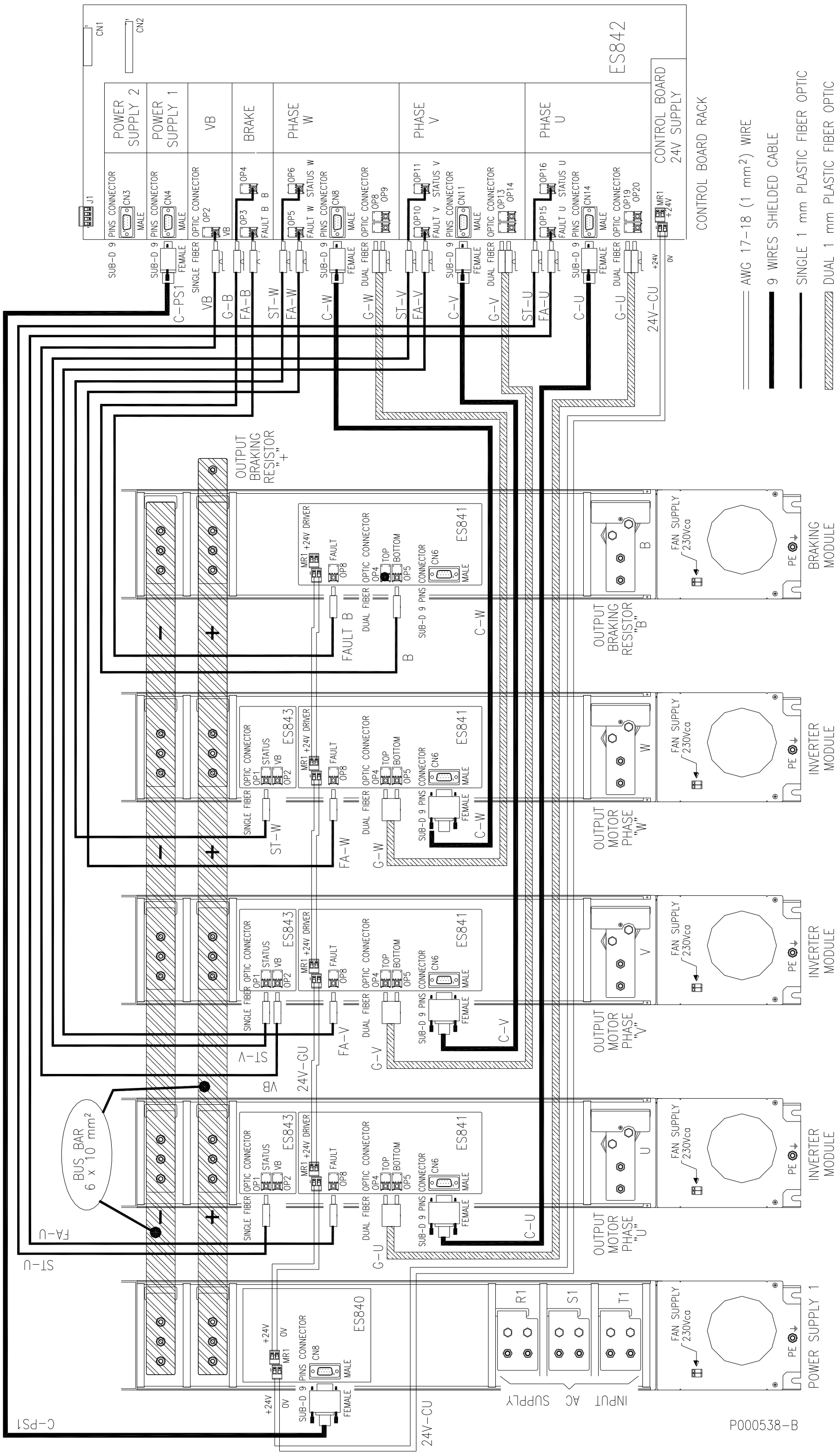


Figure 42: Internal wiring of inverters S65-S70 provided with a braking unit

3.4.5. Earth Bonding of the BU1440

For the earth bonding of the BU1440, please refer to the general instructions given in section Inverter and Motor Ground Connection in the Installation Guide.

3.4.6. Scheduled Maintenance of the BU1440

For the BU1440 scheduled maintenance, please refer to the general instructions given in section Inverter and Motor Ground Connection in the Installation Guide.

DANGER	Once power supply has been cut off from the drive connected to the BU1440, wait at least 20 minutes before operating on the DC circuits to give the capacitors time to discharge.

3.4.7. Braking Resistors for BU1440 4T

NOTE	The wire cross-sections given in the table relate to one wire per braking resistor.
NOTE	The Part Numbers of the braking resistors in the tables are given in the Available Braking Resistors section.
HOT SURFACE	The braking resistor case may reach 200 °C based on the operating cycle.
CAUTION	The cables of the braking resistors shall have insulation features and heat-resistance features suitable for the application. The minimum rated voltage of the cables must be 0.6/1 kV.
CAUTION	The power dissipated by the braking resistors may be the same as the rated power of the connected motor multiplied by the braking duty-cycle; use a proper air-cooling system. Do not install braking resistors near heat-sensitive equipment or objects.
CAUTION	Do not connect to the inverter any braking resistor with an Ohm value lower than the value given in the tables.
CAUTION	Never exceed the maximum operating time of the resistor as given in the Available Braking Resistors section.

3.4.7.1. Applications with DUTY CYCLE 10% - Class 4T

SIZE	Drive Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm² (AWG or kcmils)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S65	**0598**	1	1	1.2	64	IP23	A	1.2	95(4/0)
	0748	1	1	1.2	64	IP23	A	1.2	95(4/0)
	0831	1	2	1.6	48	IP23	B	0.8	120(250)
S75	**0964**	1	2	1.2	48	IP23	B	0.6	120(250)
	1130	1	2	1.2	64	IP23	B	0.6	120(250)
	1296	2	4	1.8	32	IP23	V	0.45	95(4/0)
S90	**1800**	2	4	1.6	48	IP23	V	0.4	120(250)
	2076	2	4	1.2	48	IP23	V	0.3	120(250)

3.4.7.2. Applications with DUTY CYCLE 20% - Class 4T

SIZE	Drive Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm² (AWG or kcmils)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S65	**0598**	1	2	2.4	64	IP23	B	1.2	120(250)
	0748	1	2	2.4	64	IP23	B	1.2	120(250)
	0831	1	3	2.4	48	IP23	B	0.8	120(250)
S75	**0964**	1	4	2.4	64	IP23	B	0.6	120(250)
	1130	1	4	2.4	64	IP23	B	0.6	120(250)
	1296	2	4	1.8	64	IP23	V	0.45	120(250)
S90	**1800**	2	6	2.4	48	IP23	V	0.4	120(250)
	2076	2	8	2.4	64	IP23	V	0.3	120(250)

3.4.7.3. Applications with DUTY CYCLE 50% - Class 4T

SIZE	**Drive Model**	**Braking Unit**	**Braking Resistor**						
			Resistors to be used				**Type of Connection**	**Value (Ω)**	**Wire Cross-section mm² (AWG or kcmils)**
		Q.ty	**Q.ty**	**Recommended Value (Ω)**	**Power (kW)**	**Degree of Protection**			
S65	**0598**	1	4	1.2	64	IP23	D	1.2	120(250)
	0748	1	4	1.2	64	IP23	D	1.2	120(250)
	0831	1	6	1.2	64	IP23	E	0.8	120(250)
S75	**0964**	1	8	1.2	64	IP23	F	0.6	120(250)
	1130	1	8	1.2	64	IP23	F	0.6	120(250)
	1296	2	12	1.4	64	IP23	ME	0.47	120(250)
S90	**1800**	2	12	1.2	64	IP23	ME	0.4	120(250)
	2076	2	16	1.2	64	IP23	MF	0.3	120(250)

A - One resistor

B - Two or multiple parallel-connected resistors

C - Two series-connected resistors

D - Four resistors (parallel-connection of two series of two resistors)

E - Six resistors (parallel-connection of three series of two resistors)

F - Eight resistors (parallel-connection of four series of two resistors)

V - Two units, each of them including a braking module connected to two or more parallel-connected braking resistors

ME - Two units, each of them including a braking module connected to six braking resistors (parallel-connection of three series of two resistors)

MF - Two units, each of them including a braking module connected to eight braking resistors (parallel-connection of four series of two resistors)

CAUTION

The cable cross-sections given in the table relate to the cable connecting each individual braking resistor. For example, if a braking resistor is connected to N.2 parallel-connected resistors, the cable cross-section in the table is the one for each resistor connected to the braking unit.
In case of a different wiring diagram, the cross-section is to be recalculated based on the RMS of the current flowing in the cable.

3.4.8. Braking Resistors for BU1440 5T-6T

NOTE The wire cross-sections given in the table relate to one wire per braking resistor.

NOTE The Part Numbers of the braking resistors in the tables are given in the Available Braking Resistors section.

HOT SURFACE The braking resistor case may reach 200 °C based on the operating cycle.

CAUTION The cables of the braking resistors shall have insulation features and heat-resistance features suitable for the application. The minimum rated voltage of the cables must be 0.6/1 kV.

CAUTION The power dissipated by the braking resistors may be the same as the rated power of the connected motor multiplied by the braking duty-cycle; use a proper air-cooling system. Do not install braking resistors near heat-sensitive equipment or objects.

CAUTION Do not connect to the inverter any braking resistor with an Ohm value lower than the value given in the tables.

CAUTION Never exceed the maximum operating time of the resistor as given in the Available Braking Resistors section.

3.4.8.1. Applications with DUTY CYCLE 10% - Class 5T

SIZE	Drive Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm² (AWG or kcmils)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S65	**0457**	1	1	1.6	64	IP23	A	1.6	95(1/0)
	0524	1	2	2.8	48	IP23	B	1.4	50(1/0)
	0598	1	2	2.4	48	IP23	B	1.2	50(1/0)
	0748	1	2	2.1	48	IP23	B	1.05	95(4/0)
S70	**0831**	1	2	1.8	64	IP23	B	0.9	95(4/0)
S75	**0964**	1	3	2.4	48	IP23	B	0.8	50(1/0)
	1130	1	3	1.8	64	IP23	B	0.6	95(4/0)
S80	**1296**	1	3	1.6	64	IP23	B	0.53	95(4/0)
S90	**1800**	2	4	1.8	64	IP23	V	0.45	95(4/0)
	2076	2	6	2.4	48	IP23	V	0.4	50(1/0)

3.4.8.2. Applications with DUTY CYCLE 20% - Class 5T

SIZE	Drive Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm² (AWG or kcmils)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S65	**0457**	1	2	3.6	64	IP23	B	1.8	95(4/0)
	0524	1	3	4.2	64	IP23	B	1.4	50(1/0)
	0598	1	3	3.6	64	IP23	B	1.2	50(1/0)
	0748	1	3	2.8	64	IP23	B	0.93	70(2/0)
S70	**0831**	1	3	2.4	64	IP23	B	0.8	95(4/0)
S75	**0964**	1	4	2.8	64	IP23	B	0.7	70(2/0)
	1130	1	6	3.6	64	IP23	B	0.6	50(1/0)
S80	**1296**	1	6	3	64	IP23	B	0.5	70(2/0)
S90	**1800**	2	6	2.4	64	IP23	V	0.4	95(4/0)
	2076	2	8	2.8	64	IP23	V	0.35	70(2/0)

3.4.8.3. Applications with DUTY CYCLE 50% - Class 5T

SIZE	Drive Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm² (AWG or kcmils)
		Q.ty	Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S65	**0457**	1	6	2.4	64	IP23	E	1.6	70(4/0)
	0524	1	6	2.1	64	IP23	E	1.4	95(4/0)
	0598	1	8	2.4	64	IP23	F	1.2	70(2/0)
	0748	1	8	1.8	64	IP23	F	0.9	95(4/0)
S70	**0831**	1	8	1.8	64	IP23	F	0.9	95(4/0)
S75	**0964**	1	10	1.8	64	IP23	G	0.7	95(4/0)
	1130	1	12	1.8	64	IP23	H	0.6	95(4/0)
S80	**1296**	1	14	1.8	64	IP23	I	0.51	95(4/0)
S90	**1800**	2	16	1.8	64	IP23	MF	0.45	95(4/0)
	2076	2	20	1.8	64	IP23	MG	0.35	95(4/0)

A - One resistor

B - Two or more parallel-connected resistors

D - Four resistors (parallel-connection of two series of two resistors)

E - Six resistors (parallel-connection of three series of two resistors)

F - Eight resistors (parallel-connection of four series of two resistors)

G - Ten resistors (parallel-connection of five series of two resistors)

H - Twelve resistors (parallel-connection of six series of two resistors)

I - Fourteen resistors (parallel-connection of seven series of two resistors)

V - Two units, each of them including a braking module connected to two or more parallel-connected braking resistors

MF - Two units, each of them including a braking module connected to eight braking resistors (parallel-connection of four series of two resistors)

MG - Two units, each of them including a braking module connected to ten braking resistors (parallel-connection of five series of two resistors)

CAUTION

The cable cross-sections given in the table relate to the cable connecting each individual braking resistor. For example, if a braking resistor is connected to N.2 parallel-connected resistors, the cable cross-section in the table is the one for each resistor connected to the braking unit.
In case of a different wiring diagram, the cross-section is to be recalculated based on the RMS of the current flowing in the cable.

3.4.8.4. Applications with DUTY CYCLE 10% - Class 6T

SIZE	Drive Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm^2 (AWG or kcmils)
			Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S65	0457	1	2	3.6	48	IP23	B	1.8	70(2/0)
	0524	1	2	2.8	48	IP23	B	1.4	70(2/0)
	0598	1	2	2.8	48	IP23	B	1.4	70(2/0)
	0748	1	2	2.4	48	IP23	B	1.2	70(2/0)
S70	0831	1	2	1.8	64	IP23	B	0.9	120(250)
S75	0964	1	3	2.4	64	IP23	B	0.8	70(2/0)
	1130	2	4	2.4	64	IP23	V	0.6	70(2/0)
S80	1296	2	4	2.1	64	IP23	V	0.52	95(4/0)
S90	1800	2	4	1.8	64	IP23	V	0.45	120(250)
	2076	2	6	2.4	64	IP23	V	0.4	70(2/0)

3.4.8.5. Applications with DUTY CYCLE 20% - Class 6T

SIZE	Drive Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm^2 (AWG or kcmils)
			Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S65	0457	1	3	5	64	IP23	B	1.7	50(1/0)
	0524	1	3	4.2	64	IP23	B	1.4	50(1/0)
	0598	1	3	4.2	64	IP23	B	1.4	70(2/0)
	0748	1	3	3.6	64	IP23	B	1.2	70(2/0)
S70	0831	1	4	3.6	64	IP23	B	0.9	70(2/0)
S75	0964	1	6	1.2	64	IP23	E	0.8	120(250)
	1130	2	8	1.2	64	IP23	MD	0.6	120(250)
S80	1296	2	8	1.2	64	IP23	MD	0.6	120(250)
S90	1800	2	8	3.6	64	IP23	V	0.45	70(2/0)
	2076	2	12	1.2	64	IP23	ME	0.4	120(250)

3.4.8.6. Applications with DUTY CYCLE 50% - Class 6T

Size	Drive Model	Braking Unit	Braking Resistor						
			Resistors to be used				Type of Connection	Value (Ω)	Wire Cross-section mm² (AWG or kcmils)
			Q.ty	Recommended Value (Ω)	Power (kW)	Degree of Protection			
S65	**0457**	1	6	2.4	64	IP23	E	1.6	95(4/0)
	0524	1	8	2.8	64	IP23	F	1.4	70(2/0)
	0598	1	8	2.8	64	IP23	F	1.4	70(2/0)
	0748	1	8	2.4	64	IP23	F	1.2	95(4/0)
S70	**0831**	1	10	2.4	64	IP23	G	0.96	95(4/0)
S75	**0964**	1	12	2.4	64	IP23	H	0.8	70(2/0)
	1130	2	16	2.4	64	IP23	MF	0.6	95(4/0)
S80	**1296**	2	16	2.1	64	IP23	MF	0.52	120(250)
S90	**1800**	2	20	2.4	64	IP23	MG	0.48	95(4/0)
	2076	2	24	2.4	64	IP23	MH	0.4	70(2/0)

A - One resistor

B - Two or more parallel-connected resistors

D - Four resistors (parallel-connection of two series of two resistors)

E - Six resistors (parallel-connection of three series of two resistors)

F - Eight resistors (parallel-connection of four series of two resistors)

G - Ten resistors (parallel-connection of five series of two resistors)

H - Twelve resistors (parallel-connection of six series of two resistors)

V - Two units, each of them including a braking resistor connected to two or more parallel-connected braking resistors

MD - Two units, each of them including a braking module connected to four braking resistors (parallel-connection of two series of two resistors)

MF - Two units, each of them including a braking module connected to eight braking resistors (parallel-connection of four series of two resistors)

MG - Two units, each of them including a braking module connected to ten braking resistors (parallel-connection of five series of two resistors)

MH - Two units, each of them including a braking module connected to twelve braking resistors (parallel-connection of six series of two resistors)

CAUTION

The cable cross-sections given in the table relate to the cable connecting each individual braking resistor. For example, if a braking resistor is connected to N.2 parallel-connected resistors, the cable cross-section in the table is the one for each resistor connected to the braking unit.
In case of a different wiring diagram, the cross-section is to be recalculated based on the RMS of the current flowing in the cable.

3.5. Available Braking Resistors

The specifications given for each resistor model also include the mean power to be dissipated and the max. operating time, depending on the inverter voltage class.
Based on these values, parameters **C211** and **C212** (concerning braking features) in the Resistor Braking menu can be set up. (See relevant section in the Programming Guide).
The max. operating time set in **C211** is factory-set in order not to exceed the allowable time for each resistor model (see section below).
Parameter **C212** represents the max. duty-cycle of the resistor and is to be set to a value lower than or equal to the value stated in the dimensioning table (see sections above).

	**HOT SURFACE**	Braking resistors may reach temperatures higher than 200 °C.
	**FIRE HAZARD**	For parameters **C211** and **C212**, do not set values exceeding the max. allowable values stated in the tables above. Failure to do so will cause irreparable damage to the braking resistors; also, fire hazard exists.
	**CAUTION**	Braking resistors may dissipate up to 50% of the rated power of the connected motor; use a proper air-cooling system. Do not install braking resistors near heat-sensitive equipment or objects.

3.5.1. 350W Models (IP55)

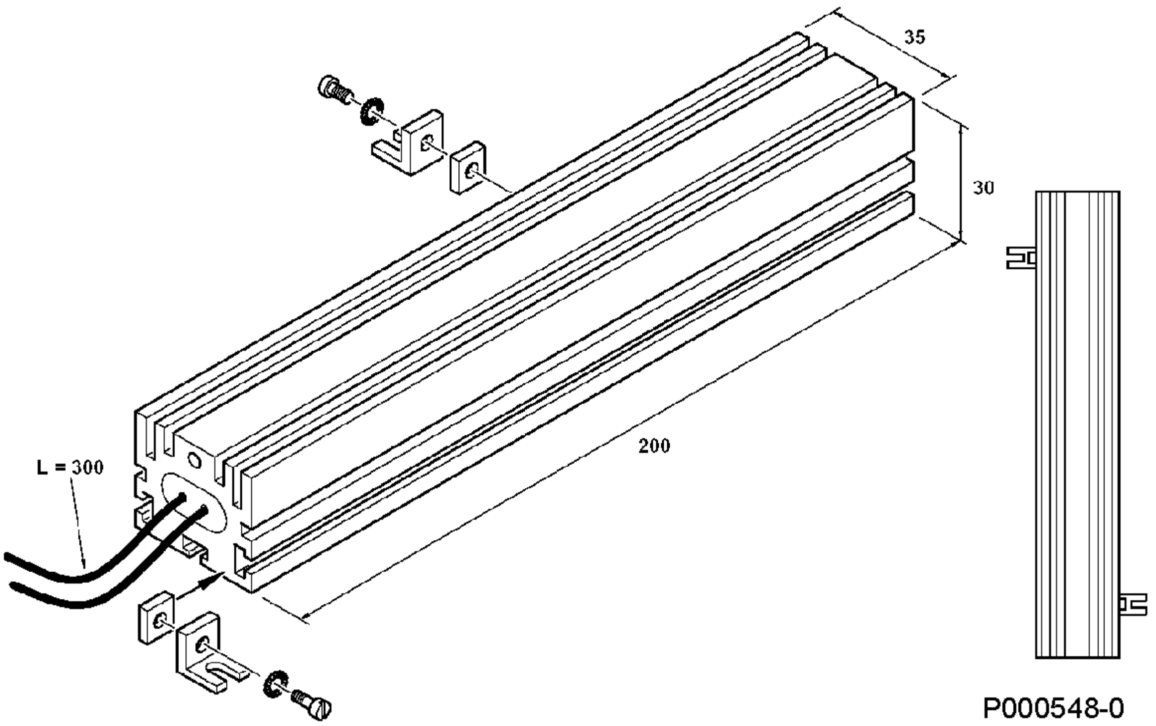


Figure 43: Overall dimensions, 350W resistor

Type	Weight (g)	Average Power to be Dissipated (W)	Max. Duration of Continuous Operation for 200-240 Vac (s)*
56Ω/350W **RE2643560**	400	350	3.5
100Ω/350W **RE2644100**	400	350	6

(*) Max. value to be set in parameter **C211** for single resistors or parallel-connected configurations.
That duration is longer for different configurations (two or more series-connected resistors).
When setting the braking duty cycle in **C212**, make sure that the maximum power dissipated from the braking resistor being used is not exceeded.

3.5.2. 550W Models (IP33)

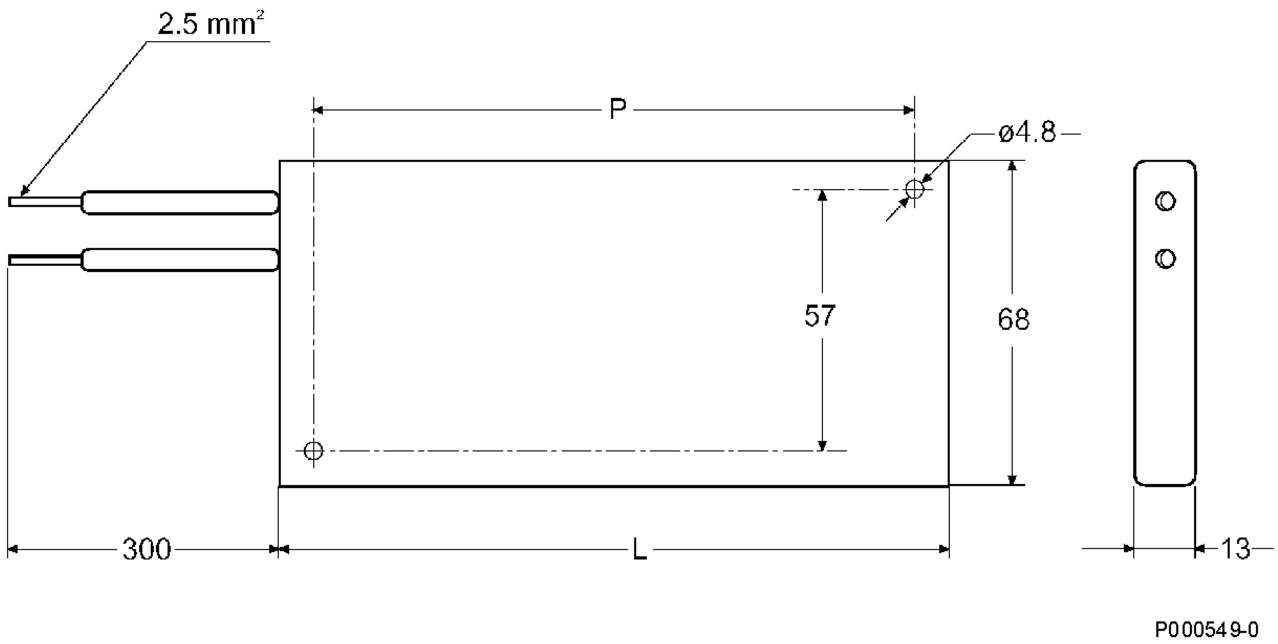


Figure 44: Overall dimensions for 550W braking resistor

Type	L (mm)	D (mm)	Weight (g)	Mean power to be dissipated (W)	Max. duration of continuous operation for 380-500 Vac (s)*
75Ω/550W **RE3063750**	195	174	500	550	4

(*) Max. value to be set in parameter **C211** for single resistors or parallel-connected configurations.
That duration is longer for different configurations (two or more series-connected resistors).
When setting the braking duty cycle in **C212**, make sure that the maximum power dissipated from the braking resistor being used is not exceeded.

3.5.3. IP54 Models from 1100W to 2200W

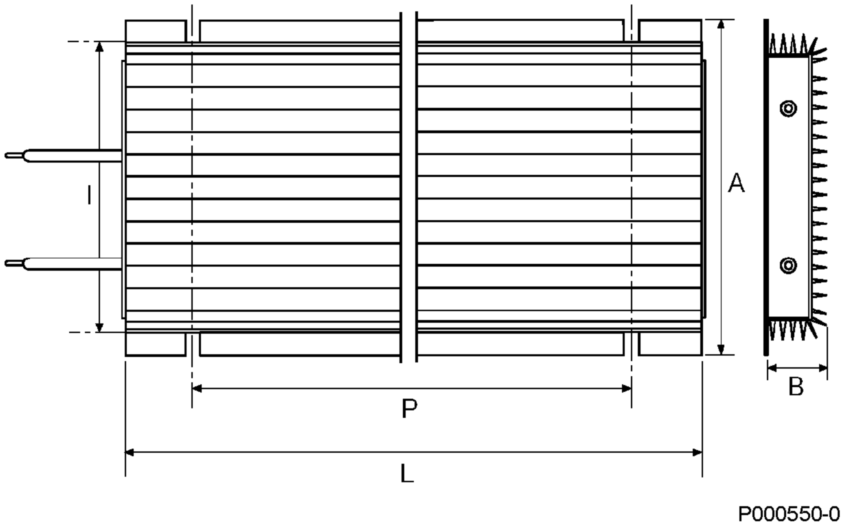


Figure 45: Overall dimensions for braking resistors from 1100W to 2200W

RESISTOR	A (mm)	B (mm)	L (mm)	I (mm)	P (mm)	Weight (g)	Average power that can be dissipated (W)	Max. duration of continuous operation (s) (*)			
								at 200-240 Vac	at 380-500 Vac	at 500-575 Vac	at 660-690 Vac
15Ω/1100W **RE3083150**	95	30	320	80-84	240	1250	950	3	Not applicable		
20Ω/1100W **RE3083200**								4	Not applicable		
50Ω/1100W **RE3083500**								11	3	Not applicable	
180Ω/1100W **RE3084180**								Not limited	10	6	4
250Ω/1100W **RE3084250**									14	9	6
10Ω/1500W **RE3093100**	120	40	320	107-112	240	2750	1100	3	Not applicable		
39Ω/1500W **RE3093390**								12	3	Not applicable	
50Ω/1500W **RE3093500**								16	4	Not applicable	
180Ω/1500W **RE3094180**								Not limited	14	8	6
250Ω/1500W **RE3094250**									20	12	8
25Ω/1800W **RE3103250**	120	40	380	107-112	300	3000	1300	9	3	Not applicable	
120Ω/1800W **RE3104120**								Not limited	11	7	4
250Ω/1800W **RE3104250**									24	14	10
15Ω/2200W **RE3113150**	190	67	380	177-182	300	7000	2000	8	3	Not applicable	
50Ω/2200W **RE3113500**								29	7	4	3
75Ω/2200W **RE3113750**								Not limited	11	6	4
100Ω/2200W **RE3114100**									14	9	6
150Ω/2200W **RE3114150**									22	13	9
180Ω/2200W **RE3114180**									26	16	11
250Ω/2200W **RE3114250**									36	22	15

(*) Max. value to be set in parameter **C211** for single resistors or parallel-connected configurations.
That duration is longer for different configurations (two or more series-connected resistors), and “Not applicable” in the table may no longer be true. When setting the braking duty cycle in **C212**, make sure that the maximum power dissipated from the braking resistor being used is not exceeded.

3.5.4. IP20 Models from 4kW-8kW-12kW

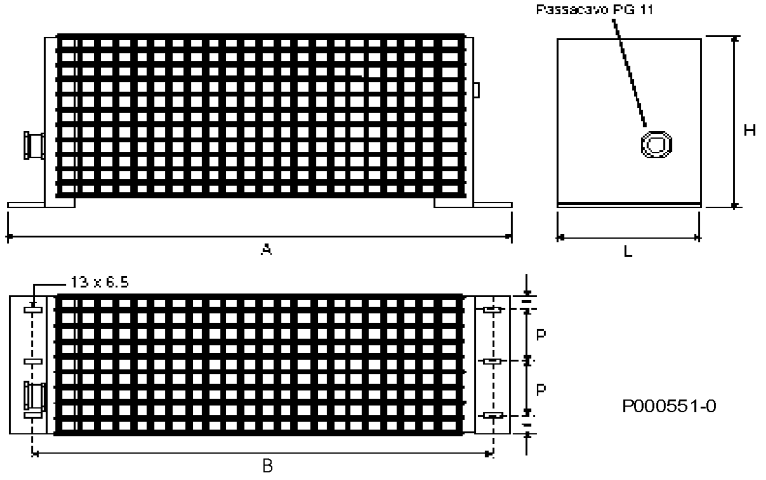


Figure 46: Overall dimensions for braking resistors 4kW, 8kW, 12kW

RESISTOR	A (mm)	B (mm)	L (mm)	H (mm)	P (mm)	Weight (g)	Average power that can be dissipated (W)	Max. duration of continuous operation (s) (*)			
								at 200-240Vac	at 380-500Vac	at 500-575Vac	at 660-690Vac
5Ω/4kW **RE3482500**	620	600	100	250	40	5.5	4000	7	Not applicable		
15Ω/4kW **RE3483150**								21	5	Not applicable	
20Ω/4kW **RE3483200**								28	7	4	3
25Ω/4kW **RE3483250**								35	8	5	3
39Ω/4kW **RE3483390**								Not limited	13	8	5
50Ω/4kW **RE3483500**									17	11	7
60Ω/4kW **RE3483600**									21	13	9
82Ω/4kW **RE3483820**									29	18	12
100Ω/4kW **RE3484100**									35	22	15
120Ω/4kW **RE3484120**									42	26	18
150Ω/4kW **RE3484150**									Not limited	33	22
180Ω/4kW **RE3484180**										39	27
250Ω/4kW **RE3484250**										Not limited	37
3.3Ω/8kW **RE3762330**	620	600	160	250	60	10.6	8000	9	Not applicable		
5Ω/8kW **RE3762500**								14			
10Ω/8kW **RE3763100**								28	7	4	3
45Ω/8kW **RE3763450**								Not limited	32	19	13
82Ω/8kW **RE3763820**									Not limited	36	24
120Ω/8kW **RE3764120**										Not limited	36
3.3Ω/12kW **RE4022330**	620	600	200	250	80	13.7	12000	14	Not applicable		
6.6Ω/12kW **RE4022660**								28	7	4	3
10Ω/12kW **RE4023100**								42	10	6	4
45Ω/12kW **RE4023450**								Not limited	48	29	20

(*) Max. value to be set in parameter **C211** for single resistors or parallel-connected configurations.
That duration is longer for different configurations (two or more series-connected resistors), and “Not applicable” in the table may no longer be true.
When setting the braking duty cycle in **C212**, make sure that the maximum power dissipated from the braking resistor being used is not exceeded.

CAUTION Because the metal frame of the braking resistor can reach high temperatures, appropriate cables capable of withstanding high temperatures must be used.

3.5.5. IP23 Boxes from 4kW to 64kW

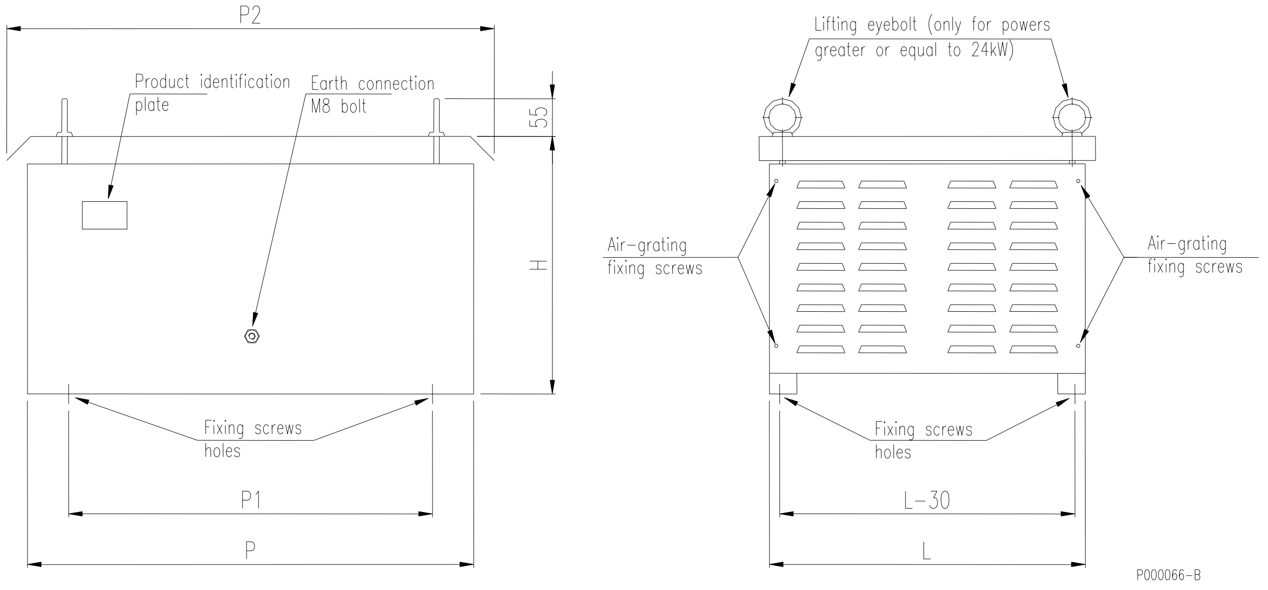


Figure 47: Overall dimensions of IP23 Box resistors

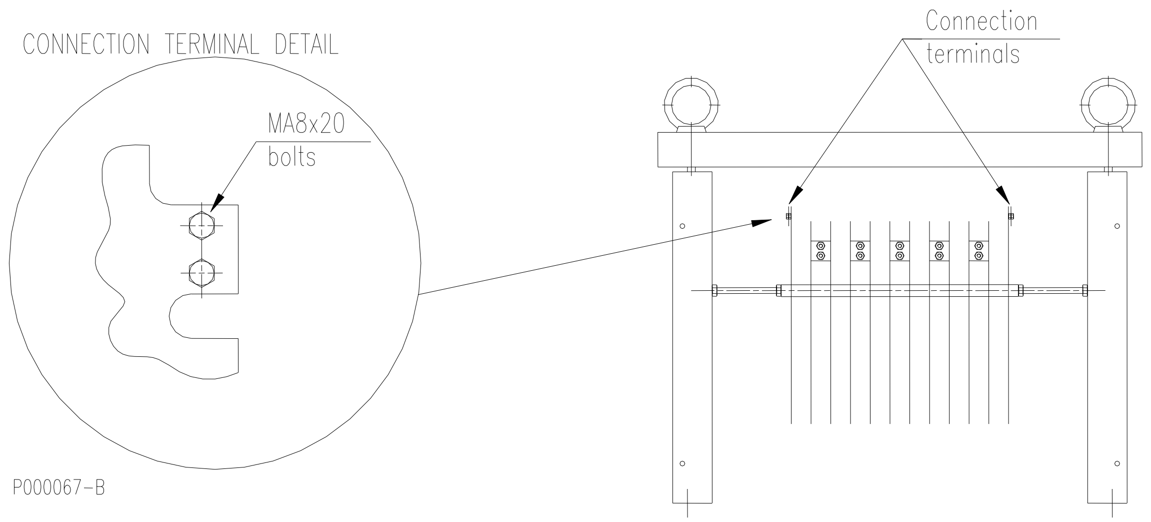


Figure 48: Position of electrical connections in box resistors

Remove the grids to gain access to wiring terminals (loosen fastening screws).

	NOTE	The figure shows 20Ω/12kW resistor. In certain models, remove both panels to gain access to the wiring terminals.
	CAUTION	Because the metal frame of the braking resistor can reach high temperatures, appropriate cables capable of withstanding high temperatures must be used.

3.5.5.1. Insulation Resistors, 1 kV (to be used in conjunction with 2T, 4T and 5T drives)

RESISTOR	P (mm)	P1 (mm)	P2 (mm)	L (mm)	H (mm)	Weight (kg)	Average power that can be dissipated (W)	Max. duration of continuous operation (s) (*)		
								at 200-240Vac	at 380-500Vac	at 500-575Vac
30Ω/4kW **RE3503300**	650	530	710	320	375	23	4000	85	21	13
45Ω/4kW **RE3503450**								128	32	19
50Ω/4kW **RE3503500**								not limited	35	22
60Ω/4kW **RE3503600**									42	26
82Ω/4kW **RE3503820**									58	36
100Ω/4kW **RE3504100**									71	44
120Ω/4kW **RE3504120**									85	53
150Ω/4kW **RE3504150**									not limited	66
180Ω/4kW **RE3504180**										79
15Ω/8kW **RE3783150**	650	530	710	380	375	30	8000	85	21	13
18Ω/8kW **RE3783180**								not limited	25	15
22Ω/8kW **RE3783220**									31	19
30Ω/8kW **RE3783300**									42	26
45Ω/8kW **RE3783450**									64	39
50Ω/8kW **RE3783500**									71	44
60Ω/8kW **RE3783600**									85	53
82Ω/8kW **RE3783820**									not limited	72
10Ω/12kW **RE4053100**	650	530	710	460	375	35	12000	85	21	13
12Ω/12kW **RE4053120**								not limited	25	15
15Ω/12kW **RE4053150**									32	19
18Ω/12kW **RE4053180**									38	23
20Ω/12kW **RE4053200**									42	26
22Ω/12kW **RE4053220**									46	29
30Ω/12kW **RE4053300**									64	39
45Ω/12kW **RE4053450**									96	59
60Ω/12kW **RE4053600**									not limited	79

RESISTOR	P (mm)	P1 (mm)	P2 (mm)	L (mm)	H (mm)	Weight (kg)	Average power that can be dissipated (W)	Max. duration of continuous operation (s) (*)		
								at 200-240Vac	at 380-500Vac	at 500-575Vac
3.6Ω/16kW **RE4162360**	650	530	710	550	375	40	16000	40	10	Not applicable
5Ω/16kW **RE4162500**								57	14	
6.6Ω/16kW **RE4162660**								75	18	11
8.2Ω/16kW **RE4162820**								Not limited	23	14
10Ω/16kW **RE4163100**									28	18
12Ω/16kW **RE4163120**									34	21
15Ω/16kW **RE4163150**									42	27
18Ω/16kW **RE4163180**									51	31
20Ω/16kW **RE4163200**									57	35
22Ω/16kW **RE4163220**									62	39
30Ω/16kW **RE4163300**									85	53
45Ω/16kW **RE4163450**									Not limited	79
2.4Ω/24kW **RE4292240**	650	530	710	750	375	50	24000	40	10	Not applicable
3Ω/24kW **RE4292300**								50	12	
5Ω/24kW **RE4292500**								85	21	13
6.6Ω/24kW **RE4292660**								Not limited	28	17
8.2Ω/24kW **RE4292820**									34	21
10Ω/24kW **RE4293100**									42	27
15Ω/24kW **RE4293150**									64	40
18Ω/24kW **RE4293180**									76	47
22Ω/24kW **RE4293220**									93	58
30Ω/24kW **RE4293300**									Not limited	79

<table>
<tr><th rowspan="2">RESISTOR</th><th rowspan="2">P (mm)</th><th rowspan="2">P1 (mm)</th><th rowspan="2">P2 (mm)</th><th rowspan="2">L (mm)</th><th rowspan="2">H (mm)</th><th rowspan="2">Weight (kg)</th><th rowspan="2">Average power that can be dissipated (W)</th><th colspan="3">Max. duration of continuous operation (s) (*)</th></tr>
<tr><th>at 200-240Vac</th><th>at 380-500Vac</th><th>at 500-575Vac</th></tr>
<tr><td>1.8Ω/32kW
RE4362180</td><td rowspan="12">650</td><td rowspan="12">530</td><td rowspan="12">710</td><td rowspan="12">990</td><td rowspan="12">375</td><td rowspan="12">60</td><td rowspan="12">32000</td><td>60</td><td>16</td><td rowspan="3">Not applicable</td></tr>
<tr><td>2.4Ω/32kW
RE4362240</td><td>54</td><td>13</td></tr>
<tr><td>2.8Ω/32kW
RE4362280</td><td>63</td><td>15</td></tr>
<tr><td>3Ω/32kW
RE4362300</td><td>68</td><td>17</td><td>10</td></tr>
<tr><td>3.6Ω/32kW
RE4362360</td><td>82</td><td>20</td><td>12</td></tr>
<tr><td>4.2Ω/32kW
RE4362420</td><td>96</td><td>23</td><td>14</td></tr>
<tr><td>5Ω/32kW
RE4362500</td><td>114</td><td>28</td><td>17</td></tr>
<tr><td>6Ω/32kW
RE4362600</td><td rowspan="5">Not limited</td><td>34</td><td>21</td></tr>
<tr><td>6.6Ω/32kW
RE4362660</td><td>37</td><td>23</td></tr>
<tr><td>10Ω/32kW
RE4363100</td><td>56</td><td>35</td></tr>
<tr><td>15Ω/32kW
RE4363150</td><td>85</td><td>53</td></tr>
<tr><td>18Ω/32kW
RE4363180</td><td>102</td><td>63</td></tr>
<tr><td>0.45Ω/48W
RE4451450</td><td rowspan="14">650</td><td rowspan="14">530</td><td rowspan="14">710</td><td rowspan="14">750</td><td rowspan="14">730</td><td rowspan="14">95</td><td rowspan="14">48000</td><td>15</td><td rowspan="3">Not applicable</td><td rowspan="6">Not applicable</td></tr>
<tr><td>0.6Ω/48kW
RE4451600</td><td>20</td></tr>
<tr><td>0.8Ω/48kW
RE4451800</td><td>27</td></tr>
<tr><td>1.2Ω/48kW
RE4452120</td><td>40</td><td>10</td></tr>
<tr><td>1.4Ω/48kW
RE4452140</td><td>47</td><td>11</td></tr>
<tr><td>1.6Ω/48kW
RE4452160</td><td>54</td><td>13</td></tr>
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RE4452180</td><td>60</td><td>15</td><td>10</td></tr>
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<tr><td>2.8Ω/48kW
RE4452280</td><td>95</td><td>23</td><td>14</td></tr>
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RE4452500</td><td>42</td><td>26</td></tr>
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<table>
<tr><th rowspan="2">RESISTOR</th><th rowspan="2">P (mm)</th><th rowspan="2">P1 (mm)</th><th rowspan="2">P2 (mm)</th><th rowspan="2">L (mm)</th><th rowspan="2">H (mm)</th><th rowspan="2">Weight (kg)</th><th rowspan="2">Average power that can be dissipated (W)</th><th colspan="3">Max. duration of continuous operation (s) (*)</th></tr>
<tr><th>at 200-240Vac</th><th>at 380-500Vac</th><th>at 500-575Vac</th></tr>
<tr><td>6Ω/48kW
RE4452600</td><td rowspan="5">650</td><td rowspan="5">530</td><td rowspan="5">710</td><td rowspan="5">750</td><td rowspan="5">730</td><td rowspan="5">95</td><td rowspan="5">48000</td><td rowspan="5">Not limited</td><td>51</td><td>31</td></tr>
<tr><td>6.6Ω/48kW
RE4452660</td><td>56</td><td>35</td></tr>
<tr><td>10Ω/48kW
RE4453100</td><td>85</td><td>53</td></tr>
<tr><td>12Ω/48kW
RE4453120</td><td rowspan="2">Not limited</td><td>63</td></tr>
<tr><td>15Ω/48kW
RE4453150</td><td>79</td></tr>
<tr><td>0.3Ω/64kW
RE4551300</td><td rowspan="19">650</td><td rowspan="19">530</td><td rowspan="19">710</td><td rowspan="19">990</td><td rowspan="19">730</td><td rowspan="19">115</td><td rowspan="19">64000</td><td>13</td><td rowspan="4">Not applicable</td><td rowspan="5">Not applicable</td></tr>
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RE4551450</td><td>20</td></tr>
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RE4551600</td><td>27</td></tr>
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RE4552300</td><td>34</td><td>21</td></tr>
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RE4552420</td><td>47</td><td>29</td></tr>
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<tr><td>8.2Ω564kW
RE4552820</td><td>93</td><td>58</td></tr>
<tr><td>10Ω/64kW
RE4553100</td><td>Not limited</td><td>70</td></tr>
</table>

(*) Max. value to be set in parameter **C211** for single resistors or parallel-connected configurations.
That duration is longer for different configurations (two or more series-connected resistors) and “Not applicable” in the table may no longer be true.
When setting the braking duty cycle in **C212**, make sure that the maximum power dissipated from the braking resistor being used is not exceeded.

3.5.5.2. Insulation Resistors, 3 kV (to be used in conjunction with 6T drives)

RESISTOR	P (mm)	P1 (mm)	P2 (mm)	L (mm)	H (mm)	Wgt (kg)	Average power that can be dissipated (W)	Max. duration of continuous operation (s) (*) at 660-690Vac
30Ω/4kW **RE3553300**	650	530	710	460	375	35	4000	9
45Ω/4kW **RE3553450**								13
50Ω/4kW **RE3553500**								15
60Ω/4kW **RE3553600**								18
82Ω/4kW **RE3553820**								24
100Ω/4kW **RE3554100**								30
120Ω/4kW **RE3554120**								36
150Ω/4kW **RE3554150**								45
180Ω/4kW **RE3554180**								54
18Ω/8kW **RE3793180**	650	530	710	550	375	40	8000	10
22Ω/8kW **RE3793220**								13
30Ω/8kW **RE3793300**								18
45Ω/8kW **RE3793450**								27
50Ω/8kW **RE3793500**								30
60Ω/8kW **RE3793600**								36
82Ω/8kW **RE3793820**								49
10Ω/12kW **RE4063100**	650	530	710	550	375	40	12000	9
12Ω/12kW **RE4063120**								10
15Ω/12kW **RE4063150**								13
18Ω/12kW **RE4063180**								16
20Ω/12kW **RE4063200**								18
22Ω/12kW **RE4063220**								19
30Ω/12kW **RE4063300**								27
45Ω/12kW **RE4063450**								40
60Ω/12kW **RE4063600**								54

RESISTOR	P (mm)	P1 (mm)	P2 (mm)	L (mm)	H (mm)	Wgt (kg)	Average power that can be dissipated (W)	Max. duration of continuous operation (s) (*) at 660-690Vac
6.6Ω/16kW **RE4172660**	650	530	710	650	375	45	16000	not applicable
8.2Ω/16kW **RE4172820**								9
10Ω/16kW **RE4173100**								12
12Ω/16kW **RE4173120**								14
15Ω/16kW **RE4173150**								18
18Ω/16kW **RE4173180**								21
20Ω/16kW **RE4173200**								24
22Ω/16kW **RE4173220**								26
30Ω/16kW **RE4173300**								36
45Ω/16kW **RE4173450**								54
5Ω/24kW **RE4302500**	650	530	710	850	375	55	24000	9
6.6Ω/24kW **RE4302660**								11
8.2Ω/24kW **RE4302820**								14
10Ω/24kW **RE4303100**								18
15Ω/24kW **RE4303150**								27
18Ω/24kW **RE4303180**								32
22Ω/24kW **RE4303220**								39
30Ω/24kW **RE4303300**								54

RESISTOR	P (mm)	P1 (mm)	P2 (mm)	L (mm)	H (mm)	Wgt (kg)	Average power that can be dissipated (W)	Max. duration of continuous operation (s) (*) at 660-690Vac
3Ω/32kW **RE4372300**	650	530	710	650	730	78	32000	Not applicable
3.6Ω/32kW **RE4372360**								
4.2Ω/32kW **RE4372420**								10
5Ω/32kW **RE4372500**								12
6Ω/32kW **RE4372600**								14
6.6Ω/32kW **RE4372660**								15
10Ω/32kW **RE4373100**								24
15Ω/32kW **RE4373150**								36
18Ω/32kW **RE4373180**								43
1.8Ω/48kW **RE4462180**	650	530	710	850	730	100	48000	Not applicable
2.1Ω/48kW **RE4462210**								
2.4Ω/48kW **RE4462240**								
2.8Ω/48kW **RE4462280**								10
3Ω/48kW **RE4462300**								10
3.6Ω/48kW **RE4462360**								13
4.2Ω/48kW **RE4462420**								15
5Ω/48kW **RE4462500**								18
6Ω/48kW **RE4462600**								21
6.6Ω/48kW **RE4462660**								23
10Ω/48kW **RE4463100**								36
12Ω/48kW **RE4463120**								43
15Ω/48kW **RE4463150**								54

RESISTOR	P (mm)	P1 (mm)	P2 (mm)	L (mm)	H (mm)	Wgt (kg)	Average power that can be dissipated (W)	Max. duration of continuous operation (s) (*)
								at 660-690Vac
1.4Ω/64kW **RE4562140**	650	530	710	750	1085	130	64000	Not applicable
1.6Ω/64kW **RE4562160**								
1.8Ω/64kW **RE4562180**								10
2.1Ω/64kW **RE4562210**								10
2.4Ω/64kW **RE4562240**								11
2.8Ω/64kW **RE4562280**								13
3Ω/64kW **RE4562300**								14
3.6Ω/64kW **RE4562360**								17
4.2Ω/64kW **RE4562420**								20
5Ω/64kW **RE4562500**								24
6Ω/64kW **RE4562600**								29
6.6Ω/64kW **RE4562660**	650	530	710	850	1085	142	64000	31
8.2Ω/64kW **RE4562820**								39
10Ω/64kW **RE4563100**								48

(*) Max. value to be set in parameter **C211** for single resistors or parallel-connected configurations. That duration is longer for different configurations (two or more series-connected resistors) and “Not applicable” in the table may no longer be true.
When setting the braking duty cycle in **C212**, make sure that the maximum power dissipated from the braking resistor being used is not exceeded.

4. NEMA 1 GLANDKIT

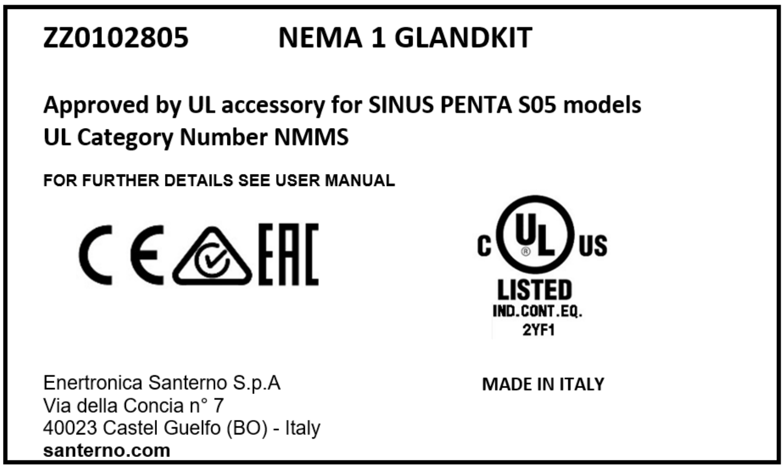
Product-Accessory Compatibility		
Product	**NEMA 1 GLANDKIT**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	√	
Solardrive Plus	√	

Table 5: Product – NEMA 1 GLANDKIT compatibility

In accordance with UL 508C, the SINUS PENTA may be provided with the special "NEMA 1 Glandkit" UL Category Number NMMS by Enertronica Santerno S.p.A. against accidental contacts.
This optional kit installed directly on SINUS PENTA drives with UL Open Type degree of protection, provides IP21/UL Type 1 degree of protection.
The definitions of UL Type 1 / NEMA 1 degree of protection are given by NEMA and UL standards.

Enclosure Rating	National Electrical Manufacturers Association (NEMA Standard 250)	Underwriters Laboratories, Inc. (UL 50 and UL 508C)
NEMA 1/ UL Type 1	Indoor use to provide a degree of protection to personnel against access to hazardous parts and to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt).	Indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection against falling dirt

4.1.1. Nameplate NEMA 1 GLANDKIT



S001011

Figure 49: Typical nameplate for SINUS PENTA NEMA KIT accessory

The UL-approved kit is given in the tables below for models from S05 to S52:

4.2. Identication Data

4.2.1. 2T-4T Voltage Classes

Inverter Frame Size	*Part Number*
S05	ZZ0102805
S12	ZZ0124812
S15	ZZ0102815
S20	ZZ0102820
S30	ZZ0102830
S41	ZZ1124907
S51	ZZ0124850

4.2.2. 5T-6T Voltage Classes

Inverter Frame Size	*Part Number*
S12	ZZ0124812
S14	ZZ0102810
S22	ZZ0124822
S32	ZZ0124832
S42	ZZ1124907
S52	ZZ0124850

CAUTION The installer is responsible for the utilization of safe materials able to preserve the equipment degree of protection. It is recommended that the cables do not enter into contact with sharp metal parts that may compromise isolation.

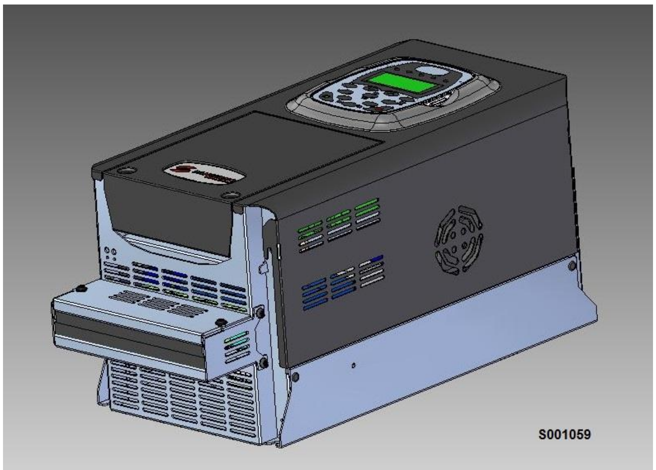


Figure 50: Example of a NEMA 1 Kit installed on a SINUS PENTA

4.2.3. Overall Dimensions when Installing an Inverter with the NEMA 1 Glandkit

4.2.3.1. 2T-4T Voltage Classes

Inverter Frame Size	Kit Dimensions (mm)			Inverter + Kit Overall Height [mm]	Kit Weight (kg)
	W	H	D	H	
S05	149	71	43	402	0.4
S12	179	74	56	460	0.4
S15	169	74	71	525	0.5
S20	275	98	104	659	0.9
S30	296	131	117	809	1.0
S41	504	295	186	1098	5.6
S51	579	295	186	1098	6.2

4.2.3.1. 5T-6T Voltage Classes

Inverter Frame Size	Kit Dimensions (mm)			Inverter + Kit Overall Height [mm]	Kit Weight (kg)
	W	H	D	H	
S12	179	74	56	460	0.4
S14	235	74	56	588	0.5
S22	232	99	95	873	0.7
S32	322	130	142	940	1.3
S42	504	295	186	1187	5.6
S52	579	295	186	1187	6.2

NOTE The W and D dimensions of the inverter are not affected. See relevant tables provided on the **Installation Guide**.

5. KEYPAD REMOTING KIT

Product-Accessory Compatibility		
Product	**Keypad remoting kit**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	√	
Solardrive Plus	√	

Table 6: Product – Keypad remoting kit compatibility

5.1. Remoting the Keypad on the Cabinet

The inverter keypad may be remoted. A special kit is supplied, which includes the following:

- plastic frame allowing installing the keypad on the front wall of the cabinet,
- keypad jig allowing installing the keypad on the front door of the cabinet,
- seal between keypad frame and cabinet,
- remoting cable (length: 5 m).

If the kit supplied is properly assembled, degree of protection IP54 is obtained for the front panel in the cabinet.
For any details on how to remote the keypad, please refer to the Operating and Remoting the Keypad in the Installation Guide.

DESCRIPTION	PART NUMBER
SINUS PENTA kit remote keypad, 3mt	ZZ0095699
SINUS PENTA kit remote keypad, 5mt	ZZ0095700

6. INDUCTORS

Product-Accessory Compatibility		
Product	**Inductors**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	√	The DC inductors may be installed only on S05 2T and S12 2T/4T
Solardrive Plus	√	AC input inductors and DC inductors – only if a power supply source other than the PV field is envisaged

Table 7: Product – Inductors compatibility

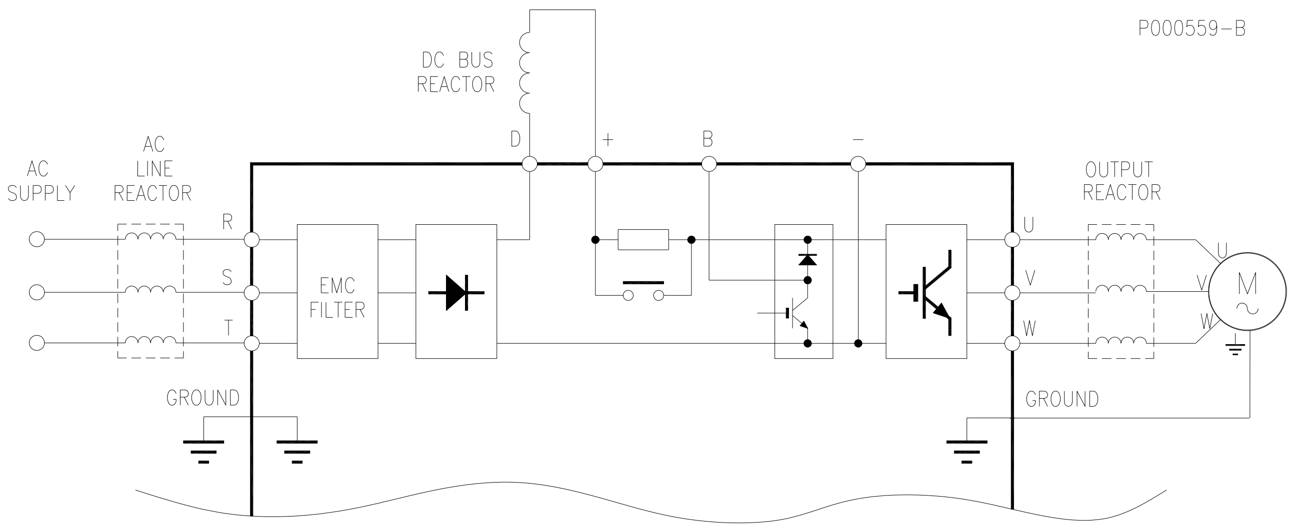


Figure 51: Wiring diagram for optional inductors

6.1. Input Inductors

We suggest that a three-phase inductor, or a DC-BUS DC inductor, be installed on the supply line to obtain the following benefits:

- limit input current peaks on the input circuit of the inverter and value di/dt due to the input rectifier and to the capacitive load of the capacitors set;
- reducing supply harmonic current;
- increasing power factor, thus reducing line current;
- increasing the duration of line capacitors inside the inverter.

Harmonic currents

The shapes of the different waves (current or voltage) may be expressed as the sum of the basic frequency (50 or 60Hz) and its multiples. In balanced, three-phase systems, only odd harmonic current exists, as even current is neutralized by symmetrical considerations.
Harmonic current is generated by non-linear loads absorbing non-sinusoidal current. Typical sources of this type are bridge rectifiers (power electronics), switching power supply units and fluorescent lamps.
Three-phase rectifiers absorb line current with a harmonic content n=6K±1 with K=1,2,3,… (e.g. 5th,7th,11th,13th,17th,19th, etc.). Harmonic current amplitude decreases when frequency increases. Harmonic current carries no active power; it is additional current carried by electrical cables. Typical effects are: conductor overload, power factor decrease and measurement systems instability. Voltage generated by current flowing in the transformer inductor may also damage other appliances or interfere with mains-synchronized switching equipment.

Solving the problem

Harmonic current amplitude decreases when frequency increases; as a result, reducing high-amplitude components determines the filtering of low-frequency components. The better way is to increase low-frequency impedance by installing an inductor. Power drive systems with no mains-side inductor generate larger harmonic currents than power drives which do have an inductor.
The inductor may be installed both on AC-side, as a 3-phase inductor on the supply line, and on DC-side, as a single-phase inductor installed between the rectifier bridge and the capacitor bank inside the inverter. Even greater benefits are obtained if an inductor is installed both on AC-side and on DC-side.
Unlike DC inductors, AC inductors filter high-frequency components as well as low-frequency components with greater efficiency.

CAUTION A DC inductor can be connected to inverters sizes S15, S20, S30. This must be specified when ordering the equipment (see the Power Terminals Modified for a DC Inductor in the Installation Guide).

CAUTION No DC inductor can be installed in S05(4T) inverters.

CAUTION When a DC inductor is used, it can happen that no braking resistor can be connected when an external braking unit is connected, and vice versa (see the Power Terminals Modified for a DC Inductor in the Installation Guide).

Harmonic currents in the inverter power supply

The amplitude of harmonic currents and their incidence on the mains voltage is strongly affected by the features of the mains where the equipment is installed. The ratings given in this manual fit most applications. For special requirements, please contact Enertronica Santerno’s Customer service.

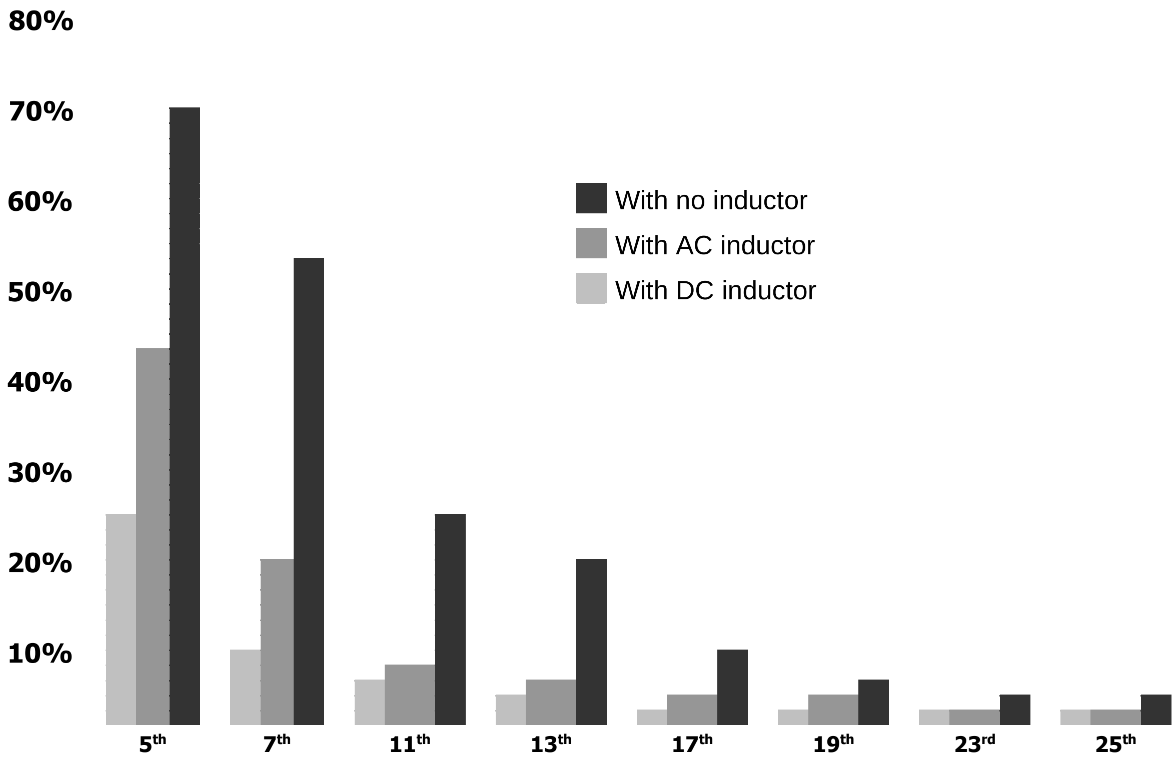


Figure 52: Amplitude of harmonic currents (approximate values)

CAUTION

Use the input inductor under the following circumstances:

- mains instability;
- converters installed for DC motors;
- loads generating strong voltage variations at startup;
- power factor correction systems.

CAUTION

Use the input inductor under the following circumstances:

- when drives up to size S12 included are connected to grids with a short-circuit power greater than 500 kVA;
- with drives from size S15 to size S60P when the short-circuit power is 20 times the inverter power;
- when using parallel-connected inverters;
- with Penta drives size S65 or greater, unless the inverter is powered via a dedicated transformer featuring Vsc=5% or greater;
- with modular inverters provided with multiple power supply units (sizes S70, S75, S80 and S90).

The ratings of optional inductor recommended based on the inverter model are detailed in the section below.

6.2. Output Inductors (DU/DT Filters)

Installations requiring cable lengths over 100m between the inverter and the motor may cause overcurrent protections to frequently trip. This is due to the wire parasite capacity generating current pulses at the inverter output; those current pulses are generated from the high du/dt ratio of the inverter output voltage. The current pulses may be limited by an inductor installed on the inverter output. Shielded cables even have a higher capacity and may cause problems with shorter cable lengths.
The maximum distance between the motor and the inverter is given as an example, as parasite capacity is also affected by the type of wiring path and wiring system. For instance, when several inverters and their connected motors are networked, segregating the inverter wires from the motor wires will avoid capacitive couplings between the wiring of each motor.
An adverse effect can also be the stress produced on the motor insulation due to the high du/dt ratio at the inverter output.

CAUTION Using du/dt filters is always recommended when the motor cable length is over 100m (50m with shielded cables).
It is recommended that Sine Filters be used (see Sine Filters) for lengths exceeding 300m (150m with shielded cables).

NOTE When using parallel-connected motors, always consider the total length of the cables being used (sum of the cable length of each motor).

CAUTION The output inductor is always required when using modular inverters and parallel-connected inverters.

CAUTION The inductors stated in the tables below may be used when the inverter output frequency is not over 120Hz. For higher output frequency, a special inductor for the max. allowable operating frequency must be used. Please contact Enertronica Santerno S.p.A..

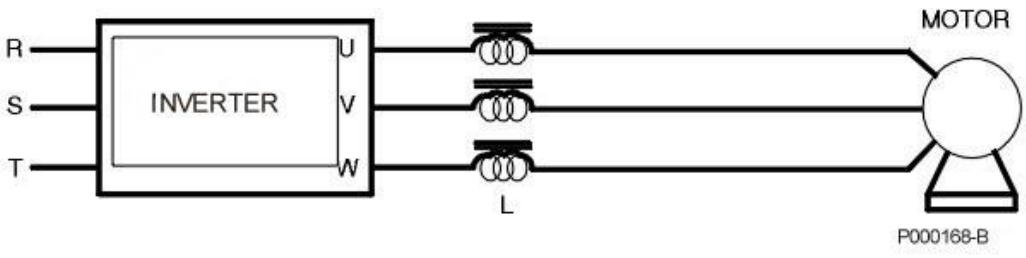


Figure 53: Output inductor wiring

6.3. Applying the Inductor to the Inverter

NOTE IP54 rated 3-phase inductors are available for inverters up to S32 included, because basically inductors are IP00 rated.

CAUTION Use the inductors described in section Input inductors to be Applied to the Drive and the SU465 for 12-pulse power supply.

6.3.1. Class 2T – AC and DC Inductors

SIZE	Drive MODEL	INPUT AC 3-PHASE INDUCTOR	DC INDUCTOR MODEL	THREE-PHASE OUTPUT AC INDUCTOR	MAX. OUTPUT FREQ. (Hz) (**)
S05	0007 0008 0010	IM0126044 1.27mH–17Arms	IM0140104 5.1mH–17A/21Apeak	IM0126044 1.27mH–17Arms	60
S05	0013 0015 0016 0020	IM0126084 0.7mH–32Arms	IM0140154 2.8mH–32.5A/40.5Apeak	IM0126084 0.7mH–32Arms (3-phase)	60
S12	0023	IM0126124 0.51mH–45Arms	IM0140204 2.0mH–47A/58.5Apeak	IM0126124 0.51mH–45Arms	60
S12	0033 0037	IM0126144 0.3mH–68Arms	IM0140254 1.2mH–69A/87Apeak	IM0126144 0.32mH–68Arms	60
S15 S20	0040 0049 0060	IM0126164 0.24mH–92Arms	IM0140284 (*) 0.96mH–100A/160Apeak	IM0126164 0.24mH–92Arms	60
S20	0067 0074 0086	IM0126204 0.16mH–145Arms	IM0140304 (*) 0.64mH–160A/195Apeak	IM0126204 0.16mH–145Arms	60
S30	0113 0129 0150 0162	IM0126244 0.09mH–252Arms	IM0140404 (*) 0.36mH–275A/345Apeak	IM0126244 0.09mH–252Arms	60
S41	0180 0202	IM0126282 (**) 0.063mH–360Arms	IM0140454 0.18mH–420A/520Apeak	IM0138200 0.070mH–360Arms	120
S41	0217 0260	IM0126332 (**) 0.05 mH–455Arms	IM0140604 0.14mH–520A/650Apeak	IM0138250 0.035mH–445Arms	120
S51	0313 0367 0402	IM0126372 0.031mH–720Arms	IM0140664 0.09mH–830A/1040Apeak	IM0138300 0.025mH–700Arms	120
S60	0457 0524	IM0126404 0.023mH–945Arms	IM0140754 0.092mH– 1040A/1300Apeak	IM0126404 0.023mH–945Arms	60

CAUTION (*) For the inverter sizes S15, S20, S30, the DC inductors required are to be specified when ordering the equipment as they involve hardware modifications.

CAUTION (**) The inductor can also be used at output frequencies higher than the one indicated, up to a maximum of twice, but taking into account current derating. This derating increases linearly with frequency and is equal to 50% corresponding to twice the indicated value.

6.3.2. Class 4T – AC and DC Inductors

<table>
<tr><th>SIZE</th><th>Drive Model</th><th>INPUT AC 3-PHASE INDUCTOR</th><th>DC INDUCTOR MODEL</th><th>OUTPUT 3-PHASE AC INDUCTOR</th><th>MAX. OUTPUT FREQ. (Hz) (**)</th></tr>
<tr><td rowspan="5">S05</td><td>0005</td><td>IM0126004
2.0mH–11Arms</td><td rowspan="5">Not applicable</td><td>IM0126004
2.0mH–11Arms</td><td>60</td></tr>
<tr><td>0007</td><td rowspan="4">IM0126044
1.27mH–17Arms</td><td rowspan="4">IM0126044
1.27mH–17Arms</td><td rowspan="4">60</td></tr>
<tr><td>0009</td></tr>
<tr><td>0011</td></tr>
<tr><td>0014</td></tr>
<tr><td rowspan="7">S12</td><td>0016</td><td rowspan="3">IM0126084
0.7mH–32Arms</td><td rowspan="3">IM0140154
2.8mH–32.5A</td><td rowspan="3">IM0126084
0.7mH–32Arms</td><td rowspan="3">60</td></tr>
<tr><td>0017</td></tr>
<tr><td>0020</td></tr>
<tr><td>0025</td><td rowspan="2">IM0126124
0.51mH–45Arms</td><td rowspan="2">IM0140204
2.0mH–47A</td><td rowspan="2">IM0126124
0.51mH–45Arms</td><td rowspan="2">60</td></tr>
<tr><td>0030</td></tr>
<tr><td>0034</td><td rowspan="2">IM0126144
0.3mH–68Arms</td><td rowspan="2">IM0140254
1.2mH–69A</td><td rowspan="2">IM0126144
0.3mH–68Arms</td><td rowspan="2">60</td></tr>
<tr><td>0036</td></tr>
<tr><td rowspan="2">S15</td><td>0040</td><td rowspan="3">IM0126164
0.24mH–92Arms</td><td rowspan="3">IM0140284 (*)
0.96mH–100A</td><td rowspan="3">IM0126164
0.24mH–92Arms</td><td rowspan="3">60</td></tr>
<tr><td>0049</td></tr>
<tr><td rowspan="4">S20</td><td>0060</td></tr>
<tr><td>0067</td><td rowspan="3">IM0126204
0.16mH–145Arms</td><td rowspan="3">IM0140304 (*)
0.64mH–160A</td><td rowspan="3">IM0126204
0.16mH–145Arms</td><td rowspan="3">60</td></tr>
<tr><td>0074</td></tr>
<tr><td>0086</td></tr>
<tr><td rowspan="4">S30</td><td>0113</td><td rowspan="4">IM0126244
0.09mH–252Arms</td><td rowspan="4">IM0140404 (*)
0.36mH–275A</td><td rowspan="4">IM0126244
0.09mH–252Arms</td><td rowspan="4">60</td></tr>
<tr><td>0129</td></tr>
<tr><td>0150</td></tr>
<tr><td>0162</td></tr>
<tr><td rowspan="4">S41</td><td>0180</td><td rowspan="2">IM0126282 (**)
0.063mH–360Arms</td><td rowspan="2">IM0140454
0.18mH–420A</td><td rowspan="2">IM0138200
0.070mH–360Arms</td><td rowspan="2">120</td></tr>
<tr><td>0202</td></tr>
<tr><td>0217</td><td rowspan="2">IM0126332 (**)
0.05 mH–455Arms</td><td rowspan="2">IM0140604
0.14mH–520A</td><td rowspan="2">IM0138250
0.035mH–445Arms</td><td rowspan="2">120</td></tr>
<tr><td>0260</td></tr>
<tr><td rowspan="3">S51</td><td>0313</td><td rowspan="3">IM0126372 (**)
0.031mH–720Arms</td><td rowspan="3">IM0140664
0.09mH–830A</td><td rowspan="3">IM0138300
0.025mH–700Arms</td><td rowspan="3">120</td></tr>
<tr><td>0367</td></tr>
<tr><td>0402</td></tr>
<tr><td rowspan="2">S60</td><td>0457</td><td rowspan="4">IM0126404
0.023mH–945Arms</td><td rowspan="4">IM0140754
0.092mH–1040A</td><td rowspan="4">IM0126404
0.023mH–945Arms</td><td rowspan="4">60</td></tr>
<tr><td>0524</td></tr>
<tr><td>S60P</td><td>0598P</td></tr>
<tr><td rowspan="3">S65</td><td>0598</td></tr>
<tr><td>0748</td><td rowspan="2">IM0126444
0.018mH–1260Arms</td><td rowspan="2">IM0140854 (*)
0.072mH–1470A</td><td rowspan="2">IM0126444
0.018mH–1260Arms</td><td rowspan="2">60</td></tr>
<tr><td>0831</td></tr>
<tr><td rowspan="3">S75</td><td>0964</td><td rowspan="2">2 x IM0126404
0.023mH–945A</td><td rowspan="2">2 x IM0140754 (*)
0.092mH–1040A</td><td rowspan="3">6 x IM0141782
0.015mH–1250Arms
(single-phase)</td><td rowspan="3">60</td></tr>
<tr><td>1130</td></tr>
<tr><td>1296</td><td>2 x IM0126444
0.018mH–1260A</td><td>2 x IM0140854 (*)
0.072mH– 1470A</td></tr>
<tr><td rowspan="2">S90</td><td>1800</td><td>3 x IM0126404
0.023mH–945Arms</td><td>3 x IM0140754 (*)
0.092mH–1040A</td><td rowspan="2">9 x IM0141782
0.015mH–1250Arms
(single-phase)</td><td rowspan="2">60</td></tr>
<tr><td>2076</td><td>3 x IM0126444
0.018mH–1260Arms</td><td>3 x IM0140854 (*)
0.072mH–1470A</td></tr>
</table>

CAUTION (*) For the inverter sizes S15, S20, S30 and from S65 to S90, the DC inductors required are to be specified when ordering the equipment as they involve hardware modifications.

CAUTION (**) The inductor can also be used at output frequencies higher than the one indicated, up to a maximum of twice, but taking into account current derating. This derating increases linearly with frequency and is equal to 50% corresponding to twice the indicated value.

6.3.3. Class 5T-6T – AC and DC Inductors

SIZE	Drive Model	INPUT AC 3-PHASE INDUCTOR	DC INDUCTOR MODEL	THREE-PHASE OUTPUT AC INDUCTOR	MAX. OUTPUT FREQ. (Hz) (**)
S12 5T S14 6T	0003	IM0127042 6.4mH–6.5Arms	Please contact Enertronica Santerno S.p.A.	IM0138000 1.9mH–9.3Arms	120
	0004	IM0127062 4.1mH–10.5Arms			
	0006			IM0138010 1.4mH–13.4Arms	120
	0012	IM0127082 2.6mH–16Arms			
	0018			IM0138020 1.0mH–17.5Arms	120
S14	0019	IM0127102 1.8mH–23Arms		IM0138030 0.70mH–25.6Arms	120
	0021				
	0022	IM0127122 1.1mH–40Arms		IM0138040 0.42mH–41Arms	120
	0024				
	0032	IM0127142 0.7mH–57Arms		IM0138045 0.28mH–62Arms	120
S22	0042				
	0051	IM0127167 0.43mH–95Arms	IM0141404 1.2mH–110A	IM0138050 0.17mH–105Arms (3-phase)	120
	0062				
	0069				
S32	0076	IM0127202 0.29mH–140Arms	IM0141414 0.80mH–160A	IM0138100 0.11mH–165Arms (3-phase)	120
	0088				
	0131	IM0127227 0.19mH–210Arms	IM0141424 0.66mH–240A	IM0138150 0.075mH–240Arms (3-phase)	120
	0164				
S42	0181	IM0127274 (**) 0.12mH–325A	IM0141434 0.32mH–375A	IM0138200 0.070mH –360Arms (3-phase)	120
	0201				
	0218	IM0127330 (**) 0.096mH–415Arms	IM0141554 0.27mH–475A	IM0138250 0.035mH –440Arms (3-phase)	120
	0259				
S52	0290	IM0127350 (**) 0.061mH–650Arms	IM0141664 0.17mH–750A	IM0138300 0.025mH–700Arms (3-phase)	120
	0314				
	0368				
	0401				
S65	0457	IM0127404 0.040mH–945Arms	IM0141804 (*) 0.16mH–1170A	IM0127404 0.040mH–945Arms (3-phase)	60
	0524				
	0598				
	0748	IM0127444 0.030mH–1260Arms	IM0141904 (*) 0.12mH–1290A	IM0127444 0.030mH–1260Arms (3-phase)	60
S70	0831	2 x IM0127364 0.058mH–662Arms	2 x IM0141704 (*) 0.232mH–830A		
S75	0964	2 x IM0127404 0.040mH–945Arms	2 x IM0141804 (*) 0.16mH–1170A	6 x IM0141782 0.015mH–1250Arms (single-phase)	60
	1130	2 x IM0127444 0.030mH–1260Arms			
S80	1296	3 x IM0127404 0.040mH–945Arms	3 x IM0141804 (*) 0.16mH–1170A		
S90	1800			9 x IM0141782 0.015mH–1250Arms (single-phase)	60
	2076	3 x IM0127444 0.030mH–1260Arms	3 x IM0141904 (*) 0.12mH–1290A		

CAUTION (*) For the inverter sizes from S65 to S90, the DC inductors required are to be specified when ordering the equipment as they involve hardware modifications.

CAUTION (**) The inductor can also be used at output frequencies higher than the one indicated, up to a maximum of twice, but taking into account current derating. This derating increases linearly with frequency and is equal to 50% corresponding to twice the indicated value.

6.4. Inductance Ratings

6.4.1. Class 2T-4T – AC 3-Phase Inductors

INDUCTOR MODEL	TYPE	INDUCTANCE RATINGS		DIMENSIONS							FIXING HOLES	WGT	LOSSES
		mH	A	TYPE	L	H	P	M	E	G	mm	kg	W
IM0126004	Input-output	2.00	11	A	120	125	75	25	67	55	Ø5	2.9	29
IM0126044	Input-output	1.27	17	A	120	125	75	25	67	55	Ø5	2.9	48
IM0126084	Input-output	0.70	32	B	150	130	115	50	125	75	7x14	5	70
IM0126124	Input-output	0.51	45	B	150	130	115	50	125	75	7x14	6	105
IM0126144	Input-output	0.30	68	B	180	160	150	60	150	82	7x14	9	150
IM0126164	Input-output	0.24	92	B	180	160	150	60	150	82	7x14	9.5	183
IM0126204	Input-output	0.16	145	B	240	210	175	80	200	107	7x14	17	280
IM0126244	Input-output	0.090	252	B	240	210	220	80	200	122	7x14	25	342
IM0126282	Input only	0.063	360	C	300	286	205	100	250	116	9x24	44	350
IM0126332	Input only	0.050	455	C	300	317	217	100	250	128	9x24	54	410
IM0126372	Input only	0.031	720	C	360	342	268	120	325	176	9x24	84	700
IM0126404	Input-output	0.023	945	C	300	320	240	100	250	143	9x24	67	752
IM0126444	Input-output	0.018	1260	C	360	375	280	120	250	200	Ø12	82	1070

6.4.2. Class 5T-6T – AC 3-Phase Inductors

INDUCTOR MODEL	INPUT/OUTPUT	INDUCTANCE RATINGS		DIMENSIONS							FIXING HOLES	WGT	LOSSES
		mH	A	TYPE	L	H	P	M	E	G	mm	kg	W
IM0127042	Input only	6.4	6.5	A	150	170	101	-	90	70	7x10	3	22
IM0127062	Input only	4.1	10.5	A	180	173	110	-	150	73	8.5x15	4.5	28
IM0127082	Input only	2.6	16	A	180	173	120	-	150	83	8.5x15	6.5	45
IM0127102	Input only	1.8	23	A	180	173	130	-	150	93	8.5x15	9	52
IM0127122	Input only	1.1	40	A	240	228	140	-	200	80	8x15	14	96
IM0127142	Input only	0.70	57	A	240	228	175	-	200	115	8x15	19	122
IM0127167	Input only	0.43	95	B	240	224	187	80	200	122	7x18	27	160
IM0127202	Input only	0.29	140	B	300	254	190	100	250	113	9x24	35	240
IM0127227	Input only	0.19	210	B	300	285	218	100	250	128	9x24	48	260
IM0127274	Input only	0.12	325	C	300	286	234	100	250	143	9x24	60	490
IM0127330	Input only	0.096	415	C	360	340	250	120	325	166	9x24	80	610
IM0127364	Input-output	0.058	662	C	360	310	275	120	325	166	9x24	79	746
IM0127350	Input only	0.061	650	C	360	411	298	120	240	220	9x24	113	920
IM0127404	Input-output	0.040	945	C	360	385	260	120	250	200	Ø12	88	1193
IM0127444	Input-output	0.030	1260	C	420	440	290	140	300	200	Ø12	110	1438

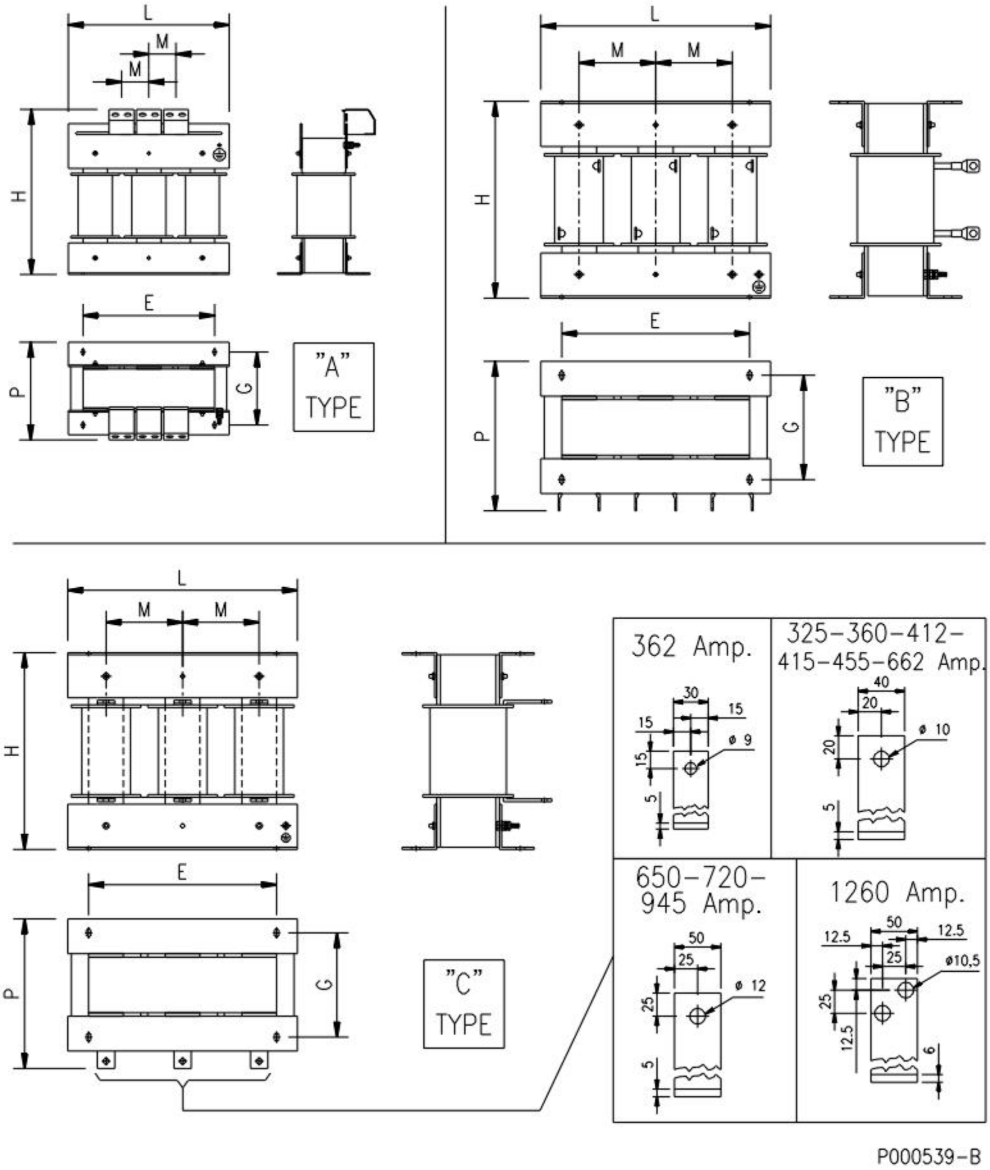


Figure 54: Mechanical features of a 3-phase inductor

6.4.3. Class 2T-4T – DC Inductors

INDUCTOR MODEL	USE	INDUCTANCE RATINGS		DIMENSIONS							FIXING HOLE	WEIGHT	LOSSES
		mH	A	TYPE	L	H	P	M	E	G	mm	kg	W
IM0140104	DC BUS	5.1	17	A	110	125	100	60	90	65	7x10	5	30
IM0140154	DC BUS	2.8	32.5	A	120	140	160	60	100	100	7x10	8	50
IM0140204	DC BUS	2.0	47	A	160	240	160	80	120	97	7x14	12	80
IM0140254	DC BUS	1.2	69	A	160	240	160	80	120	97	7x14	13	90
IM0140284	DC BUS	0.96	100	A	170	240	205	80	155	122	7x18	21	140
IM0140304	DC BUS	0.64	160	A	240	260	200	120	150	121	9x24	27	180
IM0140404	DC BUS	0.36	275	A	260	290	200	130	150	138	9x24	35	320
IM0140454	DC BUS	0.18	420	B	240	380	220	120	205	156	9x24	49	290
IM0140604	DC BUS	0.14	520	B	240	380	235	120	205	159	9x24	57	305
IM0140664	DC BUS	0.090	830	B	260	395	270	130	225	172	9x24	75	450
IM0140754	DC BUS	0.092	1040	C	310	470	320	155	200	200	Ø12	114	780
IM0140854	DC BUS	0.072	1470	C	330	540	320	165	250	200	Ø12	152	950

6.4.4. Class 5T-6T – DC Inductors

INDUCTOR MODEL	USE	INDUCTANCE RATINGS		DIMENSIONS							FIXING HOLE	WEIGHT	LOSSES
		mH	A	TYPE	L	H	P	M	E	G	mm	kg	W
IM0141404	DC BUS	1.2	110	A	170	205	205	80	155	122	7x18	21	165
IM0141414	DC BUS	0.80	160	A	200	260	215	100	150	111	9x24	27	240
IM0141424	DC BUS	0.66	240	A	240	340	260	120	205	166	9x24	53	370
IM0141434	DC BUS	0.32	375	B	240	380	235	120	205	159	9x24	56	350
IM0141554	DC BUS	0.27	475	B	240	380	265	120	205	179	9x24	66	550
IM0141664	DC BUS	0.17	750	B	260	395	295	130	225	197	9x24	90	580
IM0141704	DC BUS	0.232	830	C	330	550	340	165	250	200	Ø12	163	800
IM0141804	DC BUS	0.16	1170	C	350	630	360	175	250	200	Ø12	230	1200
IM0141904	DC BUS	0.12	1290	C	350	630	360	175	250	200	Ø12	230	1300

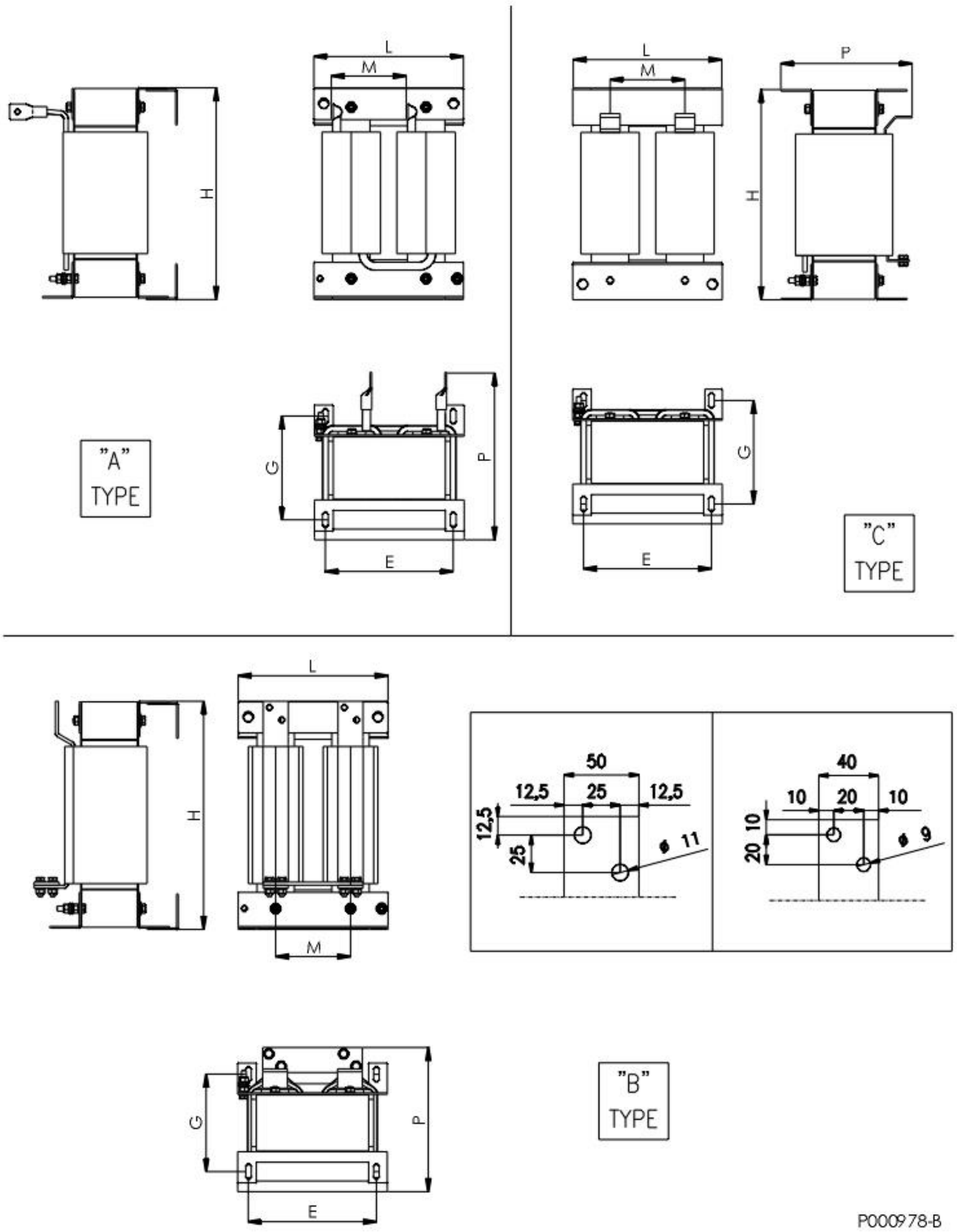


Figure 55: Mechanical features of a DC inductor

6.4.5. Class 2T, 4T, 5T, 6T – 3-Phase DU/DT Inductors

INDUCTOR MODEL	USE	INDUCTANCE RATINGS		DIMENSIONS							FIXING HOLE	WGT	LOSSES
		mH	A	TYPE	L	H	P	M	E	G	mm	kg	W
IM0138000	Output only	1.9	9.3	A	180	180	110	-	150	75	8.5x15	6	55
IM0138010	Output only	1.4	13.4	A	180	180	120	-	150	85	8.5x15	8	75
IM0138020	Output only	1.0	17.5	A	180	180	120	-	150	85	8.5x15	9	85
IM0138030	Output only	0.70	25.6	A	180	180	130	-	150	95	8.5x15	10	120
IM0138040	Output only	0.42	41	A	240	230	140	-	200	100	8x15	12	180
IM0138045	Output only	0.28	62	B	240	230	175	80	200	115	8x15	15	235
IM0138050	Output only	0.17	105	B	300	259	192	100	250	123	9x24	39	270
IM0138100	Output only	0.11	165	B	300	258	198	100	250	123	9x24	42	305
IM0138150	Output only	0.075	240	B	300	321	208	100	250	123	9x24	52	410
IM0138200	Output only	0.070	360	C	360	401	269	120	250	200	12x25	77	650
IM0138250	Output only	0.035	445	C	360	401	268	120	250	200	12x25	75	720
IM0138300	Output only	0.025	700	C	360	411	279	120	250	200	12x25	93	875

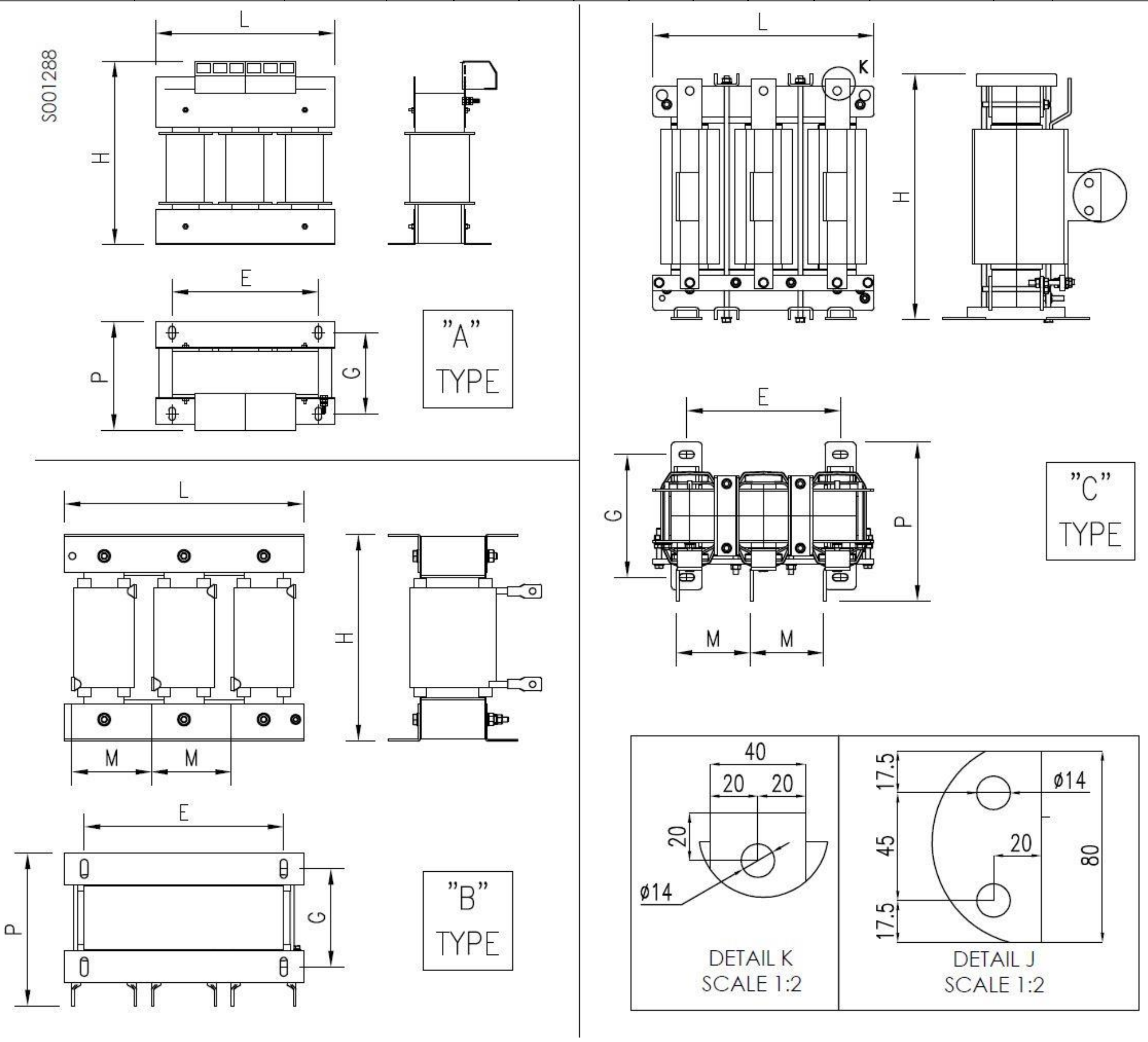


Figure 56: Mechanical features of the 3-phase du/dt inductors

6.5. Class 2T – 3-Phase AC Inductors in IP54 Cabinet

SIZE	Drive Model	INDUCTOR MODEL	USE	MECHANICAL DIMENSIONS (see Figure 58)	WEIGHT	LOSSES
				TYPE	kg	W
S05	**0007**	ZZ0112020	Input-output	A	7	48
	0008					
	0010					
	0015	ZZ0112030	Input-output	A	9.5	70
	0016					
	0020					
S12	**0023**	ZZ0112040	Input-output	A	10	96
	0033	ZZ0112045	Input-output	B	14	150
	0037					
S15	**0040**	ZZ0112050	Input-output	B	14.5	183
	0049					
S20	**0060**					
	0067	ZZ0112060	Input-output	C	26	272
	0074					
	0086					
S30	**0113**	ZZ0112070	Input-output	C	32.5	342
	0129					
	0150					
	0162					

6.6. Class 4T – 3-Phase AC Inductors in IP54 Cabinet

SIZE	Drive Model	INDUCTOR MODEL	USE	MECHANICAL DIMENSIONS (see Figure 58)	WEIGHT	LOSSES
				TYPE	kg	W
S05	**0005**	ZZ0112010	Input-output	A	6.5	29
	0007	ZZ0112020	Input-output	A	7	48
	0009					
	0011					
	0014					
S12	**0016**	ZZ0112030	Input-output	A	9.5	70
	0017					
	0020					
	0025	ZZ0112040	Input-output	A	10	96
	0030					
	0034	ZZ0112045	Input-output	B	14	150
	0036					
S15	**0040**	ZZ0112050	Input-output	B	14.5	183
	0049					
S20	**0060**					
	0067	ZZ0112060	Input-output	C	26	272
	0074					
	0086					
S30	**0113**	ZZ0112070	Input-output	C	32.5	342
	0129					
	0150					
	0162					

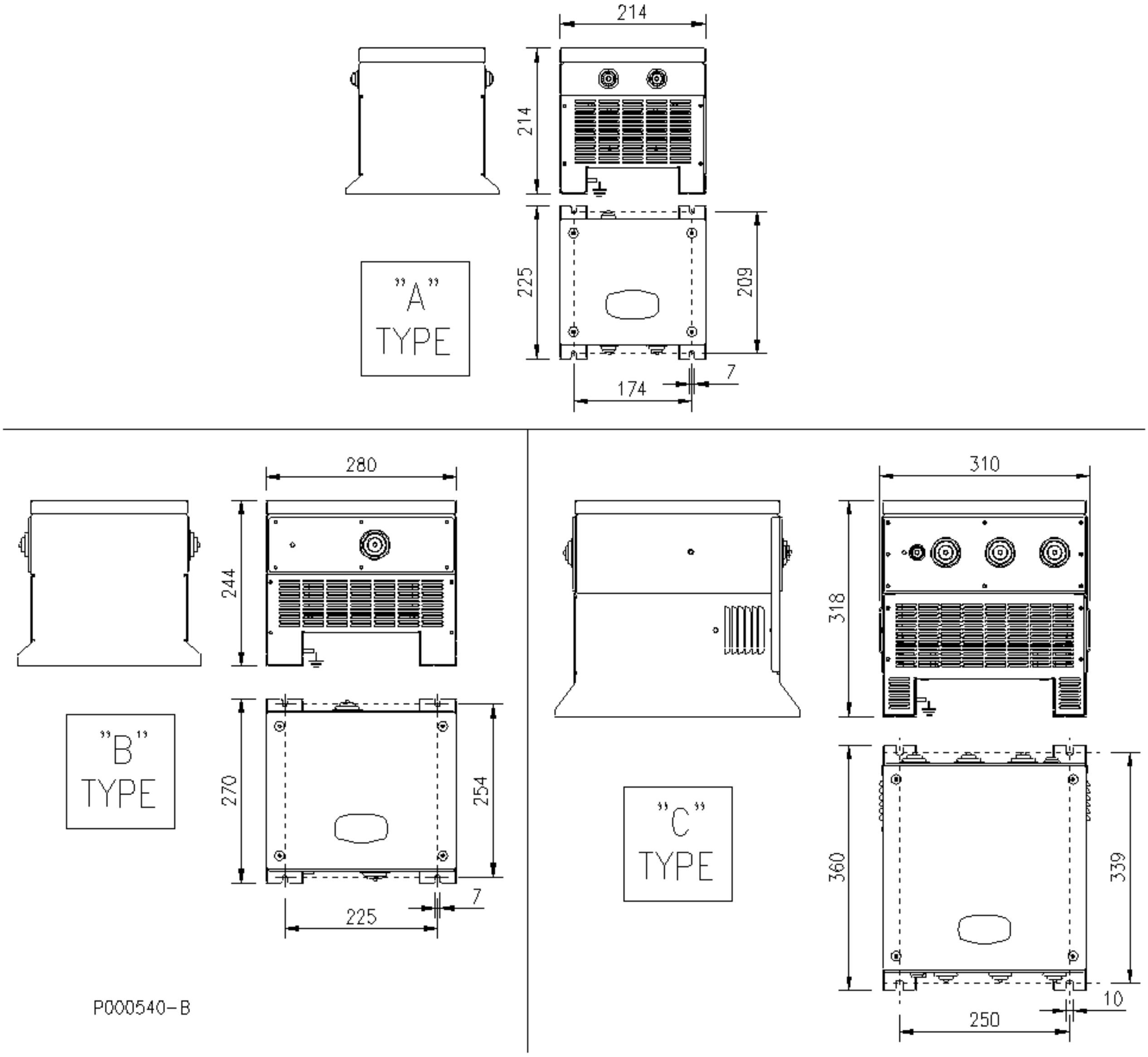


Figure 57: Mechanical features of three-phase inductors for Class 2T-4T in IP54 cabinet

6.7. Class 5T-6T – 3-Phase AC Inductors In IP54 Cabinet

SIZE	Drive Model	INDUCTOR MODEL	USE	MECHANICAL DIMENSIONS (see Figure 58)	WEIGHT	LOSSES
				SIZE	kg	W
S12 5T S14 6T	0003	ZZ0112110	Input only	1	Contact Enertronica Santerno S.p.A.	
	0004	ZZ0112120	Input only	1		
	0006					
	0012	ZZ0112130	Input only	1		
	0018					
S14	0019	ZZ0112140	Input only	1		
	0021					
	0022	ZZ0112150	Input only	2		
	0024					
	0032	ZZ0112160	Input only	2		
S22	0042					
	0051	ZZ0112170	Input only	2		
	0062					
	0069					
S32	0076	ZZ0112180	Input only	3		
	0088					
	0131	ZZ0112190	Input only	3		
	0164					

SIZE	Drive Model	INDUCTOR MODEL	USE	MECHANICAL DIMENSIONS (see Figure 58)	WEIGHT	LOSSES
				SIZE	kg	W
S12 5T S14 6T	0003	ZZ0112115	Output only	1	Contact Enertronica Santerno S.p.A.	
	0004					
	0006	ZZ0112125	Output only	1		
	0012					
	0018	ZZ0112135	Output only	1		
S14	0019	ZZ0112145	Output only	1		
	0021					
	0022	ZZ0112155	Output only	2		
	0024					
	0032	ZZ0112165	Output only	2		
S22	0042					
	0051	ZZ0112175	Output only	2		
	0062					
	0069					
S32	0076	ZZ0112185	Output only	3		
	0088					
	0131	ZZ0112195	Output only	3		
	0164					

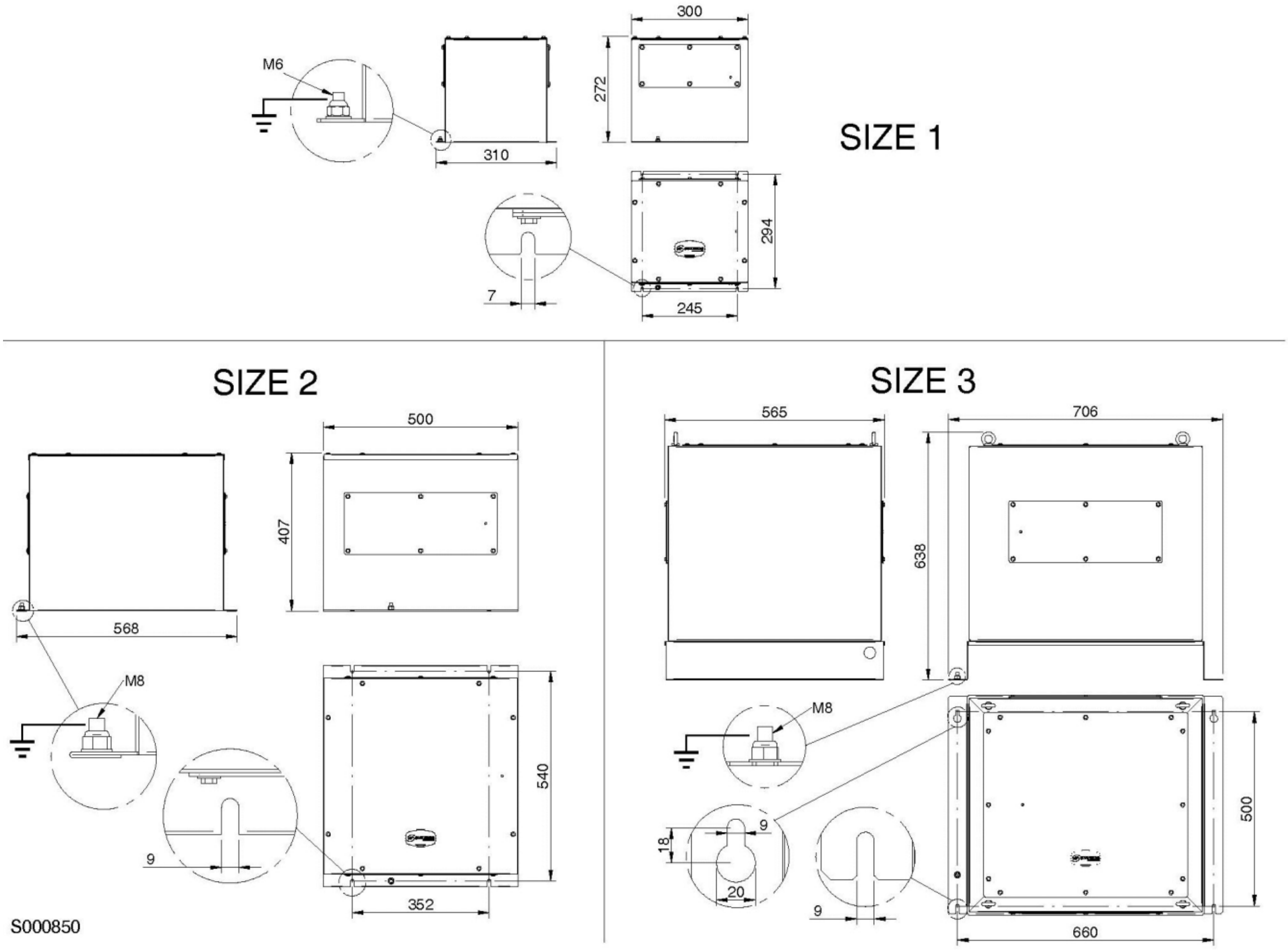


Figure 58: Mechanical features of a 3-phase inductor for Class 5T-6T in IP54 cabinet

6.8. Output Single-Phase Inductors for Modular Inverters S75, S80, S90

6.8.1. AC single-phase Inductors – Class 4T-5T-6T

INDUCTOR MODEL	USE	INDUCTOR RATINGS			DIMENSIONS						FIXING HOLE	WEIGHT	LOSSES
		mH	A	L	H	P	P1	M	E	G	mm	kg	W
IM0141782	Output S75, S80, S90	0.015	1250	260	430	385	310	136	200	270	9x24	100	940

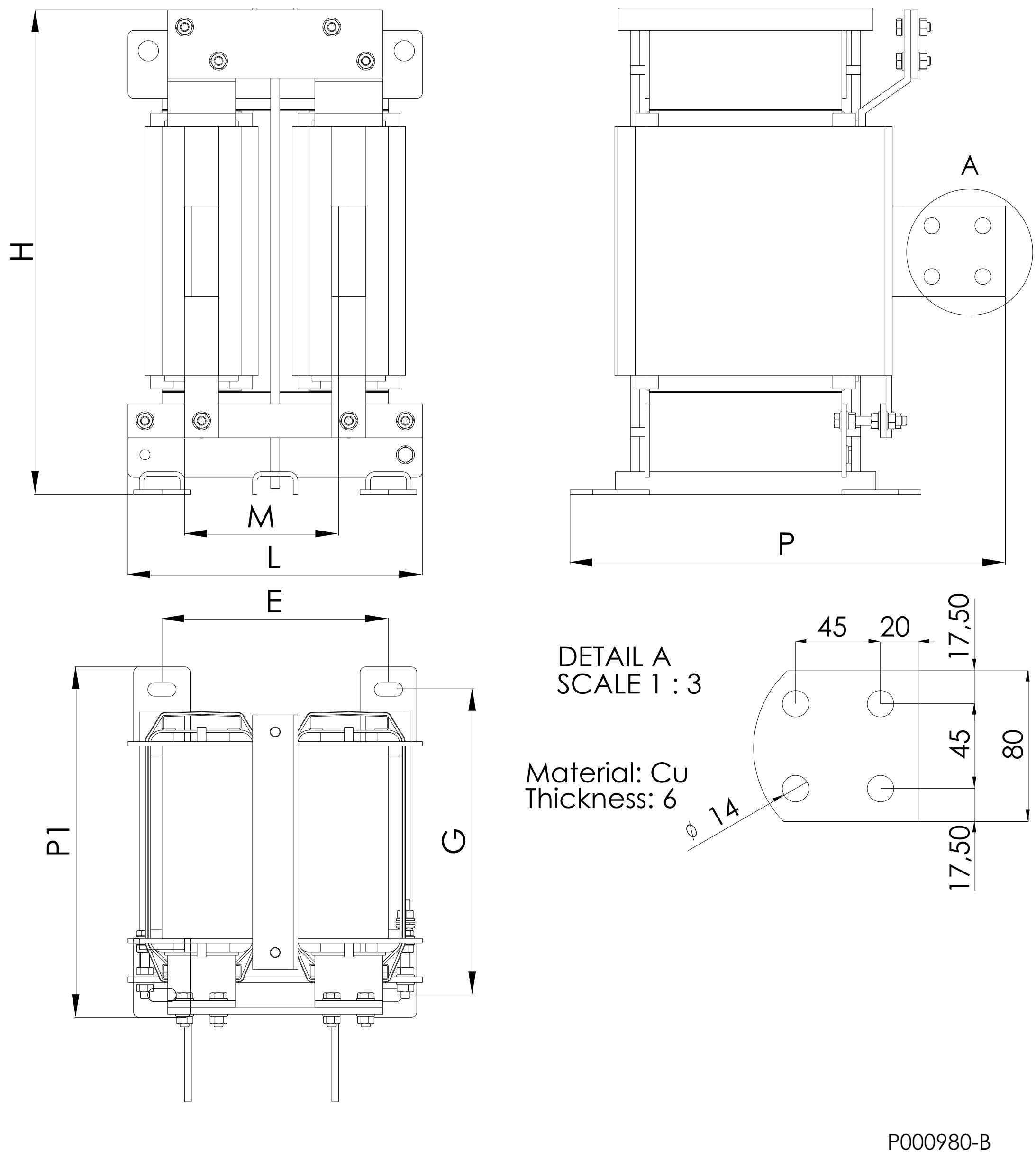


Figure 59: Mechanical features of a single-phase output inductor

6.9. Sine Filters

The sine filter is a system component to be installed between the inverter and the motor to enhance the equipment performance:

a) **The sine filter reduces the voltage peak in the motor terminals**: The overvoltage in the motor terminals may reach 100% under certain load conditions.
b) **The sine filter reduces the motor losses**.
c) **The sine filter reduces the motor noise**: The motor noise can be reduced of approx. 8 dBA because the high-frequency component of the current flowing in the motor and the cables is reduced. A noiseless motor is particularly suitable for residential environments.
d) **The sine filter reduces the probability of EMC disturbance**: When the cables between the inverter and the motor are too long, the square-wave voltage produced by the inverter is a source of electromagnetic disturbance.
e) **The sine filter allows controlling transformers:** “Normal” transformers can be powered directly from the inverter that do not need to be properly dimensioned to withstand the carrier frequency voltage.
f) The inverter can be used as a **voltage generator at constant voltage and constant frequency.**

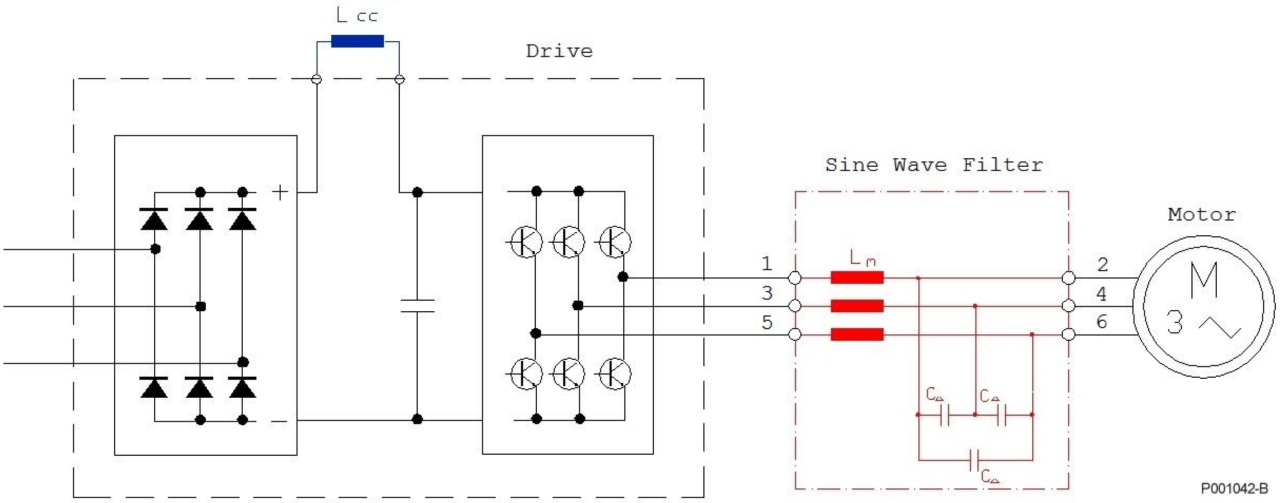


Figure 60: Sine filter

CAUTION

It is recommended that sine filters manufactured by Enertronica Santerno S.p.A. be used.
See the Sine Filters – User Manual.
Please contact Enertronica Santerno S.p.A. if sine filters from other manufacturers are used, as it may be necessary to change the drive parameterization.
The sine filters may be damaged if the drive parameters are not set accordingly.

6.10. Output Toroidal Filters

Output toroidal filters are high-permeable ferromagnetic materials used to weaken cable disturbance.

See the “EMC” section in the **Installation Guide**.

See the section related to the cross-sections of the power cables and sizes of the protective devices in the **Installation Guide**.

Part Number	TOROIDAL FILTER MODEL	Inverter Model	Cable Cross-section (mm^2)
AC1810402	**2xL0674-X830**	0003-0021	2.5-6
AC1810503	**3xL0082-X830**	0022-0034	10-16
AC1810603	**3xL0040-X830**	0036-0086	25-50
AC1811004	**4xL0084-X830**	0088-0164	70-150
AC1811202	**2xL0705-X830**	0180-0202	185-240
AC1811202	**2xL0705-X830**	0216-0368	2x120-2x185
AC1811402	**2xA0711-X830**	0401-0402	2x240

- If the connections table shows only one set of three cables (or N. 1 three-pole cable), the three cables shall go through the ferrite.
- In case of N. 2 sets of three cables (or N. 2 three-pole cables) both cable sets may go through the ferrite, or one ferrite may be mounted on each cable set.
- Where N. 3 sets of three cables are required, one ferrite shall be mounted on each individual cable set.

Examples:
Sinus Penta 0180 S41 4T: the recommended motor cable cross-section is 185 $mm^2 \Rightarrow$ the cable set shall go through one ferrite, P/N AC1811202.

Sinus Penta 0260 S41 4T: the recommended motor cable cross-section is 2x120 $mm^2 \Rightarrow$ both cable sets can either go through one ferrite, P/N AC1811202, or they can go through a separate ferrite, P/N AC1811004.

Sinus Penta 0524 S60 4T: the recommended motor cable cross-section is 3x185 $mm^2 \Rightarrow$ each of the three cable sets shall go through a separate ferrite, P/N AC1811202.

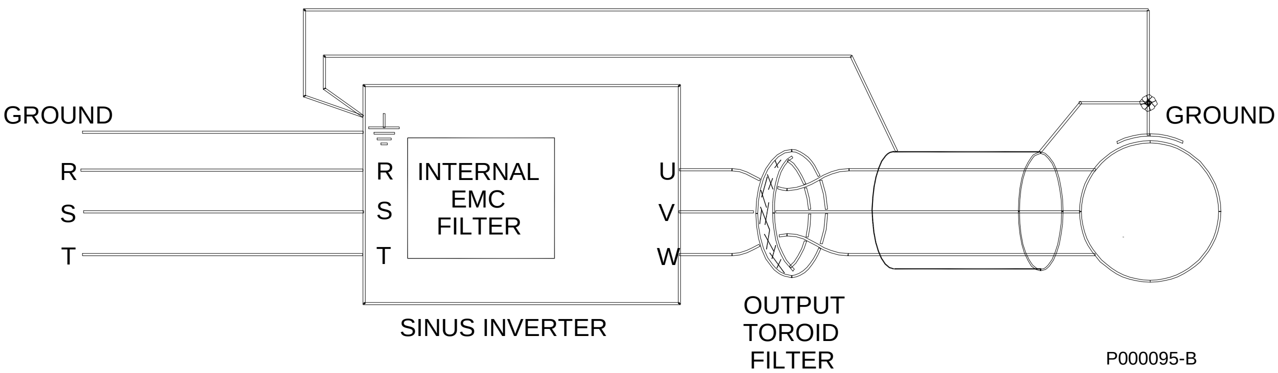


Figure 61: Output toroidal filter

7. ES836/2 ENCODER BOARD (SLOT A)

Product-Accessory Compatibility		
Product	**ES836/2 Encoder Board**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	-	
Solardrive Plus	-	

Table 8: Product – ES836/2 Encoder board compatibility

Board for incremental, bidirectional encoder to be used as a speed feedback for inverters of the Sinus Penta and Penta Marine series.
It allows the acquisition of encoders with power supply ranging from 5 to 15VDC (adjustable output voltage) with complementary outputs (line driver, push-pull, TTL outputs). It can also be connected to 24DC encoders with both complementary and single-ended push-pull or PNP/NPN outputs.
The encoder board is to be installed into SLOT A. See section Installing ES836/2 Encoder Board on the Inverter (Slot A).

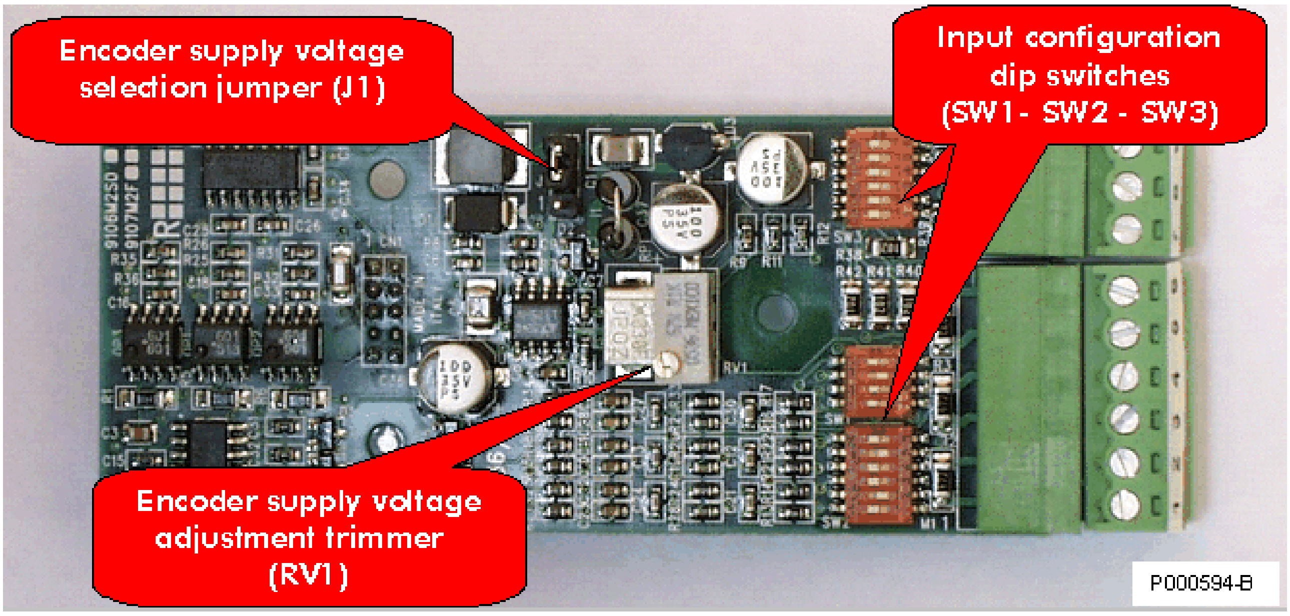


Figure 62: Encoder board (ES836/2)

7.1. Identification Data

Description	*Part Number*	COMPATIBLE ENCODERS	
		POWER SUPPLY	OUTPUT
ES836/2 Encoder board	ZZ0095834	5Vdc÷15Vdc, 24Vdc	LINE DRIVER, NPN, PNP, complementary PUSH-PULL, NPN, PNP, single-ended PUSH-PULL

7.2. Environmental Requirements

Operating temperature	–10 to +55 °C ambient temperature (contact Enertronica Santerno S.p.A. for higher ambient temperatures)
Relative humidity	5 to 95% (non-condensing)
Max. operating altitude	2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A.

7.3. Electrical Specifications

Decisive voltage class A according to EN 61800-5-1.

Electrical Specifications	*Ratings*			
	Min.	*Type*	*Max.*	*Unit*
Encoder supply current, + 24 V, protected with resettable fuse			200	mA
Electronically protected encoder supply current, +12V			350	mA
Electronically protected encoder supply current, +5V			900	mA
Adjustment range for encoder supply voltage (5V mode)	4.4	5.0	7.3	V
Adjustment range for encoder supply voltage (12V mode)	10.3	12.0	17.3	V
Input channels	Three channels: A, B, and zero notch Z			
Type of input signals	Complementary or single-ended			
Voltage range for encoder input signals	4		24	V
Pulse max. frequency with noise filter “on”	77kHz (1024pls @ 4500rpm)			
Pulse max. frequency with noise filter “off”	155kHz (1024pls @ 9000rpm)			
Input impedance in NPN or PNP mode (external pull-up or pull-down resistors required)		15k		Ω
Input impedance in push-pull or PNP and NPN mode when internal load resistors (at max. frequency) are connected		3600		Ω
Input impedance in line-driver mode or complementary push-pull signals with internal load resistors activated via SW3 (at max. frequency) (see Configuration DIP-switches)		780		Ω

ISOLATION:

The encoder supply line and inputs are galvanically isolated from the inverter control board grounding for a 500 VAC/1-minute test. The encoder supply grounding is in common with control board digital inputs available in the terminal board.

7.4. Installing ES836/2 Encoder Board on the Inverter (Slot A)

	DANGER	Before gaining access to the components inside the inverter, remove voltage from the inverter and wait at least 20 minutes. Wait for a complete discharge of the internal capacitors to avoid any electric shock hazard.
	CAUTION	Electric shock hazard: do not connect/disconnect the signal terminals or the power terminals when the inverter is on. This also prevents the inverter from being damaged.
	NOTE	All the screws used to fasten removable parts (terminals cover, serial interface connector, cable plates, etc.) are black, round-head, cross-head screws. When wiring the inverter, remove only this type of screws. If different screws or bolts are removed, the inverter warranty will be no longer valid.

1. Remove voltage from the inverter and wait at least 20 minutes.
2. Remove the cover to gain access to the inverter control terminals. The fixing spacers and the signal connector are located on the left.

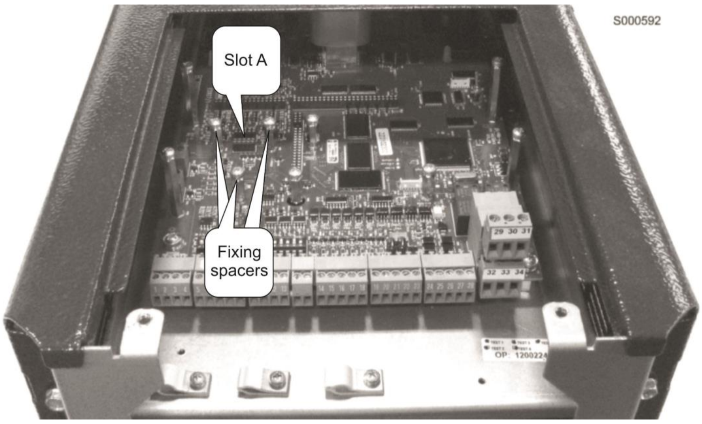


Figure 63: Position of slot A for the installation of the encoder board

3. Fit the encoder board and make sure that all contacts enter the relevant housing in the signal connector. Fasten the encoder board to the fixing spacers using the screws supplied.
4. Configure the DIP-switches and the jumper located on the encoder board based on the connected encoder. Check that the supply voltage delivered to the terminal output is correct.
5. Close the inverter frame by reassembling the cover allowing gaining access to the inverter control terminals.

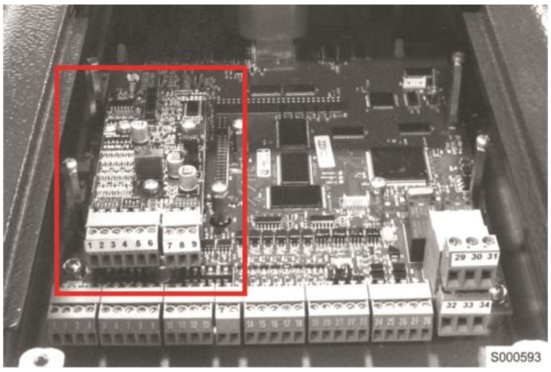


Figure 64: Encoder board fastened to its slot

7.5. Terminals in Encoder Board

A 9-pole terminal board is located on the front side of the encoder board for the connection to the encoder.

Terminal board specifications

Cable cross-section fitting the terminal mm^2 (AWG)	Tightening torque (Nm)
0.2÷2.5 (24-14)	0.5-0.6

Decisive voltage class A according to EN 61800-5-1

Terminal board, pitch 3.81 mm in two separate extractable sections (6-pole and 3-pole sections)		
Terminal	**Signal**	**Type and Features**
1	CHA	Encoder input channel A true polarity
2	$\overline{\text{CHA}}$	Encoder input channel A inverse polarity
3	CHB	Encoder input channel B true polarity
4	$\overline{\text{CHB}}$	Encoder input channel B inverse polarity
5	CHZ	Encoder input channel Z (zero notch) true polarity
6	$\overline{\text{CHZ}}$	Encoder input channel Z (zero notch) inverse polarity
7	+VE	Encoder supply output 5V...15V or 24V
8	GNDE	Encoder supply ground
9	GNDE	Encoder supply ground

For the encoder connection to the encoder board, see wiring diagrams on the following pages.

7.6. Configuration DIP-switches

Encoder board ES836/2 is provided with two DIP-switch banks to be set up depending on the type of connected encoder. The DIP-switches are located in the front left corner of the encoder board and are adjusted as shown in the figure below.

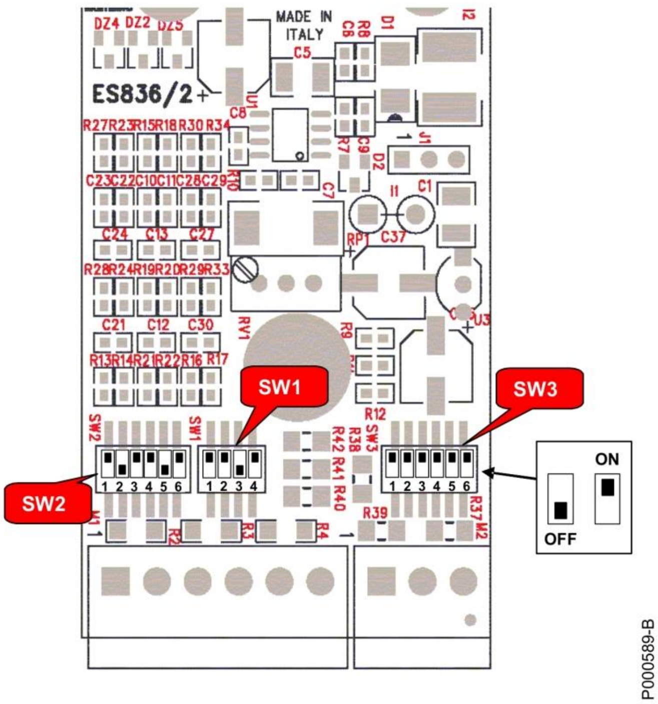


Figure 65: Positions of DIP-switches and their factory-setting

DIP-switch functionality and factory-settings are detailed in the table below.

Switch (factory-setting)	***OFF - open***	***ON - closed***
SW2.1	Channel B, NPN or PNP	Channel B, Line driver or Push-Pull (default)
SW2.2	Channel B with complementary signals (default)	Channel B with only one single-ended signal
SW2.3	Channel B with no band limit	Channel B with band limit (default)
SW2.4	Channel Z, NPN or PNP	Channel Z, Line driver or Push-Pull (default)
SW2.5	Channel Z with complementary signals (default)	Channel Z with only one single-ended signal
SW2.6	Channel Z with no band limit	Channel Z with band limit (default)
SW1.1	12V Supply voltage (J1 in pos. 2-3)	5V Supply Voltage (J1 in pos. 2-3) (default)
SW1.2	Channel A, NPN or PNP	Channel A, Line driver or Push-Pull (default)
SW1.3	Channel A with complementary signals (default)	Channel A with only one single-ended signal
SW1.4	Channel A with no band limit	Channel A with band limit (default)
SW3.1 SW3.2 SW3.3 SW3.4 SW3.5 SW3.6	Load resistors disabled	Load resistors towards ground enabled for all encoder signals (required for 5V Line driver or Push-pull encoders, especially if long cables are used – default setting)

CAUTION Keep SW3 switches "ON" only if a complementary Push-pull or Line-driver encoder is used (5V power supply). Otherwise, set contacts to OFF.

NOTE Set ALL switches in DIP-switch SW3 to ON or OFF together. Different configurations may cause the malfunctioning of the encoder board.

7.7. Jumper Selecting the Type of Encoder Supply

Two-position jumper J1 installed on encoder board ES836/2 allows setting the encoder supply voltage. It is factory-set to pos. 2-3. Set jumper J1 to position 1-2 to select non-tuned, 24V encoder supply voltage. Set jumper J1 to position 2-3 to select tuned, 5/12V encoder supply voltage. Supply values of 5V or 12V are to be set through DIP-switch SW1.1 (see table above).

7.8. Adjusting Trimmer

Trimmer RV1 installed on ES836/2 allows adjusting the encoder supply voltage. This can compensate voltage drops in case of long distance between the encoder and the encoder board, or allows feeding an encoder with intermediate voltage values if compared to factory-set values.

Tuning procedure:

1. Put a tester on the encoder supply connector (encoder side of the connecting cable); make sure that the encoder is powered.
2. Rotate the trimmer clockwise to increase supply voltage. The trimmer is factory set to deliver 5V and 12V (depending on the DIP-switch selection) to the power supply terminals. For a power supply of 5V, supply may range from 4.4V to 7.3V; for a power supply of 12V, supply may range from 10.3V to 17.3V.

NOTE Output voltage cannot be adjusted by trimmer RV1 (jumper J1 in pos. 1-2) for 24V power supply.

CAUTION Power supply values exceeding the encoder ratings may damage the encoder. Always use a tester to check voltage delivered from ES836/2 board before wiring.

CAUTION Do not use the encoder supply output to power other devices. Failure to do so would increase the hazard of control interference and short-circuits with possible uncontrolled motor operation due to the lack of feedback.

CAUTION The encoder supply output is isolated from the common terminal of the analog signals incoming to the terminals of the control board (CMA). Do not link the two common terminals together.

7.9. Encoder Wiring and Configuration

The figures below show how to connect and configure the DIP-switches for the most popular encoder types.

CAUTION A wrong encoder-board connection may damage both the encoder and the board.

NOTE In all the figures below, DIP-switches SW1.4, SW2.3, SW2.6 are set to ON, i.e. 77 kHz band limit is on. If a connected encoder requires a higher output frequency, set DIP-switches to OFF.

NOTE The max. length of the encoder wire depends on the encoder outputs, not on the encoder board (ES836/2). Please refer to the encoder ratings.

NOTE DIP-switch SW1.1 is not shown in the figures below because its setting depends on the supply voltage required by the encoder. Refer to the DIP-switch setting table to set SW1.1.

NOTE Zero notch connection is optional and is required only for particular software applications. However, for those applications that do not require any zero notch, its connection does not affect the inverter operation. See the Programming Guide for details.

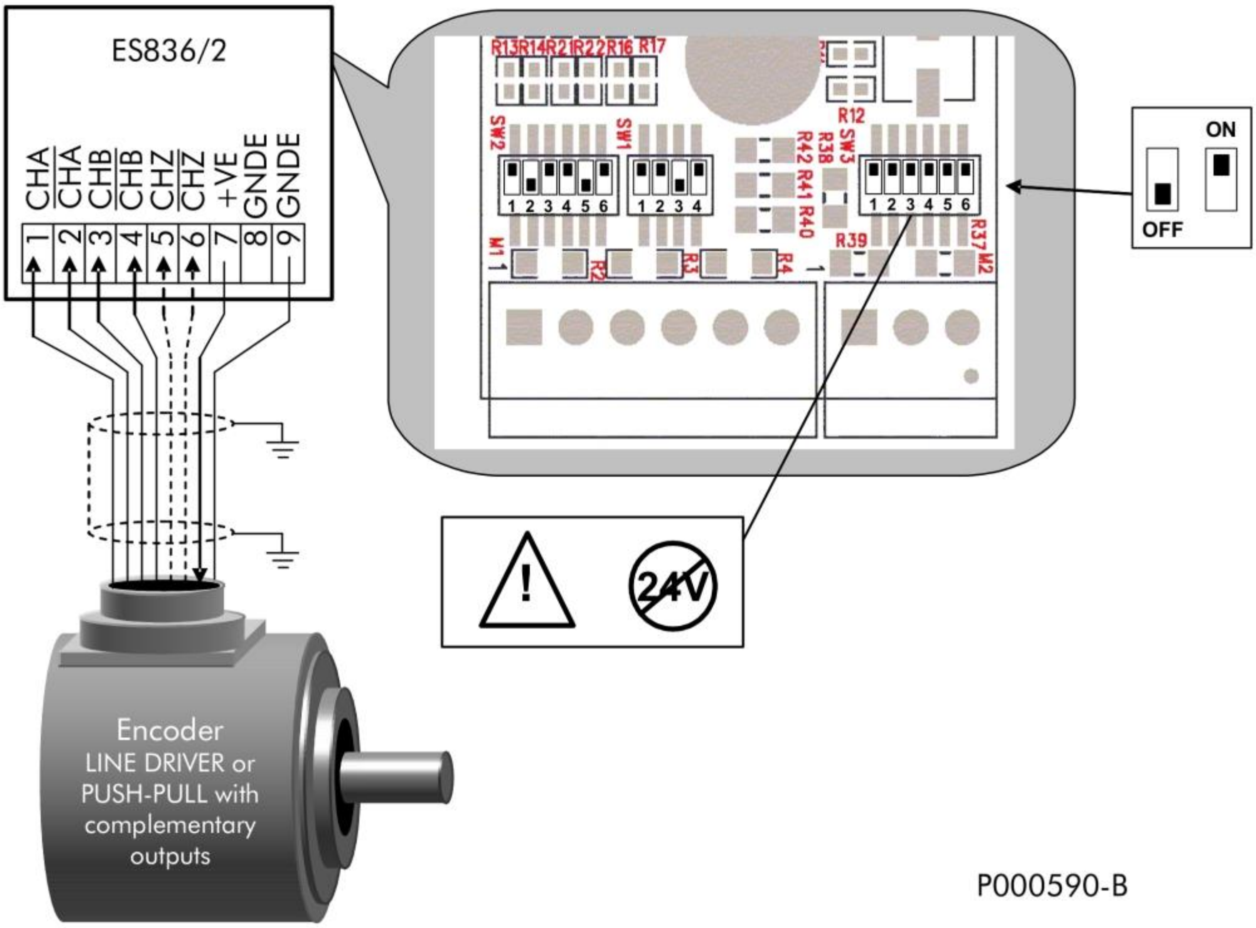


Figure 66: LINE DRIVER or PUSH-PULL encoder with complementary outputs

⚠	**CAUTION**	Put SW3 contacts to ON only if a complementary Push-pull or Line driver encoder is used (power supply: 5V or 12V). If a 24V push-pull encoder is used, put contacts to OFF.

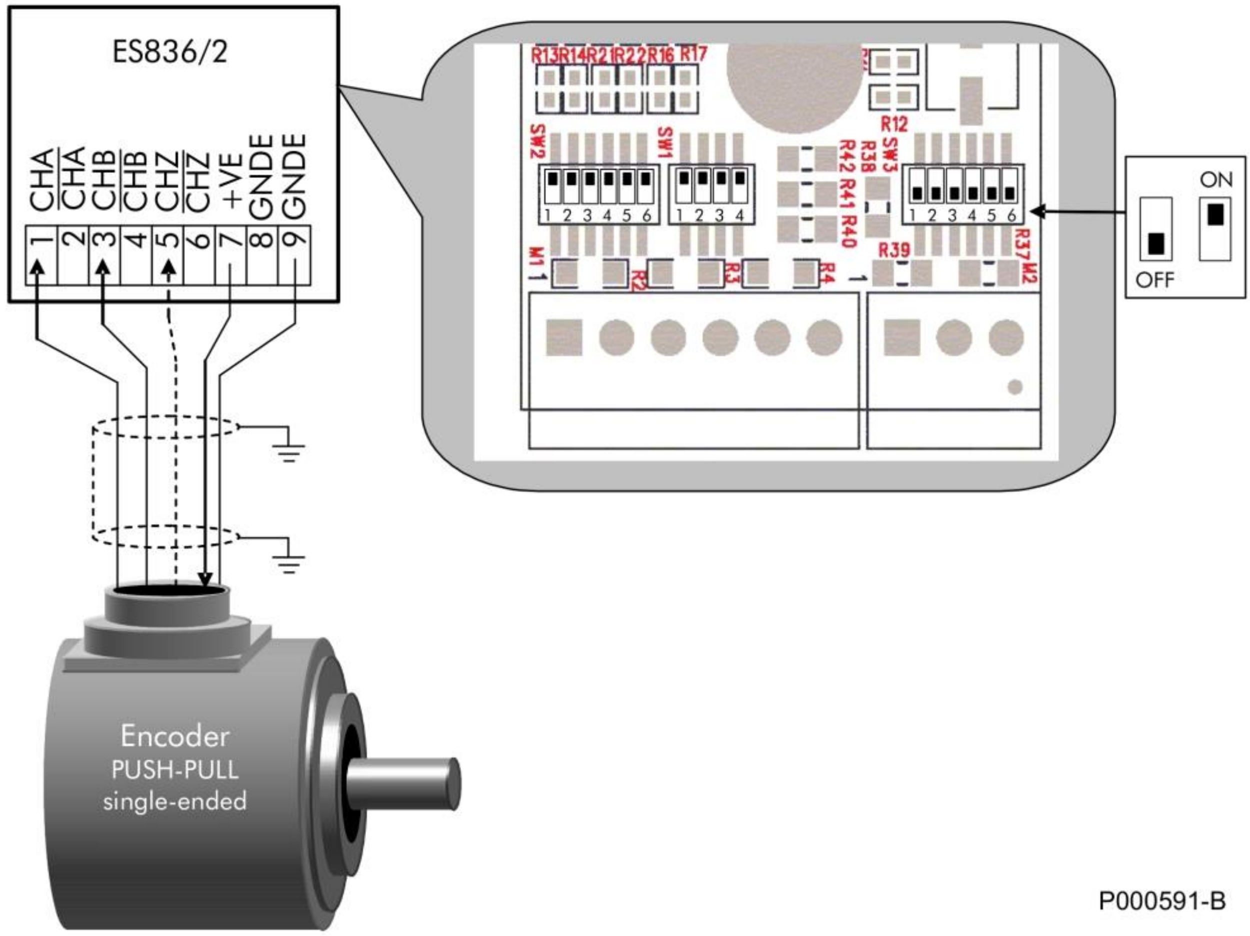


Figure 67: PUSH-PULL encoder with single-ended outputs

	CAUTION	Because settings required for a single-ended encoder deliver a reference voltage to terminals 2, 4, 6, the latter are not to be connected**.** Failures will occur if terminals 2, 4, 6 are connected to encoder conductors or to other conductors.
	NOTE	Only push-pull, single-ended encoders may be used, with an output voltage equal to the supply voltage. Only differential encoders may be connected if their output voltage is lower than the supply voltage.

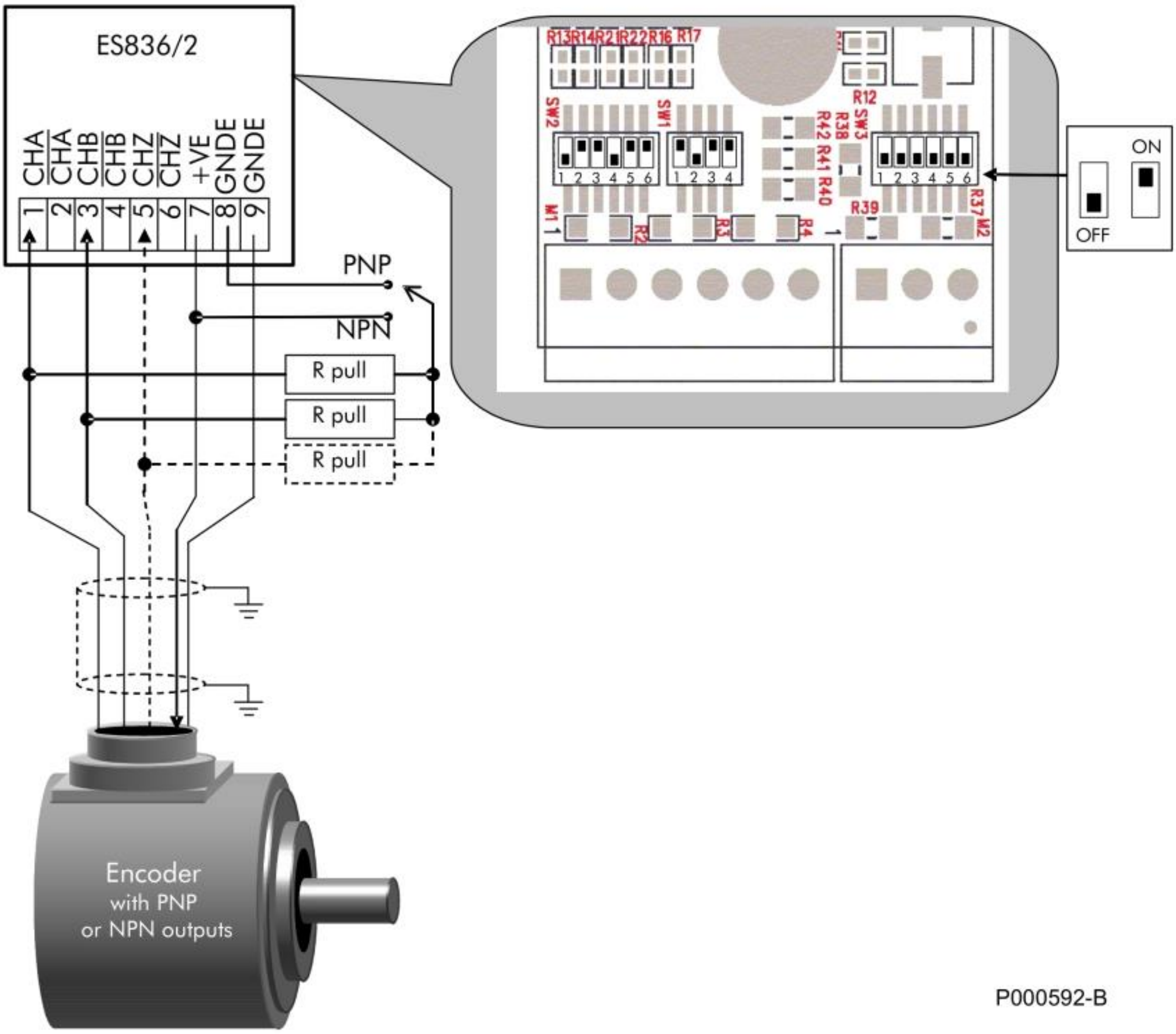


Figure 68: PNP or NPN encoder with single-ended outputs and external load resistors

NOTE NPN or PNP encoder outputs require a pull-up or pull-down resistive load to the supply or to the common. As load resistor ratings are defined by the manufacturer of the encoder, external wiring is required, as shown in the figure above. Connect the resistor common to the supply line for NPN encoders supply or to the common for PNP encoders.

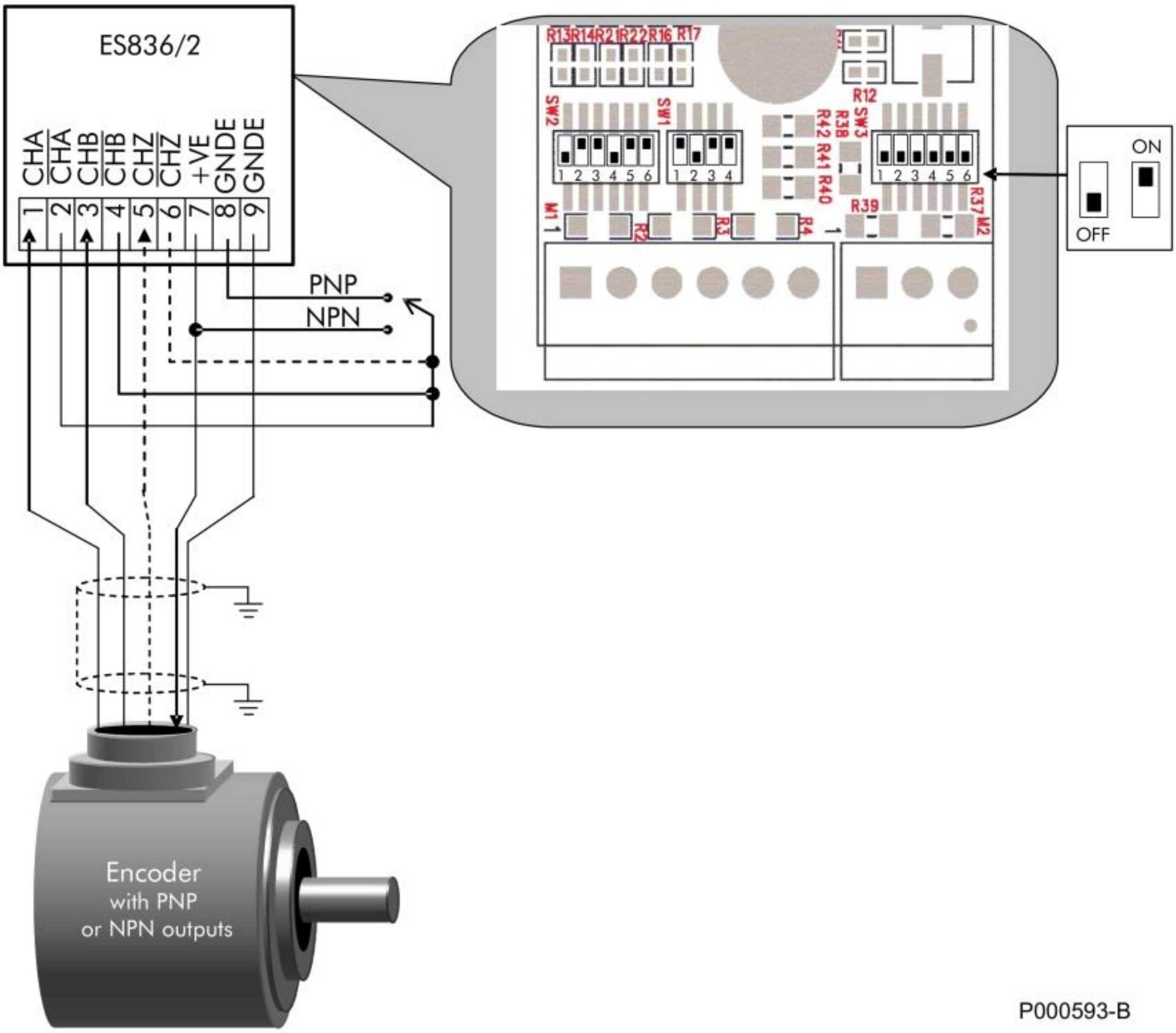


Figure 69: PNP or NPN encoder with single-ended outputs and internal load resistors

NOTE Incorporated load resistors may be used only if NPN or PNP encoders are compatible with pull-up or pull-down external resistors (4.7 kΩ).

NOTE NPN or PNP encoders cause pulse distortions due to a difference in ramp up and ramp down edges. Distortion depends on the load resistor ratings and the wire stray capacitance. PNP or NPN encoders should not be used for applications with an encoder output frequency exceeding a few kHz dozens. For such applications, use encoders with Push-Pull outputs, or better with a differential line-driver output.

7.10. Wiring the Encoder Cable

Use a shielded cable to connect the encoder to its control board; shielding should be grounded to both ends of the cable. Use the special clamp to fasten the encoder wire and ground the cable shielding to the inverter.

S000594

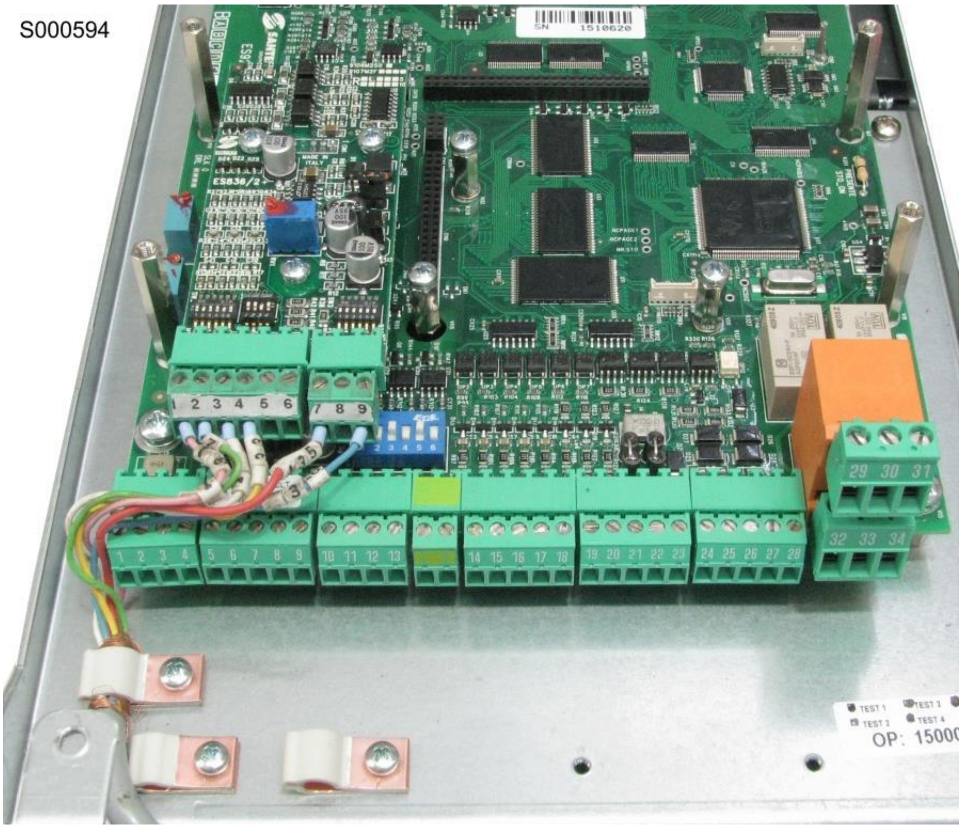


Figure 70: Wiring the encoder cable

Do not stretch the encoder wire along with the motor supply cable.
Connect the encoder directly to the inverter using a cable with no intermediate devices, such as terminals or return connectors.
Use a model of encoder suitable for your application (as for connection length and max. rev number).
Preferably use encoder models with complementary LINE-DRIVER or PUSH-PULL outputs. Non-complementary PUSH-PULL, PNP or NPN open-collector outputs offer a lower immunity to noise.
The encoder electrical noise occurs as difficult speed adjustment or uneven operation of the inverter; in the worst cases, it can lead to the inverter stop due to overcurrent conditions.

8. ES913 LINE DRIVER ENCODER BOARD (SLOT A)

Product-Accessory Compatibility		
Product	**ES913 Encoder Board**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	-	
Solardrive Plus	-	

Table 9: Product – ES913 Encoder board compatibility

Board for incremental, bidirectional encoder to be used as a speed feedback for inverters of the Sinus Penta and Penta Marine series.
It allows the acquisition of encoders with power supply ranging from 5 to 24VDC (adjustable output voltage) with line driver outputs.
The encoder board is to be installed into SLOT A. See Installing the Line Driver Board on the Inverter (Slot A).

P001034-B

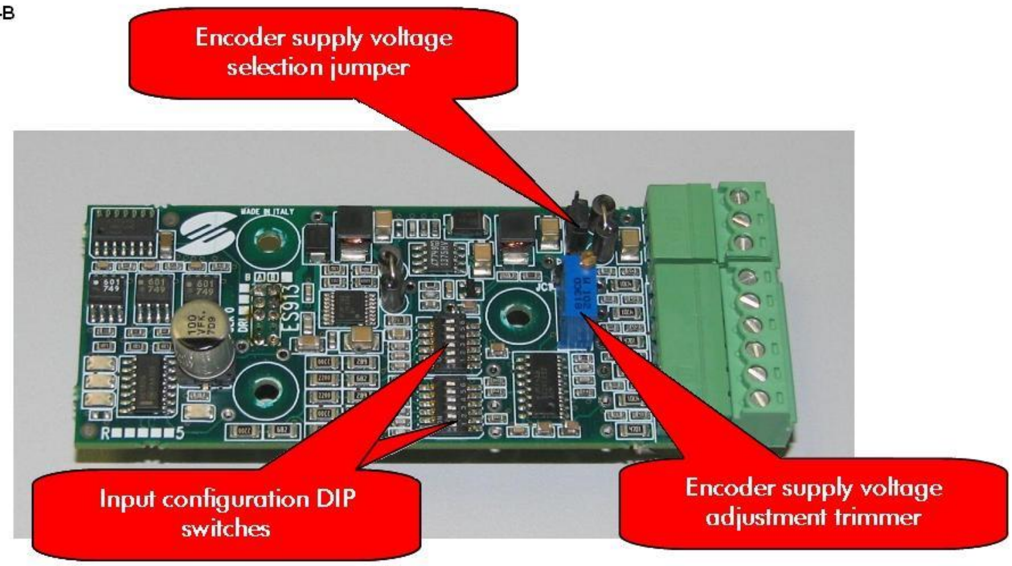


Figure 71: ES913 Encoder board

8.1. Identification Data

	Part Number	COMPATIBLE ENCODERS	
		POWER SUPPLY	OUTPUT
HTL Encoder board	ZZ0095837	5Vdc÷24Vdc	LINE DRIVER

8.2. Environmental Requirements

Operating temperature	–10 to +55 °C ambient temperature (contact Enertronica Santerno S.p.A. for higher ambient temperatures)
Relative humidity	5 to 95% (non-condensing)
Max. operating altitude	2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A..

8.3. Electrical Specifications

Decisive voltage class A according to EN 61800-5-1

Electrical Specifications	*Value*			
	Min.	*Typ.*	*Max.*	*Unit*
Encoder supply current, + 24 V, protected with resettable fuse			200	mA
Electronically protected encoder supply current, +12V			400	mA
Electronically protected encoder supply current, +5V			1000	mA
Adjustment range for encoder supply voltage (5V mode)	4.4	5.0	7.3	V
Adjustment range for encoder supply voltage (12V mode)	10.4	12.0	17.3	V
Input channels	Three channels: A, B and zero notch Z			
Type of input signals	Complementary (line driver)			
Voltage range for encoder input signals	4		30	V
Pulse max. frequency with noise filter “On”	77kHz (1024pls @ 4500rpm)			
Pulse max. frequency with noise filter “Off”	155kHz (1024pls @ 9000rpm)			

ISOLATION:

The encoder supply line and inputs are galvanically isolated from the inverter control board grounding for a 500VAC test voltage for 1 minute. The encoder supply grounding is in common with control board digital inputs available in the terminal board.

8.4. Installing the Line Driver Board on the Inverter (Slot A)

	DANGER	Before gaining access to the components inside the inverter, remove voltage from the inverter and wait at least 20 minutes. Wait for a complete discharge of the internal capacitors to avoid any electric shock hazard.
	CAUTION	Electric shock hazard: do not connect/disconnect the signal terminals or the power terminals when the inverter is on. This also prevents the inverter from being damaged.
	NOTE	All the screws used to fasten removable parts (terminals cover, serial interface connector, cable plates, etc.) are black, round-head, cross-head screws. When wiring the inverter, remove only this type of screws. If different screws or bolts are removed, the inverter warranty will be no longer valid.

1) Remove voltage from the inverter and wait at least 20 minutes.
2) Remove the cover allowing gaining access to the inverter control terminals. The fixing spacers and the signal connector are located on the left.

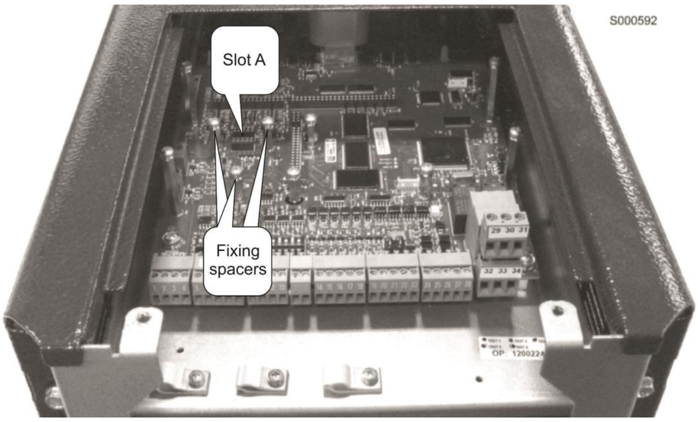


Figure 72: Position of slot A for the installation of the encoder board

Fit the encoder board and make sure that all contacts enter the relevant housing in the signal connector. Fasten the encoder board to the fixing spacers using the screws supplied.
4) Configure the DIP-switches and the jumper located on the encoder board based on the connected encoder. Check that the supply voltage delivered to the terminal output is correct.
5) Power on the inverter and set up parameters relating to the encoder feedback (see the Programming Guide).

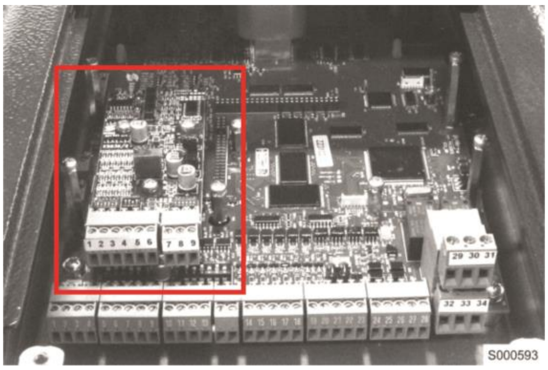


Figure 73: Encoder board fastened to its slot

8.5. Terminals in the Line Driver Encoder Board

A 9-pole terminal board is located on the front side of the encoder board for the connection to the encoder.

Terminal board specifications

Cable cross-section fitting the terminal mm² (AWG)	Tightening torque (Nm)
0.2÷2.5 (24-14)	0.5-0.6

Decisive voltage class A according to EN 61800-5-1

Terminal board, pitch 3.81mm in two separate extractable sections (6-pole and 3-pole sections)		
Terminal	**Signal**	**Type and Features**
1	CHA	Encoder input channel A true polarity
2	$\overline{\text{CHA}}$	Encoder input channel A inverse polarity
3	CHB	Encoder input channel B true polarity
4	$\overline{\text{CHB}}$	Encoder input channel B inverse polarity
5	CHZ	Encoder input channel Z (zero notch) true polarity
6	$\overline{\text{CHZ}}$	Encoder input channel Z (zero notch) inverse polarity
7	+VE	Encoder supply output 5V...15V or 24V
8	GNDE	Encoder supply ground
9	GNDE	Encoder supply ground

For the encoder connection to the encoder board, see wiring diagrams on the following pages.

8.6. Configuration DIP-switches

The encoder board (ES913) is provided with two DIP-switch banks. The DIP-switches are located in the front left corner of the board and are adjusted as shown in the figure below.

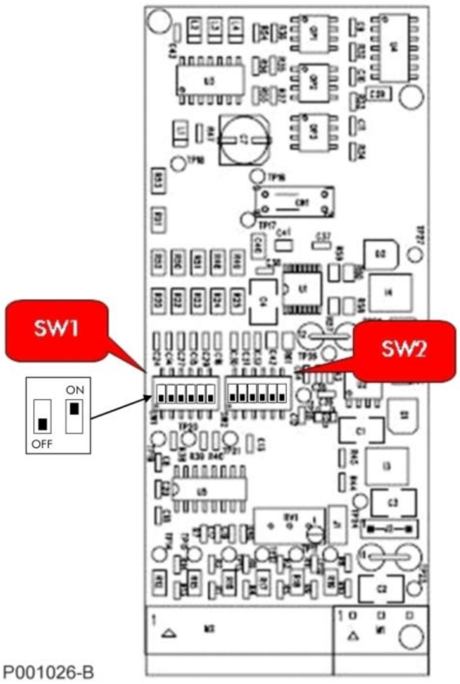


Figure 74: Location of the configuration DIP-switches

DIP-switch functionality and factory-settings are detailed in the table below.

SW1.1	***SW1.2***	
OFF	OFF	Channel A band limit disabled
OFF	ON	Min. channel A band limit
ON	OFF	Average channel A band limit
ON	ON	Max. channel A band limit (default)

SW1.3	***SW1.4***	
OFF	OFF	Channel B band limit disabled
OFF	ON	Min. channel B band limit
ON	OFF	Average channel B band limit
ON	ON	Max. channel B band limit (default)

SW1.5	***SW1.6***	
OFF	OFF	Channel Z band limit disabled
OFF	ON	Min. channel Z band limit
ON	OFF	Average channel Z band limit
ON	ON	Max. channel Z band limit (default)

SW2.1	OFF	Termination resistor between A and A# = 13.6kΩ (default)
	ON	Termination resistor between A and A# = 110Ω (only for input signals at 5V)
SW2.2	OFF	Termination resistor between B and B # = 13.6kΩ (default)
	ON	Termination resistor between B and B # = 110Ω (only for input signals at 5V)
SW2.3	OFF	Termination resistor between Z and Z# = 13.6kΩ (default)
	ON	Termination resistor between Z and Z# = 110Ω (only for input signals at 5V)
SW2.4	OFF	Termination capacitor between A and A# off
	ON	Termination capacitor between A and A# = 110pF (default)
SW2.5	OFF	Termination capacitor between B and B# off
	ON	Termination capacitor between B and B# = 110pF (default)
SW2.6	OFF	Termination capacitor between Z and Z# off
	ON	Termination capacitor between Z and Z# = 110pF (default)

CAUTION Do not select any termination resistor equal to 110Ω for encoder signal amplitude over 7.5V.

8.7. Encoder Supply Selection Jumper

Jumpers J1 and J2 select the encoder voltage supply among +5V, +12V, +24V:

Jumper J1	***Jumper J2***	***Encoder Supply Voltage***
X	2-3	+24V
Open	1-2	+12V
Closed (default)	1-2 (default)	+5V

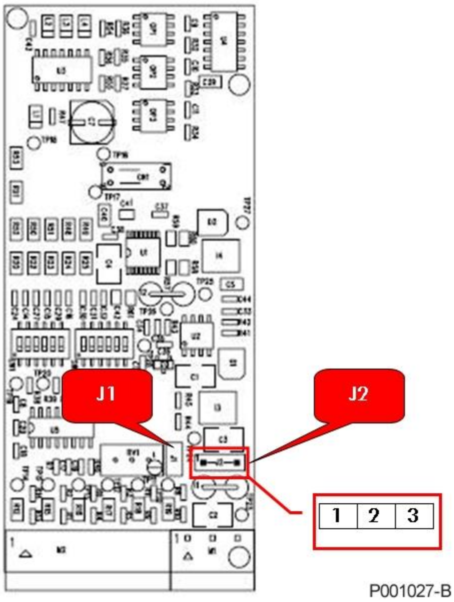


Figure 75: Location of the jumpers selecting the encoder supply voltage

8.8. Adjusting Trimmer

Trimmer RV1 located on ES913 board allows adjusting the encoder supply voltage. This can compensate voltage drops in case of long distance between the encoder and the encoder board, or allows feeding an encoder with intermediate voltage values if compared to factory-set values.

Tuning procedure:

1. Put a tester on the encoder supply connector (encoder side of the connecting cable); make sure that the encoder is powered.
2. Rotate the trimmer clockwise to increase supply voltage. The trimmer is factory set to deliver 5V and 12V (depending on the DIP-switch selection) to the power supply terminals. For a power supply of 5V, supply may range from 4.4V to 7.3V; for a power supply of 12V, supply may range from 10.4V to 17.3V.

	NOTE	The output voltage cannot be adjusted by trimmer RV1 (jumper J1 in pos. 1-2) for 24V power supply.
	CAUTION	Power supply values exceeding the encoder ratings may damage the encoder. Always use a tester to check voltage delivered from the ES913 board before wiring.
	CAUTION	Do not use the encoder supply output to power other devices. Failure to do so will increase the hazard of control interference and short-circuits with possible uncontrolled motor operation due to the lack of feedback.
	CAUTION	The encoder supply output is isolated from the common terminal of the analog signals incoming to the terminals of the control board (CMA). Do not link the two common terminals together.

9. ES860 SIN/COS ENCODER BOARD (SLOT A)

Product-Accessory Compatibility		
Product	**ES860 Encoder Board**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	-	
Solardrive Plus	-	

Table 10: Product – ES860 Encoder board compatibility

The ES860 Sin/Cos Encoder board allows interfacing encoders provided with 1Volt peak-to-peak analog outputs. Those encoders may be used to provide speed feedback and/or position feedback for Santerno drives.

NOTE Please refer to the Programming Guide and the Guide to the Synchronous Motor Application for the available control algorithms.

The ES860 board may be configured to operate in two acquisition modes as follows:

- **Three-channel mode**: increments low speed resolution and is suitable for slow rotation speed actuators requiring very accurate measurement of speed and position.
- **Five-channel mode:** detects the absolute mechanical position as soon as the inverter is first started up.

The board features are given below:

- Acquisition of five 1Volt peak-to-peak analog inputs on balanced line
- Two channels acquired via zero crossing and bidirectional digital counter with quadrature direction discriminator and x4 resolution multiplication factor (e.g. 1024 ppr to 4096 ppr)
- Zero index control for accurate alignment
- Two channels acquired in analog mode for absolute angle detection (12-bit resolution)
- Max. 140kHz input frequency in zero crossing channels for speeds up to 800rpm with 1024 ppr; alternatively up to 2000rpm with 4096 ppr
- Maximum 1kHz input frequency in analog channels
- Ability to re-direct analog signals to zero crossing channels
- Galvanic isolation in all channels for both digital and analog inputs
- 5V and 12V power supply output allowing fine tuning of the output voltage, isolated from the common for power supply output and signal output of the inverter.

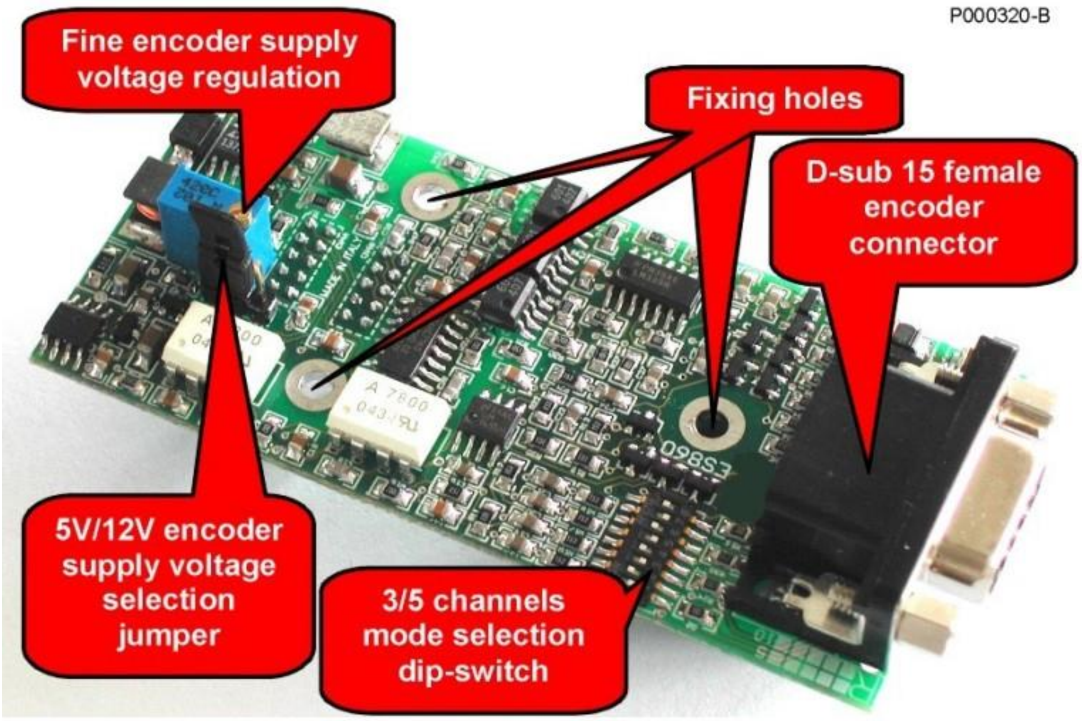


Figure 76: ES860 Sin/Cos Encoder board

9.1. Identification Data

Description	*Part Number*	*COMPATIBLE ENCODERS*	
		POWER SUPPLY	**OUTPUT**
ES860 Encoder SIN/COS Interface	ZZ0101830	5V, 12V, 15V, (5÷15V)	Sin/Cos encoder, 1Vpp, on three or five differential channels

9.2. Installing ES860 Board on the Inverter (Slot A)

1. Remove voltage from the inverter and wait at least 20 minutes.
2. The electronic components in the inverter and the communications board are sensitive to electrostatic discharge. Take any safety measure before operating inside the inverter and before handling the board. The board should be installed in a workstation equipped with proper grounding and provided with an antistatic surface. If this is not possible, the installer must wear a ground bracelet properly connected to the PE conductor.

3. Remove the protective cover of the inverter terminal board by unscrewing the two screws on the front lower part of the cover. Slot A where the ES860 board will be installed is now accessible, as shown in the figure below.

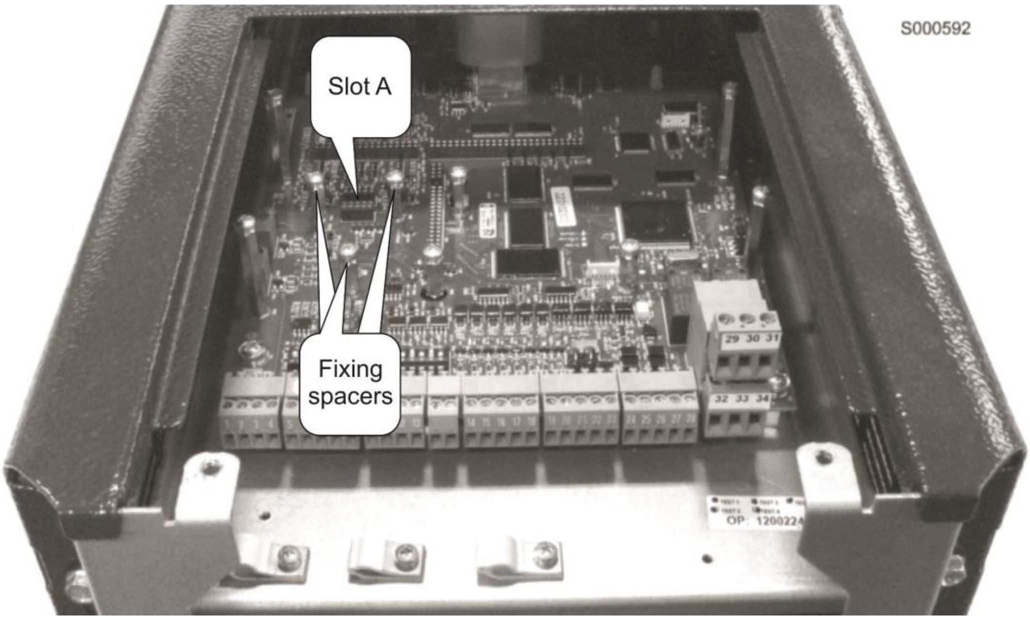


Figure 77: Location of Slot A inside the drive terminal board covers

4. Insert ES860 board into Slot A. Carefully align the contact pins with the two connectors in the slot. If the board is properly installed, the three fixing holes are aligned with the housing of the relevant fixing spacers screws. Check if alignment is correct, then fasten the three fixing screws as show in the figure below.

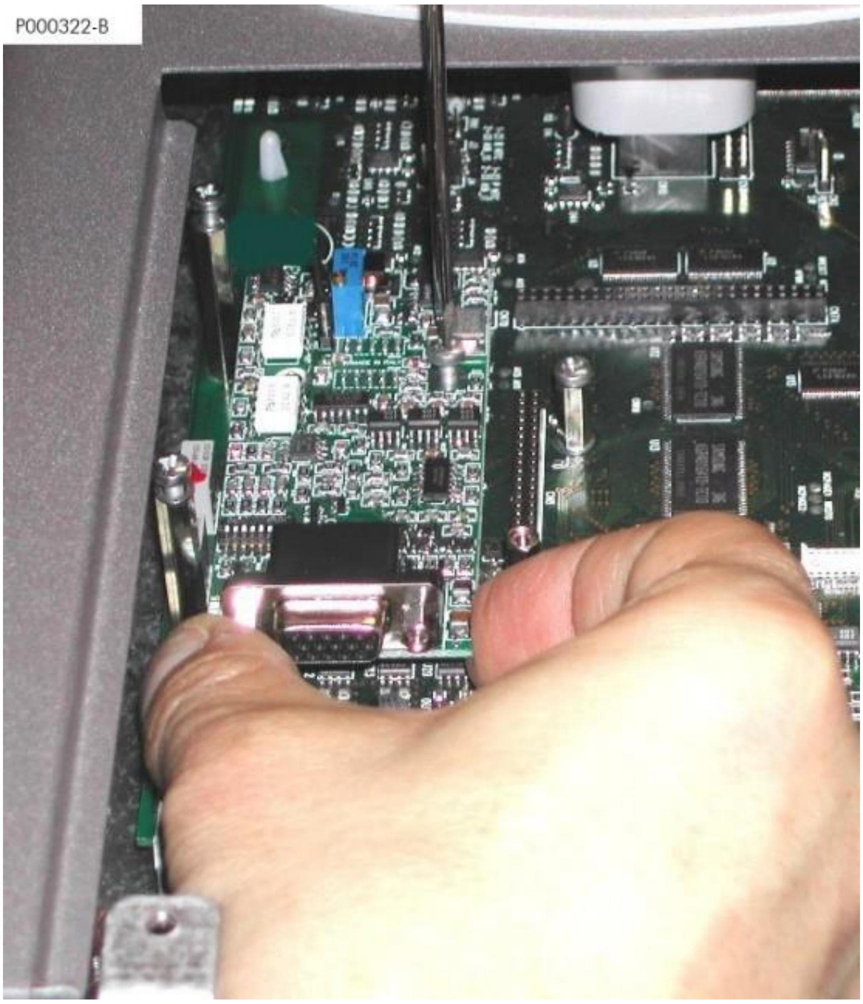


Figure 78: Fitting the ES860 board inside the drive

5. Set the correct encoder power supply and the DIP-switch configuration.
6. Power the inverter and check if the supply voltage delivered to the encoder is appropriate. Set up the parameters relating to ”Encoder A” as described in the Programming Guide.
7. Remove voltage from the inverter, wait until the inverter has come to a complete stop and connect the encoder cable.

	DANGER	Before gaining access to the components inside the inverter, remove voltage from the inverter and wait at least 20 minutes. Wait for the complete discharge of the internal capacitors to avoid electric shock hazard.
	CAUTION	Do not connect or disconnect signal terminals or power terminals when the inverter is powered to avoid electric shock hazard and to avoid damaging the inverter.
	NOTE	All fastening screws for removable parts (terminal cover, serial interface connector, cable path plates, etc.) are black, rounded-head, cross-headed screws. Only these screws may be removed when connecting the equipment. Removing different screws or bolts will void the product guarantee.

9.2.1. Sin/Cos Encoder Connector

High density D-sub 15-pin female connector (three rows). The figure shows a front view of the pin layout.

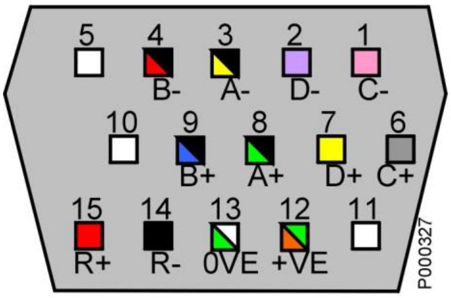


Figure 79: Pin layout on the high density connector

Decisive voltage class A according to EN 61800-5-1

No.	***Name***	***Description***
1	C–	Negative sine signal (absolute position)
2	D–	Negative cosine signal (absolute position)
3	A–	Negative sine signal
4	B–	Negative cosine signal
5	n.c.	
6	C+	Positive sine signal (absolute position)
7	D+	Positive cosine signal (absolute position)
8	A+	Positive sine signal
9	B+	Positive cosine signal
10	n.c.	
11	n.c.	
12	+VE	Encoder power output
13	0VE	Common for power supply and signals
14	R–	Negative zero index signal acquired with zero crossing
15	R+	Zero index signal acquired with zero crossing
Shell	PE	Connector shield connected to Inverter PE conductor

9.3. ES860 Configuration and Operating Modes

The ES860 Encoder Interface Board may power both 5V and 12V encoders and allows acquiring two types of encoders with 1Volt peak-to-peak sinusoidal outputs:

Three-channel mode: signals A (sine), B (cosine), R (zero index).

Input signals C+, C-, D+, D- are not used in three-channel mode. DIP-switch SW1 is to be set as in the figure below: odd-numbered switches to ON and the even-numbered switches to OFF.

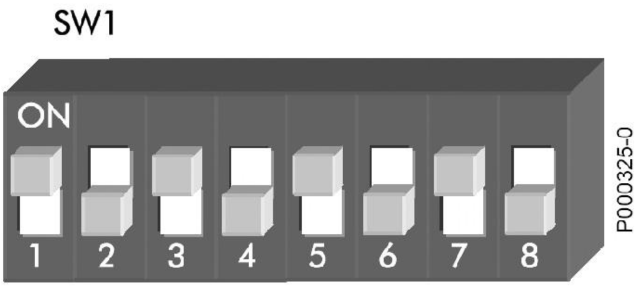


Figure 80: DIP-switch SW1 setting in three-channel mode

Five-channel mode: signals A (sine), B (cosine), R (zero index), C (sine, absolute position), D (cosine, absolute position).

All input signals are used in five-channel mode. DIP-switch SW1 shall be set as in the figure below: even-numbered switches to ON, odd-numbered switches to OFF.

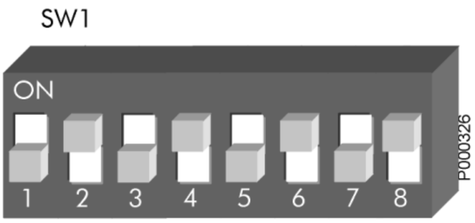


Figure 81: DIP-switch SW1 setting for five-channel mode

CAUTION

Do not alter the DIP-switch configuration and do not enable the configuration switches when the inverter is powered. Unexpected changes in switch settings, even of short duration, cause irreparable damage to the board and the encoder.

9.3.1. Configuring and Adjusting the Encoder Supply Voltage

The ES860 board may power encoders having different power supply voltage ratings. A selection Jumper and a power supply voltage regulation Trimmer are available, as shown in the figure below.

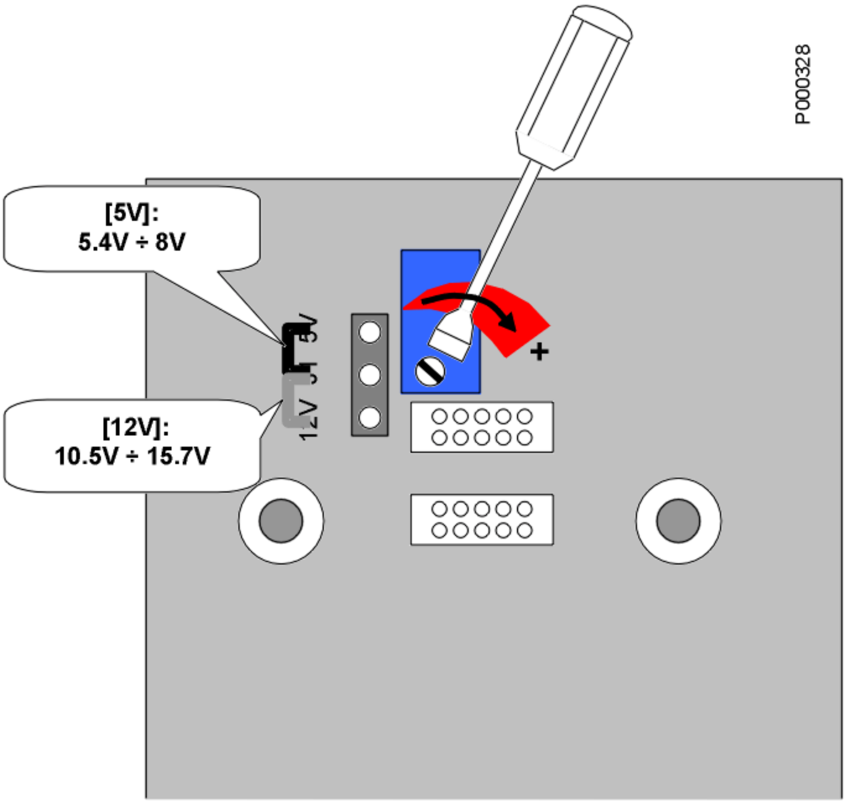


Figure 82: Position of the jumper and voltage adjusting trimmer

The ES860 board is factory-set with a minimum output voltage of 4.5V for the power supply of 5V rated encoders. Take account of ±10% due to voltage drops in cables and connector contactors. By using the trimmer, 8V voltage may be supplied.
Set the jumper to 12V to supply 12V or 15V encoders. It is now possible to operate on the trimmer to adjust voltage from 10.5 to 15.7V. Turn the trimmer clockwise to increase output voltage.
Power supply voltage is to be measured at the encoder supply terminals, thus taking account of cable voltage drops, particularly if a long cable is used.

⚠	**CAUTION**	Supplying the encoder with inadequate voltage may damage the component. Before connecting the cable and after configuring ES860 board, always use a tester to check the voltage supplied by the board itself.
✋	**NOTE**	The encoder power supply circuit is provided with an electronic current limiter and a resettable fuse. Should a short-circuit occur in the supply output, shut down the inverter and wait a few minutes to give the resettable fuse time to reset.

9.4. Connecting the Encoder Cable

State-of-the-art connections are imperative. Use shielded cables and correctly connect cable shielding.
The recommended connection diagram consists in a multipolar, dual shielded cable. The inner shield shall be connected to the connector case connected to the ES860 board, while the outer shield shall be connected to the encoder frame, usually in common with the motor frame. If the inner shield is not connected to the encoder frame, this can be connected to the inner braid.
The motor must always be earthed as instructed with a dedicated conductor connected directly to the inverter earthing point and routed parallel to the motor power supply cables.
It is not advisable to route the Encoder cable parallel to the motor power cables. It is preferable to use a dedicated signal cable conduit.
The figure below illustrates the recommended connection method.

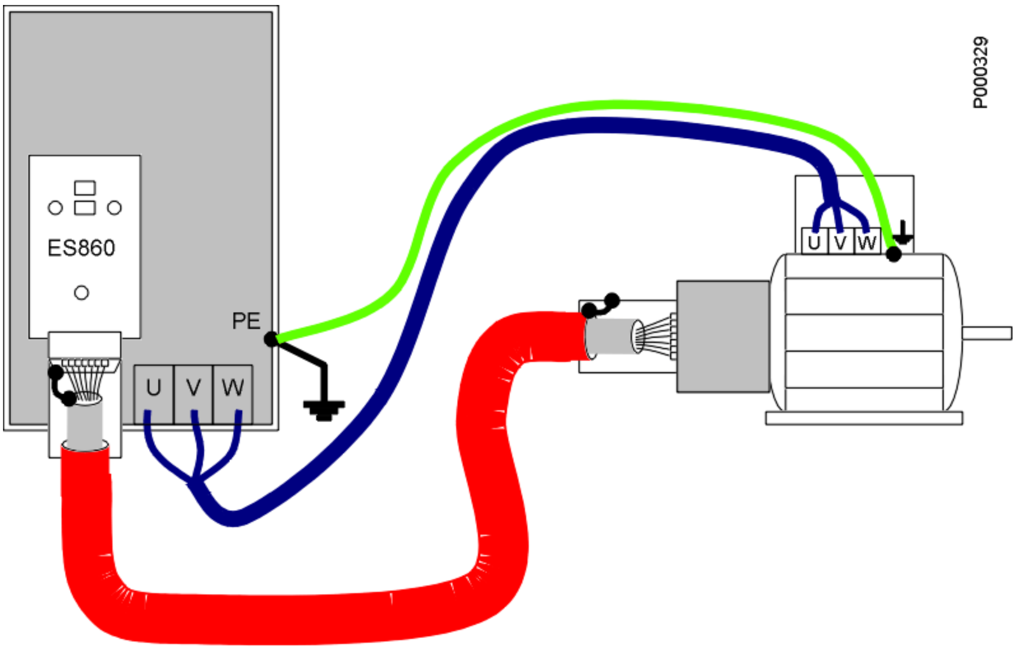


Figure 83: Recommended dual shielded connection for encoder cable

NOTE

The encoder supply output and the encoder signal common are isolated in respect to the common of the analog signals fitted in the inverter terminal board (CMA). Do not connect any conductors in common between the encoder signals and the signals in the inverter terminal board. This prevents isolation from being adversely affected.

The connector of the ES860 board shall be connected exclusively to the encoder using one single cable.

CAUTION

Correctly fasten the cable and the connectors both on the encoder side and on ES860 board side. The disconnection of one cable or even a single conductor may lead to inverter malfunction and may cause the motor to run out of control.

9.5. Environmental Requirements

Operating temperatures	–10 to +55 °C ambient temperature (contact Enertronica Santerno S.p.A. for higher ambient temperatures)
Relative humidity	5 to 95% (non-condensing)
Max. allowable operating altitude	2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A.

9.6. Electrical Ratings

Class A voltage according to EN 61800-5-1

Encoder supply output	*Ratings*			
	Min	*Typ*	*Max*	*Unit*
Encoder output current, +12V configuration			300	mA
Encoder output current, +5V configuration			500	mA
Short-circuit protection level			900	mA
Encoder supply voltage adjusting range in 5V Mode	4.5	5.3	8.0	V
Encoder supply voltage adjusting range in 12V Mode	10.5	12.0	15.7	V

Static characteristics for signal inputs	*Ratings*			
	Min	*Typ*	*Max*	*Unit*
Type of input signals, A,B	Differential analog type ~1Vpp			
Differential peak-to-peak input voltage range	0.8	1.0	1.2	Vpp
Input common mode voltage range	0		5	V
Input impedance	120			ohm
Type of input signals, C,D	Differential analog type ~1Vpp			
Differential input voltage range	0.8	1.0	1.2	Vpp
Input common mode voltage range	0		5	V
Input impedance	1			Kohm
Type of input signal R	Differential analog type ~0.5Vpp/1Vpp			
Differential encoder signal input voltage range	0.2	0.5	1.1	Vpp
Input common mode voltage range	0		5	V
Input impedance	120			ohm

Max. absolute values	*Value*			
	Min	*Typ*	*Max*	*Unit*
Maximum allowable common mode voltage amplitude causing no damage	–20		+25	V
Maximum allowable differential voltage amplitude on channels A, B, R	–3.5		+3.5	V
Maximum allowable differential voltage amplitude on channels C and D	–10		+10	V

CAUTION Exceeding the maximum differential input or common mode voltages will result in irreparable damage to the apparatus.

Dynamic characteristics of the input signals	*Value*
Maximum frequency of the signals acquired in analog mode – channels C, D or channels A, B in three-channel mode	1000Hz (60,000rpm @ 1 p/rev) (60 rpm @ 1,024 p/rev)
Maximum frequency of signals acquired with digital counting on zero crossing – channels A, B	140kHz (1,024pls @ 8,200rpm)
Minimum duration of zero crossing pulse – channel R	3.5 µs (1,024pls @ 8,200rpm)

CAUTION Exceeding the input signal frequency limits will result in a wrong measurement of the encoder position and speed. Depending on the control method selected for the inverter, it may also cause the motor to run out of control.

10. ES822 ISOLATED SERIAL BOARD (SLOT B)

Product-Accessory Compatibility		
Product	**ES822 Optoisolated serial board**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	√	
Solardrive Plus	√	

Table 11: Product – ES822 Optoisolated serial board compatibility

The isolated serial board RS232/485 controlling Santerno drives allows connecting a computer through RS232 interface or allows a multidrop connection of Modbus devices through RS485 interface. It provides galvanic isolation of interface signals relating to both the control board ground and the terminal board common of the control board.

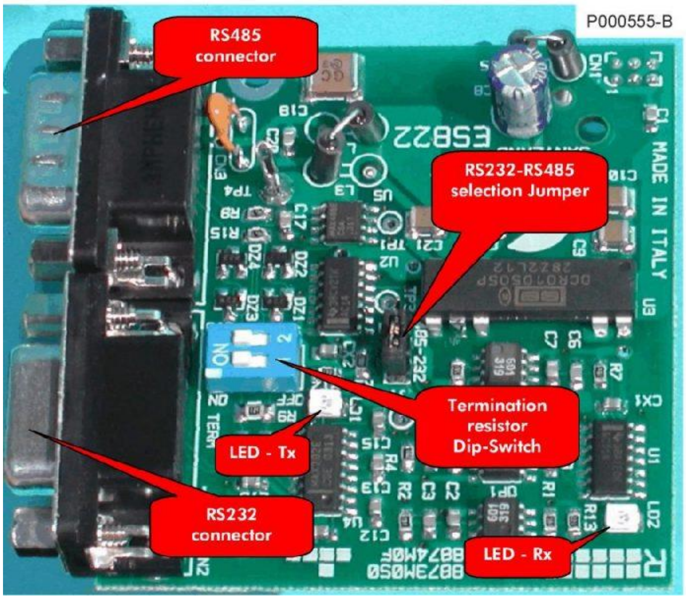


Figure 84: ES822 board

10.1. Identification Data

Description	*Part Number*
Isolated serial board - RS232/485	ZZ0095850

10.2. Environmental Requirements

Operating temperature	–10 to +55 °C ambient temperature (contact Enertronica Santerno S.p.A. for higher ambient temperatures)
Relative humidity	5 to 95% (non-condensing)
Max. operating altitude	2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A.

10.3. Electrical Features

WIRING:

Once ES822 board is fitted, connector RS485 installed on the inverter will automatically disable. D-type, 9-pole male connector (RS485) or female connector (RS232-DTE) located on ES822 board activate depending on the position of J1.

Contacts of CN3, D-type, 9-pole male connector (RS485) are as follows:

Decisive voltage class A according to EN 61800-5-1

PIN	FUNCTION
1 - 3	(TX/RX A) Differential input/output A (bidirectional) according to standard RS485. Positive polarity in respect to pins 2 – 4 for one MARK.
2 - 4	(TX/RX B) Differential input/output B (bidirectional) according to standard RS485. Negative polarity in respect to pins 1 – 3 for one MARK.
5	(GND) control board zero volt
6 - 7	Not connected
8	(GND) control board zero volt
9	+5 V, max 100mA for the power supply of an auxiliary RS485/RS232 converter (if any)

Contacts of CN2, D-type, 9-pole female connector (RS232-DCE) are as follows:

Decisive voltage class A according to EN 61800-5-1

PIN	FUNCTION
1 - 9	Not connected
2	(TX A) Output according to standard RS232
3	(RX A) Input according to standard RS232
5	(GND) zero volt
4 - 6	To be connected together for loopback DTR-DSR
7 - 8	To be connected together for loopback RTS-CTS

10.4. Installing ES822 Board on the Inverter (Slot B)

	DANGER	Before gaining access to the components inside the inverter, remove voltage from the inverter and wait at least 20 minutes. Wait for a complete discharge of the internal capacitors to avoid any electric shock hazard.
	CAUTION	Electric shock hazard: do not connect/disconnect the signal terminals or the power terminals when the inverter is on. This also prevents the inverter from being damaged.
	NOTE	All the screws used to fasten removable parts (terminals cover, serial interface connector, cable plates, etc.) are black, round-head, cross-head screws. When wiring the inverter, remove only this type of screws. If different screws or bolts are removed, the inverter warranty will be no longer valid.

1. Turn off the inverter and wait at least 20 minutes.
2. Remove the cover to access to the inverter control terminals. The fixing spacers for the encoder board and signal connector are located on the right.

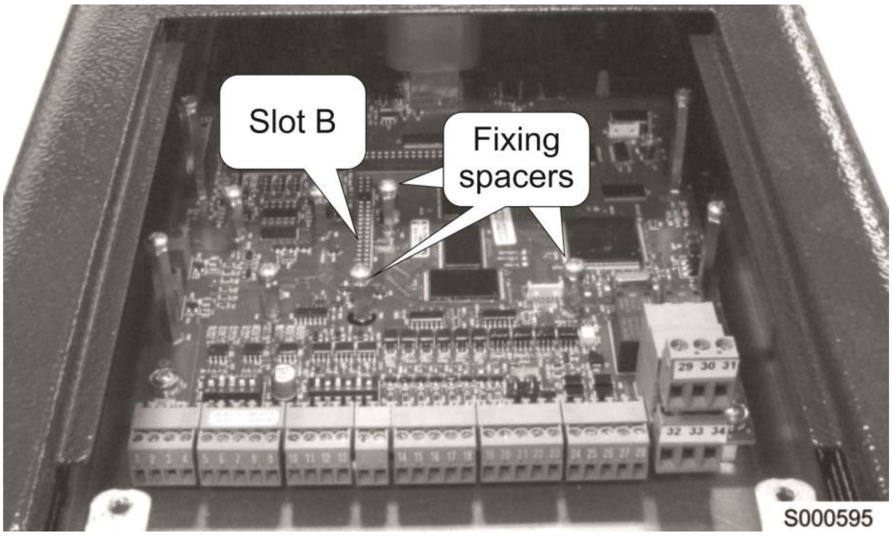


Figure 85: Position of the slot for the installation of the serial isolated board

3. Fit ES822 board and make sure that all contacts enter the relevant housing in the signal connector. Fasten the encoder board to the fixing spacers using the screws supplied.
4. Configure DIP-switches and the jumper located on the encoder board based on the connected encoder.
5. Close the inverter frame by reassembling the cover allowing gaining access to the inverter control terminals.

10.5. Jumper for RS232/RS485 Selection

Jumper J1 sets ES822 board to operate as RS485 interface or as RS232 interface. The corresponding positions are silk-screened on the board.

With a jumper between pins 1-2, CN3-(RS485) is enabled (default).

With a jumper between pins 2-3, CN2-(RS232) is enabled.

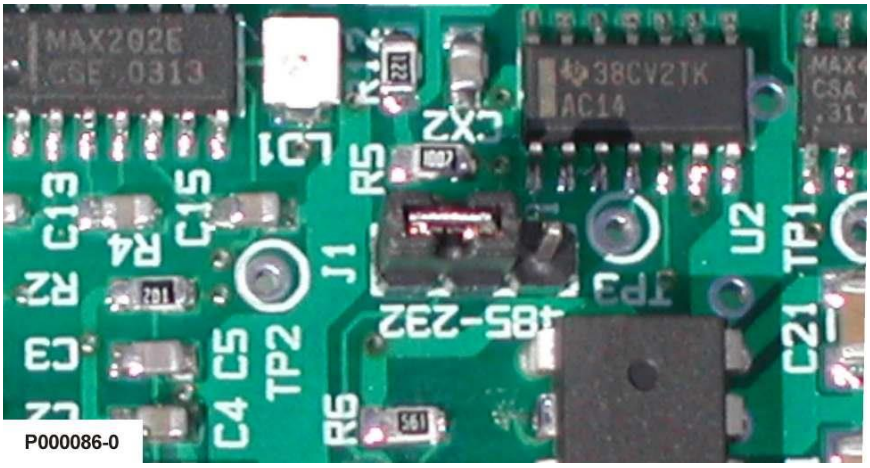


Figure 86: Jumper setting RS232/RS485

10.6. DIP-switch for RS485 Terminator

Please refer to the Serial Communications section in the Installation Guide.
For serial link RS485 in ES822 board, the line terminator is selected through DIP-switch SW1 as shown in the figure below.
When the line master (computer) is located at the beginning or at the end of the serial link, the line terminator of the farthest inverter from the master computer (or the only inverter in case of direct connection to the master computer) shall be enabled.
Line terminator enables by setting selector switches 1 and 2 to ON in DIP-switch SW1. The line terminator of the other inverters in intermediate positions shall be disabled: DIP-switch SW1, selector switches 1 and 2 in position OFF (default setting).
In order to use RS232-DTE link, no adjustment of DIP-switch SW1 is required.

Figure 87: Configuration of terminator DIP-switch for line RS485

11. OPTION BOARDS FOR FIELDBUS (SLOT B)

Product-Accessory Compatibility		
Product	**Fieldbus boards B40 series**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	√	
Solardrive Plus	√	
Product	**Anybus-S Fieldbus boards**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	√	
Solardrive Plus	√	

Table 12: Product – Fieldbus board compatibility

Several interface boards (optional) are available for the connection of Santerno drives to automation systems based on Fieldbus. Option boards allow interfacing systems based on:

- Profibus-DP®,
- PROFIdrive®,
- DeviceNet® (CAN),
- CANopen® (CAN),
- Modbus/TCP,
- EtherNet/IP,
- Profinet IRT,
- EtherCAT,

The drives compatible with this accessory can house only one option board per fieldbus. This board allows controlling the inverter through the desired bus starting from a control device (PLC, industrial computer, etc.). The control method from fieldbus integrates the control methods from local terminals, remote terminals (through MODBUS serial link) and from keypad, which are provided from the inverter. For more details on the inverter command modes and the possible matching among the different sources, refer to the Programming Guide (Control Method menu and Fieldbus menu).
The sections below cover the installation procedure and the configuration and diagnostics of the different types of option boards.

NOTE The read/write scan rate for the drives compatible with this accessory is 2ms. Please refer to the Programming Guide for details.

11.1. Identification Data

The utilities and configuration files for the fieldbus option boards are available for download from santerno.com, Software tab of the product sheet concerned.
Two series of option boards for fieldbuses are available: the B40 series and the Anybus-S series. The newest B40 series adds more Ethernet-based fieldbuses.

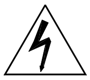
B40 Series Boards

Type of Fieldbus	***Connector***	***Electric Interface***	***Part Number***	***Motorola Firmware Version***	***See***
Profibus-DP®	9-pin D-Sub	Profibus®	ZZ4600200	≥ 4.116	B40 Series Board for PROFIBUS-DP®
DeviceNet®	5-pin Terminal board	CAN Bus	ZZ4600210	≥ 4.116	B40 Series Board for DeviceNet®
CANOpen®	D-Sub 9pin	CAN Bus	ZZ4600225	≥ 4.210	B40 Series Board for DeviceNet®
Modbus/TCP	RJ-45	Ethernet	ZZ4600220	≥ 4.116	B40 Series Boards Featuring Ethernet Interface
EtherNet/IP	RJ-45	Ethernet	ZZ4600221	≥ 4.116	
Profinet IRT	RJ-45	Ethernet	ZZ4600222	≥ 4.116	
EtherCAT	RJ-45	Ethernet	ZZ4600223	≥ 4.116	

Anybus-S Boards

Type of fieldbus	***Connector***	***Electric interface***	***Part Number***	***Motorola Firmware Version***	***See***
Profibus-DP®	9-pin D-Sub	Profibus®	ZZ4600045	Any	Anybus-S PROFIBUS-DP® Board
PROFIdrive®	9-pin D-Sub	Profibus®	ZZ4600042	Any	Anybus-S PROFIdrive® Board
DeviceNet®	5-pin Terminal board	CAN Bus	ZZ4600055	Any	Anybus-S DeviceNet® Board
CANOpen®	5-pin Terminal board	CAN Bus	ZZ4600070	Any	Anybus-S CANopen® Fieldbus Board
Modbus/TCP	RJ-45	Ethernet	ZZ4600100	Any	Anybus-S Ethernet Board for Modbus/TCP

11.2. Installing the Fieldbus Board on the Inverter (Slot B)



DANGER

Before gaining access to the components inside the inverter, remove voltage from the inverter and wait at least 20 minutes. Wait for a complete discharge of the internal capacitors to avoid any electric shock hazard.

CAUTION

Electric shock hazard: do not connect/disconnect the signal terminals or the power terminals when the inverter is on. This also prevents the inverter from being damaged.

NOTE

All the screws used to fasten removable parts (terminals cover, serial interface connector, cable plates, etc.) are black, round-head, cross-head screws.
When wiring the inverter, remove only this type of screws. If different screws or bolts are removed, the inverter warranty will be no longer valid.

1) Remove voltage from the inverter and wait at least 20 minutes.
2) The electronic components in the inverter and the communications board are sensitive to electrostatic discharge. Be careful when you reach the component parts inside the inverter and when you handle the communications board. The board should be installed in a workstation equipped with proper grounding and provided with an antistatic surface. If this is not possible, the installer must wear a ground bracelet properly connected to the PE conductor.

3) Loosen the two front screws located in the lower part of the inverter cover to remove the covering of the terminal board. In the drive control board, you can then reach the slot B, where you can install the Profibus communications board.

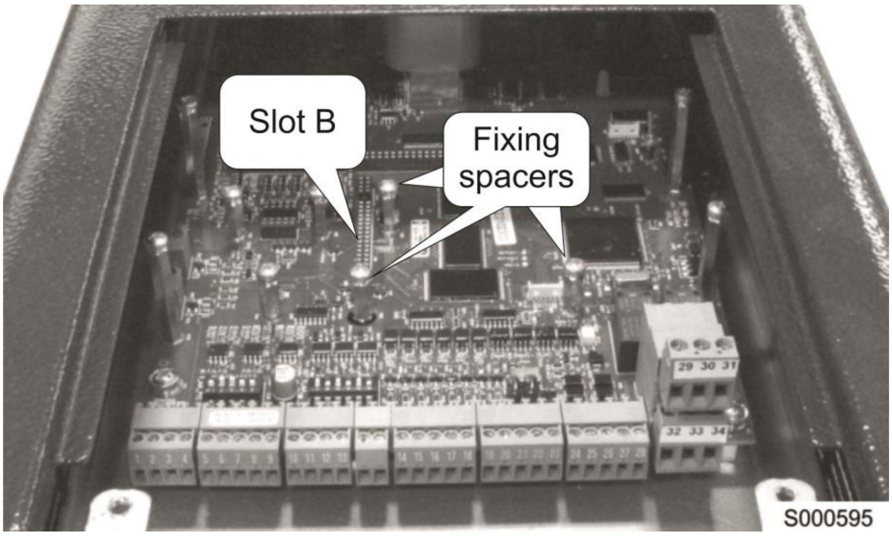


Figure 88: Location of the slot B inside the terminal board cover of Santerno drives

4) Insert the communications board in the slot B; make sure that the connector bar in the board is inserted in the front part of the slot only, and that the last 6 pins are not connected. If installation is correct, the three fastening holes will match with the housings of the fastening screws for the fixing spacers. Tighten the board fixing screws as shown in Figure 89 and Figure 90.

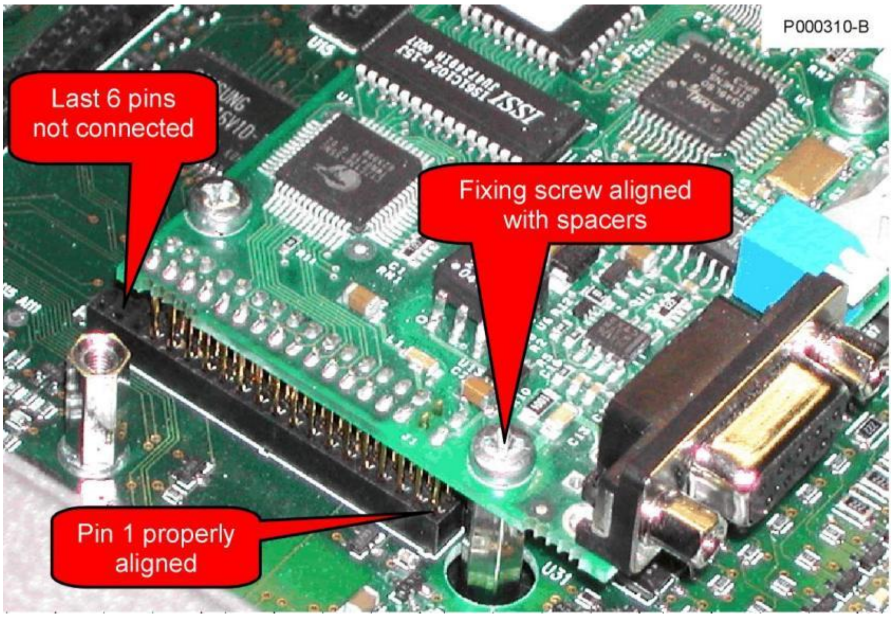


Figure 89: Checking contacts in the slot B

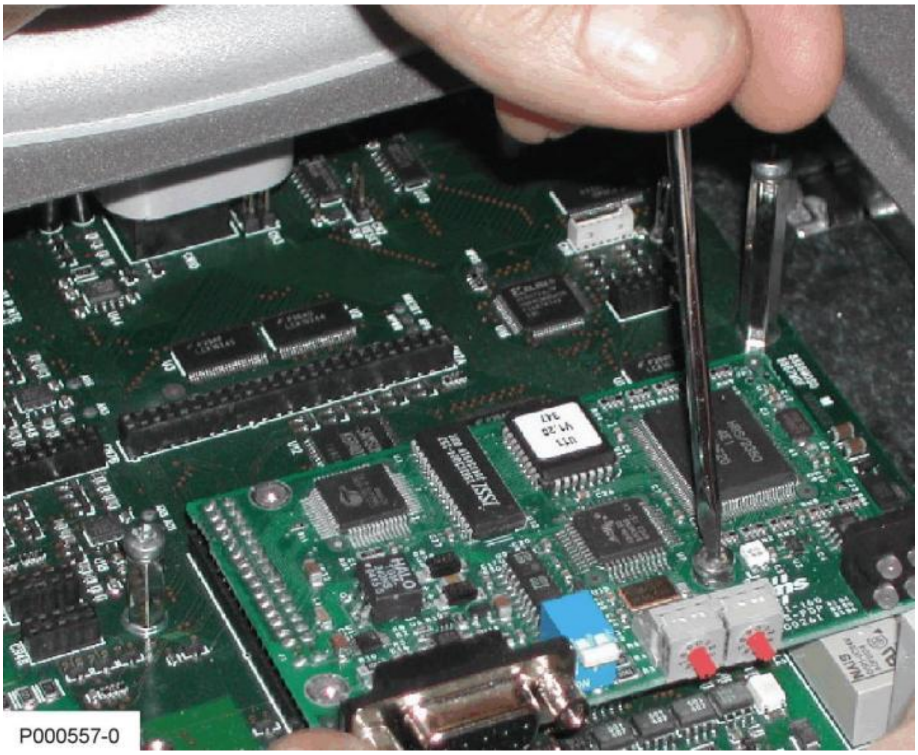


Figure 90: Fastening the communications board to slot B

5) Configure the DIP-switches and rotary-switches following the instructions given in the relevant section.

6) Connect the Fieldbus cable by inserting its connector or by connecting the wires to the terminals.

7) Close the inverter frame by reassembling the cover allowing gaining access to the inverter control terminals.

11.3. Status LEDs on the B40 Series Boards

Each B40 Fieldbus board is equipped with two red/green LEDs (NSTA L4 and MSTA L5 LEDs). Their meaning depends on the communications bus as from the tables below:

11.3.1. NSTA/MSTA LEDs - Profibus DP

L4/Operation Mode		L5/Status Mode	
LED State	Indication	LED State	Indication
Off	Not online / No power	Off	Not initialized
Green	Online, data exchange	Green	Initialized
Flashing Green	Online, clear	Flashing Green	Initialized, diagnostic event(s) present
Flashing Red (1 flash)	Parameterization error	Red	Exception error
Flashing Red (2 flash)	PROFIBUS Configuration error		

11.3.2. NSTA/MSTA LEDs - DeviceNet

L4/Network Status		L5/Module Status	
LED State	Indication	LED State	Indication
Off	Not online / No network power	Off	Not operating
Green	On-line, one or more connections are established	Green	Operating in normal condition
Flashing Green (1 Hz)	On-line, no connections established	Flashing Green (1 Hz)	Missing, incorrect or incomplete configuration, device needs commissioning.
Red	Critical link failure, fatal event	Red	Unrecoverable Fault(s)
Flashing Red (1 Hz)	One or more connections timed-out	Flashing Red (1 Hz)	Recoverable Fault(s)
Alternating Red/Green	Executing self test	Alternating Red/Green	Executing self test

11.3.3. LED NSTA/MSTA CANopen®

L4/Network Status		L5/Module Status	
LED State	Indication	LED State	Indication
Off	Not online / No network power	Off	Not online / No network power
Green	On-line, one or more connections are established, OPERATIONAL state	Off	Comunicazione attiva
Green	On-line, one or more connections are established, OPERATIONAL state	Flashing Red (1 Hz)	Comunicazione interrotta / Errore
Flashing Green (1 Hz)	On-line, connessione presente STOPPED state	Off	Comunicazione attiva
Flashing Green (1 Hz)	On-line, connessione presente STOPPED state	Flashing Red (1 Hz)	Comunicazione fermata in STOPPED state
Flashing Green (0.5 Hz)	On-line, connessione presente PRE-OPERATIONAL state	Off	Comunicazione attiva
Flashing Green (0.5 Hz)	On-line, connessione presente PRE-OPERATIONAL state	Flashing Red (0.5 Hz)	Comunicazione fermata in PRE-OPERATIONAL state

11.3.4. NSTA/MSTA LEDs - Profinet

L4/Network Status		L5/Module Status	
LED State	**Indication**	**LED State**	**Indication**
Off	Offline	Off	Not Initialized
Green	Online (RUN)	Green	Normal Operation
Green, 1 flash	Online (STOP)	Green, 1 flash	Diagnostic Event(s)
Green, blinking	Used by engineering tools to identify the node on the network	Red	Exception error Fatal event
Red	Fatal event	Alternating Red/Green	Firmware update
Red, 1 flash	Station Name error		
Red, 2 flashes	IP address error		
Red, 3 flashes	Configuration error		

11.3.5. NSTA/MSTA LEDs LEDs - Modbus/TCP

L4/Network Status		L5/Module Status	
LED State	**Indication**	**LED State**	**Indication**
Off	No IP address or in state EXCEPTION	Off	No power
Green	At least one Modbus message received	Green	Normal operation
Green, flashing	Waiting for first Modbus message	Red	Major fault, FATAL
Red	IP address conflict detected, FATAL ERROR	Red, flashing	Minor fault
Red, flashing	Connection timeout. No Modbus message has been received within the configured “process active timeout” time	Alternating Red/Green	Firmware update from file system in progress

11.3.6. NSTA/MSTA LEDs - Ethernet IP

L4/Network Status		L5/Module Status	
LED State	**Indication**	**LED State**	**Indication**
Off	No power or no IP address	Off	No power
Green	Online, one or more connections established (CIP Class 1 or 3)	Green	Controlled by a Scanner in Run state
Green, flashing	Online, no connections established	Green, flashing	Not configured, or Scanner in Idle state
Red	Duplicate IP address, FATAL error	Red	Major fault (EXCEPTION-state, FATAL error etc.)
Red, flashing	One or more connections timed out (CIP Class 1 or 3)	Red, flashing	Recoverable fault(s).

11.3.7. NSTA/MSTA LEDs - EtherCAT

L4/RUN LED		L5/ERR LED	
LED State	**Indication**	**LED State**	**Indication**
Off	INIT	Off	No error (or no power)
Green	OPERATIONAL	Red, blinking	Invalid configuration
Green, blinking	PRE-OPERATIONAL	Red, single flash	Unsolicited state change
Green, single flash	SAFE-OPERATIONAL	Red, double flash	Sync Manager watchdog timeout
Flickering	BOOT	Red	Application controller failure
Red	Fatal Event time	Flickering	Booting error detected

The models featuring serial comms (Profibus and DeviceNET) are provided with two additional LEDs indicating the bus status when transmitting (yellow TX LED L2) and receiving (green RX LED L3).

The models featuring Ethernet comms have the line LINK/Activity LEDs mounted directly on the bus connector, as described in the Ethernet Connector section.

11.3.8. Profinet Link LEDs

LINK/Activity LED	
LED State	**Indication**
Off	No Link
Green	Link
Green, flickering	Activity

11.3.9. Modbus/TCP Link LEDs

LINK/Activity LED	
LED State	**Indication**
Off	No link, no activity
Green	Link (100 Mbit/s) established
Green, flickering	Activity (100 Mbit/s)
Yellow	Link (10 Mbit/s) established
Yellow, flickering	Activity (10 Mbit/s)

11.3.10. Ethernet IP Link LEDs

LINK/Activity LED	
LED State	**Indication**
Off	No link, no activity
Green	Link (100 Mbit/s) established
Green, flickering	Activity (100 Mbit/s)
Yellow	Link (10 Mbit/s) established
Yellow, flickering	Activity (10 Mbit/s)

11.3.11. EtherCAT Link LEDs

LINK/Activity LED	
LED State	**Indication**
Off	No Link
Green	Link sensed, no activity
Green, flickering	Link sensed, activity

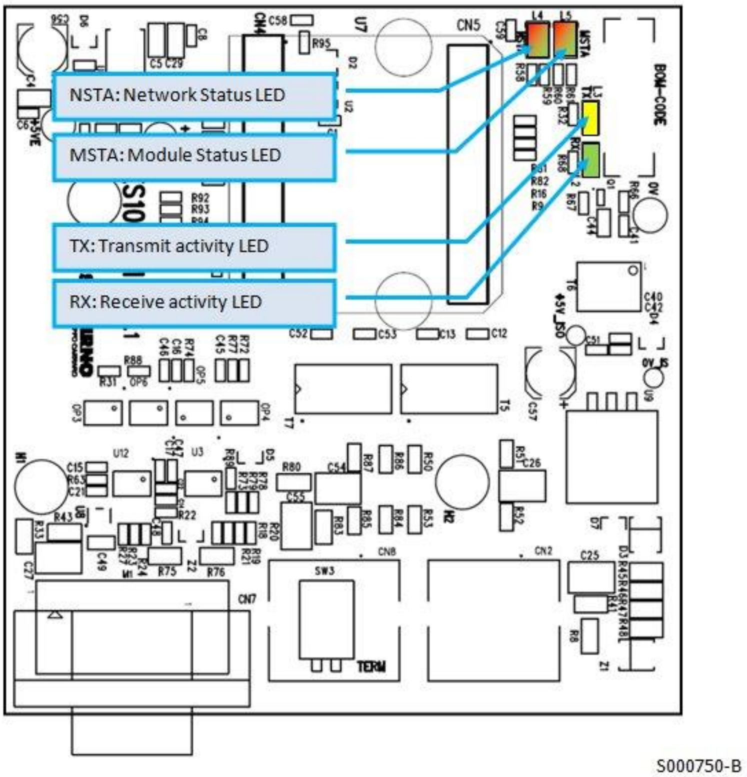


Figure 91: Position of indicator LEDs on the B40 boards

11.4. Status LEDs on the Anybus-S Boards

Each option fieldbus board of the Anybus-S series is equipped with a column provided with four LEDs installed on its front edge to monitor the bus status and with one LED (red/green) installed on the communications board for debugging, as shown in the figure below.

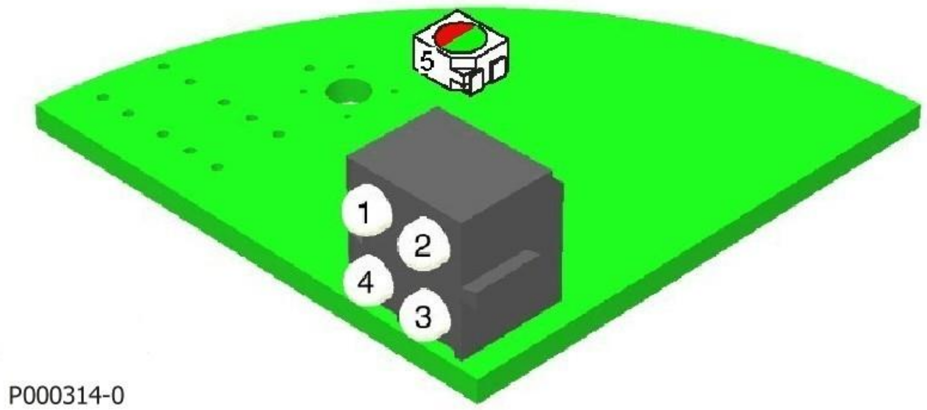


Figure 92: Position of indicator LEDs on the Anybus-S boards

The red/green LED mounted on the board relates to all interface models, whereas the LEDs mounted on the board column have different meanings based on the type of fieldbus being used.

11.4.1. LEDs for Fieldbus Interface CPU Diagnostics

The LED located on the printed circuit of any version of the interface board indicates the status of the CPU dedicated to communication. The table below shows the possible type of signals.

N. & Name	***Function***
5. Board diagnostics	**Red** – Unknown internal error, or module operating in bootloader mode **1 Hz Red blinker** – RAM fault **2 Hz Red blinker** – ASIC or FLASH fault **4 Hz Red blinker** – DPRAM fault **2 Hz Green blinker** – Module not initialized **1 Hz Green blinker** – Module initialized and operating.

11.4.2. LEDs for PROFIBUS-DP® Board Diagnostics

In the PROFIBUS-DP board, LED 1 is inactive; the remaining LEDs are described below:

N. & Name	Function
2. On-Line	It indicates that the inverter is on-line on the fieldbus: **Green** – The module is on-line; data exchange is allowed. **Off** – The module is not on-line.
3. Off-Line	It indicates that the inverter is off-line on the fieldbus: **Red** – The module is off-line; data exchange is not allowed. **Off** – The module is not off-line.
4. Fieldbus Diagnostics	It indicates some possible errors: **1 Hz Red blinker** – Configuration error: the length of IN messages and OUT messages set while initializing the module does not match with the message length set while initializing the network. **2 Hz Red blinker** – User Parameter error: the data length and/or contents for the User Parameters set while initializing the module does not match with the data length and/or contents set while initializing the network. **4 Hz Flash blinker** – Error while initializing the Fieldbus communications ASIC. **Off** – No error found.

11.4.3. LEDs for DeviceNet® Board Diagnostics

In the DeviceNet® board, LEDs 1 and 4 are not used; the remaining LEDs are described below:

N. & Name	Function
2. Network status	It indicates the status of the DeviceNet communications: **Off** – The module is not On-Line **Green** – DeviceNet communications in progress and correct **Flashing green** – The module is ready for communication but is not connected to the network **Red** – A critical error occurred (too erroneous data items) and the module switched to the “link failure” status **Flashing red** – A timeout occurred when exchanging data
3. Module status	It indicates the status of the communication module: **Off** – The module is off **Green** – The module is operating **Flashing green** – The length of the two data packets exceeds the preset value **Red** – An unresettable event error occurred **Flashing red** – A resettable event error occurred

11.4.4. LEDs for CANopen® Board Diagnostics

In the CANopen board, LED 1 is not used; the remaining LEDs are described below:

N. & Name	***Function***
2. Run	It indicates the status of the CANopen interface of the module: **Off** – The interface is off **One flash** – The interface status is STOP **Flashing** – The interface is being initialized **On** – The interface is operating
3. Error	It indicates the error status of the CANopen interface: **Off** – No error **One flash** – The frame error counter has reached the warning limit **Two flashes** – A Control Error event (guard event or heartbeat event) occurred **Three flashes** – A synchronisation error event occurred: the SYNC message was not received within the time-out **On** – The bus is disabled due to an unresettable event error
4. Power	**Off** – The module is off **On** – The module is on

The word “Flashing” in the table indicates a LED that comes on for 200ms every 200ms; “One flash”, “Two flashes” and “Three flashes” indicate a LED that comes on one, twice or three times for 200ms every 200ms and with an inactivity time of 1000ms.

11.4.5. LEDs for Ethernet Board Diagnostics

In the Ethernet board, the diagnostics LEDs indicate the status of the connection to the LAN:

N. & Name	***Function***
1. Link	**Off** – The module has not detected any legal carrier signal and is not in the LINK status **On** – The module has detected a legal carrier signal and is in the LINK status
2. Module status	**Off** – The module is off **Green** – The module is properly operating **Flashing green** – The module was not configured and communication is in stand-by **Flashing red** – the module has detected a resettable event error **Red** – the module has detected an unresettable event error **Flashing red/green** – the module is performing a self-test at power on
3. Network status	**Off** – The IP address has not yet been assigned **Green** – At least one active Ethernet/IP connection is in progress **Flashing green** – No active Ethernet/IP connection is in progress **Flashing red** – “Timeout” of one or more links performed directly to the module **Red** – The module has detected that its IP is used by another device in the LAN **Flashing red/green** – The module is performing a self-test at power on
4. Activity	**Flashing green –** A data packet is being transmitted or received

11.5. B40 Series Board for PROFIBUS-DP®

PROFIBUS-DP® is a registered trademark of PROFIBUS International.

The B40 series Profibus® communications board allows interfacing between a drive and an external control unit, such as a PLC, using a PROFIBUS-DP communications interface.
The drive operates as a Slave device and is controlled by a Master device (PLC) through command messages and reference values which are equivalent to the ones sent via terminal board. The Master device is also capable of detecting the operating status of the inverter. More details about Profibus communications are given in the Programming Guide.

The Profibus® communications board has the following features:

- Type of fieldbus: PROFIBUS-DP EN 50170 (DIN 19245 Part 1) with protocol version 1.10
- Automatic detection of the baud rate ranging from 9600 bits/s to 12 Mbits/s
- Communications device: PROFIBUS bus link, type A or B as mentioned in EN50170
- Type of fieldbus: Master-Slave communications; max. 126 stations in multidrop connection
- Fieldbus connector: female, 9-pin, DSUB connector
- Wire: copper twisted pair (EIA RS485)
- Max. length of the bus: 200m @ 1.5Mbits/s (can be longer if repeaters are used)
- Isolation: the bus is galvanically isolated from the electronic devices via a DC/DC converter
- The bus signals (link A and link B) are isolated via optocouplers
- Status indicators: indicator Led for board status and indicator Led for fieldbus status

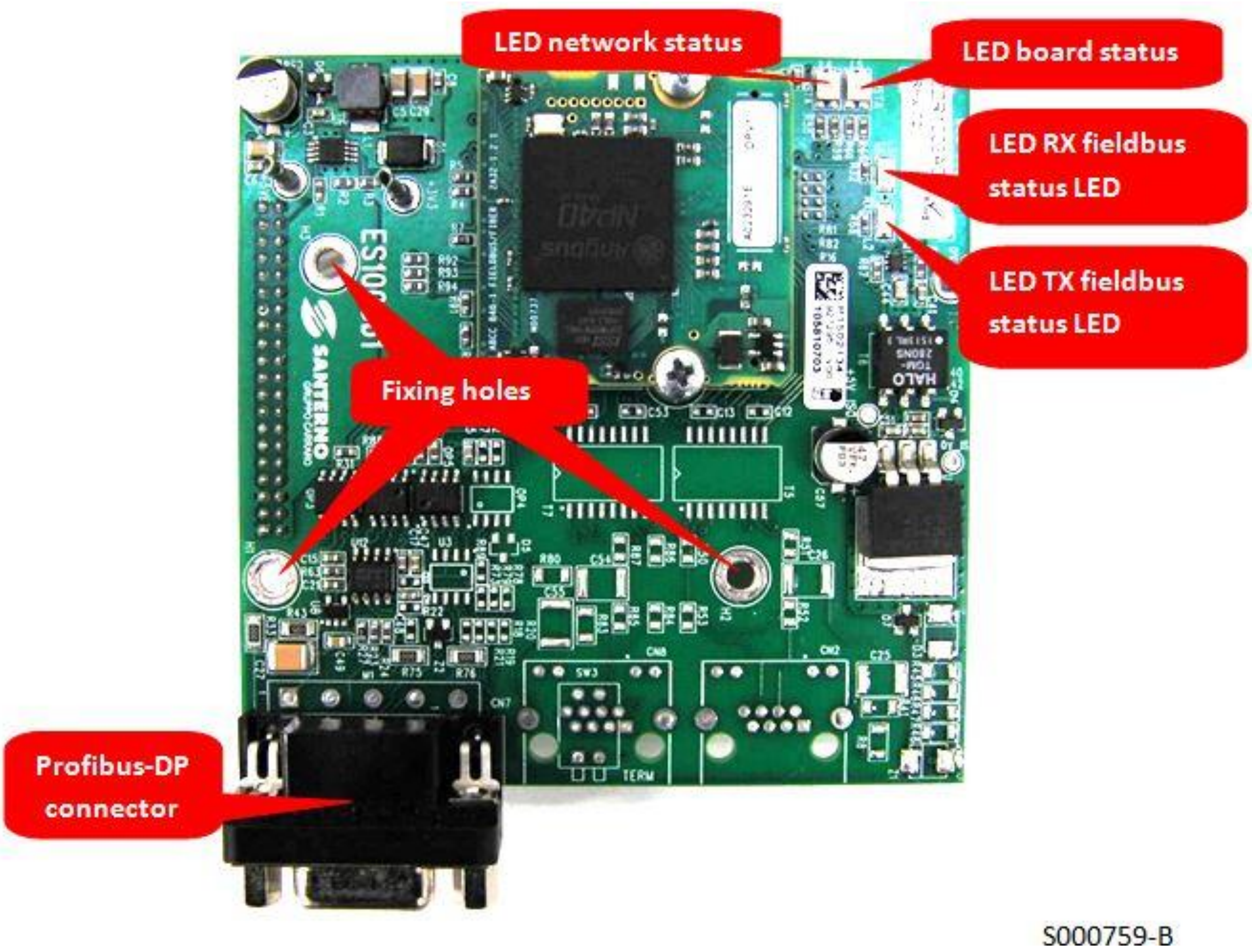


Figure 93: PROFIBUS-DP® fieldbus communications board (B40)

11.5.1. PROFIBUS® Fieldbus Connector

Female, 9-pin, D-sub connector.

Pin layout:

Decisive voltage class A according to EN 61800-5-1

N.	***Name***	***Description***
–	Shield	Connector frame connected to PE
1	N.C.	
2	N.C.	
3	B-Line	Positive RxD/TxD according to RS 485 specifications
4	RTS	Request To Send – active high level when sending
5	GND	Bus ground isolated from control board 0V
6	+5V	Bus driver supply isolated from control board circuits
7	N.C.	
8	A-Line	Negative RxD/TxD according to RS 485 specifications
9	N.C.	

11.5.2. Bus Configuration

The figure shows a common configuration where the first device is the Master (PLC, Bus Bridge or Repeater), but this device can be connected also in central position. Anyway, the rule stating that termination should always be connected to first or last device, is always valid.

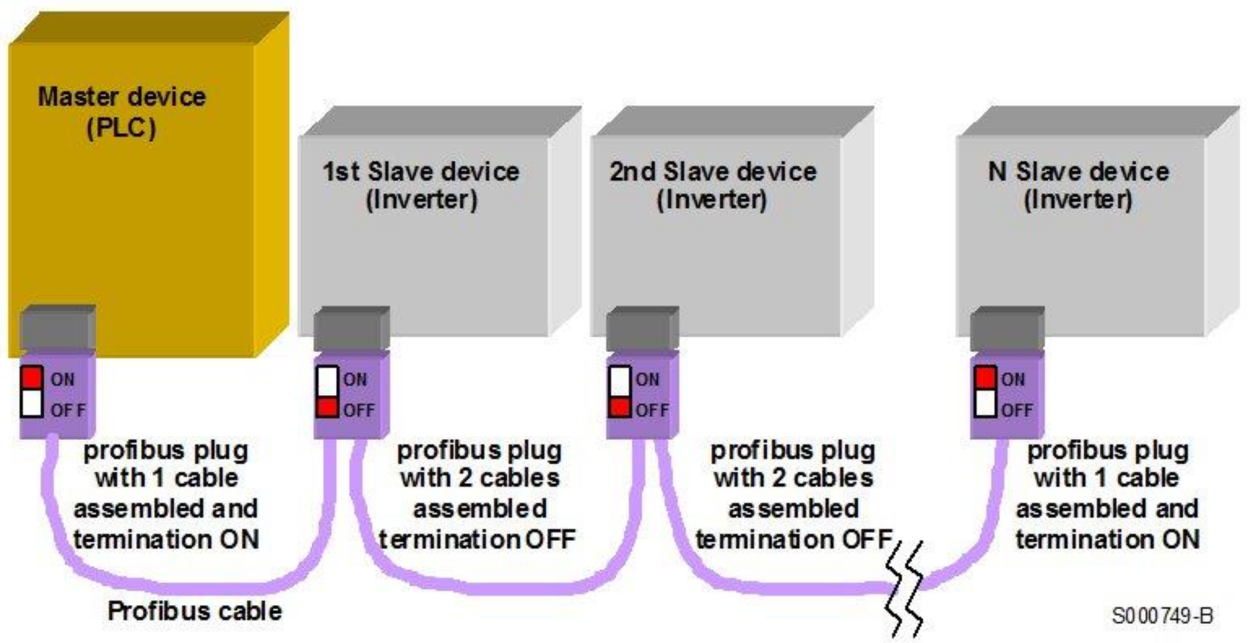


Figure 94: Example of a Profibus network (the correct setting of the line terminators is highlighted)

The termination is inserted directly by the switch on the loose male connector specific to the Profibus® cable.

11.5.3. Connection to the Fieldbus

Make sure that wiring is correct, especially if the fieldbus operates at high baud rates (higher than or equal to 1.5Mb/s).
Figure 94 is an example of a Profibus® link connecting multiple devices.
Use special Profibus cables ("Profibus Standard Bus Cable", Type A); do not exceed the max. allowable connection length based on the baud rate; use proper connectors.
The table below shows the standard baud rate values and the corresponding max. length of the bus if cables of Type A are used.

Allowable Baudrate	***Max. Length for Cable of Type A***
9.6 kbit/s	1.2 km
19.2 kbit/s	1.2 km
45.45 kbit/s	1.2 km
93.75 kbit/s	1.2 km
187.5 kbit/s	1 km
500 kbit/s	400 m
1.5 Mbit/s	200 m
3 Mbit/s	100 m
6 Mbit/s	100 m
12 Mbit/s	100 m

We recommend that Profibus® FC (FastConnect) connectors be used. They offer the following benefits:

- No soldering required for the connections inside the cable
- One ingoing cable and one outgoing cable can be used, so that connections of intermediate nodes can be stubless, thus avoiding signal reflections
- The internal resistors can be connected through a switch located on the connector frame
- Profibus FC connectors are provided with an internal impedance adapting network to compensate for the connector capacity.

Figure 95: Profibus® FC (FastConnect) connector with line termination settings

NOTE A more comprehensive overview of the Profibus is given at http://www.profibus.com/. In particular, you can download the “Installation Guideline for PROFIBUS DP/FMS”, containing detailed wiring information, and the document named “Recommendations for Cabling and Assembly” containing important guidelines to avoid the most common wiring errors.

NOTE Please refer to the Programming Guide for details on Profibus board settings: addresses, baudrate, etc.

11.6. B40 Series Board for DeviceNet®

The DeviceNet® communications board allows interfacing a drive with an external control unit through a communications interface using a CAN protocol of the DeviceNet type. Refer to the Programming Guide for more details on the inverter control modes through the DeviceNet fieldbus board.

The main features of the interface board are the following:

- CIP Parameters Object Support
- Explicit messages
- Cyclic I/O or polling management
- Automatically detectable baud rate
- Optically isolated CAN interface
- DIP-Switch for line termination insertion

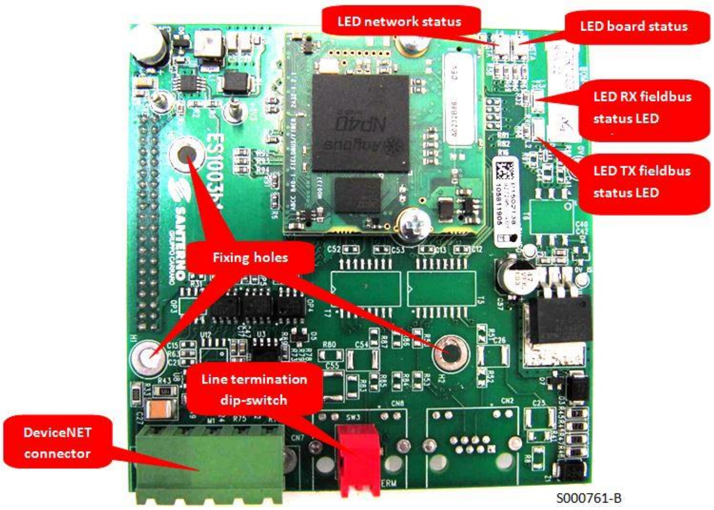


Figure 96: DeviceNET® fieldbus communications board (B40)

11.6.1. Fieldbus DeviceNET Terminal Board

The DeviceNet Fieldbus communications board is provided with a removable, screwable terminal board (pitch 5.08). The bus interface circuitry has an external supply of 24VDC ±10%, as prescribed from the CAN DeviceNet specifications.

Terminal layout as stated in the table:

Decisive voltage class A according to EN 61800-5-1

N.	Name	Description
1	GND	Common of the CAN driver circuit
2	CAN_L	CAN_L link
3	CAN_SH	Cable shielding
4	CAN_H	CAN_H link
5	V_BUS	24V±10% power supply for bus driver circuit input

The cross-sections of the allowable conductors ranges from 0.25 mm^2 to 1.5 mm^2 (AWG 22..14). A special terminal is required for the cable shielding conductor, so it is not necessary to connect the cable shielding to the drive earth through the tightening conductor collar.

11.6.2. Connection to the Fieldbus

The wiring quality is fundamental for the best reliability of the bus operation. For CANopen wiring, a shielded twisted pair with known resistance and impedance is recommended. The conductor unit is also fundamental for the quality of the signal. The higher the baud rates, the shortest the bus lengths allowed. The maximum length of the bus is also affected by the number of nodes. The tables below indicate the cable specifications based on the cable length and the variation features of the max. length based on the number of nodes and the cross-section of the conductors.
Tables refer to copper wires with a characteristic impedance of 120 Ω and a typical propagation delay of 5 ns/m.

Bus length [m]	Max. specific resistance of the cable [mΩ/m]	Recommended cross-section for conductors [mm²]	Recommended terminator resistance [Ω]	Max. baud rate [kbit/s]
0÷40	70	0.25÷0.34	124	1000
40÷300	60	0.34÷0.60	150÷300	500 (max 100 m)
300÷600	40	0.50÷0.75	150÷300	100 (max 500 m)
600÷1000	26	0.75÷0.80	150÷300	50

The total resistance of the cable and number of nodes determine the max. allowable length for the cable as per static features, not for dynamic features. Indeed, the max. voltage delivered by a node with a dominant bus is reduced by the resistive divider consisting of the cable resistor and the terminator resistors. The residual voltage must exceed the dominant voltage of the receiving node. The table below indicates the max. length values based on the cable cross-section, i.e. the cable resistance, and the number of nodes.

Cross-section of the conductors [mm²]	Max. wiring length [m] based on the number of nodes		
	n. nodes < 32	n. nodes < 64	n. nodes < 100
0.25	200	170	150
0.50	360	310	270
0.75	550	470	410

The B40 Fieldbus DeviceNET board is equipped with a DIP-switch allowing inserting the termination resistor on the bus. This DIP-switch is to be inserted only in the first and last device in a DeviceNET trunk.

NOTE Each DeviceNET trunk line must meet some geometric requirements and must provide two terminator nodes provided with suitable resistors. Consult document PUB00027R1 “Planning and Installation Manual - DeviceNetTM Cable System” and all the application notes available from ODVA web site (http://www.odva.org).

11.7. B40 Series Board for CANopen®

CANopen® and CiA® are registered trademarks of CAN in Automation e.V.

The CANopen communications board allows interfacing a drive with an external control unit using communications interface operating with a CAN protocol of the CANopen type complying with the CiA-301 V4.2.0 specifications.
The baud rate and the Device Address can be set via software parameters on the inverter control board. Three baud rate levels can be set, up to 1 Mbit/s. Please refer to the **Programming Guide** for details on the inverter control possibilities via the CANopen fieldbus card.

The main features of the interface board are the following:
- CANopen conformity: CiA-301 V4.2.0
- Automatic baud rate detection
- LSS support
- EMCY Support
- Customizable Identity Information
- PDO mapping can be customized via network configuration tool or via application (IO
- assemblies)
- Heartbeat functionality supported (Node Guarding not supported)
- Expedited- and Segmented SDO Transfer supported (Block Transfer not supported)
- Diagnostic support
- Cyclic (scan rate up to 1 ms) or polling I/O management
- Optically isolated CAN interface
- DIP-Switch for line terminators
- Possibility of implementing user profiles
- Possibility of setting Slave Watch-dog time
- Possibility of setting different Device Addresses up to max. 126 nodes

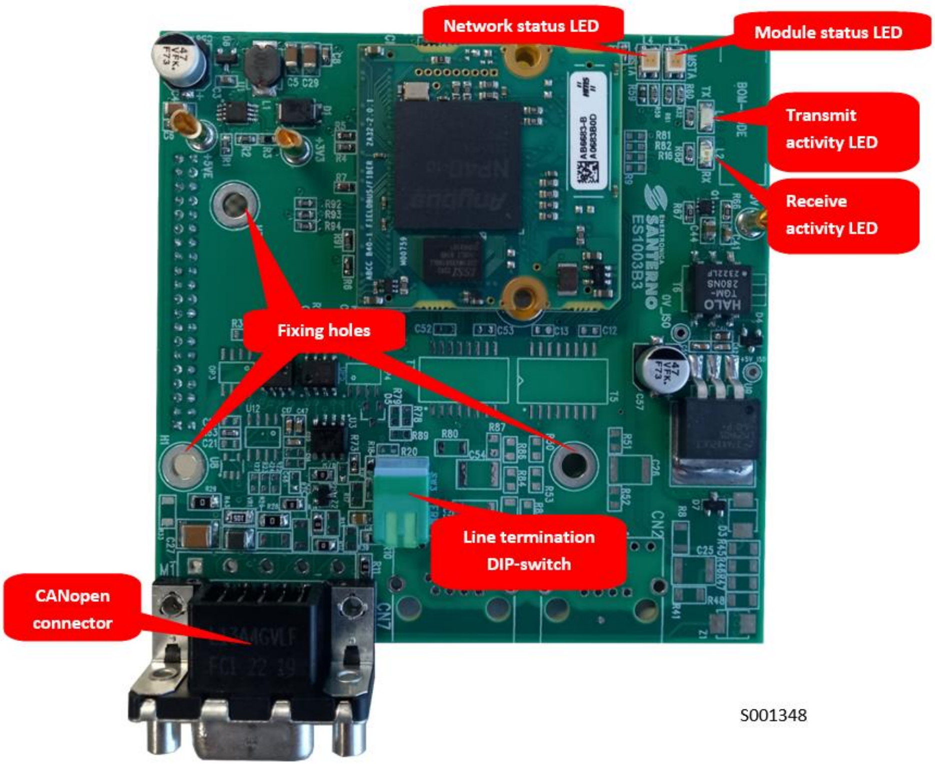


Figure 97: CANopen ® fieldbus communications board (B40)

11.7.1. CANopen® Fieldbus Connector

The board has a 9-pole male “D-type” connector. The bus interface circuits are internally powered, as required by the CANopen® specifications.

Pins are arranged as follows:

Decisive voltage class A according to EN 61800-5-1

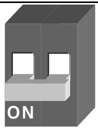
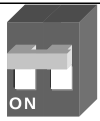
N.	*Name*	*Description*
Shell	CAN_SHLD	Cable shielding
1	–	do not use
2	CAN_L	CAN_L line
3	CAN_GND	Common terminal of the CAN driver circuit
4	–	do not use
5	CAN_SHLD	Cable shielding
6	GND	Option common terminal internally connected to pin 3
7	CAN_H	CAN_H line
8	–	do not use
9	–	do not use

CAUTION

The CANopen connector is of the same type as the connector for Modbus serial communication, but the pin arrangement and the internal electrical circuit are totally different.
Extreme caution must be taken not to mix up the connectors. Incorrect connection of the CANopen connector to the Modbus interface or vice versa can cause failures not only to the inverter, but also to other equipment present on the Modbus and CANopen networks.

11.7.2. Board configuration

CANopen communications board is provided with one DIP-switch used to set the operating mode.
The DIP-switch located next to the fieldbus connector allows activating the line terminator. The terminator is activated by pushing the lever downwards, as shown below.

Fieldbus terminator on	**Termination of Fieldbus line cut out**
	

The termination of the fieldbus line should be cut in only with the first and last device of a chain.

11.7.3. Connection to the Fieldbus

High quality wiring is fundamental for the correct operation of the bus. For CANopen wiring, a shielded twisted pair with known resistance and impedance is recommended. The conductor unit is also fundamental for the quality of the signal. The higher the baud rates, the shortest the bus lengths allowed. The maximum length of the bus is also affected by the number of nodes. The tables below indicate the cable specifications based on the cable length and the variation features of the max. length based on the number of nodes and the cross-section of the conductors.
Tables refer to copper wires with a characteristic impedance of 120 Ω and a typical propagation delay of 5 ns/m.

Bus length [m]	Max. specific resistance of the cable [mΩ/m]	Recommended cross-section for conductors [mm^2]	Recommended terminator resistance [Ω]	Max. baud rate [kbit/s]
0÷40	70	0.25÷0.34	124	1000
40÷300	60	0.34÷0.60	150÷300	500 (max 100 m)
300÷600	40	0.50÷0.75	150÷300	100 (max 500 m)
600÷1000	26	0.75÷0.80	150÷300	50

The total resistance of the cable and number of nodes determine the max. allowable length for the cable as per static features, not for dynamic features. Indeed, the max. voltage delivered by a node with a dominant bus is reduced by the resistive divider consisting of the cable resistor and the terminator resistors. The residual voltage must exceed the dominant voltage of the receiving node.
The table below indicates the max. length values based on the cable cross-section, i.e. the cable resistance, and the number of nodes.

Cross-section of the conductors [mm^2]	Max. wiring length [m] based on the number of nodes		
	number of nodes < 32	number of nodes < 64	number of nodes < 100
0.25	200	170	150
0.50	360	310	270
0.75	550	470	410

NOTE

Each CANopen trunk line shall meet particular geometric requirements and shall be equipped with two terminator nodes provided with adequate resistors.
Refer to the document CiA DR-303-1 “CANopen Cabling and Connector Pin Assignment” and to all the application notes available from http://www.can-cia.org.

11.8. B40 Series Boards Featuring Ethernet Interface

All the Fieldbus communications boards, B40 series featuring Ethernet interface share the same construction principles and installation/wiring procedure.
Four different part numbers are available for these boards. They allow interfacing a drive with an external control unit featuring one of the following comms protocols:

- Profinet IRT,
- Modbus/TCP,
- EtherCAT,
- Ethernet/IP.

For details on drive control options implemented by Fieldbus boards please refer to the Programming Guide.

The communications board performs automatic negotiation with the mains if the baud rate is set to 10 or 100 Mbits/s.

The main features of the interface board are the following:

- Autonegotiation of the baud rate and the type of cable (Auto MDI/MDIX)
- Configuration of the Ethernet parameters from the drive display (please refer to the Programming Guide)
- Ethernet interface galvanically isolated through a transformer

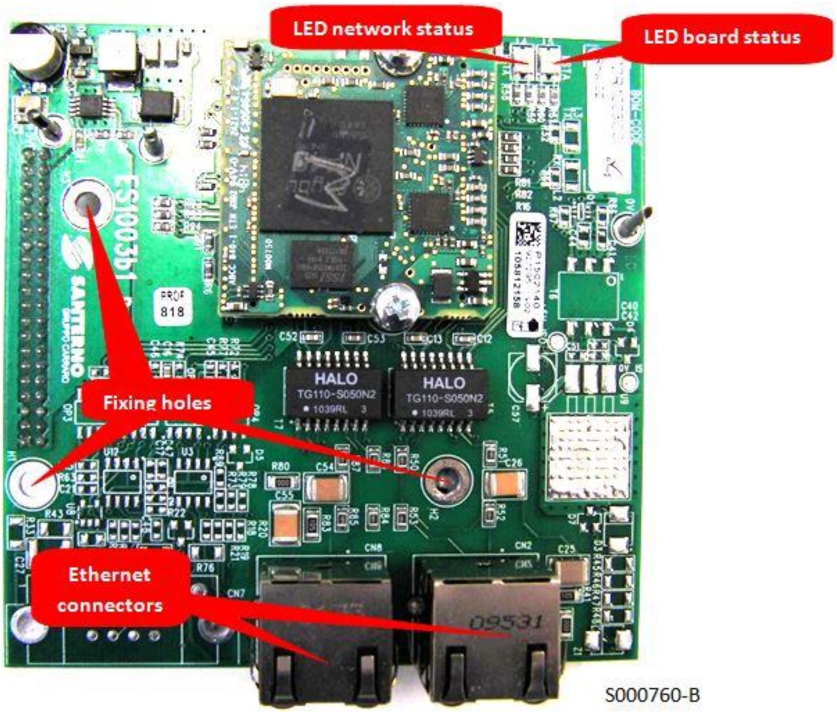


Figure 98: Ethernet fieldbus communications board (B40)

NOTE The Ethernet connectors shown in the figure are equivalent for any protocols except for the EtherCAT protocol, where the right-hand connector is INPUT only and the left-hand connector is OUTPUT only.

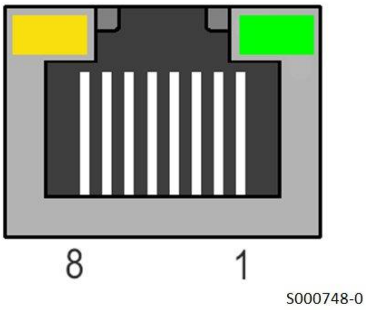
11.8.1. Ethernet Connector

The board is provided with a standard RJ-45 connector (IEEE 802) for Ethernet connection 10/100 (100Base-T, 10Base-T).
The yellow LED indicates the Link/Operation with 10Mbps baud rate, whereas the green LED indicates the Link/Operation with 100Mbps baud rate.

The pin layout is the same as the one used for each network board computers are equipped with.

Decisive voltage class A according to EN 61800-5-1

N.	*Name*	*Description*
1	TD+	Positive signal transmission line
2	TD–	Negative signal transmission line
3	RD+	Line receiving positive signals
4	Term	Terminated pair – not used
5	Term	Terminated pair – not used
6	RD–	Line receiving negative signals
7	Term	Terminated pair – not used
8	Term	Terminated pair – not used



11.8.2. Connection to the Network

The Ethernet interface board can be connected to a master device (PC or PLC) either through a LAN (Ethernet business network) or a direct point-to-point connection.
The board connection through a LAN is similar to a computer connection. Use a standard cable for a Switch or Hub connection or a Straight-Through Cable TIA/EIA-568-B of class 5 UTP (Patch cable for LAN).

NOTE

The inverter is typically installed with other electric/electronic devices inside a cubicle. Normally, the electromagnetic pollution inside the cubicle is remarkable and is due to both radiofrequency disturbance caused by the inverters and to bursts caused by the electromechanical devices. To avoid propagating disturbance to Ethernet cables, they must be segregated and kept as far as possible from the other power cables and signal cables in the cubicle.
Disturbance propagation to Ethernet cables may affect the correct operation of the inverter and the other devices (computers, PLCs, Switches, Routers) connected to the same LAN.

NOTE

The maximum length of the LAN cable, cat. 5 UTP allowed by IEEE 802 standards results from the max. transit time allowed from the protocol and is equal to 100m. The longer the cable length, the higher the risk of communications failure.

NOTE

For Ethernet wiring, only use cables certified for LAN cables of 5 UTP category or higher. For standard wiring, avoid creating your own cables; Straight-Through or Cross-Over cables should be purchased from an authorised dealer.

NOTE

For a proper configuration and utilisation of the communications board, the user should know the basics of the TCP/IP protocol and should get familiar with the MAC address, the IP address and the ARP (Address Resolution Protocol). The basic document on the Web is “RFC1180 – A TCP/IP Tutorial”.

11.8.3. Configuring B40 Series Boards with Ethernet Interface

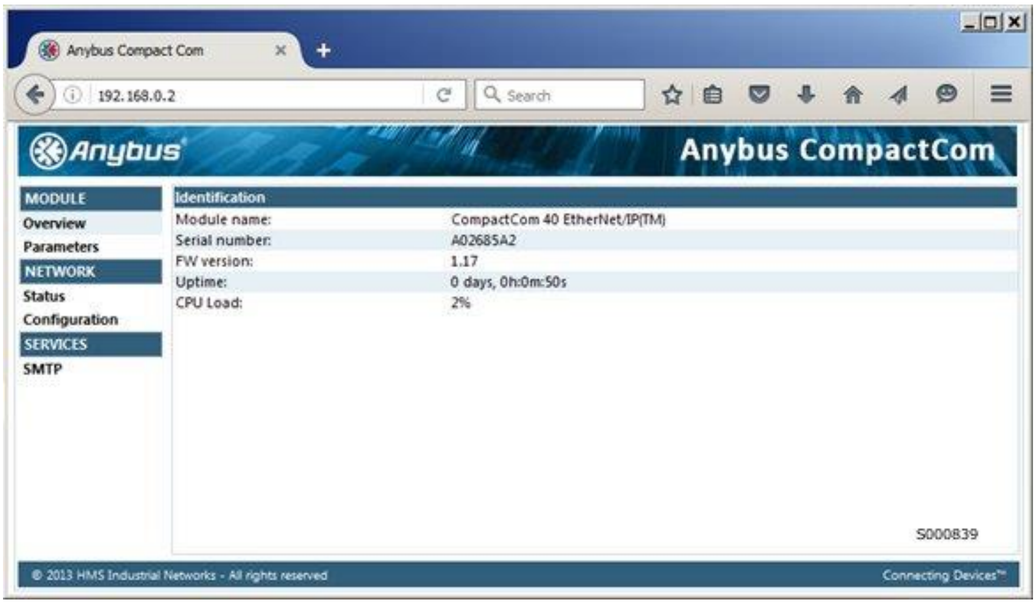
Default: At first power on, the drive is allocated to the following IP address

192.168.0.2	IP
255.255.255.0	subnet mask
0.0.0.0	gateway
DHCP disable	

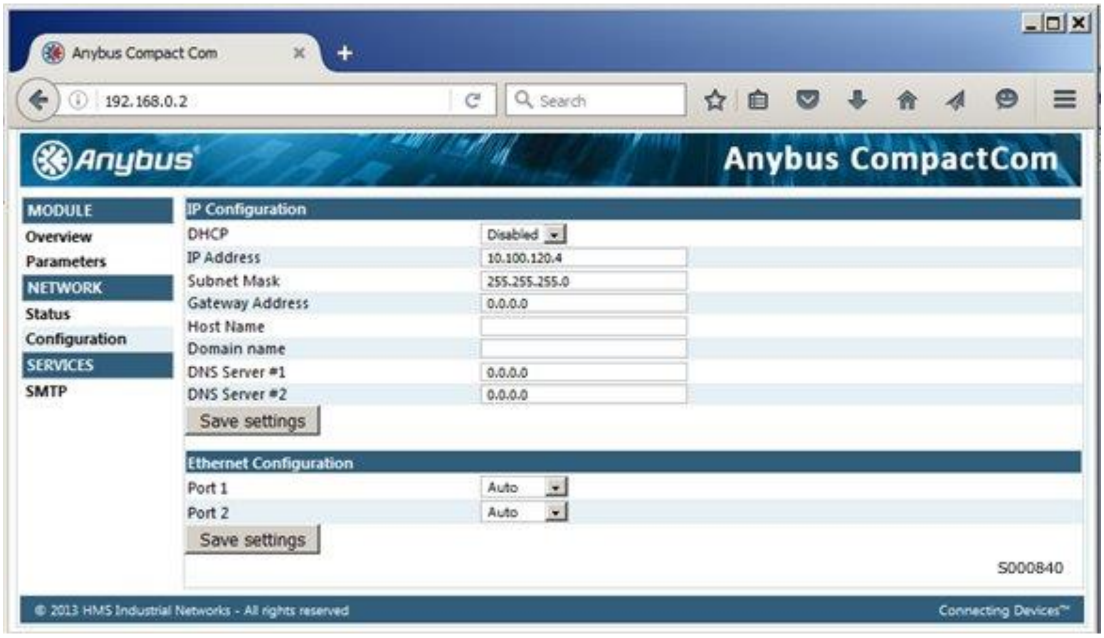
Configure your PC for the point-to-point connection, similarly to what is detailed in the Configuration of the Ethernet Board for Modbus/TCP section, by assigning the address 192.168.0.1\255.255.255.0\0.0.0.0 DHCP disable and connect an Ethernet cable from the board to the PC.

Open the browser and enter http:\\192.168.0.2 in the address bar.

The window below appears, showing the details of the comms module:



Choose Configuration and enter the IP address. 10.100.120.4 with 255.255.255.0 netmask is set in the figure below.



Afterwards, click on “Save Settings” and send a Reset command.

CAUTION

The configuration of any address is done via this interface, except for the following address:
0.0.0.0\0.0.0.0\0.0.0.0 DHCP disable.

In that case, the address is overwritten by
192.168.0.2\255.255.255.0\0.0.0.0 DHCP disable.

In case the board IP address is not known and the DHCP is not enabled, it is possible to resume control of the board by restoring the default IP address.
To restore the default address, write parameter **I080** to the drive from Modbus RTU serial interface.
Write **I080** = 1 and reset the drive to restore the TCP/IP to 192.168.0.2\255.255.255.0\0.0.0.0 DHCP disable.

NOTE

Unlike the Modbus RTU connection through the serial link, the Modbus/TCP connection with B40 board series is characterised by an offset of 800h (2048) for read variables. This is because the Ethernet board dialogues with the inverter and splits a buffer shared for two segments of 2 kbytes; one segment is dedicated to the messages sent from the inverter to the Fieldbus, the other is dedicated to the messages sent from the Fieldbus to the inverter. For instance, in order to read Word 1 Status+Alarms from Sinus Penta (refer to the Programming Guide), the Modbus/TCP transaction must be addressed to log 2049, not to log 1.
On the other hand, writing occurs without any offset.

11.9. Anybus-S PROFIBUS-DP® Board

PROFIBUS-DP® is a registered trademark of PROFIBUS International.

The Profibus communications board allows interfacing between a drive and an external control unit, such as a PLC, using a PROFIBUS-DP communications interface.
The drive operates as a Slave device and is controlled by a Master device (PLC) through command messages and reference values which are equivalent to the ones sent via terminal board. The Master device is also capable of detecting the operating status of the inverter. More details about Profibus communications are given in the Programming Guide.
Profibus communications board has the following features:

- Type of fieldbus: PROFIBUS-DP EN 50170 (DIN 19245 Part 1) with protocol version 1.10
- Automatic detection of the baud rate ranging from 9600 bits/s to 12 Mbits/s
- Communications device: PROFIBUS bus link, type A or B as mentioned in EN50170
- Type of fieldbus: Master-Slave communications; max. 126 stations in multidrop connection
- Fieldbus connector: female, 9-pin, DSUB connector
- Wire: copper twisted pair (EIA RS485)
- Max. length of the bus: 200m @ 1.5Mbits/s (can be longer if repeaters are used)
- Isolation: the bus is galvanically isolated from the electronic devices via a DC/DC converter
- The bus signals (link A and link B) are isolated via optocouplers
- PROFIBUS –DP communications ASIC: chip Siemens SPC3
- Hardware configurability: bus terminator switch and rotary-switch assigning the address to the node
- Status indicators: indicator Led for board status and indicator Led for fieldbus status.

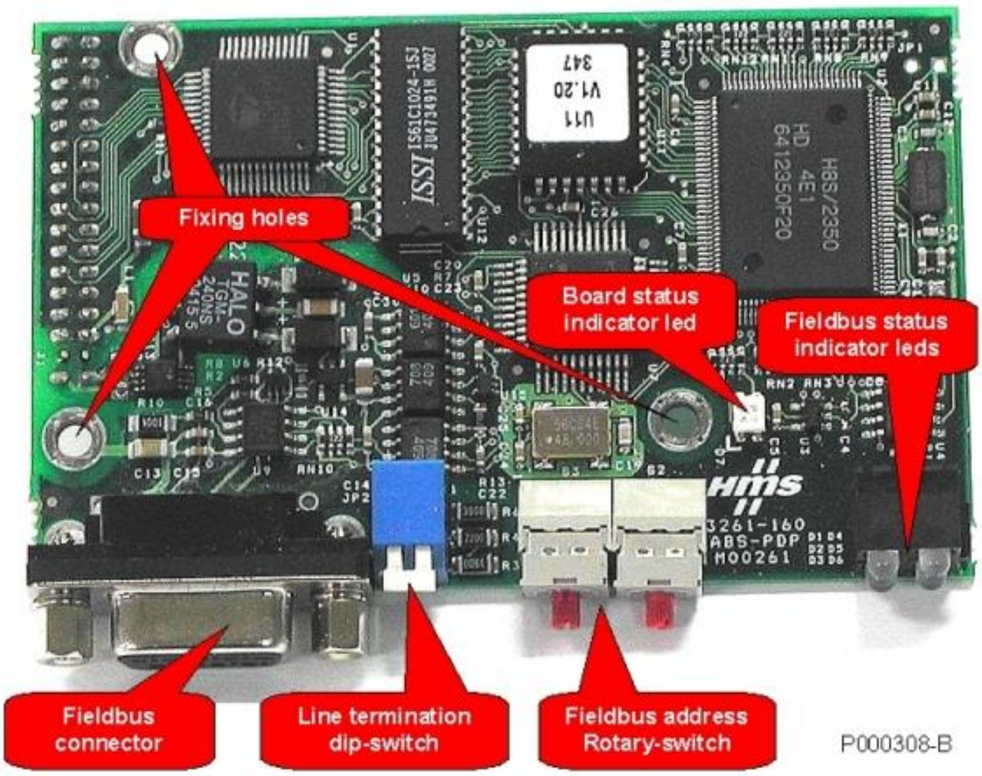


Figure 99: PROFIBUS-DP® fieldbus communications board (Anybus-S)

11.9.1. Profibus® Fieldbus Connector

Female, 9-pin, D-sub connector.

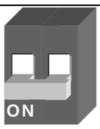
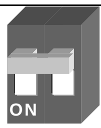
Pin layout:

Decisive voltage class A according to EN 61800-5-1

N.	***Name***	***Description***
-	Shield	Connector frame connected to PE
1	N.C.	
2	N.C.	
3	B-Line	Positive RxD/TxD according to RS 485 specifications
4	RTS	Request To Send – active high level when sending
5	GND	Bus ground isolated from control board 0V
6	+5V	Bus driver supply isolated from control board circuits
7	N.C.	
8	A-Line	Negative RxD/TxD according to RS 485 specifications
9	N.C.	

11.9.2. Configuration of the Profibus-DP Communications Board

PROFIBUS-DP communications board is provided with one DIP-switch and two rotary-switches used to set the operating mode.
The DIP-switch located next to the fieldbus connector allows activating the line terminator. The terminator is activated by pushing the lever downwards, as shown below.

Fieldbus terminator on	**Termination of Fieldbus line cut out**
	

The termination of the fieldbus line should be cut in only with the first and last device of a chain, as illustrated in Figure 100.
The figure shows a common configuration where the first device is the Master (PLC, Bus Bridge or Repeater), but this device can be connected also in central position. Anyway, the rule stating that termination should always be connected to first or last device, is always valid.

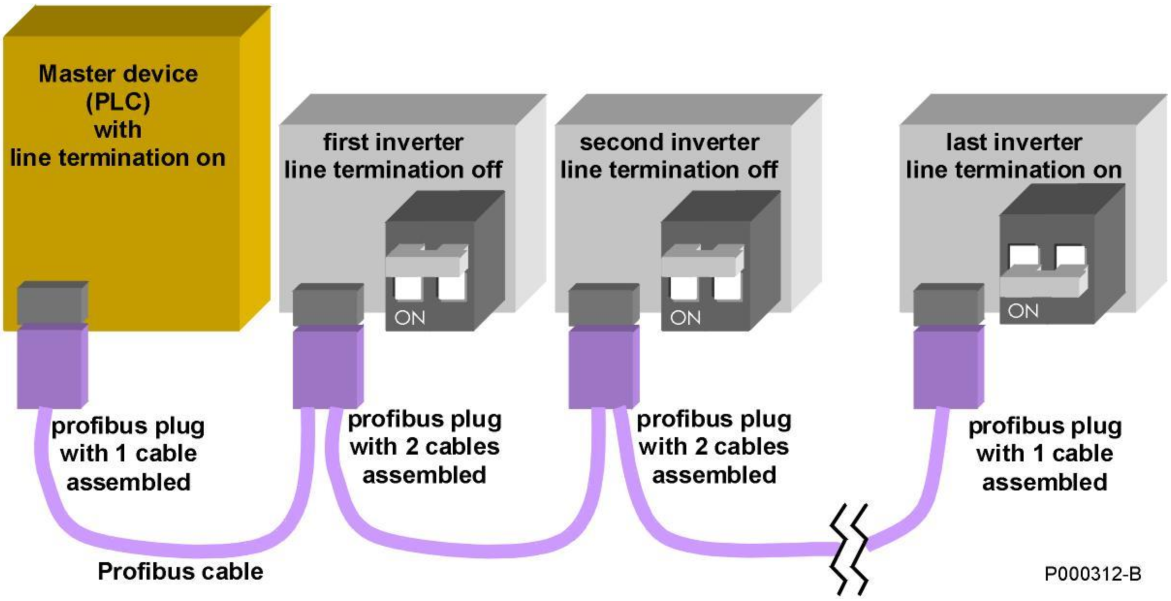


Figure 100: Example of a Profibus network (the correct setting of the line terminators is highlighted)

Each device in the network must have its own Profibus address. The addresses of the drives are set through the rotary-switches installed in the interface board. Each rotary-switch is provided with a pin that can be turned to position 0-9 using a small screwdriver.
The rotary-switch on the left sets the tenths of the Profibus address, while the rotary switch on the right sets the units. Figure 101 shows an example of the correct position to set address “19”.

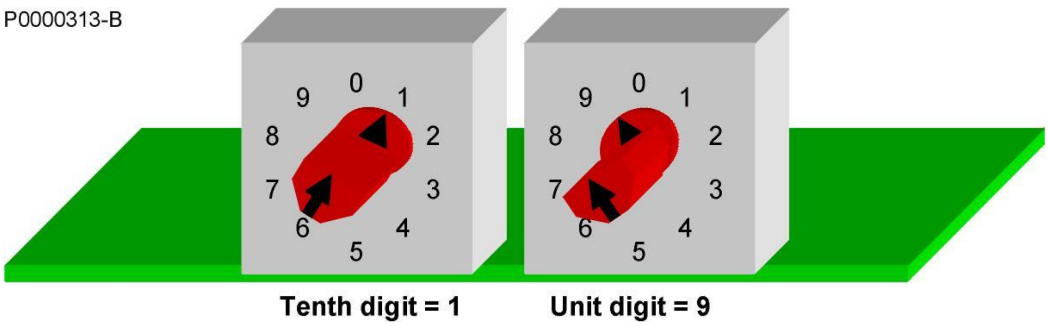


Figure 101: Example of the rotary-switch position to set Profibus address “19”

NOTE The rotary-switches allow setting Profibus addresses ranging from 1 to 99. Addresses exceeding 99 are not yet allowed.

11.9.3. Connection to the Fieldbus

Make sure that wiring is correct, especially if the fieldbus operates at high baud rates (higher than or equal to 1.5 Mb/s).
Figure 100 is an example of a Profibus link connecting multiple devices.
Use special Profibus cables ("Profibus Standard Bus Cable", Type A); do not exceed the max. allowable connection length based on the baud rate; use proper connectors.
The table below shows the standard baud rate values and the corresponding max. length of the bus if cables of Type A are used.

Allowable Baudrate	***Max. Length for Cable of Type A***
9.6 kbits/s	1.2 km
19.2 kbits/s	1.2 km
45.45 kbits/s	1.2 km
93.75 kbits/s	1.2 km
187.5 kbits/s	1 km
500 kbits/s	400 m
1.5 Mbits/s	200 m
3 Mbits/s	100 m
6 Mbits/s	100 m
12 Mbits/s	100 m

We recommend that Profibus FC (FastConnect) connectors be used. They offer the following benefits:

- No welding required for the connections inside the cable
- One ingoing cable and one outgoing cable can be used, so that connections of intermediate nodes can be stubless, thus avoiding signal reflections
- The internal resistors can be connected through a switch located on the connector frame
- Profibus FC connectors are provided with an internal impedance adapting network to compensate for the connector capacity.

NOTE If you use Profibus FC connectors with internal terminators, you can activate either the connector terminal or the board terminals (in the first/last device only). Do not activate both terminators at a time and do not activate terminators in intermediate nodes.

NOTE A more comprehensive overview of the Profibus is given at http://www.profibus.com/. In particular, you can download the "Installation Guideline for PROFIBUS DP/FMS", containing detailed wiring information, and the document named "Recommendations for Cabling and Assembly" containing important guidelines to avoid the most common wiring errors.

11.10. Anybus-S PROFIdrive® Board

PROFIdrive® is a registered trademark of PROFIBUS International.

Any detail is given in the PROFIdrive COMMUNICATIONS BOARD – .
As per the board configuration, please refer to the Configuration of the Profibus-DP Communications Board section.

11.11. Anybus-S DeviceNet® Board

DeviceNet is a registered trademark of open DeviceNet Vendor Association.

The DeviceNet® communications board allows interfacing a drive with an external control unit through a communications interface using a CAN protocol of the DeviceNet 2.0 type. The baud rate and the MAC ID can be set through the on-board DIP-switches. Max. 512 bytes for input/output data are available; some of them are used for the interfacing with the inverter. Refer to the Programming Guide for more details on the inverter control modes through the DeviceNet fieldbus board.

The main features of the interface board are the following:

- Baud Rate: 125, 250, 500 kbits/s
- DIP-switch for baud rate and MAC ID selection
- Optically isolated DeviceNet interface
- Max. 512 bytes for input & output data
- Max. 2048 bytes for input & output data through mailbox
- DeviceNet Specification version: Vol 1: 2.0, Vol 2: 2.0
- Configuration test version: A-12

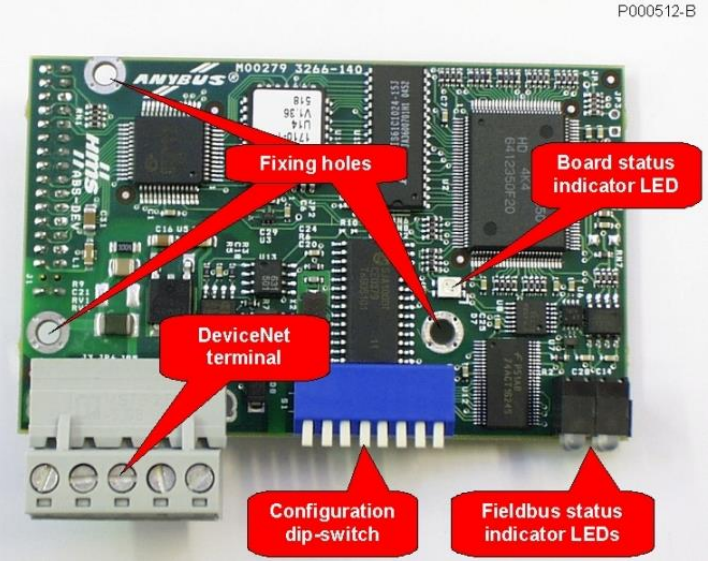


Figure 102: DeviceNet® fieldbus communications board (Anybus-S)

11.11.1. DeviceNet® Fieldbus Terminals

The DeviceNet Fieldbus communications board is provided with a removable, screwable terminal board (pitch 5.08). The bus interface circuitry has an external supply of 24VDC ±10%, as prescribed from the CAN DeviceNet specifications.

Terminal arrangement as stated in the table:

Decisive voltage class A according to EN 61800-5-1

N.	***Name***	***Description***
1	V-	Negative voltage for bus supply
2	CAN_L	CAN_L bus line
3	SHIELD	Cable shielding
4	CAN_H	CAN_H bus line
5	V+	Positive voltage for bus supply

11.11.2. Board Configuration

The on-board DIP-switches allow setting the baud rate and the MAC ID identifying the device in the DeviceNet network.
DIP-switches 1 and 2 allow setting the baud rate, that must be the same for all the related devices. The DeviceNet standard allows three baud rates: 125, 250 and 500 kbits/s. Possible settings are the following:

Baudrate	***Setting of SW.1 & SW.2***	
125 kbits/s	sw.1=OFF	sw.2=OFF
250 kbits/s	sw.1=OFF	sw.2=ON
500 kbits/s	sw.1=ON	sw.2=OFF

The MAC ID can be set between 0 and 63 by entering the configuration of the binary number for six DIP-switches, from sw.3 to sw.8. The most significant bit (MSB) is set through sw.3, while the least significant bit (LSB) is set through sw.8.
Some possible settings are shown in the table below:

MAC ID	**SW.3 (MSB)**	**SW.4**	**SW.5**	**SW.6**	**SW.7**	**SW.8 (LSB)**
0	OFF	OFF	OFF	OFF	OFF	OFF
1	OFF	OFF	OFF	OFF	OFF	ON
2	OFF	OFF	OFF	OFF	ON	OFF
3	OFF	OFF	OFF	OFF	ON	ON
…..	…..	…..	…..	…..	…..	…..
62	ON	ON	ON	ON	ON	OFF
63	ON	ON	ON	ON	ON	ON

If multiple devices are connected to the same bus, different MAC IDs are to be set.

11.11.3. Connection to the Fieldbus

The wiring quality is fundamental for the best reliability of the bus operation. The higher the baud rates, the shortest the bus lengths allowed.
Reliability is strongly affected by the type of wiring and the wire topology. The DeviceNet standard allows four types of wires based on the type of related devices. It also allows connecting signal dispatching nodes, line terminators and supply couplers. Two types of lines are defined: the trunk line and the drop lines. The figure below illustrates the topology of a typical DeviceNet trunk line.

P000513-B

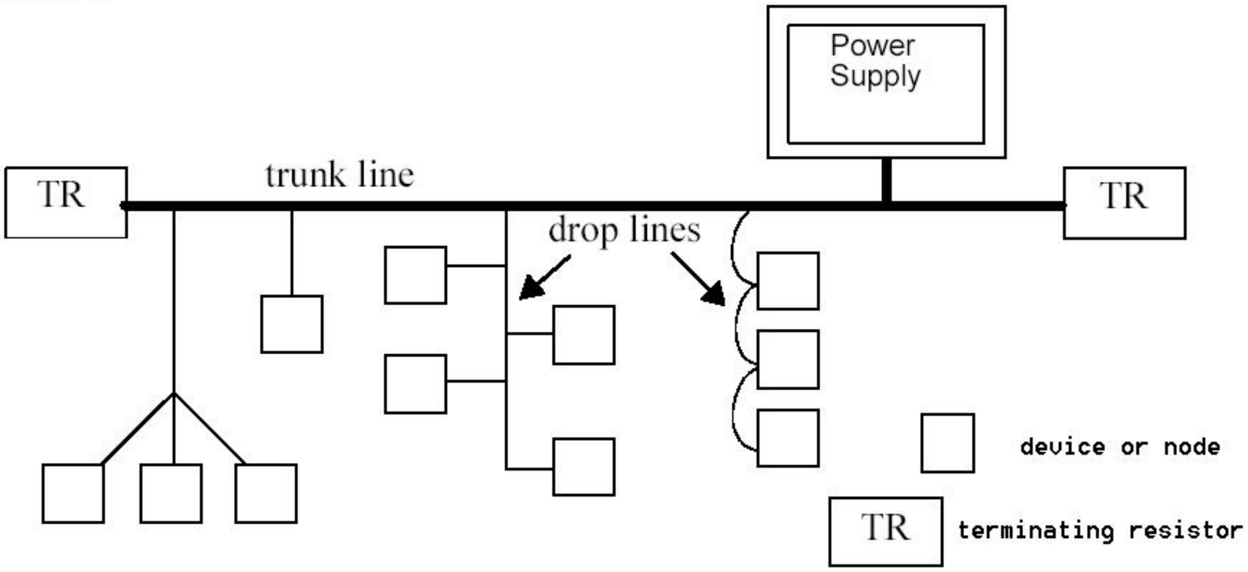


Figure 103: Outline of the topology of a DeviceNet trunk line

The inverter equipped with a DeviceNet interface board is typically connected through a drop line consisting of a 5-conductor shielded cable. The DeviceNet standard defines three shielded cables based on their diameter: THICK, MID, and THIN cables. The maximum electric length between two DeviceNet devices depends on the baud rate and the type of cable being used. The table below shows the maximum lengths that are recommended based on these variables. The FLAT cable can be used for the main trunk line if drop lines are connected through a system that does not require welding.

Baud Rate	Max. length with FLAT cable	Max. length with THICK cable	Max. length with MID cable	Max. length with THIN cable
125 kbits/s	420m	500m	300m	100m
250 kbits/s	200m	250m	250m	100m
500 kbits/s	75m	100m	100m	100m

NOTE Each DeviceNet trunk line must meet some geometric requirements and must provide two terminator nodes and at least one supply node, because devices can be totally or partially powered via the bus. The type of the cable being used also determines the max. supply current available for the bus devices.

NOTE For a more comprehensive overview of the DeviceNet standard, go to ODVA's home page (http://www.odva.org).

In particular, you can refer to the "Planning and Installation Manual" document.

NOTE In case of failures or disturbance in the DeviceNet communications, please fill in the "DeviceNet Baseline & Test Report" form in the Appendix C of the "Planning and Installation Manual" before contacting the After-sales service.

11.12. Anybus-S CANopen® Fieldbus Board

CANopen® and CiA® are registered trademarks of CAN in Automation e.V.

The CANopen communications board allows interfacing a drive with an external control unit using communications interface operating with a CAN protocol of the CANopen type complying with the CIA DS-301 V3.0 specifications. The baud rate and the Device Address can be set through the on-board rotary switches. Eight baud rate levels can be set, up to 1Mbit/s. Refer to the Programming Guide for more details on the inverter control modes through the CANopen fieldbus board.
The main features of the interface board are the following:

- Unscheduled data exchange support
- Synch & Freeze operating mode
- Possibility of setting Slave Watch-dog time
- Eight baud rate levels, from 10kbits/s to 1Mbit/s
- Possibility of setting different Device Addresses up to max. 99 nodes
- Optically isolated CAN interface
- CANopen conformity: CIA DS-301 V3.0

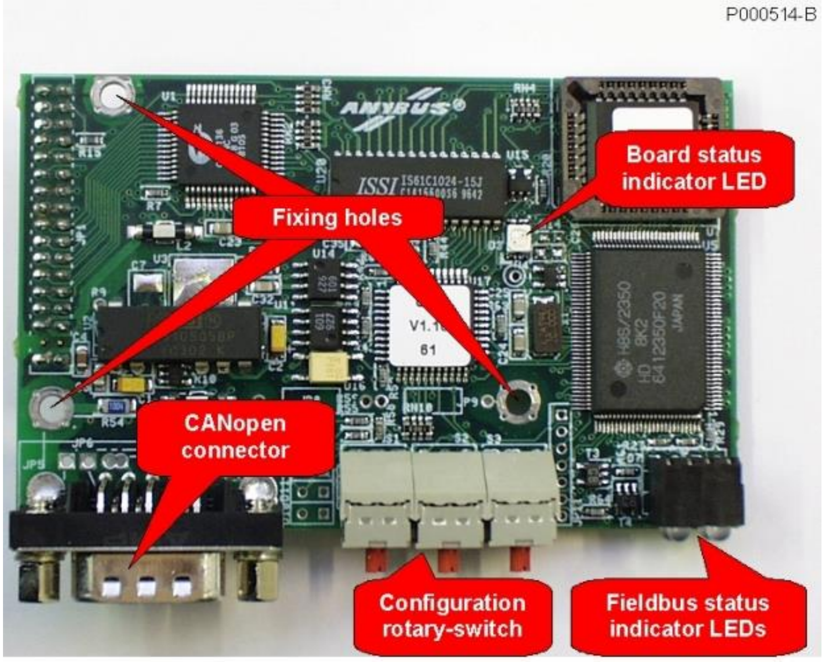


Figure 104: CANopen® fieldbus communications board (Anybus-S)

11.12.1. CANopen® Fieldbus Connector

The CANopen® communications board is provided with a 9-pin male “D” connector. The bus interface circuitry is internally supplied, as prescribed by the CANopen® specifications.

Pins are arranged as follows:

Decisive voltage class A according to EN 61800-5-1

N.	Name	Description
Shell	CAN_SHLD	Cable shielding
1	-	
2	CAN_L	CAN_L line
3	CAN_GND	Common terminal of the CAN driver circuit
4	-	
5	CAN_SHLD	Cable shielding
6	GND	Option common terminal internally connected to pin 3
7	CAN_H	CAN_H line
8	-	
9	(reserved)	do not use

CAUTION The CANopen connector is the same type as the connector fitted in all the drives series for the Modbus serial communications, but the pin layout and the internal circuitry are totally different. Make sure that connectors are not mismatched! A wrong connection of the CANopen connector to the Modbus interface or vice versa can damage the inverter and the other devices connected to the Modbus and CANopen networks.

11.12.2. Board Configuration

The CANopen communications board shall be used with three rotary-switches for configuration, which are required to set up the inverter operating mode. The rotary-switches also allow setting the baud rate and the Device Address. The figure below shows the position of the rotary-switches and a setting example with a baud rate of 125kbits/s and a Device Address equal to 29.

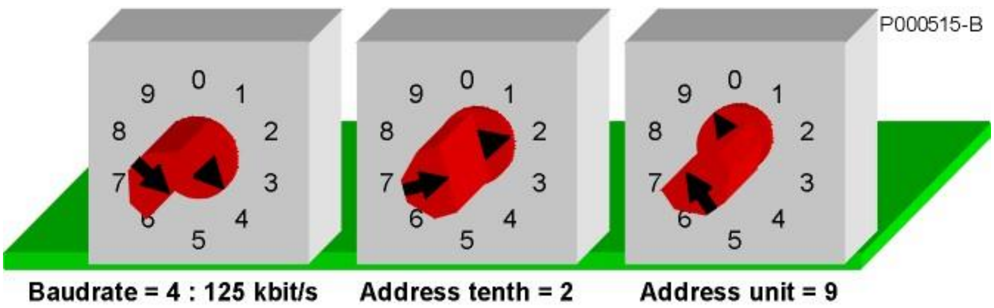


Figure 105: Example of the position of the rotary-switches for 125kbits/s and Device Address 29

NOTE Device Address = 0 is not allowed by the CANopen specifications. Values ranging from 1 to 99 can be selected.

The table below shows the possible settings of the rotary-switches for the baud rate selection.

Rotary-switch setting	Baudrate
0	setting not allowed
1	10 kbits/s
2	20 kbits/s
3	50 kbits/s
4	125 kbits/s
5	250 kbits/s
6	500 kbits/s
7	800 kbits/s
8	1000 kbits/s
9	setting not allowed

11.12.3. Connection to the Fieldbus

High quality wiring is fundamental for the correct operation of the bus. For CANopen wiring, a shielded twisted pair with known resistance and impedance is recommended. The conductor unit is also fundamental for the quality of the signal. The higher the baud rates, the shortest the bus lengths allowed. The maximum length of the bus is also affected by the number of nodes. The tables below indicate the cable specifications based on the cable length and the variation features of the max. length based on the number of nodes and the cross-section of the conductors.
Tables refer to copper wires with a characteristic impedance of 120 Ω and a typical propagation delay of 5 ns/m.

Bus length [m]	Max. specific resistance of the cable [mΩ/m]	Recommended cross-section for conductors [mm²]	Recommended terminator resistance [Ω]	Max. baud rate [kbit/s]
0÷40	70	0.25÷0.34	124	1000
40÷300	60	0.34÷0.6	150÷300	500 (max 100 m)
300÷600	40	0.5÷0.75	150÷300	100 (max 500 m)
600÷1000	26	0.75÷0.8	150÷300	50

The total resistance of the cable and number of nodes determine the max. allowable length for the cable as per static features, not for dynamic features. Indeed, the max. voltage delivered by a node with a dominant bus is reduced by the resistive divider consisting of the cable resistor and the terminator resistors. The residual voltage must exceed the dominant voltage of the receiving node. The table below indicates the max. length values based on the cable cross-section, i.e. the cable resistance, and the number of nodes.

Cross-section of the conductors [mm²]	Max. wiring length [m] based on the number of nodes		
	number of nodes < 32	number of nodes < 64	number of nodes < 100
0,25	200	170	150
0,5	360	310	270
0,75	550	470	410

NOTE Each CANopen trunk line shall meet particular geometric requirements and shall be equipped with two terminator nodes provided with adequate resistors. Refer to the document CiA DR-303-1 “CANopen Cabling and Connector Pin Assignment” and to all the application notes available from http://www.can-cia.org.

11.13. Anybus-S Ethernet Board for Modbus/TCP

Ethernet communications board allows interfacing a drive to an external control unit with a communications interface operating with a Modbus/TCP Ethernet (IEEE 802) protocol complying with the Modbus-IDA V1.0 specifications. The IP rating for the communications board can be configured both through the on-board DIP-switches and automatically (network assignation through a DHCP protocol).
The communications board performs automatic negotiation with the mains if the baud rate is set to 10 or 100 Mbits/s.
The main features of the interface board are the following:

- Parameter configuration for Ethernet connection through DIP-switches, DHCP/BOOTP, ARP or internal Web server
- Modbus/TCP slave functions of class 0, class 1 and partially class 2
- Transparent socket interface for potential implementation of “over TCP/IP” dedicated protocols
- Ethernet interface galvanically isolated through a transformer

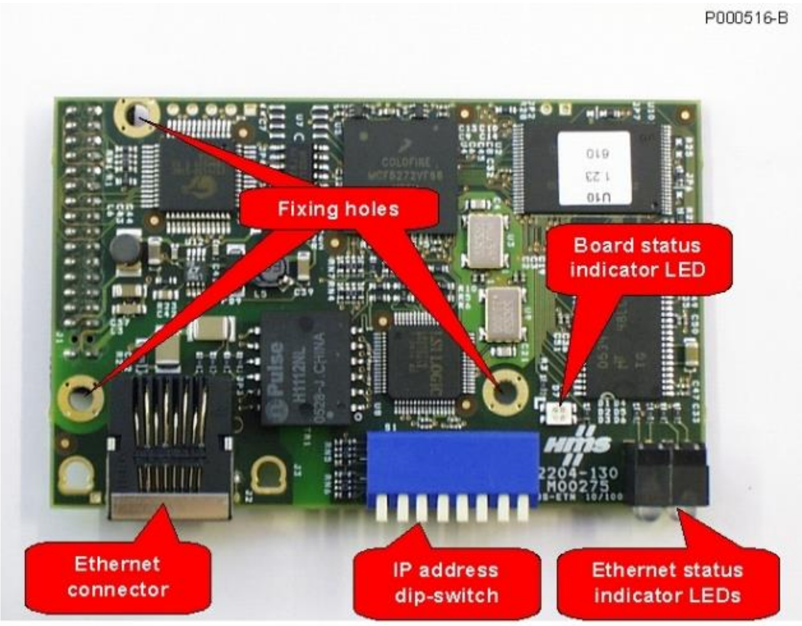


Figure 106: Ethernet Fieldbus Communications Board (Anybus-S)

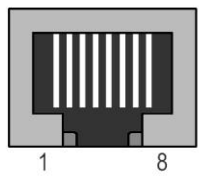
11.13.1. Ethernet Connector

The board is provided with a standard RJ-45 connector (IEEE 802) for Ethernet connection 10/100 (100Base-T, 10Base-T). The pin arrangement is the same as the one used for each network board computers are equipped with.
Pinout:

Decisive voltage class A according to EN 61800-5-1

N.	***Name***	***Description***
1	TD+	Positive signal transmission line
2	TD-	Negative signal transmission line
3	RD+	Line receiving positive signals
4	Term	Terminated pair – not used
5	Term	Terminated pair – not used
6	RD-	Line receiving negative signals
7	Term	Terminated pair – not used
8	Term	Terminated pair – not used

P000517-0



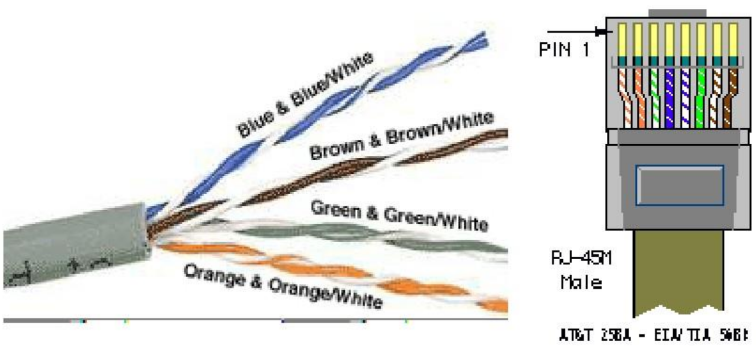
11.13.2. Connection to the Network

Ethernet interface board can be connected to an Ethernet control device with a Modbus/TCP master protocol (computer or PLC) through a LAN (Ethernet business network) or a direct point-to-point connection.
The board connection through a LAN is similar to a computer connection. Use a standard cable for a Switch or Hub connection or a Straight-Through Cable TIA/EIA-568-B of class 5 UTP (Patch cable for LAN).

NOTE The Ethernet interface board cannot be connected to old LANs using Thin Ethernet (10base2) coaxial cables. Connection to this type of LANs is possible using a Hub provided with both Thin Ethernet (10base2) connectors and 100Base-T or 10Base-T connectors. The LAN topology is a star one, with each node connected to the Hub or the Switch through its cable.

The figure below shows the pair arrangement in a 5 UTP cable and the standard colour arrangement to obtain the Straight-Through cable.

P000518-B

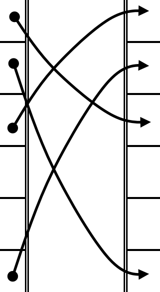


Pin	Wire color
1	orange/white
2	orange
3	green/white
4	blue
5	blue/white
6	green
7	brown/white
8	brown

Figure 107: Cable of Cat. 5 for Ethernet and standard colour arrangement in the connector

Direct point-to-point connection is obtained with a Cross-Over Cable TIA/EIA-568-B, cat. 5. This type of cable performs a cross-over of the pairs so that the TD+/TD– pair corresponds to the RD+/RD– pair, and vice versa.
The table below shows the colour matching on the connector pins for the Cross-Over Cable and the cross-over diagram of the two pairs used from 100Base-T or 10Base-T connection.

Pin and wire colour (first part of the connector)		
1	white/orange	
2	orange	
3	white/green	
4	blue	
5	white/blue	
6	green	
7	white/brown	
8	brown	



Pin and wire colour (last part of the connector)		
1	white/green	
2	green	
3	white/orange	
4	white/brown	
5	brown	
6	orange	
7	blue	
8	white/blue	

NOTE The inverter is typically installed with other electric/electronic devices inside a cubicle. Normally, the electromagnetic pollution inside the cubicle is remarkable and is due to both radiofrequency disturbance caused by the inverters and to bursts caused by the electromechanical devices. To avoid propagating disturbance to Ethernet cables, they must be segregated and kept as far as possible from the other power cables and signal cables in the cubicle.
Disturbance propagation to Ethernet cables may affect the correct operation of the inverter and the other devices (computers, PLCs, Switches, Routers) connected to the same LAN.

NOTE The maximum length of the LAN cable, cat. 5 UTP allowed by IEEE 802 standards results from the max. transit time allowed from the protocol and is equal to 100m. The longer the cable length, the higher the risk of communications failure.

NOTE For Ethernet wiring, only use cables certified for LAN cables of 5 UTP category or higher. For standard wiring, avoid creating your own cables; Straight-Through or Cross-Over cables should be purchased from an authorised dealer.

NOTE For a proper configuration and utilisation of the communications board, the user should know the basics of the TCP/IP protocol and should get familiar with the MAC address, the IP address and the ARP (Address Resolution Protocol). The basic document on the Web is “RFC1180 – A TCP/IP Tutorial”.

11.13.3. Configuration of the Ethernet Board for Modbus/TCP

The first step in configuring the Ethernet interface board consists in communicating with the board through a computer in order to update the configuration file (etccfg.cfg) stored to the non-volatile memory of the board. The configuration procedure is different if you use a point-to-point connection to the computer, if the board is connected to a LAN that is <u>not provided</u> with a DHCP server and if the board is connected to a LAN that <u>is provided</u> with a DHCP server. The section below covers these types of connection:

- Point-to-point connection to the PC,
- A board connected to a LAN that <u>does not</u> require a DHCP server and
- A board connected to a LAN that <u>requires</u> the DHCP server.

Those connection modes are detailed below.

NOTE For the connection to the LAN, consult your network administrator, who can tell if the LAN is provided with a DHCP server. If this is not the case, your network administrator will assign the static IP addresses for each inverter.

Point-to-point connection to the computer

If a point-to-point connection to the computer is used, first configure the network board of the computer by setting a static IP address as 192.168.0.nnn, where nnn is any number ranging from 1 to 254.

To set the static IP address with Windows 7, open the Network Properties folder (for example typing “LAN” in the quick search tab: see Figure 109); in the field for the properties of the TCP/IP protocol, set the address value, e.g. 192.168.0.1.

Figure 110 shows the correct setting of the TCP/IP v.4 on the PC when using Windows 7. Settings are very similar for computers running on other Windows versions.

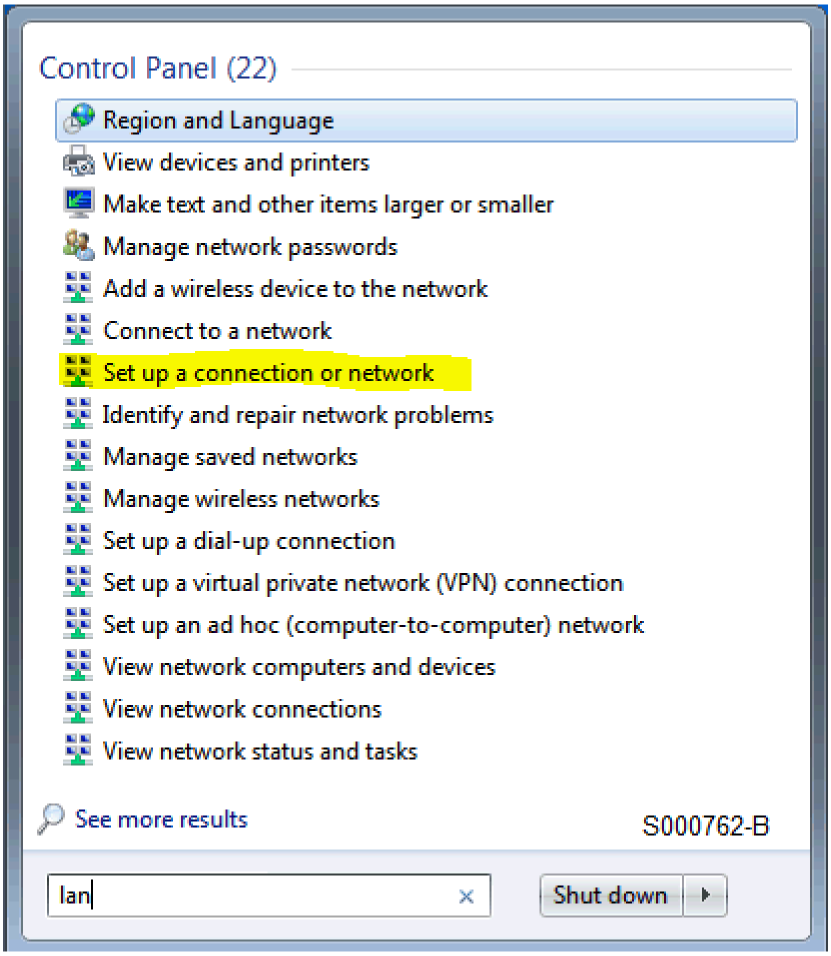


Figure 108: Windows 7 - Accessing directly to the network configuration folder

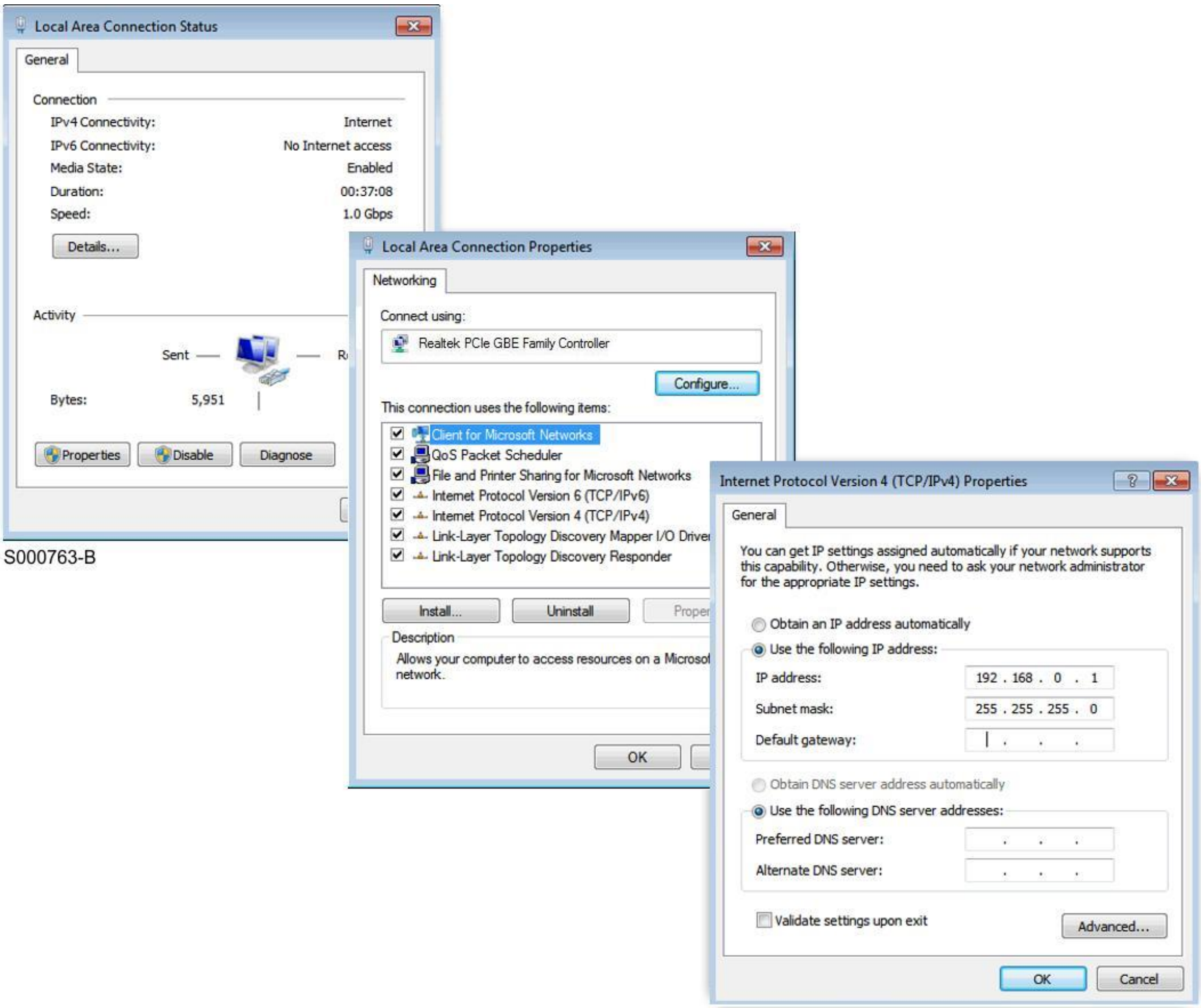


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Figure 109: Setting a computer for a point-to-point connection to the inverter

After configuring your computer as described above, in the DIP-switches of the communications board set a binary number different from 0, different from 255 and different from the number set in the low portion of the IP address of the computer. For example, number 2 can be set by lowering (logic 1) only switch 7 as shown in the figure below.

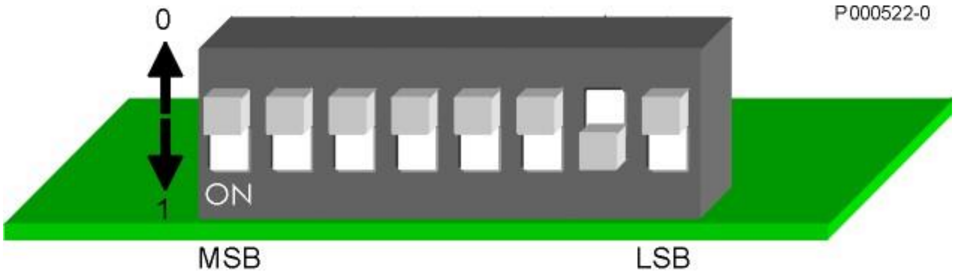


Figure 110: Setting the DIP-switches to set the IP address 192.168.0.2.

If the computer is connected to the inverter through a Cross-Over Cable, a local network is created, which is composed of two participant nodes (the computer and the inverter), with 192.168.0.1 and 192.168.0.2 as IP addresses respectively. When the inverter is powered on, the LINK LED (see below) in the interface board should turn on. The following command:

```
ping 192.168.0.2
```

launched by a command line window of the computer performs the correct connection to the board.

If the advanced configuration is required, the internal web server may be used. Enter the board IP address in the proper field from a popular browser. A configuration page opens, where different TCP/IP configuration parameters of the board can be set, as shown in Figure 111.
This procedure also allows setting other different IP addresses instead of the default addresses (the format is 192.168.0.nnn).

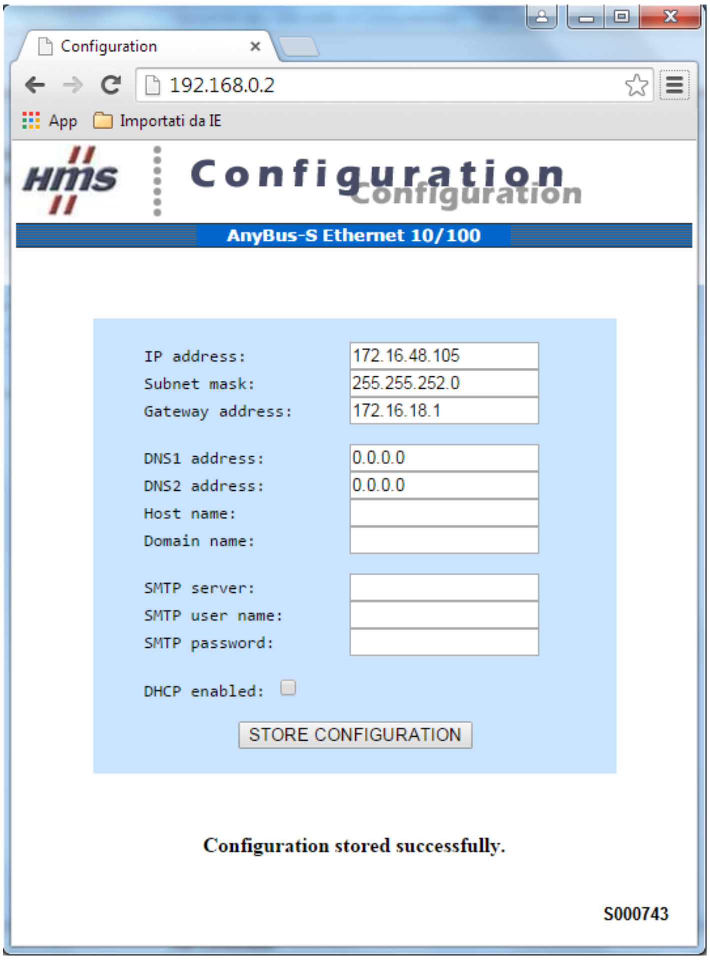


Figure 111: Internal webserver

Connection with a computer through a LAN without any DHCP server

The network administrator will assign a static IP address for each inverter to be connected to the LAN.
Suppose that the IP address assigned from the administrator to an inverter is 10.0.254.177 and proceed as follows:

- Set all the DIP-switches in the Ethernet interface board to 0 (“up” position)
- Connect the board to a switch in the LAN using a Straight-Through cable and power on the inverter
- Make sure that the green light of the LINK LED (see below) comes on
- Note down the MAC address of the Ethernet board that is written on a label placed at the bottom of the printed circuit.
  Suppose that the MAC address of the interface board is 00-30-11-02-2A-02
- In a computer connected to the same LAN (connected to the same sub-network, i.e. with an IP address equal to 10.0.254.xxx), open the command interpreter window and enter the following commands:
- `arp -s 10.0.254.177 00-30-11-02-2A-02`
  `ping 10.0.254.177`
- `arp -d 10.0.254.177`

In the ARP table of the computer, the first command will create a static entry assigning the matching between the MAC address of the board and the static IP address.
The ping command queries the interface board to check the connection and returns the transit time of the data packet between the computer and the board through the network, as shown in Figure 112.

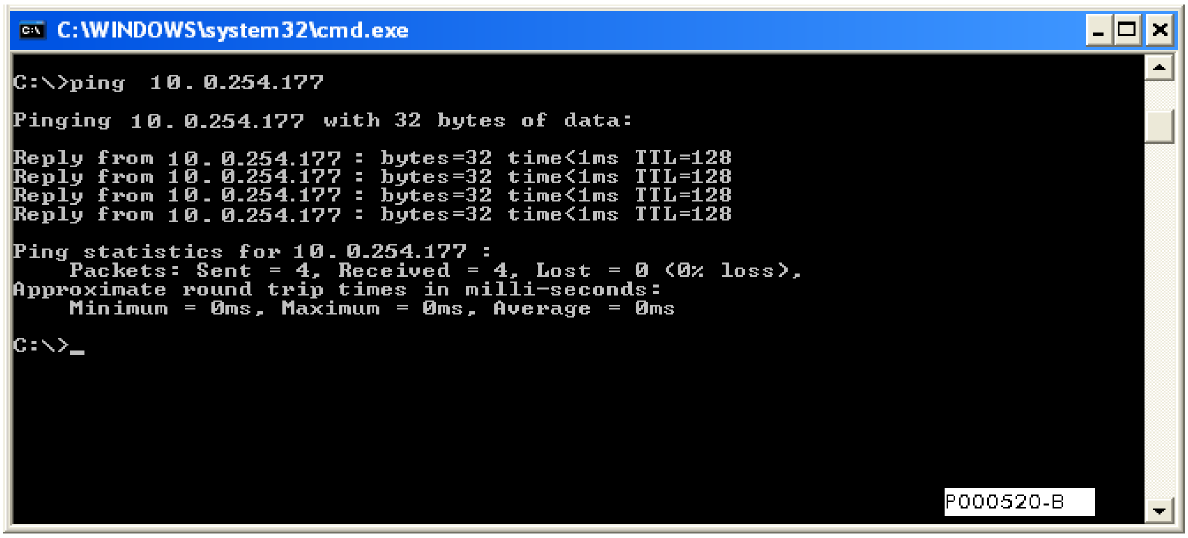


Figure 112: Example of the ping command to the IP address of the inverter interface board

When the interface board is sent the data packet, it gets the MAC address-IP address match as a permanent match, then it compiles and saves an “ethcfg.cfg” file, where the IP address 10.0.254.177 is stored as its own address each time the inverter is turned on.
Command number 3 is optional and removes the static match IP-MAC related to the inverter Ethernet board from the ARP table of the inverter.

Connection with a computer through a LAN equipped with a DHCP server
If an inverter equipped with an Ethernet board is connected to the LAN and if all the DIP-switches are set to zero (“up” position), when the inverter is powered on, automatic negotiation with the DHCP server takes place and the inverter is assigned an IP address chosen among the available ones. This configuration is then stored to the “ethcfg.cfg” file.
The “Anybus IP config” utility, available for donwload from santerno.com, Software tab of the product sheet concerned, can be used to query all the inverters with an Ethernet interface in the LAN from the same computer and, if required, the network access parameters can be reconfigured. The figure below shows the page of the programme when an inverter is acknowledged. Multiple inverters can be identified from the same network through their own value of the MAC address.

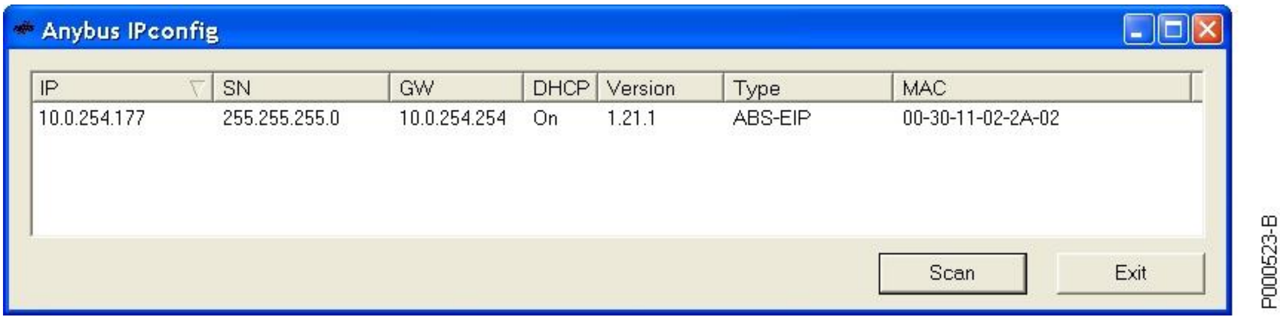
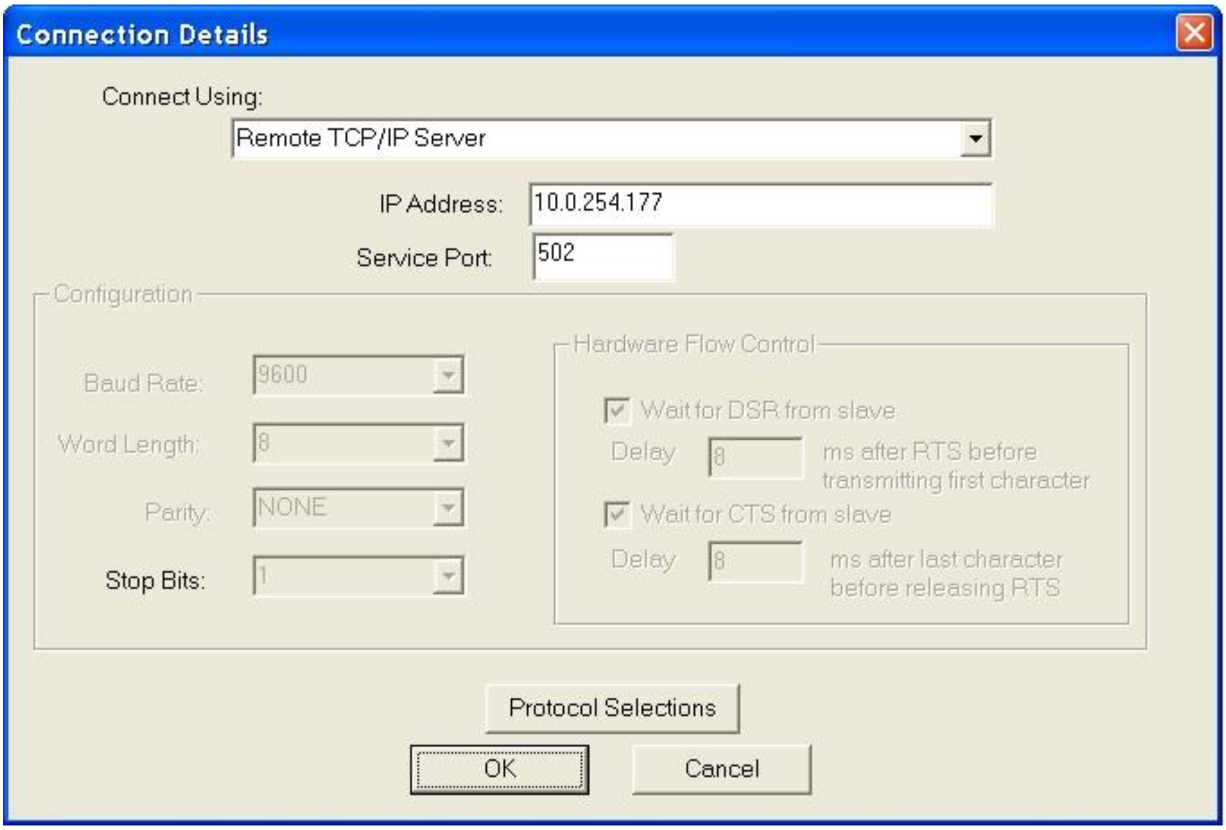


Figure 113: Anybus IP config utility

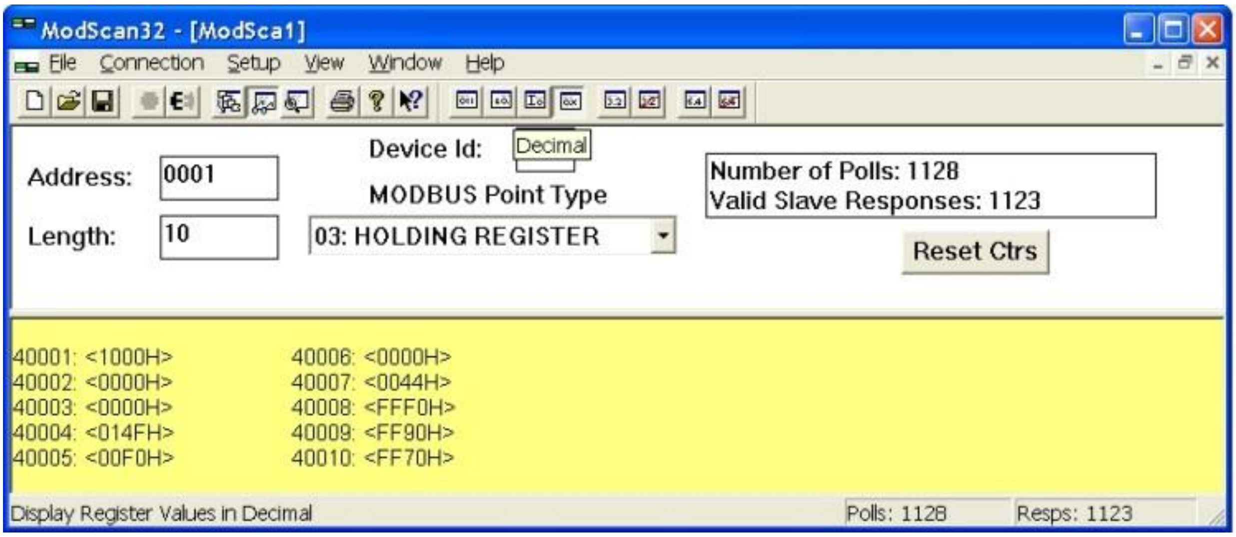
Query of the inverter data through the ModScan programme
Once configuration is achieved and the IP address of the interface board is available, you can query the inverter variables through the Modbus/TCP protocol. WinTECH’s ModScan application (http://www.win-tech.com/) allows displaying the variables read with the Modbus.
The figure below shows the setting shield of ModScan for the connection of a board with the IP address 10.0.254.177. For the Modbus/TCP connection, port 502 is provided by the Ethernet interface. Port 502 is to be used for all the Modbus transactions.



P000524-B

Figure 114: Setting ModScan for a Modbus/TCP connection

Figure 115 shows a ModScan shield related to the 10 output variables of the inverter. These variables are acquired in real time and are provided by the Modbus/TCP protocol. Refer to the Programming Guide, Fieldbus Configuration menu, for any detail about the map and the meaning of the input/output variables.



P000525-B

Figure 115: Display of the output variables of the inverter through the Modbus/TCP protocol

NOTE

Unlike the Modbus RTU connection through the serial link, the Modbus/TCP connection is characterised by an offset of 400h (1024) for write variables, because the Ethernet board dialogues with the inverter and splits a buffer shared for two segments of 1kbyte each. One segment is dedicated to the messages sent from the inverter to the Fieldbus, the other is dedicated to the messages sent from the Fieldbus to the inverter. In order to write Word 1 **M042**-Speed Reference from FIELDBUS (integer part) (refer to the Programming Guide), the Modbus/TCP transaction must be addressed to log 1025, not to log 1.

On the other hand, reading usually occurs without any offset.

11.14. Environmental Requirements Common to All Boards

Operating temperature	–10 to +55 °C ambient temperature (contact Enertronica Santerno S.p.A. for higher ambient temperatures)
Relative humidity	5 to 95% (non-condensing)
Max. operating altitude	2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A.

12. BRIDGE MINI (SLOT B)

Accessory-Product Compatibility		
Product	**Bridge Mini**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	√	
Solardrive Plus	√	

Table 13: Product – Bridge Mini compatibility

The Bridge Mini is a product designed for remote monitoring and remote servicing: its easy-to-use interface running on any Web browser allows you to straightforwardly acquire measurements and operation indicators, display the main trends, upgrade the inverter firmware and download data logs.

The Bridge Mini is able to control devices of any brand and model both via IoT standard protocols and via industrial protocols.

Compact yet highly-performing, it comes in two versions:

- Embedded: installed inside the equipment and powered directly by the inverter for optimum convenience and ease of installation.
- Stand-alone: featuring DIN support for in-cabinet installation.

The Bridge Mini interconnects to the system devices via serial links on two RS485 ports, called COM1 and COM2, and one Ethernet port. USB flash drives may be connected to the Bridge Mini to download data logs.

It is connected to Santerno Cloud via secure and encrypted Internet connections for remote monitoring and remote servicing.

Figure 116: Bridge Mini Embedded

Figure 117: Bridge Mini Stand alone

12.1. Identification Data

Description	***Part Number***
Bridge Mini Embedded	ZZR1007A0
Bridge Mini Stand alone	ZZ4600600

12.2. Installing the Board on the Inverter (Slot B)

Please refer to the **BRIDGE MINI – User Manual**.

12.3. Connectivity

Please refer to the **BRIDGE MINI – User Manual**.

13. ES847 I/O EXPANSION BOARD (SLOT C)

Product-Accessory Compatibility		
Product	**ES847 I/O Expansion board**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	√	
Solardrive Plus	√	

Table 14: Product – ES847 I/O Expansion board compatibility

ES847 Board allows implementing an additional I/O set for any product compatible with this accessory. Additional functionality includes:

- XAIN4: One “fast” sampling analog input, 12 bit ±10V f.s;
- XAIN5: One “fast” sampling analog input for 0-20mA f.s. sensor measurement, resolution 11 bits
- XAIN7: One “fast” sampling analog input for ±160mA f.s. sensor measurements; resolution: 12 bits (Energy Counter option);
- XAIN8/9/10/11: Four “slow” sampling inputs, 12-bit, configurable as 0-10V f.s., 0-20 mA f.s., 0-100 mV f.s., temperature acquisition via two-wire thermistor PT100;
- XAIN12/13: Two “slow” sampling analog inputs, 12-bit, 0-10V f.s.;
- VAP/VBP/VCP: Three voltage inputs for ADE (Energy Counter option);
- IAP/IBP/ICP: Three current inputs for ADE (Energy Counter option);
- XMDI1/2/3/4/5/6/7/8: Eight PNP, 24V multifunction digital inputs; three of them are “fast propagation” inputs and can be used for the acquisition of a PUSH-PULL, 24V encoder;
- XMDO1/2/3/4: Six multifunction digital outputs, OC outputs free from potential to be used both as PNP and NPN inputs, Vomax=48V, Iomax=50mA, providing short-circuit protection through a resettable fuse.

CAUTION Not all I/Os are controlled from all the products. Please refer to the DIP-switch/Note column in ES847 Board Terminals and to the Guide to the Regenerative Application).

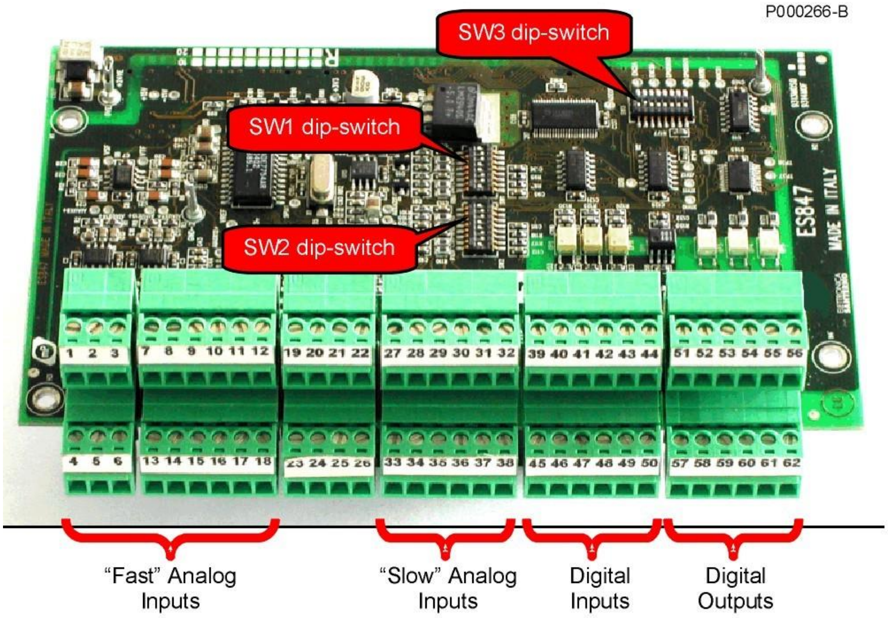


Figure 118: Signal conditioning and additional I/Os board (ES847)

13.1. Identification Data

Description	Part Number
ES847/1 Signal conditioning	ZZ0101814

13.2. Installing ES847 Board on the Inverter (Slot C)

	DANGER	Before gaining access to the components inside the inverter, remove voltage from the inverter and wait at least 20 minutes. Wait for a complete discharge of the internal capacitors to avoid any electric shock hazard.
	CAUTION	Electric shock hazard: do not connect/disconnect the signal terminals or the power terminals when the inverter is on. This also prevents the inverter from being damaged.
	NOTE	All the screws used to fasten removable parts (terminals cover, serial interface connector, cable plates, etc.) are black, round-head, cross-head screws. When wiring the inverter, remove only this type of screws. If different screws or bolts are removed, the inverter warranty will be no longer valid.

1. Remove voltage from the inverter and wait at least 20 minutes.

2. Remove the whole inverter covering by loosening the four hexagonal screws located on the top side and bottom side of the inverter to reach the fixing spacers and the signal connector (Figure 119 – Slot C.)

	CAUTION	Before removing the inverter cover, draw out the keypad and disconnect the cable connecting the keypad to the control board to avoid damaging the link between the keypad and the control board.

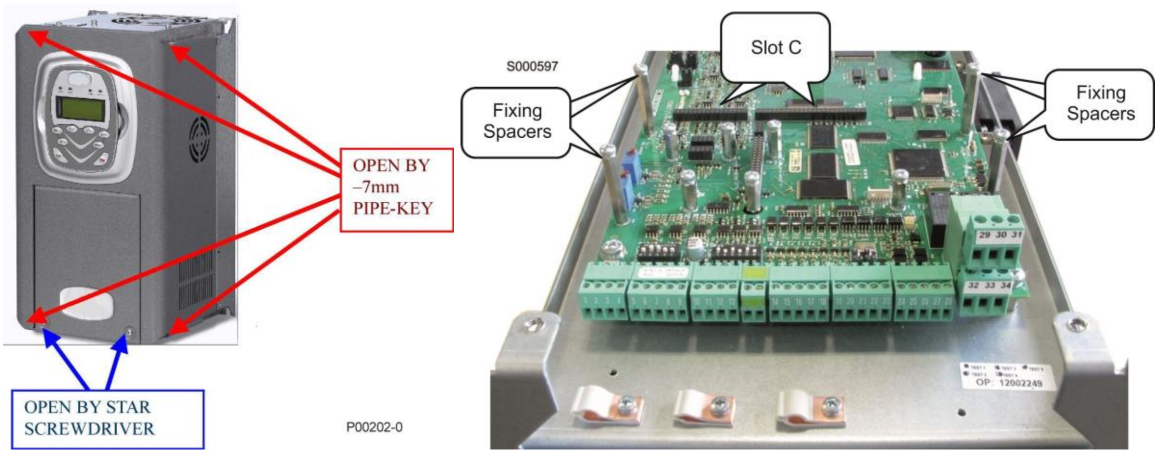


Figure 119: Removing the inverter cover; location of slot C

3. Insert the two contact strips supplied in the bottom part of ES847 board; make sure that each contact enters its slot in the connector. Insert ES847 board over the control board of the drive; make sure that each contact enters its slot in the signal connector. Use the screws supplied to fasten board ES847 to the fixing spacers (Figure 120).

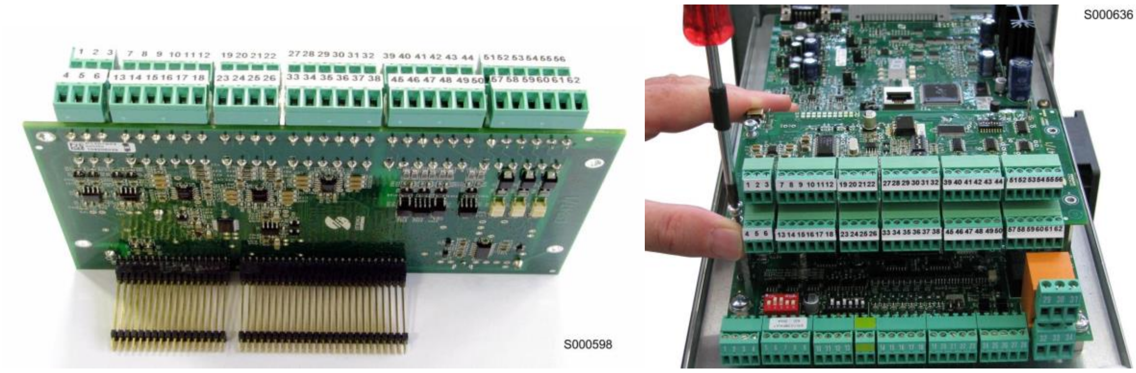


Figure 120: Fitting the strips inside ES847 board and fixing the board on slot C

4. Configure the DIP-switches located on board ES847 based on the type of signals to be acquired (see relevant section).
5. For the terminal board wiring, follow the instructions given in the section below.
6. Close the inverter frame by reassembling the cover allowing gaining access to the inverter control terminals.

13.3. ES847 Board Terminals

Screwable terminal board including 12 sections (each section can be individually removed) for 0.08 to 1.5 mm^2 (AWG 28-16) cables.
Decisive voltage class A according to EN 61800-5-1.

N.	Name	Description	I/O Features	DIP-switch/Notes
1-2	**XAIN1+ XAIN1–**	“Fast” differential auxiliary analog input, ±10V f.s., number 1	Vfs = ±10 V, Rin= 10 kΩ; Resolution: 12 bits	**n.u.**
3	**CMA**	0V for analog inputs (common to control 0V)	Control board zero Volt	
4-5	**+15VM –15VM**	Stabilized, bipolar output protected from short-circuits for auxiliary circuits.	+15 V, –15 V; Iout max: 100mA	
6	**CMA**	0V for analog inputs (common to control 0V)	Control board zero Volt	
7-8	**XAIN2+ XAIN2–**	“Fast” differential auxiliary analog input, ±10V f.s. number 2	Vfs = ±10 V, Rin= 10 kΩ; Resolution: 12 bits	**n.u.**
9-10	**XAIN3+ XAIN3–**	“Fast” differential auxiliary analog input, ±10V f.s. number 3	Vfs = ±10 V, Rin= 10 kΩ; Resolution: 12 bits	**n.u.**
11-12	**XAIN4+ XAIN4–**	“Fast” differential auxiliary analog input, ±10V f.s. number 4	Vfs = ±10 V, Rin= 10 kΩ; Resolution: 12 bits	**PD**
13	**XAIN5**	“Fast” auxiliary analog input (current input), number 5	Ifs = ±20 mA, Rin= 200 Ω; Resolution: 12 bits	**PD**
14	**CMA**	0V for analog inputs for XAIN5 return	Control board zero Volt	
15	**XAIN6**	“Fast” auxiliary analog input (current input), number 6	Ifs = ±20 mA, Rin= 200 Ω; Resolution: 12 bits	**n.u.**
16	**CMA**	0V for analog inputs for XAIN6 return	Control board zero Volt	
17	**XAIN7**	“Fast” auxiliary current analog input, number 7 (Energy Counter option)	Ifs = ±160 mA, Rin= 33 Ω; Resolution: 12 bits	**PR**
18	**CMA**	0V for analog inputs (common with control 0V)	Control board zero Volt	
19	**VAP**	Voltage analog input from ES917 – phase R (Energy Counter Option)	Vfs = ±10 V, Rin= 50 kΩ; Resolution: 12 bits	**PR**
20	**VBP**	Voltage analog input from ES917 – phase S (Energy Counter Option)	Vfs = ±10 V, Rin= 50 kΩ; Resolution: 12 bits	**PR**
21	**VCP**	Voltage analog input from ES917 – phase T (Energy Counter Option)	Vfs = ±10 V, Rin= 50 kΩ; Resolution: 12 bits	**PR**
22	**CMA**	0V for analog inputs (common with control 0V)	Control board zero Volt	
23	**IAP**	Current analog input from CT – phase R (Energy Counter Option)	Ifs = ±150 mA, Rin= 33 Ω; Resolution: 12 bits	**PR**
24	**IBP**	Current analog input from CT – phase S (Energy Counter Option)	Ifs = ±150 mA, Rin= 33 Ω; Resolution: 12 bits	**PR**
25	**ICP**	Current analog input from CT – phase T (Energy Counter Option)	Ifs = ±150 mA, Rin= 33Ω; Resolution: 12 bits	**PR**
26	**CMA**	0V for analog inputs (common with control 0V)	Control board zero Volt	

PD: Used by the firmware of all the products compatible with this accessory.

PR: Used by the Sinus Penta/Penta Marine featuring the Regenerative application when the Energy Counter option is installed.

<table>
<tr><th>N.</th><th>Name</th><th>Description</th><th>I/O Features</th><th>DIP-switch/Notes</th></tr>
<tr><td rowspan="4">27</td><td rowspan="4">XAIN8/T1+</td><td rowspan="3">“Slow” configurable auxiliary analog input, number 8</td><td>Vfs = 10 V, Rin = 30 kΩ</td><td>SW1.3 = ON
SW1.1-2-4 = OFF</td></tr>
<tr><td>Vfs = 100 mV, Rin = 1 MΩ</td><td>SW1.4 = ON
SW1.1-2-3 = OFF</td></tr>
<tr><td>Ifs = 20 mA, Rin = 124.5 Ω</td><td>SW1.2 = ON
SW1.1-3-4 = OFF</td></tr>
<tr><td>Thermistor temperature measurement, number 1</td><td>Temperature measurement with PT100
Compliant with IEC 60751 or DIN 43735</td><td>SW1.1-4 = ON
SW1.2-3 = OFF
(default)</td></tr>
<tr><td>28</td><td>CMA/T1–</td><td>0V for analog inputs for XAIN8 return</td><td>Control board zero Volt</td><td></td></tr>
<tr><td rowspan="4">29</td><td rowspan="4">XAIN9/T2+</td><td rowspan="3">“Slow” configurable auxiliary analog input, number 9</td><td>Vfs = 10 V, Rin = 30 kΩ</td><td>SW1.7 = ON
SW1.5-6-8 = OFF</td></tr>
<tr><td>Vfs = 100 mV, Rin = 1M Ω</td><td>SW1.8 = ON
SW1.5-6-7 = OFF</td></tr>
<tr><td>Ifs = 20 mA, Rin = 124.5 Ω</td><td>SW1.6 = ON
SW1.5-7-8 = OFF</td></tr>
<tr><td>Thermistor temperature measurement, number 2</td><td>Temperature measurement with PT100
Compliant with IEC 60751 or DIN 43735</td><td>SW1.5-8 = ON
SW1.6-7 = OFF
(default)</td></tr>
<tr><td>30</td><td>CMA/T2–</td><td>0V for analog inputs for XAIN9 return</td><td>Control board zero Volt</td><td></td></tr>
<tr><td rowspan="4">31</td><td rowspan="4">XAIN10/T3+</td><td rowspan="3">“Slow” configurable auxiliary analog input, number 10</td><td>Vfs = 10 V, Rin = 3 0kΩ</td><td>SW2.3 = ON
SW2.1-2-4 = OFF</td></tr>
<tr><td>Vfs = 100 mV, Rin = 1 MΩ</td><td>SW2.4 = ON
SW2.1-2-3 = OFF</td></tr>
<tr><td>Ifs = 20 mA, Rin = 124.5 Ω</td><td>SW2.2 = ON
SW2.1-3-4 = OFF</td></tr>
<tr><td>Thermistor temperature measurement, number 3</td><td>Temperature measurement with PT100
Compliant with IEC 60751 or DIN 43735</td><td>SW2.1-4 = ON
SW2.2-3 = OFF
(default)</td></tr>
<tr><td>32</td><td>CMA/T3–</td><td>0V for analog inputs for XAIN10 return</td><td>Control board zero Volt</td><td></td></tr>
<tr><td rowspan="4">33</td><td rowspan="4">XAIN11/T4+</td><td rowspan="3">“Slow” configurable auxiliary analog input, number 11</td><td>Vfs = 10 V, Rin = 30 kΩ</td><td>SW2.7 = ON
SW2.5-6-8 = OFF</td></tr>
<tr><td>Vfs = 100 mV, Rin = 1 MΩ</td><td>SW2.8 = ON
SW2.5-6-7 = OFF</td></tr>
<tr><td>Ifs = 20 mA, Rin = 124.5 Ω</td><td>SW2.6 = ON
SW2.5-7-8 = OFF</td></tr>
<tr><td>Thermistor temperature measurement, number 4</td><td>Temperature measurement with PT100
Compliant with IEC 60751 or DIN 43735</td><td>SW2.5-8 = ON
SW2.6-7 = OFF
(default)</td></tr>
<tr><td>34</td><td>CMA/T4–</td><td>0V for analog inputs for XAIN11 return</td><td>Control board zero Volt</td><td></td></tr>
<tr><td>35</td><td>XAIN12</td><td>“Slow” voltage auxiliary analog input, number 12</td><td>Vfs = 10 V, Rin = 30 kΩ</td><td>n.u.</td></tr>
<tr><td>36</td><td>CMA</td><td>0V for analog inputs for XAIN12 return</td><td>Control board zero Volt</td><td>n.u.</td></tr>
<tr><td>37</td><td>XAIN13</td><td>“Slow” voltage auxiliary analog input, number 13</td><td>Vfs = 10 V, Rin = 30 kΩ</td><td>n.u.</td></tr>
<tr><td>38</td><td>CMA</td><td>0V for analog inputs for XAIN13 return</td><td>Control board zero Volt</td><td>n.u.</td></tr>
</table>

N.	Name	Description	I/O Features	DIP-switch/Notes
39	**XMDI1**	Multifunction auxiliary digital input 1	24Vdc Opto-isolated digital inputs; positive logic (PNP): active with high level signal in respect to CMD (terminals 43 and 50). In compliance with EN 61131-2 as type 1 digital inputs (24Vdc rated voltage).	Maximum response time to processor: 500µs
40	**XMDI2**	Multifunction auxiliary digital input 2		
41	**XMDI3**	Multifunction auxiliary digital input 3		
42	**XMDI4**	Multifunction auxiliary digital input 4		
43	**CMD**	0 V digital input isolated to control 0 V		
44	**+24V**	Auxiliary supply output for opto-isolated multifunction digital inputs		
45	**XMDI5**	Auxiliary multifunction digital input 5		
46	**XMDI6 / ECHA / FINA (*)**	Auxiliary multifunction digital input 6 / Single-ended, push-pull 24V encoder input, phase A / Frequency input A		
47	**XMDI7 / ECHB (*)**	Auxiliary multifunction digital input 7 / Single-ended, push-pull 24V encoder input, phase B		Maximum response time to processor: 600ns
48	**XMDI8 / FINB**	Auxiliary multifunction digital input 8 / Frequency input B		
49	**+24V**	Auxiliary supply output for opto-isolated multifunction digital inputs	+24V±15%; Imax: 200mA Protected by resettable fuse	
50	**CMD**	0 V digital input isolated to control 0 V	Opto-isolated digital input zero volt	
51	**XMDO1**	Multifunction auxiliary digital output 1 (collector)	Open collector isolated digital outputs, Vomax = 48V; Iomax = 50mA	
52	**CMDO1**	Multifunction auxiliary digital output 1 (emitter)		
53	**XMDO2**	Multifunction auxiliary digital output 2 (collector)		
54	**CMDO2**	Multifunction auxiliary digital output 2 (emitter)		
55	**XMDO3**	Multifunction auxiliary digital output 3 (collector)		
56	**CMDO3**	Multifunction auxiliary digital output 3 (emitter)		
57	**XMDO4**	Multifunction auxiliary digital output 4 (collector)		
58	**CMDO4**	Multifunction auxiliary digital output 4 (emitter)		
59	**XMDO5**	Multifunction auxiliary digital output 5 (collector)		
60	**CMDO5**	Multifunction auxiliary digital output 5 (emitter)		
61	**XMDO6**	Multifunction auxiliary digital output 6 (collector)		
62	**CMDO6**	Multifunction auxiliary digital output 6 (emitter)		

NOTE

All digital outputs are inactive under the following conditions:
- inverter off;
- inverter initialization stage after power on;
- firmware updating.

Consider this when choosing the inverter application.

(*) CAUTION

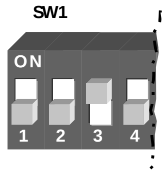
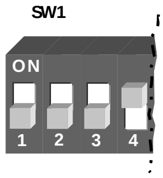
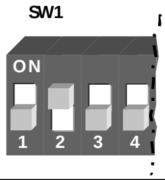
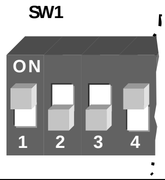
Terminals **MDI6/ECHA/FINA** and **MDI7/ECHB** on the control board are no longer active when ES847 is fitted and are automatically replaced by the relevant **XMDI6** and **XMDI7** terminals.

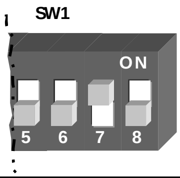
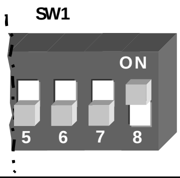
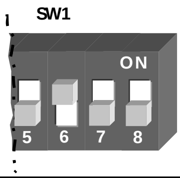
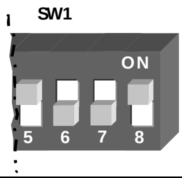
13.4. Configuration DIP-switches

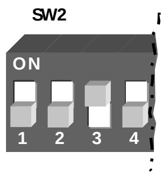
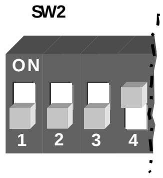
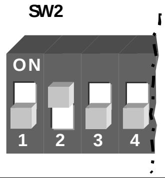
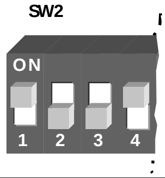
ES847 board is provided with three configuration DIP-switches (Figure 118) setting the operating mode as in the table below.

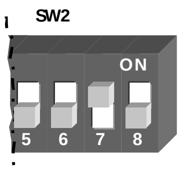
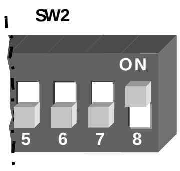
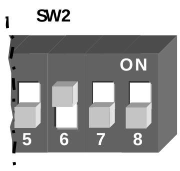
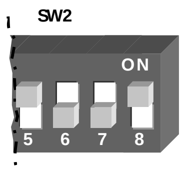
SW1	Sets the operating mode for “slow” analog inputs XAIN8 and XAIN9
SW2	Sets the operating mode for “slow” analog inputs XAIN10 and XAIN11
SW3	Factory-setting: SW3.2=SW3.5=SW3.7=ON; the other DIP-switches are OFF **– Do not change factory-setting–**

13.5. Possible Settings for DIP-switches SW1 and SW2

Configuring Slow Analog Channel XAIN8			
Mode: 0-10V f.s. (Default configuration)	**Mode: 0-100mV f.s.**	**Mode: 0-20mA f.s.**	**Temperature Reading with Thermistor PT100 (default)**
			

Setting Slow Analog Channel XAIN9			
Mode: 0-10V f.s. (Default configuration)	**Mode: 0-100mV f.s.**	**Mode: 0-20mA f.s.**	**Temperature Reading with Thermistor PT100 (default)**
			

Setting Slow Analog Channel XAIN10			
Mode: 0-10V f.s. (Default configuration)	**Mode: 0-100mV f.s.**	**Mode: 0-20mA f.s.**	**Temperature Reading with Thermistor PT100 (default)**
			

Setting Slow Analog Channel XAIN11			
Mode: 0-10V f.s. (Default configuration)	**Mode: 0-100mV f.s.**	**Mode: 0-20mA f.s.**	**Temperature Reading with Thermistor PT100 (default)**
			

Five acquisition modes are available (see the Programming Guide) corresponding to four hardware settings (see table below).

Type of Preset Acquisition	Mode Set for SW1 and SW2	Full-scale Values and Notes
Voltage: 0÷10 V	Mode: 0-10 V f.s.	0÷10 V
Voltage: 0÷100 mV	Mode: 0-100 mV f.s.	0÷100 mV
Current: 0÷20 mA	Mode: 0-20 mA f.s.	0 mA ÷ 20 mA
Current: 4÷20 mA	Mode: 0-20 mA f.s.	4 mA ÷ 20 mA. Alarm for measurement < 2 mA (cable disconnection) or for measurement > 25 mA.
Temperature	Temperature Reading with Thermistor PT100 (default)	–50 °C ÷ 125 °C. Disconnection alarm or short-circuit sensor if resistance measurement is lower/higher than the preset range.

NOTE Parameter settings must be consistent with DIP-switch settings. Otherwise, unpredictable results for real acquisition are produced.

NOTE A voltage/current value exceeding the input range will be saturated at minimum or maximum value.

CAUTION Inputs configured as voltage inputs have high input impedance and must be closed when active. The disconnection of the conductor relating to an analog input configured as a voltage input does not ensure that the channel reading is “zero”. Proper “zero” reading occurs only if the input is connected to a low-impedance signal source or is short-circuited. Do not series-connect relay contacts to inputs to obtain “zero” reading.

13.6. Wiring Diagrams

13.6.1. Connection of “Fast” Differential Analog Inputs

A differential input allows weakening disturbance due to “ground potentials” generated when the signal is acquired from remote sources. Disturbance is weaker only if wiring is correct.
Each input is provided with a positive terminal and a negative terminal of the differential amplifier. They are to be connected to the signal source and to its ground respectively. Common voltage for the signal source ground and the ground of the CMA auxiliary inputs must not exceed the maximum allowable value.
To reduce noise for a differential input, do the following:

- ensure a common path for the differential torque
- connect the source common to CMA input in order not to exceed the common mode input voltage
- use a shielded cable and connect its braiding to the terminal located next to the inverter terminal boards.

ES847 Board is also provided with an auxiliary supply output protected by a fuse which can be used to power external sensors. Do not exceed the max. current ratings.
Wiring is shown in the figure below:

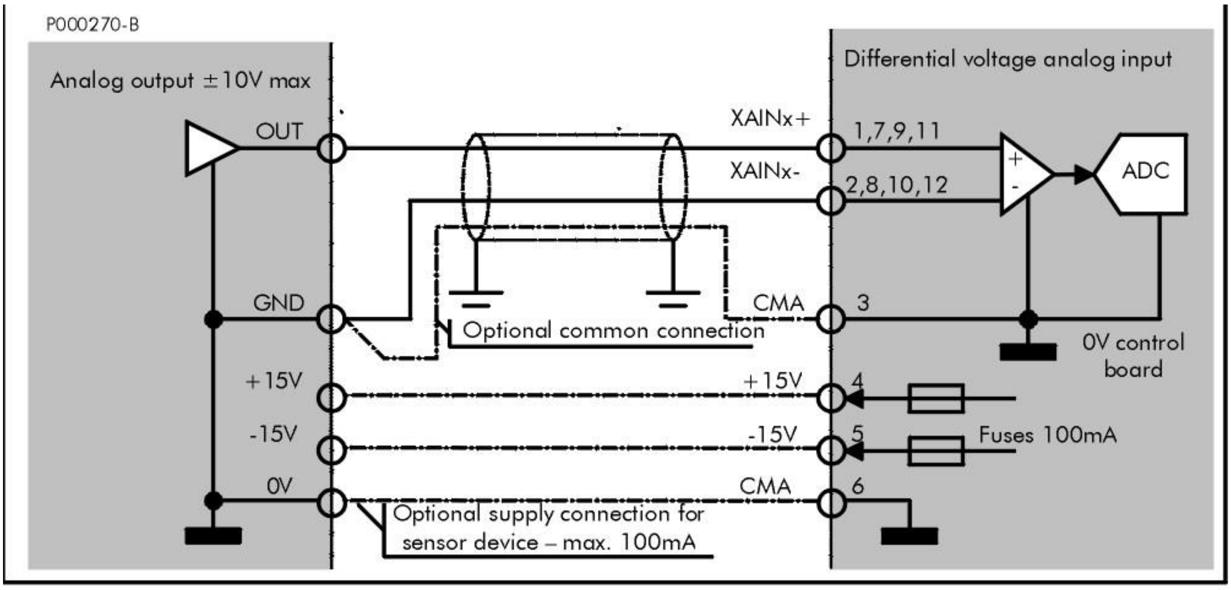


Figure 121: Connection of a bipolar voltage source to a differential input

NOTE Connecting terminal CMA to the signal source ground ensures better acquisition standards. Wiring can be external to the shielded cable or it can consist of the optional common connection of the auxiliary supply.

NOTE Auxiliary supply outputs are electronically protected against temporary short-circuits. After wiring the inverter, check output voltage, because a permanent short-circuit can damage the inverter.

13.6.2. Connection of “Fast” Current Inputs

Three “fast” low-impedance analog inputs are available, which are capable of acquiring sensors with current output.
The correct wiring is shown in the diagram below.

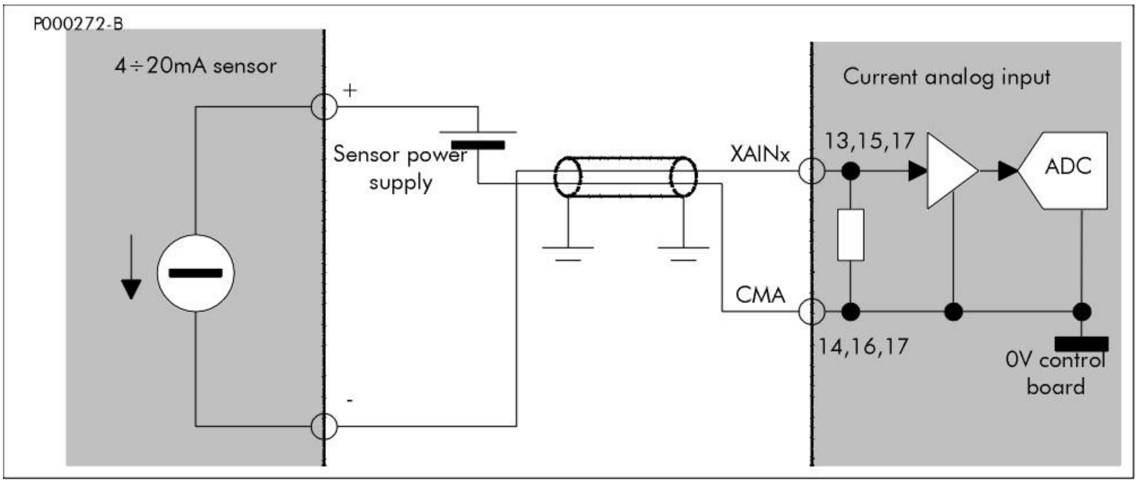


Figure 122: Connection of 0÷20mA (4÷20mA) sensors to “fast” current inputs

NOTE Do not use +24V power supply, available on terminals 44 and 49 in ES847 board, to power 4÷20mA sensors, because it is to be used for the common of the digital inputs (CMD – terminals 43 and 50), not for the common of the analog inputs (CMA). Terminals 44 and 49 are galvanically isolated and must be kept galvanically isolated.

13.6.3. Connecting “Slow” Analog Inputs to Voltage Sources

Use a shielded pair data cable and connect its braiding to the side of ES847 board. Connect the cable braiding to the inverter frame using the special conductor terminals located next to the terminal boards.
Although “slow” acquisition analog channels have a cut-off frequency slightly exceeding 10Hz and the mains frequency, which is the main disturbance source, is weakened, make sure that wiring is correct, particularly if the full-scale value is 100mV and if wires are longer than 10 m. The figure below shows a wiring example for the acquisition of a voltage source.
Properly set the DIP-switches for the configuration of the analog channel being used: set the full-scale value to 10V or to 100mV. The setting of the programming parameter must be consistent with the hardware setting.

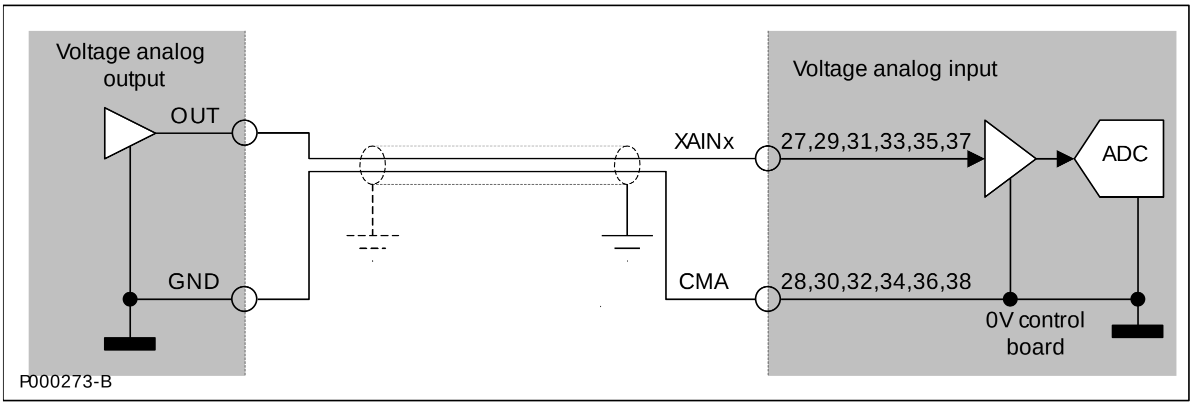


Figure 123: Connecting a voltage source to a “slow” analog input

13.6.4. Connecting “Slow” Analog Inputs to Current Sources

Figure 122 shows how to connect “slow” analog inputs to current sources. Channels XAIN8, XAIN9, XAIN10, XAIN11—corresponding to terminals 27, 29, 31, 33—are capable of acquiring current signals with a full-scale value of 20mA. Properly set the DIP-switches for the configuration of the analog channel being used: set the full-scale value to 20mA and set the relevant programming parameter to 0÷20mA or 4÷20mA.

13.6.5. Connecting “Slow” Analog Inputs to Thermistor PT100

ES847 board allows reading temperatures directly from the connection of standard thermistors PT100 complying with DIN EN 60751. Two-wire connection is used for easier wiring. Use relatively short cables and make sure that cables are not exposed to sudden temperature variations when the inverter is running. Proper wiring is shown in Figure 124: use a shielded cable and connect its braiding to the inverter metal frame through the special conductor terminals.
If a cable longer than approx. 10 m is used, measurement calibration is required. For example, if a 1 mm^2 (AWG 17) shielded pair data cable is used, this results in a reading error of approx. +1 °C every 10 m.
To perform measurement calibration, instead of the sensor connect a PT100 sensor emulator set to 0 °C (or a 100 Ω 0.1% resistor) to the line terminals, then zeroing the measurement offset. More details are given in the Programming Guide.
PT100 emulator allows checking the measurement before connecting the sensor.

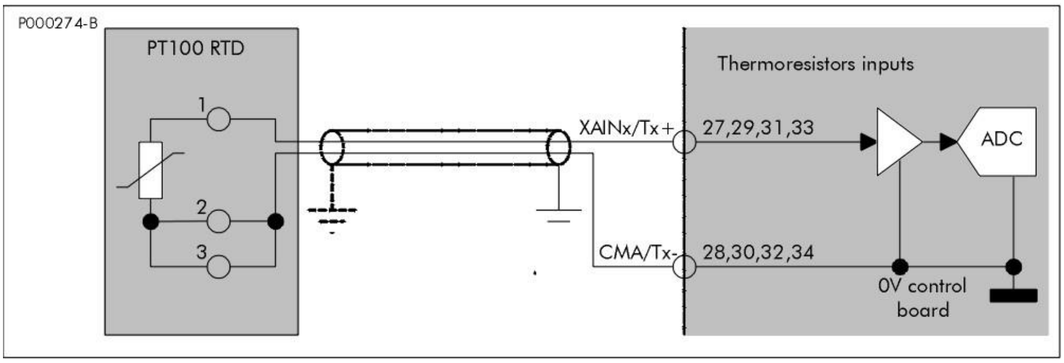


Figure 124: Connecting thermoresistors PT100 to analog channels XAIN8–11 / T1–4

NOTE	Parameter settings must be consistent with DIP-switch settings. Otherwise, unpredictable results for real acquisition are produced.
NOTE	A voltage/current value exceeding the input range will be saturated at minimum or maximum value.
CAUTION	Inputs configured as voltage inputs have high input impedance and must be closed when active. The disconnection of the conductor relating to an analog input configured as a voltage input does not ensure that the channel reading is zero. Proper “zero” reading occurs only if the input is connected to a low-impedance signal source or is short-circuited. Do not series-connect relay contacts and inputs to obtain “zero” reading.

13.6.6. Connecting Isolated Digital Inputs

All digital inputs are galvanically isolated from zero volt of the inverter control board. To activate isolated digital inputs, use either isolated supply delivered to terminals 44 and 49 or 24Vdc auxiliary supply.
Figure 125 shows the digital input control mode exploiting power inside the inverter and exploiting the output of a control device, such as a PLC. Internal supply (+24 Vdc, terminals 44 and 49) is protected by a 200mA resettable fuse.

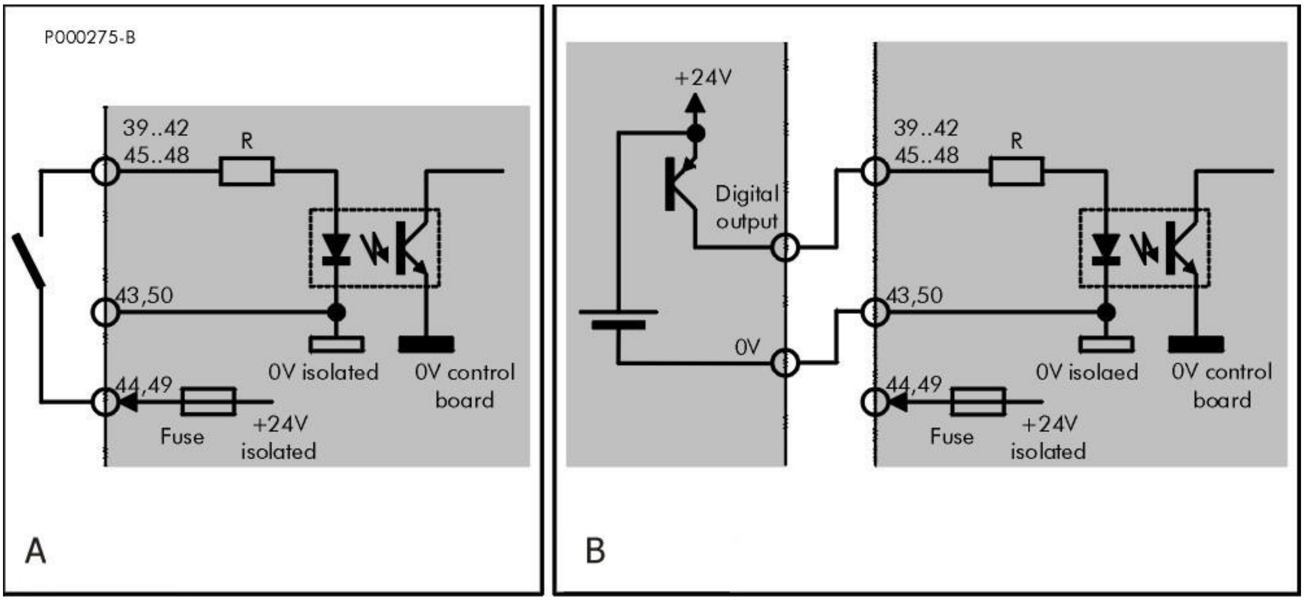


Figure 125: PNP input wiring

A: PNP Command (active to +24V) sent via a voltage free contact
B: PNP Command (active to +24V) sent from a different device (PLC, digital output board, etc.)

13.6.7. Connection to an Encoder or a Frequency Input

Auxiliary digital inputs XMDI6, XMDI7, XMDI8 may acquire fast digital signals and may be used for the connection to a push-pull single-ended incremental encoder or for the acquisition of a frequency input.
Important: When ES847 board is fitted, encoder B functions are no more implemented by the basic terminal board of the control board, but are implemented by ES847 board.

NOTE When installing ES847 board, encoder B functions are to be shifted from the basic terminal board of the control board to the terminal board of ES847 board.

The incremental encoder must be connected to "fast" digital inputs XMDI6 and XMDI7, as shown in Figure 126.

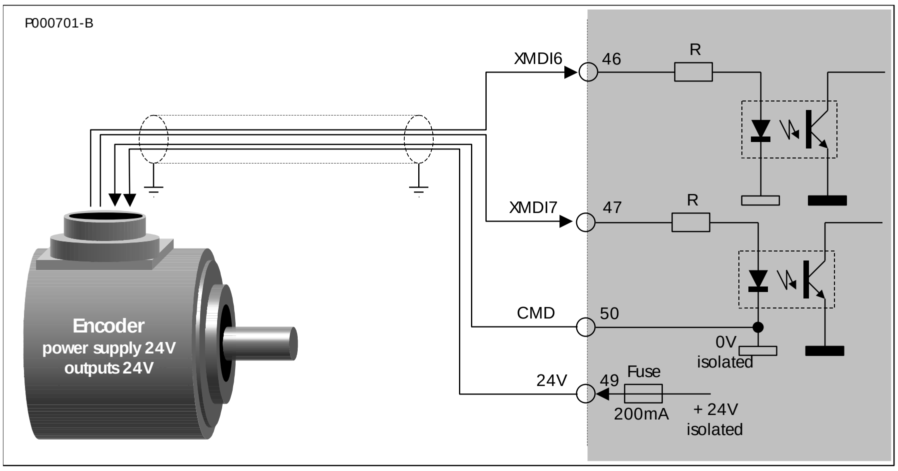


Figure 126: Connecting the incremental encoder to fast inputs XMDI7 and XMDI8

The encoder shall have PUSH-PULL outputs; its 24V power supply is delivered directly by the isolated supply internal to the inverter—terminals +24V (49) and CMD (50). The maximum allowable supply current is 200mA and is protected by a resettable fuse.
Only encoders described above can be acquired directly by the terminal board of the SINUS PENTA/PENTA MARINE; encoder signals shall have a maximum frequency of 155kHz, corresponding to 1024 pulse/rev at 9000 rpm.
Input XMDI8 can also acquire a square-wave frequency signal ranging from 10kHZ to 100kHz, which is converted into an analog value to be used as a reference. Frequency values corresponding to the min. and max. reference can be set up as parameters. Do not exceed the allowable duty-cycle ratings for the frequency inputs.
Signals are sent from a 24V Push-pull output with a reference common to terminal CMD (50), as shown in Figure 127).

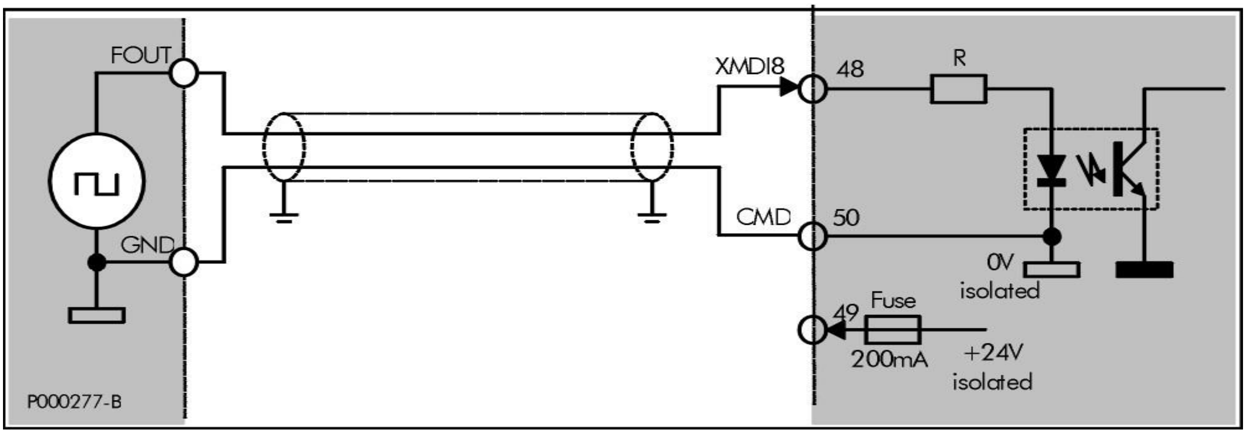


Figure 127: Signal sent from a 24V, Push-pull frequency output

13.6.8. Connection to Isolated Digital Outputs

Multifunction outputs XMDO1..8 (terminals 51..62) are all provided with a common terminal (CMDO1..8) which is isolated from the other outputs. They can be used to control both PNP and NPN loads, based on the wiring diagrams shown in Figure 128 and Figure 129.
Electrical conductivity (similar to a closed contact) is to be found between terminal MDO2 and CMDO2 when the output is active, i.e. when the ▓ symbol is displayed next to the output. Loads connected as PNP or as NPN are activated.
Outputs can be powered by the inverter isolated power supply or by an external source (24 or 48V – see dashed lines in the figure below).

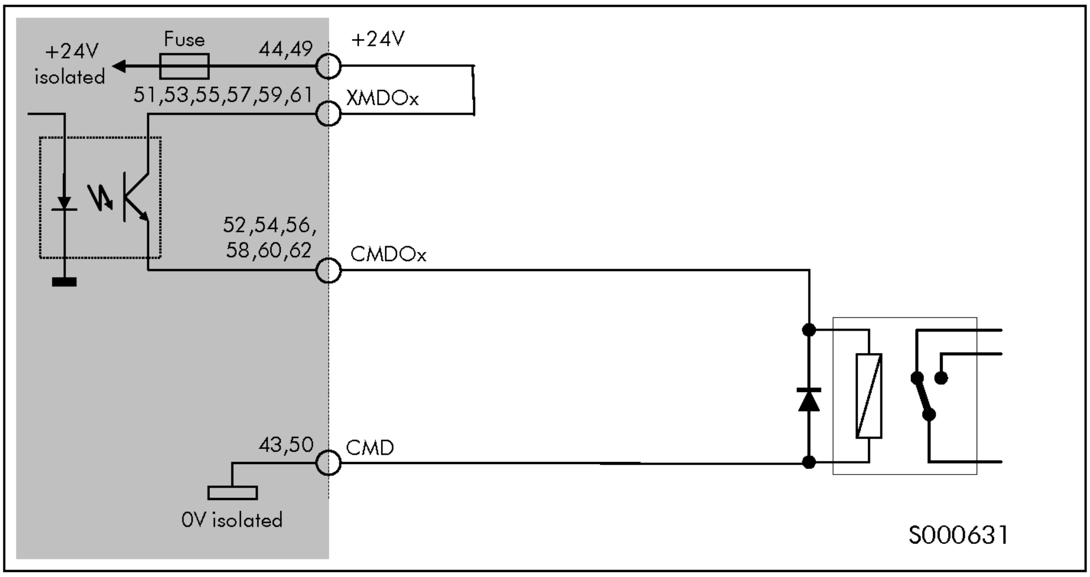


Figure 128: XMDOx output connection as PNP for relay command with internal power supply

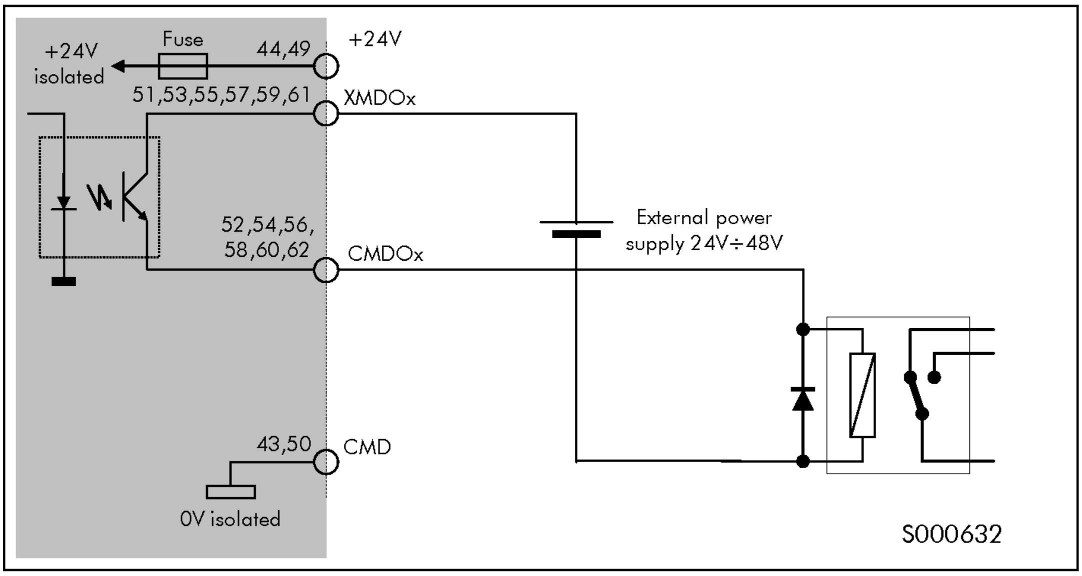


Figure 129: XMDOx output connection as PNP for relay command with external power supply

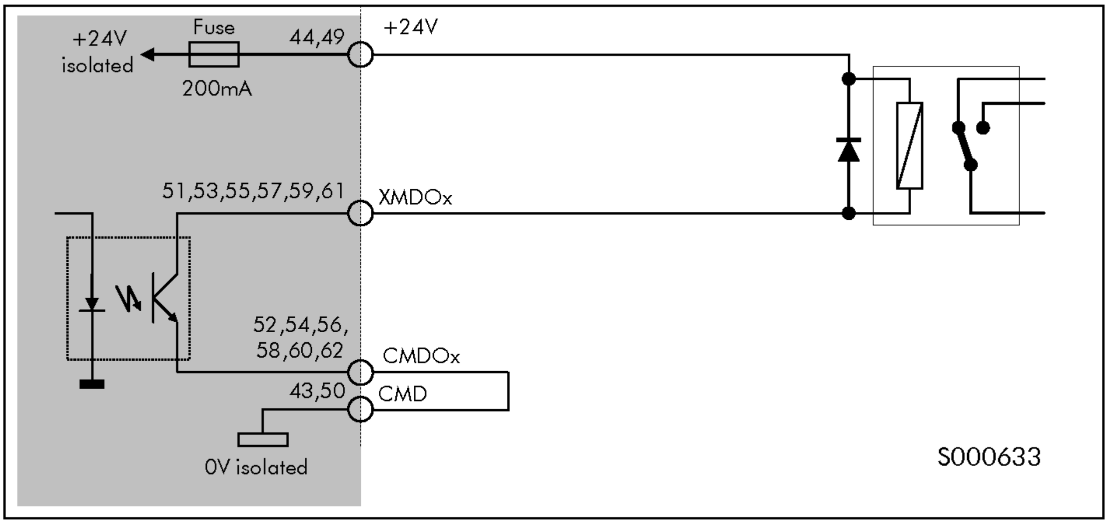


Figure 130: XMDOx output connection as NPN for relay command with internal power supply

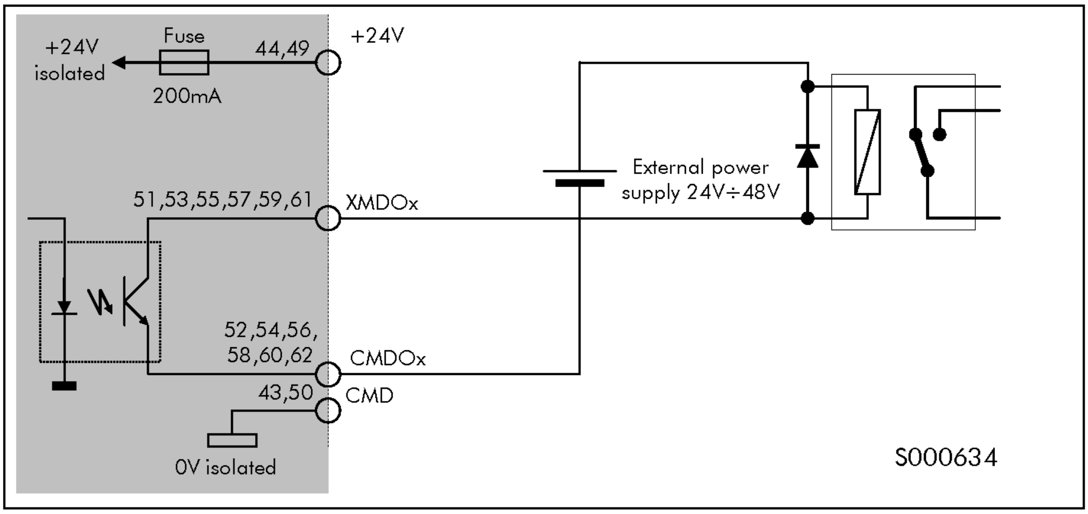


Figure 131: XMDOx output connection as NPN for relay command with external power supply

CAUTION When inductive loads (e.g. relay coils) are connected, always use the freewheel diode, which is to be connected as shown in the figure.

NOTE Do not simultaneously connect the isolated internal supply and the auxiliary supply to power the isolated digital outputs. Dashed lines in the figures are alternative to standard wiring.

NOTE Digital outputs XMDO1..8 are protected from a temporary short-circuit by a resettable fuse. After wiring the inverter, check the output voltage, as a permanent short-circuit can cause irreversible damage.

13.7. Environmental Requirements

Operating temperature	–10 to +55 °C ambient temperature (contact Enertronica Santerno S.p.A. for higher ambient temperatures)
Relative humidity	5 to 95% (non-condensing)
Max. operating altitude	2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A..

13.8. Electrical Ratings

13.8.1. Analog Inputs

Fast Sampling Analog Inputs, ±10V f.s.	*Value*			
	Min.	*Type*	*Max.*	*Unit*
Input impedance		10		kΩ
Offset cumulative error and gain in respect to full-scale value		0.5		%
Temperature coefficient of the gain error and offset			200	ppm/°C
Digital resolution			12	bit
Value of voltage LSB		5.22		mV/LSB
Common mode maximum voltage over differential inputs	–15		+15	V
Permanent overload over inputs with no damage	–30		+30	V
Input filter cut-off frequency (2nd order Butterworth filter)		5.1		kHz
Sampling time (depending on the software being used)	0.2		1.2	ms

Fast Sampling Analog Inputs for Current Measurement	*Value*			
	Min.	*Type*	*Max.*	*Unit*
Input impedance		200		Ω
Offset cumulative error and gain in respect to full-scale value		0.5		%
Temperature coefficient of the gain error and offset			200	ppm/°C
Digital resolution			12	bit
Value of current LSB		13		μA/LSB
Equivalent resolution in 0-20mA acquisition mode			10.5	bit
Permanent overload over inputs with no damage	–5		+5	V
Input filter cut-off frequency (2nd order Butterworth filter)		5.1		kHz
Sampling time (depending on the software being used)	0.2		1.2	ms

Slow Sampling Analog Inputs Configured in 0-10V mode	*Value*			
	Min.	*Type*	*Max.*	*Unit*
Input impedance		40		kΩ
Offset cumulative error and gain in respect to full-scale value		0.5		%
Temperature coefficient of the gain error and offset			200	ppm/°C
Digital resolution			12	bit
Value of voltage LSB		2.44		mV/LSB
Permanent overload over inputs with no damage	–30		+30	V
Input filter cut-off frequency (1st order low pass filter)		13		Hz
Sampling time (depending on the software being used)	10		1000	ms

Slow Sampling Analog Inputs Configured in 0-20mA mode	*Value*			
	Min.	*Type*	*Max.*	*Unit*
Input impedance		124.5		Ω
Offset cumulative error and gain in respect to full-scale value		0.5		%
Temperature coefficient of the gain error and offset			200	ppm/°C
Digital resolution			12	bit
Value of current LSB		4.90		μA/LSB
Permanent overload over inputs with no damage	–3.7		+3,7	V
Input filter cut-off frequency (1st order low pass filter)		13		Hz
Sampling time (depending on the software being used)	10		1000	ms

Slow Sampling Analog Inputs Configured in 0-100mV mode	*Value*			
	Min.	*Type*	*Max.*	*Unit*
Input impedance	1			MΩ
Offset cumulative error and gain in respect to full-scale value		0.2		%
Temperature coefficient of the gain error and offset			50	ppm/°C
Digital resolution			12	bit
Value of voltage LSB		24.7		μV/LSB
Permanent overload over inputs with no damage	–30		+30	V
Input filter cut-off frequency (1st order low pass filter)		13		Hz
Sampling time (depending on the software being used)	10		1000	ms

Slow Sampling Analog Inputs Configured in PT100 Temperature Measurement Mode	*Value*			
	Min	*Type*	*Max*	*Unit .*
Type of probe	Two-wire PT100 Thermistor			
Measurement range	–50		260	°C
Polarization current for PT100		0.49		mA
Measurement temperature coefficient			50	ppm/°C
Digital resolution			11	bit
Measurement max. cumulative error for temperature ranging from –40 to +55 °C		0.5	1.5	°C
Mean value of temperature LSB (linearization SW function)		0.135		°C/LSB
Permanent overload over inputs with no damage	–10		+10	V
Input filter cut-off frequency (1st order low pass filter)		13		Hz
Sampling time (depending on the software being used)	10		1000	ms

13.8.2. Digital Inputs

Features of the Digital Inputs	*Value*			
	Min.	*Type*	*Max.*	*Unit*
Input voltage for XMDIx in respect to CMD	–30		30	V
Voltage corresponding to logic level 1 between XMDIx and CMD	15	24	30	V
Voltage corresponding to logic level 0 between XMDIx and CMD	–30	0	5	V
Current absorbed by XMDIx at logic level 1	5	9	12	mA
Input frequency over “fast” inputs XMDI6..8			155	kHz
Allowable duty-cycle for frequency inputs	30	50	70	%
Min. time at high level for “fast” inputs XMDI6..8	4.5			μs
Isolation test voltage between terminals CMD (43 and 50) in respect to terminals CMA (3-6-14-16-18-28-30-32-34-36-38)	500Vac, 50Hz, 1min.			

13.8.3. Digital Outputs

Features of the Digital Outputs	*Value*			
	Min.	*Type*	*Max.*	*Unit*
Working voltage range for outputs XMDO1..6	20	24	50	V
Max. current that can be switched from outputs XMDO1..6			50	mA
Voltage drop of outputs XMDO1..6, when active			2	V
Leakage current of outputs XMDO1..6, when active			4	μA
Isolation test voltage between terminals CMDO1..6 and CMA	500Vac, 50Hz, 1min.			

13.8.4. Supply Outputs

Features of the Analog Supply Outputs	*Value*			
	Min.	*Type*	*Max.*	*Unit*
Voltage available on terminal +15V (4) in respect to CMA (6)	14.25	15	15.75	V
Voltage available on terminal –15V (5) in respect to CMA (6)	–15.75	–15	–14.25	V
Max. current that can be delivered from +15V output and that can be absorbed by output –15V			100	mA

Features of the Digital Supply Outputs	*Value*			
	Min.	*Type*	*Max.*	*Unit*
Voltage available on +24V terminals (44, 49) in respect to CMD (43, 50)	21	24	27	V
Max. current that can be delivered from +24V output			200	mA

CAUTION Irreversible faults occur if the min./max. input/output voltage ratings are exceeded.

NOTE The isolated supply output and the analog auxiliary output are protected by a resettable fuse capable of protecting the power supply unit inside the inverter against short-circuits. Nevertheless, in case of short-circuit, it can happen that the inverter does not temporarily lock and does not stop the motor.

14. ES870 RELAY I/O EXPANSION BOARD (SLOT C)

Product-Accessory Compatibility		
Product	**ES870 I/O Expansion board**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	√	
Solardrive Plus	√	

Table 15: Product – ES870 I/O Expansion board compatibility

The ES870 board is an expansion board for the digital I/Os of all the products compatible with this accessory. The ES870 board includes:

- XMDI1/2/3/4/5/6/7/8: Eight 24V multifunction digital inputs, type PNP. Three inputs are “fast propagation” inputs that can be used also for PUSH-PULL 24V encoder acquisition;
- XMDO1/2/3/4/5/6: Six multifunction relay digital outputs (Vomax = 250 VAC, Iomax = 5A, Vomax = 30 VDC, Iomax = 5A).

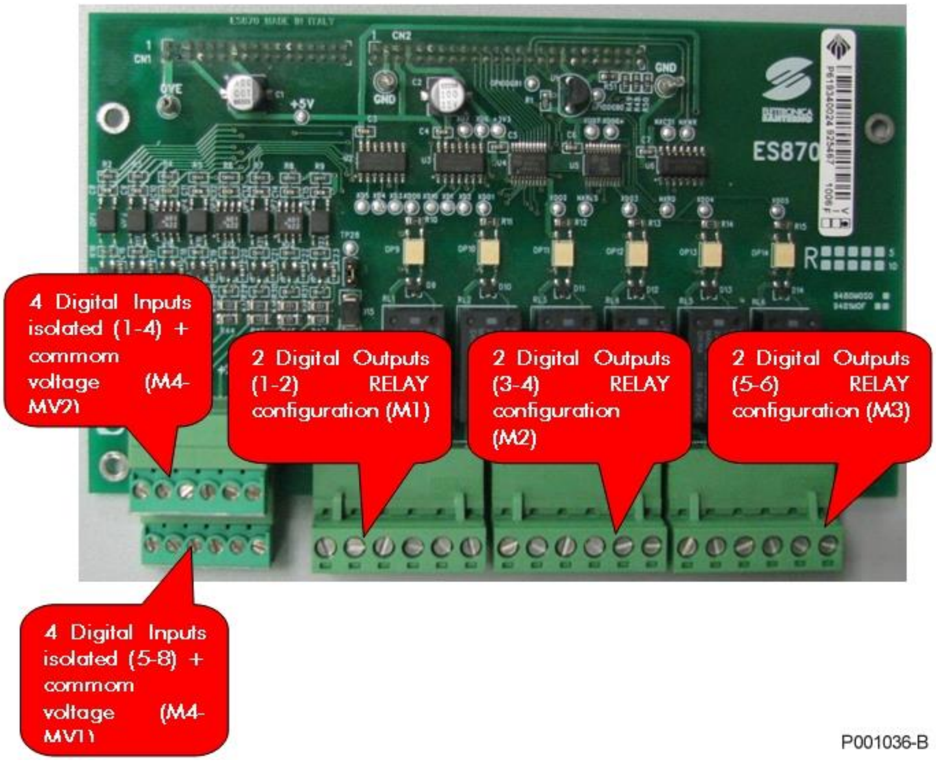


Figure 132: Relay I/O expansion board ES870

14.1. Identification Data

Description	***Part Number***
Relay I/O Board	ZZ0101840

14.2. Installing ES870 Board on the Inverter (Slot C)

DANGER Before gaining access to the components inside the inverter, remove voltage from the inverter and wait at least 20 minutes. Wait for a complete discharge of the internal capacitors to avoid any electric shock hazard.

CAUTION Electric shock hazard: do not connect/disconnect the signal terminals or the power terminals when the inverter is on. This also prevents the inverter from being damaged.

NOTE All the screws used to fasten removable parts (terminals cover, serial interface connector, cable plates, etc.) are black, round-head, cross-head screws.
When wiring the inverter, remove only this type of screws. If different screws or bolts are removed, the inverter warranty will be no longer valid.

1. Remove voltage from the inverter and wait at least 20 minutes.

2. Remove the whole inverter covering by loosening the four hexagonal screws located on the top side and bottom side of the inverter to reach the fixing spacers and the signal connector (Figure 133 – Slot C.)

CAUTION Before removing the inverter cover, draw out the keypad and disconnect the cable connecting the keypad to the control board to avoid damaging the link between the keypad and the control board.

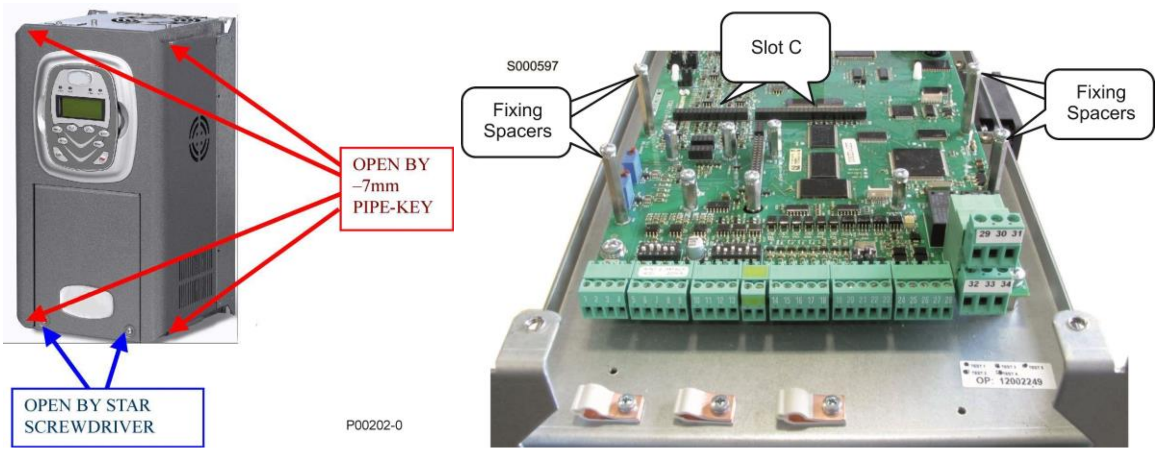


Figure 133: Removing the inverter cover; location of slot C

3. Insert the two contact strips supplied in the bottom part of ES870 board; make sure that each contact enters its slot in the connector. Insert ES870 board over the control board of the drive; make sure that each contact enters its slot in the signal connector. Use the screws supplied to fasten board ES870 to the fixing spacers.

4. For the terminal board wiring, follow the instructions given in the section below.

5. Close the inverter frame by reassembling the cover allowing gaining access to the inverter control terminals.

14.3. ES870 Board Terminals

Screwable terminal board in two extractable sections suitable for cross-sections 0.08 ÷ 1.5 mm^2 (AWG 28-16)
Decisive voltage class A according to EN 61800-5-1.

N.	Name	Description	I/O Features	Notes
1	**XMDI1**	Multifunction auxiliary digital input 1	Opto-isolated digital inputs 24 Vdc; positive logic (PNP): active with positive input in respect to 0VE (terminals 6 or 12). In compliance with EN 61131-2 as type-1 digital inputs with rated voltage equal to 24 Vdc.	Maximum response time to microprocessor: 500 µs
2	**XMDI2**	Multifunction auxiliary digital input 2		
3	**XMDI3**	Multifunction auxiliary digital input 3		
4	**XMDI4**	Multifunction auxiliary digital input 4		
5	**+24VE**	Auxiliary supply output/input for opto-isolated multifunction digital inputs/relay coils (*)	+24 V±15% ; Imax output: 125 mA; I max input: 75 mA Protected with resettable fuse.	
6	**0VE**	0V for digital inputs isolated in respect to control 0V	Opto-isolated zero volt for digital inputs; test voltage 500 Vac 50 Hz 1' in respect to inverter CMA inputs	
7	**XMDI5**	Multifunction auxiliary digital input 5	Opto-isolated digital inputs 24 VDC; positive logic (PNP): active with positive input in respect to 0VE (terminals 6 or 12). In compliance with EN 61131-2 as type-1 digital inputs with rated voltage equal to 24 Vdc.	…500 µs
8	**XMDI6 / ECHA / FINA (*)**	Multifunction auxiliary digital input 6 /Push-pull 24V single-ended phase A encoder input/Frequency input A		Maximum response time to microprocessor: 600 ns
9	**XMDI7 / ECHB (*)**	Multifunction auxiliary digital input 7/ Push-pull 24V single-ended phase B encoder input		
10	**XMDI8 / FINB**	Multifunction auxiliary digital input 8/ Frequency input B		
11	**+24VE**	Auxiliary supply output/input for opto-isolated multifunction digital inputs/relay coils (**)	+24 V±15% ; Imax output: 125 mA; I max input: 75 mA Protected with resettable fuse.	
12	**0VE**	0V for digital inputs isolated in respect to control 0V	Opto-isolated zero volt for digital inputs; test voltage 500 Vac 50 Hz 1' in respect to inverter CMA inputs	

(*)
CAUTION

Terminals **MDI6/ECHA/FIN**A and **MDI7/ECHB** on the control board are no longer active when ES847 is fitted and are automatically replaced by the relevant **XMDI6** and **XMDI7** terminals.

(**)
NOTE

The total load on +24VE inverter connection must not exceed 200 mA. The total load is referred to all +24VE connections available on the main terminal board and the option terminal board. The relay coils fitted on ES870 option board can sink up to 75 mA from +24VE. Coil consumption must be subtracted from the 200 mA rated current capability.
By opening jumper J1, terminal n. 5 and 11 can be used as +24 Vdc supply input for relay coils, unloading the inverter internal power supply.

Screwable terminal board in three extractable sections suitable for cross-sections 0.2 ÷ 2.5 mm² (AWG 24-12)
Decisive voltage class C according to EN 61800-5-1

N.	Name	Description	I/O Features
13	**XDO1-NC**	Multifunction, relay digital output 1 (NC contact)	Change-over contact: with low logic level, common terminal is closed with NC terminal; with high logic level, common terminal is open with NO; Resistive load capability: Vomax = 250 VAC, Iomax = 5A Vomax = 30 VDC, Iomax = 5A Inductive load capability (L/R=7ms): Vomax = 250 VAC, Iomax = 1.5A Vomax = 30 VDC, Iomax = 1.5A Isolation test voltage between contacts and coil 2500Vac 50Hz, 1' Min. load: 15mA, 10Vdc
14	**XDO1-C**	Multifunction, relay digital output 1 (common)	
15	**XDO1-NO**	Multifunction, relay digital output 1 (NO contact)	
16	**XDO2-NC**	Multifunction, relay digital output 2 (NC contact)	
17	**XDO2-C**	Multifunction, relay digital output 2 (common)	
18	**XDO2-NO**	Multifunction, relay digital output 2 (NO contact)	
19	**XDO3-NC**	Multifunction, relay digital output 3 (NC contact)	
20	**XDO3-C**	Multifunction, relay digital output 3 (common)	
21	**XDO3-NO**	Multifunction, relay digital output 3 (NO contact)	
22	**XDO4-NC**	Multifunction, relay digital output 4 (NC contact)	
23	**XDO4-C**	Multifunction, relay digital output 4 (common)	
24	**XDO4-NO**	Multifunction, relay digital output 4 (NO contact)	
25	**XDO5-NC**	Multifunction, relay digital output 5 (NC contact)	
26	**XDO5-C**	Multifunction, relay digital output 5 (common)	
27	**XDO5-NO**	Multifunction, relay digital output 5 (NO contact)	
28	**XDO6-NC**	Multifunction, relay digital output 6 (NC contact)	
29	**XDO6-C**	Multifunction, relay digital output 6 (common)	
30	**XDO6-NO**	Multifunction, relay digital output 6 (NO contact)	

14.4. Connection to an Encoder or a Frequency Input

Auxiliary digital inputs XMDI6, XMDI7, XMDI8 may acquire fast digital signals and may be used for the connection to a push-pull single-ended incremental encoder or for the acquisition of a frequency input.

NOTE When ES847 board is fitted, encoder B functions are no more implemented by the basic terminal board of the control board, but are implemented by ES847 board.

The electrical ratings of the aux digital inputs above are the same as the corresponding inputs in optional control board ES847.
For more details, please refer to Connection to an Encoder or a Frequency Input and ES847 Board Terminals.

15. I/O EXPANSION BOARD 120/240VAC ES988 (SLOT C)

Product-Accessory Compatibility		
Product	**ES988 I/O Expansion board**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	√	
Solardrive Plus	√	

Table 16: Product – ES988 I/O Expansion board compatibility

The ES988 option board 120/240Vac allows incrementing the digital I/O set of all the products compatible with this accessory.
The additional functions made available by ES988 option board are the following:
- N. 8 multifunction opto-isolated digital inputs. Each input features:
  120 Vac ÷ 240 Vac +10% / –15% supply voltage; 50 / 60 Hz frequency
- N. 4 relay multifunction digital outputs. Each output features:

N.1 changeover contact (Vomax = 250 VAC, Iomax = 6 A, Vomax = 30 VDC, Iomax = 6 A)
The digital inputs are divided into four groups; each group features three terminals: two terminals as the inputs and one terminal as the common for the whole group.
The two inputs of each group are to be powered by a single-phase circuit, with the neutral connected to the common of the group.
The four groups are isolated from each other, so that they can be powered also by four different power supply sources.

All digital inputs and relay outputs are programmable. For the programming parameters related to ES988 option board, please refer to the Programming Guide.

Figure 134 shows ES988 option board including the description of the terminal blocks:

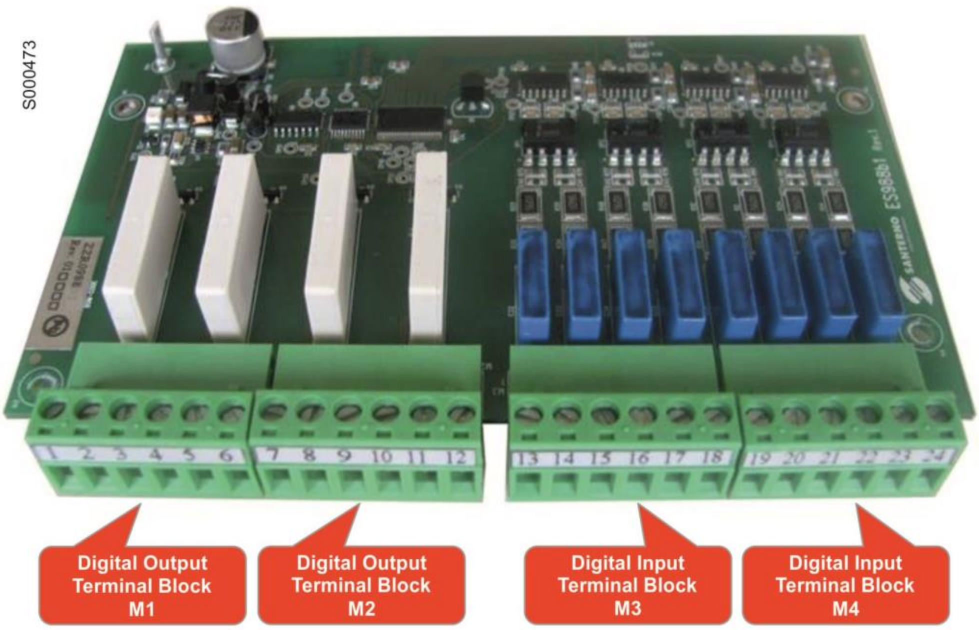


Figure 134: ES988 option board, DIGITAL I/O 120/240 Vrms

15.1. Identification Data

Description	*Part Number*
ES988 DIGITAL I/O 120/240 Vrms	ZZR0988A0

15.2. Installing the ES988 Option Board on the Drives (SLOT C)

1. Remove voltage from the inverter and wait at least 20 minutes.

2. The electronic components of the inverter and the board are sensitive to the electrostatic discharges. Take all the necessary safety measures before accessing the inverter and handling the board. The board should be installed in a workstation equipped with proper grounding and provided with an antistatic surface. If this is not possible, the installer must wear a ground bracelet properly connected to the PE conductor.

3. Loosen the two front screws located in the lower part of the inverter cover to remove the covering of the terminal board. You can then reach slot C in the control board where the ES988 is to be installed, as shown in Figure 135.

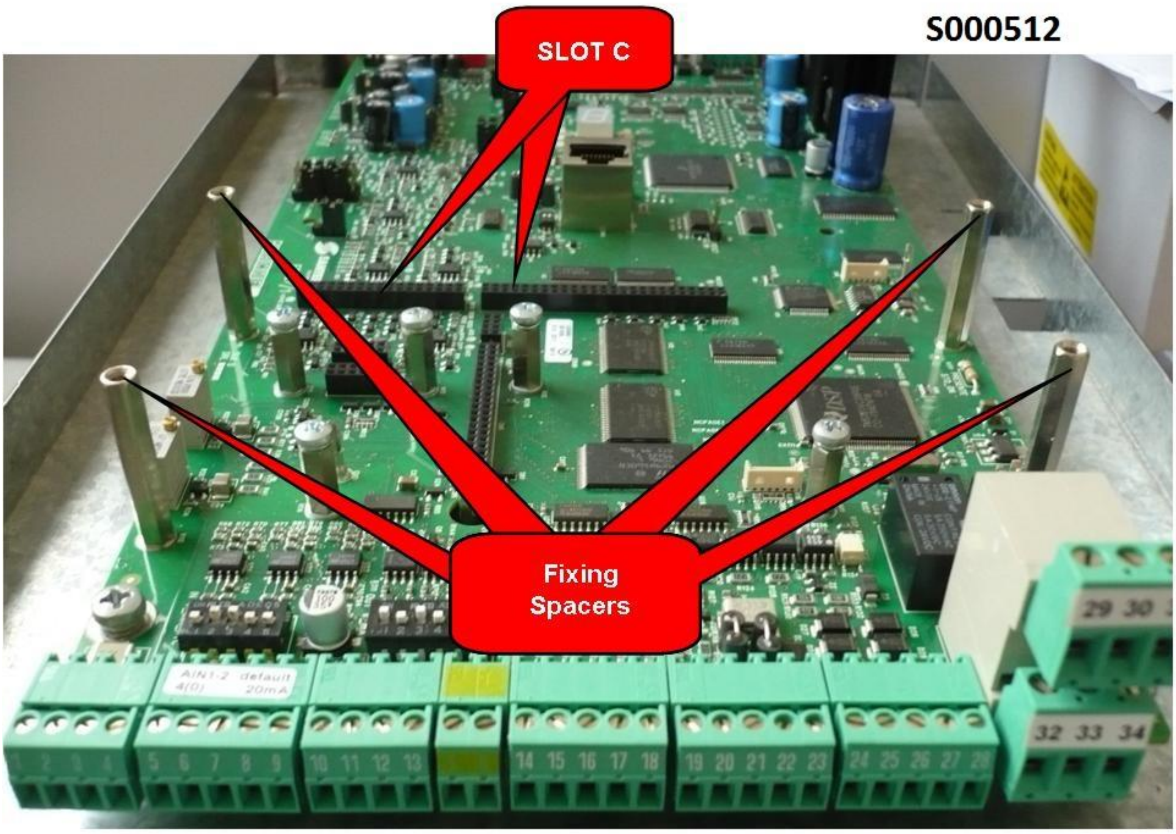


Figure 135: Location of slot C inside the terminal board cover

4. Insert the communications board into slot C. Make sure that the terminal strips with the two connectors in slot C (CN7A and CN7B) are correctly aligned See Figure 136. If the board is correctly installed, the four fastening holes will match with the housings of the fastening screws for the fixing spacers. Tighten the board fixing screws as shown in Figure 171.

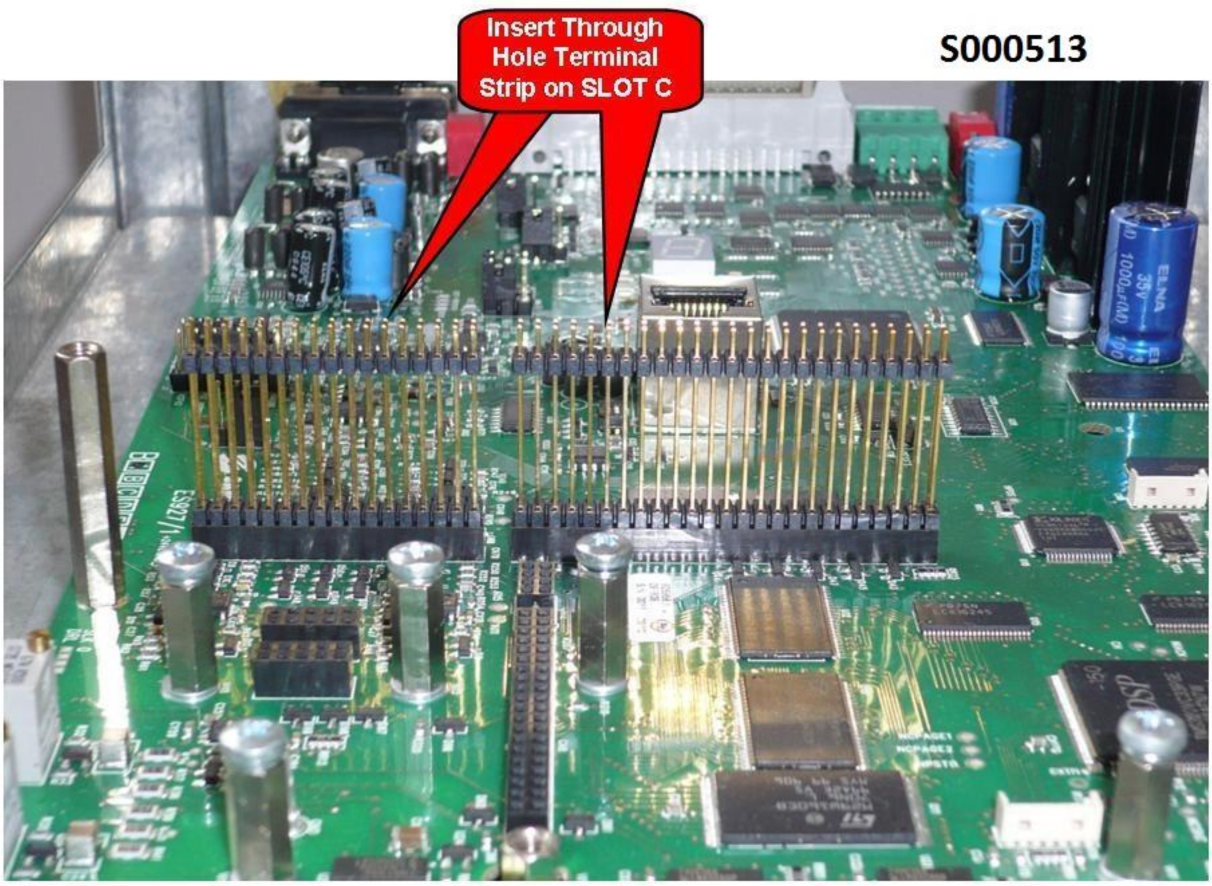
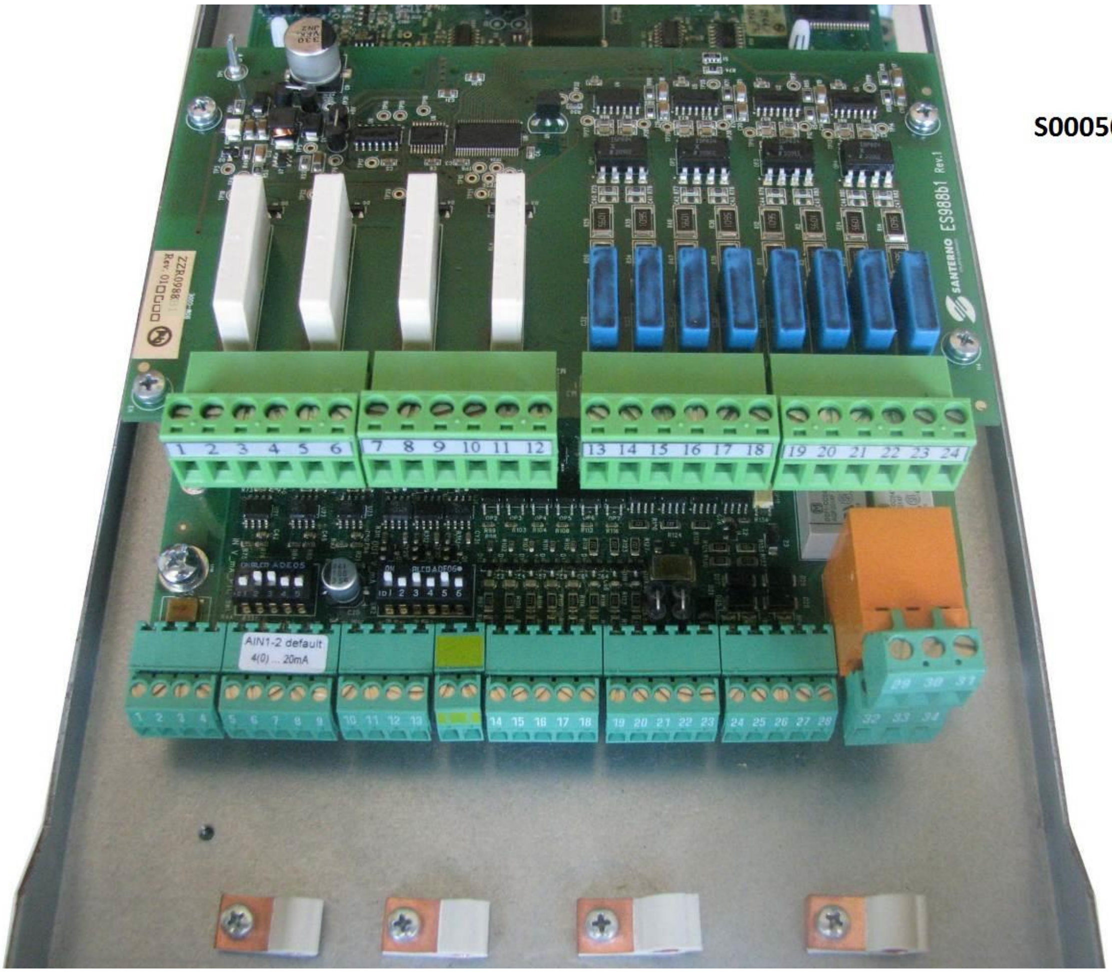


Figure 136: Terminal strips inserted into SLOT C



S000508

Figure 137: Fastening ES988 option board inside the inverter

5. Apply voltage to the inverter and check if LED L1 (+5V voltage correctly applied to board ES988) comes on. Program the parameters related to auxiliary board ES988 following the instructions given in the Programming Guide.

	DANGER	Before gaining access to the components inside the inverter, remove voltage from the inverter and wait at least 20 minutes. Wait for the complete discharge of the internal capacitors to avoid electric shock hazard.
	CAUTION	Do not connect or disconnect signal terminals or power terminals when the inverter is powered to avoid electric shock hazard and to avoid damaging the inverter and/or the connected devices.
	NOTE	All fastening screws for removable parts (terminal cover, serial interface connector, cable path plates, etc.) are black, rounded-head, cross-headed screws. Only these screws may be removed when connecting the equipment. Removing different screws or bolts will void the product guarantee.

15.3. Digital Input Terminals and Relay Output

Loose terminal blocks, 5.08 mm pitch.

Figure 138 shows the pin layout seen from the cable entry.

Figure 138: Input-output signal terminal blocks

Decisive voltage class C according to EN 61800-5-1

N.	*Name*	*Description*
1	COM1	Relay output 1 common
2	NC1	NC Relay output 1
3	NO1	NO Relay output 1
4	COM2	Relay output 2 common
5	NC2	NC Relay output 2
6	NO2	NO Relay output 2
7	COM3	Relay output 3 common
8	NC3	NC Relay output 3
9	NO3	NO Relay output 3
10	COM4	Relay output 4 common
11	NC4	NC Relay output 4
12	NO4	NO Relay output 4
13	MDI1	Digital input 1
14	COM1-2	Digital inputs 1-2 common
15	MDI2	Digital input 2
16	MDI3	Digital input 3
17	COM3-4	Digital inputs 3-4 common
18	MDI4	Digital input 4
19	MDI5	Digital input 5
20	COM5-6	Digital inputs 5-6 common
21	MDI6	Digital input 6
22	MDI7	Digital input 7
23	COM7-8	Digital inputs 7-8 common
24	MDI8	Digital input 8

CAUTION The cable cross-section required for wiring the digital inputs is 0.5 ÷ 2.5 mm². The operating voltage must not be lower than the digital input supply voltage.

CAUTION The cable cross-section required for wiring the relay outputs is 0.5 ÷ 2.5 mm². The operating voltage must not be lower than the relay output supply voltage. The cable cross-section required for the relay outputs is based on the operating current in the relay output contacts.

NOTE The cable path of the digital input cables must not be parallel to the motor cables and must not be close to disturbance sources (relays, motors, inverters, solenoids): the minimum clearance required is over 100 mm.

15.4. ES988 Operating Mode

Figure 139 shows the block diagram of ES988 board as per the digital inputs acquired from the field, the activation of the relay digital outputs to the field and the interface to the control board.
Figure 139 shows the position of LED L1 indicating that +5 V supply voltage is present.

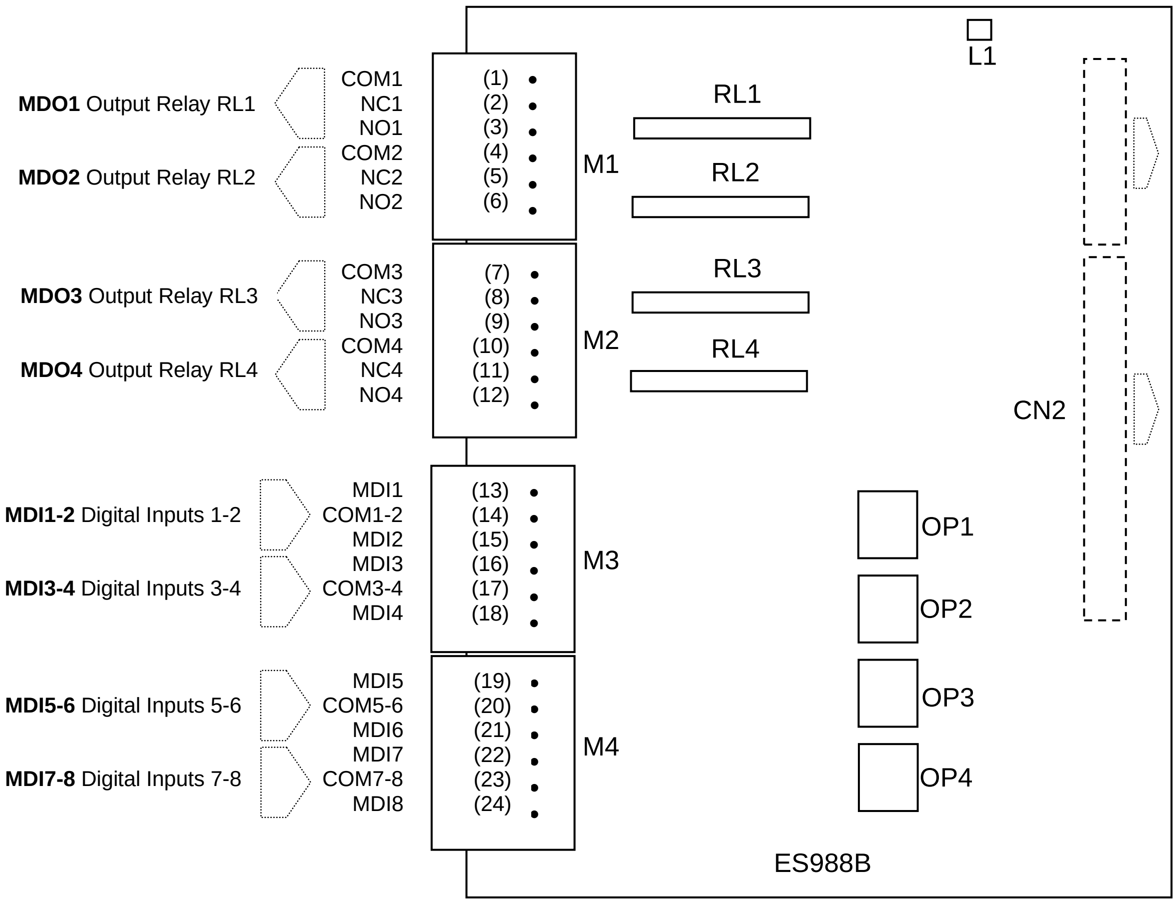


Figure 139: Block diagram for ES988 interfacing

Figure 140 shows an example of how to use digital inputs MDI1-2 and MDI3-4 energized via the same 120 ÷ 240 Vrms single-phase source.

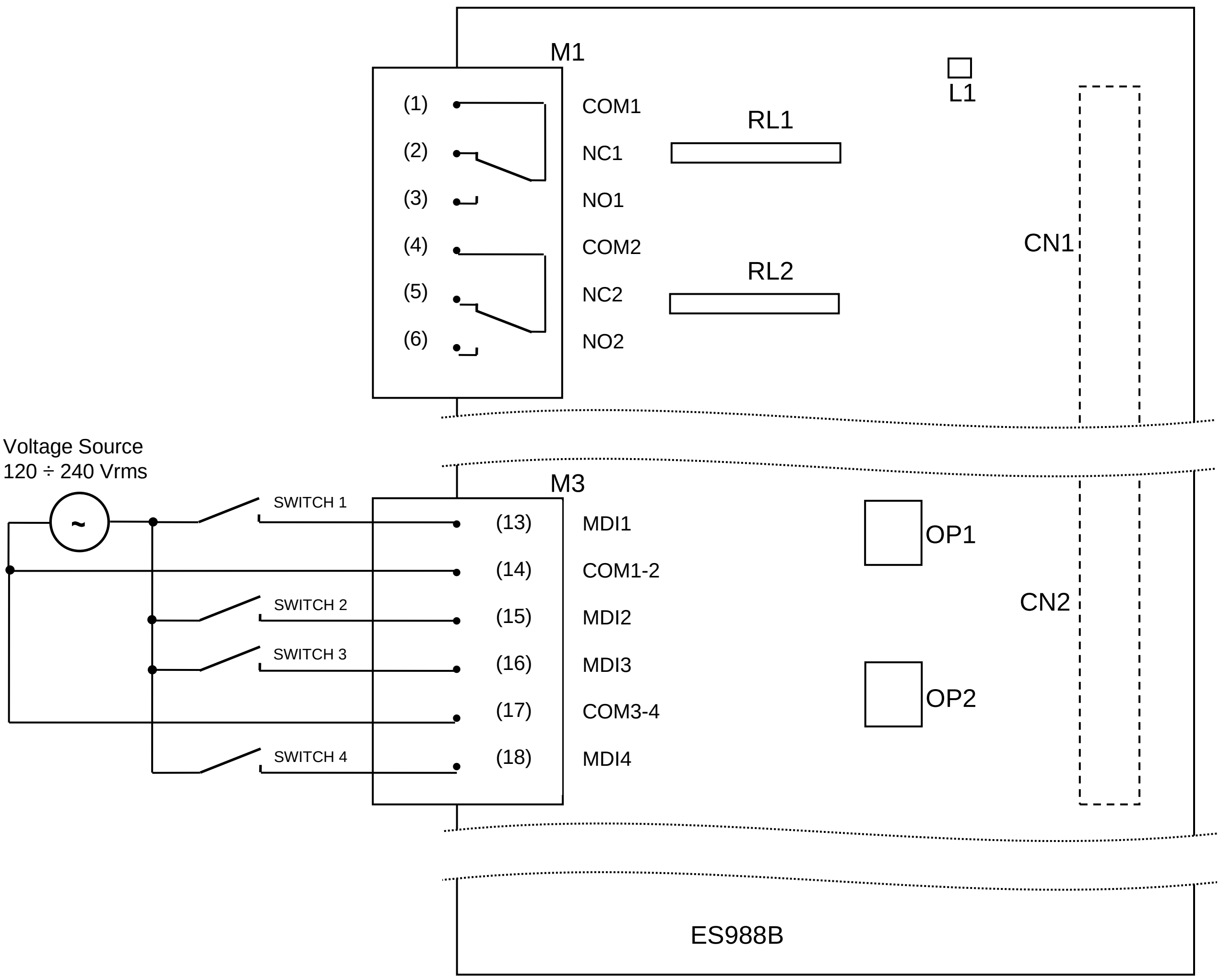


Figure 140: Utilization example of digital inputs on ES988 option board

15.5. Main Features

Santerno drives compatible with this accessory equipped with ES988 option board meet the requirements of EMC Directive 2004/108/CE and LVD 2006/95/CE issued by the European Union. They also comply with the relevant Harmonized Standards.
ES988 option board is made of ‘UL approved’ materials and components.

NOTE The installer is responsible for the observance of all the local regulations in force concerning wiring, health and safety and electromagnetic compatibility.
Carefully consider the conductor cross-sections, the fuses or other safety devices to be installed, as well as the Protective Earthing connection.

15.6. Environmental Conditions

Operating temperature	–10 to +55 °C ambient temperature (contact Enertronica Santerno S.p.A. for higher ambient temperatures)
Relative humidity	5 to 95% (non-condensing)
Max. operating altitude	2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A..

15.7. Electrical Specifications

Decisive voltage class C according to EN 61800-5-1

Digital Input Static Specs	*Value*			
	Min.	*Typ.*	*Max.*	*Unit*
Type of input signal MDI1-2 (MDI1, MDI2 in respect to COM1-2) MDI3-4 (MDI3, MDI4 in respect to COM3-4) MDI5-6 (MDI5, MDI6 in respect to COM5-6) MDI7-8 (MDI7, MDI8 in respect to COM7-8)	Digital inputs from the field			
Input voltage range		120/240	265	V AC
Voltage level for signal “1”	90			V AC
Voltage level for signal “0”			20	V AC
Input current range @ 50 Hz	1.5	1.8 / 3.6	4	mA AC
Input current range @ 60 Hz	1.8	2.2 / 4.4	4.8	mA AC

CAUTION Exceeding the maximum allowable input voltage ratings will result in irreparable damage to the apparatus.

Digital Input Electrical Isolation	*Value*
Isolation of digital inputs MDI1-2 (MDI1, MDI2 in respect to COM1-2)	NO galvanic isolation
Isolation of digital inputs MDI3-4 (MDI3, MDI4 in respect to COM3-4)	NO galvanic isolation
Isolation of digital inputs MDI5-6 (MDI5, MDI6 in respect to COM5-6)	NO galvanic isolation
Isolation of digital inputs MDI7-8 (MDI7, MDI8 in respect to COM7-8)	NO galvanic isolation
Isolation between contiguous sets of digital inputs: MDI1-2 in respect to MDI3-4 MDI3-4 in respect to MDI5-6 MDI5-6 in respect to MDI7-8	1.5 kV AC @ 50 Hz, 60 s
Isolation between digital inputs and Protective Earthing MDI1-2 in conjunction with MDI3-4, MDI5-6, MDI7-8 in respect to Hole H4 for fixing Protective Earthing to control board	1.5 kV AC @ 50 Hz, 60 s
Isolation between digital inputs and control logics MDI1-2 in conjunction with MDI3-4, MDI5-6, MDI7-8 in respect to GND	2.5 kV AC @ 50 Hz, 60 s
Isolation between digital inputs and relay outputs MDI1-2 in conjunction with MDI3-4, MDI5-6, MDI7-8 in respect to MDO1 in conjunction with MDO2, MDO3, MDO4	2.5 kV AC @ 50 Hz, 60 s

Relay Output Static Specs	*Value*			
	Min.	*Typ.*	*Max.*	*Unit*
Type of output signals MDO1 - MDO2 - MDO3 - MDO4	Relay digital signal to field			
AC voltage range / continuous AC current applicable to the contacts (resistive load)			250 / 6	V/A
AC1 Nominal load applicable to contacts (resistive load)			1500	VA
AC15 Nominal load applicable to contacts (inductive load)			300	VA
DC1 Breaking capacity applicable to the contacts (resistive load)			30 / 6 110 / 0.2 220 / 0.12	V/A
DC switchable minimum load			500 (12 / 10)	mW V/A

CAUTION Exceeding the maximum allowable output current and voltage will result in irreparable damage to the apparatus.

Relay Output Electrical Isolation	*Value*
Isolation between contiguous sets of relay outputs MDO1 in respect to MDO2 MDO2 in respect to MDO3 MDO3 in respect to MDO4	1.5 kV AC @ 50 Hz, 60 s
Isolation between relay outputs and Protective Earthing MDO1 in conjunction with MDO2, MDO3, MDO4 in respect to Hole H3 for fixing Protective Earthing to control board	1.5 kV AC @ 50 Hz, 60 s
Isolation between relay outputs and control logics MDO1 in conjunction with MDO2, MDO3, MDO4 in respect to GND	2.5 kV AC @50 Hz, 60 s

16. ES861 RESOLVER AND INCREMENTAL ENCODER BOARD (SLOT C)

Product-Accessory Compatibility		
Product	**ES861 Resolver and Encoder board**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	-	
Solardrive Plus	-	

Table 17: Product – ES861 Resolver and incremental encoder board compatibility

The ES861 board acquires resolver signals and converts them into 12-bit digital signals that can be used as speed and/or position feedback for the products compatible with this accessory.

NOTE Please refer to the Programming Guide and the Guide to the Synchronous Motor Application to check the available control algorithms.

The ES861 board also generates the sinusoidal signal for the resolver excitation and features dedicated logics for the acquisition of differential signals sent from incremental encoders and for the control of opto-isolated digital inputs and outputs.

Main features of the ES861 board:

- Resolver to Digital (RtD) conversion allowing selecting motor position readout or speed readout.
- Configurable frequency and amplitude of the excitation signal to acquire the Resolver encoder with different voltage ratios between excitation and sin/cos signals.
- Encoder input compatible with opto-isolated line-driver (TIA/EIA-422) encoders.
- Line Driver (TIA/EIA-422) incremental encoder output compatible with opto-isolated line-driver (TIA/EIA-422) encoders. It is possible to program the input for encoder repetition or the Resolver input at 1024 pulse/rev.
- Possibility of enabling a frequency divider (by 2, 4, 8) for incremental encoder signals coming from line-driver encoders, or for signals obtained from RtD conversion.
- Configurable encoder supply output (5V, 12V, 24V) allowing output voltage fine-tuning.
- Acquisition of No.3 opto-isolated digital inputs.
- Control of No.3 opto-isolated digital outputs.
- Segregated sections of individually repeated encoder input and encoder output.

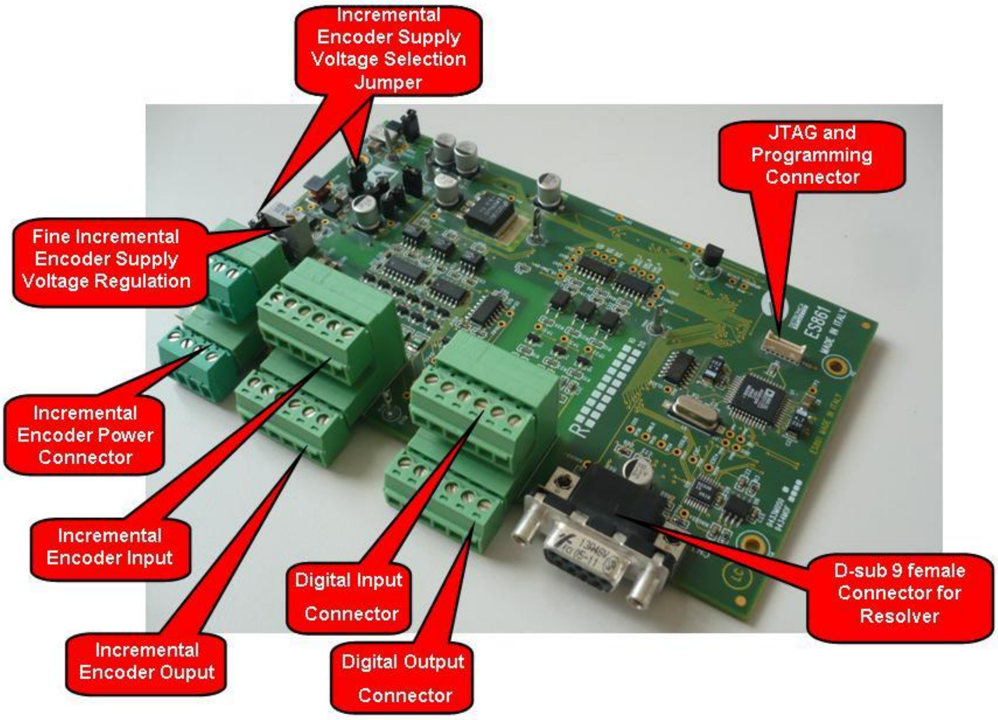


Figure 141: ES861 Incremental Encoder and Resolver expansion board

Features of the encoder inputs:

- 77kHz (1024pls @ 4500rpm) for max. input frequency with digital filter enabled
- 155kHz (1024pls @ 9000rpm) for max. input frequency with digital filter disabled
- Input with differential or single-ended signals
- Input signal error detection.

Features of the resolver inputs:

- Configurable excitation frequency ranging from 10kHz to 20 kHz
- Maximum 30 mA RMS current at excitation output
- Maximum 14.4 Vpp (5 VRMS) voltage at excitation output
- Detection of the PTC signal from the Resolver
- 12-bit RtD for positioning (0.0879° x LSB) or speed acquisition range [–60000 ÷ 60000] rpm.

16.1. Identification Data

Description	*Part Number*	*RESOLVER and COMPATIBLE ENCODERS*
ES861 Resolver and Incremental Encoder Interface	ZZ0101860	• Sin/Cos resolver inputs, 3.6Vpp ± 10% ranging from 10 kHz to 20 kHz. • Incremental encoders with signals on balanced line according to standard TIA/EIA-422 and power supply ranging from 5 to 24V.

16.2. Installing ES861 Board on the Inverter (Slot C)

1. Remove voltage from the inverter and wait at least 20 minutes.
2. The electronic components of the inverter and the board are sensitive to electrostatic discharges. Take any safety measure before operating inside the inverter and before handling the board. The board should be installed in a workstation equipped with proper grounding and provided with an antistatic surface. If this is not possible, the installer must wear a ground bracelet properly connected to the PE conductor.

3. Remove the protective cover of the inverter terminal board by unscrewing the two screws on the front lower part of the cover. Slot C where ES861 board will be installed is now accessible, as shown in the figure below.
4. Insert the ES861 board into Slot C. Make sure that the terminal strips with the two connectors in slot C (CN7A and CN7B) are correctly aligned. If the board is properly installed, the four fixing holes are aligned with the housing of the relevant fixing spacers screws. Check if alignment is correct, then fasten the four fixing screws as show in the figure below.

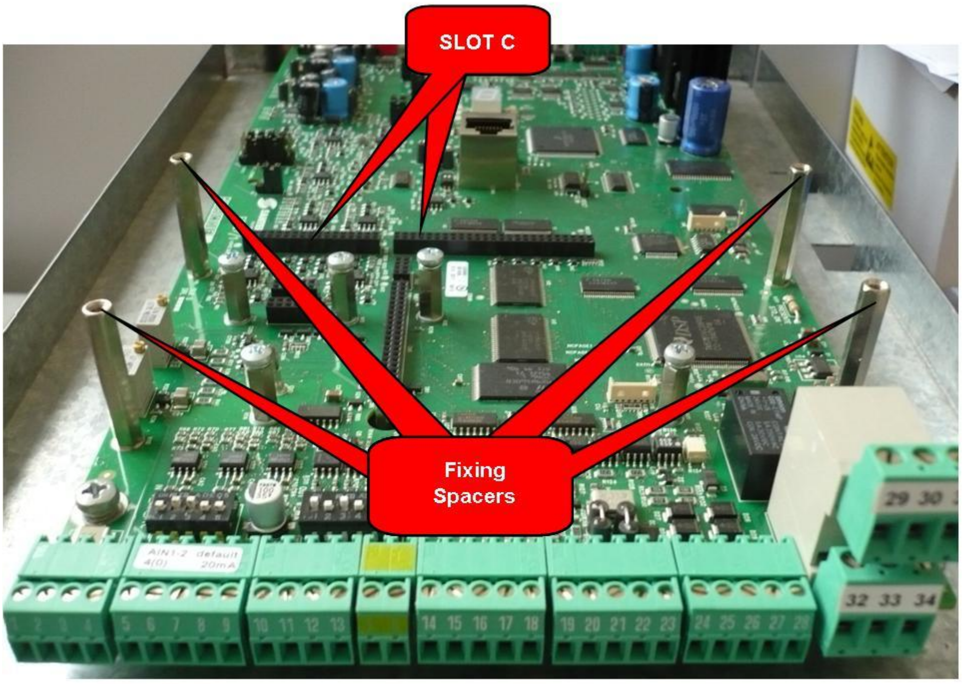


Figure 142: Location of slot C inside the terminal board cover of the drives

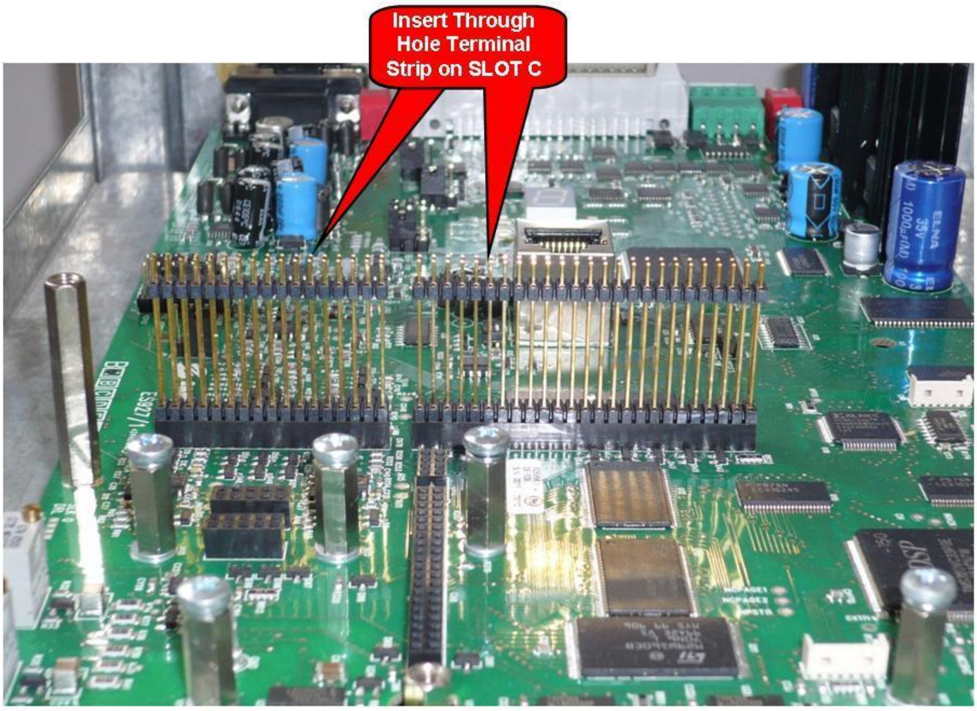


Figure 143: Terminal strips inserted into SLOT C

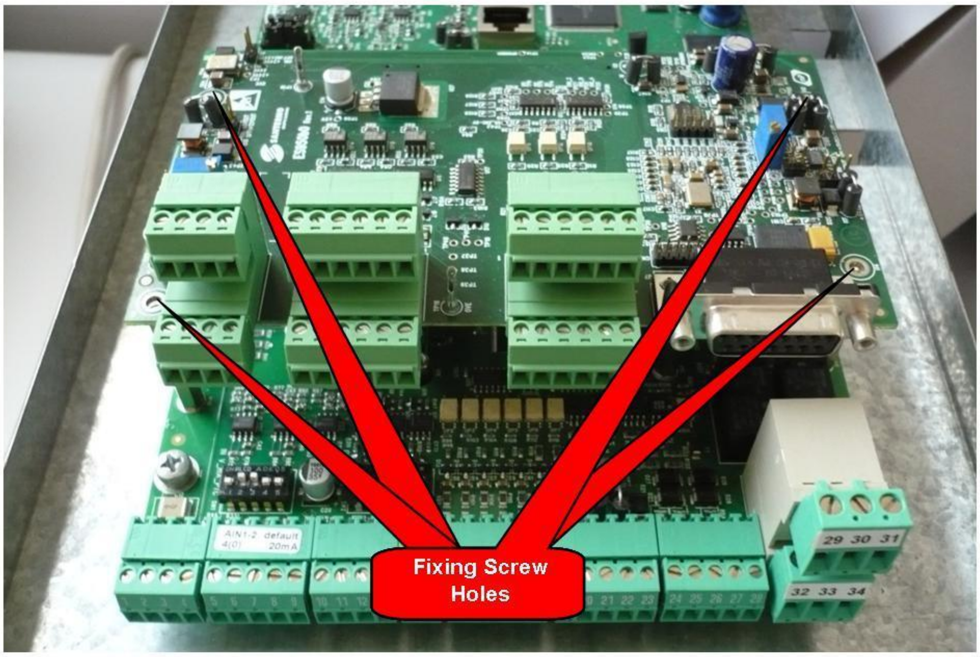


Figure 144: Fitting the ES861 board inside the drive

5. Configure the supply voltage for the incremental encoder (please refer to the relevant User Manual) by setting the configuration jumper accordingly.
6. Power the inverter and check if the supply voltage delivered to the encoder is appropriate. Set up the parameters relating to "Encoder A" as described in the Programming Guide.
7. Remove voltage from the inverter, wait until the inverter has come to a complete stop and connect the encoder/resolver cable.

DANGER	Before gaining access to the components inside the inverter, remove voltage from the inverter and wait at least 20 minutes. Wait for the complete discharge of the internal capacitors to avoid electric shock hazard.
CAUTION	Do not connect or disconnect signal terminals or power terminals when the inverter is powered to avoid electric shock hazard and to avoid damaging the inverter.
NOTE	All fastening screws for removable parts (terminal cover, serial interface connector, cable path plates, etc.) are black, rounded-head, cross-headed screws. Only these screws may be removed when connecting the equipment. Removing different screws or bolts will void the product guarantee.

16.2.1. Resolver Connector

D-sub 9-pin female connector. The figure shows a front view of the PIN layout.

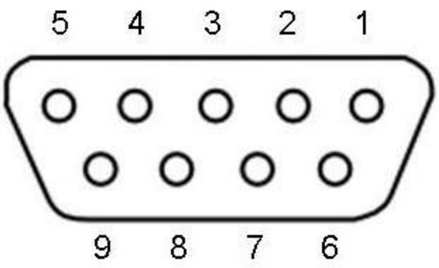


Figure 145: Pin layout on the D-sub 9-pin female connector

Decisive voltage class A according to EN 61800-5-1

N.	***Name***	***Description***
1	EXC+	Resolver excitation output (direct signal)
2	EXC–	Resolver excitation output (complementary signal)
3	SIN+	Sine signal input (direct)
4	SIN–	Sine signal input (complementary)
5	COS+	Cosine signal input (direct)
6	COS–	Cosine signal input (complementary)
7	PTC1	Terminal 1 of the Resolver PTC
8	PTC2	Terminal 2 of the Resolver PTC
9	0V	Board logics power supply common

16.2.2. Incremental Encoder and Digital Lines Connectors

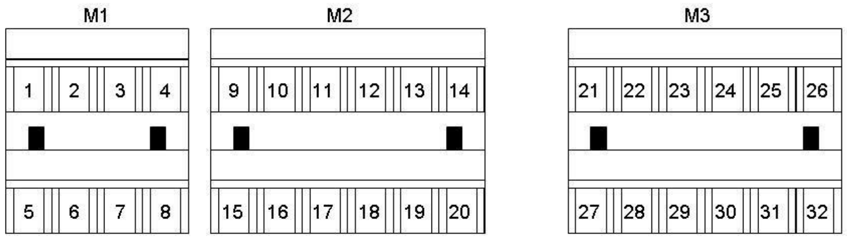


Figure 146: Input-output signal terminal boards

Decisive voltage class A according to EN 61800-5-1

N.	***Name***	***Description***
1	+VEOUT	Incremental encoder power supply output (referred to 0VE)
2	0VE	Isolated power supply common
3	0VE	Isolated power supply common
4	0VE	Isolated power supply common
5	+5V_EXT	Input for external power supply for repeated encoder output* (referred to 0V_EXT)
6	+5VE_INT	Isolated 5V power supply generated internally (referred to 0VE)
7	0V_EXT	External power supply common for repeated encoder output*
8	0VE	Isolated 5V power supply
9	CHA	Channel A input for positive incremental encoder
10	/CHA	Channel A input for inverted incremental encoder (negated)
11	CHB	Channel B input for positive incremental encoder
12	/CHB	Channel B input for inverted incremental encoder (negated)
13	CHZ	Zero index signal
14	/CHZ	Zero index signal (negated)
15	CHA_U	Incremental encoder A signal output from resolver conversion or from encoder input (CHA pin 9) – asserted signal
16	/CHA_U	Incremental encoder A signal output from resolver conversion or from encoder input (/CHA pin 10) – negated signal
17	CHB_U	Incremental encoder B signal output from resolver conversion or from encoder input (CHB pin 11) – asserted signal
18	/CHB_U	Incremental encoder B signal output from resolver conversion or from encoder input (/CHB pin 12) – negated signal
19	CHZ_U	Incremental encoder Z signal output from resolver conversion or from encoder input (CHZ pin 13) – asserted signal
20	/CHZ_U	Incremental encoder Z signal output from resolver conversion or from encoder input (/CHZ pin 14) – negated signal
21	XMDI1	Digital input
22	XMDI2	Digital input
23	XMDI3	Digital input
24	n.c.	
25	n.c.	
26	CMD	Common for digital inputs
27	XMDO1	Digital output 1 (collector)
28	CMDO1	Digital output 1 (emitter)
29	XMDO2	Digital output 2 (collector)
30	CMDO2	Digital output 2 (emitter)
31	XMDO3	Digital output 3 (collector)
32	CMDO3	Digital output 3 (emitter)

(*) In order to get internal power supply of the repeated encoder output, link together terminals 5-6 (+5V_EXT) and 7-8 (0V_EXT).

16.3. ES861 Configuration and Operating Modes

The ES861 board may power both 5V to 24V encoders and allows acquiring signals coming from the Resolver in order to convert the position/speed data into a 12-bit word.

16.4. Configuring and Adjusting the Encoder Supply Voltage

The ES861 board may power encoders having different power supply voltage ratings. A selection jumper and a power supply voltage regulation trimmer are available as shown in the figure below. The jumpers and the trimmer are located on the top side of the board. The possible configurations are given in the table below:

Incremental encoder power supply: VE OUT				No VE OUT
	24V	12V	5V	
J1	X	OFF	ON	X
J2	2-3	1-2	1-2	X
J3	ON	ON	ON	OFF

In 24V mode, the output voltage is fixed and cannot be adjusted. In 5 and 12V mode, the output voltage can be fine-tuned: in 5V mode, the no-load voltage may range from 4.5 to 7V by adjusting each individual trimmer accordingly; in 12V mode, the no-load voltage may range from 10.5 to 17V.
Turn the trimmer clockwise to increase output voltage.
Power supply voltage is to be measured at the encoder supply terminals, thus taking account of cable voltage drops, particularly if a long cable is used.

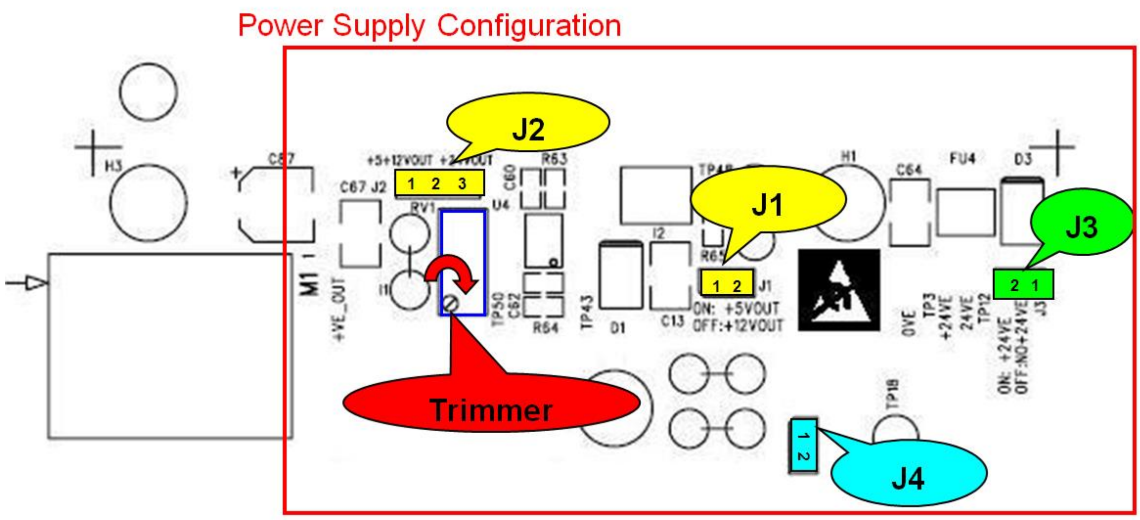


Figure 147: Jumpers and trimmer for power supply configuration

	CAUTION	Supplying the encoder with inadequate voltage may damage the component. Before connecting the cable and after configuring the ES861 board, always use a tester to check the voltage supplied by the board itself.
	CAUTION	The repeated encoder output section must be power supplied ONLY with 5V±10% voltage to terminals 5 (+5V_EXT) and 7 (0V_EXT). It is recommended that the supply voltage generated by the board is applied. That voltage is available at terminals 6 (+5VE_INT) and 8 (0VE). This configuration is obtained by linking terminals 5-6 and 7-8 together. If the signal receiver of the repeated encoder requires a potential-free signal source, an external power supply source is required (5V±10% rated).
	NOTE	The encoder power supply circuit is provided with an electronic current limiter and a resettable fuse. Should a short-circuit occur in the supply output, shut down the inverter and wait a few minutes to give the resettable fuse time to reset.

16.5. Connecting the Resolver Cable

State-of-the-art connections are imperative. Use shielded cables approved by the Resolver and correctly connect cable shielding.

The recommended connection diagram consists in a multipolar, dual shielded cable with four internal pairs individually shielded and isolated external shield. The inner shields are to be connected to the connector case (SH) connected to ES861 board, while the outer shield shall be connected to the encoder frame, usually in common with the motor case.

The motor must always be earthed as instructed with a dedicated conductor attached directly to the inverter earthing point and routed parallel to the motor power supply cables.

It is not advisable to route the encoder cable parallel to the motor power cables. It is preferable to use a dedicated signal cable conduit.

The figure below illustrates the recommended connection method.

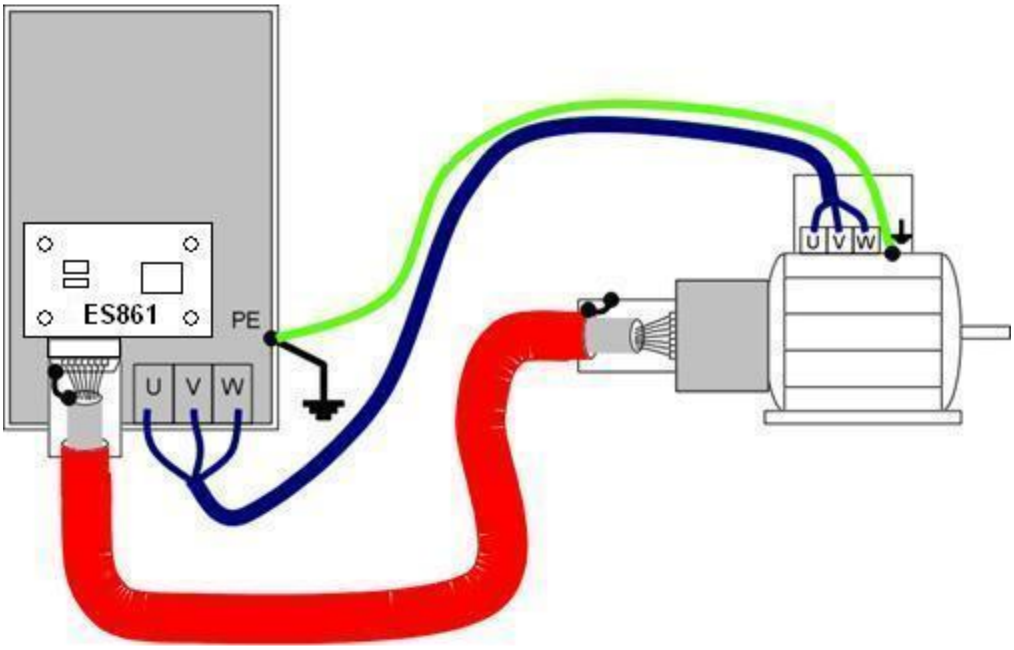


Figure 148: Recommended dual shielded connection for resolver cable

NOTE

The encoder supply output and the encoder signal common are isolated in respect to the common of the analog signals fitted in the inverter terminal board (CMA). Do not connect any conductors in common between the encoder signals and the signals in the inverter terminal board. This prevents isolation from being adversely affected.

The connector of ES861 board shall be connected exclusively to the encoder using one single cable. Do not feed back the cable on terminal boards or DC-link connectors.

CAUTION

Correctly fasten the cable and the connectors both on the encoder side and on ES861 board side. The disconnection of one cable or even a single conductor may lead to inverter malfunction and may cause the motor to run out of control.

16.6. Environmental Requirements

Operating temperatures	–10 to +55 °C ambient temperature (contact Enertronica Santerno S.p.A. for higher ambient temperatures)
Relative humidity	5 to 95% (non-condensing)
Max. allowable operating altitude	2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A..

16.7. Electrical Ratings

Decisive voltage class A according to EN 61800-5-1

Incremental encoder power supply output	*Value*			
	Min	*Typ*	*Max*	*Unit*
Encoder output current, +24V configuration			150	mA
Encoder output current, +12V configuration			200	mA
Encoder output current, +5V configuration			500	mA
24VE Short-circuit protection level			300	mA
Encoder supply voltage adjusting range in 5V mode (no-load voltage)	4.5	5.3	7	V
Encoder supply voltage adjusting range in 12V mode (no-load voltage)	10.5	12.0	17	V

Static characteristics for signal inputs	*Value*			
	Min	*Typ*	*Max*	*Unit*
Type of input signals, SIN, COS	Resolver signals			
Differential input voltage (between SIN+ and SIN-; between COS+ and COS-)		3.6		V
Input common mode voltage range in respect to AGND	0.2		5	V
Input impedance	1			Mohm
Type of input signals, CHA, CHB, CHZ	Standard TIA/EIA-422			
Differential input voltage range			±7	V
Input common mode voltage range			±7	V
Input impedance	150			ohm
Type of input signals MDI1, MDI2, MDI3 in respect to COM_MDI	Digital signals from the field			
Input voltage range	15	24	30	V

Max. absolute values	*Value*			
	Min	*Typ*	*Max*	*Unit*
Maximum allowable common mode voltage amplitude for channels CHA, CHB, CHZ	–25		+25	V

CAUTION Exceeding the maximum differential input or common mode voltages will result in irreparable damage to the apparatus.

Dynamic characteristics of the Resolver to Digital converter	*Value*			
	Min	*Typ*	*Max*	*Unit*
Band (signal amplitude modulating frequency)	1.5	1.7	2	kHz
Tracking Rate			60000	rpm

CAUTION Exceeding the input signal frequency limits will result in a wrong measurement of the encoder position and speed. Depending on the control method selected for the inverter, it may also cause the motor to run out of control.

Static characteristics of the digital outputs and the encoder outputs	*Value*			
	Min	*Typ*	*Max*	*Unit*
Type of input signals CHA_U, CHB_U, CHZ_U	Standard TIA/EIA-422			
High logic level voltage	2.5			V
Low logic level voltage			0.5	V
Limited common mode voltage	±5.6			V
Maximum current	50			mA
Type of output signals, MDOC-E1, MDOC-E2, MDOC-E3	“Open Collector” switch			
Voltage applicable to MDOC without static absorption in “open” configuration			5	V
Maximum current that can be absorbed in “closed” configuration			50	mA

CAUTION Exceeding the range in the table may cause irreparable damage to the equipment.

Static and dynamic characteristics for resolver signal excitation	*Value*			
	Min	*Typ*	*Max*	*Unit*
EXC, /EXC Output Voltage (load max. 30 mA, self-adjusted)			14.4	Vpp
EXC, /EXC Frequency	10, 12, 15, 20			kHz

17. ES950 BISS/ENDAT ENCODER BOARD (SLOT C)

Product-Accessory Compatibility		
Product	**ES950 BISS/EnDat Encoder board**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	-	
Solardrive Plus	-	

Table 18: Product – ES950 BISS/EnDat Encoder board compatibility

The ES950 BiSS/EnDat encoder board allows connecting absolute encoders with digital serial interface using mutually exclusive BiSS and EnDat 2.2 protocols and allows using them to provide speed feedback and/or position feedback for the products compatible with this accessory.

NOTE Please refer to the Programming Guide and the Guide to the Synchronous Motor Application.

The absolute measurement allows detecting the exact position of the motor as soon as the inverter is started, thus avoiding demanding alignment checks.
The ES950 board also features control logics for additional functions, such as the acquisition of differential incremental signals from external encoders and the control of opto-isolated digital inputs/outputs.

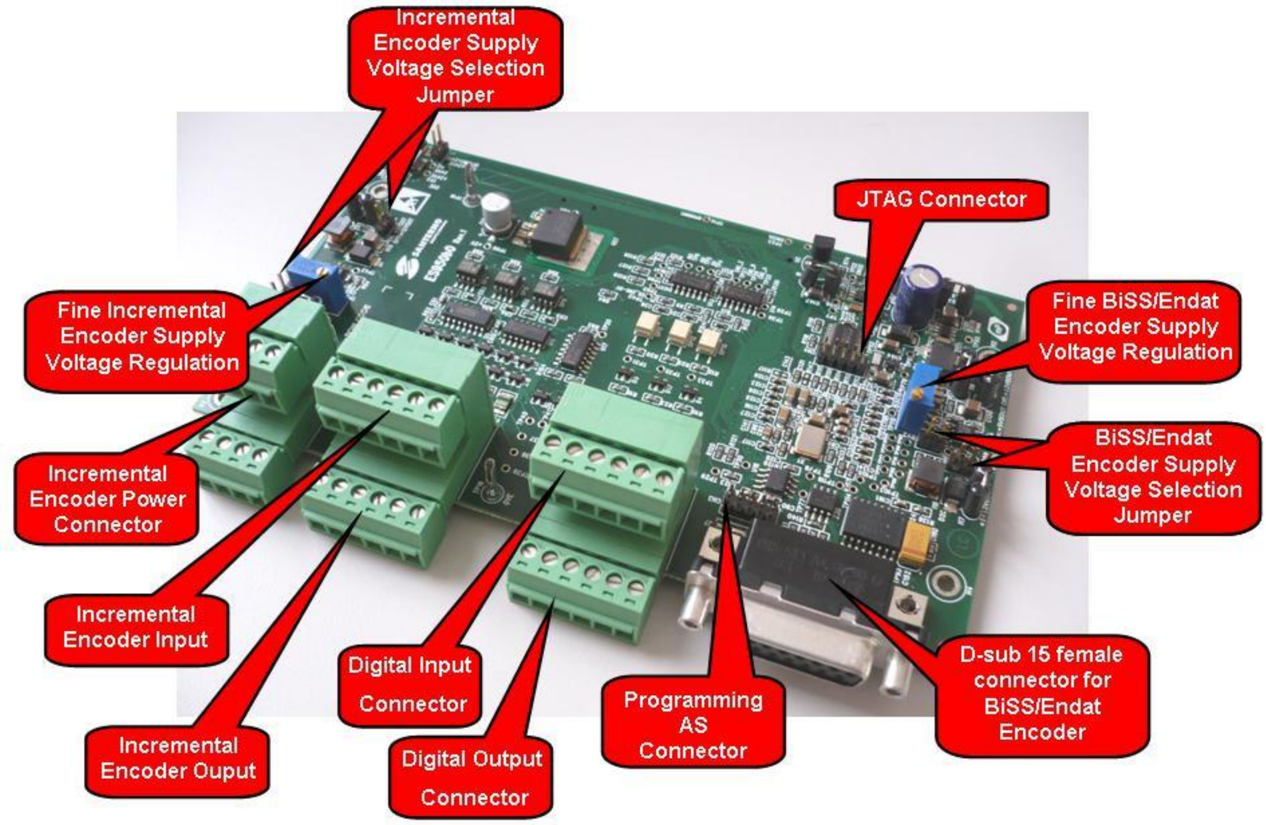


Figure 149: ES950 encoder BiSS/EnDat board

Features of the ES950 board:

- Acquisition of absolute position from SingleTurn/MultiTurn Encoder with balanced digital output (TIA/EIA-485) according to EnDat 2.2 protocol, up to max. 8MHz transmission frequency and variable resolution depending on the type of encoder.
- Acquisition of absolute position from SingleTurn/MultiTurn Encoder with balanced digital output (TIA/EIA-485) according to BiSS protocol, up to max. 10MHz transmission frequency and variable resolution depending on the type of encoder.
- Acquisition of differential incremental encoder signals compatible with opto-isolated line-driver (TIA/EIA-422) encoders.
- Galvanic isolation on all the lines.
- Configurable 5V, 12V, 24V output for BiSS/EnDat encoder supply allowing fine-tuning, isolated from the control logics.
- Configurable 5V, 12V, 24V output for external incremental encoders allowing fine-tuning, isolated from the control logics.
- Possibility to repeat the acquired incremental signals over line-driver (TIA/EIA-422) standard.
- Possibility to enable a frequency divider (by 2, 4, 8) for incremental encoder signals coming from line-driver encoders.
- Acquisition of No.3 opto-isolated digital inputs.
- Control of No.3 opto-isolated digital outputs.

The features for the incremental encoder inputs are as follows:

- 77kHz (1024pls @ 4500rpm) max. input frequency when the digital filter is enabled
- 155kHz (1024pls @ 9000rpm) max. input frequency when the digital filter is disabled
- Input with differential or single-ended signals
- Input signal error detection.

17.1. Identification Data

Description	***Part Number***	***COMPATIBLE ENCODERS***
ES950 EnDat Encoder Interface	ZZ0101880	• Absolute encoders with balanced digital EnDat interface according to TIA/EIA-485 standard and power supply voltage ranging from 5 to 24V. • Incremental encoders with balanced line signals according to TIA/EIA-422 standard and power supply voltage ranging from 5 to 24V
ES950 BiSS Encoder Interface	ZZ0101890	• Absolute encoders with balanced digital BiSS interface according to TIA/EIA-485 standard and power supply ranging from 5 to 24V. • Incremental encoders with balanced line signals according to TIA/EIA-422 standard and power supply voltage ranging from 5 to 24V.

17.2. Installing ES950 Board on the Inverter (Slot C)

1. Remove voltage from the inverter and wait at least 20 minutes.
2. The electronic components in the inverter and the communications board are sensitive to electrostatic discharge. Take any safety measure before operating inside the inverter and before handling the board. The board should be installed in a workstation equipped with proper grounding and provided with an antistatic surface. If this is not possible, the installer must wear a ground bracelet properly connected to the PE conductor.

3. Remove the protective cover of the inverter terminal board by unscrewing the two screws on the front lower part of the cover. Slot C housing the control board of the inverter where ES950 board will be installed is now accessible, as shown in the figure below.
4. Insert ES950 board into Slot C. Make sure that the terminal strips with the two connectors in slot C (CN7A and CN7B) are correctly aligned If the board is properly installed, the three fixing holes are aligned with the housing of the relevant fixing spacers screws. Check if alignment is correct, then fasten the three fixing screws as show in the figure below.

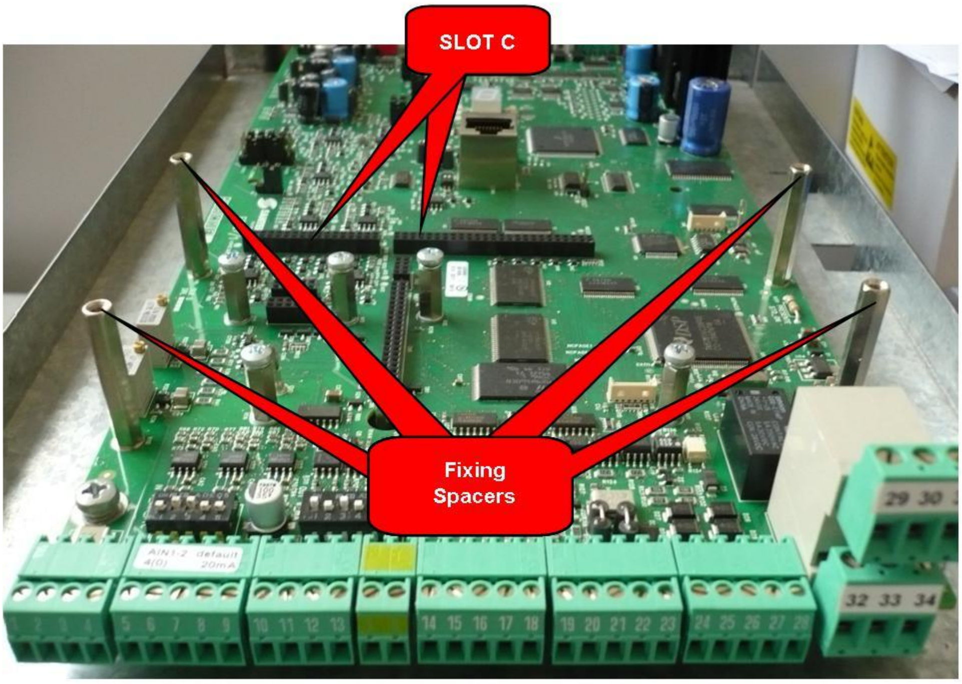


Figure 150: Location of slot C inside the terminal board cover in the drives

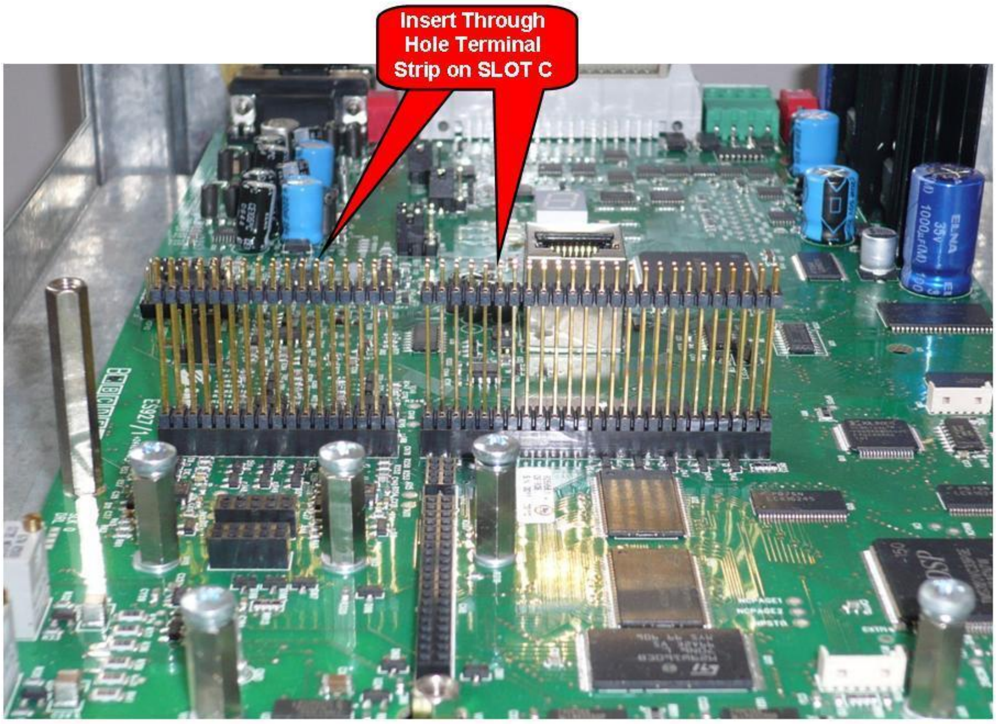


Figure 151: Terminal strips inserted into SLOT C

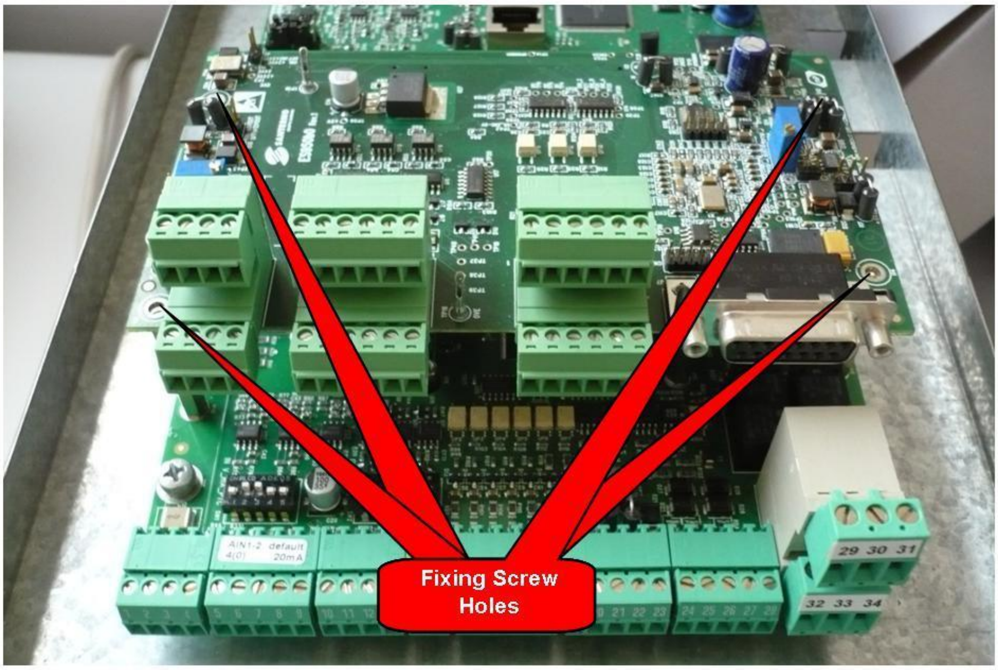


Figure 152: Fitting the ES950 board inside the inverter

5. Configure the supply voltage for the incremental encoder (please refer to the relevant User Manual) by setting the configuration jumper accordingly.
6. Power the inverter and check if the supply voltage delivered to the encoder is appropriate. Set up the parameters relating to the encoder as described in the Programming Guide.
7. Remove voltage from the inverter, wait until the inverter has come to a complete stop and connect the encoder cable.

	DANGER	Before gaining access to the components inside the inverter, remove voltage from the inverter and wait at least 20 minutes. Wait for the complete discharge of the internal capacitors to avoid electric shock hazard.
	CAUTION	Do not connect or disconnect signal terminals or power terminals when the inverter is powered to avoid electric shock hazard and to avoid damaging the inverter.
	NOTE	All fastening screws for removable parts (terminal cover, serial interface connector, cable path plates, etc.) are black, rounded-head, cross-headed screws. Only these screws may be removed when connecting the equipment. Removing different screws or bolts will void the product guarantee.

17.2.1. BiSS/EnDat Encoder Connector

D-sub 15-pin female connector (two rows). The figure shows a front view of the pin layout.

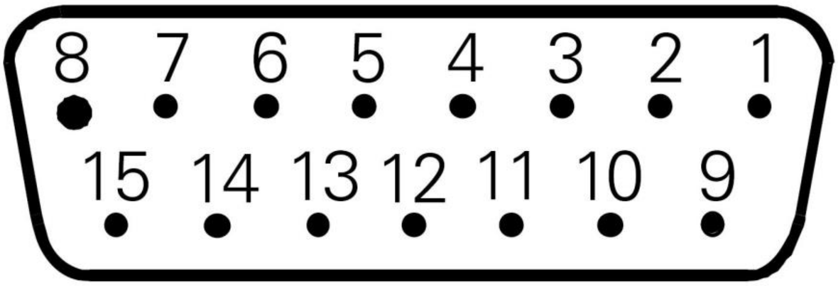


Figure 153: Pin layout on CN7 D-sub 15-pin female connector

Decisive voltage class A according to EN 61800-5-1

N.	***Name***	***Description***
1	0VE	Common for power supply and signals
2	0VE	Common for power supply and signals
3	+VEOUT_EB	Encoder power supply output
4	+VEOUT_EB	Encoder power supply output
5	DATA+	Positive data signal
6	Earth	Earth connection (PE conductor) if J7 is closed
7	n.c.	
8	TCLK+	Positive clock signal
9	reserved	
10	reserved	
11	n.c.	
12	n.c.	
13	DATA–	Negative data signal
14	n.c.	
15	TCLK–	Negative clock signal
Shell	PE	Connector shield connected to PE conductor of the inverter

17.2.2. Incremental Encoder and Digital Line Connectors

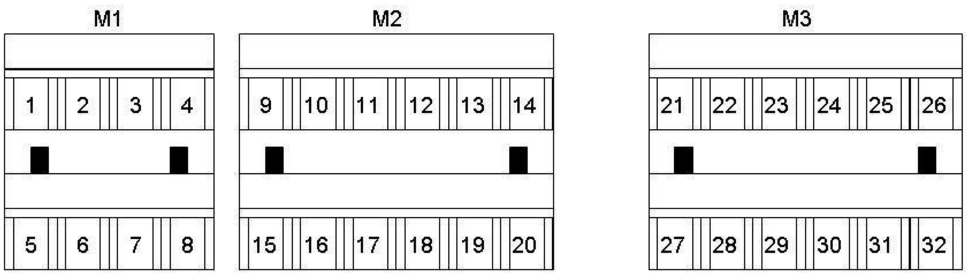


Figure 154: Input-output signal terminal board

Decisive voltage class A according to EN 61800-5-1

N.	***Name***	***Description***
1	+VEOUT	Incremental encoder power supply output
2	0VE	Isolated power supply common
3	0VE	Isolated power supply common
4	0VE	Isolated power supply common
5	+5V_EXT	External power supply input for incremental encoder
6	+5V_INT	Isolated 5V power supply generated from ES950 board
7	+0V_EXT	External power supply common
8	0VE	Isolated power supply common
9	CHA	Channel A input for positive incremental encoder
10	/CHA	Channel A input for negative incremental encoder
11	CHB	Channel B input for positive incremental encoder
12	/CHB	Channel B input for negative incremental encoder
13	CHZ	Positive zero index signal
14	/CHZ	Negative zero index signal
15	CHA_U	Encoder simulation (CHA pin 9) - positive signal
16	/CHA_U	Encoder simulation (/CHA pin 10) - negative signal
17	CHB_U	Encoder simulation (CHB pin 11) - positive signal
18	/CHB_U	Encoder simulation (/CHB pin 12) - negative signal
19	CHZ_U	Encoder simulation (CHZ pin 13) - positive signal
20	/CHZ_U	Encoder simulation (/CHZ pin 14) - negative signal
21	XMDI1	Digital input
22	XMDI2	Digital input
23	XMDI3	Digital input
24	n.c.	
25	n.c.	
26	CMD	Common for digital inputs
27	XMDO1	Digital output 1
28	CMDO1	Common for digital input 1
29	XMDO2	Digital output 2
30	CMDO2	Common for digital output 2
31	XMDO3	Digital output 3
32	CMDO3	Common for digital output 3

17.3. ES950 Configuration and Operating Modes

The ES950 encoder interface board may power both 5V to 24V encoders and allows absolute encoders readout via two different protocols based on the same types of signals: one data line and one clock line.

1	**BiSS mode**	Biss Encoder (differential lines DATA+/ DATA–, TCLK+/ TCLK–)
2	**EnDat mode**	EnDat Encoder (differential lines DATA+/ DATA–, TCLK+/ TCLK–)

The figure shows the block diagram of the ES950 board for encoder interfacing (independently of whether using the Biss or EnDat protocol) and for interfacing with the control board. The figure also shows the acquisition logics for the digital lines from/to the field and the interface with external incremental encoders (if any).

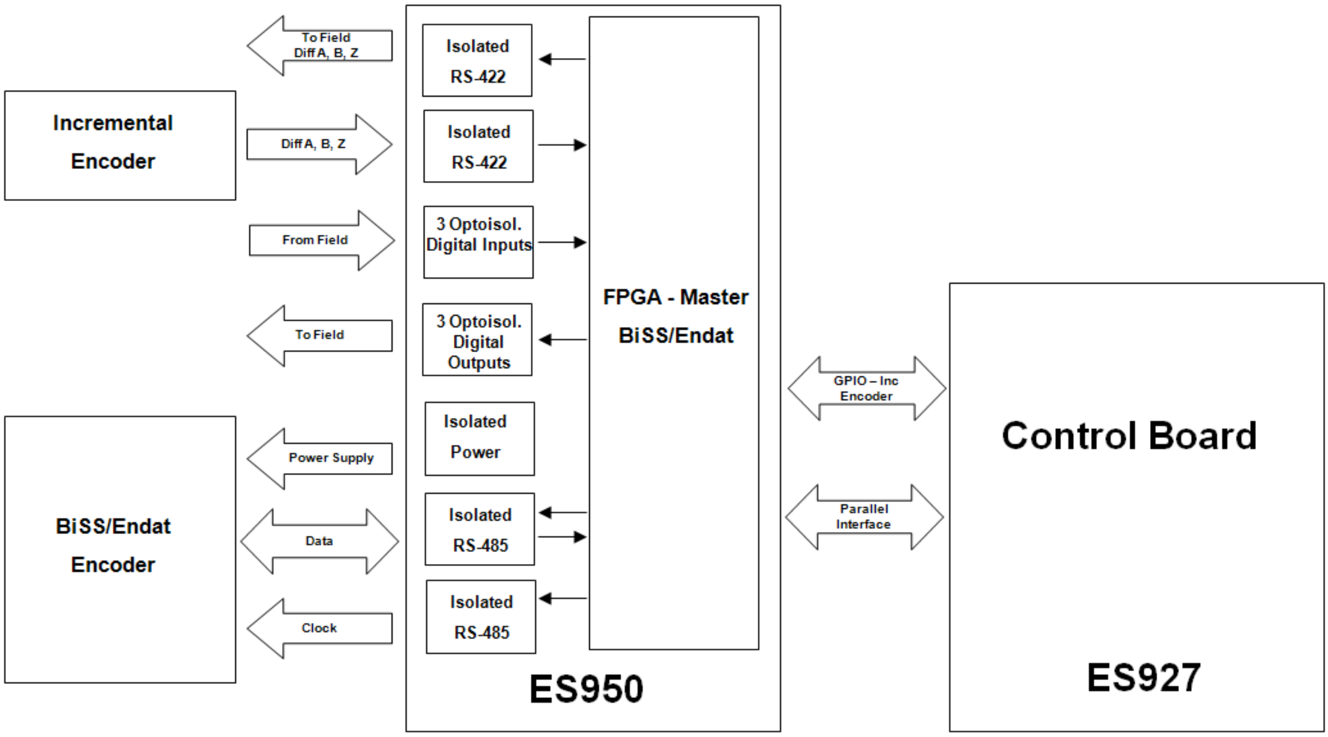


Figure 155: Block diagram for ES950 board interface

BiSS/EnDat absolute encoders are power supplied via the ES950 board according to their own specifications. Power supply is isolated in respect to the control logics. BiSS/EnDat absolute encoders interface with a Master implemented on FPGA controlling the different protocols to send absolute position information to the control board via parallel interface.
Through the FPGA Master via parallel interface, the control board may read/write additional information internally to the encoder.
The states of the opto-isolated digital inputs/outputs can be accessed via parallel interface as well, whereas the incremental lines coming from the relevant encoder, even if going through the FPGA Master, reach the control board via dedicated lines.
The ES950 board also features an error detecting mechanism for the signals sent from the incremental encoder.
Dedicated outputs make it possible to repeat the acquired encoder signals possibly applying a frequency divider by 2, 4, 8.
The protocol is chosen by programming the board (in off-line mode) accordingly and by setting proper parameters in the control board software.

17.3.1. BiSS Operating Mode

BiSS is an open source serial protocol developed by IC-HAUS. The configuration adopted for the products compatible with this accessory uses the point-point version B allowing reading the encoder absolute position (divided into SingleTurn and MultiTurn depending on the encoder being used) and allowing R/W of the logs internal to the encoder.

17.3.2. EnDat Operating Mode

EnDat is a serial protocol proprietary of Heidenhain. It is dedicated to point-to-point connections with absolute encoders (absolute position information divided by SingleTurn and MultiTurn depending on the encoder). In the products compatible with this accessory, the EnDat protocol allows reading the encoder absolute position and allows R/W of the logs internal to the encoder.

17.3.3. Configuring and Adjusting the Encoder Supply Voltage

The ES950 board may power encoders having different power supply voltage ratings. A selection jumper and a power supply voltage regulation trimmer are available as shown in Figure 156. The jumpers and the trimmer are located on the top side of the board. The possible configurations are given in the table below.

Incremental encoder supply: VE OUT				No VE OUT
	24V	12V	5V	
J1	X	OFF	ON	X
J2	2-3	1-2	1-2	X
J3	ON	ON	ON	OFF

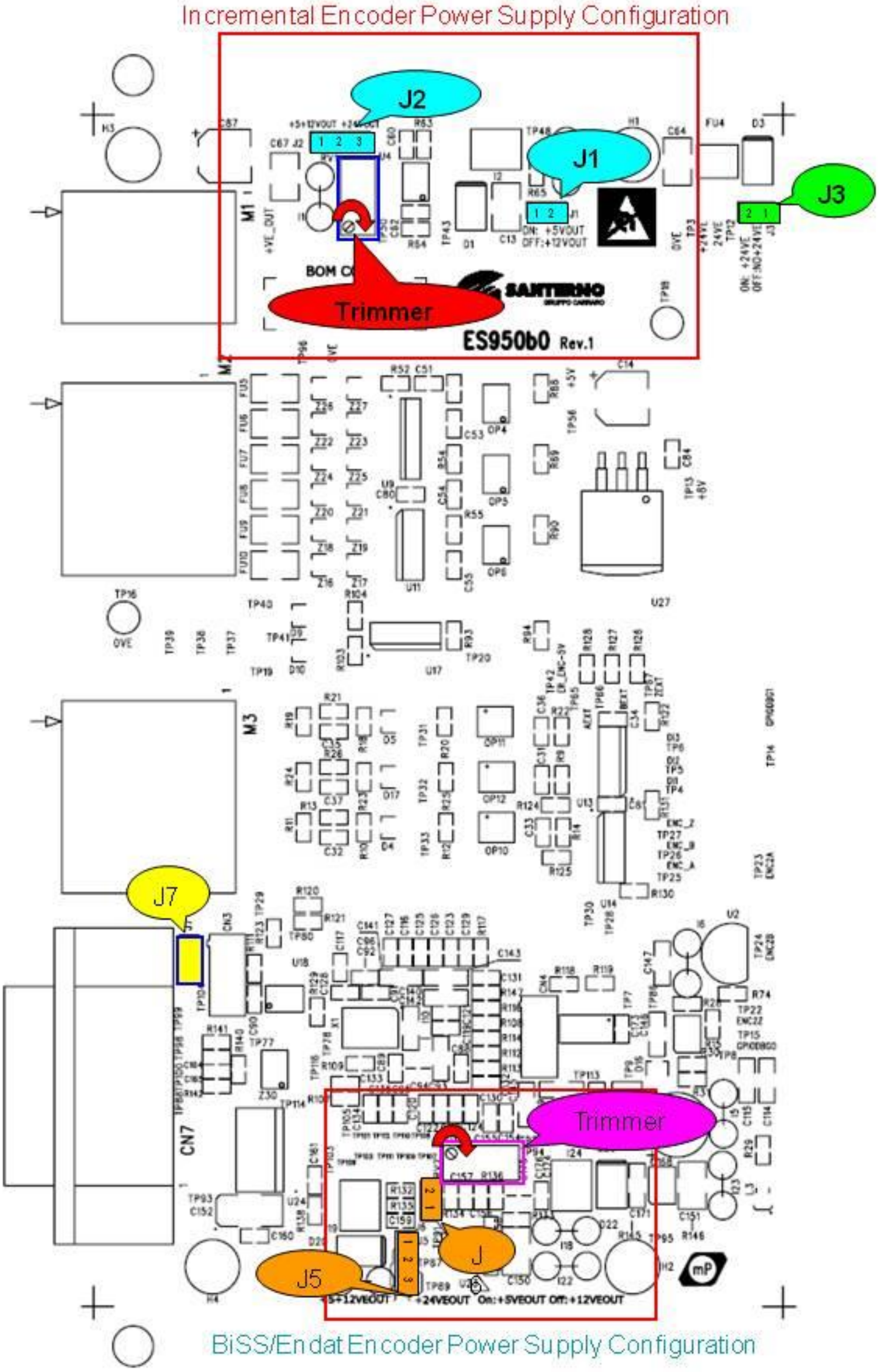


Figure 156: Jumpers and trimmer for power supply configuration

BiSS/EnDat encoder supply: VE OUT EB				No VE OUT EB
	24V	12V	5V	
J6	X	OFF	ON	X
J5	2-3	1-2	1-2	X
J3	ON	ON	ON	OFF

In 24V mode, the output voltage is fixed and cannot be adjusted. In 5 and 12V mode, the output voltage can be fine-tuned: in 5V mode, the no-load voltage may range from 4.5 to 7V by adjusting each individual trimmer accordingly; in 12V mode, the no-load voltage may range from 10.5 to 17V.
Turn the trimmer clockwise to increase output voltage.
This allows meeting the Biss/EnDat encoder requirements by taking account of voltage drops in cables and connector contacts.

- Encoder EnDat (Heidenhain): power supply typically ranges from [3.6÷14]V, [3.6÷5.25]V, [5±5%]V depending on the type of encoder being used. The latest standard, EnDat 2.2, covers [3.6÷14]V.
- Encoder BiSS: [7÷30]V, [10÷30]V, [5±10%]V

Power supply voltage is to be measured at the encoder supply terminals, thus taking account of cable voltage drops, particularly if a long cable is used.

CAUTION Supplying the encoder with inadequate voltage may damage the component. Before connecting the cable and after configuring the ES950 board, always use a tester to check the voltage supplied by the board itself.

NOTE The encoder power supply circuit is provided with an electronic current limiter and a resettable fuse. Should a short-circuit occur in the supply output, shut down the inverter and wait a few minutes to give the resettable fuse time to reset.

17.4. Connecting the Encoder Cable

State-of-the-art connections are imperative. Use shielded cables and correctly connect cable shielding.
Connect the external shielding directly to the connector plug (ES950 side) and to the connector or to a pin (if any) connected to the encoder frame (motor side). The CN7 connector plug is internally grounded.
If the cable has multiple shieldings, connect the internal shieldings to each other and connect them to the common 0V power supply and signals in ES950 (pin 1 or 2 in 15-pin CN7 connector). Do not connect the internal and external shieldings to each other, either along the cable or to the encoder.
The recommended connection diagram consists in a multipolar, dual shielded cable. The inner shield shall be connected to the connector case connected to ES950 board, while the outer shield shall be connected to the encoder frame, usually in common with the motor frame. If the inner shield is not connected to the encoder frame, this can be connected to the inner braid.
The motor must always be earthed as instructed with a dedicated conductor attached directly to the inverter earthing point and routed parallel to the motor power supply cables.
It is not advisable to route the Encoder cable parallel to the motor power cables. It is preferable to use a dedicated signal cable conduit.

The welding jumper J7 enables grounding pin 6 in CN7 connector:

J7	ON	Pin 6 connected to PE conductor through ES950
	OFF	Pin 6 *not* connected to PE conductor through ES950

The figure below illustrates the recommended connection method.

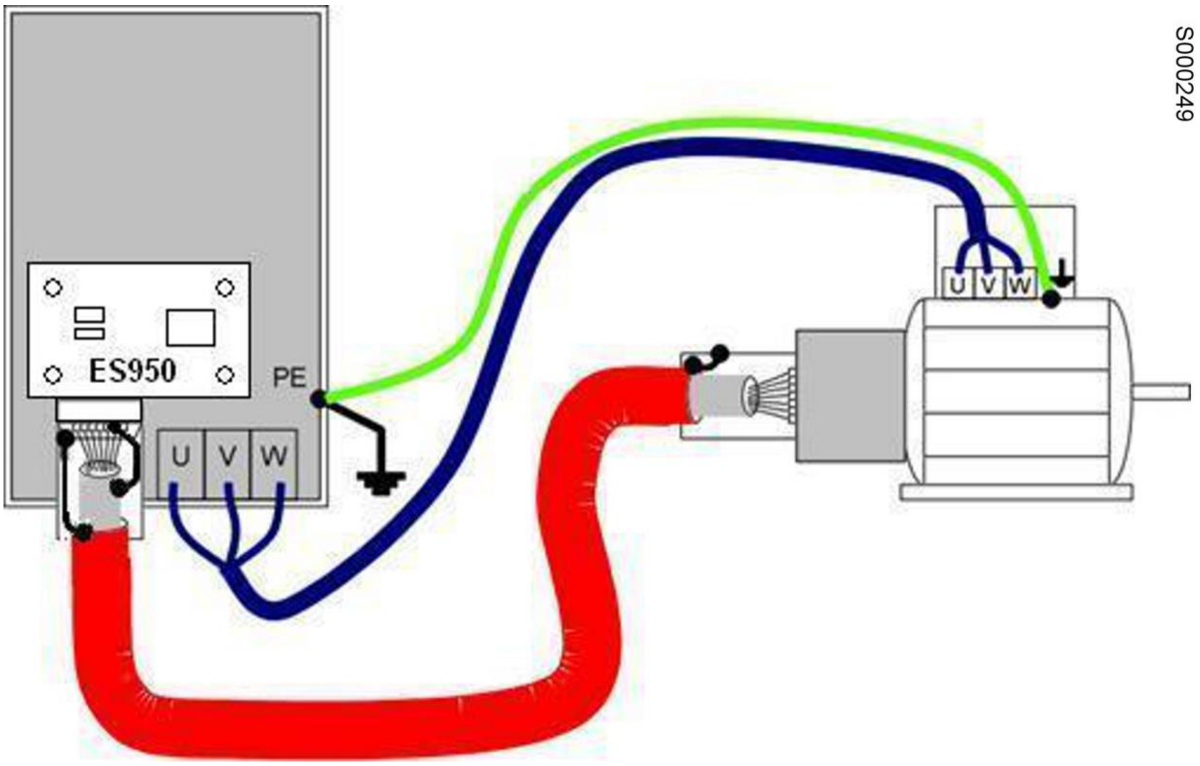


Figure 157: Recommended dual shielded connection for encoder cable

NOTE

The encoder supply output and the encoder signal common are isolated in respect to the common of the analog signals fitted in the inverter terminal board (CMA). Do not connect any conductors in common between the encoder signals and the signals in the inverter terminal board. This prevents isolation from being adversely affected.

The connector of ES950 board shall be connected exclusively to the encoder using one single cable.

CAUTION

Correctly fasten the cable and the connectors both on the encoder side and on ES950 board side. The disconnection of one cable or even a single conductor can lead to inverter malfunction and may cause the motor to run out of control.

17.4.1. Environmental Requirements

Operating temperatures	–10 to +55 °C ambient temperature (contact Enertronica Santerno S.p.A. for higher ambient temperatures)
Relative humidity	5 to 95% (non-condensing)
Max. allowable operating altitude	2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A..

17.4.2. Electrical Ratings

Decisive voltage class A according to EN 61800-5-1

Encoder supply output	*Value*			
	Min	*Typ*	*Max*	*Unit*
Encoder output current, +24V configuration			150	mA
Encoder output current, +12V configuration			200	mA
Encoder output current, +5V configuration			500	mA
24VE Short-circuit protection level			300	mA
Encoder supply voltage adjusting range in 5V mode (no-load voltage)	4.5	5.3	7	V
Encoder supply voltage adjusting range in 12V mode (no-load voltage)	10.5	12.0	17	V

Static characteristics of the input signals	*Value*			
	Min	*Typ*	*Max*	*Unit*
Type of input signals DATA+, DATA–, TCLK+, TCLK–	Standard TIA/EIA-485			
Differential input voltage range			12/–7	V
Input common mode voltage range			12/–7	V
Input impedance (termination)	120			ohm
Type of input signals CHA, CHB, CHZ	Standard TIA/EIA-422			
Differential input voltage range			±7	V
Input common mode voltage range			±7	V
Input impedance	150			ohm
Type of input signals MDI1, MDI2, MDI3 in respect to COM_MDI	Digital signals from the field			
Input voltage range	15	24	30	V

Max. absolute values	*Value*			
	Min	*Typ*	*Max*	*Unit*
Maximum allowable common mode voltage amplitude causing no damage on inputs DATA+, DATA–, TCLK+, TCLK–	–7		+12	V
Maximum allowable differential voltage amplitude on channels CHA, CHB, CHZ	–25		+25	V

CAUTION Exceeding the maximum differential input or common mode voltages will result in irreparable damage to the apparatus.

Dynamic characteristics of the input signals	*Value*
Max. frequency of Biss protocol digital signals	10 MHz
Max. frequency of EnDat protocol digital signals	8 MHz

CAUTION Exceeding the input signal frequency limits will result in a wrong measurement of the encoder position and speed. Depending on the control method selected for the inverter, it may also cause the motor to run out of control.

Static characteristics of the digital outputs and the encoder outputs	*Value*			
	Min	*Typ*	*Max*	*Unit*
Type of input signals CHA_U, CHB_U, CHZ_U	Standard TIA/EIA-422			
High logic level voltage	2.5			V
Low logic level voltage			0.5	V
Limited common mode voltage	±5.6			V
Maximum current	50			mA
Type of input signals MDOC-E1, MDOC-E2, MDOC-E3	“Open Collector”			
Voltage applicable to MDOC with no static absorption in “open” configuration			5	V
Maximum current that can be absorbed in “closed” configuration			50	mA

CAUTION Exceeding the maximum differential input or common mode voltages will result in irreparable damage to the apparatus.

18. ES966 ENCODER BOARD HIPERFACE (SLOT C)

Product-Accessory Compatibility		
Product	**ES966 Encoder Hiperface Board**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	-	
Solardrive Plus	-	

Table 19: Product – ES966 Hiperface Encoder board compatibility

The encoder board Hiperface ES966 enables interfacing absolute encoders with digital serial outputs based on Hiperface protocol that can be used as speed feedback and/or position feedback on the products compatible with this accessory.

NOTE Please refer to the Programming Guide and to the Guide to the Synchronous Motor Application to check the available control algorithms.

The absolute measurement allows getting the exact position of the motor when the system is started; in addition, the current delivered at start is such as to ensure the maximum torque, with no need to perform complex alignment adjustments at start.
The ES966 encoder board features additional functions, such as the acquisition of differential incremental signals from external encoders and the control of opto-isolated digital inputs and outputs.
It is possible to use the ES966 encoder board for Sin/Cos 5ch absolute encoders or Sin/Cos 3ch incremental encoders.
ES966 board also features additional functions:

- Acquisition of differential incremental signals from external encoders.
- Acquisition/implementation of opto-isolated digital links from/to the field.
- Acquisition of a temperature sensor.

The board features are given below:

- Acquisition of absolute position of Hiperface Encoder (RS485 and Sin/Cos) and variable resolution depending on the encoder model.
- Acquisition of differential, incremental encoder signals coming from external sources and compatible with opto-isolated, Line Driver (TIA/EIA-422) encoders.
- Galvanic isolation on all lines from/to external sources.
- Output for Hiperface encoder power supply configurable via hardware at 5V, 12V, 24V with fine-tuning option, isolated from the control logic.
- Output for external incremental encoder power supply configurable at 5V, 12V, 24V with fine-tuning option, isolated from the control logics.
- Possibility of re-addressing the acquired signals (even processed) from incremental encoders to external sources over Line Driver (TIA/EIA-422) standard.
- Acquisition of 3 opto-isolated digital lines coming from the field.
- Implementation of 3 opto-isolated digital lines to the field.
- Acquisition of motor temperature sensor, type PTC, KTY84 or PT100, selectable via DIP-switch.

The features related to the incremental encoder inputs are as follows:

- 77KHz (1024imp @ 4500rpm): max. input frequency with digital filter enabled.

- 155KHz (1024imp @ 9000rpm): max. input frequency with digital filter disabled.
- Input with Differential or Single-Ended signals.
- Error detection over input signals.

The figure below shows the ES966 board including the description of the terminal boards and the components to be used for the board setting:

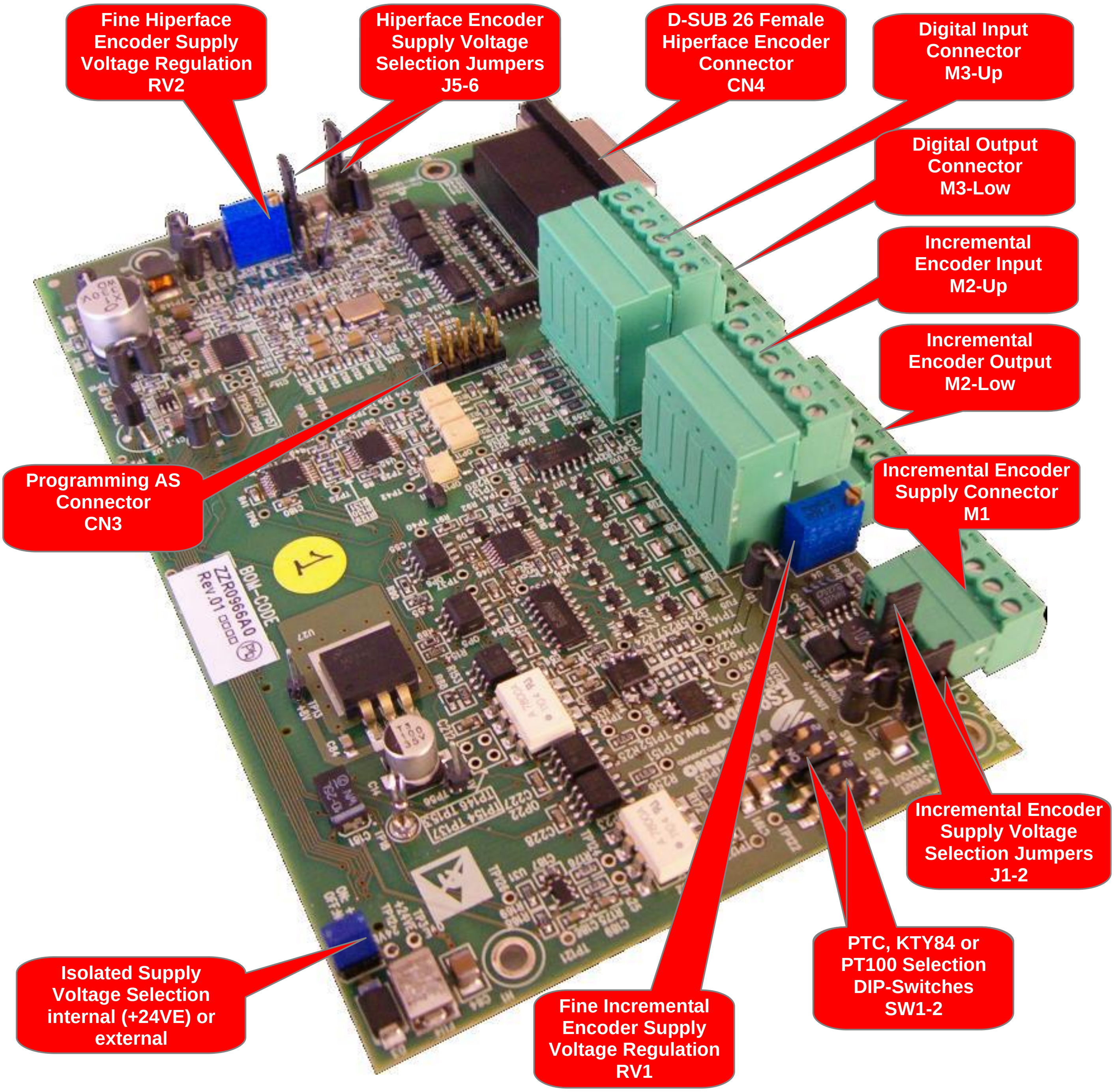


Figure 158: ES966 Hiperface Encoder Board

18.1. Part Number

Description	*Part Number*
ES966 Encoder Hiperface	ZZ0101895

18.2. Installing the ES966 Board on the Inverter (SLOT C)

1. Remove voltage from the inverter and wait at least 20 minutes.
2. The electronic components of the inverter and the board are sensitive to electrostatic discharges. Take any safety measure before operating inside the inverter and before handling the board. The board should be installed in a workstation equipped with proper grounding and provided with an antistatic surface. If this is not possible, the installer must wear a ground bracelet properly connected to the PE conductor.

3. Remove the protective cover of the inverter terminal board by unscrewing the two screws on the front lower part of the cover. Slot C where the ES966 board will be installed is now accessible, as shown in the figure below.

4. Insert the ES966 board into Slot C. Make sure that the terminal strips with the two connectors in slot C (CN7A and CN7B) are correctly aligned. See Figure 159, Figure 160 and following figures. If the board is properly installed, the four fixing holes are aligned with the housing of the relevant fixing spacers screws. Check if alignment is correct, then fasten the four fixing screws as show in Figure 161.

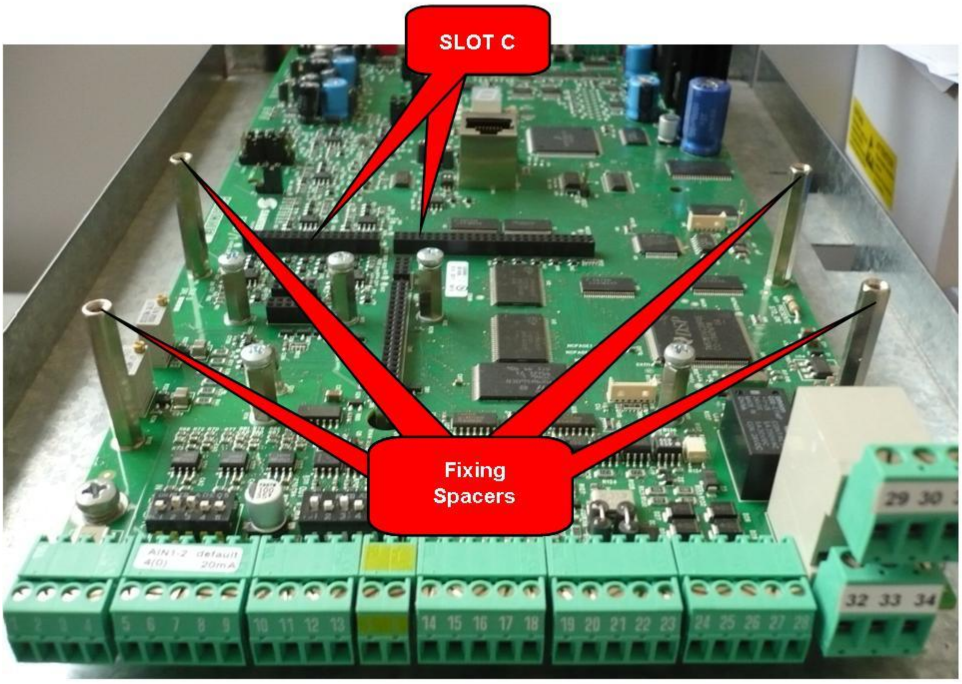


Figure 159: Location of slot C inside the terminal board cover of the drive

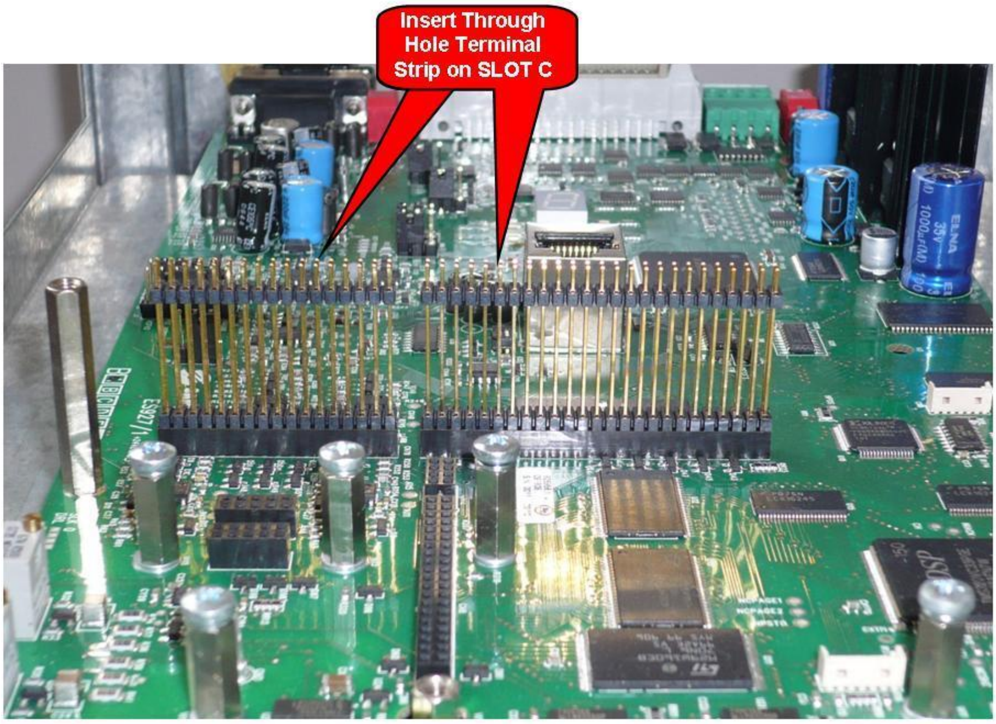


Figure 160: Inserting terminal strips to slot C

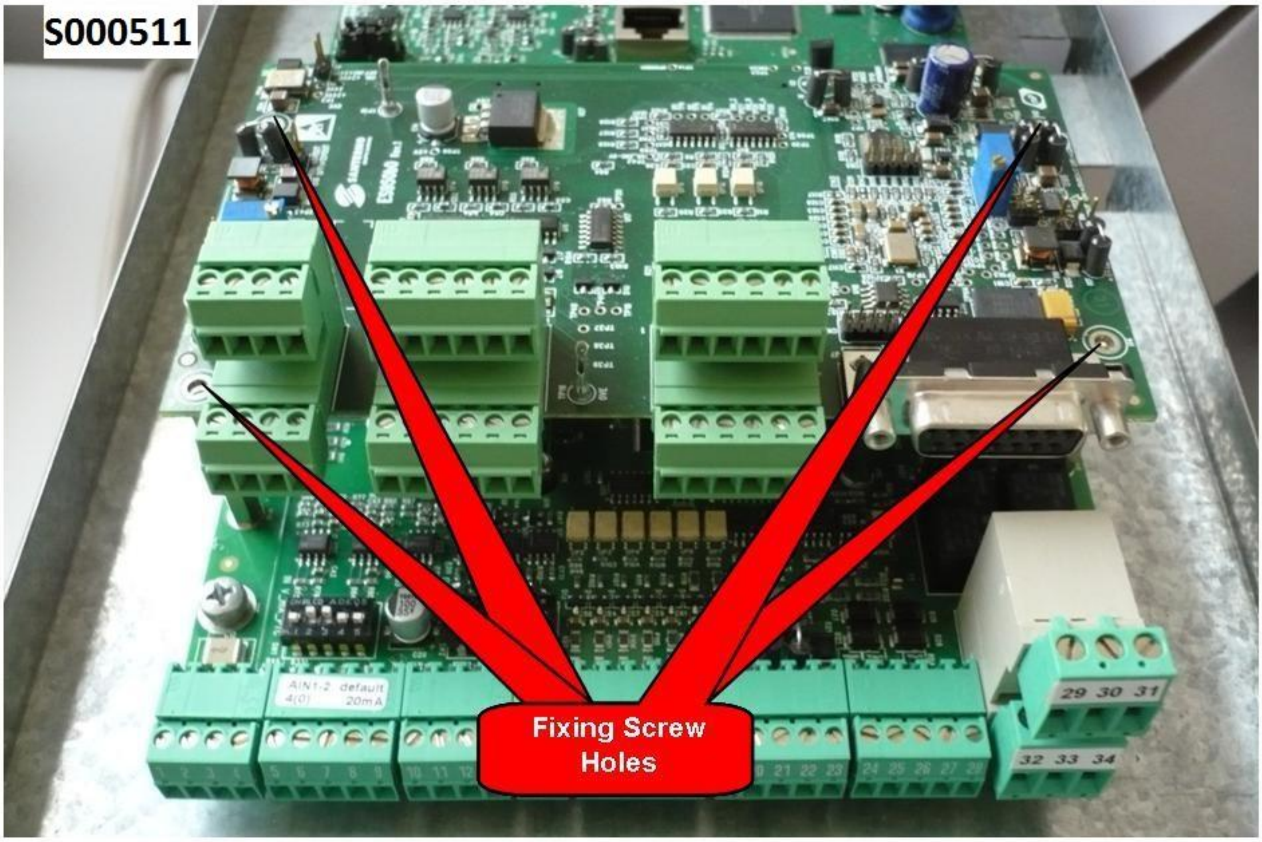


Figure 161: Fixing the ES966 board inside the drive

5. Configure the supply voltage for the incremental encoder (please refer to the relevant User Manual) by setting the configuration jumper accordingly.

6. Power the inverter and check if the supply voltage delivered to the encoder is appropriate. Set up the parameters relating to the encoder as described in the Programming Guide.

7. Remove voltage from the inverter, wait until the inverter has come to a complete stop and connect the encoder cable.

	DANGER	Before gaining access to the components inside the inverter, remove voltage from the inverter and wait at least 20 minutes. Wait for the complete discharge of the internal capacitors to avoid electric shock hazard.
	CAUTION	Do not connect or disconnect signal terminals or power terminals when the inverter is powered to avoid electric shock hazard and to avoid damaging the inverter.
	NOTE	All fastening screws for removable parts (terminal cover, serial interface connector, cable path plates, etc.) are black, rounded-head, cross-headed screws. Only these screws may be removed when connecting the equipment. Removing different screws or bolts will void the product guarantee.

18.3. HIPERFACE® Encoder Connector

High-density female D-sub 26 connector (three rows): Reference Designator CN4.
Figure 162 shows the location of the pins from the front side.

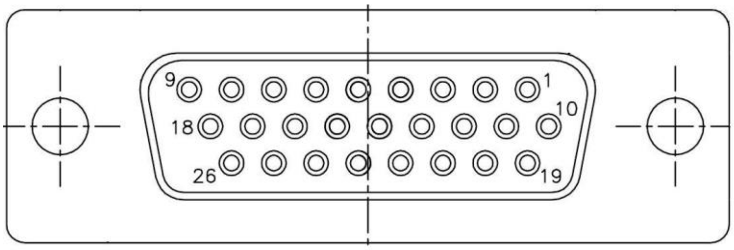


Figure 162: Pin layout on HD female D-sub 26 connector

The pin layout of High-density female D-sub 26 connector is given in the table below:

Decisive voltage class A according to EN 61800-5-1

N.	***Name***	***Description***
1	n.c.	
2	n.c.	
3	DATA–	Inverted RS485 data signal
4	DATA+	Positive RS485 data signal
5	CHB_5–	Incremental encoder, inverted channel B (fast signal B for 5 CH encoder)
6	CHB_5+	Incremental encoder, positive channel B (fast signal B for 5 CH encoder)
7	+VEOUT_EB	Encoder supply output
8	COS+	Hiperface encoder, positive cosine (D+ slow signal for 5 CH encoder)
9	COS–	Hiperface encoder, inverted cosine (D+ slow signal for 5 CH encoder)
10	n.c.	
11	n.c.	
12	n.c.	
13	n.c.	
14	CHA_5+	Incremental encoder, positive channel A (A fast signal for 5 CH encoder)
15	CHA_5–	Incremental encoder, inverted channel A (A fast signal for 5 CH encoder)
16	0VE	Power supply and signal common
17	SIN+	Hiperface encoder, positive sine (C+ slow signal for 5 CH encoder)
18	SIN–	Hiperface encoder, inverted sine (C+ slow signal for 5 CH encoder)
19	Earth	Earth connector (PE conductor) if J7 closed
20	n.c.	
21	n.c.	
22	CHZ_5+	Incremental encoder positive index (fast signal Z for 5 CH encoder)
23	CHZ_5–	Inverted index incremental encoder (fast signal Z for 5 CH encoder)
24	0VE	Power supply and signal common
25	PTC+	Motor temperature sensor, positive signal
26	PTC–	Motor temperature sensor, negative signal
Shell	PE	Connector shield connected to PE conductor of the inverter

18.4. Incremental Encoder Connectors and Digital Lines

Disconnection terminals, 3.81 mm pitch.
Figure 163 shows the pin layout of the terminals from the cable entry front side.

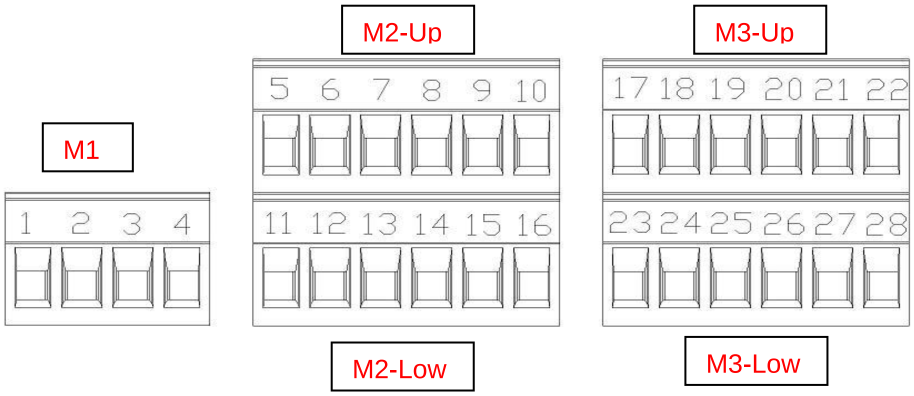


Figure 163: Input-output signal terminals

Decisive voltage class A according to EN 61800-5-1

N.	***Name***	***Description***
1	+VEOUT	Incremental encoder power supply output
2	+VEOUT	Incremental encoder power supply output
3	0VE	Isolated power supply output
4	0VE	Isolated power supply output
5	CHA	Incremental encoder positive channel A input
6	/CHA	Incremental encoder inverted channel A input
7	CHB	Incremental encoder positive channel B input
8	/CHB	Incremental encoder inverted channel B input
9	CHZ	Positive mark reference signal
10	/CHZ	Inverted mark reference signal
11	CHA_U	Incremental encoder, positive channel A reproduction output
12	/CHA_U	Incremental encoder, inverted channel A reproduction output
13	CHB_U	Incremental encoder, positive channel B reproduction output
14	/CHB_U	Incremental encoder, inverted channel B reproduction output
15	CHZ_U	Positive mark reference signal reproduction output
16	/CHZ_U	Inverted mark reference signal reproduction output
17	MDI1	Digital input from the field
18	MDI2	Digital input from the field
19	MDI3	Digital input from the field
20	n.c.	
21	n.c.	
22	COM_MDI	Digital input common from the field
23	MDOC1	Digital output 1
24	MDOE1	Digital output 1 common
25	MDOC2	Digital output 2
26	MDOE2	Digital output 2 common
27	MDOC3	Digital output 3
28	MDOE3	Digital output 3 common

18.5. Operating Mode and Configuration of Hiperface Encoder Board

The ES966 encoder board voltage range is from 5 to 24 V and allows the acquisition of Hiperface absolute encoders. It also acquires absolute Sin/Cos 5ch encoders or Sin/Cos 3ch encoders.
Figure 164 shows the operating mode of the ES966 board in terms of interfacing to the encoder device and the control board. The acquisition logic of digital lines to/from the field and the interfacing with external incremental encoders.

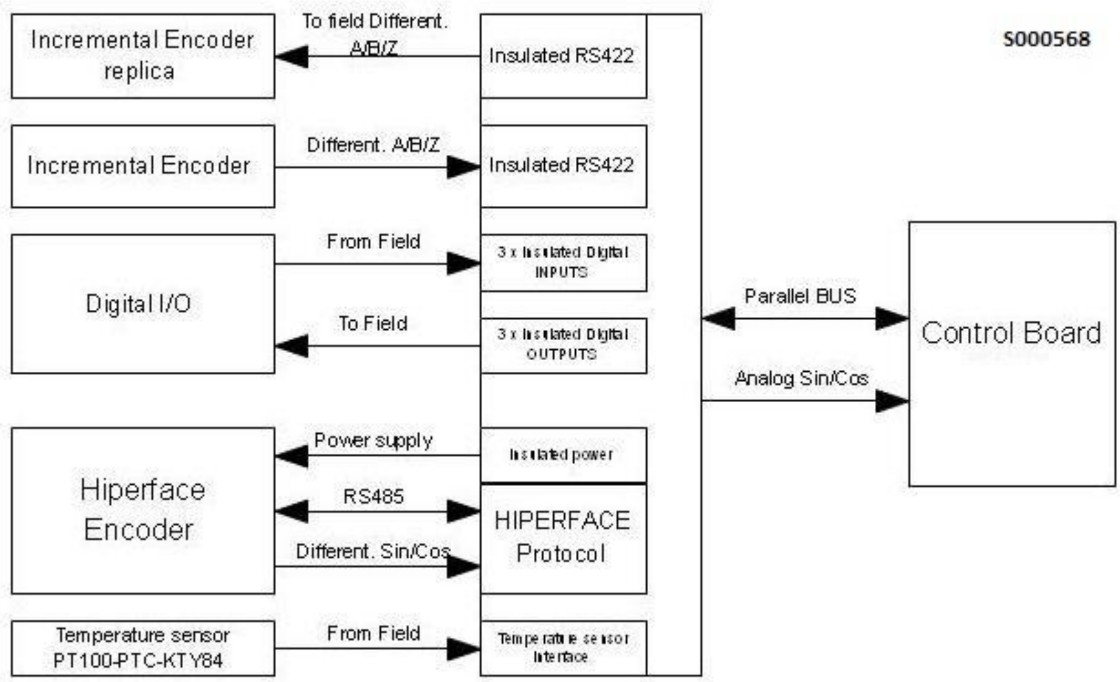


Figure 164: Block diagram of ES966 interface board

The Hiperface absolute encoders are supplied by the ES966 control board (isolated in respect to the control logics) and are interfaced with a counterpart implemented onto FPGA controlling the serial protocol and the sin/cos signals decoding. The control board may read/write additional information internally to the encoder by way of the parallel interface through the FPGA.
The states of the opto-isolated digital outputs/inputs may be accessed via parallel interface as well, while the incremental lines coming from the relative encoder, although passing through the FPGA, reach the control board by way of dedicated lines.
The board also implements a mechanism detecting signal errors from the signals coming from the incremental encoder.
Dedicated outputs may re-send the encoder channels externally acquired, also processed by frequency divider (factor 2, 4 and 8).
The protocol is selected by downloading a special firmware to the board FPGA at an off line programming level and by setting up dedicated parameters in the control board software.
The implemented protocols are detailed in the sections below.

18.6. HIPERFACE® Operating Mode

Hiperface is a protocol developed by Sick-Stegmann for the transmission of information on the encoder position for motor control functionality. This protocol extends the ordinary sine/cosine operation through a slow RS485 interface.
During initialization, the slow serial link is used to detect the encoder absolute position; the sensor is then utilized as an ordinary sine/cosine sensor with two differential tracks 1Vpp.

The Hiperface systems offers different benefits, such as redundancy of the position information sent via serial link and unencrypted signal and the utilization of relatively slow signal bands. This makes the Hiperface encoder a robust encoder suitable as a position feedback for brushless drives.

The serial protocol is a request/response one, and each packet includes a checksum allowing checking the integrity of the information contained. The RS485 comms baudrate is 9600bps by default.

When started, the drive sends a READ_POSITION command to the encoder: if no response is detected or a failure in data consistency is found, the drive triggers an encoder error alarm, otherwise, if the motor position is correctly detected, the drive switches to sine/cosine control starting from the initial position read by the RS485 protocol.

The sine/cosine control consists in decoding the position starting from the arctangent of the angle represented by the sine and cosine signals. In order to ensure the correct operation of the sensor even at relatively high speed, the sine/cosine information is controlled at a digital level as well by way of a quadrature decoder.

The maximum allowable bandwidth controlled by the ES966 is 100 kHz, corresponding to 3000 rpm of an encoder at 2048 sinusoids/rev.

18.7. Configuring and Adjusting the Encoder Supply Voltage

The ES966 board may supply encoders with different voltage ratings.
For the incremental encoder, the voltage selection jumpers are J1-2-3 and the adjusting trimmer is RV1.
For encoder Hiperface, the voltage selection jumpers are J3-5-6 and the adjusting trimmer is RV2.

The possible configurations are given in the tables below:

Incremental encoder power supply: VE OUT				No VE OUT
	24V	12V	5V	
J1	X	OFF	ON	X
J2	2-3	1-2	1-2	X
J3	ON	ON	ON	OFF

Table 20: Configuration of incremental encoder power supply

Hiperface encoder power supply: VE OUT EB				No VE OUT EB
	24V	12V	5V	
J6	X	OFF	ON	X
J5	2-3	1-2	1-2	X
J3	ON	ON	ON	OFF

Table 21: Configuration of Hiperface encoder power supply

In 24V configuration, the output voltage is fixed and cannot be adjusted, while in 5V and 12V configuration, the output voltage may be fine-tuned: in 5V configuration, each trimmer allows adjusting the no-load voltage ranging from 4.5 to 7V; in 12V configuration, the no-load range is from 10.5 to 17V.
The voltage increase may be obtained by adjusting the trimmer clockwise.
In this way, the Hiperface encoders requirements may be met, also considering the voltage drops on the cable and the connector contacts; the typical power supply range is 7 to 12V.

The supply voltage is to be measured directly on the encoder power supply terminals, also considering the voltage drops in the connection cable, especially if this is rather long.

CAUTION Inadequate voltage ratings for the encoder power supply may cause the encoder malfunction. Use a tester to check the voltage supplied by the ES966 board once it has been configured and before connecting the power supply cable.

NOTE The power supply circuit of the encoder envisages an electronic current limiter and a resetting fuse. If accidental short-circuits occur on the power supply output, power off the drive and wait a few minutes so that the fuse may be reset.

The jumpers and trimmers are on the top side of the board, see Figure 165.

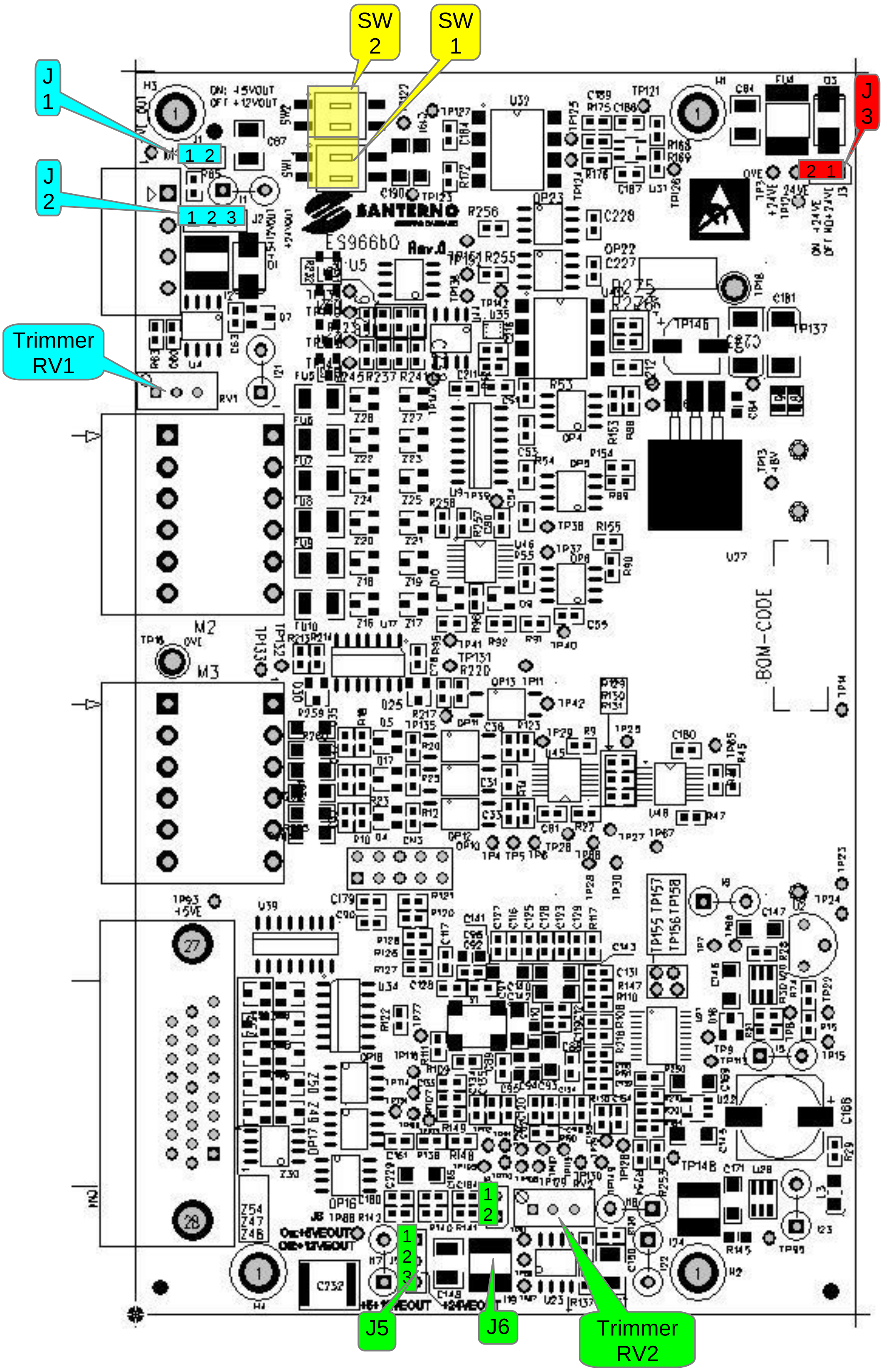


Figure 165: Location of the jumpers, trimmers and DIP-switches of ES966

18.8. Temperature Sensor Configuration

The ES966 encoder board may acquire the most popular temperature sensors in the electric motors. Two DIP-switches (SW1 and SW2 in Figure 165) are available for the selection of the type of sensor being used.

NOTE For a correct acquisition of the sensor, set the DIP-switches and the relative parameters accordingly.
See the Programming Guide.

The DIP-switches are on the top side of the board. See Figure 165.

The possible configurations are given in Table 22:

	PTC	KTY84	PT100
SW1.1	OFF	ON	OFF
SW1.2	OFF	ON	OFF
SW2.1	OFF	OFF	ON
SW2.2	OFF	OFF	ON

Table 22: DIP-switch configuration for the temperature sensor on ES966

18.9. Connecting the Encoder Cable

It is necessary to carefully connect the drive to the encoder, even if the bandwidths of the Hiperface encoders are typically low (particularly the sine/cosine signals).
Typically, shielded CAT 5 cables with twisted pair signal lines are used with capacities lower than 100 pF/m and length lower than 100 m.
It is recommended that double-shielded cables be used by connecting the internal shield to the case of CN4 type D-sub 26 connected to the ES966 board (pin 19) and the external shield to the encoder case, typically in common with the motor case. If the encoder is provided with an external shield that is not connected to the case, the external shield may be connected to the internal one.
In compliance with the applicable standards, the motor must always be earthed with a Y/G safety conductor directly to the earthing point of the drive. In order to meet the EMC requirements related to emissions and immunity for the whole equipment, it is advisable to use a shielded cable for the connection between the drive and the motor. The cable shield is to be connected to the earthing point of the drive. If no shielded cable is used, the Y/G safety conductor shall run in parallel to the motor power supply cables.
Do not run the encoder cable in parallel to the motor power supply cables and close to other disturbance sources (relays, motors, drives, solenoids): in particular, a minimum clearance exceeding 100 mm must be observed. If switching feeder inductors are located in proximity to the motor cable, the minimum allowable clearance must exceed 200 mm. Where possible, use a metal conductor dedicated to the signal cables and connected to earth.
Failure to observe the instructions above may lead to wrong reception of the position information sent from the encoder and encoder malfunction.

Figure 166 shows the recommended connection.

- Drive/motor connection shielded cable (blue), with the shield connected to the drive earthing point (shield orange in colour).
- Drive/motor connection double shielded cable (red in colour): internal shield connected to the case of CN4 connector, D-sub 26 connector on the ES966 board (pin 19); external shield to the encoder case, typically in common with the motor case.

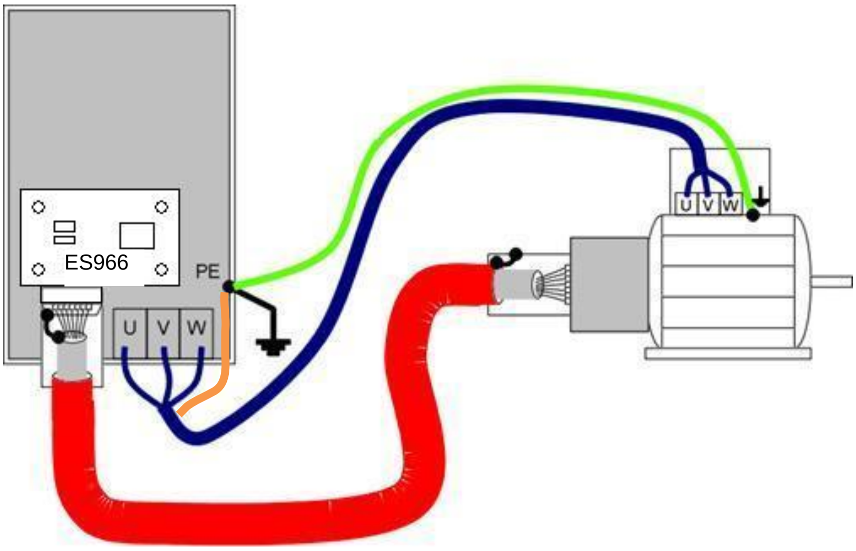


Figure 166: Connection method recommended for the double-shield encoder cable on ES966

The welded jumper J7 (bottom side in the ES966 close to CN4 connector) allows connecting the internal and external shielding of the drive/encoder cable:

- Internal shield of the drive/encoder cable connected to pin 19 in connector CN4.
- External shield of the drive/encoder cable connected to the encoder case, typically in common with the motor case.

J7	ON	Connection of the internal shielding of the drive/encoder cable to PE conductor via ES966
	OFF	NO Connection of the internal shielding of the drive/encoder cable to PE conductor via ES966

Table 23: Configuration of jumper J7

If J7 is OFF (default condition) the external shielding is connected to earth via the encoder case and the motor case, while the internal shield is connected to the case of the D-sub 26 connector but is not connected to the conductor by way of the ES966 board.

NOTE

The encoder supply output and the encoder signal common are isolated in respect to the common of the analog signals fitted in the inverter terminal board (CMA). Do not connect any conductors in common between the encoder signals and the signals in the inverter terminal board. This prevents isolation from being adversely affected.

CAUTION

The connector of the ES966 board shall be connected exclusively to the encoder using one single cable.
Correctly fasten the cable and the connectors both on the encoder side and on the ES966 board side. The disconnection of one cable or even a single conductor can lead to inverter malfunction and may cause the motor to run out of control.

18.10. Environmental Requirements

Operating temperature	–10 to +55 °C ambient temperature (contact Enertronica Santerno S.p.A. for higher ambient temperatures)
Relative humidity	5 to 95% (non-condensing)
Max. operating altitude	2000 m a.s.l. For installation above 2000 m and up to 4000 m, please contact Enertronica Santerno S.p.A..

18.11. Electrical Specifications

Decisive voltage class A according to EN 61800-5-1

Encoder power supply output	*Value*			
	Min	*Typ*	*Max*	*Unit*
Encoder power supply output current, +24V configuration			150	mA
Encoder power supply output current, +12V configuration			200	mA
Encoder power supply output current, +5V configuration			500	mA
Short-circuit safety protection device trip level, 24VE			300	mA
Adjusting range of encoder power supply, 5V mode (no-load mode)	4.5	5.3	7	V
Adjusting range of encoder power supply, 12V mode (no-load mode)	10.5	12.0	17	V

Relay Output Static Specs	*Value*			
	Min	*Typ*	*Max*	*Unit*
Type of input signals, DATA+, DATA–	Standard TIA/EIA-485			
Differential input voltage range			12/–7	V
Input common mode voltage range			12/–7	V
Input impedance (termination)	120			Ohm
Type of input signals, SIN+/SIN–/COS+/COS–	Sincos 1Vpp			
Differential input voltage range	0,9		1,1	V
Input common mode voltage range	1,5	2,5	3,5	V
Input impedance (termination)	120			Ohm
Type of input signals, CHA, CHB, CHZ	Standard TIA/EIA-422			
Differential input voltage range			±7	V
Input common mode voltage range			±7	V
Input impedance (termination)	150			Ohm
Type of input signals, MDI1, MDI2, MDI3 in respect to COM_MDI	Digital from the field			
Input voltage range	10		34	V
Type of PTC input signals	Passive sensor			
Differential input voltage range			1.7	V

Maximum absolute values	*Value*			
	Min	*Typ*	*Max*	*Unit*
Maximum allowable common mode failure-free voltage amplitude for inputs DATA+, DATA–	–7		+12	V
Maximum allowable common mode and differential mode voltage amplitude for inputs CHA, CHB, CHZ, CHA_5, CHB_5, CHZ_5,	–25		+25	V
Common mode voltage, PTC inputs	0		4	V
Common mode voltage, SIN/COS inputs	0		32	V
Incremental encoder output voltage	0		5	V
Incremental encoder output current (resettable fuse trip threshold)	0		500	mA

CAUTION Exceeding the maximum differential input or common mode voltages will result in irreparable damage to the apparatus.

Dynamic characteristics of signal inputs	*Value*
Maximum frequency of Sin/Cos Hiperface signals	100 kHz

CAUTION Exceeding the input signal frequency limits will result in a wrong measurement of the encoder position and speed. Depending on the control method selected for the inverter, it may also cause the motor to run out of control.

Static characteristics of the digital outputs and the encoder outputs	*Value*			
	Min	*Typ*	*Max*	*Unit*
Type of input signals, CHA_U, CHB_U, CHZ_U	Standard TIA/EIA-422			
High logic level voltage	2.5			V
Low logic level voltage			0.5	V
Limited common mode voltage	±5.6			V
Maximum current	50			mA
Type of output signals MDOC-E1, MDOC-E2, MDOC-E3	“Open Collector” switch			
Voltage applicable to MDOC with no static absorption in “open” configuration			5	V
Maximum current that can be absorbed in “closed” configuration			50	mA

CAUTION Exceeding the input signal frequency limits will result in a wrong measurement of the encoder position and speed. Depending on the control method selected for the inverter, it may also cause the motor to run out of control.

19. ES914 POWER SUPPLY UNIT BOARD

Product-Accessory Compatibility		
Product	**ES914 Power Supply Unit board**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	√	
Solardrive Plus	√	

Table 24: Product – ES914 Power Supply Unit board compatibility

Figure 167: ES914 Power supply unit board

Description of ES914 board

The ES914 board provides insulated power supply to the drives through the RS485 connector (see Auxiliary Power Supply in the Installation Guide). It is supplied on a board-holder support with a rear plug connector for DIN rail type OMEGA 35mm. Width is 97mm. Cross dimensions are given in the figure below.

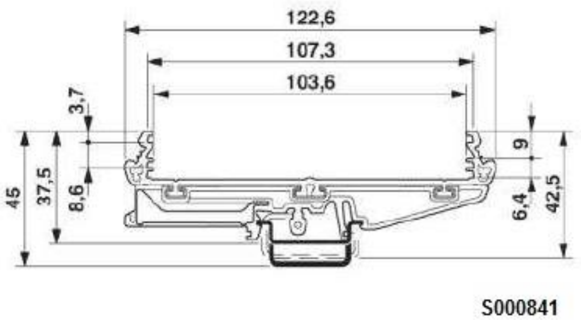
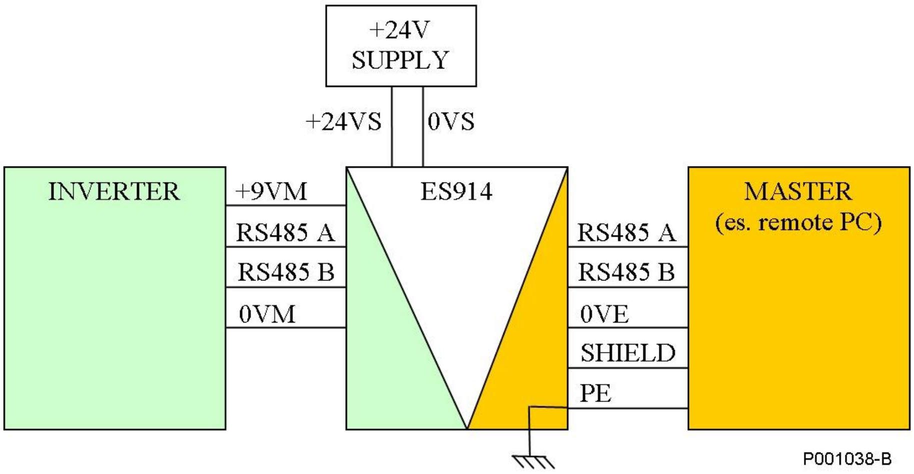


Figure 168: Dimensions of ES914 board

The ES914 board also provides insulation of RS485 signals on the inverter connector. Using the ES914 board is recommended for galvanic insulation between the control circuits of the inverter and the external communication circuits.
3-zone insulation is provided: the 24Vdc supply input section, the RS485 section on the Master side and RS485 + 9Vdc supply output on the inverter side are electrically isolated (see Figure 170).
The ES914 board transmits data in just one direction at a time (half-duplex transmission).
Transmission is typically started by the Master device, that transmits a poll packet. When receiving the start bit and the poll packet, the communication channel of the Master port opens towards the inverter port and it is kept open until the whole packet is received for a time over 4 byte-time at allowable minimum baud-rate. When the transmission time is over, both ports go idle.
The inverter then transmits the response packet. When the start bit of the response packet is received, the communications channel opens on the inverter side towards the Master port; when a second delay time has elapsed, the transmission cycle is complete.

The ES914 board is equipped with two indicator LEDs indicating RS485 communication failures. Wiring mismatch (if any) is also detected.
The ES914 board is provided with transient voltage suppressors (TVS) for the suppression of surge transients caused by bad weather events affecting RS485 serial communication cable reaching the Master device (the external device dialoguing with the inverter via the ES914 board). ES914 board complies with EN 61000-4-5: Level 4, Criterion B.



SHIELDED CABLE FOR RS485 LINK
PE-SHIELD Connection:

- Optional on inverter-side
- On master-side, it makes the signal discharger totally ineffective

Figure 169: Basic wiring diagram for ES914 board

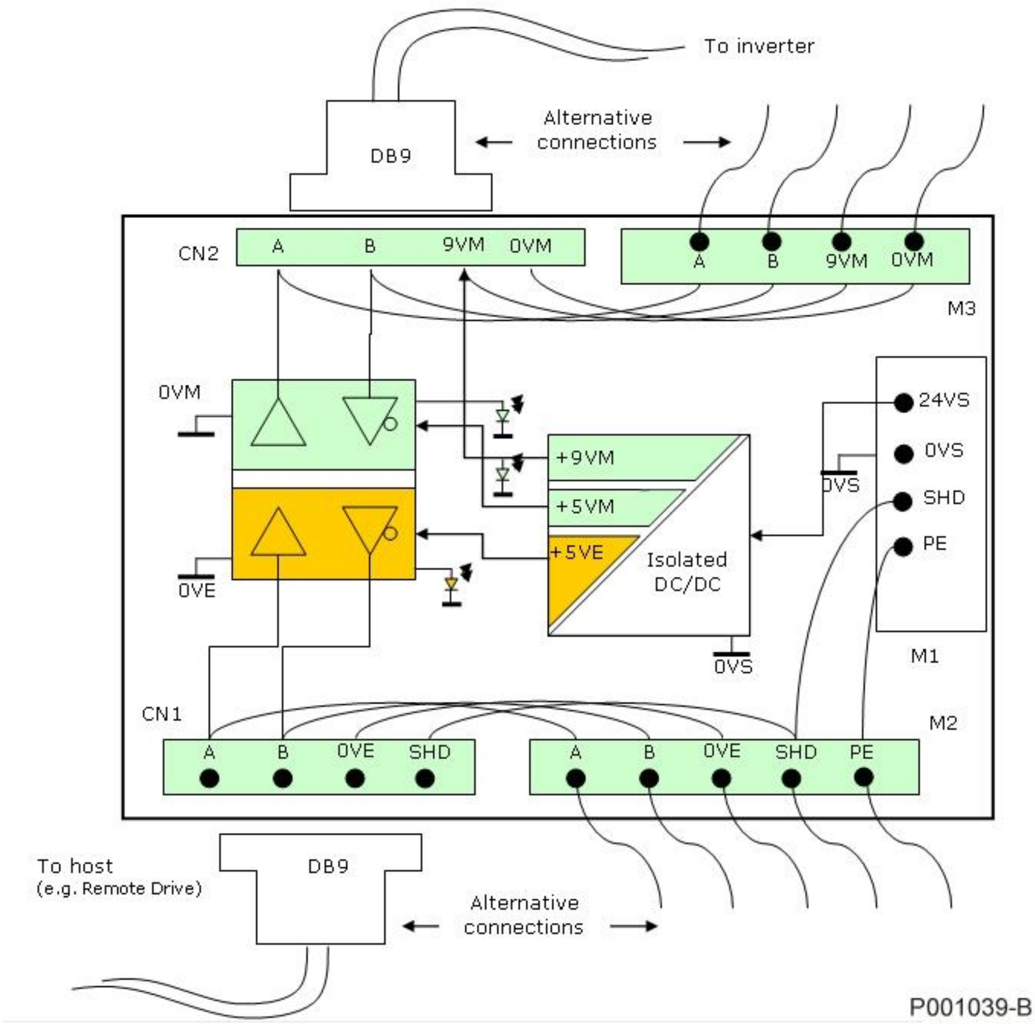


Figure 170: Block-diagram with 3-zone insulation

19.1. Identification Data

Description	*Part Number*
ES914 Adaptor for aux. power supply	ZZ0101790

19.2. Wiring ES914 Board

ES914 board includes three terminal boards and two connectors.
The signal connections going to the RS485 Master and to the inverter are available both on the screwable terminals and to DB9 connectors. This allows maximum wiring flexibility.
The SHIELD and PE conductors are located on the power supply input terminals. The PE conductor is to be connected to the safety conductor of the cabinet where the equipment is installed. The SHIELD connector is the shield of the communication cable reaching the RS485 Master. You can then decide whether and where to connect the cable shield.
The specifications of the terminals and the connectors are given below.

- M1 Terminals: power supply of ES914 board – separable terminals, 3.81 mm pitch, suitable for 0.08 ÷ 1.5 mm^2 (AWG 28-16) cables.

Decisive voltage class A according to EN 61800-5-1

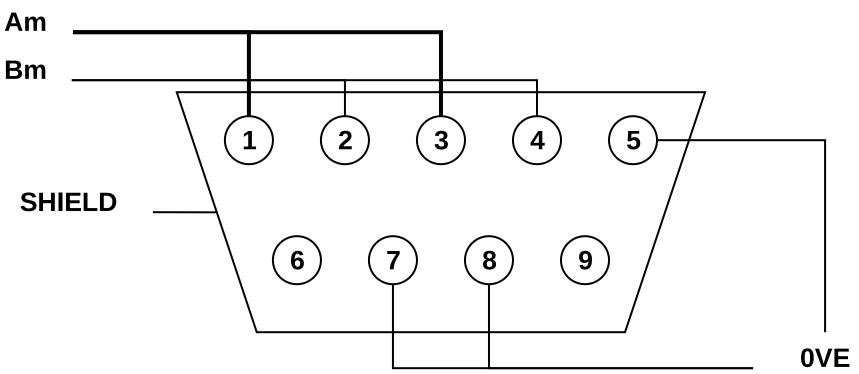
Terminal N.	Name	Description
1	+24VS	ES914 Power supply input
2	0VS	ES914 Power supply common
3	SHD	Shield of RS485 wire for external connections
4	PE	Protective Earth

- M2 Terminals: RS485 connection to the Master: separable terminals, 3.81 mm pitch, suitable for 0.08 ÷ 1.5 mm^2 (AWG 28-16) cables.

Decisive voltage class A according to EN 61800-5-1

Terminal N.	Name	Description
5	RS485 Am	RS485 signal (A) – Master
6	RS485 Bm	RS485 signal (B) – Master
7	0VE	Common for connections to the Master
8	SHD	Shield of RS485 wire
9	PE	Protective Earth

- CN1 Connector: RS485 connection to the Master: male DB9 connector

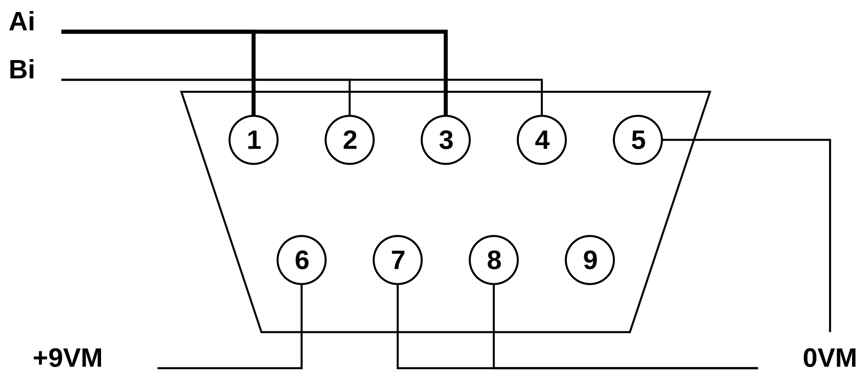


- M3 Terminals: RS485 connection to the inverter: separable terminals, 3.81 mm pitch, suitable for 0.08 ÷ 1.5 mm^2 (AWG 28-16) cables.

Decisive voltage class A according to EN 61800-5-1

Terminal N.	Name	Description
10	RS485 Ai	RS485 (A) signal – Inverter
11	RS485 Bi	RS485 (B) signal – Inverter
12	0VM	Common for connections to the inverter
13	+9VM	Inverter power supply output

- CN2 connector: RS485 connection to the inverter: female DB9 connector



Recommended connection to the inverter

It is recommended that a shielded cable with DB9 connectors be used. Connect both ends of the cable shield so that it is the same PE voltage as the inverter. The shielded cable shall have at least one twisted pair for signals RS485 A and B. Two additional conductors and one additional twisted pair for the conductors of the inverter auxiliary power supply +9VM and 0VM are also required. Make sure that the cable length and cross-section are adequate, thus avoiding excessive voltage drop. For cable length up to 5 m, the recommended minimum cross-section is 0.2 mm^2 (AWG24) for the signal conductors and the power supply conductors.

Recommended connection to the Master

It is recommended that a shielded cable with at least one twisted pair be used. The cable shield shall be connected to the SHIELD terminal of the connector. The connection of the cable shield allows full exploitation of the suppressors located on the Master conductors.
The shielded cable shall have at least one twisted pair for signals RS485 A and B and shall propagate the common signal (0VE).
The following specifications are recommended for the shielded cable:

Type of cable	Shielded cable composed of a balanced pair named D1/D0 + common conductor (“Common”).
Recommended cable model	Belden 3106 (distributed from Cavitec)
Min. cross-section of the conductors	AWG24 corresponding to 0.25 mm^2. For long cable length, larger cross-sections up to 0.75 mm^2 are recommended.
Max. cable length	500 m (based on the max. distance between two stations)
Characteristic impedance	Better if exceeding 100 Ω (120 Ω is typically recommended)
Standard colours	Yellow/brown for D1/D0 pair, grey for “Common” signal

Power Supply LEDs

ES914 board is equipped with three indicator LEDs for indicating the status of the power supply voltage.

LED	Colour	Function
L1	Green	Presence of power supply voltage (5V) in inverter-side RS485 circuits
L2	Green	Presence of inverter power supply voltage (9V)
L3	Green	Presence of power supply voltage (5V) in Master-side RS485 circuits

RS485 FAULT Signals

ES914 board is equipped with two LEDs indicating the fault status for the RS485 signals both on the inverter side and to the Master side. The FAULT indication is valid only when the line is properly terminated, i.e. DIP-switches SW1 and SW2 are “ON”.

LED	Colour	Function
L5	Red	Inverter-side RS485 signal fault
L6	Red	Master-side RS485 signal fault

The following faults can be detected:

- Differential voltage between A and B lower than 450mV
- A or B exceed the common mode voltage range [–7V; 12V]
- A or B connected to fixed voltage (this condition can be detected only when communication is in progress).

Diagnostic Display

Figure 171 shows the indicator LEDs and the configuration DIP-switches of ES914 board.

Configuration of ES914 board

ES914 board includes two 2-position DIP-switches. These DIP-switches allow RS485 line termination to be configured both on inverter-side and on master-side.

DIP-switch	Function	Notes
SW1	Master-side RS485 termination	ON: 150Ω resistor between A and B; 430Ω resistor between A and +5VE; 430Ω resistor between B and 0VE (default) OFF: no termination and polarisation resistor
SW2	Inverter-side RS485 termination	ON: 150Ω resistor between A and B; 430Ω resistor between A and +5VM; 430Ω resistor between B and 0VM (default) OFF: no termination and polarisation resistor

Electrical Specifications	*Value*			
	Min.	*Typ.*	*Max.*	*Unit*
Operating temperature range of the components (standard version)	0		70	°C
Max. relative humidity (non-condensing)			95	%
Environment pollution degree (according to EN 61800-5-1)			2	

Degree of protection of the plastic case	IP20			
Insulation test voltage between the encoder signals and the power supply ground	500Vac 1’			
Connection to the inverter	*Value*			
	Min.	*Typ.*	*Max.*	*Unit*
Input voltage	19	24	30	V
Power supply voltage to the inverter	8.5	9.16	11.1	V
Inverter power supply output current			830	mA
Input lines	Two lines: signals A and B, RS485 bus			
Type of input signals	RS485 Standard (from 4800bps to 115200bps)			
Connection to the power supply line	*Value*			
	Min.	*Typ.*	*Max.*	*Unit*
+24V Power supply absorption			700	mA
Compliance				
EN 61000-4-5	Level 4, Criterion B			

Figure 171: Position of the LEDs and DIP-switches in ES914 board

20. "LOC-0-REM" KEY SELECTOR SWITCH AND EMERGENCY PUSH-BUTTON FOR IP54 MODELS

Product-Accessory Compatibility		
Product	**Key selector switch and Emergency push-button for IP54 models**	**Comments**
Sinus Penta	√	
Penta Marine	√	
Iris Blue	√	
Solardrive Plus	-	

Table 25: Product – Key selector switch and Emergency push-button for IP54 models compatibility

The IP54 models can be provided with a key selector switch and an emergency push-button (optional devices supplied by request).

The key selector switch selects the following operating modes:

POSITION	OPERATING MODE	DESCRIPTION
LOC	INVERTER IN LOCAL MODE	The inverter operates in "Local" mode; the Start command and the frequency/speed reference are sent via display/keypad.
0	INVERTER DISABLED	Inverter disabled
REM	INVERTER IN REMOTE MODE	The control mode is defined by programming in parameters **C140** ÷ **C147** of the Control Method menu.

When pressed, the emergency push-button immediately stops the inverter.

An auxiliary terminal board with voltage-free contacts is provided for the selector switch status, the emergency push-button status and the Enable command.

Decisive voltage class C according to EN 61800-5-1

TERMINALS	FEATURES	FUNCTION	DESCRIPTION
1	Opto-isolated digital input	ENABLE	Connect terminal 1 to terminal 2 to enable the inverter (terminals 1 and 2 are connected together—factory-setting)
2	0 V digital inputs	CMD	digital input ground
3-4	voltage-free contacts (230V - 3A, 24V - 2.5A)	STATUS OF LOC-0-REM SELECTOR SWITCH	contacts closed: selector switch in position LOC; contacts open: selector switch in position 0 or REM
5-6	voltage-free contacts (230V - 3A, 24V - 2.5A)	STATUS OF LOC-0-REM SELECTOR SWITCH	contacts closed: selector switch in position REM; contacts open: selector switch in position 0 or LOC
7-8	voltage-free contacts (230V - 3A, 24V - 2.5 A)	STATUS OF EMERGENCY PUSH-BUTTON	contacts closed: emergency push-button not depressed contacts open: emergency push-button depressed

NOTE

When the key selector switch and the emergency push-button are installed, multifunction digital input MDI4 (terminal 12) cannot be used.
The ground of multifunction digital inputs is available also on terminal 2 in the auxiliary terminal board.

20.1. Wiring IP54 Inverters with Optional “LOC-0-REM” Key Selector Switch and Emergency Push-button

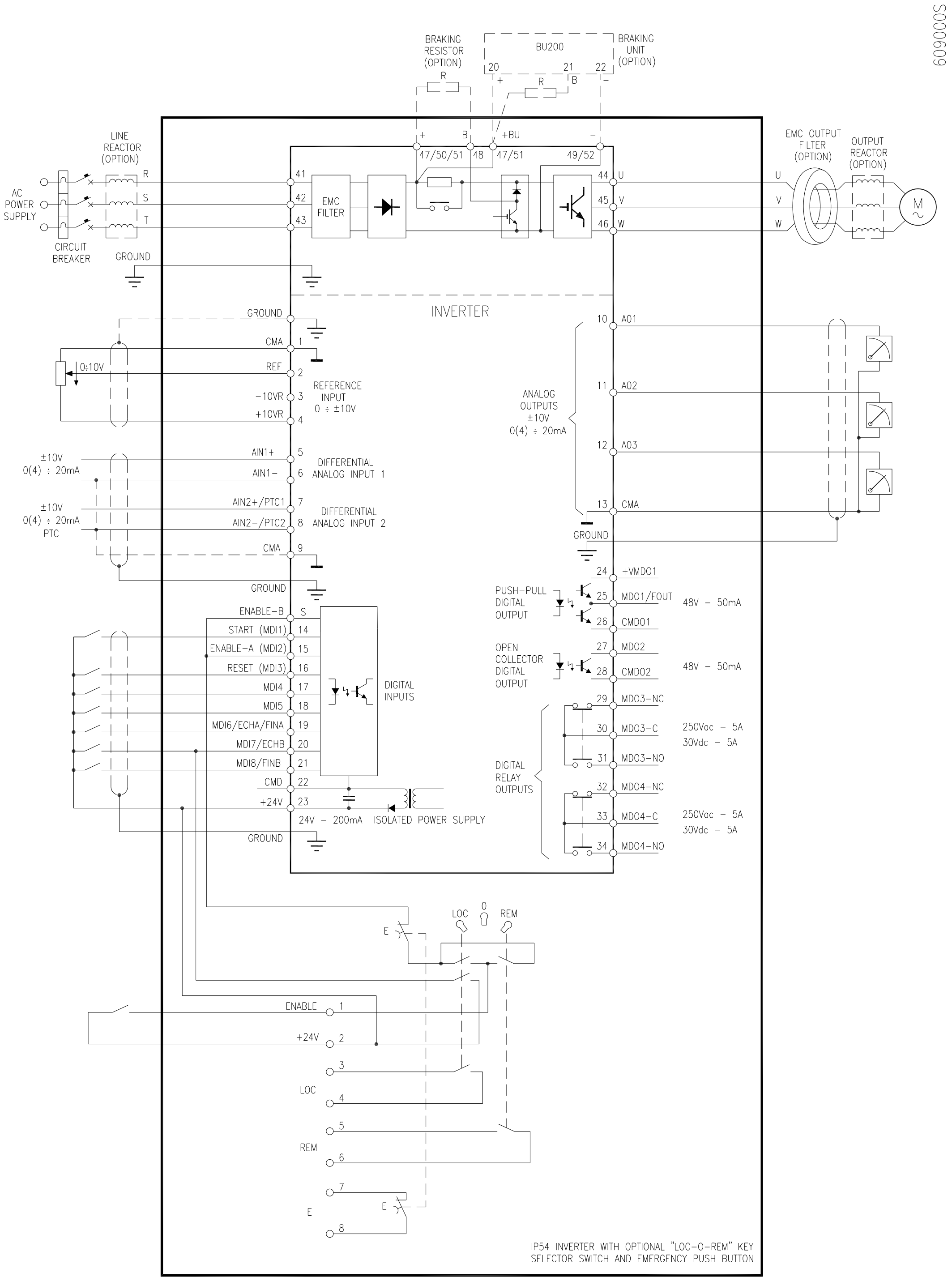


Figure 172: Wiring diagram for IP54 inverters

CAUTION The wiring shown in this schematic does not allow to implement the STO function (see the Safe Torque Off Function – Application Manual).

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