Products Tde Macno

Installation

OPDE AFE Energy

Cod. MP00400E00 V_1.6

INDEX

1 INTRODUCTION

This manual contains the necessary instructions for installing the OPDE AFE ENERGY equipment.
For other product information please refer to the "User's Manual" for the specific type of converter.

1.1 SYMBOLS USED IN THE CONVERTER MARKING

The OPDE AFE ENERGY converter bears - outside and inside (in the accessible parts for wiring) - **labels** that indicate the presence of danger for people. Here below, there is a legend with the meaning of the symbols used:

SYMBOL	DESCRIPTION
	Caution, risk of danger
	Caution, risk of electric shock
	Caution, risk of electric shock. Accumulation of energy, wait for the time indicated close to the symbol.
	Caution, hot surface
	Protective conductor fastening terminal
	Refer to the installation manual

TAB. 1 – Symbols

1.2 WARRANTY

1) Within the limits set forth in this warranty, the undersigned manufacturer undertakes to repair any and all manufacturing defects that occur during the warranty period.
2) The warranty becomes void if the purchaser does not properly follow all the instructions described in these "Installation Instructions".
3) In order to take advantage of the right of warranty, the purchaser, upon occurrence of the fault, shall timely notify it to the manufacturer and allow the same, if necessary, to carry out the related inspections and repairs.
4) The purchaser shall bear the transport charges to send the defective part covered by warranty to the manufacturer and then back to the purchaser, in order to allow the repair or replacement of the same. The warranty obligation, as provided in this clause, shall be deemed fulfilled with the delivery to the purchaser of the part properly repaired or replaced.
5) During the warranty period referred to in clause 1), labor costs for the repair will be borne by the manufacturer. If repairs or replacements have to be made at the customer's premises, the costs of travel and lodge of the personnel shall be borne by the purchaser.
6) The guarantee does not include breaks caused by wrong operation, incompetence, accident or otherwise attributable to the user, both due to himself and to third parties, or when the user has made modifications or repairs without the written consent of the manufacturer, regardless of the connection between such changes or repairs and the detected defects.
7) It is expressly agreed that the manufacturer will be relieved from any responsibility for any damages caused to the purchaser by a loss of or decreased production, resulting from manufacturing faults or defects.

1.3 CE MARKING / RATING PLATE

The CE marking certifies the conformity of the equipment with the essential safety and health requirements set forth by the European Directives mentioned on the Declaration of CE Conformity.
The rating plate consists of a silver polyester adhesive label with black print, having the following dimensions: L= 102 mm - H= 50 mm **(FIG. 1)**. It is applied externally on one side or on the front panel. The rating plate bears the logo, CE marking, type, serial number, main rating data, and power supply voltages.

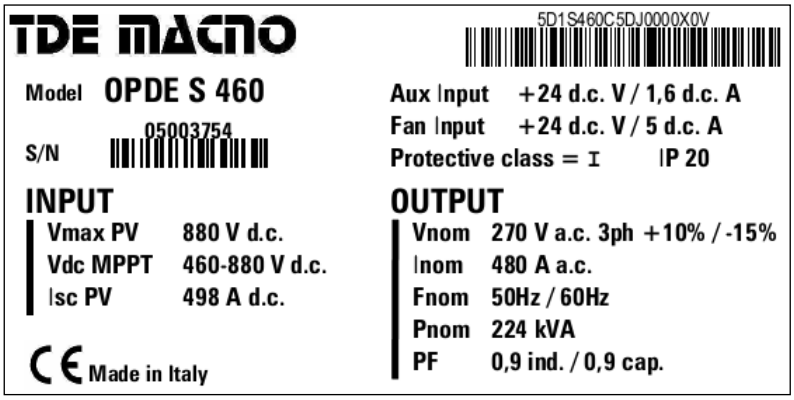


FIG. 1 – CE marking and rating plate

1.4 IMPORTANCE OF THE MANUAL

BEFORE USING THE EQUIPMENT, THE AUTHORIZED OPERATORS MUST MANDATORY READ AND UNDERSTAND THIS MANUAL IN ALL ITS PARTS.

This technical installation manual was drawn in order to assure an easy and correct understanding of the covered contents by the operators entrusted with the use and maintenance of the involved equipment.
If, despite the attention paid by the manufacturer in drawing up this document, the above mentioned operators should have any doubts concerning the understanding of the document, in order to avoid misinterpretations that may jeopardize safety, they are kindly requested to promptly ask for correct explanations and further information to the manufacturer.
Before using the involved equipment, the authorized operators must mandatory read and understand this technical manual of "Instructions for installation" in all its parts and strictly follow the instructions herein described in order to assure one's own safety and that of others, attain better equipment performance, and assure maximum efficiency and duration of all machine components.

This manual shall be available for the authorized operators at any time and shall always be well stored and protected close to the equipment.

THIS MANUAL SHALL ALWAYS BE AVAILABLE FOR THE AUTHORIZED OPERATORS AND SHALL ALWAYS BE CLOSE TO THE EQUIPMENT, WELL STORED AND PROTECTED.

THE MANUFACTURER SHALL NOT BE MADE LIABLE FOR ANY DAMAGES TO PEOPLE, ANIMALS AND/OR THINGS CAUSED BY THE INOBSERVANCE OF THE INSTRUCTIONS AND WARNINGS HEREIN CONTAINED.

IN CASE OF TRANSFER OF THE EQUIPMENT TO ANOTHER USER, IT IS COMPULSORY FOR THIS MANUAL TO BE HANDED OUT TOGETHER WITH THE EQUIPMENT.

THIS MANUAL COMPLIES WITH THE STATE OF THE ART OF TECHNOLOGY AT THE TIME OF THE TRADING OF THE EQUIPMENT AND SHALL NOT BE CONSIDERED INAPPROPRIATE IF, DUE TO NEW EXPERIENCES, IT MAY BE UPDATED LATER ON.

IN CASE OF LOSS OR DETERIORATION OF THE MANUAL REQUEST A COPY FROM THE MANUFACTURER SPECIFYING THE IDENTIFICATION DATA OF THE EQUIPMENT (SEE CE MARKING / RATING PLATE) AND THE REVISION.

IF THE INVOLVED EQUIPMENT IS USED IN A DIFFERENT WAY THAN THAT SPECIFIED BY THE MANUFACTURER, THE SAFETY GIVEN BY THE EQUIPMENT COULD BE LOST.

1.1 READING HINTS

THE GENERIC HAZARD SIGN AND THE FRAMED TEXT IN CAPITAL LETTERS FOCUSES THE ATTENTION OF THE USER ON THE WARNINGS CONTAINED IN THIS MANUAL.

Bold: It highlights some meaningful sentences in the text.

2 INTENDED USE

The **OPDE AFE ENERGY converter** has been designed and implemented for the following intended use:

Field of use	DC/AC power conversion for power plants connected to the three-phase mains.
Place of use	In a close, covered, and dry environment showing the temperature and humidity values indicated under **TAB. 7, TAB. 8, TAB. 9, TAB. 10** and complying with the law provisions in force in the country of use concerning occupational safety and health in the place of work. The converter OPDE ENERGY must be fixed to a wall that assures its stability in relation to the involved overall dimensions and weight **(TAB. 3A, TAB 3B, TAB 3C)**, and respecting the minimum positioning measures. **N.B.: IN THE PLACE OF USE OF THE ENERGY OPDE CONVERTER, THE PRESENCE OF WATER OR HUMIDITY ABOVE 95% THAT CAN EASE OR INCREASE THE RISK OF ACCIDENTAL ELECTRIC SHOCK AND/OR CAUSE DAMAGE TO THE SAME IS STRICTLY FORBIDDEN.**
Entrusted operator (suitable person)	This technical manual is intended exclusively for the authorized operators entrusted with the use and maintenance of the equipment according to the specific technical and professional skills required by the type of works. **THE AUTHORIZED OPERATORS SHALL PERFORM ON THE EQUIPMENT EXCLUSIVELY THE INTERVENTIONS INCLUDED IN THEIR SPECIFIC AREA OF COMPETENCE. BEFORE PERFORMING ANY INTERVENTION ON THE EQUIPMENT, THE AUTHORIZED PEOPLE SHALL MAKE SURE TO BE IN SUCH A MENTAL AND PHYSICAL CONDITION AS TO ASSURE THE OBSERVANCE OF SAFETY CONDITIONS AT ANY TIME.** The entrusted operator is a qualified technician (a suitable person meeting the technical and professional requirements required by current standards), authorized to install and use the equipment operating even in the presence of voltage and with disabled protections (with the consent of the Safety Manager) in strict compliance with the instructions contained in this manual or any other document, which is provided exclusively by the manufacturer.

2.1 STATE OF "SWITCHED OFF" DEVICE

Before performing any type of maintenance and/or adjustment on the equipment, it is compulsory to disconnect the power source. The converter can be considered turned off when at least one of the following conditions is met:
• the main switches on the AC mains side and on the DC side are disconnected;
• the fuses series connected to the AC mains and DC bus are removed;
• not any power supply is provided.
Moreover, it is necessary to wait at least minimum 8 minutes to be sure that all the live parts are discharged as indicated in the adhesive labels applied to the **OPDE AFE ENERGY (FIG. 2)** converter.

FIG. 2 – Sign labels

3 NAME OF THE DEVICE

The device in question is named as follows: **OPDE AFE ENERGY**
The code OPDE AFE ENERGY that is shown on the device label is described below.

6	Level	**6**= level 6		
D 1	OPDE	**D1**= OPDE		
S	Type	**S**= OPDEAFE ENERGY **M**= OPDE-SM ENERGY	**B**= OPDE-SB ENERGY **V**= OPDE-SV ENERGY	
	Size	**007**= 7A - **015**= 15A - **022**= 22A - **032**= 32A - **A48**= 48A - **A60**=60A **070**= 70A - **090**= 90A - **110**= 110A - **150**= 150A CASE1 **175**= 175A - **220**= 220A - **250**= 250A CASE2 **310=** 310A - **370**=370A - **460**= 460A CASE3		
	Overload	**X**= Standard (5kHz PWM) (All possible overloads) **C**= 3 kHz PWM		
5 D	Mains voltage	**5D**= 560V VDC		
	Drive	**A**= Drive + Reg. → 24V esterno (S - M - L - XL) **H**= Drive + Reg. → 24V external (case 1) **J**= Drive + Reg. → 24V external (case 2-3)		
0	Brake	**0**= NO BRAKE **1**= BRAKE		
0	Speed sensor 1	**0**= no feedback **B**= resolver **C**= high resolution resolver **D**= encoder sin/cos	**E**= Endat/Biss encoder **F**= high resolution frequency input **G**= TTL encoder + Hall sensor **H**= hiperface encoder	
0	Speed sensor 2	**0**= no feedback **B**= resolver **C**= high resolution resolver **D**= encoder sin/cos	**E**= Endat/Biss encoder **F**= high resolution frequency input **G**= TTL encoder + Hall sensor **H**= hiperface encoder	
	Fieldbus	**0**= No fieldbus **1**= Profibus **3**= Can Bus	**4**= Ethercat **5**= Hsc (high speed communication)	
	I/O	**0**= No **X**= Display + I/O + RS485 serial line OPTO		
0	Field	**0**= Standard		
V	Customization	**V**= standard TDE (a different letter refers to a specific customization)		

TAB. 2 – Name

4 NAME OF THE COMPONENTS AND MECHANICAL DIMENSIONS

FIG. 3A, FIG. 3B, FIG. 3C, FIG. 4, FIG. 5, TAB. 3A, TAB. 3B, TAB 3C, TAB. 3D, TAB, 3E represent and show the names of the main components and the overall dimensions of the **OPDE AFE ENERGY converter**.

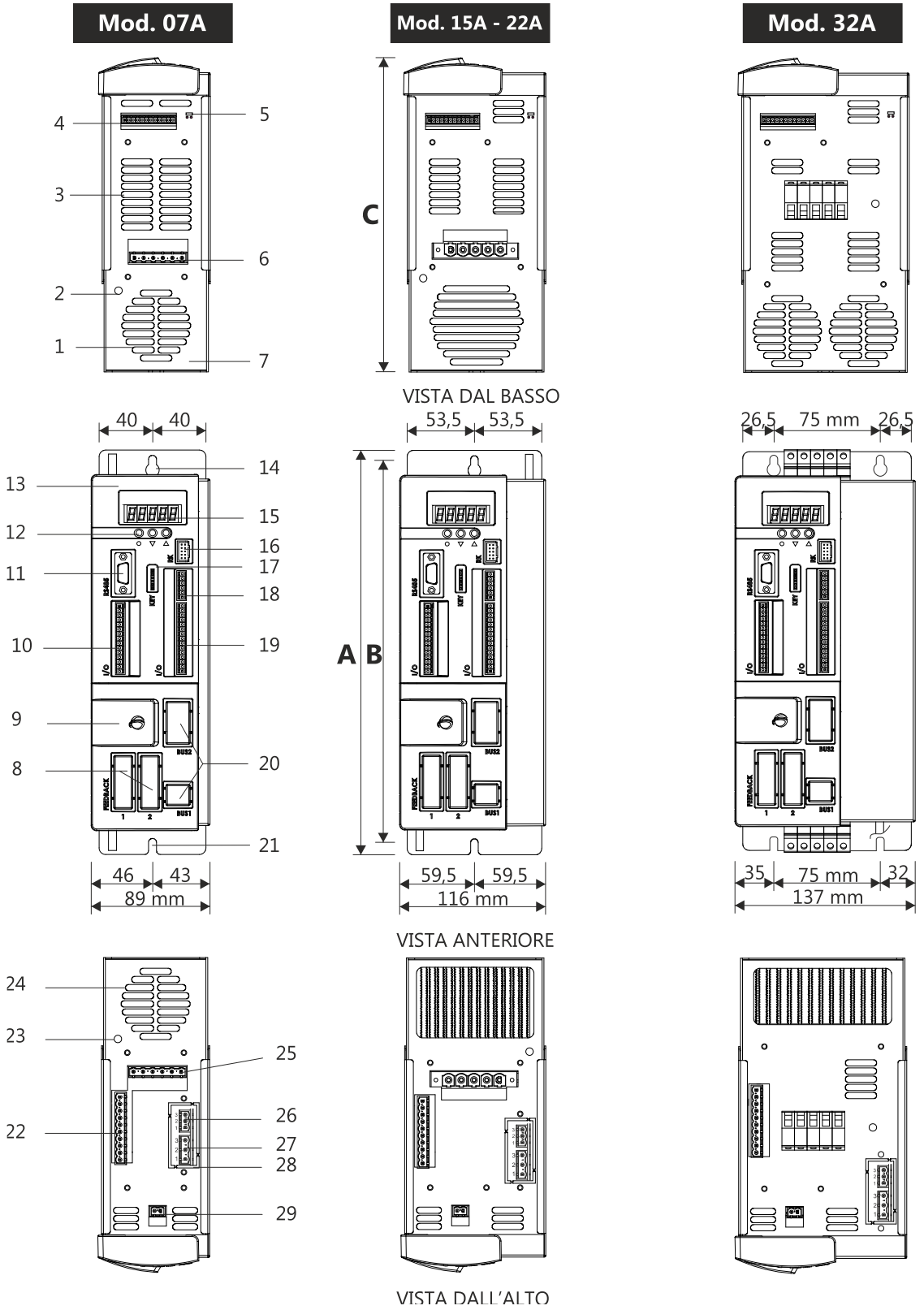


FIG. 3A – Name of the components OPDE S 7, 15, 22, 32

LEGEND FIG. 3A:
1) Cooling fans of the power module
2) Ground terminal for motor cable
3) Ventilation opening
4) Connector for the management of the temperature sensors of the motor and simulated encoder (X4) (not used for OPDE AFE ENERGY)
5) +24 V power supply connector for cooling fans (X6)
6) Terminal block for grid connection
7) Case
8) "Feedback" cards (not used for OPDE AFE ENERGY)
9) Removable plastic cover
10) Digital and analog I/O connector (M1)
11) 485/422 serial port (J1)
12) Keys for setting and displaying the parameters
13) Fixed plastic cover
14) Bracket for upper wall hooking
15) Display for converter status and parameter display
16) Connector for handheld or remote keypad
17) Connector for parameterization key
18) Input connector frequency input (M2)
19) Digital and analog I/O connector (M3)
20) Fieldbus connector (optional)
21) Bracket for bottom wall hooking
23) Ground terminal
24) Upper side venting openings
25) DC-Bus terminal block
26) Precharge relay output connector (X2)
27) Synchronism connector (X1)
29) Power supply +24VDC (X3)

MOD. OPDE AFE ENERGY		7	15	22	32
Height [mm]	A	303			322
	B	287			
Width [mm]		89	116		137
Depth [mm]	C	253			
Fastening screws		M4			
Weight [kg]		3,6	4,8	5,5	6,4

TAB. 3A – Dimensioni meccaniche e peso OPDE S 7, 15, 22 e 32

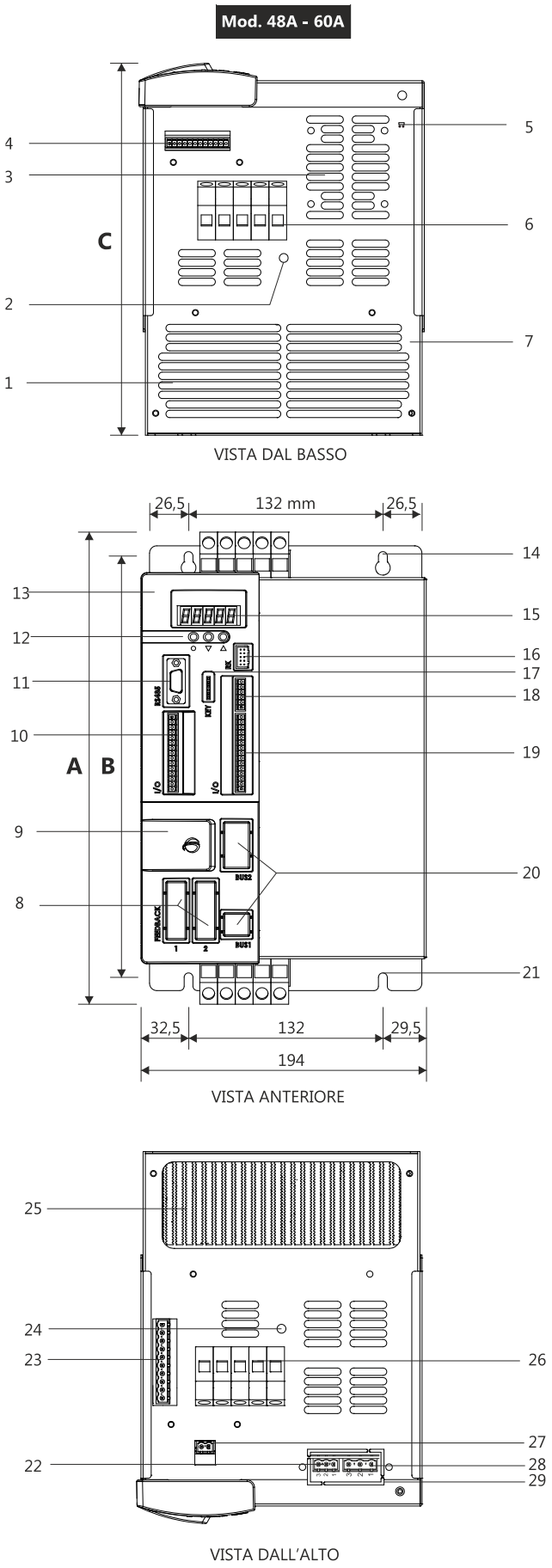


FIG. 3B – Name of the components OPDE S 48, 60

LEGENDA FIG. 4B:
1) Cooling fans of the power module
2) Ground terminal for motor cable
3) Ventilation opening
4) Connector for the management of the temperature sensors of the motor and simulated encoder (X4) (not used for OPDE AFE ENERGY)
5) +24 V power supply connector for cooling fans (X6)
6) Terminal block for grid connection
7) Case
8) "Feedback" cards (not used for OPDE AFE ENERGY)
9) Removable plastic cover
10) Digital and analog I/O connector (M1)
11) 485/422 serial port (J1)
12) Keys for setting and displaying the parameters
13) Fixed plastic cover
14) Bracket for upper wall hooking
15) Display for converter status and parameter display
16) Connector for handheld or remote keypad
17) Connector for parameterization key
18) Input connector frequency input (M2)
19) Digital and analog I/O connector (M3)
20) Fieldbus connector (optional)
21) Bracket for bottom wall hooking
23) Ground terminal
24) Upper side venting openings
25) DC-Bus terminal block
26) Precharge relay output connector (X2)
27) Synchronism connector (X1)
29) Power supply +24VDC (X3)

MOD. OPDE AFE ENERGY		48	60
Height [mm]	A	322	
	B	287	
Width [mm]		194	
Depth [mm]	C	273	
Fastening screws		M4	
Weight [kg]		9,3	10

TAB. 3B – Dimensioni meccaniche e peso OPDE S 48, 60

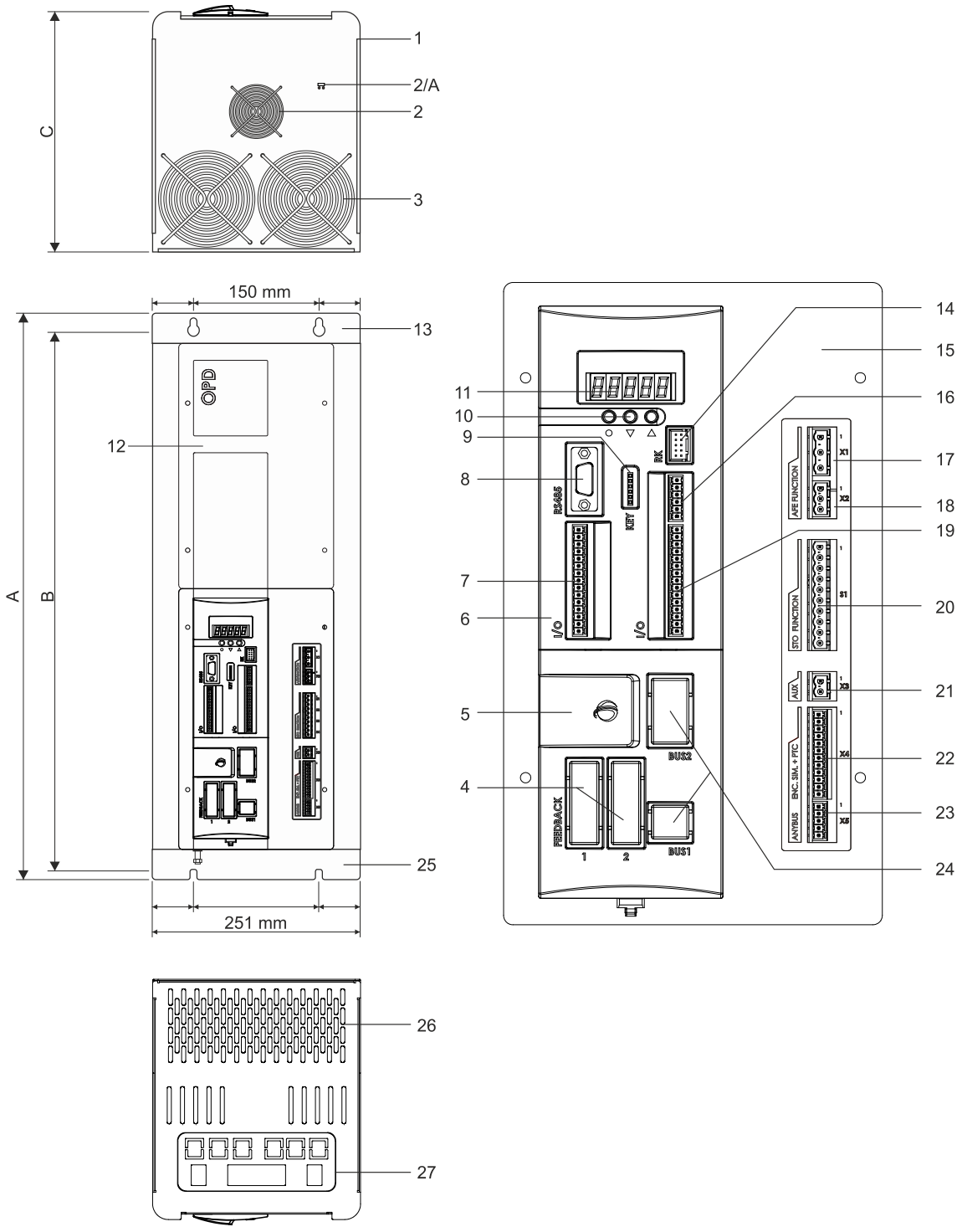


FIG. 3C – Name of the components OPDE S 70, 90, 110 and 150

LEGEND FIG. 5C:
1) Case
2) Fan cooling the electronic boards
2A) +24 V power supply connector for cooling fans (X6)
3) Cooling fans of the power module
4) "Feedback" cards (not used for OPDE AFE ENERGY)
5) Removable plastic cover
6) Fixed plastic cover
7) Digital and analog I/O connector (M1)
8) 485/422 serial port (J1)
9) Connector for parameterization key
10) Keys for setting and displaying the parameters
11) Display for converter status and parameter display
12) Power connection cover
13) Bracket for top wall hooking
14) Connector for handheld or remote keypad
15) Fixed cover
16) Input connector in frequency (M2)
17) Synchronism connector (X1)
18) Precharge relay output connector (X2)
19) Digital and analog I/O connector (M3)
20) “STO” function terminals (STO function not forecast for OPDE AFE ENERGY, terminal used for enabling the cooling fans)
21) Adjustment card power connector +24VDC (X3)
22) Connector for the management of the temperature sensors of the motor and simulated encoder (X4) (not used for OPDE AFE ENERGY)
23) Anybus connector (X5) (not used for OPDE AFE ENERGY)
24) Fieldbus connector (optional)
25) Bracket for bottom wall hooking
26) Upper side venting openings
27) Holes for cable passage

MOD. OPDE AFE ENERGY		70, 90, 110, 150
Height [mm]	A	675
	B	660
Width [mm]		251
Depth [mm]	C	290
Fastening screws		M6
Weight [kg]		22

TAB. 3C – Mechanical dimensions and weight of OPDE S 70, 90, 110 and 150

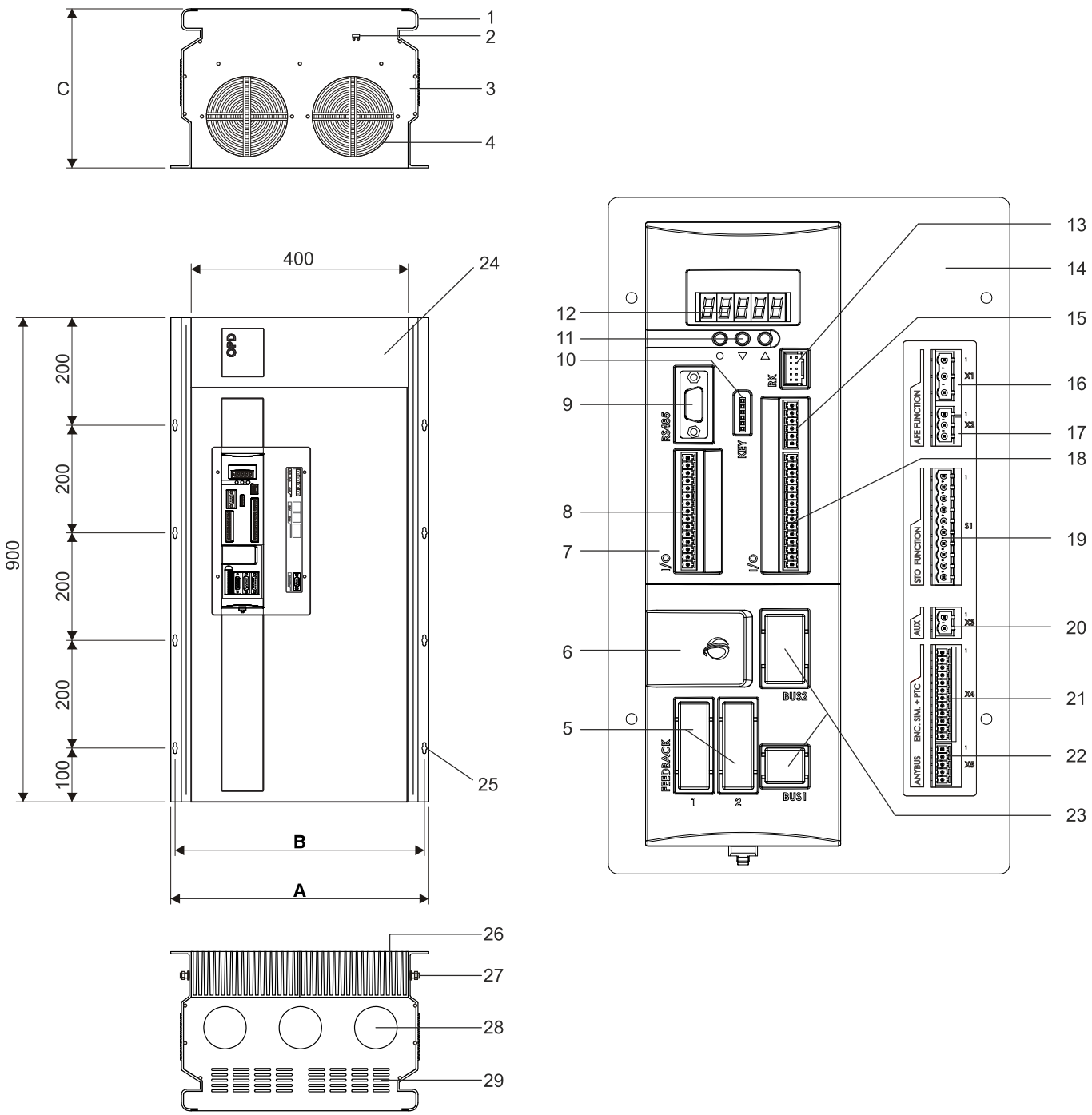


FIG. 4 – Name of the components OPDE S 175, 220 and 250

LEGEND FIG. 6:
1) Case supporting shoulders or wall hooking
2) +24 V power supply connector for cooling fans (X6)
3) Case
4) Cooling fans of the power module
5) "Feedback" cards (optional) (not used for OPDE AFE ENERGY)
6) Removable plastic cover
7) Fixed plastic cover
8) Digital and analog I/O connector (M1)
9) 485/422 serial port (J1)
10) Connector for parameterization key
11) Keys for setting and displaying the parameters
12) Display for converter status and parameter display
13) Connector for handheld or remote keypad
14) Fixed cover
15) Input connector in frequency (M2)
16) Synchronism connector (X1)
17) Precharge relay output connector (X2)
18) Digital and analog I/O connector (M3)
19) “STO” function terminals (STO function not forecast for OPDE AFE ENERGY, terminal used for enabling the cooling fans)
20) Adjustment card power connector (X3)
21) Connector for the management of the temperature sensors of the motor and simulated encoder (X4) (not used for OPDE AFE ENERGY)
22) Anybus connector (X5) (not used for OPDE AFE ENERGY)
23) Fieldbus connector (optional)
24) Panel covering the power terminals
25) Mounting holes
26) Cooling heat sink fins
27) Ground terminal
28) Holes for cable/bar passage
29) Upper side venting openings

MOD. OPDE AFE ENERGY		175, 220, 250
Height [mm]		900
Width [mm]	A	478
	B	462
Depth [mm]	C	296
Fastening screws		M6
Weight [kg]		65

TAB. 3D – Mechanical dimensions and weight of OPDE S 175, 220, 250

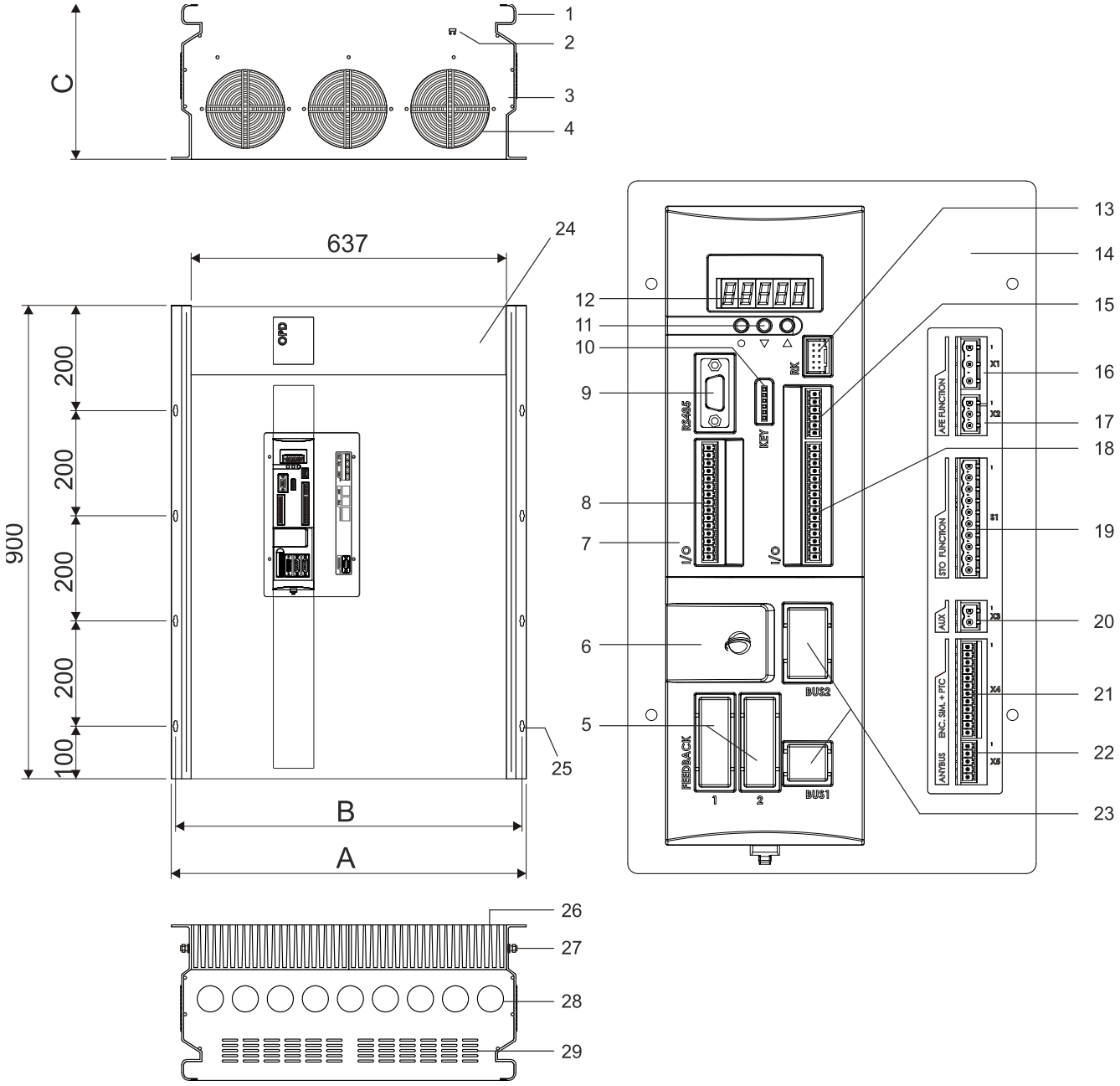


FIG. 5 – Name of the components OPDE S 310, 370 and 460

LEGEND FIG. 7:
1) Case supporting shoulders or wall hooking
2) +24 V power supply connector for cooling fans (X6)
3) Case
4) Cooling fans of the power module
5) "Feedback" cards (not used for OPDE AFE ENERGY)
6) Removable plastic cover
7) Fixed plastic cover
8) Digital and analog I/O connector (M1)
9) 485/422 serial port (J1)
10) Connector for parameterization key
11) Keys for setting and displaying the parameters
12) Display for converter status and parameter display
13) Connector for handheld or remote keypad
14) Fixed cover
15) Input connector in frequency (M2)
16) Synchronism connector (X1)
17) Precharge relay output connector AFE (X2)
18) Digital and analog I/O connector (M3)
19) “STO” function terminals (STO function not forecast for OPDE AFE ENERGY, terminal used for enabling the cooling fans)
20) Adjustment card power connector +24VDC (X3)
21) Connector for the management of the temperature sensors of the motor and simulated encoder (X4) (not used for OPDE AFE ENERGY)
22) Anybus connector (X5) (not used for OPDE AFE ENERGY)
23) Fieldbus connector (optional)
24) Panel covering the power terminals
25) Mounting holes
26) Cooling heat sink fins
27) Ground terminal
28) Holes for cable/bar passage
29) Upper side venting openings

MOD. OPDE AFE ENERGY		310, 370, 460
Height [mm]		900
Width [mm]	A	678
	B	662
Depth [mm]	C	296
Fastening screws		M6
Weight [kg]		80

TAB. 3E – Mechanical dimensions and weight OPDE S 310, 370 and 460

5 STORAGE - HANDLING

5.1 STORAGE ENVIRONMENTAL CONDITIONS

If the **OPDE AFE ENERGY converter** has to remain stored for a long time, it is necessary to store it in a safe environment with an adequate temperature and humidity degree, and protected against dust.

Temperature	-20÷60	°C
Humidity	5÷95	%
Condensation	NO	

TAB. 4 – Storage

EVERY 6 MONTHS – 1 YEAR, IT IS NECESSARY TO REGENERATE THE POWER BUS CAPACITORS. FIRST IMPLEMENT THE RECOVERY PROCEDURE AFTER STORAGE (PAR. 5.2) WITH SWITCHED OFF CONVERTER. THEN, FEED THE OPDE ENERGY THROUGH X3 (AUXILIARY POWER SUPPLY FOR THE ADJUSTMENT SIDE) AND THE + AND - BARS (POWER SUPPLY OF THE POWER SIDE) FOR AT LEAST 2 HOURS WITHOUT GIVING THE RUNNING CONSENT.

5.2 RECOVERY PROCEDURE AFTER THE STORAGE

The converter cannot be used immediately after a storage period. To prevent faults, it is necessary to adopt the following recovery procedure.

PHASE 1: Let the converter stay for an hour under the environmental conditions specified in TAB. 6

Not powered converter		
Temperature	15÷35	°C
Humidity	5÷75	%
Condensation	NO	
Atmospheric pressure	86÷106	kPa
Recovery time (1)	1	h

(1) After this recovery time, there should be no trace of condensation inside or outside the converter (well ventilated environment).

TAB. 5 – Recovery after storage

PHASE 2: If the time since the last regeneration of the electrolytic capacitors in the power bus is included between 6 months and one year, it is necessary to perform the regeneration once again: feed the OPDE AFE ENERGY through the terminal X3 (24 Vdc auxiliary power supply for the regulation side) and the + and - bars (560 Vdc power supply of the power side, by means of external precharge) for at least 2 hours without giving the running consent.
Once the regeneration process has ended, the converter can work normally.

THE REGENERATION PROCEDURE OF THE POWER BUS ELECTROLYTIC CAPACITORS GIVEN ABOVE IS NO MORE VALID IF:

- **THE TIME ELAPSED SINCE THE LAST REGENERATION IS GREATER THAN 1 YEAR**
- **THE TIME ELAPSED SINCE THE PURCHASE IS GREATER THAN 1 YEAR AND THE REGENERATION PROCEDURE HAS NEVER BEEN DONE**

IN THESE CASES, IT IS NECESSARY TO REQUEST FROM TDE MACNO WHICH IS THE OPERATING PROCEDURE TO BE ADOPTED.

5.3 HANDLING

The OPDE AFE ENERGY converters size 175, 220, 250, 310, 370 and 460, after unpacking, are easily transportable with a forklift truck or a crane equipped with suitable lifting hooks to be attached to the lifting brackets applied on the sides of the converters. Dimensions and weights are given in Chapter 4. For OPDE AFE ENERGY converters size 70, 90, 110 and 150, instead, there are no brackets for lifting. Given their limited size and weight, the converters can be transported directly by the entrusted personnel.
Protect the equipment against bumps during handling.

6 LIMITS OF USE

OPDE AFE ENERGY has to be installed inside an electrical panel, which can also not be conditioned. In this case, the environmental limits of use are given below.

6.1 CLIMATIC CONDITIONS

Environmental parameter	Limits	Measurement unit
Operating temperature	-20÷50	°C
Humidity	5÷95	%
Atmospheric pressure	70÷106 (1)	kPa
Maximum movement of the surrounding air	1	m/s
Maximum temperature gradient	0.5	°C/min
Maximum thermal radiation	700	W/m^2
Condensation	NO	
Rainfall with wind	NO (2)	
Water of different origin from rain	NO	
Icing	NO	

(1) The air pressure limits correspond to an operating field of 0÷2000m a.s.l. In fact, over 1000 m above sea level, it is necessary to derate the rated current of the converter by 1% per 100 m.
(2) The converter must be installed inside an electrical panel and, therefore, not outdoor.

TAB. 6 – Climatic conditions

6.2 RESISTANCE TO CHEMICALLY ACTIVE SUBSTANCES

3C1R class according to EN 60721-3-3

Environmental parameter	Maximum value	Measurement unit
Sea salts	NO	-
Sulfur dioxide	0.01	mg/m^3
	0.0037	cm^3/m^3
Hydrogen sulfide	0.0015	mg/m^3
	0.001	cm^3/m^3
Chlorine	0.001	mg/m^3
	0.00034	cm^3/m^3
Hydrochloric acid	0.001	mg/m^3
	0.00066	cm^3/m^3

Environmental parameter	Maximum value	Measurement unit
Hydrofluoric acid	0.001	mg/m^3
	0.0012	cm^3/m^3
Ammonia	0.03	mg/m^3
	0.042	cm^3/m^3
Ozone	0.004	mg/m^3
	0.002	cm^3/m^3
Nitrogen oxide	0.01	mg/m^3
	0.005	cm^3/m^3

TAB. 7 – Resistance to chemically active substances

6.3 RESISTANCE TO VIBRATIONS

As regards vibrations, the limits of use are the following:

10Hz ≤ frequency ≤ 57Hz	0,075	mm (amplitude)
57Hz ≤ frequency ≤ 150Hz	1	G

TAB. 8 – Vibrations

In the case of vibration above the indicated limits, it is necessary to adopt suitable damping solutions .

6.4 PROTECTION AND POLLUTION DEGREE

Protection degree	IP20
Pollution degree	3

TAB. 9 – Protections

7 INSTALLATION INSTRUCTIONS

OPDE AFE ENERGY has to be installed under the ambient conditions specified in the section "Limits of use" and in compliance with the following instructions:

1) Position the **OPDE AFE ENERGY** converter observing the minimum positioning measures.
2) Connect the **OPDE AFE ENERGY** converter to the wall using screws, according to the dimensions shown.
3) Prevent metallic residues resulting from drilling or works performed on connection electrical cables from falling into the converter.
4) In no case, the converter has to be mounted close to easily flammable materials.

IT IS COMPULSORY TO HAVE AUTHORIZED OPERATORS PERFORM THE INSTALLATION OF THE OPDE AFE ENERGY CONVERTER

IT IS COMPULSORY TO INSTALL THE OPDE AFE ENERGY CONVERTER BEING SURE THAT THE ELECTRICAL PANEL TO WHICH IT IS GOING TO BE CONNECTED DOES NOT SHOW ANY POWER SUPPLY.

ANY OPERATION WITHIN THE OPDE AFE ENERGY CONVERTER MUST BE DONE WITHOUT VOLTAGE PRESENCE AND, IN ANY CASE, WAIT FOR AT LEAST 8 MIN. BEFORE ACCESSING THE SAME (FIG. 2).

IT IS COMPULSORY TO INSTALL THE OPDE AFE ENERGY CONVERTER ONLY IN VERTICAL POSITION BECAUSE ONLY IN THIS WAY HEAT CONVECTION IS NOT HINDERED, WHICH WOULD CAUSE DAMAGES. IF IT IS NECESSARY TO INSTALL THE CONVERTER IN NON VERTICAL POSITION CONTACT THE TECHNICIAN OF TDE TO EVALUATE THE SITUATION CASE BY CASE.

IT IS COMPULSORY TO ASSURE A GOOD ACCESS TO ALL THE CONTROL ELEMENTS.

OPDE AFE ENERGY MUST NECESSARILY BE INSTALLED CLOSE TO THE SUPPORT WALL IN ORDER TO PROPERLY CHANNEL THE AIR FLOW IN THE HEAT SINK.

IT IS COMPULSORY TO INSTALL SEVERAL OPDE AFE ENERGY DRIVES SIDE BY SIDE TO ASSURE A GOOD VENTILATION AND PREVENT THE COOLING AIR FLOW OF A CONVERTER FROM AFFECTING THE OTHER.

THE CONVERTER INSTALLATION SHALL NOT HINDER ACCESS TO DISCONNECTING AND CUTTING-OFF TOOLS.

IF THE CONVERTER IS USED IN A DIFFERENT WAY THAN THOSE SPECIFIED BY THE MANUFACTURER, THE PROTECTIONS PROVIDED BY THE CONVERTER ARE NOT GUARANTEED.

7.1 CLOSED ENVIRONMENT: DISSIPATED POWER

TAB. 11 indicates the power dissipated by the converter operating at rated current, including adjustment, ventilation and power IGBT losses. During an installation in a closed environment, e.g. in a cabinet, it is necessary to make sure that the inner temperature does not exceed the ambient temperature permissible for the converter. The environment has to be ventilated with a sufficient air quantity as to remove the heat generated by the same and by the other components.

Size	Dissipated power [W]	Air flow rate [m^3/h]
70	800	480
90	1100	480
110	1200	480
150	1500	620
175	1900	820
220	2500	1080
250	2700	1080
310	3300	1620
370	3900	1620
460	3500	1620

TAB. 10 – Dissipated power

SOME PARTS OF THE CONVERTER METAL CASE MAY EXCEED 70 °C DURING OPERATION. THEY ARE MARKED BY THE SPECIAL LABEL "CAUTION, HOT SURFACE" SHOWN HERE ON THE SIDE.

7.2 ELECTRIC CONNECTIONS

ALL THE FOLLOWING OPERATIONS ARE NECESSARY TO PREPARE THE ELECTRIC CONNECTION OF OPDE AFE ENERGY CONVERTER.

THE POWER SUPPLY PHOTOVOLTAIC ARRAY AND THE MAINS TO WHICH THE MAINS CONVERTER OPDE AFE ENERGY IS CONNECTED SHALL SATISFY THE TECHNICAL FEATURES SHOWN IN THE TAB. 22A, 22B, 22C, 35A, 35B, 35C AND MEET THE REQUIREMENTS SET FORTH BY THE REGULATIONS IN FORCE IN THE COUNTRY OF USE THEREOF.

ANY TYPE OF ELECTRICAL EQUIPMENT (CABLES, OUTLETS, PLUGS, ETC.) USED FOR THE CONNECTION MUST BE SUITABLE FOR USE, "CE" MARKED - IF SUBJECT TO THE LOW VOLTAGE DIRECTIVE 2006/95/EC, AND COMPLY WITH THE REQUIREMENTS SET FORTH BY THE APPLICABLE LAW IN FORCE IN THE COUNTRY OF USE OF THE OPDE AFE ENERGY CONVERTER.

THE MANUFACTURER DENIES ALL LIABILITY FOR FAULTS OR MALFUNCTIONS OF THE OPDE AFE ENERGY CONVERTER DUE TO SUDDEN VOLTAGE CHANGES EXCEEDING THE TOLERANCES SET BY THE POWER DISTRIBUTION COMPANY (VOLTAGE ± 10%).

FAILURE TO FOLLOW THE ABOVE PRECAUTIONS MAY RESULT IN PERMANENT DAMAGES TO THE ELECTRICAL EQUIPMENT OF THE OPDE AFE ENERGY CONVERTER, AND IN THE FOLLOWING VOIDNESS OF THE WARRANTY.

THE MANUFACTURER DENIES ALL LIABILITY FOR ANY DAMAGES TO PEOPLE, ANIMALS AND/OR PROPERTY CAUSED BY THE INCORRECT ELECTRICAL CONNECTION OF THE OPDE AFE ENERGY CONVERTER AND ITS COMPONENTS.

Here below, there is the list of the main power and input/output ports of OPDE AFE ENERGY:

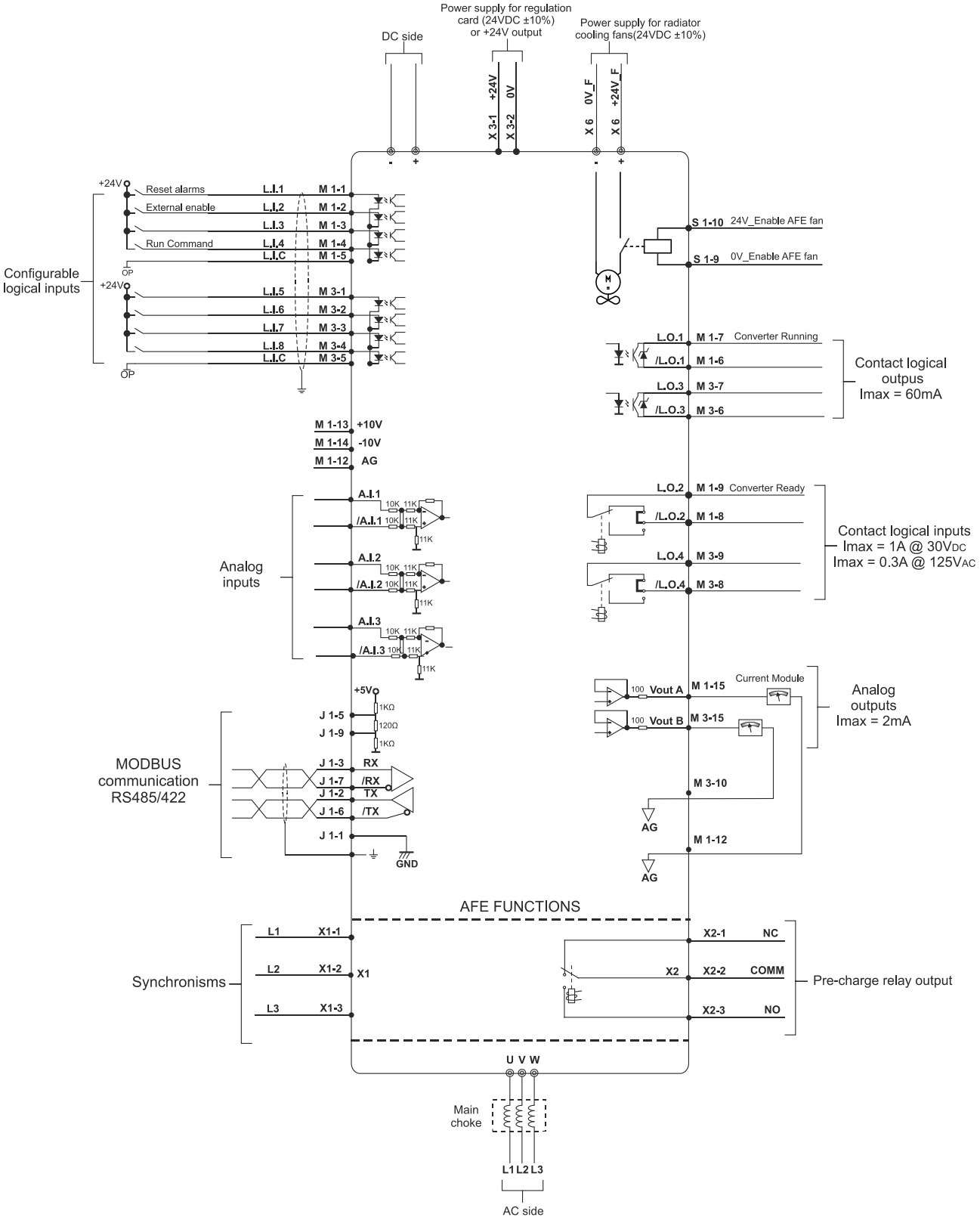


FIG. 6 – Electric connections

7.2.1 Power side

The OPDE AFE ENERGY converter is a DC/AC converter with six IGBT bridge. The power side is shown in the following figure.

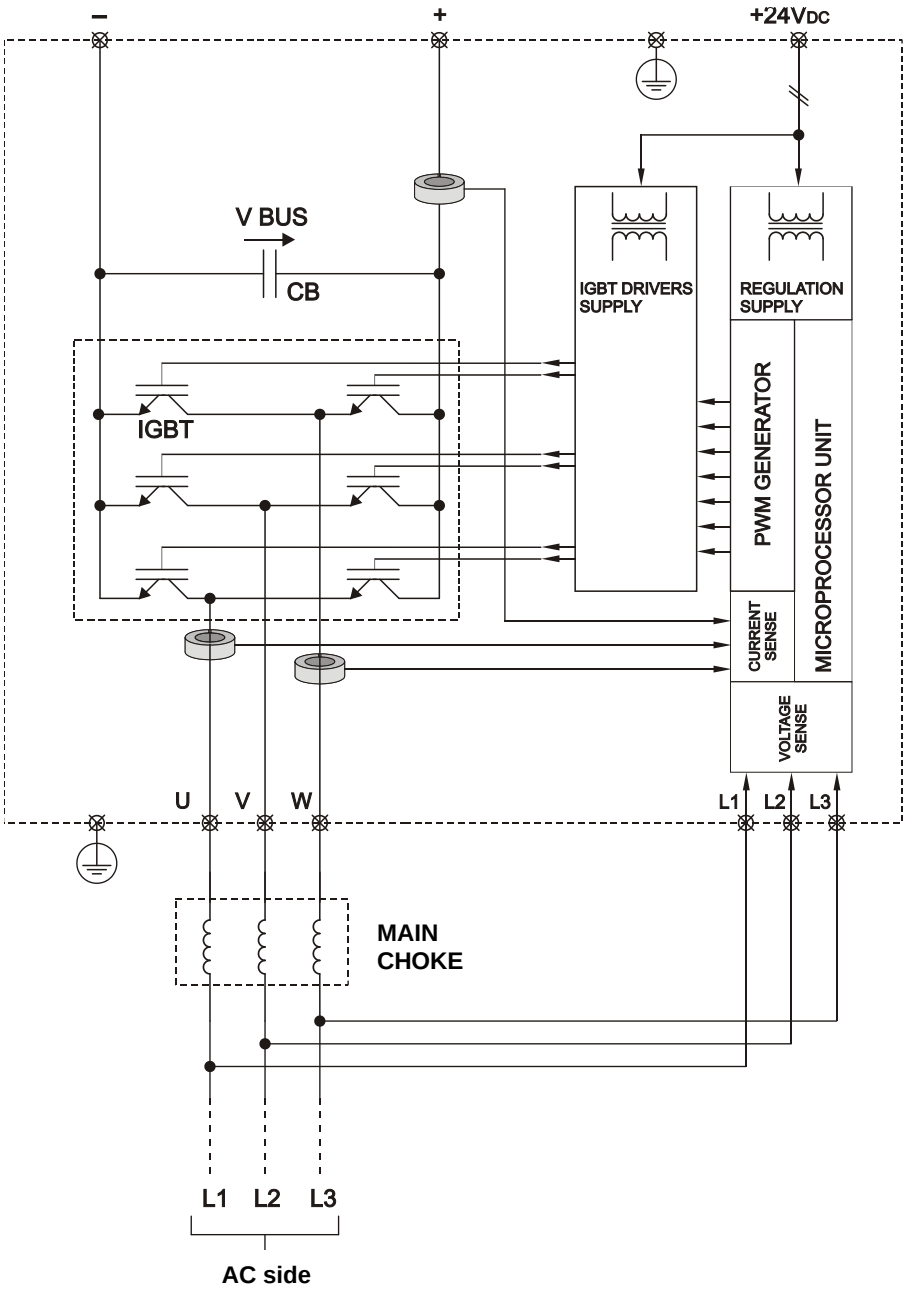


FIG. 7 – Power side

7.2.2 EXAMPLES OF CONNECTION

In order to be used in energy conversion applications, the OPDE AFE ENERGY converter must be connected to other additional components necessary for its proper operation.
As a matter of fact, the OPDE AFE ENERGY converter is a power and control unit of a six-IGBT bridge.

Externally, it is necessary to connect:
- an LC or LCL filter;
- a transformer;
- a precharge circuit (optional);
- electromechanical devices disconnecting and/or protecting the DC side and AC side;
- other control devices (including insulation controllers and Residual Current Devices);
- EMC filters.

Normally, the OPDE AFE ENERGY converter and the other external components are installed inside an electric cabinet that will be the final and complete electrical equipment.

Please refer to the **chapters 8 and 9** for examples for the correct connection of the OPDE AFE ENERGY converter.
Two types of installation will be taken into consideration:
- photovoltaic application (chap. 8);
- application with rotating machine connected to an AC/DC inverter (chap. 9);

and the additional components will be indicated as if they were enclosed within a single electric cabinet.

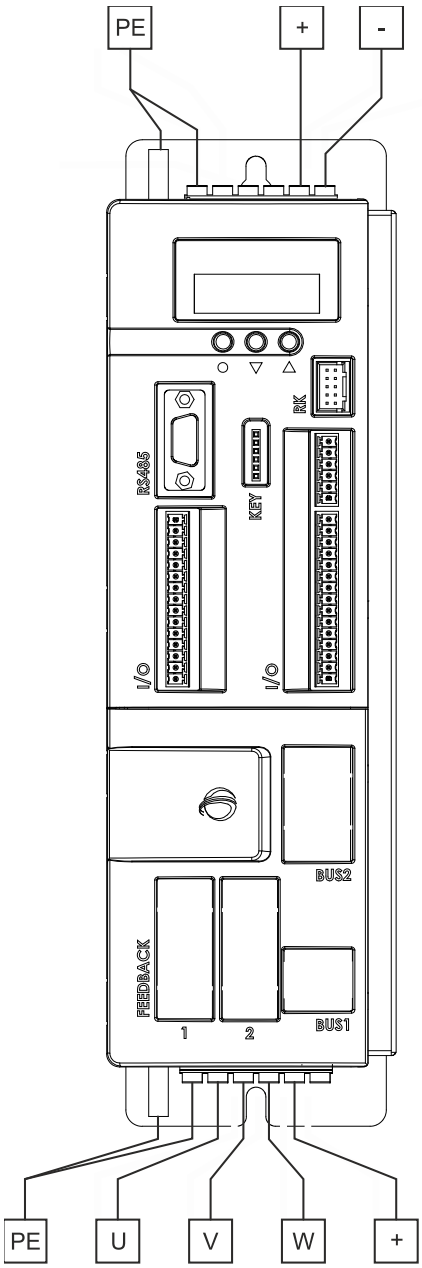
The transformer is indicated outside the cabinet, but depending on the customer's need, it can also be enclosed within the same electric cabinet containing the OPDE AFE ENERGY converter.

The connection to the mains can be performed in several ways that differ by:
- presence or absence of the transformer;
- presence or absence of the precharge circuit.

7.2.3 AVAILABLE POWER CONNECTIONS

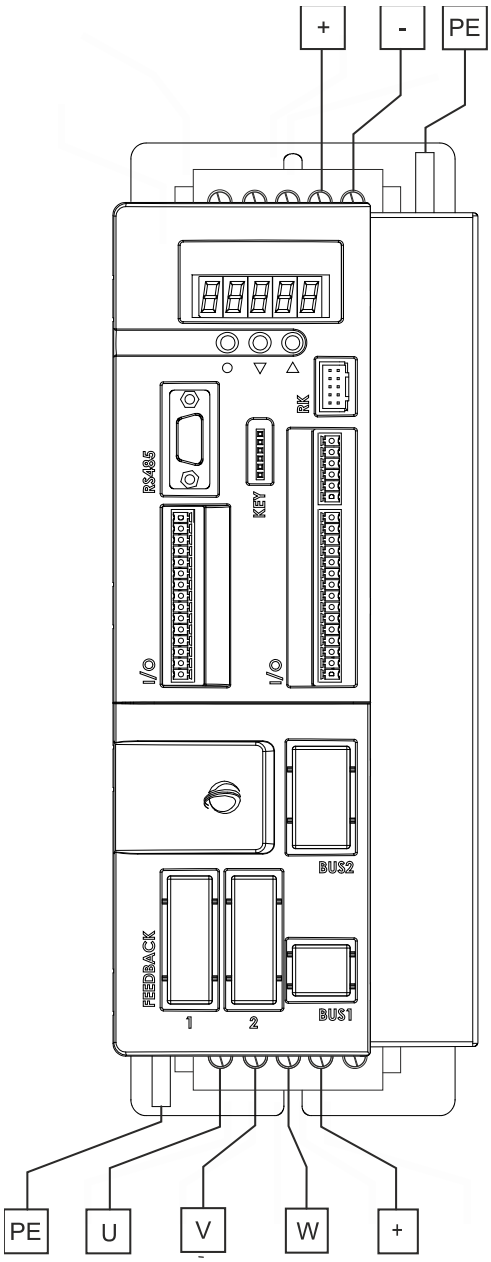
The following figures show the arrangement of the power connections.

TO ACCESS POWER CONNECTIONS, IT IS COMPULSORY TO DISCONNECT THE AC SIDE AND DC SIDE VOLTAGE, WAIT FOR A DISCHARGE TIME EQUAL TO 8 min AND THEN REMOVE THE REMOVABLE PANEL THAT COVERS THE CONNECTIONS.



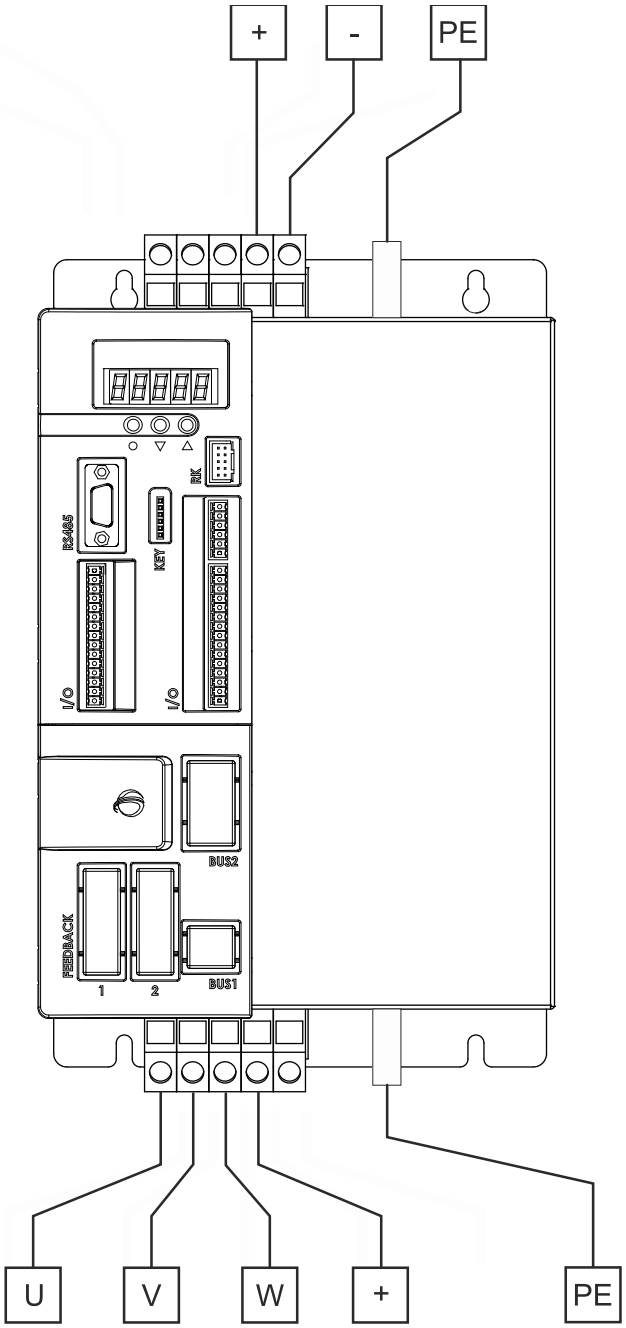
"+" "-" : ingresso lato DC
"U" "V" "W" : uscita lato AC
"PE": collegamento conduttore di protezione

FIG. 88A – Power connections OPDE S 7



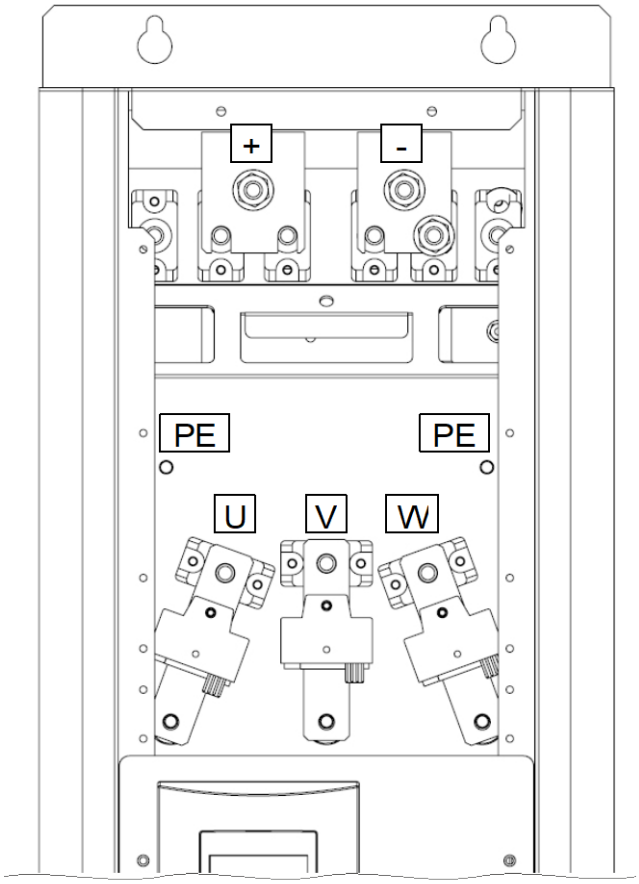
"+" "-" : ingresso lato DC
"U" "V" "W" : uscita lato AC
"PE": collegamento conduttore di protezione

FIG. 8B – Power connections OPDE S 15, 22



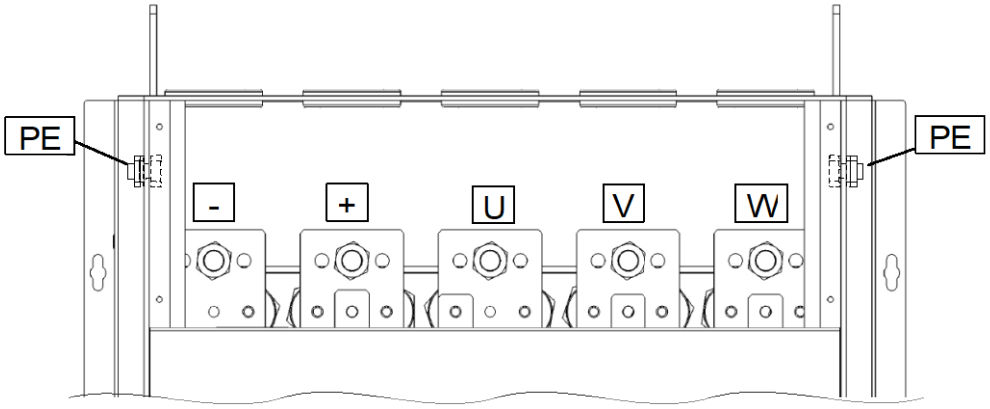
“+” “-“ : ingresso lato DC **“U” “V” “W”** : uscita lato AC
“PE”: collegamento conduttore di protezione

FIG. 8C – Power connections OPDE S 32, 48, 60



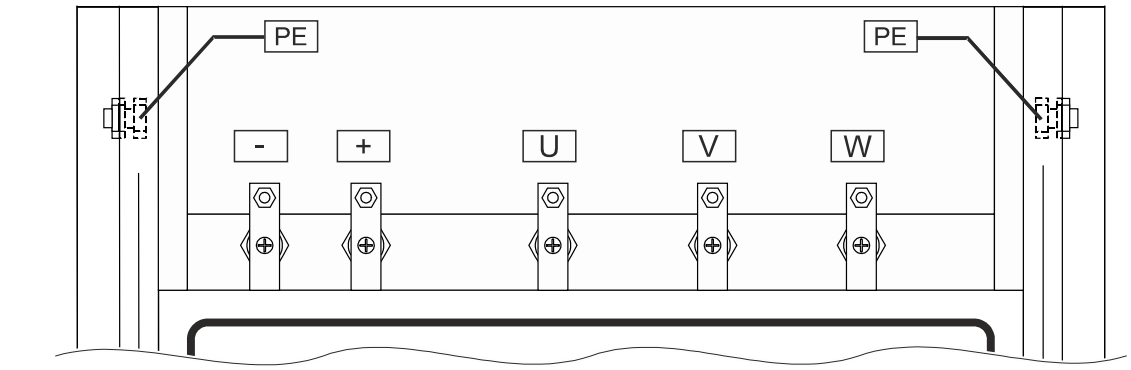
“+” “-“ : DC side input **“U” “V” “W”** : AC side output
“PE”: protective conductor connection

FIG. 89D – Power connections OPDE S 70, 90, 110, 150 (CASE 1)



“+” “-“ : DC side input **“U” “V” “W”** : AC side output
“PE”: protective conductor connection

FIG. 9 – Power connections OPDE S 175, 220, 250 (CASE 2)



"+" "-" : DC side input **"U" "V" "W"** : AC side output **"PE"**: protective conductor connection

FIG. 10 – Power connections OPDE S 310, 370, 460 (CASE 3)

Size OPDE S	Connection cables/bars				
	Indications for the use of PVC cables at 70°C (1)				
	DC side cable section	I^2T at 5s of the DC side PVC cable	AC side cable section	I^2T at 5s of the AC side PVC cable	PVC protection cable section at 70°C
	[mm^2]	[kA^2s]	[mm^2]	[kA^2s]	[mm^2]
OPDE S 70	35	16200	35	16200	25
OPDE S 90	50	33000	50	33000	25
OPDE S 110	50	33000	50	33000	35
OPDE S 150	95	119300	95	119300	50
			70 (2)	64800	50
OPDE S 175	2 x 50	132250	2 x 50	132250	50
			120	190500	50
OPDE S 220	2 x 70	259200	2 x 70	259200	70
	185	452600	185	452600	70
OPDE S 250	2 x 95	477500	2 x 70	259200	95
OPDE S 310	2 x 120	761800	2 x 95	761800	120
OPDE S 370	2 x 150	1190000	2 x 150	1190000	150
OPDE S 460	2 x 185	1811000	2 x 150	1190000	185
	Indications for the use of bare copper bars (1)				
	Min-max width DC side bar	Minimum DC side bar section	Min-max width AC side bar	Minimum AC side bar section	PVC protection cable section at 70°C
	[mm]	[mm^2]	[mm]	[mm^2]	[mm^2]
OPDE S 70	min. 15 max. 20	30	min. 15 max. 20	30	25
OPDE S 90	min. 15 max. 20	30	min. 15 max. 20	30	25
OPDE S 110	min. 15 max. 20	45	min. 15 max. 20	45	35
OPDE S 150	min. 15 max. 20	60	min. 15 max. 20	60	50
OPDE S 175	min. 30 max. 40	90	min. 30 max. 40	90	70
OPDE S 220	min. 30 max. 40	120	min. 30 max. 40	120	70
OPDE S 250	40	120	min. 30 max. 40	120	95
OPDE S 310	30	240	30	180	120
	40	200	40	160	
OPDE S 370	30	300	30	240	150
	40	280	40	200	
OPDE S 460	30	360	30	300	185
	40	320	40	280	

(1) Calculations carried out considering Tamb=50°C.
(2) With PVC cable at 80°C.

TAB. 11 - Connection cables / bars

Size OPDE S	Features of power connections			
	Connection	Connection type	Hole/screw diameter	Tightening torque with steel screw class 8.8 (according to DIN267) [Nm]
OPDE S 70, 90, 110, 150	+,-,U,V,W	PVC cable with cable lugs	M8	20
	PE	PVC cable with cable lugs	M6	9
OPDE S 175, 220, 250	+,-,U,V,W	Copper bar	M12	60
	PE	PVC cable with cable lugs	M8	20
OPDE S 250, 310, 460	+,-,U,V,W	Copper bar	M12	60
	PE	PVC cable with cable lugs	M8	20

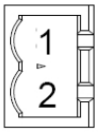
TAB. 12 – Features of the power connections

PERIODICALLY CHECK THE PROPER TIGHTENING OF THE SCREWS OF THE POWER CONNECTIONS.

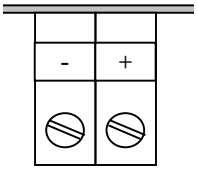
TO ASSURE THE PROPER AND LASTING TIGHTENING OF THE SCREWS, ALL CONNECTIONS TO THE POWER CONNECTIONS SHOULD NOT BE SUBJECT TO MECHANICAL STRESSES (TRACTION OR TWISTING).

7.2.4 POWER SUPPLIES

OPDE AFE ENERGY requires two auxiliary power supply voltages: one for the power supply of the control (adjustment) side and driver, and one for the power supply of the cooling fans. The adjustment and driver power supply must be provided through the removable terminal X3, which is located on the front of OPDE AFE ENERGY. The power supply of the fans, instead, must be provided through the bulkhead terminals on the bottom side of the converter.

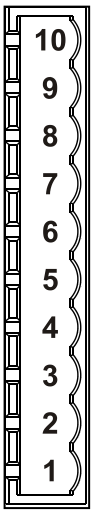
X3	PIN	FUNCTION	DESCRIPTION
	1	+24V	Control side and starters power supply. Power supply voltage: 24Vdc (22÷26Vdc). Maximum absorbed current 1.6A.
	2	0V	

TAB. 13 – Connector X3

X6	PIN	FUNCTION	DESCRIPTION
	+	+24V_F	Heat sink cooling fans power supply. Power supply voltage: 24Vdc (22÷26Vdc). Maximum absorbed current: OPDE S 70, 90, 110 1.5A OPDE S 150, 175 2.5A OPDE S 220, 250 3.5A OPDE S 310, 370, 460 5.0A
	-	0V_F	

TAB. 14 – Fan terminals

X6 is just the power supply terminal of the fans. To enable the operation of the fans, it is necessary to connect a voltage of 24V between the terminals 10 and 9 of connector S1 (FIG. 16 left side).
Using a generic logical output LOx set as "O32 - Enable AFE fans" and following the connection of (FIG. 16 right side). It is possible to control the switching on of the fans based on the temperature of the heat sink.

S1	PIN	FUNCTION	DESCRIPTION
	10	+24V ENABLE AFE FAN	Input for enabling the internal fans cooling the heat sink. +24V ±10% - min. 200mA
	9	0V ENABLE AFE FAN	
	8		Not used
	7		Not used
	6		Not used
	5		Not used
	4		Not used
	3		Not used
	2		Not used
	1		Not used

TAB. 15 – Internal fans enabling input

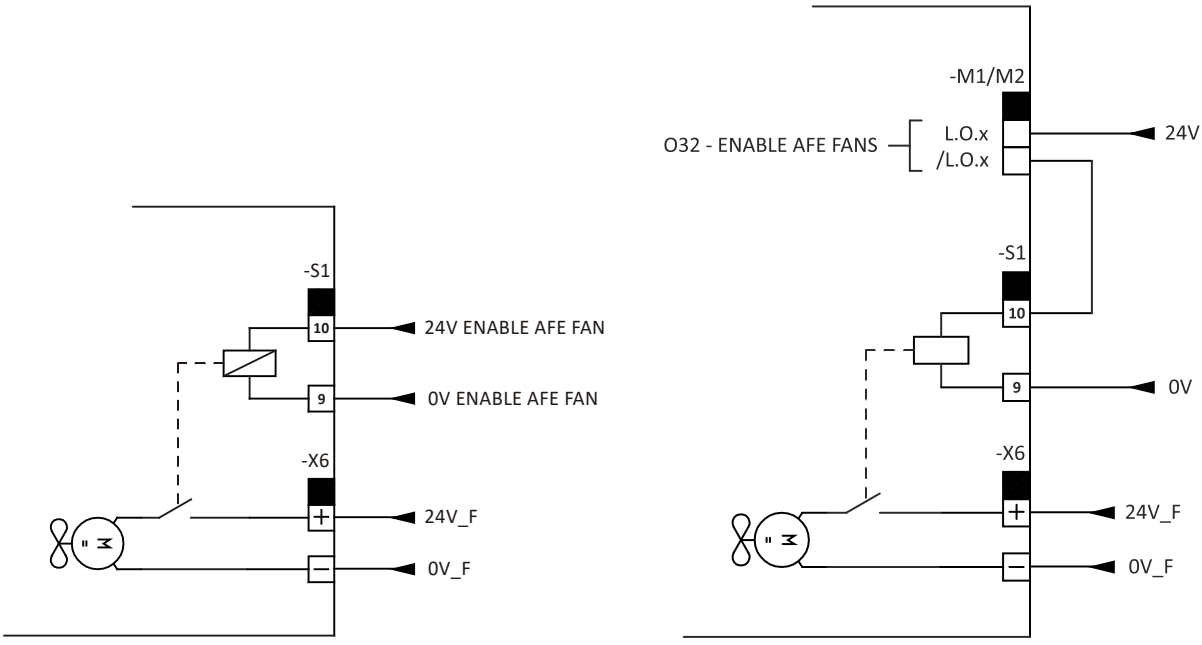
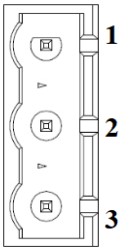


FIG. 11 – Example of connection of the fans power terminal (X6) and fans enabling terminal (S1). On the left, connection with fans always on. On the right, connection with fans controlled via L.O.x logical output set as "O32 – Enable AFE fans" (automatic switching-on depending on the heat sink temperature).

7.2.5 SYNCHRONISM CONNECTIONS

In the OPDE AFE ENERGY converter, it is necessary to connect to the terminal X1 the mains voltages so that the converter can be synchronized with the line. The phase voltages can be connected directly to the connector given that the insulation and adaptation of the signals is implemented internally in the input stage of the synchronism card.

X1	PIN	FUNCTION	DESCRIPTION
	1	L1	Synchronism - voltage phase U (400Vrms for application with rotating machine / 270Vrms for photovoltaic application)
	2	L2	Synchronism - voltage phase V (400Vrms for application with rotating machine / 270Vrms for photovoltaic application)
	3	L3	Synchronism - voltage phase W (400Vrms for application with rotating machine / 270Vrms for photovoltaic application)

TAB. 16 – Synchronism connector

7.2.6 PRECHARGE FROM THE MAINS

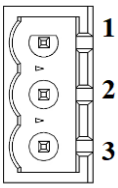
The management of the precharge from the mains is a function that is always available, but it can be exploited in optional manner depending on the application.

OPDE AFE ENERGY is able to handle the precharge of the power electrolytic capacitors through a logical output present on the connector X2, where there are the clean contacts with which it is possible to directly control the precharge contactor coil.

In case of use of the OPDE AFE Energy converter in applications with rotating machine connected to an AC/DC inverter, the connection of the precharge is required.

In case of photovoltaic application, the use of the precharge is optional and it is used in case one wants to have the possibility to perform a precharge of the power electrolytic capacitors of the DC-Bus directly from the three-phase 270Vac mains, without using any external DC source. This function can be useful if one wishes to start the converter running even without the PV array operation, for maintenance, for example.

For examples of connection and management of the precharge circuit, refer to the connection examples given in par. 8.2.2.1 and 9.2.2.1.

X2	PIN	FUNCTION	DESCRIPTION
	1	N.C.	Normally closed contact of the precharge management relay. 4A max. current, 230Vac max voltage
	2	COMM	Common of the precharge management relay. 4A max. current, 230Vac max voltage
	3	N.O.	Normally open contact of the precharge management relay. 4A max. current, 230Vac max voltage

TAB. 17 – Precharge management connector

IF THE OVERCOMING OF GRID FAILURES PURSUANT TO CEI 0-21 OR CEI 0-16 IS REQUIRED, THEN THE PRECHARGE SHOULD NOT BE MANAGED USING THE CONTACTS PRESENT IN THE TERMINAL BOARD X2; RATHER AN APPROPRIATE LOGIC OUTPUT CONFIGURED AS "O33 – ON-GRID CONTACTOR COMMAND" MUST BE USED.
FOR THE MANAGEMENT OF MAINS FAILURES REFER TO PAR. 8.2.2.1 and 9.2.2.1.

7.2.7 LOGICAL CONNECTIONS

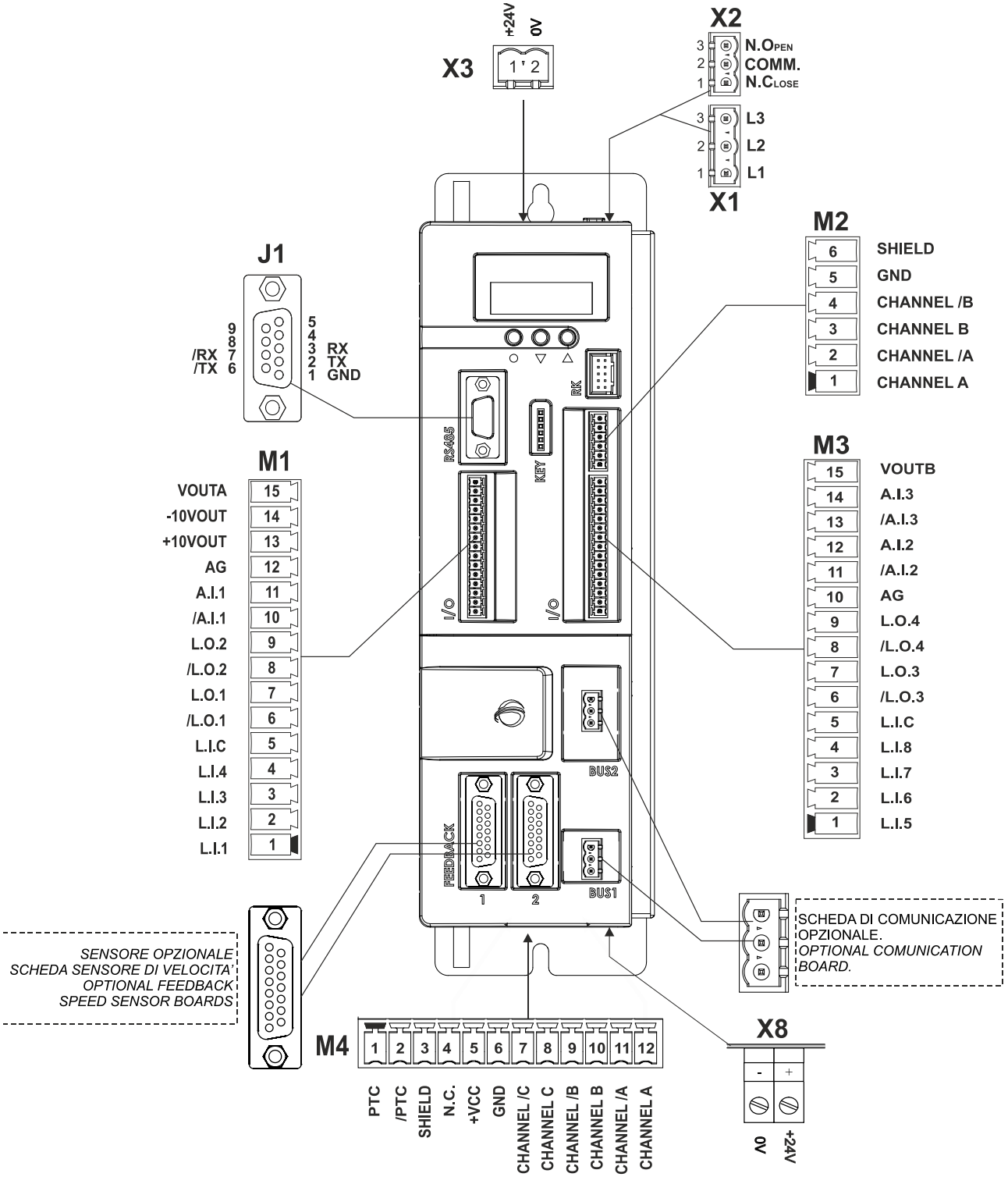


FIG. 12A – Logical Connections 7A ÷ 60A

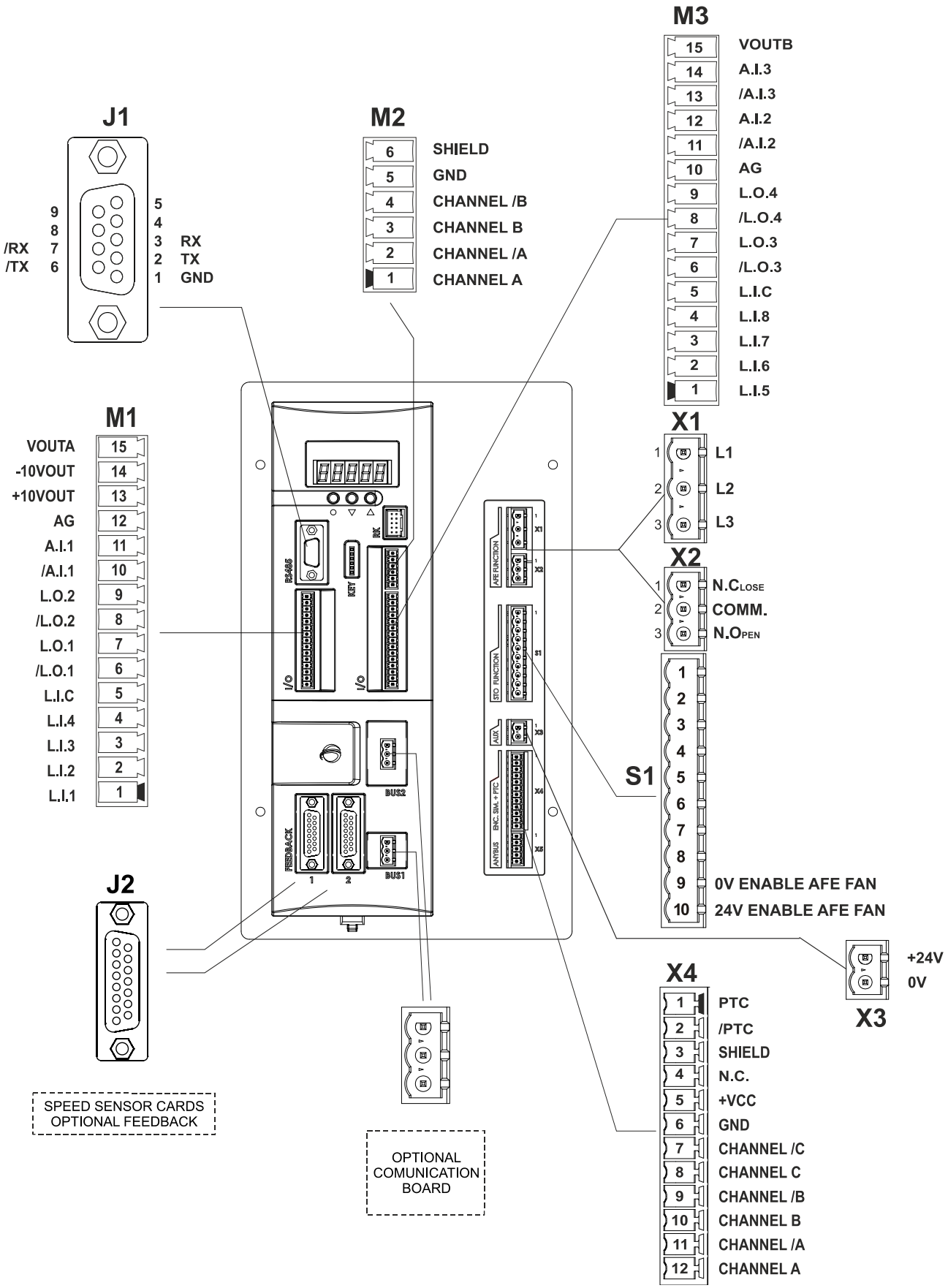
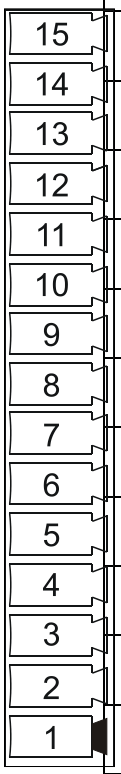


FIG. 12B – Logical Connections 70A ÷ 460A

7.2.7.1 Digital and Analog Logical Connections

M1	PIN	FUNCTION	DESCRIPTION
	1	L.I.1	Configurable logical inputs **(see FIG. 13)** All inputs are optically isolated from the internal regulation. L.I.C. is the common of the inputs L.I.1, L.I.2, L.I.3, L.I.4. 24Vdc ±10% Imax=10mA
	2	L.I.2	
	3	L.I.3	
	4	L.I.4	
	5	L.I.C	Common of the logical inputs to be connected to the negative of the input power supply.
	6	/L.O.1	Configurable optically isolated logical output **(see FIG. 16)** The transistor is conductive when the output is ON. Imax = 60 mA @ 30Vdc
	7	L.O.1	
	8	/L.O.2	Configurable logical output with relay contact. The contact is normally open. Imax = 1A @ 30VDC / 0.3A @ 125VAC
	9	L.O.2	
	10	/A.I.1	Configurable analog input **(see FIG. 15).** Input: +/-10V (max. 0.5 mA) or 4 ÷ 20 mA, settable with the appropriate jumper.
	11	A.I.1	
	12	AG	0V
	13	+10VOUT	Stabilized power supply - 10mA maximum (ref. PIN 12).
	14	-10VOUT	
	15	VOUTA	Configurable analog output **(see FIG. 16).** Output: ± 10V /2mA.

TAB. 18 – Connections: Digital and analog I/O

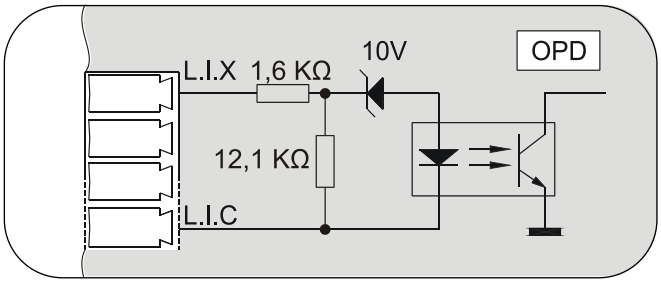


FIG. – Configurable logical inputs

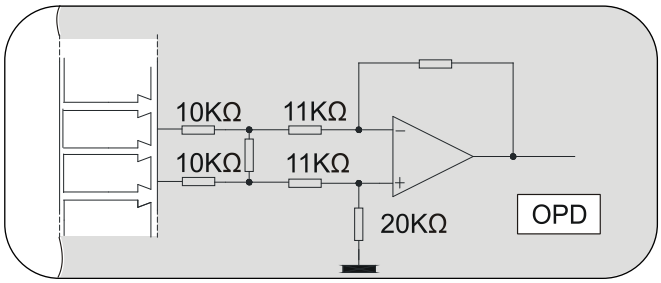


FIG. – Configurable analog input

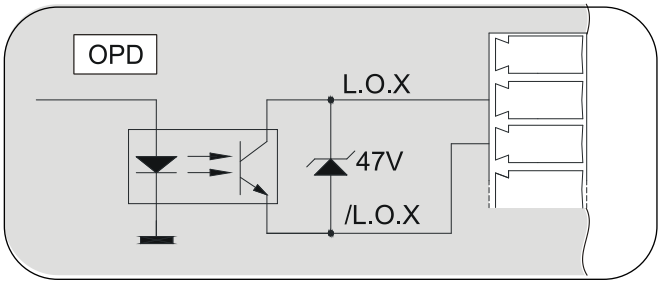


FIG. – Configurable logical outputs

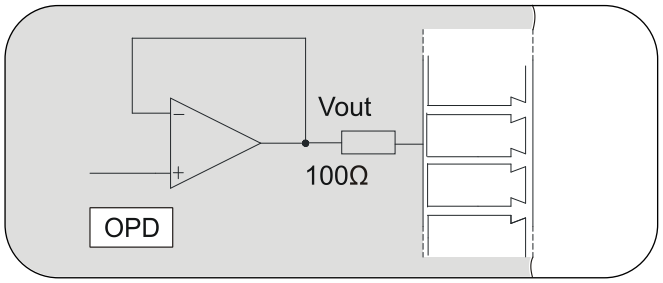
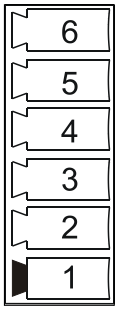


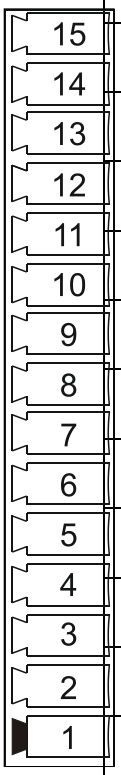
FIG. — Configurable analog output

7.2.7.2 Frequency Input

M2	PIN	FUNCTION	DESCRIPTION
	1	E-A	Channel A input, if differential (otherwise not connected). *f max 300 kHz - 5÷24V*
	2	E-/A (F)	Channel /A frequency input or frequency input. *f max 300 kHz - 5÷24V*
	3	E-B	Channel B input, if differential (otherwise not connected). *f max 300 kHz - 5÷24V*
	4	E-/B (UP)	Channel /B frequency or direction input. (UP/DOWN). *f max 300 kHz - 5÷24V*
	5	GND	0V
	6		Shield

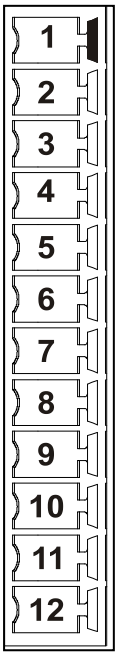
TAB. 19 – Frequency input

7.2.7.3 Digital and Analog I/O Connections

M3	PIN	FUNCTION	DESCRIPTION
	1	L.I.5	Configurable logical inputs **(see FIG. 21)** All inputs are optically isolated from the internal regulation. L.I.C. is the common of the inputs L.I.5, L.I.6, L.I.7, L.I.8. 24Vdc ±10% Imax=10mA
	2	L.I.6	
	3	L.I.7	
	4	L.I.8	
	5	L.I.C	Common of all logical inputs to be connected to the negative of the input power supply.
	6	/L.O.3	Fast configurable logical outputs (max. 5 kHz) **(see FIG. 23).** All outputs are optically isolated from the internal regulation. The transistor is conductive when the output is ON. Imax = 60 mA @ 30Vdc
	7	L.O.3	
	8	/L.O.4	Configurable logical outputs with relay contact. The contact is normally open. Imax = 1A @ 30VDC / 0.3A @ 125VAC
	9	L.O.4	
	10	AG	0V
	11	/A.I.2	Configurable analog inputs (**see FIG. 22).** Inputs: +/-10V (max. 0.5 mA) or 4 ÷ 20 mA, settable with the appropriate jumpers.
	12	A.I.2	
	13	/A.I.3	
	14	A.I.3	
	15	VOUTB	Configurable analog output **(see FIG. 24).** Output: ± 10V /2mA.

TAB. 20 – Connections: Digital and analog I/O

7.2.7.4 Management of the Resistor Thermal Sensor and Simulated Encoder

X4	PIN	FUNCTION	DESCRIPTION
	1	PTC Bimetallic	Resistor thermal probe input (PTC or NTC or KTY84).
	2	/PTC Bimetallic	
	3	PE	
	4	N.C.	
	5	+Vcc	Vmax = 27Vdc
	6	GND	
	7	CHANNEL /C	Connections for Simulated Encoder
	8	CHANNEL C	
	9	CHANNEL /B	
	10	CHANNEL B	
	11	CHANNEL /A	
	12	CHANNEL A	

TAB. 21 – Management of the motor thermal sensor and simulated encoder

7.2.7.5 I/O default configuration

Refer to the user manual for more information on I/O configuring.

DEFAULT I/O - PHOTOVOLTAIC APPLICATION		
INPUT	**DEFAULT**	**CONNECTION**
L.I.1	I27 – Surge Protection Device ok	C01 =27
L.I.2	I00 – Run command	C02 = 0
L.I.3	I31 – Interface protection ok	C03 = 31
L.I.4	I30 – PV switch close and PV insulation ok	C04 = 30
L.I.5	I29 – Fan ok	C05 = 29
L.I.6	I28 – Grid contactor close and line fuse ok	C06 = 28
L.I.7	Not Enabled (free input)	C07 = -1
L.I.8	Not Enabled (free input)	C08 = -1
OUTPUT	**DEFAULT**	**CONNECTION**
L.O.1	O23 – Enable AfE fans	C10 = 23
L.O.2	O33 – On-grid contactor command	C11 = 33
L.O.3	O36 – Active power limitation	C12 = 36
L.O.3	O33 – On-grid contactor command	C13 = 33
OUTPUT	**DEFAULT**	**CONNECTION**
VOUTA	osc11 – Current module	C15 = 11
VOUTB	osc86 – P active limit	C16 = 89

TAB. 22 – I/O default configuration with photovoltaic application

DEFAULT I/O - ROTATING MACHINE APPLICATION		
INPUT	**DEFAULT**	**CONNECTION**
L.I.1	I08 – Reset alarms	C01 = 8
L.I.2	I02 – External enable	C02 = 2
L.I.3	I31 – Interface protection ok	C03 = 31
L.I.4	I00 – Run command	C04 = 0
L.I.5	Not enabled (free input)	C05 = -1
L.I.6	Not enabled (free input)	C06 = -1
L.I.7	Not enabled (free input)	C07 = -1
L.I.8	Not enabled (free input)	C08 = -1
OUTPUT	**DEFAULT**	**CONNECTION**
L.O.1	O23 – Enable AfE fans	C10 = 23
L.O.2	O33 – On-grid contactor command	C11 = 33
L.O.3	O36 – Active power limitation	C12 = 36
L.O.3	O33 – On-grid contactor command	C13 = 33
OUTPUT	**DEFAULT**	**CONNECTION**
VOUTA	osc11 – Current module	C15 = 11
VOUTB	Osc86 – P active limit	C16 = 89

TAB. 23 – I/O default configuration with rotating machine application

7.3 CONNECTION OF OPTIONAL CARDS

7.3.1 CAN BUS

The pin assignment of the optional card for CAN BUS communication is given here below.

code 274B000110VV

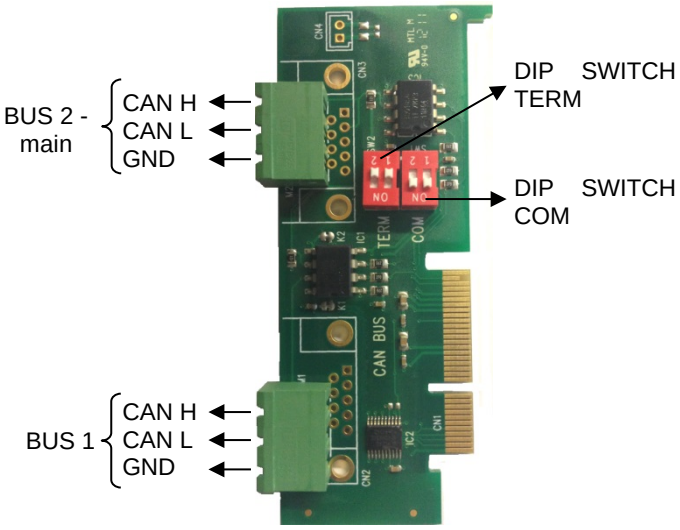
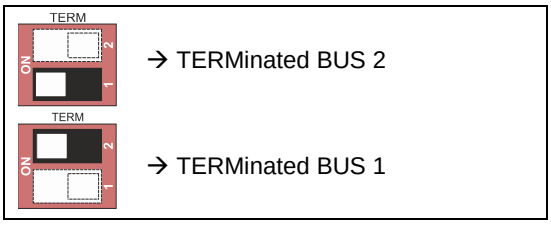


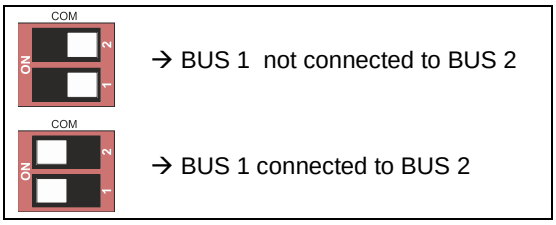
FIG. 13 – CAN bus card

On the card there are 2 double dip switches identified as:

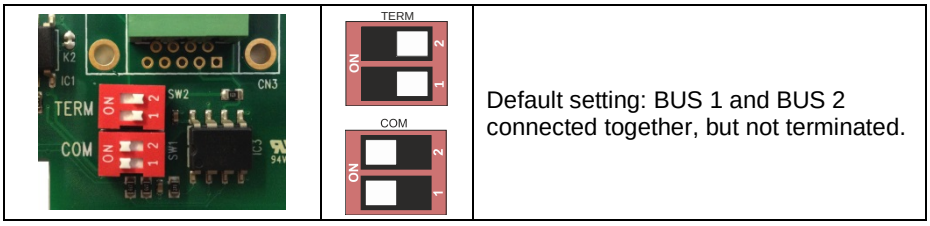
- TERM
- COM

The contacts of the dip switch "TERM" (one for each CAN connector), if set to ON, enable the terminating resistor (120 Ω) between CAN H and CAN L.
The contacts of the dip switch "COM" join the signals CAN L and CAN H of the two Buses so that the two connectors can be used one as input and one as output. The two dip switches shall always be positioned in pairs.





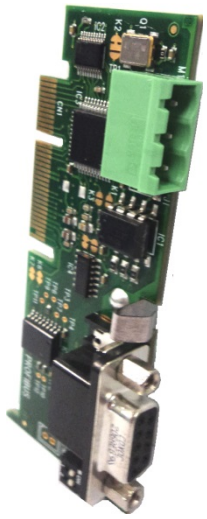
IF BUS 1 AND BUS 2 ARE CONNECTED TOGETHER, NEVER CONNECT BOTH THE TERMINATION RESISTORS (TERM dip switches).



ANY OPERATION MAY BE MADE ONLY WITH OFF CONVERTER.

7.3.2 PROFIBUS

The pin assignment of the optional card for PROFIBUS – CAN BUS communication is given here below.



code 274B000220VV

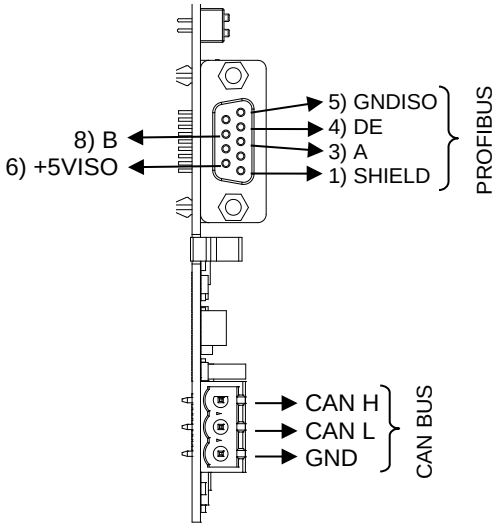
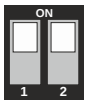


FIG. 14 – Profibus card

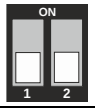
PIN No.	NAME	DESCRIPTION
1	Shield	Protective shield
2	-	-
3	A	Rx/Tx positive data
4	DE	Control signal for repeater
5	GNDISO	0V of +5V supply
6	+5VISO	Output supply +5V
7	-	-
8	B	Rx/Tx negative data
9	-	-

TAB. 24 – Profibus connections

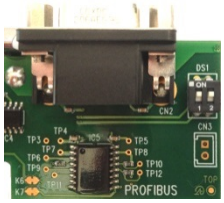
On the card there is a double dip switch referred to as DS1 that, if closed, connects the signal CAN H and CAN L by means of a 120 Ω resistor for the line termination.

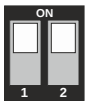


→ CAN H and CAN L terminated by 120 Ω resistor



→ CAN H and CAN L not terminated by resistor



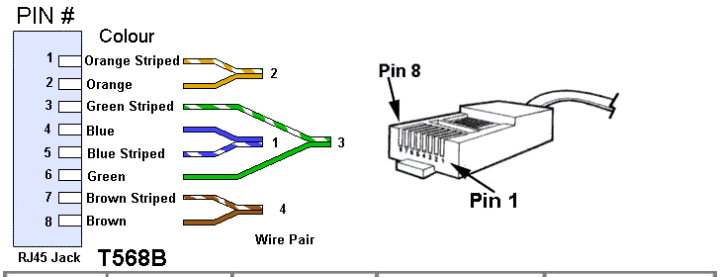


Default setting: CAN H and CAN L signals terminated on 120 Ω resistor.

ANY OPERATION MAY BE MADE ONLY WITH OFF CONVERTER.

7.3.3 ETHERCAT

FIG. 15 – Ehtercat card



RJ45 Pin #	Wire Color (T568A)	Wire Diagram (T568A)	10Base-T Signal 100Base-TX Signal	1000Base-T Signal
1	White/Green		Transmit+	Bl_DA+
2	Green		Transmit-	Bl_DA-
3	White/Orange		Receive+	Bl_DB+
4	Blue		Unused	Bl_DC+
5	White/Blue		Unused	Bl_DC-
6	Orange		Receive-	Bl_DB-
7	White/Brown		Unused	Bl_DD+
8	Brown		Unused	Bl_DD-

FIG. 16 – T568-B standard

The card is equipped with two interfaces 10/100 Base-T RJ45. The individual contacts of the RJ45 port are assigned according to the "T 568-B" standard.
The patch or crossover Ethernet cable belonging to **CAT 5e** can be used as connection cables; CAT 5e is a standard Ethernet network cable defined pursuant to EIE/TIA specifications. Using CAT 5e cables, the maximum recommended length is 100 m.

Also TDE MACNO recommends shielded cables for use in environments where the close proximity to the power cord or the proximity to power or RF appliances may cause interferences.

FIG. 17 - Type of cables

ANY OPERATION MAY BE MADE ONLY WITH OFF CONVERTER.

7.4 INDICATION OF FAULTS AND ALARMS

The OPDE AFE ENERGY converter shows on the keypad and remote keypad display the alarm status of the converter.

It is possible to check the status of the alarms, also remotely, by connecting to the converter through one of the field buses and of the available communication protocols (Modbus, Profibus, CAN Open).

See the user manual for a description of the alarms.

7.5 CONNECTION OF THE RS422/485 SERIAL LINE

The serial line present on the OPDE AFE ENERGY drives foresees the connection for the "4-wire" transmission of data and, therefore, it has the ability to communicate in full-duplex mode. In fact, by virtue of the protocol used (MODBUS RTU) it always communicates in "half-duplex" mode. Therefore, it is possible to perform the connection with only **"two wires"** by connecting to one another **RX** with **TX and /RX with TX.**
In the J1 connector, the RX and /RX signals are the signals received by the converter; while the TX and /TX signals are transmitted signals.
Here below there is an example of connection with a USB port using a suitable USB-RS422/485 converter.

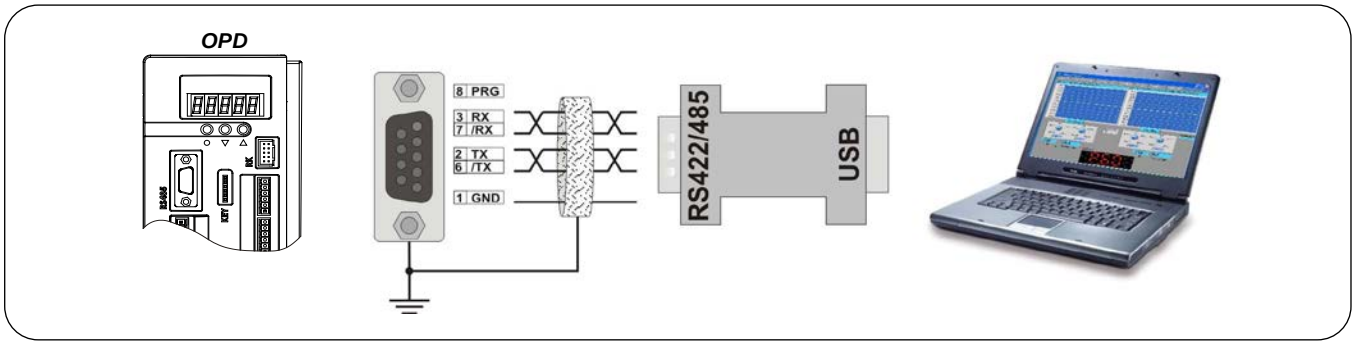


FIG. – Example of connection with USB port

Inside the converter there are the impedances to "terminate" the connection (120Ω) and polarize the line, as indicated in **FIG. 22**. To use such termination connect the terminals **5-3** and **9-7** of connector **J1** to one another (only for the last converter of the line).
The communication wires must be twisted.
The screen may possibly be connected to the metal cap, because through the converter, the metallic basin is connected to ground.

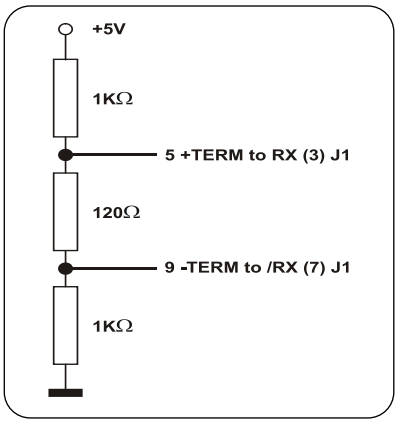


FIG. – 120Ω Connections

Upon request, TDE MACNO supplies a "serial package" consisting of the supervisor software and a cable with RS232/RS485 adapter. For further information consult the **OPDE booklet of the** MODBUS RTU serial protocol.

8 PHOTOVOLTAIC APPLICATION

This chapter contains all the information for the correct use of OPDE AFE ENERGY for photovoltaic applications.

8.1 TECHNICAL DATA

MOD. OPDE AFE ENERGY		OPDE S 7	OPDE S 15	OPDE S 22
Input data from the photovoltaic array (DC side)				
Maximum input voltage	[V d.c.]	780		
Operating voltage	[V d.c.]	380÷780		
Maximum operating current	[A d.c.]	4,2	15,5	23,2
Maximum recommended PV power	[kW]	3,1	6,6	9,6
Rated input power	[kW]	2.8	5,9	8,8
Photovoltaic array maximum short circuit current (Isc PV)	[A d.c.]	7,3	15,7	23,0
Maximum current returning from the inverter to the PV array	[A d.c. / A a.c.]	0 / 0		
Intermediate circuit capacity	[µF]	340	600	1010
Overvoltage category	OVC	III		
Input data for auxiliary power supplies				
Auxiliary power supply for control board	[V d.c.]	24Vdc (22÷26Vdc) 1A		
Auxiliary power supply of the cooling fans	[V d.c.]	24Vdc (22÷26Vdc) 0,2A		
Output data (AC side)				
Rated output voltage	[V a.c.]	225 +10%/-15%		
Maximum output continuous current	[A a.c.]	7,0	15,0	22,0
Inrush current (1)	[A]	0		
Mains frequency	[Hz]	50 / 60		
Maximum output continuous power	[kVA]	2,7	5,8	8,6
Power factor		0.95 cap ÷ 0.95 ind	0.9 capacitivo ÷ 0.9 induttivo	
Maximum output fault current	[A]	32 durata 2µs	68 durata 2µs	100 durata 2µs
Maximum output protection current	[A]	32	68	100
Connection type		Trifase (3P+T)		
Overvoltage category	OVC	III		
Other data				
Operating temperature	[°C]	-20 ÷ +50		
Maximum altitude (2)	[m]	2000		
Insulation protection class		I		
Protection degree		IP20		
PWM frequency	[kHz]	5		
Modulation		Space Vector PWM / Mod abc		
Life (3)	[kh]	14,5	30	30

(1) On the AC side, there is never the inrush current required by the line because it is always the photovoltaic array that precharges the electrolytic power capacitors. The AC line is enabled only when the voltage of the photovoltaic array is greater than the mains rectified value and, therefore, there is not the required inrush current. The inrush current of the externally connected transformer has not been considered.
(2) For altitudes above 1000 m above sea level, derate the current by 1% per 100 m.
(3) Calculated with converter running at maximum continuous current and at the maximum expected ambient temperature.

TAB. 25A – Technical data

MOD. OPDE AFE ENERGY		OPDE S 32	OPDE S 48	OPDE S 60
Input data from the photovoltaic array (DC side)				
Maximum input voltage	[V d.c.]	780		
Operating voltage	[V d.c.]	380÷780		
Maximum operating current	[A d.c.]	33,7	50,3	62,9
Maximum recommended PV power	[kW]	14,0	21,0	26,2
Rated input power	[kW]	12,8	19,1	23,9
Photovoltaic array maximum short circuit current (Isc PV)	[A d.c.]	33,5	50,2	62,8
Maximum current returning from the inverter to the PV array	[A d.c. / A a.c.]	0 / 0		
Intermediate circuit capacity	[µF]	1230	1640	2400
Overvoltage category	OVC	III		
Input data for auxiliary power supplies				
Auxiliary power supply for control board	[V d.c.]	24Vdc (22÷26Vdc) 1A		
Auxiliary power supply of the cooling fans	[V d.c.]	24Vdc (22÷26Vdc) 0,4A	24Vdc (22÷26Vdc) 0,5A	24Vdc (22÷26Vdc) 0,5A
Output data (AC side)				
Rated output voltage	[V a.c.]	225 +10%/-15%		
Maximum output continuous current	[A a.c.]	32,0	48,0	60,0
Inrush current (1)	[A]	0		
Mains frequency	[Hz]	50 / 60		
Maximum output continuous power	[kVA]	12,5	18,7	23,4
Power factor		0.9 capacitivo ÷ 0.9 induttivo		
Maximum output fault current	[A]	145 durata 2µs	208 durata 2µs	260 durata 2µs
Maximum output protection current	[A]	145	208	260
Connection type		Trifase (3P+T)		
Overvoltage category	OVC	III		
Other data				
Operating temperature	[°C]	-20 ÷ +50		
Maximum altitude (2)	[m]	2000		
Insulation protection class		I		
Protection degree		IP20		
PWM frequency	[kHz]	5		
Modulation		Space Vector PWM / Mod abc		
Life (3)	[kh]	30	30	30

(1) On the AC side, there is never the inrush current required by the line because it is always the photovoltaic array that precharges the electrolytic power capacitors. The AC line is enabled only when the voltage of the photovoltaic array is greater than the mains rectified value and, therefore, there is not the required inrush current. The inrush current of the externally connected transformer has not been considered.
(2) For altitudes above 1000 m above sea level, derate the current by 1% per 100 m.
(3) Calculated with converter running at maximum continuous current and at the maximum expected ambient temperature.

TAB. 25B – Technical data

MOD. OPDE AFE ENERGY		OPDE S 70	OPDE S 90	OPDE S 110	OPDE S 150
Input data from the photovoltaic array (DC side)					
Maximum input voltage	[V d.c.]	880			
Operating voltage	[V d.c.]	460÷880			
Maximum operating current	[A d.c.]	83	107	113	157
Maximum recommended PV power	[kW]	42	54	58	80
Rated input power	[kW]	38	49	52	72
Photovoltaic array maximum short circuit current (Isc PV)	[A d.c.]	83	107	113	157
Maximum current returning from the inverter to the PV array	[A d.c. / A a.c.]	0 / 0			
Intermediate circuit capacity	[μF]	2050	2870	3280	3280
Overvoltage category	OVC	III			
Input data for auxiliary power supplies					
Auxiliary power supply for control board	[V d.c.]	24Vdc (22÷26Vdc) 1.6A			
Auxiliary power supply of the cooling fans	[V d.c.]	24Vdc (22÷26Vdc) 1.5A	24Vdc (22÷26Vdc) 1.5A	24Vdc (22÷26Vdc) 1.5A	24Vdc (22÷26Vdc) 2.5A
Output data (AC side)					
Rated output voltage	[V a.c.]	270 +10%/-15%			
Maximum output continuous current	[A a.c.]	79	103	110	152
Inrush current (1)	[A]	0			
Mains frequency	[Hz]	50 / 60			
Maximum output continuous power	[kVA]	37	48	51	71
Power factor		0.9 capacitive ÷ 0.9 inductive			
Maximum output fault current	[A]	303 duration 5μs	394 duration 5μs	453 duration 5μs	640 duration 5μs
Maximum output protection current	[A]	303	394	453	640
Connection type		Three-phase (3P+E)			
Overvoltage category	OVC	III			
Other data					
Operating temperature	[°C]	-20 ÷ +50			
Maximum altitude (2)	[m]	2000			
Insulation protection class		I			
Protection degree		IP20			
PWM frequency	[kHz]	5			
Modulation		Space Vector PWM / Mod abc			
Life (3)	[kh]	65	75	75	30

(1) On the AC side, there is never the inrush current required by the line because it is always the photovoltaic array that precharges the electrolytic power capacitors. The AC line is enabled only when the voltage of the photovoltaic array is greater than the mains rectified value and, therefore, there is not the required inrush current. The inrush current of the externally connected transformer has not been considered.

(2) For altitudes above 1000 m above sea level, derate the current by 1% per 100 m.

(3) Calculated with converter running at maximum continuous current and at the maximum expected ambient temperature.

TAB. 25C – Technical data

MOD. OPDE AFE ENERGY		OPDE S 175	OPDE S 220	OPDE S 250
Input data from the photovoltaic array (DC side)				
Maximum input voltage	[V d.c.]	880		
Operating voltage	[V d.c.]	460÷880		
Maximum operating current	[A d.c.]	202	258	293
Maximum recommended PV power	[kW]	102	130	148
Rated input power	[kW]	93	118	135
Photovoltaic array maximum short circuit current (Isc PV)	[A d.c.]	202	258	293
Maximum current returning from the inverter to the PV array	[A d.c. / A a.c.]	0 / 0		
Intermediate circuit capacity	[µF]	13600	13600	13600
Overvoltage category	OVC	III		
Input data for auxiliary power supplies				
Auxiliary power supply for control board	[V d.c.]	24Vdc (22÷26Vdc) 1.6A		
Auxiliary power supply of the cooling fans	[V d.c.]	24Vdc (22÷26Vdc) 2.5A	24Vdc (22÷26Vdc) 3.5A	24Vdc (22÷26Vdc) 3.5A
Output Data (AC side)				
Rated output voltage	[V a.c.]	270 +10%/-15%		
Maximum output continuous current	[A a.c.]	195	248	282
Inrush current (1)	[A]	0		
Mains frequency	[Hz]	50 / 60		
Maximum output continuous power	[kVA]	91	116	132
Power factor		0.9 capacitive ÷ 0.9 inductive		
Maximum output fault current	[A]	582 duration 5µs	740 duration 5µs	839 duration 5µs
Maximum output protection current	[A]	582	740	839
Connection type		Three-phase (3P+E)		
Overvoltage category	OVC	III		
Other data				
Operating temperature	[°C]	-20 ÷ +50		
Maximum altitude (2)	[m]	2000		
Insulation protection class		I		
Protection degree		IP20		
PWM frequency	[kHz]	5		
Modulation		Space Vector PWM / Mod abc		
Life (3)	[kh]	75	45	30

(1) On the AC side, there is never the inrush current required by the line because it is always the photovoltaic array that precharges the electrolytic power capacitors. The AC line is enabled only when the voltage of the photovoltaic array is greater than the mains rectified value and, therefore, there is not the required inrush current. The inrush current of the externally connected transformer has not been considered.
(2) For altitudes above 1000 m above sea level, derate the current by 1% per 100 m.
(3) Calculated with converter running at maximum continuous current and at the maximum expected ambient temperature.

TAB. 25D – Technical data

MOD. OPDE AFE ENERGY		OPDE S 310	OPDE S 370	OPDE S 460
Input data from the photovoltaic array (DC side)				
Maximum input voltage	[V d.c.]	880		
Operating voltage	[V d.c.]	460÷880		
Maximum operating current	[A d.c.]	361	430	498
Maximum recommended PV power	[kW]	182	217	255
Rated input power	[kW]	166	198	229
Photovoltaic array maximum short circuit current (Isc PV)	[A d.c.]	361	430	498
Maximum current returning from the inverter to the PV array	[A d.c. / A a.c.]	0 / 0		
Intermediate circuit capacity	[μF]	20400	20400	20400
Overvoltage category	OVC	III		
Input data for auxiliary power supplies				
Auxiliary power supply for control board	[V d.c.]	24Vdc (22÷26Vdc) 1.6A		
Auxiliary power supply of the cooling fans	[V d.c.]	24Vdc (22÷26Vdc) 5.0A	24Vdc (22÷26Vdc) 5.0A	24Vdc (22÷26Vdc) 5.0A
Output Data (AC side)				
Rated output voltage	[V a.c.]	270 +10%/-15%		
Maximum output continuous current	[A a.c.]	348	414	480
Inrush current (1)	[A]	0		
Mains frequency	[Hz]	50 / 60		
Maximum output continuous power	[kVA]	163	194	224
Power factor		0.9 capacitive ÷ 0.9 inductive		
Maximum output fault current	[A]	1036 duration 5μs	1233 duration 5μs	1560 duration 5μs
Maximum output protection current	[A]	1036	1233	1560
Connection type		Three-phase (3P+E)		
Overvoltage category	OVC	III		
Other data				
Operating temperature	[°C]	-20 ÷ +50		
Maximum altitude (2)	[m]	2000		
Insulation protection class		I		
Protection degree		IP20		
PWM frequency	[kHz]	5	5	3
Modulation		Space Vector PWM / Mod abc		
Life (3)	[kh]	50	30	30

(1) On the AC side, there is never the inrush current required by the line because it is always the photovoltaic array that precharges the electrolytic power capacitors. The AC line is enabled only when the voltage of the photovoltaic array is greater than the mains rectified value and, therefore, there is not the required inrush current. The inrush current of the externally connected transformer has not been considered.

(2) For altitudes above 1000 m above sea level, derate the current by 1% per 100 m.

(3) Calculated with converter running at maximum continuous current and at the maximum expected ambient temperature.

TAB. 25E – Technical data

8.2 ELECTRIC CONNECTIONS

8.2.1 CONNECTIONS COMPLYING WITH CEI 0-21 OR CEI 0-16

The OPDE AFE ENERGY converter is suitable for use in applications requiring compliance with the standard:

- CEI 0-21;V1 2012-12 “Reference technical rules for connecting active and passive utilities to the LV grids of electricity distribution companies", including previous editions; or
- CEI 0-16;V1 2013-12 “Reference technical rules for connecting active and passive utilities to the HV and MV grids of electricity distribution companies", including previous editions.

Some functions provided by CEI 0-21 and CEI 0-16, such as:

a) insensitivity to voltage sags (LVFRT);
b) conditions of connection, reconnection and gradual power supply;

require the execution of appropriate connections to be performed.

They consist respectively in:

a) properly management of the on-grid command of the KM01 contactor that connects to the network through the logical output "O33-On-grid contactor command";
b) proper connection of the converter to the interface protection (SPI) used in the production plant;
c) assure continuity of supply of part of the circuits using a UPS;

The following table summarizes the regulatory requirements for photovoltaic applications; they differ depending on whether compliance with CEI 0-21 or CEI 0-16 is required.

PHOTOVOLTAIC APPLICATION					
Regulatory requirement	**Required connections**	**Diagram**	**Applicability**		
			CEI 0-21; V1 2012-12	**CEI 0-16 Ed III: 2012-12**	**CEI 0-16; V1 2013-12**
- insensitivity to voltage sags (LVFRT);	- On-grid contactor control from logical output "O33-On-grid contactor command" - Feeding of ancillary equipment from UPS - SPI adjusted to prevent it from tripping during voltage lowering	- FIG. 29 - FIG. 29 - FIG. 29	YES	YES	YES
- Conditions of connection, reconnection and gradual power supply;	- Bringing the status of SPI back to input "I31-Interface protection ok"	- FIG. 29	YES	YES	YES

TAB. 26

8.2.2 EXAMPLES OF CONNECTION

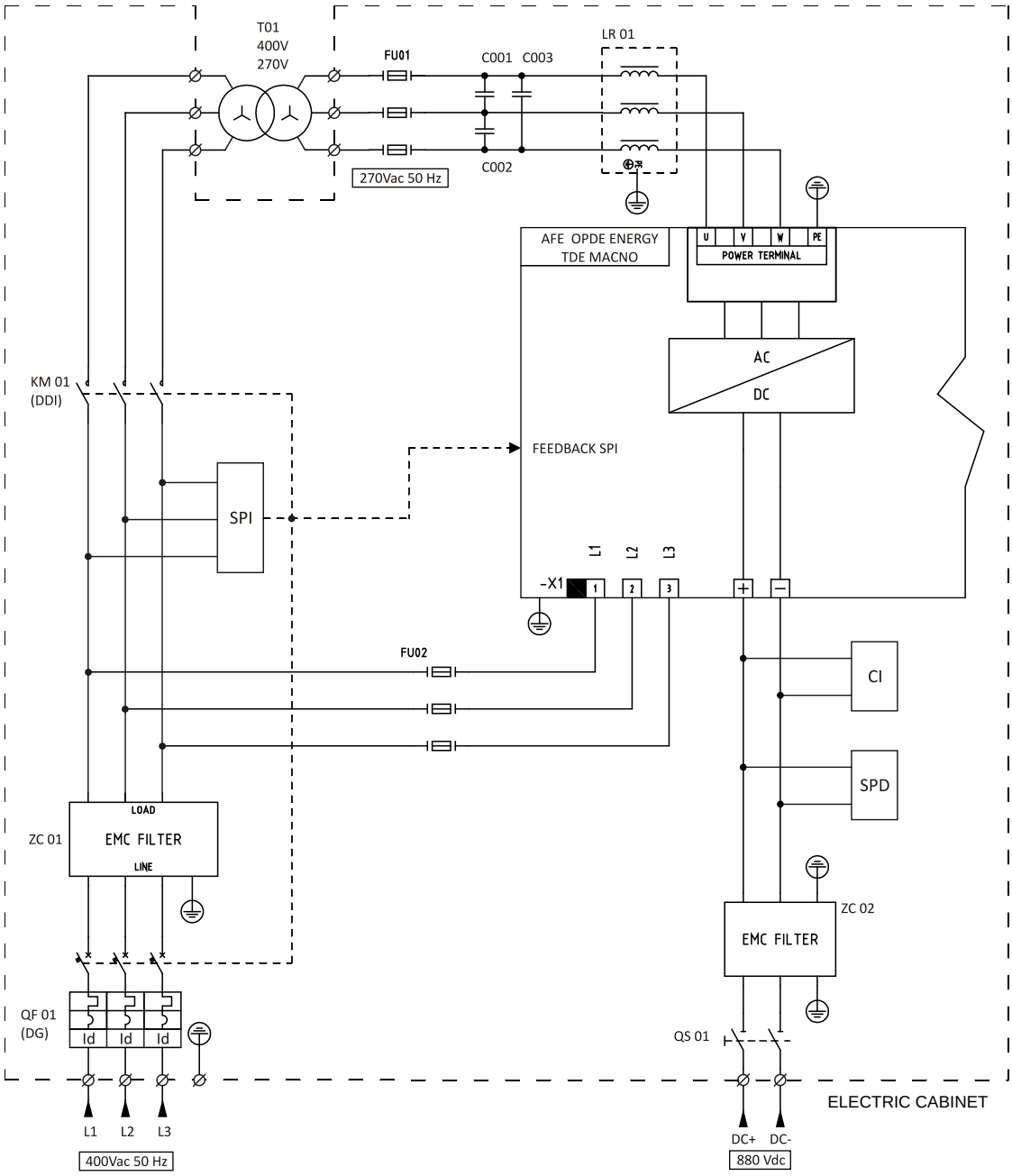


FIG. 18 – Example of LV connection without precharge circuit and transformer downstream of the contactor. Connections according to CEI 0-21. DDI=KM01, DG=QF01 (also other configurations are possible).

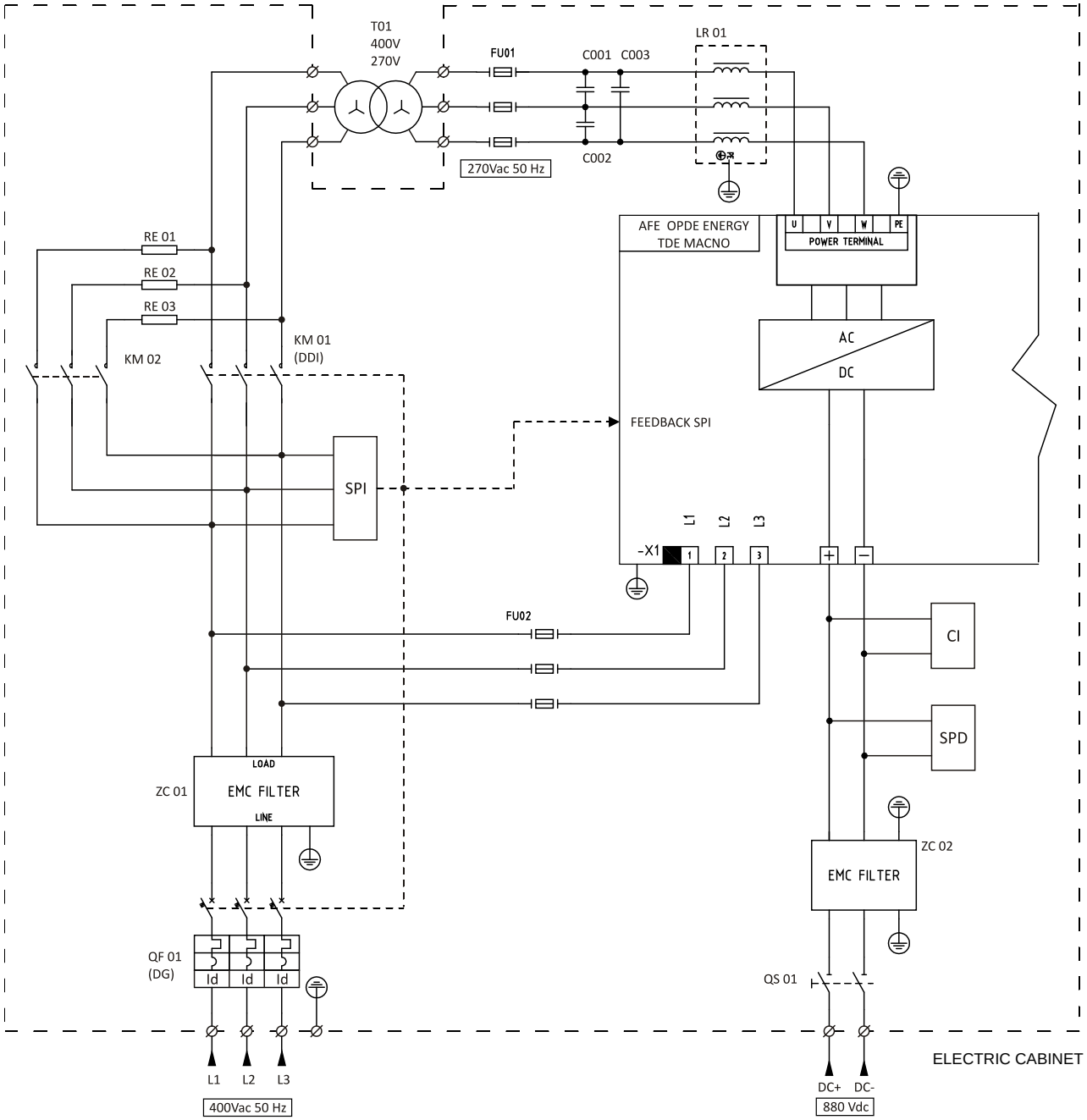


FIG. 19 – Example of LV connection with precharge circuit and transformer downstream of the contactor (DDI). DDI=KM01, DG=QF01 (also other configurations are possible).

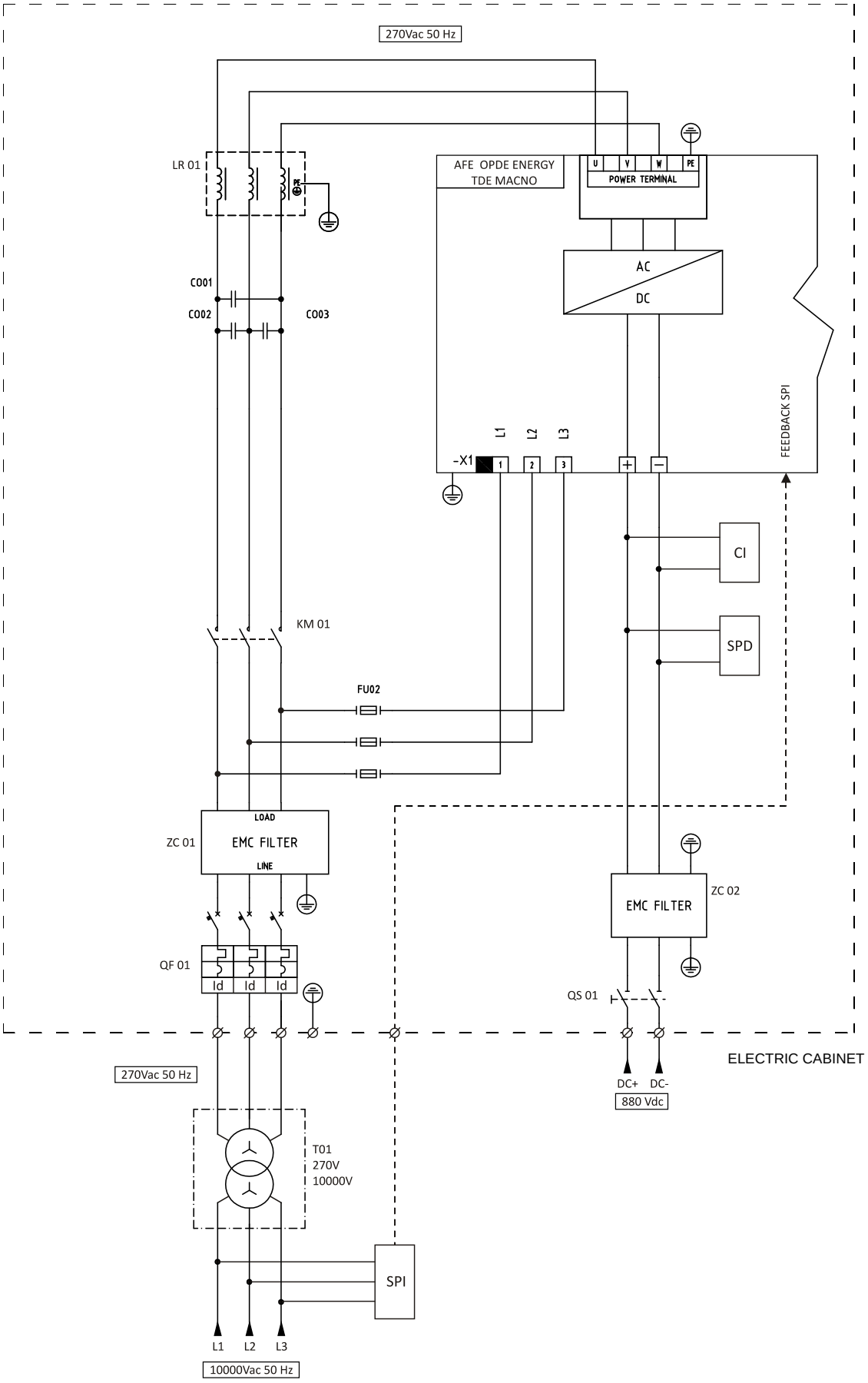


FIG. 20 – Example of MV connection. Connections according to CEI 0-16.

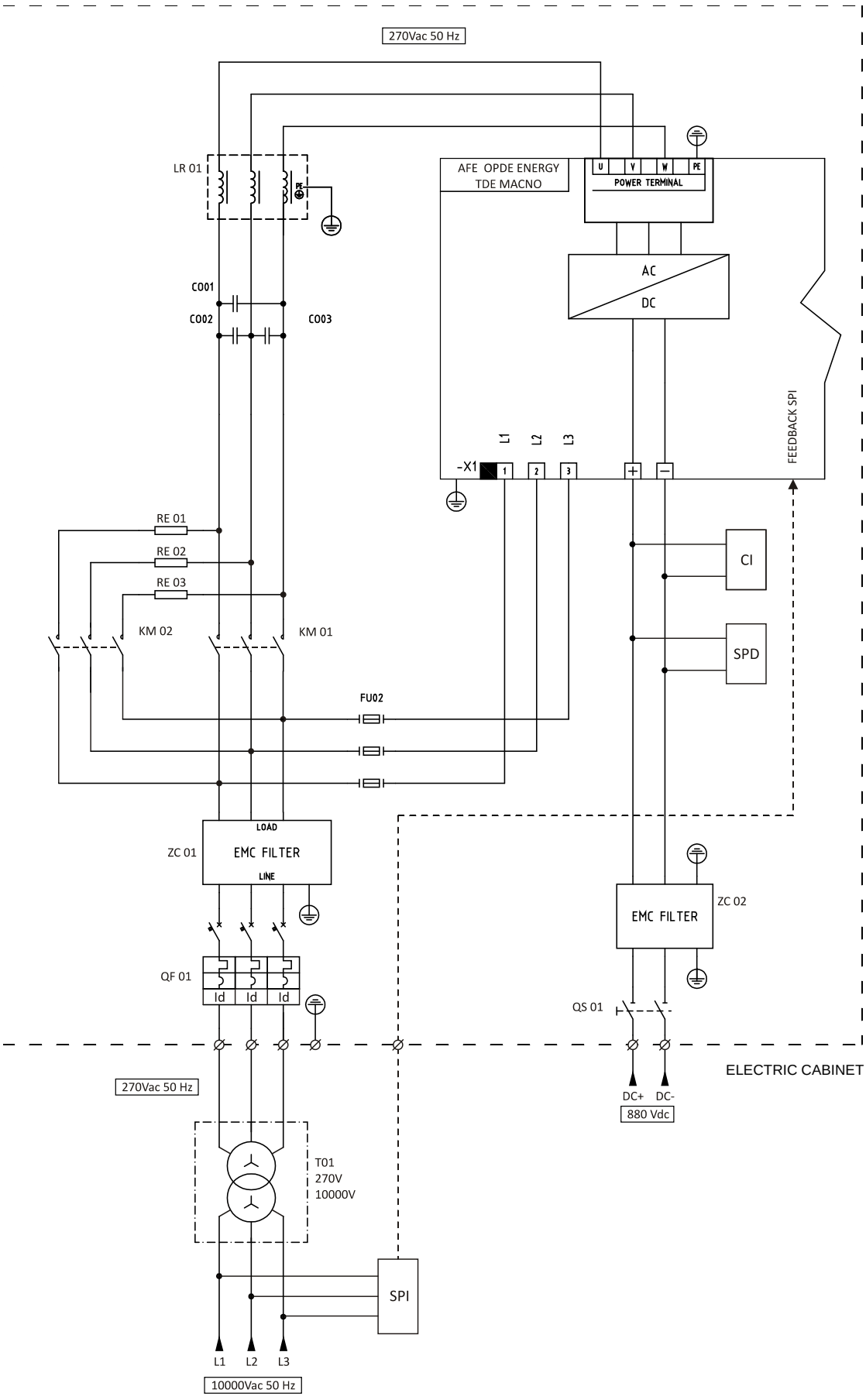


FIG. 21 – Example of MV connection with precharge circuit.

8.2.2.1 Management of on-grid sequence

In the connection examples shown in the previous paragraph, a on-grid KM01 contactor is visible. In photovoltaic applications, it must be controlled by the logical output "O33-ON-GRID CONTACTOR COMMAND" to allow the management of the connection according to the state machine of the control software.

Depending on how the control of this contactor is managed, it is possible to attain insensitivity to voltage sags (LVFRT) or not.

INSENSITIVITY TO VOLTAGE SAGS (LVFRT) IN PHOTOVOLTAIC APPLICATIONS IS MANDATORY IF THE STANDARD CEI 0-21 OR CEI 0-16 APPLIES

In addition, some examples of connection show diagrams in which the on-grid contactor is equipped with a precharge circuit: this circuit is optional. In fact, the precharge circuit in photovoltaic applications is not compulsory because usually it is the PV array that precharges the capacitors in the DC bus. The precharge is used only in case you want to have also the possibility to perform a precharge of the DC-Bus directly from the 270 Vac three-phase mains, for example for maintenance needs.

Some examples of connection of the on-grid sequence are given now. It should be underlined that also the connection for signaling the SPI state on input "I31 - Interface protection ok" was represented. This connection is required if you want to meet the requirements relating to the conditions for connection, reconnection and gradual power supply (for details refer to par. 8.2.2.3).
In all examples, the command of the KM01 contactor coil is performed using two logical outputs to meet the electrical safety requirements that require the opening to be performed also in case of single failure of the control device.

The management of the on-grid control, if it **is not required to exceed the LVFRT values** and if the precharge is not required, is shown in FIG. 28. It involves controlling the KM01 on-grid contactor through the logical output "O33-ON-GRID CONTATOR COMMAND" to allow the management of the connection according to the state machine of the control software.
In the diagram, the tripping of SPI controls the opening of the KM01 on-grid contactor.

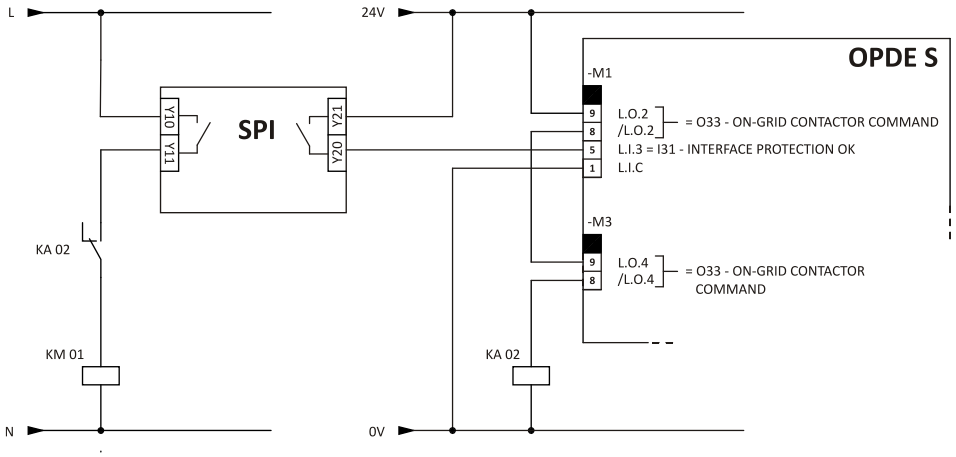


FIG. 22 – Connection of the on-grid sequence without LVFRT management and without precharge

The management of the on-grid control, if it **is required to exceed the LVFRT values** and if the precharge is not required, is shown in FIG. 29. It involves:

- use of the logical output "O33-ON-GRID CONTACTOR COMMAND" to allow controlling the main contactor KM01 closing even during voltage sags;
- feeding of the precharge contactor and OPDE AFE ENERGY converter coils with a voltage derived from a UPS;
- regulation of the interface protection (SPI) in order to avoid unwanted tripping during voltage sags.

During voltage sags, the converter momentarily interrupts the supply of power and resumes it within 400ms from the restoration of voltage supply.
If SPI trips due to a prolonged power failure, then it determines the opening of the KM01 on-grid contactor.

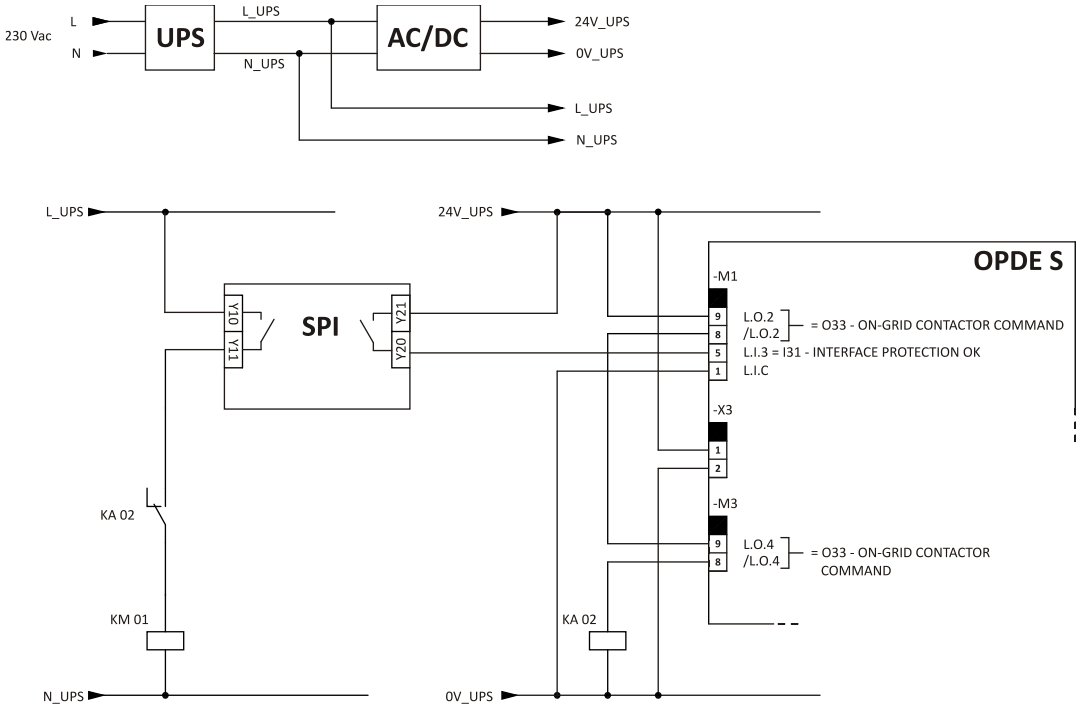


FIG. 23 – Connection of the on-grid sequence for LVFRT management, without precharge

The management of the on-grid control, if the **precharge is required**, is shown in FIG. 30. It involves controlling the KM01 on-grid contactor through the logical output "O33-ON-GRID CONTACTOR COMMAND" to allow the management of the connection according to the state machine of the control software. But in the on-grid sequence trips also the precharge end contact present in the terminal board X2

In the diagram, the tripping of SPI controls the opening of the KM01 on-grid contactor and of the KM02 precharge contactor.

THE USE OF PRECHARGE DOES NOT ALLOW TO OBTAIN INSENSITIVITY TO VOLTAGE SAGS (LVFRT)

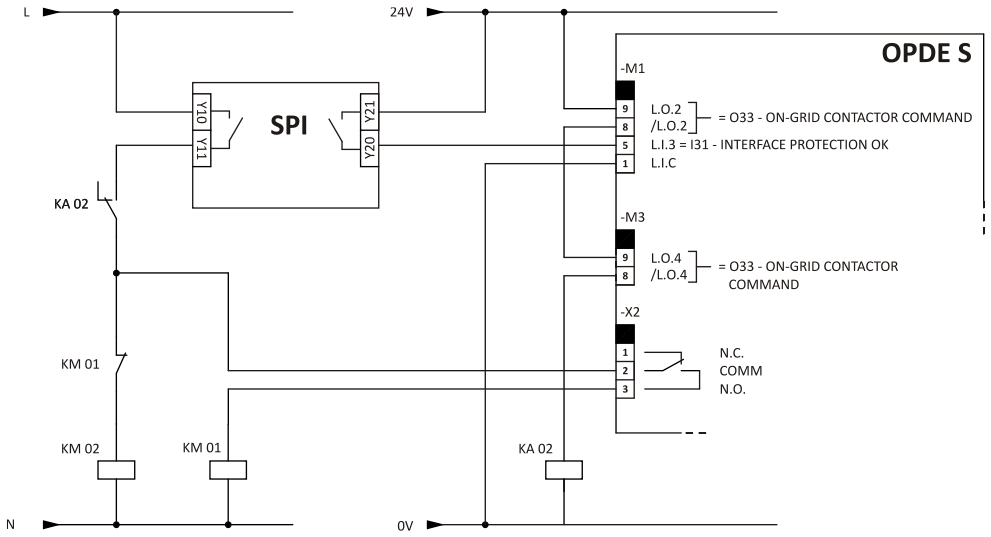


FIG. 24 – Connection of the on-grid sequence with precharge (no LVFRT management)

8.2.2.2 I/O connections

The following figure shows an example of I/O connection in the case of photovoltaic application. It involves:

- N.C. contact for signaling the tripping of the dischargers (SPD) connected to the input "I27-Surge Protection Device ok";
- hardware run command always enabled;
- signaling of the SPI status via N.O. contact connected to the input "I31-Interface protection ok";
- signaling of the status of the insulation controller (CI) and the PV side disconnecting device by means of N.O. contacts series connected to the input "I30-PV switch close and PV insulation ok";
- signaling of anomalies relating to the fans of the electric cabinet - where the OPDE AFE ENERGY was connected - via N.C. contact connected to the input "I29–Fan ok";
- signaling of the status of the KM01 on-grid contactor through N.O. contact and of the line fuses through N.C. contact series connected to the input "I28-Grid contactor close and line fuse ok";
- use of the logical output "O33-On-grid contactor command" for controlling the KM01 contactor;
- use of the logical output "O23-Enable AFE fans" to control the fans of the converter.

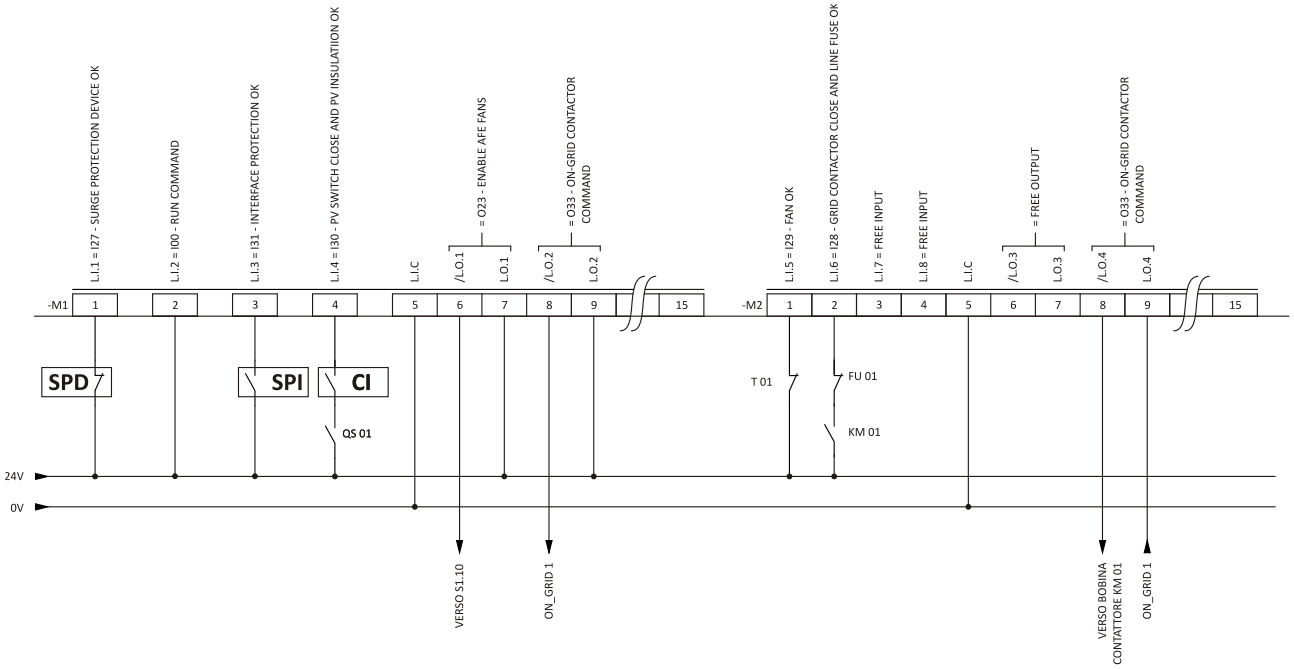


FIG. 25 – Example of O/I connection.

The command of the KM01 on-grid contactor coil is performed using two logical outputs to meet the electrical safety requirements that require the opening to be performed also in case of single failure of the control device.

8.2.2.3 Interface protection management

The proper management of the interface protection allows meeting the requirements concerning the conditions for connection, reconnection and gradual power supply set forth be the standards **CEI 0-21 and CEI 0-16.** These requirements involve a gradual supply of the active power and specific waiting times for reconnection after SPI tripping.

To meet the requirements, it is necessary to follow the diagram of FIG. 32 which includes:

- signaling on the SPI status on the input "I31 - Interface protection ok"

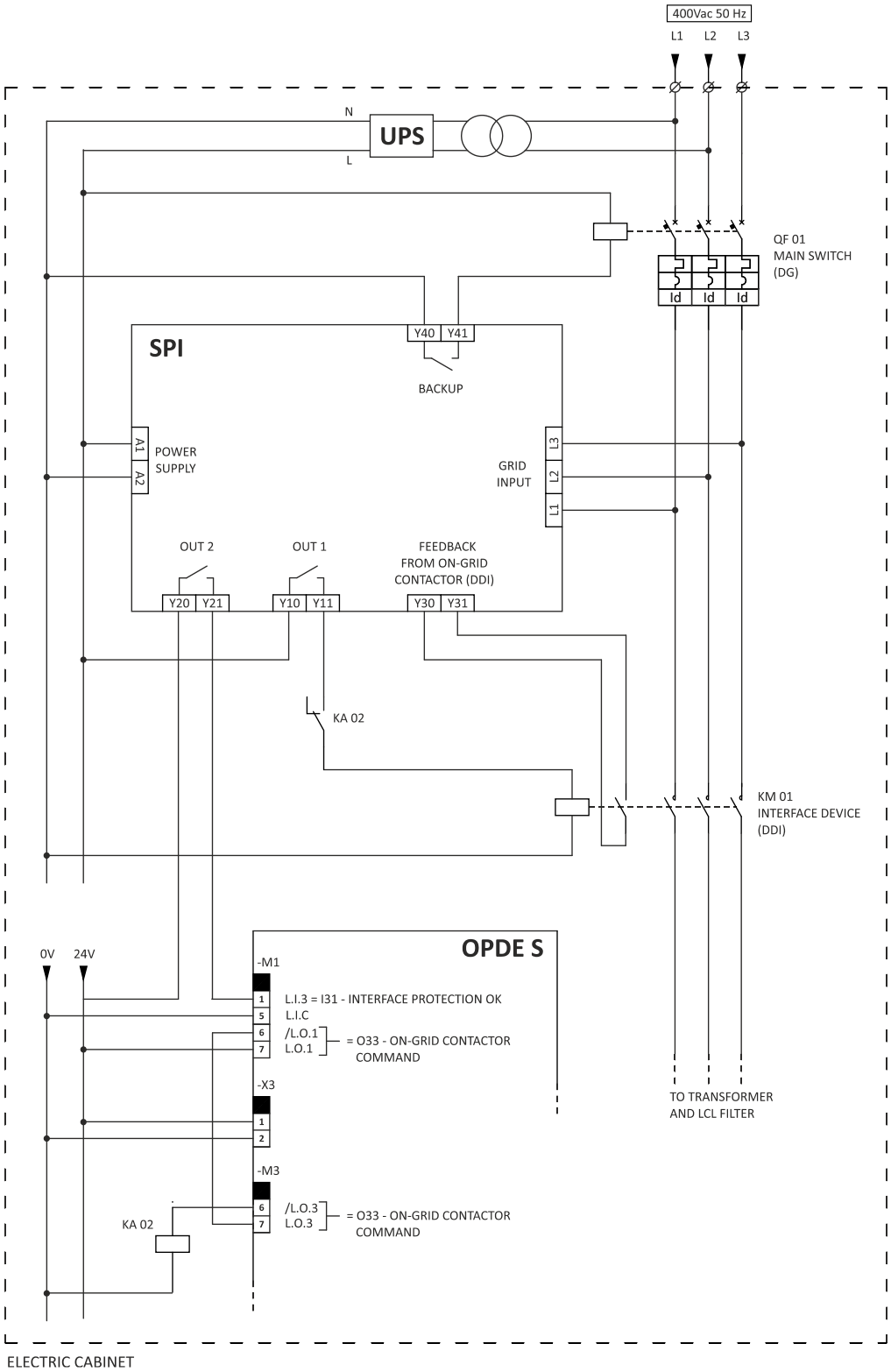


FIG. 26 – SPI connections in case of internal SPI and DDI.
DDI = KM01, backup= QF01, UPS necessary to assure the functioning of the backup (other configuration are possible)

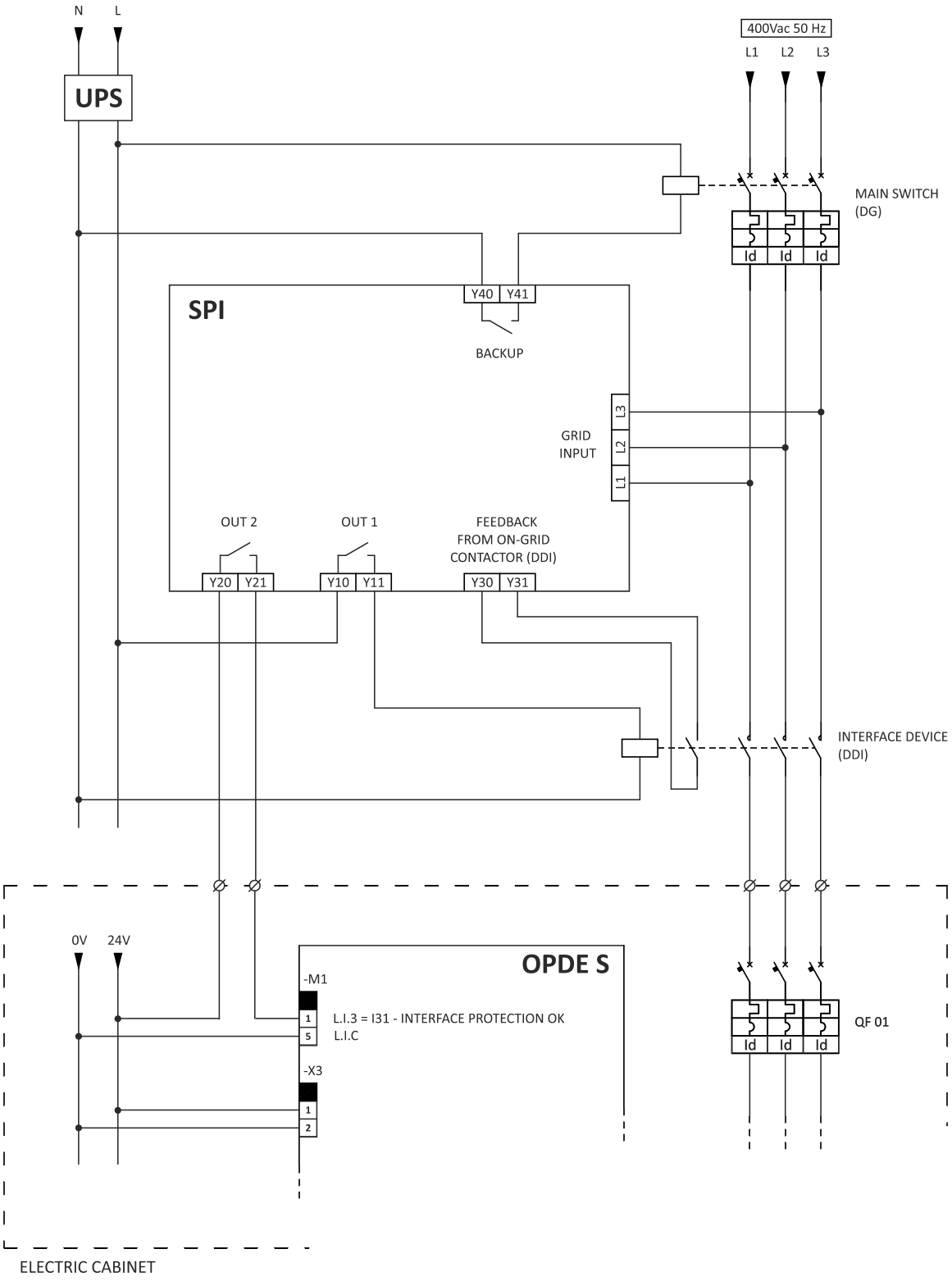


FIG. 27 – SPI connections in case of external SPI and DDI. UPS necessary to assure the functioning of the backup (other configuration are possible)

8.2.3 AC SIDE PARALLEL CONNECTION

The wiring diagrams shown in par. 8.2.2 refer to the use of a single OPDE AFE ENERGY converter. They are summarized in the following figures.

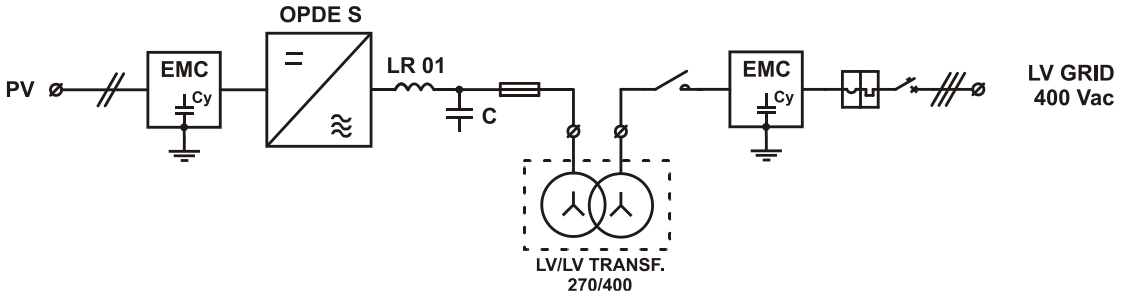


FIG. 28 – OPDE S, LV connected, photovoltaic application

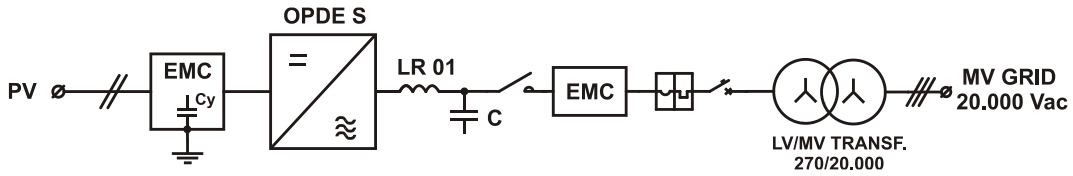


FIG. 29 – OPDE S, MV connected, photovoltaic application

For parallel connecting several OPDE AFE ENERGY in the same three-phase AC line, it is necessary to follow these guidelines:

1) OPDE AFE ENERGY can be connected to the mains through a single transformer, but it must have 270Vac secondary windings dedicated for each OPDE S. The secondary windings must be positioned vertically one above the other in the column of the transformer (they must not be wound one above the other).

2) Due to the presence of the filter capacitors to the ground of EMC filter on the PV side, the star center of the windings dedicated to each OPDE AFE ENERGY must be isolated from ground.

3) In case of connection to the LV mains, it is necessary to connect a single EMC filter in the 400Vac side of the transformer (FIG. 36). In case of connection to the MV mains, it is necessary to connect a dedicated EMC filter for each OPDE AFE ENERGY; in this case, the filter must be free of capacitors to the ground (FIG. 37).

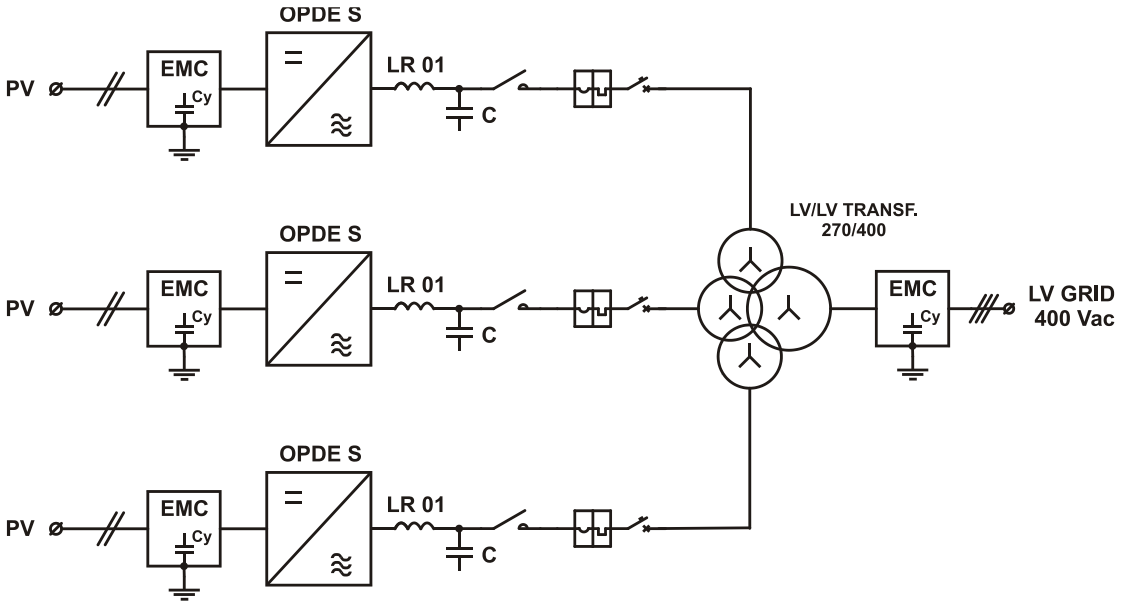


FIG. 30 – 3 x OPDE S, LV parallel connected, photovoltaic application

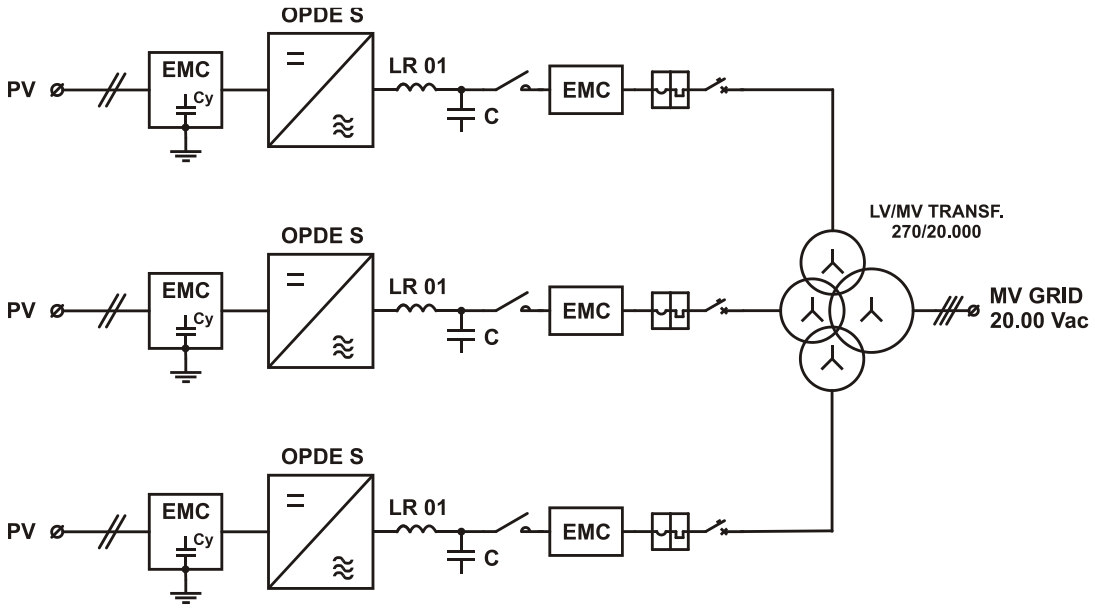


FIG. 31 – 3 x OPDE S, MV parallel connected, photovoltaic application

8.2.4 COMPONENTS FOR THE CONNECTION TO THE THREE-PHASE MAINS

For the correct operation of OPDE AFE ENERGY and to meet the regulations on electrical safety, it is necessary to install external components in the connection to the three-phase mains.
The required external components are the following ones (depending on the final installation, some components may not be compulsory):

- main choke LR01;
- filter capacitors C001, C002, C003;
- secondary choke LR02 (optional);
- external transformer T01;
- fuse FU01;
- on-grid contactor KM02;
- pre-charge contactor KM01;
- EMC filter ZC01;
- circuit breaker QF01;
- interface protection SPI.

The following section shows the features of the external components on the mains side.

	Main choke LR01			
Size OPDE S	**OPDE S 70**	**OPDE S 90**	**OPDE S 110**	**OPDE S 150**
Three-phase inductance [mH]	0,942	0,723	0,677	0,490
Effective thermal current [Arms]	83	108	115.5	160
Effective overload current [Arms]	99.5	130	139	192
Overload duration (s)	30			
Rated voltage [Vrms]	270			
Rated frequency [Hz]	50			
Current THD [% of thermal current]	4.92			
Switching frequency [kHz]	5			
Ambient temperature [° C]	50			
Cooling	Natural air			
Overtemperature class	F			
Insulation class of materials	H			
Insulation voltage [kV]	1.1 / 3 for 30s			
TDE code	054R42028		054R42027	054R42021

TAB. 27A - Main choke

	Main choke LR01		
Size OPDE S	**OPDE S 175**	**OPDE S 220**	**OPDE S 250**
Three-phase inductance [mH]	0,382	0,300	0,264
Effective thermal current [Arms]	205	260	296
Effective overload current [Arms]	246	313	355
Overload duration [s]	30		
Rated voltage [Vrms]	270		
Rated frequency [Hz]	50		
Current THD [% of thermal current]	4.92	4.92	4.92
Switching frequency [kHz]	5	5	5
Ambient temperature [° C]	50		
Cooling	Natural air		
Overtemperature class	F		
Insulation class of materials	H		
Insulation voltage [kV]	1.1 / 3 for 30s		
TDE code	054R42029	054R42022	

TAB. 24B - Main choke

Size OPDE S	Main choke LR01		
	OPDE S 310	OPDE S 370	OPDE S 460
Three-phase inductance [mH]	0,214	0,180	0,155
Effective thermal current [Arms]	365	435	504.0
Effective overload current [Arms]	438	522	605.0
Overload duration [s]	30		
Rated voltage [Vrms]	270		
Rated frequency [Hz]	50		
Current THD [% of thermal current]	4.93	4.93	8.21
Switching frequency [kHz]	5	5	3
Ambient temperature [° C]	50		
Cooling	Natural air		
Overtemperature class	F		
Insulation class of materials	H		
Insulation voltage [kV]	1.1 / 3 for 30s		
TDE code			

TAB. 24C - Main choke

Size OPDE S	Insulation transformer T01									
	OPDE S 70	OPDE S 90	OPDE S 110	OPDE S 150	OPDE S 175	OPDE S 220	OPDE S 250	OPDE S 310	OPDE S 370	OPDE S 460
Transformer type	Three-phase									
Rated frequency [Hz]	50 / 60									
Windings connection	YNyn0									
Primary winding										
Rated voltage [Vrms]	270±10%									
Maximum continuous power [kVA]	37	48	51	71	91	116	132	163	194	224
Primary winding connection	Star									
Secondary winding										
Rated voltage [Vrms]	400±10%									
Maximum continuous power [kVA]	37	48	51	71	91	116	132	163	194	224
Primary winding connection	Star									
Other data										
Ambient temperature [° C]	50									
Cooling	Natural air									
Overtemperature class	F									
Insulation class of materials	H									
Insulation voltage [kV]	1.1 / 3 for 30s									

TAB. 28 – Insulation transformer

Size OPDE S	Capacitors C001 C002 C003 for LC filter				
	Capacity [μF]	Minimum current [Arms]	Minimum voltage [Vrms]		
OPDE S 70	25	3.7	270		
OPDE S 90	25	4.3			
OPDE S 110	25	4.5			
OPDE S 150	50	7.3			
OPDE S 175	50	8.4			
OPDE S 220	75 / 100	11.4 / 13.2			
OPDE S 250	75 / 100	12.3 / 14.4			
OPDE S 310	100 / 150	15.6 / 19.4			
OPDE S 370	150	20.8			
OPDE S 460	225 / 250	35.6 / 37.3			
Examples of usable capacitors					
	Capacity [μF]	MODEL	Supplier code	TDE MACNO code	Quantity
OPDE S 70	25	MKP 1.44A ARCOTRONIC	C44AJGP5250ZA0J	06EJA3250	3
OPDE S 90	25	MKP 1.44A ARCOTRONIC	C44AJGP5250ZA0J	06EJA3250	3
OPDE S 110	25	MKP 1.44A ARCOTRONIC	C44AJGP5250ZA0J	06EJA3250	3
OPDE S 150	50	MKP 1.44A ARCOTRONIC	C44AJGP5500ZA0J	06EJA3500	3
	50	SUPERIPHASO 7,5KVAR 400V ICAR	SRWT750153C1000	06F0400005	1
OPDE S 175	50	MKP 1.44A ARCOTRONIC	C44AJGR5500ZA0J	06EJA3500	3
	50	SUPERIPHASO 7,5KVAR 400V ICAR	SRWT750153C1000	06F0400005	1
OPDE S 220	75	MKP 1.44A ARCOTRONIC	C44AJGR5750ZA0J	06EJA3750	3
	100	SUPERIPHASO 15KVAR 400V ICAR	SRWT150253C2000	06F0400003	1
OPDE S 250	75	MKP 1.44A ARCOTRONIC	C44AJGR5750ZA0J	06EJA3750	3
	100	SUPERIPHASO 15KVAR 400V ICAR	SRWT150253C2000	06F0400003	1
OPDE S 310	150	MKP 1.44A ARCOTRONIC	2 x C44AJGR5750ZA0J	2 x 06EJA3750	6
	100	SUPERIPHASO 15KVAR 400V ICAR	SRWT150253C2000	06F0400003	1
OPDE S 370	150	MKP 1.44A ARCOTRONIC	2 x C44AJGR5750ZA0J	2 x 06EJA3750	6
	150	SUPERIPHASO 22,5KVAR 400V ICAR	SRWT225253C3000	06F0400004	1
OPDE S 460	225	MKP 1.44A ARCOTRONIC	3 x C44AJGR5750ZA0J	2 x 06EJA3750	6
	250	SUPERIPHASO 22,5KVAR 400V ICAR	SRWT225253C3000	06F0400004	1

TAB. 29 – Filter capacitors

Size OPDE S	Protection fuses FU01, 270V AC side (optional)			
	Fuse current [A]	Voltage [Vrms]	TYPE	Example
OPDE S 70	125	500	gL/gG	Ferraz Shawmut NH0GG50V125
OPDE S 90	160			Ferraz Shawmut NH0GG50V160
OPDE S 110	160			Ferraz Shawmut NH0GG50V160
OPDE S 150	250			Ferraz Shawmut NH1GG50V250
OPDE S 175	300			Ferraz Shawmut NH2GG50V300
OPDE S 220	355			Ferraz Shawmut NH2GG50V355
OPDE S 250	400			Ferraz Shawmut NH2GG50V400
OPDE S 310	500			Ferraz Shawmut NH3GG50V500
OPDE S 370	630			Ferraz Shawmut NH3GG50V630
OPDE S 460	630			Ferraz Shawmut NH3GG50V630

TAB. 30 – Protection fuses AC side

Size OPDE S	EMC filters ZC01, 400V AC side (1)		
	Minimum current [Arms]	Minimum operating voltage [Vrms]	Example
OPDE S 70	54	400	Schaffner FN 3270H-65-34
OPDE S 90	70		Schaffner FN 3270H-80-35
OPDE S 110	75		Schaffner FN 3270H-80-35
OPDE S 150	103		Schaffner FN 3270H-100-35
OPDE S 175	132		Schaffner FN 3270H-150-99
OPDE S 220	168		Schaffner FN 3270H-200-99
OPDE S 250	190		Schaffner FN 3270H-200-99
OPDE S 310	235		Schaffner FN 3270H-235-99
OPDE S 370	280		Schaffner FN 3270H-320-99
OPDE S 460	324		Schaffner FN 3270H-400-99

(1) Filters that can be used in case of LV connection, to be positioned downstream of the 270Vac/400Vac transformer, in the 400Vac side. For filters suitable for use in case of MT connection, contact TDE MACNO.

TAB. 31 – EMC filter, AC side

Size OPDE -S	KM01 contactors			Main switch QF01
	On-grid contactor KM01 TYPE AC-3			MAGNETO-THERMAL
	Minimum current [Arms]	Minimum operating voltage [Vrms]	Mimimum rated power [kW]	Minimum current [Arms]
OPDE S 70	54	400	22	54
	79	270	37	79
OPDE S 90	70	400	37	70
	103	270	55	103
OPDE S 110	75	400	37	75
	110	270	55	110
OPDE S 150	103	400	55	103
	152	270	75/90	152
OPDE S 175	132	400	75	132
	195	270	90/110	195
OPDE S 220	168	400	90	168
	248	270	132	248
OPDE S 250	190	400	90	190
	282	270	160	282
OPDE S 310	235	400	132	235
	348	270	200	348
OPDE S 370	280	400	160	280
	414	270	200	414
OPDE S 460	324	400	200	324
	480	270	250/315	480

TAB. 32 – Contactors and main switch, AC side

Interface protection SPI complying with CEI 0-21 (valid for all OPDE S sizes)	
Example for Italy	CM-UFD.M32

TAB. 33 – Interface protection

FOR THE SIZING OF THE OPTIONAL PRECHARGE RESISTORS AND OF THE RELATED PRECHARGE CONTACTOR, CONTACT TDE MACNO.

FOR THE INSTALLATION OF THE INTERFACE PROTECTION SPI REFER TO THE REGULATIONS IN FORCE IN THE COUNTRY OF INSTALLATION.

8.2.5 CONNECTION OF THE PV ARRAY

For the correct operation of OPDE AFE ENERGY and to meet the regulations on electrical safety, it is necessary to install external components in the connection to the PV array:

- EMC filter;
- Insulator controller (CI);
- DC disconnecting device;

The PV array has to be connected to the positive (+) and negative (-) bar to which the DC-Bus of the OPDE AFE ENERGY converter refers, thereby observing the polarity.

FOR THE CONNECTION OF THE PHOTOVOLTAIC ARRAY IT IS IMPORTANT TO COMPLY WITH THE VOLTAGE LIMITS INDICATED IN TECHNICAL DATA.
INSIDE THE CONVERTER THERE IS NOT ANY RESISTOR FOR THE FUNCTIONAL CONNECTION OF THE PV ARRAY TO GROUND.
THE POSSIBLE FUNCTIONAL CONNECTION TO GROUND, IF REQUIRED BY THE APPLICATION, MUST BE PERFORMED BY THE INSTALLER.

IF THE CONNECTION BETWEEN PV ARRAY AND OPDE ENERGY IS NOT INTERRUPTED BY AN EXTERNAL CUTTING DEVICE, THE PRESENCE OF A SOLAR RADIATION (EVEN MINIMAL) OF THE PV ARRAY RESULTS IN THE PRESENCE OF A HIGH VOLTAGE AT THE + AND - BARS

8.2.5.1 Features of the external, DC side

OPDE S size	EMC ZC02 filter		
	Minimum current [Adc]	Minimum operating voltage [Vdc]	Example
OPDE S 70	83	900 Vdc	Schaffner FN2200-100-35
OPDE S 90	107		Schaffner FN2200-100-35
OPDE S 110	113		Schaffner FN2200-150-40
OPDE S 150	157		Schaffner FN2200-150-40
OPDE S 175	202		Schaffner FN2200-250-99
OPDE S 220	258		Schaffner FN2200-250-99
OPDE S 250	293		Schaffner FN2200-400-99
OPDE S 310	361		Schaffner FN2200-400-99
OPDE S 370	430		Schaffner FN2200-400-99
OPDE S 460	498		Schaffner FN2200-600-99

TAB. 34 – EMC filter, DC side

Insulation controller CI (valid for all sizes OPDE S)			
Operating voltage range [Vdc]	Tripping threshold setting [kOhm]	Output	Example
460 ÷ 880	30 ÷ 300	Free contact relay output	Contrel RI-R15 1000V

TAB. 35 – Insulation controller

Size OPDE S	Disconnector DC side QS01			
	Minimum current [Adc]	Minimum operating voltage [Vdc]	Type	Example
OPDE S 70	83	900	disconnector	ABB T1D 160 PV
OPDE S 90	107			ABB T1D 160 PV
OPDE S 110	113			ABB T1D 160 PV
OPDE S 150	157			ABB T3D 200 PV
OPDE S 175	202			ABB T3D 200 PV
OPDE S 220	258			ABB T4D 250 PV
OPDE S 250	293			ABB T5D 500 PV
OPDE S 310	361			ABB T5D 500 PV
OPDE S 370	430			ABB T5D 500 PV
OPDE S 460	498			ABB T5D 500 PV

TAB. 36 – Disconnector DC side

8.2.6 MEASUREMENT OF THE INSULATION RESISTANCE OF THE PHOTOVOLTAIC ARRAY

In order to prevent the risk of electric shock to people and fire hazards due to an accidental connection between the PV array and ground, it is compulsory to take steps to control the insulation resistance of the PV array to ground.

In the case of OPDE AFE ENERGY, the presence of the transformer allows defining the final electrical cabinet as an **isolated inverter.**

According to IEC 62109-2, in the case of isolated inverter, the presence of two simultaneous failures of the photovoltaic array to ground, both when the array is isolated from ground and when the array is functionally connected to ground via a resistor, can lead to the passage of a high current through circuits not dimensioned to support such a current, resulting in a risk of fire.
As protection measure against these risks related to failure of the photovoltaic array to ground, the detection and signaling of the first fault by measuring the insulation resistance of the PV array to ground is required.

The OPDE AFE ENERGY converter does not implement an insulation resistance measurement system, therefore, it is necessary to use an **external insulation controller (CI)** that fulfills this function.
It must be installed as shown in the diagram in FIG. 24 (see the CI block, insulation controller). Usually, the CI has a clean contact that signals if the insulation resistance falls below the value set as tripping threshold.
The clean contact of the CI is connected to the logical input LI4 of the OPDE AFE ENERGY converter as shown in the diagram of FIG. 38.

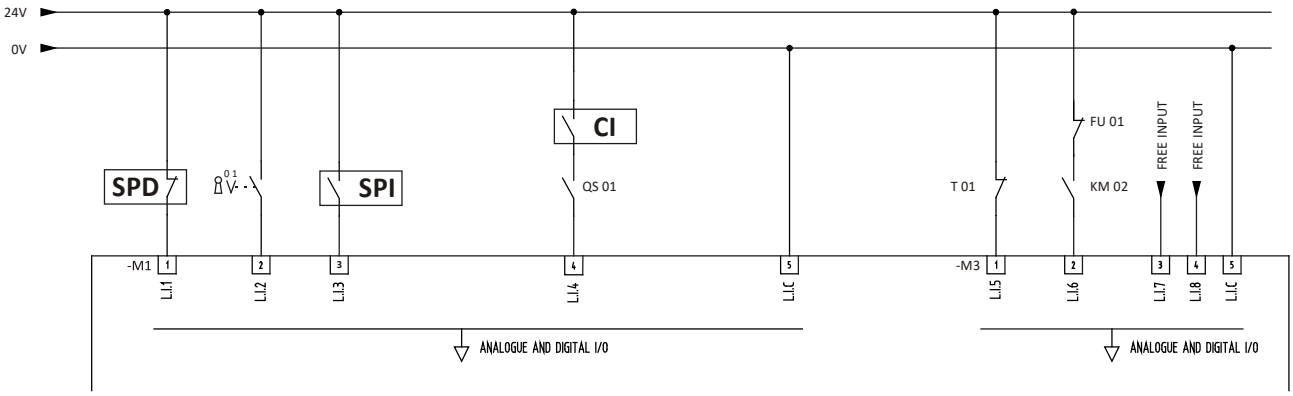


FIG. 32 - Example of physical inputs connections (the initials of the components shown below refer to the preceding figures)

In the diagram, it is assumed that the clean contact of CI is closed if the insulation resistance R_{ISO} is below the threshold R_{ISO_LIMIT} set in the CI ($R_{ISO} < R_{ISO\_LIMIT}$).
In remote keypad, the INS_OK LED, when lit, indicates that R_{ISO} is above the minimum threshold, i.e. $R_{ISO} > R_{ISO\_LIMIT}$.

The OPDE AFE Energy converter, before connecting and running, checks the status of CI via the input LI4 and also indicates the presence of any anomaly turning off the INS_OK LED in the remote keypad.
If there is an anomaly ($R_{ISO} < R_{ISO\_LIMIT}$), the converter does not block, but it connects to the mains and starts running, as provided for in case of isolated inverters for which only the verification and indication of the first fault of the PV array to ground is required.

The anomaly signal will remain active until the insulation resistance returns above the calculated threshold set in CI.

The threshold to be set for the insulation resistance is equal to:

$R_{ISO\_LIMIT} = (V_{MAX\_PV}/30mA)\ \Omega = (880V/30mA)\ \Omega = 29,3\ k\Omega$

In the case of **photovoltaic array with functional connection to ground**, this resistance is intended to be the overall resistance including:

- the resistance for the functional connection of the PV array to ground;
- the insulation resistance of the PV array to ground;
- the resistance of other networks connected to ground (for example, measurement networks).

The insulation resistance of the PV array to ground has to be calculated based on the surface of the array and considering an insulation resistance of the array of 40MΩ/m^2 (it is advisable to adopt, if necessary, further margins for considering the effects of panel aging that leads to a reduction in the insulation resistance.

IT IS RECOMMENDED TO REFER TO THE REGULATIONS IN FORCE IN THE COUNTRY OF INSTALLATION TO CHECK WHETHER THERE ARE ADDITIONAL REQUIREMENTS RELATED TO THE MEASUREMENT OF INSULATION RESISTANCE TO BE MET.

8.2.7 DETECTION OF THE PV ARRAY LEAKAGE CURRENT

In order to prevent the risk of electric shock to people and fire hazards, it is necessary to perform an analysis to see if the electric cabinet of the final application (cabinet where the OPDE AFE ENERGY converter will be installed along with the other components) has to integrate additional protections to prevent these risks.

Here below there is a list of the **additional protections** for the protection against electric shock and fire risks.

8.2.7.1 Additional protection against electric shock

According to IEC 62109-2, a PV array connected to ground shows a risk of **electric shock** if a person comes into contact with the live parts and there is a return path for the contact currents. In the case of not isolated inverter or in the case of isolated inverter that does not limit in an appropriate manner the contact current, the network connection to ground (through the neutral connected to ground) represents a return path for the contact currents if a person inadvertently touches the active parts of the PV array and the ground simultaneously.

In the case of OPDE AFE ENERGY, the presence of the transformer allows defining the final electrical cabinet as an **isolated inverter.** In this case, to understand whether additional protections are needed, it is necessary to consider the contact current.

If the contact current is lower than 30 mA, it is not necessary to use additional devices for the protection **against electric shock.** Otherwise, it is necessary to install an appropriate circuit breaker (i.e. a residual current detector, RCD), calibrated to 30 mA, between the inverter and the three-phase mains or, alternatively, a device for monitoring the leakage current (i.e. a residual current monitoring RCM).

For selecting the differential switch refer to the regulations in force.

IT IS RECOMMENDED TO REFER TO THE REGULATIONS IN FORCE IN THE COUNTRY OF INSTALLATION TO CHECK WHETHER THERE ARE ADDITIONAL PROVISIONS LINKED TO ELECTRIC SHOCK RISKS TO BE MET.

8.2.7.2 Additional protection against the risk of fire

According to IEC 62109-2, a PV array, connected or not connected to ground, shows risks of fire if a fault to ground occurs that determines the flow of a high current through circuits not dimensioned to support such a current.

In the case of OPDE AFE ENERGY, the presence of the transformer allows defining the final electrical cabinet as an **isolated inverter.** In this case, to understand whether additional protections are needed, it is necessary to consider the fault current.

If the fault current is lower than:

- 300 mA RMS, for inverters with a rated continuous power ≤ 30 kVA, or
- 10 mA RMS per kVA of rated continuously power per inverter with rated continuous power > 30 kVA;

it is not necessary to use additional devices to assure protection **against fire risks**, otherwise, it is necessary to install an appropriate circuit breaker (i.e. a residual current detector, RCD) between the inverter and the three-phase mains or, alternatively, a device for monitoring the leakage current (i.e. a residual current monitoring RCM).

IT IS RECOMMENDED TO REFER TO THE REGULATIONS IN FORCE IN THE COUNTRY OF INSTALLATION TO CHECK WHETHER THERE ARE ADDITIONAL PROVISIONS LINKED TO FIRE RISKS TO BE MET.

NOTE The leakage currents referred to for electric shocks and fire hazards are currently defined in two different ways. The current limit of 30mA for the contact current is verified with a test that uses a model of the human body. The current limit for the fire risk is measured using a standard ammeter.

9 APPLICATION WITH ROTATING MACHINE

This chapter contains all the information for the correct use of OPDE AFE ENERGY for applications with rotating machine connected to an AC/DC inverter.

9.1 TECHNICAL DATA

MOD. OPDE AFE ENERGY		OPDE S 7	OPDE S 15	OPDE S 22
Input data (DC side)				
Maximum input voltage	[V d.c.]	780		
Operating voltage	[V d.c.]	630÷780		
Maximum input current	[A d.c.]	7,8	16,8	24,6
Rated input power	[kW]	4,9	10,6	15,5
Intermediate circuit capacity	[µF]	340	600	1010
Overvoltage category	OVC	III		
Input data for auxiliary power supplies				
Auxiliary power supply for control board	[V d.c.]	24Vdc (22÷26Vdc) 1A		
Auxiliary power supply of the cooling fans	[V d.c.]	24Vdc (22÷26Vdc) 0,2A		
Output data (AC side)				
Rated output voltage	[V a.c.]	400 +10%/-15%		
Maximum output continuous current	[A a.c.]	7,0	15,0	22,0
Inrush current (1)	[A]	4	5	9
Mains frequency	[Hz]	50 / 60		
Maximum output continuous power	[kVA]	4,8	10,4	15,2
Power factor		0.95 cap ÷ 0.95 ind	0.9 capacitivo ÷ 0.9 induttivo	
Maximum output fault current	[A]	32 durata 2µs	680 durata 2µs	100 durata 2µs
Maximum output protection current	[A]	32	68	100
Connection type		Trifase (3P+T)		
Overvoltage category	OVC	III		
Other data				
Operating temperature	[°C]	-20 ÷ +50		
Maximum altitude (2)	[m]	2000		
Insulation protection class		I		
Protection degree		IP20		
PWM frequency	[kHz]	5		
Modulation		Space Vector PWM / Mod abc		
Life (3)	[kh]	14,5	30	30

(1) It is the current during the precharge; the inrush current of the externally connected transformer has not been considered.
(2) For altitudes above 1000 m above sea level, derate the current by 1% per 100 m.
(3) Calculated with converter running at maximum continuous current and at the maximum expected ambient temperature.

TAB. 37A – Technical data

MOD. OPDE AFE ENERGY		OPDE S 32	OPDE S 48	OPDE S 60
Input data (DC side)				
Maximum input voltage	[V d.c.]	780		
Operating voltage	[V d.c.]	630÷780		
Maximum input current	[A d.c.]	36,0	54,0	67,3
Rated input power	[kW]	22,7	34,0	42,4
Intermediate circuit capacity	[μF]	1230	1640	2400
Overvoltage category	OVC	III		
Input data for auxiliary power supplies				
Auxiliary power supply for control board	[V d.c.]	24Vdc (22÷26Vdc) 1A		
Auxiliary power supply of the cooling fans	[V d.c.]	24Vdc (22÷26Vdc) 0,4A	24Vdc (22÷26Vdc) 0,5A	24Vdc (22÷26Vdc) 0,5A
Output data (AC side)				
Rated output voltage	[V a.c.]	400 +10%/-15%		
Maximum output continuous current	[A a.c.]	32,0	48,0	60,0
Inrush current (1)	[A]	9	9	9
Mains frequency	[Hz]	50 / 60		
Maximum output continuous power	[kVA]	22,2	33,3	41,6
Power factor		0.9 capacitivo ÷ 0.9 induttivo		
Maximum output fault current	[A]	145 durata 2μs	208 durata 2μs	260 durata 2μs
Maximum output protection current	[A]	145	208	260
Connection type		Trifase (3P+T)		
Overvoltage category	OVC	III		
Other data				
Operating temperature	[°C]	-20 ÷ +50		
Maximum altitude (2)	[m]	2000		
Insulation protection class		I		
Protection degree		IP20		
PWM frequency	[kHz]	5		
Modulation		Space Vector PWM / Mod abc		
Life (3)	[kh]	30	30	30

(1) It is the current during the precharge; the inrush current of the externally connected transformer has not been considered.
(2) For altitudes above 1000 m above sea level, derate the current by 1% per 100 m.
(3) Calculated with converter running at maximum continuous current and at the maximum expected ambient temperature.

TAB. 3738B – Technical data

MOD. OPDE AFE ENERGY		OPDE S 70	OPDE S 90	OPDE S 110	OPDE S 150
Input data (DC side)					
Maximum input voltage	[V d.c.]	880			
Operating voltage	[V d.c.]	630÷880			
Maximum input current	[A d.c.]	89	114	122	170
Rated input power	[kW]	56	72	77	107
Intermediate circuit capacity	[µF]	2050	2870	3280	3280
Overvoltage category	OVC	III			
Input data for auxiliary power supplies					
Auxiliary power supply for control board	[V d.c.]	24Vdc (22÷26Vdc) 1.6A			
Auxiliary power supply of the cooling fans	[V d.c.]	24Vdc (22÷26Vdc) 1.5A	24Vdc (22÷26Vdc) 1.5A	24Vdc (22÷26Vdc) 1.5A	24Vdc (22÷26Vdc) 2.5A
Output data (AC side)					
Rated output voltage	[V a.c.]	400 +10%/-15%			
Maximum output continuous current	[A a.c.]	79	103	110	152
Inrush current (1)	[A]	13	19	26	36
Mains frequency	[Hz]	50 / 60			
Maximum output continuous power	[kVA]	55	71	76	105
Power factor		0.9 capacitive ÷ 0.9 inductive			
Maximum output fault current	[A]	303 duration 5µs	394 duration 5µs	453 duration 5µs	640 duration 5µs
Maximum output protection current	[A]	303	394	453	640
Connection type		Three-phase (3P+E)			
Overvoltage category	OVC	III			
Other data					
Operating temperature	[°C]	-20 ÷ +50			
Maximum altitude (2)	[m]	2000			
Insulation protection class		I			
Protection degree		IP20			
PWM frequency	[kHz]	5			
Modulation		Space Vector PWM / Mod abc			
Life (3)	[kh]	65	75	75	30

(1) It is the current during the precharge; the inrush current of the externally connected transformer has not been considered.
(2) For altitudes above 1000 m above sea level, derate the current by 1% per 100 m.
(3) Calculated with converter running at maximum continuous current and at the maximum expected ambient temperature.

TAB. 37C – Technical data

MOD. OPDE AFE ENERGY		OPDE S 175	OPDE S 220	OPDE S 250
Input data (DC side)				
Maximum input voltage	[V d.c.]	880		
Operating voltage	[V d.c.]	630÷880		
Maximum input current	[A d.c.]	219	278	316
Rated input power	[kW]	138	175	199
Intermediate circuit capacity	[μF]	13600	13600	13600
Overvoltage category	OVC	III		
Input data for auxiliary power supplies				
Auxiliary power supply for control board	[V d.c.]	24Vdc (22÷26Vdc) 1.6A		
Auxiliary power supply of the cooling fans	[V d.c.]	24Vdc (22÷26Vdc) 2.5A	24Vdc (22÷26Vdc) 3.5A	24Vdc (22÷26Vdc) 3.5A
Output Data (AC side)				
Rated output voltage	[V a.c.]	400 +10%/-15%		
Maximum output continuous current	[A a.c.]	195	248	282
Inrush current (1)	[A]	57	57	71
Mains frequency	[Hz]	50 / 60		
Maximum output continuous power	[kVA]	135	172	195
Power factor		0.9 capacitive ÷ 0.9 inductive		
Maximum output fault current	[A]	582 duration 5μs	740 duration 5μs	839 duration 5μs
Maximum output protection current	[A]	582	740	839
Connection type		Three-phase (3P+E)		
Overvoltage category	OVC	III		
Other data				
Operating temperature	[°C]	-20 ÷ +50		
Maximum altitude (2)	[m]	2000		
Insulation protection class		I		
Protection degree		IP20		
PWM frequency	[kHz]	5		
Modulation		Space Vector PWM / Mod abc		
Life (3)	[kh]	75	45	30

(1) It is the current during the precharge; the inrush current of the externally connected transformer has not been considered.
(2) For altitudes above 1000 m above sea level, derate the current by 1% per 100 m.
(3) Calculated with converter running at maximum continuous current and at the maximum expected ambient temperature.

TAB. 37D – Technical data

MOD. OPDE AFE ENERGY		OPDE S 310	OPDE S 370	OPDE S 460
Input data (DC side)				
Maximum input voltage	[V d.c.]	880		
Operating voltage	[V d.c.]	630÷880		
Maximum input current	[A d.c.]	390	465	538
Rated input power	[kW]	246	293	339
Intermediate circuit capacity	[µF]	20400	20400	20400
Overvoltage category	OVC	III		
Input data for auxiliary power supplies				
Auxiliary power supply for control board	[V d.c.]	24Vdc (22÷26Vdc) 1.6A		
Auxiliary power supply of the cooling fans	[V d.c.]	24Vdc (22÷26Vdc) 5.0A	24Vdc (22÷26Vdc) 5.0A	24Vdc (22÷26Vdc) 5.0A
Output Data (AC side)				
Rated output voltage	[V a.c.]	400 +10%/-15%		
Maximum output continuous current	[A a.c.]	348	414	480
Inrush current (1)	[A]	71	71	95
Mains frequency	[Hz]	50 / 60		
Maximum output continuous power	[kVA]	241	287	332
Power factor		0.9 capacitive ÷ 0.9 inductive		
Maximum output fault current	[A]	1036 duration 5µs	1233 duration 5µs	1560 duration 5µs
Maximum output protection current	[A]	1036	1233	1560
Connection type		Three-phase (3P+E)		
Overvoltage category	OVC	III		
Other data				
Operating temperature	[°C]	-20 ÷ +50		
Maximum altitude (2)	[m]	2000		
Insulation protection class		I		
Protection degree		IP20		
PWM frequency	[kHz]	5	5	3
Modulation		Space Vector PWM / Mod abc		
Life (3)	[kh]	50	30	30

(1) It is the current during the precharge; the inrush current of the externally connected transformer has not been considered.
(2) For altitudes above 1000 m above sea level, derate the current by 1% per 100 m.
(3) Calculated with converter running at maximum continuous current and at the maximum expected ambient temperature.

TAB. 37E – Technical data

9.2 ELECTRIC CONNECTIONS

9.2.1 CONNECTIONS COMPLYING WITH CEI 0-21 OR CEI 0-16

The OPDE AFE ENERGY converter is suitable for use in applications requiring compliance with the standard:

- CEI 0-21;V1 2012-12 “Reference technical rules for connecting active and passive utilities to the LV grids of electricity distribution companies", including previous editions; or
- CEI 0-16;V1 2013-12 “Reference technical rules for connecting active and passive utilities to the HV and MV grids of electricity distribution companies", including previous editions.

Some functions provided by CEI 0-21 and CEI 0-16, such as:
- insensitivity to voltage sags (LVFRT);
- conditions of connection, reconnection and gradual power supply;
- active power limitation in over-frequency;
- active power limitation on external control of the distributor;

require the execution of appropriate connections to be performed.

They involve respectively:
- properly management of the on-grid command of the KM01 contactor that connects to the network through the logical output "O33-On-grid contactor command";
- bringing the status of SPI back to input "I31-Interface protection ok" or to input "I02-External enable";
- assuring continuity of supply of part of the circuits using a UPS;
- transmitting the active power limit to the OPDE ENERGY "osc86-P active limit" to the plant control/automation system.

The following table summarizes the regulatory requirements for applications with rotating machine connected to an AC/DC inverter; they differ depending on whether compliance with CEI 0-21 or CEI 0-16 is required.

APPLICATION WITH ROTATING MACHINE CONNECTED TO AN AC/DC INVERTER					
Regulatory requirement	**Required connections**	**Diagram**	**Applicable**		
			CEI 0-21; V1 2012-12	**CEI 0-16 Ed III: 2012-12**	**CEI 0-16; V1 2013-12**
- insensitivity to voltage sags (LVFRT);	- On-grid contactor control from logical output "O33-On-grid contactor command" - Feeding of ancillary equipment from UPS - SPI adjusted to prevent it from tripping during voltage lowering	- FIG. 42 - FIG. 42 - FIG. 42	NO	NO	YES
- Conditions of connection, reconnection and gradual power supply;	- Transmission of the active power limit to the OPDE ENERGY "osc86-P active limit" to the plant control/automation system. - Bringing the status of SPI back to input "I31-Interface protection ok"	- FIG. 47 - FIG. 42	NO	YES	YES
- Active power limitation in over-frequency	- Transmission of the active power limit to the OPDE ENERGY to the plant control/automation system.	- FIG. 47	YES	NO	YES
- Active power limitation on external control of the distributor;	- Transmission of the active power limit to the OPDE ENERGY to the plant control/automation system.	- FIG. 47	YES	YES	YES

TAB. 38 – Regulatory requirements for applications with rotating machine.

9.2.2 EXAMPLES OF CONNECTION

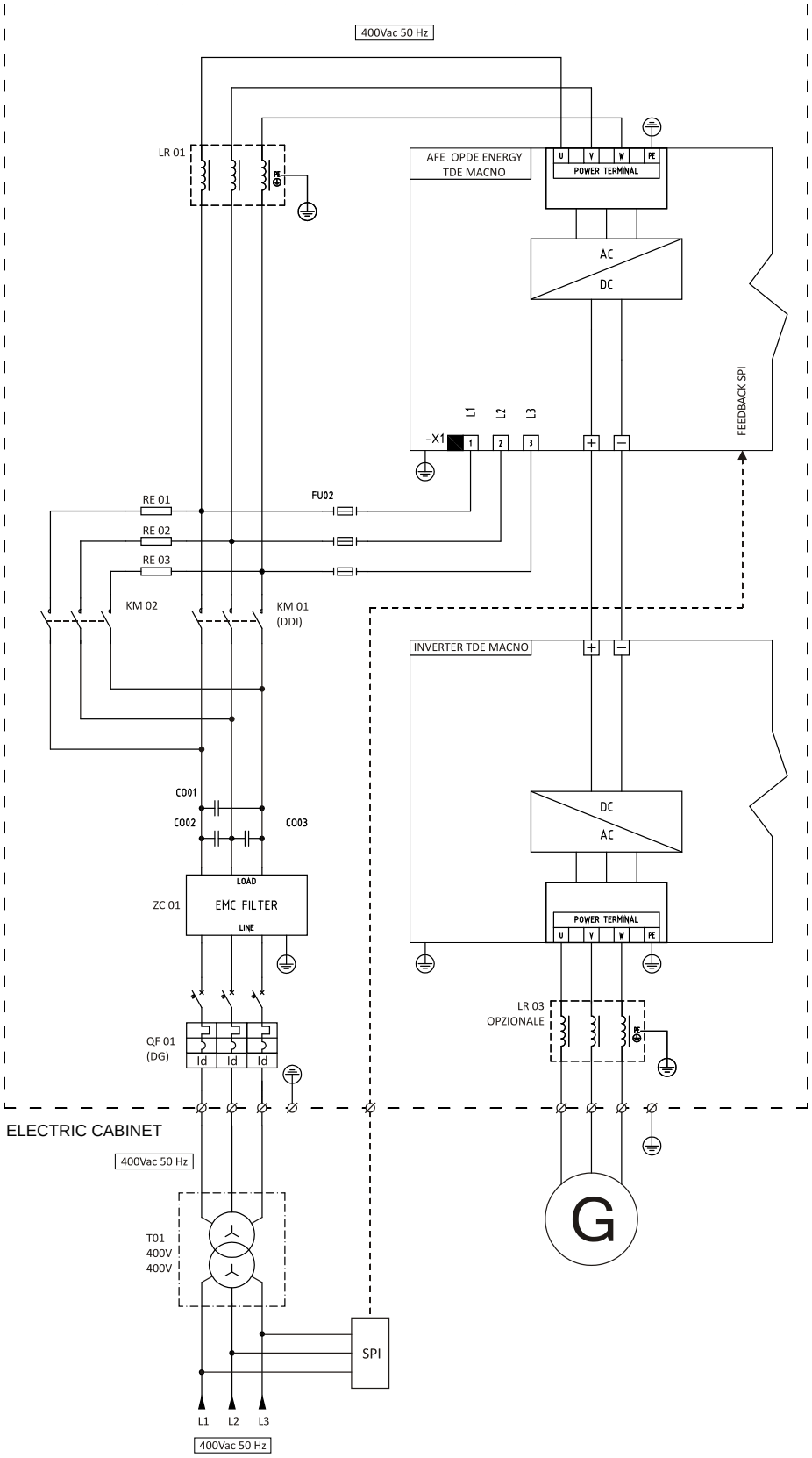


FIG. 33 - Example of connection with rotating machine connected to an AC/DC inverter
Case: LV mains, connections according to CEI 0-21, DDI=KM01, DG=QF01 (also other configuration are possible).

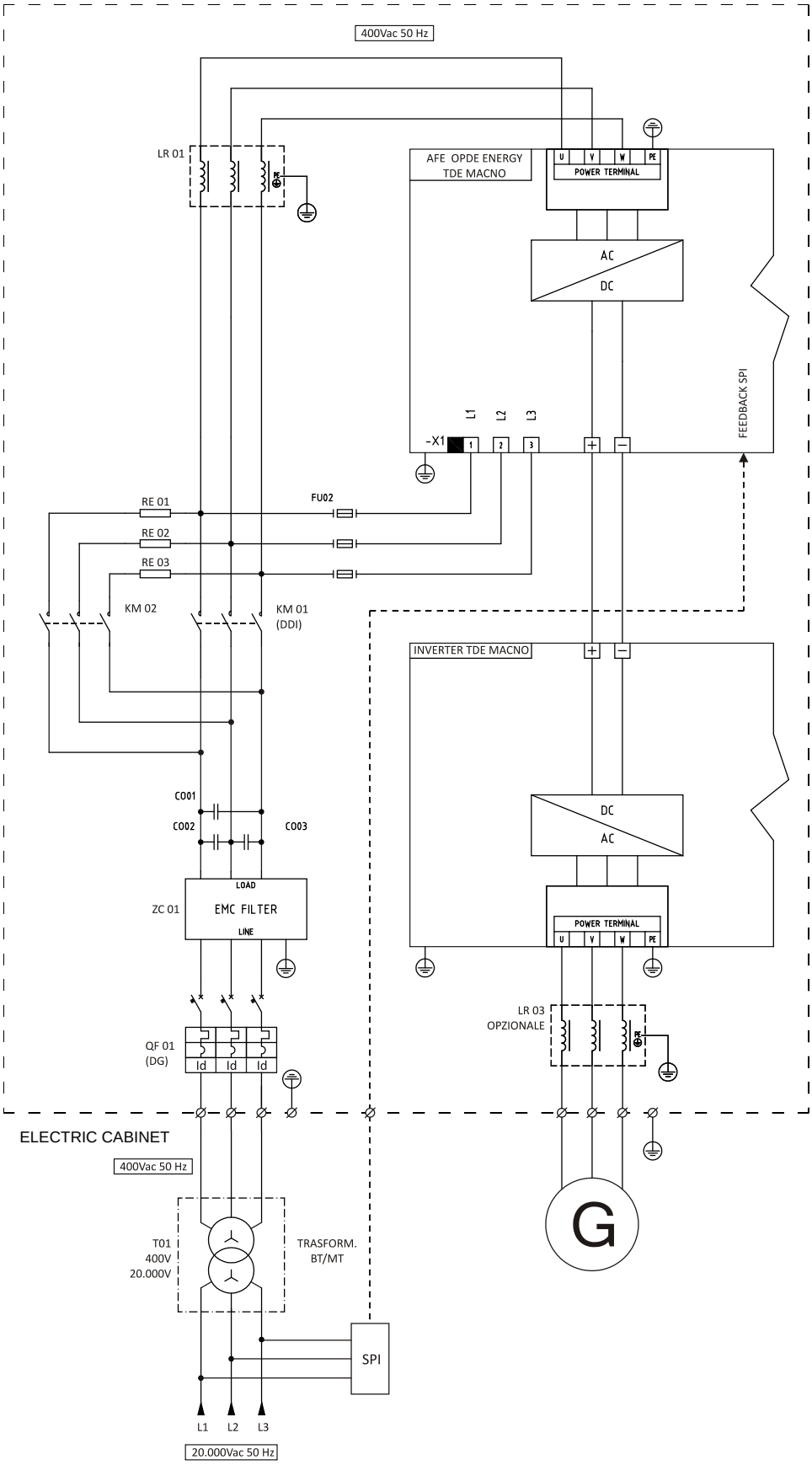


FIG. 34 - Example of connection with rotating machine connected to an AC/DC inverter
Case: MV mains, connections according to CEI 0-16, DDI=KM01, DG=QF01 (also other configuration are possible).

9.2.2.1 Management of on-grid sequence

In the connection examples shown in the previous paragraph a precharge circuit can be seen that allows limiting the current absorbed when the converter is included in the network.
Depending on how the control of the precharge contactor coils is managed, it is possible to attain insensitivity to voltage sags (LVFRT) or not.

INSENSITIVITY TO VOLTAGE SAGS (LVFRT) IN APPLICATIONS WITH ROTATING MACHINE IS MANDATORY ONLY IF THE STANDARD CEI 0-16; V1: 2013-12 APPLIES.

Some examples of connection of the on-grid sequence are given now. It should be underlined that also the connection for signaling the SPI state on input "I31 - Interface protection ok" was represented. This connection is required if you want to meet the requirements relating to the conditions for connection, reconnection and gradual power supply (for details refer to par. 9.2.2.3).
In all examples, the command of the KM01 contactor coil is performed using two logical outputs to meet the electrical safety requirements that require the opening to be performed also in case of single failure of the control device.

The management of the on-grid control, if it **is not required to exceed the LVFRT values**, is shown in FIG. 41. It involves controlling the main contactor KM01 via the precharge end contact present in the connector X2. The possible tripping of SPI controls the opening of the KM01 on-grid contactor and of the KM02 precharge contactor.

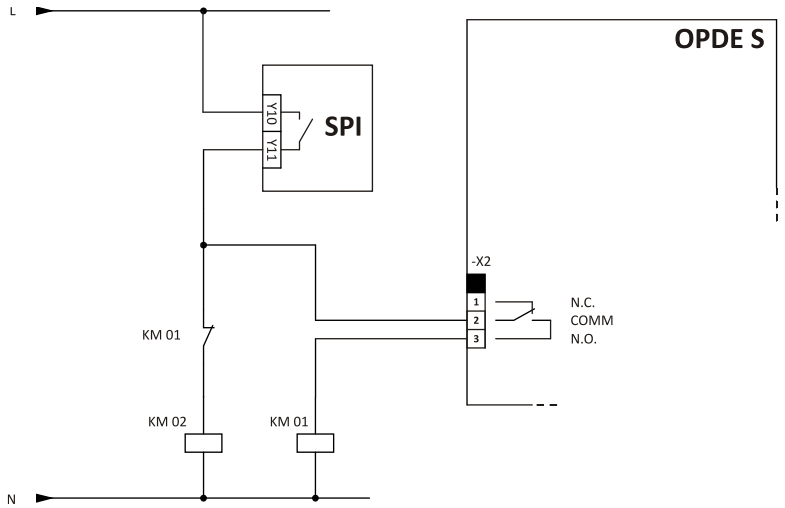


FIG. 35 – Connection of the on-grid sequence without LVFRT management

If the system has to **exceed the LVFRT values**, the management of the on-grid control shall occur according to FIG. 42. It involves:

- use of the logical output "O33-ON-GRID CONTACTOR COMMAND" to allow controlling the main contactor KM01 closing even during voltage sags;
- feeding of the precharge contactor and OPDE AFE ENERGY converter coils with a voltage derived from a UPS;
- regulation of the interface protection (SPI) in order to avoid unwanted tripping during voltage sags.

During voltage sags, the converter momentarily interrupts the supply of power and resumes it within 400 ms from the restoration of voltage supply.
If SPI trips due to a prolonged power failure, then it determines the opening of the KM01 on-grid contactor and of the KM02 precharge contactor.

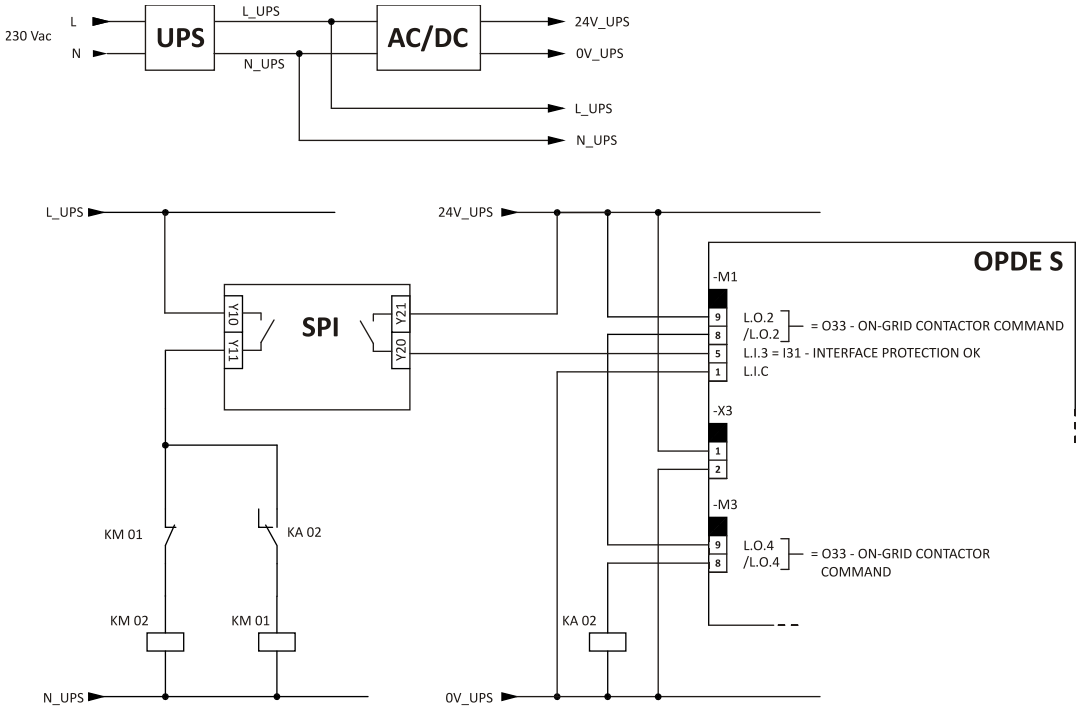


FIG. 36 – Connection of the on-grid sequence for LVFRT management

9.2.2.2 I/O connections

The I/O connections differ depending on whether you should or should not:

- manage the exceeding of the LVFRT values;
- meet the requirements relating to the conditions for connection, reconnection and gradual power supply.

FIG. 43 shows an example of a connection that meets **both the requirements** listed above. It involves:

- use of the logical output "O33-ON-GRID CONTACTOR COMMAND" to allow controlling the main contactor KM01 closing even during voltage sags;
- signaling of the SPI status to the converter on input "I31-Interface protection ok"

The command of the KM01 on-grid contactor coil is performed using two logical outputs to meet the electrical safety requirements that require the opening to be performed also in case of single failure of the control device.

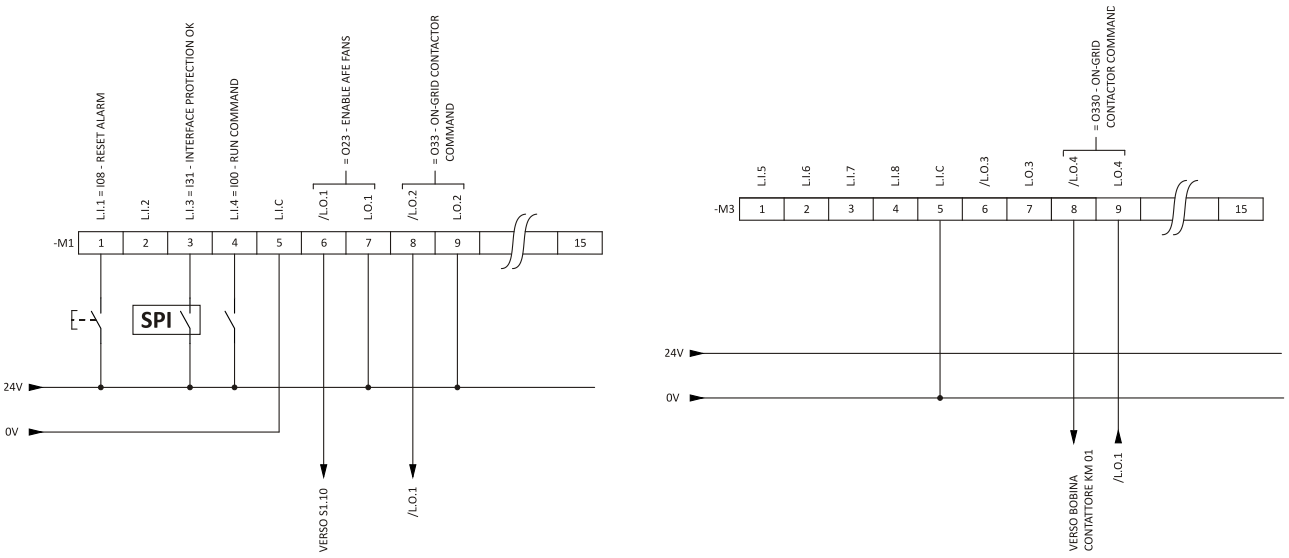


FIG. 37 – Example of I/O connection on M1 and M3 for exceeding LVFRT and for the requirements relating to the conditions for connection, reconnection and gradual power supply

FIG. 44 shows an example of connection, if it is not necessary to exceed the LVFRT values and if it is not required to meet the requirements of connection, reconnection and gradual power supply. It involves:

- using the signaling of the SPI status as input "I02-External enable".

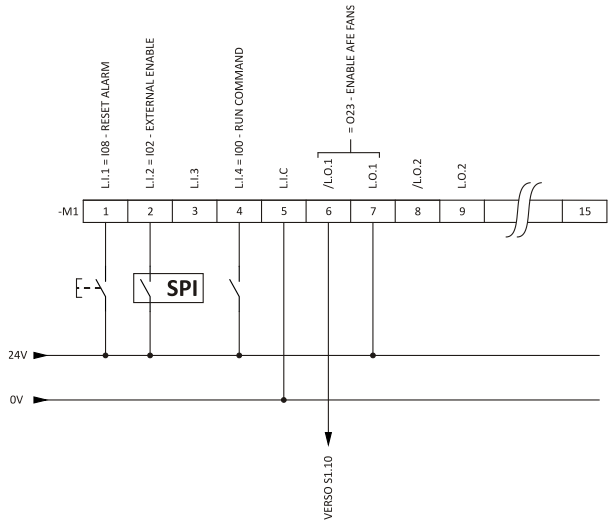


FIG. 38 - Example of I/O connection on M1, if it is not necessary to exceed the LVFRT values and if it is not required to meet the requirements of connection, reconnection and gradual power supply.

9.2.2.3 Interface protection management

The proper management of the interface protection allows meeting the requirements concerning the conditions for connection, reconnection and gradual power supply set forth be the standard **CEI 0-16.** These requirements involve a gradual supply of the active power and specific waiting times for reconnection after SPI tripping.

To meet the requirements, it is necessary to follow the diagram of FIG. 45 which includes:

- signaling on the SPI status on the input "I31 - Interface protection ok"

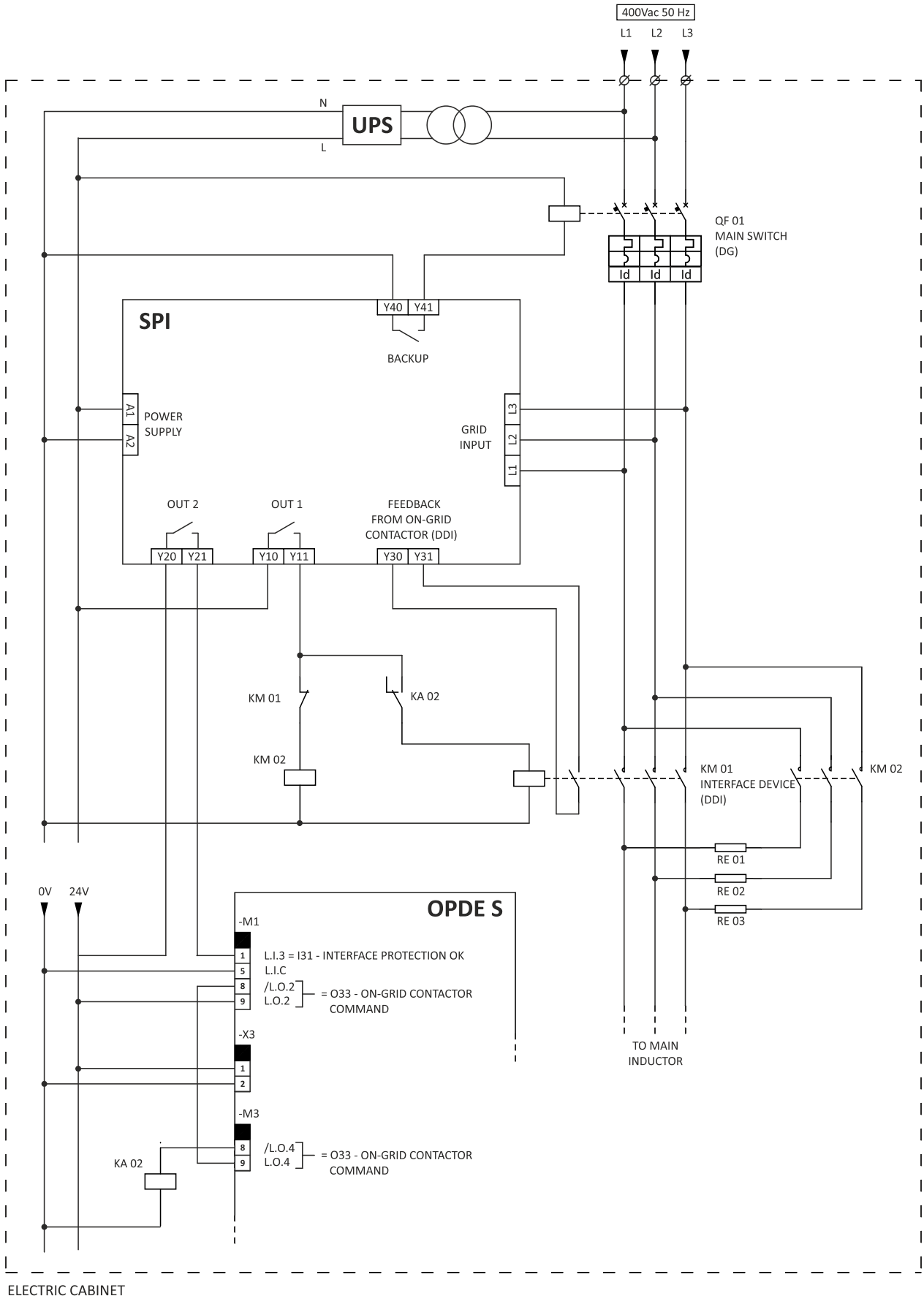


FIG. 39 – SPI connections according to CEI 0-16 in the case of application with rotating machine.
SPI connected to LV side, DDI = KM01, backup= QF01, UPS necessary to assure the functioning of the backup (other configuration are possible)

In case of plant with rotating machine connected to the AC/DC inverter, the provision concerning the conditions for connection, reconnection and gradual power supply **is not applicable in the case of CEI 0-21.** In any case, it is necessary to assure the proper coordination of the OPDE AFE ENERGY converter in the case of tripping of the SPI, in order to follow the connection shown in FIG. 46, wherein the feedback signal of the external SPI is brought to the input "I02 - External enable".

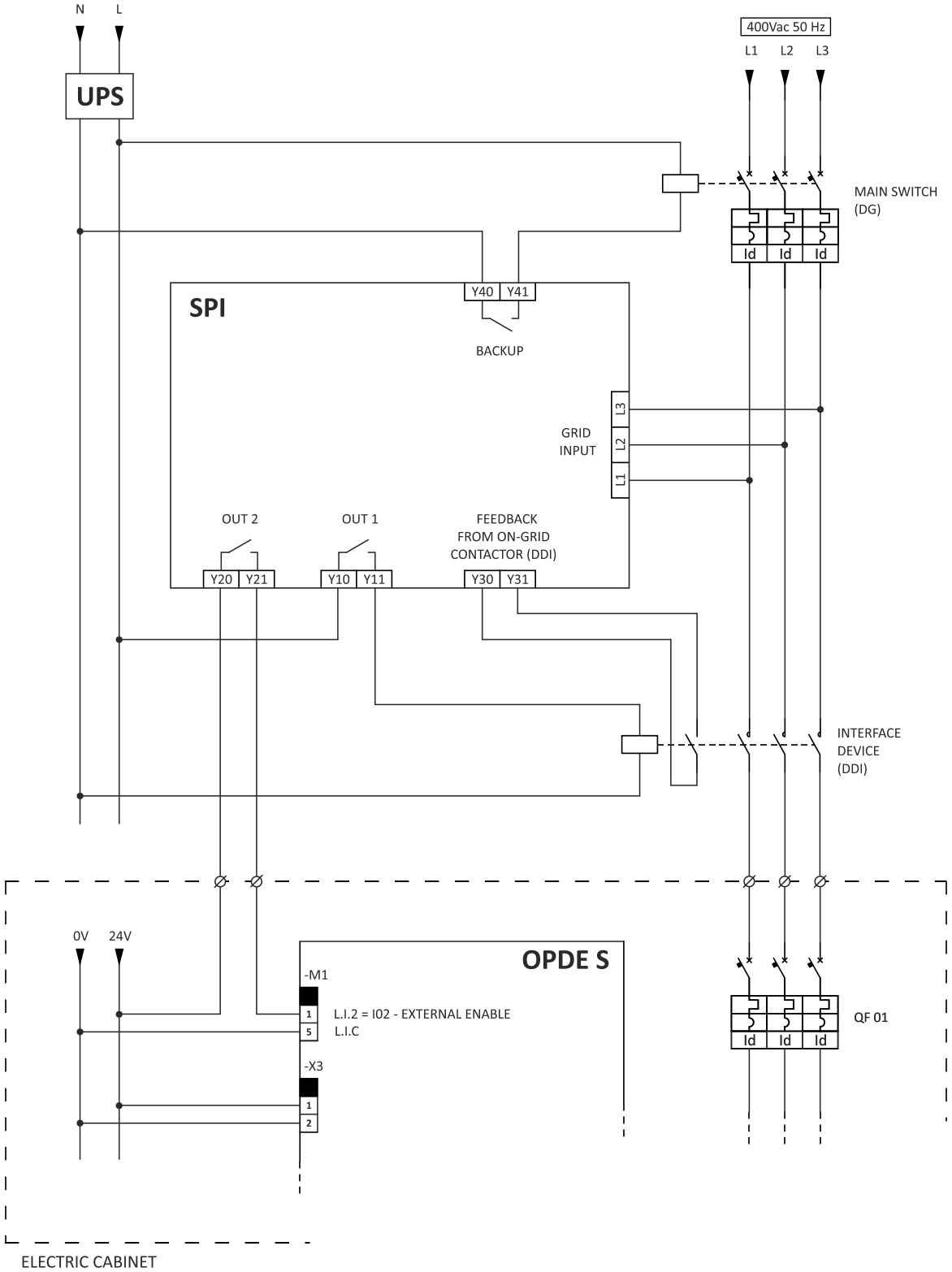


FIG. 40 – SPI connections according to CEI 0-21 in the case of application with rotating machine.
External SPI and DDI, backup=main switch, UPS necessary to assure the functioning of the backup (other configuration are possible).

9.2.2.4 Active power limit management on the plant control/automation system

Some of the functions required by the standard CEI 0-21 or CEI 0-16 involve the limitation of the active power injected into the grid. This power reduction is performed automatically by the OPDE AFE ENERGY converter that signals the inclusion of the active power limit with the logical output "O36 – Active Power Limitation" and indicates under "osc86 – P active limit" the actual value of the power limit.

The automation system (hydroelectric, wind power, ORC or other), which manages the power converted by the generator must properly manage this power limit in order to properly adjust the speed of the generator to assure a safe operation of the plant.

CONTACT TDE MACNO FOR INFORMATION ON THE MANAGEMENT OF THE POWER LIMIT.

The following figure shows a schematic diagram of an example of an automation system with hydroelectric turbine, where the exchange of sizes O36 and osc86 via the communication bus between OPDE AFE ENERGY and plant control/automation PLC.

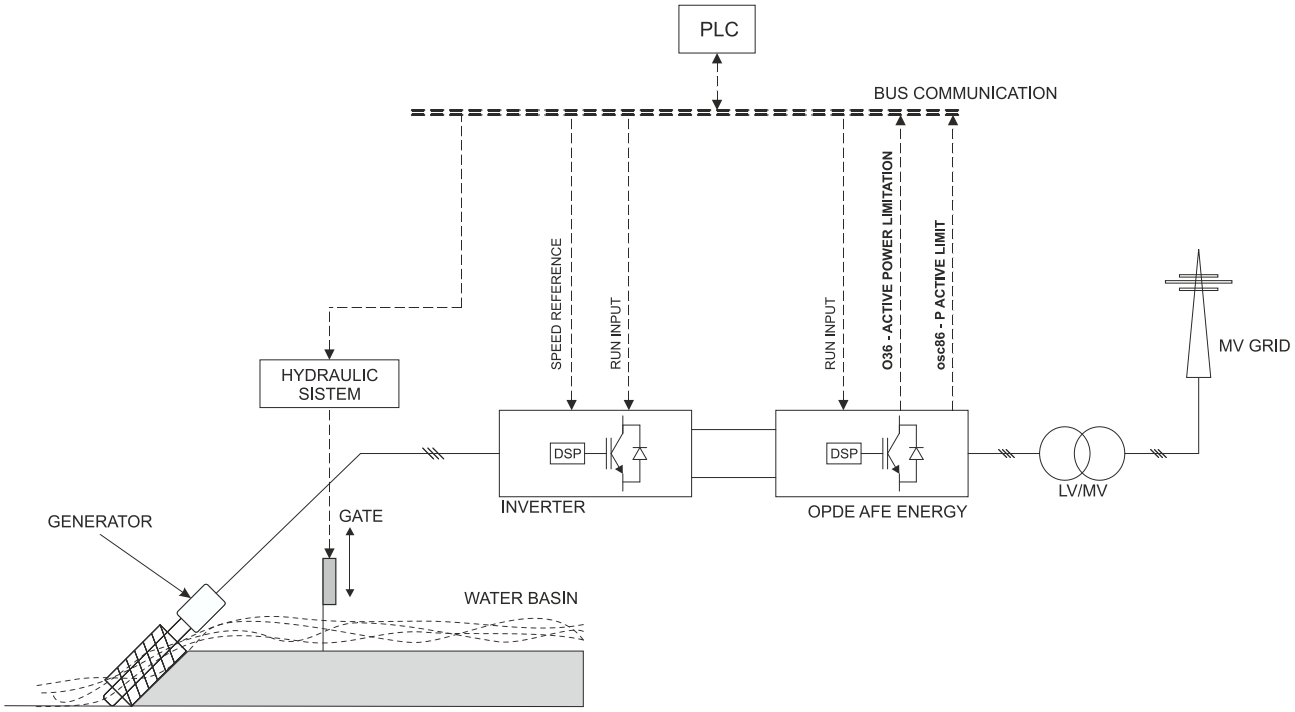


FIG. 41 – Example of hydroelectric automation system

9.2.3 AC SIDE PARALLEL CONNECTION

The wiring diagrams shown in par. 9.2.2 refer to the use of a single OPDE AFE ENERGY converter. They are summarized in the following figures.

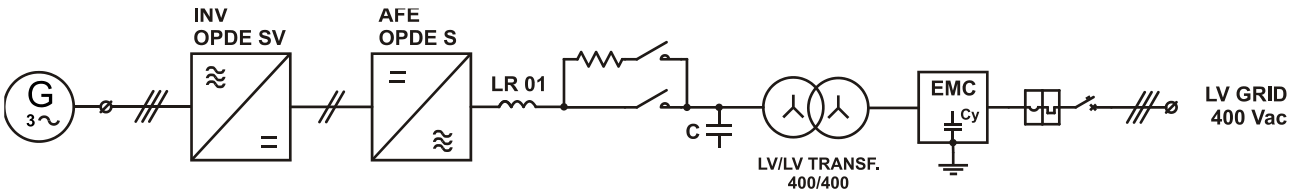


FIG. 42 – LV connected OPDE S, application with rotating machine connected to an AC/DC inverter

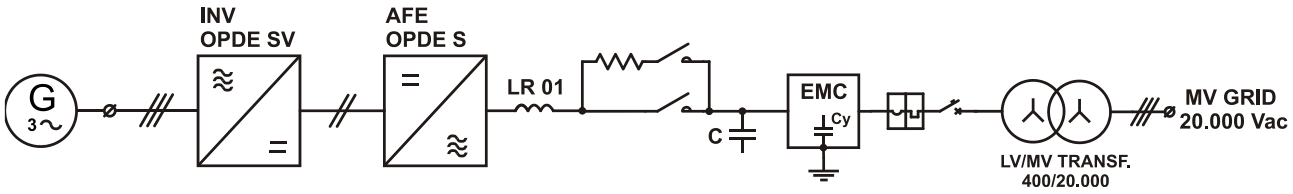


FIG. 43 – MV connected OPDE S, application with rotating machine connected to an AC/DC inverter

For parallel connecting several OPDE AFE ENERGY in the same three-phase AC line, in case of application with rotating machine, it is necessary to follow these guidelines:

1) The OPDE ENERGY AFE can be connected to the grid through a transformer with a single winding common to all OPDE AFE ENERGY converters; however, it is not necessary to include the secondary choke LR02.

2) In case of connection to the LV mains, it is necessary to connect a single EMC filter in the 400Vac side of the transformer (FIG. 50). In case of connection to the MV mains, it is necessary to connect a dedicated EMC filter at the output of each OPDE AFE ENERGY converter (FIG. 51).

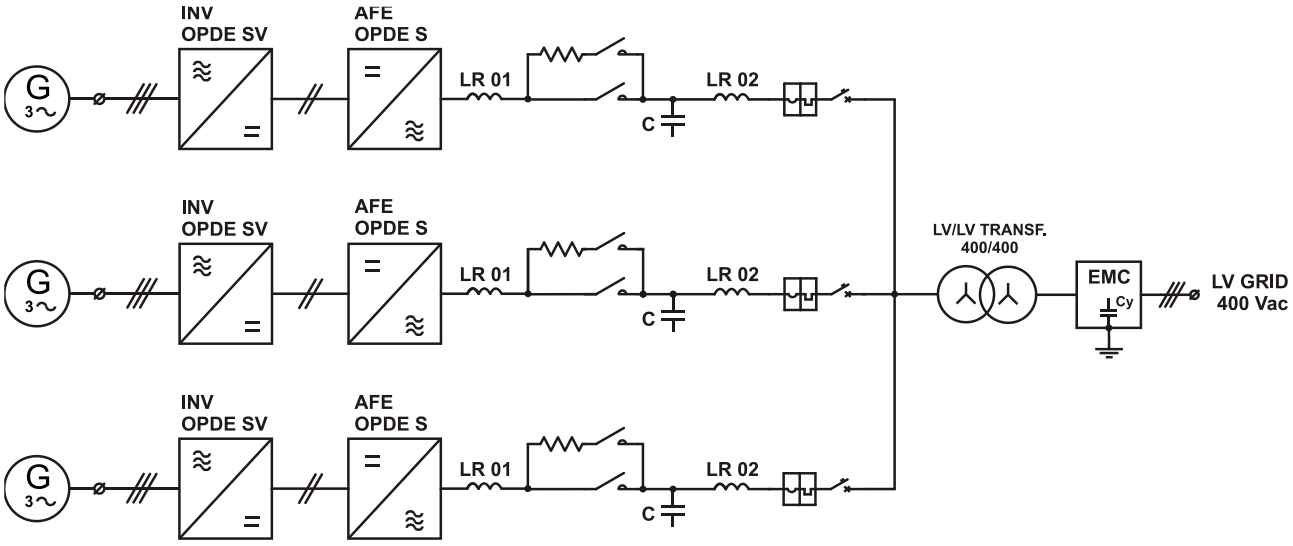


FIG. 44 – 3 x LV parallel connected OPDE S, application with rotating machine connected to an AC/DC inverter

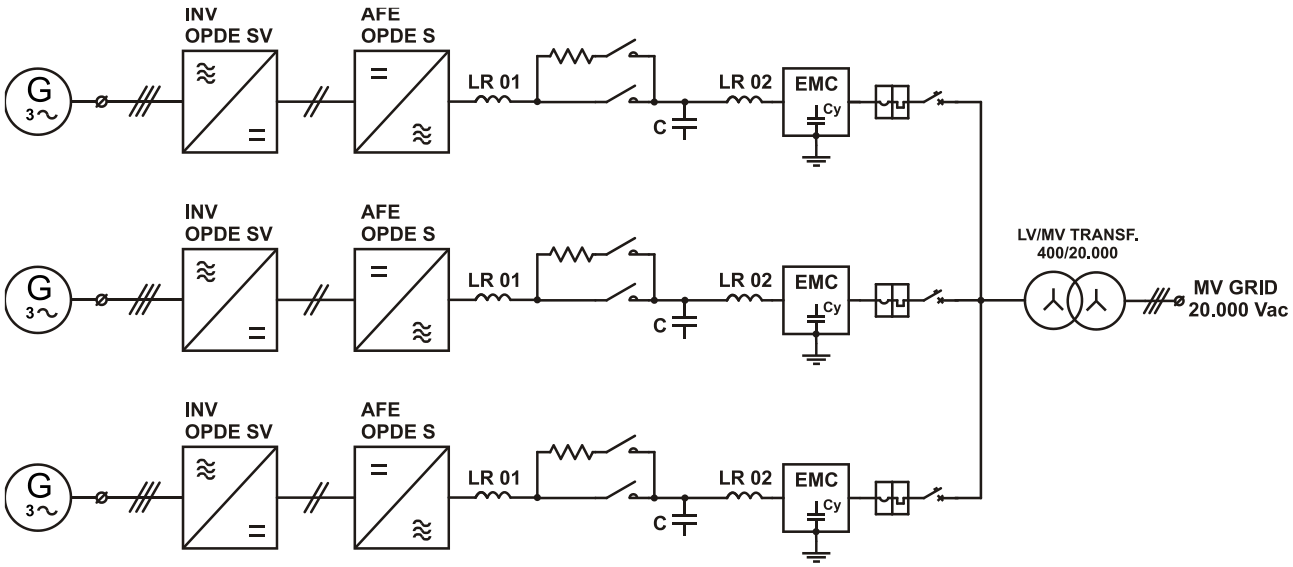


FIG. 45 – 3 x MV parallel connected OPDE S, application with rotating machine connected to an AC/DC inverter

9.2.4 CONNECTION TO THE AC/DC INVERTER OF THE ROTATING MACHINE - BRAKING

In applications with rotating machine with AC/DC inverter, it is necessary to connect the DC-bus of the AC/DC inverter to the DC-bus of the OPDE AFE ENERGY converter. The AC/DC inverter shall be suitably controlled to convert the energy from the rotating machine to the DC bus. The OPDE AFE ENERGY unit will control the DC bus to a constant value and convert the energy incoming from the generator into energy injected into the three-phase grid.

For the interface with rotating machine, use of TDE MACNO AC/DC inverters series OPDE ENERGY is recommended.

IF INVERTER NOT PRODUCED BY TDE MACNO ARE USED, CHECK THE SIZE OF PRECHARGE RESISTORS BASED ON THE VALUE OF CAPACITY OF THE INVERTER DC-BUS.

When insensitivity to voltage sags (**LVFRT**) is required, besides the inverter, it is necessary to install a **braking chopper** on the resistor. The braking chopper can be integrated in the AC/DC inverter that manages the rotating machine or it can consist of a separate braking unit.

INSENSITIVITY TO VOLTAGE SAGS (LVFRT) IN APPLICATIONS WITH ROTATING MACHINE IS MANDATORY ONLY IF THE STANDARD CEI 0-16; V1: 2013-12 APPLIES.

The chopper and brake resistor must be appropriately sized to dissipate the maximum power of the generator for a time equal to the maximum duration of the voltage sag.

During voltage sags, the converter momentarily interrupts the supply of power and resumes it within 400ms from the restoration of voltage supply.

CONTACT TDE MACNO FOR FURTHER DETAILS ON THE MANAGEMENT OF LVFRT.

The following figures provide some example block diagrams for the connection of the AC/DC inverter.

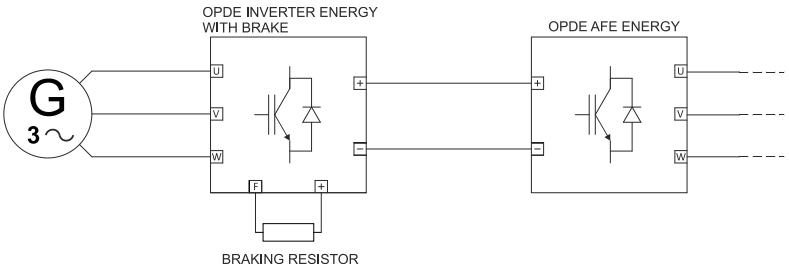


FIG. 46 – Connection of the inverter with brake on board

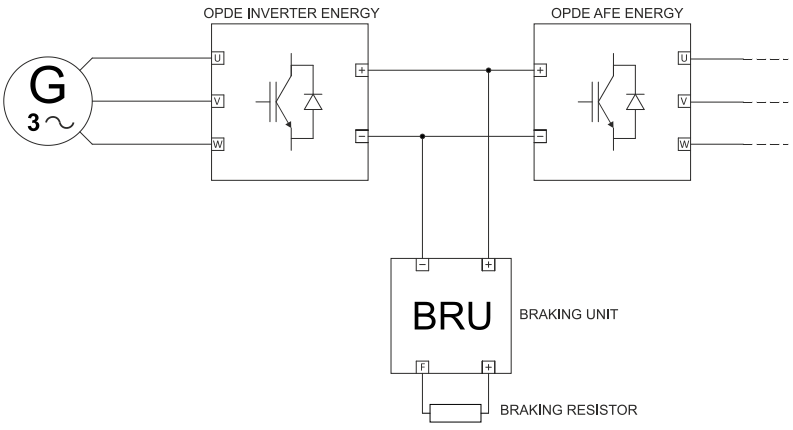


FIG. 47 – Connection of the inverter and of the separate braking unit

9.2.5 COMPONENTS FOR THE CONNECTION TO THE THREE-PHASE MAINS

For the correct operation of OPDE AFE ENERGY and to meet the regulations on electrical safety, it is necessary to install external components in the connection to the three-phase mains.
The required external components are the following ones (depending on the final installation, some components may not be compulsory):

- main choke LR01;
- filter capacitors C001, C002, C003;
- secondary choke LR02;
- external transformer T01;
- fuse FU01;
- on-grid contactor KM02;
- pre-charge contactor KM01;
- EMC filter ZC01;
- circuit breaker QF01;
- interface protection SPI.

The following section shows the features of the external components on the mains side.

	Main choke LR01				**Secondary choke LR02 (optional);**			
Size OPDE S	**OPDE S 70**	**OPDE S 90**	**OPDE S 110**	**OPDE S 150**	**OPDE S 70**	**OPDE S 90**	**OPDE S 110**	**OPDE S 150**
Three-phase inductance [mH]	1,396	1,071	1,002	0,725	0,279	0,214	0,200	0,145
Effective thermal current [Arms]	83.0	108.0	115.5	160.0	83.0	108.0	115.5	160.0
Effective overload current [Arms]	99.5	130.0	139.0	192.0	99.5	130.0	139.0	192.0
Overload duration [s]	30				30			
Rated voltage [Vrms]	400				400			
Rated frequency [Hz]	50				50			
Current THD [% of thermal current]	3.33				-			
Switching frequency [kHz]	5				-			
Ambient temperature [° C]	50				50			
Cooling	Natural air				Natural air			
Overtemperature class	F				F			
Insulation class of materials	H				H			
Insulation voltage [kV]	1.1 / 3 for 30s				1.1 / 3 for 30s			
TDE code	054R43019	054R43020	054R43021	054R43012				

TAB. 39A - Main and secondary choke

	Main choke LR01			**Secondary choke LR02 (optional);**		
Size OPDE S	**OPDE S 175**	**OPDE S 220**	**OPDE S 250**	**OPDE S 175**	**OPDE S 220**	**OPDE S 250**
Three-phase inductance [mH]	0,565	0,445	0,391	0,113	0,089	0,078
Effective thermal current [Arms]	205.0	260.0	296.1	205.0	260.0	296.1
Effective overload current [Arms]	246.0	313.0	355.3	246.0	313.0	355.3
Overload duration [s]	30			30		
Rated voltage [Vrms]	400			400		
Rated frequency [Hz]	50			50		
Current THD [% of thermal current]	3.33	3.33	3.33	-		
Switching frequency [kHz]	5	5	5	-		
Ambient temperature [° C]	50			50		
Cooling	Natural air			Natural air		
Overtemperature class	F			F		
Insulation class of materials	H			H		
Insulation voltage [kV]	1.1 / 3 for 30s			1.1 / 3 for 30s		
TDE code	054R43022	054R43023	054R43024			

TAB. 39B - Main and secondary choke

Size OPDE S	Main choke LR01			Secondary choke LR02 (optional);		
	OPDE S 310	OPDE S 370	OPDE S 460	OPDE S 310	OPDE S 370	OPDE S 460
Three-phase inductance [mH]	0,317	0,266	0,230	0,063	0,053	0,046
Effective thermal current [Arms]	365.4	434.7	504.0	365.4	434.7	504.0
Effective overload current [Arms]	438.5	521.6	605.0	438.5	521.6	605.0
Overload duration [s]	30			30		
Rated voltage [Vrms]	400			400		
Rated frequency [Hz]	50			50		
Current THD [% of thermal current]	3.33	3.33	5.55	-		
Switching frequency [kHz]	5	5	3	-		
Ambient temperature [° C]	50			50		
Cooling	Natural air			Natural air		
Overtemperature class	F			F		
Insulation class of materials	H			H		
Insulation voltage [kV]	1.1 / 3 for 30s			1.1 / 3 for 30s		
TDE code	054R43025	054R43026	054R43027			

TAB. 39C - Main and secondary choke

Size OPDE S	Insulation transformer T01									
	OPDE S 70	OPDE S 90	OPDE S 110	OPDE S 150	OPDE S 175	OPDE S 220	OPDE S 250	OPDE S 310	OPDE S 370	OPDE S 460
Transformer type	Three-phase									
Rated frequency [Hz]	50 /60									
Windings connection	YNyn0									
Primary winding										
Rated voltage [Vrms]	400±10%									
Maximum continuous power [kVA]	55	71	76	105	135	172	195	241	287	332
Primary winding connection	Star									
Secondary winding										
Rated voltage [Vrms]	400±10%									
Maximum continuous power [kVA]	55	71	76	105	135	172	195	241	287	332
Primary winding connection	Star									
Other data										
Ambient temperature [° C]	50									
Cooling	Natural air									
Overtemperature class	F									
Insulation class of materials	H									
Insulation voltage [kV]	1.1 / 3 for 30s									

TAB. 40 – Insulation transformer

Size OPDE S	Capacitors C001 C002 C003 for LC filter				
	Capacity [μF]	Minimum current [Arms]	Minimum voltage [Vrms]		
OPDE S 70	25	4.2	400		
OPDE S 90	25	4.5			
OPDE S 110	25	4.5			
OPDE S 150	25	5.1			
OPDE S 175	50	8.8			
OPDE S 220	50	9.5			
OPDE S 250	50	10.0			
OPDE S 310	75 / 100	13.9 / 17.1			
OPDE S 370	75 / 100	14.8 / 17.9			
OPDE S 460	150	29.2			
Examples of usable capacitors					
	Capacity [μF]	MODEL	Supplier code	TDE MACNO code	Quantity
OPDE S 70	25	MKP 1.44A ARCOTRONIC	C44AJGP5250ZA0J	06EJA3250	3
OPDE S 90	25	MKP 1.44A ARCOTRONIC	C44AJGP5250ZA0J	06EJA3250	3
OPDE S 110	25	MKP 1.44A ARCOTRONIC	C44AJGP5250ZA0J	06EJA3250	3
OPDE S 150	25	MKP 1.44A ARCOTRONIC	C44AJGP5250ZA0J	06EJA3250	3
OPDE S 175	50	MKP 1.44A ARCOTRONIC	C44AJGP5500ZA0J	06EJA3500	3
	50	SUPERIPHASO 7,5KVAR 400V ICAR	SRWT750153C1000	06F0400005	1
OPDE S 220	50	MKP 1.44A ARCOTRONIC	C44AJGP5500ZA0J	06EJA3500	3
	50	SUPERIPHASO 7,5KVAR 400V ICAR	SRWT750153C1000	06F0400005	1
OPDE S 250	50	MKP 1.44A ARCOTRONIC	C44AJGP5500ZA0J	06EJA3500	3
	50	SUPERIPHASO 7,5KVAR 400V ICAR	SRWT750153C1000	06F0400005	1
OPDE S 310	75	MKP 1.44A ARCOTRONIC	C44AJGP5750ZA0J	06EJA3750	3
	100	SUPERIPHASO 15KVAR 400V ICAR	SRWT150253C2000	06F0400003	1
OPDE S 370	75	MKP 1.44A ARCOTRONIC	C44AJGP5750ZA0J	06EJA3750	3
	100	SUPERIPHASO 15KVAR 400V ICAR	SRWT150253C2000	06F0400003	1
OPDE S 460	150	MKP 1.44A ARCOTRONIC	2 x C44AJGR5750ZA0J	2 x 06EJA3750	6
	150	SUPERIPHASO 22,5KVAR 400V ICAR	SRWT225253C3000	06F0400004	1

TAB. 41 – Filter capacitors

Size OPDE S	Pre-charge resistors RE01 RE02 RE03			
	Single adiabatic pulse [kJoule]	Minimum value [Ω]	Resistor available on the market (I.R.E. RFH) [Ω]	TDE MACNO code
OPDE S 70	3 x 1100	19	RFH75 47Ω 150W	02M5N0470
OPDE S 90	3 x 1500	14	RFH100 15Ω 200W	02M6N0151
OPDE S 110	3 x 1700	12	RFH100 15Ω 200W	02M6N0151
OPDE S 150	3 x 1700	12	RFH100 15Ω 200W	02M6N0151
OPDE S 175	3 x 7000	3	RFH220 3Ω 400W	02M8N9300
OPDE S 220	3 x 7000	3	RFH220 3Ω 400W	02M8N9300
OPDE S 250	3 x 7000	3	RFH220 3Ω 400W	02M8N9300
OPDE S 310	3 x 10500	2	RFH220 3Ω 400W	02M8N9300
OPDE S 370	3 x 10500	2	RFH220 3Ω 400W	02M8N9300
OPDE S 460	3 x 10500	2	RFH220 3Ω 400W	02M8N9300

TAB. 42 – Pre-charge resistors

Size OPDE S	EMC filters ZC01, 400V AC side		
	Minimum current [Arms]	Minimum operating voltage [Vrms]	Example
OPDE S 70	79	400	Schaffner FN 3270H-80-35
OPDE S 90	103		Schaffner FN 3270H-100-35
OPDE S 110	110		Schaffner FN 3270H-150-35
OPDE S 150	152		Schaffner FN 3270H-150-99
OPDE S 175	195		Schaffner FN 3270H-200-99
OPDE S 220	248		Schaffner FN 3270H-250-99
OPDE S 250	282		Schaffner FN 3270H-320-99
OPDE S 310	348		Schaffner FN 3270H-400-99
OPDE S 370	414		Schaffner FN 3270H-400-99
OPDE S 460	480		Schaffner FN 3270H-600-99

TAB. 43 – EMC filters, AC side

OPDE S size	KM01 and KM02 contactors						Main switch QF01
	On-grid contactor KM01 TYPE AC-3			Pre-charge contactor KM02 TYPE AC-3			MAGNETO-THERMAL
	Minimum current [Arms]	Minimum operating voltage [Vrms]	Mimimum rated power [kW]	Minimum current [Arms]	Minimum operating voltage [Vrms]	Mimimum rated power [kW]	Minimum current [Arms]
OPDE S70	79	400	37	9	400	4	79
OPDE S 90	103	400	55	12	400	5.5	103
OPDE S 110	110	400	55	12	400	5.5	110
OPDE S 150	152	400	75/90	12	400	5.5	152
OPDE S 175	195	400	90/110	32	400	15	195
OPDE S 220	248	400	132	32	400	15	248
OPDE S 250	282	400	160	32	400	15	282
OPDE S 310	348	400	200	32	400	15	348
OPDE S 370	414	400	200	32	400	15	414
OPDE S 460	480	400	250/315	32	400	15	480

TAB. 44 – Contactors and main switch, AC side

Interface protection SPI complying with CEI 0-21 (valid for all OPDE S sizes)	
Example for Italy	CM-UFD.M32

TAB. 45 – Interface protection

FOR THE USE OF THE INTERFACE PROTECTION SPI REFER TO THE REGULATIONS IN FORCE IN THE COUNTRY OF INSTALLATION

10 REMOTE KEYPAD

The OPDE AFE ENERGY converter integrates, directly on-board, a 5-digit 7-segment display, and a 3-key keypad. With it, it is possible to access all converter parameters, but in case of photovoltaic application it is not possible to access all the functions.
To access all the features of the control software of the photovoltaic application, the OPDE AFE ENERGY converter must be used in conjunction with the remote keypad (code 374T000601V), which implements a RTU Modbus communication protocol and can be connected via the RS485 bus to the OPDE AFE ENERGY converter.
Using a single keypad, it is possible to connect also to several ENERGY AFE OPDE converters simultaneously connected on the Modbus line. To select the converter with which one wants to communicate (one at a time), it is sufficient to set its Modbus address and its baudrate.

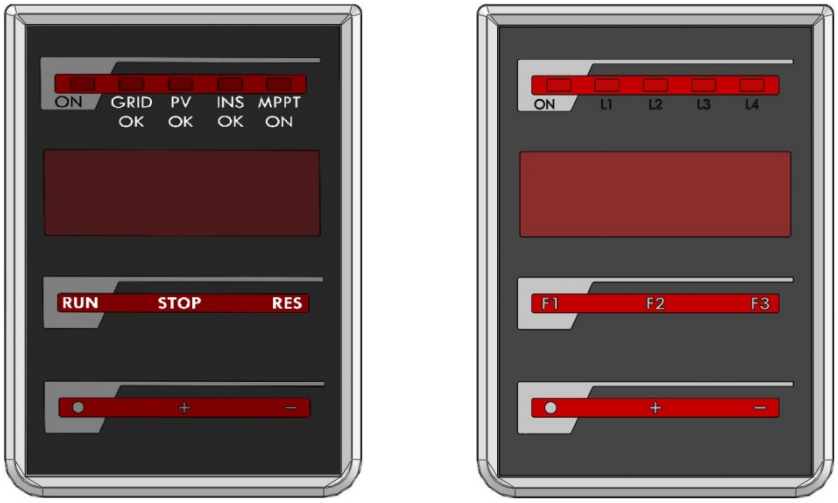


FIG. 48 – Keypad, front view (on the left, version for photovoltaic application; on the right, version for application with rotating machine)

10.1 PHYSICAL LAYOUT

The remote keypad includes 5 LEDs, a 5-digit 7-segment display with sign and 6 keys. Here below the meaning of the LEDs and buttons is given in the case of photovoltaic application.

LED name	Meaning
ON GRID (green)	*Inverter connected to the mains, i.e. interface device closed*
GRID OK (yellow)	*The network parameters (voltage and frequency) controlled by the interface protection and by AFE are within the limits and the grid side fuses are ok*
PV OK (yellow)	*PV array voltage within the limits, i.e. ranging from 380V to 780V*
INS OK (yellow)	*With closed PV side disconnector and the presence of voltage on the PV side, it indicated that the PV side insulation is within the limits set in the insulation controller*
MPPT ON (green)	*Fixed light = MPPT enabled* *Fast flashing = manual MPPT enabled* *Slow flashing = the start command is stored and the inverter is ready to start*

Key name	Meaning
S	*Selection*
▲	*Increase*
▼	*Decrease*
RUN	*It allows starting the device (starts the running, starts the MPPT)*
RESET	*It allows resetting the alarm (after that the condition that generated it has been solved)*
STOP	*It allows stopping the device (it stops the converter, it stops the MPPT)*

TAB. 46 – Keys and LEDs on the remote keypad

10.2 SPECIFICATIONS

Power supply

Voltage	5 ÷ 30 Vdc (protected against reverse polarity) to be provided in the 3-pole connector positioned on the rear
Current	<200 mA (total power <1000 mW for any voltage included in the range)

Communication

Data link interface	RS-485, half duplex, DB9 male connector on the back of the keypad with standard drive OPDE converter pinout for short-distance connections. Internal termination and polarization network available in the connector for multi-drop and/or long-distance connections.
Data link protocol	Modbus RTU 8N1, master
Connection capabilities	Up to 128 devices can be point-to-point or point-to-multipoint (multi-drop) connected by selecting the slave address and the bit rate (from 19.2 up to 115.2 kbps)

10.3 LIMITS OF USE

Environmental parameter	Limits	Measurement unit
Operating temperature	-10÷50	°C
Storage temperature	-20÷70	°C
Humidity	5÷95	%
Mechanical vibrations	2g 30min X, Y, Z direction 10-25 Hz	g
CE/FCC	Complies with EN 61000-4-4, EN 61000-6	

TAB. 47 – Use limits for the remote keypad

10.4 MECHANICAL DIMENSIONS

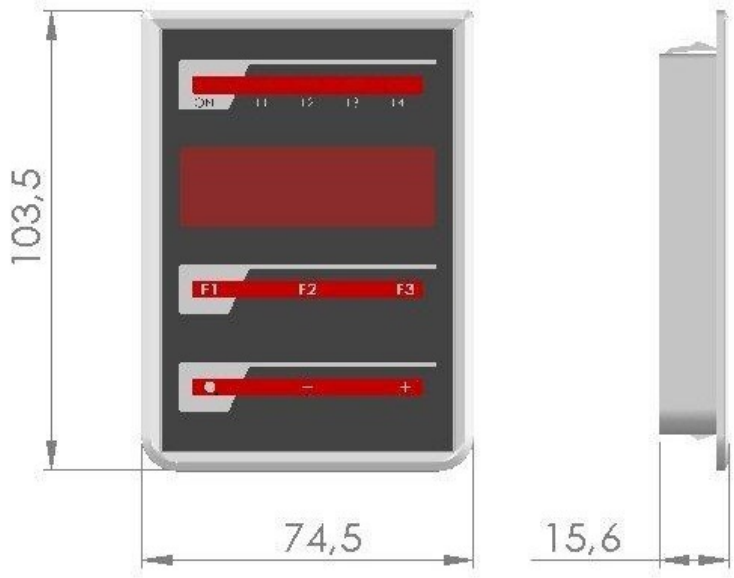
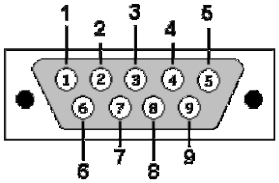


FIG. 49 – Keypad, mechanical dimensions

10.5 CONNECTIONS

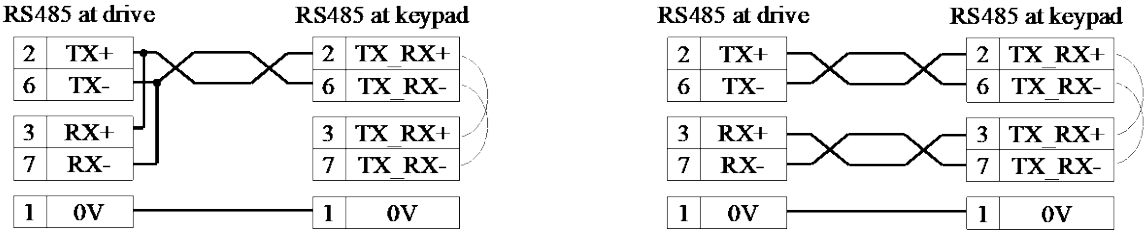
CN1 is the data connector: a DB9 male connector that controls the RS485 signals with a pinout compatible with that of the DB9 connector on board of the OPDE AFE ENERGY converter. It is used for the direct connection of the keypad to the converter using a 1-to-1 cable.

CN1	Pin #	Name	Description
	1	0V	signal reference voltage
	2	TX_RX +	RS485 half duplex non inverting signal (Tx / Rx) 2 -3 internally shorted
	3	TX_RX +	
	4		
	5	Term +	positive polarization/termination
	6	TX_RX -	RS485 half duplex inverting signal (Tx / Rx) 6 – 7 internally shorted
	7	TX_RX -	
	8		
	9	Term -	negative polarization/termination

TAB. 48 – Remote keypad connections

Make sure that the remote keypad uses a RS485 HALF DUPLEX interface; then, it is possible to use only 3 cables/signals (TX_RX+, TX_RX-, 0V) to perform the connection between keypad and converter. Pins 2 and 3 are short-circuited internally; consequently also pins 6 and 7 are short-circuited internally.

In order to properly communicate with the OPDE AFE ENERGY converter, which has a RS485 FULL DUPLEX interface, it is necessary to short-circuit the same pins also on the converter side or, alternatively, to connect pin 2 to pin 3 and pin 6 to pin 7.



The first wiring diagram represented is always recommended and it is compulsory in case of long-distance and/or multi-drop connections.
For the long-distance and/or multi-drop connection, it is also compulsory to connect the polarization/termination network in the first and in the last device connected to the serial bus: to do this, connect pin 5 to pin 2 (2 and 3 if the device is a converter), and pin 9 to pin 6 (6 and 7, if the device is a converter).
It is also recommended to use a shielded cable with pair twisted conductors (min AWG 22).

CN2 is the power connector.

CN2	Pin #	Name	Description
	**1**	**0V**	supply voltage reference
	2	**+V**	positive supply voltage
	3	**PE**	ground

TAB. 49 – Remote keypad power connector

The power supply has a wide range (see technical data) and the keypad is protected against reverse polarity. Internally, there is a DC-DC converter of switching type, which ensures high efficiency and a constant power consumption over the whole range of the supply voltage.

The RS485 interface **IS NOT ISOLATED** with reference to the supply voltage; therefore, it is necessary to pay attention during installation to prevent the connection of different voltages and the creation of ground loop.

FIG. 50 – Keypad, view from the back

10.6 PANEL ASSEMBLY

Follow these procedure to assemble the remote keypad on the front panel of the cabinet; use the optional kit:

1. remove the two screws from the rear side of the keypad
2. apply the seal into the groove along the side of the keypad structure
3. place the remote keypad in the panel
4. apply the bracket to the back of the remote keypad tightening it using the provided screws
5. fix the remote keypad to the panel using the screws on the fins of the bracket until the seal is completely pressed between the keypad structure and the panel

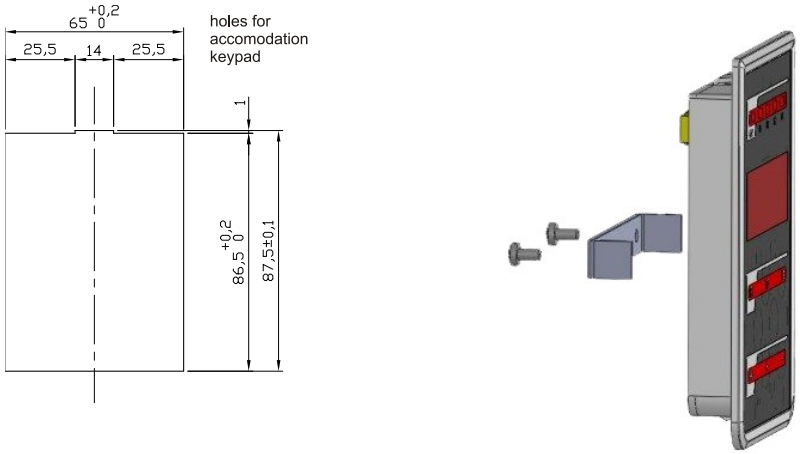


FIG. 51 – Keypad, Panel assembly

10.7 ADAPTER FOR REMOTE KEYPAD

The remote keypad was originally developed to be connected directly to the RS485 interface (DB9F connector) of the OPDE AFE ENERGY converter, in both point-to-point and multi-point configurations.
Usually, the RS485 interface of the converter is used for communication to a PC to use the OPD Explorer supervision software or for reading/writing parameters with other management systems.

In these cases, the RS485 interface of the converter is not be available for the connection of the remote keypad because there would be two masters on the same bus: the converter and the remote keypad.

It is possible to set a parameter from the remote keypad to make it "idle" (not active); in this way, it is possible pt leave it connected to the bus to allow communication on the same bus by another master. This may be a temporary solution when it is necessary to connect via PC with the OPD Explorer supervision software during commissioning.

For all other cases where it is necessary to use the serial interface of the OPDE AFE ENERGY converter independently from the remote keypad, it is necessary to use an **adapter that allows adding a second interface to the RS485 converter.**

FIG. 52 – Adapter for remote keypad

The adapter is an external device that is connected to the "remote keypad" connector on the front panel of the converter (the keypad of the converter turns off automatically when the adapter is inserted: only one segment remains lit to indicate that the converter is power supplied).

The adapter can be connected/disconnected when the converter is powered

The adapter adds a second RS485, half-duplex interface with DB9F connector, suitable for direct connection to the remote keypad.

It should be noted that this second RS485 interface has fixed (non-editable) address and slave address, respectively slave address=1 bitrate=38.4 kbps; and it is not isolated from the converter adjustment board, therefore, it is possible to perform only short-distance point-to-point connections (not multi-drop connections)

Obviously, the second RS485 interface can be used to connect also other types of master different from the remote keypad.

10.8 PROGRAMMING KEY

The programming key is a device that is used to duplicate the parameter settings among two or more drives. The storage of data occurs in a memory of EPROM type, therefore, **no batteries are required** for keeping the data. The switch on the upper part of the key is used to protect the data in the memory against overwriting.

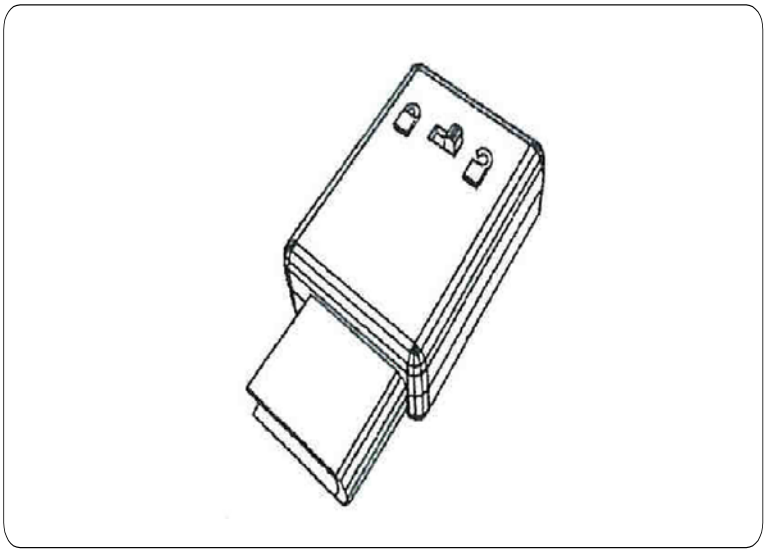


FIG. 53 – Programming key

Operating instructions:

Transfer of parameters from the key to the inverter:

a) Insert the key into the proper connector;
b) With the ▲ and ▼ keys available on the converter, select the "**Load**" function (shown on the display) and press "**S**".

During data transfer, "**RUNN**." will be displayed.
If the key contains incorrect parameters, the default parameters will be loaded and "**Err**" will be displayed for 4 s; otherwise, the data contained in the key will be stored and the message "**don**E" will be displayed for 2 s to confirm that the process was successful.

Transfer of parameters from the inverter to the key:

a) Insert the key into the proper connector;
b) With the ▲ and ▼ keys available on the converter, select the "**Save**" function (shown on the display) and press "**S**".

If the key is protected against writing, the command is interrupted and the message "**Prot**" is displayed for 4 s; otherwise, the parameters will be stored in the key and the message "**RUNN**" appears first and then "**donE**" for 2 s to confirm that the process was successful.
By using the key, it is possible to store or transfer only the standard parameters. The parameters of some applications (positioner, etc.) cannot be stored or transferred via the programming key. The programming key does not store the firmware but only the parameters.

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