TWERD ENERGO-PLUS

Active Front End converter
type:

MFC1000AcR

30 kW, 37 kW
45 kW, 55 kW, 75 kW
90 kW, 110 kW

3 x 400 V
3 x 500 V
3 x 690 V

User Manual
Part I: Hardware

Document version: 4.1,1

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H.1. Conditions of safe operations

Before starting any work with the MFC1000 frequency converter read carefully this User manual.

This User manual contains notices intended to ensure personal safety, as well as to protect the MFC1000 frequency converter and connected equipment against damage.

Ignorance or not knowing of the information contained in It can cause physical injury or death!
It can also cause damage to the MFC1000 frequency converter and connected equipment!

In the further part of this User manual, the MFC1000 frequency converter, to which this instruction applies, will be also referred to as the "drive" or "converter".

H.1.1. Warnings

Incorrect installation, usage, and maintenance of the drive can cause physical injury or death, or damage to the drive and connected equipment!

R I S K O F E L E C T R I C
S H O C K!

The drive contains high voltage when connected to mains voltage!
Dangerous voltage present inside the device for at least 10 minutes after disconnecting the power supply!

- Installation, usage, and maintenance of the drive must be performed only by qualified personnel.
- Don't make any connections changes when the drive is connected to the power supply.
- Before switching on the main power supply and control circuit voltage make sure the drive has been correctly installed and all housing elements have been properly assembled.
- It is forbidden to touch the drive's voltage terminals if it is connected to the power supply.
- After connecting the drive to the supply voltage, its internal components (without the control terminals) are on the power supply potential. Touching these components can cause an electric shock.
- When the drive is connected to the supply voltage, dangerous voltage appears at its output terminals U, V, W even when the electric motor is not running.
- Externally supplied control circuits may carry dangerous voltage even when the input power of the drive is switched off.
- After disconnecting the drive from the supply voltage, dangerous voltages still remain inside the drive due to the energy stored in the power circuit capacitors (DC-link circuit). It can cause an electric shock! The time required for self-discharge of capacitors in an undamaged drive is usually between 5÷15 minutes (a higher power rating of the drive means the longer time).
  For this reason before starting any works on the drive, the electric motor or the electric motor cable always wait at least 10 minutes after disconnecting all power supplies sources and make sure that a voltage on a clamps is not present.
  Attention! The lack of the voltage at the connection terminals does not ensure the lack of dangerous voltage in the internal DC-link circuit of the drive!
- The drive is not adapted for use in flammable or explosive environment because it can cause fire or explosion. Use suitable flameproof enclosures.

H.1.2. Basic rules

- Don’t connect mains voltage to output terminals U, V, W.
- Don’t measure the voltage endurance of any unit drives.
- To measure the cables insulation it is necessary to disconnect them from the drive.
- Do not try to repair the unit yourself. Any repairs must be performed only by authorized service.

  Any modifications or self-repairs of the drive can cause physical injury, death, or damage to the drive and the connected equipment. Any attempt at unauthorised repairs will void any warranty.
- Don’t touch integrated circuits and any other parts on the drive’s electronic board.
- Don't connect any capacitors to motor wires (e.g. intended for improvement of power factor).
- Don't measure output voltage of a converter using digital voltmeters without low-pass filter. The voltage can only be measured correctly with an electromagnetic voltmeter.
- The drive is not designed to operate with periodically switched on/off supply voltage.
- If the electric motor runs at low speed (below 25 Hz), additional cooling of the motor is necessary.

H.1.3. Operation list

The operations applied at installation and the first start-up of the drive	
1.	After unpacking the converter, it is necessary to check up visually the presence of damages which could arise during transport.
2.	Check whether the delivery is in accordance with the order - check the nameplate.
3.	Check up the correspondence between the conditions in which the converter will be used and conditions of an environment for which it is designed (section H.1.4).
4.	Installation of the frequency converter should be made due to the principles of safety and EMC rules.
5.	Perform the configuration of the converter in accordance with the chapters of this manual.

H.1.4. Environmental conditions

Degree of pollution

The second degree of pollution has been assumed during the design, at which there are normally only non-conducting pollution. However, there is a probability of temporary conductivity caused by a condensation, when the converter is disconnected from the voltage source.
In case the environment in which the frequency converter will work contains pollution, which can influence its safety, it is necessary to apply appropriate counteraction, using, for example, additional cases, air channels, filters etc.

Climatic conditions

	Installation site	***During warehousing***	***During transport***
Temperature	from -10°C to +50°C[1])	-25°C to +55°C	-25°C to +70°C
		Protective packing	
Relative humidity	from 5% to 95%	from 5% to 95%	to 95%
	Short-term, insignificant condensation on the external side of the converter case is permitted only when the converter is disconnected from the voltage source.		
Air pressure	from 86 kPa to 106 kPa	from 86 kPa to 106 kPa	from 70 kPa to 106 kPa

1) For nominal load temperature 40°C was assumed; however, for lower loads higher temperatures are acceptable.

H.1.5. Recycle

Equipment containing electrical and electronic components can not be removed into municipal waste containers. Such equipment must be separated from other wastes and attached to electrical and electronic waste in accordance with applicable local regulations.
This way you help to prevent uncontrolled waste disposal and promote the recycling of materials.

H.1.6. Limits of responsibility

Despite all the efforts and due diligence of TWERD ENERGO-PLUS sp. z o.o. does not guarantee that the published data is error-free.

The User is obliged to read the information contained in this Manual before using the device. The TWERD ENERGO-PLUS sp. z o.o. is not responsible for any consequences of incorrect use of information contained in this Manual or any infringement of patents or other rights of third parties that may arise from their use.

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For more information contact out technical support at: twerd@twerd.pl

H.1.7. CE marking

Frequency converters of MFC1000, MFC1000AcR fulfill the fundamental requirements of following instructions of the new approach:
- the Instruction low-voltage LVD 2014/35/EU,
- the Instruction EMC 2014/30/EU.

Mentioned above instructions are fulfilled only after installation of the frequency converter and configuration of the electric drive according to instructions of installation principles and the principles of safety resulted below. User is obliged to fulfill this requirements.

Safety	
IEC/EN 50178:2003	Electronic products which are used in installations of the high power.
IEC/EN 61800-5-1:2007 + A1:2017	Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy.

Electromagnetic compatibility	
IEC/EN 61800-3:2008	Electric power drives with regulated speed. Electromagnetic compatibility (EMC) in consideration of special methods of research
Conducted emission	IEC/EN 61800-3:2008 second environment
	Class C3 - with use of installation principles (section 2.1.2) and the equipment (section 2.1.2 without item “**f.4**” and “**f.5**”).
Radiation emission	IEC/EN 61800-3:2008 second environment
	Class C3 - with use of installation principles (section 2.1.2) and the equipment (section 2.1.2 without item “f.4” and “f.5”).
Resistance	IIEC/EN 61800-3:2008 first and second environment

In a frequency converter where to meet the emission requirements for Class C3 the RFI filter is not required, the possibility of radio interference may be expected.

The inverters are not intended for use in the public low voltage network that supplies residential premises. Radio frequency interference is expected when used in such a network.

In IT grids usage of asymmetric filters of high frequency (capacitors Y) to reduce emission of interference, ruins the concept of the distributive grid isolated from the ground. Additional grounded impedances can become threat of safety in such systems.

Before buying a drive for use in an IT grid, please contact us to set the individual design of the system.

For technical reasons in some applications (current higher than 400A) fulfilling requirements of EMC is not possible. In such cases user and manufacturer should decide on ways of satisfying EMC requirements in this particular application.

H.2. Technical data

This User's manual refers to frequency converter MFC1000AcR. Table H.2.1 shows the technical data.

Table H.2.1 – Technical data

Power supply	Voltage U_{in} / freq.	Depending on the type: • **3 x 400 V** (-15%, +10%), 45..66Hz • **3 x 500 V** (-15%, +10%), 45..66Hz • **3 x 690 V** (-15%, +10%), 45..66Hz *Note: information contained the supply voltage is placed on the nameplate.*
Output	Output voltage	0 ... U_{in} [V]
	Frequency	0,0 ... 400 Hz – U/f operation mode 0,0 ... 120 Hz – Vector operation mode
	Frequency resolution	0.01 Hz
Cooling system	Cooling is made by a forced ventilation from down to up	
Control system	Modulator	SVPWM
	Operation mode	U/f (linear, exponential), Vector DTC-SVM without sensor Vector DTC-SVM with sensor of the rotor position
	Switching frequency	1 ... 8 kHz *Default: 2,5 kHz for nominal power when supply voltage is 3x400Vac and 2,0kHz for nominal power when supply voltage is 3x690V*
	Rotation speed setting	Analog inputs, control panel, motopotentiometer, PID controller, communication unit RS-485 and other possibilities. Resolution of 0.1% for analog inputs or 0.1Hz / 1 rpm for the control panel and RS.
Control inputs/outputs	Analog inputs	5 analog inputs (1 voltage mode, 4 voltage-current mode): AI0: voltage mode 0(2) ... 10V, R_{in} ≥ 200kΩ; AI1, AI2, AI3, AI4: voltage mode 0(2) ... 10V, R_{in} ≥ 100kΩ; current mode 0(4)...20mA, R_{in} = 250Ω, Operation mode and polarity are chosen by parameters. Accuracy: 0.5 % of the full range.
	Digital inputs	10 digital separated inputs 0/(15...24)V, R_{in} ≥ 3kΩ. The possibility of obtaining up to 30 digital inputs on expansion cards.
	Analog outputs	2 analog outputs (voltage-current mode) AO1, AO2: Voltage mode 0(2)...10 V Current mode 0(4)...20 mA Configured by parameters, accuracy: 0.5%. The possibility of obtaining up to 10 digital inputs on expansion cards (2 inputs on one each expansion card).
	Digital outputs	6 output relays K1 … K6 – breaking capacity: 250V/1A AC, 24V/1A DC. Fully programmable signal source. The possibility of obtaining up to 5 digital inputs on expansion cards.
	Encoder interface	Possibility of direct connection of incremental encoder: 5V DC, line driver (RS422), <250kHz. Recommended pulse rate: 1024-2048.
	Temperature sensor	Pt100
Communication	Connectors	RS-485 x2, USB, Ethernet
	Communication protocol	MODBUS RTU. Function 3 (Read Register), function 6 (Write Register), function 16 (Write Multiple Registers).
	Baud-rate	2400, 4800,9600, 19200, 38400, 57600, 115200 bit/s
	Application	Remote control of unit operation and programming of all parameters of the frequency converter.

Special functions	PID controller	Build-in 4 PIC controllers. Choice of referencing-unit signal source and feedback signal source, possibility of inverting polarity of an control error signal , SLEEP function and output erasing on STOP signal, limitation of an output value.
	PLC controller	Possibility of taking control over converter's operation, START / STOP system, direction of rotation and frequency, possibility of controlling any external process without connection of external PLC controller. 100 universal functional blocks, 43 functions: simple logic and arithmetic blocks; block of 8-state sequencer, 2 multiplexers with 8 inputs, curve shaping unit, maximum execution time of the PLC program: 10ms.
	Additional functions of the panel	Definition of User's values for direct observation of the process variables- choice of measurement unit, scale and data source (e.g. from PLC controller).
		Definition of User's referencing-device for direct changing of the process variables – choice of measurement unit and scale
		Copying parameter settings between frequency converters
Protections	Short-circuit	Short-circuit on unit output
	Overcurrent	Instantaneous value 3.2 $I_{n;}$; effective value 2.25 I_n
	Overvoltage AC/DC	MFC1000 400 V: 1,43 U_{in} AC, 750 Vdc MFC1000 500 V: 1,43 U_{in} AC, 900 Vdc MFC1000 690 V: 1,28 U_{in} AC, 1200 Vdc
	Undervoltage	0.65 U_{in}
	Thermal: device	Heatsink's heat sensor
	Thermal: motor	I^2t limit, motor heat sensor
	Supervision of communication with control panel	Established permissible time of connection absence
	Supervision of communication through RS	Established permissible time of connection absence
	Control of analog inputs	Check of absence of “living null” in modes 2 ... 10V and 4 ... 20mA
	Control of a load symmetry	E.g. break in one of the motor phases
	Underload	Protection from operating without any load
	Stall	Protection against stall of a motor

Table H.2.2 – Technical data of frequency converters of the **MFC1000AcR 400V** series, depending on a type

Type of frequency converter	**P_n [kW]**	**I_n [A]**	**I_p [A]**
MFC1000AcR/30kW	30	60	90
MFC1000AcR/37kW	37	75	112
MFC1000AcR/45kW	45	90	135
MFC1000AcR/55kW	55	110	165
MFC1000AcR/75kW	75	150	225
MFC1000AcR/90kW	90	180	270
MFC1000AcR/110kW	110	210	215

Table H.2.3 – Technical data of frequency converters of the **MFC1000AcR 500V** series, depending on a type

Type of frequency converter	**P_n [kW]**	**I_n [A]**	**I_p [A]**
MFC1000AcR/30kW 500V	30	50	75
MFC1000AcR/37kW 500V	37	60	90
MFC1000AcR/45kW 500V	45	72	108
MFC1000AcR/55kW 500V	55	90	135
MFC1000AcR/75kW 500V	75	120	180
MFC1000AcR/90kW 500V	90	150	225
MFC1000AcR/110kW 500V	110	180	270

Table H.2.4 – Technical data of frequency converters of the **MFC1000AcR 690V** series, depending on a type

Type of frequency converter	**P_n [kW]**	**I_n [A]**	**I_p [A]**
MFC1000AcR/30kW 690V	30	36	52
MFC1000AcR/37kW 690V	37	43	65
MFC1000AcR/45kW 690V	45	52	78
MFC1000AcR/55kW 690V	55	64	95
MFC1000AcR/75kW 690V	75	87	130
MFC1000AcR/90kW 690V	90	104	156
MFC1000AcR/110kW 690V	110	121	182

P_n – nominal output power
I_n – nominal output current
I_p – overload current: for 60 seconds every 10 minutes

MECHANICAL DIMENSIONS

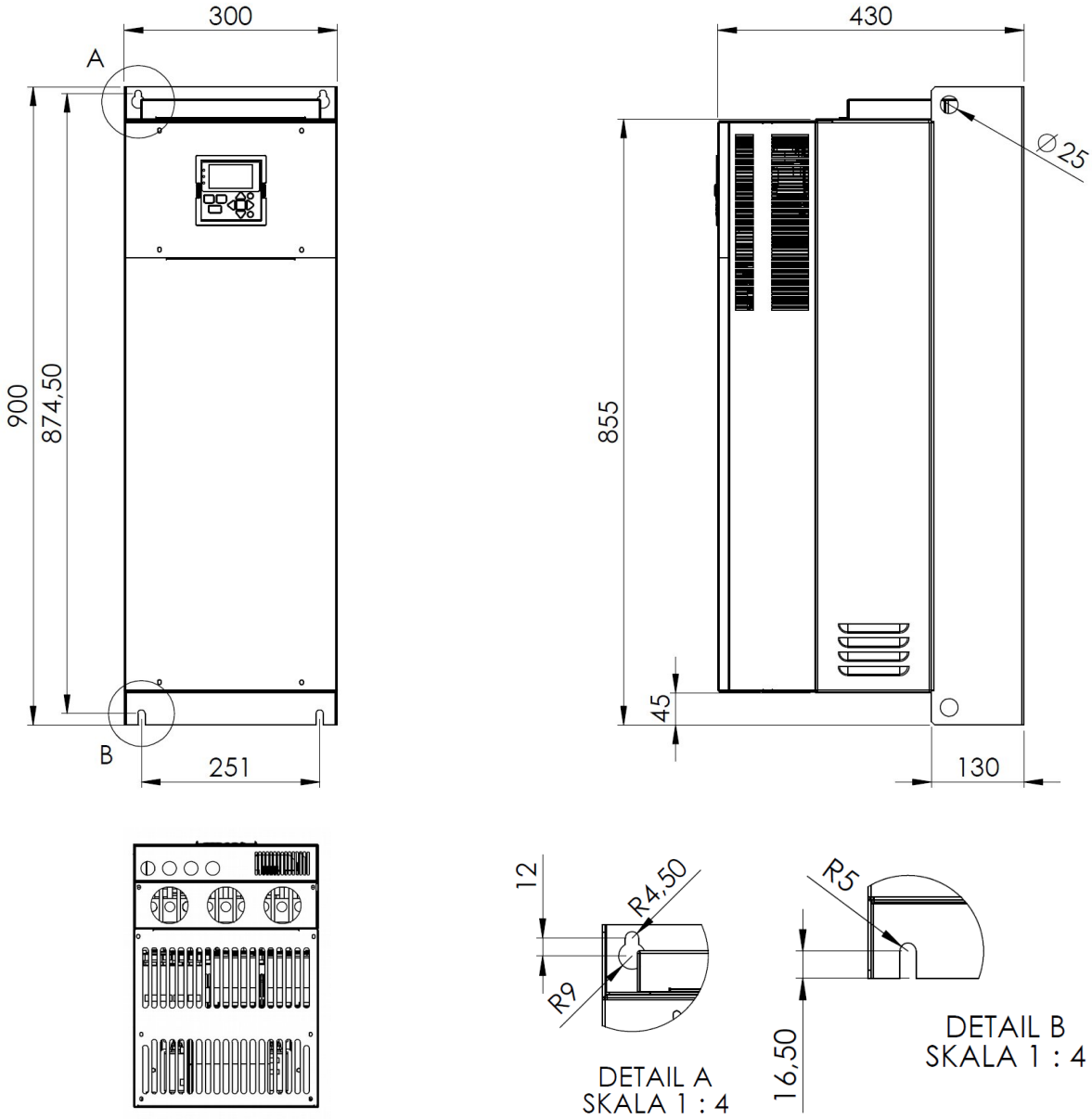

Fig. H.2.1. Mechanical dimensions MFC1000AcR converters

Weight: approximately 102 kg ±10 kg – depending on the nominal power.

H.3. Installation

H.3.1. Safety principles

a. Leveling connections

Touch protection encompasses the automatic switching off of the power supply by means of the special short circuit (differential type) or limitation of voltages which may be touched if the insulation is damaged to a level not exceeding the permissible values.

Due to the intermediate circuit operation, a short to ground in the output circuit of the frequency converter may not be detected by the short circuit protection. The frequency converter provides protection against short circuits between the phases and the output, but this protection is based on putting the IGBT transistors in the blocking state, which does not meet the requirements of fire protection.

In this regard, in order to ensure the staff safety, it is necessary to make local leveling connections in a corresponding way.

The special, respectively designated and protected from corrosion points for connection of the leveling wires are provided in the frequency converter.

b. Protections

Usage of gG or aM fuses is allowed in the circuits, however taking into account necessity of protection of the rectifier bridge of the frequency converter, the best solution is gR or aR fuses.

Frequency converter is protected from: drive overloading, motor overheating, under- and overvoltage in an DC link circuit of the converter, a short-circuit at the converter output - it protects converter only!

c. The switching devices

To comply with the EU Directive, in accordance with PN-EN 60204-1: 2010, a device for switching off the power must be provided in the motor controller system, which consists of a frequency converter and an electric machine. This device must be one of the following:

- a disconnector (with or without fuses), an AC-23B category of use that meets the requirements EN 60947-3,
- a disconnector (with or without fuses), which ensures disconnection of the load circuit by opening the main contacts, complying with the requirements of EN 60947-3,
- circuit breaker complying with EN 60947-2.

Fulfilment of the requirements is the responsibility of the organization performing the installation.

d. Emergency stop

To comply with the EU Directive, in accordance with PN-EN 60204-1: 2010, on the basis of the staff and equipment safety, it is necessary to use an emergency stop switch, which has an advantage over other functions, regardless of the operation mode. The STOP key on the operator panel cannot be considered as an emergency stop switch, because pressing it does not turn off the frequency converter from the power supply.

Fulfilment of the requirements is the responsibility of the organization performing the installation.

e. Housing

The housing meets the requirements of IP00 degree of protection. The housing is designed in such a way that it cannot be removed without the use of tools.

f. Discharging capacitors

There is a battery of relatively large capacitors in the intermediate circuit of the frequency converter. After turning off the supply voltage of the frequency converter, dangerous voltage is held at its terminals for a certain time. It is necessary to wait 10 min. before switching at the terminals of the power terminal connections of the frequency converter. Information about the danger of such a voltage is on the panel, which closes the terminal connections of the supply voltage.

H.3.2. Electromagnetic Compatibility (EMC)

The installation principles reducing EMC problems are divided into four groups. To achieve full success it is necessary to apply all principles listed below. Not applying to one of principles ruins the effect of others.

- separation,
- equalizer connections,
- shielding,
- filtration.

a. Separation
Power cables (supplying, motor's) must be separated from signal wires. It is necessary to avoid parallel leading of power and signal wires in the common wire channels, and especially in group of cables. The crossing of power cables and signal cables under a right angle is allowed.

b. Equipotential connections
The frequency converter and the filter should be mounted as close as possible, preferably on a common metal plate which act as a ground. For this purpose you can use, a mounting plate or a back wall of a case for example. The casing of the frequency converter, the filter and the metal plate shouldn't be coated with any insulation materials. It is necessary to pay attention to an opportunity of oxidation of a surface that results in deterioration of contact. For limitation of asymmetric disturbance level, it is necessary to apply many connections of the cable shielding to ground.

c. Shielding
Wires between the mains filter and the frequency converter are not necessary for shielding, if their length doesn't exceed 300mm. In case the length of conductors exceeds 300mm it is necessary to use the shielded wires. Completely shielded cable is a cable which fully complies with requirements of interference radiation according to EN 55011 norms. Such cable should have the screen consisting of spiral metallized aluminium foil and tinned copper plait with a puls-duty factor of not less than 85 %, not separated galvanically.

Connection of the cable ends to ground is obligatory. It is necessary to use grounding of the cable shielding on whole section of a cable, on both ends. For this purpose a special EMC grommets are used. They provide valid contact of cable shielding to the case of the equipment. In addition it is necessary to use special cable clips to connect it to back wall of a case for example. It is necessary to pay attention that the unshielded cables, are as short as possible. Junctions of the shielding with a ground should be free from insulating coat on a whole section. Be careful not to damage the shielding. It is not recommended to weave the copper plait in one point (without using EMC grommet) in order to realize grounding.
In case of need control signal wires should also be shielded using the same principles.

d. Filtration
Use of the EMC filter limits noises spreading from electric drive system to mains. Principles of filter installation are described at the description of equipotential connections and shielding.

e. Ferrite rings
The reduction of interference emission can be obtained by using ferrite rings located on the input wires (power supply wires) and output wires (to an electric motor).

f. The list of the equipment reducing EMC problems
The list contains the equipment which can be additionally established in the electric drive system to increase its noise stability and to reduce emission of interferences in the certain environment of operation.

1. completely shielded cables - we recommend cables TOPFLEX EMV and TOPFLEX EMV 3 PLUS (HELUKABEL),
2. EMC grommets (throttles),
3. Ferrite rings,
4. RFI filter (REO, SCHAFFNER),
5. EMC case - an option, which is not necessary for fulfillment of the EMC instructions.

H.3.3. Connecting the power circuit

The frequency converter is powered by a three-phase power line through terminals L1, L2, L3. Information about the supply voltage is also placed on the nameplate. Figure 3.1 shows the electric scheme of the power circuit connections.

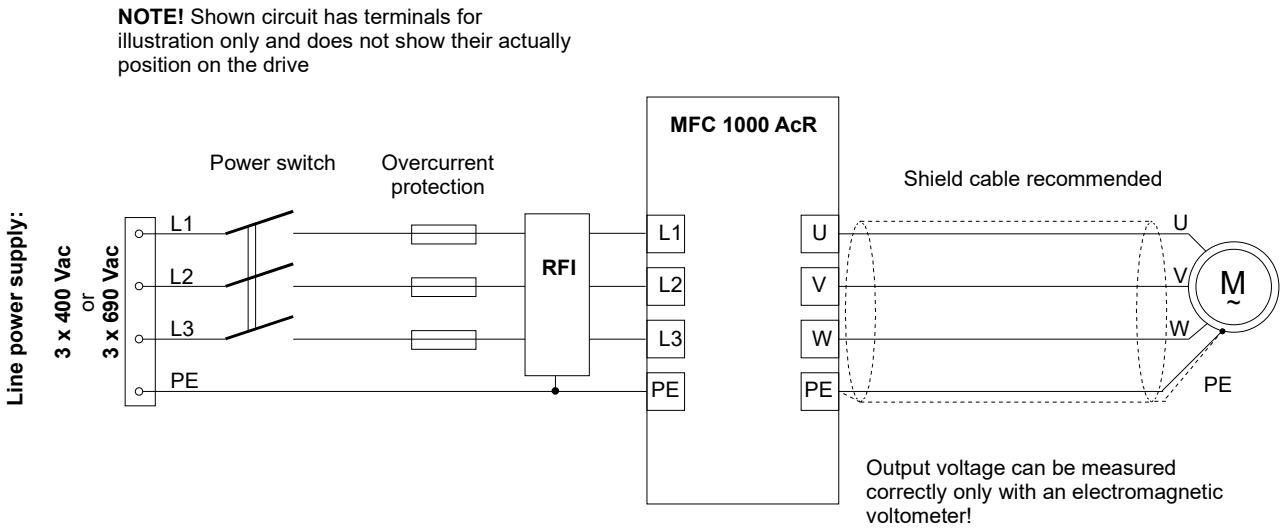

Fig. H.3.1. Example connections of the power circuit

H.3.4. Using contactors between the frequency converter and the motor

If it is necessary to use contactors between the drive and the motor, make sure to switch the contactor when there is no voltage on the output terminals and the drive is stopped (STOP status). Otherwise, there is a high probability of damage to the drive.

CAUTION: just issuing the STOP command is not enough, because there is a possibility of programmatic delay of the reaction to the STOP command (par. 13.20) and the possibility of setting the ramp stop (par. 11.20). For this reason, in order to avoid damage, it is necessary to check the operation status of the converter (PCH514), e.g. by using one of the relays output K.

H.3.5 Connection of control circuits

Figure H. 3.2. shows the control electronics board used in the converter.

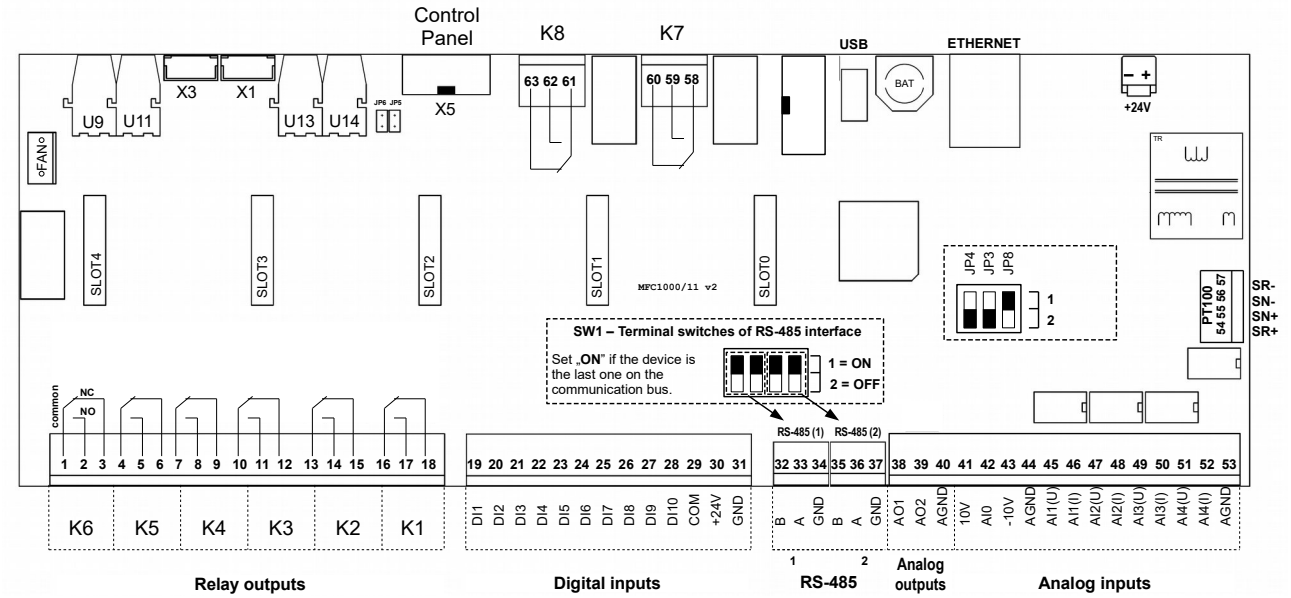

Fig. H.3.2. MFC1000/11 board - the placement of the main elements: analog / digital inputs / outputs, configuration switches and fiber optic connections

Note: The JP8 micro switch is used only for device diagnostics. During normal operation should be set to position 1.

Table H.3.1 – Description of the connections used by a user

K1[16-18] - K6[1-3]	Digital relay outputs
DI1[19] - DI10[28]	To trigger the digital inputs, use the output voltage of 24V DC [30] or external voltage
+24 V [30]	Internal power supply for digital inputs (max. 200mA)
GND [31]	The GND potential for digital inputs
B[32], A[33], B[35], A[36]	RS-485 communication
GND [34], [37]	The GND potential for RS-485
AO1[38], AO2[39]	Analog outputs
+10V [41], -10V [43]	+/- 10V DC voltage (max. 20mA)
AGND [40], [44], [53]	The GND potential for analogue inputs / outputs
AI1(U)[45] - AI4(I)[52]	Analog inputs

Digital inputs can work in two variants: common ground or common + 24V. The choice of the variant is made by shortening the clamps on the terminal block:

- variant 1 - common mass: COM - GND terminals
- variant 2 - common + 24V: COM terminals - + 24V

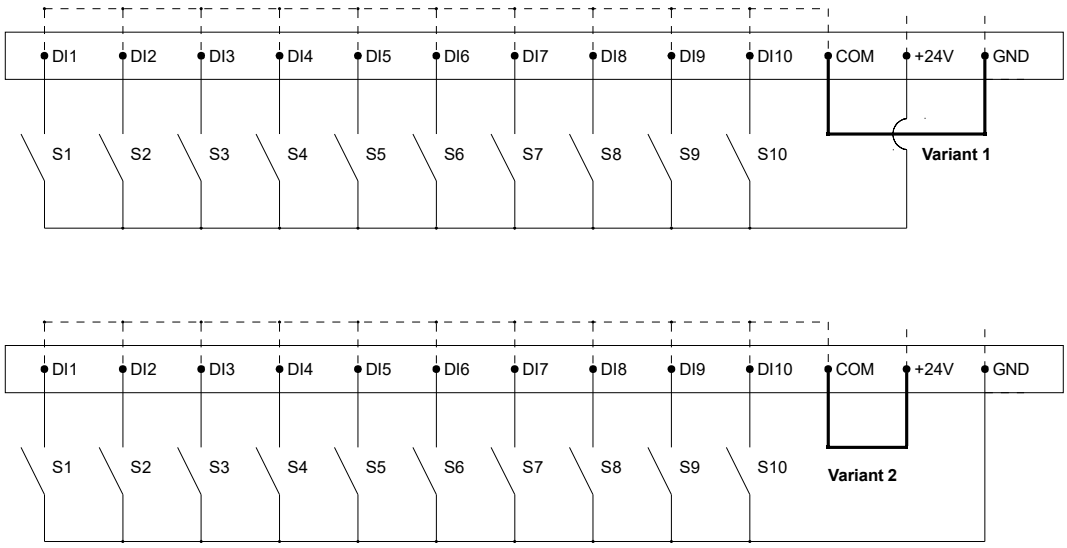

Fig. 3.3: Two variants of using digital inputs: variant 1 and 2.
he internal connections of the board are marked by a dashed line.
S1 ÷ S10: exemplary connectors to switch on/off the digital inputs.

H.3.6. Expansion cards

Expansion cards enable extending the drive with additional inputs / outputs. There are 5 slots available: 0 ÷ 4. In each of them, one expansion card can be installed. Expansion boards are available:

- 6 digital inputs,
- 6 digital outputs,
- 3 relay outputs,
- 2 analog outputs,
- CAN,
- ProfiBus.

Examples of the use of extension cards are shown in Fig. 3.4.

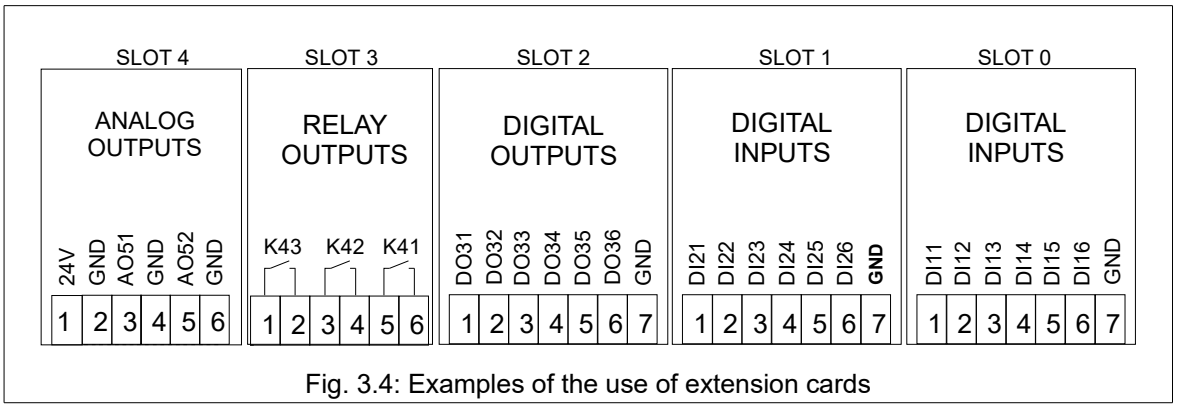

Fig. 3.4: Examples of the use of extension cards

Note: communication cards should be placed in slot 0.

SLOT0			
Digital Inputs expansion card	Digital Outputs expansion card	Relays expansion card	Analog Outputs expansion card
DI11	DO11	K13	AO11
DI12	DO12	K12	AO12
DI13	DO13	K11	xxx
DI14	DO14	xxx	xxx
DI15	DO15	xxx	xxx
DI16	DO16	xxx	xxx

SLOT1			
Digital Inputs expansion card	Digital Outputs expansion card	Relays expansion card	Analog Outputs expansion card
DI21	DO21	K23	AO21
DI22	DO22	K22	AO22
DI23	DO23	K21	xxx
DI24	DO24	xxx	xxx
DI25	DO25	xxx	xxx
DI26	DO26	xxx	xxx

SLOT2			
Digital Inputs expansion card	Digital Outputs expansion card	Relays expansion card	Analog Outputs expansion card
DI31	DO31	K33	AO31
DI32	DO32	K32	AO32
DI33	DO33	K31	xxx
DI34	DO34	xxx	xxx
DI35	DO35	xxx	xxx
DI36	DO36	xxx	xxx

SLOT3			
Digital Inputs expansion card	Digital Outputs expansion card	Relays expansion card	Analog Outputs expansion card
DI41	DO41	K43	AO41
DI42	DO42	K42	AO42
DI43	DO43	K41	xxx
DI44	DO44	xxx	xxx
DI45	DO45	xxx	xxx
DI46	DO46	xxx	xxx

SLOT4			
Digital Inputs expansion card	Digital Outputs expansion card	Relays expansion card	Analog Outputs expansion card
DI51	DO51	K53	AO51
DI52	DO52	K52	AO52
DI53	DO53	K51	xxx
DI54	DO54	xxx	xxx
DI55	DO55	xxx	xxx
DI56	DO56	xxx	xxx

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