AGEON
Electronic Controls

Technical guide

AG DRIVE

FREQUENCY INVERTERS

AG Drive Mini

XF2-05-1P1 | XF2-10-1P1

Summary

Chapter 1 – Quick start

1.1 Parameters list

Param.	Function	Range of values	Factory default value	Reg. Modbus
P001	Output frequency visualization	0,00 to 500.0 Hz	-	0
P002	DC bus voltage visualization	0 to 400 V	-	1
P003	Output current visualization	0 to 15.0 A	-	2
P004	Output voltage visualization	0 to 400 V	-	3
P005	IGBT module temperature visualization	0 to 100 °C (Models that do not have temperature measurement will display "--------")	-	4
P006	Visualization of the last 5 errors occurred	E002 to E009	-	5
P007	Parameter to block changes	28 = inverter unblock/block	0	6
P008	Parameter to redefine to factory default	103 = redefine to factory default	-	7
P009	Inverter software visualization			8
P010	Ramp stop/direct stop	0 = ramp-down stop; 1 = Direct stop	0	9
P011	Ramp-up time	0,1 to 600.0 s	10.0 s	10
P012	Ramp-down time	0.1 to 600.0 s	10.0 s	11
P021	Frequency backup	0 = backup disabled 1 = enabled: uses the last reference. 2 = uses the reference set in **P022**.	1	12

P022	Start-up frequency	P023 to P024	5.00 Hz	13
P023	Motor frequency low limit	0.00 Hz to P024	5.00 Hz	14
P024	Motor frequency high limit	P023 to 500.0 Hz	60.00 Hz	15
P028	Standard display unit	0 = frequency 1 = ampere 2 = RPM	0	16
P041	Torque Boost	0 to 9 %	0 %	17
P043	Switching frequency	5 kHz to 15 kHz	10 kHz	18
P051	Overload current	XF2-05 = 0 to 3.4 A XF2-10 = 0 to 5.2 A	XF2-05 = 3.4A XF2-10 = 5.2A	19
P053	Auto-reset	oFF or 3 to 255 s	oFF	20
P054	Lower limit for DC bus voltage	100 to 200 V	180 V	21
P100	Analog Input Gain Control	0.1 to 999.0	100.0	22
P201	Multi-step speed 1	P23 to P24	5.00 Hz	23
P202	Multi-step speed 2	P23 to P24	5.00 Hz	24
P203	Multi-step speed 3	P23 to P24	5.00 Hz	25
P204	Multi-step speed 4	P23 to P24	5.00 Hz	26
P301	Inverter output frequency setting	0 = analog input reference 1 = HIM keyboard reference 2 = increment/decrement speed via digital signal 3 = multi-step speed function reference 4 = Modbus	1	27

P302	Inverter command mode selection	0 = HIM keyboard command 1 = digital inputs command: • DI 1 = start/stop • DI 2 = rotation direction 2 = digital inputs command: • DI 1 = forward • DI 2 = backward 3 = Modbus command.	0	28
P303	Rotation direction	0 = standard direction 1 = reverse direction. 2 = defined by digital command	2	29
P304	DI2 digital input function	0 = P302 1 = P301 2 = enables overall operation	0	30
P305	Selection of logic levels for digital inputs	0 = Inputs NO 1 = Inputs NC	0	31
P602	Motor rated frequency	10.00 to 500.0 Hz	60.00 Hz	32
P603	Motor rated rotation	0 to 9999 rpm	0	33
P701	Address	1 to 247 or iHre	iHre (remote HMI)	34
P702	Baud rate	0 = 9,600 bps 1 = 19,200 bps 2 = 38,400 bps 3 = 115,200 bps	0	35
P703	Parity	oFF = none 1 = even 2 = odd	oFF	36
P704	Watchdog	0.0 to 100.0 s	oFF	37

Table 1 – Parameters table.

1.2 Understanding the Human Machine Interface (HMI)

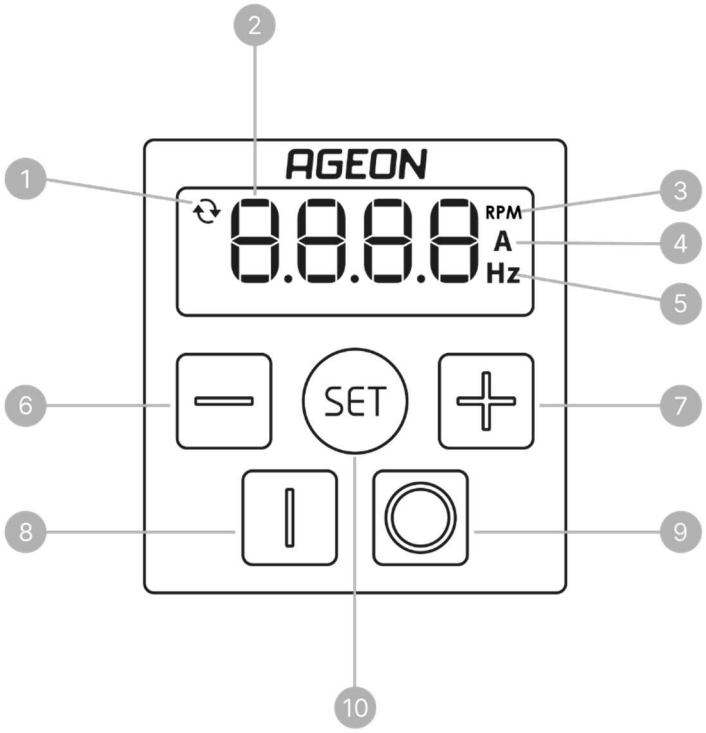


Figure 1 – Human Machine Interface (HMI)

Number	Name	Function
1	When this LED is on, it indicates a reversal in the rotation direction.	
2	HIM display.	
3	Indicates that the values displayed are in revolutions per minute.	
4	Indicates that the values displayed are in Ampere.	
5	Indicates that the values displayed are in hertz.	
6	**key " - "**	Key used to decrement values.
7	**key " + "**	Key used to increment values.
8	**key "ON"**	Starts the motor if P302 = 0. When pressed, it alters the motor rotation direction.
9	**key "OFF"**	Stops the motor if P302 = 0.
10	**key "SET"**	Used to enter/exit parameters listing.

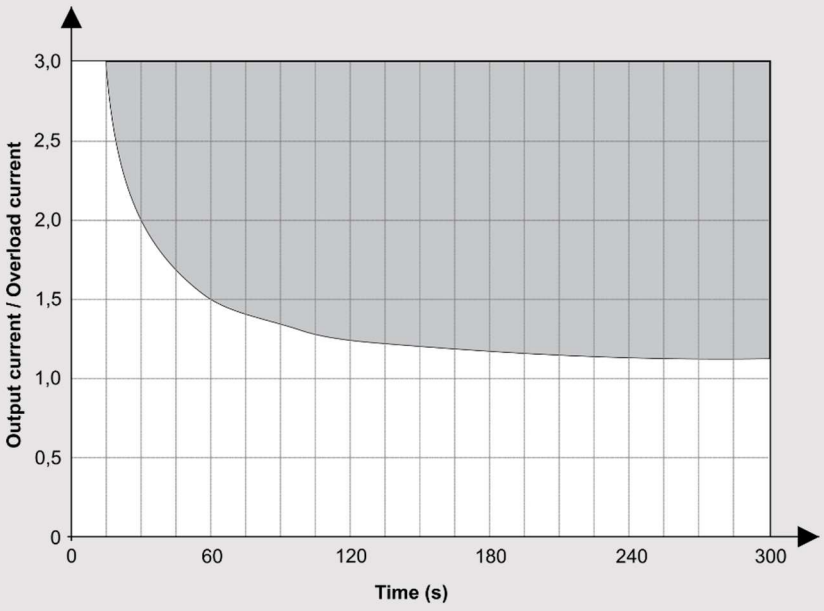
1.3 HIM messages

Operation messages

Message	Description

Rdy	This indicates that the inverter is ready to operate. In this state, the motor is awaiting a start command.
Sub	This indicates that the input voltage is insufficient to operate the motor.
Stop	This indicates that the inverter has been disabled via the DI2 digital input. For additional details, refer to the **P304** parameter description.

Error message

Message	Description
E002 – DC bus overvoltage	This error occurs when the DC bus voltage exceeds the safe operational threshold.
E003 – DC bus undervoltage	This error occurs when the DC bus voltage falls below the minimum operational threshold.
E004 – Overtemperature	This error occurs when the IGBT module reaches the maximum operational temperature threshold.
E005 - Overload	This error occurs when the output current (P003) exeeds the threshold defined in P051. The overload protection acting time and the subsequent triggering of this error follow the curve shown in the graphic below.  Figure 2 – Overload curve.
E006 – Hardware overcurrent	This error occurs when a sudden increase in current value is detected within a very short period, it is considered a short-circuit current.

E007 – Hardware failure	If you encounter this error message on your device, please reach out to AGEON technical support for assistance.
E009 – Communication failure with remote HMI or Modbus	This error occurs if no valid Modbus message is received within the watchdog time duration (P704) or in case of communication loss with the Remote HMI.

Chapter 2 – Safety instructions

2.1 Safety symbols

DANGER!

This warning symbol indicates the presence of dangerous voltage. This symbol informs you of high voltage conditions, situations, and locations that may cause death or serious injury if you do not follow precautions and proper steps.

WARNING

This warning symbol indicates a general caution for various electrical conditions that may pose a risk of death, injury, or equipment damage.

CAUTION!

The device contains components which can be destroyed by electrostatic discharge. These components can be easily destroyed if not carefully handled.

NOTE

Indicates important information.

2.2 Safety precautions

DANGER!

When in operation, this device can cause electric shock if handled incorrectly. Not following these recommendations may result in death, injuries, or damage to the equipment.

- The installation and maintenance of the inverter must be performed by a professional qualified for this task;
- Prior to installing or performing maintenance on the inverter, ensure that it is de-energized;
- During installation, ensure the protection of other live parts;
- Ensure proper grounding of the inverter power supply and output circuits according to local and international normatives;
- Make sure to adhere to standards for local and international electrical installations and workplace safety normatives;
- Be cautious against unintentional device initialization. Always power off the inverter before making any parameter changes and ensure that the output cannot be enabled remotely during programming;
- Enable the auto-reset option only after ensuring the entire process operates safely;
- Never attempt to alter the power terminals or motor connection during operation. Even after de-energizing, these terminals still pose a risk of electric shock;
- This device contains capacitors that remain energized even after the device is turned off. Wait at least 5 minutes after switching off before handling the device;
- For any voltage or current measurement on any inverter external component, ensure that the instrument belongs to the appropriate class for the procedure;
- Read and adhere to any additional guidance provided in this manual in subsequent sections, as well as the consulted standards.

NOTE

This device is a source of electromagnetic emissions; therefore, the following information must be taken into consideration:

- **Whenever possible, use shielded power cables with grounded shielding.**
- **Keep other equipment and devices with low electromagnetic immunity away from the inverter, motor, or adequately protected.**

WARNING!

This device should not be used as an emergency stop equipment. It must be adapted to local and international standard using the recommended means, meeting the requirements for this purpose.

WARNING!

This device controls rotating machinery that may be coupled to other equipments. Failure to adhere to the following recommendations may result in death, injury, or damage to the equipment.

- Ensure the inverter is free from any damage before its initial operation;
- Be cautious of hot surfaces. The inverter includes a heat sink that retains high temperatures even after the device is powered off;
- Do not operate the inverter outside the panel. It is recommended that any maintenance requiring the removal of the product from the panel is performed by qualified technical professionals;
- Before adjusting and operating the inverter, ensure that the motor and other rotating machines intended to be driven can operate safely within the limits of the device;
- Ensure the presence of safety circuits compliant with local and international normatives, and their functionality has been validated;
- Read and adhere to any additional guidance provided in this manual in subsequent sections.

NOTE

Use cables and connectors compatible with the installed power and in accordance with local regulations.

DANGER!

The inverter and the motor must be properly grounded for the safety of the user and other equipments. Failing to comply with the following guidelines may result in death or serious injuries and can cause irreversible failure to the motor, inverter, and other equipments.

- The grounding of the inverter must adhere to both local and international current technical standards;
- The grounding terminal of the inverter and the motor must be connected to the local equipotentialization bus;
- Each inverter and motor will have its exclusive conductor;
- The motor grounding must be connected to the motor grounding terminal on the inverter.

NOTE

For shielded signal and control cables, one end should be connected to the equipotential bonding bar, and the other end should be isolated to prevent grounding loops.

CAUTION!

This device contains Printed Circuit Boards (PCBs) that are sensitive to electrostatic discharge. Do not remove the cabinet or handle the PCBs. Ensure that no other device installed near the inverter is a source of electrostatic discharge.

2.4 Failure sollutions

Each error displayed in the error message list may have one or more causes that need to be resolved for the correct operation of the inverter.

DANGER!

If there is any uncertainty in resolving errors generated during operation, please contact AGEON technical support.

Possible solutions for some problems that generate the error messages presented earlier are provided in the Table 2 bellow.

Error	Cause	Possible sollutions
E002	DC bus overvoltage	- Verify the input voltage of the inverter and ensure the power supply is appropriate; - Adjust the power supply to meet the inverter requirements. The power line voltage should be between 200 Vac and 240 Vac for an efficient inverter operation; - Increase ramp-down time; - If the error persists, contact AGEON technical support.
E003	DC bus undervoltage	- Verify the input voltage of the inverter and ensure the power supply is appropriate; - Adjust the power supply to meet the inverter requirements. The power line voltage should be between 200 Vac and 240 Vac for an efficient inverter operation; - If the error persists, contact AGEON technical support.
E004	Overtemperature	- Perform the cleaning of the heat sink; - Check if the installation ambient temperature complies with the inverter specifications; - Ensure that there is adequate ventilation in the installation ambient. - Ensure that the installation location has air filters, and those filters are clean; - Ensure that the installation follows the recommendations indicated in the section 'Installation'; - Ensure that the output power is in accordance with the inverter specifications; - If the error persists, contact AGEON technical support.

E005	Overload	- Ensure that the motor power is in accordance with the inverter specifications; - Verify if the value of **P051** is appropriate for the application; - Ensure that the shaft of the motor is not blocked; - Ensure that the load is suitable for the motor power; - If the error persists, contact AGEON technical support.
E006	Hardware overcurrent	- Ensure there is no short circuit between the motor supply phases; - Ensure that the shaft of the motor is not blocked; - Increase the ramp-up time; - Ensure that the motor power is in accordance with the inverter specifications; - Ensure that the load is suitable for the motor power; - If the error persists, contact AGEON technical support.
E007	Hardware failure	- Turn off the inverter, and after 5 minutes, turn it on again; - If the error persists, contact AGEON technical support.
E009	Communication failure with remote HMI or Modbus	- Ensure that there is a reliable connection between the inverter and the Modbus network master. If a Remote HMI is being used, ensure that **P701** = **iHre**. - Verify if all communication parameters are aligned with the master parameters. - Ensure the quality and integrity of the wiring used. - Make sure that the communication cables are properly distant from noise sources. - Check if the watchdog time value (**P704**) is suitable for the application. - If the error persists, contact AGEON technical support.

Table 2 - Solution to the errors displayed on the HMI.

DANGER!

The adaptation of the Power supply must be carried out by qualified and authorized professionals.

WARNING!

Never use compressed air equipments to clean the inverter. Never remove the heat sink. Use appropriate tools to clean the fins of the heat sink to ensure proper air circulation.

Chapter 3 – Installation and Assembly

WARNING!

The inverter must be installed in a suitable location and in accordance with safety standards. Failure to follow the recommendations below may result in irreversible failures to the inverter and/or drastically reduce the equipment's lifespan.

- The ambient temperature should be between 0 °C and 50 °C throughout the operation of the inverter;
- If the inverter is installed in a panel or cabinet, ensure there is sufficient air exhaust to keep the temperature within acceptable limits as described in the inverter specifications;
- Ensure that the installation location is clean, free of debris such as metal shavings or any other conductive material that may be drawn into the inverter air intake;
- Ensure that the installation location provides protection against liquids, corrosive gases, oil, sunlight, rain, excessive humidity (above inverter specifications) or sea spray;
- The installation ambient should not experience excessive vibration;
- This equipment cannot operate in explosive atmospheres or specific classified zones.

3.2 Mechanical installation

3.2.1 Dimensions

The product dimensions are presented in the Figure 3 below.

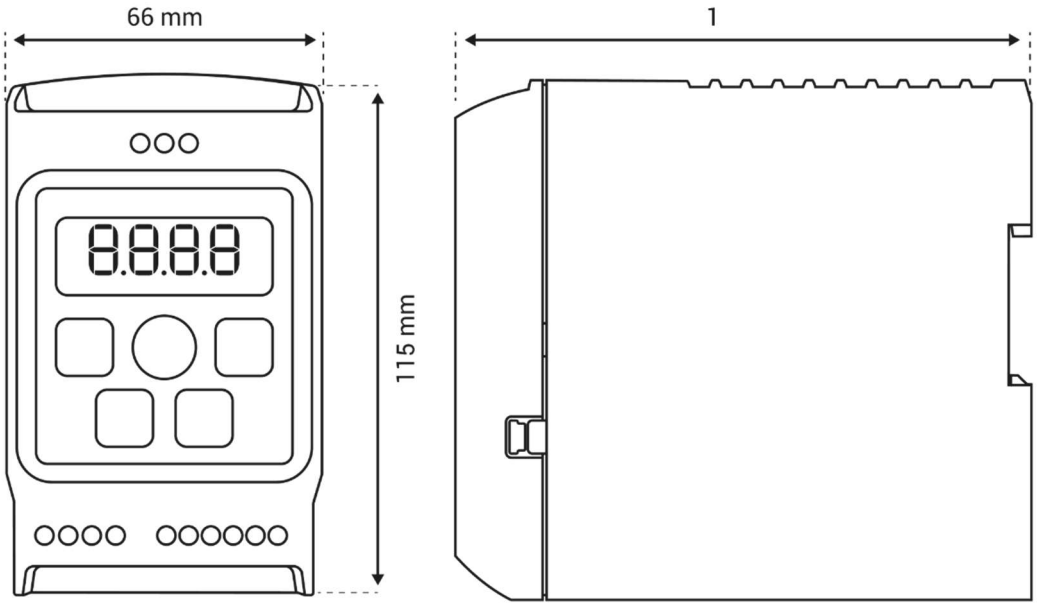


Figure 3 – Product dimensions.

3.2.2 Positioning and Drilling

It is possible to install the inverter using the mounting holes (Figure 4) or DIN-35 rail (Figure 5). The recommended mounting spacing from Figure 6 and Figure 7 must be respected. The installation should ensure that the inverter is securely fixed and that the air inputs and outputs are unobstructed.

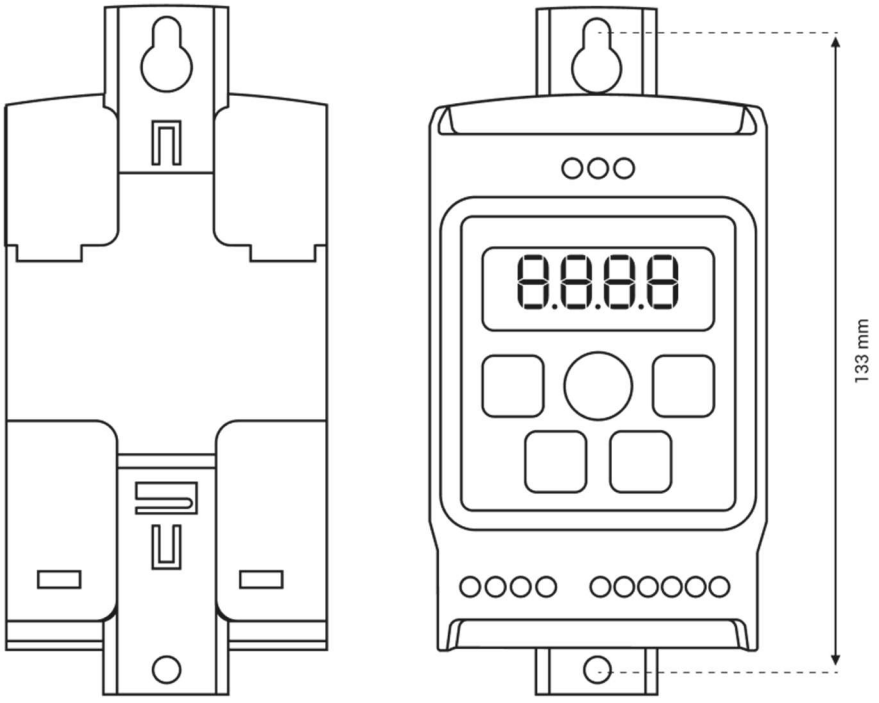


Figure 4 - Minimum dimensions for mechanical installation.

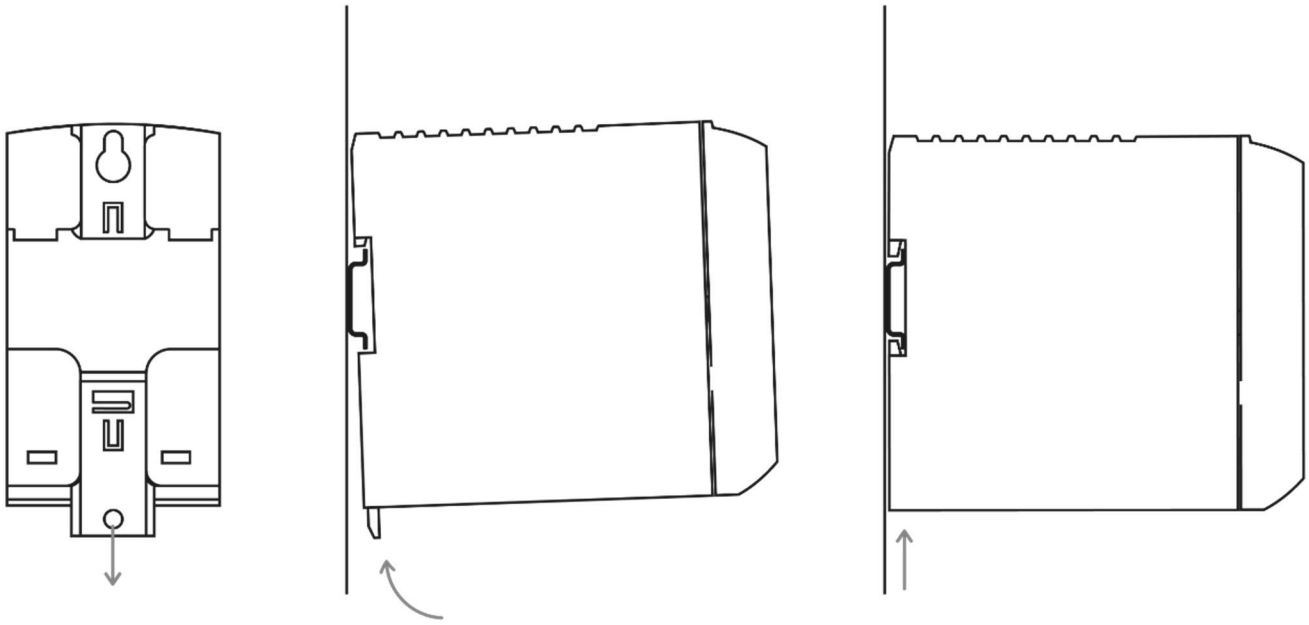


Figure 5 - Detail for Mounting on DIN-35 Rail.

NOTE

If the installation environment experiences excessive vibration, it is not recommended to use DIN rail fixation. Whenever possible, use the mounting holes with appropriate screws for securing the device.

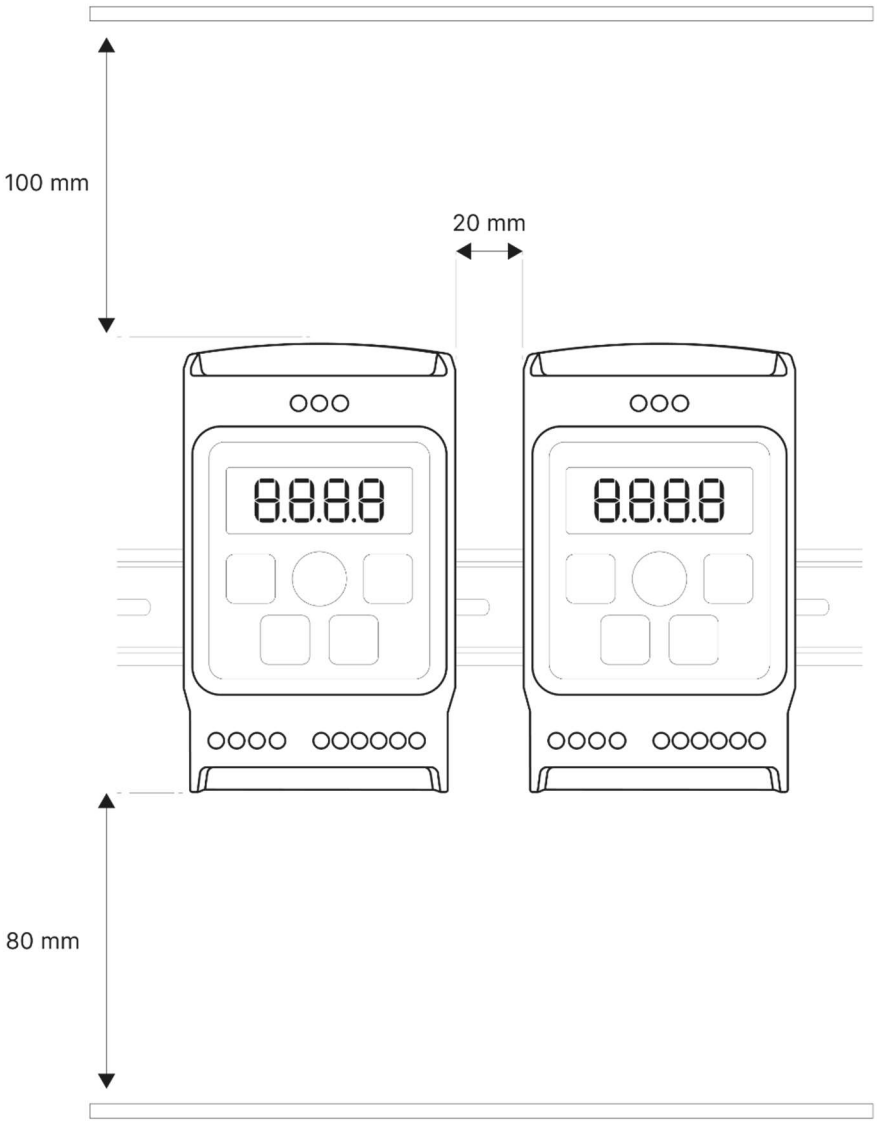


Figure 6 - Detail for DIN-35 lail mounting spacing.

WARNING!

Ensure the mounting dimensions as shown in figures. Risk of irreversible damage to the inverter due to overheating.

WARNING!

Never install inverters in a stacked configuration, meaning with horizontal spacing less than 20 mm, even if the vertical distance is greater than 80 mm. Risk of irreversible failure due to poor air circulation in the fins of the heat sinks.

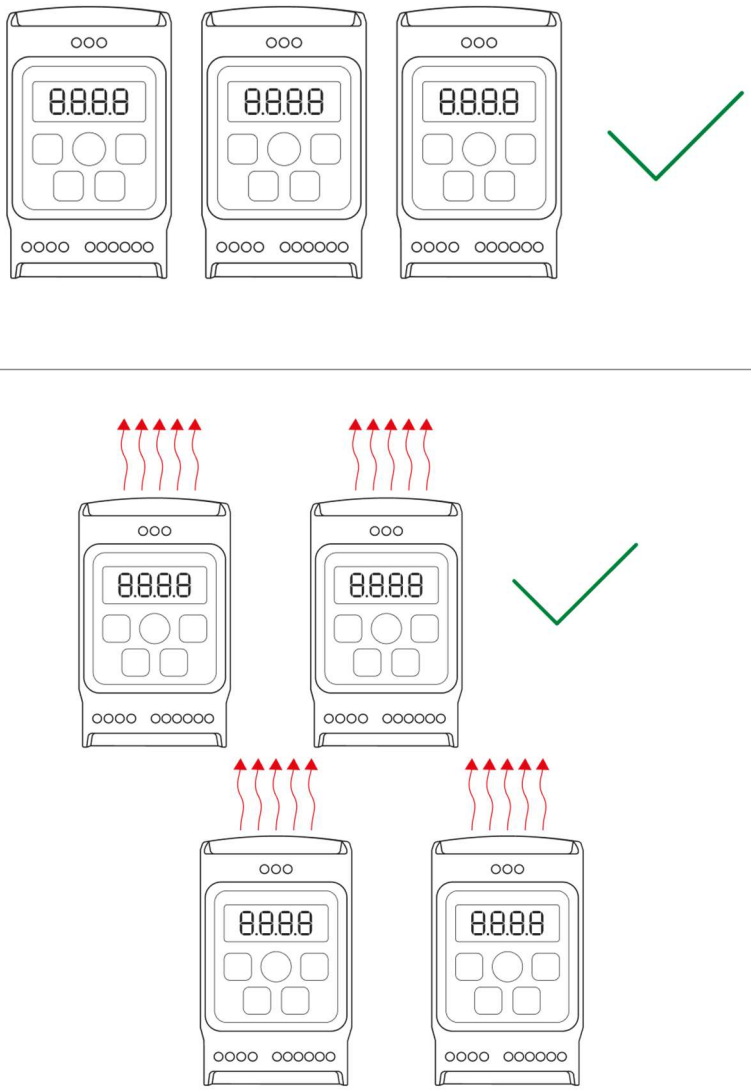


Figure 7 – Best practices for mechanical installation.

WARNING!

Avoid placing components that generate excessive heat near the inverter, even if the minimum distance is met. This contributes to more efficient equipment operation and reduces the risk of overheating.

3.3 Electrical installation

3.3.1 General aspects regarding electromagnetic compatibility.

- For the wiring, it is recommended to use shielded cable with a cross-section between 0.75 mm² and 1.5 mm² with a copper braid, where only one end of the shielding should be grounded. Figure 8 provides instructions on isolating the braid.

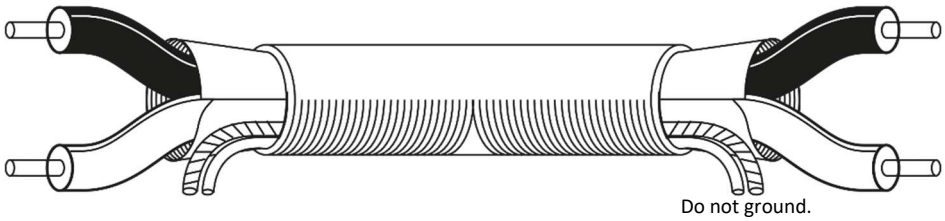


Figure 8 - Instructions on shielding Isolation.

- Contactors, coils, solenoids, and other inductive loads can generate interference in the inverter or control signals. Therefore, it is recommended to use noise filters, directly connected to the AC power supply of these loads. When the load is DC supplied, flyback diodes can be used, especially when connected to the inverter output relay.
- For communication and control, it is recommended to use suitable shielded cables with a copper braid.

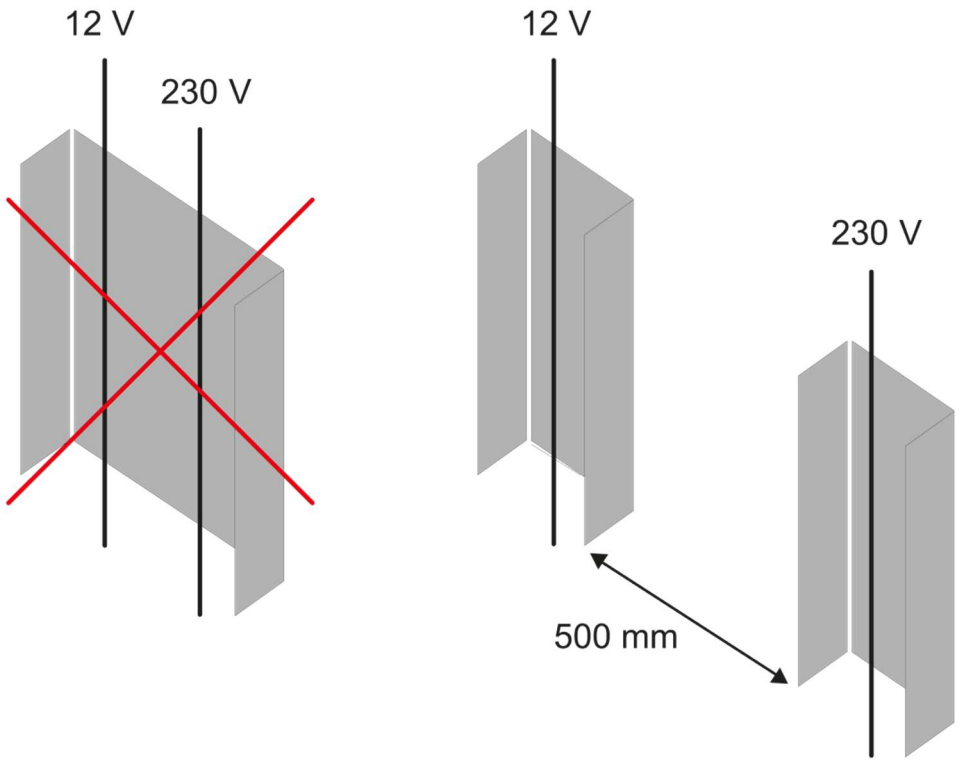


Figure 9 - Best practices for cable tray installation.

NOTE

Power cables should not run alongside control cables in cable trays or conduits unless the control cable has suitable insulation for this purpose.

When control cables lack appropriate insulation, place them in separate cable trays with a minimum distance of 500 mm, as shown in Figure 9.

When it's necessary to cross control cables with power cables, cross them perpendicularly (90 degrees).

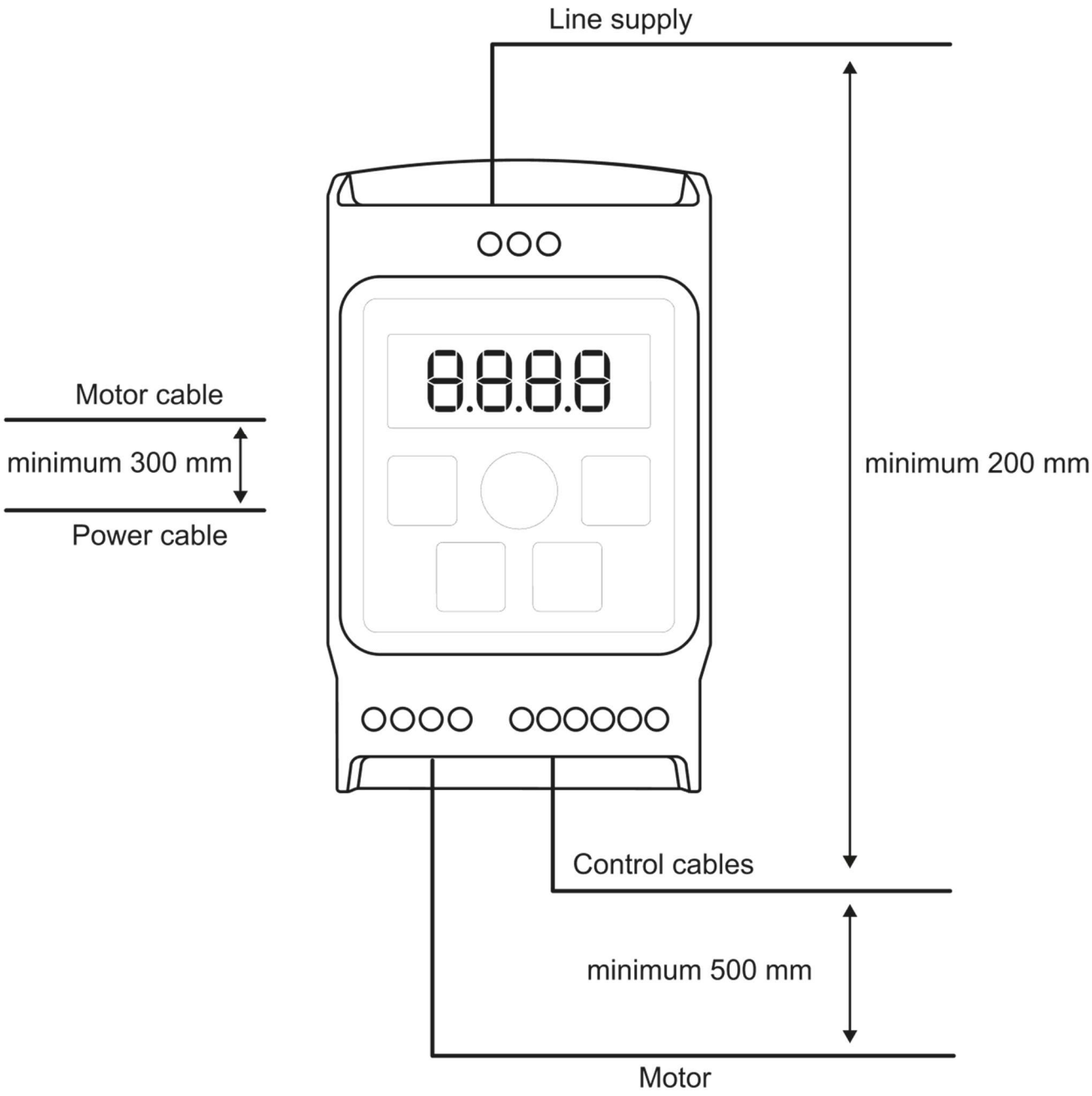


Figure 10 - Best Practices for Cable Routing.

- When power cables to supply the inverter and/or other equipment are installed in trays parallel to the motor cable tray, ensure a distance of at least 300 mm between them, as shown in Figure 10.

Figure 11 represents an installation that follows some guidelines according to best practices for electromagnetic compatibility.

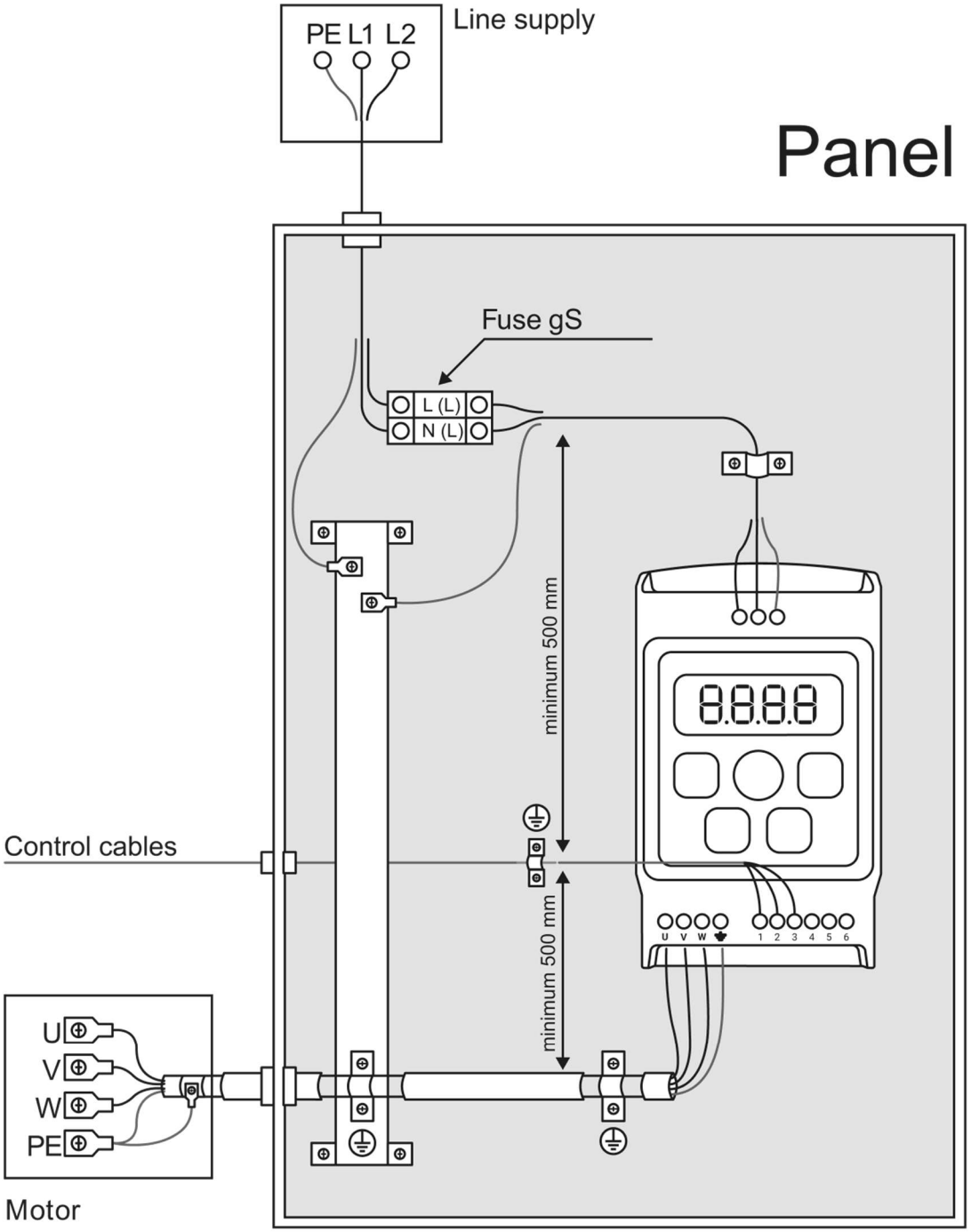


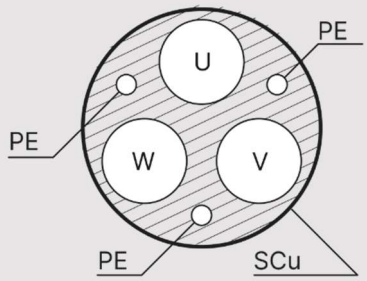
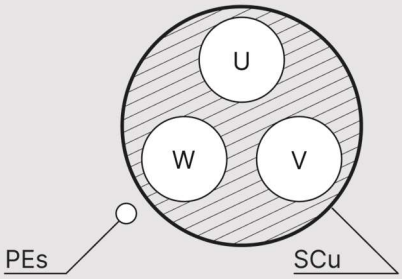
Figure 1 - Best practices for electrical panel installation.

3.3.2 Selection of power supply wiring

DANGER!

The wiring must be sized according to the current technical standards. The use of incorrectly sized and/or low-quality cables can result in death, injury, or irreversible damage to the equipment.

It is recommended to use specific multipolar cables for frequency inverter applications. The recommended cable has three symmetrical conductors for the phases, three symmetrical conductors for grounding (PE) and copper (SCu) or aluminum shielding. The same multipolar cable can be used for the driver power supply. The table below presents the recommended options for each situation in terms of EMC performance.

Figure	Description	Shielding	EMC performance
	Multipolar cable with 3 conductors + 3 symmetrical GND conductors.	Copper (Scu) ou aluminum	Excellent
	Multipolar cable with 3 symmetrical conductors. When the shielding is intended to act as a protective ground, it should have at least 50% of the conductivity of the phase conductors. If necessary, add a conductor for external grounding to the cable, or use the shielding solely as EMC protection	Copper (Scu) or aluminum	Reasonable

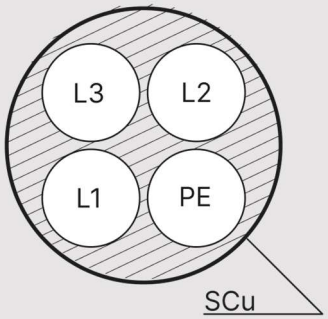
	When the conductors are smaller than 10 mm², as an alternative, you can use this model of cable.	Copper (Scu) or aluminum	Acceptable

Table 3 – Recommended cable options.

Legend:

U, V, W – Phase conductors	PE – Ground conductor	SCu – Copper shielding

3.3.3 Selection of digital and analog signal wiring.

The wiring should be sized according to current technical standards and the type of signal to be transmitted, taking into account signal attenuation. It is recommended to use copper-shielded cable in areas susceptible to low-frequency electromagnetic interference. For locations where the primary source of electromagnetic interference comes from high-frequency signals (RFI), shielded cables with a metalized polyester film should be used.

3.3.4 Identification of power terminals.

The power terminals of the inverter are indicated in Figure 12 (L1 and L2) which should be powered with 220 VAC. The terminal for grounding the equipment should be interconnected with the equipotentialization bus.

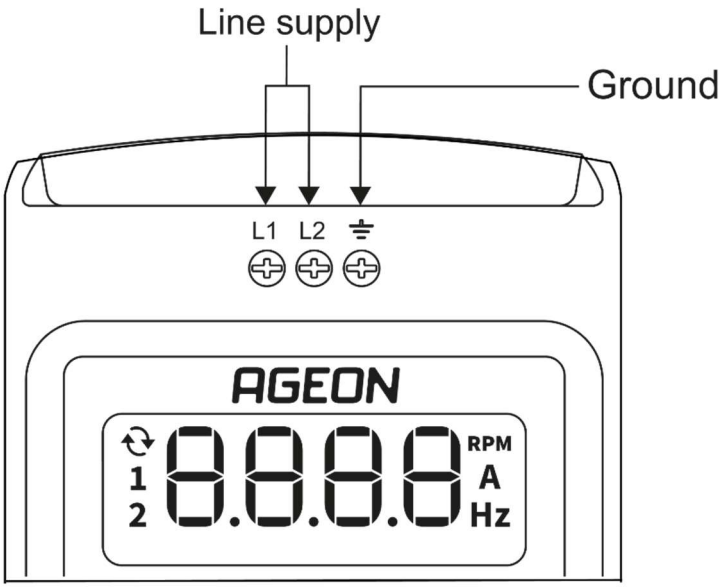


Figure 2 – Inverter power supply.

In Figure 13, it is shown the motor power terminals and the grounding terminal for the motor frame. The inverter output is 220 VAC (three-phase).

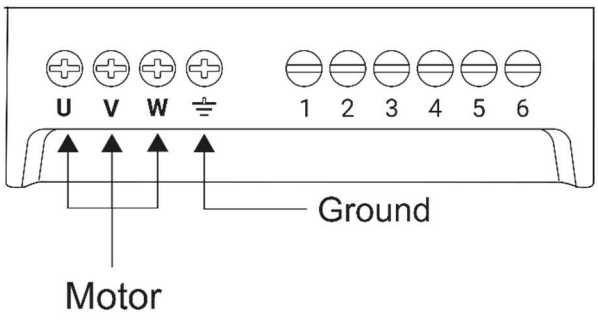
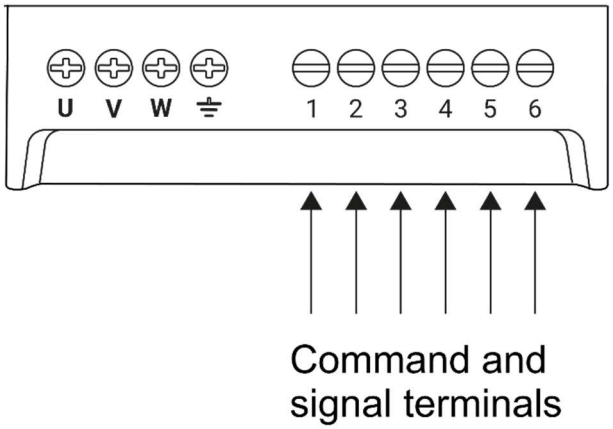


Figure 3 – Motor power supply

3.3.5 Identification of command terminals.



Command terminal number	Description
1	10V power supply, 25 mA capacity
2	Analog input for voltage or current.
3	Ground (reference point for electrical circuits).
4	Digital Input 1.
5	Digital Input 2.
6	Digital Input 3.

Figure 4 – Command and signal terminals.

3.3.6 Connections of command terminals.

Figure 14 is used to show the command and control terminals. Below, some possible ways to use these terminals are listed.

Digital inputs

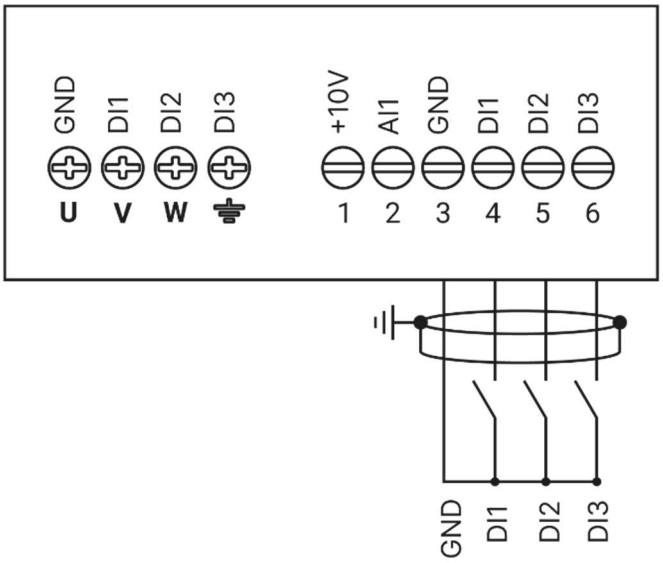


Figure 5 - Example of digital input connection.

Analog input with potentiometer connection

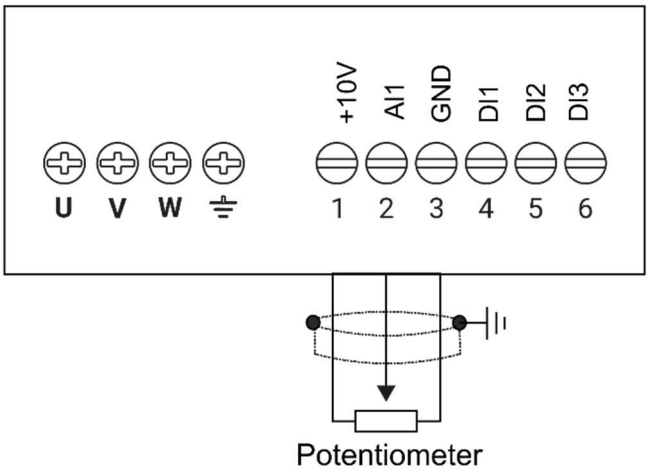


Figure 6 - Wiring diagram for potentiometer motor speed control.

Analog Input in voltage function with external electrically isolated device

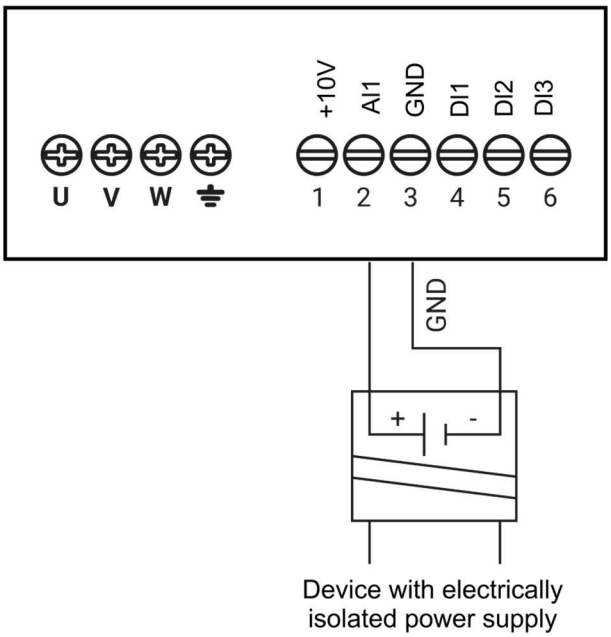


Figure 7 - Wiring diagram for external device via voltage signal (isolated).

Analog Input in voltage function with nonisolated external device

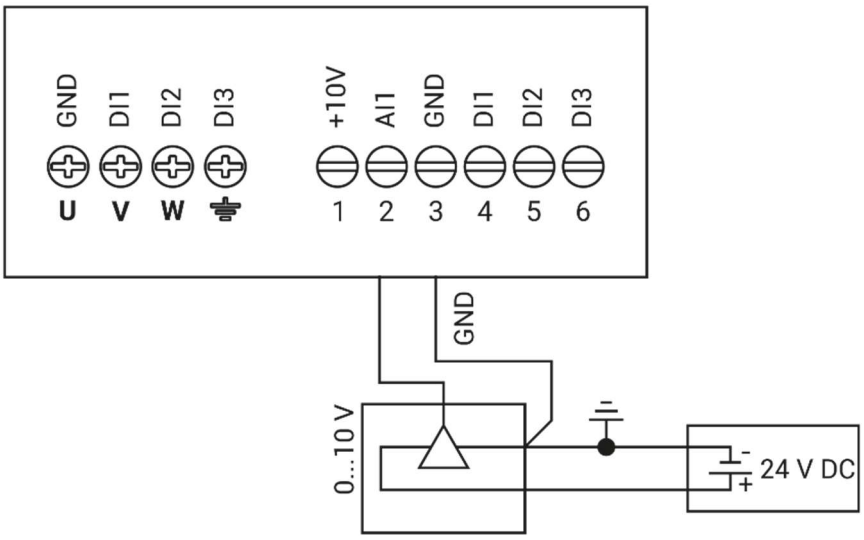


Figure 8 - Wiring diagram for external device via voltage signal (nonisolated).

WARNING!

Incorrect sizing of protection fuses and/or cable can cause irreversible damage to the equipment as well as the electrical installation. Properly size the fuses according to Table 4 and in accordance with current standards.

To protect the inverter output, an ultra-fast gR or gS type fuse, specifically designed for semiconductors protection, should be used with a current rating according to Table 3.

Inverter	Fuse [A]	Power supply wiring [mm²]	Ground wiring [mm²]
XF2-05	10	1,5	2,5
XF2-10	15	1,5	4

Table 4 – Sizing of protection fuses.

Chapter 4 – Parameters description

The inverter can be programmed by the HMI or via Modbus communication. To set up the inverter by the HMI, use the following keys.

- Enter the parameters screen by pressing the **SET** key and holding it for 5 s;
- Navigate through the parameters using the **+** and **–** keys;
- When the desired parameter appears on the display, press the **SET** key again to enter the parameter. The parameter value will blink on the display;
- Adjust the parameter using the **+** and **–** keys;
- To confirm the programmed value and exit the parameter, press the **SET** key again;
- To exit the parameter screen, press the **SET** key and hold it for 5 s or do not press any key for 10 s.

To program the inverter via Modbus communication, connect the network master to the inverter communication port and access the desired parameters through the respective registers indicated in Table 1. For more details on Modbus communication, refer to 'CHAPTER 5 - Modbus RTU Communication'.

WARNING!

The parameterization of the inverter must be carried out by a qualified professional. Ensure that the motor to be driven and all peripheral devices to be used comply with current standards and are in good working condition before commissioning the programming.

P001 - Output frequency visualization

Indicates the output frequency to the motor, in Hertz (Hz).

P002 - DC bus voltage visualization

Indicates the voltage in the DC bus, in Volts (V).

P003 - Output current visualization

Indicates the inverter output current to the motor, in Amperes (A).

P004 - Output voltage visualization

Indicates the inverter output voltage applied to the motor, in Volts (V).

P005 - IGBT module temperature visualization

Indicates the IGBT module temperature. If the temperature surpasses the protection threshold, it will trigger the E004 error.

P006 - Visualization of the last 5 errors occurred

This parameter indicates the last 5 errors that occurred in the inverter, which can be:

- E002 = Power supply overvoltage;
- E003 = Power supply undervoltage;
- E004 = Overtemperature;
- E005 = Overload error defined by P051 parameter;
- E006 = Hardware overcurrent;
- E007 = Hardware failure;
- E009 = Communication failure with remote HMI or Modbus.

For more detailed information, please refer to section ‘2.4 – Failure sollutions’.

P009 - Inverter software visualization

Indicates the software version installed in the inverter.

4.1 Writting parameters

P007 - Parameter to block changes

It is used to lock or unlock any change in the inverter parameters. When accessing the parameter P007, it can have the following values:

- 0 = Parameters unlocked, the user can modify the inverter parameters;
- 1 = Parameters locked, the user cannot modify the inverter parameters.

Enter the value **28** to lock or unlock changes in the inverter. To confirm the modification, exit the parameter configuration screen.

P008 - Parameter to redefine to factory default

To reset all inverter parameters to factory default, enter the value **103** to this parameter.

P010 - Ramp stop/direct stop

Determines whether the motor stop will be by ramp or direct, according to the values associated to this parameter:

- 0 = Ramped stop according to the time programmed in parameter **P012**;
- 1 = Direct stop, meaning the motor will stop based on the load inertia.

P011 - Ramp-up time

WARNING!

Acceleration and/or deceleration ramps that are too fast can cause overload on the inverter. Ensure that acceleration/deceleration times are suitable for the motor power and load.

Defines the time, in seconds, for the motor to accelerate to the nominal frequency set in parameter **P602**. This ramp will also be applied whenever there is an increase in the frequency reference. The acceleration has a linear profile (ramp) as shown in Figure 19. The acceleration time when reference changes will always be proportional to the time defined in **P011**. Example: If the nominal frequency is 60 Hz (**P602** = 60) and the acceleration ramp is 10 s (**P011** = 10), and you want to accelerate from 0 Hz to 30 Hz, the total acceleration time will be 5s.

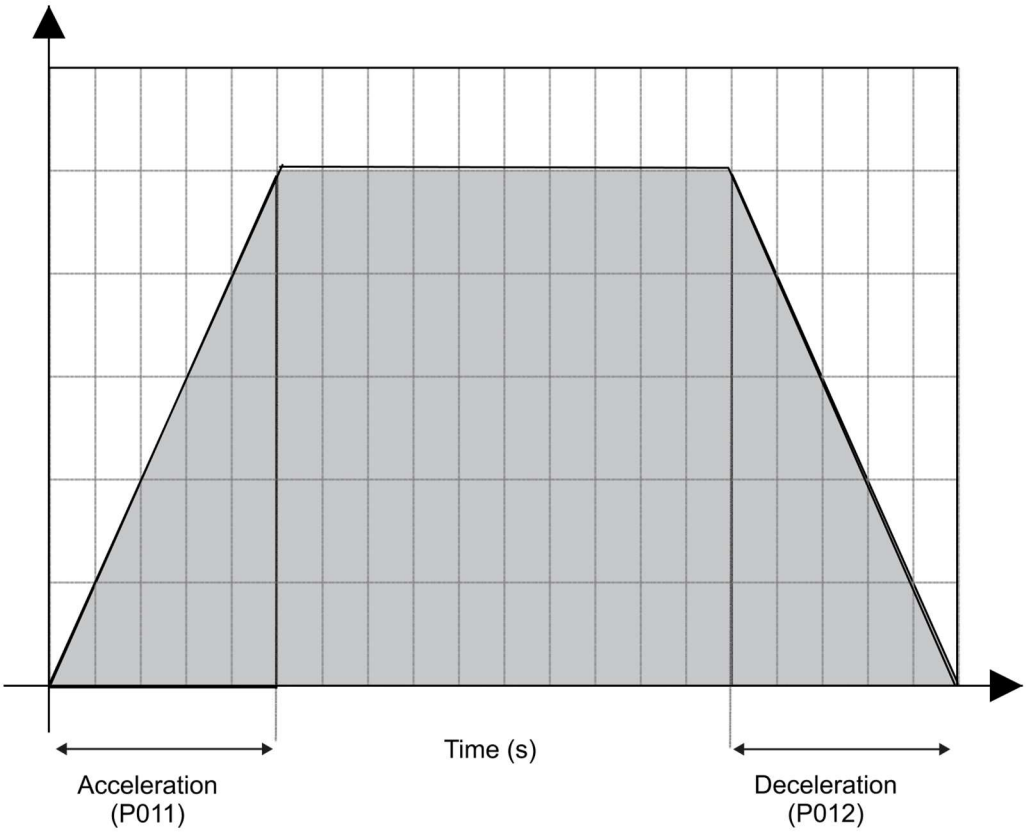


Figure 9 – Acceleration/Deceleration profile.

P012 - Ramp-down time

Defines the time, in seconds, for the motor to decelerate to 0 Hz. This ramp will also be applied whenever there is a decrease in the frequency reference. The deceleration has a linear profile (also show in Figure 19).

P021 - Frequency backup

Determines which frequency reference will be achieved at the startup.

- 0 = Backup disabled: when the output is activated, the motor will accelerate following the acceleration ramp defined in **P011** up to the minimum frequency programmed in **P023**;
- 1 = Backup enabled: when the output is activated, the motor will accelerate following the acceleration ramp defined in **P011** up to the frequency applied to the motor before the last output deactivation;

- 2 = When the output is activated, the motor will accelerate following the acceleration ramp defined in **P011** up to the frequency defined in **P022**.

P022 - Start-up Frequency

If **P021** = 2, after activation, the motor will accelerate following the acceleration ramp defined in **P011** up to the frequency defined in this parameter.

P023 - Motor speed low limit

Defines a minimum limit for the frequency reference. Example: If **P023** = 45 and **P024** = 65, the user cannot set an output frequency lower than 45 Hz or higher than 65 Hz.

P024 - Motor speed high limit

Defines a maximum limit for the frequency reference. Example: If **P023** = 45 and **P024** = 65, the user cannot set an output frequency lower than 45 Hz or higher than 65 Hz.

P028 - Selection of the default unit on the display.

The display allows presenting values in Hertz, Ampere, or RPM. In this parameter, the user defines which one of these will be displayed when the inverter initializes:

- 0 - The inverter, when activated, will show the motor frequency in Hertz (Hz) on the display.
- 1 - The inverter, when activated, will show the motor current in Ampere (A) on the display.
- 2 - The inverter, when activated, will show the motor speed in revolutions per minute (RMP) on the display.

For example, if the value is set to 2, whenever the inverter is powered, the value in RPM will be displayed. If manually changed to Ampere by pressing the **SET** key, it will remain in that mode until the user changes it again or, if the equipment is turned off, it will return to RPM when powered back on.

P041 - Torque Boost

If the load to be driven by the motor has high inertia, the user can apply, through this parameter, an increase in the output voltage at low frequencies, called torque boost, torque compensation or torque enhancement. This parameter is especially useful for driving motors with high inertia loads at low speeds.

Note: Increase the value of this parameter only if necessary, as the increase in motor voltage is directly proportional to the increase in its temperature.

P043 - Switching Frequency

This parameter allows you to configure the switching frequency of the IGBTs. For optimal configuration of this parameter, consider the factors described in Table 5.

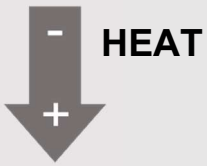
P43	Motor	IGBT temperature
5 kHz		
10 kHz		
15 kHz		

Table 5 - Relationship between switching frequency and acoustic noise/temperature.

- The higher the switching frequency, the greater the heating of the IGBTs/heat sink and the lower the acoustic noise emitted by the motor;
- The lower the switching frequency, the lower the heating of the IGBTs/heat sink and the higher the acoustic noise emitted by the motor.

P051 - Overload current

It defines the motor overload current, taking into account the rated current and service factor indicated by the motor manufacturer. If the current value of this parameter is reached or exceeded, the inverter will trigger the **E005** error.

The actuation of the motor overload protection follows the curve presented in Figure 20. The higher the value of the ratio between the output current and the value of **P051**, the shorter the activation time of the protection.

Example: Suppose the motor to be driven has a nominal current of 2.8 A at 220 V and a service factor of 1.15. Therefore, a safe value for **P051** would be 3.2 A (2.8 x 1.15). Now, suppose that at a certain operating point, the load driven by the motor results in a current of 5 A. According to the overload curve, if the current remains at 5 A, in approximately 45 s, the inverter output will be disabled, generating error **E005**, protecting the motor. Note: The nominal current is usually expressed on the motor plate as "Inom","In or “Amps”. The service factor is often expressed as "Fs." or “S.F.”. If you can’t find any service factor on the manufacturer motor plate, it would be prudent to use the value **1**.

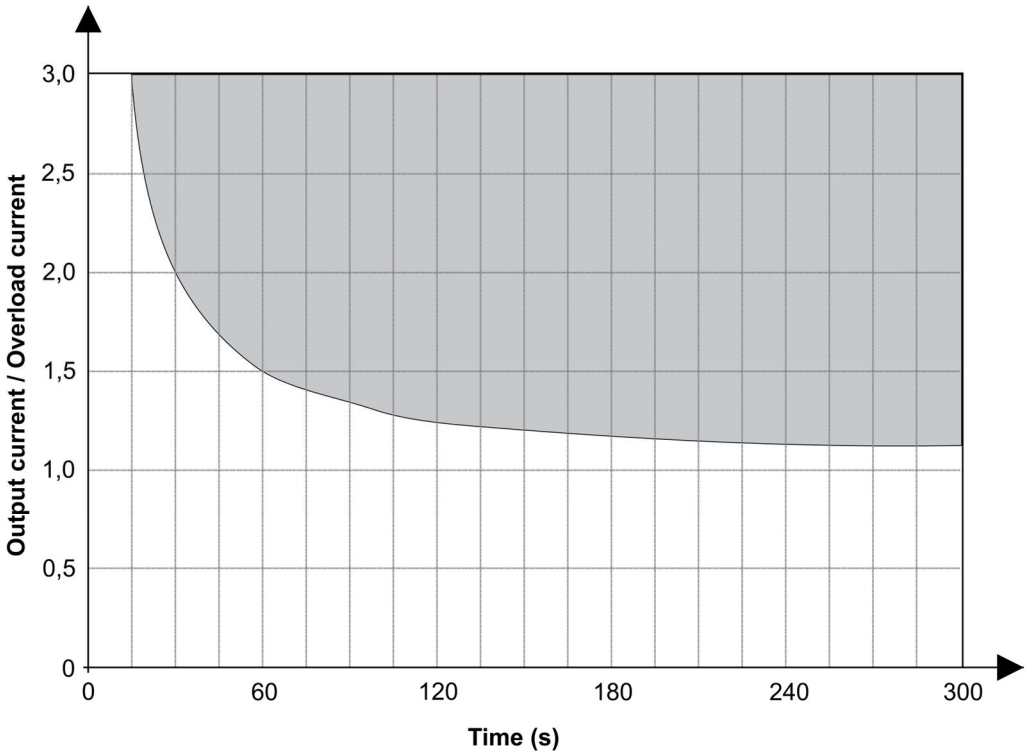


Figure 20 – Overload curve.

This parameter can be deactivated, in which case the motor would no longer have overcurrent protection. However, the inverter continues to protect against hardware short-circuit (**E006**) and overtemperature (**E004**).

P053 - Auto-reset

A time (3 to 255 seconds) can be set, after the error, during which the inverter will automatically restart. The inverter returns to the ready state after the time specified in this parameter if the error condition does not persist.

P054 - Lower Limit for DC Bus Voltage

It defines the minimum voltage of the DC bus that the inverter will generate the **E003** error. Example: If **P54** = **190**, and the voltage on the DC bus is lower than 190 Vdc, the inverter will turn off the motor and trigger the **E003** error.

P100 - Analog Input Gain Control

In this parameter, the user can apply a gain to the analog input. The gain is applied according to the equation below:

$$AI' = \frac{AI\ x\ G}{100}$$

Where:

- **AI**' is the internal value effectively used by the inverter;
- **AI** is the external value, i.e., the actual value read at the analog input;
- **G** is the value of **P100.**

Example: If the gain is 50% (P100 = 50.0), and the amplitude of the signal at the input is 5.0 V (AI = 5.0 V), the final voltage for the frequency reference will be 2.5 V (AI' = 2.5 V).

P201 - Multi-step speed 1

Frequency reference 1 for multi-step speed control. See parameter **P301**.

P202 - Multi-step speed 2

Frequency reference 2 for multi-step speed control. See parameter **P301**.

P203 - Multi-step speed 3

Frequency reference 3 for multi-step speed control. See parameter **P301**.

P204 - Multi-step speed 4

Frequency reference 4 for multi-step speed control. See parameter **P301**.

P301 - Inverter output frequency setting

P301 Value	Reference type
0	**Analog input:** see parameter **P100**. The frequency reference will be proportional to the reading value of the analog input within the limits of **P023** and **P024**.
1	**HMI Keyboard:** the frequency reference is adjusted using the HMI keys. During operation, to increase the reference frequency, press and hold the **"+" key**. To decrease it, press and hold the **"-" key**. A single touch on the keys increments/decrements the frequency by 0.1 Hz.

<table>
<tr><td>2</td><td>Electronic Potentiometer (digital inputs DI2 and DI3): while the state of DI2 is high, the output frequency is continuously increased. Similarly, while the state of DI3 is high, the output frequency is continuously decreased. If the inputs are in a low state, the frequency remains unchanged. For the configuration of digital inputs, refer to parameter P305.</td></tr>
<tr><td>3</td><td>Multi-step speed: the multispeed control allows the speed to be varied for predetermined values according to the states of the digital inputs DI2 and DI3. These values are programmed in parameters P201 to P204. The speed configuration is according to the following table:
<table>
<tr><th>DI2</th><th>DI3</th><th>REFERENCE VALUE</th></tr>
<tr><td>0</td><td>0</td><td>Value defined in P201</td></tr>
<tr><td>0</td><td>1</td><td>Value defined in P202</td></tr>
<tr><td>1</td><td>0</td><td>Value defined in P203</td></tr>
<tr><td>1</td><td>1</td><td>Value defined in P204</td></tr>
</table>
To set the digital inputs, refer to parameter P305.</td></tr>
<tr><td>4</td><td>Modbus: the frequency reference value comes from Modbus communication. See Chapter 5.</td></tr>
</table>

Table 1 – Frequency reference selection

P302 - Inverter command mode selection

P302 value	Command type
0	**HIM keyboard:** All commands are performed only by the HMI keys.
1	**Command via digital inpupt (ON/OFF):** Command to start and stop via digital input **DI1** (high state, ON; low state, OFF). If **P303** = 2 and **P304** = 0, the direction of rotation is defined by **DI2** (high state, normal direction; low state, reverse direction).
2	**Advance in the first ramp, return in the second ramp:** Advance by **DI1**, return by **DI2**, in other words, if **DI1** is high, the inverter is activated in the normal direction, if **DI2** is high, the inverter is activated in the reverse direction.
3	**Modbus:** Commands performed by Modbus communication. See Chapter 5.

Table 7 – Command selection.

P303 - Spin direction

Defines the direction of motor rotation according to the following options:

- 0 - Normal direction (forward): It will always remain in the normal direction, regardless of any command;
- 1 - Reverse direction (return): It will always remain in the reverse direction, regardless of any command;
- 2 - Direction defined by commands: Depending on the direction command (see parameters **P302** and **P304**). When this option is set, the inverter starts the motor in the normal direction by default.

P304 - DI2 digital input function

P304 value	DI2 digital input function*
0	**If P302 = 1: rotation direction.** If the state of DI2 is low, the rotation will be in starndard direction; if high, it will be in reverse direction. **If P302 = 2: backwards.** If DI1 is low and DI2 is high, the motor rotation will be backwards.
1	**If P301 = 2: electronic potentiometer.** The reference frequency is incremented while the state of DI2 is high. **If P301 = 3: multispeed.** See the table presented in P301.
2	**General enablement**: if the state of DI2 is low, the inverter is disabled (HMI displays stop message); if high, the inverter is enabled (HIM shows ready message).

Table 2 - DI2 function.

* For the configuration of the logic level of digital inputs, refer to parameter **P305**.

P305 - Selection of logic levels for ligital inputs (NO/NC)

Defines the type of digital inputs as normally open (NO) or normally closed (NC).

- 0 - Normally open (NO): In this option, in state 0 (or low) the digital input is floating. In state 1 (or high) the digital input is connected to GND.
- 1 - Normally closed (NC): In this option, in state 0 (or low) the digital input is connected to GND. In state 1 (or high) the digital input is floating.

P602 - Motor rated frequency

This parameter should be adjusted according to the information on the motor specifications plate.

WARNING!

It is crucial to adjust this parameter correctly as it determines the V/f curves through which the control method operates. Incorrect adjustment can lead to permanent damage to the motor.

P603 - Motor rated rotation

This parameter should be adjusted according to the information on the motor specifications plate.

P701 - Inverter address (Modbus)

Defines the address of the inverter on the Modbus network. All devices on the network must have unique addresses. It is not recommended to change this parameter via Modbus communication. See Chapter 5.

P702 - Baud rate (Modbus)

This parameter defines the baud rate (or Modbus communication transmission rate). The value of this parameter must match the Modbus network master one. All devices on the network must communicate at the same baud rate. For operation in electromagnetically aggressive environments, it is recommended to use slower rates to reduce the likelihood of communication errors. In less aggressive environments and applications where the communication demand is higher (higher read/write rates), a higher transmission rate can be used. See Chapter 5.

P703 - Parity (Modbus)

Defines the type of parity used in the Modbus communication framing. Options include (see Chapter 5):

P703 value	Parity type
0	**OFF:** no parity or None. In this configuration, there is no parity calculation, and each message field will have 2 stop bits.
1	**Even:** the number of 1 bits is counted. If the count is odd, the parity bit is set to 1 so that the total number of 1 bits in the message is even; if the count is even, the parity bit is set to 0.

2	**Odd:** the number of 1 bits is counted. If the count is odd, the parity bit is set to 0 so that the total number of 1 bits in the message is odd; if the count is even, the parity bit is set to 1.

Table 3 – Type of parity in Modbus communication.

P704 - Watchdog (Modbus)

Defines the amount of time for the watchdog timer. This timer is a mechanism for detecting Modbus communication failure. If **P301** = **4** and **P302** = **3**, and the value of this parameter is different from OFF, the timer starts counting from the last valid message received from the Modbus communication master. If, after the time defined in **P704**, no message is received, error **E008** is generated. It is recommended that in electromagnetically aggressive environments, the value of **P704** be higher, as the probability of message loss or invalid messages is higher, but it does not necessarily indicate that the master has failed. See Chapter 5.

Chapter 5 – Modbus RTU Communication

5.1 Preliminary information

The AG Drive inverter family has native Modbus communication. However, for the AG Drive Mini model, the Serial-RS-485 adapter must be purchased separately. The implemented protocol is Modbus RTU, widely used in the industry. Modbus communication allows the device to be controlled remotely and be included in a communication network. The basic operating principles are described below. In this section, decimal numbers are displayed without a suffix, hexadecimal numbers are displayed with the 'h' suffix, and bits are displayed with the 'b' suffix.

Hardware and connection

The physical layer protocol used is the EIA/TIA-485 or RS-485 standard. In the XF2, RS-485 is implemented in half-duplex mode, where sending and receiving messages are done on the same bus. The physical medium should be selected by the user according to the RS-485 standard. Shielded twisted pair cable is recommended.

NOTE

The following points should be observed:

- **Always use cables suitable for the operating environment, preferably with copper shielding.**
- **Pay attention to the minimum distance between signal/communication cables and power cables.**

The recommended topology for RS-485 is the Daisy Chain, as illustrated in Figure 21, in which the communication cabling comes from the master device to the first slave device, from this device to the next slave, and so on.

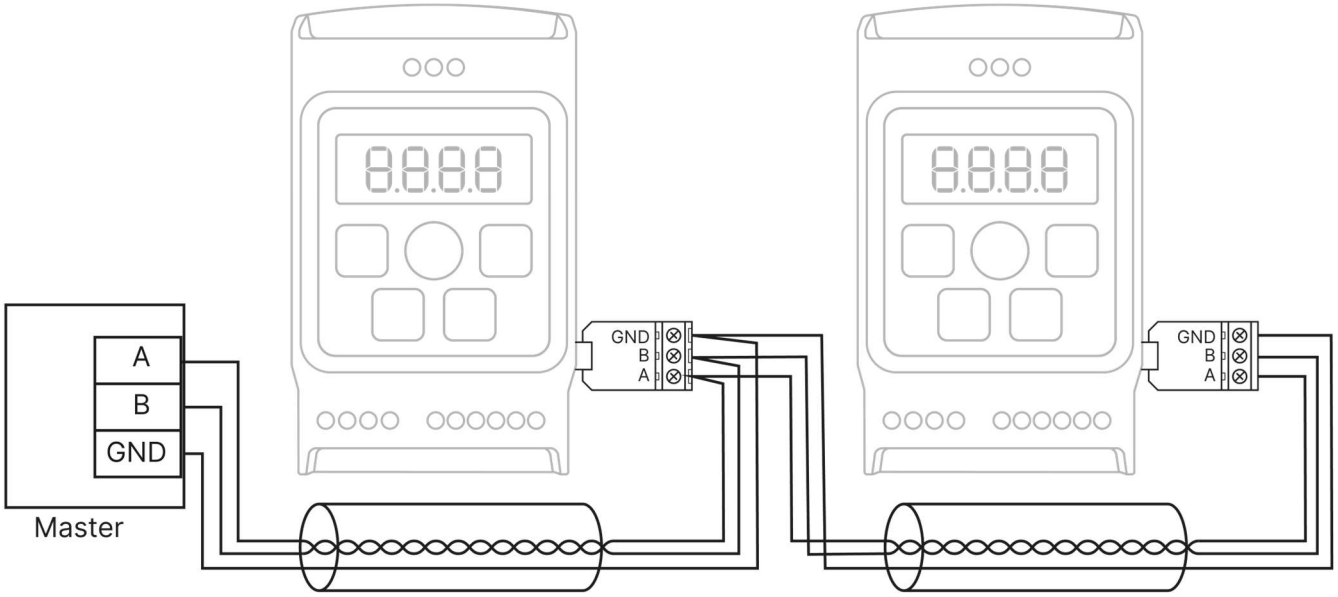
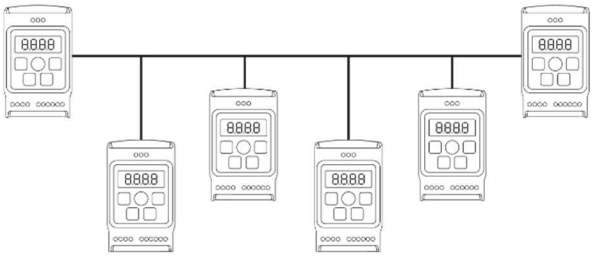


Figure 10 - Daisy Chain connection example.

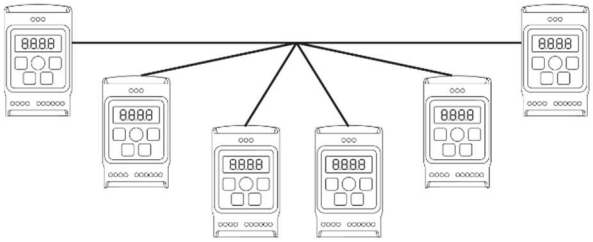
WARNING!

The use of communication adapters or similar devices should be tested and validated before operation. Use only devices that comply with safety standards.

The other connection methods are acceptable or should be avoided as indicated in Figure 22.



Backbone with stubs (workable)



Star network (avoid)

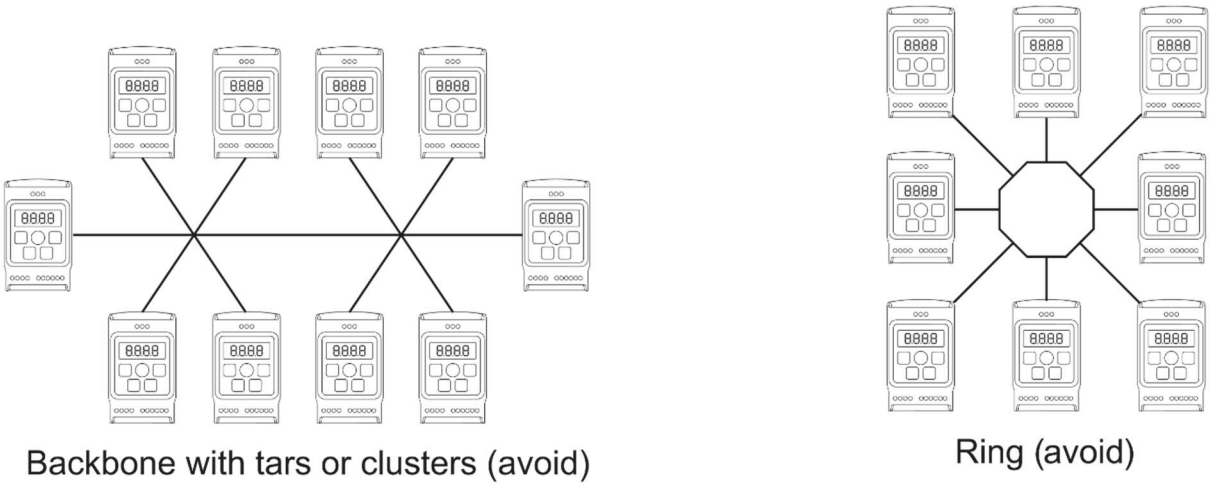


Figure 11 - Network connection methods.

The Table 10 presents the wiring diagram of the RS-485 Serial Adapter. The adapter should be connected to the Mini USB port located on the right side of the inverter.

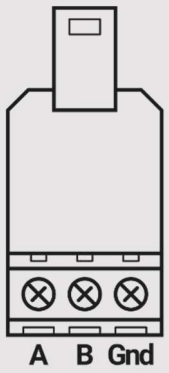
Connectors	Function	Description
	GND	Ground. Common point of the circuit. Do not mistake with protection ground or panel ground.
	A	RS-485 A. Low for logic state 1, high for 0.
	B	RS-485 B. Low for logic state 0, high for 1.

Table 4 - RJ-45 Connector pinout for the inverter.

NOTE

The master device in the network must have a termination resistor between points A and B.

Programming

To use Modbus communication, the following parameters must be configured:

- **P301 - Inverter output frequency setting:** Set this parameter to 4 for frequency reference selection exclusively via Modbus. If this parameter is not configured, attempting to command the inverter via Modbus will result in the inverter sending exception message 4.

- **P302 - Inverter command mode selection**: Set this parameter to 3 for command selection exclusively via Modbus. If this parameter is not configured, attempting to command the inverter via Modbus will result in the inverter sending exception message 4.
- **P701 - Address:** This is the address of the inverter on the Modbus network. Each slave must have a unique address.
- **P702 - Baud Rate:** This parameter sets the transmission rate in bps (bits per second). All slaves on the network must be configured with the same baud rate as the master. In electromagnetically aggressive environments, it is recommended to use lower transmission rates, and the same applies to long distances between devices.
- **P703 - Parity:** Choose the parity type. All slaves should be configured with the same parity as the master. It is recommended to leave it as OFF.
- **P704 - Watchdog:** This timer checks for communication errors. In the absence of receiving a valid message for a period longer than the time set for the watchdog timer, a communication error (**E009**) is generated. The timer starts when set and restarts every time a valid message is received.

Note: Refer to the parameter description list for more details on these parameters.

5.2.0 The protocol

The implemented protocol is Modbus RTU, as described in the following documents:

- Modbus Application Protocol Specification v1.1b3;
- Modicon Modbus Protocol Reference Guide.

Framing

Each character in a protocol message consists of 11 bits, as follows:

- With parity:

Start bit	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8	Parity	Stop

- Without parity:

Start bit	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8	Stop	Stop

Bit 1 is the least significant bit (LSB), and bit 8 is the most significant bit (MSB). In an RTU frame, there are generally six fields:

Start	Address	Function	Data	CRC	End
3.5 times the character duration	8 bits	8 bits	N x 8 bits	16 bits	3.5 times the character duration

In Modbus communication, devices interpret the start and end of a message based on a specific silence time on the bus. The time should be 3.5 times the character time (time for 11 bits). The character time varies according to the baud rate used, as shown in Table 5.2.1 below:

Baud rate (b/s)	Bit time (us)	Character time (ms)	3.5x character duration (ms)
9,600	104	1.2	4
19,200	52	0.573	2
38,400	26	0.286	1.75 (1)
115,200	8.7	0.095	1.75 (0.33)

Table 5 - Protocol timings in accordance with the baud rate.

Regardless of the baud rate value, the minimum time of 3.5 times the character time is 1.75 ms. If the silence time on the bus between messages is less than 3.5 times the character time, the device may interpret the information as part of the previous message, resulting in a checksum error. Similarly, if the time between bits is greater than 3.5 times the character time, the device may interpret the incoming information as the start of a new message, again generating a checksum error. The user must configure the network master device appropriately to meet the mentioned times. A minimum timeout of 500 ms between requests is recommended.

Parity control has been implemented in XF2 and is configurable through parameter **P703**. Parity is a message error control method. There are three possible types of parity control:

- **No Parity (None):** In this case, the message parity is not calculated, and the master must be configured so that the request has 2 stop bits per character.
- **Even Parity (Even):** In this case, the parity bit of the character is calculated as follows: if the total number of 1 bits is even, the parity bit is 0; if it is odd, the parity bit is 1, making the total number of bits in the character even.
- **Odd Parity (Odd):** In this case, the parity bit of the character is calculated as follows: if the total number of 1 bits is even, the parity bit is 1, making the total number of bits in the character odd; if it

is odd, the parity bit is 0. If there is a parity error in the request, XF2 simply does not provide any response.

The only type of Modbus RTU protocol variable implemented in XF2 is the holding register. The implemented tasks are 03 and 06, described below:

- **Reading holding registers, code 03x**: reading a register or contiguous group of 16-bit registers. The maximum number of registers for reading is 1.
- **Writing holding register, code 06x:** writing a single 16-bit register.

In the Modbus protocol, 16-bit registers are represented by a set of 4 hexadecimal characters of 4 bits each, and the value of the registers is transmitted in 2 fields of 8 bits. The first field has the two most significant 4-bit characters (Hi), and the second field has the two least significant 4-bit characters (Lo). For example, register 4100 stores the inverter's state. The conversion to hexadecimal results in 1004h. Thus, the first field of the register will be 10h, and the second 04h.

The following are examples of requests and responses for the implemented tasks.

Reading Example: Check the ramp-up time of the inverter, parameter **P011** (factory value 10 s), by reading register 10 (0Ah). In Table 12, the request and response are presented.

Request (Master)		Answer (Slave)	
Field	**Value**	**Field**	**Value**
Slave address	01h	Slave address	01h
Function code	03h	Function code	03h
Starting register number (Hi)	00h	Bytes counting	02h
Starting register number (Lo)	0Ah	Register data (Hi)	00h
Number of registers (Hi)	00h	Register data (Lo)	0Ah
Number of registers (Lo)	01h	CRC Lo	CRC Lo
CRC Lo	CRC Lo	CRC Hi	CRC Hi
CRC Hi	CRC Hi		

Table 6 - Request and response for task 3.

Writing example: Activating the inverter via Modbus by writing the value 1 to register 4101 (1005h). The request and response are presented in Table 13.

Request (Master)		Answer (Slave)	
Field	**Value**	**Field**	**Value**
Slave address	01h	Slave address	01h
Function code	06h	Function code	06h
Register number (Hi)	10h	Register number (Hi)	10h
Register number (Lo)	05h	Register number (Lo)	05h
Value (Hi)	00h	Value (Hi)	00h
Value (Lo)	01h	Value (Lo)	01h
CRC Lo	CRC Lo	CRC Lo	CRC Lo
CRC HI	CRC HI	CRC HI	CRC HI

Table 7 - Request and response for task 6.

In the case of an invalid request or communication error, the protocol suggests the possibility for the slave to send exception responses. The only implemented exception message is the code 04 - server device failure. This message will be sent under the following conditions:

- Illegal register address, read/write: The master attempted to read/write to an unavailable address;
- Illegal value: The master attempted to write an unrecognized value;
- Illegal read range: The master attempted to read more registers than allowed, i.e., more than 1.

The message sent by the master should be investigated to identify if any of these conditions exist.

5.3 Controlling the inverter via Modbus

As mentioned earlier (in “Programming”), to command the inverter, Modbus communication-related parameters must be properly configured. Nevertheless, it is possible to read and write any inverter parameter via Modbus even if the command selection and frequency reference are not configured for Modbus communication.

WARNING!

Set the command selection parameters (P301) and frequency reference (P302) for Modbus only after the validation and preliminary tests of the motor and load to be controlled. Risk of unintentional activation.

For the activation of the inverter, a set of registers has been defined with basic command functions. These registers are described in Table 14.

Register	Function
4097	**Listing the total number of parameters:** retrieves the overall parameters count of the inverter. Read-only register. Useful for communication debugging.
4101	**ON/OFF:** writing the value 1 to this register activates the inverter output; writing the value 0 deactivates the output. Operates identically to the ON and OFF keys (respectively) on the HMI.
4103	**Increment/Decrement frequency:** writing the value 1 to this register increments the reference frequency by 0.1 Hz. Writing the value 0 decrements the frequency by 0.1 Hz. This action only takes effect when the output is activated (inverter ON). Operates identically to the **+ and - keys** on the HMI.
4105	**Reset:** In an error condition, setting this register to a value of 1 resets the error. Same effect as pressing the **OFF key** on the HMI in the case of an error.
4106	**Output Frequency:** Sets the output frequency according to the value written in the register. The value must be a positive 16-bit integer (the standard size of a holding register), providing a range of 0 to 32767 for this field. The frequency value has precision to one decimal place; however, since this function only accepts integer values, the desired frequency value should be multiplied by 10. For example, if the desired frequency is 46.8 Hz, the value to be written in the register is 468.
4107	**Rotation Direction:** Sets the rotation direction. Writing 0 sets the direction to standard, writing 1 sets the direction to reverse.

Table 8 - Command functions via Modbus registers.

5.4 Recommendations for Modbus Communication Implementation

This section describes some recommendations and precautions to assist in the correct implementation of Modbus communication.

- When there is a connection between devices within the same building but in different panels, it is recommended to ensure equipotential grounding;
- When there is a connection between devices in different buildings, we recommend using RS-485 to optical fiber converters to isolate the signal. When not possible, it is recommended to ensure equipotential grounding;
- When it is necessary to extend RS-485 for more than 1000 meters or when the network infrastructure is very close to locations with high electromagnetic interference, it is recommended to use RS485 to optical fiber converters;
- Always use the cables indicated in the manual, of good quality, and in accordance with EIA/TIA-485. When not possible, make sure that every adapter or converter is properly connected and protected from electromagnetic interference;
- It is recommended to decrease the baud rate for long cable runs;
- It is not recommended to alter inverter parameters via Modbus communication unless absolutely necessary. Parameter changes should always be done with caution, preferably with the entire system out of operation;
- During the system commissioning phases, it is recommended to set the value of parameter **P704** (Watchdog Timer) to **OFF** so that communication errors are not generated unnecessarily. This parameter should be adjusted based on the how robust the communication of the system in operation is.

Chapter 7 – Technical specifications

Parameters	Model	
	XF2-05	XF2-10
Maximum motor power (in HP)	0.5 hp	1 hp
Rated output current	2.6 A	4.0 A
Maximum output current	3.4 A	5.2 A
Maximum input current	5.1 A	7.8 A
Power supply	Single-phase / Two-phase	
Rated voltage	200 to 240 VAC RMS	
Input frequency	50 to 60 Hz	
Output frequency	0 to 500 Hz	
Switching frequency	5k, 10k and 15 kHz	
Type of control	V/f	
Protection index	IP20	
Operation temperature	0 to 50°C	
Relative humidity	5 to 90%	
Analog input	1 input (0 to 10 V)	
Digital input	3 digital inputs	
Communication	Modbus RTU*	
Output voltage at maximum frequency	220 VAC (three-phase)	

* It is necessary to acquire a Serial-RS485 adapter

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