AGEON
Electronic Controls

Technical Guide

AG DRIVE

FREQUENCY INVERTERS

AG Drive Pro

Summary

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 430 V	-	1
P003	Output current visualization	0 to 24.0 A	-	2
P004	Output voltage visualization	0 to 400 V	-	3
P005	IGBT module temperature visualization	0 to 100 ºC (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-down / 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
P013	2nd Ramp-up time	0.1 to 600.0 s	10.0 s	12
P014	2nd Ramp-down time	0.1 to 600.0 s	10.0 s	13
P021	Frequency backup	0 = Backup disabled 1 = Enabled: it uses the last reference 2 = It uses the reference set in P022	1	14

Param.	Function	Range of values	Factory default value	Reg. Modbus
P022	Start-up frequency	P023 to P024	5.00 Hz	15
P023	Lowest frequency limit	0.00 Hz to P024	5.00 Hz	16
P024	Highest frequency limit	P023 to 500.0 Hz	60.00 Hz	17
P028	Standard display unit	0 = Hertz 1 = Ampere 2 = RPM	0	18
P041	Torque boost	0 to 30%	5%	19
P043	Switching frequency	5 kHz to 15 kHz	10 kHz	20
P051	Overload current	XF2-05 = 0 to 3.4 A XF2-10 = 0 to 5.2 A XF2-20 = 0 to 9.5 A	XF2-05 = 3.4 A XF2-10 = 5.2 A XF2-20 = 9.5 A	21
P052	Overload current control	XF2-05 = oFF to 3.4 A XF2-10 = oFF to 5.2 A XF2-20 = oFF to 9.5 A	XF2-05 = oFF XF2-10 = oFF XF2-20 = oFF	22
P053	Auto reset	oFF to 255	oFF	23
P054	Lower limit for DC bus voltage	100 to 200 V	180 V	24
P100	Analog input gain control	0.1 to 999.0	100.0	25
P101	Analog input type	0 = 0 to 10 V 1 = 0 to 20 mA 2 = 4 to 20 mA	0	26
P102	Function selection for terminals 7 and 8	0 = 0 to 10 V 1 = 0 to 20 mA 2 = 4 to 20 mA	0	27
P103	Analog output type	0 = oFF 1 = Indicating output frequency 2 = Indicating output current	0	28

Param.	Function	Range of values	Factory default value	Reg. Modbus
P104	Relay output function	0 = When the output frequency equals the frequency set point 1 = When the reference frequency is greater than the value set in parameter P105 2 = When the output frequency is greater than P105 3 = When the output current is greater than P106 4 = When the inverter is running 5 = When the inverter is executing the deceleration ramp 6 = While the inverter is error-free	2	29
P105	Relay output frequency	P23 to P24	60.00 Hz	30
P106	Relay output current	XF2-05 = 0 to 3.4 A XF2-10 = 0 to 5.2 A XF2-20 = 0 to 9.5 A	XF2-05 = 3.4A XF2-10 = 5.2A XF2-20 = 9.5A	31
P201	Multi-step speed 1	P23 to P24	5.00 Hz	32
P202	Multi-step speed 2	P23 to P24	5.00 Hz	33
P203	Multi-step speed 3	P23 to P24	5.00 Hz	34
P204	Multi-step speed 4	P23 to P24	5.00 Hz	35
P205	Multi-step speed 5	P23 to P24	5.00 Hz	36
P206	Multi-step speed 6	P23 to P24	5.00 Hz	37

Param.	Function	Range of values	Factory default value	Reg. Modbus
P207	Multi-step speed 7	P23 to P24	5.00 Hz	38
P208	Multi-step speed 8	P23 to P24	5.00 Hz	39
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	40
P302	Inverter command mode selection	0 = HIM keyboard command 1 = Digital inputs command: • DI 1 = Start / stop • DI 2 = Defined by P304 2 = Digital inputs command: • DI 1 = Forward • DI 2 = Backward 3 = Modbus command	0	41
P303	Rotation direction	0 = Standard direction 1 = Reverse direction 2 = Defined by digital command	2	42

Param.	Function	Range of values	Factory default value	Reg. Modbus
P304	DI2 digital input function	0 = Rotation direction 1 = Second ramp 2 = Accelerates using the first ramp and decelerates using the second ramp 3 = Multi-step speed 4 = Enables overall operation	0	43
P305	Selection of logic levels for digital inputs	0 = Inputs NO 1 = Inputs NC	0	44
P401	DC braking % of motor rated current	0 to 100 %	0 %	45
P402	Braking duration at startup	oFF to 15.0 s	oFF	46
P403	Braking duration at stop	oFF to 15.0 s	oFF	47
P404	Braking frequency at stop	0.00 to 60.00 Hz	0.00 Hz	48
P501	Band to be avoided	0.00 to 25.00 Hz	0.00 Hz	49
P502	Frequency 1 to be avoided	0.00 to 500.0 Hz	0.00 Hz	50
P503	Frequency 2 to be avoided	0.00 to 500.0 Hz	0.00 Hz	51
P504	Frequency 3 to be avoided	0.00 to 500.0 Hz	0.00 Hz	52
P601	Control Type	0 = Linear V/f control 1 = Quadratic V/f control	0	53
P602	Motor rated frequency	10.00 to 500.0 Hz	60.00 Hz	54
P603	Motor rated rotation	0 to 9999 RPM	0	55

Param.	Function	Range of values	Factory default value	Reg. Modbus
P604	Rated motor current	XF2-05 = 2.6 A XF2-10 = 4.0 A XF2-20 = 7.3 A	0 to 7.3 A	56
P701	Address	1 to 247 or iHrE	iHrE (remote HMI)	57
P702	Baud rate	0 = 9,600 bps 1 = 19,200 bps 2 = 38,400 bps 3 = 115,200 bps	0	58
P703	Parity	oFF = None 1 = Even 2 = Odd	oFF	59
P704	Watchdog	oFF to 100,0 s	oFF	60

Table 1.1.1 – Quick reference guide to inverter parameters.

1.2 Understanding the Human Machine Interface (HMI)

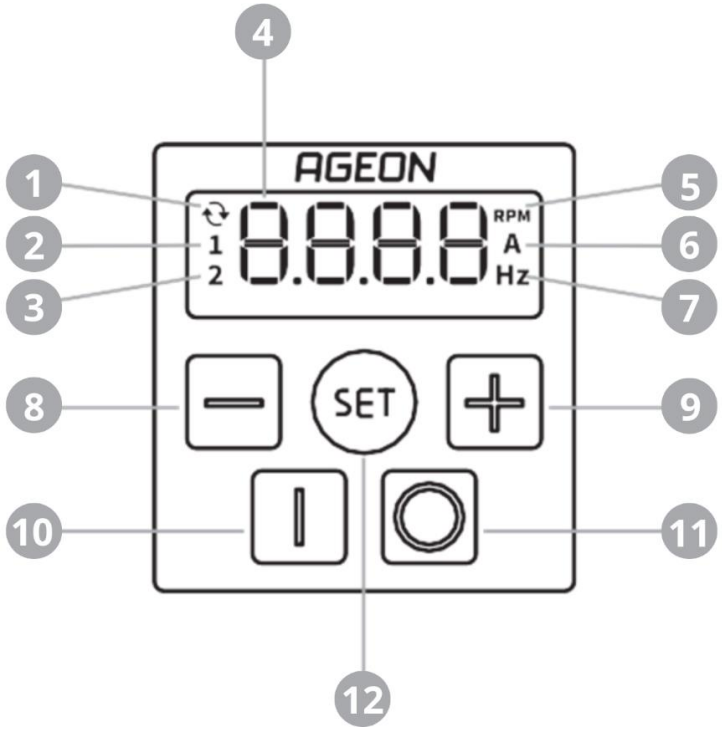


Figure 1.2.1 – Human Machine Interface (HMI).

Number	Name	Function
1	When this LED is on, it indicates reverse rotation direction.	
2	When this LED is on, it indicates that the relay output is active.	
3	When this LED is on, it indicates that the second ramp is active. When flashing, it indicates that the maximum current control is active.	
4	HIM display.	
5	Indicates that the value displayed is in revolutions per minute. So this indication functions, the motor maximum RPM must be set in P603.	
6	Indicates that the value displayed is in Ampere.	
7	Indicates that the value displayed is in Hertz.	
8	Key used to decrement values.	
9	Key used to increment values.	
10	Activates the motor when P302 = 0 Press and hold to reverse the rotation direction.	
11	Deactivates the driver when P302 = 0	
12	When clicked in the parameter table, it is used to enter or exit the parameters. When clicked on the operation screen, it switches the displayed variable between frequency, current, or RPM.	

Table 1.2.2 – Getting to know the HIM.

1.3 HIM messages

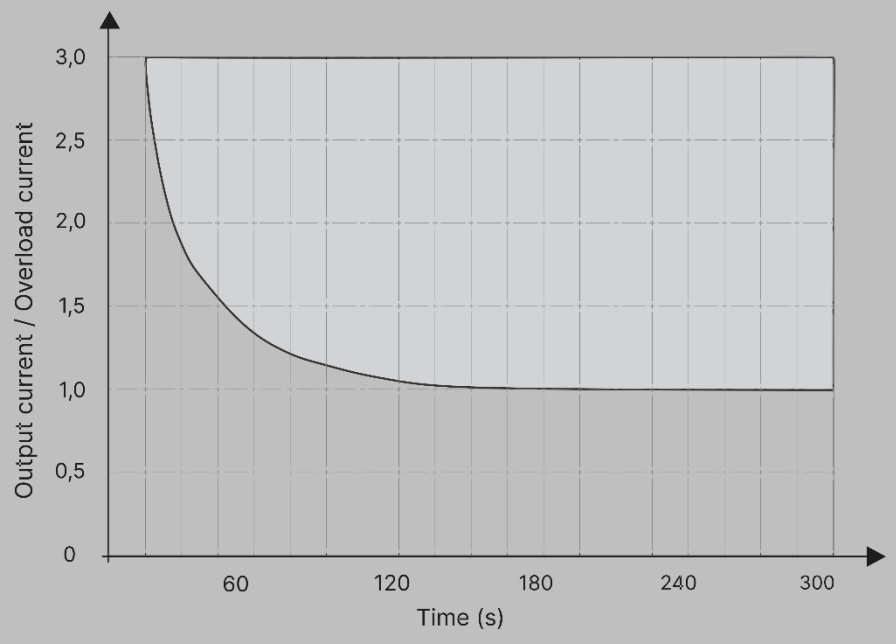
Operation messages

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.

Table 1.3.1 – Operation messages.

Error messages

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. Verify the value set in P054.
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) exceeds the threshold defined in P051. The overload protection acting time and the subsequent triggering of this error follow the curve shown in the figure below.  *Figure 1.3.2*

Message	Description
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, please reach out to AGEON technical support for assistance.
E008 - Phase loss at output	Occurs when the inverter detects the absence of one of the motor phases.
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.

Table 1.3.3 – Error message.

Chapter 2 – Safety instructions

2.1 Safety symbols

Danger!

This warning symbol indicates presence 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 nonelectrical conditions that may pose a risk of death, injury, or equipment damage.

CAUTION!

The device contains components which can be damaged 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 normative;
- Make sure to adhere to standards for local and international electrical installations and workplace safety normative;
- 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 normative, 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.

2.3 Grounding

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 solutions

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 2.4.1 bellow.

Error	Cause	Possible solutions
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 the ramp-down time; • If the error persists, contact Ageon technical support.

Error	Cause	Possible solutions
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; • Verify the value set in P054; • 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.

Error	Cause	Possible solutions
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.
E008	Phase Loss at Output	• Ensure that all motor power cables are properly connected to the inverter's output; • Make sure that all connections are secure and tightly fastened at the inverter terminals; • Verify that the motor is in good operating condition; • If the problem 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

Error	Cause	Possible solutions
		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 2.4.1 – Failure solution.

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.

3.1 Environmental conditions

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

Dimensions

It is possible to install the inverter using the mounting holes (Figure 3.2.2) or DIN-35 rail (Figure 3.2.3). The recommended mounting spacing from Figure *3.2.4* and Figure *3.2.5* must be respected. The installation should ensure that the inverter is securely fixed and that the air inputs and outputs are unobstructed.

The product dimensions are presented in the Figure 3.2.1 below.

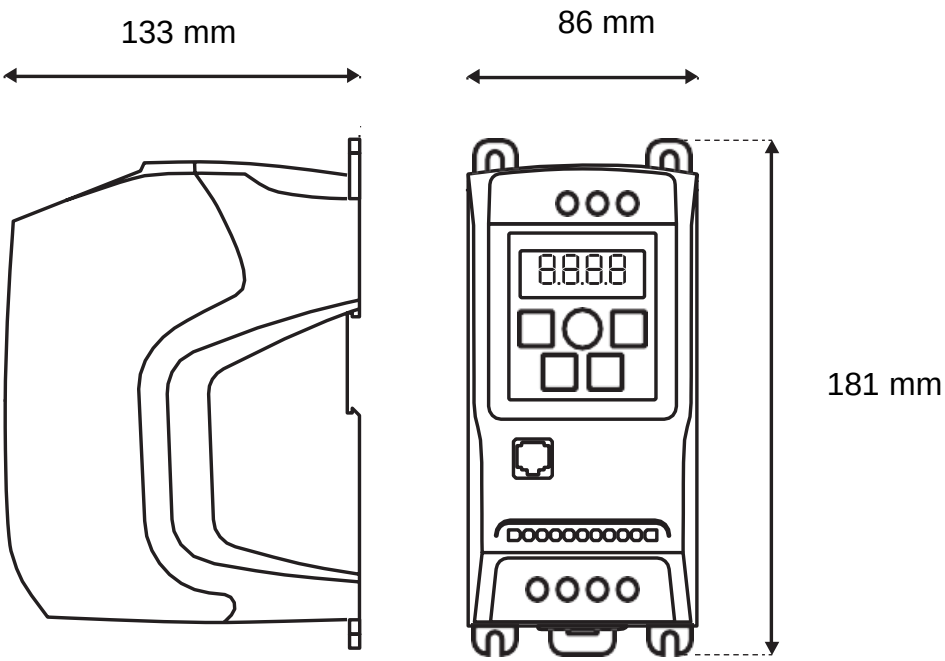


Figure 3.2.1 – Dimensions.

Positioning and drilling

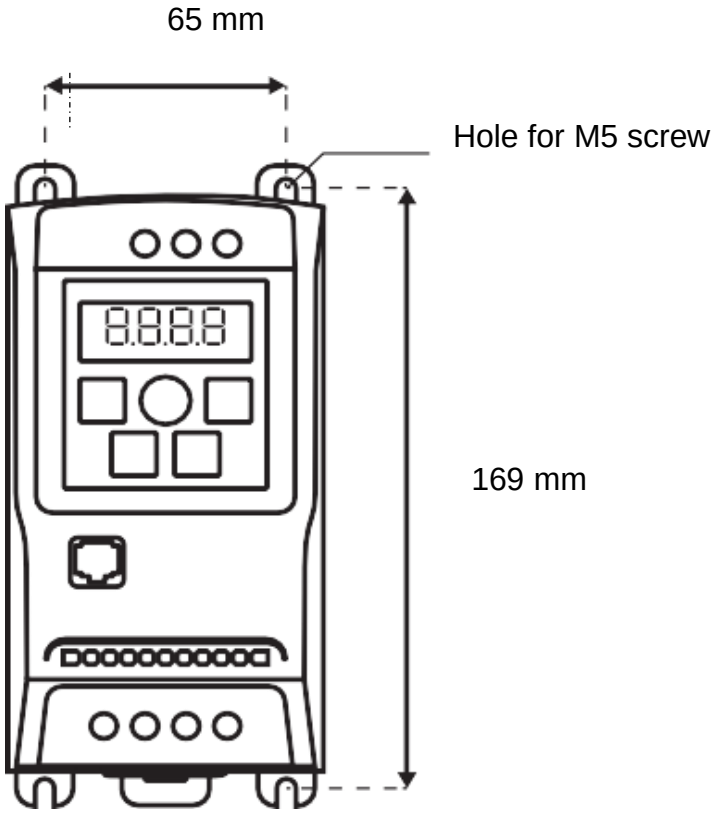


Figure 3.2.2 – Positioning and drilling.

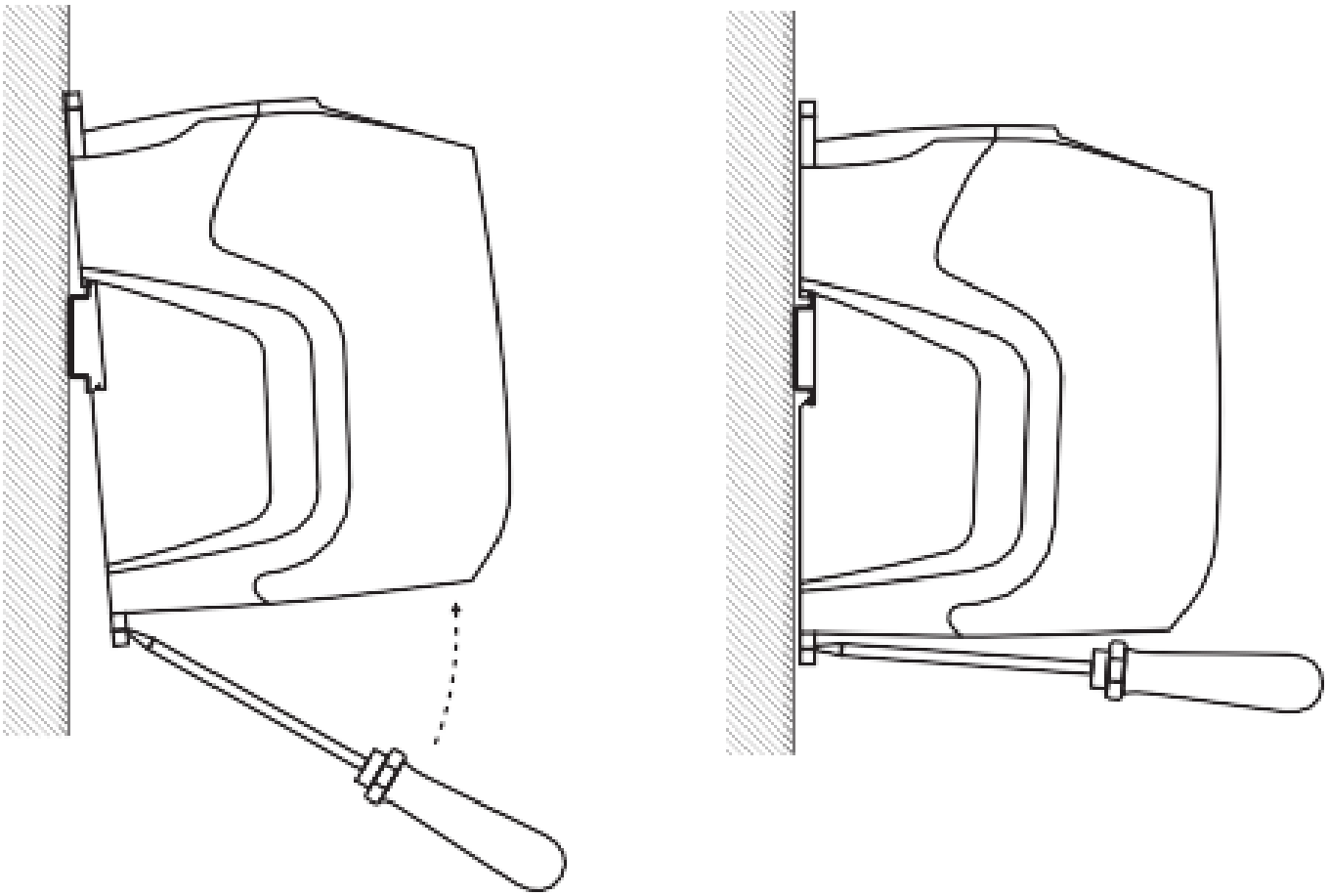


Figure 3.2.3 – Fixing.

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.

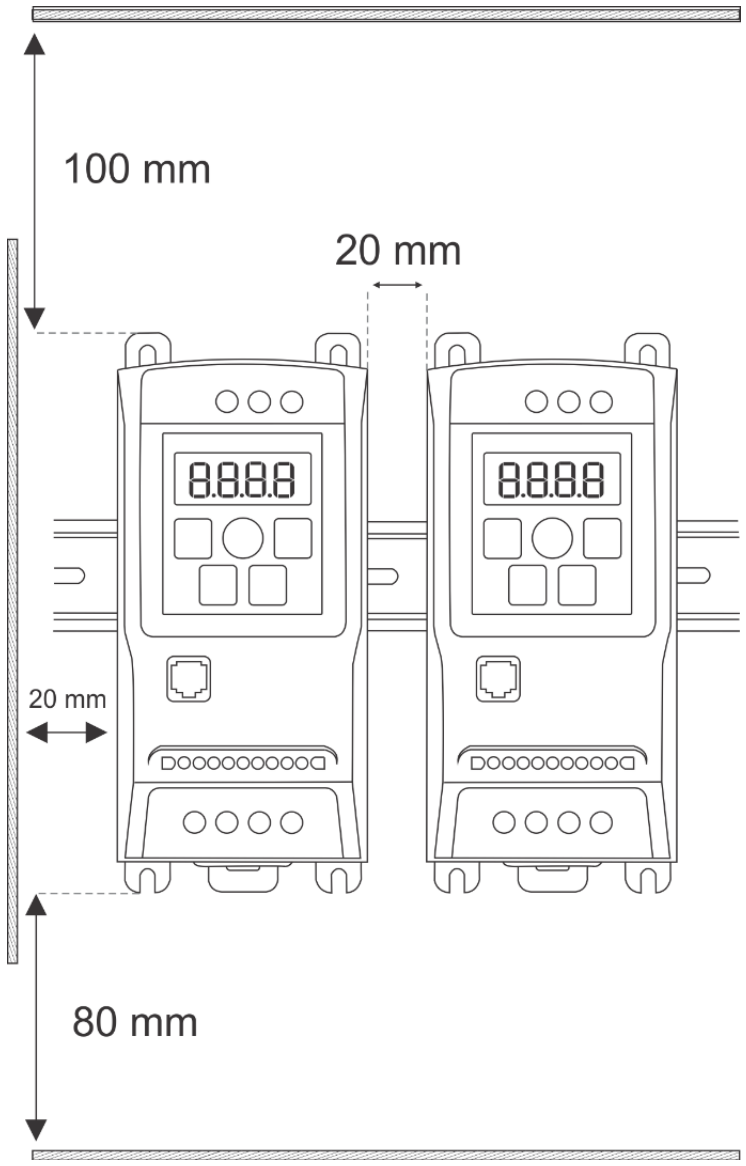


Figure 3.2.4 – Detail for DIN-35 rail mounting spacing.

WARNING!

Ensure the mounting dimensions as shown in Figure 3.2.4. 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.

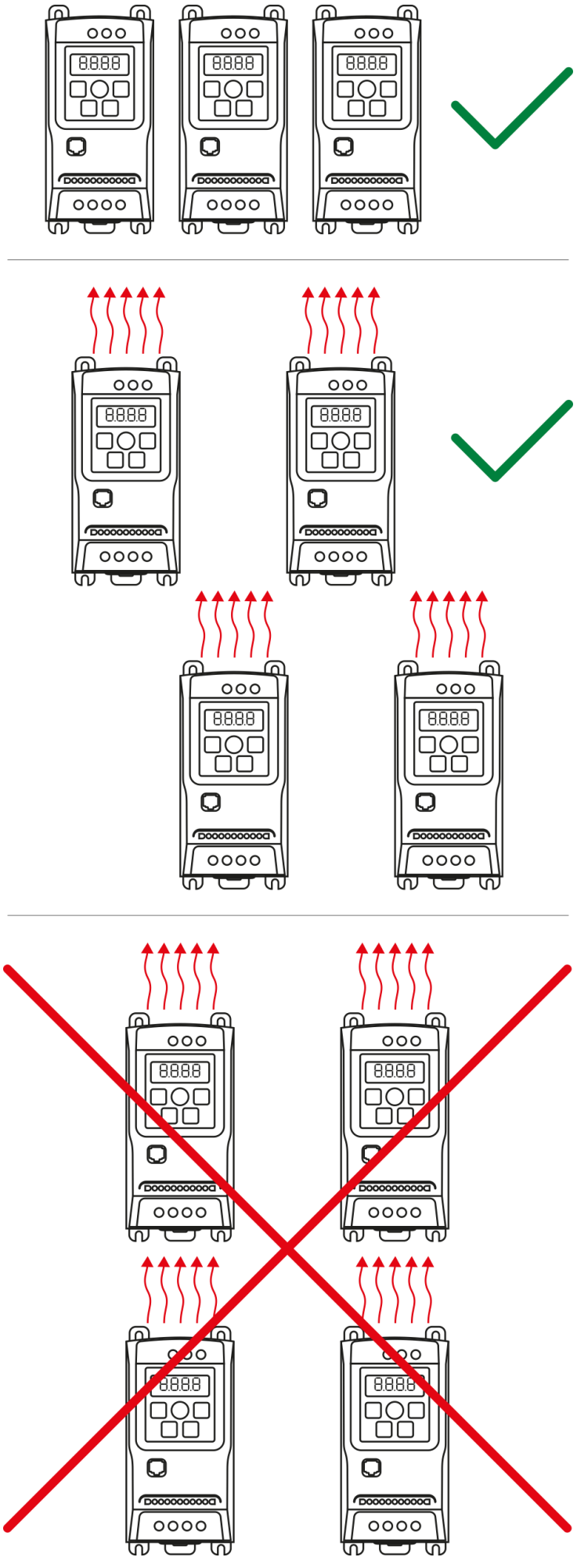


Figure 3.2.5 – Best practices for mechanical installation.

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

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, only one end of the shielding should be grounded. Figure 3.3.1 provides instructions on isolating the braid.

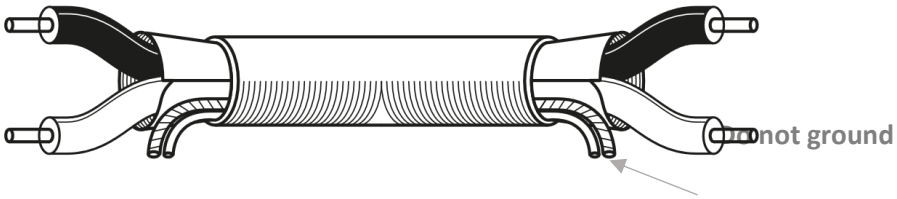


Figure 3.3.1 – Instructions on shielding Isolation.

- 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.

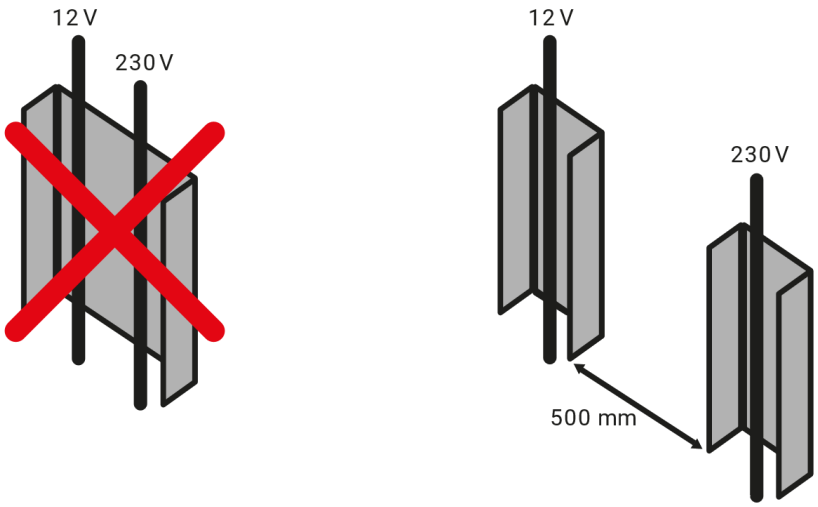


Figure 3.3.2 – Best practices for cable tray installation.

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.

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

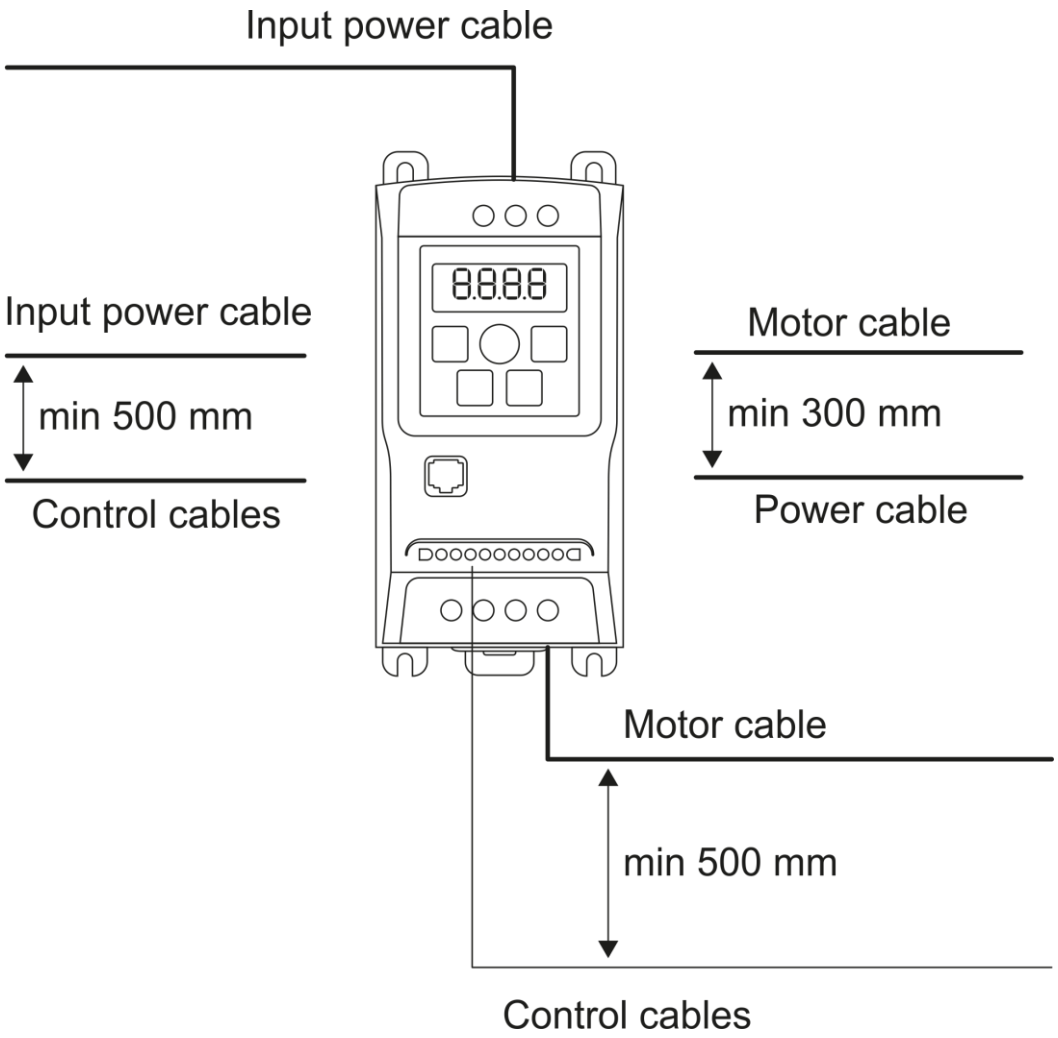


Figure 3.3.3 – Best Practices for cable routing.

- 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 3.3.3.
- Figure 3.3.4 represents an installation that follows guidelines according to best practices for electromagnetic compatibility.

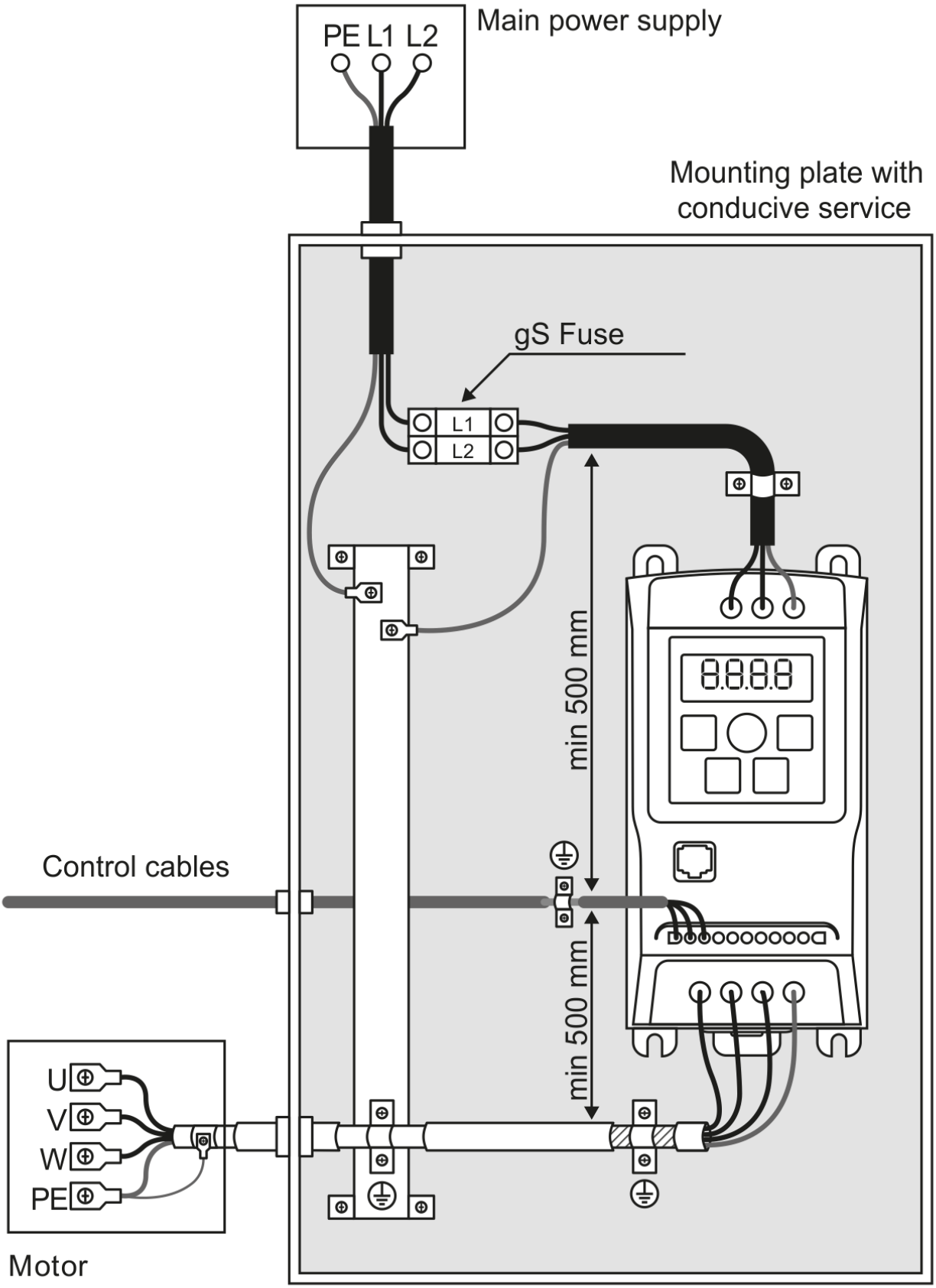


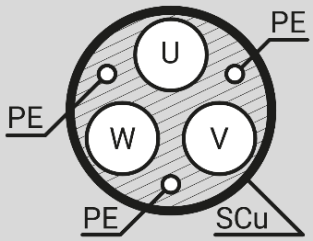
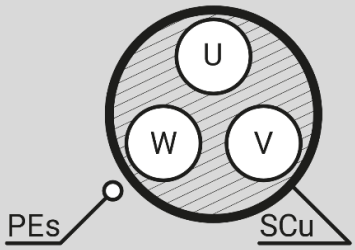
Figure 3.3.4 – Best practices for electrical panel installation.

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 aluminium 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 or aluminium	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 or aluminium	Reasonable

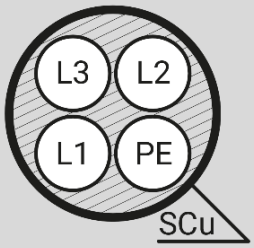
	When the conductors are smaller than 10 mm², as an alternative, you can use this model of cable.	Copper or aluminium	Acceptable
Notes			
U, V, W – Phase conductors	PE – Ground conductor	SCu – Copper shielding	

Figure 3.3.5 – Recommended cable options.

In cases where the conductors have a cross-section of up to 10 mm², a multi-core cable can be used. If an unshielded cable is used, it can be routed through a metallic conduit that is properly grounded to reduce the electromagnetic emissions generated.

Unshielded cables can only be used when compliance with any electromagnetic compatibility standard or directive is not required.

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.

Identification of power terminals.

The power terminals of the inverter are indicated in Figure 3.3.6 (L2 and L3) which should be powered with 220 VAC. The terminal for grounding the equipment should be interconnected with the equipotentialization bus.

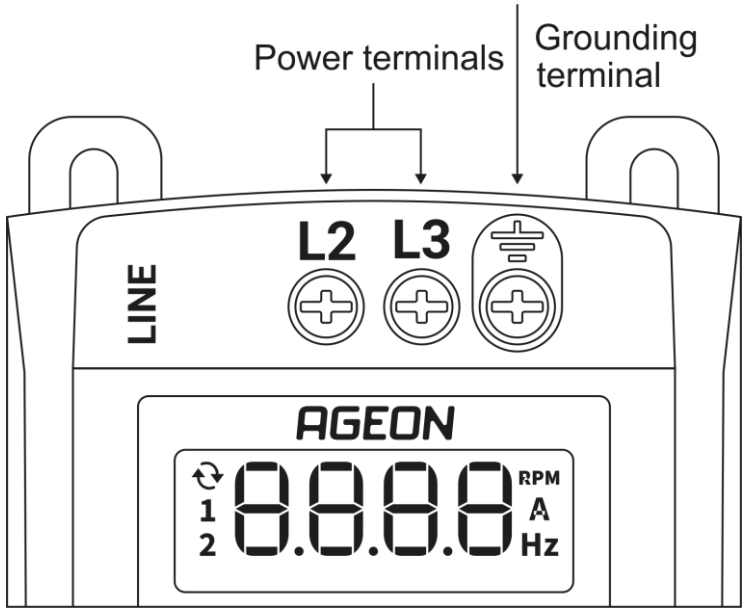


Figure 3.3.6 – Inverter power supply.

In Figure 3.3.7, it is shown the motor power terminals and the grounding terminal for the motor frame. The inverter output is 220 VAC (three-phase).

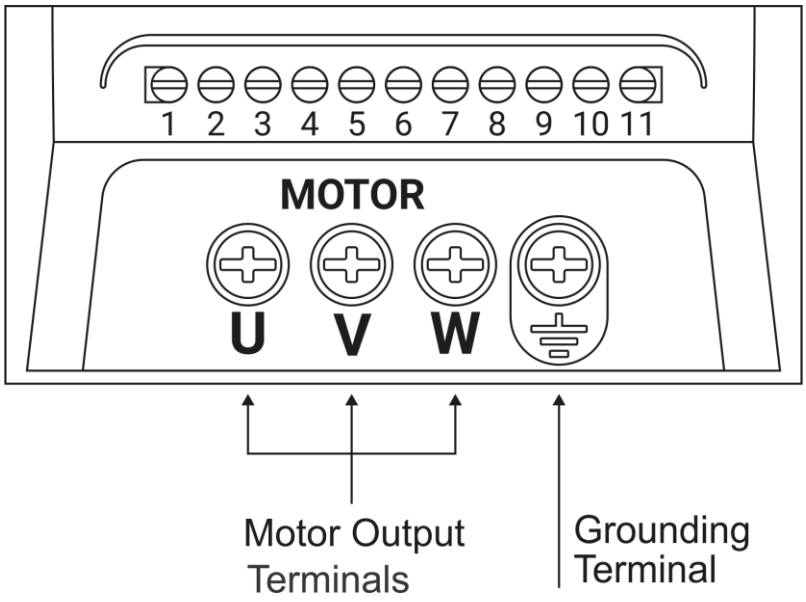


Figure 3.3.7 - Motor power supply.

Identification of command terminals

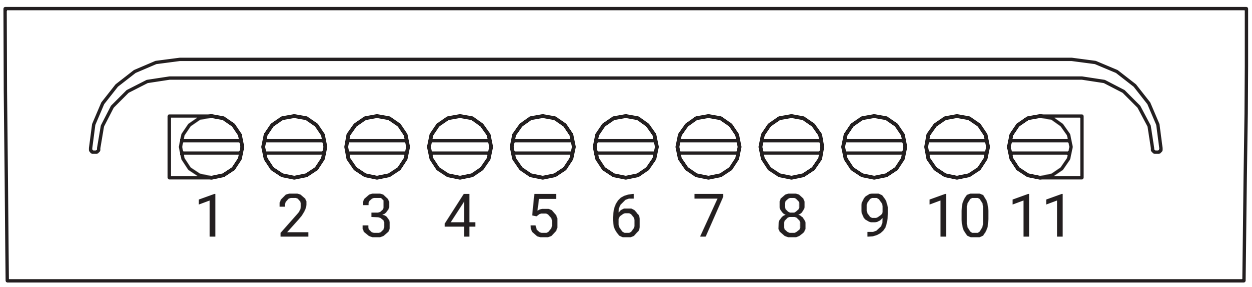


Figure 3.3.8 – Command and signal terminals.

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 (DI1). 5 – Digital İnput 2 (DI2). 6 – Digital input 3 (DI3).	7 – Digital input 4 or analog current output. 8 – Voltage or current analog output. 9 – Relay normally open (NO) contact. 10 – Relay common terminal. 11 – Relay normally closed (NC) contact.

Connections of command terminals

Figure 3.3.8 is used to show the command and control terminals. Below, some possible ways to use these terminals are listed.

Digital inputs

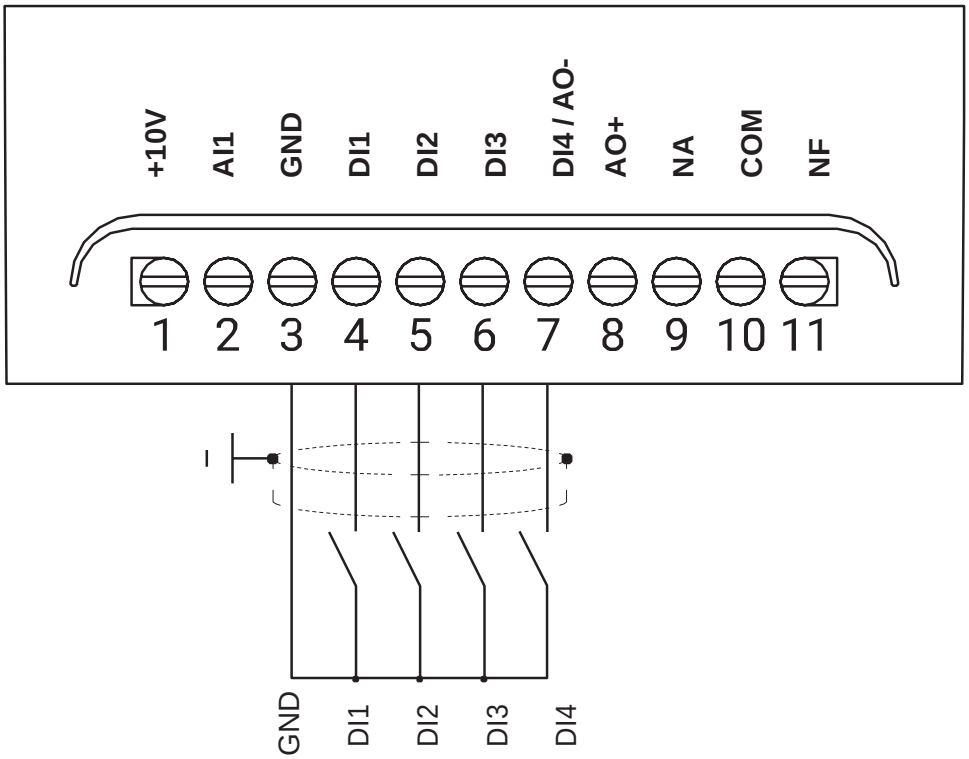


Figure 3.3.9 – Example of digital input connection.

Relay output

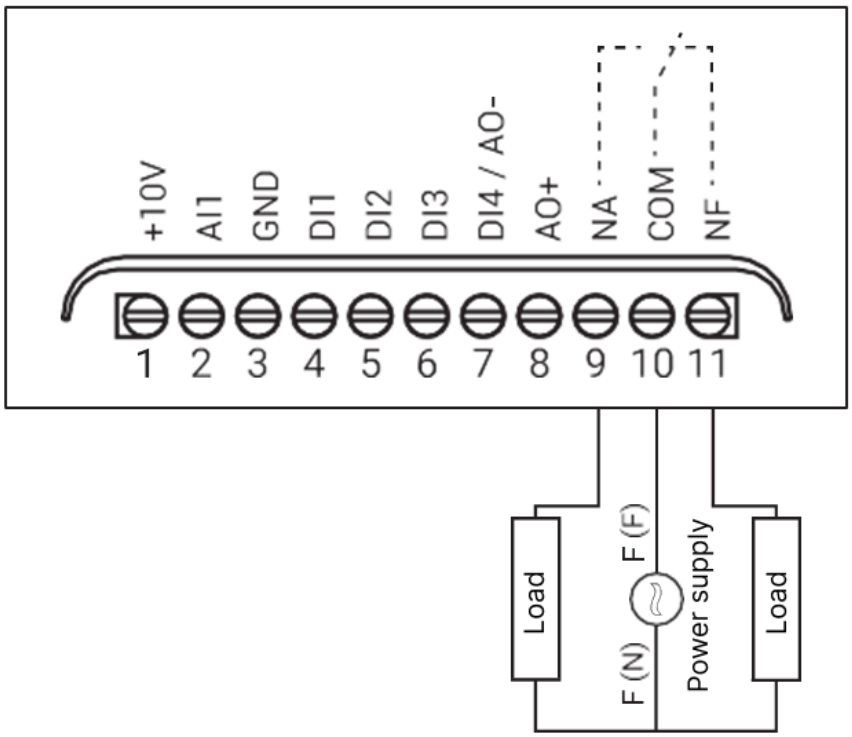


Figure 3.3.10 – Relay output.

Analog input with potentiometer connection

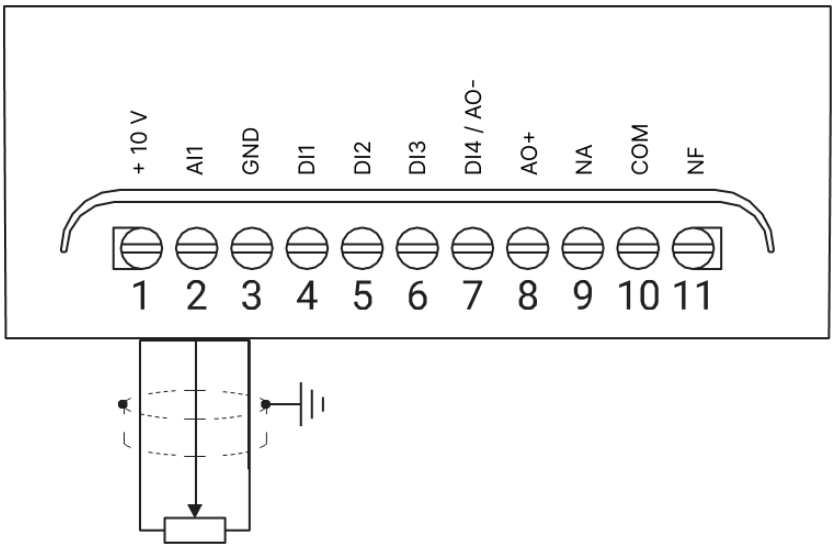


Figure 3.3.11 – Wiring diagram for potentiometer motor speed control.

Analog Input in voltage function with external electrically isolated device

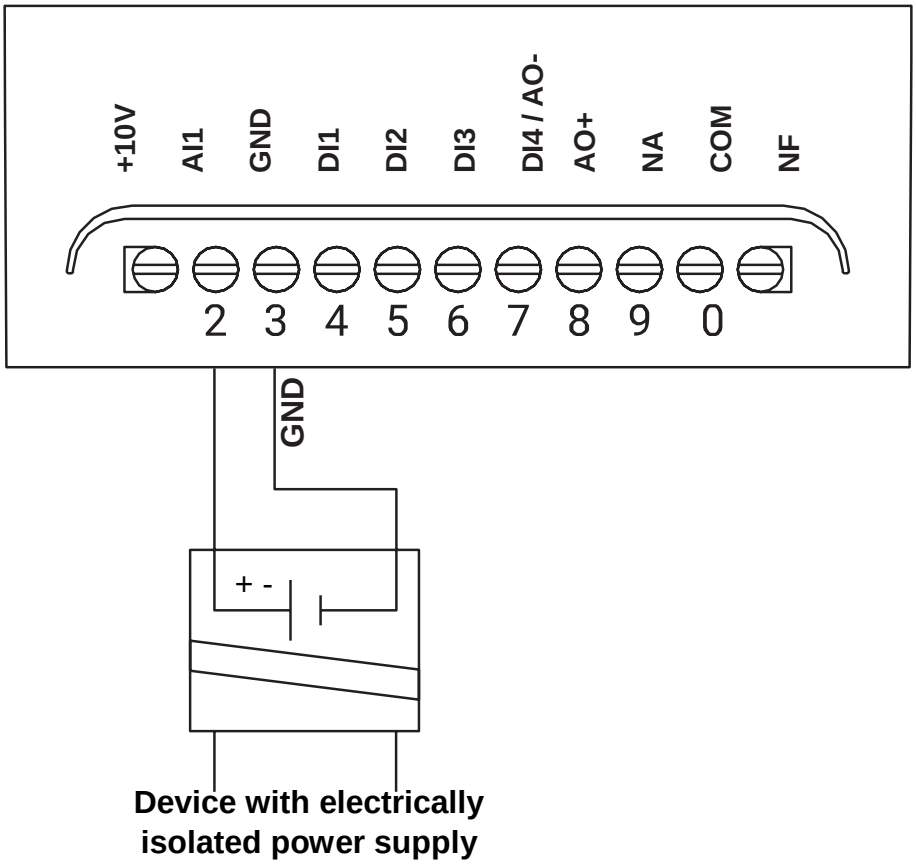


Figure 3.3.12 – Wiring diagram for external device via voltage signal (isolated).

Analog Input in voltage function with non-isolated external device

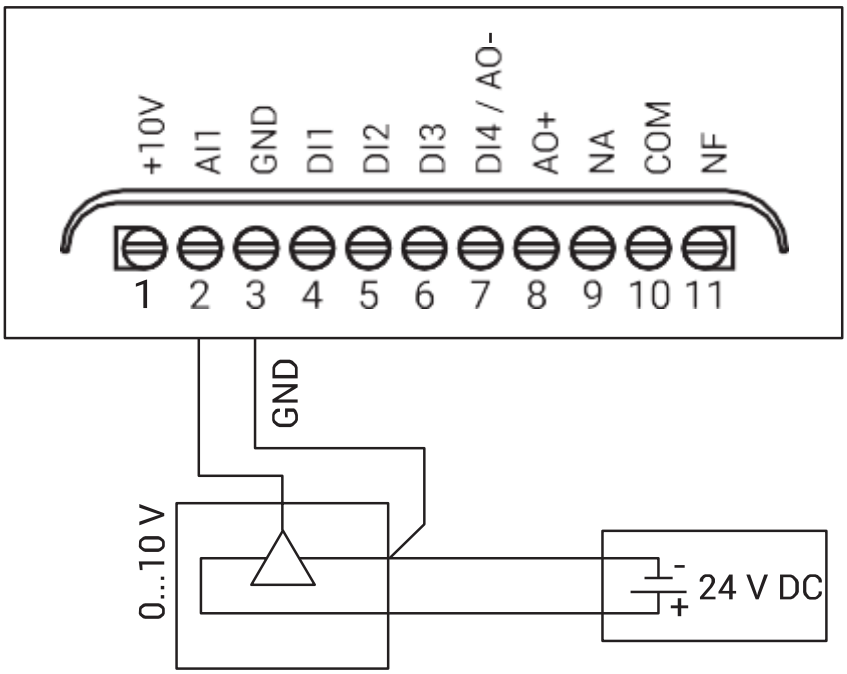


Figure 3.3.13 – Wiring diagram for external device via voltage signal (non-isolated).

Analog voltage output

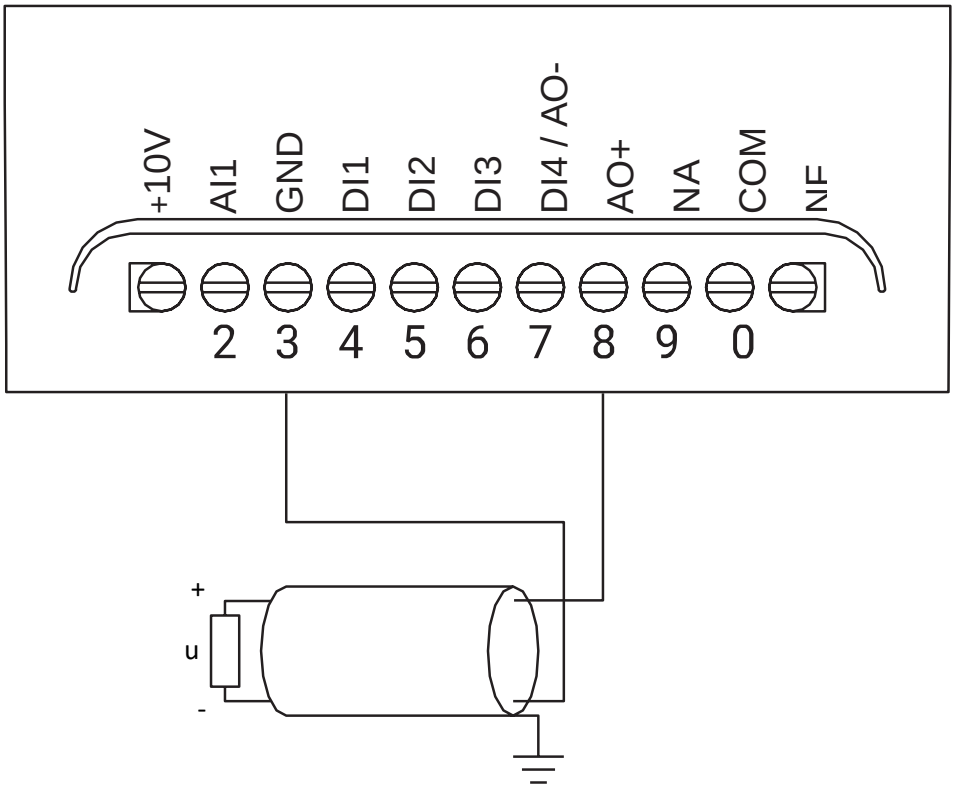


Figure 3.3.14 – Wiring diagram for analog voltage output.

Analog input with current connection and isolated external device

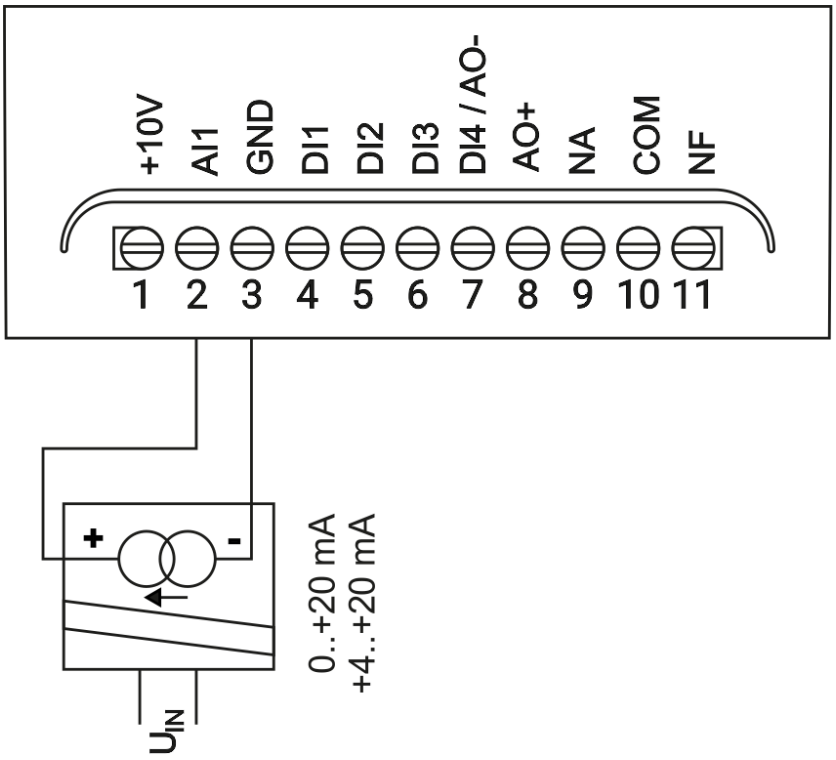


Figure 3.3.15 – Wiring diagram for isolated external device via current signal.

Analog input with current connection and non-Isolated external device

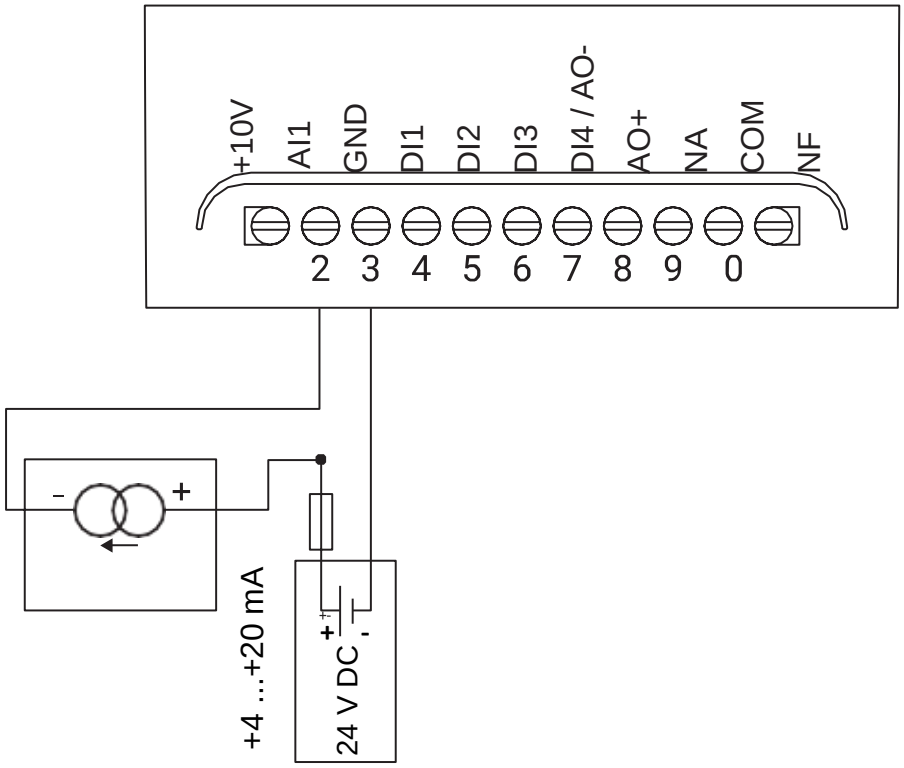


Figure 3.3.16 – Wiring diagram for non-isolated external device via current signal

Analog current output

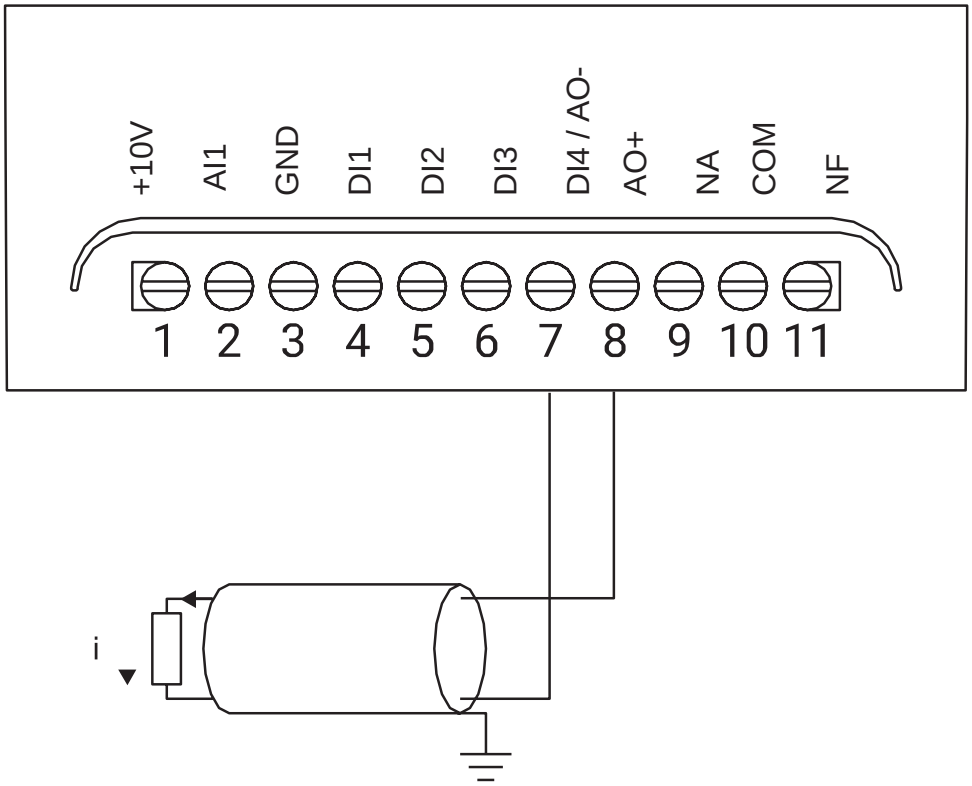


Figure 3.3.17 – Wiring diagram for analog current output.

3.4 Protection

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 3.4.1, as it follows.

Inverter	Fuse [A]	Power supply wiring [mm²]	Ground wiring [m²]
XF2-05	10	1.5	2.5
XF2-10	15	1.5	4
XF2-20	20	2.5	4
XF2-50	32	2.5	6

Table 3.4.1 – 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 1.1.1*. 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.

4.1 Read-only parameters

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

Visualization of the last 5 errors occurred:

- E002 = Power supply overvoltage;
- E003 = Power supply undervoltage;
- E004 = Overtemperature;
- E005 = Overload error defined by P051 parameter;
- E006 = Hardware overcurrent;
- E007 = Hardware failure;
- E008 = Phase Loss at Output;
- E009 = Communication failure with remote HMI or Modbus.

P009 – Visualization of the inverter software version

Indicates the software version present in the inverter.

4.2 Changable 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 directly, according to the values associated to this parameter:

0 = Ramp 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 4.2.1. 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 5 s.

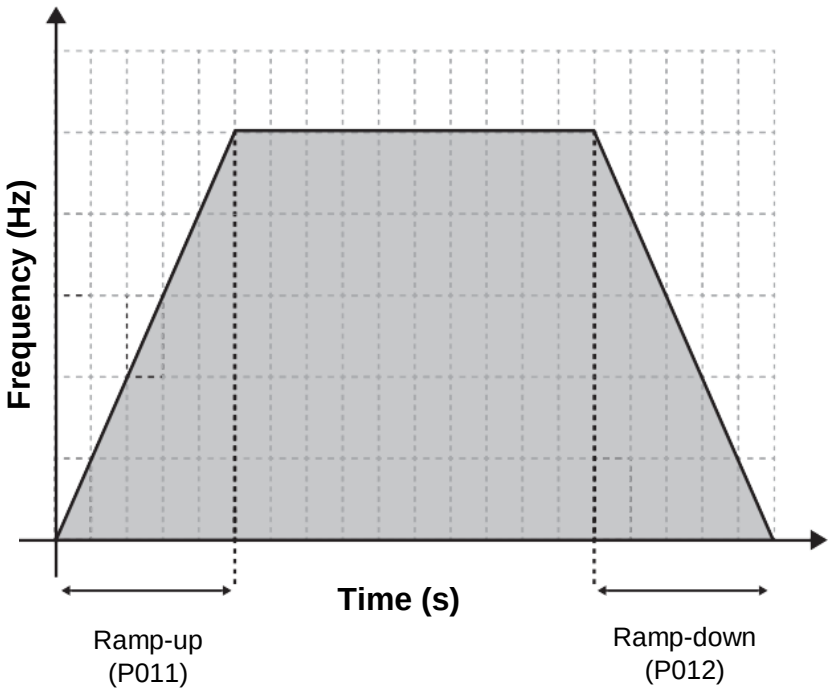


Figure 4.2.1 – Acceleration/Deceleration profile.

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 4.2.1).

P013 – 2nd Ramp-up time

If the inverter is in ramp switching mode via digital inputs (configurable in **P304**), this parameter allows the user to configure the 2nd acceleration ramp, following the same logic as the 1st acceleration ramp (**P011**).

P014 – 2nd Ramp-down time

If the inverter is in ramp switching mode via digital inputs (configurable in **P304**), this parameter allows the user to configure the 2nd deceleration ramp, following the same logic as the 1st deceleration ramp (**P012**).

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.

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, as described above.

P43	Motor	IGBT temperature
5 kHz	 **NOISE**	 **HEAT**
10 kHz		
15 kHz		

Table 4.2.1 – Switching frequency.

- 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.

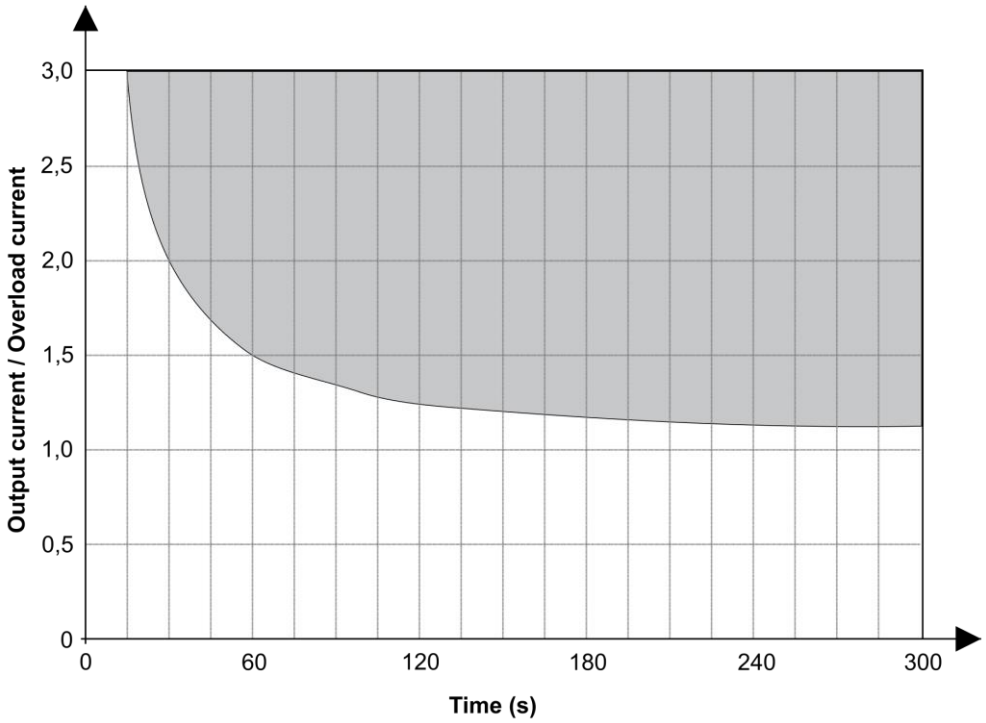


Figure 4.2.2 – Overload curve.

The actuation of the motor overload protection that generates the E005 error follows the curve presented in Figure 4.2.2. 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 60 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 “S.F.”.

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).

P052 – Maximum current control

Defines the maximum current at which the inverter will automatically reduce the motor speed to ensure that the output current does not exceed the programmed value.

Example: Suppose the nominal motor speed is 60 Hz and the expected nominal load results in a current of 3 A. By setting P052 to 3 A, if there is an increase in the motor load, the inverter will automatically adjust the output frequency so that the current remains below 3 A.

- Note 1: This parameter can be disabled by setting the value to “oFF.”
- Note 2: In some cases, there may be oscillatory behaviour in the motor speed due to the load dynamics and the type of control applied.

P053 – Auto-reset

A time (in 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 1 below:

$$AI' = \frac{AI \,.\, G}{100}$$ **Equation 1**

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), P101 = 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).

P101 – Analog input type

Defines the type of analog input used to generate the reference value for motor speed, as follows:

0 = Voltage from 0 to 10 V;

1 = Current from 0 to 20 mA;

2 = Current from 4 to 20 mA.

P102 - Selection of digital input 4 or analog current output A0-

Digital input 4 (DI4) is shared with the analog current output. Therefore, the user must define its function as follows:

If P102 = 0:

Pin 7 = Digital input (DI4);

Pin 8 = Analog voltage output with a range of 0 to 10 Volts (A0+).

If P102 = 1:

Pin 7 = Negative terminal of the analog input (A0-);

Pin 8 = Analog Current Output with a range of 0 to 20 mA (A0+).

If P102 = 2:

Pin 7 = Negative terminal of the analog input (A0-);

Pin 8 = Analog Current Output with a range of 4 to 20 mA (A0+).

Note: If P102 ≠ 0, it is not possible to use the frequency reference via digital potentiometer (P301 = 2) and four-speed multispeed (P301 = 3). See parameter P301.

P103 – Analog output type

Reference for the inverter to generate the analog output, as follows:
0 = oFF: analog output disabled;
1 = Scaled according to the motor frequency (from 0 Hz to the value programmed in P024);
2 = Scaled according to the motor output current.

P104 – Relay output function

Defines the relay behavior, as follows:

0 = When the output frequency is equal to the reference frequency (Fout = Fref);

1 = When the reference frequency is greater than the value programmed in parameter P105 (Fref > P105);

2 = When the output frequency is greater than the value programmed in parameter P105 (Fout > P105);

3 = When the output current is greater than the value programmed in P106 (Iout > P106);

4 = In ‘run’ mode, meaning the relay will activate when the motor is running;

5 = During the motor deceleration ramp;

6 = The relay will remain activated as long as the inverter does not report any errors.

P105 - Output frequency to activate the relay

If P104 = 1 or 2, defines the frequency that will activate the relay output.

P106 - Output current to activate the relay

If P104 = 3, defines the motor output current that will activate the relay output.

P201 - Multi-step speed 1

Frequency Reference 1 for multi-step speed control. See parameter **P301**. Has no effect if P102 = 1 or 2.

P202 - Multi-step speed 2

Frequency Reference 2 for multi-step speed control. See parameter **P301**. Has no effect if P102 = 1 or 2.

P203 - Multi-step speed 3

Frequency Reference 3 for multi-step speed control. See parameter **P301**. Has no effect if P102 = 1 or 2.

P204 - Multi-step speed 4

Frequency Reference 4 for multi-step speed control. See parameter **P301**. Has no effect if P102 = 1 or 2.

P205 - Multi-step speed 5

Frequency Reference 5 for multi-step speed control. See parameter **P301**. Has no effect if P102 = 1 or 2.

P206 - Multi-step speed 6

Frequency Reference 6 for multi-step speed control. See parameter **P301**. Has no effect if P102 = 1 or 2.

P207 - Multi-step speed 7

Frequency Reference 7 for multi-step speed control. See parameter **P301**. Has no effect if P102 = 1 or 2.

P208 - Multi-step speed 8

Frequency Reference 8 for multi-step speed control. See parameter **P301**. Has no effect if P102 = 1 or 2.

P301 - Inverter output frequency setting

<table>
<tr><th>P301 value</th><th>Reference type</th></tr>
<tr><td>0</td><td>Analog input: see parameters P100 and P101. The frequency reference will be proportional to the reading value of the analog input within the limits of P023 and P024.</td></tr>
<tr><td>1</td><td>HMI keyboard: 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.</td></tr>
<tr><td>2</td><td>Electronic potentiometer (digital inputs DI3 and DI4): while the state of DI3 is high, the output frequency is continuously increased. Similarly, while the state of DI4 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. *Without effect if P102 = 1 or 2.</td></tr>
<tr><td>3</td><td>Multi-step speed: It allows the speed to be varied to predetermined values according to the states of the digital inputs DI2 (if P304 = 3), DI3, and DI4. These values are programmed in parameters P201 to P208. The speed configuration is done according to the following table, if P102 = 0:
<table>
<tr><th></th><th>DI2</th><th>DI3</th><th>DI4</th><th>REFERENCE VALUE</th></tr>
<tr><td rowspan="8">If P304 = 3</td><td>0</td><td>0</td><td>0</td><td>Value set in P201</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>Value set in P202</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>Value set in P203</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>Value set in P204</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>Value set in P205</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>Value set in P206</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>Value set in P207</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>Value set in P208</td></tr>
</table>
</td></tr>
<tr><td>4</td><td>Modbus: Described in Chapter 5.</td></tr>
</table>

Table 4.2.2 – 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). Behaviour of DI2 is defined in P304.
2	**Command via digital input (Forward/Reverse):** If DI1 is high, forward (motor running in the normal direction); if DI2 is high, reverse (reverse direction). If P304 = 2, the second ramp is used for this function.
3	**Modbus:** Commands performed by Modbus communication. See Chapter 5.

Table 4.2.3 – 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:** Normal rotation direction; if high, reverse direction.
1	**If P302 = 1:** Second ramp – If the state of DI2 is low, ramp according to P011 and P012; if high, ramp according to P013 and P014.
2	**If P302 = 2:** Forward on the first ramp, reverse on the second ramp – When DI1 is low and DI2 is high, ramp according to P013 and P014 and reverse the rotation direction.
3	**If P302 = 1:** Multi-step speed – DI2 is part of the logic for selecting the speed in the multispeed frequency reference, determining whether 4 or 8 speeds will be used in multispeed. See parameter P301.
4	**If P302 = 1:** General enable – If DI2 is low, the inverter is disabled and displays the message STOP; if high, the inverter is enabled.

Table 4.2.4 – DI2 function.

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

P305 – Selection of logic levels for digital 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.

P401 – Percentage of nominal current during DC braking

Defines the value of DC current that will be applied to the motor during DC braking. This value is expressed as a percentage of the motor's nominal current, as defined in parameter P602, according to the Equation 2 as it follows:

$$I_{cc} = \frac{K \cdot I_{NOM}}{100}$$ **Equation 2**

Where:

- ***Icc*** is the current applied to the motor during DC braking;
- ***K*** is the value of P401;
- I_{NOM} is the nominal current value of the motor specified in parameter P602.

Example: If the motor to be driven has a nominal current of 6.5 A (P602 = 6.5) and the desired DC braking current is 15% of the nominal current, i.e., P401 = 15, then the current applied to the motor during DC braking will be 975 mA.

P402 – DC braking duration at start

Define o tempo em que a corrente CC definida no parâmetro P401 será aplicada ao motor na partida. No momento em que a saída do inversor é habilitada, a corrente CC é aplicada ao motor pelo tempo definido neste parâmetro e ao fim deste tempo o motor acelera para frequência de referência de acordo com as configurações.

P403 - DC braking duration at stop

Defines the time during which the DC current specified in parameter P401 will be applied to the motor at stop. After the inverter output is disabled, the motor decelerates according to the defined settings, and when it reaches the braking frequency (P404), the DC current is applied to the motor for the duration specified in this parameter.

P404 - Braking frequency at stop

Defines the frequency at which DC braking is initiated at stop. After the inverter output is disabled, the motor decelerates according to the defined settings, and when it reaches the braking frequency, the DC current specified in P401 is applied to the motor for the duration defined in P403.

P501 - Frequency band to be avoided

Defines a frequency band to be avoided at the inverter output. See parameters P502, P503, and P504.

P502 - Frequency 1 to be avoided

Defines a frequency to be avoided, meaning the inverter will not operate continuously at the frequency specified in this parameter and within the range defined by parameter P501, as shown in Figure 4.2.5.

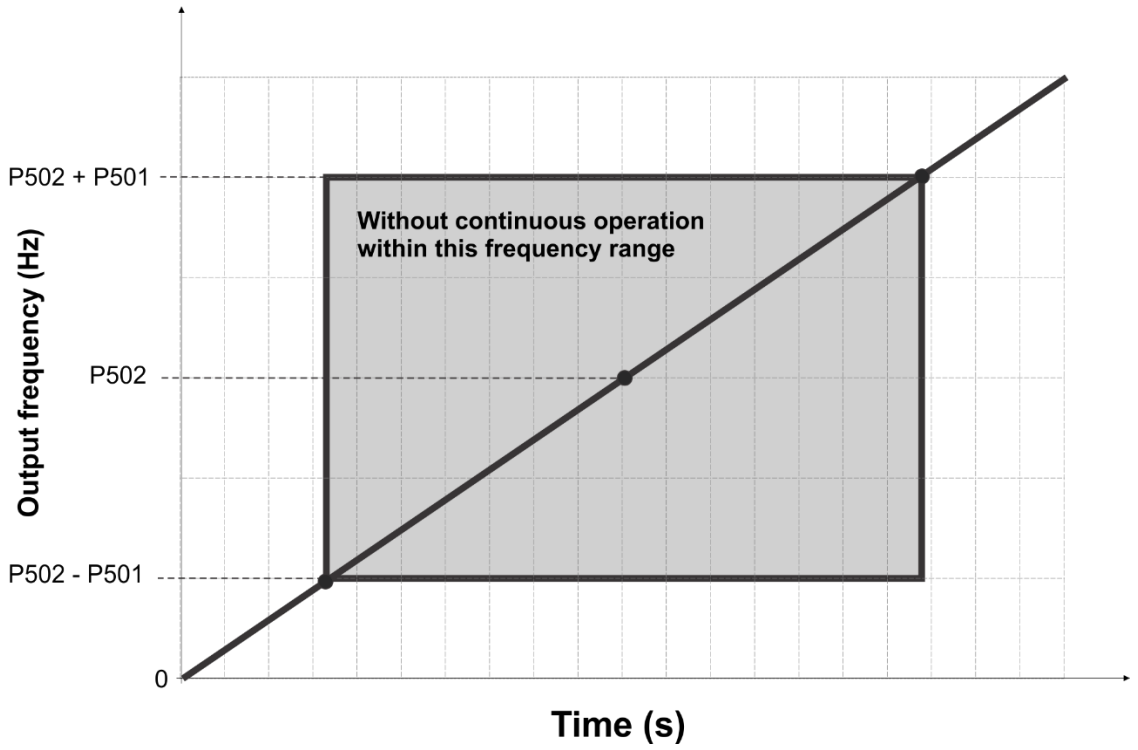


Figure 4.2.3 – DI2 function.

Example: Suppose the frequency to be avoided is 15 Hz (P502 = 15) and the band to be avoided is 5 Hz (P501 = 5). Thus, if the frequency reference is between 10 Hz and 20 Hz (range P502 - P501 to P502 + P501), depending on the command condition (accelerating or decelerating to a new reference), the entire range will be avoided. That is, the inverter will transition from 10 Hz to 20 Hz considering the acceleration ramp, as well as from 20 Hz to 10 Hz considering the deceleration ramp.
Note: If the result of P502 - P501 is less than P023, the value of P023 prevails, and if the result of P502 + P501 exceeds P024, the value of P024 prevails.

P503 – Frequency 2 to be avoided

Defines a second frequency to be avoided. See Figure 4.2.3 and the example provided in parameter P502.

Note: If the result of P503 - P501 is less than P023, the value of P023 prevails, and if the result of P503 + P501 exceeds P024, the value of P024 prevails.

P504 - Frequency 3 to be avoided

Defines a frequency to be avoided. See Figure 4.2.3 and the example provided in parameter P502.

Note: If the result of P504 - P501 is less than P023, the value of P023 prevails, and if the result of P504 + P501 exceeds P024, the value of P024 prevails.

P601 – Control type

Defines the mode in which the motor's rotation speed will be controlled.

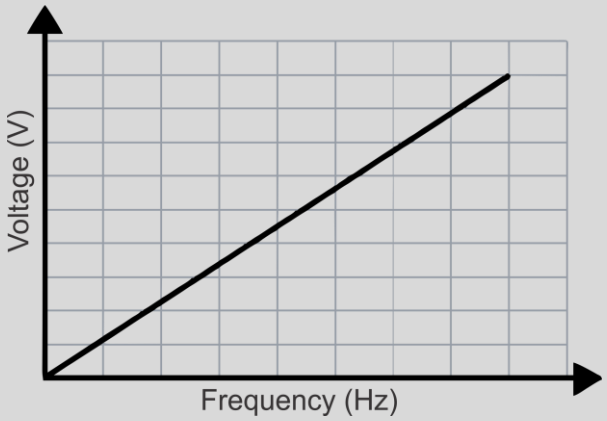
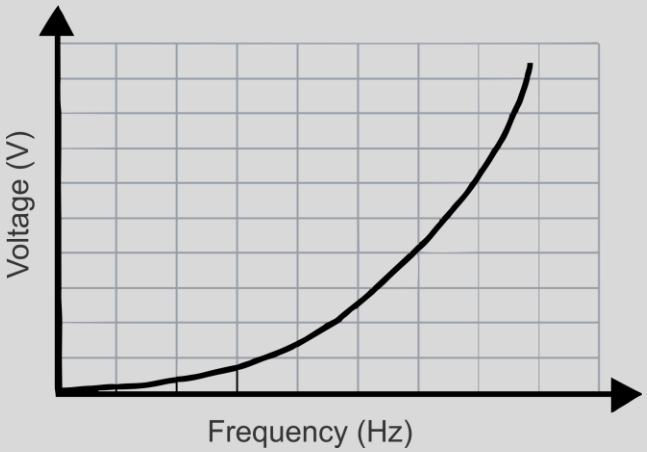
Control type	Output frequency behaviour
0 - V/f Linear	Linear V/f control adjusts the output frequency and voltage in a linear manner, meaning that the frequency is directly proportional to the voltage. 
1 - V/f Quadratic	In quadratic V/f control, the voltage is proportional to the square of the frequency. This reduces energy consumption at low frequencies and mitigates potential current spikes. It is recommended to use this type of control with low-inertia loads. 

Table 4.2.5 – Control type.

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.

P604 - Rated motor current

This parameter should be adjusted according to the rated current information available on the motor nameplate.

WARNING!

It is very important to adjust this parameter correctly, as the value of P602 is used in the calculation of the DC current applied during DC braking (see parameter P401). Incorrect values may result in the application of excessive DC current, potentially damaging the motor.

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 3.3.20 – Parity types.

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 Pro inverter family features native Modbus communication, meaning no additional module is required. The implemented protocol is Modbus RTU. Modbus communication allows the device to be remotely controlled and included in a communication network. The following section describes the basic principles of operation. In this section, decimal numbers are displayed without a suffix, hexadecimal numbers are displayed with the suffix 'h', and bits are displayed with the suffix 'b'.

Hardware and connection

The physical layer protocol used is the EIA/TIA-485 standard. In the AG Drive family, RS-485 is implemented in half-duplex mode, where sending and receiving messages is done over the same bus. The physical medium used is the TIA/EIA-568-B.1-2001 Category 6 (CAT6) cable or Category 5/5e (CAT5) for backward compatibility. The connection to the inverter uses an RJ-45 connector.

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 is the Daisy Chain, as illustrated in Figure 5.1.1, 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.

One implementation method is using a Y adapter with connections as shown in Figure 5.1.2.

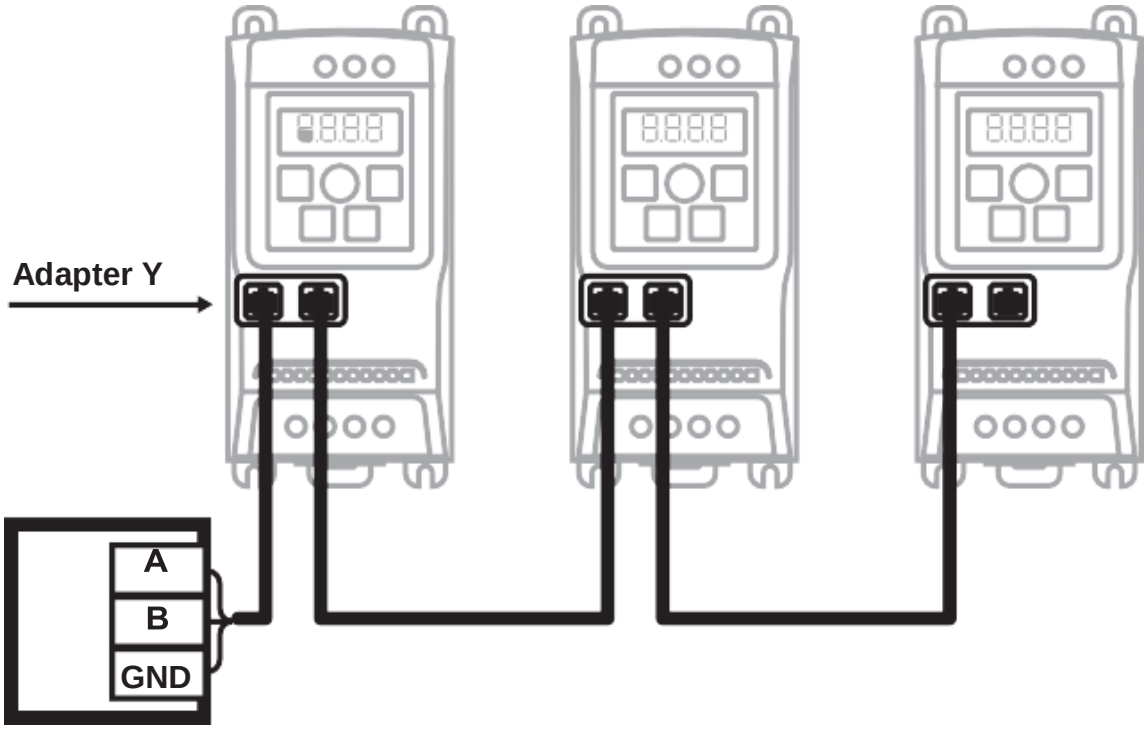


Figure 5.1.1 – Daisy Chain connection example.

WARNING!

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

To implement the Daisy Chain topology, it is recommended to use a Y adapter to avoid splices and faulty connections between devices with RJ-45 connectors. There are various models of this adapter, so ensure that the selected adapter has connections as shown in Figure 5.1.1 and that the connections conform to the following figure.

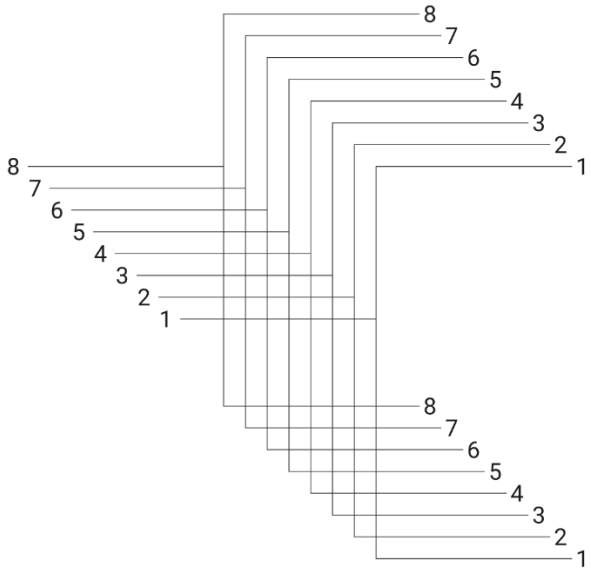
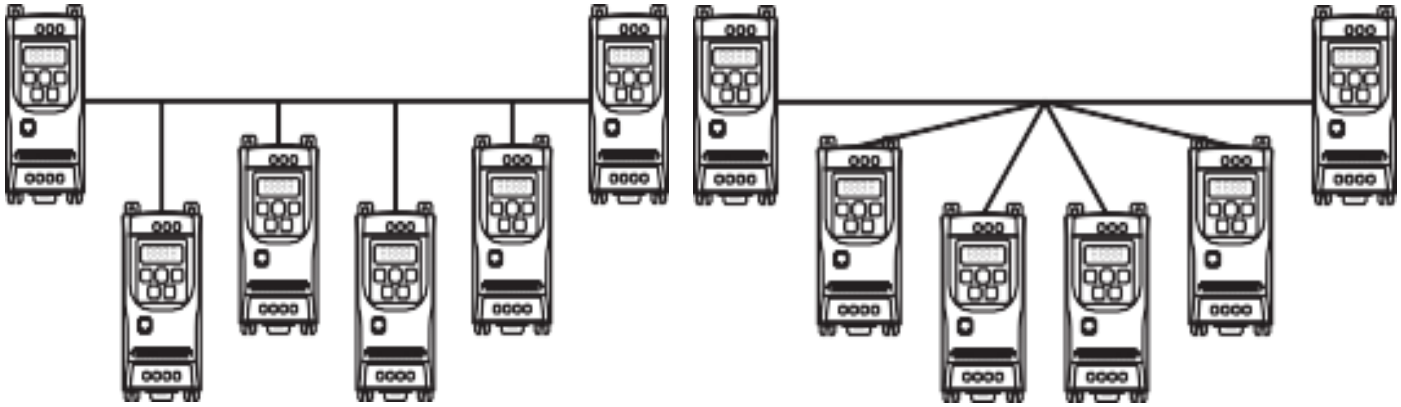


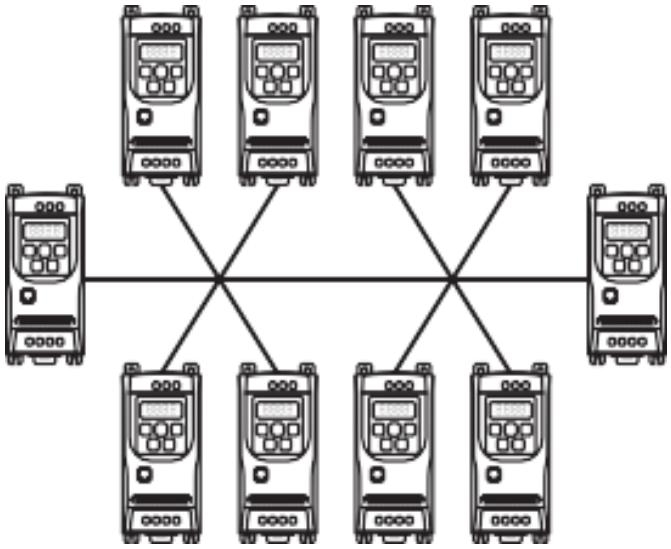
Figure 5.1.2 – Adapter Y connection

Other connection methods are acceptable or should be avoided, as shown in Figure 5.1.2.



Bus with branches (acceptable).

Star topology (inadmissible).



Star bus topology (inadmissible).

Ring topology (inadmissible).

Figure 5.1.3 – Network connection methods

The following table shows the wiring diagram for the inverter's RJ-45 port.

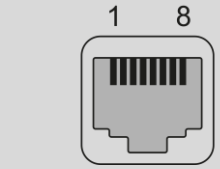
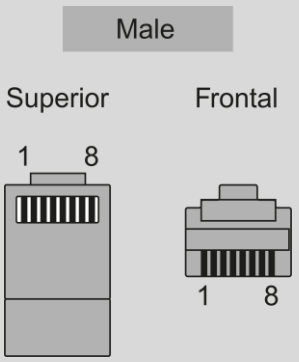
Connectors	RJ-45 connector pin	Function	Description
Female  Male 	1 and 8	GND	Ground. Common point of the circuit. Do not confuse with protective ground or panel ground.
	2	+15 Vcc	Output voltage +15 V @ 400 mA. Can be used to power peripheral devices.
	3	B	Do not use.
	4	A	RS-485 A. Low for logical state 1, high for logical state 0.
	5	B	RS-485 B. Low for logical state 0, high for logical state 1.
	6	A	Do not use.
	7	+5 Vcc	Output voltage +5 V @ 100 mA. Can be used to power communication interfaces.

Table 5.1.1- Connector pins description

NOTE

The network master device 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 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 t able below:

Baud rate (b/s)	Bit time (us)	Character time (ms)	3.5 times 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 5.2.1 – Character time.

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 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, the inverter simply does not provide any response.

The only type of Modbus RTU protocol variable implemented in AG Drive 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 four 4-bit hexadecimal characters, and the register values are transmitted in two 8-bit fields. The first field contains the two most significant 4-bit characters (Hi), and the second field contains the two least significant characters (Lo). For example, register 4100 stores the inverter status. Converting this to hexadecimal results in 1004h. Thus, the first field of the register will be 10h, and the second will be 04h.

There are examples of requests and responses for the implemented tasks below.

- **Reading Example:** Check the ramp-up time of the inverter, parameter P011 (factory value 10 s), by reading register 10 (0Ah). In Table 5.2.2, 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 5.2.2 – Reading example.

- **Writing example:** Activating the inverter via Modbus by writing the value 1 to register 4101 (1005h). The request and response are presented in Table 5.2.3.

Request (*Master*)		Answer (*Slave*)	
Field	Value	Field	Value
Slave address	01h	Slave address	01h
Function code	06h	Function code	06h
Register number (Hi)	10h	Bytes counting	10h
Register number (Lo)	05h	Register data (Hi)	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 5.2.3 – Writing example.

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.

5.3 Controlling the inverter via Modbus

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 5.3.1.

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. For example, if the desired frequency is 46.8 Hz, the value to be written in the register is 4680.
4107	**Rotation Direction:** Sets the rotation direction. Writing 0 sets the direction to standard, writing 1 sets the direction to reverse.

Table 5.3.1 - 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 6 – Technical specifications

Parameters	Model				
	XF2-05	XF2-10	XF2-20	XF2-30	XF2-50
Maximum motor power	0.5 HP	1 HP	2 HP	3 HP	5 HP
Rated output current	2.6 A	4.0 A	7.3 A	10 A	16 A
Maximum output current	3.4 A	5.2 A	9.5 A	15 A	24 A
Maximum input current	5.1 A	7.8 A	14.3 A	18 A	18 A
Dynamic braking, resistor ≥ 30 ohms	No			Yes	
Power supply	Single-phase / two-phase			Single-phase / two-phase/ three-phase	Three-phase
Rated voltage	200 to 240 Vac RMS				
Input frequency	50 to 60 Hz				
Output frequency	0 to 500 Hz			0 to 60 Hz	
Switching frequency	5k, 10k and 15 kHz				
Type of control	V/f and quadratic				
Protection index	IP20				
Operation temperature	0 to 50 °C				
Relative humidity	5 to 90%			10 to 90%	
Analog input	1 input (0 to 10 V, 0 to 20 mA and 4 to 20 mA)				
Analog output	1 output (0 to 10 V, 0 to 20 mA and 4 to 20 mA)				
Digital input	4 digital inputs				
Relay output	1 contact NO/NF (7 A / 220 V)				
Communication	Modbus RTU				
Output voltage at maximum frequency	220 VAC (three-phase)				

AGEON
Electronic Controls

www.ageon.com.br

blog.ageon.com.br
facebook.com/AgeonElectronicControls
instagram.com/ageonelectroniccontrols
twitter.com/AgeonElectronic
youtube.com/c/AgeonBr
linkedin.com/company/ageon-electronic-controls