

**VACON<sup>®</sup> 20 X**  
AC DRIVES

**INSTALLATION, TECHNICAL AND MAINTENANCE  
MANUAL**

**VACON<sup>®</sup>**



**INDEX**

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## 1. SAFETY

This manual contains clearly marked warning information which is intended for your personal safety and to avoid any unintentional damage to the product or connected appliances.

**Please read the warning information carefully.**




**VACON® 20 X is a drive designed to control asynchronous AC motors and permanent magnet motors. The product is intended to be installed in a restricted access location and for a general purpose use.**

**Only VACON® authorized, trained and qualified personnel are allowed to install, operate and maintain the drive.**

### 1.1 SIGNS

The cautions and warnings are marked as follows:

*Table 1. Warning signs.*

	= <b>DANGEROUS VOLTAGE!</b>
	= <b>HOT SURFACE!</b>
	= <b>WARNING or CAUTION</b>

### 1.2 UNITS

The dimensions used in this manual conform to International Metric System units, otherwise known as SI (Système International d'Unités) units. For the purpose of the equipment's UL certification, some of these dimensions are accompanied by their imperial equivalents.

*Table 2. Unit conversion table.*

Physical dimension	SI value	US value	Conversion factor	US designation
length	1 mm	0.0394 inch	25.4	inch
Weight	1 kg	2.205 lb	0.4536	pound
Speed	1 min <sup>-1</sup>	1 rpm	1	revolution per minute
Temperature	1 °C (T1)	33.8 °F (T2)	$T2 = T1 \times 9/5 + 32$	Fahrenheit
Torque	1 Nm	8.851 lbf in	0.113	pound-force inches
Power	1 kW	1.341 HP	0.7457	horsepower

**1.3 DANGER**

The **components of the power unit of VACON® 20 X drives are live** when the drive is connected to the mains potential. Coming into contact with this voltage is **extremely dangerous** and may cause death or severe injury.

---



The **motor terminals (U, V, W) are live** when VACON® 20 X Drive is connected to the mains, even if the motor is not running.

---



**After disconnecting** the AC drive from the mains, **wait** until the indicators on the keypad go out (if no keypad is attached, see the indicators on the cover). Wait an additional 30 seconds before starting any work on the connections of VACON® 20 X Drive. After expiration of this time, use measuring equipment to absolutely ensure that no voltage is present. **Always ensure absence of voltage before starting any electrical work!**

---



The control I/O-terminals are isolated from the mains potential. However, the **relay outputs and other I/O-terminals may have a dangerous control voltage** present even when VACON® 20 X Drive is disconnected from the mains.

---



During a coast stop (see the Application Manual), the motor is still generating voltage to the drive. Therefore, do not touch the components of the AC drive before the motor has completely stopped. Wait until the indicators on the keypad go out (if no keypad is attached, see the indicators on the cover). Wait an additional 30 seconds before starting any work on the drive.

## 1.4 WARNINGS



VACON<sup>®</sup> 20 X AC drive is meant for **fixed installations only**.



**Only DVC A circuits (Decisive Voltage Class A, according to IEC 61800-5-1) are allowed to be connected to the control unit.** This advice aims to protect both the drive and the client-application. VACON<sup>®</sup> is not responsible for direct or consequential damages resulting from unsafe connections of external circuits to the drive. See paragraph 1.6 for more details.



**Do not perform any measurements** when the AC drive is connected to the mains.



The **touch current** of VACON<sup>®</sup> 20 X drives exceeds 3.5mA AC. According to standard EN61800-5-1, a **reinforced protective ground connection** must be ensured. See paragraph 1.5.



If the AC drive is used as a part of a machine, the **machine manufacturer is responsible** for providing the machine with a **supply disconnecting device** (EN 60204-1). See paragraph 4.1



Only **spare parts** supplied by VACON<sup>®</sup> can be used.



At power-up, power brake or fault reset, **the motor will start immediately** if the start signal is active, unless the pulse control for Start/Stop logic has been selected. Furthermore, the I/O functionalities (including start inputs) may change if parameters, applications or software are changed. Disconnect, therefore, the motor if an unexpected start can cause danger. This is valid only if STO inputs are energized. For prevention on unexpected restart, use appropriate safety relay connected to the STO inputs.



The **motor starts automatically** after automatic fault reset if the autoreset function is activated. See the Application Manual for more detailed information. This is valid only if STO inputs are energized. For prevention on unexpected restart, use appropriate safety relay connected to the STO inputs.



**Before performing any measurement on the motor or the motor cable**, disconnect the motor cable from the AC drive.



Do not perform any voltage withstand test on any part of VACON<sup>®</sup> 20 X. The tests shall be performed according to a specific procedure. Ignoring this procedure may damage the product.



**Do not touch the components on the circuit boards.** Static voltage discharge may damage the components.



Check that the **EMC level** of the AC drive corresponds to the requirements of your supply network.



In a domestic environment, this product may cause radio interference, in which case supplementary mitigation measures may be required.




Optional keypad is IP66/Type 4X outdoor rated. Strong exposure to direct sunlight or to heavy temperatures might cause the degradation of display LCD.



## 1.5 GROUNDING AND EARTH FAULT PROTECTION



### CAUTION!

The VACON® 20 X AC drive must always be grounded with a grounding conductor connected to the grounding terminal marked with .

Since the touch current exceeds 3.5 mA AC (for the three-phase version), according to EN61800-5-1, the drive must have a fixed connection and provision of an additional terminal for a second protective grounding conductor of the same cross-sectional area as the original protective grounding conductor.

Three screws (for the three-phase version) are provided for: the ORIGINAL protective grounding conductor, the SECOND protective conductor and the MOTOR protective conductor (the customer can choose the screw for each one). See Figure 1 for the location of the three screws in the two possible options available.

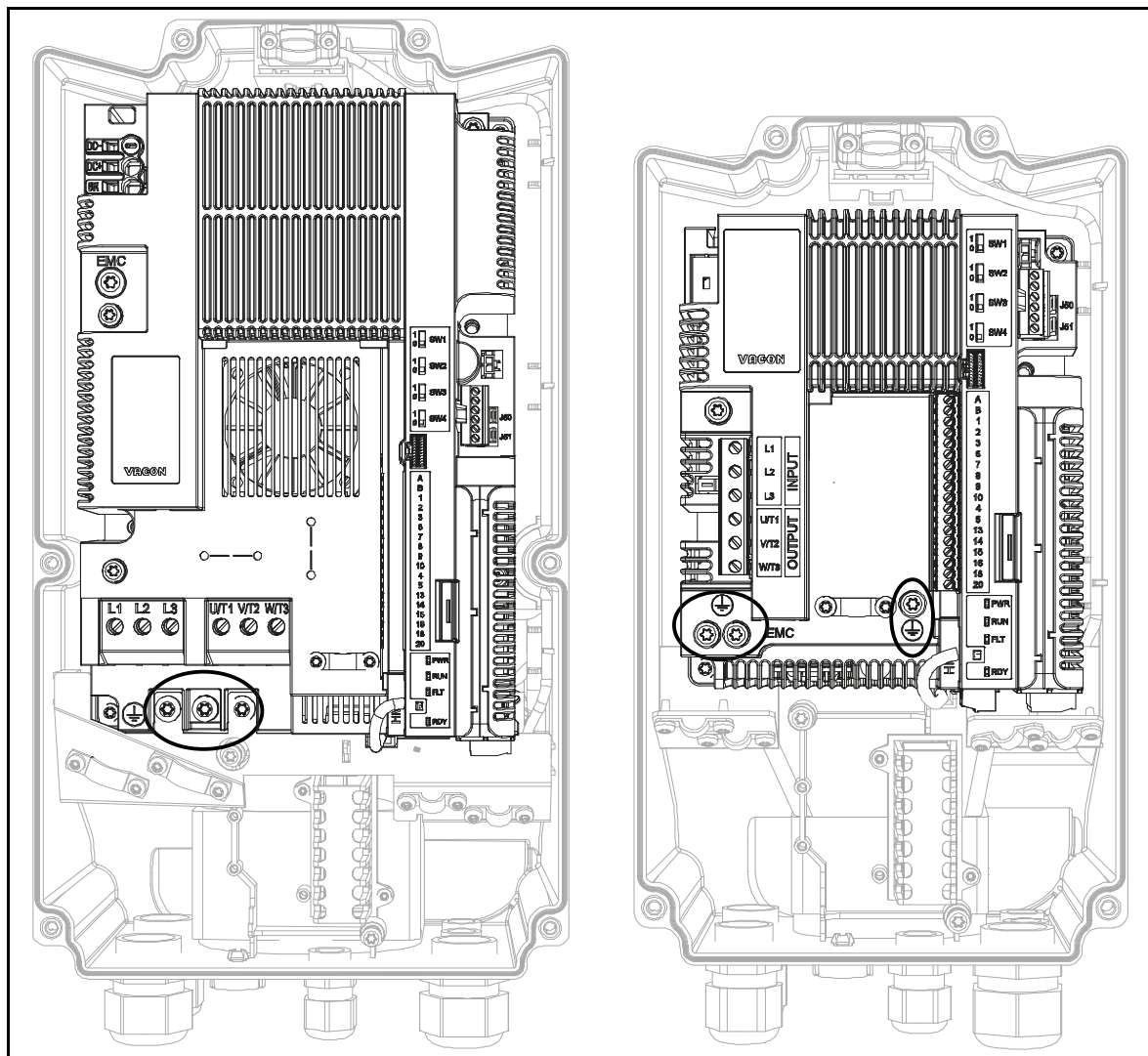


Figure 1. Protective grounding connections MU2 and MU3, three-phase version.

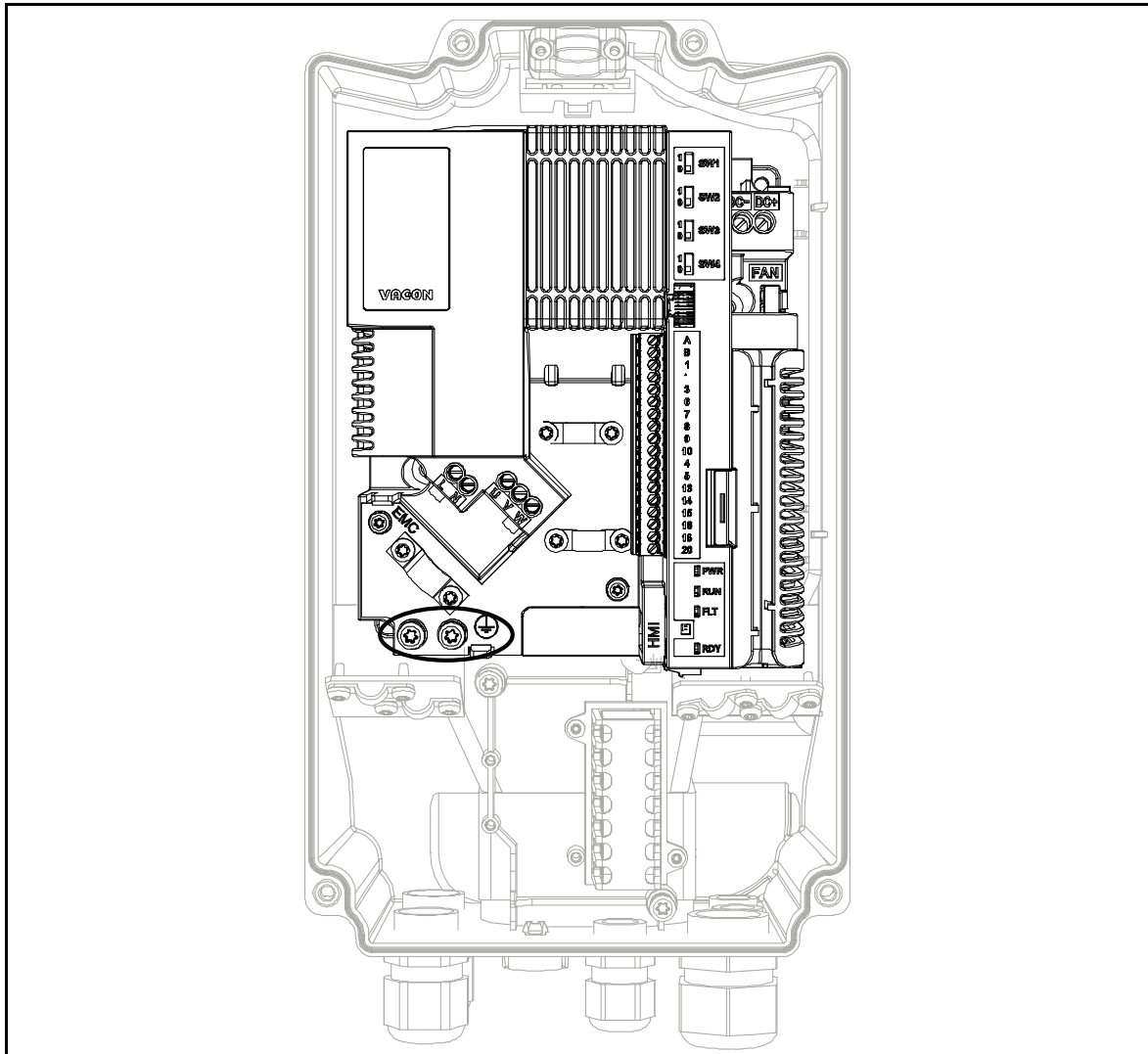


Figure 2. Protective grounding connections MU2, single-phase version.

In VACON<sup>®</sup> 20 X, the phase conductor and the corresponding protective grounding conductor can be of the same cross-sectional area, provided they are made of the same metal (because the cross-sectional area of the phase conductor is less than 16 mm<sup>2</sup>).

The cross-sectional area of every protective grounding conductor which does not form a part of the supply cable or cable enclosure must not, in any case, be less than:

- 2.5 mm<sup>2</sup> if mechanical protection is provided or
- 4 mm<sup>2</sup> if mechanical protection is not provided. For cord-connected equipment, provisions shall be made so that the protective grounding conductor in the cord must, in the case of failure of the strain-relief mechanism, be the last conductor to be interrupted.

**However, always follow the local regulations for the minimum size of the protective grounding conductor.**

**NOTE:** Due to the high capacitive currents present in the AC drive, fault current protective switches may not function properly.

## 1.6 INSULATION SYSTEM



Please, consider carefully the insulation system depicted in Figure 2, before connecting any circuit to the unit.



The control unit of VACON® 20 X fulfils the insulation requirements of the standard IEC 61800-5-1 regarding DVC A circuits and also the strongest insulation requirements of IEC 60950-1 regarding SELV circuits.

A distinction has to be made for the following three groups of terminals, according to the insulation system of VACON® 20 X:

- Mains and motor connections (L1, L2, L3, U, V, W) or (L, N, U, V, W)
- Relays (R01, R02)<sup>(\*\*)</sup>
- Control terminals (I/Os, RS485, STO)

The Control terminals (I/Os, RS485, STO) are isolated from the Mains (the insulation is reinforced, according to IEC 61800-5-1) and **the GND terminals are referred to PE**.

This is important when you need to connect other circuits to the drive and test the complete assembly. Should you have any doubts or questions, please contact your local VACON® distributor.

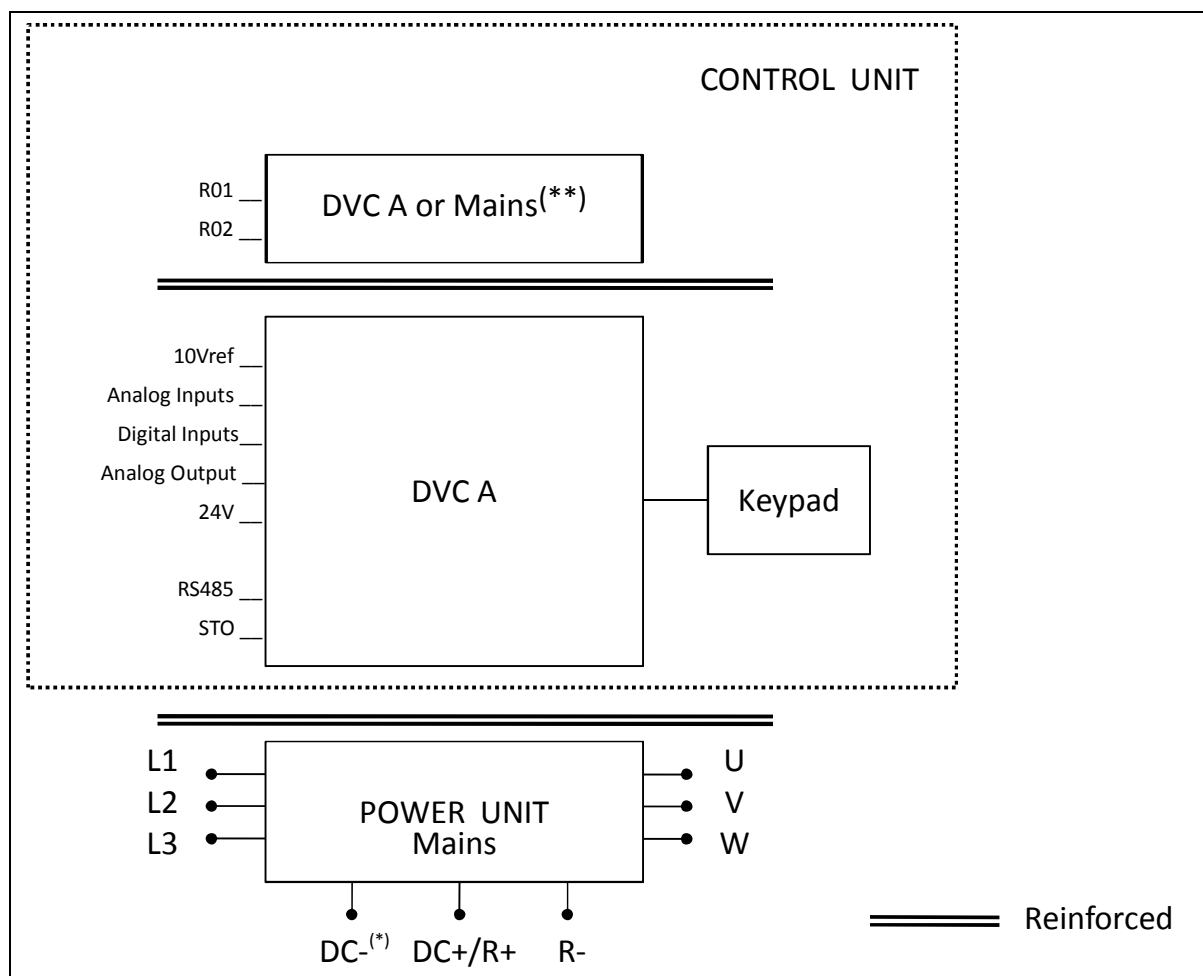


Figure 3. Insulation system (three-phase version).

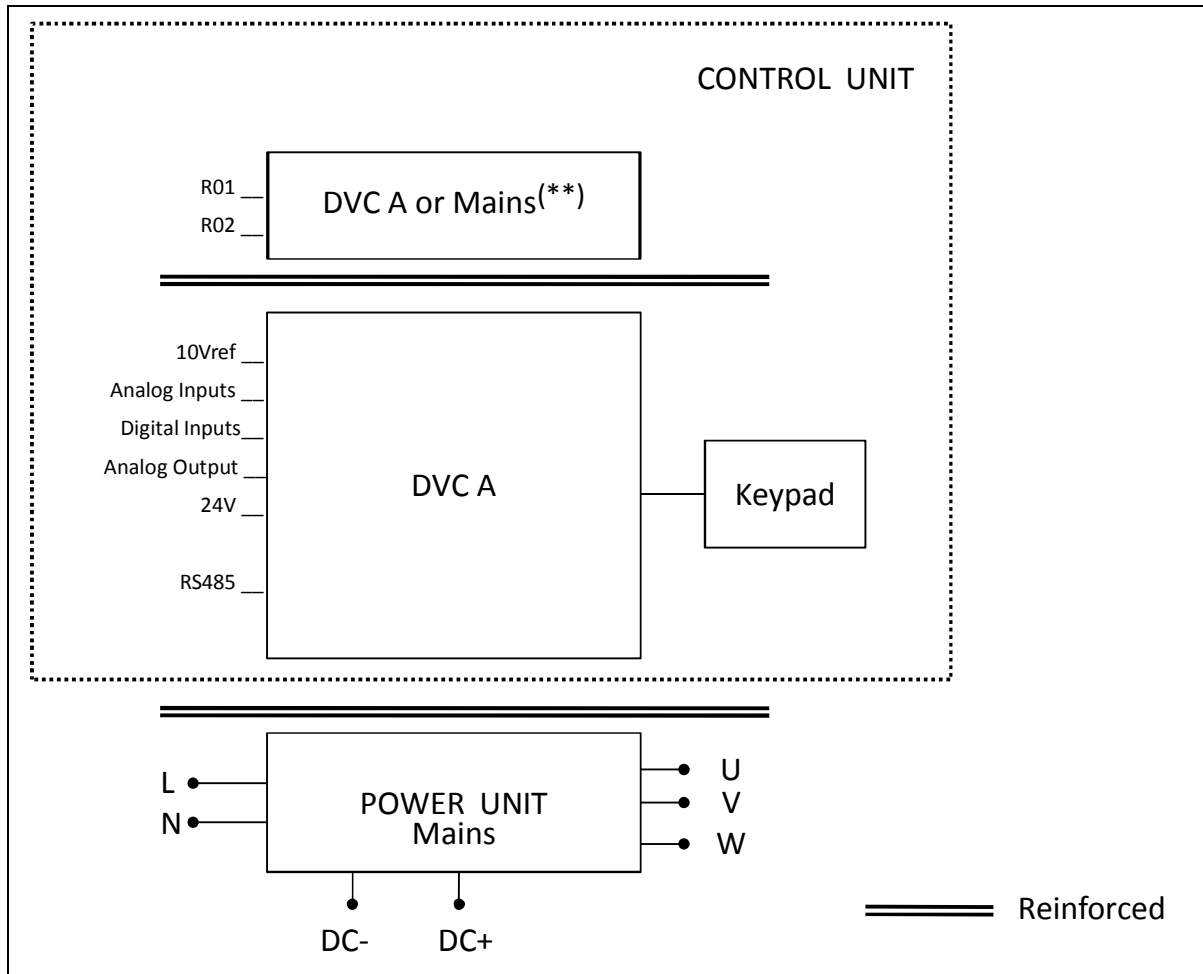


Figure 4. Insulation system (single-phase version).

(\*) Only for 3~ units.



(\*\*) The relays may be used also with DVC A circuits. This is possible only if both relays are used for DVC A circuitry: **to mix Mains and DVC A is not allowed.**



By performing the cabling, a suitable clearance has to be guaranteed between DVC A circuits and Mains (reinforced insulation is required, according to IEC 61800-5-1).



1.7 COMPATIBILITY WITH RCDs



This product can cause a d.c. current in the protective grounding conductor. Where a residual current-operated protective (RCD) or monitoring (RCM) device is used for protection in case of direct or indirect contact, only an RCD or RCM of Type B is allowed on the supply side of this product.

### 1.8 EXTENDED TEMPERATURE RANGE

VACON<sup>®</sup> 20 X has **an integrated cooling system**, independent from the motor fan. Under maximum operating conditions, the ambient temperature cannot exceed **40 °C**. See Table 28 for the output rated current. Higher temperatures are allowed only with derating of the output current. With derating the unit can **operate up to 50°C**.

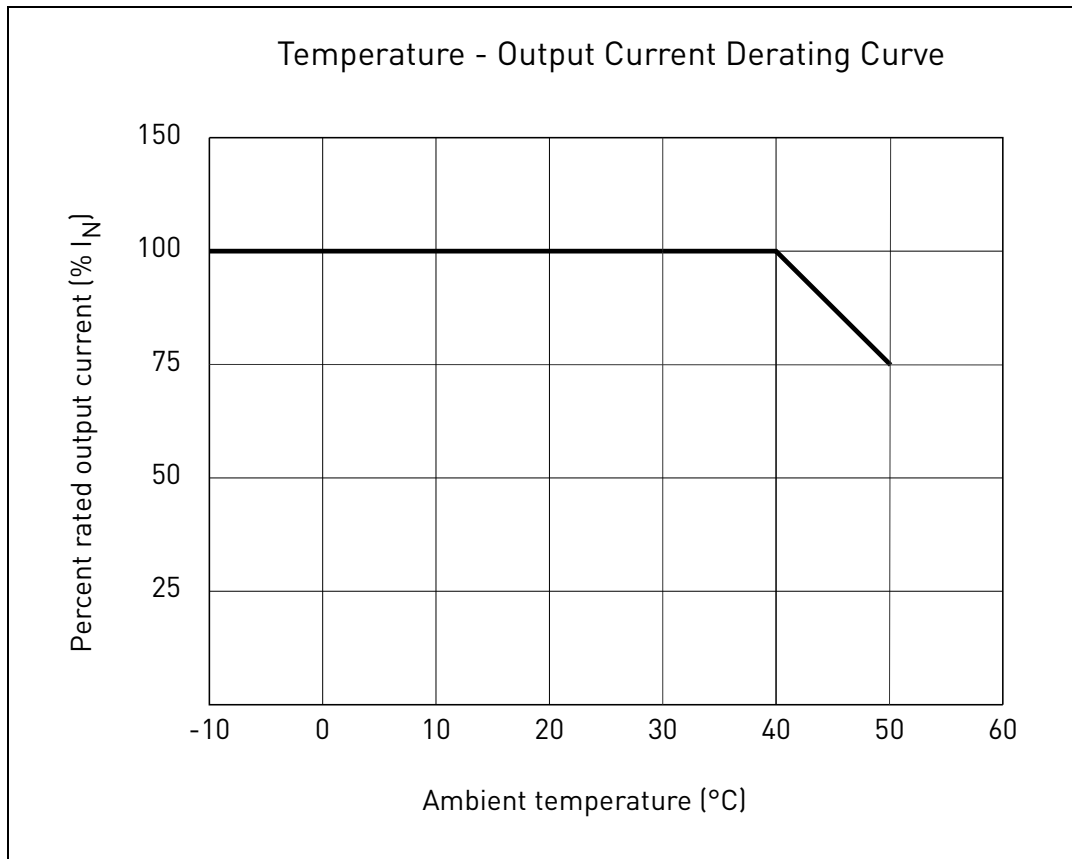


Figure 5. Temperature-output current derating curve.

The AC drive is cooled down by air-ventilation. Therefore, make sure that enough free space is left around the AC drive to ensure sufficient air circulation (see for more details the mounting instructions on chapter 3).

**NOTE:** Up to 1.5 kW (Voltage range 380-480V) and 0.75 kW (Voltage range 208-240V) the drive is not equipped with external cooling fan.

1.9 DECLARATION OF CONFORMITY



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**EU DECLARATION OF CONFORMITY**

**Danfoss A/S**  
Vacon Ltd

declares under our sole responsibility that the

Product(s)	Vacon 20 CP and Vacon 20 X AC drives	
Type(s)	Vacon 0020 1L 0004 2...0007 2 CP	Vacon 0020 1L 0004 2...0007 2 X
	Vacon 0020 3L 0004 2...0017 2 CP	Vacon 0020 3L 0004 2...0017 2 X
	Vacon 0020 3L 0003 4...0016 4 CP	Vacon 0020 3L 0003 4...0016 4 X
	Vacon 0020 3L 0003 5...0016 5 CP	Vacon 0020 3L 0003 5...0016 5 X

Product Safety Functions:

Safe Torque Off (EN 61800-5-2:2007) and Emergency stop (EN-60204-1:2006+A1:2009+AC:2010 in extracts) available only on three-phase models.

Covered by this declaration is in conformity with the following directive(s), standard(s) or other normative document(s), provided that the product is used in accordance with our instructions.

- EN 61800-5-2:2007
- EN 61800-5-1:2007 (LV Directive compliance)
- EN 61800-3:2004+A1:2012 (EMC Directive compliance)
- EN ISO 13849-1:2008+AC:2009
- EN 62061:2005+AC:2010

and conforms to the relevant safety provisions of Low Voltage Directive 2006/95/EC (until April 19th, 2016), 2014/35/EU (from April 20th, 2016) and EMC Directive 2004/108/EC (until April 19th, 2016), 2014/30/EU (from April 20th, 2016), and EC Machinery Directive 2006/42/EC.

Notified body that carried out the EC type examination:

TÜV Rheinland Industrie Service GmbH,  
Alboinstr. 56, 12103 Berlin / Germany  
Certification Body for Machinery NB 0035, Certificate No. 01/205/5215/12 (applied to 480V, 500V)

The year the CE marking was affixed: 2012

Date 15-04-2016	Issued by Signature Name: Antti Vuola Title: Head of Standard Drives	Date 15-04-2016	Approved by Signature Name: Timo Kasi Title: VP, Design Center Finland and Italy
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Danfoss only vouches for the correctness of the English version of this declaration. In the event of the declaration being translated into any other language, the translator concerned shall be liable for the correctness of the translation

Figure 6. Declaration of conformity.

 <b>TÜVRheinland®</b>	
<b>ZERTIFIKAT</b>	<b>EC Type-Examination Certificate</b>
<b>CERTIFICATE</b>	<b>Reg.-No.: 01/205/5215/12</b>
<b>Product tested</b>	Safety function "Safe Torque Off (STO)" within Adjustable Frequency AC Drive
<b>Certificate holder</b>	Vacon S.R.L. Via Roma, 2 I-39014 Postal (BZ) Italy
<b>Type designation</b>	Vacon 20 AC Drive VACON0020-3L-a-b-c +d +e a = 0001-0008; (Frame Size 2), a = 0009-0016; (Frame Size 3), b = 4, 5; (Voltage Rating), c = CP, X; (Enclosure Option), +d, +e = Additional Codes
<b>Manufacturer</b>	see certificate holder
<b>Codes and standards forming the basis of testing</b>	EN 61800-5-2:2007 EN 61800-5-1:2007 EN 61800-3:2004 EN ISO 13849-1:2008 + AC:2009
	EN 62061:2005 + AC:2010 IEC 61508 Parts 1-7:2010 EN 60204-1:2006 + A1:2009 + AC:2010 (in extracts)
<b>Intended application</b>	The safety function "Safe Torque Off" complies with the requirements of the relevant standards (PL e acc. to EN ISO 13849-1, SIL CL 3 acc. to EN 61800-5-2 / EN 62061 / IEC 61508) and can be used in applications up to PL e acc. to EN ISO 13849-1 and SIL 3 acc. to EN 62061 / IEC 61508.
<b>Specific requirements</b>	The instructions of the associated Installation and Operating Manual shall be considered.
It is confirmed that the product under test complies with the requirements for machines defined in Annex I of the EC Directive 2006/42/EC.	
This certificate is valid until 2017-04-27.	
<p>The test report-no.: 968/M 349.00/12 dated 2012-04-27 is an integral part of this certificate.</p> <p>This certificate is valid only for products which are identical with the product tested at any change of the codes and standards forming the intended application.</p>	
	
Berlin, 2012-04-27	Dipl.-Ing. Eberhard Frejno
Certification Body for Machinery, NB 0035	

TÜV Rheinland Industrie Service GmbH, Althofstr. 56, 12103 Berlin / Germany  
 Tel.: +49 30 7562-1557, Fax: +49 30 7562-1370, E-Mail: tovral@de.tuv.com

Figure 7. STO certificate.

**NOTE!** You can download the English and French product manuals with applicable safety, warning and caution information from <http://drives.danfoss.com/knowledge-center/technical-documentation/>.

**REMARQUE** Vous pouvez télécharger les versions anglaise et française des manuels produit contenant l'ensemble des informations de sécurité, avertissements et mises en garde applicables sur le site <http://drives.danfoss.com/knowledge-center/technical-documentation/>.



## 2. RECEIPT OF DELIVERY

Check the correctness of delivery by comparing your order data to the drive information found on the package label. If the delivery does not correspond to your order, contact your supplier immediately. See paragraph 2.4.

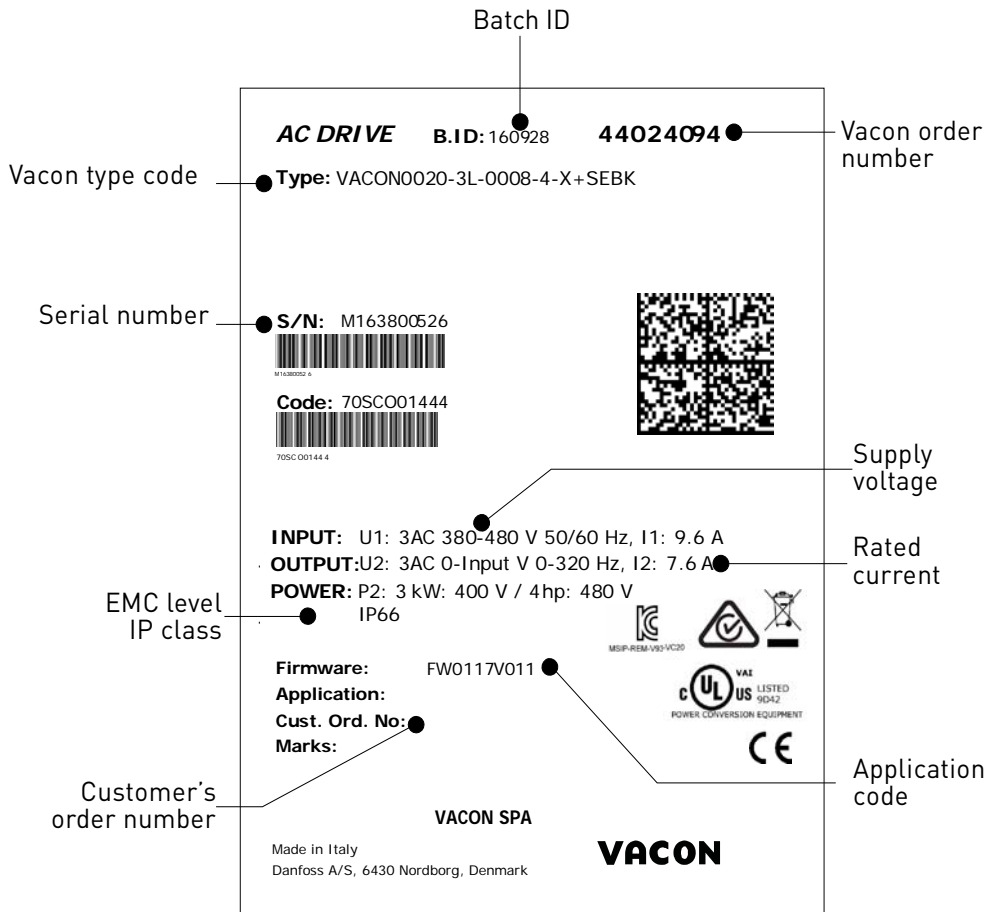


Figure 8. VACON® package label.

## 2.1 TYPE DESIGNATION CODE

VACON® type designation code is formed of a nine-segment code and optional +codes. Each segment of the type designation code uniquely corresponds to the product and options you have ordered. The format of the code is as follows:

**VACON0020-3L-0009-4-X +xxxx +yyyy**

### VACON

This segment is common for all products.

### 0020

Product range:

0020 = Vacon 20

### 3L

Input/Function:

3L = Three-phase input

1L = Single-phase input

### 0009

Drive rating in ampere; e.g. 0009 = 9 A

See Table 27 and Table 29 for all the drive ratings

### 4

Supply voltage:

2 = 208-240 V

4 = 380-480 V

### X

- IP66/Type 4X enclosure

### +xxxx +yyyy

Additional codes.

Examples of additional codes:

+HMTX

Text keypad IP66

+QDSS

Integrated disconnect switch

+QDSH

Simple operator panel

## 2.2 ORDER CODES

The order codes for VACON® 20 X drive family are shown in the following table:

Table 3. Order codes of VACON® 20 X.

Enclosure size	Order code	Description
<b>Supply voltage 3AC 208-240V</b>		
<b>MU2</b>	VACON0020-3L-0004-2-X	0.75 kW - 1.0 HP drive
	VACON0020-3L-0005-2-X	1.1 kW - 1.5 HP drive
	VACON0020-3L-0007-2-X	1.5 kW - 2.0 HP drive
<b>MU3</b>	VACON0020-3L-0011-2-X	2.2 kW - 3.0 HP drive
	VACON0020-3L-0012-2-X	3.0 kW - 4.0 HP drive
	VACON0020-3L-0017-2-X	4.0 kW - 5.0 HP drive
<b>Supply voltage 1AC 208-240V</b>		
<b>MU2</b>	VACON0020-1L-0004-2-X	0.75 kW - 1.0 HP drive
	VACON0020-1L-0005-2-X	1.1 kW - 1.5 HP drive
	VACON0020-1L-0007-2-X	1.5 kW - 2.0 HP drive
<b>Supply voltage 3AC 380-480V</b>		
<b>MU2</b>	VACON0020-3L-0003-4-X	0.75 kW - 1.0 HP drive
	VACON0020-3L-0004-4-X	1.1 kW - 1.5 HP drive
	VACON0020-3L-0005-4-X	1.5 kW - 2.0 HP drive
	VACON0020-3L-0006-4-X	2.2 kW - 3.0 HP drive
	VACON0020-3L-0008-4-X	3.0 kW - 4.0 HP drive
<b>MU3</b>	VACON0020-3L-0009-4-X	4.0 kW - 5.0 HP drive
	VACON0020-3L-0012-4-X	5.5 kW - 7.5 HP drive
	VACON0020-3L-0016-4-X	7.5 kW - 10.0 HP drive

For all technical details, see chapter 7.

### 2.3 UNPACKING AND LIFTING THE AC DRIVE

The weights of the AC drives vary according to enclosure size. Note the weights of each individual enclosure size in Table below.

Table 4. Enclosure weights.

Enclosure size	Weight	
	[kg]	[lb]
MU2	3.4	7.5
MU3	6.0	13.2

VACON® 20 X drives have undergone scrupulous tests and quality checks at the factory before they are delivered to the customer. However, after unpacking the product, check that no signs of transport damage are to be found on the product and that the delivery is complete.

Should the drive have been damaged during shipping, please contact the cargo insurance company or the carrier in the first instance.

### 2.4 ACCESSORIES

After lifting the AC drive out, check that the delivery is complete and the following accessories are included:

Table 5. Content of accessory bag.

Item	Quantity	Purpose
STO terminal connector	1	Six pin black connector (see Figure 9) to use STO function
M3.5 x 8 TapTite screw	4	Screws for control cable clamps
M1-3 Cable clamp	2	Clamping control cables
'Product modified' sticker	1	Information about modifications
HMI cap*	1	Closing cap for the HMI connector

\*. Provided only if the drive is delivered with the keypad mounted.

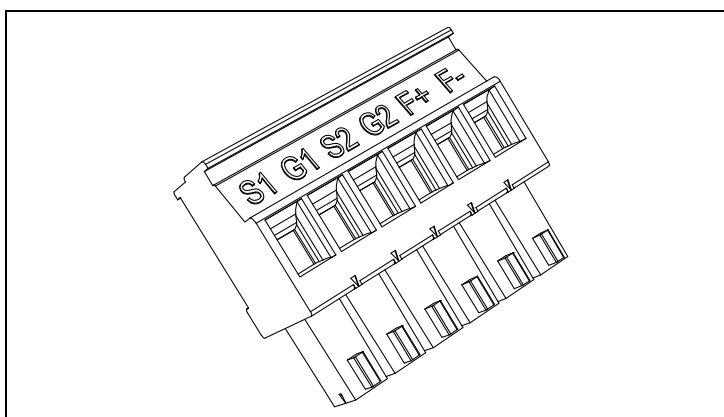


Figure 9. STO connector.

**2.4.1 ‘PRODUCT MODIFIED’ STICKER**

In the small plastic bag included in the delivery, you will find a silver *Product modified* sticker. The purpose of the sticker is to notify the service staff about the modifications made in the AC drive. Attach the sticker on the side of the AC drive to avoid losing it. Should the AC drive be later modified, mark the change on the sticker.

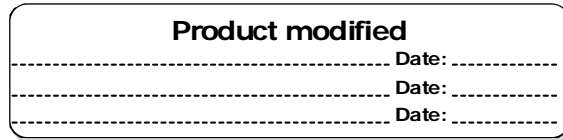


Figure 10. ‘Product modified’ sticker.

**2.4.2 DISPOSAL**

	<p>When the device reaches the end of its operating life do not dispose of it as a part of standard household garbage. Main components of the product can be recycled, but some need to be fragmented to separate different types of materials and components that need to be treated as special waste from electrical and electronic components. To ensure environmentally sound and safe recycling treatment, the product can be taken to appropriate recycling center or returned to the manufacturer.</p> <p>Observe local and other applicable laws as they may mandate special treatment for specific components or special treatment may be ecologically sensible.</p>
--	---

### 3. MOUNTING

The AC drive **has to be mounted** on the wall or on the back plane of a cubicle. Ensure that the mounting plane is relatively even. Both enclosure sizes can be mounted in any position. Fix the drive with four screws (or bolts, depending on the unit size).

#### 3.1 DIMENSIONS

##### 3.1.1 ENCLOSURE MU2 AND MU3

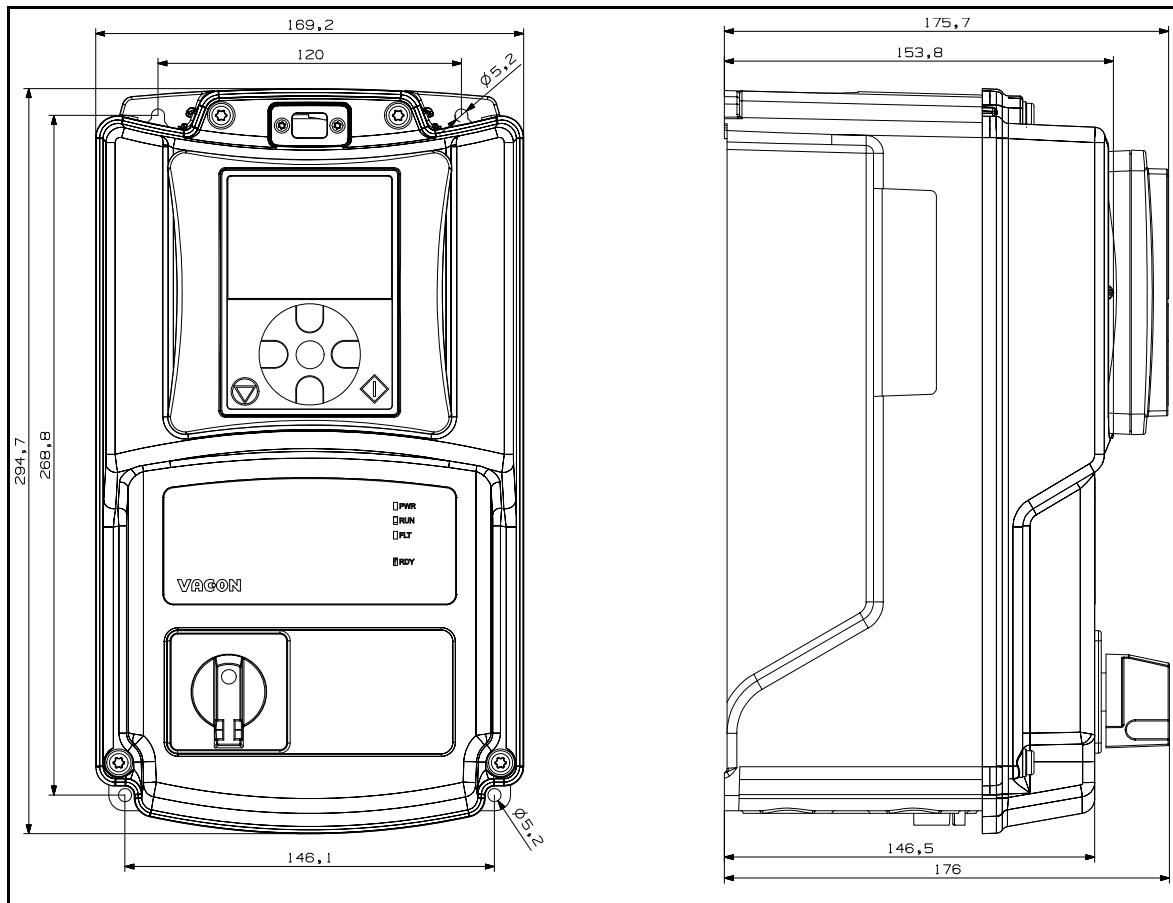


Figure 11. VACON® 20 X, MU2.

Enclosure size	Dimensions W x H x D	
	[mm]	[in]
MU2	169.2 x 294.7 x 146.1	6.66 x 11.60 x 5.75
MU2 +HMTX	169.2 x 294.7 x 175.7	6.66 x 11.60 x 6.92
MU2 +QDSS	169.2 x 294.7 x 176	6.66 x 11.60 x 6.93

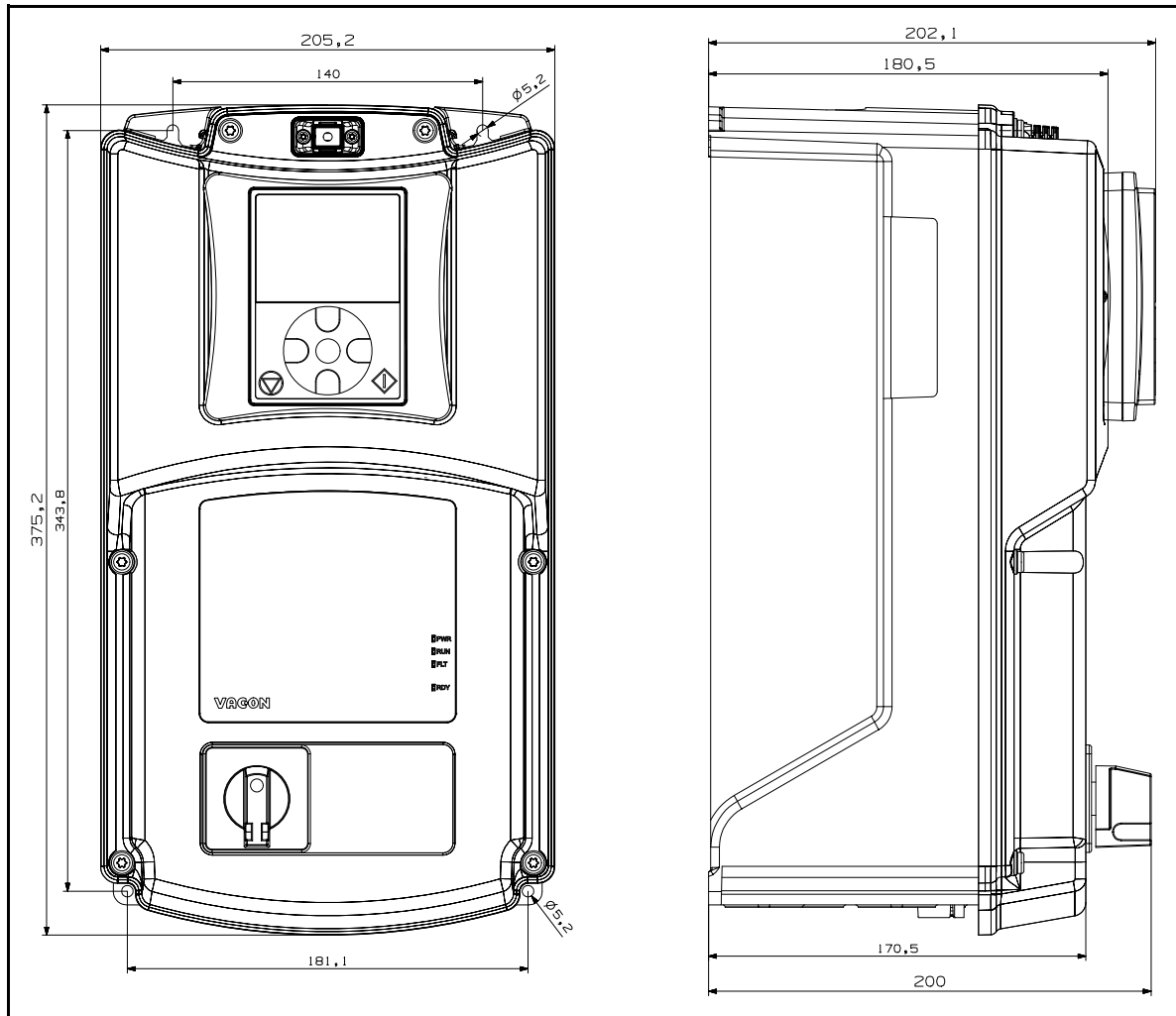


Figure 12. VACON® 20 X, MU3.

Enclosure size	Dimensions W x H x D	
	[mm]	[in]
MU3	205.2 x 375.2 x 180.5	8.08 x 14.77 x 7.11
MU3 +HMTX	205.2 x 375.2 x 202.1	8.08 x 14.77 x 7.96
MU3 +QDSS	205.2 x 375.2 x 200.0	8.08 x 14.77 x 7.87

The drive can be mounted in vertical or horizontal position on the wall or any other relatively even mounting plane or machine enclosure and fixed with the screws recommended in Table 6. Recommended screw or bolt size for MU2 and MU3 is M5.

Enclosure size	Screw number	Screw size
MU2	4	M5
MU3	4	M5

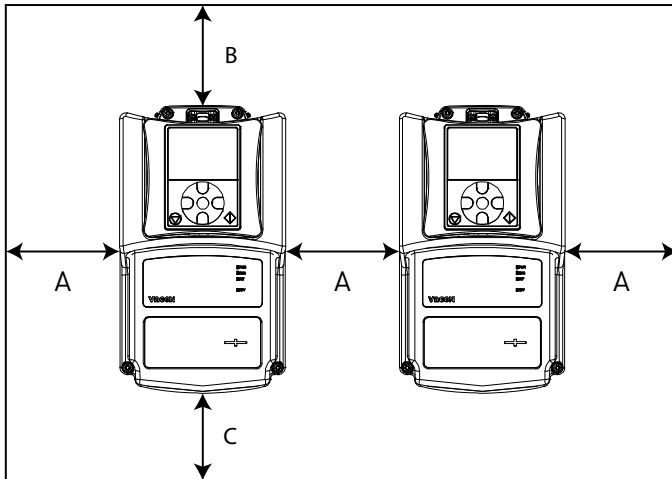
Table 6. Screws for wall mounting.

### 3.2 COOLING

The AC drive produces heat in operation and is cooled down by air circulated by a fan. Enough free space must be left around the AC drive to ensure sufficient air circulation and cooling. Different acts of maintenance may also require certain amount of free space.

The minimum clearances given in Table 7 should be respected. It is also important to ensure that the temperature of the cooling air does not exceed the maximum environment temperature of the AC drive.

Contact our factory for more information on required clearances in different installations.



Min clearance [mm]			
Type	A	B	C
MU2	15	30	60
MU3	15	30	80

Table 7. Min. clearances around AC drive.

A = Clearance left and right from the drive  
 B = Clearance above the drive  
 C = Clearance underneath the AC drive

Figure 13. Installation space.

Table 8. Required cooling air.

Type	Cooling air required [m <sup>3</sup> /h]
MU2	50
MU3	110

**NOTE** that if several units are mounted **above** each other the required free space equals B+C (see the Figure 14.). Moreover, the outlet air used for cooling by lower unit must be directed away from the air intake of the upper unit by means of e.g. a piece of metal plate fixed to the wall between the drives as shown in Figure 14..



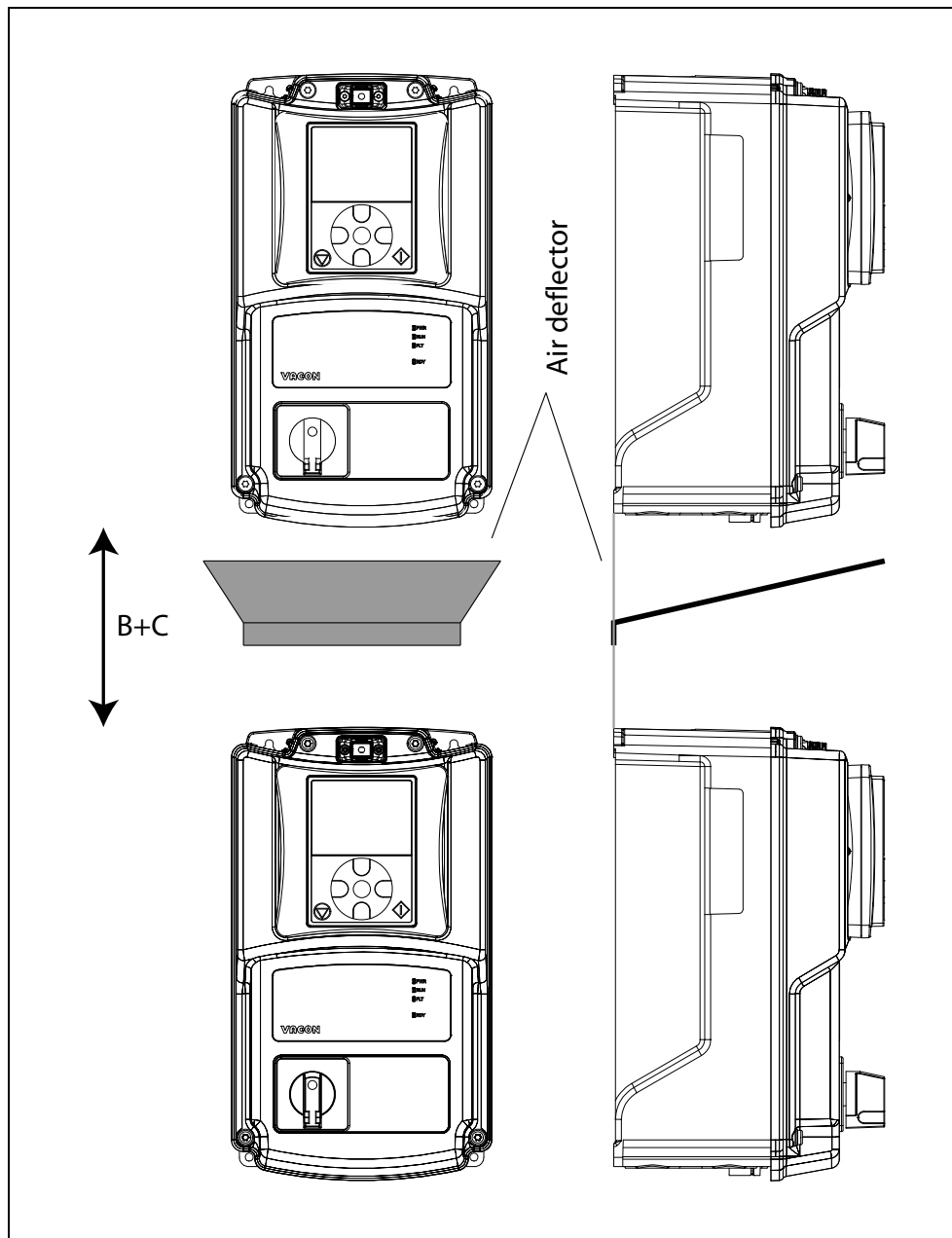


Figure 14. Installation space when drives are mounted on top of each other.

## 4. POWER CABLING

The mains cables are connected to terminals L1, L2 and L3 (or L and N) and the motor cables to terminals marked with U, V and W. See principal connection diagrams in Figure 15 and Figure 16.

See also Table for the cable recommendations for different EMC levels.

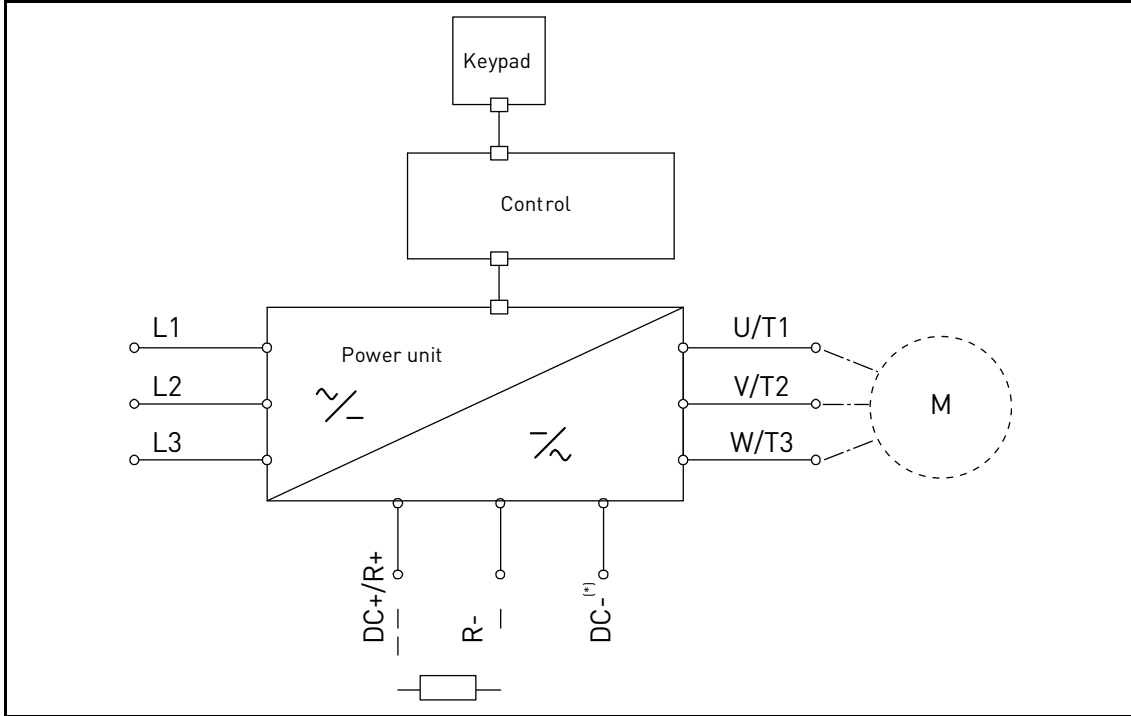


Figure 15. Principal connection diagram (three-phase version).

\* Only for 3~ units.

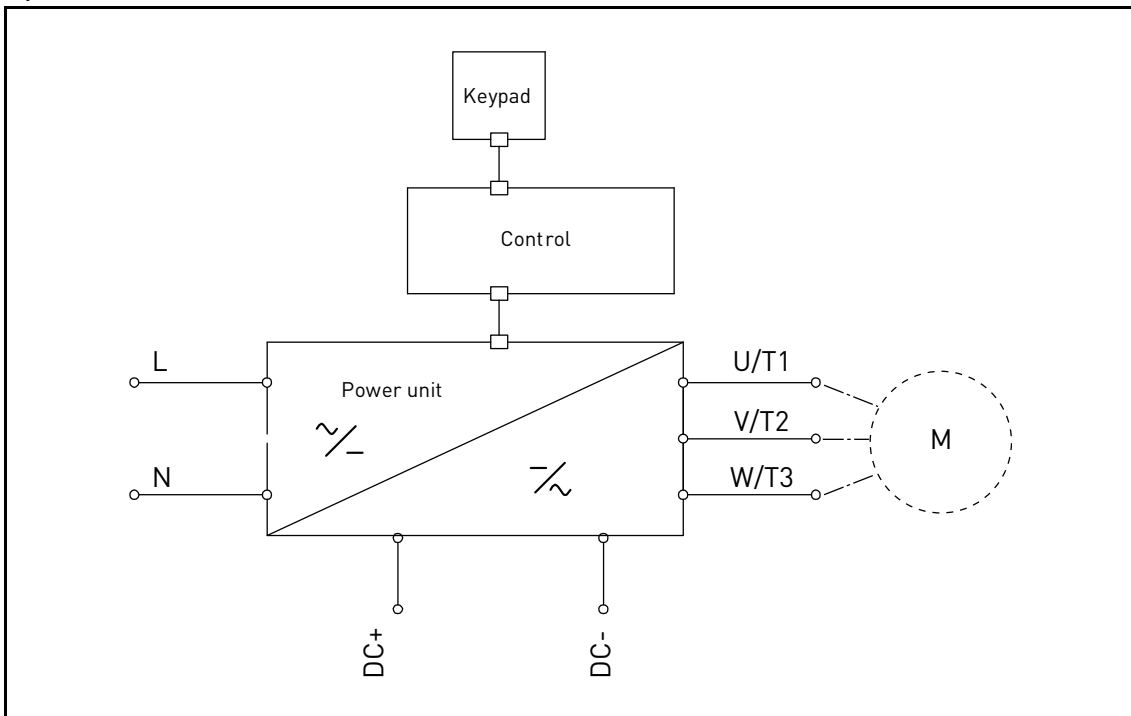


Figure 16. Principal connection diagram (single-phase version)

Use cables with heat resistance in accordance with the application requirements. The cables and the fuses must be dimensioned according to the AC drive nominal OUTPUT current which you can find on the rating plate.

Table 9: Cable types required to meet standards.

Cable type	EMC levels		
	1 <sup>st</sup> environment	2 <sup>nd</sup> environment	
	Category C1 and C2	Category C3	Category C4
Mains cable	1	1	1
Motor cable	3*	2	2
Control cable	4	4	4

- 1 = Power cable intended for fixed installation and the specific mains voltage. Shielded cable not required. (MCMK or similar recommended).
- 2 = Symmetrical power cable equipped with concentric protection wire and intended for the specific mains voltage. (MCMK or similar recommended). See Figure 17.
- 3 = Symmetrical power cable equipped with compact low-impedance shield and intended for the specific mains voltage. [MCCMK, EMCMK or similar recommended; Recommended cable transfer impedance (1...30MHz) max. 100mohm/m]. See Figure 17.  
\*360° grounding of the shield with cable glands in motor end needed for EMC category C2.
- 4 = Screened cable equipped with compact low-impedance shield (JAMAK, SAB/ÖZCuY-0 or similar).

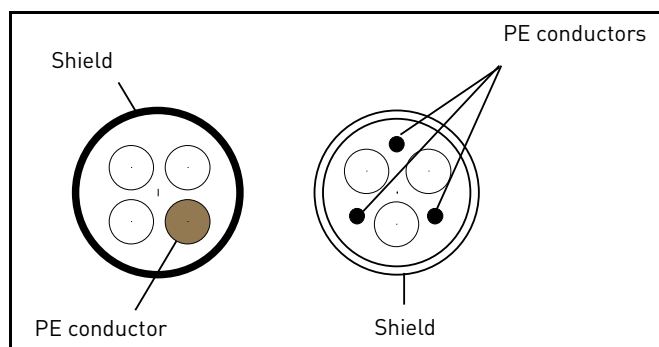


Figure 17.

**NOTE:** The EMC requirements are fulfilled at factory defaults of switching frequencies (all enclosures).

**NOTE:** If safety switch is connected, the EMC protection must be continuous over the whole cable installation.

#### 4.1 CIRCUIT BREAKER

Disconnect the drive via an external circuit breaker. You have to provide a switching device between the supply and main connection terminals.

When connecting the input terminals to the power supply using a circuit breaker, observe that this is of **type B or type C** and ensure it has a **capacity of 1.5 to 2 times of the inverter's rated current** (see Table 27 and Table 29).

**NOTE:** circuit breaker is not allowed in installations where C-UL is required. Only fuses are recommended.

#### 4.2 UL STANDARDS ON CABLING

To meet the UL (Underwriters Laboratories) regulations, use a UL-approved copper cable with a minimum heat-resistance of +70/75°C. Use Class 1 wire only.

The units are suitable for use on a circuit capable of delivering no more than 50,000 rms symmetrical amperes, 500V AC maximum, when protected by T or J class fuses.



Integral solid state short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the **National Electrical Code** and any additional local codes.

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4.3 DESCRIPTION OF THE TERMINALS

The following pictures describe the power terminals and the typical connections in VACON® 20X drives.

4.3.1 MU2 THREE-PHASE VERSION POWER CONNECTIONS

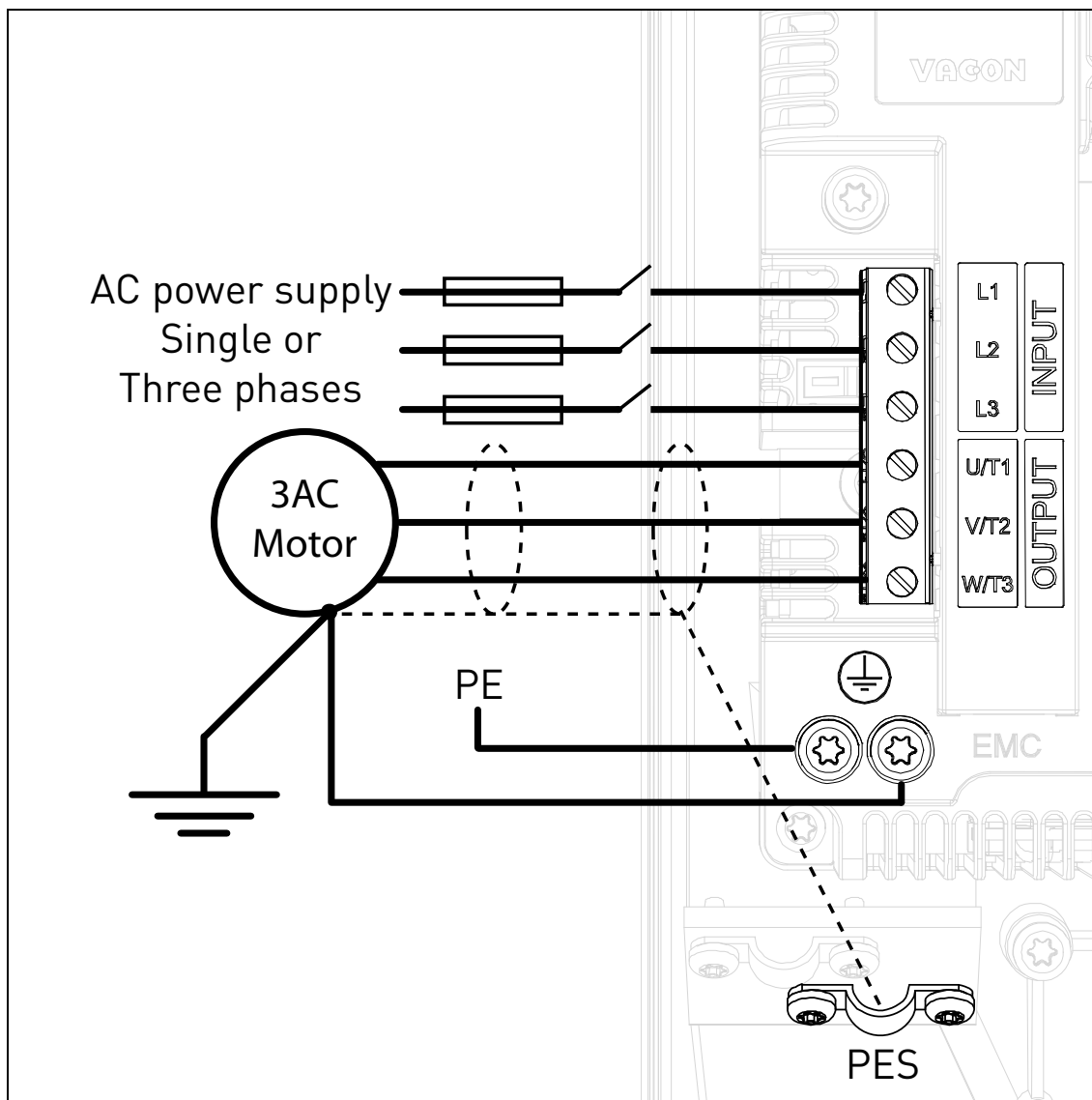


Figure 18. Power connections, MU2 three-phase version.

Table 10. Description of VACON® 20X MU2 power terminals.

Terminal	Description
L1 L2 L3	These terminals are the input connections for the power supply. 230 VAC models can be supplied by single-phase voltage by connecting to L1 and L2 terminals (with derating of 50%).
U/T1 V/T2 W/T3	These terminals are for motor connections.

4.3.2 MU2 SINGLE-PHASE VERSION POWER CONNECTIONS

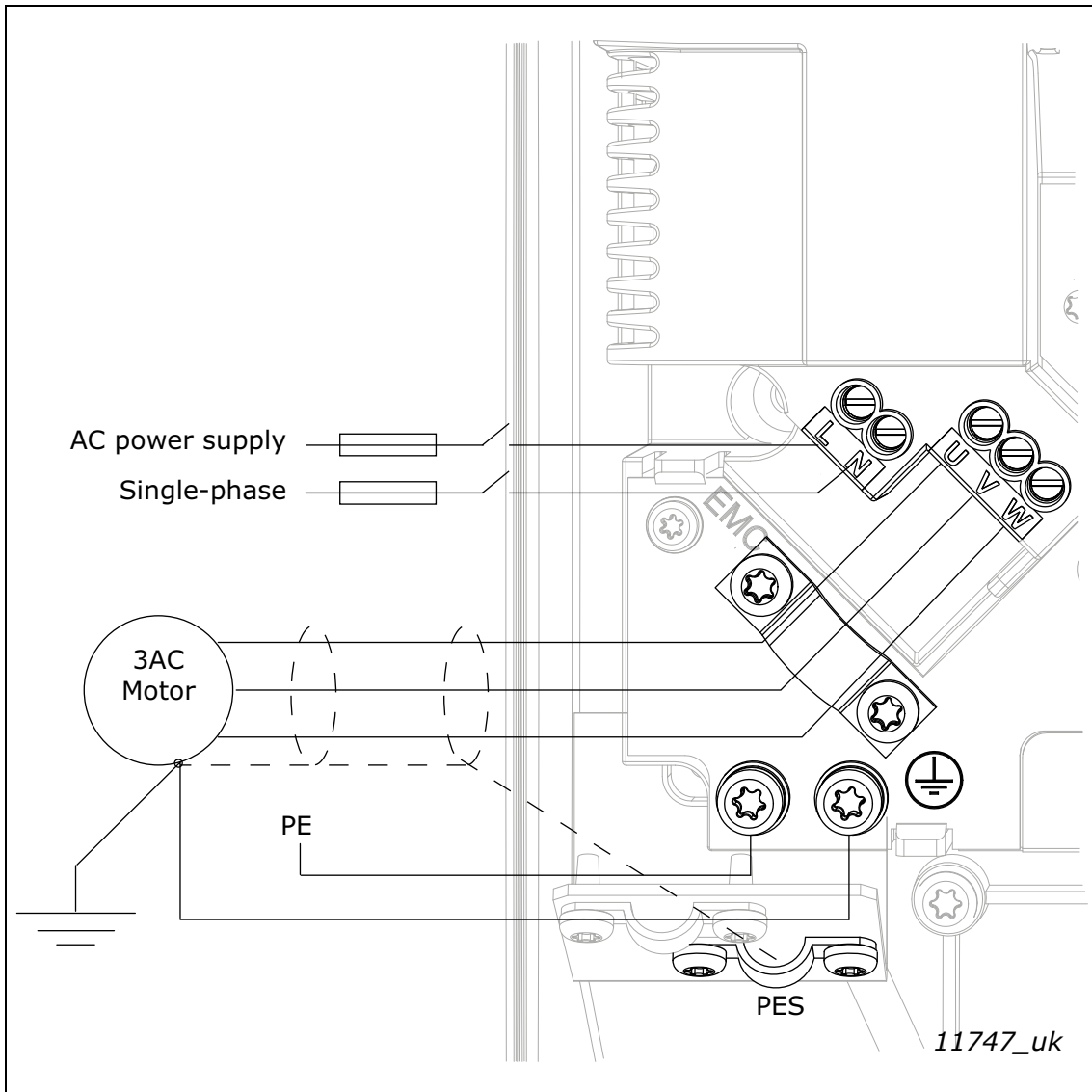


Figure 19. Power connections, MU2 single-phase version.

Table 11. Description of VACON® 20 X MU2 power terminals (single-phase version).

Terminal	Description
L N	These terminals are the input connections for the power supply. Single-phase 230 VAC voltage has to be connected to L and N terminals.
U V W	These terminals are for motor connections.

4.3.3 MU3 POWER CONNECTIONS

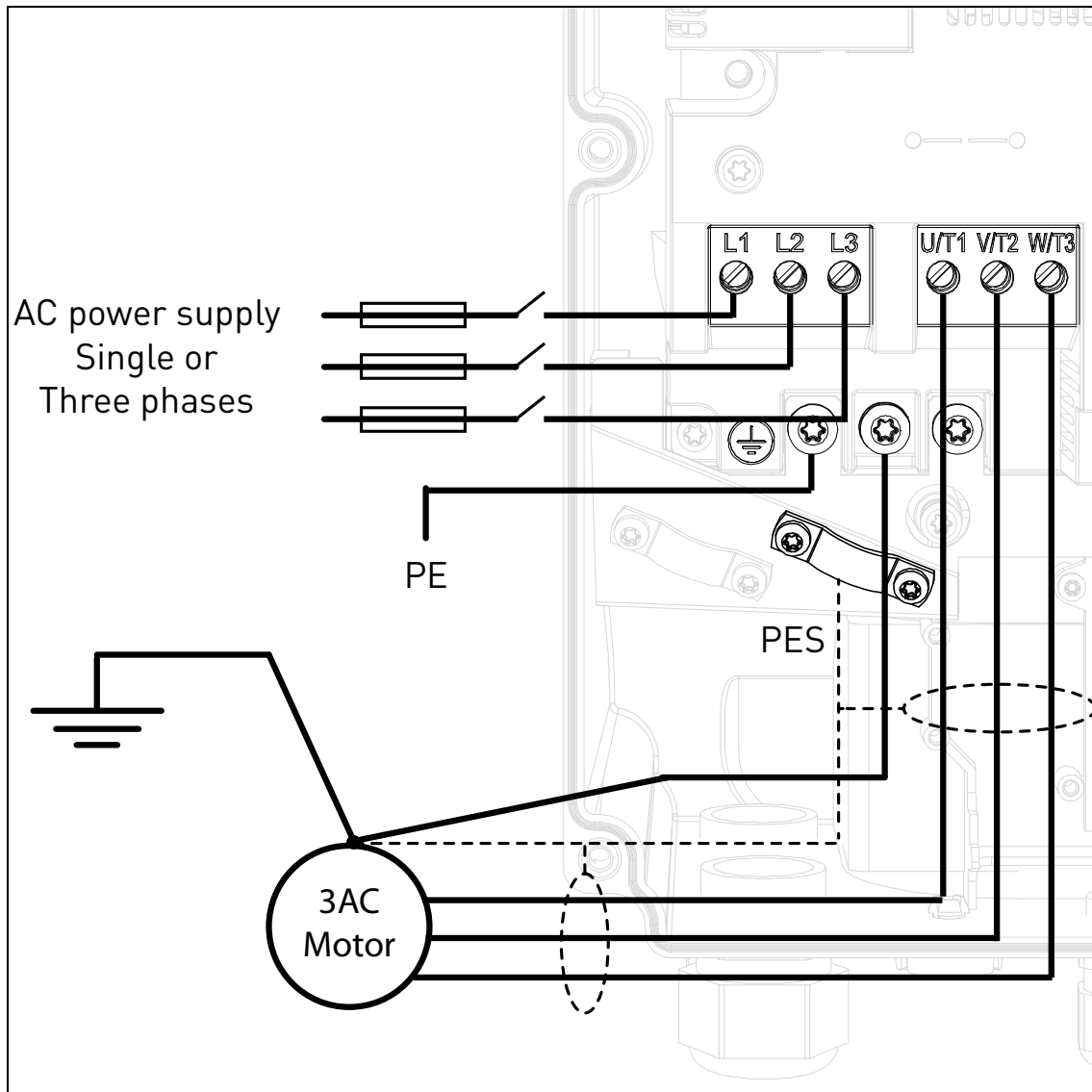


Figure 20. Power connections, MU3.

Table 12. Description of VACON® 20 X power terminals.

Terminal	Description
L1 L2 L3	These terminals are the input connections for the power supply. 230 VAC models can be supplied by single-phase voltage by connecting to L1 and L2 terminals (with derating of 50%).
U/T1 V/T2 W/T3	These terminals are for motor connections.

#### 4.4 CABLE DIMENSIONING AND SELECTION

Table 13 shows the minimum dimensions of the Cu cables and the corresponding fuse sizes.

These instructions apply only to cases with one motor and one cable connection from the AC drive to the motor. In any other case, ask the factory for more information.

##### 4.4.1 CABLE AND FUSE SIZES, ENCLOSURES MU2 AND MU3

The recommended fuse types are gG/gL (IEC 60269-1). The fuse voltage rating should be selected according to the supply network. The final selection should be made according to local regulations, cable installation conditions and cable specifications. Bigger fuses than those recommended below must not be used.

Check that the fuse operating time is less than 0.4 seconds. Operating time depends on used fuse type and impedance of the supply circuit. Consult the factory about faster fuses. VACON® also recommends for high speed gS (IEC 60269-4) fuse ranges.

Table 13. Cable and fuse sizes for VACON® 20 X.

Enclosure size	Type	I <sub>INPUT</sub> [A]	Fuse (gG/gL) [A]	Mains and motor cable Cu [mm <sup>2</sup> ]	Terminal cable size	
					Main terminal [mm <sup>2</sup> ]	Earth terminal
MU2	0004 2	4.3	6	3*1.5+1.5	0.2 – 2.5	M4 ring terminal
	0003 4 - 0004 4	3.2 - 4.0				
	0005 2 - 0007 2	6.8 - 8.4	10	3*1.5+1.5	0.2 – 2.5	M4 ring terminal
	0005 4 - 0006 4	5.6 - 7.3				
0008 4	9.6	16	3*2.5+2.5	0.2 – 2.5	M4 ring terminal	
MU2 1-phase	0004 2	8.3	20	(Mains) 2*1.5+1.5 (Motor) 3*1.5+1.5	0.2 – 2.5 stranded	M4 ring terminal
	0005 2	11.2	20	(Mains) 2*2.5+2.5 (Motor) 3*2.5+2.5	0.2 – 2.5 stranded	M4 ring terminal
	0007 2	14.1	25	(Mains) 2*2.5+2.5 (Motor) 3*2.5+2.5	0.2 – 2.5 stranded	M4 ring terminal
MU3	0011 2	13.4	16	3*2.5+2.5	0.5 – 16.0	M5 ring terminal
	0009 4	11.5				
	0012 2	14.2	20	3*2.5+2.5	0.5 – 16.0	M5 ring terminal
	0012 4	14.9				
	0017 2	20.6	25	3*6+6	0.5 – 16.0	M5 ring terminal
0016 4	20.0					

The cable dimensioning is based on the criteria of the International Standard IEC60364-5-52: Cables must be PVC-isolated; use only cables with concentric copper shield; Max number of parallel cables is 9.

When using cables in parallel, **NOTE HOWEVER** that the requirements of both the cross-sectional area and the max number of cables must be observed.

For important information on the requirements of the grounding conductor, see chapter Grounding and earth fault protection of the standard.

For the correction factors for each temperature, see International Standard IEC60364-5-52.



#### 4.4.2 CABLE AND FUSE SIZES, ENCLOSURES MU2 AND MU3, NORTH AMERICA

The recommended fuse types are class T (UL & CSA). The fuse voltage rating should be selected according to the supply network. The final selection should be made according to local regulations, cable installation conditions and cable specifications. Bigger fuses than those recommended below shall not be used.

Check that the fuse operating time is less than 0.4 seconds. Operating time depends on used fuse type and impedance of the supply circuit. Consult the factory about faster fuses. VACON® also recommends for high speed J (UL & CSA) fuse ranges.

Table 14. Cable and fuse sizes for VACON® 20 X, North America.

Enclosure size	Type	I <sub>INPUT</sub> [A]	Fuse (class T) [A]	Mains and motor cable Cu	Terminal cable size	
					Main terminal	Earth terminal
MU2	0004 2	4.3	6	AWG14	AWG24-AWG12	AWG17-AWG10
	0003 4 - 0004 4	3.2 - 4.0				
	0005 2 - 0007 2	6.8 - 8.4	10	AWG14	AWG24-AWG12	AWG17-AWG10
0005 4 - 0006 4	5.6 - 7.3					
MU2 1-phase	0008 4	9.6	15	AWG14	AWG24-AWG12	AWG17-AWG10
	0004 2	8.3	20	AWG14	AWG24-AWG12	AWG17-AWG10
	0005 2	11.2	20	AWG14	AWG24-AWG12	AWG17-AWG10
MU3	0007 2	14.1	25	AWG14	AWG24-AWG12	AWG17-AWG10
	0011 2	13.4	15	AWG14	AWG20-AWG6	AWG17-AWG10
	0009 4	11.5				
	0012 2	14.2	20	AWG12	AWG20-AWG6	AWG17-AWG10
	0012 4	14.9				
0017 2	20.6	25	AWG10	AWG20-AWG6	AWG17-AWG10	
0016 4	20.0					

The cable dimensioning is based on the criteria of the **Underwriters' Laboratories UL508C**: Cables must be PVC-isolated; Max ambient temperature +40 °C (104 °F), max temperature of cable surface +70/+75 °C (158/167 °F); Use only cables with concentric copper shield; Max number of parallel cables is 9.

When using cables in parallel, **NOTE HOWEVER** that the requirements of both the cross-sectional area and the max number of cables must be observed.

For important information on the requirements of the grounding conductor, see standard Underwriters' Laboratories UL508C.

For the correction factors for each temperature, see the instructions of standard **Underwriters' Laboratories UL508C**.

#### 4.4.3 RECOMMENDED FUSE SIZES FOR GROUP INSTALLATION

A group installation is a configuration in which one fuse is intended to provide protection for more than one drive. In this case, the fuse acts as BCP (Branch Circuit Protection) device for multiple drives. VACON® 20 X is suitable for motor group installation on a circuit capable of delivering not more than 50,000 rms symmetrical amperes, 500 V max, when protected by Class J or T fuses.

VACON® 20 X is approved for group installation by UL provided the fuse in the main branch circuit is a 60 A class T or J fuse (300V or 600V AC maximum according to the drive rating).

It is possible to choose any combination of AC drives, but you have to pay attention that the total current does not open the fuses in normal operation.

**Example:**

Eight MU2 type 0003 4 with input current 3.2 A ( $3.2 \cdot 8 = 25.6$  A) and one MU3 type 0016 4 with input current 20 A have total input current:  $25.6 + 20 = 45.6$  A.

#### 4.5 BRAKE RESISTOR CABLES

VACON® 20 X AC drives (three-phase version) are equipped with terminals for an optional external brake resistor.

For MU2, brake resistor wires with faston 6.3 mm have to be used.

For MU3, a PCB terminal block with push-in spring-cage connector is provided. Stranded wires (max. 4 mm<sup>2</sup>) with ferrules should be used.

See Table 30 and Table 31 for the resistor ratings.

#### 4.6 CONTROL CABLES

For information on control cables see chapter Control unit cabling.

### 4.7 CABLE INSTALLATION

- Before starting, check that none of the components of the AC drive is live. Read the warnings in chapter 1 carefully
- Place the motor cables sufficiently far from other cables
- Avoid placing the motor cables in long parallel lines with other cables.
- If the motor cables run in parallel with other cables note the minimum distances between the motor cables and other cables given in table below.

Distance between cables, [m]	Shielded cable, [m]
0.3	≤ 50
1.0	≤ 200

- The given distances also apply between the motor cables and signal cables of other systems.
- The **maximum length** for motor cables is **30 m**
- The motor cables should cross other cables at an angle of 90 degrees.
- If cable insulation checks are needed, see chapter Cable and motor insulation checks.

Start the cable installation according to the instructions below:

1

Strip the motor and mains cables as recommended below.

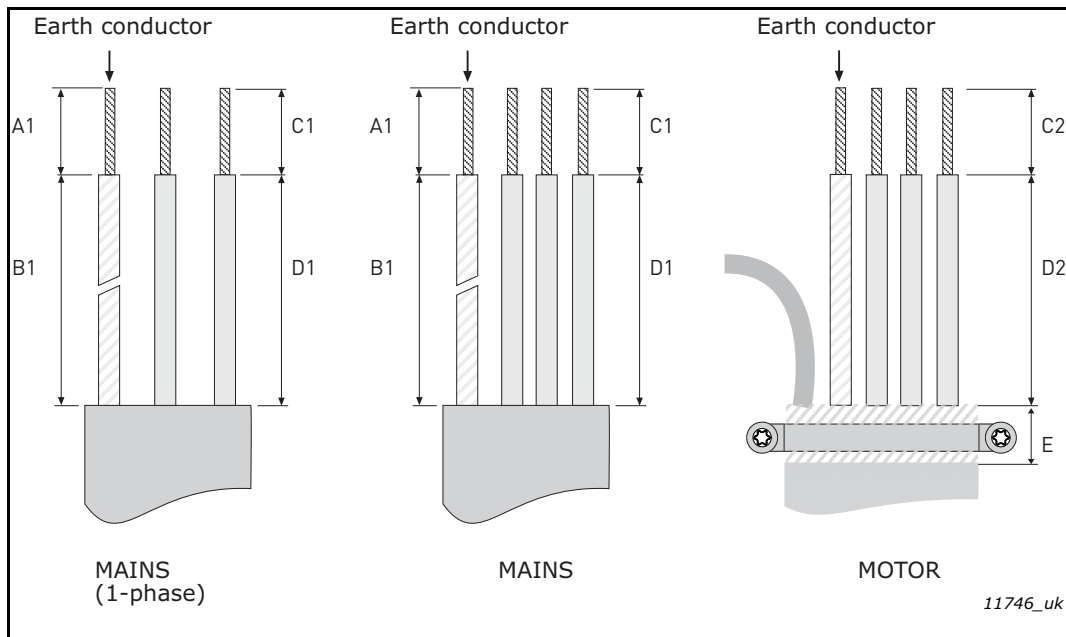


Figure 21. Stripping of cables.

Table 15. Cables stripping lengths [mm].

Enclosure size	A1	B1	C1	D1	C2	D2	E
MU2	8	8	8	20	8	20	Leave as short as possible (Cable clamps are used for Motor cable shielding)
MU2 1-phase	7	8	8	20	8	20	
MU3	8	8	8	20	8	20	

- |          |  |
|----------|--|
| <b>2</b> | <ul style="list-style-type: none"> <li>Remove the plastic cover of the drive as shown in Figure 22.</li> </ul> |
|----------|--|

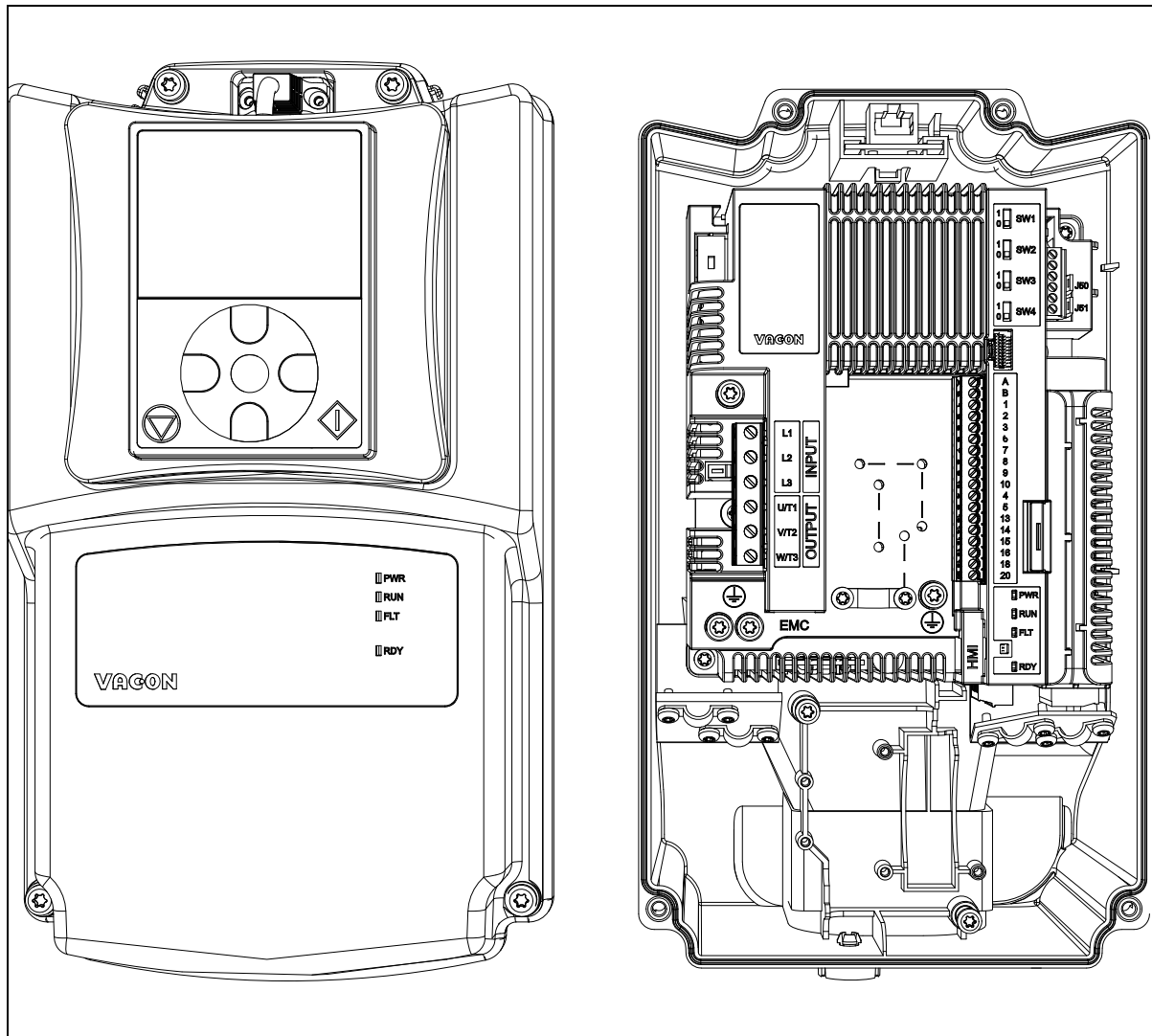


Figure 22. MU2 example: open cover.

**IEC installations:**

- |          |  |
|----------|--|
| <b>3</b> | <ul style="list-style-type: none"> <li>The cable entries consists of several openings available for the cables with ISO metric thread.</li> <li>Open only the inlet holes where you need to run the cables.</li> </ul> |
| <b>4</b> | <ul style="list-style-type: none"> <li>Choose the correct cable glands (in compliance with CE rules) according to drive and cable size as shown in the following pictures.</li> </ul>                                  |

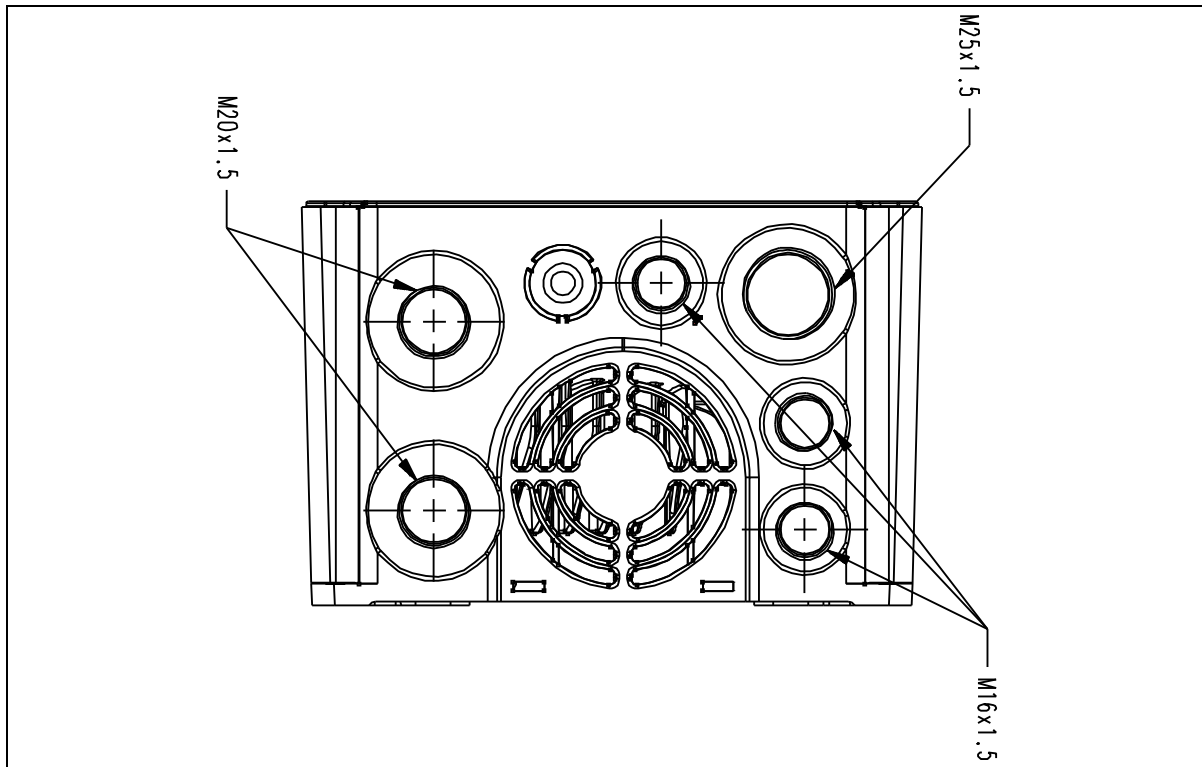


Figure 23. Cable entries, MU2.

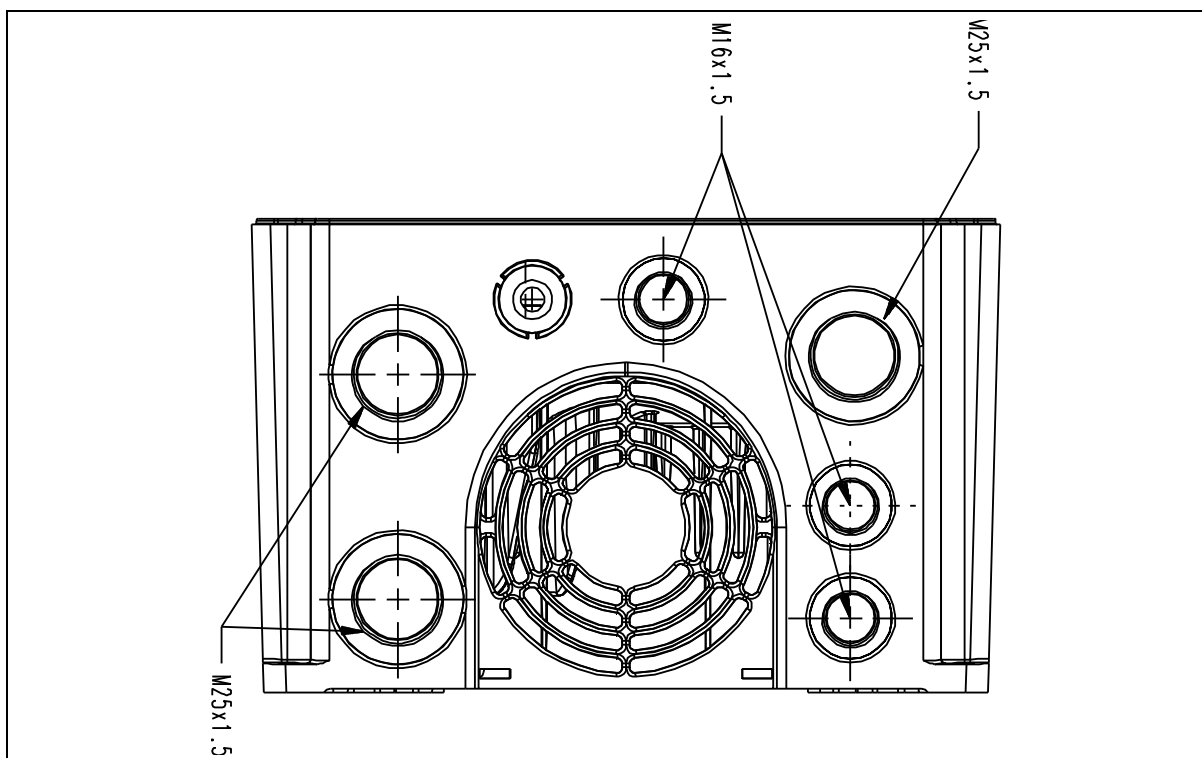


Figure 24. Cable entries, MU3.

<b>5</b>	<ul style="list-style-type: none"> <li>• Cable glands must be made of plastic materials. They are used for sealing cables passing through cable entries to ensure the characteristics of the enclosure.</li> </ul>
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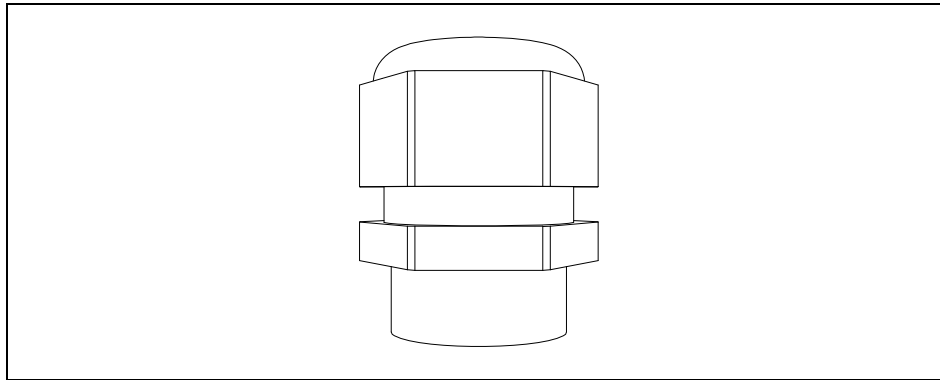


Figure 25. Cable gland.



Plastic cable glands are recommended. If metal cable glands are needed, all insulation system and protective grounding requirements have to be fulfilled in accordance with the national electrical regulations and IEC 61800-5-1.

<b>6</b>	<ul style="list-style-type: none"> <li>Screw the cable glands (in compliance with CE rules) on the cable entry holes using the proper tightening torque as shown in Table 16.</li> </ul>
----------	--

**Tightening torque and dimensions of cable glands:**

Table 16. Tightening torque and dimension of cable glands.

Enclosure size	Gland screw type [metric]	Tightening torque	
		[Nm]	lbs-in.
MU2	M16	1.0	8.9
	M20	2.0	17.7
	M25	4.0	35.5
MU3	M16	1.0	8.9
	M25	4.0	35.5

**UL installations:**

<b>7</b>	<ul style="list-style-type: none"> <li>Flexible conduit (plastic or metallic) are used as raceway for wires and cables in accordance with the National Electrical Code.</li> </ul>
<b>8</b>	<ul style="list-style-type: none"> <li>To connect NPT conduits to the metric threads of cable entries, adapters must be used. These adapters must first be connected to the cable entries plate, using the proper tightening torque as shown in the Table 16, and then to the pipes according to UL regulations.</li> </ul>
<b>9</b>	<ul style="list-style-type: none"> <li>For MU2 three NPT-to-Metric adapters must be used: number two 1/2" - M20 adapters and number one 3/4" - M25 adapter. See Table 17 for further details.</li> </ul>
<b>10</b>	<ul style="list-style-type: none"> <li>For MU3 three NPT-to-Metric adapters must be used: 3/4" - M25 adapters. See Table 17 for further details.</li> </ul>

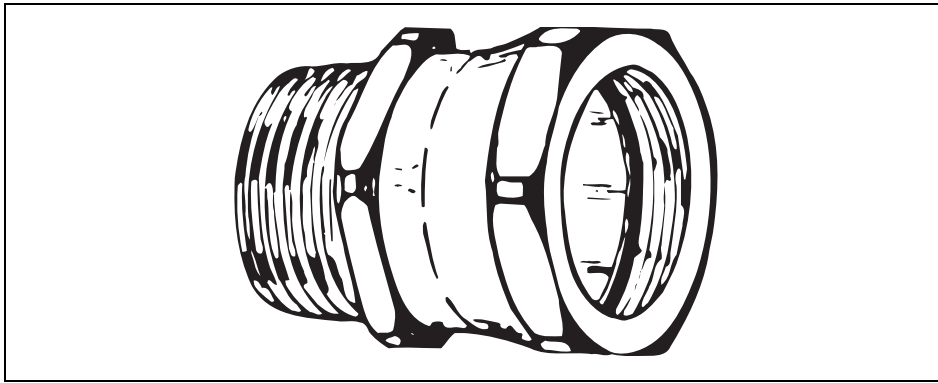


Figure 26. NPT-to-metric threads adapter.

<b>11</b>	<ul style="list-style-type: none"> <li>Teflon tape has to be used to ensure that you get a water tight seal on pipe joints.</li> </ul>
<b>12</b>	<ul style="list-style-type: none"> <li>Start by cleaning the male threads at the end of the pipe with a clean rag.</li> <li>Place the end of the Teflon tape on the second thread in and hold it in place with one hand.</li> <li>Wrap the tape in the same direction of the threads.</li> <li>Keep tension on the tape and wrap it several times working away from the end of the NPT pipe.</li> <li>When you have finished wrapping the Teflon smooth the loose end down into the threads.</li> <li>Screw the NPT-to-metric adapter on the cable entry using the proper tightening torque. See Table 17 for more details.</li> <li>Screw the NPT pipes on the adapters.</li> </ul>

**Tightening torque of NPT adapters to metric threads cable entries:**

Table 17. Tightening torque of NPT adapters to metric threads cable entries.

Enclosure size	Thread male metric	Thread female NPT	Tightening torque	
			[Nm]	lbs-in.
<b>MU2</b>	M20	1/2"	2.0	17.7
	M25	3/4"	4.0	35.5
<b>MU3</b>	M25	3/4"	4.0	35.5



The VACON® 20 X drive is IP66/Type 4X rated. To keep this rating, the use of a sealed conduit is required: if the approved conduit is not used, all warranty claims against water will be void.

**NPT adapter order information:**

M20 -> ADEC M20-T12

M25 -> ADEC M25-T34




**Cables installation:**

<b>13</b>	<ul style="list-style-type: none"> <li>Pass the cables (supply cable, motor cable, brake cable and I/O cables) through the pipes and adapters (UL installations) or through the cable glands (IEC installations) and cable entries.</li> </ul>
<b>14</b>	<ul style="list-style-type: none"> <li>Detach the cable clamps and the grounding clamps.</li> </ul>
<b>15</b>	<p>Connect the stripped cables:</p> <ul style="list-style-type: none"> <li>Expose the shield of the motor cable in order to make a 360-degree connection with the cable clamp (reverse the shield over the plastic cover of the cable and fix all together).</li> <li>Connect the phase conductors of the supply and motor cables into their respective terminals.</li> <li>Form the rest of the cable shield of both cables into "pigtailes" and make a grounding connection with the clamp. Make the pigtailes just long enough to reach and be fixed to the terminal - no longer.</li> </ul>

**Tightening torques of cable terminals:**

*Table 18. Tightening torques of terminals.*

Enclosure size	Type	Tightening torque Power and motor terminals		Tightening torque EMC grounding clamps		Tightening torque, Grounding terminals	
		[Nm]	lbs-in.	[Nm]	lbs-in.	[Nm]	lbs-in.
<b>MU2</b>	0003 4—0008 4	0.5—0.6	4.5—5.3	1.5	13.3	2.0	17.7
	0004 2—0007 2						
<b>MU3</b>	0009 4—0016 4	1.2—1.5	10.6—13.3	1.5	13.3	2.0	17.7
	0011 2—0017 2						

<b>16</b>	<ul style="list-style-type: none"> <li>Check the connection of the earth cable to the motor and the AC drive terminals marked with .</li> </ul>
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### 4.8 WIRING WAY

In the following picture an example of wire cabling is given:

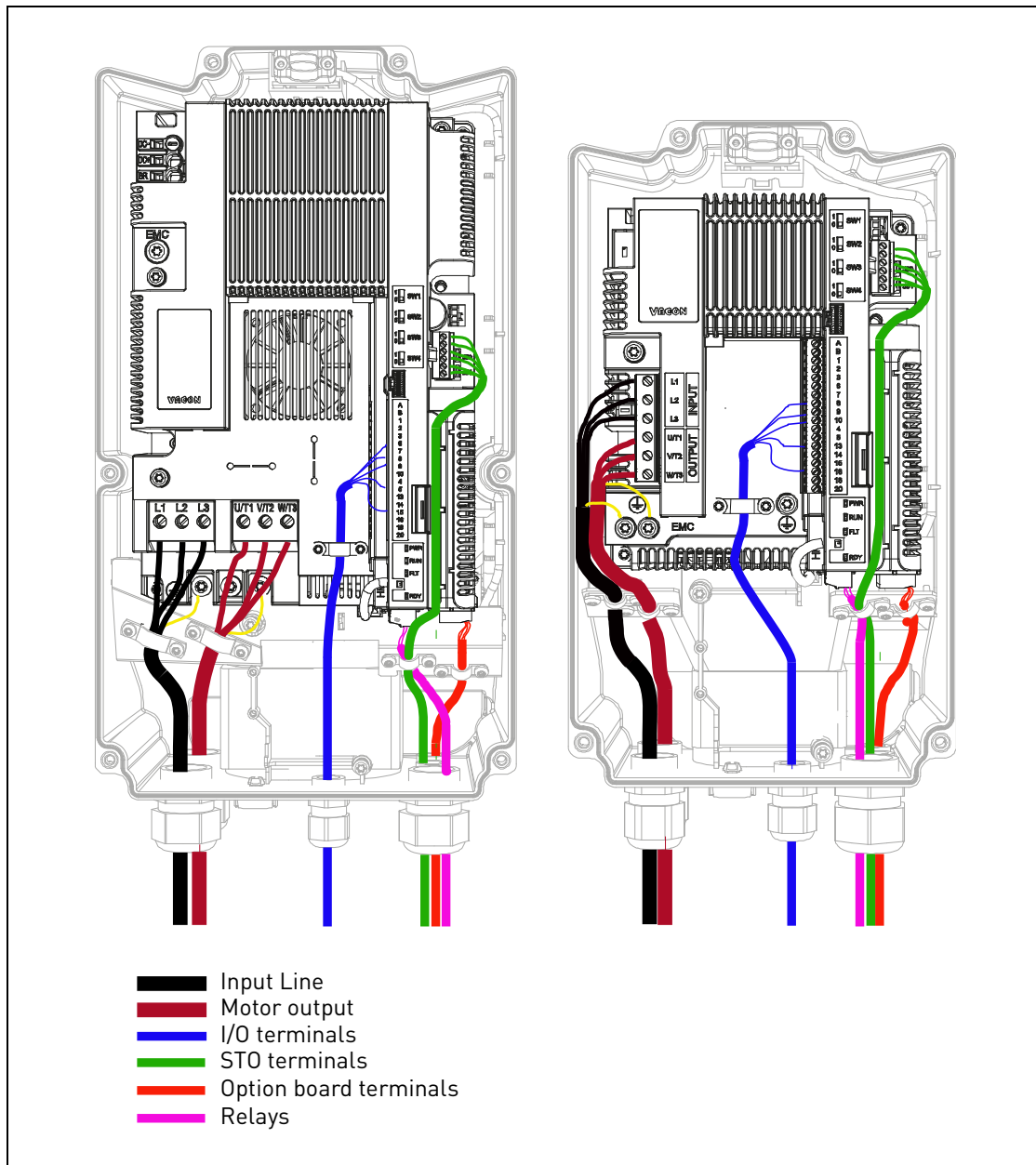


Figure 27. Wiring example with three-phase versions.

## 5. CONTROL UNIT

### 5.1 OPENING THE DRIVES

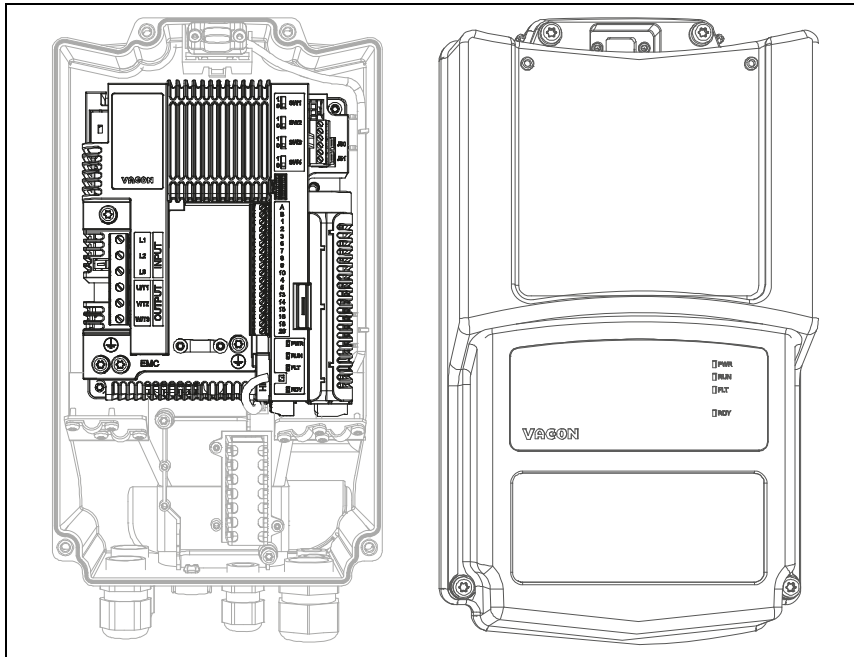


Figure 28. Open front cover of the drive: control unit MU2 (three-phase version).

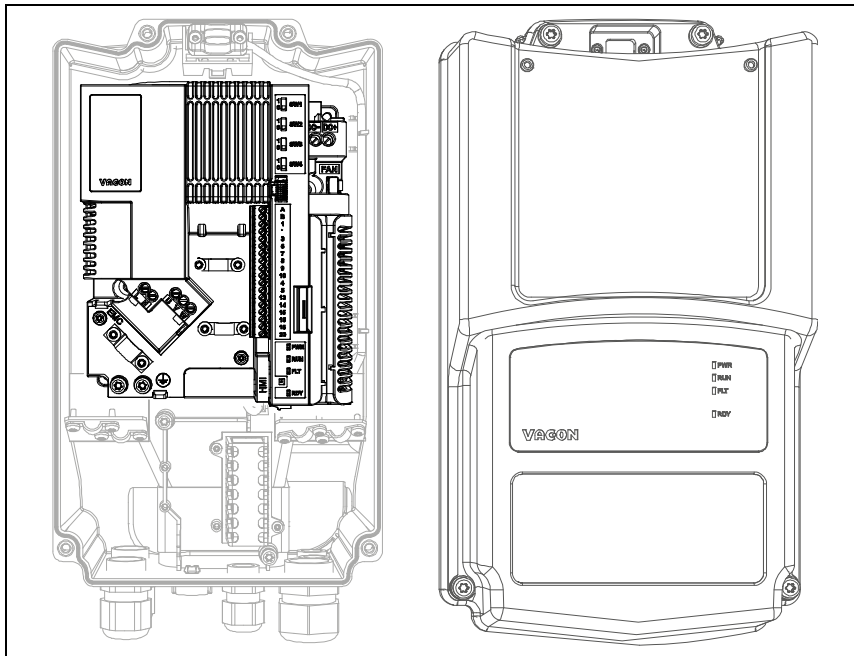


Figure 29. Open front cover of the drive: control unit MU2 (single-phase version).

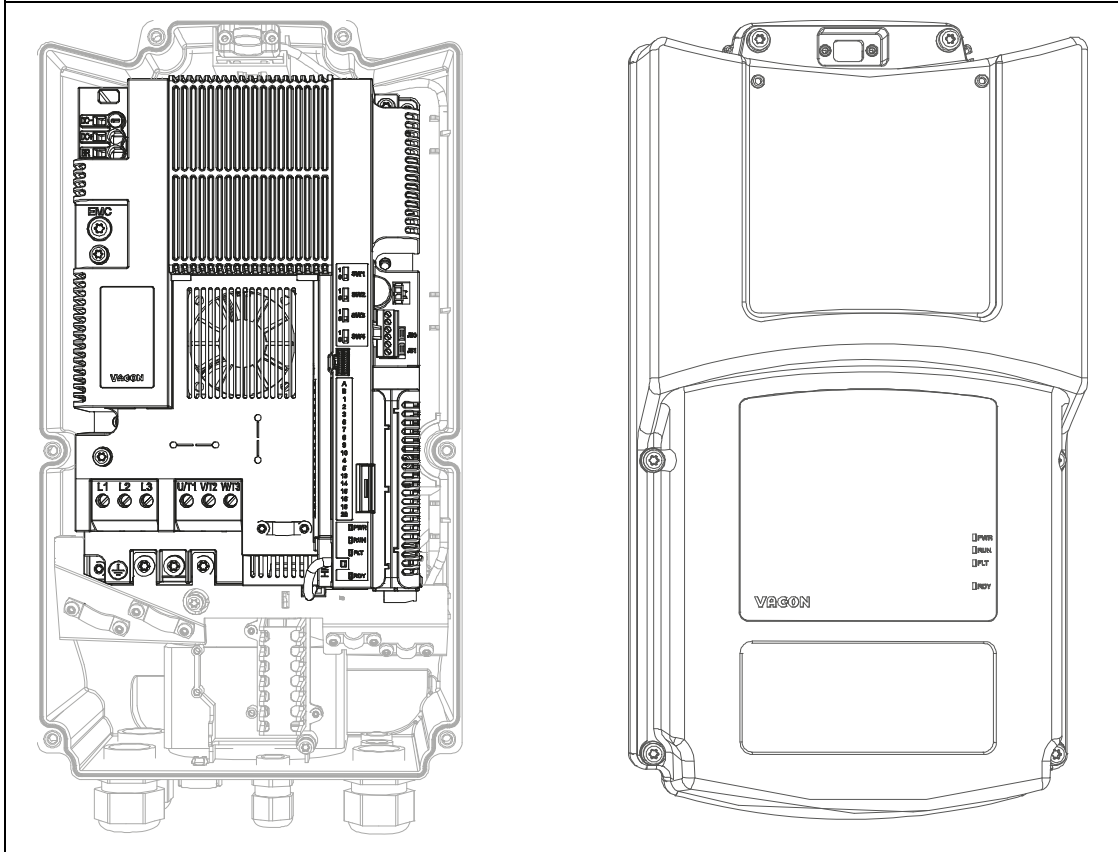


Figure 30. Open front cover of the drive: control unit MU3.

## 5.2 CONTROL UNITS MU2 AND MU3

The control unit of the AC drive consists of the control board and additional boards (option boards) connected to the slot connectors of the control board. The locations of boards, terminals and switches are presented in Figure 31, Figure 32 and Figure 33.

Table 19. Locations of components in control unit

Number	Meaning
1	Control terminals A-20
2	STO terminals (only in three-phase version)
3	Relay terminals
4	Option board terminals
5	STO Jumpers (only in three-phase version)
6	DIP switches
7	Status LEDs
8	HMI connector (RJ45 keypad connector)*
9	Optional brake resistor terminals
10	Supply voltage connector for external fan
11	Control terminals A-20 echo connector
12	HMI echo connector (keypad connector)
13	DC-bus terminals



\* The HMI connector is only to connect the keypad and not for Ethernet communication.

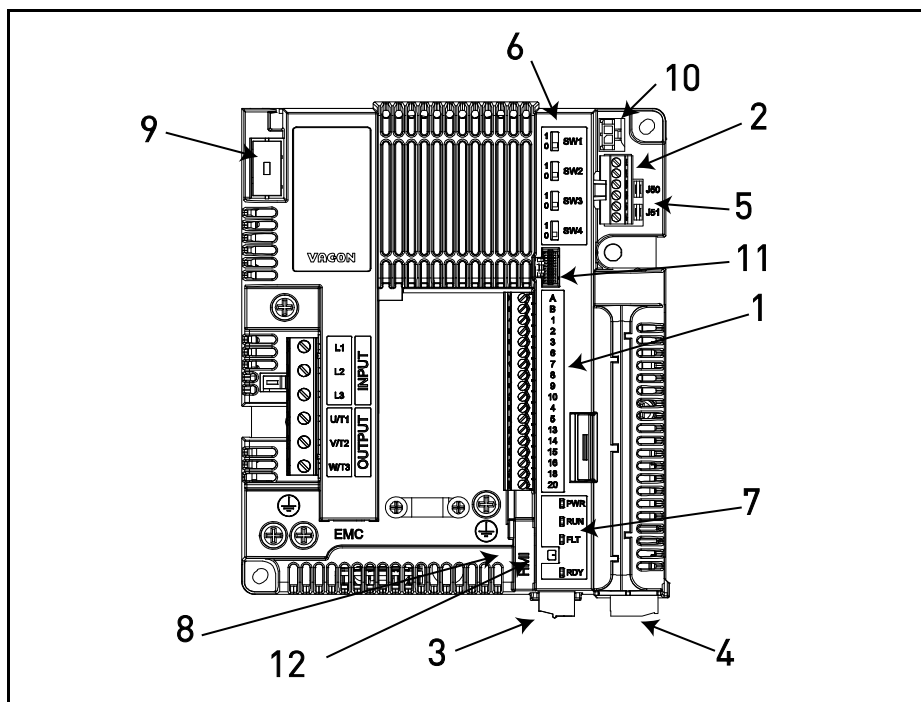


Figure 31. Locations of the components in control unit of MU2 (three-phase version).

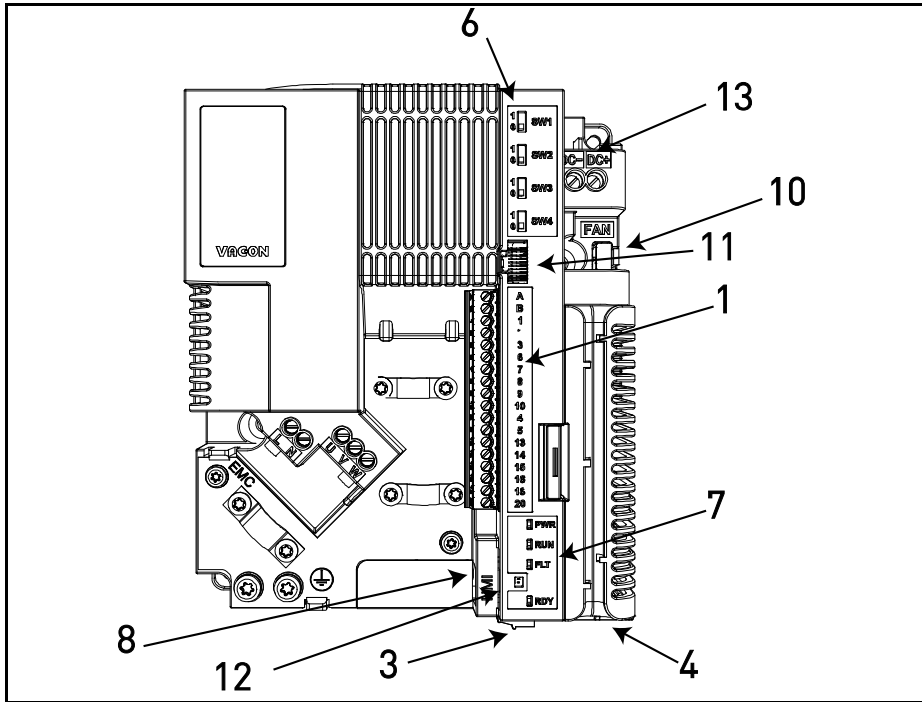


Figure 32. Locations of the components in control unit of MU2 (single-phase version).

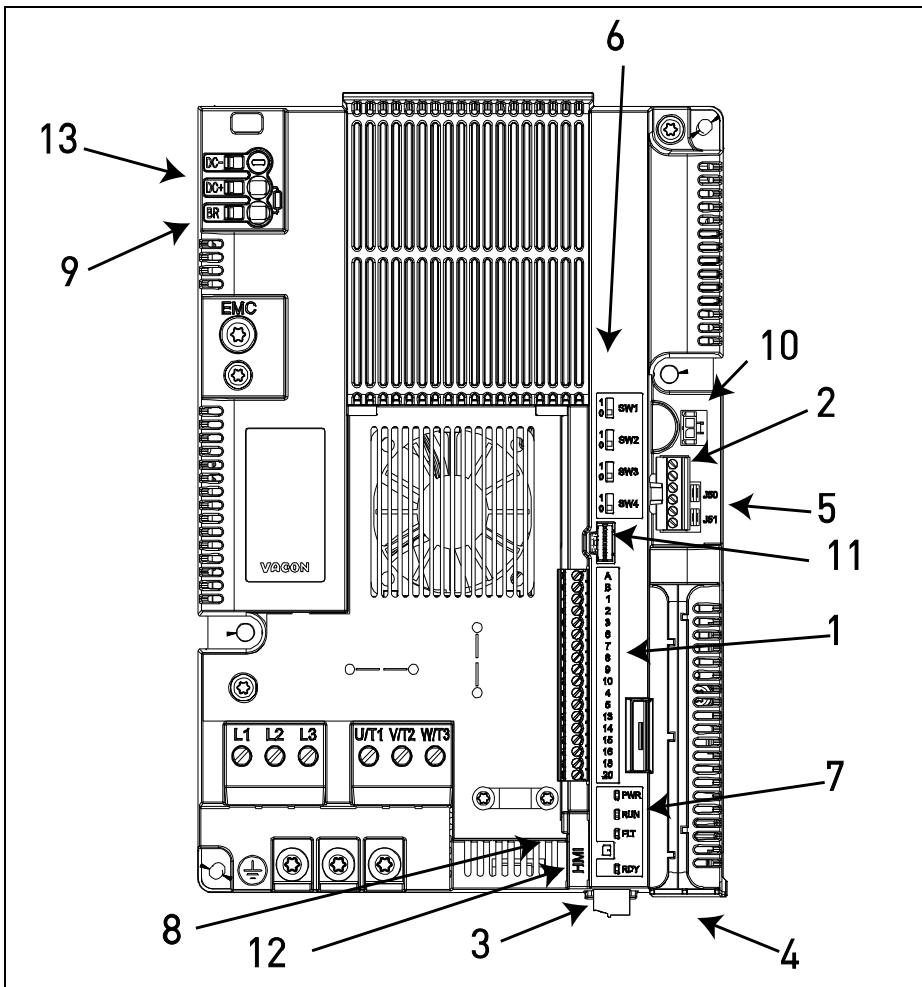


Figure 33. Location of the components in the control unit of MU3.

When delivered from the factory, the control unit of the AC drive contains the standard controlling interface - the control terminals of the control board and the relay board - unless otherwise specifically ordered. In the following pages you will find the arrangement of the control I/O and the relay terminals, the general wiring diagram and the control signal descriptions.

The control board can be powered externally (+24VDC  $\pm$ 10%, 1000mA) by connecting the external power source between terminal #6 and GND, see chapter 5.3.2. This voltage is sufficient for parameter setting and for keeping the control unit active. Note however that the values of the measurements of the main circuit (e.g. DC-link voltage, unit temperature) are not available when the mains is not connected.

### 5.3 CONTROL UNIT CABLING

The principal terminal block placement is shown in Figure 34 below. The control board is equipped with 18 fixed control I/O terminals and the relay board with 5. Additionally, the terminals for the Safe Torque Off (STO) function (see chapter 9) can be seen in the picture below. All signal descriptions are also given in Table 21.

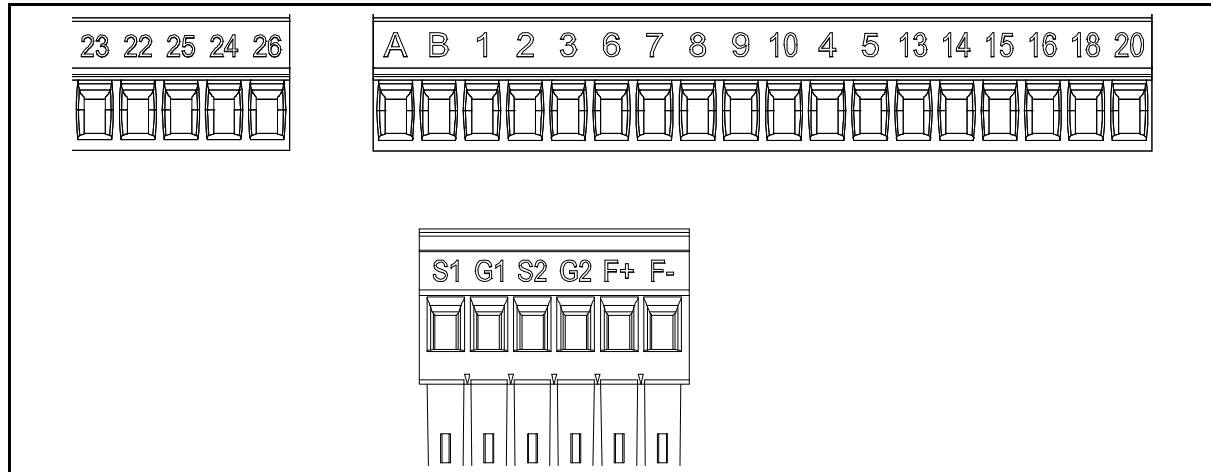


Figure 34. Control terminals.

#### 5.3.1 CONTROL CABLE SIZING

The I/O (control and relays) and STO cables must be screened multi core cables with the following cable sizes:

- 0.14 -1.5 mm<sup>2</sup> without ferrules
- 0.25 - 1.5 mm<sup>2</sup> with ferrules (no plastic neck)
- 0.25 - 1.5 mm<sup>2</sup> with ferrules (with plastic neck).

Find the tightening torques of the I/O (control and relays) and STO terminals in the Table 20 below.

Table 20. Control cable tightening torques.

Terminal screw	Tightening torque	
	Nm	lb-in.
I/O terminals and STO terminals (screw M2)	0.22 min 0.25 max	1.94 min 2.21 max

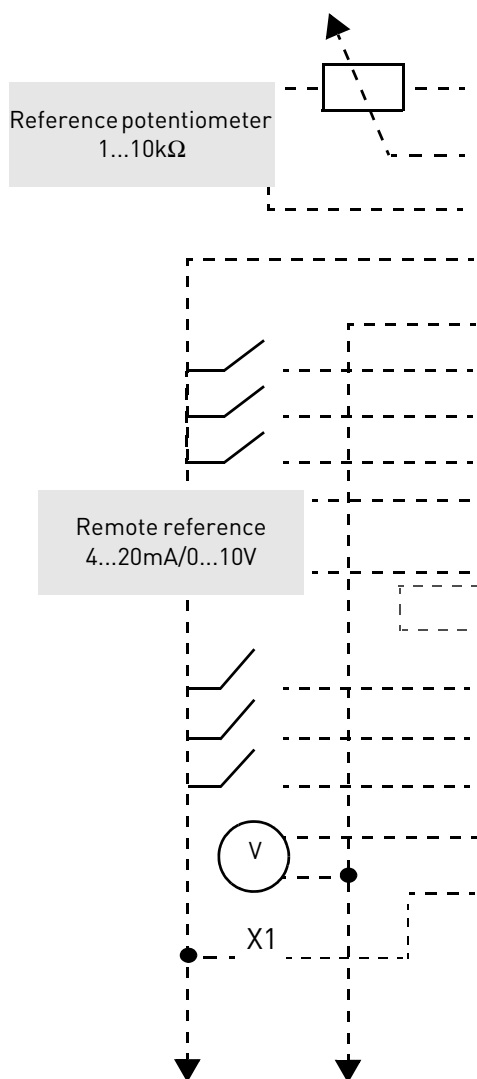


### 5.3.2 STANDARD I/O TERMINALS

The terminals of the *Standard I/O* and the *Relays* are described below. For more information on connections, see chapter 7.3.1.

The terminals shown on shadowed background are assigned for signals with optional functions selectable with DIP switches. For more information, see chapter 5.3.7.

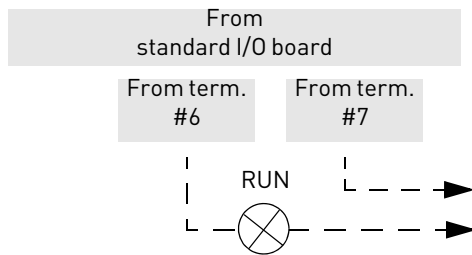
Table 21. Control I/O terminal signals and connection example.



Standard I/O terminals		
Terminal		Signal
<b>A</b>	RS485_A	Serial bus, negative
<b>B</b>	RS485_B	Serial bus, positive
<b>1</b>	+10 Vref	Reference output
<b>2</b>	AI1+	Analogue input, voltage or current
<b>3</b>	GND	I/O signal ground
<b>6</b>	24Vout	24V aux. voltage
<b>7</b>	DIN COM	Digital inputs common
<b>8</b>	DI1	Digital input 1
<b>9</b>	DI2	Digital input 2
<b>10</b>	DI3	Digital input 3
<b>4</b>	AI2+	Analogue input, voltage or current
<b>5</b>	GND	I/O signal ground
<b>13</b>	DO1-	Digital output 1 common
<b>14</b>	DI4	Digital input 4
<b>15</b>	DI5	Digital input 5
<b>16</b>	DI6	Digital input 6
<b>18</b>	A01+	Analogue signal (+output)
<b>20</b>	DO1+	Digital output 1

5.3.3 RELAY TERMINALS

Table 22. I/O terminal signals for relays and connection example.



Relays terminals		
Terminal		Signal
22	R01/2	Relay output 1
23	R01/3	
24	R02/1	Relay output 2
25	R02/2	
26	R02/3	

5.3.4 SAFE TORQUE OFF (STO) TERMINALS

For more information on the functionalities of the Safe Torque Off (STO), see chapter 9. This function is available only in the three-phase version.

Table 23. I/O terminal signals for the STO functions.

Safe Torque Off terminals	
Terminal	Signal
S1	Isolated digital input 1 (interchangeable polarity); +24V ±20% 10...15mA
G1	
S2	Isolated digital input 2 (interchangeable polarity); +24V ±20% 10...15mA
G2	
F+	Isolated feedback (CAUTION! Polarity to be respected); +24V ±20%
F-	Isolated feedback (CAUTION! Polarity to be respected); GND

### 5.3.5 DESCRIPTION OF ADDITIONAL ECHO CONNECTORS

In this paragraph you will find the description of the additional echo connector for the I/O terminals.

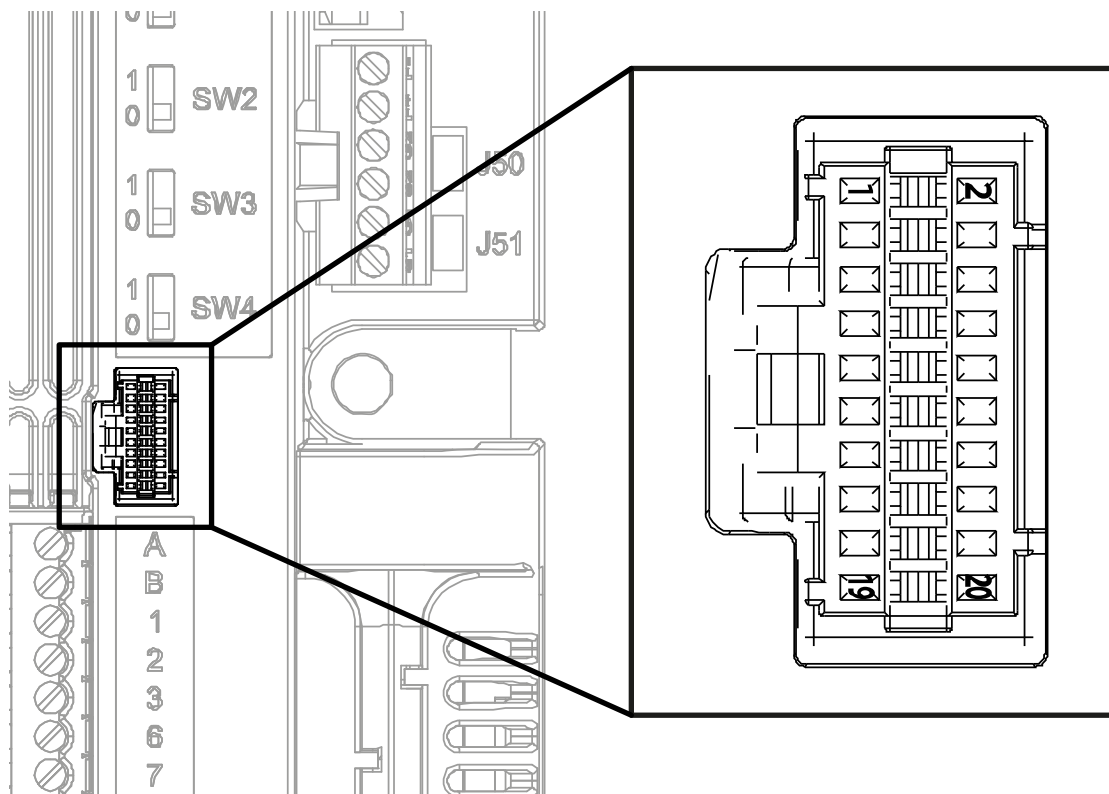


Figure 35. The I/O remote echo connector mounted on the control board.

In Figure 35 the view of Molex<sup>®</sup> connector for the I/O terminals is shown. In the control unit the position of this connector is numbered with 11 as shown in Figure 31, Figure 32 and Figure 33. The type of this connector is Pico-Clasp<sup>™</sup> Wire-to Board PCB Header, Dual Row, Right Angle. The code by Molex<sup>®</sup> is: 501571-2007.

It mates with Pico-Clasp<sup>™</sup> Wire-to Board Receptacle Housing (crimp housing), Dual Row, 20 Circuits. The code by Molex<sup>®</sup> is: 501189-2010. See Figure 36.

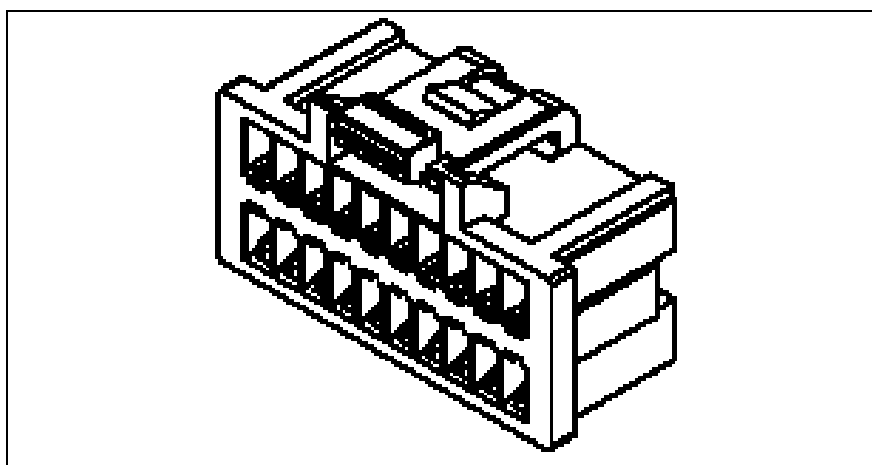


Figure 36. Receptacle housing for I/O remote echo connector.

To connect I/Os to the control unit through echo terminals this connector has to be used. In the following table, the correspondence between the pins of this connector and the VACON® 20 X terminals is shown.

*Table 24. I/O remote connector description.*

Pin number	Signal	Description
1	RS485_B	Serial bus, positive
2	DI2	Digital input 2
3	RS485_A	Serial bus, negative
4	DI3	Digital input 3
5	NC	not connected
6	AI2+	
7	NC	not connected
8	GND	
9	+10Vref	
10	DO1-	common for digital output 1
11	AI1+	
12	DI4	Digital input 4
13	GND	
14	DI5	Digital input 5
15	24Vout	
16	DI6	Digital input 6
17	DIN COM	
18	AO1+	Analogue output 1
19	DI1	Digital input 1
20	DO1+	Digital output 1

### 5.3.6 LED HANDLING

As VACON® 20 X is often without the keypad, on the plastic cover of the drive there are 4 status LEDs. See the picture below.

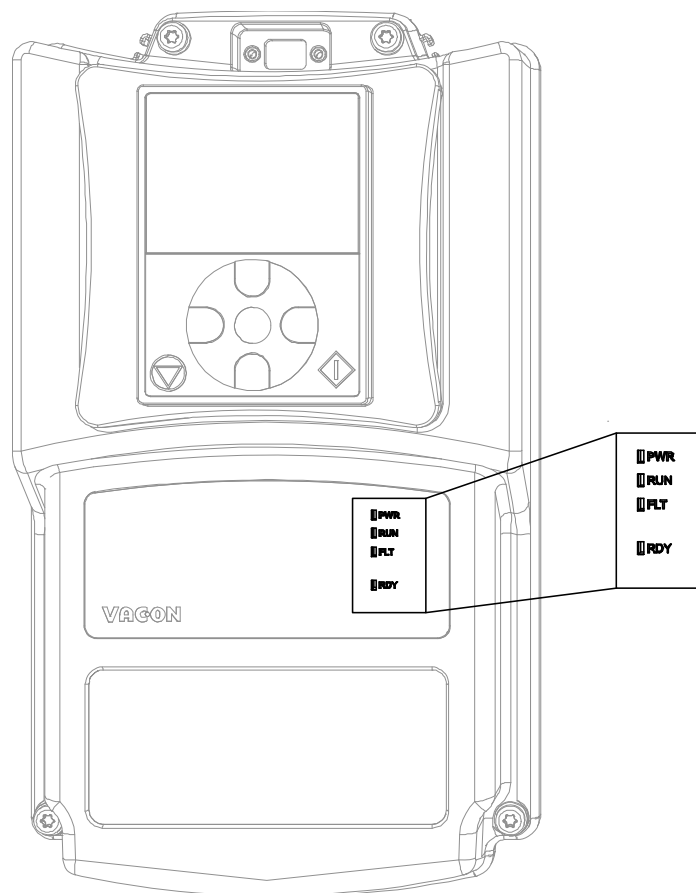


Figure 37. LED position on the MU2 cover.

Led "PWR" (orange led) means the drive is supplied by mains.

Led "RUN" (green led) means the drive is running.

Led "FLT" (red led) means the drive is experiencing a fault.

Led "RDY" (orange led) means the drive is ready and no fault is present. When a Warning is active, the led starts blinking.

### 5.3.7 SELECTION OF TERMINAL FUNCTIONS WITH DIP SWITCHES

The VACON® 20 X drive embodies four so-called *switches* that allow for two functional selections each. The shadowed terminals in Table 21 can be functionally modified with the dip switches.

The switches have two positions: 0 and 1. See Figure 38 to locate the switches and make appropriate selections for your requirements.

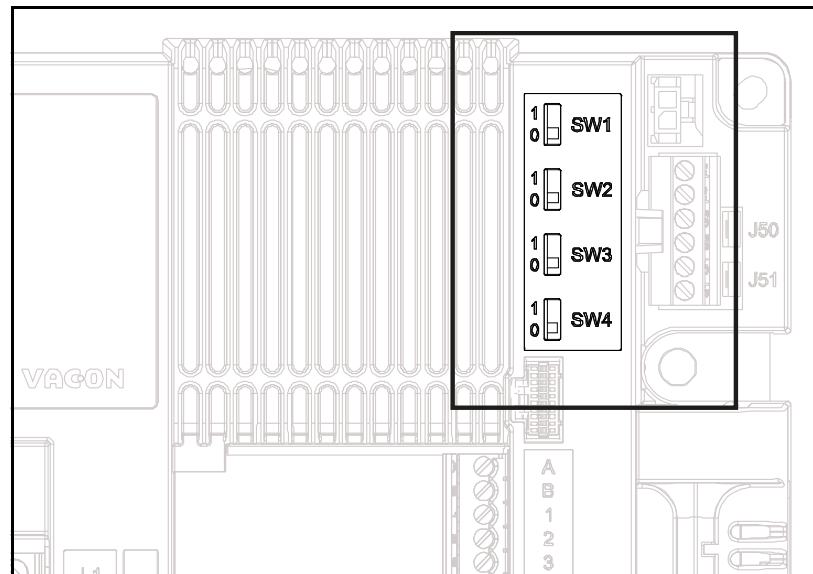


Figure 38. Dip switches on the control unit.

#### 5.3.7.1 Switch SW1

The digital inputs (terminals 8-10 and 14-16) on the standard I/O board can be **isolated** from ground by setting the *dip switch* SW1 to position '1'. See Figure 38. Locate the switch and set it in the desired position. The switch in the position "0" means that the common of digital input have been connected to the ground. The default position is "0".

#### 5.3.7.2 Switches SW2 and SW3

Analogue inputs can be used as either current inputs or voltage inputs. The signal type is selected with two switches on the control board.

The switch SW2 is related to analogue input AI1. In position "1" the analogue input AI1 works in voltage mode. In position "0" the analogue input works in current mode. The default position for SW2 is "1".

The voltage range is 0...10V and the current is 0/4.....20 mA.

The switch SW3 is related to analogue input AI2. In the position "1" the analogue input AI2 works in voltage mode. In the position "0" the analogue input works in current mode. The default position for SW3 is "0".

The voltage range is 0...10V and the current is 0/4.....20 mA.

#### 5.3.7.3 Switch SW4

The switch SW4 is related to the RS485 connection. It is used for bus termination. The bus termination must be set to the first and to the last device on the network. The switch SW4 in position "0" means that termination resistance is connected and the termination of the bus has been set. If the VACON® 20 X is the last device on the net, this switch must be set to "0" position. The default position for SW4 is "0".

## 5.4 FIELDBUS CONNECTION

Modbus is a communication protocol developed by Modicon systems. In other words, it is a way of sending information between electronic devices. The device requesting the information is called the Modbus Master and the devices supplying information are Modbus Slaves. In a standard Modbus network, there is one Master and up to 247 Slaves, each with a unique Slave Address from 1 to 247. The Master can also write information to the Slaves. Modbus is typically used to transmit signals from instrumentation and control devices back to a main controller or data gathering system.

The Modbus communication interface is built around messages. The format of these Modbus messages is independent of the type of physical interface used. The same protocol can be used regardless of the connection type. Thanks to this, Modbus allows for the easy upgrade of the hardware structure of an industrial network, without the need for significant changes in the software. A device can also communicate with several Modbus nodes at once, although they are connected with different interface types, without the need to use a different protocol for every connection.

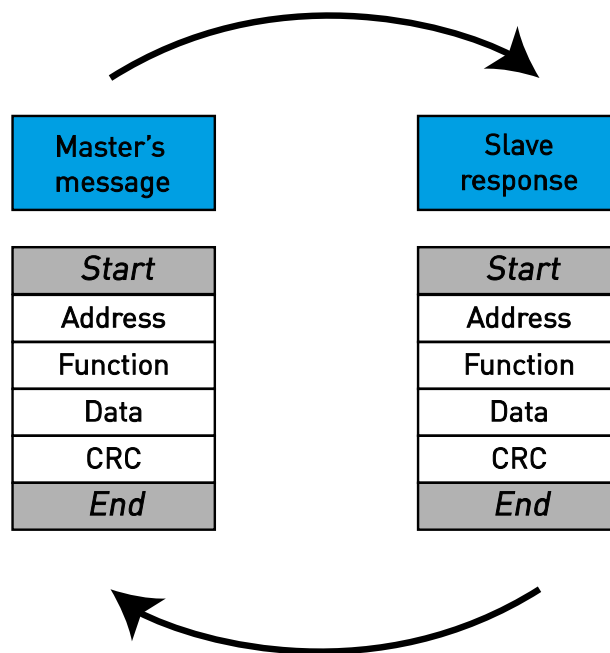


Figure 39. Basic structure of Modbus frame.

On simple interfaces such as RS485, the Modbus messages are sent in plain form over the network. In this case the network is dedicated to Modbus.

Each Modbus message has the same structure. Four basic elements are present in each message. The sequence of these elements is the same for all messages, to make it easy to parse the content of the Modbus message. A conversation is always started by a master in the Modbus network. A Modbus master sends a message and—depending on the contents of the message— a slave takes action and responds to it. There can be more masters in a Modbus network. The address in the message header is used to define which device should respond to a message. All other nodes on the Modbus network ignore the message if the address field does not match their own address.

5.4.1 MODBUS RTU PROTOCOL

Table 25.

<b>Connections and communications</b>	Interface	RS-485
	Data transfer method	RS-485 MS/TP, half-duplex
	Transfer cable	STP (shielded twisted pair), type Belden 9841 or similar
	Connector	2.5 mm <sup>2</sup>
	Electrical isolation	Functional
	Modbus RTU	As described in "Modicon Modbus Protocol Reference Guide"
	Baud rate	300, 600, 1200, 2400, 4800, 9600, 19200, 38400 and 57600 baud
	Addresses	1 to 247

VACON® 20 X drive is equipped with Modbus support as standard. The AC drive can be connected to fieldbus through RS485. The connection for RS485 is on the standard I/O (terminals A and B). See Figure 40.

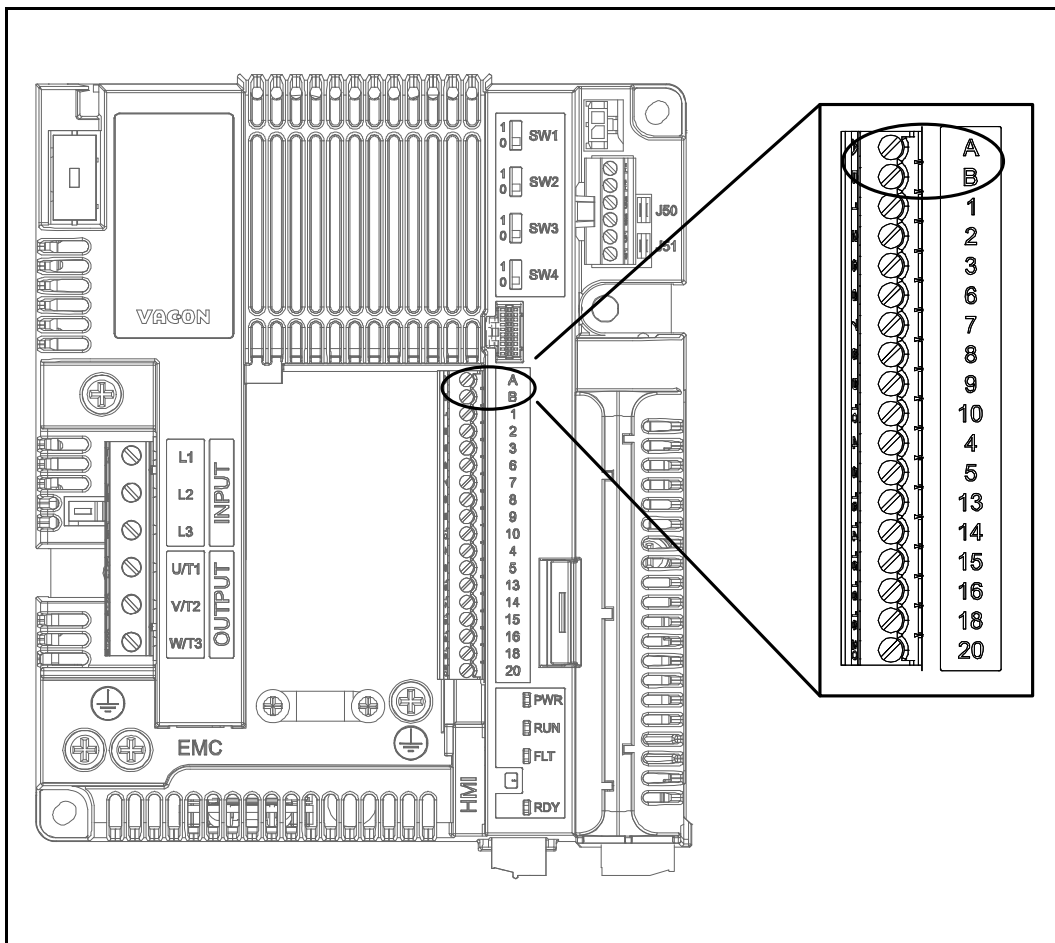
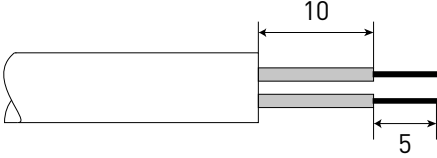
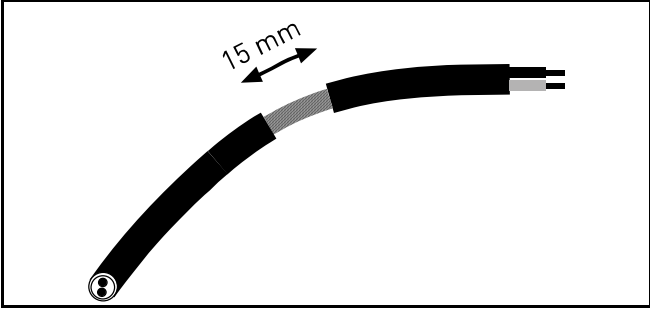
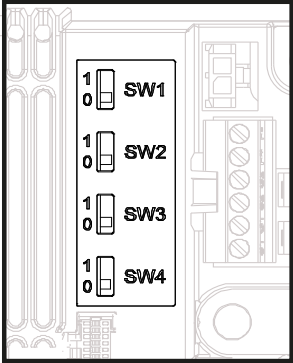


Figure 40. Position of the RS485 terminals on the I/O standard terminal connector (MU2 control unit example).



5.4.2 PREPARATION FOR USE THROUGH RS485

<p><b>1</b></p>	<p>Strip about 15 mm of the RS485 cable (see specification on Table 25) and cut off the grey cable shield. Remember to do this for both bus cables (except for the last device).</p> <p>Leave no more than 10 mm of the cable outside the terminal block and strip the cables at about 5 mm to fit in the terminals. See picture below.</p>  <p>Also strip the cable now at such a distance from the terminal that you can fix it to the enclosure with the grounding clamp. Strip the cable at a maximum length of 15 mm. <b>Do not strip the aluminium cable shield!</b></p> 
<p><b>2</b></p>	<p>Then connect the cable to its appropriate terminals on VACON® 20 X AC drive standard terminal block, terminals <b>A and B</b> (A = negative, B = positive).</p>
<p><b>3</b></p>	<p>Using the cable clamp included in the supply of the drive, ground the shield of the RS485 cable to the enclosure of the AC drive.</p>
<p><b>4</b></p>	<p><b>If VACON® 20 X drive is the last device on the bus,</b> the bus termination must be set. Locate the switches to the right of the control terminals (see Figure 38) and turn the SW4 switch to position "0". Biasing is built in the termination resistor.</p> 
<p><b>5</b></p>	<p><b>NOTE:</b> When planning the cable runs, remember to keep the distance between the fieldbus cable and the motor cable at a <b>minimum of 30 cm</b>.</p>
<p><b>6</b></p>	<p>The bus termination must be set for the first and the last device of the fieldbus line. We recommend that the first device terminated is the Master device.</p>

## 6. COMMISSIONING

Before commissioning, note the following directions and warnings:



Internal components and circuit boards of VACON<sup>®</sup> 20 X drive (except for the galvanically isolated I/O terminals) are live when it is connected to the mains potential. **Coming into contact with this voltage is extremely dangerous and may cause death or severe injury.**

---



The motor terminals **U, V, W** and the brake resistor terminals **are live** when VACON<sup>®</sup> 20 X drive is connected to the mains, **even if the motor is not running.**

---



The control I/O-terminals are isolated from the mains potential. However, the **relay outputs may have a dangerous control voltage** present even when VACON<sup>®</sup> 20 X drive is disconnected from the mains.

---



Do not make any connections to or from the AC drive when it is connected to the mains.

---




**After disconnecting** the AC drive from the mains, **wait** until the indicators on the cover go out. Wait an additional 30 seconds before doing any work on the connections of VACON<sup>®</sup> 20 X Drive. Do not open the unit before this time has expired. After expiration of this time, use a measuring equipment to absolutely ensure that no voltage is present. **Always ensure absence of voltage before starting any electrical work!**

---

### 6.1 COMMISSIONING OF THE DRIVE

Read carefully the safety instructions in Chapter 1 and above and follow them.

After the installation:

<input type="checkbox"/>	Check that both the AC drive and the motor are grounded.
<input type="checkbox"/>	Check that the mains and motor cables comply with the requirements given in chapter 4.1.1.
<input type="checkbox"/>	Check that the control cables are located as far as possible from the power cables, see chapter 4.4.
<input type="checkbox"/>	Check that the shields of the shielded cables are connected to protective earth marked with  .
<input type="checkbox"/>	Check the tightening torques of all terminals.
<input type="checkbox"/>	Check that the wires do not touch the electrical components of the drive.
<input type="checkbox"/>	Check that the common inputs of digital input groups are connected to +24V or ground of the I/O terminal.
<input type="checkbox"/>	Check the quality and quantity of cooling air.
<input type="checkbox"/>	Check the inside of the AC drive for condensation.
<input type="checkbox"/>	Check that all Start/Stop switches connected to the I/O terminals are in the Stop-position.
<input type="checkbox"/>	Before connecting the AC drive to mains: Check mounting and condition of all fuses and other protective devices.

## 6.2 CHANGING EMC PROTECTION CLASS

If your supply network is an IT (impedance-grounded) system but your AC drive is EMC-protected according to class C1 or C2 you need to modify the EMC protection of the AC drive to EMC-level T (C4). This is done as described below:



Warning! Do not perform any modifications on the AC drive when it is connected to mains.

### 6.2.1 CHANGING EMC PROTECTION CLASS - MU2 THREE-PHASE VERSION

1

Remove the three screws on the EMC plate from the unit.

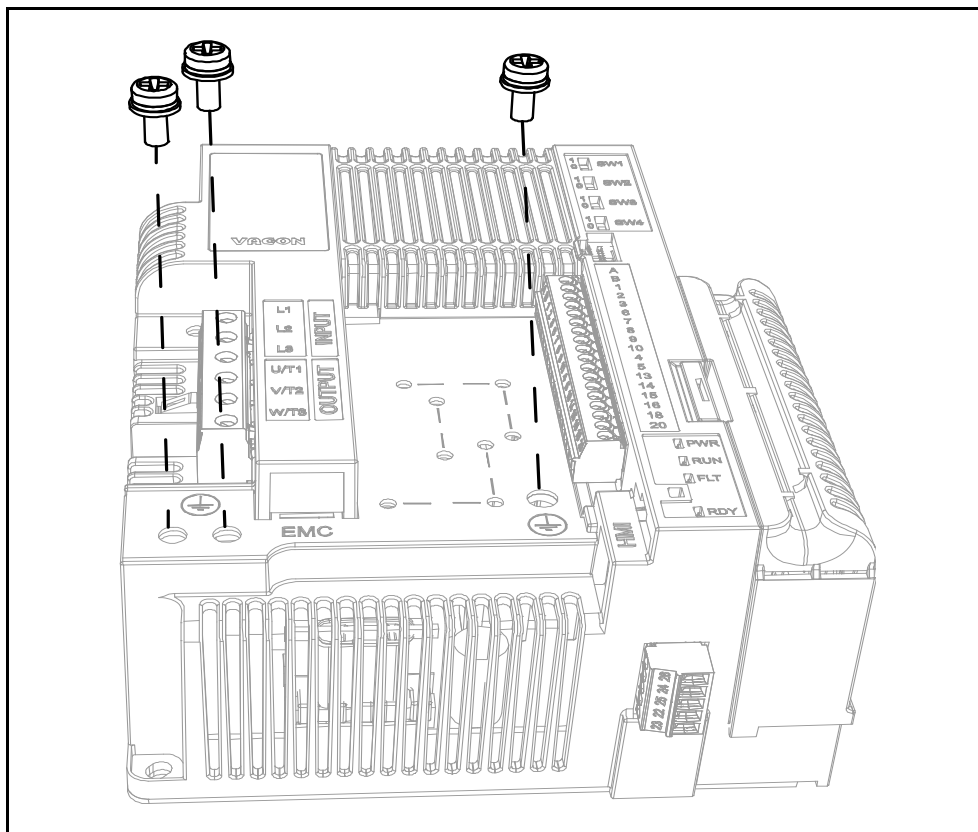


Figure 41. Changing of the EMC class in MU2 control unit.

**2** Remove the EMC plate from the control unit. Then lift the plate with pliers to disconnect the EMC plate from the ground. See Figure 42.  
Then reconnect the EMC plate to the unit.

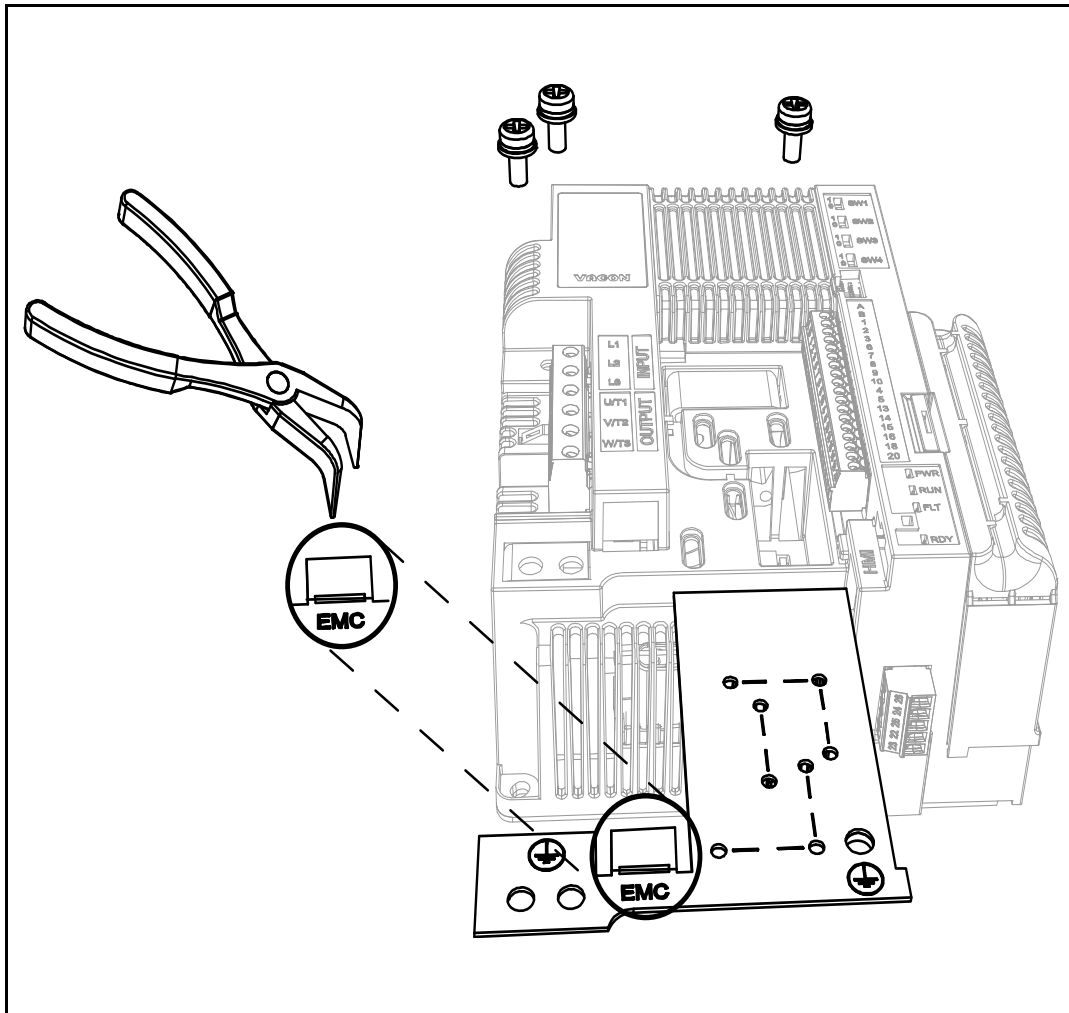


Figure 42. Changing of the EMC class in MU2 control unit.

## 6.2.2 CHANGING EMC PROTECTION CLASS - MU2 SINGLE-PHASE VERSION

**1**

Remove the EMC screw as shown in the Figure 43.

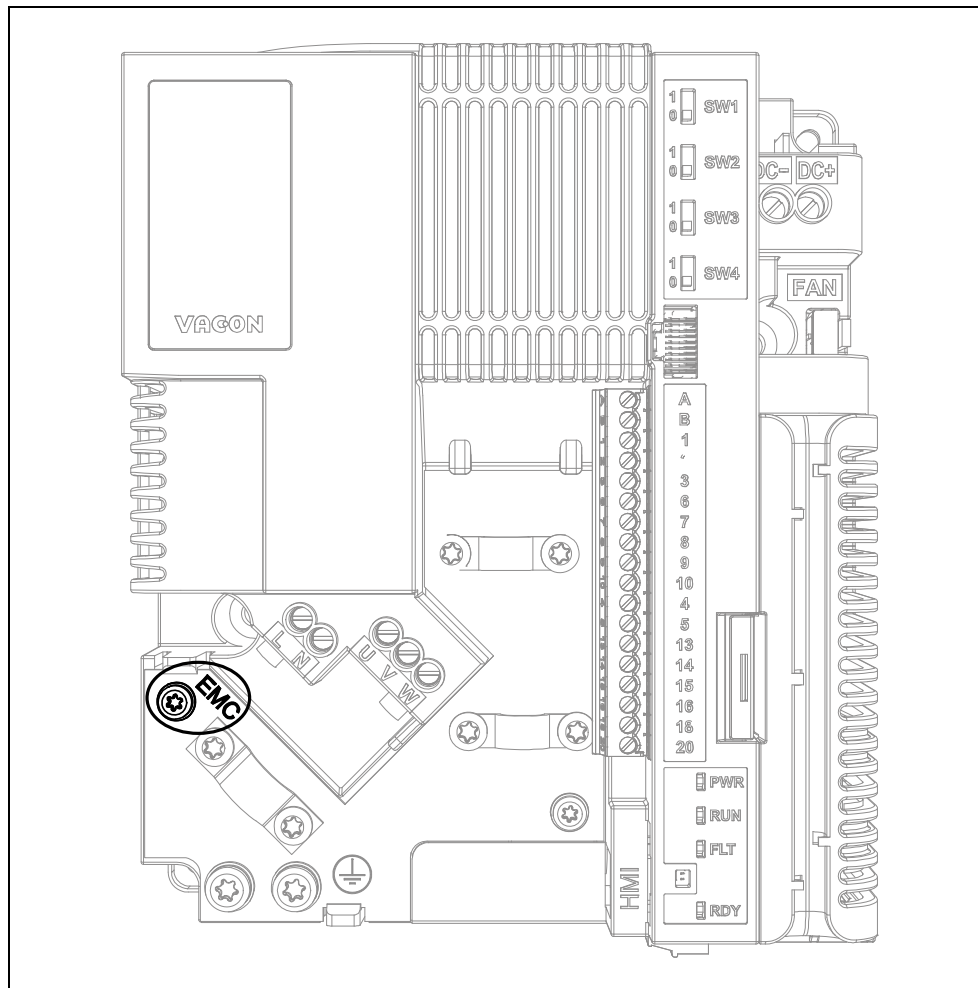


Figure 43. Changing the EMC class in the MU2 (single-phase version).

6.2.3 CHANGING EMC PROTECTION CLASS - MU3

**1** Remove the EMC screw as shown in the Figure 44.

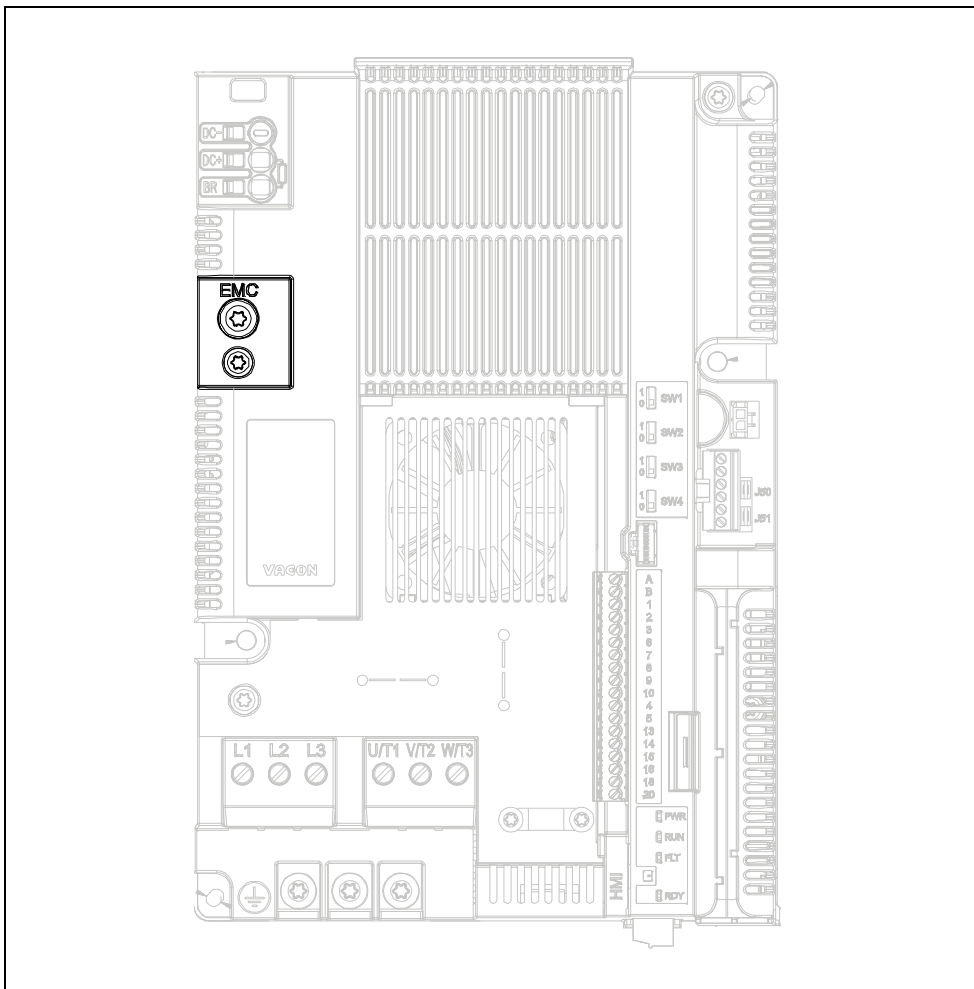


Figure 44. Changing the EMC class in the MU3 control unit.

	<p><b>CAUTION!</b> Before connecting the AC drive to mains make sure that the EMC protection class settings of the drive are appropriately made.</p>
	<p><b>NOTE!</b> After having performed the change write 'EMC level modified' on the sticker included in the VACON® 20 X delivery (see below) and note the date. Unless already done, attach the sticker close to the name plate of the AC drive.</p> <div style="border: 1px solid black; padding: 5px; margin: 10px auto; width: fit-content;"> <p style="text-align: center;"><b>Product modified</b></p> <p style="text-align: center;">Date: .....</p> <p style="text-align: center;">Date: .....</p> <p style="text-align: center;">EMC-level modified C1-&gt;C4 Date: DDMYY </p> </div>

### 6.3 RUNNING THE MOTOR

#### MOTOR RUN CHECK LIST



**Before starting the motor**, check that the motor is **mounted properly** and ensure that the machine connected to the motor allows the motor to be started.

---



Set the maximum motor speed (frequency) according to the motor and the machine connected to it.

---



**Before reversing the motor** make sure that this can be done safely.

---



Make sure that no power correction capacitors are connected to the motor cable.

---



Make sure that the motor terminals are not connected to mains potential.

#### 6.3.1 CABLE AND MOTOR INSULATION CHECKS

1. Motor cable insulation checks  
Disconnect the motor cable from terminals U, V and W of the AC drive and from the motor. Measure the insulation resistance of the motor cable between each phase conductor as well as between each phase conductor and the protective ground conductor. The insulation resistance must be  $>1\text{M}\Omega$  at ambient temperature of  $20^\circ\text{C}$ .
2. Mains cable insulation checks  
Disconnect the mains cable from terminals L1, L2 and L3 of the AC drive and from the mains. Measure the insulation resistance of the mains cable between each phase conductor as well as between each phase conductor and the protective ground conductor. The insulation resistance must be  $>1\text{M}\Omega$  at ambient temperature of  $20^\circ\text{C}$ .
3. Motor insulation checks  
Disconnect the motor cable from the motor and open the bridging connections in the motor connection box. Measure the insulation resistance of each motor winding. The measurement voltage must equal at least the motor nominal voltage but not exceed 1000 V. The insulation resistance must be  $>1\text{M}\Omega$  at ambient temperature of  $20^\circ\text{C}$ .



## 6.4 MAINTENANCE

In normal conditions, the AC drive is maintenance-free. However, regular maintenance is recommended to ensure trouble-free operation and longevity of the drive. We recommend the table below is followed for maintenance intervals.

Table 26.

Maintenance interval	Maintenance action
Regularly and according to general maintenance interval	<ul style="list-style-type: none"> <li>• Check tightening torques of terminals.</li> </ul>
6...24 months (depending on environment)	<ul style="list-style-type: none"> <li>• Check input and output terminals and control I/O terminals.</li> <li>• Check for corrosion on terminals and other surfaces.</li> <li>• Check the heatsink for dust and clean if necessary.</li> </ul>
6...10 years	<ul style="list-style-type: none"> <li>• Change the main fan.</li> </ul>
12...24 months	<ul style="list-style-type: none"> <li>• Charge capacitors, only after long storage times or long down times without supply: contact your nearest VACON® service center.</li> </ul>

## 7. TECHNICAL DATA

### 7.1 AC DRIVE POWER RATINGS

#### 7.1.1 MAINS VOLTAGE 3AC 208-240V

Table 27. Power ratings of VACON® 20 X, supply voltage 208-240V.

Mains Voltage 3AC 208-240V, 50/60 Hz							
	AC drive type	Input current [A]	Loadability			Motor shaft power	
			Rated continuous current I <sub>N</sub> [A]	50% overload current [A]	Max current I <sub>S</sub>	230V	240V
						[kW]	[HP]
<b>MU2</b>	0004	<b>4.3</b>	<b>3.7</b>	5.6	7.4	<b>0.75</b>	<b>1.0</b>
	0005	<b>6.8</b>	<b>4.8</b>	7.2	9.6	<b>1.1</b>	<b>1.5</b>
	0007	<b>8.4</b>	<b>7.0</b>	10.5	14.0	<b>1.5</b>	<b>2.0</b>
<b>MU3</b>	0011	<b>13.4</b>	<b>11.0</b>	16.5	22.0	<b>2.2</b>	<b>3.0</b>
	0012	<b>14.2</b>	<b>12.5</b>	18.8	25.0	<b>3.0</b>	<b>4.0</b>
	0017	<b>20.6</b>	<b>17.5</b>	26.3	35.0	<b>4.0</b>	<b>5.0</b>

**NOTE:** The rated currents in given ambient temperatures (in Table 27) are achieved only when the switching frequency is equal to or less than the factory default.

#### 7.1.2 MAINS VOLTAGE 1AC 208-240V

Table 28. Power ratings of VACON® 20 X, supply voltage 1AC 208-240V.

Mains Voltage 1AC 208-240V, 50/60 Hz							
	AC drive type	Input current [A]	Loadability			Motor shaft power	
			Rated continuous current I <sub>N</sub> [A]	50% overload current [A]	Max current I <sub>S</sub>	230V	230V
						[kW]	[HP]
<b>MU2</b>	0004	<b>8.3</b>	<b>3.7</b>	5.6	7.4	<b>0.75</b>	<b>1.0</b>
	0005	<b>11.2</b>	<b>4.8</b>	7.2	9.6	<b>1.1</b>	<b>1.5</b>
	0007	<b>14.1</b>	<b>7.0</b>	10.5	14.0	<b>1.5</b>	<b>2.0</b>

**NOTE:** The rated currents in given ambient temperatures (in Table 28) are achieved only when the switching frequency is equal to or less than the factory default.

7.1.3 MAINS VOLTAGE 3AC 380-480V

Table 29. Power ratings of VACON® 20 X, supply voltage 380-480V.

Mains Voltage 3AC 380-480V, 50/60 Hz							
	AC drive type	Input current [A]	Loadability			Motor shaft power	
			Rated continuous current $I_N$ [A]	50% overload current [A]	Max current $I_S$	400V	480V
						[kW]	[HP]
MU2	0003	3.2	2.4	3.6	4.8	0.75	1.0
	0004	4.0	3.3	5.0	6.6	1.1	1.5
	0005	5.6	4.3	6.5	8.6	1.5	2.0
	0006	7.3	5.6	8.4	11.2	2.2	3.0
	0008	9.6	7.6	11.4	15.2	3.0	4.0
MU3	0009	11.5	9.0	13.5	18.0	4.0	5.0
	0012	14.9	12.0	18.0	24.0	5.5	7.5
	0016	20	16.0	24.0	32.0	7.5	10.0

**NOTE:** The rated currents in given ambient temperatures (in Table 29) are achieved only when the switching frequency is equal to or less than the factory default.

7.1.4 DEFINITIONS OF OVERLOADABILITY

**Overloadability** =Following continuous operation at rated output current  $I_N$ , the AC drive supplies 150% \*  $I_N$  for 1 min, followed by a period of at least 9 min at  $I_N$  or below.

Example: If the duty cycle requires 150% rated current for 1 min in every 10 min, the remaining 9 min must be at rated current  $I_N$  or less.

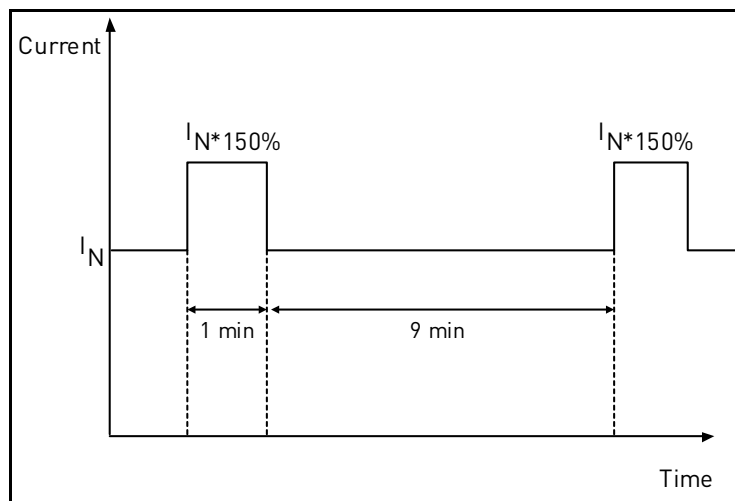


Figure 45. High overload.

## 7.2 BRAKE RESISTOR RATINGS

Make sure that the resistance is higher than the minimum resistance defined. The power handling capacity must be sufficient for the application. Brake chopper is available only in three-phase version.

Recommended minimum brake resistor values for VACON® 20 X AC drives:

Table 30. Brake resistor ratings, 208-240V.

Mains Voltage 3AC 208-240 V, 50/60 Hz		
Enclosure size	Type	Minimum Resistance recommended [Ohm]
MU2	0004	50
	0005	50
	0007	50
MU3	0011	25
	0012	25
	0017	25

Table 31. Brake resistor ratings, 380-480V.

Mains Voltage 3AC 380-480 V, 50/60 Hz		
Enclosure size	Type	Minimum Resistance recommended [Ohm]
MU2	0003	100
	0004	100
	0005	100
	0006	100
	0008	100
MU3	0009	50
	0012	50
	0016	50

7.3 VACON® 20 X - TECHNICAL DATA

Table 32. VACON® 20 X technical data.

<b>Mains connection</b>	Input voltage $U_{in}$	3AC 208...240V 1AC 208...240V 3AC 380...480V
	Input voltage tolerance	-15%...+10% continuously
	Input frequency	50/60 Hz
	Input frequency tolerance	45...66 Hz
	Protection class	I
	Connection to mains	Once per minute or less
	Starting delay	4 s
	Supply network	IT and TN-networks (cannot be used with corner earthed networks)
	Short-circuit current	Maximum short-circuit current has to be <50kA
	DC connection	Available as standard in MU2 single-phase enclosures and MU3
<b>Motor connection</b>	Output voltage	3AC 0... $U_{in}$
	Rated output current	$I_N$ : Ambient temperature max. +40°C. See Table 27 and Table 29.
	Overload output current	$1.5 \times I_N$ (1 min/10 min)
	Starting current	$I_S$ for 2 s every 20 s ( $I_S = 2.0 * I_N$ )
	Output frequency	0...320 Hz
	Frequency resolution	0.01 Hz
	Protection class	I
	Motor characteristics	AC squirrel cage motors Permanent magnet motors
	Cable type	Screened motor cable
<b>Control characteristics</b>	Cable maximum length	30 m
	Switching frequency	Programmable 2...16 kHz; Default 6 kHz. Automatic switching frequency derating in case of overheating
	Frequency reference: Analogue input Panel reference	Resolution $\pm 0.05\%$ (11-bit), accuracy $\pm 1\%$ Resolution 0.01 Hz
	Field weakening point	8...320 Hz
	Acceleration time	0.1...3000 sec
	Deceleration time	0.1...3000 sec
Braking	Brake chopper standard in all three-phase enclosures. External brake resistor optional.	
<b>Control connections</b>	See Chapter 5.	

Table 32. VACON® 20 X technical data.

<b>Communication interface</b>	Fieldbus	Standard: Serial communication (RS485/Modbus); Optional: CANopen; Profibus DP, Lonworks, DeviceNet, Profinet IO, Ethernet IP, Modbus TCP, EtherCAT, AS-interface	
	Status indicators	Drive status indicators (LED) on top side (POWER, RUN, FAULT, READY)	
<b>Ambient conditions</b>	Ambient operating temperature	-10°C...+40°C	
	Extended temperature range	up to 50°C with current derating (see chapter 1.8)	
	Storage temperature	-40°C...+70°C	
	Relative humidity	0 to 100% R <sub>H</sub> . Good resistance to most acids, alkalis and oils. Contact factory for more details.	
	Pollution degree	PD2 used for PCB design. However the drive is suitable for outdoor use because of dust-tight enclosure to numeral 6 [acc. to IEC 60529]	
	Altitude	100% load capacity (no derating) up to 1,000m; derating 1% / 100m at 1.000...3.000m	
	Degree of protection	IP66/Type 4X (IP65 when used with Simple Operator Panel +QDSH)	
	Stationary vibration: Sinusoidal	3 Hz ≤ f ≤ 8.43 Hz: 7.5mm 8.43 Hz ≤ f ≤ 200 Hz: 2g (3M6 acc. to IEC 60721-3-3)	
	Shock/Bump:	25g/6ms (3M6 acc. to IEC 60721-3-3)	
<b>Directives</b>	EMC	2004/108/EC	
	Low Voltage	2006/95/EC	
	RoHS	2002/95/EC	
	WEEE	2012/19/EC	
<b>Standards</b>	Immunity	EN61800-3: 2004 + A1: 2011, 1 <sup>st</sup> and 2 <sup>nd</sup> environment	
	Emissions	EN61800-3: 2004 + A1: 2011,	
		3-phase version	Category C2 as standard for conducted and radiated emissions
		1-phase version	Category C1 as standard for conducted emissions
			Category C2 as standard for radiated emissions.
The drive can be modified to category C4.			
Safety	EN 61800-5-1		
<b>Production quality</b>	ISO 9001		

Table 32. VACON® 20 X technical data.

<b>Approvals</b>	Functional Safety	TÜV - Tested
	Electrical Safety	TÜV - Tested
	EMC	TUV - Tested
	USA, Canada	cULus approval, file number E171278
<b>Declaration of Conformity</b>	Korea	KC mark
	Australia	RMA Declaration of Conformity Registration number E2204
	Europe	EC Declaration of Conformity
<b>Protections</b>	Undervoltage trip limit	Depends on supply voltage (0.8775*supply voltage): Supply voltage 240 V: Trip limit <b>211 V</b> Supply voltage 400 V: Trip limit <b>351 V</b> Supply voltage 480 V: Trip limit <b>421 V</b>
	Earth fault protection	Yes
	Mains supervision	Yes
	Motor phase supervision	Yes (not available in 1-phase version)
	Overcurrent protection	Yes
	Unit overtemperature protection	Yes
	Motor overload protection	Yes. These devices provide motor overload protection at 105% of full load amperes.
	Motor stall protection	Yes
	Motor underload protection	Yes
	Short-circuit protection of +24V and +10V reference voltages	Yes
	Thermal motor protection	Yes (by PTC with option card)

## 7.3.1 TECHNICAL INFORMATION ON CONTROL CONNECTIONS

Table 33. Technical information on standard I/O terminals.

Standard I/O		
Terminal	Signal	Technical information
A	RS485	Differential receiver/transmitter Set bus termination with dip switches (see Chapter 5)
B	RS485	
1	Reference output	+10V, $\pm 5\%$ ; Maximum current 10 mA
2	Analogue input, voltage or current	Analogue input channel 1 0- +10V ( $R_i = 200 \text{ k}\Omega$ ) 0/4-20 mA ( $R_i = 250 \text{ }\Omega$ ) Resolution 0.05%, accuracy $\pm 1 \%$ Selection V/mA with dip-switches (see Chapter 5). Default 0- +10V
3	I/O ground	Ground for reference and controls (connected internally to enclosure earth through $2\text{M}\Omega$ )
6	24V aux. voltage	+24V, $\pm 10\%$ , max volt. ripple < 100mVrms; max. 100 mA Short-circuit protected Can be used with an external power supply (with a current limiter or fuse protected) to supply the control unit and fieldbus for backup purposes. Dimensioning: max. 1000mA/control unit.
7	DIN COM	Common for digital inputs. Connected to GND with dip-switch SW1. See Chapter 5
8	Digital input 1	Positive or negative logic $R_i = \text{min. } 4\text{k}\Omega$ 15...30V = "1" 0...5V = "0"
9	Digital input 2	
10	Digital input 3	
4	Analogue input, voltage or current	Analogue input channel 2 0- +10V ( $R_i = 200 \text{ k}\Omega$ ) 0/4-20 mA ( $R_i = 250 \text{ }\Omega$ ) Resolution 0.05%, accuracy $\pm 1 \%$ Selection V/mA with dip-switches (see Chapter 5). Default 0/4-20 mA
5	I/O ground	Ground for reference and controls (connected internally to enclosure earth through $2\text{M}\Omega$ )
13	Digital output common	Common for digital output 1 (DO1-)
14	Digital input 4	Positive or negative logic $R_i = \text{min. } 4\text{k}\Omega$ 15...30V = "1" 0...5V = "0"
15	Digital input 5	
16	Digital input 6	
18	Analogue signal (+output)	Analogue output channel 1, 0-10V (30mA max) Resolution 0.1%, accuracy $\pm 2.5 \%$ Short-circuited protected.
20	Digital Output 1	Open Collector max 35V / 50mA (DO1+)



Table 34. Technical information on Relays.

Relays		
Terminal	Signal	Technical information
22	Relay output 1*	Switching capacity 250VAC/3A (only earthed network allowed)
23		
24	Relay output 2*	Switching capacity NO 250VAC/5A NC 250VAC/3A (only earthed network allowed)
25		
26		

\* If 230VAC is used as control voltage from the output relays, the control circuitry must be powered with a separate isolation transformer to limit short circuit current and overvoltage spikes. This is to prevent welding on the relay contacts. Refer to standard EN 60204-1, section 7.2.9

## 8. OPTIONS

### 8.1 VACON® KEYPAD WITH SEVEN-SEGMENT DISPLAY

The text keypad is an option available for VACON® 20 X. The control keypad is the interface between the VACON® 20 X AC drive and the user.

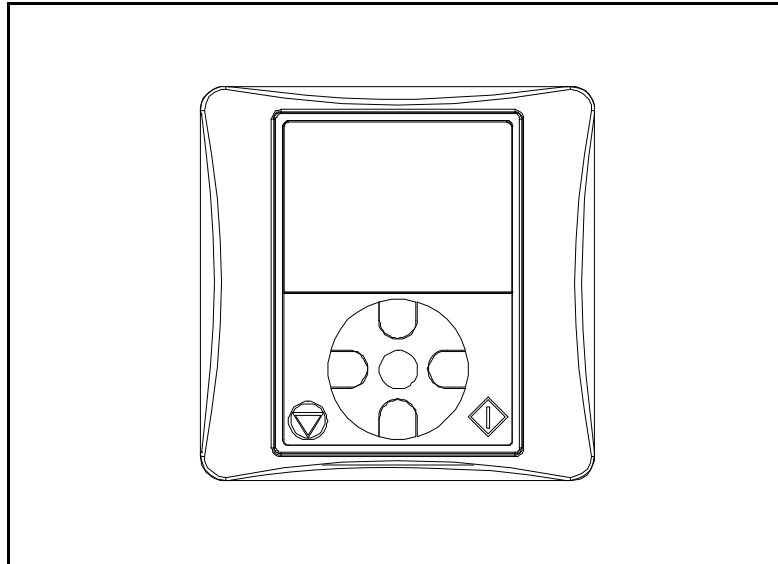


Figure 46. Text keypad.

Order code	Description	Type of option
VACON-PAN-HMTX-MC06-X	Handheld/Magnetic fixing IP66 text keypad w/ cable, l=1m/39,37 inches	Loose option

#### 8.1.1 MOUNTING ONTO THE DRIVE

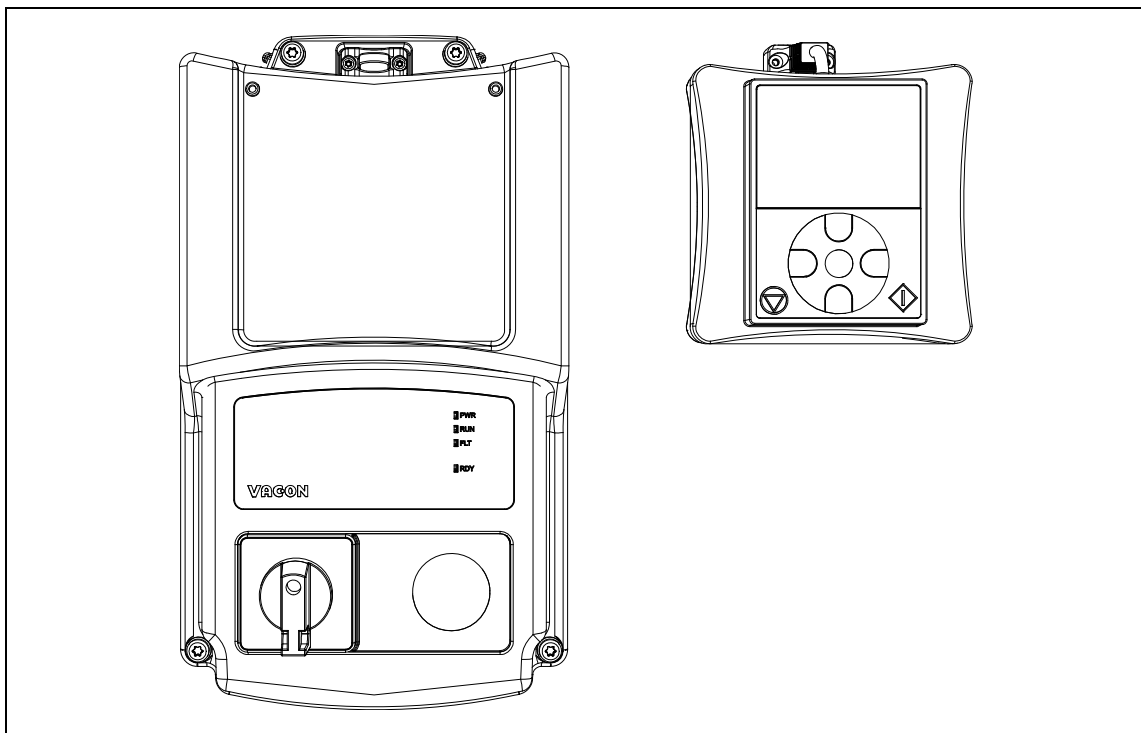


Figure 47. Drive and the optional keypad kit. The optional keypad kit includes: keypad and cable.

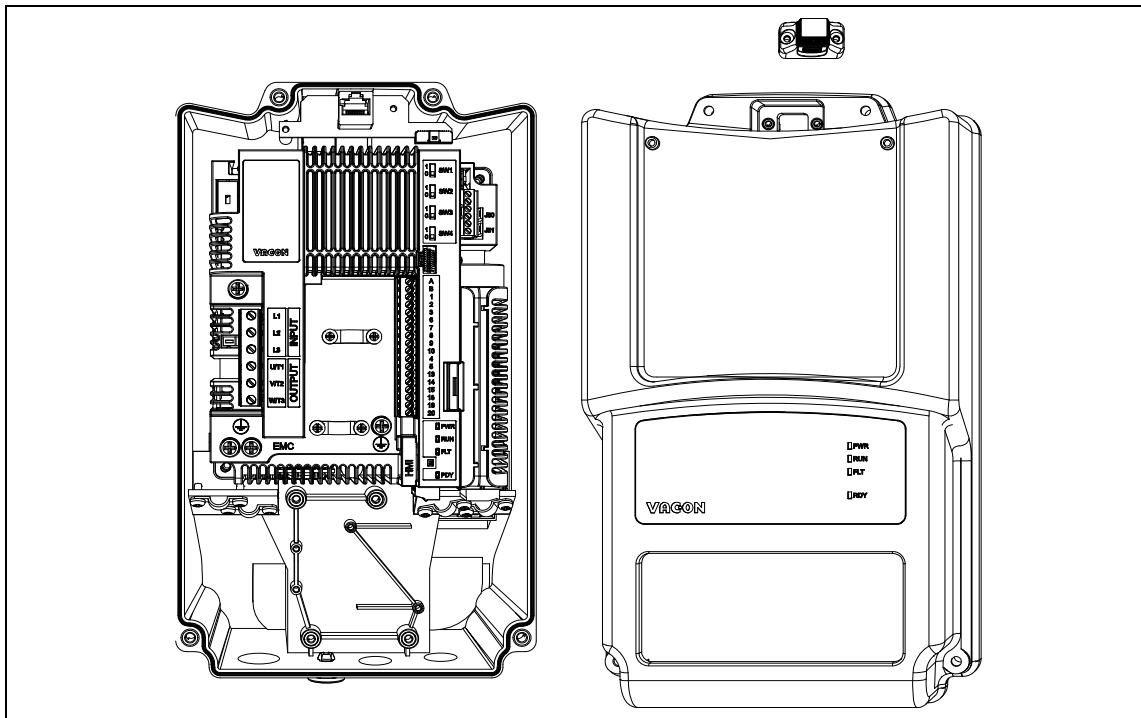


Figure 48. Disconnection of the HMI cap from the drive.



Figure 49. Mounting of the keypad.

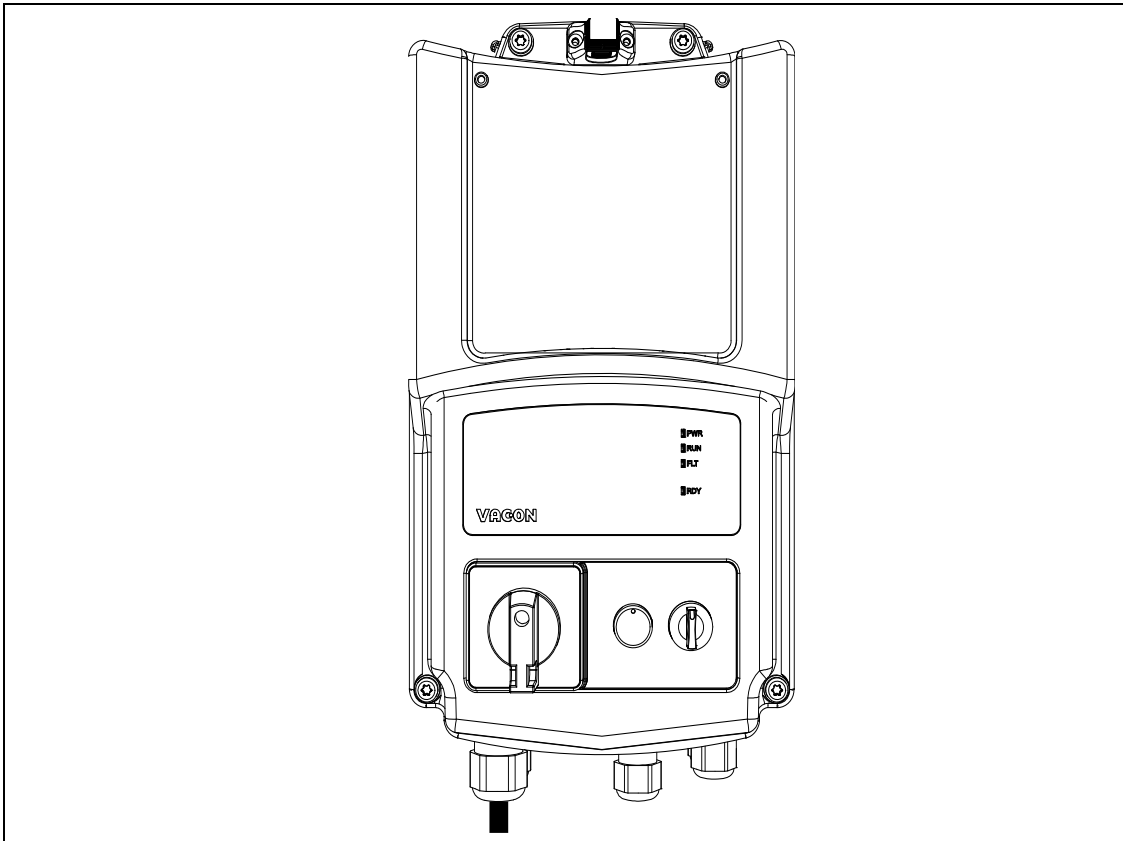


Figure 50. Tighten the two screws (maximum tightening torque 0.5 Nm) of the keypad cable to the enclosure of the drive. Keypad mounted onto the drive.

**8.1.2 TEXT KEYPAD - BUTTONS**

With the keypad it is possible to control the speed of the motor, to supervise the state of the drive and to set the AC drive's parameters.

The button section of the text keypad is shown in the following picture.

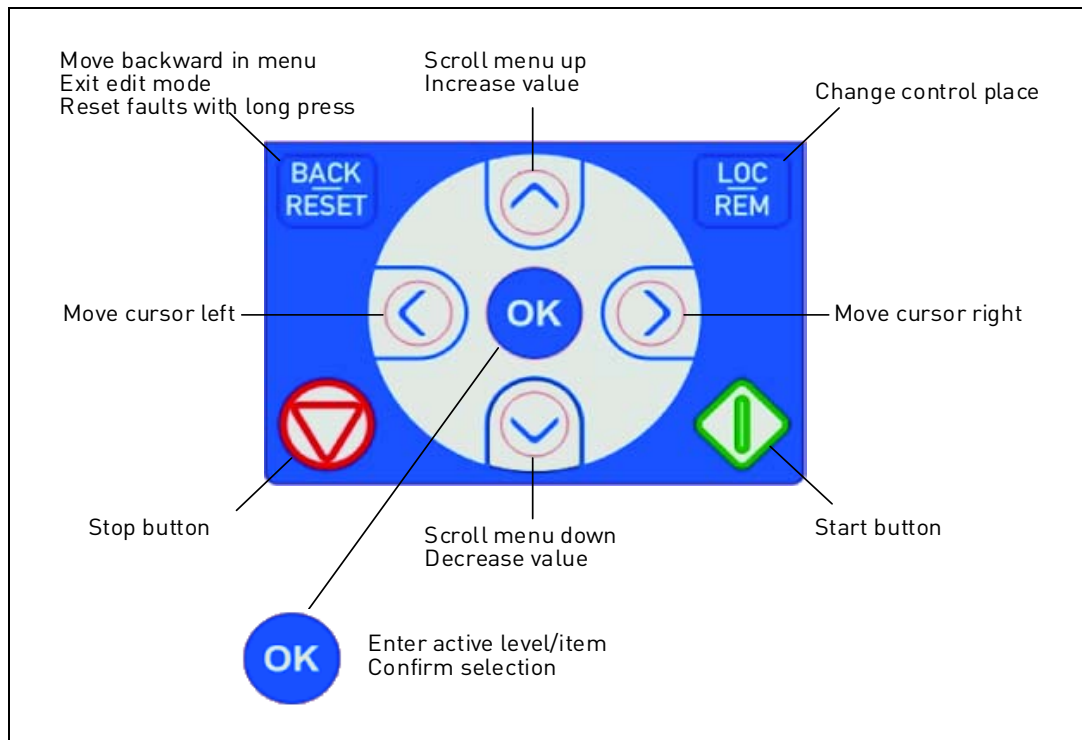


Figure 51. Keypad buttons.

### 8.2 TEXT KEYPAD

The keypad display indicates the status of the motor and the drive and any irregularities in motor or drive functions. On the display, the user can see the information about his present location in the menu structure and the item displayed.

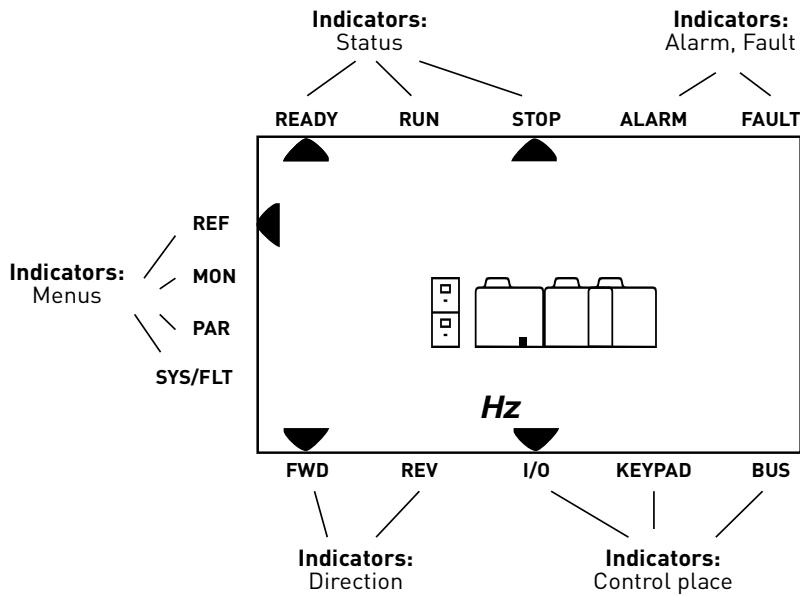


Figure 52. Keypad display.

### 8.3 MENU STRUCTURE

The data on the control keypad are arranged in menus. Use the Up and Down arrows to move between the menus. Enter the group/item by pressing the OK button and return to the former level by pressing the Back/Reset button. The arrows on the left of the display show the active menu. In Figure 52 the REF menu is active. The table below shows the structure of the main menu:

Table 35. Keypad menus.

<b>Reference (REF)</b>	Reference from Keypad
<b>Monitor (MON)</b>	Monitoring values
<b>Parameters (PAR)</b>	Application parameters
<b>System/Fault (SYS/FLT)</b>	System Menu
	Active fault
	History fault

### 8.4 USING THE KEYPAD

This chapter provides you with information on navigating the menus on VACON® 20 X and editing the values of the parameters.

#### 8.4.1 MAIN MENU

The menu structure of VACON® 20 X control software consists of a main menu and several submenus. Navigation in the main menu is shown below:

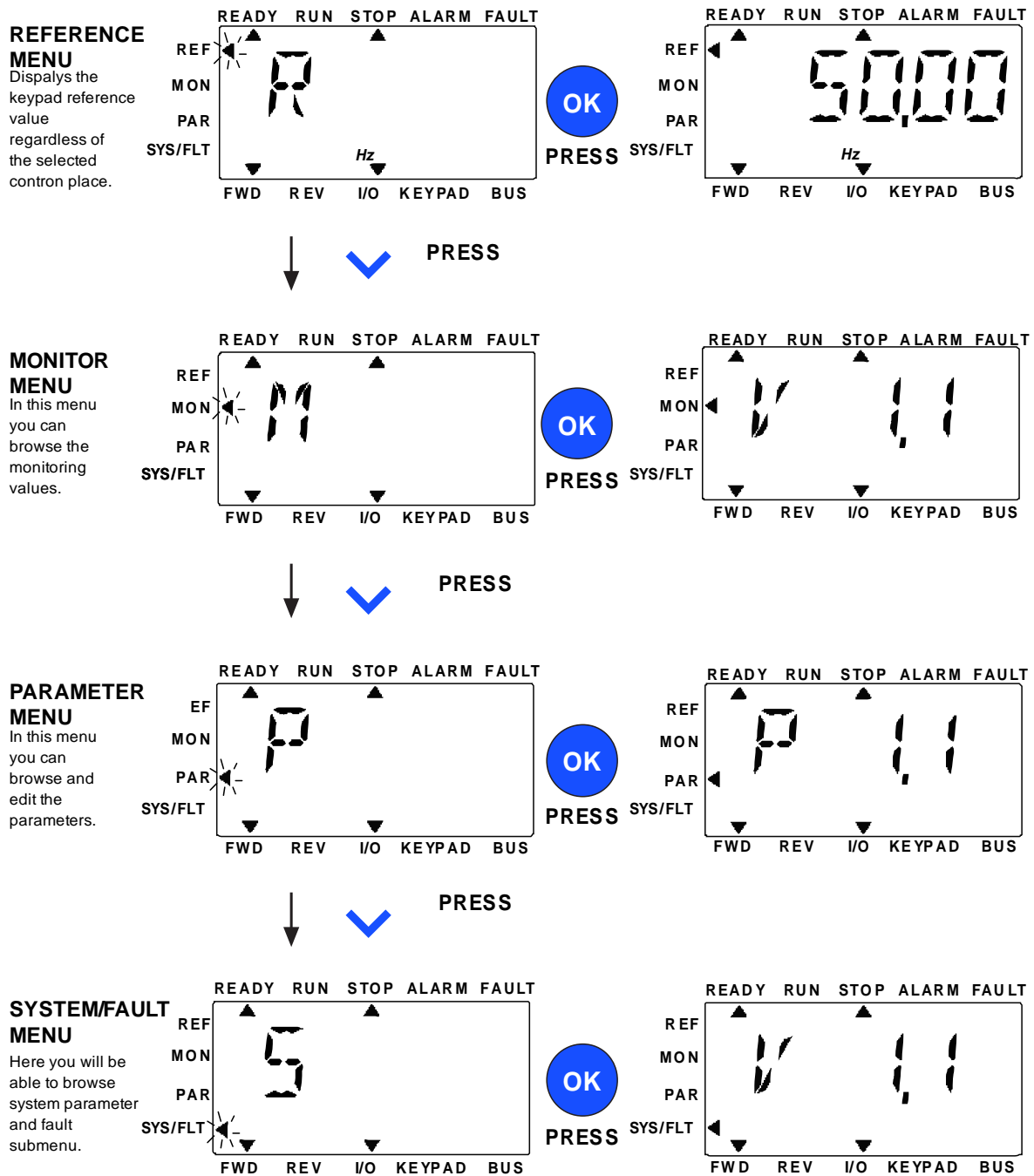


Figure 53. The Main menu of VACON® 20 X.

**8.4.2 RESETTING FAULT**

When a fault appears and the drive stops, examine the cause of the fault, perform the action advised in the Fault Tracing paragraph and reset the fault by pressing the RESET button.

**8.4.3 LOCAL/REMOTE CONTROL BUTTON**

The LOC/REM button is used for two functions: to quickly access the Control page and to easily change between the Local (Keypad) and Remote control places.

**Control places**

The *control place* is the source of control where the drive can be started and stopped. Every control place has its own parameter for selecting the frequency reference source. In the VACON® 20 X drive, the *Local control place* is always the keypad. The *Remote control place* is determined by parameter (I/O or Fieldbus). The selected control place can be seen on the status bar of the keypad.

**Remote control place**

I/O and Fieldbus can be used as remote control places.

**Local control**

Keypad is always used as control place while in local control. Local control has higher priority than remote control. Switching between Local and Remote Control can be done by pressing the LOC/REM-button on the keypad.

**8.4.4 REFERENCE MENU**

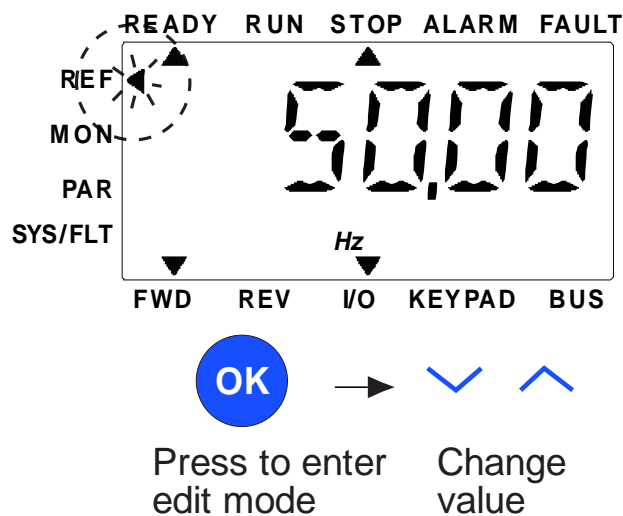


Figure 54. Reference menu.

The reference value can be changed with UP / DOWN button as shown in Figure 54.

If the value has big change, first press Left and Right buttons to select the digit which has to be changed, then press Up button to increase and Down button to decreases the value in the selected digit. The changing reference frequency will be taken into use immediately without pressing OK.

**NOTE!** LEFT and RIGHT buttons can be used to change the direction in Ref menu in local control mode.



8.4.5 MONITORING MENU

Monitoring values are actual values of measured signals as well as status of some control settings. It is visible in VACON® 20 X display, but it can not be edited. The monitoring values are listed in the Application Manual.

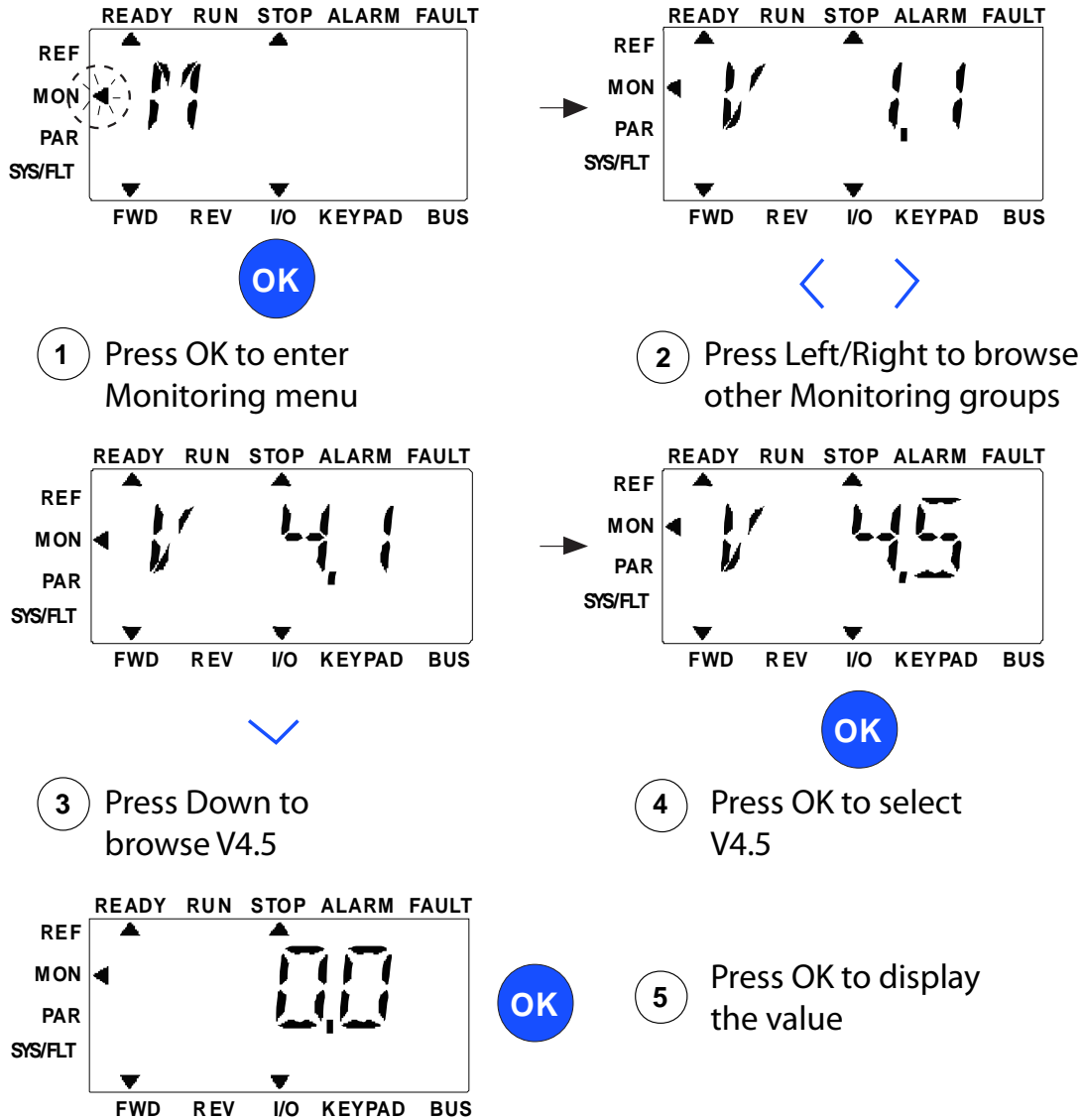


Figure 55. Monitoring menu.

Pressing Left/Right button to change the actual parameter to the first parameter of the next group, to browse monitor menu from V1.x to V2.1 to V3.1 to V4.1. After entering the desired group, the monitoring values can be browsed by pressing UP/DOWN button, as shown in Figure 55. In MON menu the selected signal and its value are alternating in the display by pressing OK button.

**NOTE!** Turn on drive power, arrowhead of main menu is at MON, V x.x or monitor parameter value of Vx.x is displayed in Panel. Display Vx.x or monitor parameter value of Vx.x is determined by the last show status before power shut down.

8.4.6 PARAMETER MENU

In Parameter menu only the Quick setup parameter list is shown as default. To view the other advanced parameter groups, see the Application Manual. The following figure shows the parameter menu view:

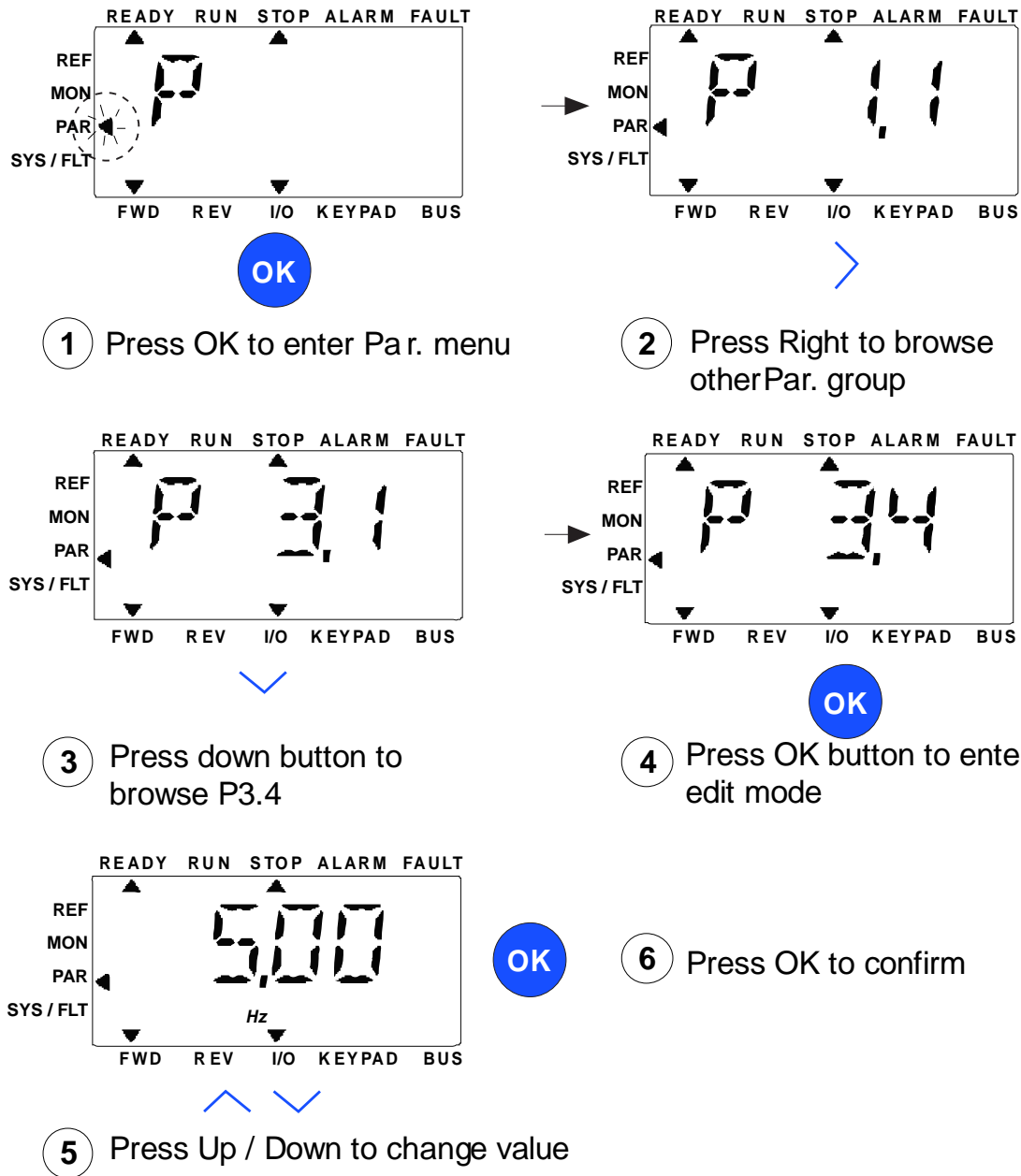


Figure 56.Parameter menu

Change the value of a parameter following the procedure below:

1. Locate the parameter.
2. Enter the Edit mode by pressing OK.
3. Set new value with the arrow buttons up/down. You can also move from digit to digit with the arrow buttons left/right if the value is numerical and change then the value with the arrow buttons up/down.
4. Confirm change with OK button or ignore change by returning to previous level with Back/Reset button.

8.4.7 SYSTEM/FAULT MENU

SYS/FLT menu including fault submenu, field bus submenu and system parameter submenu. In system parameter submenu, there are some editable parameter (P) and some not editable parameters (V). The Fault submenu of SYS/FLT menu includes active fault submenu and fault history submenu.

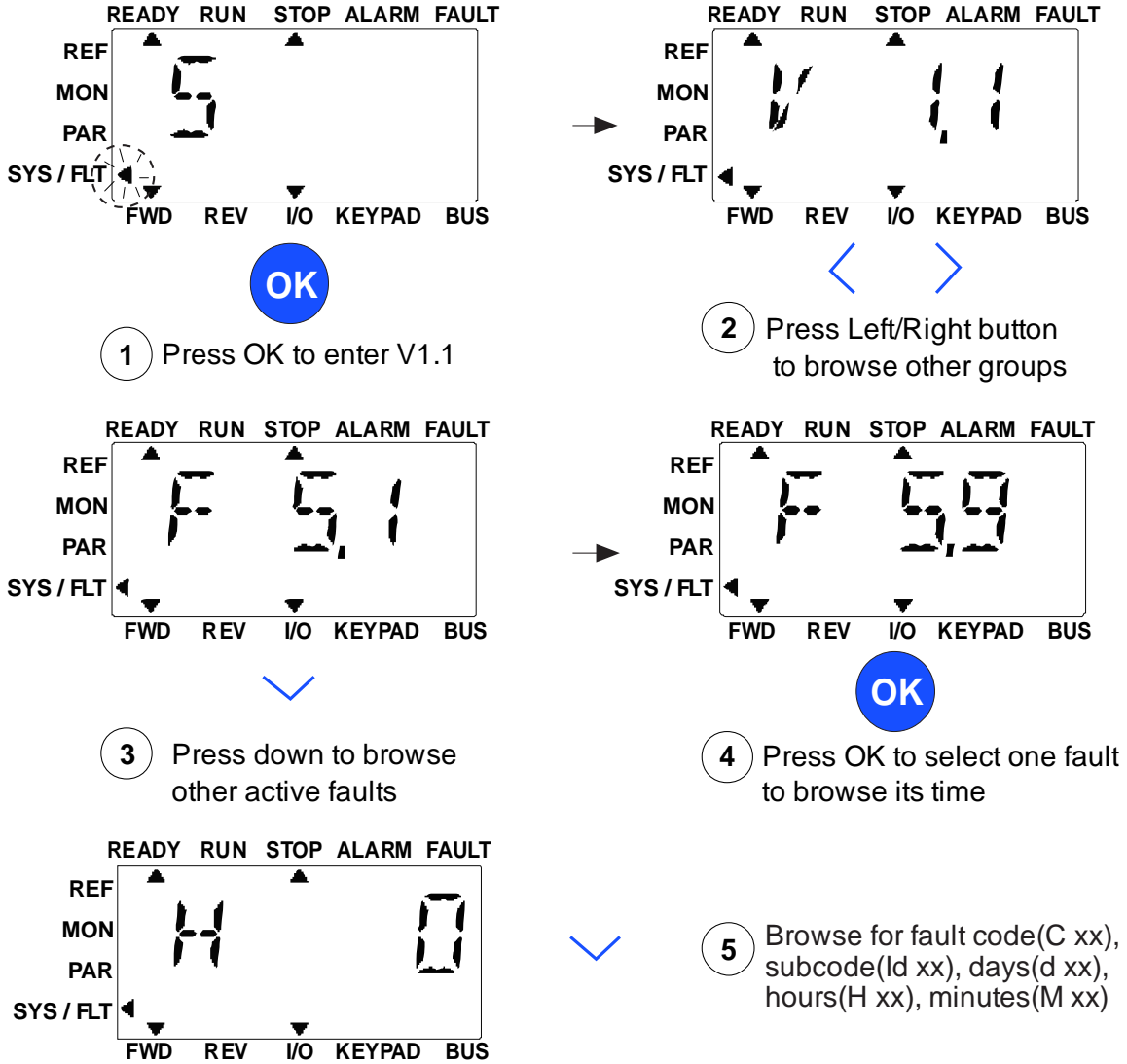


Figure 57. System and Fault menu.

### 8.4.7.1 *Faults*

Under this menu, you can find *Active faults*, *Reset faults*, *Fault history*, *Counters* and *Software info*.

In active fault situation, FAULT arrow is blinking and the display is blinking active fault menu item with fault code. If there are several active faults, you can check it by entering the active fault submenu F5.x. F5.1 is always the latest active fault code. The active faults can be reset by pressing BACK / RESET button with long time (>2 s), when the API is in active fault submenu level (F5.x). If the fault cannot be reset, the blinking continues. It is possible to select other display menus during active fault, but in this case the display returns automatically to the fault menu if no button is pressed in 10 seconds. The fault code, subcode and the operating day, hour and minute values at the fault instant are shown in the value menu (operating hours = displayed reading).

#### Active faults

Menu	Function	Note
<b>Active faults</b>	When a fault/faults appear(s), the display with the name of the fault starts to blink. Press OK to return to the Diagnostics menu. The <i>Active faults</i> submenu shows the number of faults. Select the fault and push OK to see the fault-time data.	The fault remains active until it is cleared with the RESET button or with a reset signal from the I/O terminal or fieldbus or by choosing <i>Reset faults</i> (see below). The memory of active faults can store the maximum of 10 faults in the order of appearance.

#### Fault history

Menu	Function	Note
<b>Fault history</b>	10 latest faults are stored in the Fault history.	Entering the Fault history and clicking OK on the selected fault shows the fault time data (details).

8.4.8 FAULT TRACING

Table 36. Fault codes and descriptions.

Fault code	Fault name	Subcode	Possible cause	Remedy
1	Overcurrent		AC drive has detected too high a current ( $>4 \cdot I_H$ ) in the motor cable: <ul style="list-style-type: none"> <li>sudden heavy load increase</li> <li>short circuit in motor cables</li> <li>unsuitable motor</li> </ul>	Check loading. Check motor. Check cables and connections. Make identification run. Check ramp times.
2	Overvoltage		The DC-link voltage has exceeded the limits defined. <ul style="list-style-type: none"> <li>too short a deceleration time</li> <li>brake chopper is disabled</li> <li>high overvoltage spikes in supply</li> <li>Start/Stop sequence too fast</li> </ul>	Make deceleration time longer. Use brake chopper or brake resistor (available as options). Activate overvoltage controller. Check input voltage.
3	Earth fault		Current measurement has detected that the sum of motor phase current is not zero. <ul style="list-style-type: none"> <li>insulation failure in cables or motor</li> </ul>	Check motor cables and motor.
8	System Fault	84	MPI communication crc error	Reset the fault and restart. Should the fault re-occur, contact the distributor near to you.
		89	HMI receives buffer overflow	Check PC-drive cable. Try to reduce ambient noise
		90	Modbus receives buffer overflow	Check Modbus specifications for time-out. Check cable length. Reduce ambient noise. Check baudrate.
		93	Power identification error	Try to reduce ambient noise. Reset the fault and restart. Should the fault re-occur, contact the distributor near to you.
		97	MPI off line error	Reset the fault and restart. Should the fault re-occur, contact the distributor near to you.
		98	MPI driver error	Reset the fault and restart. Should the fault re-occur, contact the distributor near to you.
		99	Option board driver error	Check contact in option board slot Try to reduce ambient noise; Reset the fault and restart. Should the fault re-occur, contact the distributor near to you.
100	Option board configuration error	Check contact in option board slot Try to reduce ambient noise; Should the fault re-occur, contact the distributor near to you.		

Table 36. Fault codes and descriptions.

Fault code	Fault name	Subcode	Possible cause	Remedy
8	System Fault	101	Modbus buffer overflow	Check Modbus specifications for time-out. Check cable length. Reduce ambient noise. Check baudrate.
		104	Option board channel full	Check contacts in option board slot. Try to reduce ambient noise. Should the fault re-occur, contact the distributor near to you.
		105	Option board memory allocation fail	Check contacts in option board slot. Try to reduce ambient noise. Should the fault re-occur, contact the distributor near to you.
		106	Option board Object queue full	Check contacts in option board slot. Try to reduce ambient noise. Should the fault re-occur, contact the distributor near to you.
		107	Option board HMI queue full	Check contacts in option board slot. Try to reduce ambient noise. Should the fault re-occur, contact the distributor near to you.
		108	Option board SPI queue full	Check contacts in option board slot. Try to reduce ambient noise. Should the fault re-occur, contact the distributor near to you.
		111	Parameter copy error	Check if parameter set is compatible with drive. Do not remove Keypad until copy is finished.
		113	Frequency detective timer overflow	Check keypad contacts. Try to reduce ambient noise. Should the fault re-occur, contact the distributor near to you.
		114	PC control time out fault	Do not close VACON <sup>®</sup> Live when PC control is active. Check PC-Drive cable. Try to reduce ambient noise.
		115	DeviceProperty data format	Reset the fault and restart. Should the fault re-occur, contact the distributor near to you.
		120	Task stack overflow	Reset the fault and restart. Should the fault re-occur, contact the distributor near to you.

Table 36. Fault codes and descriptions.

Fault code	Fault name	Subcode	Possible cause	Remedy
9	Undervoltage		<p>DC-link voltage is under the voltage limits defined.</p> <ul style="list-style-type: none"> <li>• most probable cause: too low a supply voltage</li> <li>• AC drive internal fault</li> <li>• defect input fuse</li> <li>• external charge switch not closed</li> </ul> <p><b>NOTE!</b> This fault is activated only if the drive is in Run state.</p>	<p>In case of temporary supply voltage break reset the fault and restart the AC drive. Check the supply voltage. If it is adequate, an internal failure has occurred.</p> <p>Contact the distributor near to you.</p>
10	Input phase		Input line phase is missing.	Check supply voltage, fuses and cable.
11	Output phase		Current measurement has detected that there is no current in one motor phase.	Check motor cables and motor.
13	AC drive undertemperature		Too low temperature measured in power unit's heatsink or board. Heatsink temperature is under - 10°C.	Check the ambient temperature.
14	AC drive overtemperature		Too high temperature measured in power unit's heatsink or board. Heatsink temperature is over 100°C.	<p>Check the correct amount and flow of cooling air.</p> <p>Check the heatsink for dust.</p> <p>Check the ambient temperature.</p> <p>Make sure that the switching frequency is not too high in relation to ambient temperature and motor load.</p>
15	Motor stalled		Motor is stalled.	<p>Check motor and load.</p> <p>Insufficient motor power, check motor stall protection parametrization.</p>
16	Motor overtemperature		Motor is overloaded.	<p>Decrease motor load.</p> <p>If no motor overload exists, check the temperature model parameters.</p>
17	Motor underload		Motor is under loaded	Check load. Check underload protection parametrization.
19	Power overload		Supervision for drive power	Drive power is to high: decrease load.
25	Watchdog		<p>Error in the microprocessor monitoring</p> <p>Malfunction</p> <p>Component fault</p>	<p>Reset the fault and restart.</p> <p>If the fault occurs again, please contact your closest VACON® representative.</p>
27	Back EMF		Protection of unit when starting with rotating motor	<p>Reset the fault and restart.</p> <p>Should the fault re-occur, contact the distributor near to you.</p>
30	STO fault		Safe torque off signal does not allow drive to be set as ready	<p>Reset the fault and restart.</p> <p>Should the fault re-occur, contact the distributor near to you.</p>

Table 36. Fault codes and descriptions.

Fault code	Fault name	Subcode	Possible cause	Remedy
35	Application error	0	Firmware Interface version between Application and Control not matching	Load a compatible application. Please contact your closest VACON® representative.
		1	Application software flash error	Reload Application
		2	Application header error	Load a compatible application. Please contact your closest VACON® representative.
41	IGBT temp		IGBT temperature (UnitTemperature + I2T) too high	Check loading. Check motor size. Make identification run.
50	4 mA fault (Analog input)		Selected signal range: 4...20 mA (see Application Manual) Current less than 4 mA Signal line broken detached The signal source is faulty	Check the analog input's current source and circuit.
51	External fault		Error message on digital input. The digital input was programmed as an input for external error messages. The input is active.	Check the programming and check the device indicated by the error message. Check the cabling for the respective device as well.
52	Keypad Communication fault		The connection between the control keypad and the AC drive is broken.	Check keypad connection and keypad cable.
53	Fieldbus communication fault		The data connection between the fieldbus master and fieldbus board is broken	Check installation and fieldbus master.
54	Fieldbus Interface error		Defective option board or slot	Check board and slot.
55	Wrong run command		Wrong run alarm and stop command	Run forward and backward are activated at the same time
56	Temperature		Temperature fault	Board OPTBH is installed and measured temperature is above (or below) the limit
57	Identification		Identification alarm	Motor identification has not been successfully completed
63	Quick Stop		Quick Stop activated	The drive has been stopped with Quick Stop digital input or Quick Stop command by fieldbus



### 8.5 OPTION BOARDS

VACON® 20 X drive family embodies a wide selection of expander boards with which the available I/O of VACON® 20 X AC drive can be increased and its versatility improved.

There is one board slot (labelled D) on the VACON® 20 X control board. To locate the slot, see Chapter 5. Usually, when the AC drive is delivered from the factory, the control unit does not include any option board in the board slot.

The following option boards are supported:

Table 37. Option boards supported in VACON® 20 X

Order Code	Description	Note
OPT-B1-V	Option board with six bidirectional terminals.	With jumper blocks, it is possible to use each terminal as digital input or as digital output.
OPT-B2-V	I/O expander board with a thermistor input and two relay outputs.	
OPT-B4-V	I/O expander board with one galvanically isolated analogue input and two galvanically isolated analogue outputs (standard signals 0(4)...20mA).	
OPT-B5-V	I/O expander board with three relay outputs	
OPT-B9-V	I/O expander board with five 42...240 VAC digital inputs and one relay output.	
OPT-BF-V	I/O expander board with analogue output, digital output and relay output.	On the OPTBF board, there is one jumper block for selecting the analogue output mode (mA/V).
OPT-BH-V	Temperature measurement board with three individual channels.	Supported sensors: PT100, PT1000, NI1000, KTY84-130, KTY84-150, KTY84-131
OPT-BK-V	ASi option board	AS-interface option card
OPT-C4-V	Lonworks option board	Pluggable connector with screw terminals
OPT-C3/E3-V	Profibus DP option board	Pluggable connector with screw terminals
OPT-C5/E5-V	Profibus DP option board	9-pin Sub-D terminal
OPT-C6/E6-V	CANopen option board	
OPT-C7/E7-V	DeviceNet option board	
OPT-CI-V	Modbus TCP option board	
OPT-CP-V	Profinet option board	
OPT-CQ-V	Ethernet IP option board	
OPT-EC-V	EtherCat option board	

See the Option boards User's Manual to use and install the option boards.

## 8.5.1 OPTION BOARD INSTALLATION



**NOTE!** Do not add or replace option boards or fieldbus boards on an AC drive with the power switched on. This may damage the boards.

**1**

- Remove the HMI cap and open the cover of the drive.

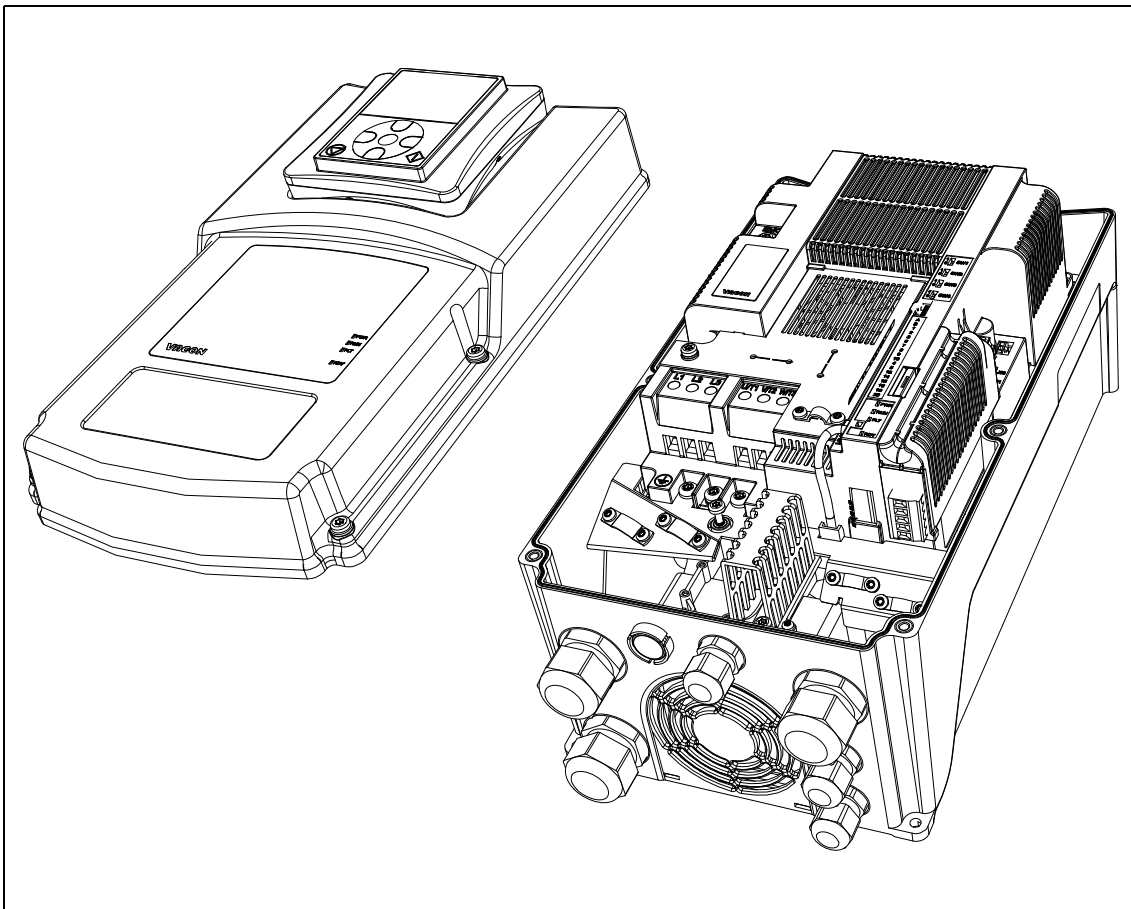


Figure 58. Opening the main cover, MU3 example.



The relay outputs and other I/O-terminals may have a dangerous control voltage present even when the drive is disconnected from mains.

**2**

- Remove the option slot cover.

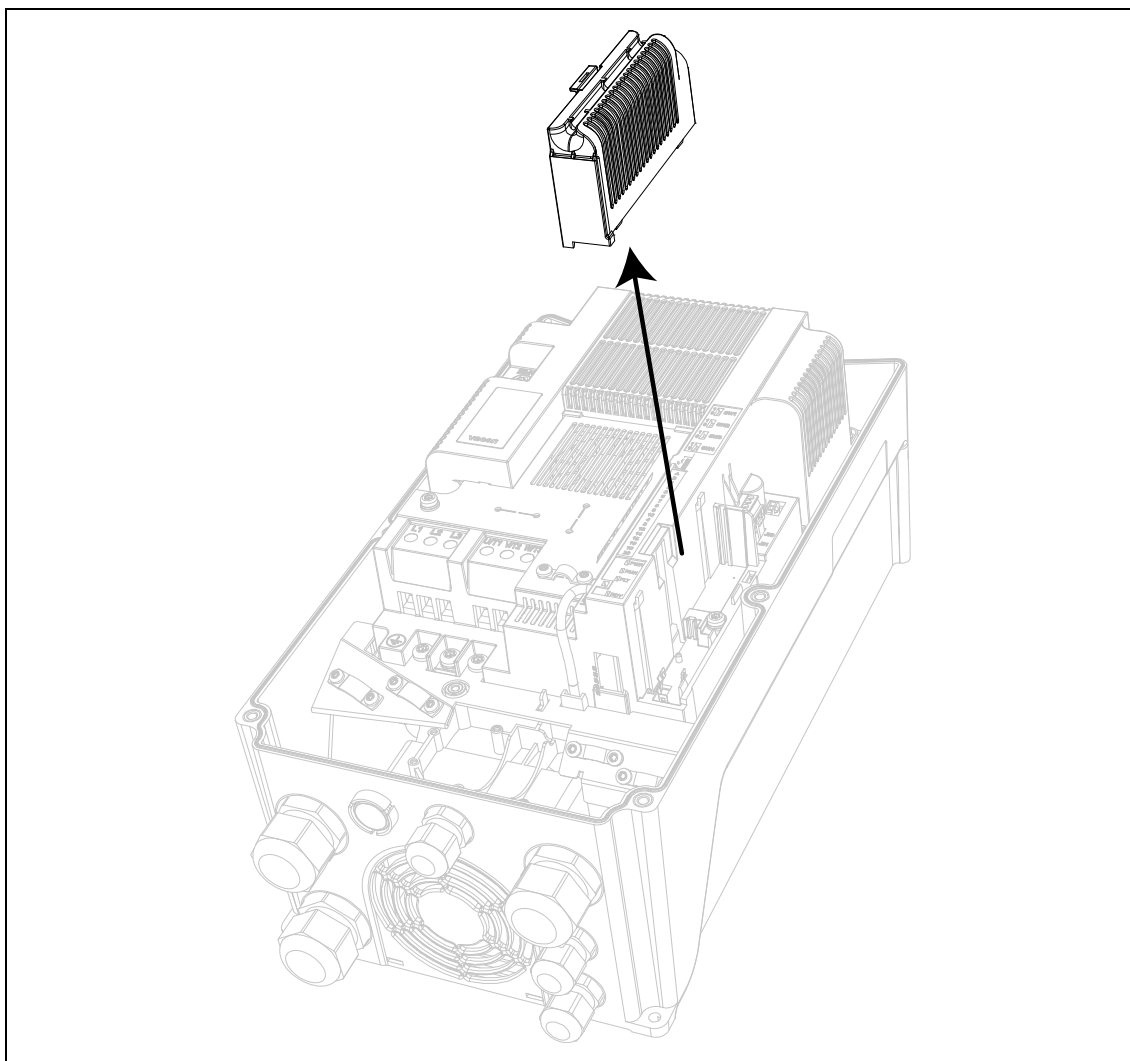
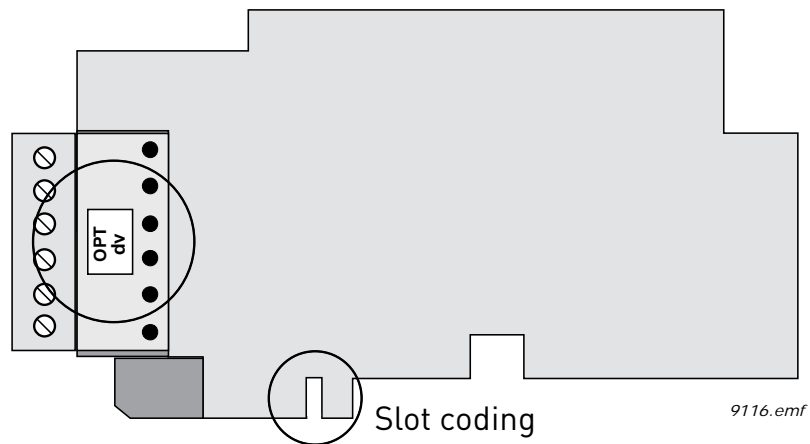


Figure 59. Removing the option slot cover.

3

- Make sure that the sticker on the connector of the board says “dv” (dual voltage). This indicates that the board is compatible with VACON® 20 X. See below:



- **NOTE:** Incompatible boards cannot be installed on VACON® 20 X. Compatible boards have a slot coding that enables the placing of the board (see above)

4

- Install the option board into the slot as shown in the picture below.

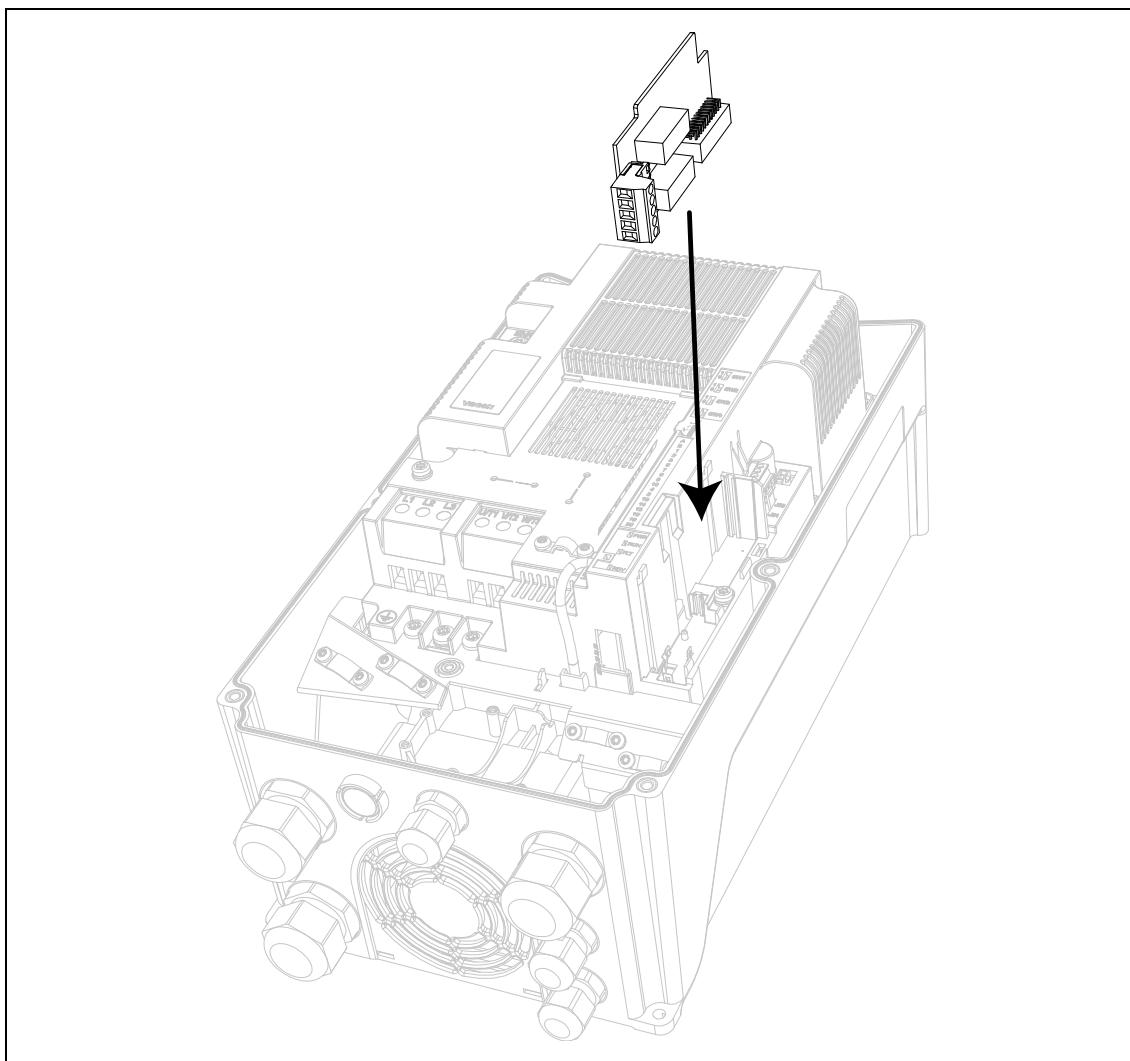


Figure 60. Option board installation.

<b>5</b>	<ul style="list-style-type: none"> <li>• Mount the option slot cover.</li> </ul>
----------	--

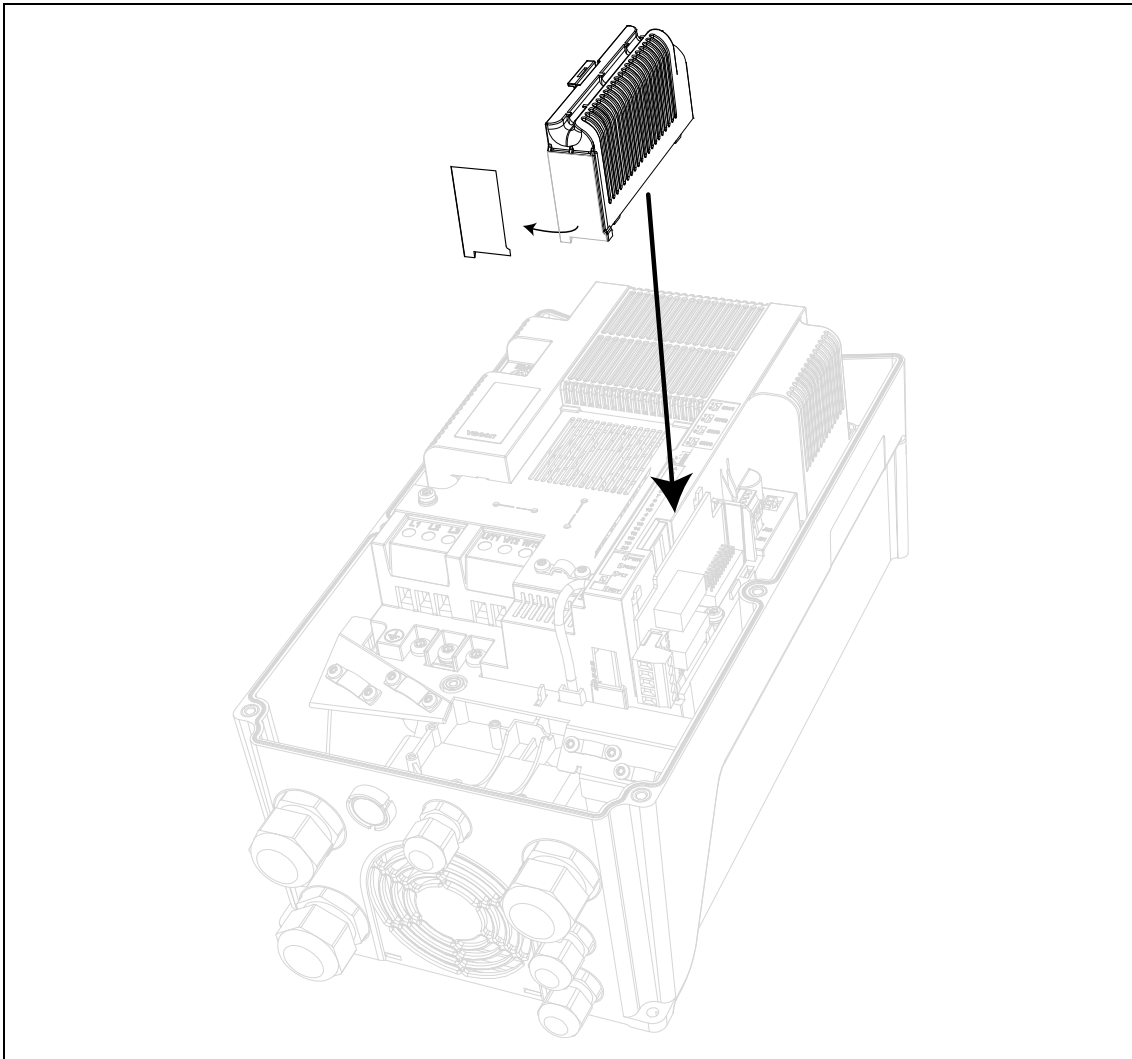


Figure 61. Mounting of option slot cover: remove the plastic opening for the option board terminals.

### 8.6 MAINS SWITCH

The purpose of the *Mains switch* is to disconnect the VACON® 20 X from the mains when, for example, service actions are needed. The mains switch is available as option and it can be integrated in the drive. The switch can be mounted on the front side of the drive. See Figure 62.

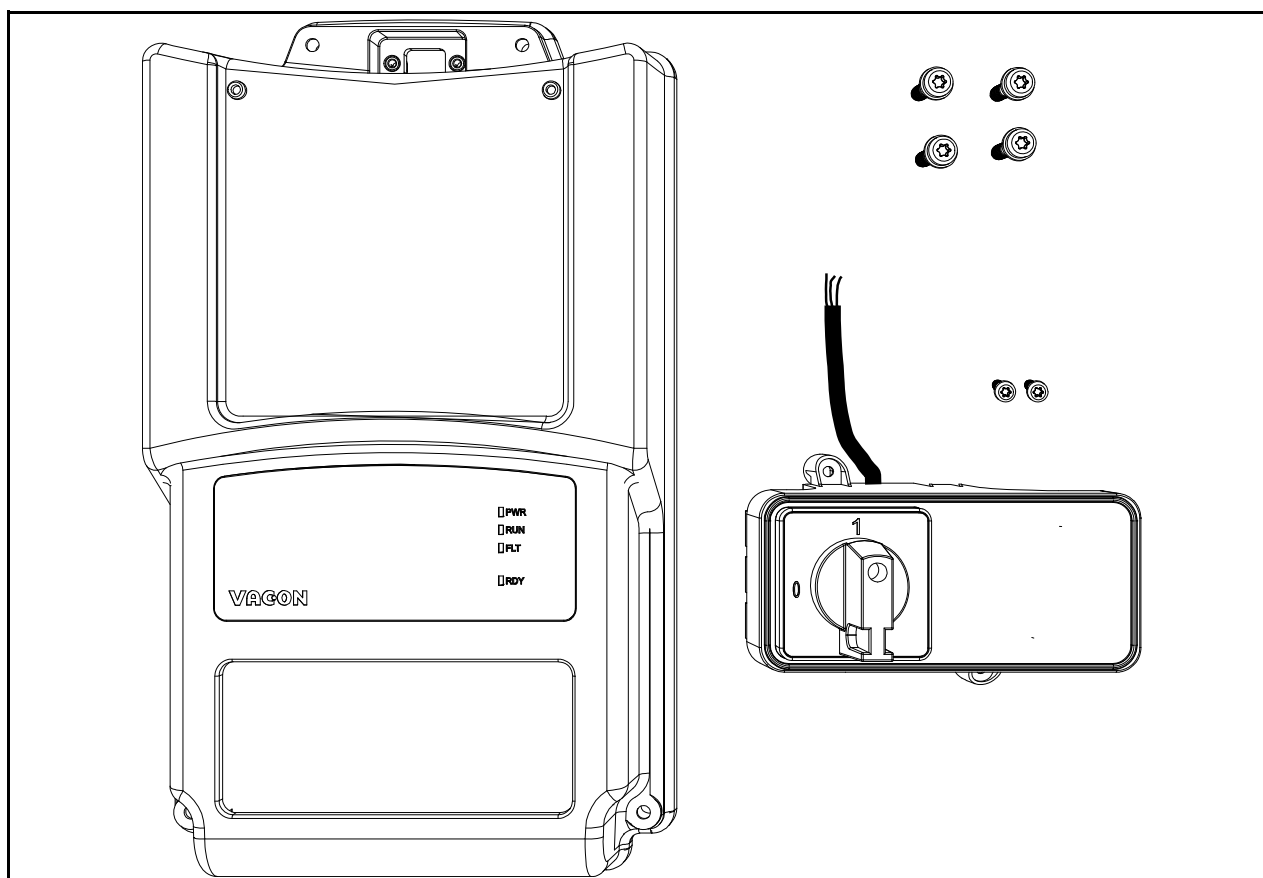


Figure 62. The mains switch option spare kit (MU2 example).

Table 38. Mains switch kit content.

Enclosure size	Description and type code	Item	Quantity
MU2 (3-phase version)	MU2 QDSS option spare kit 60S01128	Main switch 40A NLT40 assembly	1
		MU2 cover for main switch	1
		M4x14 screw	2
		M5x23 screws	4
MU2 (1-phase version)	MU2 QDSS option spare kit 60S01234	Main switch 40A NLT40 assembly	1
		MU2 cover for main switch	1
		M4x14 screw	2
		M5x23 screws	4
MU3	MU3 QDSS option spare kit 60S01129	Main switch 40A NLT40 assembly	1
		MU3 cover for main switch	1
		M4x14 screw	2
		M5x23 screws	6

8.6.1 INSTALLATION

<b>1</b>	<ul style="list-style-type: none"> <li>Remove the HMI cap and the cover from the drive. See the Figure 63.</li> </ul>
----------	---

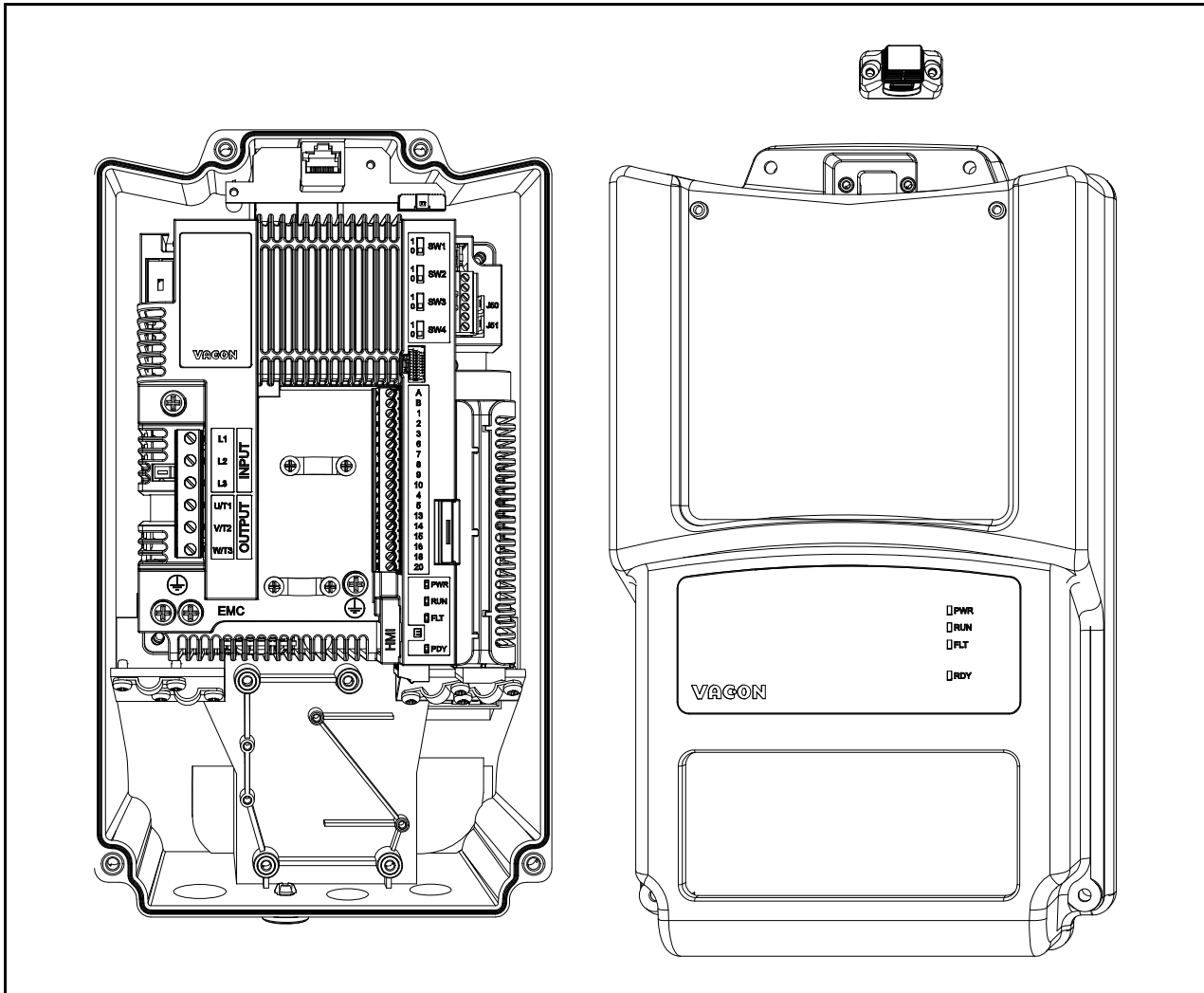


Figure 63. Cover open (MU2 3-phase example).

<b>2</b>	<ul style="list-style-type: none"> <li>Open only the inlet holes where you need to run the cables. Cables pass through this inlet hole.</li> </ul>
<b>3</b>	<ul style="list-style-type: none"> <li>Connect the supply cable to the Mains switch passing through the cable gland from the bottom side (use the cable gland for sealing the cable to the drive) and then through the terminal box as shown in the figure below.</li> </ul>
<b>4</b>	<ul style="list-style-type: none"> <li>Place the Mains switch with the cables inside the drive and fix it with its screws.</li> </ul>
<b>5</b>	<ul style="list-style-type: none"> <li>Connect the cables from the Mains switch to the line terminal. The cables have to be connected to the terminals L1, L2 and L3.</li> </ul> <p><b>NOTE:</b></p> <ul style="list-style-type: none"> <li>For single-phase version connect BLU cable to N and BROWN cable to L.</li> </ul>
<b>6</b>	<ul style="list-style-type: none"> <li>Fix the cables with cable clamp.</li> </ul>



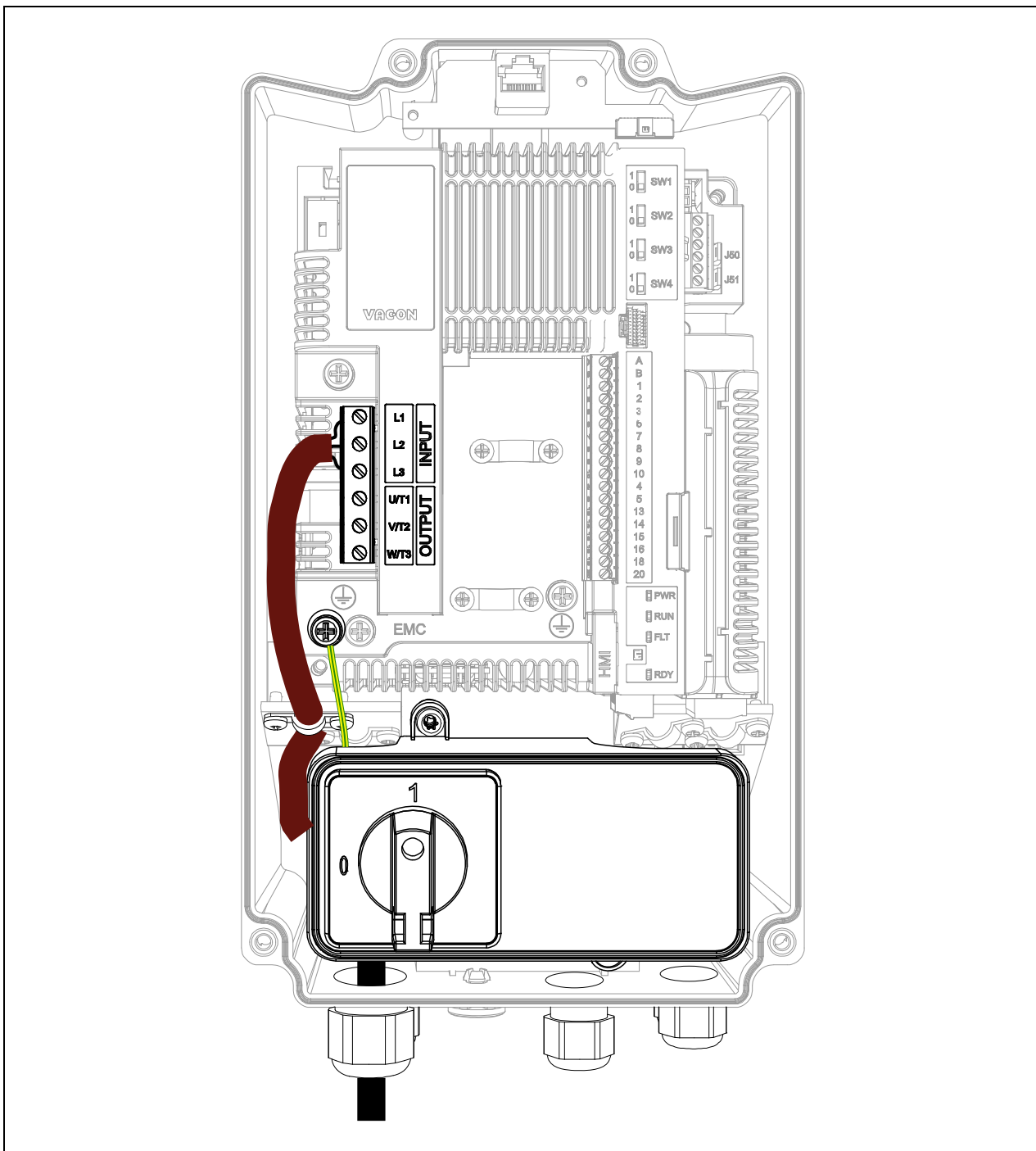


Figure 64. Mains switch and cables connected (MU2 3-phase example).

- |          |   |
|----------|---|
| <b>7</b> | <ul style="list-style-type: none"> <li>• Connect the GROUND wire to the proper terminal (see the yellow-green cable on Figure 64).</li> </ul> |
|----------|---|

**8**

- Mount the plastic cover onto the drive with its screws and HMI cap: the installation process has been completed. See Figure 65.

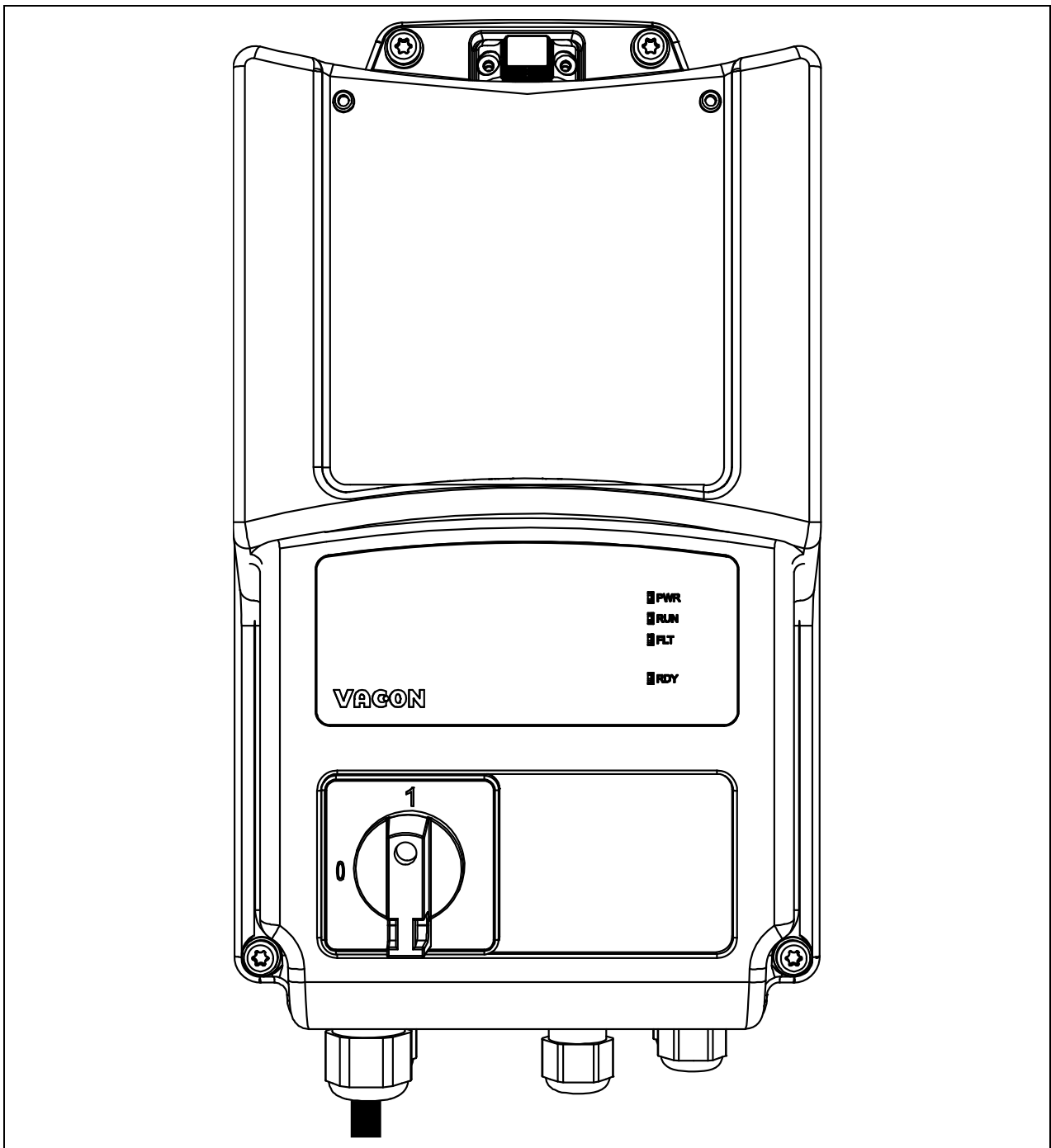


Figure 65. Mount the plastic cover.

### 8.7 SIMPLE OPERATOR PANEL

The purpose of the *Simple operator panel* is to provide a local control with Start/Stop selector and potentiometer for frequency reference together with a mains switch to disconnect the VACON® 20 X from the mains when, for example, service actions are needed. This option can be mounted on the front side of the drive. See Figure 66.

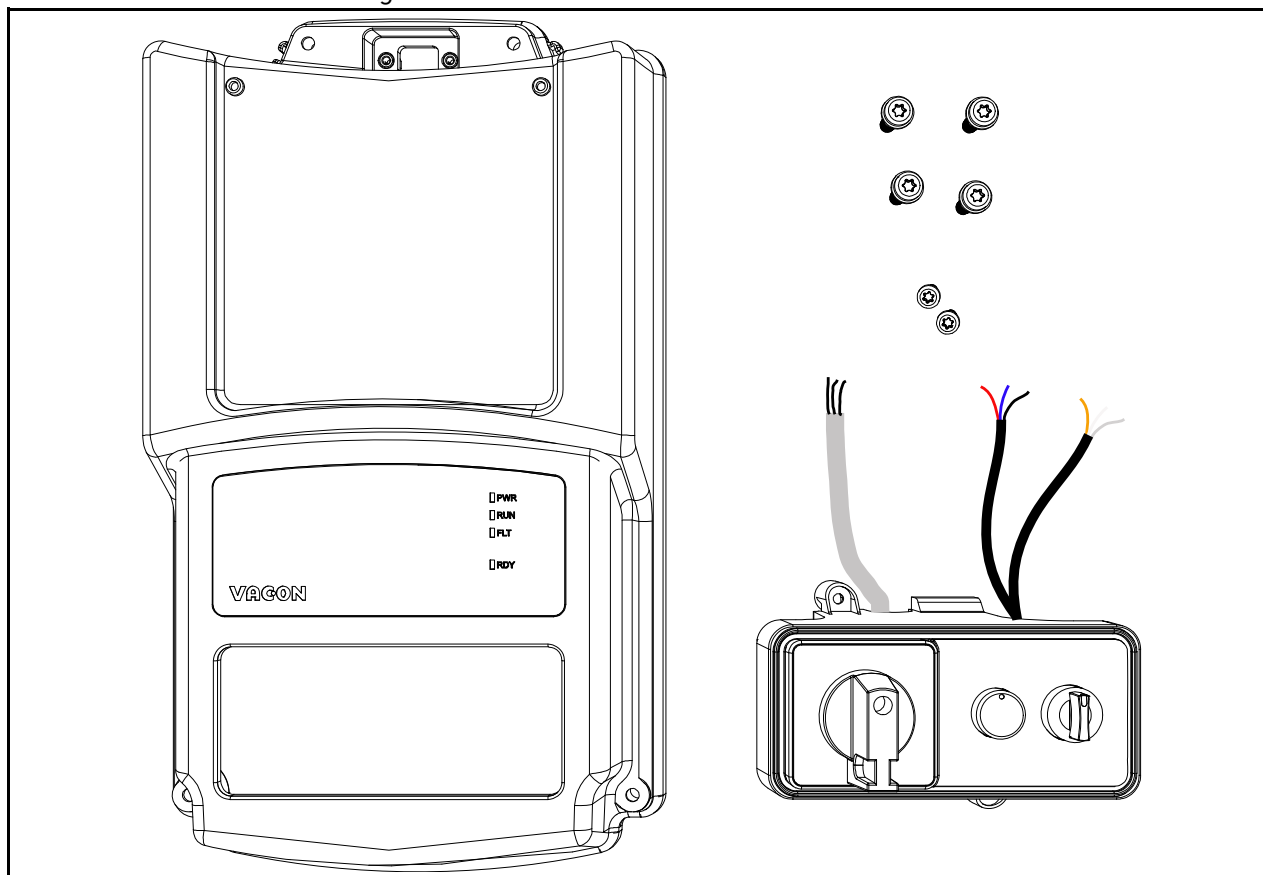


Figure 66. The Simple operator panel option spare kit (MU2 example).

Table 39. Simple operator panel kit content.

Enclosure size	Description and type code	Item	Quantity
MU2 (3-phase version)	MU2 QDSH option spare kit 60S01208	Main switch 40A NLT40 and operator panel assembly	1
		MU2 cover for main switch	1
		M4x14 screw	2
		M5x23 screws	4
MU2 (1-phase version)	MU2 QDSH option spare kit 60S01235	Main switch 40A NLT40 and operator panel assembly	1
		MU2 cover for main switch	1
		M4x14 screw	2
		M5x23 screws	4

Table 39. Simple operator panel kit content.

Enclosure size	Description and type code	Item	Quantity
MU3	MU3 QDSH option spare kit 60S01209	Main switch 40A NLT40 and operator panel assembly	1
		MU3 cover for main switch	1
		M4x14 screw	2
		M5x23 screws	6

8.7.1 INSTALLATION

- |          |   |
|----------|---|
| <b>1</b> | <ul style="list-style-type: none"> <li>Remove the HMI cap and the cover from the drive. See the Figure 67.</li> </ul> |
|----------|---|

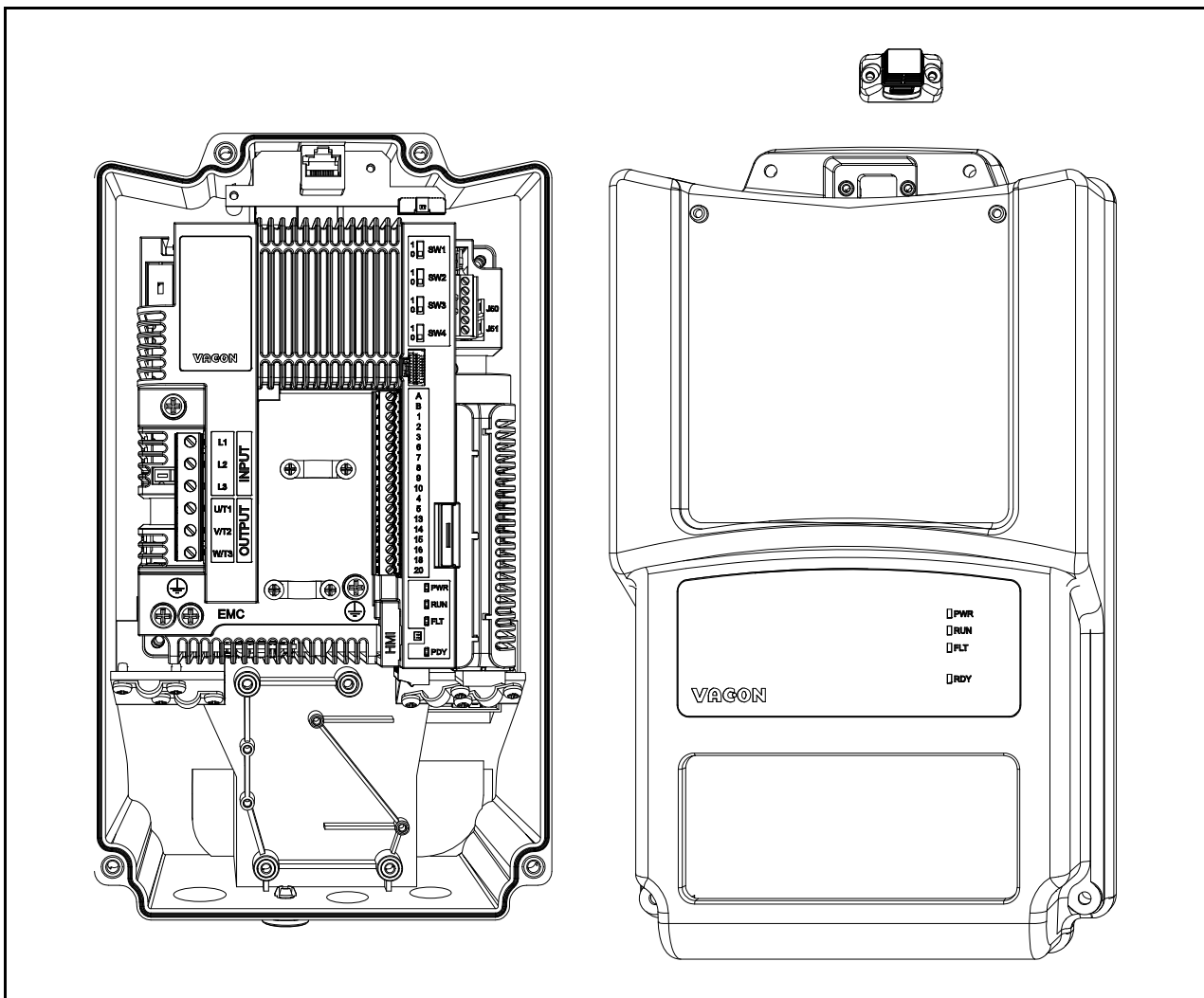


Figure 67. Cover open (MU2 3-phase example).

- |          |  |
|----------|--|
| <b>2</b> | <ul style="list-style-type: none"> <li>Open only the inlet holes where you need to run the cables. Cables pass through this inlet hole.</li> </ul> |
|----------|--|

<b>3</b>	<ul style="list-style-type: none"> <li>Connect the supply cable to the Mains switch passing through the cable gland from the bottom side (use the cable gland for sealing the cable to the drive) and then through the terminal box as shown in the figure below.</li> </ul>
<b>4</b>	<ul style="list-style-type: none"> <li>Place the Simple Operator panel assembly with the cables inside the drive and fix it with its screws.</li> </ul>
<b>5</b>	<ul style="list-style-type: none"> <li>Connect the cables from the Mains switch to the line terminals. The cables have to be connected to the terminals L1, L2 and L3.</li> </ul> <p><b>NOTE:</b></p> <ul style="list-style-type: none"> <li>For single-phase version connect BLU cable to N and BROWN cable to L.</li> </ul>
<b>6</b>	<ul style="list-style-type: none"> <li>Fix the cables with the cable clamp.</li> </ul>

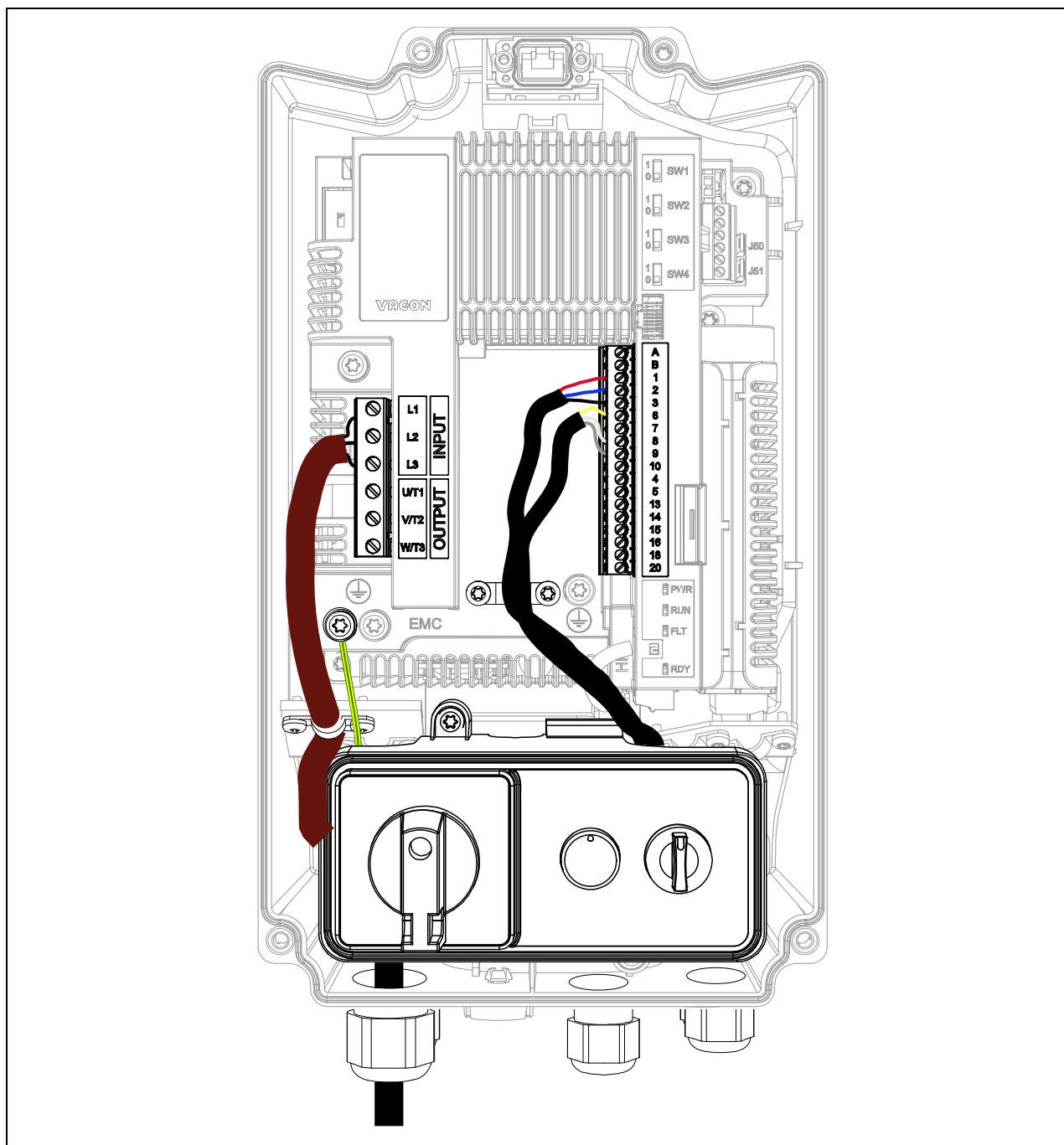


Figure 68. Simple operator panel connected (MU2 3-phase example).

<b>7</b>	<ul style="list-style-type: none"> <li>Connect the GROUND wire to the proper terminal (see the yellow-green cable on Figure 68).</li> </ul>
<b>8</b>	<ul style="list-style-type: none"> <li>Connect the cables from the potentiometer and from the selector to the I/O control terminals. The cables have to be connected to the I/O terminals as shown in the Figure 68 and in the Table 40.</li> </ul>
<b>9</b>	<ul style="list-style-type: none"> <li>RED, BLUE and BLACK wires are signals from the potentiometer.</li> </ul>
<b>10</b>	<ul style="list-style-type: none"> <li>YELLOW, WHITE and GREY wires are signal from the selector switch.</li> </ul>

Table 40. Control I/O terminal signal connections to the simple operator panel.

Standard I/O terminals		
Terminal		Signal
A	RS485_A	Serial bus, negative
B	RS485_B	Serial bus, positive
1	+10 Vref	Reference output
2	AI1+	Analogue input, voltage or current
3	GND	I/O signal ground
6	24Vout	24V aux. voltage
7	DIN COM	Digital inputs common
8	DI1	Digital input 1
9	DI2	Digital input 2
10	DI3	Digital input 3
4	AI2+	Analogue input, voltage or current
5	GND	I/O signal ground
13	DO1-	Digital output 1 common
14	DI4	Digital input 4
15	DI5	Digital input 5
16	DI6	Digital input 6
18	AO1+	Analogue signal (+output)
20	DO1+	Digital output 1

Function	Description	Wire colors	Terminal
Potentiometer	10V reference output	RED wire	1
	AI1+	BLUE wire	2
	AI1-	BLACK wire	3

Table 41. Simple operator panel connection description.

Function	Description	Wire colors	Terminal
Switch selector	24V auxiliary voltage	YELLOW wire	6
	digital input DI1	WHITE wire	8
	digital input DI2	GREY wire	9

Table 41. Simple operator panel connection description.

- |           |  |
|-----------|--|
| <b>11</b> | <ul style="list-style-type: none"> <li>Mount the plastic cover onto the drive with its screws (use torque 2Nm) and the HMI cap: the installation process has been completed. See Figure 69.</li> </ul> |
|-----------|--|

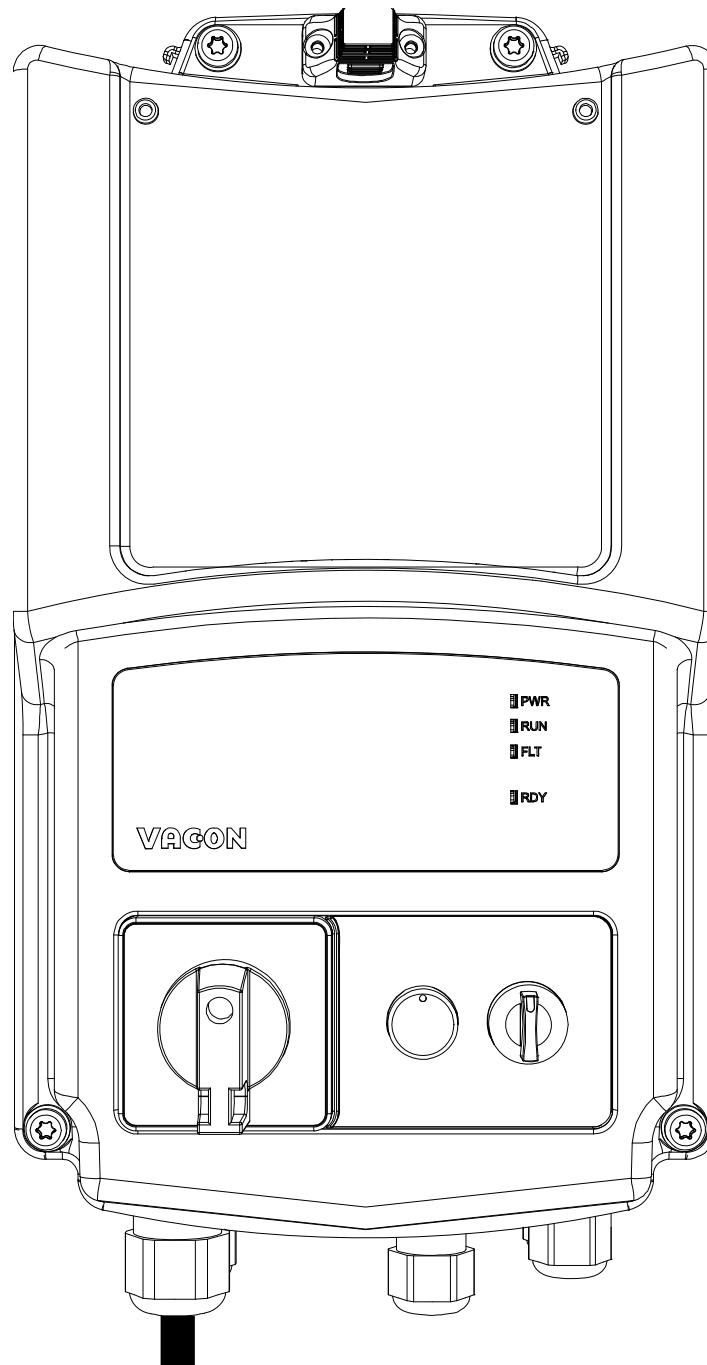


Figure 69. Mount the plastic cover.

## 9. SAFE TORQUE OFF









This chapter describes the Safe Torque Off (STO) function which is a functional safety feature present into VACON® 20 X drive products as standard. This function is available only in the three-phase version.

### 9.1 GENERAL DESCRIPTION

The STO function brings the motor in no-torque-state as defined by 4.2.2.2 of the IEC 61800-5-2: *“Power that can cause rotation (or motion in the case of a linear motor) is not applied to the motor. The Power Drive System (Safety Related) will not provide energy to the motor which can generate torque (or force in the case of a linear motor).”*

Therefore, the STO function is suitable for applications that rely on the immediate removal of power to the actuator, resulting in an uncontrolled coast to stop (activated by an STO demand). **Additional protective measures need to be applied when an application requires a different stop method.**

### 9.2 WARNINGS

	Designing of safety-related systems requires specialist knowledge and skills. Only qualified people are permitted to install and set up the STO function. The use of STO does not itself ensure safety. <b>An overall risk evaluation is required for ensuring that the commissioned system is safe.</b> Safety devices must be correctly incorporated into the entire system which must be designed in compliance with all relevant standards within the field of industry.
	The information in this manual provides guidance on the use of the STO function. This information is in compliance with accepted practice and regulations at the time of writing. However, the end product/system designer is responsible for ensuring that the <b>end-system</b> is safe and in compliance with relevant regulations.
	When a permanent magnet motor is used and in case of a multiple IGBT power semiconductor failure, when the STO option energizes the drive outputs to the off state, the drive system may still provide an alignment torque which maximally rotates the motor shaft by $180^\circ/p$ (where p is the number of poles of the motor) before the torque production ceases.
	Electronic means and contactors are not adequate for protection against electric shock. The Safe Torque Off function does not disconnect the voltage or the mains from the drive. Therefore hazardous voltages may still be present on the motor. If electrical or maintenance work has to be carried out on electrical parts of the drive or the motor, the drive has to be completely isolated from the main supply, e.g. using an external supply disconnecting switch (see EN60204-1 section 5.3).
	This safety function corresponds to an uncontrolled stop in accordance with stop category 0 of IEC 60204-1. The STO function does not comply with Emergency Switching Off according to IEC 60204-1 (no galvanic insulation from the Mains in case the motor is stopped).
	The STO function is not a prevention of unexpected start-up. To fulfil those requirements, additional external components are required according to appropriate standards and application requirements.
	In circumstances where external influences (e.g. falling of suspended loads) are present additional measures (e.g. mechanical brakes) may be necessary to prevent any hazard.
	STO must not be used as a control for starting or stopping the drive.



### 9.3 STANDARDS

The STO function has been designed for use in accordance with the following standards:

Table 42. Safety Standards.

Standards
IEC 61508, Parts 1-7
EN 61800-5-2
EN 62061
ISO 13849-1
EN 954-1
IEC 60204-1

The STO function has to be applied correctly to achieve the desired level of operational safety. Four different levels are allowed, depending on the use of the STO signals (see the following table).

Table 43. Four different STO levels. (\*) see 9.5.1.

STO inputs	STO feedback	Cat.	PL	SIL
Both dynamically used(*)	Used	4	e	3
Both statically used	Used	3	e	3
Connected in parallel	Used	2	d	2
Connected in parallel	Not used	1	c	1

The same values are calculated for SIL and SIL CL. According to EN 60204-1, the emergency stop category is 0.

The SIL value for the safety related system, operating in high demand/continuous mode, is related to the probability of dangerous failure per hour (PFH), reported in the following table.

Table 44. SIL values. (\*) see 9.5.1.

STO inputs	STO feedback	PFH	PFDav	MTTFd (years)	DCavg
Both dynamically used(*)	Used	8.0 E-10 1/h	7.0 E-05	8314 y	HIGH
Both statically used	Used	8.1 E-10 1/h	7.1 E-05	8314 y	MEDIUM
Connected in parallel	Used	8.1 E-10 1/h	7.1 E-05	8314 y	MEDIUM
Connected in parallel	Not used	9.2 E-10 1/h	8.0 E-05	8314 y	NONE



**The STO inputs must always be supplied by a safety device.**

The power supply of the safety device may be external or taken from the drive (as long as this is compliant with the rating specified for terminal 6).

9.4 THE PRINCIPLE OF STO

The STO functionality, such as the technical principles and data (wiring examples and commissioning) will be described in this chapter.

In VACON® 20 X, the STO function is realized by preventing the propagation of the control signals to the inverter circuit.

The inverter power stage is disabled through redundant disabling paths which start from the two separated and galvanically isolated STO inputs (S1-G1, S2-G2 in Figure 70). In addition, an isolated output feedback is generated to improve the diagnostics of the STO function and to achieve a better safety capability (F+, F- terminals). The values assumed by the STO output feedback are indicated in the following table:

Table 45. Values of the STO output feedback (and torque on the motor). (\*) Only one channel is preventing the drive from moving.

STO inputs	Operating conditions	STO feedback output	Torque at the motor shaft
Both inputs energized with 24V DC	Normal operation	The feedback must be 0V	present (motor on)
Power removed from both inputs	STO demand	The feedback must be 24V	disabled (motor de-energized)
The STO inputs have different values	Failure in demand or due to internal fault	The feedback must be 0V	disabled (motor de-energized)(*)

The diagram below is a conceptual schematic diagram and is presented to illustrate the safety function with relevant safety components only shown.

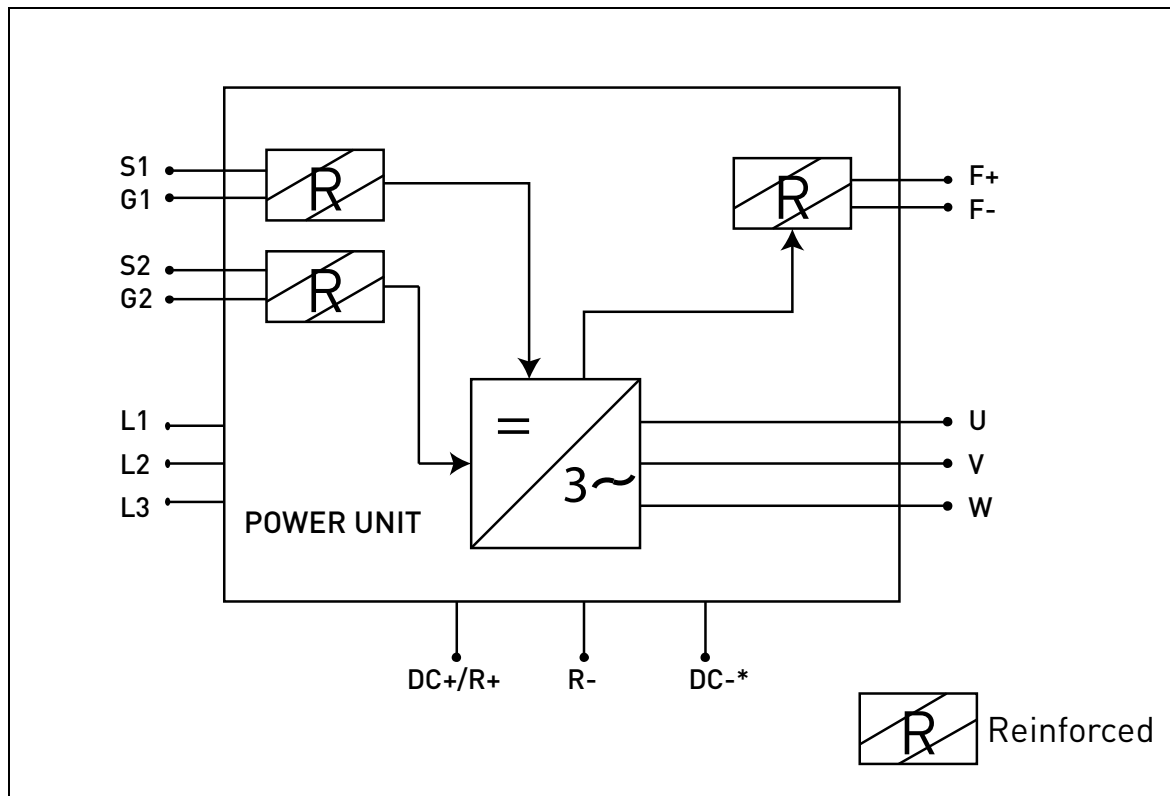


Figure 70. STO function principle. (\*) Only for 3~ units.

#### 9.4.1 TECHNICAL DETAILS

The STO inputs are digital inputs intended for a nominal 24V d.c. input, positive logic (e.g. enabled when high).

Table 46. Electrical data.

Technical information:	Technical values
Maximum voltage	30 V
Typical input current at 24V	10...15 mA
Logic threshold	according to IEC 61131-2 15V...30V = "1" 0V...5V = "0"
Response time at nominal voltage:	
Reaction time	<20ms

The reaction time of the STO function is the amount of time which passes from the moment in which the STO is demanded until the system is in the Safe State. For VACON<sup>®</sup> 20 X, the reaction time is 20 ms maximum.

### 9.5 CONNECTIONS

To make the STO function available and ready to be used, both STO jumpers have to be removed. They have been located in front of the STO terminal to mechanically prevent the insertion of the STO inputs. For the correct configuration, see the following table and the Figure 71.

Table 47. STO connector and data signals.

Signal	Terminal	Technical information	Data
STO1	S1	Insulated digital input 1 (interchangeable polarity)	24V ±20% 10...15 mA
	G1		
STO 2	S2	Insulated digital input 2 (interchangeable polarity)	24V ±20% 10...15 mA
	G2		
STO feedback	F+	Insulated digital output for STO feedback (CAUTION! Polarity must be respected)	24V ±20% 15 mA max.
	F-		GND

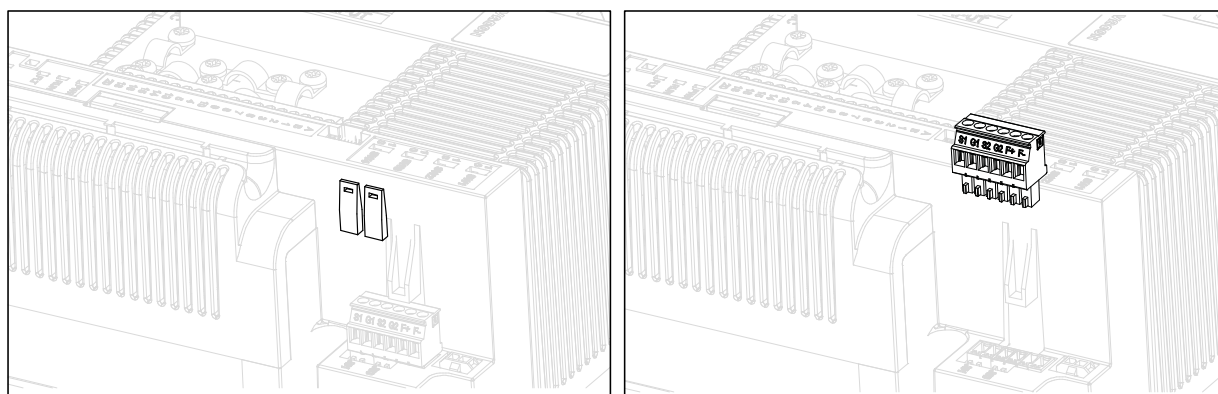


Figure 71. Removing the STO jumpers from the control unit.

	Make sure that the AC drive is switched off before cabling.
	When the STO function is used, <b>the IP-class of the drive may not be reduced below IP54</b> . The IP-class of drive is IP66. It can be reduced by the wrong use of the cable entry plates or the cable glands.
	Disconnect both STO jumpers to allow the cabling of the terminals.

The following examples show the basic principles for wiring the STO inputs and the STO output feedback. Local standards and regulations should be always followed in the final design.

### 9.5.1 SAFETY CAPABILITY CAT.4 / PL e / SIL 3

For this safety capability, an external safety device must be installed. This must be used to dynamically activate the STO inputs and to monitor the STO output feedback.

The STO inputs are dynamically used when they do not commute together (static use), but according to the following picture (where the inputs are released with delay in turn). The dynamic use of the STO inputs allows detecting faults that may otherwise accumulate.

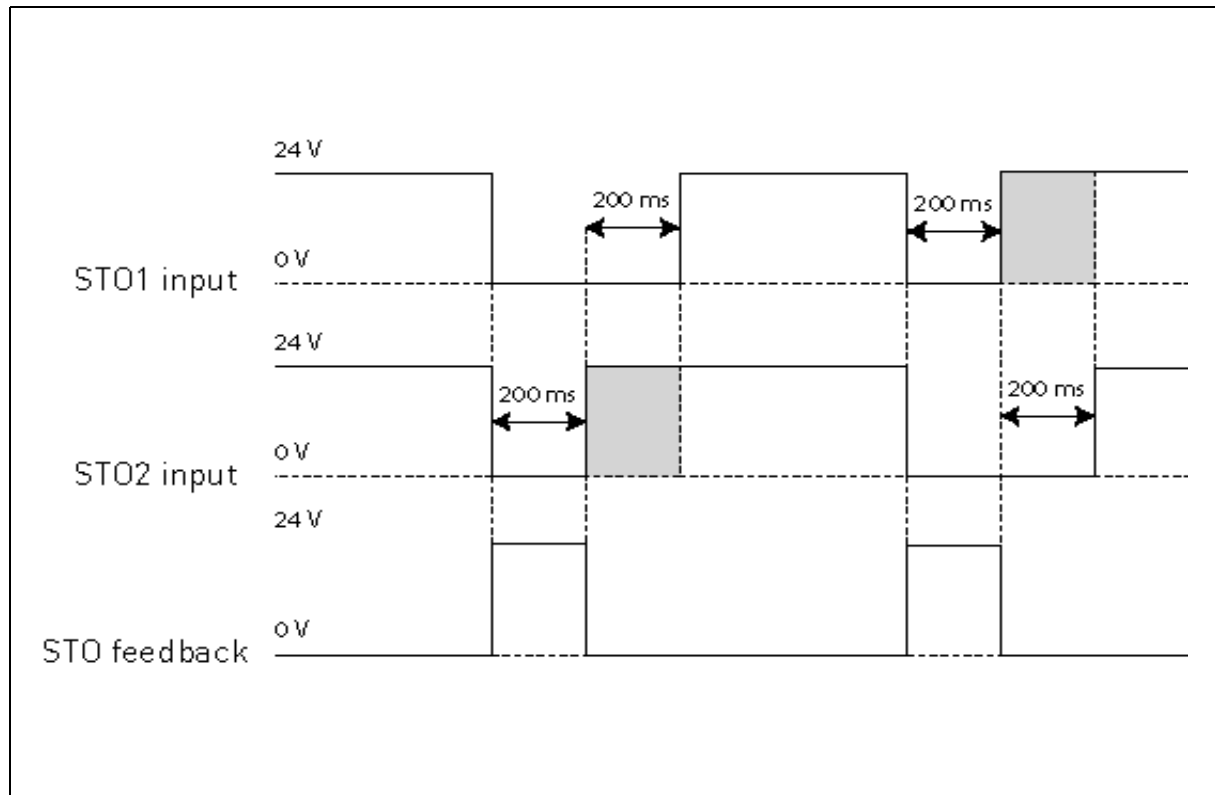





Figure 72.

	<p>An emergency push button connected to the STO inputs does not assure the same quality, because no fault detection is performed at a sufficient frequency (<b>once a day is recommended</b>).</p>
	<p>The external safety device, which forces the STO inputs and evaluates the STO output feedback, has to be a <b>safe device</b> and it has to fulfil the requirements of the specific application.</p>
	<p>A simple switch cannot be used in this case!</p>

The picture below shows an example of connection for the STO function. The external device has to be connected with 6 wires to the drive.

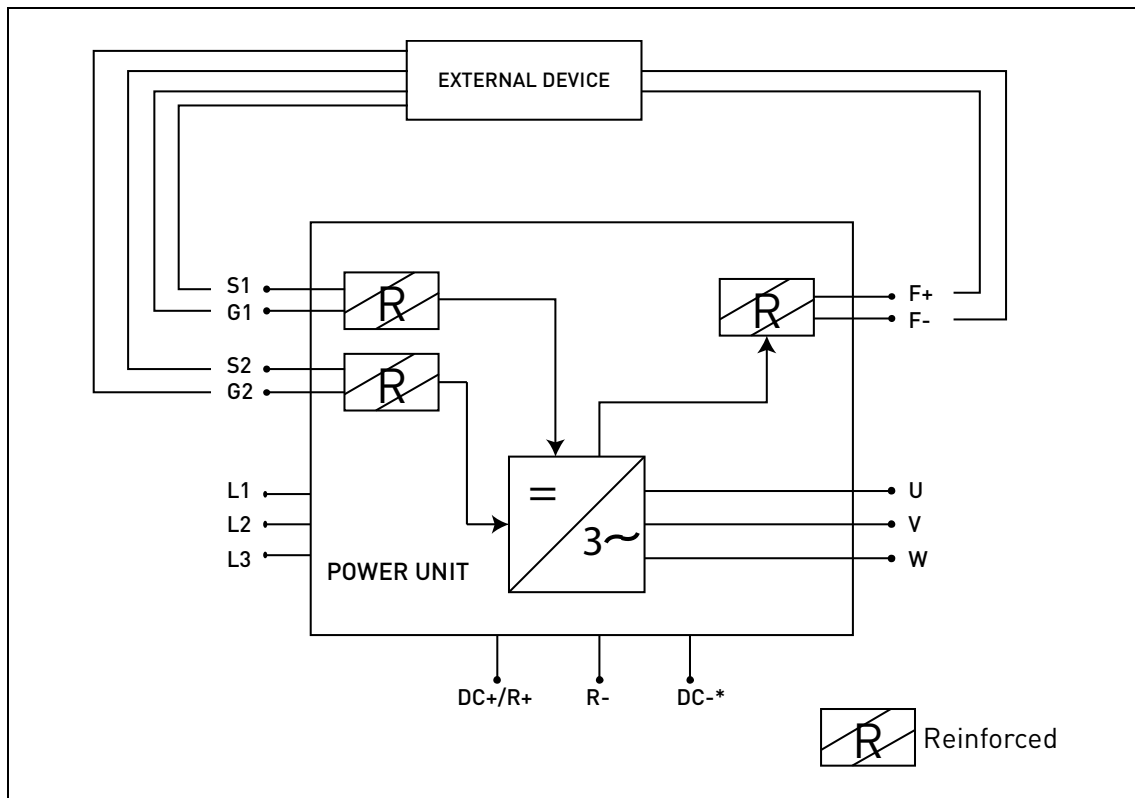


Figure 73. STO example with automatic monitoring of the feedback and both STO inputs used.  
 (\*) Only for 3~ units.

The external device has to monitor the STO function in accordance with the Table 45. The device has to periodically de-energize the STO inputs and it has to verify that the STO output feedback assumes the expected value.

Any difference between the expected and the real value has to be considered as a failure and has to drive the system into a Safe State. In case of failure, check the wiring. If the fault recognized by the external safety device persists, **the drive will have to be replaced/repaired.**

### 9.5.2 SAFETY CAPABILITY CAT. 3 / PL e / SIL 3

The safety capability is reduced to Cat. 3 / PL e / SIL 3 if the STO inputs are statically used (which means they are forced to commute together).

Both STO inputs and the STO feedback have to be used. The same warnings and cabling instruction as 9.5.1 apply.

### 9.5.3 SAFETY CAPABILITY CAT. 2 / PL d / SIL 2

The safety capability is reduced to Cat. 2 / PL d / SIL 2 if the STO inputs are connected in parallel (no redundancy of the STO inputs).

The STO feedback has to be used. The same warnings as 9.5.1 apply. The picture below shows an example of connection for the STO function. The external device has to be connected with 4 wires to the drive.

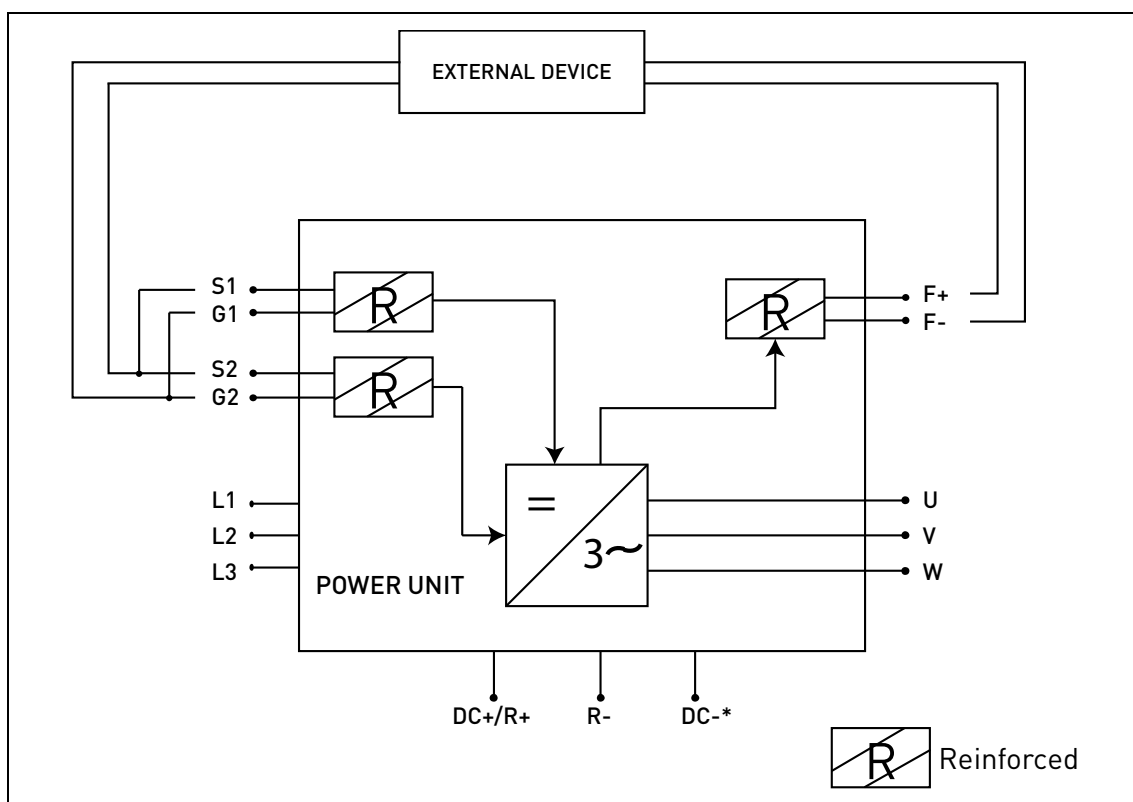





Figure 74. STO Example with automatic monitoring of the feedback and STO inputs connected in parallel. (\*) Only for 3~ units.

9.5.4 SAFETY CAPABILITY CAT.1 / PL c / SIL 1

Without any automatic monitoring of STO output feedback, the safety capability is reduced to Cat. 1 / PL c / SIL 1. The STO inputs (which can be connected in parallel) must be supplied by a safety push button or a safety relay.

	The choice of using the STO inputs (without the automatic monitoring of the output feedback) does not allow the <b>other safety capabilities to be achieved</b> .
	The standards for functional safety require that functional proof tests are performed on the equipment at user-defined intervals. Therefore, <b>this safety capability</b> can be achieved, as long as the STO function is manually monitored at the frequency determined by the specific application ( <b>once a month can be acceptable</b> ).
	This <b>safety capability</b> can be achieved by connecting in parallel the STO inputs externally and by ignoring the use of the STO output feedback.

The picture below shows an example of connection for the STO function. A switch (a safety push button or a safety relay) may be connected with 2 wires to the drive.

When the contacts of the switch are opened, the STO is demanded, the drive indicates F30 (=“Safe Torque Off”) and the motor stops by coasting.

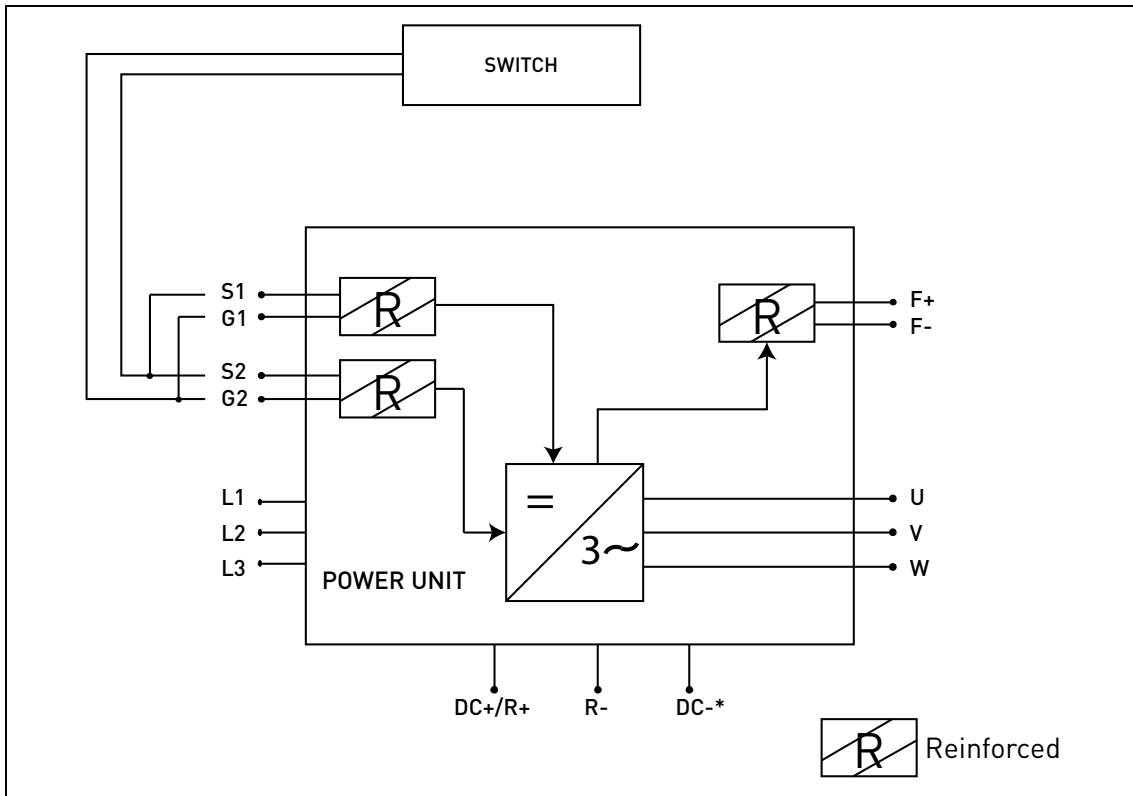




Figure 75. STO example without automatic monitoring of the feedback and STO inputs connected in parallel. (\*) Only for 3~ units.



## 9.6 COMMISSIONING

### 9.6.1 GENERAL WIRING INSTRUCTIONS

	Protect the STO cabling with a shielding or an enclosure to exclude external damage.
	Wires ferrules are highly recommended for all STO signals (inputs and feedback).

The wiring should be done according to the general wiring instructions for the specific product. A shielded cable is required. In addition, the voltage drop from the supply point to the load must not exceed 5% [EN 60204-1 part 12.5].

The following table indicates examples of cables to be used.

*Table 48. Cable types required to meet the standards. (\*) Additional wires are needed for restarting the drive after each STO demand.*

STO feedback	Cable size
STO feedback automatically monitored by an external safety device	3 x (2 + 1) x 0.5 mm <sup>2</sup> (*)
STO feedback ignored, simply safety device (switch) used	2 x (2 + 1) x 0.5 mm <sup>2</sup>

### 9.6.2 CHECKLIST FOR COMMISSIONING




Follow the checklist shown in the table below for steps required to use the STO function.

*Table 49. Checklist for commissioning of STO.*

<input type="checkbox"/>	Carry out a risk assessment of the system to ensure that the use of the STO function is safe and according to the local regulations.
<input type="checkbox"/>	Include in the assessment an examination of whether the use of external devices, such as a mechanical brake, are required.
<input type="checkbox"/>	Check if the switch (if used) has been chosen according to the required safety performance target (SIL/PL/Category) set during the risk evaluation.
<input type="checkbox"/>	Check if the external device for automatic monitoring of the STO output feedback (if used) has been chosen in accordance with the specific application.
<input type="checkbox"/>	Check if the reset function with the STO function (if used) is edge sensitive.
<input type="checkbox"/>	The shaft of a permanent magnet motor might, in an IGBT fault situation, still provide energy before the torque production ceases. This may result in a jerk of max. 180° electrically. Ensure that the system is designed in such a way that this can be accepted.
<input type="checkbox"/>	Check if the degree of protection of the <b>enclosure is at least IP54</b> . See paragraph 9.5.
<input type="checkbox"/>	Check if the recommendations on EMC for cables have been followed.
<input type="checkbox"/>	Check if the system has been designed in such a way that enabling of the drive through STO inputs will not lead to an unexpected start of the drive.
<input type="checkbox"/>	Check if only approved units and parts have been used.
<input type="checkbox"/>	Set up a routine to ensure that the functionality of the STO function is being checked at regular intervals.

## 9.7 PARAMETERS AND FAULT TRACING



There are no parameters for the STO function itself.

	<p>Before testing the STO function, make sure that the checklist (Table 49) is inspected and completed.</p>
	<p>When STO function is demanded, the drive always generates a fault ("F30") and the motor stops by coasting.</p>
	<p>In the application the STO state can be indicated using a digital output.</p>

To re-enable motor operation, after the STO state, it is necessary to perform the following steps:

- Release the switch or the external device ("F30" is displayed even after this has been released).
- Reset the fault (through a digital input or from the keypad).
- It is possible that a new start command is required for the restart (depending on the application and your parameter settings).

## 9.8 MAINTENANCE AND DIAGNOSTICS

	If any service or repair has to be conducted on the drive installed, please inspect the checklist given in Table 49.
	During maintenance breaks, or in case of service/repair, <b>ALWAYS</b> make sure that the STO function is available and fully functional by testing it.

The STO function or the STO input/output terminals do not need any maintenance.

The following table shows faults that may be generated by the software that monitors the hardware related to the STO safety function. If you detect any failure in safety functions, including STO, contact your local VACON® supplier.

Table 50. Fault related to the STO function.



Fault Code	Fault	Cause	Correction
30	Safe Torque Off	STO inputs in a different state or both de-energized	Check cabling

**NOTE!** See Table 36 for detailed fault code descriptions.

## 10. SOLAR PUMP APPLICATION

The installation instructions in this chapter are intended only for VACON® 20 X Drives with additional solar pump application.

### 10.1 DANGER

	<b>The terminals are live</b> when the VACON® 20 X Drive is connected to a photovoltaic system. <b>Photovoltaic cells generate DC voltage even at low intensity of sunlight.</b>
	<b>Wait 60 seconds</b> until the drive is discharged, <b>before switching between AC and DC supply</b> (photovoltaic system) and vice versa.

### 10.2 DC FUSE SELECTION

The fuses on the DC-Input of the inverter must have the following characteristics:

Table 51. Fuse characteristics

Fuse type	Min. Voltage rating
DC current	1000 V

It is recommended to use gPV fuses, which are developed for solar application, in order to protect cables and panels against reverse overcurrent, when multiple strings are connected in parallel. See chapter 10.3. for recommended gPV fuse manufacturer.

The photovoltaic fuses have to meet the IEC 60269-6 or the UL 2579 standard.

See table below for recommended fuse sizes:

Table 52. Recommended fuse sizes, Mains voltage 3AC 208-240V, 50/60 Hz, up to 400V in VDC

Enclosure size	AC drive type	Rated continuous current [A]	IEC60269-6 Fuse size [A]	UL-2579 Fuse size [A]
MU3	0011	11.0	20	20
	0012	12.5	25	25
	0017	17.5	30	32

Table 53. Recommended fuse sizes, Mains voltage 1AC 208-240V, 50/60 Hz, up to 400V in VDC

Enclosure size	AC drive type	Rated continuous current [A]	IEC60269-6 Fuse size [A]	UL-2579 Fuse size [A]
MU2	0004	3.7	6	8
	0005	4.8	8	10
	0007	7	12	15

Table 54. Recommended fuse sizes, Mains voltage 3AC 380-480V, 50/60 Hz, up to 800V in VDC

Enclosure size	AC drive type	Rated continuous current [A]	IEC60269-6 Fuse size [A]	UL-2579 Fuse size [A]
MU3	0009	9.0	16	16
	0012	12.0	20	25
	0016	16.0	30	30

### 10.3 MANUFACTURERS OF GPV FUSES

Recommended manufacturers of gPV type fuses:

- Littelfuse
- Siba
- Bussmann
- Mersen
- ETI
- DF Electric

### 10.4 PARALLEL DIODE SELECTION

When VACON® 20 X is used in the Solar Pump application, a diode must be connected between DC+ and DC- to protect the inverter against reverse voltage. See tables below for diode specification.

Table 55. Diode specification, Mains voltage 3AC 208-240V, 50/60 Hz, up to 400V in VDC

AC drive		Diode specifications	
Enclosure size	AC drive type	min. IFav [A]	Min. Voltage rating
MU3	0011	25	1200V
	0012	28	
	0017	40	

Table 56. Diode specification, Mains voltage 1AC 208-240V, 50/60 Hz, up to 400V in VDC

AC drive		Diode specifications	
Enclosure size	AC drive type	min. IFav [A]	Min. Voltage rating
MU2	0004	9	1200 V
	0005	12	
	0007	16	

Table 57. Diode specification, Mains voltage 3AC 380-480V, 50/60 Hz, up to 800V in VDC

AC drive		Diode specifications	
Enclosure size	AC drive type	min. IFav [A]	Min. Voltage rating
MU3	0009	20	1200 V
	0012	28	
	0016	36	

**10.5 PHOTOVOLTAIC SYSTEM DIMENSIONING**

The photovoltaic system has to be dimensioned in order to not exceed the values specified in the tables below.

Table 58. VACON® 20 X (208...240V 3AC 50/60Hz) DC-link input ratings

Enclosure size	AC drive type	DC supply [V]	Max. Recommended PV Array Power [kW]
MU3	0011	234 ... 400V <sub>DC</sub> No tolerance permissible, 0%	4.4
	0012		6.0
	0017		8.0

Table 59. VACON® 20 X (208...240V 1AC 50/60Hz) DC-link input ratings

Enclosure size	AC drive type	DC supply [V]	Max. Recommended PV Array Power [kW]
MU2	0004	234 ... 400V <sub>DC</sub> No tolerance permissible, 0%	1.5
	0005		2.2
	0007		3.0

Table 60. VACON® 20 X (380...480V 3AC 50/60Hz) DC-link input ratings

Enclosure size	AC drive type	DC supply [V]	Max. Recommended PV Array Power [kW]
MU3	0009	436 ... 800V <sub>DC</sub> No tolerance permissible, 0%	8.0
	0012		11.0
	0016		14.0

## 10.6 GROUNDING

### 10.6.1 POLE GROUNDING

It is prohibited to connect any pole, DC+ or DC-, of the photovoltaic system directly to PE.

### 10.6.2 DRIVE GROUNDING

All non-current-carrying metal parts (module enclosures, enclosures) and also the midpoint of the current carrying conductors of the photovoltaic system must be connected to the PE of the drive.

## 10.7 AC GRID CONNECTION

### 10.7.1 MORE THAN ONE SOURCE OF SUPPLY

It is not allowed to supply the drive simultaneously from photovoltaic cell and from grid.

### 10.7.2 TOGGLE BETWEEN AC AND DC

If both the DC input and the AC input are used (e.g. in case of not sufficient energy from the photovoltaic system) it is not allowed to switch directly between AC and DC supply. When switching from one supply to the other it is mandatory to wait until the drive is discharged. The discharge time and subsequently the minimum delay to switch between the supplies is 30 seconds.

Minimum AC-DC switchover delay = 60s.

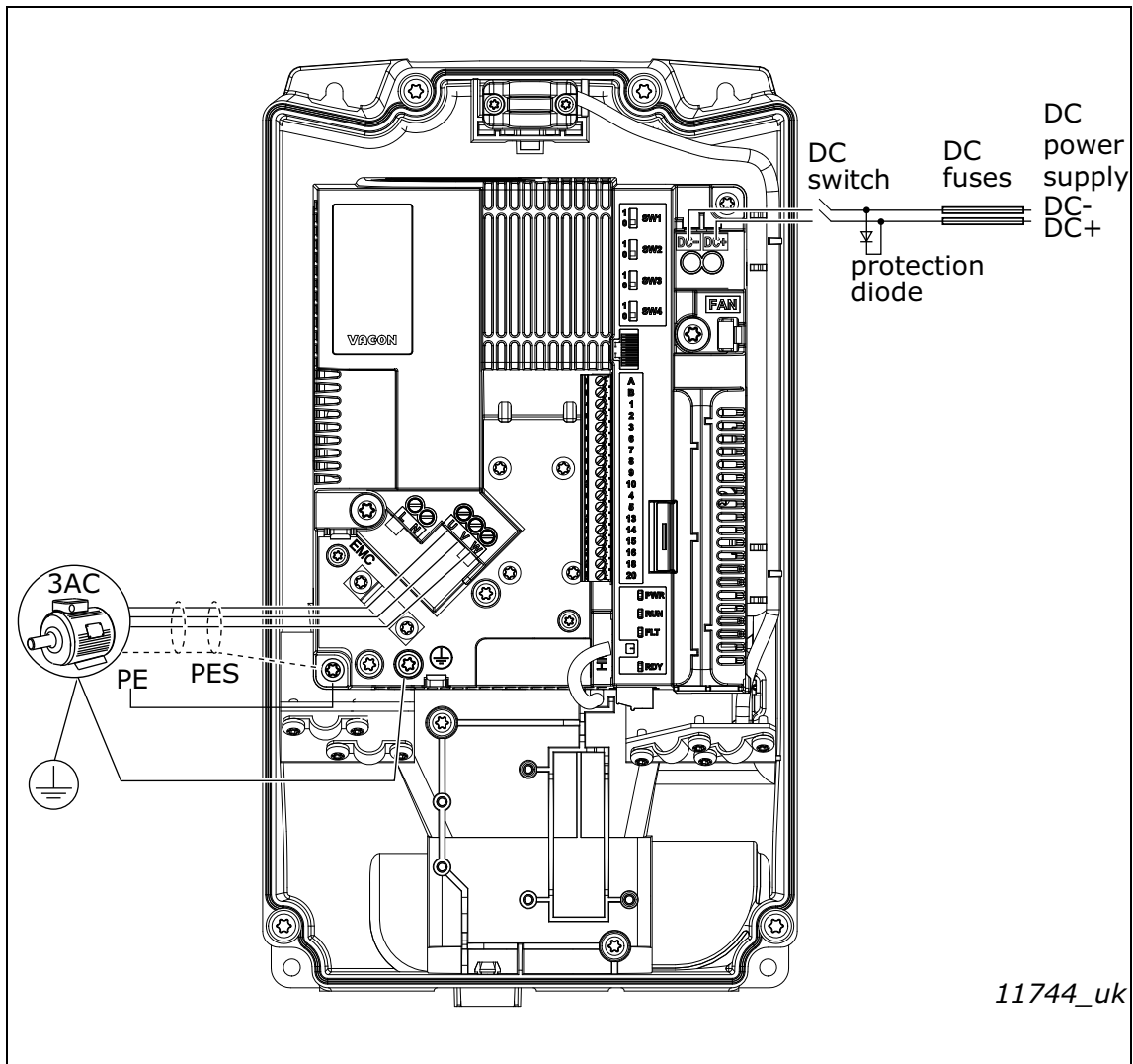


Danfoss recommends to use a two-pole disconnect switch as well for photovoltaic input (suitable for DC) as for grid input (AC switch) to completely isolate the equipment. Only one of these switches is allowed to be on at a time and delay time must be respected when changing from one switch to the other.

## 10.8 EXTERNAL +24V SUPPLY

It is not supported and not allowed to supply the control-board with external +24V when the drive is connected to a photovoltaic source (DC-supplied drive).

10.9 DC POWER CONNECTION



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Figure 76. Example of the power connections: MU2 1AC



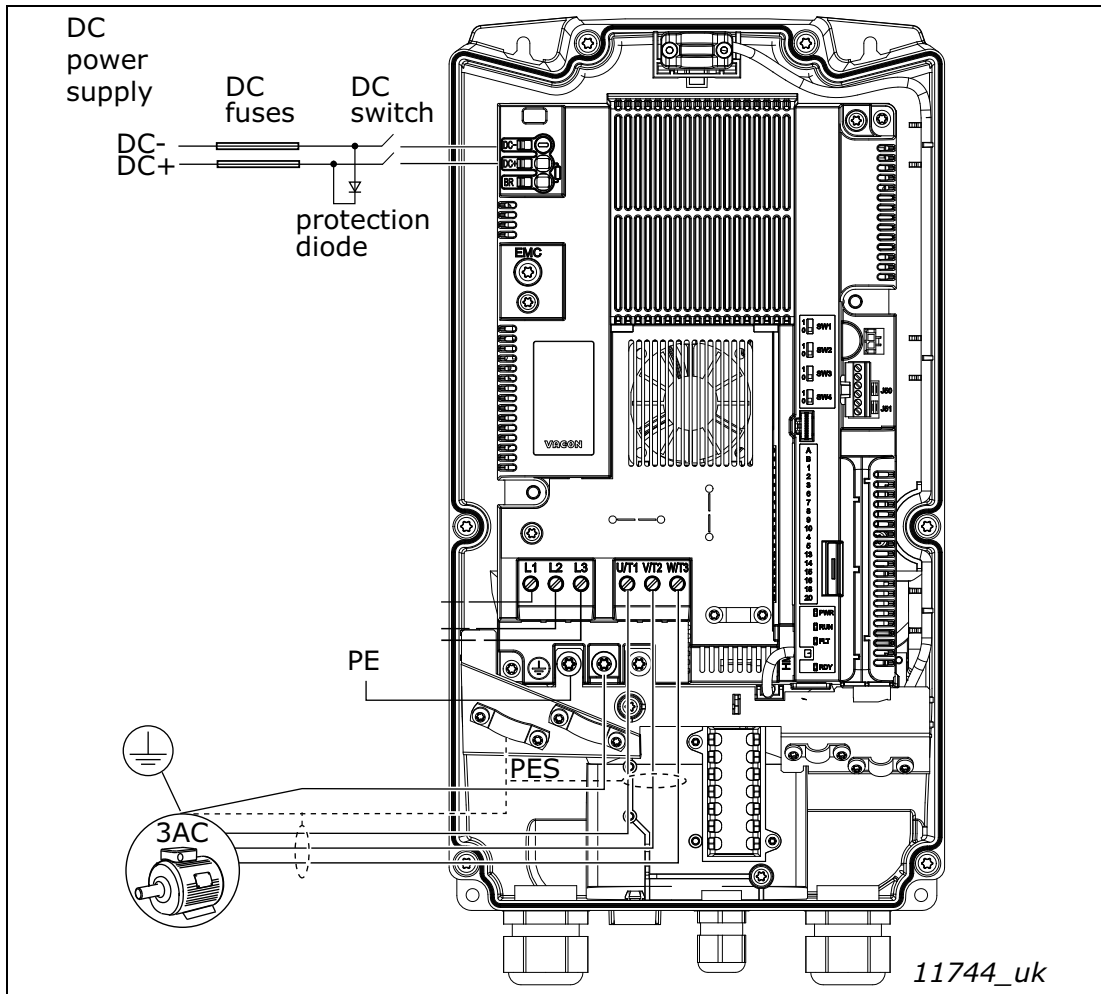


Figure 77. Example of the power connections: MU3

# VACON<sup>®</sup>

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