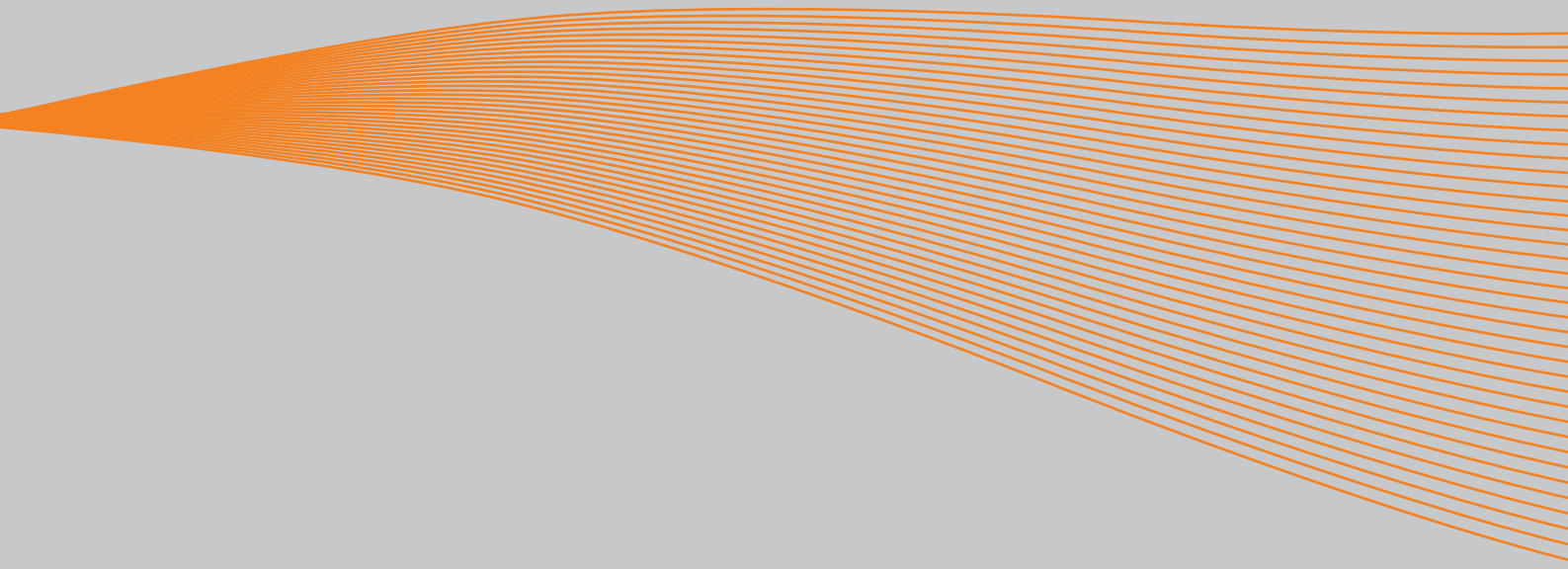
VACON® 20 X
AC DRIVES

INSTALLATION, TECHNICAL AND MAINTENANCE MANUAL



VACON®
DRIVEN BY DRIVES

INDEX

Document code(Original Instructions): DPD00992B
Order code: DOC-INS06663+DLUK
Rev. B
Revision release date: 1.8.12

1. SAFETY

This manual contains clearly marked cautions and warnings which are intended for your personal safety and to avoid any unintentional damage to the product or connected appliances.

Please read the information included in cautions and warnings carefully.

VACON® 20 X is a drive conceived for controlling asynchronous AC motors and permanent magnet motors. The product is inteded to be installed in a restricted access location and for a general purpose use.

Only by Vacon authorized, trained and qualified personnel are allowed to install, operate and maintain the drive.

The cautions and warnings are marked as follows:

	**= DANGEROUS VOLTAGE!**
	**= HOT SURFACE!**
	**= WARNING or CAUTION**

Table 1. Warning signs.

1.1 DANGER

The **components of the power unit of** VACON® 20 X drives **are live** when the drive is connected to 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 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 additional 30 seconds before starting any work on the connections of VACON® 20 X Drive. 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!**

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 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 additional 30 seconds before starting any work on the drive.

1.2 WARNINGS

VACON® 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 hint aims to protect both the drive and the client-application. Vacon is not responsible for direct or consequential damages resulting from unsafe connections of external circuits to the drive. See paragraph 1.4 for more details.

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

The **touch current** of VACON® 20 X drives exceeds 3.5mA AC. According to standard EN61800-5-1, **a reinforced protective ground connection** must be ensured. See paragraph 1.3.

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 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® 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.

1.3 EARTHING AND EARTH FAULT PROTECTION

CAUTION!

The VACON® 20 X AC drive must always be earthed with an earthing conductor connected to the earthing terminal marked with ⏚.

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

Three screws are provided for: the ORIGINAL protective earthing 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.

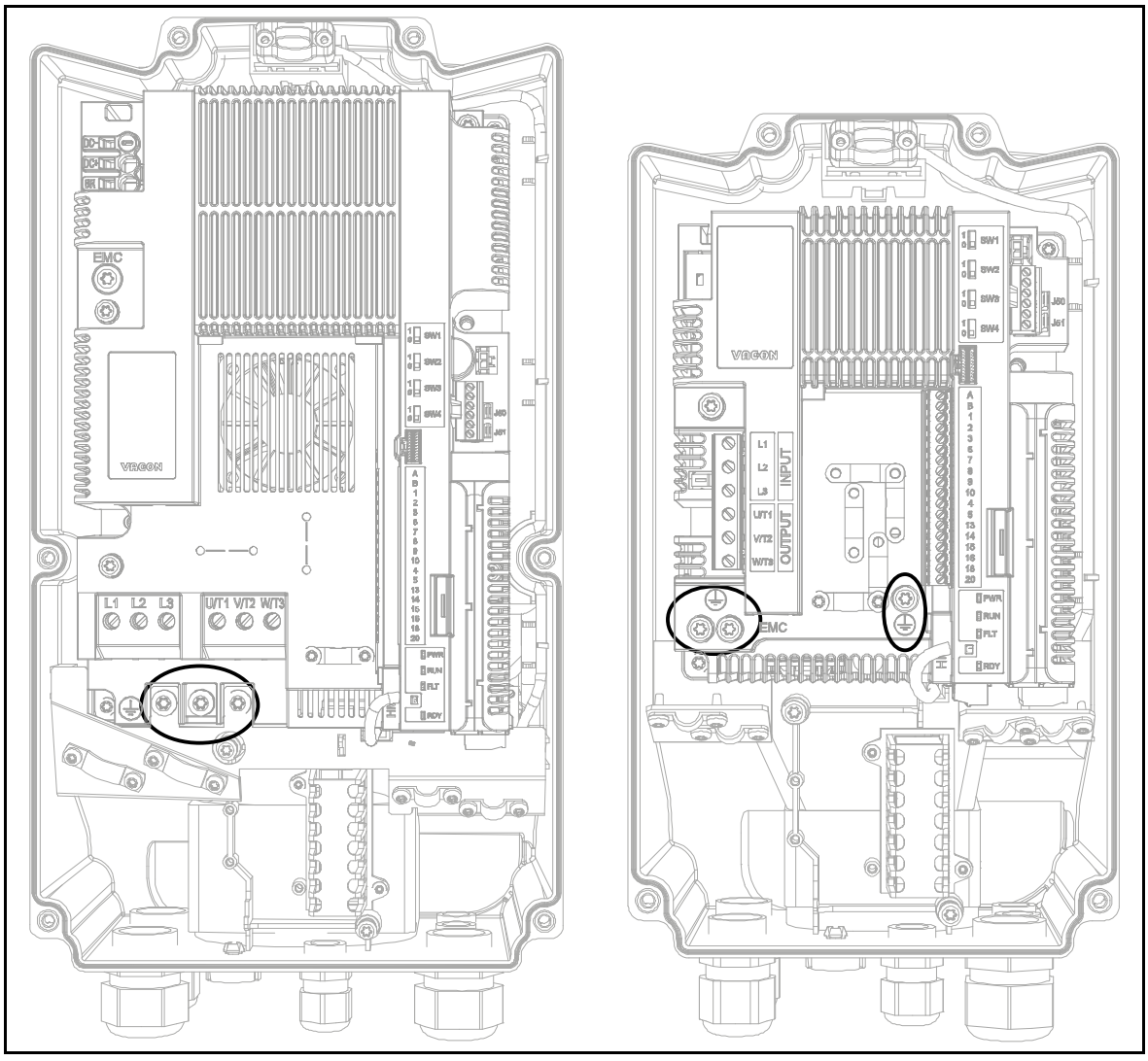


Figure 1. Protective earthing connections.

In VACON® 20 X, the phase conductor and the corresponding protective earthing 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^2).

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

- 2.5 mm^2 if mechanical protection is provided or
- 4 mm^2 if mechanical protection is not provided. For cord-connected equipment, provisions shall be made so that the protective earthing conductor in the cord shall, 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 earthing conductor.

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

1.4 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)
- Relays (R01, R02)(**)
- 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.

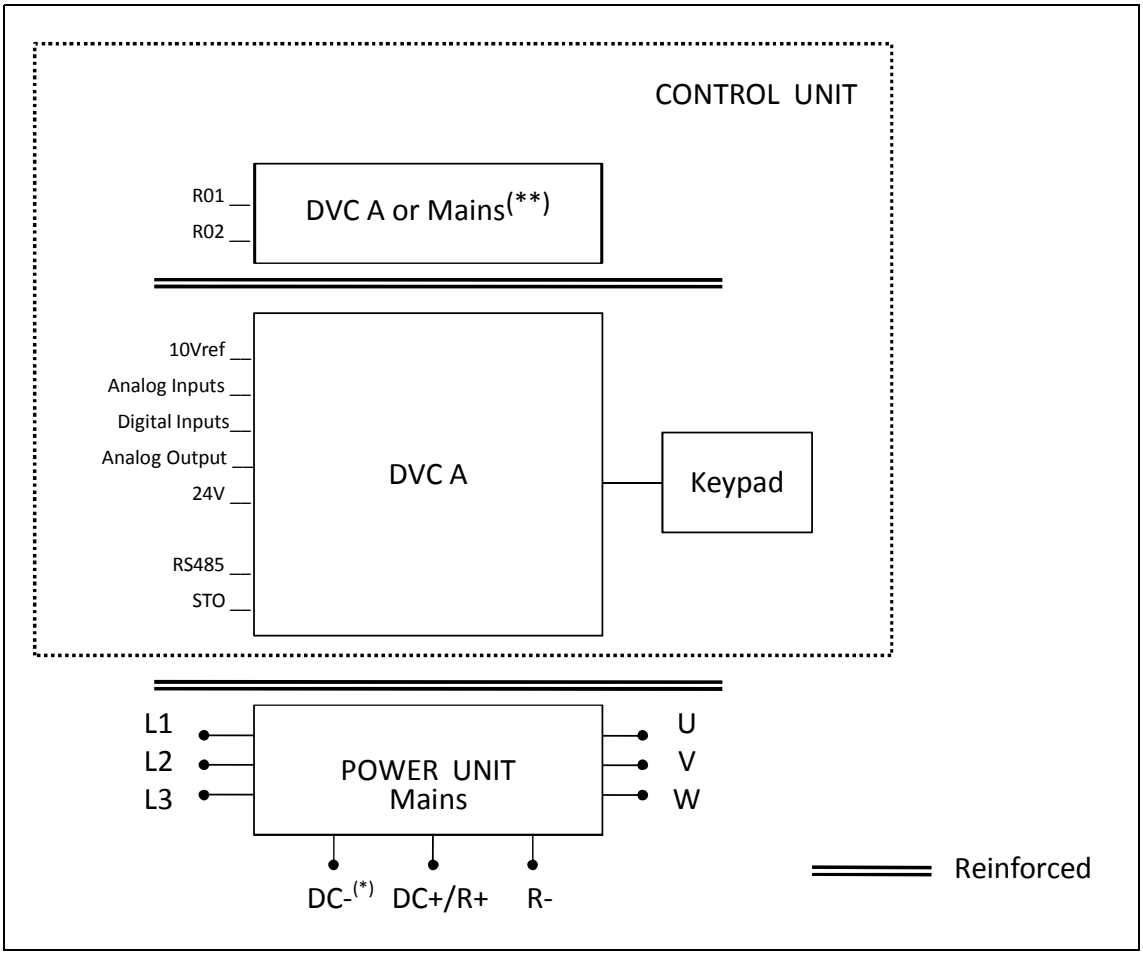


Figure 2. Insulation system(only for MU3).*

(**) 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).

1.5 COMPATIBILITY WITH RCDS

This product can cause a d.c. current in the protective earthing 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.

1.6 EXTENDED TEMPERATURE RANGE

VACON® 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 19 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**.

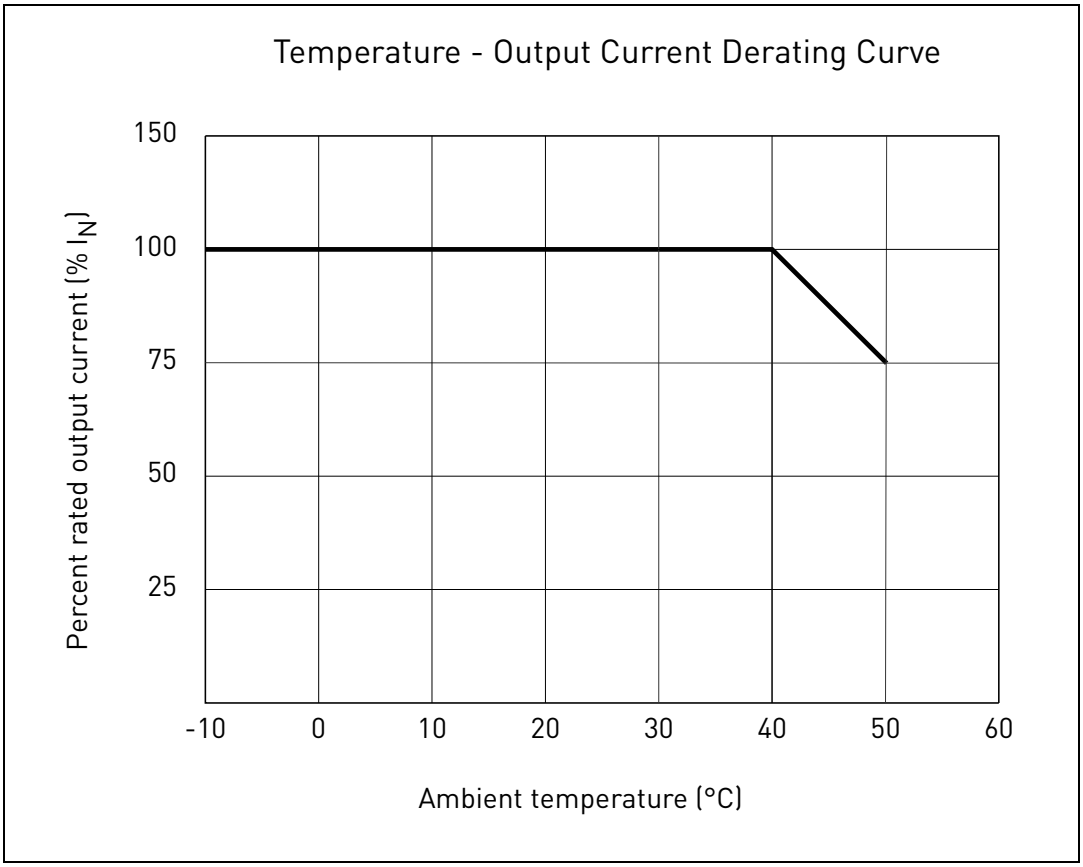


Figure 3.Temperature-output current derating curve.

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).

1.7 DECLARATION OF CONFORMITY

VACON
DRIVEN BY DRIVES

DECLARATION OF CONFORMITY

Manufacturer's name:	Vacon Srl
Manufacturer's address:	Via Roma, 2 I-39014 Postal (BZ), Italy

We hereby declare that the following product

Product name:	Vacon 20 AC drive
Product Identification:	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
Product Safety Functions:	Safe Torque Off (EN 61800-5-2:2007) and Emergency stop (EN 60204-1:2006 + A1:2009 + AC:2010 in extracts)

Complies with the following EU legislation: Low Voltage Directive (LVD) 2006/95/EC, Electromagnetic Compatibility (EMC) 2004/108/EC, 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

The following standards and/or technical specifications referenced below were used:

EN 61800-5-2:2007

EN 61800-5-1:2007 (LV Directive compliance)

EN 61800-3:2004 (EMC Directive compliance)

EN ISO 13849-1:2008+AC:2009

EN 62061:2005+AC:2010

These products are intended for installation in machines. Operation is prohibited until it has been determined that the machines in which these products are to be installed, conforms to the above mentioned EC Directive(s).

Signature

Postal, 03.05.2012

Andrea Perin
Country Manager

Figure 4. Declaration of conformity.

TÜVRheinland®

ZERTIFIKAT
CERTIFICATE

EC Type-Examination Certificate

Reg.-No.: 01/205/5215/12

Product tested	Safety function "Safe Torque Off (STO)" within Adjustable Frequency AC Drive	**Certificate holder**	Vacon S.R.L. Via Roma, 2 I-39014 Postal (BZ) Italy
Type designation	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	**Manufacturer**	see certificate holder
Codes and standards forming the basis of testing	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)
Intended application	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.		
Specific requirements	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.			

The test report-no.: 968/M 349.00/12 dated 2012-04-27 is an integral part of this certificate.

This certificate is valid only for products which are identical with the product tes at any change of the codes and standards forming the ntended application.

TÜVRheinland 0035 Notified Body

Berlin, 2012-04-27

Certification Body for Machinery, NB 0035

Dipl.-Ing. Eberhard Frejno

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

Figure 5. STO certificate.

2. RECEIPT OF DELIVERY

Check 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 2.3.

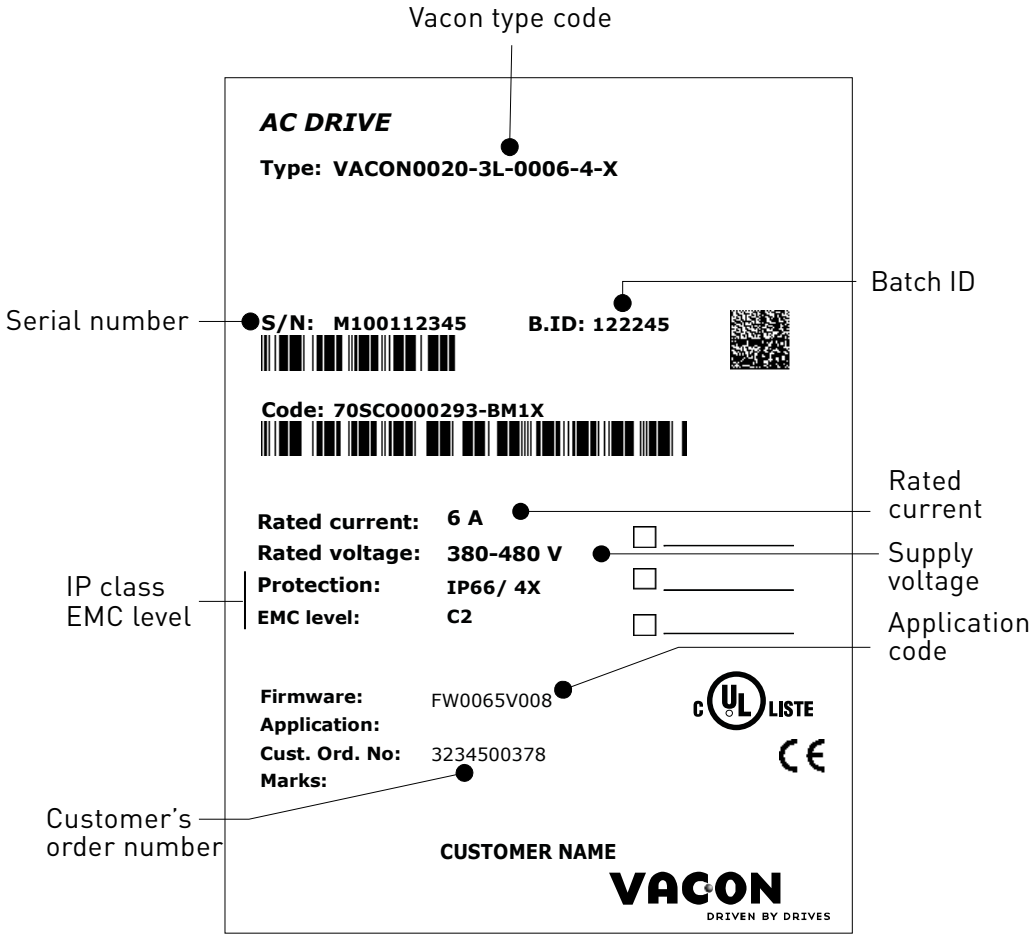


Figure 6. Vacon package label

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

0009

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

See Table 19 and Table 20 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

2.2 UNPACKING AND LIFTING THE AC DRIVE

The weights of the AC drives vary according to frame size. Note the weights of each individual frame size in Table 2 below.

Frame	Weight [kg]
MU2	3.4
MU3	6.0

Table 2. Frame weights

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 damages are to be found on the product and that the delivery is complete.

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

2.3 ACCESSORIES

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

- STO terminal connector (six pins black connector, see Figure 7)
- 'Product modified' sticker

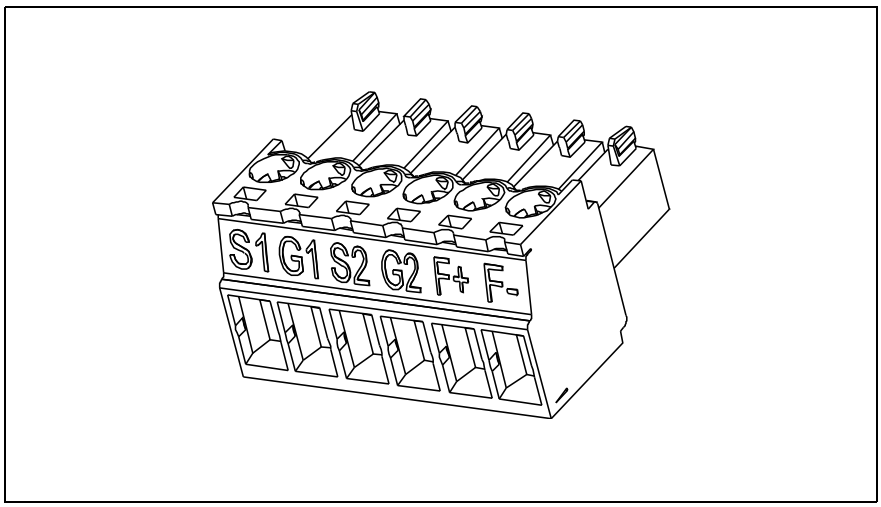


Figure 7. STO connector.

2.3.1 '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.

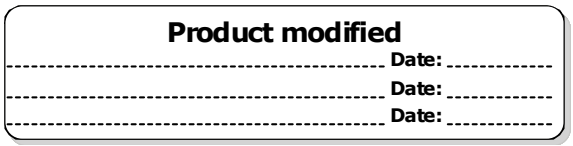


Figure 8. 'Product modified' sticker

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 frame sizes can be mounted in any position. The drive shall be fixed with four screws (or bolts, depending on the unit size).

3.1 DIMENSIONS

3.1.1 FRAME MU2 AND MU3

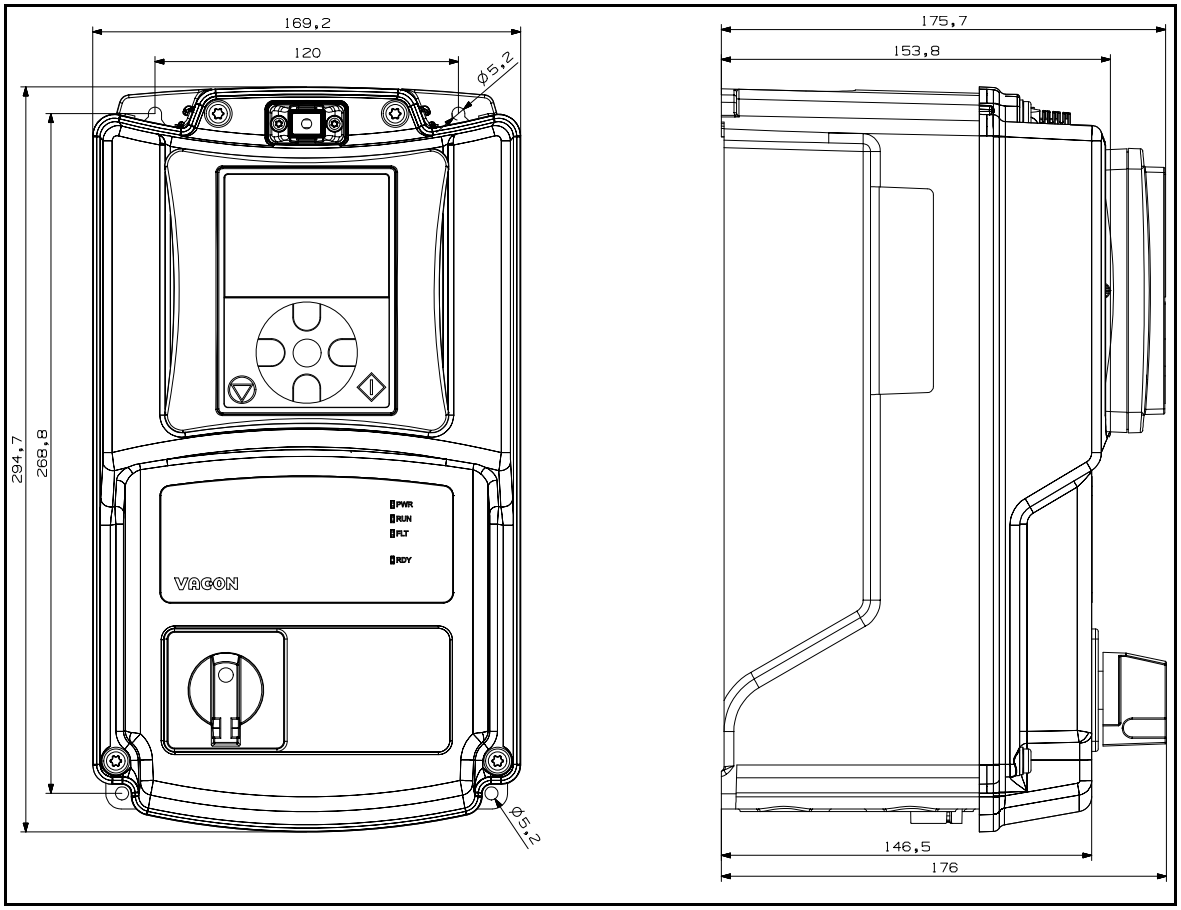


Figure 9. VACON® *20 X, MU2.*

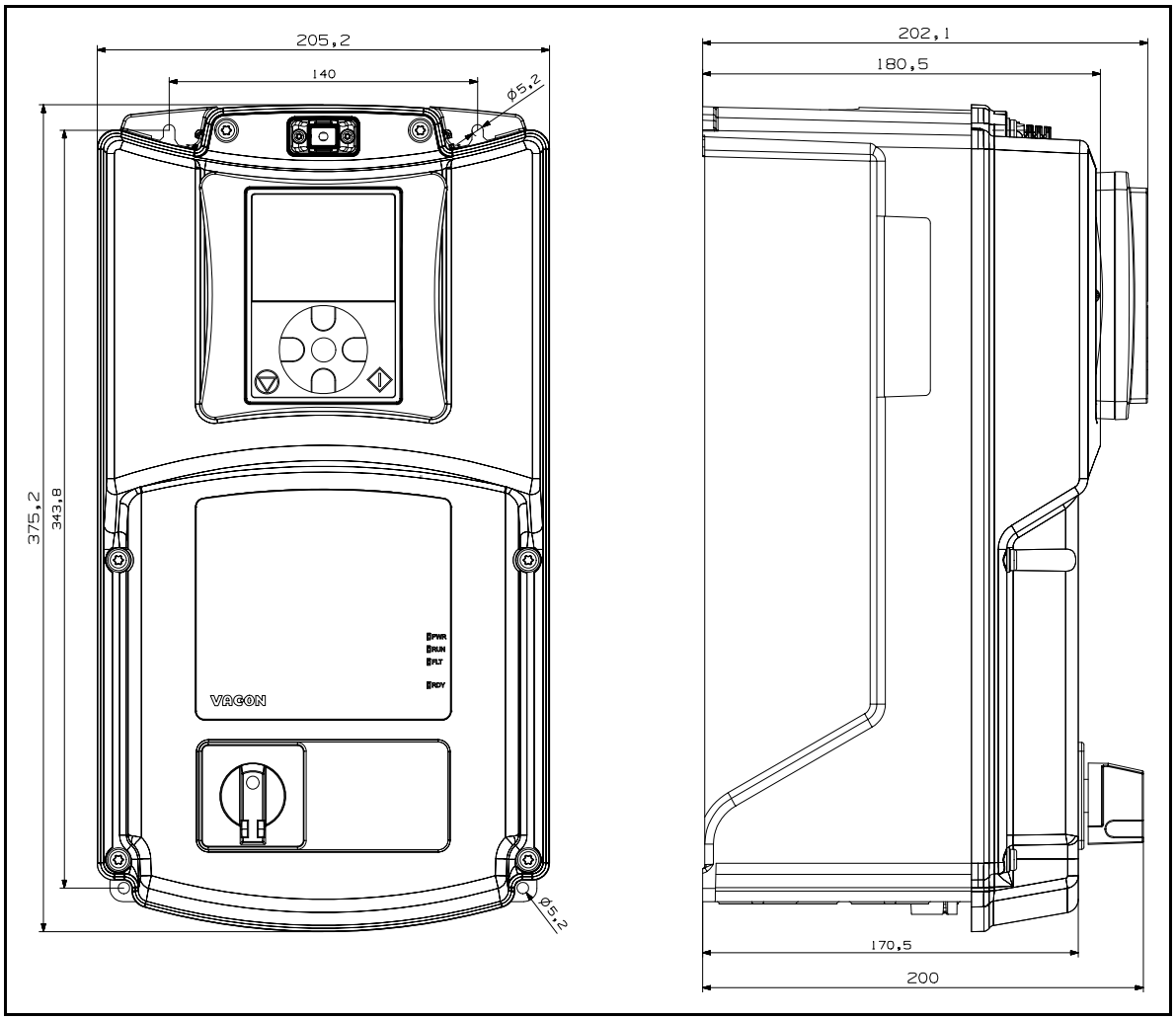


Figure 10. VACON® *20 X, MU3.*

3.2 WALL-MOUNTING

The drive can be mounted in vertical or horizontal position on the wall or any other relatively even mounting plane or machine frame and fixed with the screws recommended in Table 3.

Recommended screw or bolt size for MU2 and MU3 is M5.

Frame	Screw number	Screw size
MU2	4	M5
MU3	4	M5

Table 3. Screws for wall mounting.

3.3 COOLING

The AC drive produces heat in operation and is cooled down by air circulated by a fan. Enough free space shall therefore 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 4 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 converter.

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

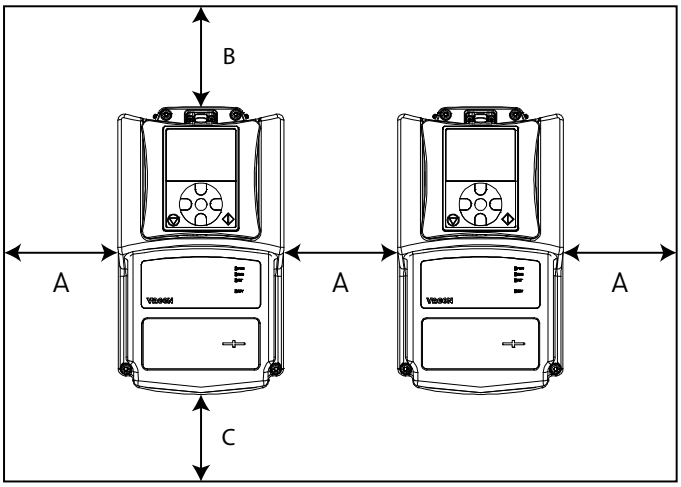


Figure 11. Installation space.

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

Table 4. Min. clearances around AC drive.

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

Type	Cooling air required [m^3/h]
MU2	50
MU3	110

Table 5. Required cooling air.

Note that if several units are mounted **above** each other the required free space equals B+C (see the Figure 12.). 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 12..

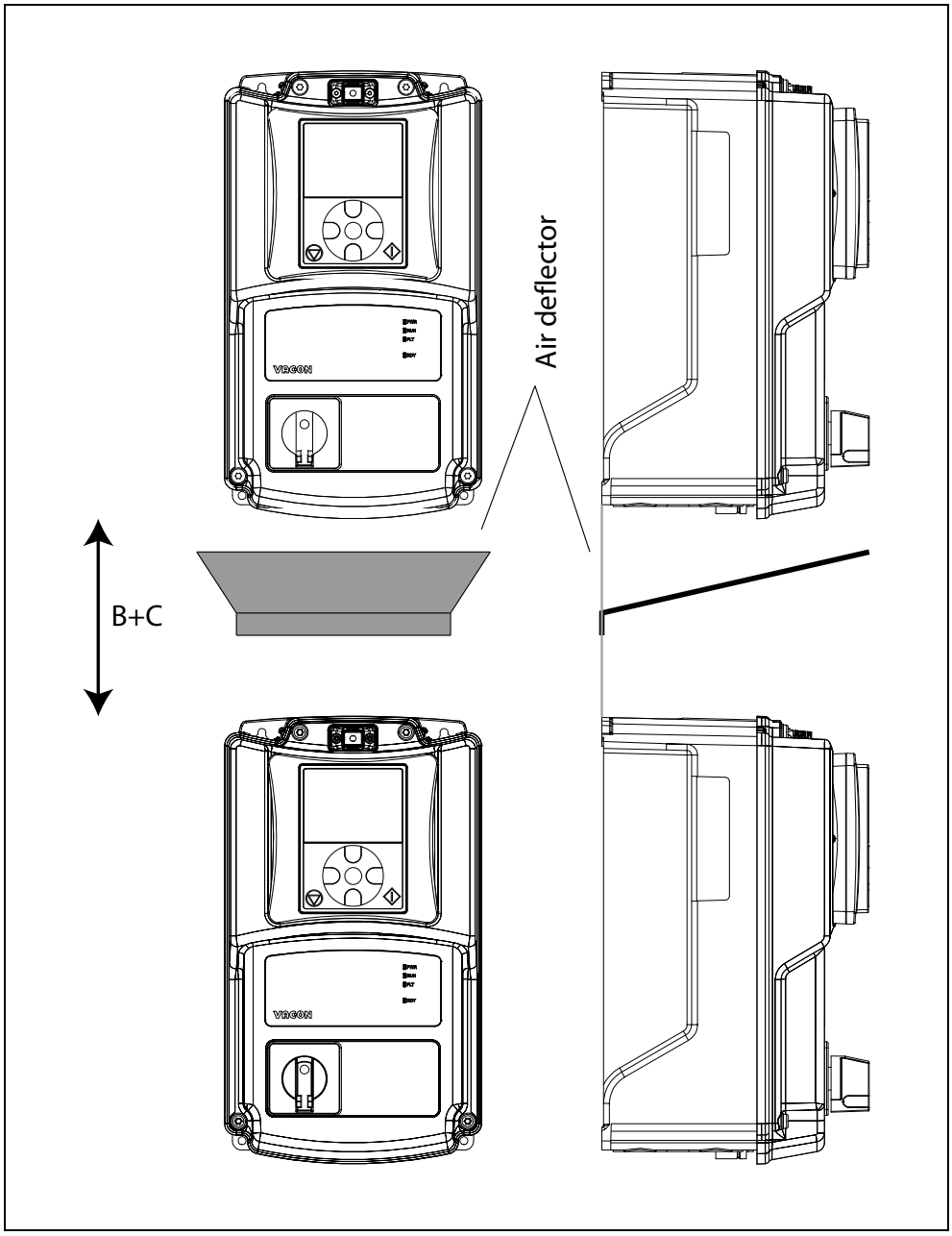


Figure 12. Installation space when drives are mounted on top of each other.

4. POWER CABLING

The mains cables are connected to terminals L1, L2 and L3 and the motor cables to terminals marked with U, V and W. See principal connection diagram in Figure 13. See also Table for the cable recommendations for different EMC levels.

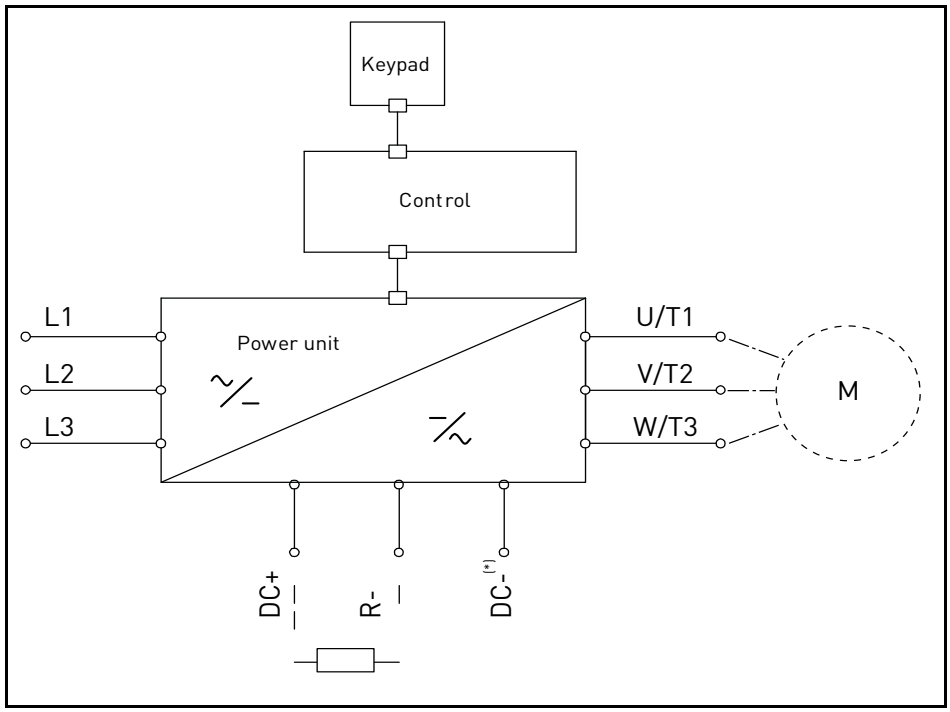


Figure 13. Principal connection diagram(only MU3).*

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.

	EMC levels		
Cable type	1st environment	2nd environment	
	Category C2	Category C3	Category C4
Mains cable	1	1	1
Motor cable	3*	2	2
Control cable	4	4	4

Table 6: Cable types required to meet standards.

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 14.
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 14.
*360º earthing 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-O or similar).

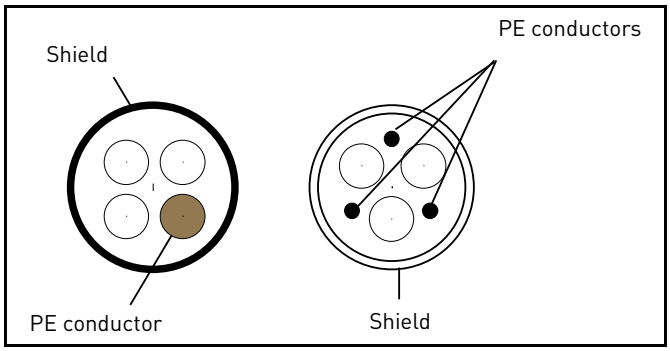


Figure 14.

NOTE: The EMC requirements are fulfilled at factory defaults of switching frequencies (all frames).
NOTE: If safety switch is connected the EMC protection shall be continuous over the whole cable installation.

4.1 CIRCUIT BREAKER

Please, disconnect the drive via an external circuit breaker. You have to provide a switching device between 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 chose it with a **capacity of 1.5 to 2 times of the inverter's rated current** (see Table 19 and Table 20).

4.2 UL STANDARDS ON CABLING

To meet the UL (Underwriters Laboratories) regulations, use a UL-approved copper cable. Use Class 1 wire only.

The units are suitable for use on a circuit capable of delivering no more than 100,000 rms symmetrical amperes, 600V AC maximum.

4.2.1 CABLE DIMENSIONING AND SELECTION

Table 7 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.

4.2.1.1 CABLE AND FUSE SIZES, FRAMES MU3 TO MU3

The recommended fuse types are gG/gL (IEC 60269-1) or 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 what is 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 offers recommendations also for high speed J (UL & CSA), aR (UL recognized, IEC 60269-4) and gS (IEC 60269-4) fuse ranges.

Frame	Type	I_{INPUT} [A]	Fuse (gG/gL) [A]	Mains and motor cable Cu [mm²]	Terminal cable size	
					Main terminal [mm²]	Earth terminal [mm²]
MU2	0004 2—0007 2	4.3—8.4	10	3*1.5+1.5	0.2 — 2.5	ring terminal
MU3	0011 2	13.4	20	3*2.5+2.5	0.5 — 16.0	ring terminal
	0012 2	14.2	20	3*2.5+2.5	0.5 — 16.0	ring terminal
	0017 2	20.6	25	3*2.5+2.5	0.5 — 16.0	ring terminal

Table 7. Cable and fuse sizes for VACON® *20 X, 208-240V (MU2 and MU3).*

Frame	Type	I_{INPUT} [A]	Fuse (gG/gL) [A]	Mains and motor cable Cu [mm²]	Terminal cable size	
					Main terminal [mm²]	Earth terminal [mm²]
MU2	0003 4—0004 4	3.2—4.0	6	3*1.5+1.5	0.2 — 2.5	ring terminal
	0005 4—0006 4	5.6—7.3	10	3*1.5+1.5	0.2 — 2.5	ring terminal
	0008 4	9.6	20	3*2.5+2.5	0.2 — 2.5	ring terminal
MU3	0009 4	11.5	20	3*2.5+2.5	0.5 — 16.0	ring terminal
	0012 4	14.9	20	3*2.5+2.5	0.5 — 16.0	ring terminal
	0016 4	20	25	3*6+6	0.5 — 16.0	ring terminal

Table 8. Cable and fuse sizes for VACON® *20 X, 380-480V (MU2 and MU3)*

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 earthing conductor, see chapter Earthing and earth fault protection of the standard.

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

4.3 BRAKE RESISTOR CABLES

VACON® 20 X AC drives are equipped with terminals for an optional external brake resistor.

For MU2, break resitor 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 mm2) with ferrules should be used.

See Table 21 and Table 22 for the resistor ratings.

4.4 CONTROL CABLES

For information on control cables see chapter Control unit cabling.

4.5 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 **30m**
- 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 below recommended.

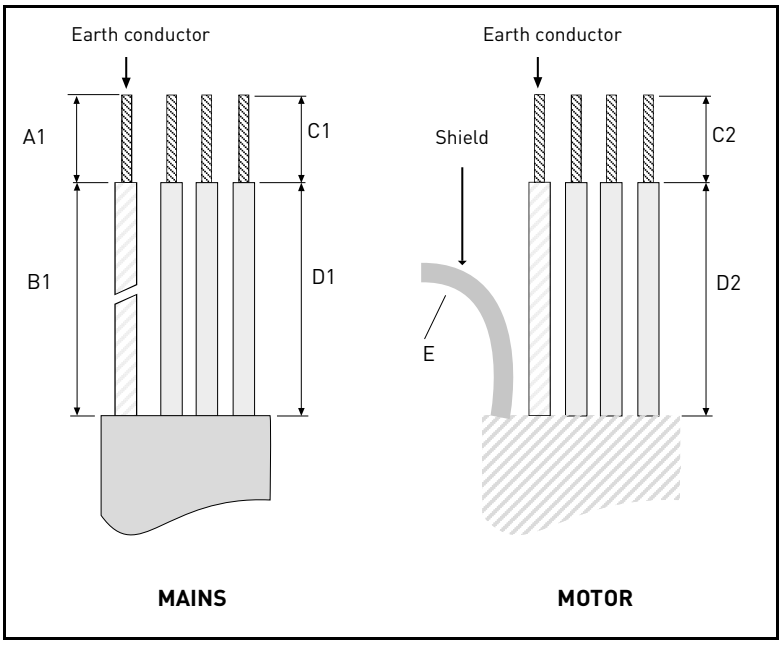


Figure 15. Stripping of cables.

Frame	A1	B1	C1	D1	C2	D2	E
MU2	8	8	8	20	36	20	Leave as short as possible
MU3	8	8	8	20	36	20	

Table 9. Cables stripping lengths [mm].

2	• Remove the plastic cover of the drive as shown in Figure 16. The cable entries consists of several openings available for the cables with ISO metric thread. • Open only the inlet holes where you need to run the cables.
3	• Choose the correct cable glands according to drive and cable size as shown in the following pictures.

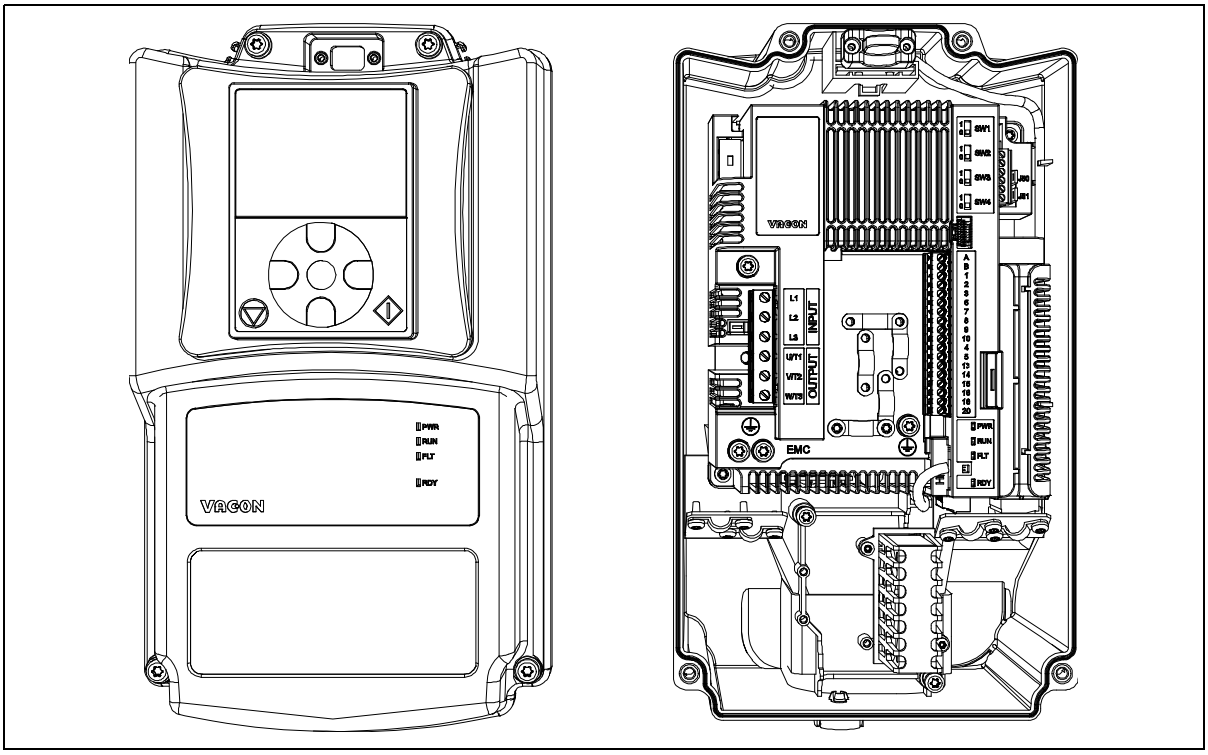


Figure 16. MU2 example: open cover.

4	• Cable glands must be constructed from plastic materials. They are used for sealing cables passing through gland plates to ensure the characteristics of the enclosure which the cable enters can be maintained adequately.

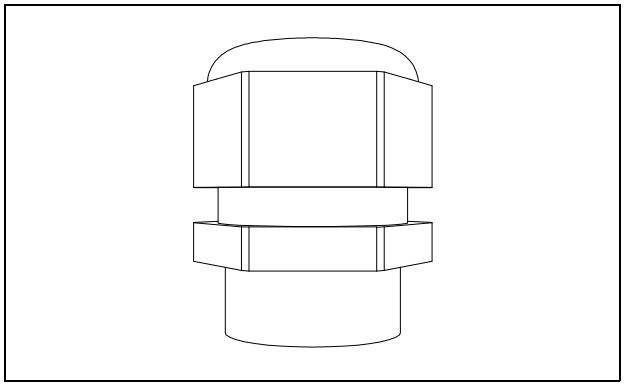


Figure 17. Cable gland.

ONLY PLASTIC GLANDS ARE ALLOWED! METAL GLANDS ARE FORBIDDEN!

5	• Screw the cable glands on the cable entry holes.
6	• Pass the cables (supply cable, motor cable, brake cable and I/O cables) through the cable glands.
7	• Detach the cable clamps and the grounding clamps.
8	Connect the stripped cables: • 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). • Connect the phase conductors of the supply and motor cables into their respective terminals. • Form the rest of the cable shield of all two cables into "pigtails" and make a grounding connection with the clamp. Make the pigtails just long enough to reach and be fixed to the terminal - no longer.

Tightening torques of cable terminals:

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

Table 10. Tightening torques of terminals.

9	• Check the connection of the earth cable to the motor and the AC drive terminals marked with ⏚.

5. CONTROL UNIT

5.1 OPENING THE DRIVES

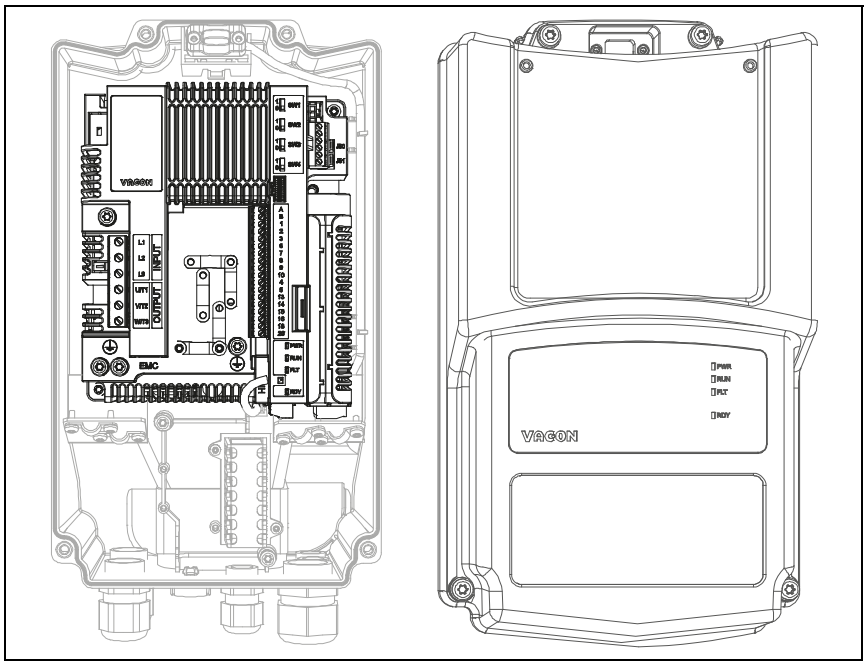


Figure 18. Open front cover of the drive: control unit MU2.

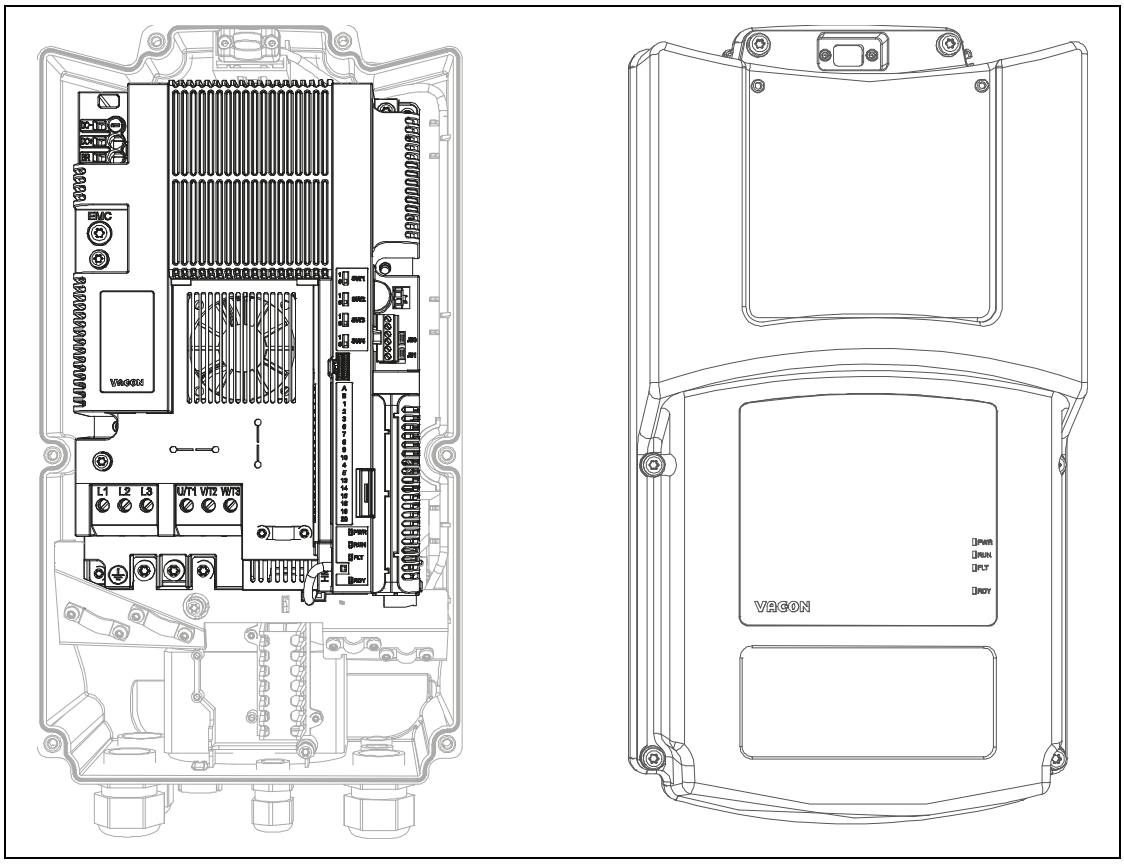


Figure 19. Open front cover of the drive: control unit MU3.

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 20 and Figure 21.

Number	Meaning
1	Control terminals A-20
2	STO terminals
3	Relay terminals
4	Option board terminals
5	STO Jumpers
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)

Table 11. Locations of components in control unit

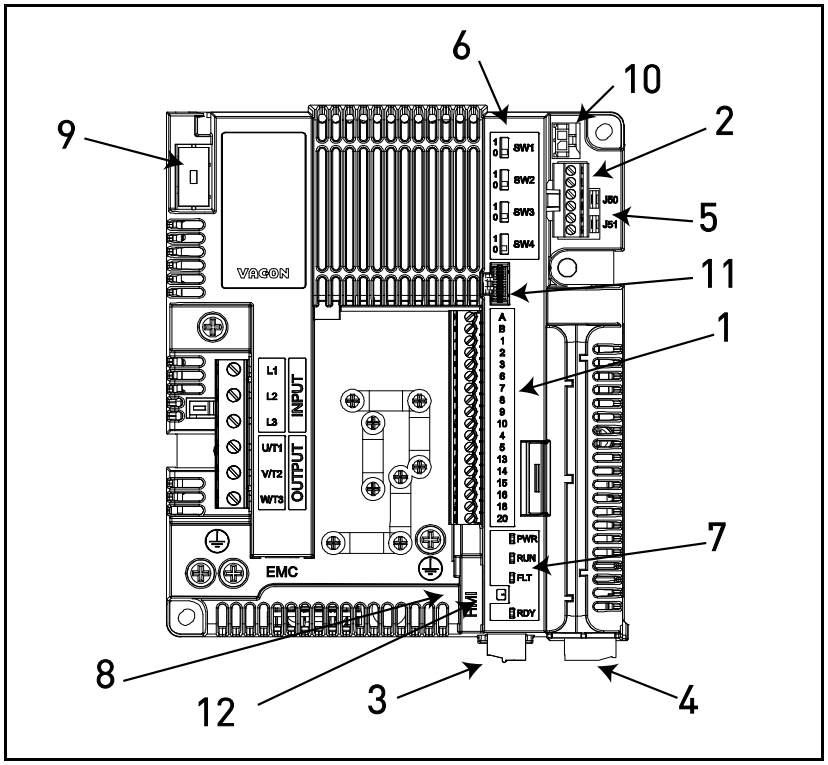


Figure 20. Locations of the components in control unit of MU2.

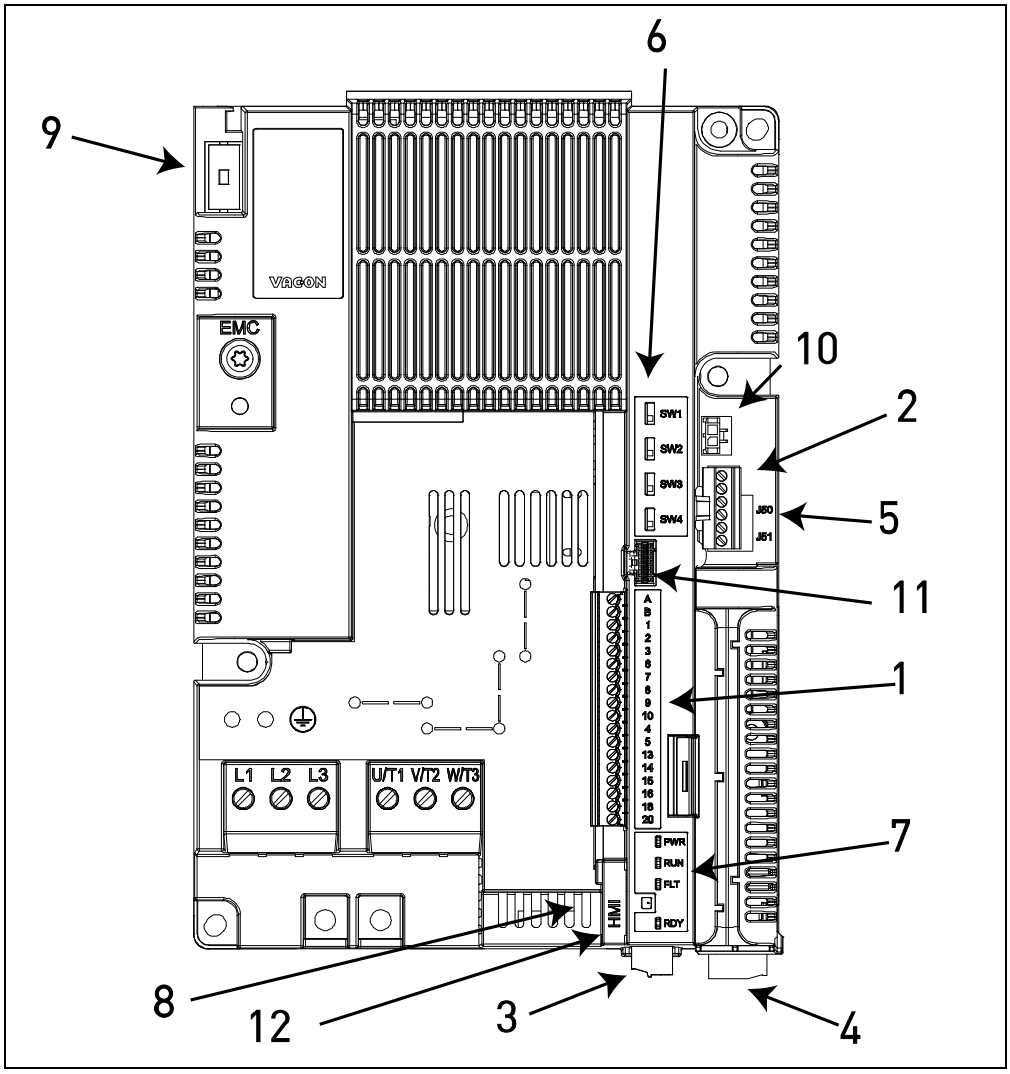


Figure 21. Location of the components in the control unit of MU3.

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 ±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 22 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 given in Table 13 too.

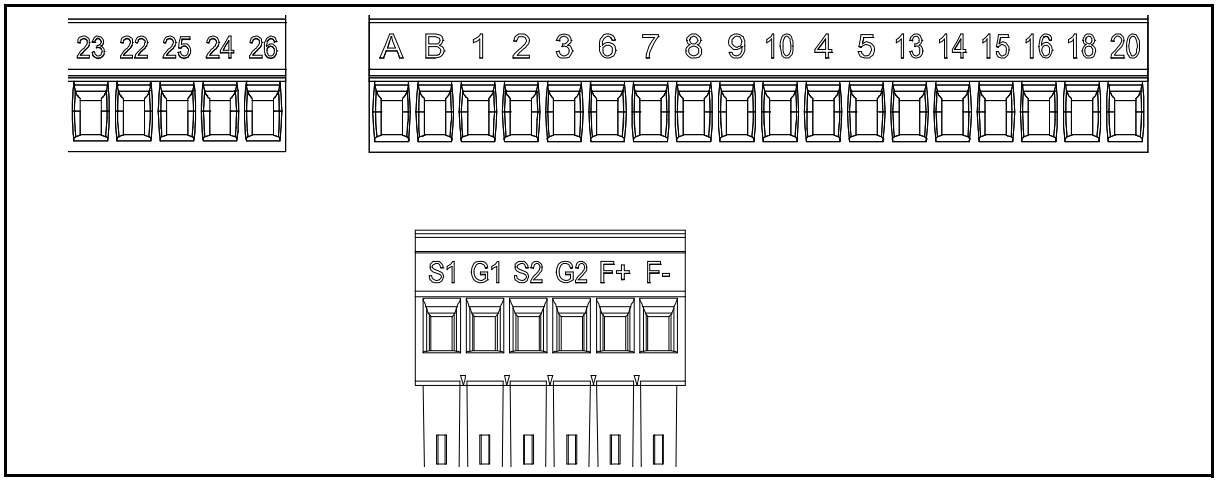


Figure 22. Control terminals.

5.3.1 CONTROL CABLE SIZING

The control cables shall be at least 0.14 mm² screened multi core cables, see Table . The maximum terminal wire size for the I/O terminals is 1.5 mm².

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

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

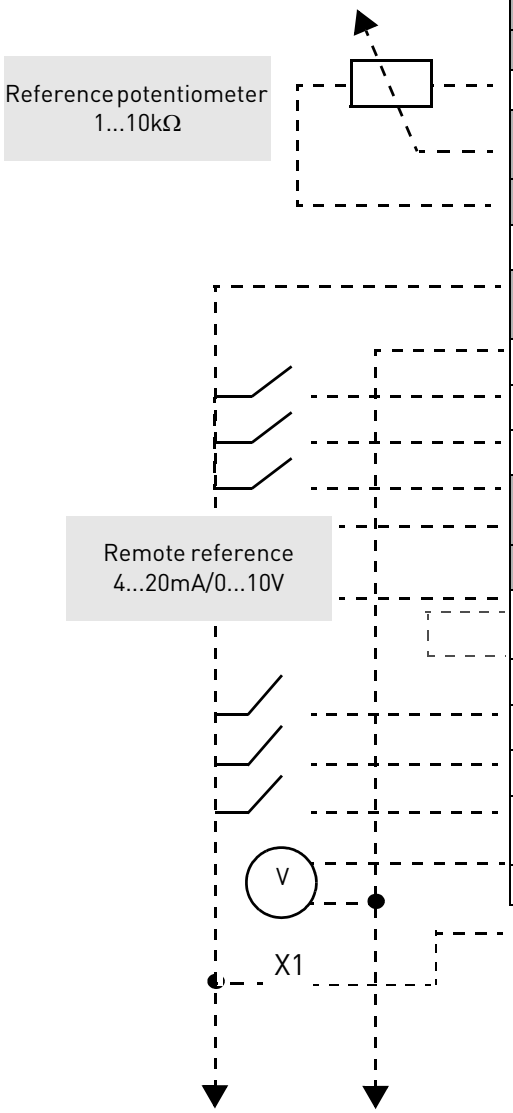
Table 12. Control cable tightening torques.

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.

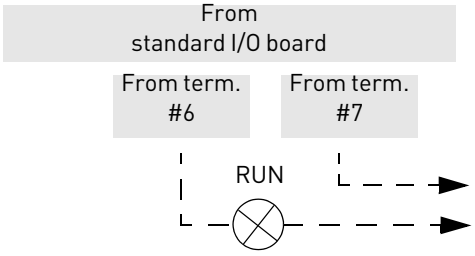
Table 13. Control I/O terminal signals and connection example.



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 com-mon
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 com-mon
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

5.3.3 RELAY TERMINALS

Table 14. I/O terminal signals for relays and connection example.



Relays terminals		
Terminal		**Signal**
22	RO1/2	Relay output 1
23	RO1/3	
24	RO2/1	Relay output 2
25	RO2/2	
26	RO2/3	

5.3.4 SAFE TORQUE OFF (ST0) TERMINALS

For more information on the functionalities of the Safe Torque Off (STO), see chapter chapter 9..

Table 15. I/O terminal signals for the STO functions.

Safe Torque Off terminals	
Terminal	**Signal**
S1	Isolated digital input 1 (inter-changeable polarity); +24V ±20% 10...15mA
G1	
S2	Isolated digital input 2 (inter-changeable 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.

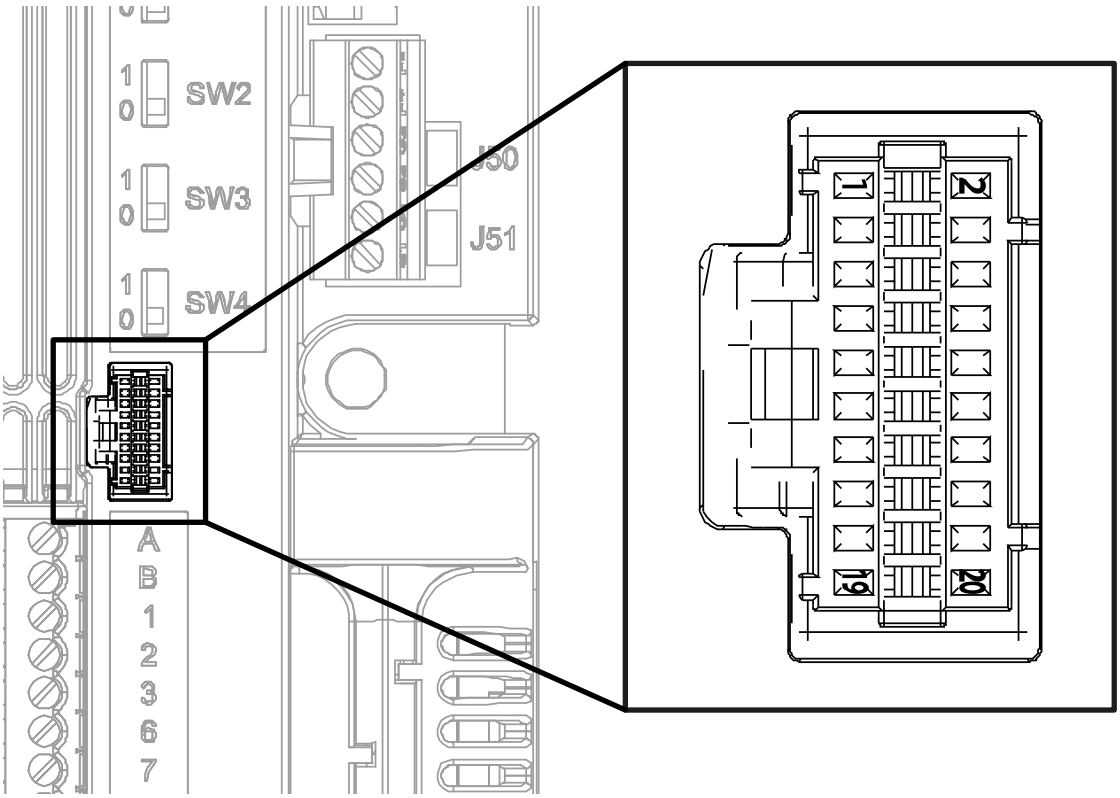


Figure 23. The I/O remote echo connector mounted on the control board.

In Figure 23 the view of Molex® 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 20 and Figure 21. The type of this connector is Pico-Clasp™ Wire-to Board PCB Header, Dual Row, RIght Angle. The code by Molex® is: 501571-2007.

It mates with Pico-Clasp™ Wire-to Board Receptacle Housing (crimp housing), Dual Row, 20 Circuits. The code by Molex® is: 501189-2010. See Figure 24.

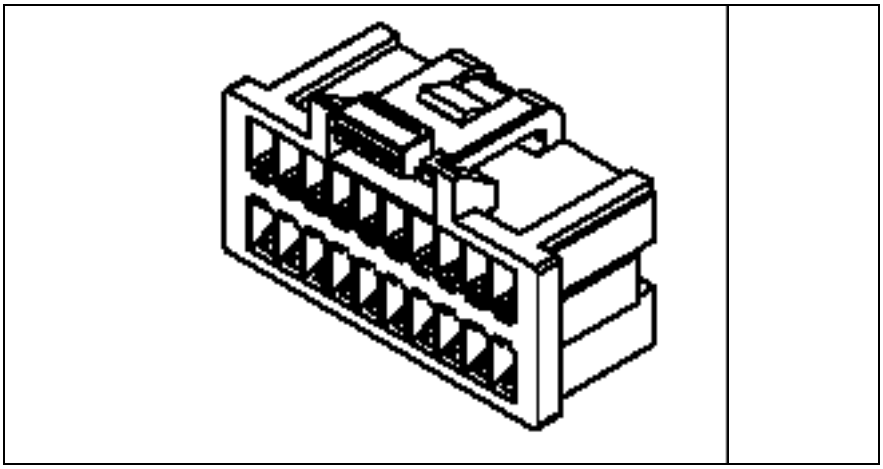


Figure 24.Receptacle housing for I/O remote echo connector.

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.

Pin number	Signal	Description
1	RS485_B	Serial bus, negative
2	DI2	Digital input 2
3	RS485_A	Serial bus, positive
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

Table 16. I/O remote connector description.

5.3.6 LED HANDLING

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

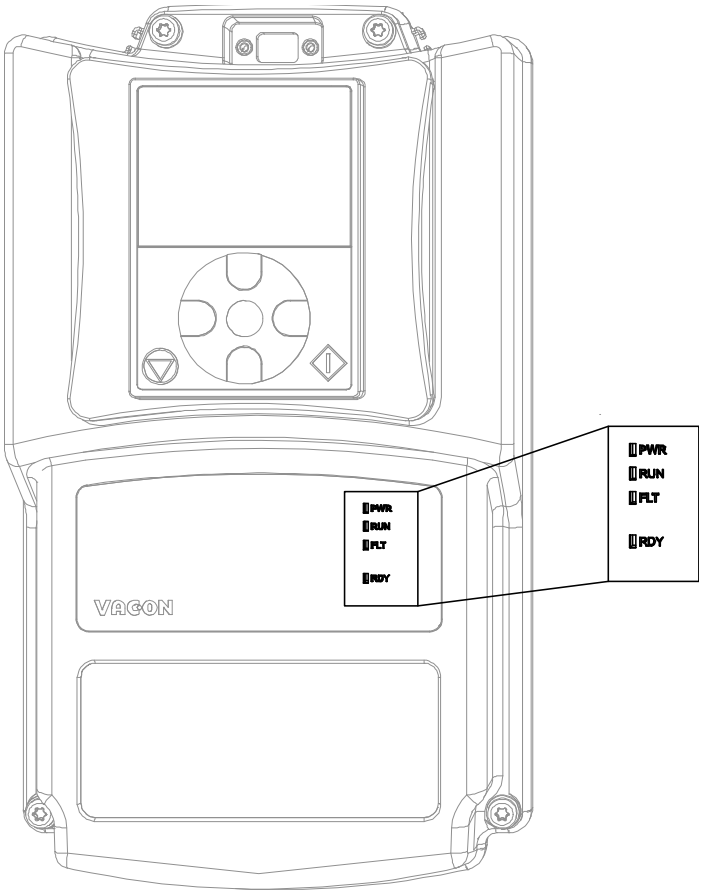


Figure 25. LED position on the MU2 cover.

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 in 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 13 can be functionally modified with the dip switches.

The switches have two positions: 0 and 1. See Figure 26 to locate the switches and make appropriate selections for your requirements.

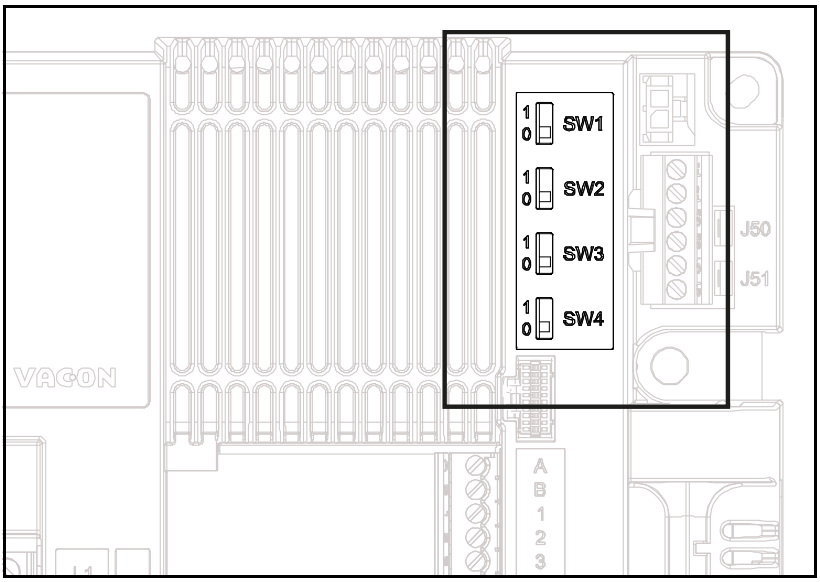


Figure 26. Dip switches on the control unit.

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 26. 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's 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 "1".

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 gives the possibility to easily upgrade the hardware structure of an industrial network, without the need for large changes in the software. A device can also communicate with several Modbus nodes at once, although they are connected with different interface types, with no need to use a different protocol for every connection.

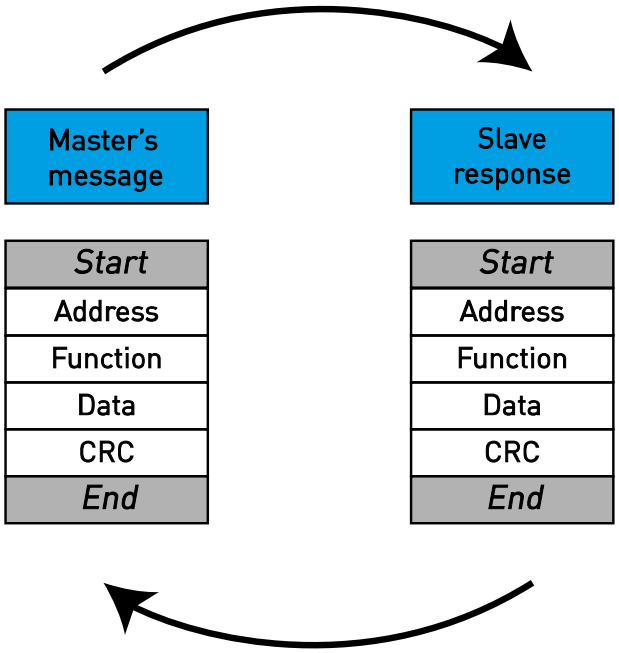


Figure 27.Basic structure of Modbus frame.

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 of the contents of the message— a slave takes action and responds to it. There can be more masters in a Modbus network. Addressing 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 doesn't match their own address.

5.4.1 MODBUS RTU PROTOCOL

Connections and communications	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^2
	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

Table 17.

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 28.

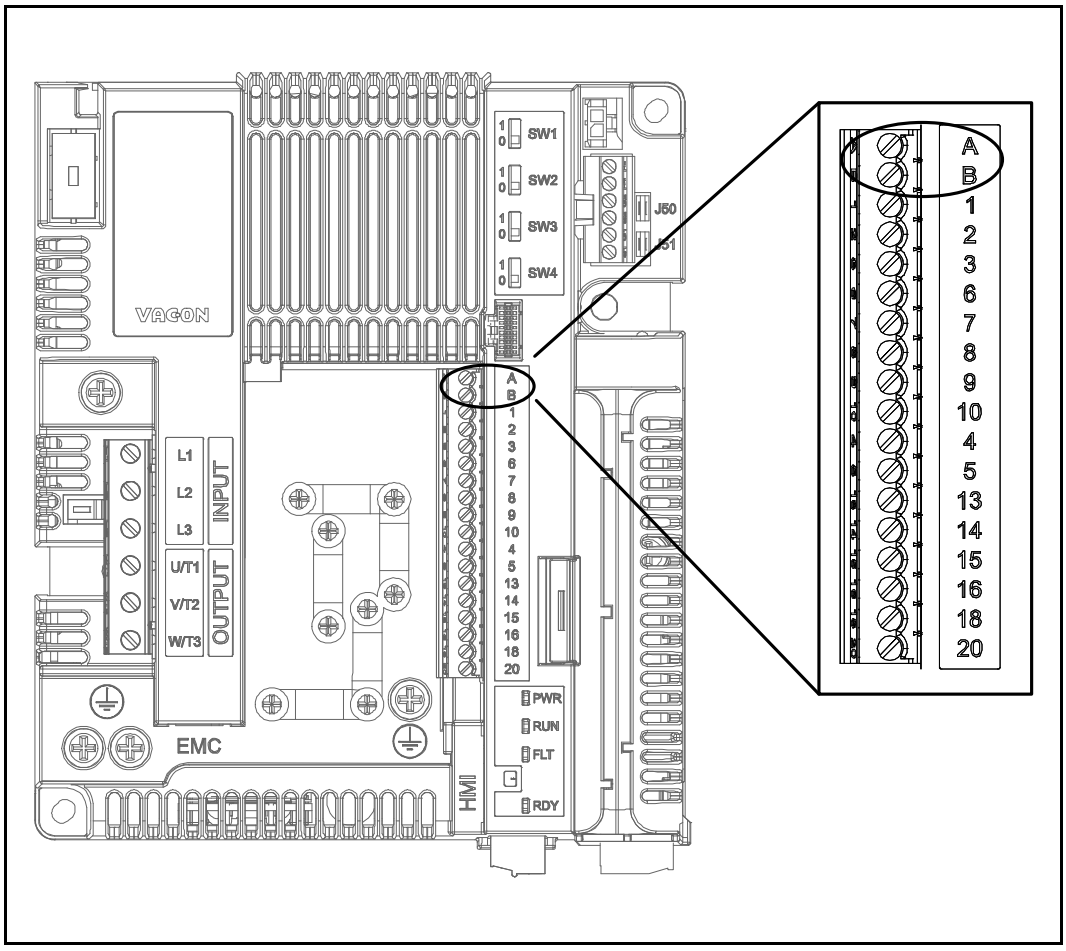
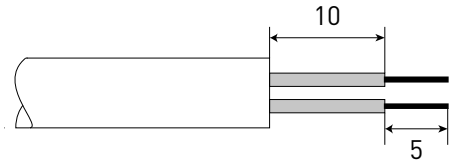
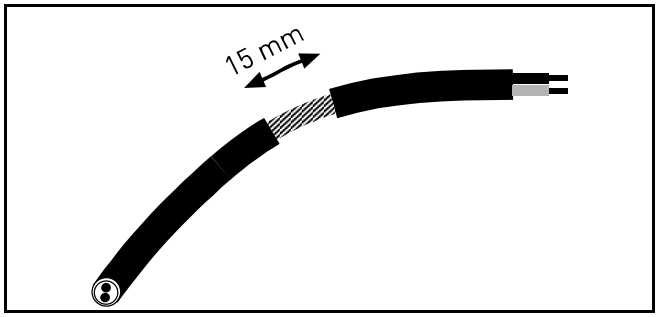
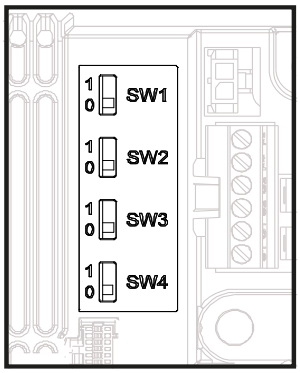


Figure 28. Position of the RS485 terminals on the I/O standard terminal connector(MU2 control unit example).

5.4.2 PREPARATION FOR USE THROUGH RS485

1	Strip about 15 mm of the RS485 cable (see specification on Table 17) and cut off the grey cable shield. Remember to do this for both bus cables (except for the last device). 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.  Also strip the cable now at such a distance from the terminal that you can fix it to the frame with the grounding clamp. Strip the cable at a maximum length of 15 mm. **Do not strip the aluminium cable shield!** 
2	Then connect the cable to its appropriate terminals on Vacon20 X AC drive standard terminal block, terminals **A and B** (A = negative, B = positive).
3	Using the cable clamp included in the supply of the drive, ground the shield of the RS485 cable to the frame of the AC drive.
4	**If VACON® 20 X drive is the last device on the bus**, the bus termination must be set. Locate the switches to the right of the control terminals (see Figure 26) and turn the SW4 switch to position "1". Biasing is built in the termination resistor. 
5	**NOTE:** When planning the cable runs, remember to keep the distance between the fieldbus cable and the motor cable at a **minimum of 30 cm**.
6	The bus termination must be set for the first and the last device of the fieldbus line. We recommend that the first device on the bus and, thus, terminated, was the Master device.

6. COMMISSIONING

Before commissioning, note the following directions and warnings:

Internal components and circuit boards of VACON® 20 X drive (except for the galvanically isolated I/O terminals) are live when it is connected to 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® 20 X drive is connected to 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® 20 X drive is disconnected from mains.

Do not make any connections to or from the frequency converter when it is connected to the mains.

After disconnecting the AC drive from the mains, **wait** until the indicators on the powerhead go out. Wait additional 30 seconds before doing any work on the connections of VACON® 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:

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

6.2 CHANGING EMC PROTECTION CLASS

The EMC protection class of Vacon 20 X can be changed from class C2 to class 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

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

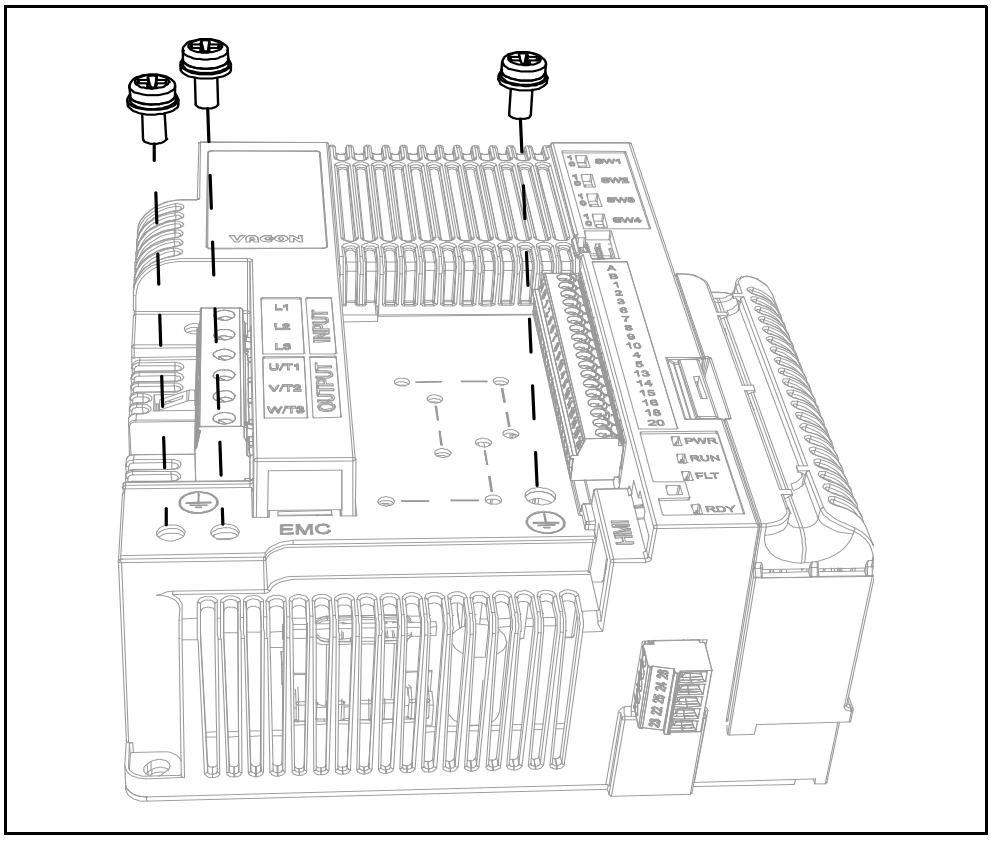


Figure 29.Changing of the EMC class in MU2 control unit.

2	Remove the EMC plate from the control unit. Then turn up the thin plate with pliers to disconnect the EMC plate from the ground. See Figure 30. Then reconnect the EMC plate to the unit.

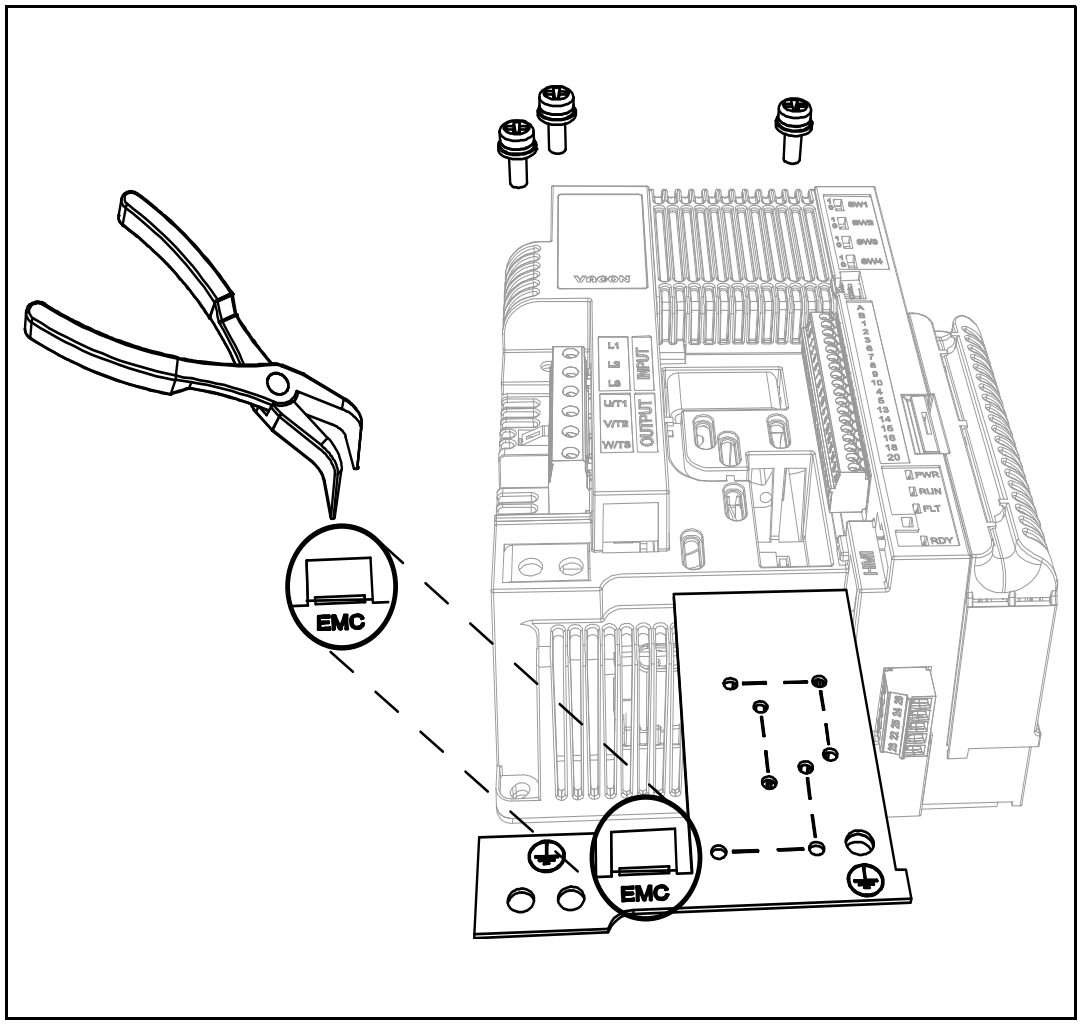


Figure 30. Changing of the EMC class in MU2 control unit.

6.2.2 CHANGING EMC PROTECTION CLASS - MU3

1	Remove the EMC screw as shown in the Figure 31.

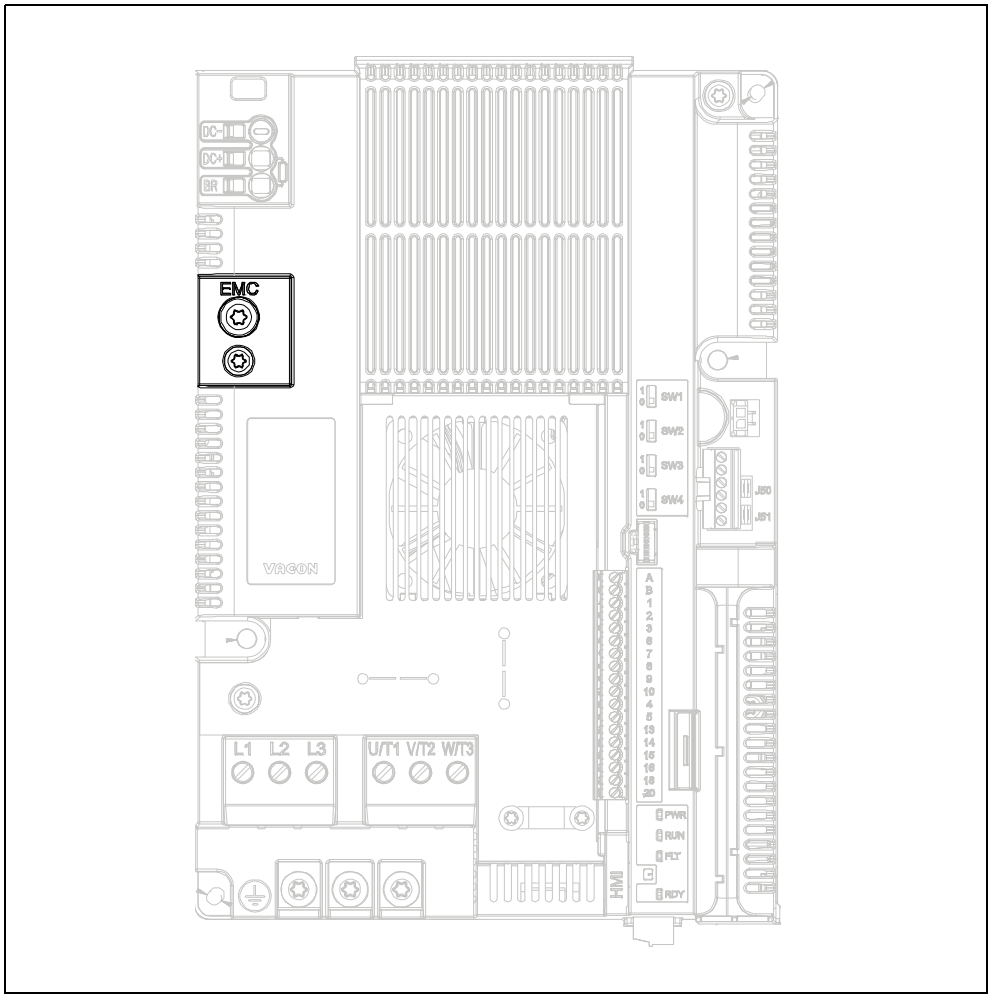


Figure 31. Changing the EMC class in the MU3 control unit.

	CAUTION! Before connecting the AC drive to mains make sure that the EMC protection class settings of the drive are appropriately made.
	NOTE! 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.

Product modified
Date:
Date:
EMC-level modified C1->C4 Date:DDMMYY

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 >1MΩ at ambient temperature of 20°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 >1MΩ at ambient temperature of 20°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 >1MΩ at ambient temperature of 20°C.

6.4 MAINTENANCE

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

Maintenance interval	Maintenance action
Regularly and according to general maintenance interval	• Check tightening torques of terminals
6...24 months (depending on environment)	• Check input and output terminals and control I/O terminals. • Check for corrosion on terminals and other surfaces • Check the heatsink for dust and clean if necessary
6...10 years	• Change main fan

Table 18.

7. TECHNICAL DATA

7.1 AC DRIVE POWER RATINGS

7.1.1 MAINS VOLTAGE 3AC 208-240 V

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

Table 19. Power ratings of VACON® *20 X, supply voltage 208-240V.*

NOTE: The rated currents in given ambient temperatures (in Table 19) are achieved only when the switching frequency is equal to or less than the factory default.

7.1.2 MAINS VOLTAGE 3AC 380-480V

	Mains Voltage 3AC 380-480V, 50/60 Hz						
	Converter type	Input current [A]	Loadability			Motor shaft power	
						400V	480V
			Rated continuous current I_N [A]	50% overload current [A]	Max current I_S	[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**

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

NOTE: The rated currents in given ambient temperatures (in Table 20) are achieved only when the switching frequency is equal to or less than the factory default.

7.1.3 DEFINITIONS OF OVERLOADABILITY

Overloadability =Following continuous operation at rated output current I_N, the converter 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.

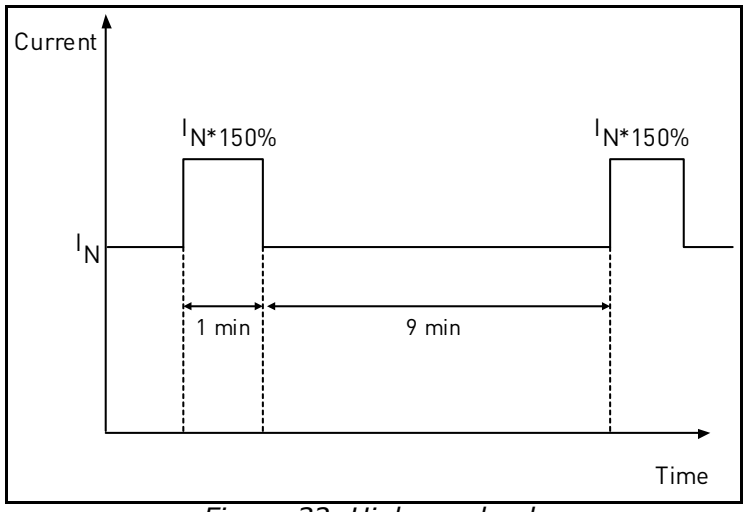


Figure 32. High overload.

7.2 BRAKE RESISTORS

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

Table 21. Brake resistor ratings, 208-240V.

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

Table 22. Brake resistor ratings, 380-480V.

7.3 VACON® 20 X - TECHNICAL DATA

Mains connection	Input voltage U_{in}	3AC 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	TN-networks (cannot be used with corner earthed networks)
	Short-circuit current	Maximum short-circuit current has to be <50kA
Motor connection	Output voltage	3AC 0...U_{in}
	Rated output current	I_N: Ambient temperature max. +40°C. See Table 19 and Table 20.
	Overload output current	1.5 x 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
	Cable maximum length	30 m
Control characteristics	Switching frequency	Programmable 2...16 kHz; Default 6 kHz. Automatic switching frequency derating in case of overheating
	Frequency reference: Analogue input Panel reference	 Resolution ±0.05% (11-bit), accuracy ±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 frames. External brake resistor optional.
Control connections	See Chapter 5.	

Communication interface	Fieldbus	Standard: Serial communication (RS485/ Modbus); Optional: CANopen; Profibus DP, DeviceNet
	Status indicators	Drive status indicators (LED) on top side (POWER, RUN, FAULT, READY)
Ambient conditions	Ambient operating temperature	-10°C...+40°C
	Extended temperature range	up to 50°C with current derating(see chapter 1.6)
	Storage temperature	-40°C...+70°C
	Relative humidity	0 to 100% $R_{H.}$ Good resistance to most acids, alkalis and oils. Contact factory for more details.
	Pollution degree	PD2
	Altitude	100% load capacity (no derating) up to 1,000m; derating 1% / 100m at 1.000...3.000m
	Degree of protection	IP66/Type 4X
	Stationary vibration: Sinusoidal IEC 60068-2	MU2: 3 Hz ≤ f ≤ 9Hz: 10mm 9 Hz ≤ f ≤ 200Hz: 3g
		MU3: 10 Hz ≤ f ≤ 57Hz: 0.075mm 57 Hz ≤ f ≤ 150Hz: 1g
	Shock/Bump: IEC 60068-2-29	MU2: 25g/6ms 3M7 (IEC 60721-3-3)
		MU3: --
Directives	EMC	2004/108/EC
	Low Voltage	2006/95/EC
Standards	Immunity	EN61800-3 (2004), 1st and 2nd environment
	Emissions	EN61800-3 (2004), Category C2 as standard. The drive can be modified for category C4.
	Safety	EN 61800-5-1
Approvals	Safety	TÜV - Mark
Declaration of Conformity	USA, Canada	VACON® Compliance testing
	EMC	TÜV - Tested
CE	EC Conformation Declaration	

Protections	Undervoltage trip limit	Depends on supply voltage (0,8775*supply voltage): Supply voltage 400 V: Trip limit **351 V** Supply voltage 480 V: Trip limit **421 V** Supply voltage 240 V: Trip limit **211 V**
	Earth fault protection	Yes
	Mains supervision	Yes
	Motor phase supervision	Yes
	Overcurrent protection	Yes
	Unit overtemperature protection	Yes
	Motor overload protection	Yes
	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)

Table 23. Vacon 20 X technical data.

7.3.1 TECHNICAL INFORMATION ON CONTROL CONNECTIONS

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, ±5%; Maximum current 10 mA
2	Analogue input, voltage or current	Analogue input channel 1 0- +10V (Ri = 200 kΩ) 0/4-20 mA (Ri =250 Ω) Resolution 0.05 %, accuracy ±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 frame earth through 2MΩ)
6	24V aux. voltage	+24V, ±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 Ri = min. 4kΩ 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 (Ri = 200 kΩ) 0/4-20 mA (Ri =250 Ω) Resolution 0.05 %, accuracy ±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 frame earth through 2MΩ)
13	Digital output com-mon	Common for digital output 1 (DO1-)
14	Digital input 4	Positive or negative logic Ri = min. 4kΩ 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 ±2,5 % Short-circuited protected.
20	Digital Output 1	Open Collector max 35V / 50mA (DO1+)

Table 24. Technical information on standard I/O terminals.

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

Table 25. Technical information on Relays.

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 frequency converter and the user.

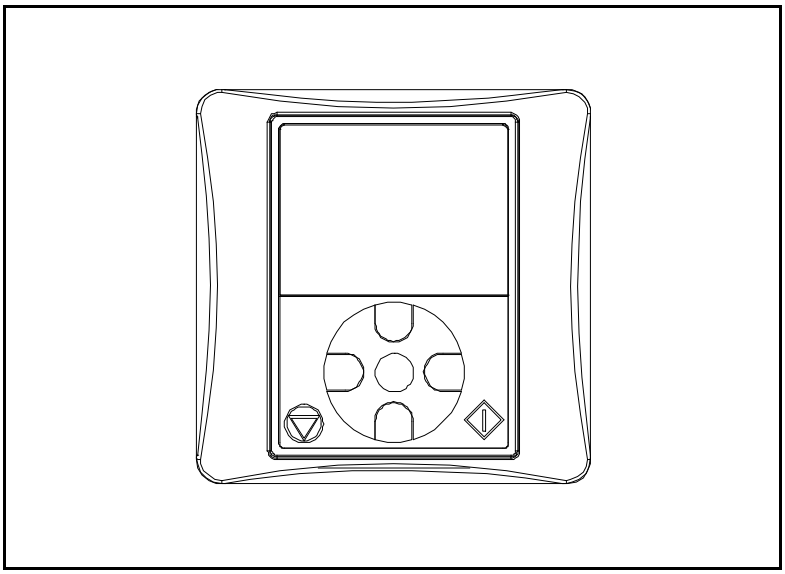


Figure 33. Text keypad.

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

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

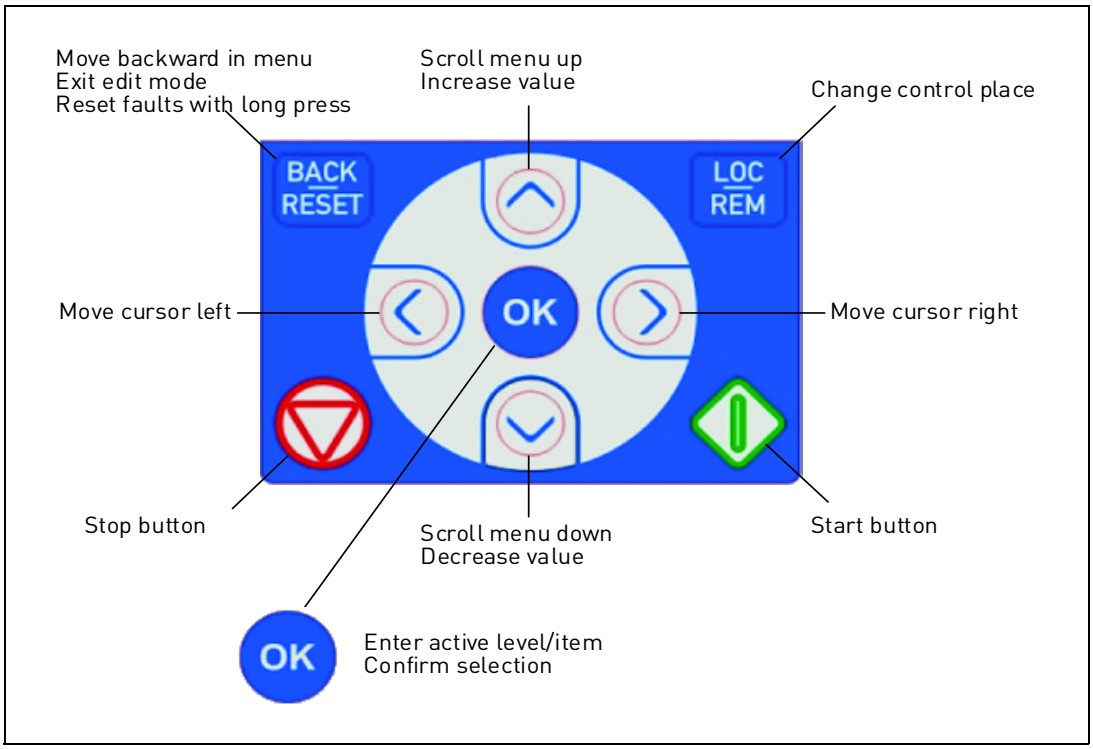


Figure 34.Keypad buttons.

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.

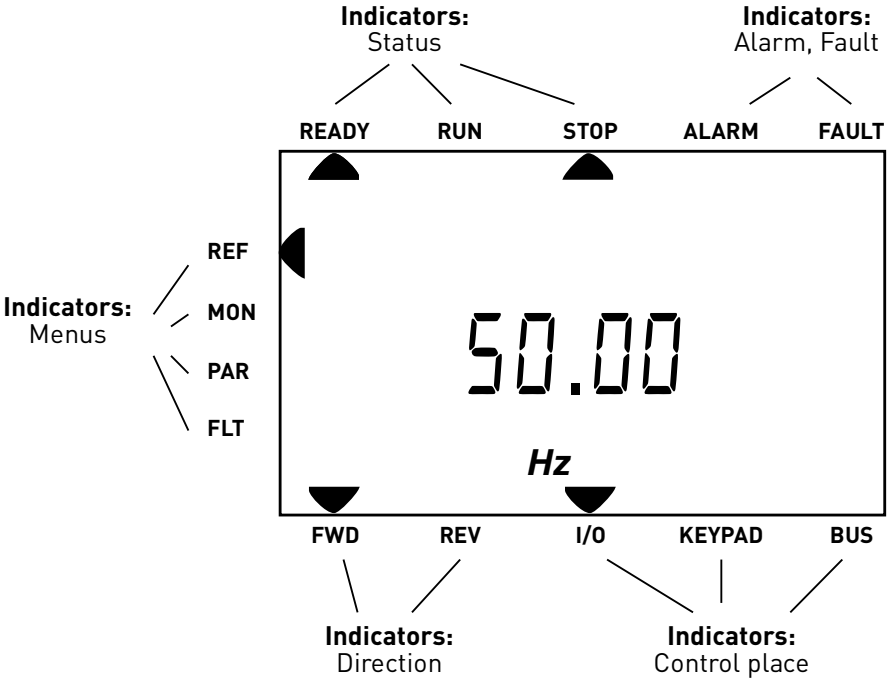


Figure 35. Keypad display.

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 35 the REF menu is active. The table below shows the structure of the main menu:

Reference (REF)	Reference from Keypad
Monitor (MON)	Monitoring values
Parameters (PAR)	Application parameters
Fault (FLT)	Active fault
	History fault

Table 26. Keypad menus.

8.4 USING THE KEYPAD

8.4.1 EDITING VALUES

Change 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.

8.4.2 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 PARAMETERS

Through this submenu, you can reach the application parameter groups and parameters. More information on parameters in the VACON® 20 X Application Manual.

8.4.5 FAULTS

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

Active faults

Menu	Function	Note
Active faults	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 *Active faults* 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 *Reset faults* (see below). The memory of active faults can store the maximum of 10 faults in the order of appearance.

Fault history

Menu	Function	Note
Fault history	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).

8.5 FAULT TRACING

Fault code	Fault name	Possible cause	Remedy
1	Overcurrent	AC drive has detected too high a current (>4*I_H) in the motor cable: • sudden heavy load increase • short circuit in motor cables • unsuitable motor	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. • too short a deceleration time • brake chopper is disabled • high overvoltage spikes in supply • Start/Stop sequence too fast	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. • insulation failure in cables or motor	Check motor cables and motor.
8	System fault	Component fault Malfunction	Reset the fault and restart. Should the fault re-occur, contact the distributor near to you.
9	Undervoltage	DC-link voltage is under the voltage limits defined. • most probable cause: too low a supply voltage • AC drive internal fault • defect input fuse • external charge switch not closed **NOTE!** This fault is activated only if the drive is in Run state.	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. Contact the distributor near to you.
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.	Check the correct amount and flow of cooling air. Check the heatsink for dust. Check the ambient temperature. Make sure that the switching frequency is not too high in relation to ambient temperature and motor load.
15	Motor stalled	Motor is stalled.	Check motor and load.
16	Motor overtemperature	Motor is overloaded.	Decrease motor load. If no motor overload exists, check the temperature model parameters.
17	Motor Underload	Motor is under loaded	Check load.
19	Power overload	Supervision for drive power	Drive power is to high: decrease load.

Table 27. Fault codes and descriptions.

Fault code	Fault name	Possible cause	Remedy
25	Watchdog	Error in the microprocessor monitoring Malfunction Component fault	Reset the fault and restart. If the fault occurs again, please contact your closest Vacon representative.
27	Back EMF	Protection of unit when starting with rotating motor	Reset the fault and restart. Should the fault re-occur, contact the distributor near to you.
30	STO fault	Safe torque off signal does not allow drive to be set as ready	Reset the fault and restart. Should the fault re-occur, contact the distributor near to you.
35	Application error	The application is not working	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 frequency converter 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		

Table 27. Fault codes and descriptions.

8.6 OPTION BOARDS

VACON® 20 X drive family embodies a wide selection of expander boards with which the available I/O of VACON® 20 X frequency converter 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 5 . Usually, when the AC drive is delivered from the factory, the control unit doesn't include any option board in the board slot.

The following option boards are supported:

Code	Description	Note
OPTB1	Option board with six bidirectional terminals.	With jumper blocks it's possible to use each terminal as digital input or as digital output.
OPTB2	I/O expander board with a thermistor input and two relay outputs.	
OPTB4	I/O expander board with one galvanically isolated analogue input and two galvanically isolated analogue outputs (standard signals 0(4)...20mA).	
OPTB5	I/O expander board with three relay outputs	
OPTB9	I/O expander board with five 42...240 VAC digital inputs and one relay output.	
OPTBF	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).
OPTBH	Temperature measurement board with three individual channels.	Supported sensors: PT100, PT1000, NI1000, KTY84-130, KTY84-150, KTY84-131
OPTC3	Profibus DP option board	Pluggable connector with screw terminals
OPTC5	Profibus DP option board	9-pin Sub-D terminal
OPTC6	CANopen option board	
OPTC7	DeviceNet option board	
OPTE3	Profibus DP option board	Pluggable connector with screw terminals
OPTE5	Profibus DP option board	9-pin Sub-D terminal
OPTE6	CANopen option board	
OPTE7	DeviceNet option board	

Table 28. Option boards supported in VACON® *20 X.*

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

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.

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 stopping action**.

9.2 WARNINGS

	Designing of safety-related systems require 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. **An overall risk evaluation is required for ensuring that the commissioned system is safe.** 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 **end-system** 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°/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 shall not be used as a control for starting or stopping the drive.

9.3 STANDARDS

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

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

Table 29. Safety Standards.

The STO function has to be abblied 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).

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

Table 30. Four different STO levels. (*) see 9.5.1.

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 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.

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

Table 31. SIL values. (*) see 9.5.1.

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 36). 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:

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)(*)

Table 32. Values of the STO output feedback (and torque on the motor). (*) Only one channel is preventing the drive from moving.

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

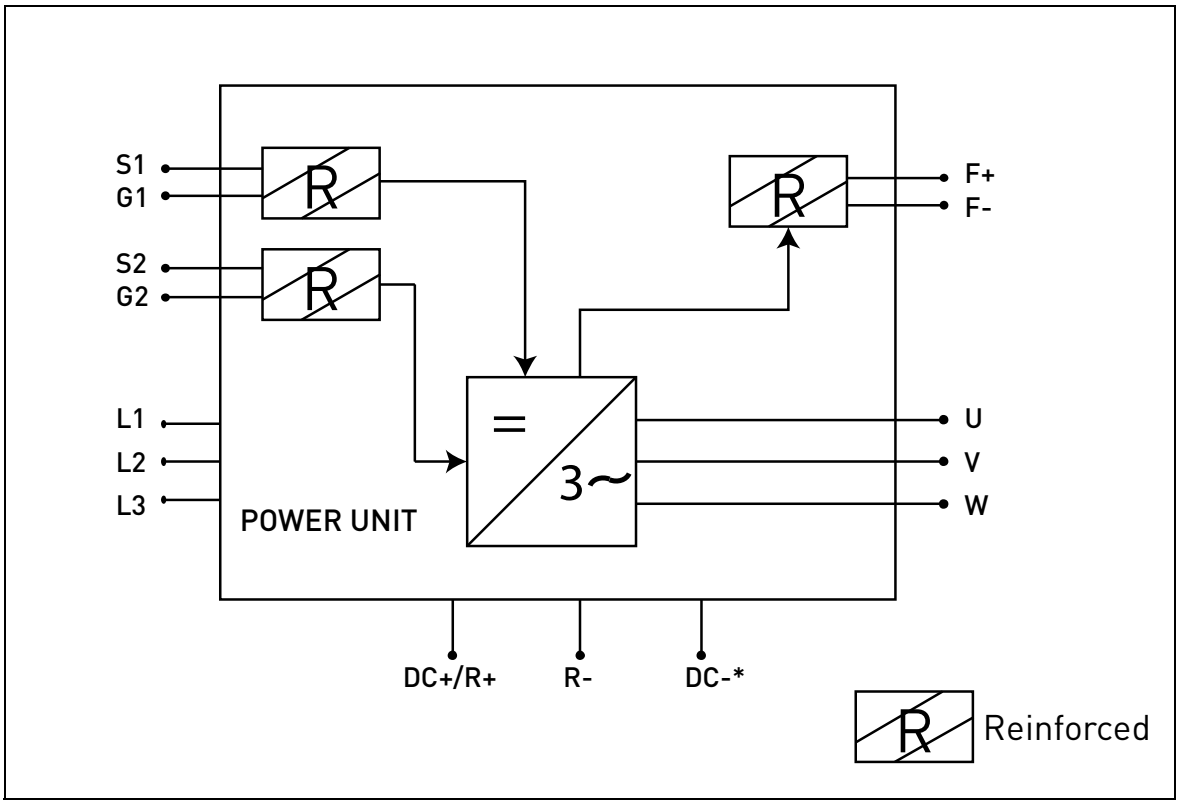


Figure 36. STO function principle. (*) Only for MU3.

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).

Technical information:	Technical values
Absolute maximum voltage range	24V ±20%
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

Table 33. Electrical data.

The reaction time of the STO function is the amount of time which passes from the moment in which the STO is demanded till the system is in the Safe State. For VACON® 20 X, the reaction time is 20 ms minimum.

9.5 CONNECTIONS

To make the STO function available and ready to be used, both the 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 37.

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

Table 34. STO connector and data signals.

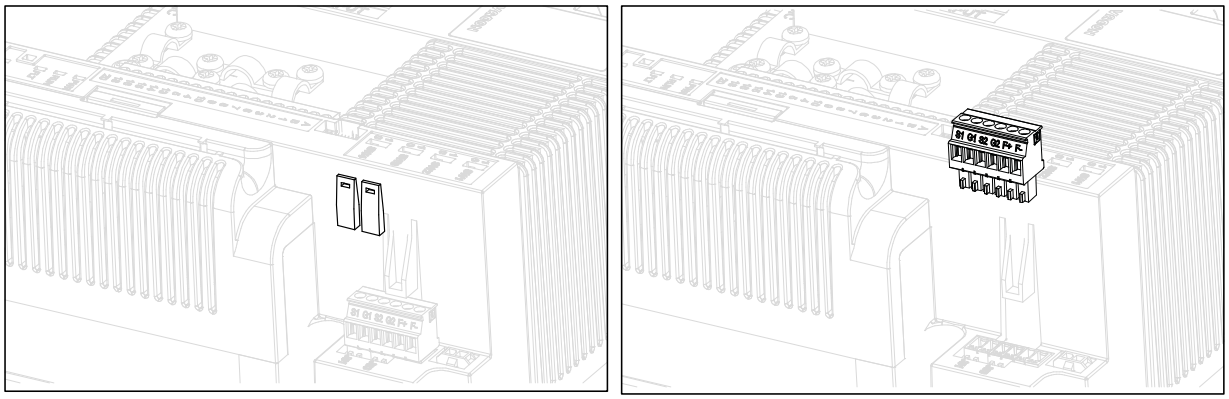


Figure 37. Removing the STO jumpers from the control unit.

⚠	Make sure that the frequency converter is switched off before cabling.
⚠	When the STO function is used, **the IP-class of the drive may not be reduced below IP54**. 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 the 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 dinamically 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.

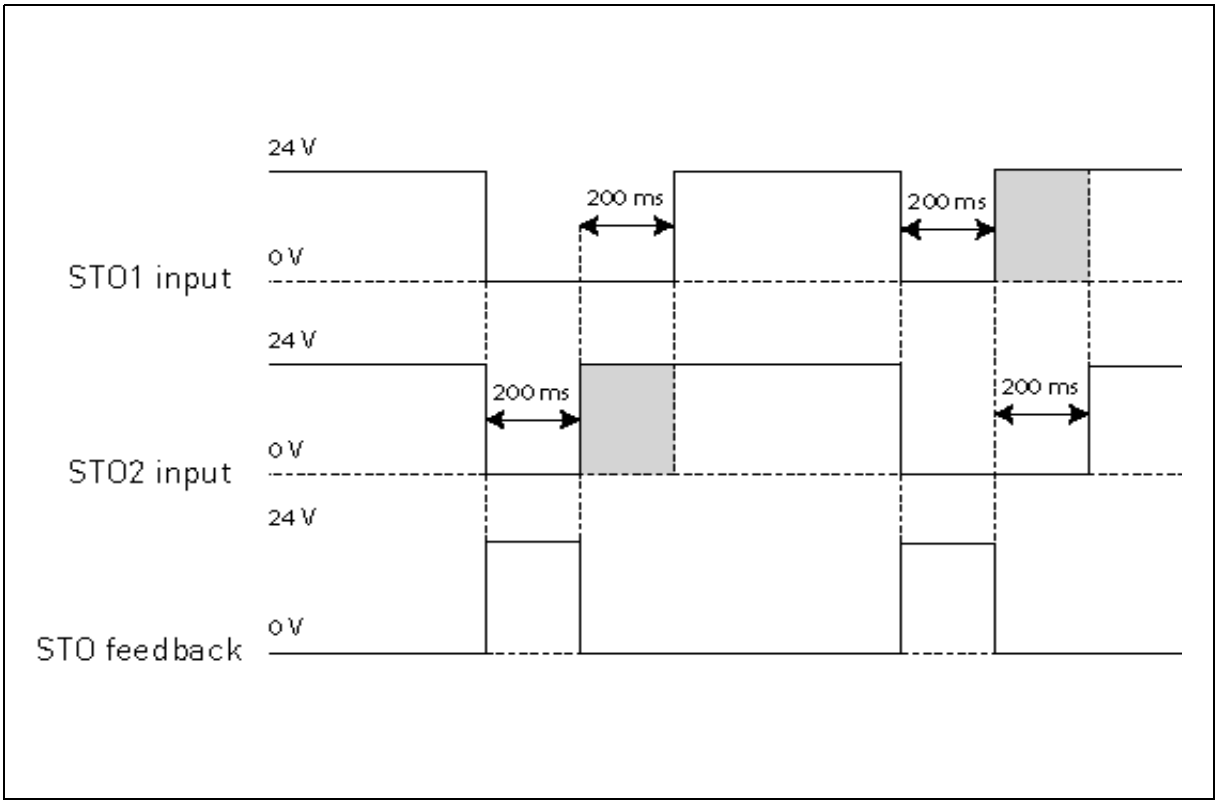


Figure 38.

⚠	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 **(once a day is recommended)**.
⚠	The external safety device, which forces the STO inputs and evaluates the STO output feedback, has to be a **safe device** and it has to fulfil the requirements of the specific application.
⚠	A simple switch cannot be used in this case!

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.

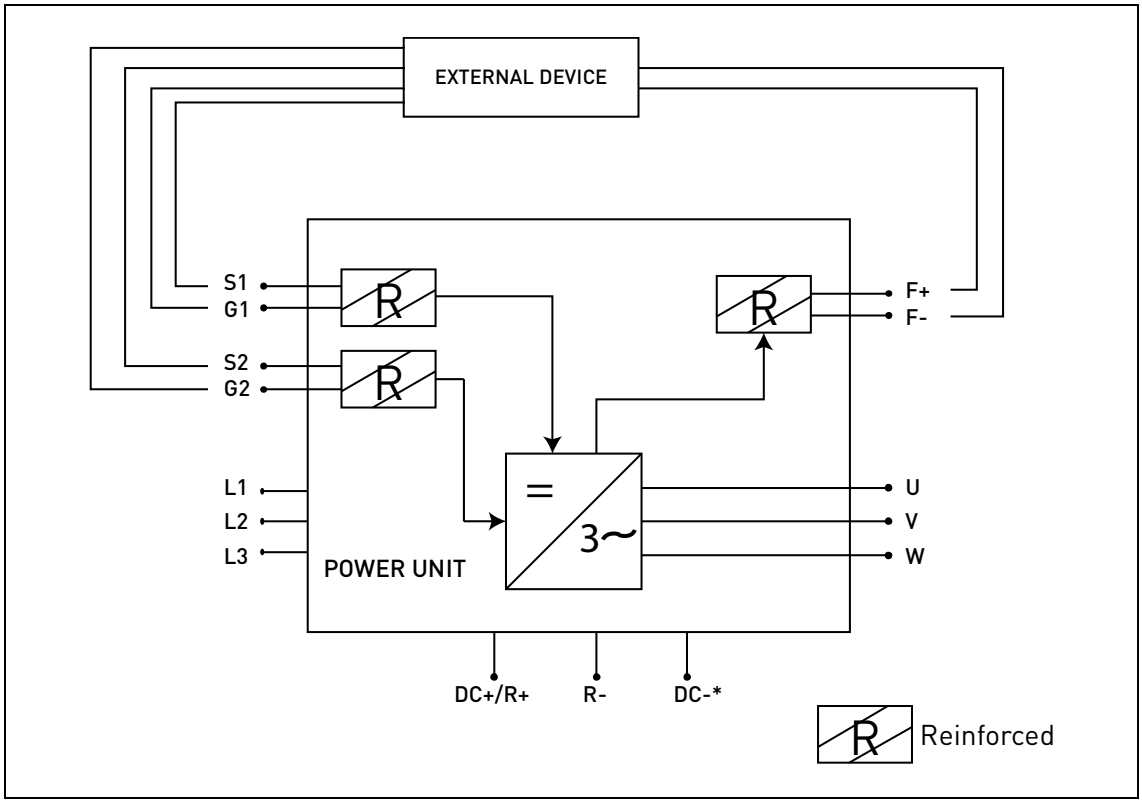


Figure 39. STO example with automatic monitoring of the feedback and both STO inputs used. (*) Only for MU3.

The external device has to monitor the STO function in accordance with theTable 32. 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 of 9.5.1 apply.

9.5.3 SAFETY CAPABILITY CAT. 2 / PL D / SIL 2

The safety capability is even more 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 of 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.

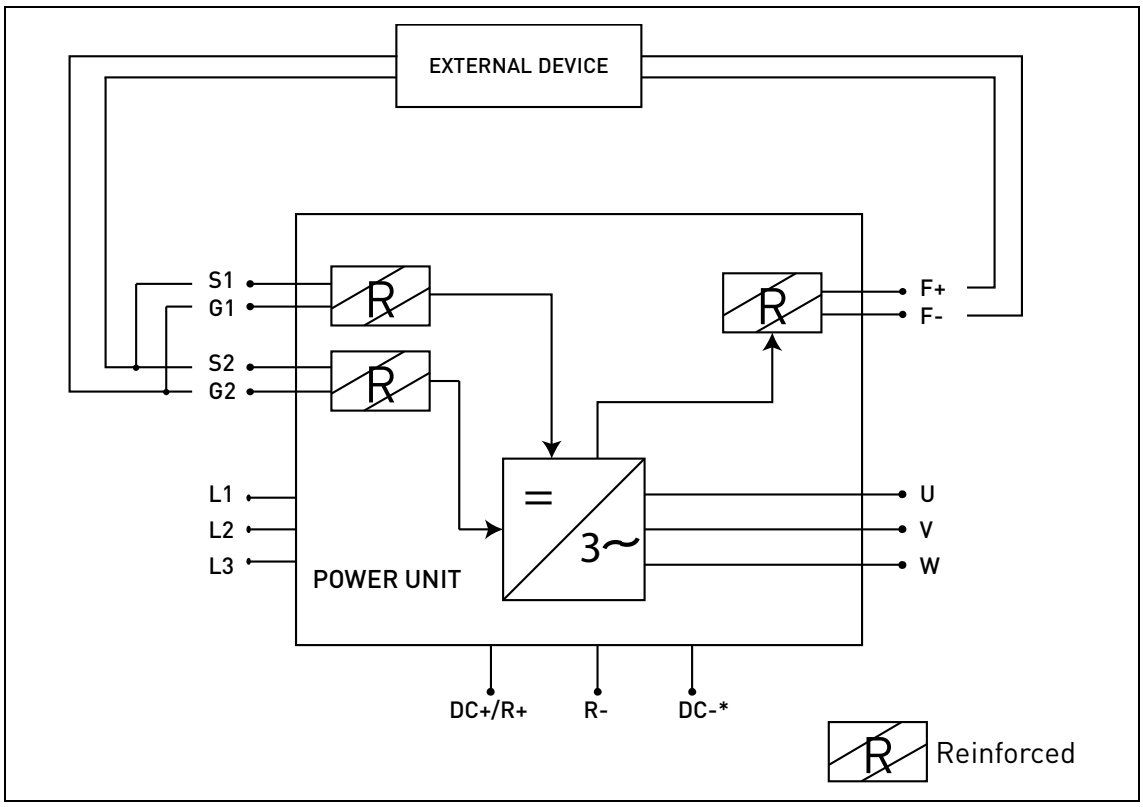


Figure 40. STO Example with automatic monitoring of the feedback and STO inputs connected in parallel. (*) Only for MU3.

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 permit to achieve the **other safety capabilities**.
⚠	The standards for functional safety require that functional proof tests are performed on the equipment at user-defined intervals. Therefore, **this safety capability** can be achieved, as long as the STO function is manually monitored at the frequency determined by the specific application **(once a month can be acceptable)**.
⚠	This **safety capability** 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.

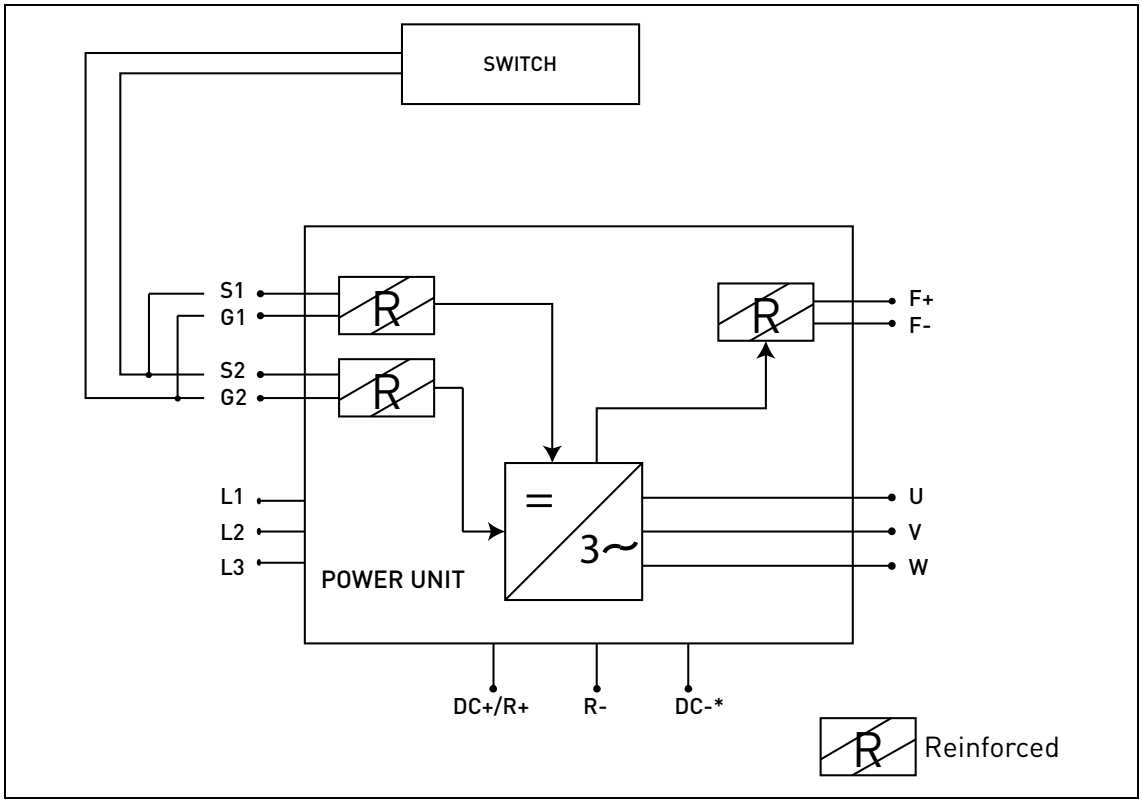


Figure 41. STO example without automatic monitoring of the feedback and STO inputs connected in parallel. (*)Only for MU3.

9.6 COMMISSIONING

9.6.1 GENERAL WIRING INSTRUCTIONS

	Protect the STO cabling with a shielding or an enclosure to exclude external fault.
	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 shall not exceed 5% [EN 60204-1 part 12.5].

The following table indicates examples of cables to be used.

STO feedback	Cable size
STO feedback automatically monitored by an external safety device	3 x (2 + 1) x 0,5 mm^2(*)
STO feedback ignored, simply safety device (switch) used	2 x (2 + 1) x 0,5 mm^2

Table 35. Cable types required to meet the standards. (*) Additional wires are needed for restarting the drive after each STO demand.

9.6.2 CHECKLIST FOR THE COMMISSIONING

Follow the checklist of the table below with the steps required to use the STO function.

☐	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
☐	Include in the assessment an examination of whether the use of external devices, such as a mechanical brake, is required.
☐	Check if the switch (if used) has been chosen according to the required safety performance target (SIL/PL/Category) set during the risk evaluation
☐	Check if the external device for automatic monitoring of the STO output feedback (if used) has been chosen in accordance with the specific application
☐	Check if the reset function with the STO function (if used) is edge sensitive.
☐	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. Ensured that the system is designed in such a way that this can be accepted.
☐	Check if the degree of protection of the **enclosure is at least IP54.** See paragraph 9.5.
☐	Check if the recommendations on EMC for cables have been followed.
☐	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
☐	Check if only approved units and parts have been used.
☐	Set up a routine to ensure that the functionality of the STO function is being checked at regular intervals.

Table 36. Checklist for the commissioning of STO.

9.7 PARAMETERS AND FAULT TRACING

There are no parameters for the STO function itself.

	Before testing the STO function, make sure that the checklist (Table 36) is inspected and completed.
	When STO function awakes, the drive always generates a fault ("F30") and the motor stops by coasting.
	In the application the STO state can be indicated using a digital output.

To re-enable the 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 further setting).

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 36.
	During maintenance breaks, or in case of service/repair, **ALWAYS** 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.

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

Table 37. Fault related to the STO function.

VACON®

DRIVEN BY DRIVES

Find your nearest Vacon office
on the Internet at:

www.vacon.com

Document ID:
DPD00992

Order code:
DOC-INS06663+DLUK

Rev. B

Manual authoring:
documentation@vacon.com

Vacon Plc.
Runsorintie 7
65380 Vaasa
Finland