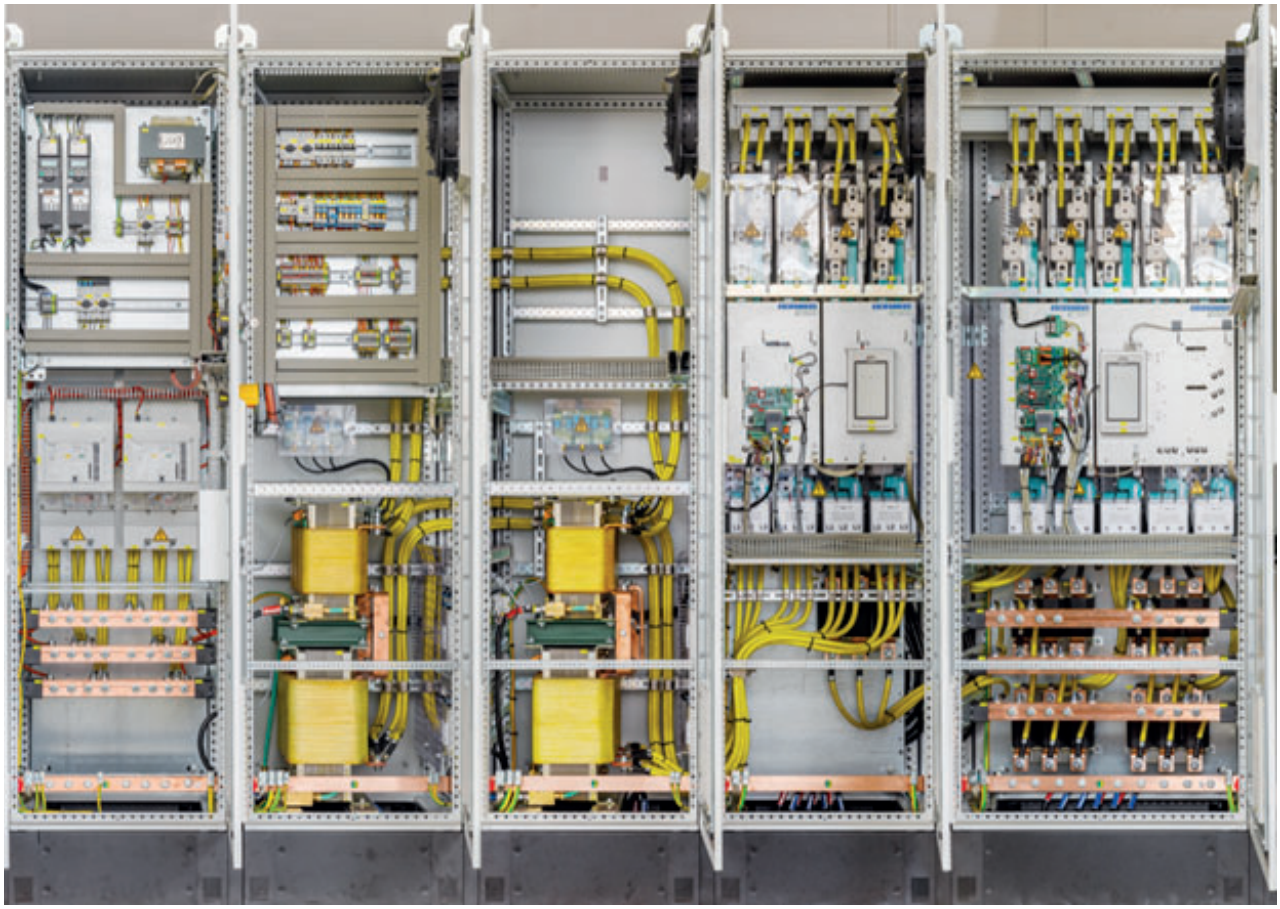
Emotron AFE Drives

Slim-LC Liquid cooled drives



Hardware manual

English

emotron

DEDICATED DRIVE

A CG Product

Safety Instructions

Congratulations for choosing a product from CG Drives & Automation!

Before you begin with installation, commissioning or powering up the unit for the first time it is very important that you carefully study this Instruction manual. Following symbols can appear in this instruction or on the product itself. Always read these first before continuing.

NOTE: Additional information as an aid to avoid problems.

CAUTION!
Failure to follow these instructions can result in malfunction or damage to the AC drive.

Warning!
Failure to follow these instructions can result in serious injury to the user in addition to serious damage to the AC drive.

HOT SURFACE!
Failure to follow these instructions can result in injury to the user.

Handling the AC drive

Installation, commissioning, demounting, taking measurements, etc, of or on the AC drive may only be carried out by personnel technically qualified for the task. A number of national, regional and local regulations govern handling, storage and installation of the equipment. Always observe current rules and legislation.

Opening the AC drive

WARNING!
Always switch off the mains voltage before opening the AC drive and wait at least 7 minutes to allow the capacitors to discharge.

Always take adequate precautions before opening the AC drive. Although the connections for the control signals and the switches are isolated from the main voltage, do not touch the control board when the AC drive is switched on.

Incorrect connection

The AC drive is not protected against incorrect connection of the mains voltage, and in particular against connection of the mains voltage to the motor outlets U, V and W. The AC drive can be damaged in this way. Risk for personal injury.

Precautions to be taken with a connected motor

If work must be carried out on a connected motor or on the driven machine, the mains voltage must always be disconnected from the AC drive first. Wait at least 7minutes before starting work.

Earthing

The AC drive must always be earthed via the mains safety earth connection.

Earth leakage current

CAUTION!
This AC drive has an earth leakage current which does exceed 3.5 mA AC. Therefore the minimum size of the protective earth conductor must comply with the local safety regulations for high leakage current equipment which means that according to the standard IEC61800-5-1 the protective earth connection must be assured by one of following conditions:
PE conductor cross-sectional area shall for phase cable size $\leq$ 16 mm^2 (6 AWG) be >10 mm^2 Cu (16 mm^2 Al) or use a second PE conductor with same area as original PE conductor.
For cable size above 16 mm^2 (6 AWG) but smaller or equal to 35mm^2 (2 AWG) the PE conductor cross-sectional area shall be at least 16mm^2 (6 AWG).
For cables >35 mm^2 (2 AWG) the PE conductor cross-sectional area should be at least 50 % of the used phase conductor.
When the PE conductor in the used cable type is not in accordance with the above mentioned cross-sectional area requirements, a separate PE conductor should be used to establish this.

Residual current device (RCD) compatibility

This product cause a DC current in the protective conductor. Where a residual current device (RCD) is used for protection in case of direct or indirect contact, only a Type B RCD is allowed on the supply side of this product. Use RCD of 300 mA minimum.

EMC Regulations

In order to comply with the EMC Directive, it is absolutely necessary to follow the installation instructions. All installation descriptions in this manual follow the EMC Directive.

Mains voltage selection

The AC drive may be ordered for use with the mains voltage range listed below.

FDUL46/VFXR46/AFR46: 380-460 V, +10%/-15%
FDUL69/VFXR69/AFR69: 480-690 V, +6%/-15%

Voltage tests (Megger)

Do not carry out voltage tests (Megger) on the motor, before all the motor cables have been disconnected from the AC drive.

Condensation

If the AC drive is moved from a cold (storage) room to a room where it will be installed, condensation can occur. This can result in sensitive components becoming damp. Do not connect the mains voltage until all visible dampness has evaporated.

Power factor capacitors for improving cosφ

Remove all capacitors from the motor and the motor outlet.

Precautions during Autoreset

When the automatic reset is active, the motor will restart automatically provided that the cause of the trip has been removed. If necessary take the appropriate precautions.

Transport

To avoid damage, keep the AC drive in its original packaging during transport. This packaging is specially designed to absorb shocks during transport.

IT Mains supply

The AC drives can be modified for an IT mains supply, (non-earthed neutral), please contact your supplier for details.

Alarms

Never disregard an alarm. Always check and remedy the cause of an alarm.

Heat warning

HOT SURFACE!
Be aware of specific parts on the AC drive having high temperature.

DC-link residual voltage

WARNING!
After switching off the mains supply, dangerous voltage can still be present in the AC drive. When opening the AC drive for installing and/or commissioning activities wait at least 7 minutes. In case of malfunction a qualified technician should check the DC-link or wait for one hour before dismantling the AC drive for repair.

Table of contents

1. Introduction

1.1 Software manual

Refer to manual Emotron AFR/AFG 2.1 manual 01-7690-01 regarding the software.

1.2 Delivery and unpacking

Check for any visible signs of damage. Inform your supplier immediately of any damage found. Do not install the AC drive if damage is found.
Check that all items are present and that the type number is correct.

1.3 Using of the instruction manual

Within this instruction manual the abbreviation “AC drive” is used to indicate the complete variable speed drive as a single unit.

Check that the software version number on the first page of this manual matches the software version in the AC drive.

With help of the index and the table of contents it is easy to track individual functions and to find out how to use and set them.

The Quick Setup Card can be put in a cabinet door, so that it is always easy to access in case of an emergency.

1.3.1 Instruction manuals for optional equipment

In the following table we have listed available options and the name of the Instruction manual or data sheet/ Instruction plus document number. Further in this main manual we are often referring to these instructions.

Table 1 Available options and documents

Option	Valid instruction manual/ document number
I/O board	I/O board 2.0, instruction manual / 01-5916-01
Encoder board	Emotron Encoder board 2.0, Instruction manual / 01-5917-01
PTC/PT100 board	PTC/PT100 board 2.0, instruction manual / 01-5920-01
CRIO board (VFX)	Emotron AC Drive Crane option 2.0, Instruction manual
Crane interface (VFX)	
Fieldbus - Profibus	Fieldbus Option, Instruction manual / 01-3698-01
Fieldbus - DeviceNet	
Fieldbus - CANopen	
Ethernet - Modbus TCP	
Ethernet - EtherCAT	
Ethernet - Profinet IO 1-port	
Ethernet - Profinet IO 2-port	
Ethernet - EtherNet/IP 2-port	
Safe Torque Off board	Option Safe Torque Off OSTO – 100 option board 01-7513-11

1.4 Warranty

The warranty applies when the equipment is installed, operated and maintained according to instructions in this instruction manual. Duration of warranty as per contract. Faults that arise due to faulty installation or operation are not covered by the warranty.

1.5 Standards

The AC drives described in this instruction manual comply with the standards listed in table 2. For the declarations of conformity and manufacturer's certificate, contact your supplier for more information or visit www.emotron.com/ www.cgglobal.com.

1.5.1 Product standard for EMC

Product standard EN (IEC) 61800-3, second edition of 2018 defines the:

First Environment (Extended EMC) as environment that includes domestic premises. It also includes establishments directly connected without intermediate transformers to a low voltage power supply network that supplies buildings used for domestic purposes.

Category C2: Power Drive System (PDS) of rated voltage<1.000 V, which is neither a plug in device nor a movable device and, when used in the first environment, is intended to be installed and commissioned only by a professional.

Second environment (Standard EMC) includes all other establishments.

Category C3: PDS of rated voltage <1.000 V, intended for use in the second environment and not intended for use in the first environment.

Category C4: PDS or rated voltage equal or above 1.000 V, or rated current equal to or above 400 A, or intended for use in complex systems in the second environment.

The AC drive complies with the product standard EN(IEC) 61800-3 Ed. 2.0:2018 (Any kind of metal screened cable may be used). The standard AC drive is designed to meet the requirements according to category C3, for a motor cable length of maximum 80 m.

By using the optional "Extended EMC" filter the AC drive fulfils requirements according to category C2.

WARNING!
In a domestic environment this product may cause radio interference, in which case it may be necessary to take adequate additional measures.

WARNING!
The standard AC drive, complying with category C3, is not intended to be used on a low-voltage public network which supplies domestic premises; radio interference is expected if used in such a network. Contact your supplier if you need additional measures.

Table 2 Standards

Market	Standard	Description
European	EMC Directive	2014/30/EU
	Low Voltage Directive	2014/35/EU
	WEEE Directive	2012/19/EU
All	EN 60204-1	Safety of machinery - Electrical equipment of machines Part 1: General requirements.
	EN(IEC) 61800-3 Ed. 2.0: 2018	Adjustable speed electrical power drive systems Part 3: EMC requirements and specific test methods. **EMC Directive: Declaration of Conformity and CE marking**
	EN(IEC)61800-5-1 Ed. 2.0	Adjustable speed electrical power drive systems Part 5-1. Safety requirements - Electrical, thermal and energy. **Low Voltage Directive: Declaration of Conformity and CE marking**
	IEC 60721-3-3	Classification of environmental conditions. Air quality chemical vapours, unit in operation. Chemical gases 3C2, Solid particles 3S2. Optional with coated boards Unit in operation. Chemical gases Class 3C3, Solid particles 3S2.
North & South America	ULC508C	UL Safety standard for Power Conversion Equipment
	USL	USL (United States Standards - Listed) complying with the requirements of UL508C Power Conversion Equipment
	UL 840	UL Safety standard for Power Conversion Equipment. Insulation coordination including clearances and creepage distances for electrical equipment.
	CNL	CNL (Canadian National Standards - Listed) complying with the requirements of CAN/CSA C22.2 No. 14-10 Industrial Control Equipment.
Russian	EAC	For all sizes.

1.6 Dismantling and scrapping

The enclosures of the drives are made from recyclable material as aluminium, iron and plastic. Our AC-drives comply to RoHS II directive, and contain electronic waste (e-waste). Any local or national regulations in force for the disposal and recycling of e-waste must be complied with.

1.6.1 Disposal of old electrical and electronic equipment

This symbol on the product or on its packaging indicates that this product shall be taken to the applicable collection point for the recycling of electrical and electronic equipment. By ensuring this product is disposed of correctly, you will help prevent potentially negative consequences for the environment and human health, which could otherwise be caused by inappropriate waste handling of this product. The recycling of materials will help to conserve natural resources. For more detailed information about recycling this product, please contact the local distributor of the product.

1.7 Glossary

1.7.1 Abbreviations

In this manual the following abbreviations are used:

Table 3 Abbreviations

Abbreviation/ symbol	Description
AC drive	Frequency converter
AFR	Regenerative, low harmonic active front end without Emotron motor inverter.
AnIn	Analogue input
AnOut	Analogue output
DigIn	Digital input
DigOut	Digital output
FDUL	Non-regenerative, low harmonic drive including active front end (AFR) together with Emotron motor inverter FDU.
IGBT	Insulated Gate Bipolar Transistor
PEBB	Power Electronic Building Block
SELV	Safety Extra Low Voltage
VFXR	Regenerative, low harmonic drive including active front end (AFR) together with Emotron motor inverter VFX.

1.8 Single line diagrams FDUL/VFXR and AFR

1.9 General description

The Emotron active front end (AFE) is a regenerative active front end unit designed to be used either in combination with Emotron motor inverter (VSIs) i.e. VFX/FDU or without Emotron motor inverter (VSIs). The main objective of the Emotron AFE is to rectify the supply AC voltage into DC voltage to be fed to or regenerated from the VSIs. This is achieved with the minimal impact on the supply by the control of the active rectifier module which provides sinusoidal input currents with a very low harmonic content, typically a THD(I) below 5%. Different variants of Emotron active front end drives are: AFR, FDUL and VFXR.

CAUTION!
Always consult CG Drives & Automation before connecting an Emotron AFR/AFG to a standard VSI.

1.10 AC drive types

1.10.1 Standard AC drive (as comparison)

A standard AC drive consists of a rectifier module and an inverter module. The rectifier module (front-end) consists of a 6-pulse diode bridge, i.e. diode front-end (DFE) while the inverter module (VSI) consists of IGBTs with anti-parallel free wheeling diodes, see Fig. 1. The main advantages of DFEs are the simple and robust design together with their high efficiency, i.e. low losses. The main disadvantages are unidirectional power flow and the high harmonic content in the line current, typically THD 30- 40%.

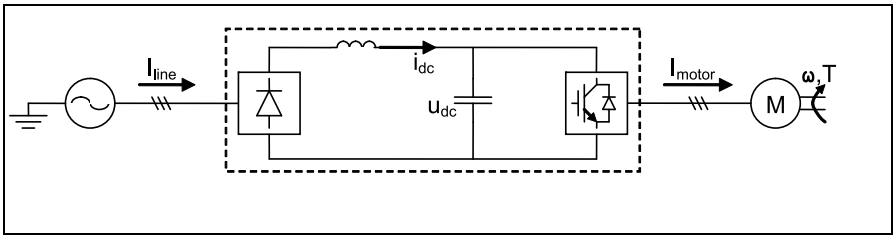


Fig. 1 Standard AC drive.

1.10.2 AC drive with AFR or AFG (FDUL/VFXR/FDUG/VFXG)

An AFE unit is basically a VSI towards the supply (via a filter) where the IGBTs are used as an active rectifier, see Fig. 2. The main advantages are inherent 4Q-operation, i.e. bi-directional power flow, and sinusoidal supply currents, i.e. low harmonics, regeneration and improved power factor. The AFE unit is controlled in such a way to keep the energy between motor and supply in balance. This is achieved by controlling the DC-link voltage (U_{dc}). Other features are the possibility for reactive power compensation and boosted DC-link voltage.

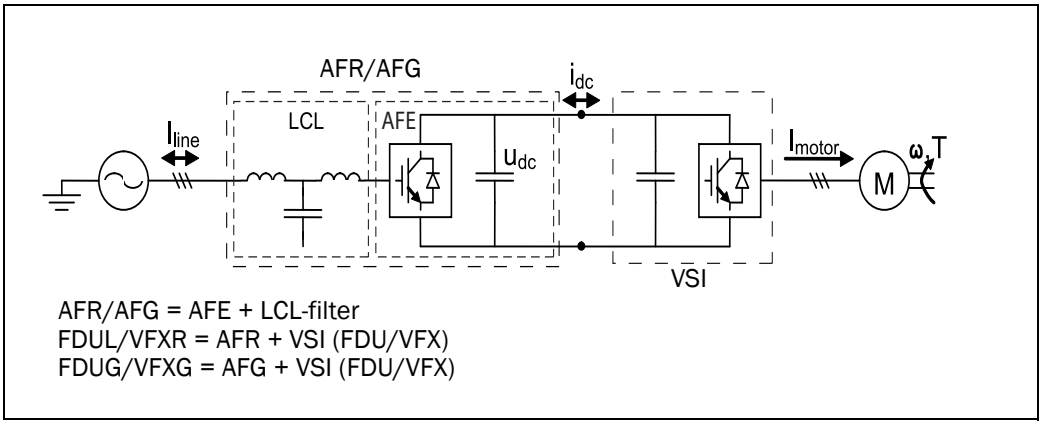


Fig. 2 VSI with AFR/AFG.

1.10.3 AFR

AFR consists of Emotron power electronic module (AFE) connected to grid through LCL filter as shown in Fig. 3. The main objective of the Emotron AFR is to rectify the supply AC voltage into the DC voltage to be fed to or regenerated from the VSIs (motor inverter). It also keeps the harmonic content of the current exchanged with grid at low level, maintaining the THD(I) below 5%. AFR offers standard AFE functionality such as:

- Active power control.
- Reactive power control.
- Low harmonic operation.

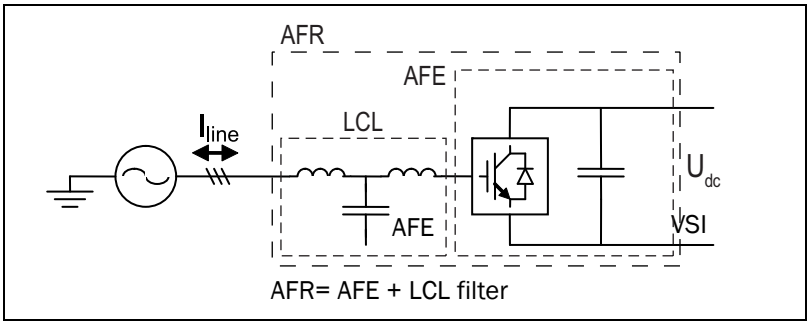


Fig. 3 AFR

1.11 Emotron single drive cabinet concept

1.11.1 FDUL/VFXR/FDUG/VFXG (single drive) applications

The Emotron low harmonic and regenerative AC drive i.e. FDUL/VFXR/FDUG/VFXG is comprised by an AFR or AFG unit i.e. AFE and filters and a VSI, i.e. Emotron VFX or FDU. The concept is designed as a cabinet solution, see Fig. 4.

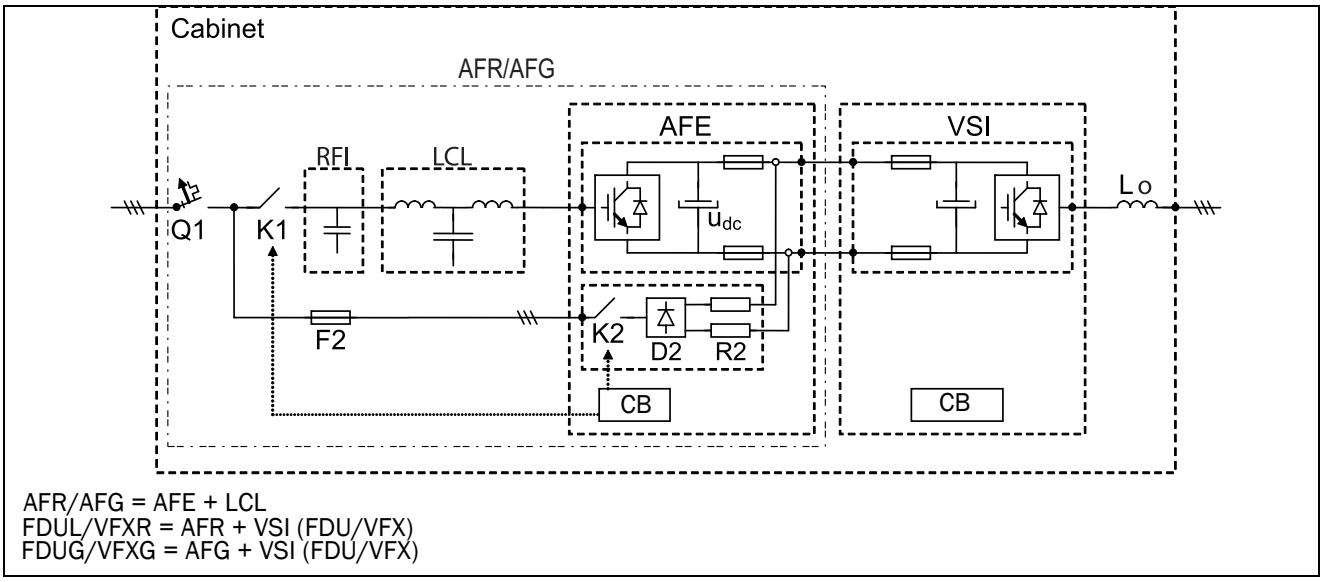


Fig. 4 Single drive in cabinet

where

- Cabinet - IP54 cabinet with fans
- Q1 - Main switch *
- K1 - Main contactor *
- RFI - EMC filter
- LCL - LCL filter
- F2 - MCB (Miniature circuit breaker) for pre-charge circuit
- AFE - Emotron AFE module with 24V standby supply board, voltage measurement board, brake chopper switch (optional) and integrated pre-charge circuit (K2,D2,R2)
- AFR/AFG - Emotron AFE and filters
- VSI - DC-voltage fed VSI module, i.e. Emotron VFX or FDU
- CB - Control board
- Lo - Output coil

* For larger units, Q1 Main switch and K1 Main contact are replaced by Q1 Motorized circuit breaker.

NOTE:
For AFG/FDUG/VFXG, supply voltage measurement board (SVMB) is mandatory. It is mounted and connected internally to K2.

1.11.2 Common DC-bus applications

For common DC-bus applications, the cabinet will contain only the AFR/AFG part of Fig. 4, i.e. all except the VSI & Lo.

1.12 Emotron AFR/AFG concept

Emotron also offers only AFR/AFG solution for the applications where complete FDUL/VFXR/FDUG/VFXG drive train is not required. In this concept, the DC power load/source is connected to the DC-terminals of AFR/AFG. AFR/AFG consists of AFE power electronic module and LCL filters as main components along with other necessary components. AFR/AFG concept is shown in Fig. 5.

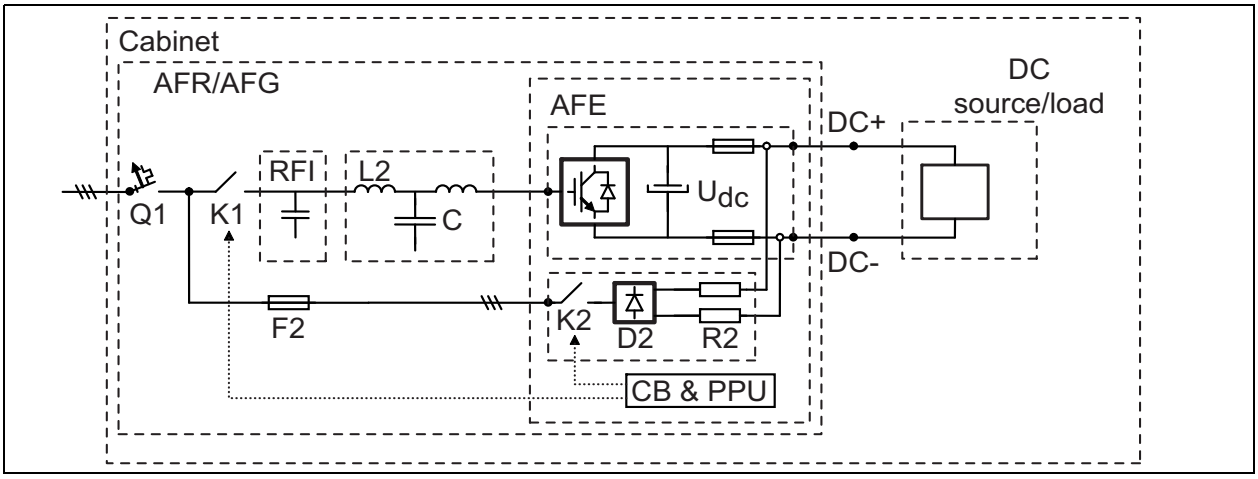


Fig. 5 AFR/AFG concept

where

- Cabinet - outer cabinet (for example IP54)
- Q1 - Main switch *
- K1 - Main contactor *
- RFI - EMC filter
- LCL - LCL filter
- F2 - MCB (Miniature circuit breaker) for pre-charge circuit
- AFE - Emotron AFE module with 24V standby supply board, voltage measurement board, optional brake chopper switch and integrated pre-charge circuit (K2, D2, R2)
- AFR/AFG - Emotron AFE and filters
- DC source/load - External DC power source or load based on the application.
- CB - Control board

* For larger units, Q1 Main switch and K1 Main contact are replaced by Q1 Motorized circuit breaker.

NOTE:
For AFG/FDUG/VFXG, supply voltage measurement board (SVMB) is mandatory. It is mounted and connected internally to K2.

2. Mounting

This chapter describes how to mount the AC drive.

Before mounting it is recommended that the installation is planned out first.

- Be sure that the AC drive suits the mounting location.
- The mounting site must support the weight of the AC drive.
- Will the AC drive continuously withstand vibrations and/or shocks?
- Consider using a vibration damper.
- Check ambient conditions, ratings, required cooling air/ water flow, compatibility of the motor, etc.
- Know how the AC drive will be lifted and transported.

2.1 Lifting instructions

Note: To prevent personal risks and any damage to the unit during lifting, it is advised that the lifting methods described below are used.

2.1.1 Transport by crane

All enclosures are suitable for transporting by crane, either as free-standing enclosures or as bayed suites.

With eyebolts

Individual enclosures are safely transported using the eyebolts.

For symmetrical loads, the following maximum permissible overall loads apply:

Table 4

Cable/chain angle A	Permitted load (F)
45 °	4 800 N (1080 lbf)
60 °	6 400 N (1439 lbf)
90 °	13 600N (3057 lbf)

Note: Calculated load F as F [N] = m [kg] x 9.81.

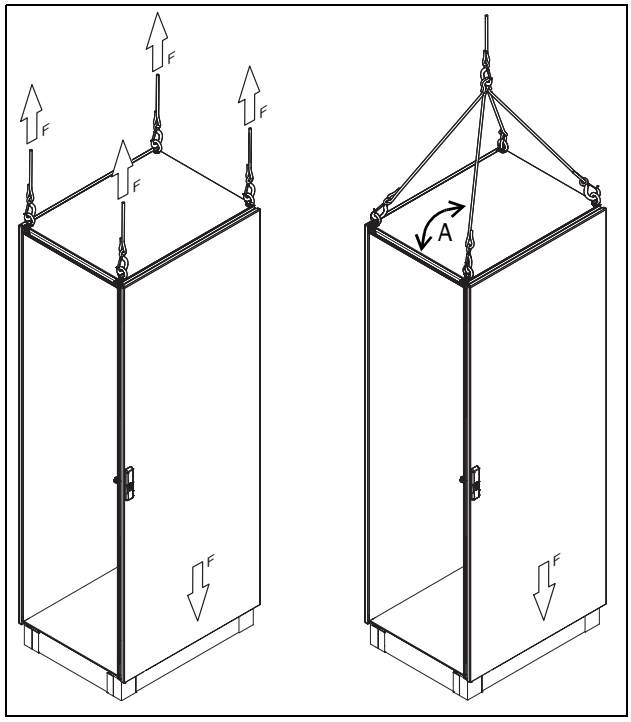


Fig. 6 Lifting enclosures with eyebolts.

With combination angle

For the enclosure combination with internal baying brackets and combination angles shown here, the load capacity with a cable pull angle of 60° is as follows:

F1 = 7000 N
F2 = 7000 N

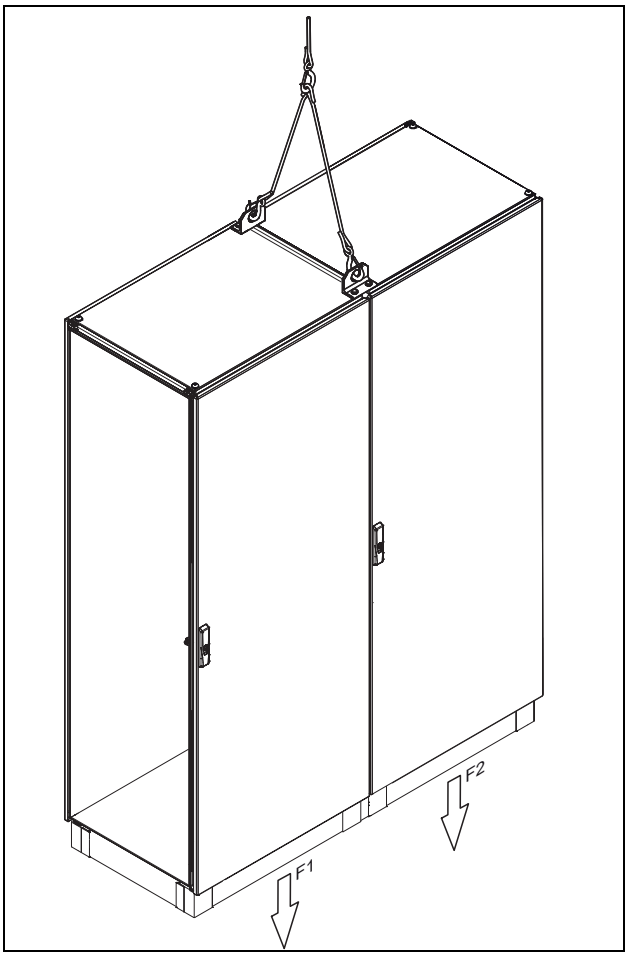


Fig. 7 Enclosure combination with internal brackets.

For the enclosure combination with internal baying brackets and combination angles shown here, the load capacity with a cable pull angle of 60° is as follows:

F1 = 7000 N
F2 = 14000 N
F3 = 7000 N

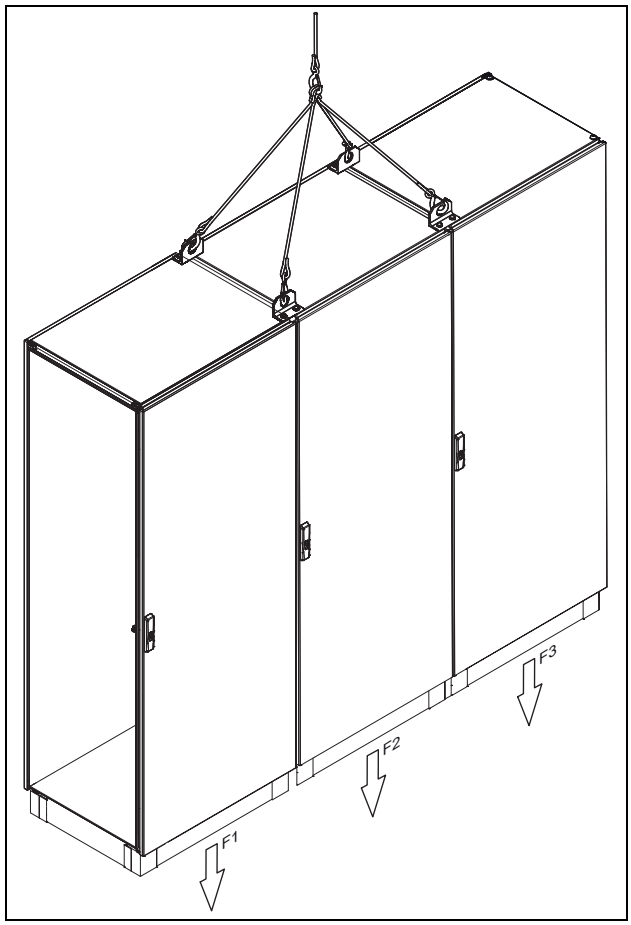


Fig. 8 Enclosure combination with internal brackets.

2.1.2 Transport by fork-lift truck

When transporting individual and bayed enclosures, please take care to ensure that the base/plinth trim panels are fitted, and loads are restricted to the immediate vicinity of the base/plinth corner pieces.

Transport of individual enclosures

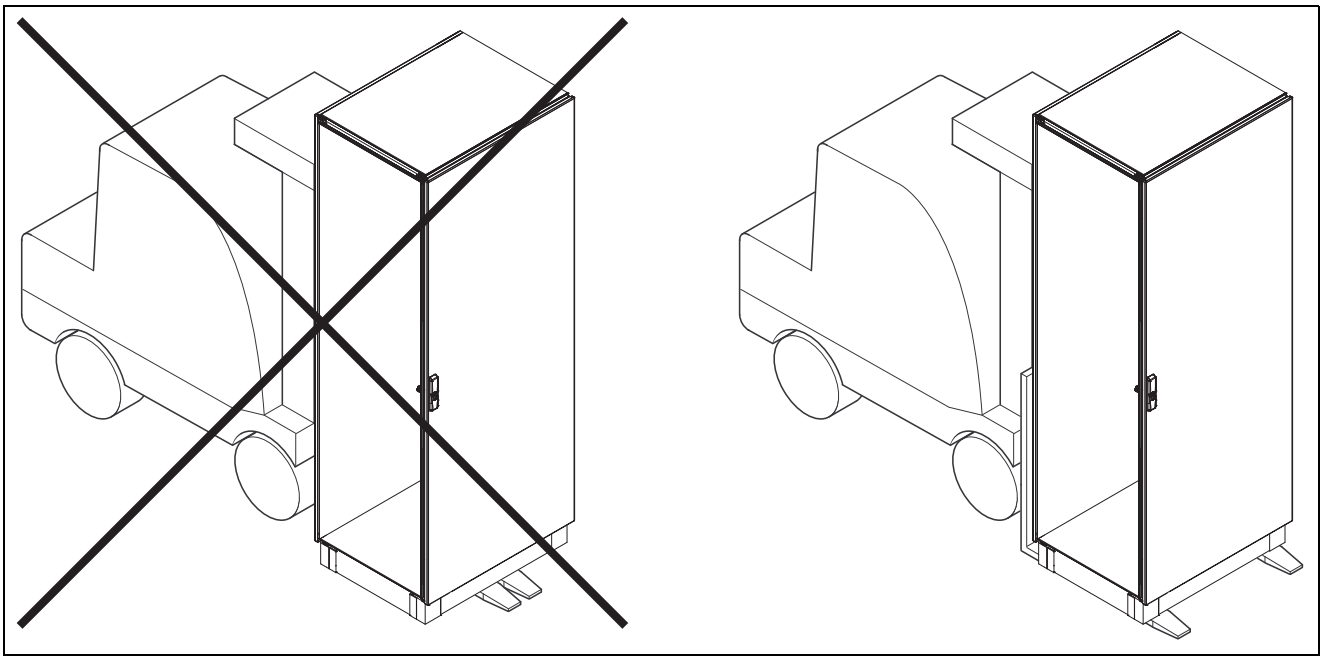


Fig. 9 Transport of individual enclosure with fork-lift truck.

Transport of bayed enclosure suites

For the enclosure combination with internal baying brackets the following load capacities are supported:

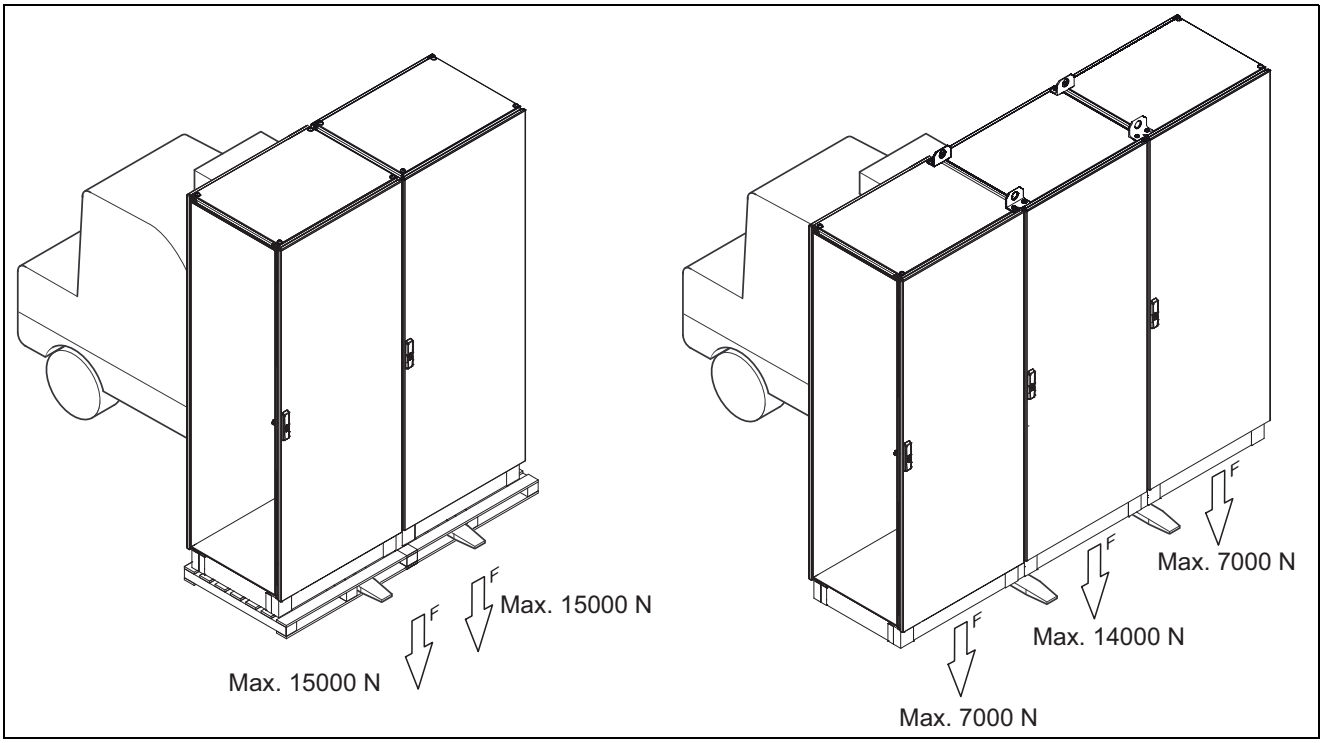


Fig. 10 Transport of enclosure combination with fork-lift truck.

3. Control Connection

3.1 Control board location

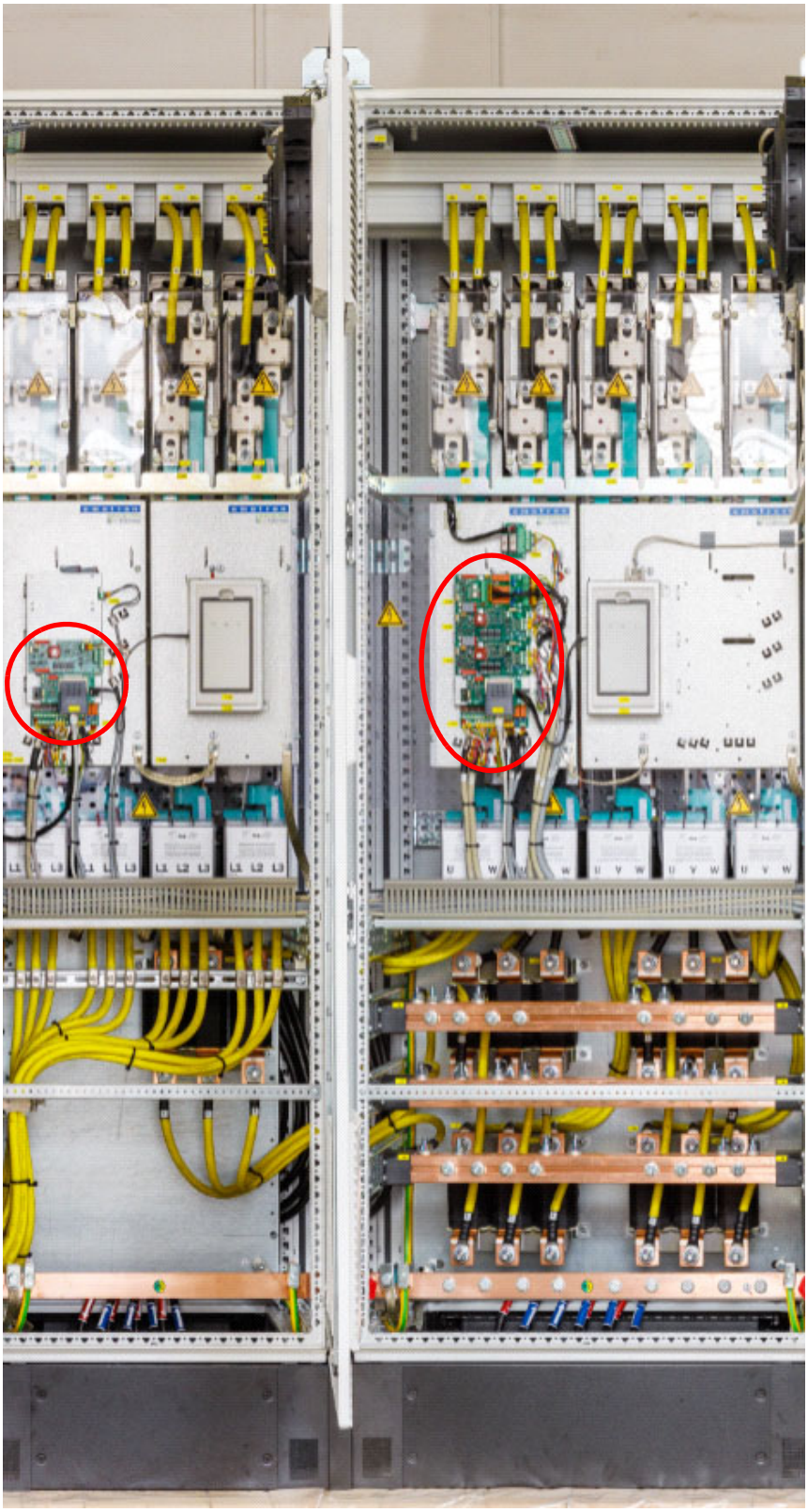


Fig. 11 Control board location (example FDUL46-1710-CL (left side AFR, right side VSI)

3.2 Control board

Fig. 12 shows the layout of the control board which is where the parts most important to the user are located. Although the control board is galvanically isolated from the mains, for safety reasons do not make changes while the mains supply is on!

WARNING!
Always switch off the mains voltage and wait at least 7 minutes to allow the DC capacitors to discharge before connecting the control signals or changing position of any switches. If the option External supply is used, switch of the mains to the option. This is done to prevent damage on the control board.

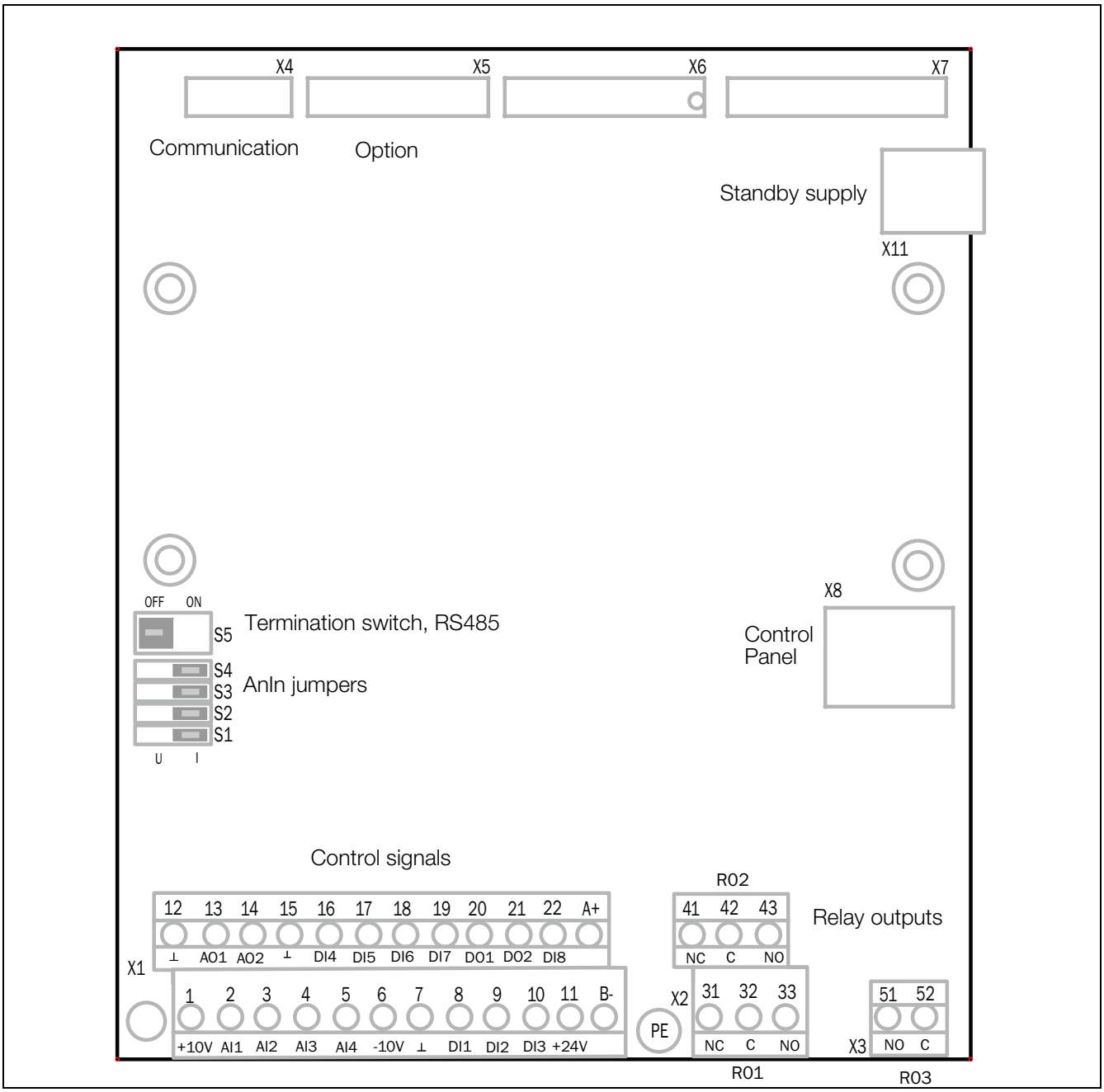


Fig. 12 Control board layout.

3.3 Terminal connections

The terminal strip for connecting the control signals is accessible after opening the front panel.

The table describes the default functions for the signals.

NOTE: The maximum total combined current for outputs 11, 20 and 21 is 100mA.

NOTE: It is possible to use external 24V DC if connection to Common (15).

Table 5 Control signals

Terminal	Name	Function (Default)
Outputs		
1	+10 V	+10 VDC supply voltage
6	-10 V	-10 VDC supply voltage
7	Common	Signal ground
11	+24 V	+24 VDC supply voltage
12	Common	Signal ground
15	Common	Dig signal ground *
Digital inputs		
8	DigIn 1	RunL (reverse)
9	DigIn 2	RunR (forward)
10	DigIn 3	Off
16	DigIn 4	Off
17	DigIn 5	Off
18	DigIn 6	Off
19	DigIn 7	Off
22	DigIn 8	RESET
Digital outputs		
20	DigOut 1	Ready
21	DigOut 2	Brake No trip
Analogue inputs		
2	AnIn 1	Process Ref
3	AnIn 2	Off
4	AnIn 3	Off
5	AnIn 4	Off
Analogue outputs		
13	AnOut 1	Min speed to max speed
14	AnOut 2	0 to max torque

Table 5 Control signals

Terminal	Name	Function (Default)
Integrated RS-485[1]		
A+	A+	RS-485 Differential transmit and receive
B-	B-	
Relay outputs		
31	N/C 1	Relay 1 output Trip, active when the AC drive is in a TRIP condition.
32	COM 1	
33	N/O 1	
41	N/C 2	Relay 2 output Run, active when the AC drive is started.
42	COM 2	
43	N/O 2	
51	COM 3	Relay 3 output Off
52	N/O 3	

*** Digital signal ground connected to 0V via ferrite (600 Ohm @ 100MHz).**

[1] The integrated RS-485 interface is a isolated interface supporting Modbus RTU protocol with baudrates ranging from 2400 bit/s up to 115.2 kbit/s. Termination and fail-safe can be activated via switch S5 when applicable. Note that proper termination and fail-safe is critical for a stable RS-485 network. It is recommended to use screened RS-485 cable which protects the signals from EMI. The cable screen should (in normal cases) be connected to inverter PE via provided screen clamps, see fig. 13. For further information about Modbus RTU protocol and physical network connection see Emotron option manual for Serial communication RS-232/485 available on our website.

NOTE: N/C is opened when the relay is active and N/O is closed when the relay is active.

NOTE! Using potentiometer for reference signal to Analogue input: Possible potentiometer value in range of 1 kΩ to 10 kΩ (¼ Watt) linear, where we advice to use a linear 1 kΩ / ¼ W type potentiometer for best control linearity.

WARNING!
The relay terminals 31-52 are single isolated. Do NOT mix SELV voltage with e.g. 230 VAC on these terminals. A solution when dealing with mixed SELV/system voltage signals is to install an additional I/O board option and connect all SELV voltage signals to the relay terminals of this option board while connecting all 230VAC signals to the control board relay terminals 31 - 52.

3.3.1 Stand by supply interface (SBS)

The control board mounted standby supply, X11 connector, provides the possibility of keeping the communication system up and running without having the 3-phase mains connected. Another advantage is that the system can be set up without mains power. The option will also give backup for communication failure if main power is lost.

The standby supply should be supplied with a 24 VDC ±10% double isolated transformer capable of supplying 1A continues current. Recommended fuse is 2A. Cable length limited to 30 m. If the cable is longer than 30 m, a shielded cable must be used.

Table 6 X11 terminals

Terminal	Name	Function
1	+	24 VDC ±10%
2	-	0 V

NOTE: In case the isolated DC measurement board (that incorporate stand by supply [SBS] functionality) the control-board SBS should not be used. Rather the SBS on the isolated DC measurement board should be used. Failure to comply with this will break DC-link voltage measurement.

3.4 Configuration with jumpers and switches

3.4.1 Analogue input configuration (S1 - S4)

The jumpers selections S1 to S4 are used to set the input configuration for the 4 analogue inputs AnIn1, AnIn2, AnIn3 and AnIn4 as described in table 7. See fig. 12 for the location of the jumpers.

Table 7 Setting selectors S1-S4

Input	Signal type	Selector configuration
AnIn1	Voltage	S1 
	Current (default)	S1 
AnIn2	Voltage	S2 
	Current (default)	S2 
AnIn3	Voltage	S3 
	Current (default)	S3 
AnIn4	Voltage	S4 
	Current (default)	S4 

NOTE: Scaling and offset of AnIn1 - AnIn4 can be configured using the software.

NOTE: the 2 analogue outputs AnOut 1 and AnOut 2 can be configured using the software.

3.4.2 RS-485 termination (S5)

Switch S5 is used to activate termination and fail-safe resistors for the integrated RS-485-interface on terminal X1: A+ and B-. See fig. 12 for the location of the switch.

Table 8 Settings switch S5

Input	Termination	Selector configuration
RS-485	Off	S5 
	Activated	S5 

NOTE: It is important to have termination and fail-safe activated on at least one node on the network to secure proper function. The termination shall ONLY be enabled in the cable ends of a RS-485 network. The termination resistor is used to avoid reflections of transmitted signals and the fail-safe resistors will keep A+ and B- terminals at a steady state when no node is transmitting. It is important not to enable any additional termination apart from the two in each cable end as it will impose as an additional load for a transmitting transceiver and may cause malfunctioning.

3.5 Connection example

Fig. 13 gives an overall view of a AC drive connection example.

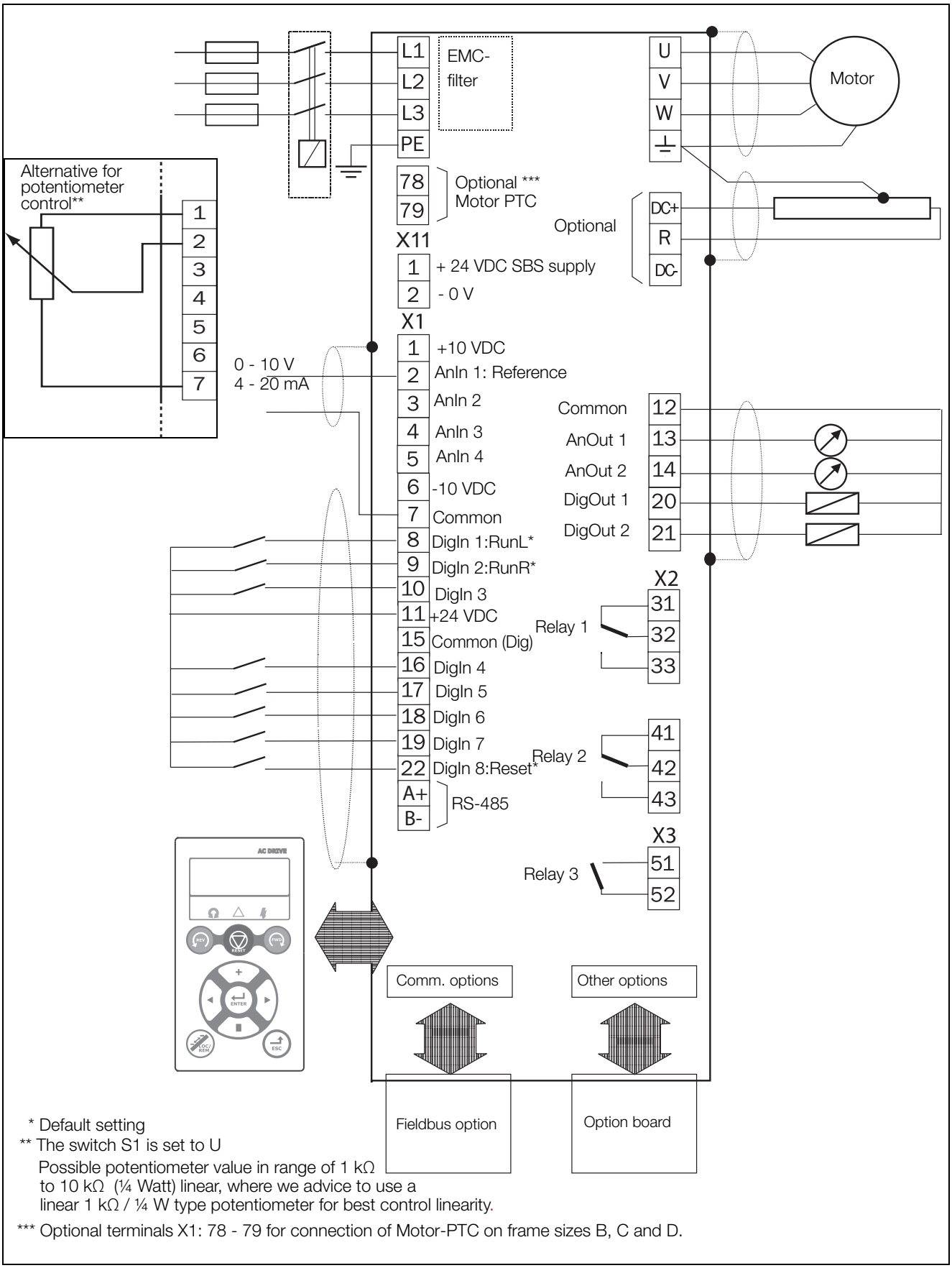


Fig. 13 Connection example.

4. Installation

The description of installation in this chapter complies with the EMC standards and the Low Voltage Directive.

Select cable type and screening according to the EMC requirements valid for the environment where the AC drive is installed.

Also refer to chapter 5. Water cooling.

4.1 Connection of motor and mains cables

Mains cables should normally be connected to input terminals of circuit breaker. Motor cables to be connected to motor bus bar terminals (white boxes). For connection of PE and earth there is grounding bus bars.

Also refer to schematic set included with drive delivery.

NOTE: See tightening torque in chapter 4.3.1.

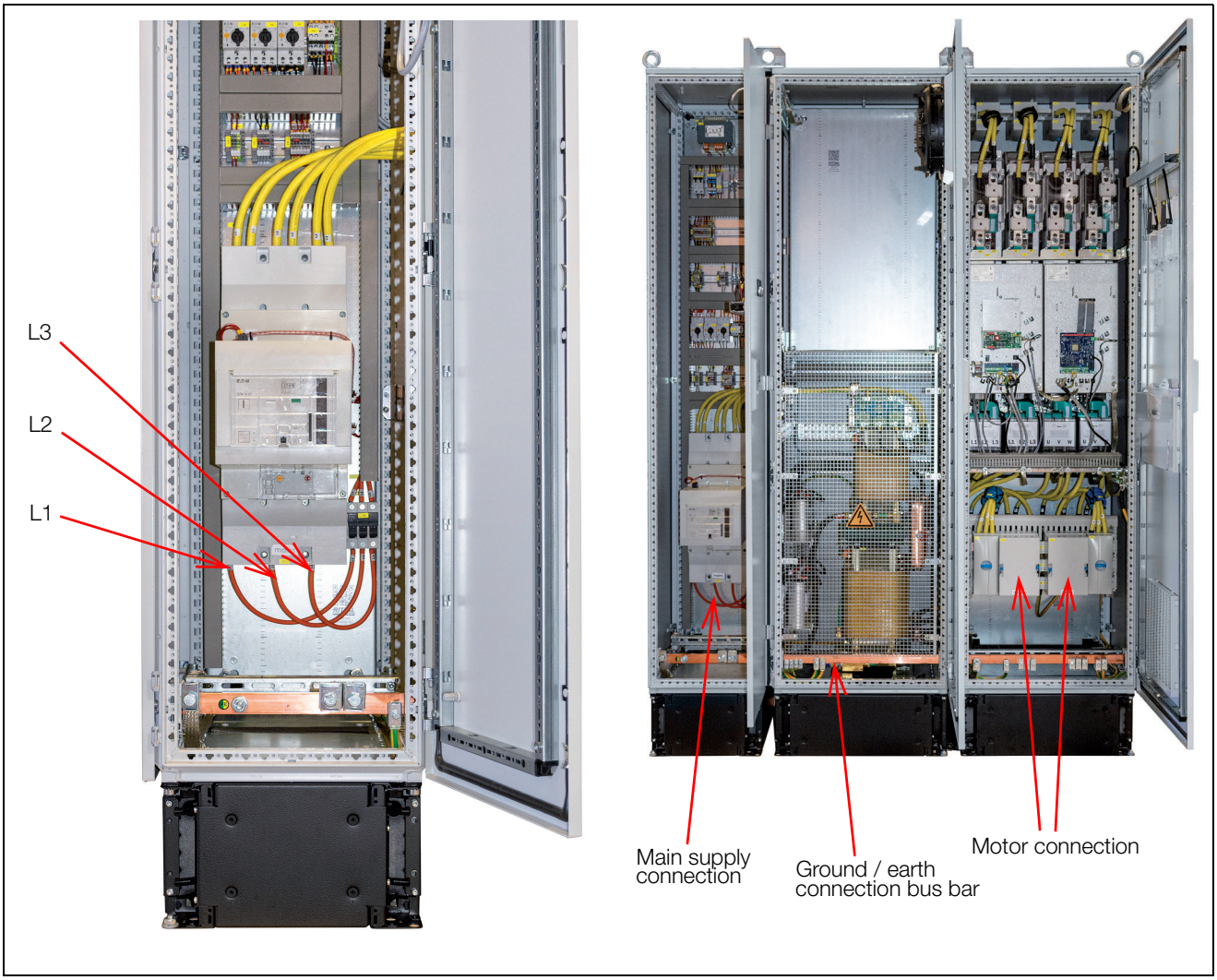


Fig. 14 Typical cables connection in cabinet.

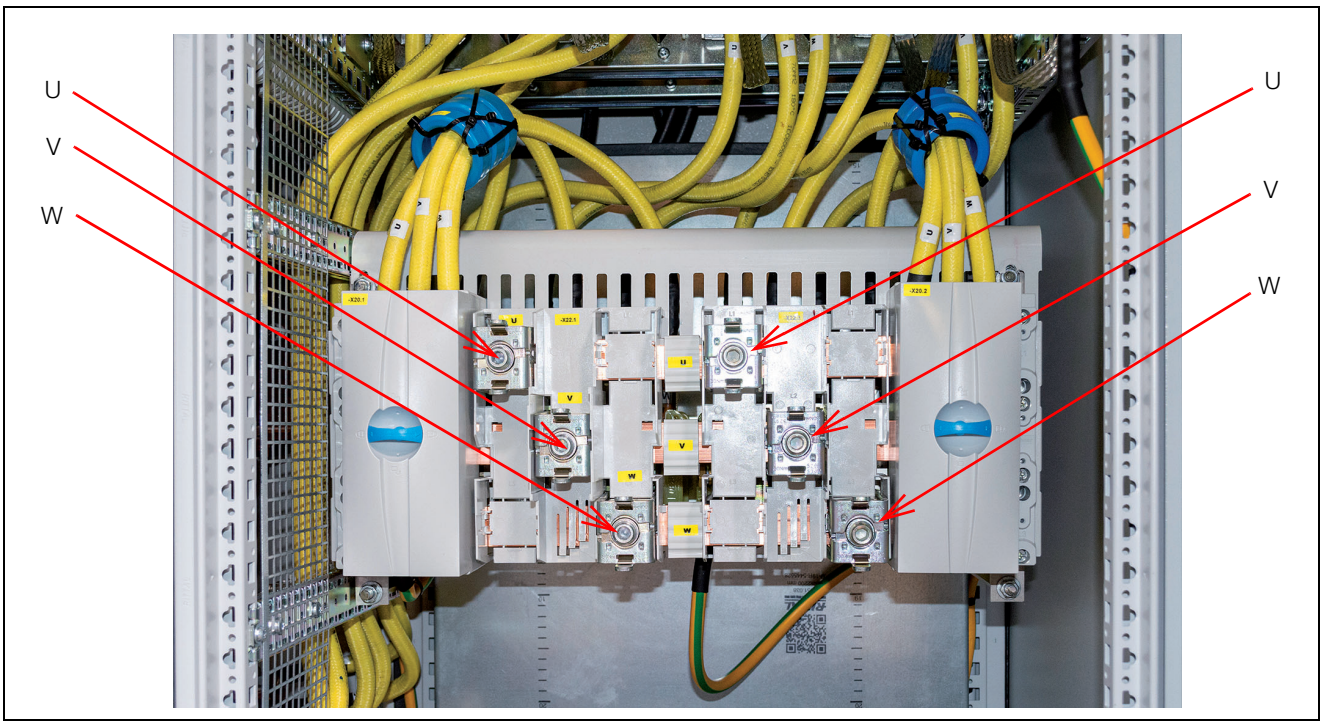


Fig. 15 Typical motor cables connection in cabinet.

4.2 Cables

To comply with the EMC emission standards the AC drive is provided with a RFI mains filter. The motor cables must also be screened and connected on both sides. In this way a so-called “Faraday cage” is created around the AC drive, motor cables and motor. The RFI currents are now fed back to their source (the IGBTs) so the system stays within the emission levels.

4.3 Cable specifications

Table 9

Cable	Cable specification
Mains	Power cable suitable for fixed installation for the voltage used.
Motor	Symmetrical three conductor cable with concentric protection (PE) wire or a four conductor cable with compact low-impedance concentric shield for the voltage used.
Control	Control cable with low-impedance shield, screened.

4.3.1 Cable connection data for mains, motor and PE cables according to IEC ratings

Slim-AFE drives, typical motor power at 400 V

Table 10 Cable connector range and tightening torque (mains voltage 400 V)

Model	Max. fuse input (A)	Cable cross section connector range					
		Mains cable		Motor cable		PE cable	
		Cable area mm^2 / Number of cables	Tightening torque	Cable area mm^2 / Number of cables	Tightening torque	Cable area mm^2 / Number of cables	Tightening torque
FDUL/VFXR46-250-CL	250	1 x 25-185*	14 Nm	1 x bolt M12	20 Nm	1 x bolt M10 3 x 70-185 clamp***	22 Nm
FDUL/VFXR46-295-CL	250	1 x 25-185*	14 Nm	1 x bolt M12	20 Nm	1 x bolt M10 3 x 70-185 clamp***	22 Nm
FDUL/VFXR46-365-CL	400	2 x 50-240*	31 Nm	1 x bolt M12	20 Nm	1 x bolt M10 3 x 70-185 clamp***	22 Nm
FDUL/VFXR46-590CL	630	2 x 50-240*	31 Nm	2 x 95-300	30 Nm	2 x bolt M10 6 x 70-185 clamp***	22 Nm
FDUL/VFXR46-730-CL	800	4 x 50-240*	31 Nm	2 x 95-300	30 Nm	2 x bolt M10 6 x 70-185 clamp***	22 Nm
FDUL/VFXR46-810-CL	800	4 x 50-240*	31 Nm	3 x bolt M12	10/40 Nm	4 x bolt M10	22 Nm
FDUL/VFXR46-1010-CL	1000	4 x 50-240*	31 Nm	3 x bolt M12	10/40 Nm	4 x bolt M10	22 Nm
FDUL/VFXR46-1100-CL	1250	4 x 50-240*	31 Nm	3 x bolt M12	10/40 Nm	4 x bolt M10	22 Nm
FDUL/VFXR46-1250-CL	1250	4 x 50-240*	31 Nm	4 x bolt M12	10/40 Nm	4 x bolt M10	22 Nm
FDUL/VFXR46-1460-CL	1600	6 x bolt M12**	10/40 Nm	6 x bolt M12	10/40 Nm	6 x bolt M12	40 Nm
FDUL/VFXR46-1710-CL	1600	6 x bolt M12**	10/40 Nm	6 x bolt M12	10/40 Nm	6 x bolt M12	40 Nm
FDUL/VFXR46-2200-CL	2 x 1250	8 x bolt M12**	10/40 Nm	8 x bolt M12	10/40 Nm	8 x bolt M12	40 Nm
FDUL/VFXR46-2500-CL	2 x 1250	8 x bolt M12**	10/40 Nm	8 x bolt M12	10/40 Nm	8 x bolt M12	40 Nm

* Tunnel clamp

** Bolt clamp

*** For symmetrical EMC cable (3xPE)

Slim-AFE drives, typical motor power at 690 V

Table 11 Cable connector range and tightening torque (mains voltage 690 V)

Model	Max. fuse input (A)	Cable cross section connector range					
		Mains cable		Motor cable		PE cable	
		Cable area mm^2 / Number of cables	Tightening torque	Cable area mm^2 / Number of cables	Tightening torque	Cable area mm^2 / Number of cables	Tightening torque
FDUL/VFXR69-200-CL	200	1 x 25-185*	14 Nm	1 x bolt M12	20 Nm	1 x bolt M10 3 x 70-185 clamp**	22 Nm
FDUL/VFXR69-250-CL	250	1 x 25-185*	14 Nm	1 x bolt M12	20 Nm	1 x bolt M10 3 x 70-185 clamp***	22 Nm
FDUL/VFXR69-500-CL	500	2 x 50-240*	31 Nm	2 x 95-300	30 Nm	2 x bolt M10 6 x 70-185 clamp***	22 Nm
FDUL/VFXR69-750CL	800	4 x 50-240*	31 Nm	2 x 95-300	30 Nm	4 x bolt M10	22 Nm
FDUL/VFXR69-1000-CL	1000	4 x 50-240*	31 Nm	3 x bolt M12	10/40 Nm	4 x bolt M10	22 Nm
FDUL/VFXR69-1250-CL	1250	4 x 50-240*	31 Nm	4 x bolt M12	10/40 Nm	4 x bolt M10	22 Nm
FDUL/VFXR69-1500-CL	1600	6 x bolt M12**	10/40 Nm	6 x bolt M12	10/40 Nm	6 x bolt M12	40 Nm
FDUL/VFXR69-2000-CL	2 x 1000	8 x bolt M12**	10/40 Nm	8 x bolt M12	10/40 Nm	8 x bolt M12	40 Nm
FDUL/VFXR69-3000-CL	2 x 1600	8 x bolt M12**	10/40 Nm	12 x bolt M12	10/40 Nm	12 x bolt M12	40 Nm
FDUL/VFXR69-4000-CL	2 x 1000	2 x 8xBolt M12	10/40 Nm	4 x 4x bolt M12	10/40 Nm	12 x bolt M12	40 Nm

* Tunnel clamp

** Bolt clamp

*** For symmetrical EMC cable (3xPE)

Slim-AFR Regenerative DC-bus supply unit, output DC power at 400 V

Table 12 Cable connector range and tightening torque (400 V)

Model	Max. fuse input (A)	Cable cross section connector range					
		Mains cable		Motor cable		PE cable	
		Cable area mm^2 / Number of cables	Tightening torque	Cable area mm^2 / Number of cables	Tightening torque	Cable area mm^2 / Number of cables	Tightening torque
AFR46-250-CL	250	1 x 25-185*	14 Nm	-	-	1 x bolt M10	22 Nm
AFR46-365-CL	400	2 x 50-240*	31 Nm	-	-	2 x bolt M10	22 Nm
AFR46-500-CL	630	2 x 50-240*	31 Nm	-	-	2 x bolt M10	22 Nm
AFR46-700-CL	800	4 x 50-240*	31 Nm	-	-	2 x bolt M10	22 Nm
AFR46-885-CL	1000	4 x 50-240*	31 Nm	-	-	2 x bolt M10	22 Nm
AFR46-1050-CL	1250	4 x 50-240*	31 Nm	-	-	2 x bolt M10	22 Nm
AFR46-1400-CL	1600	6 x bolt M12**	10/40 Nm	-	-	3 x bolt M10	22 Nm
AFR46-1770-CL	2 x 1000	6 x bolt M12**	10/40 Nm	-	-	3 x bolt M10	22 Nm
AFR46-2100-CL	2 x 1250	8 x bolt M12**	10/40 Nm	-	-	4 x bolt M10	22 Nm

* Tunnel clamp
** Bolt clamp

Slim-AFR Regenerative DC-bus supply unit, output DC power at 690 V

Table 13 Cable connector range and tightening torque (690 V)

Model	Max. fuse input (A)	Cable cross section connector range					
		Mains cable		Motor cable		PE cable	
		Cable area mm^2 / Number of cables	Tightening torque	Cable area mm^2 / Number of cables	Tightening torque	Cable area mm^2 / Number of cables	Tightening torque
AFR69-175-CL	200	1 x 25-185*	14 Nm	-	-	1 x bolt M10	22 Nm
AFR69-233-CL	250	1 x 25-185*	14 Nm	-	-	1 x bolt M10	22 Nm
AFR69-466-CL	630	2 x 50-240*	31 Nm	-	-	1 x bolt M10	22 Nm
AFR69-700-CL	800	4 x 50-240*	31 Nm	-	-	2 x bolt M10	22 Nm
AFR69-900-CL	1000	4 x 50-240*	31 Nm	-	-	2 x bolt M10	22 Nm
AFR69-1400CL	1600	6 x bolt M12**	10/40 Nm	-	-	3 x bolt M10	22 Nm
AFR69-1800-CL	2 x 1000	6 x bolt M12**	10/40 Nm	-	-	4 x bolt M10	22 Nm
AFR69-2100-CL	2 x 1250	8 x bolt M12**	10/40 Nm	-	-	4 x bolt M10	22 Nm
AFR69-2700-CL	2 x 1600	8 x bolt M12**	10/40 Nm	-	-	6 x bolt M12	40 Nm
AFR69-3600-CL	4 x 1000	2x5 bolt M12**	10/40 Nm			6 x bolt M12	40 Nm

* Tunnel clamp

** Bolt clamp

5. Water cooling

5.1 Connection with cooling section

Fig. 16 shows a simplified example of an open loop cooling system.

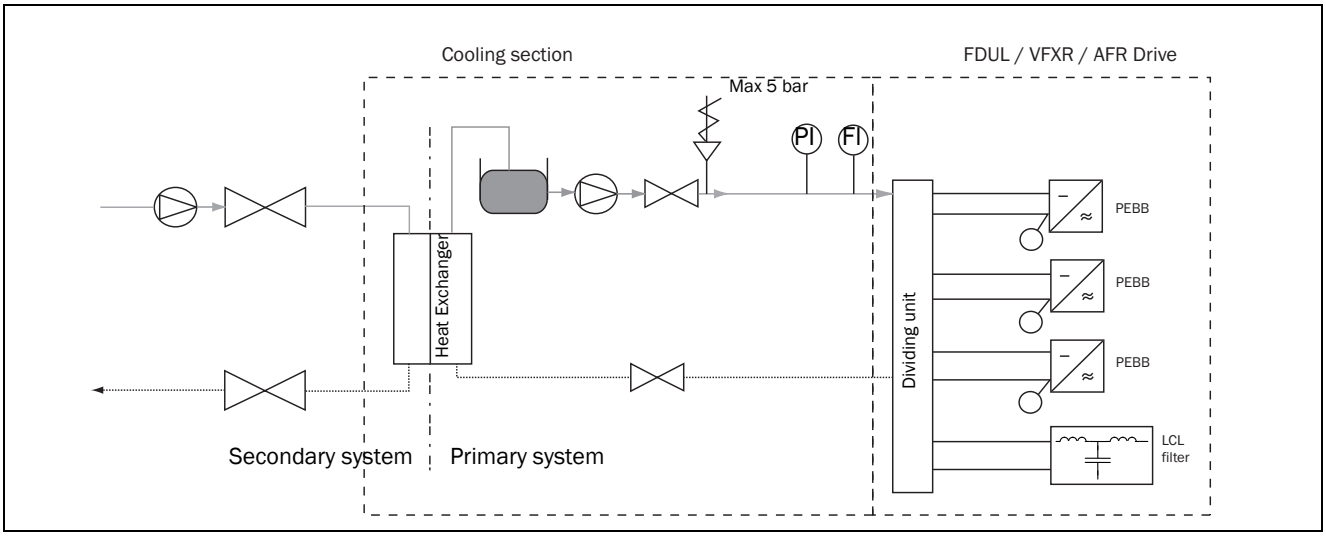


Fig. 16 Example open-loop system with cooling section.

Table 14

FI	Flow Indicator (option)
PI	Pressure Indicator (option)
	Pump
	Valve
	Overpressure valve
PEBB	Power Electronic Building Block

Table 15

Max pressure	4 bar
Max inlet temperature (higher temperature on request)	35 °C
Water/Glycol	70% / 30%

The liquid temperature is indirectly controlled with an internal temperature circuit of the AC drive. This will switch off the AC drive if the internal temperature becomes too high.

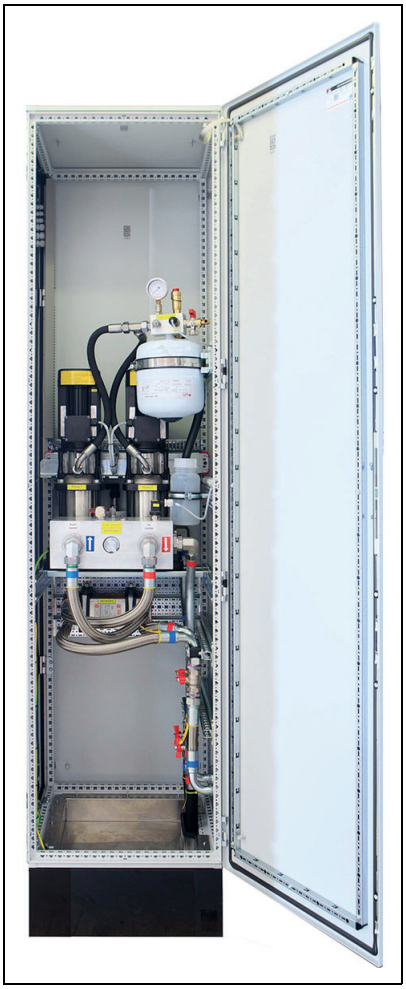


Fig. 17 Typical cooling section.

5.2 Connection without cooling section

Fig. 18 shows a simplified example of an open loop cooling system. Here is the secondary system not included.

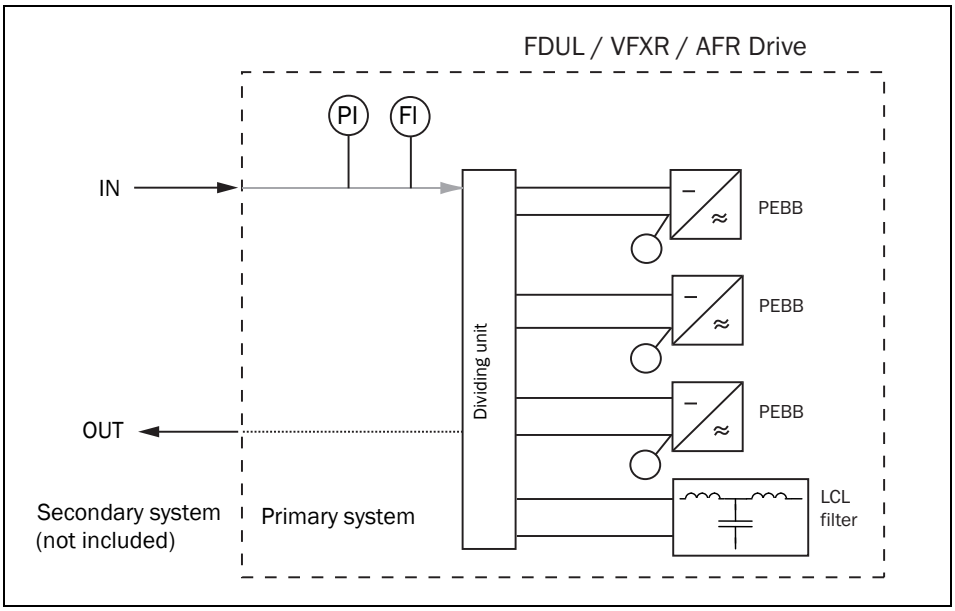


Fig. 18 Example open-loop system without cooling section.

Table 16

FI	Flow Indicator (option)
PI	Pressure Indicator (option)
PEBB	Power Electronic Building Block

Table 17

Max pressure	4 bar
System pressure drop	1.5 - 2 bar
Max inlet temperature (higher temperature on request)	35 °C
Water/Glycol	70% / 30%

The liquid temperature is indirectly controlled with an internal temperature circuit of the AC drive. This will switch off the AC drive if the internal temperature becomes too high.

Fig. 19 shows water connections without a cooling section. Water pipe connections (In/Out) are of type G1.

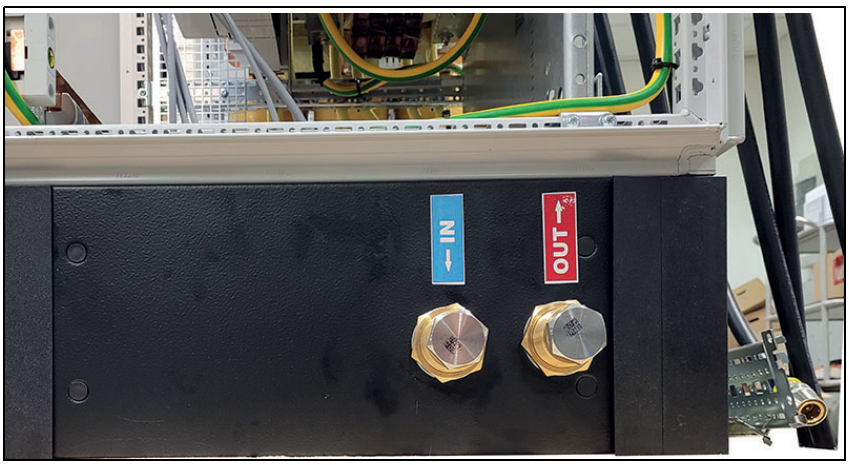


Fig. 19 Water connections.

6. Troubleshooting

6.1 Trip conditions, causes and remedial action

The table later on in this section must be seen as a basic aid to find the cause of a system failure and to how to solve any problems that arise. An AC drive is mostly just a small part of a complete AC drive system. Sometimes it is difficult to determine the cause of the failure, although the motor inverter gives a certain trip message it is not always easy to find the right cause of the failure. Good knowledge of the complete drive system is therefore necessary. Contact your supplier if you have any questions.

Failures occurring during commissioning or shortly after commissioning are most likely to be caused by incorrect settings or even bad connections.

Failures or problems occurring after a reasonable period of failure-free operation can be caused by changes in the system or in its environment (e.g. wear).

Failures that occur regularly for no obvious reasons are generally caused by Electro-Magnetic Interference. Be sure that the installation fulfils the demands for installation stipulated in the EMC directives.

Sometimes the so-called “Trial and error” method is a quicker way to determine the cause of the failure. This can be done at any level, from changing settings and functions to disconnecting single control cables or replacing entire drives.

The Trip Log can be useful for determining whether certain trips occur at certain moments. The Trip Log also records the time of the trip in relation to the run time counter.

WARNING!
If it is necessary to open the FDUL/VFXR/AFR or any part of the system (motor cable housing, conduits, electrical panels, cabinets, etc.) to inspect or take measure-ments as suggested in this instruction manual, it is absolutely necessary to read and follow the safety instructions in the manual.

6.1.1 Technically qualified personnel

Installation, commissioning, demounting, making measurements, etc., of or at the motor inverter may only be carried out by personnel technically qualified for the task.

6.1.2 Opening the FDUL/VFXR/AFR

WARNING!
Always switch the mains voltage off if it is necessary to open the FDUL/VFXR/AFR and wait at least 7 minutes to allow the capacitors to discharge.

WARNING!
In case of malfunctioning always check the DC-link voltage, or wait one hour after the mains voltage has been switched off, before dismantling the FDUL/VFXR/AFR for repair.

The connections for the control signals and the switches are isolated from the mains voltage. Always take adequate precautions before opening the FDUL/VFXR/AFR.

6.1.3 Precautions to take with a connected motor

If work must be carried out on a connected motor or on the driven machine, the mains voltage must always first be disconnected from the FDUL/VFXR/AFR.Wait at least 5 minutes before continuing.

6.1.4 Trip conditions

Table 18

Trip condition	Possible Cause	Remedy
Trip over temp	The pump has stopped. There is no water.	- Check the pump - Check the water supply.
Over temp	There is air in the system.	Exhaust the air from the system.
	The inlet temperature is too high.	Reduce the inlet temperature.
	Wrong pump direction.	Change pump direction.

6.2 Maintenance

6.2.1 Check of the liquid

In time the liquid can get contaminated by floating particles from the system. This will decrease the conductivity. When the conductivity of the liquid decreases, the risk of electrochemical reactions between the different alloys, in the primary system, increases. The contamination for a closed system is less than for an open system.

For both open- and closed systems inhibitors are advised. Checking the liquid is an important part of the maintenance. See table 19.

6.2.2 Maintenance schedule

There are a few systematic maintenance tasks that have to be followed to ensure an optimal operation of the liquid cooling unit and they are presented in table 19.

Table 19 Maintenance schedule

	Every 6 months	Once a year
Checking quick couplers		√
Inspection	√	√

The 6 monthly inspections include the followings tasks:

- Check the system for possible leaks. It is dangerous to use the AC drive while leaking.
- This check has only to be done for a closed system. Check the pressure of the system for abnormal variations. Rising pressure can indicate flow obstruction.
- Check the flow in the primary circuit at flow indicator. The flow must be minimal as initial setup.
- Check the IGBT temperature in menu [71A]. A higher value as normal can indicate cooling problems. The nominal value shall not exceed 70°C.
- Check the quick couplings for leakage. Please report abnormalities to CG Drives & Automation.

The first year inspection includes the following tasks:

- Disconnect the quick couplers and check for visible residue. Please report abnormalities to CG Drives & Automation.
- The checklist from the 6 monthly inspections.

6.3 Fault messages from software

Please refer to the Emotron AFR/AFG manual 01-7491-01 for fault messages from the software.

7. Technical Data

7.1 Drive data

7.1.1 Slim-AFE drives, typical motor power at 400 V

Table 20

Model	Max. output current [A]*	Normal duty (120%, 1 min every 10 min)		Heavy duty (150%, 1 min every 10 min)		Number of PEBB´s **
		Rated current [A]	Power @400V [kW]	Rated current [A]	Power @400V [kW]	
FDUL/VFXR46-250-CL	300	250	132	200	110	2
FDUL/VFXR46-295-CL	354	295	160	236	132	2
FDUL/VFXR46-365-CL	438	365	200	292	160	2
FDUL/VFXR46-590CL	708	590	315	472	250	4
FDUL/VFXR46-730-CL	876	730	400	584	315	4
FDUL/VFXR46-810-CL	972	810	450	648	355	5
FDUL/VFXR46-1010-CL	1212	1010	560	808	450	6
FDUL/VFXR46-1100-CL	1320	1100	630	880	500	6
FDUL/VFXR46-1250-CL	1500	1250	710	1000	560	8
FDUL/VFXR46-1460-CL	1752	1460	800	1168	630	8
FDUL/VFXR46-1710-CL	2052	1710	900	1368	710	9
FDUL/VFXR46-2200-CL	2640	2200	1250	1760	1000	12
FDUL/VFXR46-2500-CL	3000	2500	1350	2000	1120	13

* Available during limited time and as long as allowed by drive temperature.
** PEBB= Power Electronic Building Block (power module).

7.1.2 Slim-AFE drives, typical motor power at 690 V

Table 21

Model	Max. output current [A]*	Normal duty (120%, 1 min every 10 min)		Heavy duty (150%, 1 min every 10 min)		Number of PEBB´s **
		Rated current [A]	Power @690V [kW]	Rated current [A]	Power @690V [kW]	
FDUL/VFXR69-200-CL	240	200	200	160	160	2
FDUL/VFXR69-250-CL	300	250	250	200	200	2
FDUL/VFXR69-500-CL	600	500	500	400	400	4
FDUL/VFXR69-750CL	900	750	710	600	600	6
FDUL/VFXR69-1000-CL	1200	1000	1000	800	800	8
FDUL/VFXR69-1250-CL	1500	1250	1250	1000	1000	11
FDUL/VFXR69-1500-CL	1800	1500	1500	1200	1200	12
FDUL/VFXR69-2000-CL	2400	2000	2000	1600	1600	16
FDUL/VFXR69-3000-CL	3600	3000	3000	2400	2400	24
FDUL/VFXR69-4000-CL	4800	4000	4000	3200	3200	32

* Available during limited time and as long as allowed by drive temperature.

** PEBB= Power Electronic Building Block (power module).

7.1.3 Slim-AFR Regenerative DC-bus supply unit, output DC power at 400 V

Table 22

Model	Max. output current [A]*	Normal duty (120%, 1 min every 10 min)		Heavy duty (150%, 1 min every 10 min)		Number of PEBB´s **
		Rated current [A]	Power @400V [kW]	Rated current [A]	Power @400V [kW]	
AFR46-250-CL	300	250	170	200	136	1
AFR46-365-CL	438	365	248	292	198	1
AFR46-500-CL	600	500	340	400	272	2
AFR46-700-CL	840	700	475	560	380	2
AFR46-885-CL	1062	885	600	708	480	3
AFR46-1050-CL	1260	1050	713	840	570	3
AFR46-1400-CL	1680	1400	950	1120	760	4
AFR46-1770-CL	2124	1770	1200	1416	960	6
AFR46-2100-CL	2520	2100	1425	1680	1140	6

* Available during limited time and as long as allowed by drive temperature.
** PEBB= Power Electronic Building Block (power module).

7.1.4 Slim-AFR Regenerative DC-bus supply unit, output DC power at 690 V

Table 23

Model	Max. output current [A]*	Normal duty (120%, 1 min every 10 min)		Heavy duty (150%, 1 min every 10 min)		Number of PEBB´s **
		Rated current [A]	Power @690V [kW]	Rated current [A]	Power @690V [kW]	
AFR69-175-CL	210	175	205	140	164	1
AFR69-233-CL	280	233	275	186	220	1
AFR69-466-CL	559	466	545	373	436	2
AFR69-700-CL	840	700	820	560	656	3
AFR69-900-CL	1080	900	1050	720	840	4
AFR69-1400-CL	1680	1400	1640	1120	1312	6
AFR69-1800-CL	2160	1800	2100	1440	1680	8
AFR69-2100-CL	2520	2100	2460	1680	1968	9
AFR69-2700-CL	3240	2700	3150	2160	2520	12
AFR69-3600-CL	4320	3600	4200	2880	3360	16

* Available during limited time and as long as allowed by drive temperature.
** PEBB= Power Electronic Building Block (power module).

7.2 Power losses and flow

7.2.1 FDUL/VFXR 400 V units

Table 24

Model	Losses in water (kW)	Losses in air (kW)	Water flow (l/min)
FDUL/VFXR46-250-CL	2,6	1	7
FDUL/VFXR46-295-CL	3,2	1	7
FDUL/VFXR46-365-CL	4	2	7
FDUL/VFXR46-590CL	8	1,5	18
FDUL/VFXR46-730-CL	10	2	19
FDUL/VFXR46-810-CL	11	2,5	22
FDUL/VFXR46-1010-CL	14	3	27
FDUL/VFXR46-1100-CL	16	3,5	28
FDUL/VFXR46-1250-CL	18	4	34
FDUL/VFXR46-1460-CL	21	4,5	38
FDUL/VFXR46-1710-CL	23	5	41
FDUL/VFXR46-2200-CL	31	6	55
FDUL/VFXR46-2500-CL	34	7	58

7.2.2 FDUL/VFXR 690 V units

Table 25

Model	Losses in water (kW)	Losses in air (kW)	Water flow (l/min)
FDUL/VFXR69-200-CL	4	2	7
FDUL/VFXR69-250-CL	5	2	7
FDUL/VFXR69-500-CL	12	1,5	20
FDUL/VFXR69-750CL	18	3,5	28
FDUL/VFXR69-1000-CL	23	4,5	36
FDUL/VFXR69-1250-CL	30	6	52
FDUL/VFXR69-1500-CL	35	7	55
FDUL/VFXR69-2000-CL	46	9	70
FDUL/VFXR69-3000-CL	70	13	106
FDUL/VFXR69-4000-CL	92	18	2x70

7.2.3 AFR 400 V

Table 26

Model	Losses in water (kW)	Losses in air (kW)	Water flow (l/min)
AFR46-250-CL	1,3	1	3,5
AFR46-365-CL	2	0,75	3,5
AFR46-500-CL	4,5	1	7
AFR46-700-CL	6	1,5	11
AFR46-885-CL	8	1,7	17
AFR46-1050-CL	9	2	18
AFR46-1400-CL	12,5	3	24
AFR46-1770-CL	18	3,5	33
AFR46-2100-CL	20	4	35

7.2.4 AFR 690 V

Table 27

Model	Losses in water (kW)	Losses in air (kW)	Water flow (l/min)
AFR69-175-CL	2	1	3,5
AFR69-233-CL	2,5	1,5	3,5
AFR69-466-CL	7	1,3	12
AFR69-700-CL	10	2	18
AFR69-900-CL	13	2,5	22
AFR69-1400-CL	18	4	35
AFR69-1800-CL	26	5	44
AFR69-2100-CL	30	6	53
AFR69-2700-CL	40	7	66
AFR69-3600-CL	53	10	88

7.3 General electrical specifications

General	
Mains voltage: FDUL/VFXR46/AFR46 FDUL/VFXR69/AFR69 Mains frequency: Mains voltage imbalance: Input power factor: Input switching frequency: Output voltage: Output frequency: Output switching frequency: Efficiency at nominal load: Harmonics to supply, THDI:	380-460 V, +10%/-15% 480-690 V, +6%/-15% 48-52 Hz/58-62 Hz max. ±3.0% of nominal phase to phase input voltage. 1.0 3 kHz (0-1.2) x Mains voltage 0–100 Hz (higher frequency on request) 2 kHz for units 46-xxxx 3 kHz for units 69-xxxx 97% for FDUL/VFXR 46/69 98% for AFR 46/69 <5%
Control signal inputs: Analogue (differential)	
Analogue Voltage/current: Max. input voltage: Input impedance: Resolution: Hardware accuracy: Non-linearity	0-±10 V/0-20 mA via switch +30 V/30 mA 40 kohm (voltage) 252 ohm (current) 11 bits + sign 1% type + 1 ½ LSB fsd 1½ LSB
Digital:	
Input voltage: Max. input voltage: Input impedance: Signal delay:	High: >9 VDC, Low: <4 VDC +30 VDC <3.3 VDC: 4.7 kohm ≥3.3 VDC: 3.6 kohm ≤8 ms
Control signal outputs: Analogue	
Output voltage/current: Max. output voltage: Short-circuit current (∞): Output impedance: Resolution: Maximum load impedance for current Hardware accuracy: Offset: Non-linearity:	0-10 V/0-20 mA via software setting +13 V @5 mA cont. +160 mA (voltage), +160 mA (current) 0 ohm (voltage) 10 bit 500 ohm 1.9% type fsd (voltage), 2.4% type fsd (current) 3 LSB 2 LSB
Digital	
Output voltage: Short circuit current(∞):	High: >20 VDC @50 mA, >23 VDC open Low: <1 VDC @50 mA 100 mA max (together with +24 VDC)
Relays	
Contacts	0.1 – 2 A/Umax 250 VAC or 42 VDC (30 VDC acc. to UL requirement) for general Purpose or Resistive use only .
RS-485 communication	
Differential voltage:	-7 V to 12 V
References	
+10VDC -10VDC +24VDC	+10 V_{DC} @10 mA Short-circuit current +30 mA max - 10 V_{DC} @10 mA +24 V_{DC} Short-circuit current +100 mA max (together with Digital Outputs)
Standby supply	
Standby supply input voltage for control unit.	24 VDC ±10% (max 1A consumption)

7.4 Dimensions and Weights

The table below gives an overview of the dimensions and weights.
Protection class IP54 is according to the EN 60529 standard.

Table 28 Mechanical specifications FDUL/VFXR

Models	Width (mm) IP54 Cabinet without heat exchanger section (water/water)	Width (mm) IP54 Cabinet with heat exchanger section (water/water)	Weight cabinet / Weight heat exchanger (water/water) kg (lb)
FDUL/VFXR46-250-CL	600	1000	441 / +170 (972 / +375)
FDUL/VFXR46-295-CL	600	1000	441 / +170 (972 / +375)
FDUL/VFXR46-365-CL	800	1200	468 / +170 (1032 / +375)
FDUL/VFXR46-590CL	1400	1800	722 / + 250 (1592 / +551)
FDUL/VFXR46-730-CL	1600	2000	722 / + 250 (1592 / +551)
FDUL/VFXR46-810-CL	1800	2200	806 / + 250 (1777 / +551)
FDUL/VFXR46-1010-CL	1800	2200	961 / + 250 (2119 / +551)
FDUL/VFXR46-1100-CL	2000	2400	961 / + 250 (2119 / +551)
FDUL/VFXR46-1250-CL	2000	2400	1021 / +250 (2251 / +551)
FDUL/VFXR46-1460-CL	3000	3600	1500 / + 320 (3307/ +705)
FDUL/VFXR46-1710-CL	3200	3800	1500 / + 320 (3307/ +705)
FDUL/VFXR46-2200-CL	3600	4200	1850 / +320 (4079 / +705)
FDUL/VFXR46-2500-CL	3600	4200	1950/ + 320 (4299/ +705)
FDUL/VFXR69-200-CL	600	1000	441 / +170 (972 / +375)
FDUL/VFXR69-250-CL	800	1200	468 / +170 (1032 / +375)
FDUL/VFXR69-500-CL	1200	1600	577 / + 250 (1272 / +551)
FDUL/VFXR69-750CL	1800	2200	961 / + 250 (2119 / +551)
FDUL/VFXR69-1000-CL	1800	2200	1021 / + 250 (2251 / +551)
FDUL/VFXR69-1250-CL	3000	3600	1894 / + 320 (4176 / +705)
FDUL/VFXR69-1500-CL	3400	4000	1774 / +320 (3911 / +705)
FDUL/VFXR69-2000-CL	3600	4200	1951 / + 380 (4301 / +838)
FDUL/VFXR69-3000-CL	5200	6000	2973 / +480 (6554 / +1058)
FDUL/VFXR69-4000-CL	7200	8800	3966 / +2 x 480 (8743 / +2 x 1058)

Cabinets complete with incoming breaker / contactor, LCL-filter, EMC-filter and inverters.

Cabinet H=2200mm / D=600mm

Table 29 Mechanical specifications AFR

Models	Width (mm) IP54 Cabinet without heat exchanger section (water/water)	Width (mm) IP54 Cabinet with heat exchanger section (water/water)	Weight cabinet / Weight heat exchanger (water/water) kg (lb)
AFR46-250-CL	600	1000	369 / +170 (813 / +375)
AFR46-365-CL	600	1000	392 / +170 (864 / +375)
AFR46-500-CL	1000	1400	520 / +170 (1146 / +375)
AFR46-700-CL	1200	1600	570 / + 250 (1257 / +551)
AFR46-885-CL	1200	1600	720 / + 250 (1587 / +551)
AFR46-1050-CL	1400	1800	720 / + 250 (1587 / +551)
AFR46-1400-CL	2400	2800	950 / +250 (2094 / +551)
AFR46-1770-CL	2400	3000	1370 / + 320 (3020 / +705)
AFR46-2100-CL	2400	3000	1370 / + 320 (3020 / +705)
AFR69-175-CL	600	1000	369 / +170 (813 / +375)
AFR69-233-CL	800	1200	419 / +170 (924 / +375)
AFR69-466-CL	1000	1400	517 / +170 (1139 / +375)
AFR69-700-CL	1200	1600	700 / +250 (1543 / +551)
AFR69-900-CL	1200	1600	729 / +250 (1607 / +551)
AFR69-1400-CL	2200	2600	1370 / +250 (3020 / +551)
AFR69-1800-CL	2400	2800	1397 / +250 (3080 / +551)
AFR69-2100-CL	3400	4000	1956 / +320 (4312 / +705)
AFR69-2700-CL	3400	4000	2046 / +320 (4511 / +705)
AFR69-3600-CL	4800	5600	2774 / +350 (6116 /+772)

NOTE:
A connection cabinet is needed if for example a battery system is connected to the DC busbars at the top of the cabinet. Contact the supplier.

7.5 Derating

Derating of output current is possible with -1% / degree Celsius to max +10 °C * (= max temp 55 °C ambient) or - 055% / degree Fahrenheit to max +18 °F (=max temp 131 °F).

7.6 Environmental conditions

Table 30

Parameter	Normal operation
Nominal ambient temperature	See section 7.5 page 41 for different conditions 0 °C - 45 °C (32 °F - 113 °F)
Atmospheric pressure	86–106 kPa (12.5 - 15.4 PSI)
Relative humidity according to IEC 60721-3-3	Class 3K4, 5...95% and non condensing
Contamination, according to IEC 60721-3-3	No electrically conductive dust allowed. Cooling air must be clean and free from corrosive materials. Chemical gases, class 3C2. Solid particles, class 3S2.
Vibrations	According to IEC 60068-2-6, Sinusodial vibrations: 10<f<57 Hz, 0.075 mm (0.00295 ft) 57<f<150 Hz, 1g (0,035 oz)
Altitude	0–1000 m (0 - 3280 ft) 480V AC drives, with derating 1%/100 m (328 ft) of rated current up to 4000 m (13123 ft) 690V AC drives, with derating 1%/100 m (328 ft) of rated current up to 2000 m (6562) ft Coated boards required for 2000 - 4000 m(6562 - 13123 ft)

Table 31

Parameter	Storage condition
Temperature	-20 to +60 °C (-4 to + 140 °F)
Atmospheric pressure	86–106 kPa (12.5 - 15.4 PSI)
Relative humidity according to IEC 60721-3-1	Class 1K4, max. 95% and non condensing and no formation of ice.

WARNING!
If the device is stored for more than two years, the DC link capacitor of the devices must be reformed during commissioning.
The reforming procedure is described in manual “Capacitor reforming unit”.

7.7 Water cooling

7.7.1 Option Water/ Water- cooling section including IP54 cabinet

The cooling section includes heat exchanger, pump, pump inverter, expansion tank, valves and cabinet.

Table 32

Max water pressure in	4 bar
Max inlet water temperature	35 °C
Pipe coupling dimension for in and out water	G1”

Table 33

Cooling section	Max power losses in kW (to water)	Water flow in l/min	Cabinet dimensions HxWxD (mm)	Cabinet dimensions with redundant pumps HxWxD (mm)
Cooling section 12 kW	12	20	2200x400x600	2200x400x600
Cooling section 24 kW	24	50	2200x400x600	2200x600x600
Cooling section 30 kW	30	50	2200x400x600	2200x600x600
Cooling section 48 kW	48	80	2200x600x600	2200x600x600
Cooling section 55kW	50	100	2200x800x600	2200x1000x600
Cooling section 70kW	70	120	2200x800x600	2200x1000x600

7.7.2 Cooling water data

Material used in external water connections = Brass.

Ambient conditions:

- Temp: +0 – +45°C
- RH: 5–90%, no condensation allowed

Pressure ratings primary circuit:

- max. working pressure 4 bar
- max. peak pressure 7 bar.
- System pressure drop 1.5 - 2 bar.

Temperature ratings cooling liquid:

- max. outlet temperature 65 °C
- Input temperature must be higher as ambient temperature to prevent condensation.

Required flow of liquid cooling:

- Approximately 4 l/min per PEBB
- Range 3 – 15 l/min per PEBB

Water volume:

- 4 l per PEBB
- 7 l per LCL-filter

Anti corrosion inhibitor:

- Open-loop system
  Cortec VpCI-647
  Ferrofos 8500
- Closed-loop system
  Cortec VpCI-649
  Ferrolix 335
- Mixture water/inhibitor: depending on the mixture glycol/water and type of system (open / closed), advice is to check supplier of inhibitor for the exact values.

Antifreeze protection:

- Antifrogen with an active substance glycol; e.g. available from Clariant (www.clariant.com).
- Mixture water/antifreeze: depending on the mixture glycol/water, type of inhibitor and type of system (open / closed), advice is to check supplier of glycol for the exact values.
  Typical use water/antifreeze mixture of 70 % water and 30 % glycol.

7.7.3 Cooling water specification

Table 34 Specification water quality

Quality	Value	Unit
pH	6....8	
Hardness of liquid	3....8	°dH
Free carbon dioxide	8....15	mg/dm^3
Associated carbon dioxide	8....16	mg/dm^3
Aggressive carbon dioxide	0	mg/dm^3
Sulphides free	free	
Oxygen	<10	mg/dm^3
Chlorides ions	<40	ppm
Sulphate ions	<50	ppm
Nitrates and nitrites	<10	mg/dm^3
COD	<7	mg/dm^3
Ammonia	<5	mg/dm^3
Iron, Fe	0.2	mg/dm^3
Manganese	0.2	mg/dm^3
Conductivity	<400	µS/cm
Solid residue from evaporation	<500	mg/dm^3
Potassium permanganate consumption	<25	mg/dm^3
Suspended matter	<3	mg/dm^3
Maximum particle size	<100	µm
Dissolved substances	<340	ppm

7.8 DC fuses for VSI units

For VSI drive units connected to the DC bus, use standard Emotron FDU/VFX 2.1 drive units equipped with optional DC+/DC- terminals. See FDU/VFX Technical Catalogue 01-4948-01 for drive unit selection.

Each VSI drive unit connected to the DC-bus should be fed via DC fuses. No DC switches to be used. For selection of correct DC fuse type and size, see table 35 below.

NOTE: VSI fuses below assumes using Emotron AFR DC-bus feeder, also with DC-fuses.

Table 35 Recommended DC fuses for connected VSI drive units.

VSI model	Frame	Recommended DC fuses F_{DC} (A)	Bussman type
FDU/VFX48/52-003	B	25	170M4803
FDU/VFX48/52-004, 006	B	25	170M4803
FDU/VFX48/52-008, 010	B	25	170M4803
FDU/VFX48/52-013, 018	B	40	170M4806
FDU/VFX48/52-026, 031	C	80	170M4809
FDU/VFX48-025, 030	C2	80	170M4809
FDU/VFX48/52-037 046	C	80	170M4809
FDU/VFX48-036, 045	C2	100	170M4810
FDU/VFX48/52-061, 074	D	160	170M4810
FDU/VFX48-060, 072	D2	160	170M4812
FDU/VFX48-088	D2	200	170M4812
FDU/VFX48-090, 109	E	200	170M4813
FDU/VFX48-106	E2	200	170M4813
FDU/VFX48-142, 171	E2	315	170M4815
FDU/VFX48-146, 175	E	315	170M4815
FDU/VFX48-205, 244	F2	400	170M4821
FDU/VFX48-210, 250	F	400	170M4821
PEBB48-175/VSI	E	315	170M4815
PEBB48-250/VSI	F	400	170M4821
FDU/VFX69-090	F69	200	170M4813
FDU/VFX69-109	F69	200	170M4813
FDU/VFX69-146	F69	315	170M4815
FDU/VFX69-175	F69	315	170M4815
FDU/VFX69-200	F69	400	170M4821
PEBB48-295/VSI	G1	630	A070UD32KI630*
PEBB48-365/VSI	H1	630	A070UD32KI630*
PEBB69-200/VSI	F69	400	170M4821

* Mersen type

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Instruction manual: 01-7694-01r0
2022-06-01