ENGINEERING TOMORROW

Design Guide

VLT® Compressor Drive CDS 803

drives.danfoss.com | VLT®

Contents

1 Introduction

1.1 Purpose of this Design Guide

This Design Guide is intended for qualified personnel, such as:

- Project and systems engineers.
- Design consultants.
- Application and product specialists.

The Design Guide provides technical information to understand the capabilities of the VLT® Compressor Drive CDS 803 for integration into motor control and monitoring systems. Its purpose is to provide design considerations and planning data for integration of the drive into a system. It caters for selection of drives and options for a diversity of applications and installations. Reviewing the detailed product information in the design stage enables developing a well-conceived system with optimal functionality and efficiency.

This manual is targeted at a worldwide audience. Therefore, wherever occurring, both SI and imperial units are shown.

1.2 Trademarks

VLT® is a registered trademark for Danfoss A/S.

1.3 Additional Resources

Other resources are available to understand advanced drive functions and programming.

- The Programming Guide provides greater detail on working with parameters and shows many application examples.
- The Operating Guide provides detailed information about installation and commissioning of the drive.
- Supplementary publications and manuals are available from Danfoss .

See www.danfoss.com for supplementary documentation.

VLT® Motion Control Tool MCT 10 software support

Download the software from the Service and Support download page on www.danfoss.com.

During the installation process of the software, enter CD-key 34544400 to activate the CDS 803 functionality. An activation key is not required for using the CDS 803 functionality.

The latest software does not always contain the latest updates for the drive. Contact the local sales office for the latest drive updates (in the form of *.upd files), or download the drive updates from the Service and Support download page on www.danfoss.com.

1.4 Manual and Software Version

This manual is regularly reviewed and updated. All suggestions for improvement are welcome.

Table 1: Manual and Software Version

Edition	Remarks	Software version
AJ330233902305, version 0101	New power sizes added to product range.	6.0–10 kW (8–15 hp): Version 2.0 18–30 kW (25–40 hp): Version 1.00

2 Safety

2.1 Safety Symbols

The following symbols are used in this manual:

DANGER

Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

Indicates information considered important, but not hazard-related (for example, messages relating to property damage).

2.2 Qualified Personnel

To allow trouble-free and safe operation of the unit, only qualified personnel with proven skills are allowed to transport, store, assemble, install, program, commission, maintain, and decommission this equipment.

Persons with proven skills:

- Are qualified electrical engineers, or persons who have received training from qualified electrical engineers and are suitably experienced to operate devices, systems, plant, and machinery in accordance with pertinent laws and regulations.
- Are familiar with the basic regulations concerning health and safety/accident prevention.
- Have read and understood the safety guidelines given in all manuals provided with the unit, especially the instructions given in the Operating Guide.
- Have good knowledge of the generic and specialist standards applicable to the specific application.

2.3 Safety Precautions

WARNING

HIGH VOLTAGE

AC drives contain high voltage when connected to AC mains input, DC supply, or load sharing. Failure to perform installation, start-up, and maintenance by qualified personnel can result in death or serious injury.

- Only qualified personnel must perform installation, start-up, and maintenance.

WARNING

UNINTENDED START

When the drive is connected to AC mains, DC supply, or load sharing, the motor may start at any time. Unintended start during programming, service, or repair work can result in death, serious injury, or property damage. Start the motor with an external switch, a fieldbus command, an input reference signal from the local control panel (LCP), via remote operation using MCT 10 software, or after a cleared fault condition.

- Disconnect the drive from the mains.
- Press [Off/Reset] on the LCP before programming parameters.
- Ensure that the drive is fully wired and assembled when it is connected to AC mains, DC supply, or load sharing.

⚠ W A R N I N G ⚠

DISCHARGE TIME

The drive contains DC-link capacitors, which can remain charged even when the drive is not powered. High voltage can be present even when the warning indicator lights are off.

Failure to wait the specified time after power has been removed before performing service or repair work could result in death or serious injury.

- Stop the motor.
- Disconnect AC mains, permanent magnet type motors, and remote DC-link supplies, including battery back-ups, UPS, and DC-link connections to other drives.
- Wait for the capacitors to discharge fully. The minimum waiting time is specified in the table *Discharge time* and is also visible on the nameplate on top of the drive.
- Before performing any service or repair work, use an appropriate voltage measuring device to make sure that the capacitors are fully discharged.

Table 2: Discharge Time

Voltage [V]	Power range [kW (hp)]	Minimum waiting time (minutes)
3x200	6.0–10 (8.0–15)	15
3x400	6.0–7.5 (8.0–10)	4
3x400	10–30 (15–40)	15

⚠ W A R N I N G ⚠

LEAKAGE CURRENT HAZARD

Leakage currents exceed 3.5 mA. Failure to ground the drive properly can result in death or serious injury.

- Ensure the correct grounding of the equipment by a certified electrical installer.

⚠ W A R N I N G ⚠

EQUIPMENT HAZARD

Contact with rotating shafts and electrical equipment can result in death or serious injury.

- Ensure that only trained and qualified personnel perform installation, start-up, and maintenance.
- Ensure that electrical work conforms to national and local electrical codes.
- Follow the procedures in this manual.

⚠ C A U T I O N ⚠

INTERNAL FAILURE HAZARD

An internal failure in the drive can result in serious injury when the drive is not properly closed.

- Ensure that all safety covers are in place and securely fastened before applying power.

3 Approvals and Certifications

3.1 CE Mark

The drive complies with relevant directives and their related standards for the extended Single Market in the European Economic Area.

Table 3: EU Directives Applicable to Drives

EU Directive	Version
Low Voltage Directive	2014/35/EU
EMC Directive	2014/30/EU
ErP Directive	2009/125/EU

3.2 Low Voltage Directive

The aim of the Low Voltage Directive is to protect persons, domestic animals and property against dangers caused by the electrical equipment, when operating electrical equipment that is installed and maintained correctly, in its intended application. The directive applies to all electrical equipment in the 50–1000 V AC and the 75–1500 V DC voltage ranges.

3.3 EMC Directive

The purpose of the EMC (electromagnetic compatibility) Directive is to reduce electromagnetic interference and enhance immunity of electrical equipment and installations. The basic protection requirement of the EMC Directive states that devices that generate electromagnetic interference (EMI), or whose operation could be affected by EMI, must be designed to limit the generation of electromagnetic interference and shall have a suitable degree of immunity to EMI when properly installed, maintained, and used as intended. Electrical equipment devices used alone or as part of a system must bear the CE mark. Systems do not require the CE mark, but must comply with the basic protection requirements of the EMC Directive.

3.4 ErP Directive

The ErP Directive is the European Ecodesign Directive for energy-related products. The directive sets ecodesign requirements for energy-related products, including drives, and aims at reducing the energy consumption and environmental impact of products by establishing minimum energy-efficiency standards.

3.5 UL Listing

The Underwriters Laboratory (UL) mark indicates the safety of products and their environmental claims based on standardized testing. Drives of voltage 525–690 V are UL-certified for only 525–600 V. The drive complies with UL 61800-5-1 thermal memory retention requirements.

3.6 UL Recognized

UL recognized products are UL approved components which cannot be used as standalone products. When UL recognized components are used in an end product, that end product complies with UL requirements.

The VLT® Compressor Drive CDS 803 , S096 (18–30 kW (22–40 hp)) is UL recognized and complies with UL 60730.

3.7 RCM Mark Compliance

Illustration 1: RCM Mark

The RCM Mark label indicates compliance with the applicable technical standards for Electromagnetic Compatibility (EMC). An RCM Mark label is required for placing electrical and electronic devices on the market in Australia and New Zealand. The RCM Mark regulatory arrangements only deal with conducted and radiated emission. For drives, the emission limits specified in EN/IEC 61800-3 apply. A declaration of conformity can be provided on request.

3.8 EAC

Illustration 2: EAC Mark

The EurAsian Conformity (EAC) Mark indicates that the product conforms to all requirements and technical regulations applicable to the product per the EurAsian Customs Union, which is composed of the member states of the EurAsian Economic Union.

The EAC logo must be both on the product label and on the packaging label. All products used within the EAC area must be bought at Danfoss inside the EAC area.

3.9 UkrSEPRO

Illustration 3: UkrSEPRO Mark

The UkrSEPRO certificate indicates quality and safety of both products and services, in addition to manufacturing stability according to Ukrainian regulatory standards. The UkrSEPRO certificate is a required document to clear customs for any products coming into and out of the territory of Ukraine.

4 Specifications

4.1 Mains Supply 3x200–240 V AC

Table 4: 3x200–240 V AC

Drive	4 TR/VZH028	5 TR/VZH035	6.5 TR/VZH044
Typical shaft output [kW]	6.0	7.5	10
IP20 enclosure protection rating	H4	H4	H5
Maximum cable size in terminals (mains, compressor) [mm^2/AWG]	16/6	16/6	16/6
Output current			
Continuous (3x200–240 V) [A]	20.7	25.9	33.7
Intermittent (3x200–240 V) [A]	–	–	37.1
Maximum input current			
Continuous (3x200–240 V) [A]	23	28.3	37
Intermittent (3x200–240 V) [A]	–	–	41.5
Maximum mains fuses, see 6.8.5 Recommendation of Fuses			
Estimated power loss [W], best case/typical[1]	182/204	229/268	369/386
Weight enclosure protection IP20 [kg/(lb)]	7.9 (17.4)	7.9 (17.4)	9.5 (21)
Efficiency [%], best case/typical[1]	97.3/97	98.5/97.1	97.2/97.1

[1] At rated load conditions.

4.2 Mains Supply 3x380–480 V AC

Table 5: 3x380–480 V AC

Drive	4 TR/VZH028	5 TR/VZH035	6.5 TR/VZH044	13 TR/VZH088	17 TR/VZH117	26 TR/ VZH170
Typical shaft output [kW]	6.0	7.5	10	18.5	22.0	30.0
Typical shaft output [hp]	8.0	10	15	25	30	40
Protection rating IP20	H3	H3	H4	H5	H5	H6
Maximum cable size in terminals (mains, motor) [mm^2 (AWG)]	4/10	4/10	16/6	16 (6)	16 (6)	35 (2)
Output current - 40 °C (104 °F) ambient temperature						
Continuous (3x380–440 V) [A]	11.6	14.3	16.4	37	44	61
Intermittent (3x380–440 V) [A]	–	–	18	40.7	46.8	67.1
Continuous (3x441–480 V) [A]	9.8	12.3	15.5	34	40	52

Drive	4 TR/VZH028	5 TR/VZH035	6.5 TR/VZH044	13 TR/VZH088	17 TR/VZH117	26 TR/ VZH170
Intermittent (3x441–480 V) [A]	–	–	17	37.4	44	57.2
Output current - 50 °C (122 °F) ambient temperature						
Continuous (3x380–440 V) [A]				34.1	38	48.8
Intermittent (3x380–440 V) [A]				37.5	41.8	53.7
Continuous (3x441–480 V) [A]				31.3	35	41.6
Intermittent (3x441–480 V) [A]				34.4	38.5	45.8
Maximum input current						
Continuous (3x380–440 V) [A]	12.7	15.1	18	35.2	42.6	57
Intermittent (3x380–440 V) [A]	–	–	19.8	38.7	45.7	62.7
Continuous (3x441–480 V) [A]	10.8	12.6	17	29.3	34.6	49.2
Intermittent (3x441–480 V) [A]	–	–	18.7	32.2	38.1	54.1
Maximum mains fuses, see 6.8.5 Recommendation of Fuses.						
Estimated power loss [W], best case/typical[1]	104/131	159/198	248/274	412/456	475/523	733
Weight enclosure protection rating IP20 [kg (lb)]	4.3 (9.5)	4.3 (9.5)	7.9 (17.4)	9.5 (20.9)	9.5 (20.9)	24.5 (54)
Efficiency [%], best case/ typical[2]	98.4/98	98.2/97.8	98.1/97.9	98.1/97.9	98.1/97.9	97.8

[1] Applies to dimensioning of drive cooling. If the switching frequency is higher than the default setting, the power losses may increase. LCP and typical control card power consumptions are included. For power loss data according to EN 50598-2, refer to the section on energy efficiency at www.danfoss.com.

[2] Efficiency measured at nominal current. For energy efficiency class, see 4.3.14 Ambient Conditions. For part load losses, see the section on energy efficiency at www.danfoss.com.

4.3 General Technical Data

4.3.1 Protection and Features

- Electronic compressor thermal protection against overload.
- Temperature monitoring of the heat sink ensures that the drive trips if there is overtemperature.
- The drive is protected against short circuits between compressor terminals U, V, W.
- When a compressor phase is missing, the drive trips and issues an alarm.
- When a mains phase is missing, the drive trips or issues a warning (depending on the load).

- Monitoring of the DC-link voltage ensures that the drive trips when the DC-link voltage is too low or too high.
- The drive is protected against ground faults on compressor terminals U, V, W.

4.3.2 Mains Supply (L1, L2, L3)

Supply voltage	200–240 V ±10%
Supply voltage	380–480 V ±10%
Supply frequency	50/60 Hz
Maximum imbalance temporary between mains phases	3.0% of rated supply voltage
True power factor (λ)	≥0.9 nominal at rated load
Displacement power factor (cosφ) near unity	(>0.98)
Switching on the input supply L1, L2, L3 (power-ups)	Maximum 2 times/minute
Environment according to EN 60664-1	Overvoltage category III/pollution degree 2
The unit is suitable for use on a circuit capable of delivering not more than 100000 A_{rms} symmetrical Amperes, 240/480 V maximum.	

4.3.3 Compressor Output (U, V, W)

Output voltage	0–100% of supply voltage
Output frequency	0–200 Hz (VVC^{+}), 0–400 Hz (u/f)
Switching on output	Unlimited
Ramp times	0.05–3600 s

4.3.4 Cable Lengths and Cross-sections

Maximum compressor cable length, shielded/armored (EMC-correct installation)	See 6.2.3 EMC Emission Test Results.
Maximum compressor cable length, unshielded/unarmoured	50 m (164 ft)
Maximum cross-section to compressor, mains	See 4.2 Mains Supply 3x380–480 V AC for more information
Cross-section DC terminals for filter feedback on enclosure size H3	4 mm^2/11 AWG
Cross-section DC terminals for filter feedback on enclosure sizes H4–H6	16 mm^2/6 AWG
Maximum cross-section to control terminals, rigid wire	2.5 mm^2/14 AWG
Maximum cross-section to control terminals, flexible wire	2.5 mm^2/14 AWG
Minimum cross-section to control terminals	0.05 mm^2/30 AWG

4.3.5 Digital Inputs

Programmable digital inputs	4
Terminal number	18, 19, 27, 29
Logic	PNP or NPN
Voltage level	0–24 V DC
Voltage level, logic 0 PNP	<5 V DC
Voltage level, logic 1 PNP	>10 V DC
Voltage level, logic 0 NPN	>19 V DC
Voltage level, logic 1 NPN	<14 V DC
Maximum voltage on input	28 V DC
Input resistance, R_i	Approximately 4 kΩ
Digital input 29 as thermistor input	Fault: >2.9 kΩ and no fault: <800 Ω
Digital input 29 as pulse input	Maximum frequency 32 kHz push-pull-driven & 5 kHz (O.C.)

4.3.6 Analog Inputs

Number of analog inputs	2
Terminal number	53, 54
Terminal 53 mode	*Parameter 6-61 Terminal 53 Setting*: 1=voltage, 0=current
Terminal 54 mode	*Parameter 6-63 Terminal 54 Setting*: 1=voltage, 0=current
Voltage level	0–10 V
Input resistance, R_i	Approximately 10 kΩ
Maximum voltage	20 V
Current level	0/4–20 mA (scalable)
Input resistance, R_i	<500 Ω
Maximum current	29 mA
Resolution on analog input	10 bit

4.3.7 Analog Outputs

Number of programmable analog outputs	2
Terminal number	42, 45[1]
Current range at analog output	0/4–20 mA
The load resistor to common at analog out	500 Ω
Maximum voltage at analog output	17 V
Accuracy on analog output	Maximum error: 0.4% of full scale
Resolution on analog output	10 bit

[1] Terminals 42 and 45 can also be programmed as digital outputs.

4.3.8 Digital Outputs

Number of digital outputs	4
Terminals 27 and 29	
Terminal number	27, 29[1]
Voltage level at digital output	0–24 V
Maximum output current (sink and source)	40 mA
Terminals 42 and 45	
Terminal number	42, 45[2]
Voltage level at digital output	17 V
Maximum output current at digital output	20 mA
The load resistor at digital output	1 kΩ

[1] Terminals 27 and 29 can also be programmed as input.

[2] Terminals 42 and 45 can also be programmed as analog output.

The digital outputs are galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

4.3.9 Control Card, RS485 Serial Communication

Terminal number	68 (P, TX+, RX+), 69 (N, TX-, RX-)
Terminal number	61 common for terminals 68 and 69

4.3.10 Control Card, 24 V DC Output

Terminal number	12
Maximum load	80 mA

4.3.11 Relay Outputs, Enclosure Sizes H3–H5

Programmable relay output	2
Relay 01 and 02, enclosure sizes H3–H5	01–03 (NC), 01–02 (NO), 04–06 (NC), 04–05 (NO)
Maximum terminal load (AC-1)[1] on 01–02/04–05 (NO) (Resistive load)	250 V AC, 3 A
Maximum terminal load (AC-15)[1] on 01–02/04–05 (NO) (Inductive load @ cosφ 0.4)	250 V AC, 0.2 A
Maximum terminal load (DC-1)[1] on 01–02/04–05 (NO) (Resistive load)	30 V DC, 2 A
Maximum terminal load (DC-13)[1] on 01–02/04–05 (NO) (Inductive load)	24 V DC, 0.1 A
Maximum terminal load (AC-1)[1] on 01–03/04–06 (NC) (Resistive load)	250 V AC, 3 A
Maximum terminal load (AC-15)[1] on 01–03/04–06 (NC) (Inductive load @ cosφ 0.4)	250 V AC, 0.2 A
Maximum terminal load (DC-1)[1] on 01–03/04–06 (NC) (Resistive load)	30 V DC, 2 A
Minimum terminal load on 01–03 (NC), 01–02 (NO)	24 V DC 10 mA, 24 V AC 20 mA
Environment according to EN 60664-1	Overvoltage category III/pollution degree 2

[1] IEC 60947 parts 4 and 5. Endurance of the relay varies with different load type, switching current, ambient temperature, driving configuration, working profile, and so forth. Mount a snubber circuit when connecting inductive loads to the relays.

4.3.12 Relay Outputs, Enclosure Size H6

Programmable relay output	2
Relay 01 and 02	01–03 (NC), 01–02 (NO), 04–06 (NC), 04–05 (NO)
Maximum terminal load (AC-1)[1] on 04–05 (NO) (Resistive load)[2] [3]	400 V AC, 2 A
Maximum terminal load (AC-15)[1] on 04–05 (NO) (Inductive load @ cosφ 0.4)	240 V AC, 0.2 A
Maximum terminal load (DC-1)[1] on 04–05 (NO) (Resistive load)	80 V DC, 2 A
Maximum terminal load (DC-13)[1] on 04–05 (NO) (Inductive load)	24 V DC, 0.1 A
Maximum terminal load (AC-1)[1] on 04–06 (NC) (Resistive load)	240 V AC, 4 A
Maximum terminal load (AC-15)[1] on 04–06 (NC) (Inductive load @ cosφ 0.4)	240 V AC, 0.2 A
Maximum terminal load (DC-1)[1] on 04–06 (NC) (Resistive load)	50 V DC, 2 A
Maximum terminal load (DC-13)[1] on 04–06 (NC) (Inductive load)	24 V DC, 0.1 A
Minimum terminal load on 01–03 (NC), 01–02 (NO), 04–06 (NC), 04–05 (NO)	24 V DC 10 mA, 24 V AC 20 mA
Environment according to EN 60664-1	Overvoltage category III/pollution degree 2

[1] IEC 60947 parts 4 and 5. Endurance of the relay varies with different load type, switching current, ambient temperature, driving configuration, working profile, and so forth. Mount a snubber circuit when connecting inductive loads to the relays.

[2] Overvoltage Category II.

[3] UL applications 300 V AC 2 AC.

4.3.13 Control Card, 10 V DC Output

Terminal number	50
Output voltage	10.5 V ±0.5 V
Maximum load	25 mA

4.3.14 Ambient Conditions

Enclosure protection rating	IP20
Enclosure kit available	IP21, TYPE 1
Vibration test	1.0 g
Maximum relative humidity	5–95% (IEC 60721-3-3; Class 3K3 (non-condensing) during operation)
Aggressive environment (IEC 60721-3-3), coated (standard), enclosure sizes H3–H5	Class 3C3
Aggressive environment (IEC 60721-3-3), non-coated enclosure size H6	Class 3C2
Test method according to IEC 60068-2-43 H2S (10 days)	
Ambient temperature, enclosure sizes H3–H5 (6–10 kW (8–15 hp)) (1)	50 °C (122 °F)
Ambient temperature, enclosure size H5 (18–22 kW (25–30 hp))	52 °C (125 °F)
Ambient temperature, enclosure size H6	45 °C (113 °F)
Minimum ambient temperature during full-scale operation	0 °C (32 °F)
Minimum ambient temperature at reduced performance, enclosure sizes H3–H5	-20 °C (-4 °F)
Minimum ambient temperature at reduced performance, enclosure size H6	-10 °C (14 °F)
Temperature during storage/transport	-30 to +65/70 °C (-22 to +149/158°F)
Maximum altitude above sea level without derating	1000 m (3281 ft)
Maximum altitude above sea level with derating	3000 m (9843 ft)
Derating for high altitude, see the Derating section.	
Safety standards	EN/IEC 61800-5-1, UL 508C, EN/IEC/UL 60730-1
EMC standards, Emission	EN 61800-3, EN 61000-6-3/4, EN 55011, IEC 61800-3
EMC standards, Immunity	EN 61800-3, EN 61000-3-12, EN 61000-6-1/2, EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6
Energy efficiency class(2)	IE2

1 Refer to the Derating section for:

- Derating for high ambient temperature.
- Derating for high altitude.

2 Determined according to EN 50598-2 at:

- Rated load.
- 90% rated frequency.
- Switching frequency factory setting.
- Switching pattern factory setting.

NOTICE

The VLT® Compressor Drive CDS803 with S096 in the type code (400 V, 18–30 kW (25–40 hp) is certified to UL/EN/IEC 60730-1. The drive is also designed for systems compliant to UL/IEC/EN 60335.

4.4 Acoustic Noise or Vibration

If the compressor or the equipment driven by the compressor, for example a fan, is making noise or vibrations at certain frequencies, configure the following parameters or parameter groups to reduce or eliminate the noise or vibrations:

- *Parameter group 4-6* Speed Bypass*.
- Set *parameter 14-03 Overmodulation* to *[0] Off*.
- Switching pattern and switching frequency, *parameter group 14-0* Inverter Switching*.
- *Parameter 1-64 Resonance Dampening*.

Acoustic noise from the drives comes from 3 sources:

- DC-link coils
- Integral fan
- RFI filter inductor

Table 6: Typical Values Measured at a Distance of 1 m (3.3 ft) from the Unit

Enclosure	Level [dBA]
H3	53.8
H4	64
H5	63.7
H6	71.5

4.5 Shipping Dimensions

Table 7: Shipping Dimensions

Enclosure size	T2 (200–240 V AC) [kW (hp)]	T4 (380–480 V AC) [kW (hp)]	T6 (525–600 V AC) [kW (hp)]	IP frame	Maximum weight [kg (lb)]	Height [mm (in)]	Width [mm (in)]	Depth [mm (in)]
H3	3.7 (5)	5.5–7.5 (7.5–10)	–	IP20	4.5 (9.9)	280 (11.0)	155 (6.1)	320 (12.6)
H4	5.5–7.5 (7.5–10)	11–15 (15–20)	–	IP20	7.9 (17.4)	380 (15.0)	200 (7.9)	315 (12.4)
H5	11 (15)	18.5–22 (25–30)	–	IP20	9.5 (20.9)	395 (15.6)	233 (9.2)	380 (15.0)
H6	15–18.5 (20–25)	30–45 (40–60)	18.5–30 (25–40)	IP20	24.5 (54.0)	850 (33.5)	370 (15.6)	460 (18.1)

5 Mechanical Installation Considerations

5.1 Storage

Store the drive in a dry location and keep the equipment sealed in its packaging until installation. Periodic forming (capacitor charging) is not necessary during storage unless storage exceeds 12 months.

If shelf life is longer than 4 years, a simple method, under no load conditions, can be used to check the condition of the capacitors.

If the stable DC-link voltage is approximately equal to 1.41 x U_{mains}, the capacitors are OK. To check the DC-link voltage in the drive, either measure it or check the corresponding parameters in the display.

If the DC-link voltage is significantly smaller than 1.41 x U_{mains}, it takes time for the capacitors to recover. If the DC-link voltage stays at a low level and does not reach approximately 1.41 x U_{mains} , contact the local service agent.

5.2 Operating Environment

In environments with airborne liquids, particles, or corrosive gases, ensure that the IP/Type rating of the equipment matches the installation environment. For specifications regarding ambient conditions, see 4.3.14 Ambient Conditions.

N O T I C E

CONDENSATION

Moisture can condense on the electronic components and cause short circuits. Avoid installation in areas subject to frost. Install an optional space heater when the drive is colder than the ambient air. Operating in standby mode reduces the risk of condensation as long as the power dissipation keeps the circuitry free of moisture.

N O T I C E

EXTREME AMBIENT CONDITIONS

Hot or cold temperatures compromise unit performance and longevity.

- Do not operate in environments where the ambient temperature exceeds 55 °C (131 °F).
- The drive can operate at temperatures down to -10 °C (14 °F). However, proper operation at rated load is only guaranteed at 0 °C (32 °F) or higher.
- If the temperature exceeds ambient temperature limits, extra air conditioning of the cabinet or installation site is required.

5.2.1 Gases

Aggressive gases, such as hydrogen sulfide, chlorine, or ammonia, can damage electrical and mechanical components of a drive. Contamination of the cooling air can also cause the gradual decomposition of PCB tracks and door seals. Aggressive contaminants are often present in sewage treatment plants or swimming pools. A clear sign of an aggressive atmosphere is corroded copper.

In aggressive atmospheres, restricted IP enclosures are recommended along with conformal-coated circuit boards.

Table 8: Conformal Coating Class Ratings

Gas type	Unit	Class	
		3C3	
		Average value	Maximum value(1)
Sea salt	n/a	Salt mist	
Sulfur oxide	mg/m^3	5.0	10
Hydrogen sulfide	mg/m^3	3.0	10
Chlorine	mg/m^3	0.3	1.0
Hydrogen chloride	mg/m^3	1.0	5.0
Hydrogen fluoride	mg/m^3	0.1	3.0
Ammonia	mg/m^3	10	35

Gas type	Unit	Class	
Ozone	mg/m^3	0.1	0.3
Nitrogen	mg/m^3	3.0	9.0

[1] Maximum values are transient peak values and are not to exceed 30 minutes per day.

5.2.2 Dust

Installation of drives in environments with high dust exposure is often unavoidable. Consider the following when installing drives in such environments:

- Reduced cooling.
- Cooling fans.
- Periodic maintenance.

Reduced cooling

Dust forms deposits on the surface of the device and inside on the circuit boards and the electronic components. These deposits act as insulation layers and hamper heat transfer to the ambient air, reducing the cooling capacity. The components become warmer. This causes accelerated aging of the electronic components and the service life of the unit decreases. Dust deposits on the heat sink in the back of the unit also decrease the service life of the unit.

Cooling fans

The airflow for cooling the unit is produced by cooling fans, usually on the back of the unit. The fan rotors have small bearings into which dust can penetrate and act as an abrasive. This leads to bearing damage and fan failure.

Periodic maintenance

Under the conditions described above, it is recommended to clean the drive during periodic maintenance. Remove dust from the heat sink and fans.

5.2.3 Air Humidity

The drive has been designed to meet the IEC/EN 60068-2-3 standard, EN 50178 9.4.2.2 at 50 °C (122 °F).

5.2.4 Vibration and Shock

The drive has been tested according to the following standards:

- IEC/EN 60068-2-6: Vibration (sinusoidal) - 1970
- IEC/EN 60068-2-64: Vibration, broad-band random

The drive complies with the requirements that exist for units mounted on the walls and floors of production premises, and in panels bolted to walls or floors.

5.3 Derating according to Ambient Temperature and Switching Frequency

5.3.1 Derating Curves, 6.0, 7.5, and 10 kW Drives

The ambient temperature measured over 24 hours should be at least 5 °C (41 °F) lower than the maximum ambient temperature. If the drive is operated at high ambient temperature, decrease the constant output current. If the ambient temperature is higher than 50 °C (122 °F) or the installation by altitude is higher than 1000 m (3281 ft), a larger VLT® Compressor Drive CDS 803 might be needed to run an undersized compressor. Consult Danfoss for support.

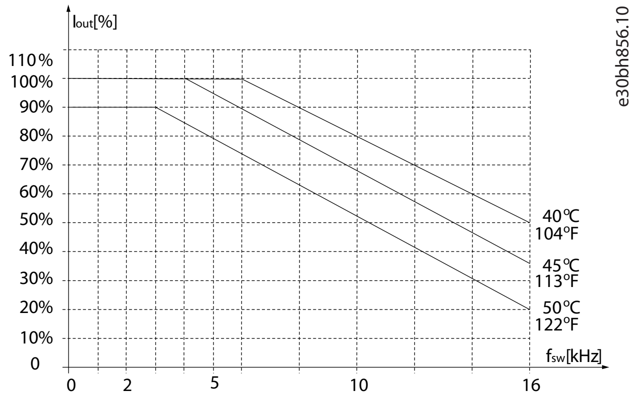

Illustration 4: 400 V IP20 H3 6.0–7.5 kW (8.0–10 hp)

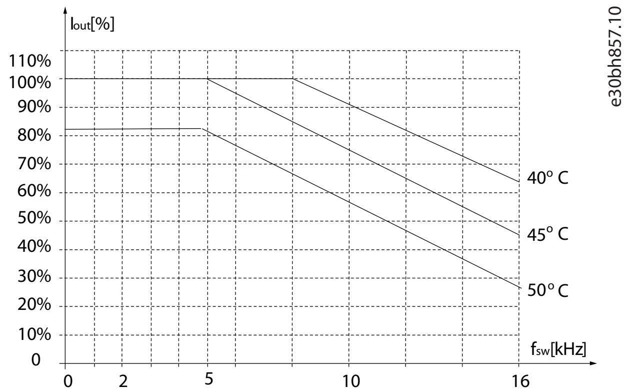

Illustration 5: 200 V IP20 H4 6.0–7.5 kW (8.0–10 hp)

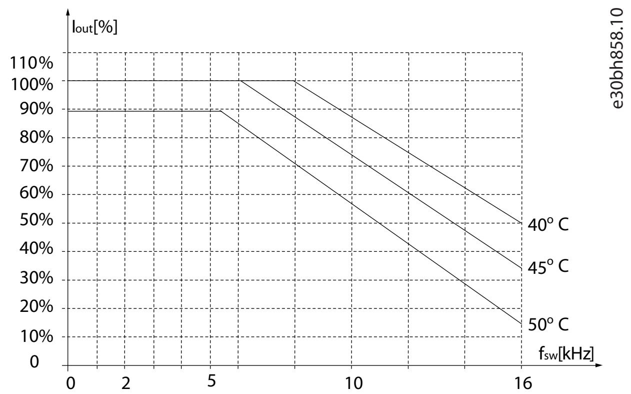

Illustration 6: 400 V IP20 H4 10 kW (15 hp)

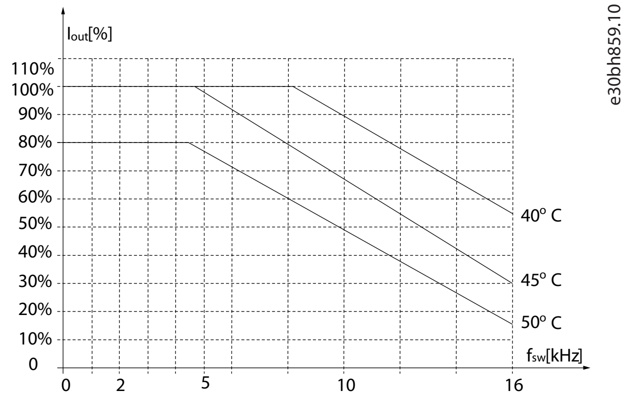

Illustration 7: 200 V IP20 H5 10 kW (15 hp)

5.3.2 Derating Curves, 18.5–22 kW Drives

Drives in the power range 18.5–22 kW are able to deliver 100% current in ambient temperatures up to 52 °C (125 °F) with a default switching frequency of 5.0 kHz (f_sw). If the switching frequency is increased, the following derating curves apply.

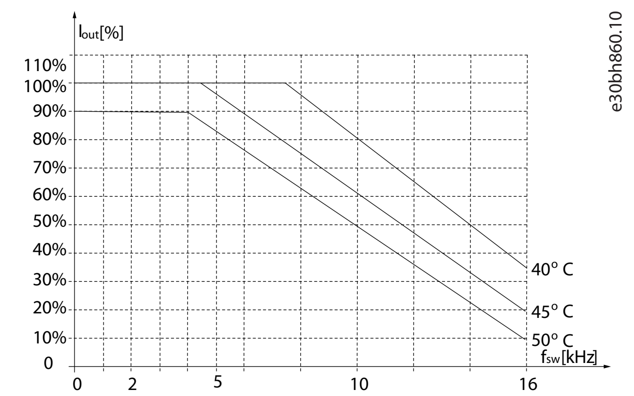

Illustration 8: 400 V IP20 H5 18.5–22 kW (25–30 hp)

5.3.3 Derating Curves, 30 kW Drives

Drives in the power range 30 kW are able to deliver 100% current in ambient temperatures up to 45 °C (113 °F) with a default switching frequency of 4.0 kHz (f_sw). If the switching frequency is increased, the following derating curves apply.

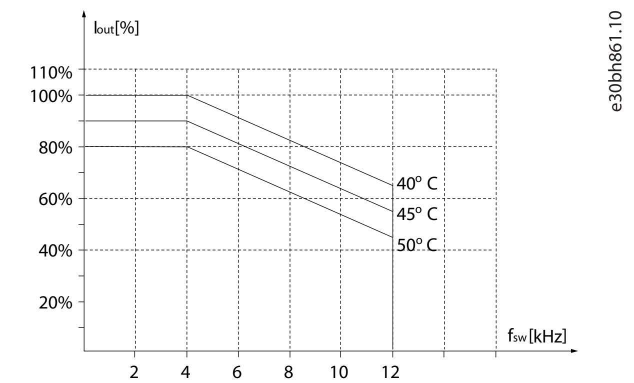

Illustration 9: 400 V IP20 H6 30 kW (40 hp)

5.3.4 Derating for Low Air Pressure and High Altitudes

The cooling capability of air is decreased at low air pressure. For altitudes above 2000 m (6562 ft), contact Danfoss regarding PELV. Below 1000 m (3281 ft) altitude, derating is not necessary. For altitudes above 1000 m (3281 ft), decrease the ambient temperature or the maximum output current. Decrease the output by 1% per 100 m (328 ft) altitude above 1000 m (3281 ft) or reduce the maximum ambient temperature by 1 °C (33.8 °F) per 200 m (656 ft).

6 Electrical Installation Considerations

6.1 Electrical Wiring

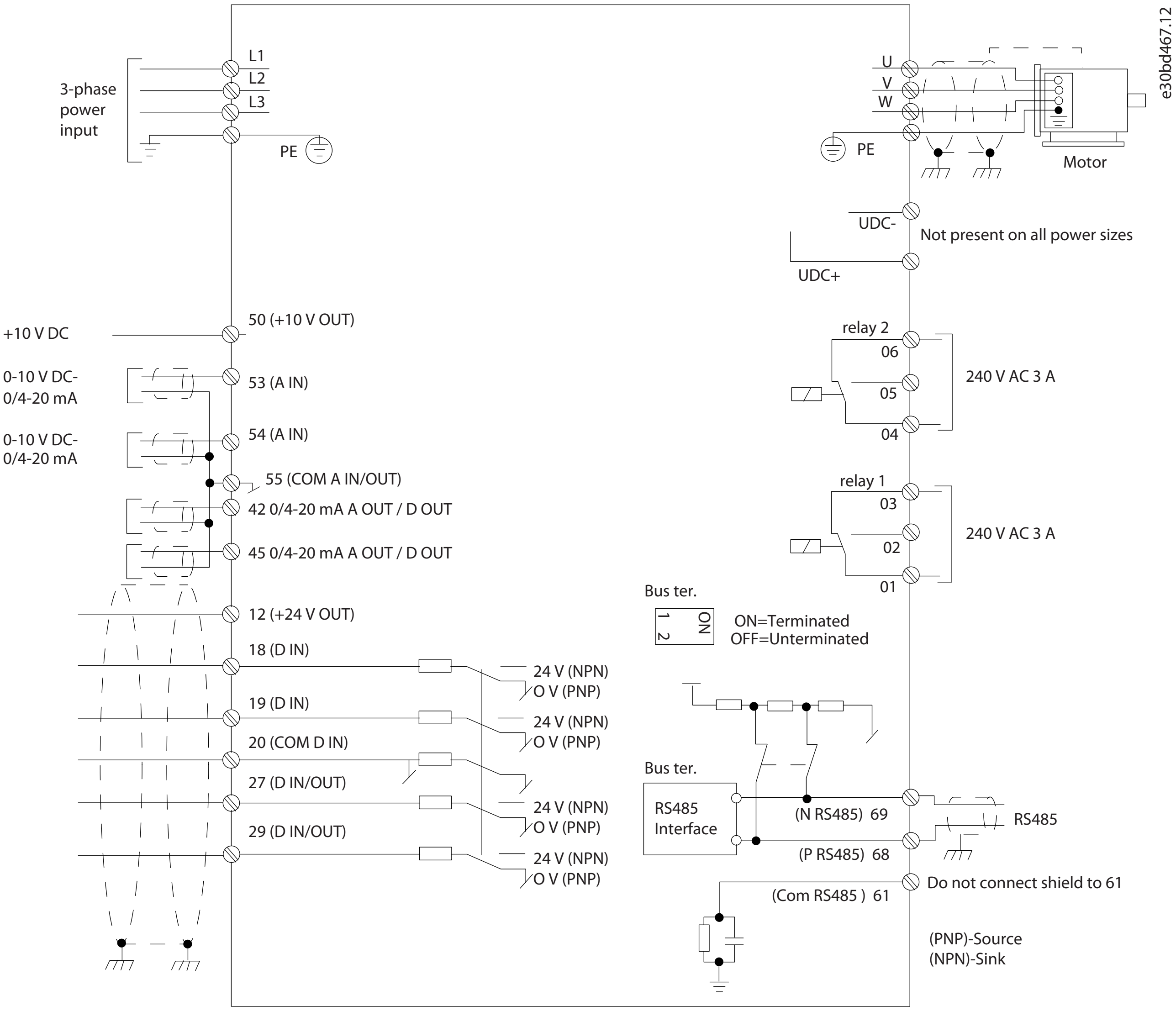

Illustration 10: Basic Wiring Schematic Drawing

NOTICE

There is no access to UDC- and UDC+ on the following units:

- IP20, 380–480 V, 30 kW (40 hp).

6.2 General Aspects of EMC

6.2.1 Overview of EMC Emissions

Drives (and other electrical devices) generate electronic or magnetic fields that may interfere with their environment. The electromagnetic compatibility (EMC) of these effects depends on the power and the harmonic characteristics of the devices.

Uncontrolled interaction between electrical devices in a system can degrade compatibility and impair reliable operation. Interference may take the form of mains harmonics distortion, electrostatic discharges, rapid voltage fluctuations, or high-frequency interference. Electrical devices generate interference along with being affected by interference from other generated sources.

Burst transient usually occurs at frequencies in the range 150 kHz to 30 MHz. Airborne interference from the drive system in the range 30 MHz to 1 GHz is generated from the inverter, the motor cable, and the compressor.

Capacitive currents in the motor cable coupled with a high dU/dt from the compressor voltage generate leakage currents, as shown in the following illustration.

The use of a shielded motor cable increases the leakage current (see the following illustration) because shielded cables have higher capacitance to ground than unshielded cables. If the leakage current is not filtered, it causes greater interference on the mains in the radio frequency range below approximately 5 MHz. Since the leakage current (I_1) is carried back to the unit through the shield (I_3), there is only a small electromagnetic field (I_4) from the shielded motor cable according to the following illustration.

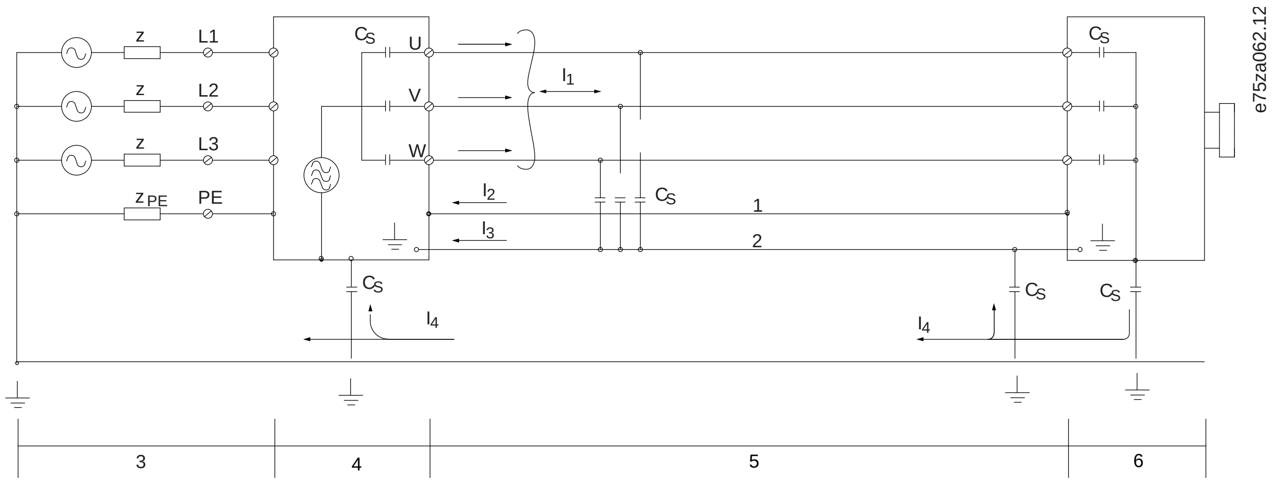

Illustration 11: Generation of Leakage Currents

1	Ground wire	4	Drive
2	Shield	5	Shielded motor cable
3	AC mains supply	6	Motor

The shield reduces the radiated interference, but increases the low-frequency interference on the mains. Connect the motor cable shield to the drive enclosure and on the compressor enclosure. This is best done by using integrated shield clamps to avoid twisted shield ends (pigtails). Pigtails increase the shield impedance at higher frequencies, which reduces the shield effect and increases the leakage current (I_4).

If a shielded cable is used for relay, control cable, signal interface, and brake, mount the shield on the enclosure at both ends. In some situations, however, it is necessary to break the shield to avoid current loops.

If the shield is to be placed on a mounting plate for the drive, the mounting plate must be made of metal to convey the shield currents back to the unit. Moreover, ensure good electrical contact from the mounting plate through the mounting screws to the drive chassis.

When using unshielded cables, some emission requirements are not complied with, although most immunity requirements are observed.

To reduce the interference level from the entire system (unit+installation), make compressor and brake cables as short as possible. Avoid placing cables with a sensitive signal level alongside motor and brake cables. Radio interference higher than 50 MHz (airborne) is especially generated by the control electronics.

6.2.2 Emission Requirements

The EMC product standard for drives defines 4 categories (C1, C2, C3, and C4) with specified requirements for emission and immunity. The following table states the definition of the 4 categories and the equivalent classification from EN 55011.

Table 9: Correlation between IEC 61800-3 and EN 55011

EN/IEC 61800-3 Category	Definition	Equivalent emission class in EN 55011
C1	Drives installed in the first environment (home and office) with a supply voltage less than 1000 V.	Class B

EN/IEC 61800-3 Category	Definition	Equivalent emission class in EN 55011
C2	Drives installed in the first environment (home and office) with a supply voltage less than 1000 V, which are neither plug-in nor movable and are intended to be installed and commissioned by a professional.	Class A Group 1
C3	Drives installed in the second environment (industrial) with a supply voltage lower than 1000 V.	Class A Group 2
C4	Drives installed in the second environment with a supply voltage equal to or above 1000 V or rated current equal to or above 400 A or intended for use in complex systems.	No limit line. Make an EMC plan.

When the generic (conducted) emission standards are used, the drives are required to comply with the limits in the following table.

Table 10: Correlation between Generic Emission Standards and EN 55011

Environment	Generic emission standard	Equivalent emission class in EN 55011
First environment (home and office)	EN/IEC 61000-6-3 Emission standard for residential, commercial and light industrial environments.	Class B
Second environment (industrial environment)	EN/IEC 61000-6-4 Emission standard for industrial environments.	Class A Group 1

6.2.3 EMC Emission Test Results

The following test results have been obtained using a system with a drive, a shielded control cable, a control box with potentiometer, and a shielded motor cable.

Table 11: EMC Emission Test Results

RFI filter type	Conduct emission. Maximum shielded cable length [m (ft)]						Radiated emission					
EN 55011	**Class A Group 2** Industrial environment		**Class A Group 1** Industrial environment		**Class B** Housing, trades, and light industries		**Class A Group 2** Industrial environment		**Class A Group 1** Industrial environment		**Class B** Housing, trades, and light industries	
EN/IEC 61800-3	**Category C3** Second environment Industrial		**Category C2** First environment Home and office		**Category C1** First environment Home and office		**Category C3** Second environment Industrial		**Category C2** First environment Home and office		**Category C1** First environment Home and office	
	Without external filter	**With external filter**	**Without external filter**	**With external filter**	**Without external filter**	**With external filter**	**Without external filter**	**With external filter**	**Without external filter**	**With external filter**	**Without external filter**	**With external filter**
H4 RFI filter (EN 55011 A1, EN/IEC61800-3 C2)												
6.0– 10 kW (8.0– 15 hp) 3x200– 240 V IP20	–	–	25 (82)	50 (164)	–	20 (66)	–	–	Yes	Yes	–	No
H2 RFI filter (EN 55011 A2, EN/IEC 61800-3 C3)												

RFI filter type	Conduct emission. Maximum shielded cable length [m (ft)]						Radiated emission					
18–30 kW (25– 40 hp) 3x380–480 V IP20	5 (16.4)	–	–	–	–	–	Yes	–	No	–	No	–

6.2.4 EMC-correct Electrical Installation

To ensure EMC-correct electrical installation, observe the following:

- Use only shielded/armored motor cables and shielded/armored control cables.
- Ground the shield at both ends.
- Avoid installation with twisted shield ends (pigtails), because it reduces the shielding effect at high frequencies. Use the cable clamps provided.

- Ensure the same potential between the drive and the ground potential of PLC.
- Use star washers and galvanically conductive installation plates.

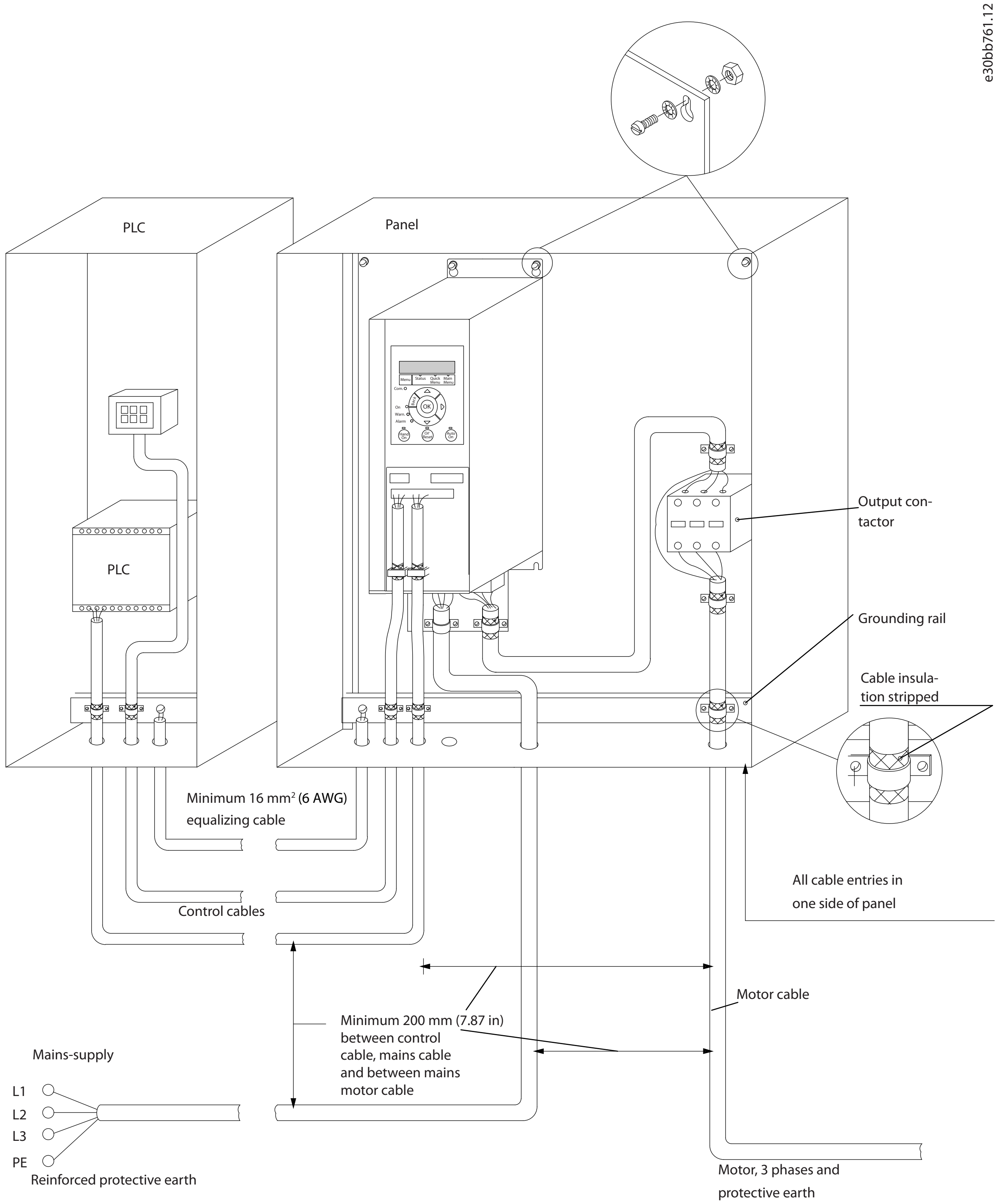

Illustration 12: EMC-correct Electrical Installation

6.3 Harmonics

6.3.1 Overview of Harmonics Emission

A drive takes up a non-sinusoidal current from mains, which increases the input current IRMS. A non-sinusoidal current is transformed with a Fourier analysis and split into sine-wave currents with different frequencies, that is, different harmonic currents In with 50 Hz basic frequency:

Table 12: Harmonic Currents

	I_1	I_5	I_7
Hz	50	250	350

The harmonics do not affect the power consumption directly, but increase the heat losses in the installation (transformer, cables). So, in plants with a high percentage of rectifier load, maintain harmonic currents at a low level to avoid overload of the transformer and high temperature in the cables.

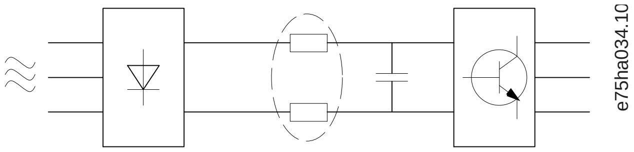

Illustration 13: DC-link Coils

NOTICE

SOME OF THE HARMONIC CURRENTS MIGHT DISTURB COMMUNICATION EQUIPMENT CONNECTED TO THE SAME TRANSFORMER OR CAUSE RESONANCE WITH POWER FACTOR CORRECTION BATTERIES.

To ensure low harmonic currents, the drive is equipped with DC-link coils as standard. This normally reduces the input current I_{RMS} by 40%.

The voltage distortion on the mains supply voltage depends on the size of the harmonic currents multiplied by the mains impedance for the frequency in question. The total voltage distortion THDv is calculated based on the individual voltage harmonics using this formula:

$$\text{THD}\,\% = \sqrt{U\frac{2}{5} + U\frac{2}{7} + \ldots + U\frac{2}{N}}$$

(U_N% of U)

6.3.2 Harmonics Emission Requirements

Equipment is connected to the public supply network.

Table 13: Connected Equipment

Options	Definition
1	IEC/EN 61000-3-2 Class A for 3-phase balanced equipment (for professional equipment only up to 1 kW (1.3 hp) total power).
2	IEC/EN 61000-3-12 Equipment 16–75 A and professional equipment as from 1 kW (1.3 hp) up to 16 A phase current.

6.3.3 Harmonics Test Results (Emission)

Power sizes up to PK75 in T4 and P3K7 in T2 comply with IEC/EN 61000-3-2 Class A. Power sizes from P1K1 and up to P18K in T2 and up to P90K in T4 comply with IEC/EN 61000-3-12, Table 4.

Table 14: Harmonic Current 6.0–10 kW (8.0–15 hp), 200 V

	Individual harmonic current I_n/I_1 (%)			
	I_5	I_7	I_{11}	I_{13}

Actual 6.0–10 kW (8.0–15 hp), IP20, 200 V (typical)	32.6	16.6	8.0	6.0
Limit for R_{sce}≥120	40	25	15	10
	Harmonic current distortion factor (%)			
	THDi		**PWHD**	
Actual 6.0–10 kW (8.0–15 hp), 200 V (typical)	39		41.4	
Limit for R_{sce}≥120	48		46	

Table 15: Harmonic Current 6.0–22 kW (8.0–30 hp), 380–480 V

	Individual harmonic current I_n/I_1 (%)			
	I_5	I_7	I_{11}	I_{13}
Actual 6.0–22 kW (8.0–30 hp), IP20, 380–480 V (typical)	36.7	20.8	7.6	6.4
Limit for R_{sce}≥120	40	25	15	10
	Harmonic current distortion factor (%)			
	THDi		**PWHD**	
Actual 6.0–22 kW (8.0–30 hp), 380–480 V (typical)	44.4		40.8	
Limit for R_{sce}≥120	48		46	

Table 16: Harmonic Current 30 kW (40 hp), 380–480 V

	Individual harmonic current I_n/I_1 (%)			
	I_5	I_7	I_{11}	I_{13}
Actual 30 kW (40 hp), IP20, 380–480 V (typical)	36.7	13.8	6.9	4.2
Limit for R_{sce}≥120	40	25	15	10
	Harmonic current distortion factor (%)			
	THDi		**PWHD**	
Actual 30 kW (40 hp), 380–480 V (typical)	40.6		28.8	
Limit for R_{sce}≥120	48		46	

If the short-circuit power of the supply S_{sc} is greater than or equal to:

$$S_{SC} = \sqrt{3} \times R_{SCE} \times U_{mains} \times I_{equ} = \sqrt{3} \times 120 \times 400 \times I_{equ}$$

at the interface point between the user's supply and the public system (R_{sce}).

The installer or user of the equipment is responsible for ensuring that the equipment is connected only to a supply with a short-circuit power S_{sc} greater than or equal to what is specified above. If necessary, consult with the distribution network operator. Other power sizes can be connected to the public supply network by consultation with the distribution network operator.

Compliance with various system level guidelines: The harmonic current data in Table 14 to Table 16 are given in accordance with IEC/EN 61000-3-12 with reference to the Power Drive Systems product standard. They may be used as the basis for calculation of the harmonic currents' influence on the power supply system and for the documentation of compliance with relevant regional guidelines: IEEE 519 -1992; G5/4.

If there is a need for further reduction of harmonic currents, passive or active filters in front of the drives can be installed. Consult Danfoss for further information.

6.3.4 Immunity Requirements

The immunity requirements for drives depend on the environment in which they are installed. The requirements for the industrial environment are higher than the requirements for the home and office environment. All Danfoss drives comply with the requirements for the industrial environment and therefore comply also with the lower requirements for home and office environment with a large safety margin.

6.4 Galvanic Isolation (PELV)

PELV offers protection through extra low voltage. Protection against electric shock is ensured when the electrical supply is of the PELV type and the installation is made as described in local/national regulations on PELV supplies.

All control terminals and relay terminals 01-03/04-06 comply with PELV (protective extra low voltage) (does not apply to grounded delta leg above 440 V).

Galvanic (ensured) isolation is obtained by fulfilling requirements for higher isolation and by providing the relevant creepage/clearance distances. These requirements are described in the EN 61800-5-1 standard.

The components that make up the electrical isolation, as described, also comply with the requirements for higher isolation and the relevant test as described in EN 61800-5-1. The PELV galvanic isolation is shown in Illustration 14.

To maintain PELV, all connections made to the control terminals must be PELV, for example, thermistors must be reinforced/double insulated.

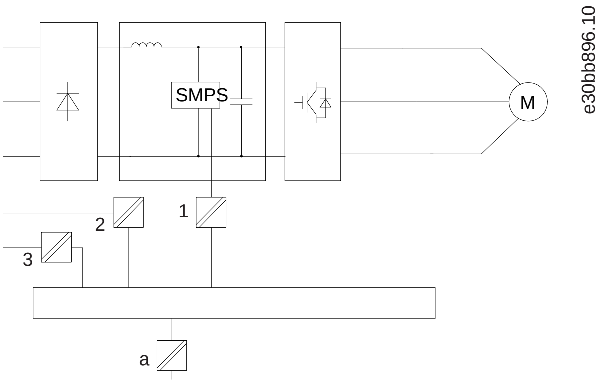

Illustration 14: Galvanic Isolation 6.0–22 kW (8.0–30 hp)

1	Supply (SMPS)	3	Custom relays
2	Optocouplers, communication between AOC and BOC	a	Control card terminals

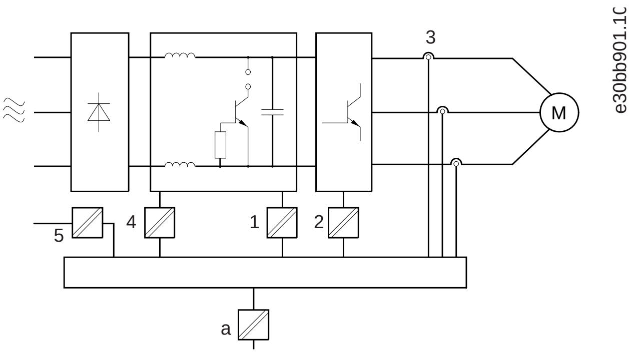

Illustration 15: Galvanic Isolation 30 kW (40 hp)

1	Supply (SMPS) including signal isolation of UDC, indicating the intermediate current voltage	4	Internal soft-charge, RFI, and temperature measurement circuits
2	Gate drive that runs the IGBTs (trigger transformers/optocouplers)	5	Custom relays
3	Current transducers	a	Control card terminals

⚠ CAUTION ⚠

INSTALLATION AT HIGH ALTITUDE

At altitudes above 2000 m (6500 ft), contact Danfoss regarding PELV.

6.5 Ground Leakage Current

⚠ WARNING ⚠

DISCHARGE TIME

Touching the electrical parts, even after the equipment has been disconnected from mains, could be fatal.

- Make sure that other voltage inputs have been disconnected, such as load sharing (linkage of DC-link), and the motor connection for kinetic back-up.
- Before touching any electrical parts, wait at least the amount of time indicated in the safety chapter. Shorter time is allowed only if indicated on the nameplate for the specific unit.

⚠ WARNING ⚠

LEAKAGE CURRENT HAZARD

Leakage currents exceed 3.5 mA. Failure to ground the drive properly can result in death or serious injury.

- Ensure the correct grounding of the equipment by a certified electrical installer.

⚠ WARNING ⚠

RESIDUAL CURRENT DEVICE PROTECTION

This product can 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 an RCD of Type B is allowed on the supply side of this product. Otherwise, apply another protective measure, such as separation from the environment by double or reinforced insulation, or isolation from the supply system by a transformer. See also application note Protection against Electrical Hazards.

- Protective grounding of the drive and the use of RCDs must always follow national and local regulations.

6.6 Extreme Running Conditions

Short circuit (motor phase-to-phase)

The drive is protected against short circuits by current measurement in each of the 3 compressor phases or in the DC link. A short circuit between 2 output phases causes an overcurrent in the drive. The drive is turned off individually when the short-circuit current exceeds the allowed value (alarm 16, trip lock).

Switching on the output

Switching on the output between the compressor and the drive is fully allowed and does not damage the drive. However, fault messages may appear.

Mains dropout

During a mains dropout, the drive keeps running until the DC-link voltage drops below the minimum stop level, which is typically 15% below the lowest rated supply voltage of the drive. The mains voltage before the dropout and the compressor load determines how long it takes for the drive to coast.

6.7 Electrical Installation in General

All cabling must comply with national and local regulations on cable cross-sections and ambient temperature. Copper conductors are required. 75 °C (167 °F) is recommended.

Table 17: Tightening Torques for Enclosure Sizes H3–H6, 3x200–240 V & 3x380–480 V

Power [kW (hp)]				Torque [Nm (in-lb)]					
Enclosure size	IP protection rating	3x200–240 V	3x380–480 V	Mains	Motor	DC connection	Control terminals	Ground	Relay
H3	IP20	–	6.0–7.5 (8.0–10)	0.8 (7)	0.8 (7)	0.8 (7)	0.5 (4)	0.8 (7)	0.5 (4)
H4	IP20	6.0–7.5 (8.0–10)	10–15 (15–20)	1.2 (11)	1.2 (11)	1.2 (11)	0.5 (4)	0.8 (7)	0.5 (4)
H5	IP20	10 (15)	18.5–22 (25–30)	1.2 (11)	1.2 (11)	1.2 (11)	0.5 (4)	0.8 (7)	0.5 (4)
H6	IP20	–	30 (40)	4.5 (40)	4.5 (40)	–	0.5 (4)	3 (27)	0.5 (4)

6.8 Fuses and Circuit Breakers

6.8.1 Branch Circuit Protection

To prevent fire hazards, protect the branch circuits in an installation - switch gear, machines, and so on - against short circuits and overcurrent. Follow national and local regulations.

6.8.2 Short-circuit Protection

Danfoss recommends using the fuses and circuit breakers listed in this chapter to protect service personnel or other equipment in case of an internal failure in the unit or a short circuit on the DC link. The drive provides full short-circuit protection in case of a short circuit on the motor.

6.8.3 Overcurrent Protection

Provide overload protection to avoid overheating of the cables in the installation. Overcurrent protection must always be carried out according to local and national regulations. Design circuit breakers and fuses for protection in a circuit capable of supplying a maximum of 100000 A_{rms} (symmetrical), 480 V maximum.

6.8.4 UL/Non-UL Compliance

To ensure compliance with UL or IEC 61800-5-1, use the circuit breakers or fuses listed in this chapter. Circuit breakers must be designed for protection in a circuit capable of supplying a maximum of 10000 A_{rms} (symmetrical), 480 V maximum.

6.8.5 Recommendation of Fuses

NOTICE

If malfunction occurs, failure to follow the protection recommendation may result in damage to the drive.

Table 18: Fuses

	Fuse				
	UL				Non-UL
	Bussmann	Bussmann	Bussmann	Bussmann	Maximum fuse
Power [kW (hp)]	Type RK5	Type RK1	Type J	Type T	Type G
3x200–240 V IP20					
6.0 (8.0)	FRS-R-50	KTN-R50	JKS-50	JJN-50	50
7.5 (10)	FRS-R-50	KTN-R50	JKS-50	JJN-50	50

10 (15)	FRS-R-80	KTN-R80	JKS-80	JJN-80	65
3x380–480 V IP20					
6.0 (8.0)	FRS-R-25	KTS-R25	JKS-25	JJS-25	25
7.5 (10)	FRS-R-25	KTS-R25	JKS-25	JJS-25	25
10 (15)	FRS-R-50	KTS-R50	JKS-50	JJS-50	50
18.5 (25)	FRS-R-80	KTS-R80	JKS-80	JJS-80	63
22 (30)	FRS-R-80	KTS-R80	JKS-80	JJS-80	63
30 (40)	FRS-R-125	KTS-R125	JKS-R125	JJS-R125	80

7 Basic Control Principles

7.1 Control Structures

Select the configuration mode in *parameter 1-00 Configuration Mode*.

7.1.1 Control Structure Open Loop

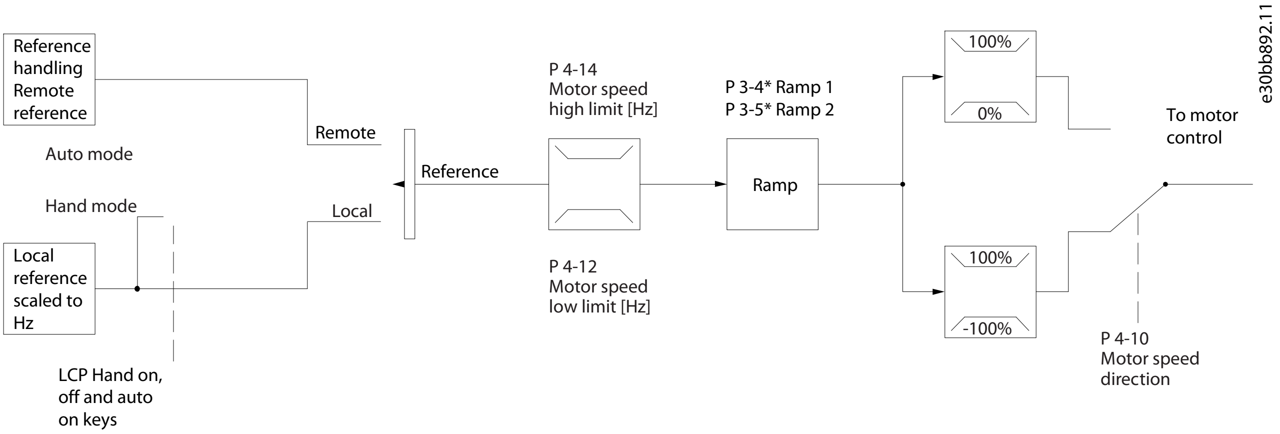

Illustration 16: Open-loop Structure

In the configuration shown in the above illustration, *parameter 1-00 Configuration Mode* is set to *[0] Open loop*. The resulting reference from the reference handling system or the local reference is received and fed through the ramp limitation and speed limitation before being sent to the motor control. The output from the motor control is then limited by the maximum frequency limit.

7.1.2 Local (Hand On) and Remote (Auto On) Control

The drive can be operated manually via the local control panel (LCP), remotely via analog/digital inputs, or via fieldbus. If allowed in *parameter 0-40 [Hand on] Key on LCP*, *parameter 0-44 [Off/Reset] Key on LCP*, and *parameter 0-42 [Auto on] Key on LCP*, it is possible to start and stop the drive via the LCP by pressing [Hand On] and [Off/Reset]. Alarms can be reset via the [Off/Reset] key.

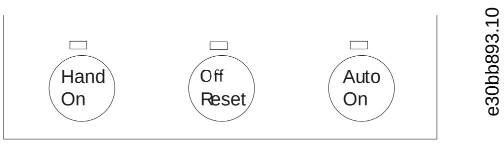

Illustration 17: LCP Keys

Local reference forces the configuration mode to open loop, independent of the setting in *parameter 1-00 Configuration Mode*.

Local reference is restored at power-down.

7.1.3 Control Structure Closed Loop

The internal controller allows the drive to become a part of the controlled system. The drive receives a feedback signal from a sensor in the system. It then compares this feedback to a setpoint reference value and determines the error, if any, between these 2 signals. It then adjusts the speed of the motor to correct this error.

For example, consider a pump application where the speed of a pump is to be controlled to ensure a constant static pressure in a pipe. The static pressure value is supplied to the drive as the setpoint reference. A static pressure sensor measures the actual static pressure in the pipe and supplies this data to the drive as a feedback signal. If the feedback signal is greater than the setpoint reference, the drive slows the pump down to reduce the pressure. In a similar way, if the pipe pressure is lower than the setpoint reference, the drive automatically speeds the pump up to increase the pressure provided by the pump.

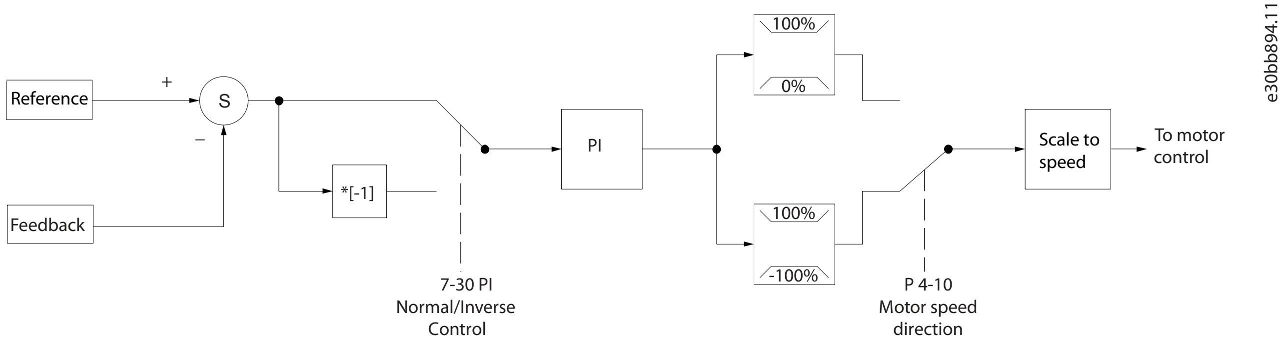

Illustration 18: Control Structure Closed-loop

While the default values for the closed-loop controller of the drive often provide satisfactory performance, the control of the system can often be optimized by adjusting parameters.

7.1.4 Feedback Conversion

In some applications, it may be useful to convert the feedback signal. One example of this is using a pressure signal to provide flow feedback. Since the square root of pressure is proportional to flow, the square root of the pressure signal yields a value proportional to the flow. See the following illustration.

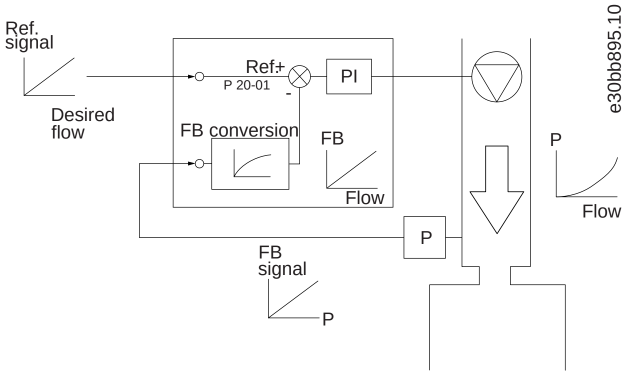

Illustration 19: Feedback Signal Conversion

7.1.5 Reference Handling

Details for open-loop and closed-loop operation.

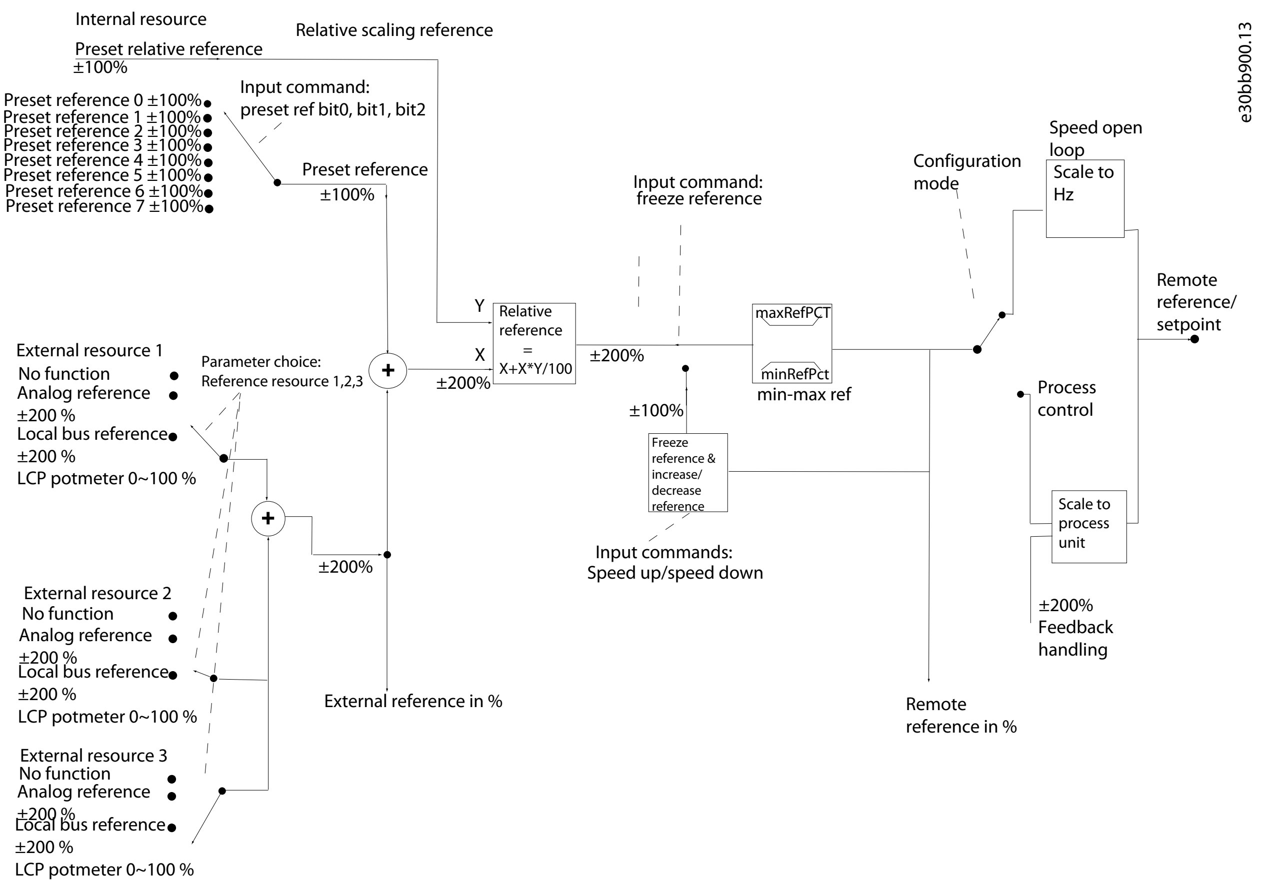

Illustration 20: Block Diagram Showing Remote Reference

The remote reference consists of:

- Preset references.
- External references (analog inputs and serial communication bus references).
- The preset relative reference.
- Feedback-controlled setpoint.

Up to 8 preset references can be programmed in the drive. The active preset reference can be selected using digital inputs or the serial communications bus. The reference can also be supplied externally, most commonly from an analog input. This external source is selected by 1 of the 3 reference source parameters (*parameter 3-15 Reference 1 Source*, *parameter 3-16 Reference 2 Source*, and *parameter 3-17 Reference 3 Source*). All reference resources and the bus reference are added to produce the total external reference. The external reference, the preset reference, or the sum of the 2 can be selected to be the active reference. Finally, this reference can by be scaled using *parameter 3-14 Preset Relative Reference*.

The scaled reference is calculated as follows:

$$\text{Reference} = X + X \times \left(\frac{Y}{100}\right)$$

Where X is the external reference, the preset reference or the sum of these and Y is *parameter 3-14 Preset Relative Reference* in [%].

If Y, *parameter 3-14 Preset Relative Reference*, is set to 0%, the reference is not affected by the scaling.

7.2 Tuning the Drive Closed-loop

Once the drive's closed-loop controller has been set up, test the performance of the controller. Often, its performance may be acceptable using the default values of *parameter 20-93 PI Proportional Gain* and *parameter 20-94 PI Integral Time*. However, sometimes it may be helpful to optimize these parameter values to provide faster system response while still controlling speed overshoot.

7.3 Adjusting the Manual PI

Procedure

1. Start the compressor.

2. Set *parameter 20-93 PI Proportional Gain* to 0.3 and increase it until the feedback signal begins to oscillate. If necessary, start and stop the drive or make step changes in the setpoint reference to attempt to cause oscillation.
3. Reduce the PI proportional gain until the feedback signal stabilizes.
4. Reduce the proportional gain by 40–60%.
5. Set *parameter 20-94 PI Integral Time* to 20 s and reduce it until the feedback signal begins to oscillate. If necessary, start and stop the drive or make step changes in the setpoint reference to attempt to cause oscillation.
6. Increase the PI integral time until the feedback signal stabilizes.
7. Increase the integral time by 15–50%.

8 How to Order

8.1 Drive Configurator

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
C	D	S	8	0	3	P				T					H		X			X	X	X	S	X	X	X	X	A	X	B	X	C	X	X	X	X	D	X

e30bd938.11

Illustration 21: Type Code Example

Configure the right drive for the right application from the internet-based Drive Configurator and generate the type code string. The Drive Configurator automatically generates an 8-digit sales number to be delivered to the local sales office. Furthermore, it is possible to establish a project list with several products and send it to a Danfoss sales representative.

The Drive Configurator can be found on the global website: www.danfoss.com/drives.

8.2 Type Code Description

Table 19: Type Code Descriptions

Position	Description	Options
01–06	Product group	CDS 803
07–10	Power rating	6.0–30 kW (8.0–40 hp)
11	Number of phases	3
11–12	Mains voltage	T2: 200–240 V AC
		T4: 380–480 V AC
13–15	Enclosure	E20: IP20/Chassis
16–17	RFI	H2: RFI filter class A2
		H4: RFI filter class A1
18	Brake	X: No brake chopper included
19	Display	A: Alpha-numeric LCP
		X: No LCP
20	Coating PCB	X: No coated PCB
		C: Coated PCB
21	Mains option	X: No mains option
22–23	Adaptation	X: No adaptation
24–27	Software release	SXXX: Latest release - standard software S096: Software and hardware UL 60730 compliant.
28	Software language	X: Standard
29–30	A options	AX: No A options
31–32	B options	BX: No B options
33–34	C0 options	CX: No C options
35	C1 options	X: No C1 options
36–37	C option software	XX: No options

Position	Description	Options
38–39	D option	DX: No D options

8.3 Options and Accessories

8.3.1 Local Control Panel (LCP)

Table 20: Order Number for LCP

Order number	Description
120Z0581	LCP for all IP20 units

Table 21: Technical Data of LCP

Enclosure	IP55 front-mounted
Maximum cable length to unit	3 m (10 ft)
Communication standard	RS485

8.3.2 LCP, Remote Mounting Kit

Order number	Description
132B0201	LCP kit for remote mounting

8.3.3 IP21/NEMA Type 1 Enclosure Kit

IP21/NEMA Type 1 is an optional enclosure element available for IP20 units. If the enclosure kit is used, an IP20 unit is upgraded to comply with enclosure IP21/NEMA Type 1.

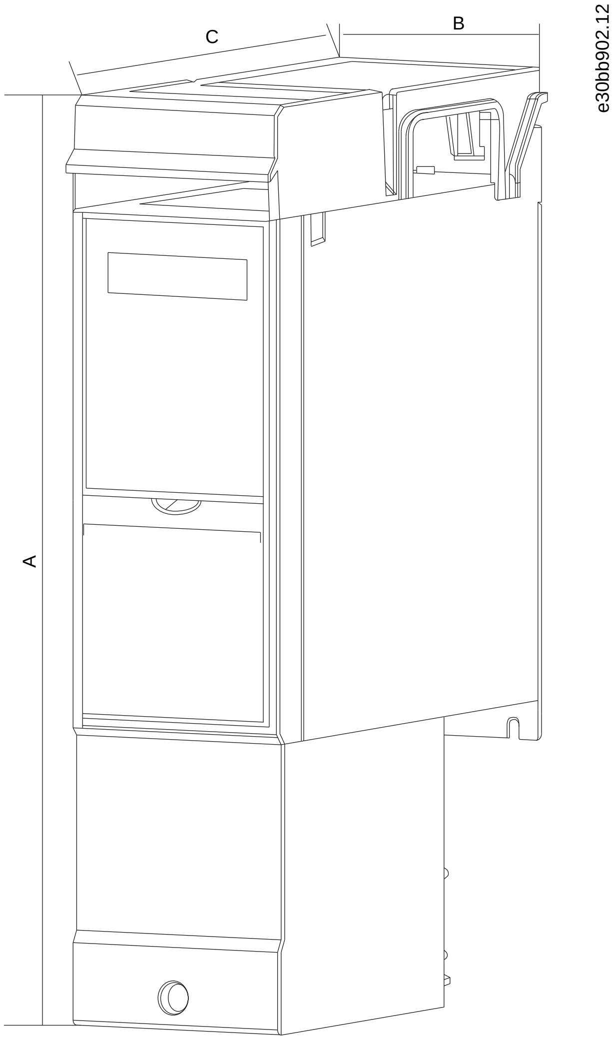

Illustration 22: H3–H6

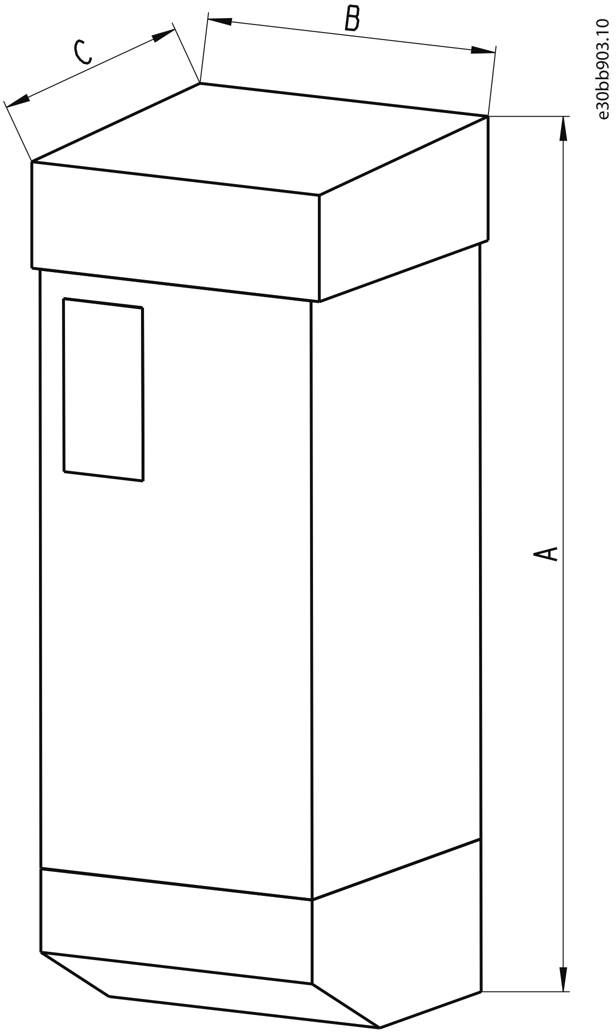

Illustration 23: Dimensions

Table 22: Enclosure Kit Specifications

Enclo-sure size	Power [kW (hp)]		Height [mm (in)] A	Width [mm (in)] B	Depth [mm (in)] C	IP21 conversion kit order num-ber	NEMA Type 1 kit order num-ber
	3x200-240 V	3x380-480 V					
H3	–	6.0–7.5 (8.0–10)	346 (13.6)	106 (4.2)	210 (8.3)	132B0214	132B0224
H4	6.0–7.5 (8.0–10)	10 (14)	374 (14.7)	141 (5.6)	245 (9.6)	132B0215	132B0225
H5	10 (14)	18.5–22 (25–30)	418 (16.5)	161 (6.3)	260 (10.2)	132B0216	132B0226
H6	–	30 (40)	663 (26.1)	260 (10.2)	242 (9.5)	132B0217	132B0217

8.3.4 Decoupling Plate

Use the decoupling plate for EMC-correct installation. The following illustration shows the decoupling plate on an H3 enclosure.

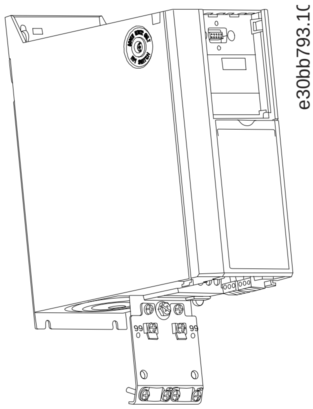

Illustration 24: Decoupling Plate

Table 23: Dimensions, Decoupling Plate

	Length [mm/(in)]	Width [mm/(in)]
H3	80.8 (3.2)	72 (2.8)
H4–H6	85 (3.3)	84.8 (3.3)

Table 24: Decoupling Plate Specifications

Enclosure size	Power [kW (hp)]		Decoupling plate order number
	3x200–240 V	3x380–480 V	
H3	–	6.0–7.5 (8.0–10)	120Z0582
H4	6.0–7.5 (8.0–10)	10 (14)	120Z0583
H5	10 (14)	18.5–22 (25–30)	120Z0583
H6	–	30 (40)	132B0207

8.3.5 External RFI Filter

With external filters listed in the following table, the maximum shielded cable length of 50 m (164 ft) according to EN/IEC 61800-3 C2 (EN 55011 A1), or 20 m (65.6 ft) according to EN/IEC 61800-3 C1(EN 55011 B) can be achieved.

Table 25: RFI Filters - Details

		Power [kW (hp)] size 380–480 V	
		6.0–7.5 (8.0–10)	**10 (15)**
Type		FN3258-16-45	FN3258-30-47
Dimensions [mm (in)]	**A**	250 (9.8)	270 (10.6)
	B	45 (1.8)	50 (2.0)
	C	70 (2.8)	85 (3.3)
	D	22 0 (8.7)	24 0 (9.4)
	E	235 (9.2)	255 (10)
	F	25 (1.0)	30 (1.18)
	G	4.5 (0.18)	5.4 (0.21)
	H	1.0 (0.04)	1.0 (0.04)

		Power [kW (hp)] size 380–480 V	
	I	10. 6 (0.4)	10. 6 (0.4)
	J	M5	M5
	K	22. 5 (0.9)	25 (1.0)
	L1	31 (1.2)	40 (1.6)
Torque [Nm (in-lb)]		0.7–0.8 (6.2–7.1)	1.9–2.2 (16.8–19.5)
Weight [kg (lb)]		0.8 (1.8)	1.2 (2.6)
Order number		132B0245	132B0246

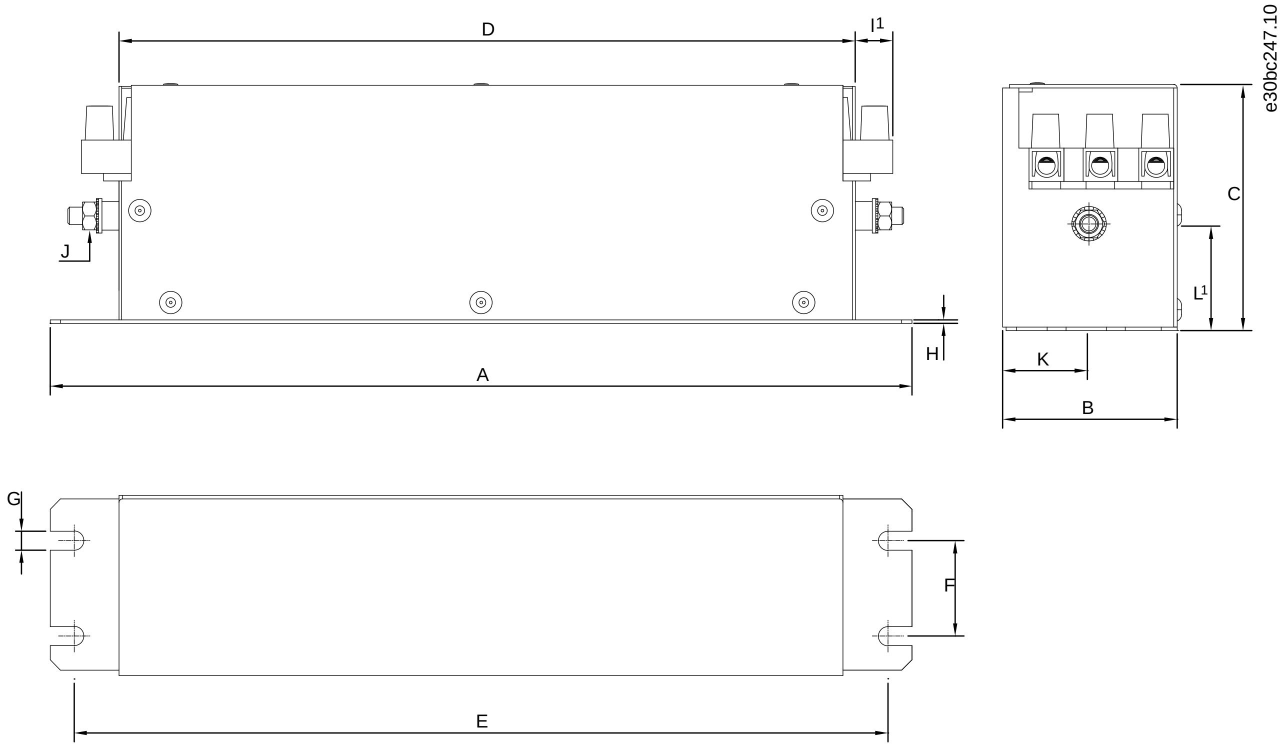

Illustration 25: RFI Filter - Dimensions

9 Appendix

9.1 Abbreviations

°C	Degrees Celsius
°F	Degrees Fahrenheit
A	Ampere/AMP
AC	Alternating current
AMA	Automatic motor adaptation
AWG	American wire gauge
DC	Direct current
EMC	Electro-magnetic compatibility
ETR	Electronic thermal relay
$f_{M,N}$	Nominal motor frequency
Hz	Hertz
I_{INV}	Rated inverter output current
I_{LIM}	Current limit
$I_{M,N}$	Nominal motor current
$I_{VLT,MAX}$	Maximum output current
$I_{VLT,N}$	Rated output current supplied by the drive
kg	Kilogram
kHz	Kilohertz
LCP	Local control panel
m	Meter
mA	Milliampere
MCT	Motion Control Tool
mH	Milli Henry inductance
min	Minute
ms	Millisecond
nF	Nano Farad
Nm	Newton meter
n_s	Synchronous motor speed
$P_{M,N}$	Nominal motor power
PCB	Printed circuit board
PELV	Protective extra low voltage

Regen	Regenerative terminals
RPM	Revolutions per minute
s	Second
T_{LIM}	Torque limit
$U_{M,N}$	Nominal motor voltage
V	Volts

9.2 Conventions

- Numbered lists indicate procedures.
- Bulleted and dashed lists indicate listings of other information where the order of the information is not relevant.
- Bolded text indicates highlighting and section headings.
- Italicized text indicates the following:
  - Cross-reference.
  - Link.
  - Footnote.
  - Parameter name.
  - Parameter option.
  - Parameter group name.
  - Alarms/warnings.
- All dimensions in drawings are in metric values (imperial values in brackets).
- An asterisk (*) indicates the default setting of a parameter.

9.3 Definitions

Definitions related to the AC drive.

- $I_{VLT,MAX}$
  - The maximum output current.
- $I_{VLT,N}$
  - The rated output current supplied by the drive.
- $U_{VLT,MAX}$
  - The maximum output voltage.

Definitions related to input:

- Control command
  - Start and stop the connected motor using the LCP and the digital inputs. Functions are divided into two groups. Functions in group 1 have higher priority than functions in group 2.

Table 26: Control Command Functions

Function group	Functions
1	Reset, coast stop, reset and coast stop, quick stop, DC braking, stop, and the [Off] key.
2	Start, pulse start, reversing, start reversing, jog, and freeze output.

Definitions related to the compressor

- f_{jog}
  - The motor frequency when the jog function is activated (via digital terminals).
- f_M

- Motor frequency.
- f_{MAX}
  - The maximum compressor frequency.
- f_{MIN}
  - The minimum compressor frequency.
- $f_{M,N}$
  - The rated motor frequency (nameplate data).
- I_{M}
  - The motor current.
- $I_{M,N}$
  - The rated motor current (nameplate data).
- $n_{M,N}$
  - The nominal motor speed (nameplate data).
- $P_{M,N}$
  - The rated motor power (nameplate data).
- U_{M}
  - The instant motor voltage.
- $U_{M,N}$
  - The rated motor voltage (nameplate data).
- Break-away torque
  - 
- η_{VLT}
  - The efficiency of the drive is defined as the ratio between the power output and the power input.
- Start-disable command
  - A stop command belonging to the group 1 control commands, see *table Control Command Functions*.
- Stop command
  - See *table Control Command Functions*.

Definitions related to references

- Analog reference
  - A signal transmitted to the analog inputs 53 or 54 can be voltage or current.
    - Current input: 0–20 mA and 4–20 mA
    - Voltage input: 0–10 V DC
- Bus reference
  - A signal transmitted to the serial communication port (FC port).
- Preset reference
  - A defined preset reference to be set from -100% to +100% of the reference range. Selection of 8 preset references via the digital terminals.
- Ref_{MAX}
  - Determines the relationship between the reference input at 100% full scale value (typically 10 V, 20 mA) and the resulting reference. The maximum reference value is set in *parameter 3-03 Maximum Reference*.
- Ref_{MIN}
  - Determines the relationship between the reference input at 0% value (typically 0 V, 0 mA, 4 mA) and the resulting reference. The minimum reference value is set in *parameter 3-02 Minimum Reference*.

Miscellaneous:

- Analog inputs

    - The analog inputs are used for controlling various functions of the drive. There are 2 types of analog inputs:
        - Current input: 0–20 mA and 4–20 mA
        - Voltage input: 0–10 V DC
- Analog outputs
    - The analog outputs can supply a signal of 0–20 mA, 4–20 mA, or a digital signal.
- Automatic motor adaptation, AMA
    - The AMA algorithm determines the electrical parameters for the connected compressor at standstill.
- Digital inputs
    - The digital inputs can be used for controlling various functions of the drive.
- Digital outputs
    - The drive features 2 solid-state outputs that can supply a 24 V DC (maximum 40 mA) signal.
- Relay outputs
    - The drive features 2 programmable relay outputs.
- ETR
    - Electronic thermal relay is a thermal load calculation based on present load and time. Its purpose is to estimate the compressor temperature.
- Initializing
    - If initializing is carried out (*parameter 14-22 Operation Mode*), the programmable parameters of the drive return to their default settings. *Parameter 14-22 Operation Mode* does not initialize communication parameters.
- Intermittent Duty Cycle
    - An intermittent duty rating refers to a sequence of duty cycles. Each cycle consists of an on-load and an off-load period. The operation can be either periodic duty or non-periodic duty.
- LCP
    - The local control panel (LCP) makes up a complete interface for control and programming of the drive. The control panel is detachable and can be installed up to 3 m (9.8 ft) from the drive, that is, in a front panel with the installation kit option.
- lsb
    - Least significant bit.
- msb
    - Most significant bit.
- MCM
    - Short for Mille Circular Mil, an American unit for measuring cable cross-section. 1 MCM=0.5067 mm^2.
- On-line/Off-line Parameters
    - Changes to on-line parameters are activated immediately after the data value is changed. To activate the off-line parameters, press [OK].
- PI controller
    - The PI controller maintains the required speed, pressure, temperature, and so on, by adjusting the output frequency to match the varying load.
- RCD
    - Residual Current Device.
- Setup
    - Parameter settings in 2 setups can be saved. Change between the 2 parameters setups and edit 1 setup while another setup is active.
- Slip Compensation
    - The drive compensates for the compressor slip by giving the frequency a supplement that follows the measured compressor load keeping the compressor speed almost constant.
- Smart Logic Control (SLC)

- The SLC is a sequence of user-defined actions executed when the associated user-defined events are evaluated as true by the Smart Logic Controller.

- Thermistor
  - A temperature-dependent resistor placed where the temperature is to be monitored (drive or compressor).
- Trip
  - A state entered in fault situations, for example, if the drive is subject to an overtemperature or when the drive is protecting the compressor, process, or mechanism. Restart is prevented until the cause of the fault has disappeared and the trip state is canceled by activating reset or, sometimes, by being programmed to reset automatically. Do not use trip for personal safety.
- Trip lock
  - A state entered in fault situations when the drive is protecting itself and requiring physical intervention, for example, if the drive is subject to a short circuit on the output. A locked trip can only be canceled by cutting off mains, removing the cause of the fault, and reconnecting the drive. Restart is prevented until the trip state is canceled by activating reset or, sometimes, by being programmed to reset automatically. Trip may not be used for personal safety.
- VT Characteristics
  - Variable torque characteristics used for pumps and fans.
- VVC^{plus}
  - If compared with standard voltage/frequency ratio control, voltage vector control (VVC^{plus}) improves the dynamics and the stability, both when the speed reference is changed and in relation to the load torque.
- Power factor
  - The power factor is the relation between I_1 and I_{RMS}. The power factor indicates to which extent the drive imposes a load on the mains supply. The lower the power factor, the higher the I_{RMS} for the same kW performance.

$$\text{Power factor} = \frac{\sqrt{3}\ x\ U\ x\ I_1 \cos\phi}{\sqrt{3}\ x\ U\ x\ I_{\text{RMS}}}$$

The power factor for 3-phase control:

$$= \frac{I1\ x \cos\phi 1}{I_{\text{RMS}}} = \frac{I_1}{I_{\text{RMS}}} \text{ since } \cos\phi 1 = 1$$

$$I_{\text{RMS}} = \sqrt{I_1^2 + I_5^2 + I_7^2} + .. + I_n^2$$

A high power factor indicates that the different harmonic currents are low. The built-in DC coils of the drive produce a high power factor, which minimizes the imposed load on the mains supply.

Index

ENGINEERING
TOMORROW

Danfoss A/S
Ulsnaes 1
DK-6300 Graasten
vlt-drives.danfoss.com

130R0596

M0022101

AJ330233902305en-000101 /130R0596