ENGINEERING
TOMORROW

Selection Guide | VLT® Refrigeration Drive FC 103

Lower lifecycle costs

Increase efficiency with speed control of compressors, fans and pumps

25%

Energy savings can be achieved by using VLT® drives to control refrigeration compressors

www.danfossdrives.com

VLT® THE REAL DRIVE

VLT® Refrigeration Drive FC 103 reduces lifecycle costs

For over 60 years the Danfoss Refrigeration team has specialized in the development of innovative and effective refrigeration technology solutions.

Out of this wealth of experience over so many decades, Danfoss has now developed the ideal drive for the fans, pumps and compressors used in these applications: the VLT® Refrigeration Drive FC 103.

To help dramatically reduce lifecycle costs of your refrigeration systems, the VLT® Refrigeration Drive FC 103 offers a control and commissioning environment specifically designed to meet the needs of refrigeration compressor, fan, and pump applications.

All-inclusive

- Top efficiency (98%)
- Automatic Energy Optimization (AEO)
- Mains chokes
- Refrigerant tables
- Large performance range
- Neutral zone controller
- Open for all kind of controllers including Danfoss ADAP-KOOL®

Integrated functions save money

- Cascade controller
- Dry-running protection
- Overload protection
- Safe stop
- Sleep mode
- Flow compensation

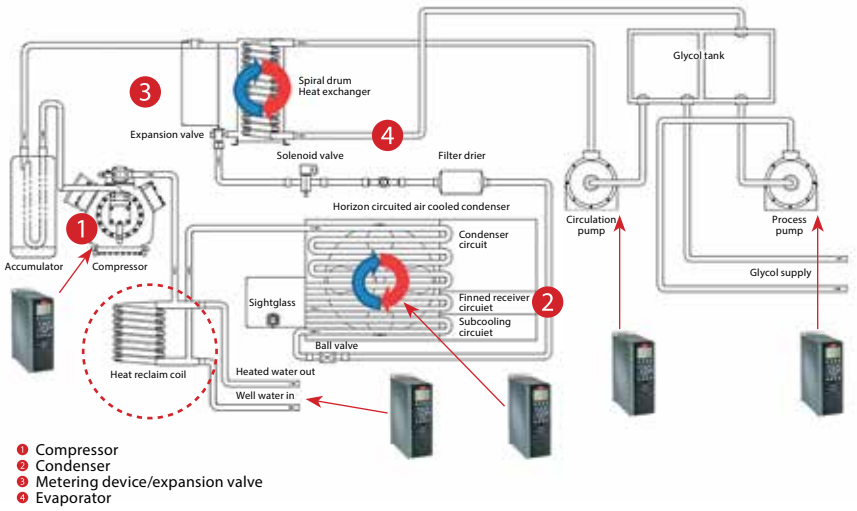
Easy installation

- Quick Menu
- Commissioning Wizard menu is friendly to engineers
- Speaks "refrigeration language"
- Small frame size
- IP20–IP66 enclosure rating

Faster system payback with speed control

Reducing the operating costs of refrigeration systems with quick payback is becoming increasingly important. Speed control of the electric drives used in these systems is a pragmatic and effective approach. Load-dependent speed control reduces power consumption and therefore saves money.

When you consider that energy costs amount to 90% or more of total operating costs over the total product lifetime, it's easy to see that there is plenty of potential for savings in this area. Speed control also lowers mechanical stress in the system, which reduces service and maintenance costs.



VLT® Refrigeration Drive FC 103 provides speed control of all motor driven components and interacts with the major components

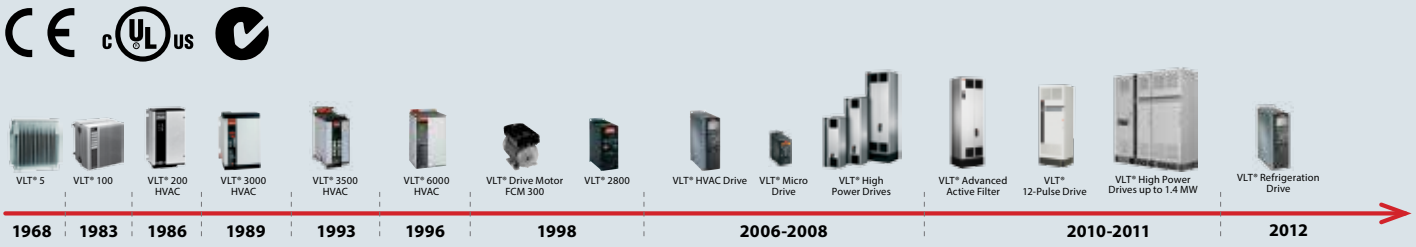
VLT® Refrigeration Drive FC 103 – simply uncomplicated

Danfoss developed the VLT® Refrigeration Drive FC 103 to allow all users in the refrigeration world to benefit from the advantages of speed control in a simple, uncomplicated manner. With its functions specifically tailored for refrigeration technology, it reduces total life cycle costs in the application.

The drive cuts the external component count, integrates easily into existing refrigeration systems, and makes motors energy efficient thanks to its high performance. In this way it improves the energy balance of the overall refrigeration system and reduces its environmental footprint.

Proven reliability

Starting with the first VLT® Drive – the VLT® 5 from 1968 – every drive series from Danfoss has proven the reliability of VLT® drives.



VLT® Refrigeration Drive
Systematic energy savings

The VLT® Refrigeration Drive FC 103 benefits from Danfoss' many years of experience in both refrigeration and drive technology. It combines an energy-efficient power stage with advanced software algorithms. This is the only way to effectively realize potential energy savings.

VVC+ vector control

The FC 103 uses proven VVC+ vector control, which automatically adapts to all load conditions and supplies exactly the right voltage to the motor.

Fan and pump applications

Due to their nonlinear load characteristics, the power consumption of fans and pumps can be radically reduced by using intelligent speed control. Power consumption decreases with the cube of the reduction in speed.

Higher system efficiency reduces power dissipation

With efficiency ratings up to 98% and a power factor greater than 0.9, VLT® frequency converters are distinctly better than comparable devices. Losses for chokes and filters are already allowed for in the rating.

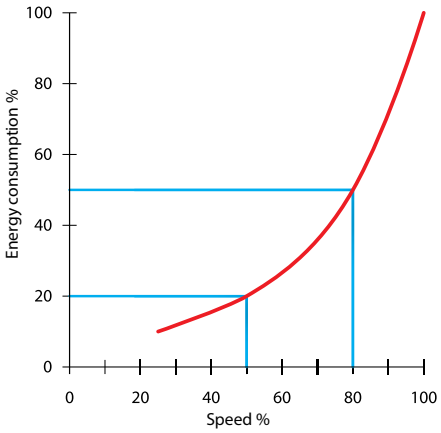
This reduces not only direct energy costs for the drive itself, but also the costs for air conditioning or removing additional heat.

Low power consumption in standby mode

Speed-controlled cooling fans with control electronics designed for low current draw can ensure low power consumption even in standby mode. Thanks to its short start-up period when switched on, the power stage can be completely disconnected from the mains during short breaks in operation.

AEO control for automatic load balancing

Automatic Energy Optimizing (AEO) provides additional energy savings of up to 5%. This feature matches the input current to the actual motor speed and load, and draws only the amount of power necessary for motor excitation and operation with this load. This avoids additional thermal losses in the motor.



On fan and pumps up to 50% energy can be saved by reducing the speed from 100% to 80%.

Optimize the compressor's performance coefficient Achieve system-wide energy efficiency

The performance of a refrigeration system is expressed using the energy efficiency ratio (EER) or the coefficient of performance (COP). This is the ratio of the generated cooling or heating capacity to the power actually consumed, and is usually based on full-load operation.

However, it is not enough to rate a refrigeration unit at just one load level, since most refrigeration systems operate under partial load conditions. This means that significant energy savings can be obtained using speed control.

Refrigeration system without speed control

In a refrigeration system without speed control, the refrigerant compressor always runs at full speed, regardless of the cooling capacity actually required. The cooling output is regulated by the evaporator, which is filled by the expansion device.
Since the expansion valve constantly tries to fill the evaporator optimally, this adjustment causes the evaporation pressure to change and therefore creates oscillation in the system.
With the compressor operating at full output capacity, this oscillation can persist for a very long time. As a result, the evaporator is never properly filled and operates ineffectively, and the cooling capacity of the refrigerant is not optimal.

Refrigeration system with speed control

The continuous variable speed control by VLT® Refrigeration Drive FC 103 makes intelligent capacity control possible. By creating stability while balancing the capacity to the actual load, system-wide COP improves providing significant energy savings. Intelligent compressor and condenser fan control is a "must" in any optimized refrigeration system.

The following positive effects can be achieved in a refrigeration system with variable-speed compressor operation:

Compressor

- Stable suction pressure
- Increased capacity using a smaller compressor
- Built-in soft starter function
- Reduced mechanical load
- Fewer start and stops extends the lifetime
- No mechanical capacity control

Condenser fan control

- Load dependent capacity control
- Operate single fans/multiple parallel operating fans
- Stable condensing pressure
- Reduced charge of refrigerant
- Less dirt build-up on condenser
- Stand-alone control using VLT® Refrigeration Drive FC 103

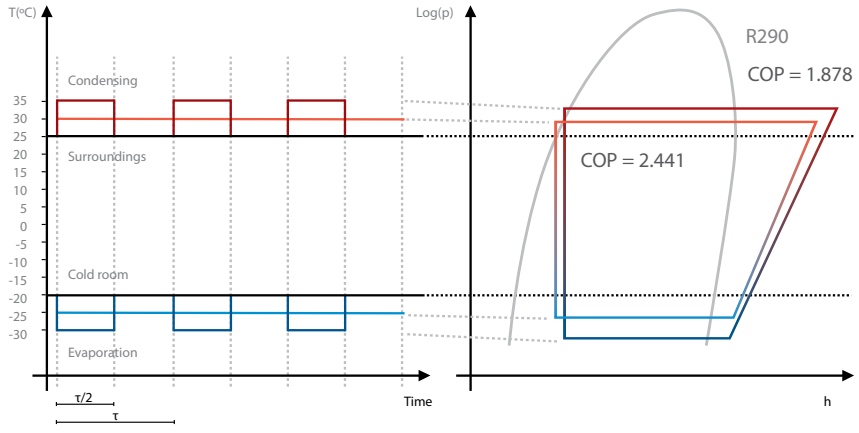
Pumps in A/C or indirect cooling systems

- Coolant pump capacity according to demand
- Stable coolant flow and pressure
- Stand-alone control using VLT® Refrigeration Drive FC 103
- Operate from direct signal (0/4-20 mA or 0-10 V DC)

Fans in air-conditioning systems

- Optimized operation of air handling units
- High efficiency
- Airflow according to demand
- Stand-alone control using VLT® Refrigeration Drive FC 103
- Operate from direct signal (0/4-20 mA or 0-10 V DC)

Depending on the concrete application, speed control can result in energy savings ranging from 10% to as much as 70%.



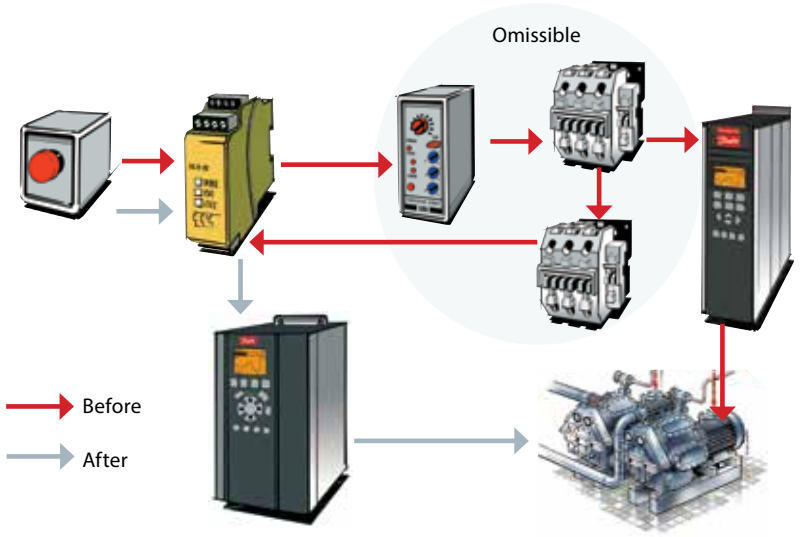
The figure on the left shows the condensation temperature curve (red) and the evaporation temperature curve (blue). The effect of on/off operational behavior compared to a stable temperature (straight line) is clearly visible.

The right-hand figure shows a log (p) h diagram. The standard condensation or evaporation processes are shown as dark red and dark blue lines.

Protect people and equipment

To protect people and equipment, in practically all refrigeration applications, the system operator must ensure that compressors are actually stopped and cannot start up again. This is important in order to avoid HP tripping or vacuum formation in the suction line or the evaporator.

The Safe Torque Off function (compliant with EN 61800-5-2) of the VLT® Refrigeration Drive FC 103 provides a cost-effective way to implement this with high reliability. Unlike software functions that trigger a stop command using the digital inputs, here the control voltage of the output module is enabled or disabled directly via the safe terminal of the frequency converter. This reduces cabling cost, and the functionality integrated in the Refrigeration Drive eliminates the need for costly and bulky external components, such as contactors and relays, that are used for this purpose in conventional solutions.



Two contactors and a timer can be omitted in safety installations due to the safety functionality in VLT® Refrigeration Drive

Easy commissioning

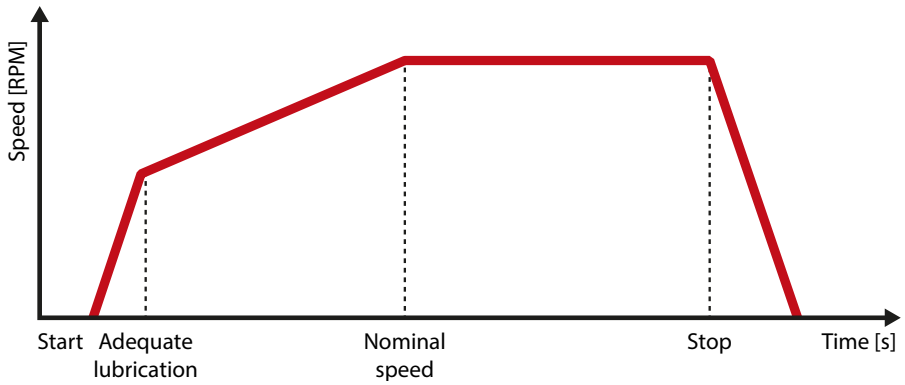
Another significant advantage of the integrated safety function in the VLT® Refrigeration Drive FC 103 is that it can be activated without special software or complicated set-up procedures. This considerably simplifies commissioning, servicing, and the replacement of individual components.

Simplified installation

VLT® Refrigeration Drive FC 103 eliminates the need for special start equipment due to built-in current reduction. It offers motor protection against overload and high temperature conditions and has built-in crank case heater functionality.

Start up compressors gently and reduce wear and tear

There is often insufficient lubrication when compressors are started or operated at excessively low speeds. This is not a problem when compressors are started directly from the mains, since they pass through the critical area quickly. However, in theory the situation is different with variable speed operation: long ramp times mean slow acceleration, resulting in extended operation in the critical region.
To effectively avoid this potential source of wear, the FC 103 provides a separate start ramp for the start-up process when working with a compressor. Once the compressor has passed through the critical region and adequate lubrication is assured, it automatically switches to a slower and gentler starting ramp. Naturally, the fast ramp is also active during the stop process.



Fast start ramp for compressors: just one of the many intelligent functions of the FC 103 VLT® Refrigeration Drive.

Pack Controller
Energy savings thanks to optimal control

There is a speed range in the interaction between the compressor and frequency converter that allows the system to save energy. The compressor should function within this range most of the time. If the difference between the maximum required performance and the average performance under partial load is too great, it is a good idea to use a cascade configuration. The efficiency of the drive, and especially the motor, drops significantly under partial load conditions. In many cases the required capital investment, including the conversion of an existing system, will be amortized quickly.

Cascading the system

In a system with cascaded compressors, the base load is handled by a speed-controlled compressor. If the consumption rises, the drive starts up additional compressors one at a time. As a result, the compressors work largely at their optimum efficiency point, with the control constantly ensuring that the system is operating at maximum energy efficiency. This cascading principle can also be applied to fans and pumps using the VLT® Refrigeration Drive FC 103.

Easy commissioning

The VLT® Refrigeration FC 103 drive offers a setup wizard, using common refrigeration terms rather than computer language. During field testing, programming ease made installers and service technicians more comfortable and confident, and made their jobs easier and quicker.

The wizard menu also supports the commissioning engineers if they encounter any problems. The menu will help the engineer troubleshoot and offer 'quick fixes' to get the drive up and running if there is a problem.

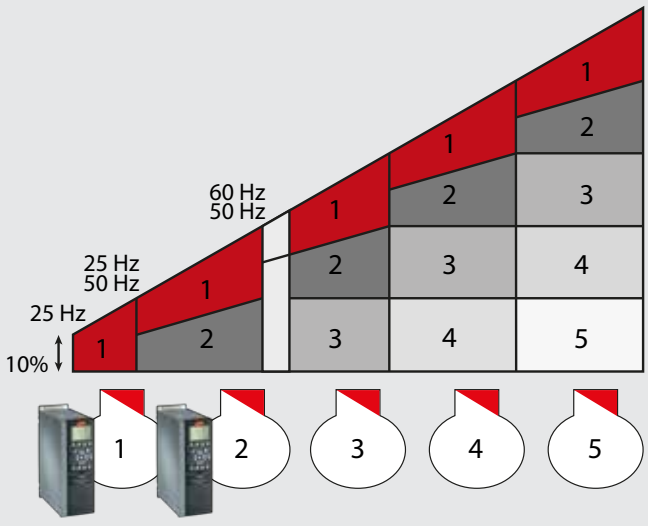
Commissioning is fast and easy using the drive display panel. The wizard that appears the first time the device is switched on guides the user through the necessary settings.

The user only has to switch from external to internal control. If necessary, the wizard can be called up again from the Quick Menu. Configuring the necessary parameters is even easier with the wizard in the VLT® Motion Control Tool MCT 10 software.
During operations, the VLT® Refrigeration Drive FC 103 can show the compressor status on the drive display panel and log the compressor's operating time and number of starts.

The compressor status can be read directly from the display.
D = Variable speed control, O = Off, R = Mains operation, X = Deactivated

Reduced service costs

Mechanical wear is automatically reduced by the fact that only as many compressors are running as are actually needed. This allows service intervals to be extended. The user can configure rotation of mains-powered compressors to ensure that they all end up with a similar number of operating hours.



Speed Control of lead Compressor plus one more, offers improved and streamlined design possibilities and a better choice of Compressors sizing to adapt to varying load conditions

The modular VLT® Refrigeration Drive – adapted to your requirements

The VLT® Refrigeration Drive is built on Danfoss' modular concept. Real plug-and-play adding and exchanging of options. Just upgrade instead of buying a new drive.

1 Fieldbus
- Option:
  VLT® AK-LonWorks MCA 107
- Built-in:
  Modbus RTU as standard
  VLT® PROFIBUS DP MCA 101
  VLT® PROFINET MCA 120

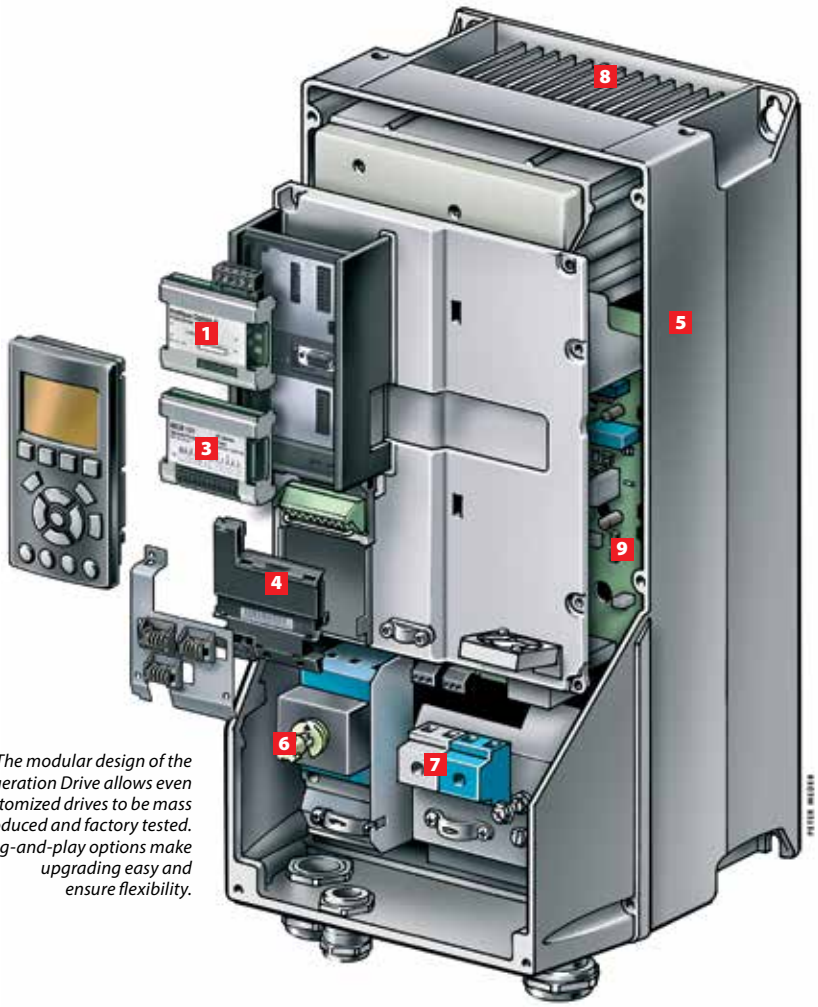
2 Local Control Panel (LCP)
Choose graphical or no display

3 I/O option
- General Purpose I/O
  (3DI + 2AI + 2DO + 1AO)
- Analog I/O option
  (3AI (0 – 10 V / PT1000 / NI 1000) + 3AO (0 – 10 V))
- Relay output (3 x relays)

4 24 V supply option

5 RFI filter
Built-in RFI filter for long motor cables compliant with the IEC 61800-3 and EN 55011 standards.

6 AC mains disconnect
No need for an external switch when you want to disconnect the drive from the mains.



The modular design of the VLT® Refrigeration Drive allows even highly customized drives to be mass produced and factory tested. Plug-and-play options make upgrading easy and ensure flexibility.

7 Input mains option
Various input configurations are available including mains switch (disconnect) or RFI filter. Input plates are field adaptable.

8 Unique cooling concept
- No ambient air flow over the electronics up to 125 HP
- Above 125 HP, designed with back channel cooling (85% heat dissipated via back channel)

9 Durable in aggressive environments
In some refrigeration applications, it is recommended to protect the drive with coated PCB's. VLT® Refrigeration Drive is designed for level 3C2 according to IEC 60721-3-3. Protection level 3C3 is optionally delivered from factory.

This option offers significantly improved protection against chlorine, hydrogen sulphide, ammonia and other corrosive environments.

VLT® quality up to 350 HP
The VLT® Refrigeration Drive FC 103 is available from 1.5 HP to 350 HP.

Danfoss' drive experience since 1968 lies behind the intelligent design of VLT® drives.

All enclosures are mechanically designed with focus on:
- Robustness
- Easy access and installation
- Intelligent cooling
- High ambient temperatures

High Ambient Temperatures

VLT® Refrigeration Drive FC 103 is designed to operate in ambient temperatures up to 50° C with an autoderate capability. This derating enables reduced operation for a period of time at higher ambient temperatures to maintain operation of the VLT® Refrigeration Drive FC 103 system in extreme climate conditions.

Robust to Mains issues

In most cases, the VLT® Refrigeration Drive will handle abnormal situations without needing attention.

VLT® Refrigeration Drive will manage the loss of a mains phase or a high mains imbalance by autoderating speed and load to maintain a period of reduced operation, enabling technicians to respond to the situation.

Maintenance free

Due to a series of self-protecting and monitoring features and a highly durable mechanical design, the VLT® Refrigeration Drive is maintenance free, except for general cleaning. No replacement of internal fans or capacitors is required.

Save space

Due to its compact dimensions, the VLT® Refrigeration Drive is easily mounted inside a panel, reducing overall enclosure costs and freeing up panel backspace for other devices.

Save energy

The energy consumption from fans and pumps rises with the cube of the flow. That's the reason why VLT® control of such applications typically saves up to 48% or more energy compared to on-off operation. The energy saving potential from compressors and entire refrigerating appliances depends on compressor type and system setup.

Save money

We offer a standard & integrated NEMA 12/IP55 protection class equal to that of the motor.

This eliminates the cost of a separate enclosure and saves on the additional installation costs associated with installation in a remote location.

NEMA 4X/IP 66 Indoor for harsh environments

The NEMA 4X/IP 66 enclosure option for harsh environments can eliminate the cost of a separate enclosure and reduce the installation costs associated with remote installations.

Protection mode

As soon as the system detects a critical status, (e.g. over-current or overvoltage) the frequency of the VLT® Refrigeration Drive will automatically be reduced and the modulation process adjusted.

Due to its ability to limit its switching operations, the VLT® Refrigeration Drive is extremely reliable and robust.
The protection mode will – if allowable – end after 10 seconds and the frequency will be restored under control.

Minimum 98% efficiency

The VLT® Refrigeration Drive provides 98% efficiency at full load. This reduces initial costs and operating costs due to the smaller heat load/air conditioning requirement in the switch room/plant room, thereby maximizing energy efficiency. Every kW of losses requires another ~0.5 kW of energy to remove the heat.

Installed in an air conditioned switch room, lower losses can easily result in operating cost savings from >5% – 10% of the cost of the drive every year (based on a typical load profile, with the drive operating 24/7). Also system energy consumption and CO_2 emissions are reduced.

The common approach to drive programming

1 Graphical display
- International letters and signs
- Graphical display with bar-charts
- Easy overview
- 8 language selections

2 Menu structure
- Based on the well known matrix system in today's VLT® Drives
- Easy shortcuts for the experienced user
- Edit and operate in different set-ups simultaneously
- Speaks refrigeration language

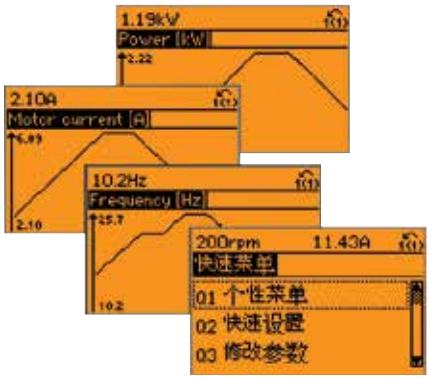
3 Other benefits
- Demountable during operation
- Upload and download functionality
- IP 65/NEMA 4 rating when panel door mounted. (A remote mounting kit is available)
- Up to 5 different variables visible at a time
- Manual speed/torque setting
- 100% user defined information and size

4 Illumination
- Relevant buttons are illuminated when active
- LEDs indicate the status of the drive

5 Quick Menus
- A Danfoss-defined Quick Menu
- A user-defined Quick Menu
- A Changes Made menu lists the parameters unique to your application
- A Wizard set up menu
- A Logging menu provides access to operation history

6 Intuitive functions
- Info (on board manual)
- Cancel (undo)
- Alarm log (quick access)

The user interface may be mounted remotely on a control panel fascia, eliminating the need for additional switches and instrumentation.



The VLT® Refrigeration Drive is controlled locally via a control panel. This is plugged in directly or connected via a cable.

Panel options: Graphical and blind cover.

The VLT® Refrigeration Drive can be remote-commissioned and monitored via a USB cable or RS-485 communication.

Efficient setup wizard speaks refrigeration language

The setup wizard uses the language of the refrigeration trade, rather than technical jargon, to guide users through setup to create a logical easy-to-follow process for engineers and installers.

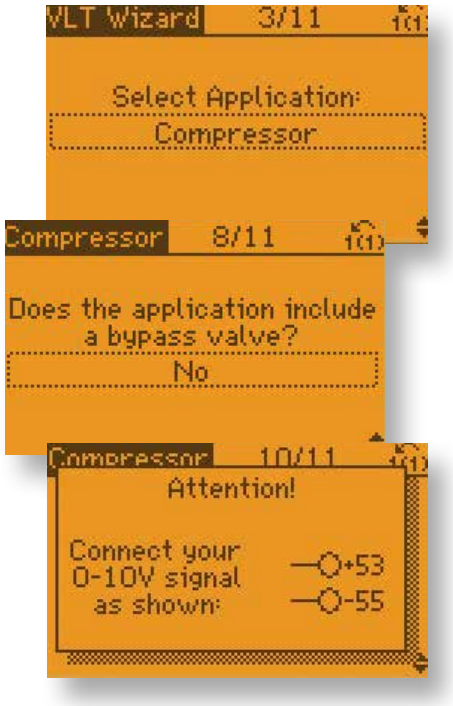
For making installation even more efficient, the built in wizard set up menu guides the user through the set up of the drive in a clear and structured manner. The following applications are supported:

- Multi compressor control
- Multi condenser fan, cooling tower / evaporative condensing
- Single fan and pump
- Pump system

The feature is activated at the first power up, after a factory reset, or from the quick menu. When activating the wizard, the drive will ask for the information it needs to run the application.

You will be guided though the programming of all important parameters like motor data and used control signal (including instructions for connection). At every single step help is easily available by pressing the info button on the display.

Finally, you can also choose to start the Automatic Motor Adaptation (AMA). This functionality will determine the exact motor data and thereby ensure robust and energy efficient operation of your appliance.



VLT® Motion Control Tool The real effect is money saved

Free VLT® Motion Control Tool MCT 10 set-up software provides easy control of details as well as a general overview of drive systems, large or small. The tool handles all drives-related data.

Explorer-like interface
The MCT 10 software features explorer-like interface design and functionality to ease both use and learning of the facilities.

More efficient service organization
- Scope & logging: analyze problems easily
- Read out alarms, warnings and error log in one view
- Compare a saved project with an on-line drive

More efficient commissioning
- Offline commissioning off-site
- Save/send/mail projects anywhere
- Easy fieldbus handling, multiple drives in project file. Enables the service organization to be more efficient

Basic
- Scope & Graph
- Alarm history in saved projects
- Graphical Timebased Actions, Preventive Maintenance and Basic Cascade Controller
- Multiple fieldbus support

Advanced
- No limitation in the number of drives
- Motor database
- Real-time logging from the drive

Online and offline mode
In the online mode, you work with the actual setup of the drives in question. Your actions will have immediate effect on the performance of the drive(s).

Connections
- USB
- RS485

Project oriented
In project mode you work with the drive parameters as a 'virtual' set-up. This allows you to adjust the whole system before you implement it into the drives and put it in action. In project mode you can set the system up even before the drives are installed. A single command will update the whole system. In case a drive is exchanged, it is easily set up to perform exactly as its predecessor.

Dedicated pump features

The VLT® Refrigeration Drive FC 103 offers a vast number of pump-specific features developed in cooperation with OEMs, contractors and manufacturers around the world.

Embedded Pump Cascade Controller

The Pump Cascade Controller distributes running hours evenly across all pumps, keeps wear and tear on individual pumps to a minimum and ensures that all pumps are in great shape.

Leakage or broken pipe

Continuous liquid supply can be assured in the event of leakage or a broken pipe. For example, overload is prevented by reducing drive speed – and supply is secured at lower flow.

Sleep Mode

In Sleep Mode the drive detects situations with low or no flow. Instead of continuous operation, sleep mode boosts the system pressure and then stops to save energy. The drive starts automatically when the pressure falls below the lower set point.

1 Dry Pump Protection and End of Curve

Dry Pump Protection and End of Curve relate to situations where the pump runs without creating the desired pressure – as when a well runs dry or a pipe leaks. In this situation the drive sets off an alarm, shuts off the pump, or performs another pre-programmed action.

2 Auto tuning of the PI controllers

With auto tuning of the PI controllers, the drive monitors how the system reacts to corrections made by the drive, learns from it, and calculates the 'P' and 'I' values so that precise and stable operation is achieved quickly.

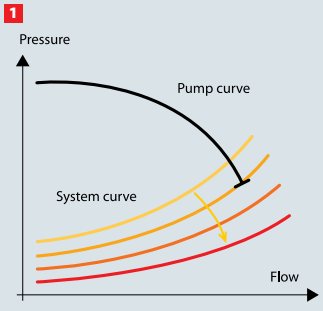
This applies to each PI controller in the 4-menu sets individually. Exact P and I settings at start-up will not be necessary – which lowers commissioning costs.

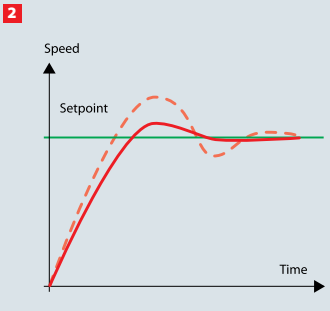
3 Flow compensation

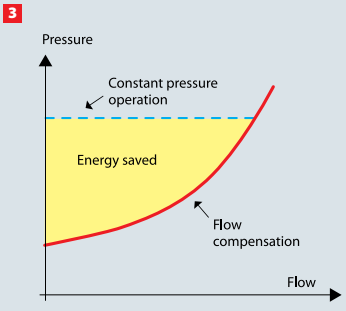
Significant energy savings and reduced installation costs are provided by flow compensation in both fan and pump systems.
A pressure sensor mounted close to the fan or pump provides a reference enabling pressure to be kept constant at the discharge end of the system. The drive constantly adjusts the pressure reference to follow the system curve.

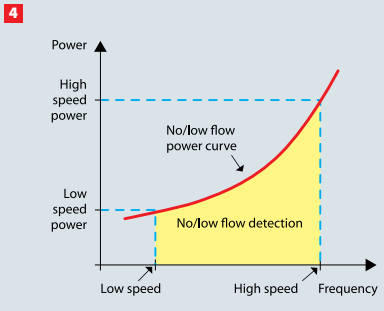
4 No/low flow

An operating pump will normally consume more power the faster it runs – according to a curve determined by the pump and application design. The FC 103 will detect situations where the pump runs fast but is not fully loaded – and thereby not consuming adequate power. This is the case when water circulation stops, the pump runs dry, or when pipes leak.









Dedicated compressor features

The VLT® Refrigeration Drive FC 103 is designed for operating piston, scroll, screw compressors and centrifugal compressors. Variable speed control allows the refrigeration capacity of a compressor to be adapted to exactly match the demand.

Day/night control

Compressors usually operate with different setpoints depending on the time of day. This in turn results in different evaporator fan speeds, resulting in reduced energy consumption. This function can be easily programmed with day/night control.

P0 optimization

The VLT® Refrigeration Drive FC 103 supports connection of an ADAP-KOOL® LonWorks control for P0 optimization.

Neutral Zone

The VLT® Refrigeration FC 103 drive continues to control fixed speed compressors in situations where the variable speed compressor fails. Neutral zone is in a fail situation set by a special parameter "Fixed speed neutral zone", which gives the opportunity to have fewer starts by expanding the neutral zone.

Condensation final temperature monitoring

The frequency converter can monitor the Floating Head Pressure high pressure level control using connected temperature sensors. Speed is reduced before the high pressure reaches a critical value.

Single compressor or pack

The user has the choice of operating the system with a single large compressor or using the pack controller to operate the system with several smaller compressors which are activated as necessary.

Direct entry of evaporation pressure temperature

The user can enter the desired evaporation pressure temperature directly in the control panel of the VLT® Refrigeration Drive. The frequency converter also takes the properties of the refrigerant into account. Tables for the most commonly used refrigerants are preloaded in the frequency converter. User-defined entry of the refrigerant used in the system is also possible.

Inject ON

When all connected compressors on the FC 103 are stopped due to a missing safety circuit, this will be registered by the system unit which will close all valves connected to the case controllers. This prevents a flow of liquid going to the compressor when the FC 103 starts again.
As soon as a compressor starts running again, the valves are allowed to reopen.

Fewer starts and stops

Start-up is the critical phase of compressor operation. The VLT® Refrigeration Drive minimizes the number of required starts and stops by varying the speed of the compressor to tune its capacity during operation. In addition, the maximum number of start/stop cycles in a given period can be configured using the control panel.

Unloaded start

To further extend the lifetime of the VLT® Refrigeration Drive a pressure relief valve can be opened to allow the compressor to start up quickly with no load.

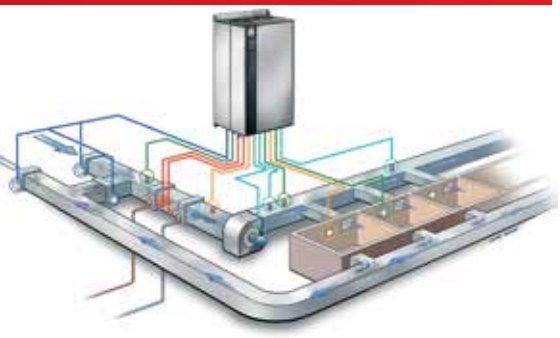
135% Starting torque

The VLT® Refrigeration Drive delivers 135% of the rated starting torque for a period of half a second. In normal operation, 110% of the rated torque is available for 60 seconds.

Smaller compressors with the same peak load

The operator can configure the system with a smaller compressor for a given peak load. Provided the compressor is designed for over-speed operation, the VLT® Refrigeration Drive can run it at up to 90 Hz. This may allow brief peak loads to be handled in this way without necessarily requiring a larger compressor for this purpose.

Dedicated fan features



4 x PID controller

(Individual set-points/feed-backs)

- 1 PID for closed loop control of the motor connected to the drive
- 3 PIDs for external closed loop control of refrigeration equipment
- Auto-tuning of all 4 PID loops
- Eliminates the need for other controllers
- Provides flexibility for the controller and reduces the load

The drive controller uses an input sensor that measures pressure, temperature or other variables to change the speed of the motor connected to the VLT® Refrigeration Drive FC 103, by adjusting its output frequency to match the varying load.

The additional 3 PID controllers can be used for external sensors (i.e. pressure, temperature, flow) to control components.

User-friendly, distributed intelligence and reduced power consumption are beneficial for fan applications.

Velocity-to-flow conversion

The VLT® Refrigeration Drive FC 103 is able to convert velocity pressure sensor values into flow values. Operators can configure the drive to provide a fixed flow or differential flow, which optimizes both comfort and energy consumption. Using a pressure sensor instead of a flow sensor saves money.

Intelligent functions

The FC 103 handles logical rules and inputs from sensors, real time functionality, and time-related actions. This enables the FC 103 to control a wide range of functions, including:

- Weekend and working-day operations
- Cascaded P-PI for temperature control
- Flow balancing between fresh and outlet air
- Belt monitoring

Extended I/O capacity

When operated by an external controller, all the Refrigeration Drive I/O points are available as remote I/O to extend the capacity of the controller. For example, room temperature sensors (Pt1000/Ni1000) can be directly connected.

Resonance monitoring

By pressing a few buttons on the Local Control Panel, the drive can be set to avoid frequency bands, at which connected fans create resonances in the ventilation system. This reduces vibration noise and wear and tear on equipment.

Auto tuning of the PI controllers

With auto tuning of the PI controllers, the drive monitors how the system reacts on corrections made by the drive – and learns from it.

Keeps EMC on the safe side

Optimum EMC protection coupled with integrated harmonic filters ensure that the optimum EMC environment and cleanest power supplies are maintained throughout the operational lifetime of the system, negating any reduction in lifecycle costs.

VLT® Refrigeration Drive FC 103 meets the EMC product standard EN 61800-3 without additional external components, even when using long motor cables. The drive corresponds to the EMC guidelines 2004/108/EC, and offers performance superior to other drives.

Critical for practical use is compliance with the environment standard EN 61800-3, class C1 (residential) and Class C2 (industrial area).

C2 ensures reliable plant operation through full compliance with all EMC requirements, product standards, prescribed warnings and restrictions.

Integrated chokes minimize the network effects dramatically and thus maintain operation within the limits of EN 61000-3-12.

The chokes also make the FC 103 stable and highly dynamic, even during short supply voltage drops or other poor network conditions.

Categories according to EN 61800-3	C1	C2	C3	C4
Limits according to EN 55011	Class B	Class A1	Class A2	Exceeding class A2

Comparison of limits EN 55011/61800-3

Clean power supply

VLT® Refrigeration Drive FC 103 introduces a minimum of RFI or harmonic pollution into the building and avoids problematic performance.

FC 103 is a reliable and cost effective investment.

DC coils reduce harmonic noise and protect the drive. Also EMC filters are integrated (meets EN 55011 A2, A1 or B).

Keep your power supply clean

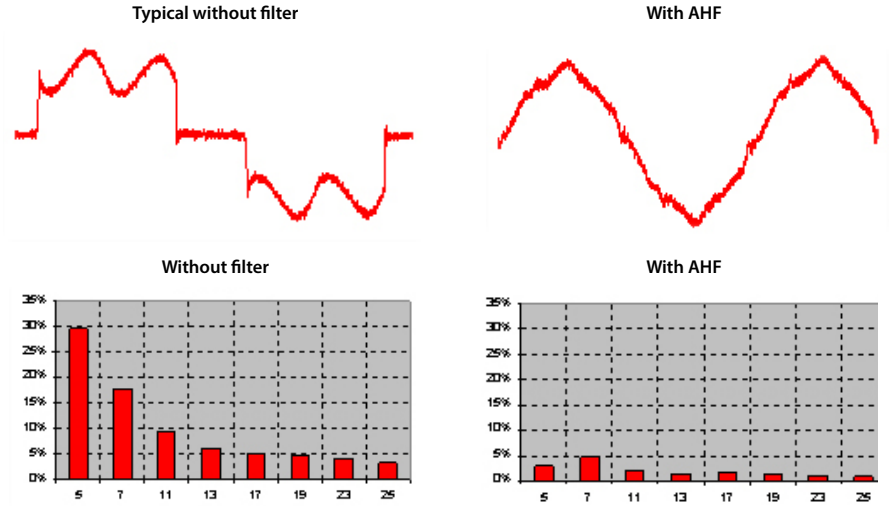
Harmonic distortion on the supply grid is an increasing problem, mainly caused by electronic power devices, including frequency converters, drawing non-sinusoidal current from the mains supply. This creates harmonic distortion on the supply depending on the supply impedance.

Danfoss' VLT® Motion Control Tool MCT 31 makes it possible to calculate the extent of these harmonics at the planning stage and can suggest mitigation countermeasures.

Harmonic mitigation can be particularly valuable when the power supply is backed up with emergency generators, which have poorer tolerance to non-sinusoidal currents.

Current standards (EN 50106) are included in the software analysis tool, which can quickly and easily be downloaded from www.danfossdrives.com.

Data can be entered, stored and recalled project by project. At a click the software presents a clear overview of each project with data presented in both tabular and bar-chart formats.



Harmonic disturbance with and without AHF filter.

High reliability in any environment

All VLT® Refrigeration Drive FC 103 versions have manganese phosphor rear bodies.

IP66/NEMA 4X enclosed drives are suitable for installation in demanding environments.

Cooling air is kept outside the device to prevent any pollution of the electronics. The surfaces are smooth and easily cleaned.

The IP55/66, NEMA 4X series are designed for easy accessibility and time-saving installation.

Furthermore, all components such as EMC filters for compliance with EN 55011, class A1/B, as well as the DC coils, are protected inside the drive.

Because of the high-density integration, the tight housings of the VLT® Refrigeration Drive are significantly smaller when compared to other drives of the same performance.

Motor and power cables are mounted securely through glands in the base plate.

The VLT® Refrigeration Drive is also available with a mains switch option. This switch interrupts the mains supply and has a free useable auxiliary contact.

An external watertight USB plug connected to the control card inside IP 55/66 enclosures makes USB access easy.

VLT® Refrigeration Drive FC 103 – optimized for installation in panels

IP 20/NEMA 1 enclosures

The functionality fulfills the highest requirements even for applications with high overload, long motor cables and ambient temperatures up to 50°C (55°C with derating).

Optimized design
Optimized efficiency and intelligent cooling technology make for a compact and service-friendly design. Supplementary equipment such as EMC filters, harmonics suppression and brake modules are integrated into the enclosure.

Save installation time
The IP20/NEMA 1 series is designed for easy accessibility and time-saving installation.

Mechanical fastening points are easy to access from the front even with automatic tools.

All terminals are sufficiently dimensioned and clearly marked. One need only loosen a few screws to get to the terminals.

Accessories for bonding screened cables are included. The compact enclosures are easier to install. This is important especially within existing installations with limited accessibility. An extensive range of options and accessories are available, optimizing the drive for the respective application.

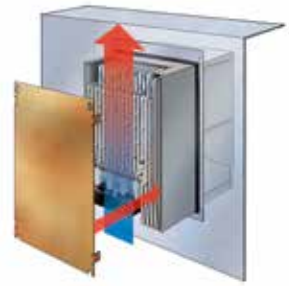
Intelligent heat management – cooling methods for additional benefits

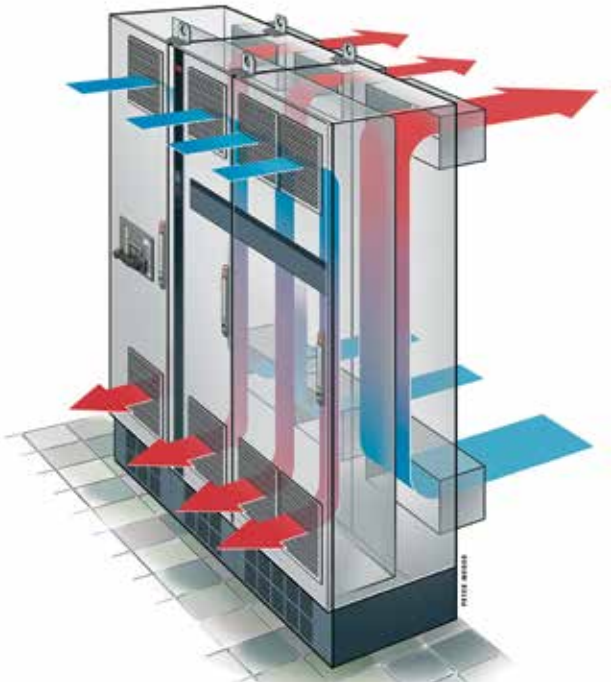
Total separation between cooling air and electronics protects the electronics and allows for installation where heat is removed from outside of the cabinets.

With the VLT® Refrigeration Drive FC 103, a flanged heat sink kit is available for mounting the drive in the backplate of a cabinet, separating the heatsink airflow from the electronics.

Eliminating airflow over the electronics increases drive lifetime as contaminants are excluded from the drive.

Back channel cooling minimizes heat loss while increasing energy efficiency, a significant benefit for high power drives.





Proven refrigeration experience

Maersk Containers, Denmark
VLT® drives are employed to keep correct and constant temperature in Maersk containers.
Compact design, high efficiency, extreme reliability and dedicated refrigeration features are necessary for drives to operate cooling containers at sea and in trains and trucks all over the world.
The quality of the cargo depends on it.

CUB Yatala brewery, Australia
Carlton & United Breweries' Yatala brewery in Queensland, North Australia, boasts better than world's best practice kWh-per-hectolitre figures after a major revamp of its brine chilling plant.
The chiller systems' VLT® drives allow the pumping and compressor capacities to be modulated according to plant demand for chilled brine.

Helsinki Ice Stadium, Finland
Helsinki Ice Stadium opened 1966 and it is the oldest ice stadium in Helsinki. The spectator capacity is 8120. For the opening hockey game in 1967, there were almost 11000 spectators.
Besides hockey, the stadium hosts exhibitions, concerts and other sport events.

Corman, Belgium
Located a stone's throw from the famous Gileppe dam, Belgium, the Corman public limited company specializes in a broad range of anhydrous dairy fats, concentrated butter and technically adapted butter to the needs of food and agriculture industries throughout the world.
Installing VLT® drives proved to be the best way to reduce operation costs and to cater effectively for the changing needs in the production lines.

Versacold Group, Canada
The Versacold Group operates approximately 24 large cold storage and distribution facilities across Canada and the Pacific Northwest, United States.
The warehouses are refrigerated by VLT® drives and provide storage for a variety of pharmaceutical and retail-wholesale grocery chains, contributing to improved quality of life in large metropolitan areas and small villages throughout North America.

Crowne Plaza Copenhagen Towers Hotel, Denmark
The climate-friendly hotel deploys an innovative ground water cooling system with a COP up to 40. VLT® drives-controlled screw compressors enable the heat pumps to adjust the heat capacity continuously from low to full performance with the same efficiency.

Specifications
(Basic unit without extensions)

Main supply (L1, L2, L3)	
Supply voltage	200 – 240 V ±10%
Supply voltage	380 – 480 V ±10%
Supply voltage	525 – 600 V ±10%
Supply frequency	50/60 Hz
Displacement power factor (cos ϕ)	near unity > 0.98
Switching on input supply L1, L2, L3	1–2 times/min.
Harmonic disturbance	Meets EN 61000-3-12

Output data (U, V, W)	
Output voltage	0 – 100% of supply voltage
Output frequency	0–590 Hz
Switching on output	Unlimited
Ramp times	1 – 3600 sec.

Digital inputs	
Programmable digital inputs	6*
Changeable to digital output	2 (terminal 27, 29)
Logic	PNP or NPN
Voltage level	0 – 24 V DC
Maximum voltage on input	28 V DC
Input resistance, Ri	Approx. 4 kΩ
Scan interval	5 ms

** 2 can be used as digital outputs*

Analog inputs	
Analog inputs	2
Modes	Voltage or current
Voltage level	0 to +10 V (scaleable)
Current level	0/4 to 20 mA (scaleable)
Accuracy of analog inputs	Max. error: 0.5% of full scale

Pulse inputs	
Programmable pulse inputs	2*
Voltage level	0 – 24 V DC (PNP positive logic)
Pulse input accuracy (0.1 – 1 kHz)	Max. error: 0.1% of full scale

** Utilize some of the digital inputs*

Digital outputs	
Programmable digital/pulse outputs	2
Voltage level at digital/frequency output	0 – 24 V DC
Max. output current (sink or source)	40 mA
Maximum output frequency at frequency output	0 to 32 kHz
Accuracy on frequency output	Max. error: 0.1% of full scale

Analog output	
Programmable analog outputs	1
Current range at analog output	0/4 – 20 mA
Max. load to common at analog output (clamp 30)	500 Ω
Accuracy on analog output	Max. error: 1% of full scale

Control card	
USB interface	1.1 (Full Speed)
USB plug	Type "B"
RS485 interface	Up to 115 kBaud
Max. load (10 V)	15 mA
Max. load (24 V)	200 mA

Relay output	
Programmable relay outputs	2
Max. terminal load (AC) on 1-3 (break), 1-2 (make), 4-6 (break) power card	240 V AC, 2 A
Max. terminal load (AC) on 4-5 (make) power card	400 V AC, 2 A
Min. terminal load on 1-3 (break), 1-2 (make), 4-6 (break), 4-5 (make) power card	24 V DC 10 mA, 24 V AC 20 mA

Surroundings/external	
Enclosure	IP: 20/21/54/55/66 UL Type: Chassis/1/12/ NEMA 4x Outdoor
Vibration test	1.0 g (D, E & F-enclosures: 0.7 g)
Max. relative humidity	5% – 95% (IEC 721-3-3; Class 3K3 (non-condensing) during operation
Ambient temperature	Max. 50° C w/o derating
Galvanic isolation of all	I/O supplies according to PELV
Aggressive environment	Designed for coated/uncoated 3C3/3C2 (IEC 60721-3-3)

Fieldbus communication	
Standard built-in: FC Protocol N2 Metasys Modbus RTU	Optional: LonWorks for ADAP-KOOL® (MCA 107)

Protection mode for longest possible up-time
– Electronic thermal motor protection against overload
– Temperature monitoring of the heatsink ensures that the frequency converter trips if the temperature reaches 95° C ± 5° C.
– The frequency converter is protected against short-circuits on motor terminals U, V, W.
– The frequency converter is protected against earth faults on motor terminals U, V, W.
– Protection against mains phase loss

Power, currents and enclosures

			T2 200 – 240 V					T4 380 – 480 V						T6 525 – 600 V					
								Max Cont. Current						Max Cont. Current					
FC 103	kW	HP	Max Cont. Current	IP 20 / Chassis	IP 21 / NEMA 1	IP 55 / NEMA 12	IP 66 / NEMA 4X	≤440 V	>440 V	IP 20 / Chassis	IP 21 / NEMA 1	IP 54 / NEMA 12	IP 55 / NEMA 12	IP 66 / NEMA 4X	≤550 V	>550 V	IP 20 / Chassis	IP 21 / NEMA 1	IP 55 / NEMA 12	IP 66 / NEMA 4X
P1K1	1.1	1.5	6.6	A2	A2	A4/A5	A4/A5	3	2.7	A2	A2		A4/A5	A4/A5	2.6	2.4	A3	A3	A5	A5
P1K5	1.5	2	7.5					4.1	3.4						2.9	2.7				
P2K2	2.2	3	10.6					5.6	4.8						4.1	3.9				
P3K0	3	4	12.5	A3	A3	A5	A5	7.2	6.3						5.2	4.9				
P3K7	3.7	5	16.7																	
P4K0	4	5.5						10	8.2	A2	A2		A5	A5	6.4	6.1	A3	A3	A5	A5
P5K5	5.5	7.5	24.2	B3	B1	B1	B1	13	11	A3	A3				9.5	9				
P7K5	7.5	10	30.8					16	14.5						11.5	11				
P11K	11	15	46.2					24	21	B3	B1		B1	B1	19	18	B3	B1	B1	B1
P15K	15	20	59.4	B4	B2	B2	B2	32	27						23	22				
P18K	18	25	74.8		C1	C1	C1	37.5	34						28	27				
P22K	22	30	88	C3				44	40	B4	B2		B2	B2	36	34	B4	B2	B2	B2
P30K	30	40	115					61	52						43	41				
P37K	37	50	143	C4	C2	C2	C2	73	65		C1		C1	C1	54	52		C1	C1	C1
P45K	45	60	170					90	80	C3					65	62	C3			
P55K	55	75						106	105						87	83				
P75K	75	100						147	130	C4	C2		C2	C2	105	100	C4	C2	C2	C2
P90K	90	125						177	160						137	131				
N110	110	150						212	190	D3h	D1h	D1h								
N132	132	200						260	240											
N160	160	250						315	302											
N200	200	300						395	361	D4h	D2h	D2h								
N250	250	350						480	443											
N315	315	400						588	535											

IP 00/Chassis	IP 20/Chassis	IP 21/NEMA 1	With upgrade kit – available in US only	IP 54/NEMA 12	IP 55/NEMA 12	IP 66/NEMA 4X

Dimensions

inches	A2	A3	A4	A5	B1	B2	B3	B4	C1	C2	C3	C4	D1h	D2h	D3h	D4h
H	10.6		15.4	16.5	18.9	25.6	15.7	20.5	26.8	30.3	21.7	26	35.5	43.6	35.8	44.2
W	3.5	5.1	7.9	9.5			6.5	9.1	12.1	14.6	12.1	14.6	12.8	16.5	9.8	13.8
D	8.1		6.9	7.9	10.2		9.8	9.5	12.2	13.2	13.1		14.9		14.8	
H+	14.8						18.7	26.4			29.7	37.4				
W+	3.5	5.1					6.5	10			13	15.4				

mm	A2	A3	A4	A5	B1	B2	B3	B4	C1	C2	C3	C4	D1h	D2h	D3h	D4h
H	268		390	420	480	650	399	520	680	770	550	660	901	1107	909	1122
W	90	130	200	242			165	231	308	370	308	370	325	420	250	350
D	205		175	200	260		248	242	310	335	333		378		375	
H+	375						475	670			755	950				
W+	90	130					165	255			329	391				

Note: *H and W dimensions are with back-plate. H+ and W+ are with IP upgrade kit. D dimensions are without option. A or B for A2 and A3.*

Ordering type code for VLT® Refrigeration Drive

[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]
FC-103	–	–	–	–	–	–	–	–	–	– X – SXX X –	X	–	–	– CX	– X	– XX	–

[1] Application

103	VLT® Refrigeration Drive FC 103

[2] Power Size

P1K1	
P1K5	
P2K2	
P3K0	
P3K7	
P4K0	
P5K5	
P7K5	
P11K	
P15K	
P18K	
P22K	*See ratings data on page 20 for power ratings*
P30K	
P37K	
P45K	
P55K	
P75K	
P90K	
N110	
N132	
N160	
N200	
N250	
N315	

[3] AC Line Voltage

T2	3 x 200/240 V AC *(1.5 - 60 HP)*
T4	3 x 380/480 V AC *(1.5 - 350 HP)*
T6	3 x 525/600 V AC *((1.5 - 125 HP)*

[4] Enclosure

For cabinet mounting:	
E20	IP 20/Chassis (encl. A2, A3, B3, B4, C3, C4, D3h, D4h)
Standalone:	
E21	IP 21/NEMA 1 (encl. B1, B2, C1, C2, D1h, D2h)
E54	IP 54/NEMA 12 (encl. D1h, D2h,)
E55	IP 55/NEMA 12 (encl. A5, B1, B2, C1, C2)
E66	IP 66/NEMA 4x (encl. A5, B1, B2, C1, C2)
Special designs:	
P20	IP 20/Chassis (encl. B4, C3, C4 – Back Plate)
E2M	IP 21/NEMA 1 (encl. D1h, D2h – protective cover)
P21	IP 21/NEMA 1 (encl. as E21 – Back Plate)
E5M	IP 54/NEMA 12 (encl. D1h, D2h – protective cover)
P55	IP 55/NEMA 12 (encl. as E55 – Back Plate)

[5] RFI Filter (EN 55011)

H1	RFI-Filter Class A1/B (A, B, C)
H2	RFI-Filter, Class A2 (A, B, C, D)
H4	RFI-Filter, Class A1 (D)
HX	No RFI-Filter (A, B, C, 525 – 600 V)

[6] Braking & Safety

X	No brake IGBT
T	Safe stop without brake

[7] Display (Local Control Panel)

X	Blank faceplate, no LCP installed
G	LCP 102 – Graphic LCP installed

[8] Conformal Coating (IEC 721-3-3)

X	No conformal coating
C	Conformal coating on all PCBs

[9] Mains Input

X	No option
1	Mains disconnect
3	Mains disconnect and fuses
5	Mains disconnect, fuses and load sharing
7	Fuses

[10] Cable

X	Standard Cable Entries
S	US smooth cable entries

[13] A Option (Fieldbus)

AX	No fieldbus option
AZ	MCA 107 – LonWorks for ADAP-KOOL®

[14] B Option (Application)

BX	No application option
BK	MCB 101 – General Purpose I/O
BP	MCB 105 – Relay Expansion
B0	MCB 109 – Analog I/O

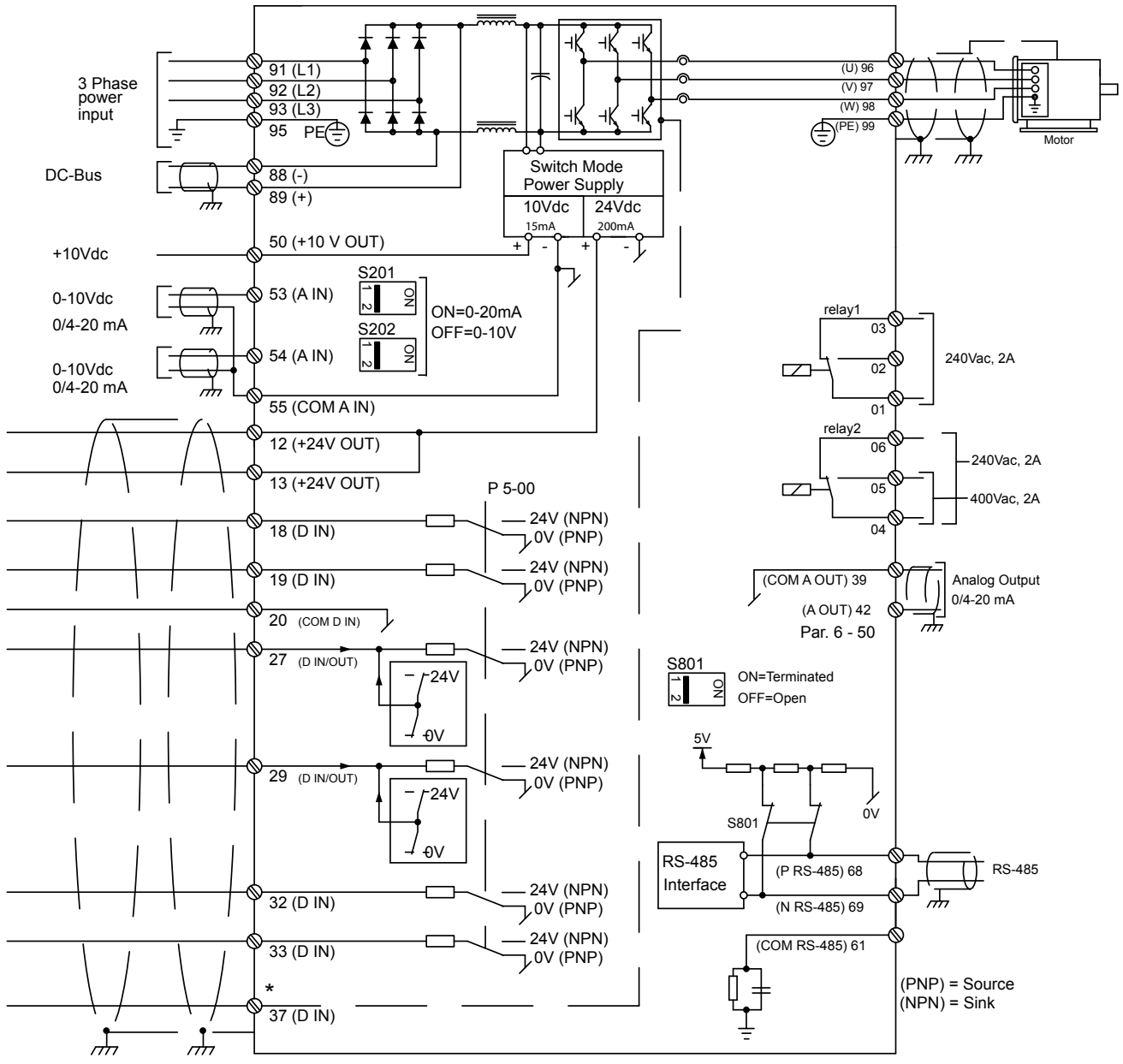
[18] D Option (Control Power Backup Input)

DX	No DC input installed
D0	MCB 107 24 VDC backup input

Please note that not all combinations are possible. Find help for configuring your drive with the online configurator found under: www.danfossdrives.com

Based on your selection, Danfoss manufactures the desired VLT® Refrigeration Drive FC 103 to your specification. You will receive a fully assembled frequency converter, tested under full load conditions.

Connection examples
The numbers represent the terminals on the drive



** Safe Stop optional*

This diagram shows a typical installation of the VLT® Refrigeration Drive FC 103. Power is connected to the terminals 91 (L1), 92 (L2) and 93 (L3) and the motor is connected to 96 (U), 97 (V) and 98 (W).

Terminals 88 and 89 are used for load sharing between drives.

Analog inputs can be connected to the 53 (V or mA), and for 54 (V or mA) terminals.
These inputs can be set up as either reference, feedback or thermistor inputs. There are 6 digital inputs to be connected to terminals 18, 19, 27, 29, 32, and 33. Two digital input/output terminals (27 and 29) can be set up as digital outputs to show an actual status or warning. The terminal 42 analog output can show process values such as 0 - I^{max}.

On the 68 (P+) and 69 (N-) terminals' RS 485 interface, the drive can be controlled and monitored via serial communication.

200 – 240 VAC

Enclosure			IP 20 (IP 21*)/Chassis(NEMA 1)	A2			A3	
			IP 55/NEMA 12, IP 66/NEMA 4X	A4 + A5			A5	
				P1K1	P1K5	P2K2	P3K0	P3K7
Typical Shaft Output			[kW]	1.1	1.5	2.2	3	3.7
Typical Shaft Output at 208 V			[HP]	1.5	2.0	2.9	4.0	4.9
Output Current (3 x 200 – 240 V)	Continuous		[A]	6.6	7.5	10.6	12.5	16.7
	Intermittent		[A]	7.3	8.3	11.7	13.8	18.4
Output Power (208 V AC)	Continuous		[kVA]	2.38	2.70	3.82	4.50	6.00
Max. cable size (Mains, motor, brake)			[mm²] ([AWG])	4 (12)				
Max. Input Current (3 x 200 – 240 V)	Continuous		[A]	5.9	6.8	9.5	11.3	15.0
	Intermittent		[A]	6.5	7.5	10.5	12.4	16.5
Max. pre-fuses			[A]	20	20	20	32	32
Environment								
Estimated power loss at rated max. load			[W]	63	82	116	155	185
Weight								
IP 20			[lbs (kg)]	10.8 (4.9)			14.5 (6.6)	
IP 21			[lbs (kg)]	12.1 (5.5)			16.5 (7.5)	
IP 55, IP 66			[lbs (kg)]	29.7 (13.5)				
Efficiency				0.96	0.96	0.96	0.96	0.96

Enclosure		IP 20 (IP 21*)/Chassis(NEMA 1)	B3			B4		C3		C4	
		IP 21/NEMA 1, IP 55/NEMA 12, IP 66/NEMA 4X	B1			B2	C1			C2	
			P5K5	P7K5	P11K	P15K	P18K	P22K	P30K	P37K	P45K
Typical Shaft Output		[kW]	5.5	7.5	11	15	18.5	22	30	37	45
Typical Shaft Output at 208 V		[HP]	7.5	10	15	20	25	30	40	50	60
Output Current (3 x 200 – 240 V)	Continuous	[A]	24.2	30.8	46.2	59.4	74.8	88.0	115	143	170
	Intermittent	[A]	26.6	33.9	50.8	65.3	82.3	96.8	127	157	187
Output Power (208 V AC)	Continuous	[kVA]	8.7	11.1	16.6	21.4	26.9	31.7	41.4	51.5	61.2
Max. cable size Mains, motor, brake		[mm²] ([AWG])	10 (8)		35, 25 (2, 4)	35 (2)	50 (1/)		150 (300 MCM)		
Max. cable size mains With mains disconnect switch included		[mm²] ([AWG])	16 (6)			35 (2)	35 (2)			70 (3/0)	185 (kcmil 350)
Max. Input Current (3 x 200 – 240 V)	Continuous	[A]	22.0	28.0	42.0	54.0	68.0	80.0	104.0	130.0	154.0
	Intermittent		24.2	30.8	46.2	59.4	74.8	88.0	114.0	143.0	169.0
Max. pre-fuses		[A]	63	63	63	80	125	125	160	200	250
Environment											
Estimated power loss at rated max. load		[W]	269	310	447	602	737	845	1140	1353	1636
Weight											
IP 20		[lbs (kg)]	26.4 (12)			51.8 (23.5)		77.1 (35)		110.2 (50)	
IP 21, IP 55, IP 66		[lbs (kg)]	50.7 (23)			59.5 (27)	99.2 (45)			143.3 (65)	
Efficiency			0.96	0.96	0.96	0.96	0.96	0.97	0.97	0.97	0.97

* *(A2, A3, B3, B4, C3 and C4 may be converted to IP21/NEMA 1 using a conversion kit.*
(Please also see items Mechanical mounting in Operating Instructions and IP 21/ NEMA 1 Enclosure kit in the Design Guide.))

380 – 480 VAC

Enclosure			IP 20 (IP 21*)/Chassis(NEMA 1)	A2					A3	
			IP 55/NEMA 12, IP 66 NEMA 4X	A4 + A5					A5	
				P1K1	P1K5	P2K2	P3K0	P4K0	P5K5	P7K5
Typical Shaft Output			[kW]	1.1	1.5	2.2	3	4	5.5	7.5
Typical Shaft Output at 460 V			[HP]	1.5	2.0	2.9	4.0	5.0	7.5	10
Output Current (3 x 380 – 440 V)	Continuous		[A]	3	4.1	5.6	7.2	10	13	16
	Intermittent		[A]	3.3	4.5	6.2	7.9	11	14.3	17.6
Output Current (3 x 441 – 480 V)	Continuous		[A]	2.7	3.4	4.8	6.3	8.2	11	14.5
	Intermittent		[A]	3.0	3.7	5.3	6.9	9.0	12.1	15.4
Output Power (400 V AC)	Continuous		[kVA]	2.1	2.8	3.9	5.0	6.9	9.0	11.0
Output Power (460 V AC)	Continuous		[kVA]	2.4	2.7	3.8	5.0	6.5	8.8	11.6
Max. cable size (Mains, motor, brake)			[mm²] ([AWG])	4 (12)						
Max. Input Current (3 x 380 – 440 V)	Continuous		[A]	2.7	3.7	5.0	6.5	9.0	11.7	14.4
	Intermittent		[A]	3.0	4.1	5.5	7.2	9.9	12.9	15.8
Max. Input Current (3 x 441 – 480 V)	Continuous		[A]	2.7	3.1	4.3	5.7	7.4	9.9	13.0
	Intermittent		[A]	3.0	3.4	4.7	6.3	8.1	10.9	14.3
Max. pre-fuses			[A]	10	10	20	20	20	32	32
Environment										
Estimated power loss at rated max. load			[W]	58	62	88	116	124	187	255
Weight										
IP 20			[lbs (kg)]	10.5 (4.8)	10.8 (4.9)				14.5 (6.6)	
IP 55, IP 66			[lbs (kg)]	29.7 (13.5)					31.3 (14.2)	
Efficiency				0.96	0.97	0.97	0.97	0.97	0.97	0.97

Enclosure		IP 20 (IP 21*)/Chassis(NEMA 1)	B3			B4			C3		C4	
		IP 21/NEMA 1, IP 55/NEMA 12, IP 66/NEMA 4X	B1			B2			C1		C2	
			P11K	P15K	P18K	P22K	P30K	P37K	P45K	P55K	P75K	P90K
Typical Shaft Output		[kW]	11	15	18.5	22	30	37	45	55	75	90
Typical Shaft Output at 460 V		[HP]	15	20	25	30	40	50	60	75	100	125
Output Current (3 x 380 – 439 V)	Continuous	[A]	24	32	37.5	44	61	73	90	106	147	177
	Intermittent	[A]	26.4	35.2	41.3	48.4	67.1	80.3	99	117	162	195
Output Current (3 x 440 – 480 V)	Continuous	[A]	21	27	34	40	52	65	80	105	130	160
	Intermittent	[A]	23.1	29.7	37.4	44	61.6	71.5	88	116	143	176
Output Power (400 V AC)	Continuous	[kVA]	16.6	22.2	26	30.5	42.3	50.6	62.4	73.4	102	123
Output Power (460 V AC)	Continuous	[kVA]	16.7	21.5	27.1	31.9	41.4	51.8	63.7	83.7	104	128
Max. cable size Mains, motor, brake		[mm²] ([AWG])	10, 10, 16 (6, 8, 6)		35, 25, 25 (2, 4, 4)		50 (1/0)			150 (300 MCM)		
Max. cable size mains With mains disconnect switch included		[mm²] ([AWG])	16 (6)					35 (2)			70 (3/0)	185 (kcmil 350)
Max. Input Current (3 x 380 – 439 V)	Continuous	[A]	22	29	34	40	55	66	82	96	133	161
	Intermittent		24.2	31.9	37.4	44	60.5	72.6	90.2	106	146	177
Max. Input Current (3 x 440 – 480 V)	Continuous	[A]	19	25	31	36	47	59	73	95	118	145
	Intermittent		20.9	27.5	34.1	39.6	51.7	64.9	80.3	105	130	160
Max. pre-fuses		[A]	63	63	63	63	80	100	125	160	250	250
Environment												
Estimated power loss at rated max. load		[W]	278	392	465	525	698	739	843	1083	1384	1474
Weight												
IP 20		[lbs (kg)]	26.4 (12)			51.8 (23.5)			77.1 (35)		110.2 (50)	
IP 21, IP 55, IP 66		[lbs (kg)]	50.7 (23)			59.5 (27)		99.2 (45)			143.3 (65)	
Efficiency			0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.99

* *(A2, A3, B3, B4, C3 and C4 may be converted to IP21 using a conversion kit. Please contact Danfoss.*
(Please see also items Mechanical mounting in Operating Instructions and IP 21/ NEMA 1 Enclosure kit in the Design Guide.))

1) With brake and load sharing 95 (4/0)

525 – 600 VAC

Enclosure																		
IP 20 Chassis		**A3**				**A3**			**B3**			**B4**		**C3**			**C4**	
IP 21/NEMA 1									**B1**			**B2**		**C1**			**C2**	
IP 55/NEMA 12, IP 66/NEMA 4X		**A5**																
		P1K1	**P1K5**	**P2K2**	**P3K0**	**P4K0**	**P5K5**	**P7K5**	**P11K**	**P15K**	**P18K**	**P22K**	**P30K**	**P37K**	**P45K**	**P55K**	**P75K**	**P90K**
Typical Shaft Output	[kW]	1.1	1.5	2.2	3	4	5.5	7.5	11	15	18.5	22	30	37	45	55	75	90
Output Current																		
Continuous (3 x 525 – 550 V)	[A]	2.6	2.9	4.1	5.2	6.4	9.5	11.5	19	23	28	36	43	54	65	87	105	137
Intermittent (3 x 525 – 550 V)	[A]	2.9	3.2	4.5	5.7	7.0	10.5	12.7	21	25	31	40	47	59	72	96	116	151
Continuous (3 x 525 – 600 V)	[A]	2.4	2.7	3.9	4.9	6.1	9.0	11.0	18	22	27	34	41	52	62	83	100	131
Intermittent (3 x 525 – 600 V)	[A]	2.6	3.0	4.3	5.4	6.7	9.9	12.1	20	24	30	37	45	57	68	91	110	144
Output Power																		
Continuous (525 V AC)	[kVA]	2.5	2.8	3.9	5.0	6.1	9.0	11.0	18.1	21.9	26.7	34.3	41	51.4	61.9	82.9	100	130.5
Continuous (575 V AC)	[kVA]	2.4	2.7	3.9	4.9	6.1	9.0	11.0	17.9	21.9	26.9	33.9	40.8	51.8	61.7	82.7	99.6	130.5
Max. cable size IP 20 (mains, motor, brake)	[mm²] ([AWG])	4 (12)							10 (8)		35 (2)			50 (1)		150 (300 MCM)		
Max. cable size IP 21/55/66 (mains, motor, brake)	[mm²] ([AWG])	4 (12)							10 (8)		35, 25 (2, 4)	35 (2)		50 (1)		150 (300 MCM)	95 (4/0)	
Max. cable size mains With mains disconnect switch included	[mm²] ([AWG])	4 (12)							16, 10 (6, 8)					50, 35 (1, 2)		95, 70 (3/0, 2/0)	185, 150, 120 (350 MCM, 300 MCM 4/0)	
Max. Input Current																		
Continuous (3 x 525 – 600 V)	[A]	2.4	2.7	4.1	5.2	5.8	8.6	10.4	17.2	20.9	25.4	32.7	39	49	59	78.9	95.3	124.3
Intermittent (3 x 525 – 600 V)	[A]	2.7	3.0	4.5	5.7	6.4	9.5	11.5	19	23	28	36	43	54	65	87	105	137
Max. pre-fuses	[A]	10	10	20	20	20	32	32	63	63	63	63	80	100	125	160	250	250
Environment																		
Estimated power loss at rated max. load	[W]	50	65	92	122	145	195	261	300	400	475	525	700	750	850	1100	1400	1500
Weight																		
IP 20	[lbs (kg)]	14.3 (6.5)				14.5 (6.6)			26.4 (12)			51.8 (23.5)			77.1 (35)		110.2 (50)	
IP 21, IP 55, IP 66	[lbs (kg)]	29.7 (13.5)				31.3 (14.2)			50.7 (23)			59.5 (27)			99.2 (45)		143.3 (65)	
Efficiency		0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98

1) With brake and load sharing 95 (4/0)

380 – 480 VAC
High Power

380 – 480 VAC

Enclosure			D1h			D2h		
	IP 21/NEMA 1, IP 54/NEMA 12		D3h			D4h		
	IP 20/Chassis		N110	N132	N160	N200	N250	N315
Typical Shaft Output at 400 V		[kW]	110	132	160	200	250	315
Typical Shaft Output at 460 V		[HP]	150	200	250	300	350	450
Output Current								
Continuous (at 400 V)		[A]	212	260	315	395	480	588
Intermittent (60 sec overload) (at 400 V)		[A]	233	286	347	435	528	647
Continuous (at 460/480 V)		[A]	190	240	302	361	443	535
Intermittent (60 sec overload) (at 460/480 V)		[A]	209	264	332	397	487	588
Output Power								
Continuous (at 400 V)		[kVA]	147	180	218	274	333	407
Continuous (at 460 V)		[kVA]	151	191	241	288	353	426
Max. Input Current								
Continuous (at 400 V)		[A]	204	251	304	381	463	567
Continuous (at 460/480 V)		[A]	183	231	291	348	427	516
Max. cable size Mains motor, brake and load share		[mm²] ([AWG])	2 x 95 (2 x 3/0)			2 x 185 (2 x 350)		
Max. external pre-fuses		[A]	315	350	400	550	630	800
Estimated power loss at rated max. load – 400 V		[W]	2555	2949	3764	4109	5129	6663
Estimated power loss at rated max. load – 460 V		[W]	2257	2719	3622	3561	4558	5703
Weight	IP 21, IP 54	[lbs (kg)]	136.6 (62)			275.5 (125)		
	IP 20	[lbs (kg)]	136.6 (62)			275.5 (125)		
Efficiency			0.98					

Constant-torque applications

Low starting torque (110% overload)

Scroll compressor	[0.6 to 0.9 nominal]
Screw compressor	[0.4 to 0.7 nominal]
Piston compressor	[0.6 to 0.9 nominal]

Normal starting torque [overtorque]

Scroll compressor	[1.2 to 1.6 nominal]
Screw compressor	[1.0 to 1.6 nominal]
2-cylinder compressor	[up to 1.6 nominal]
4-cylinder compressor	[up to 1.2 nominal]
6-cylinder compressor	[up to 1.2 nominal]

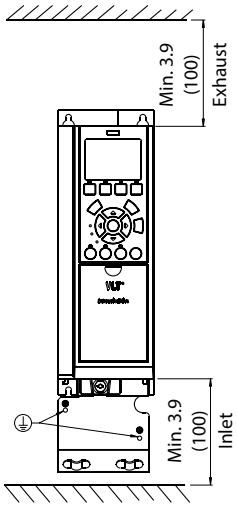
High starting torque [overtorque]

2-cylinder compressor	[up to 2.2 nominal]
4-cylinder compressor	[up to 1.8 nominal]
6-cylinder compressor	[up to 1.6 nominal]

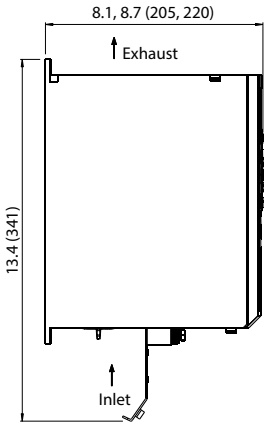
Dimensions VLT® Refrigeration Drive

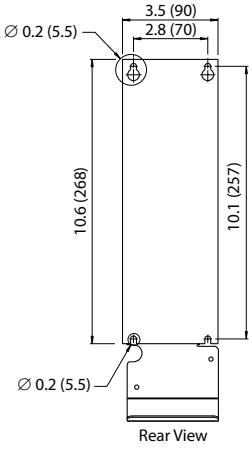
In inches (mm)

A2 enclosures



Depth 8.7 inches with A/B-Options

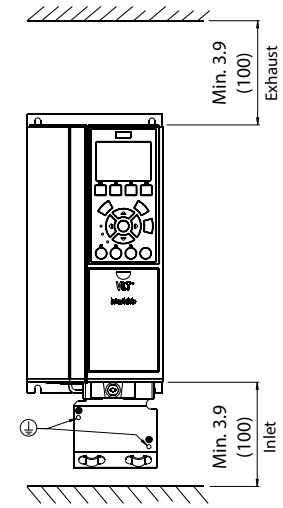




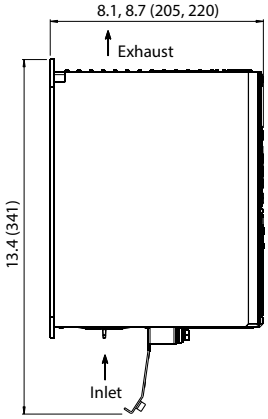
IP 20/ Chassis	(200-240V)	110%	1.1 – 2.2 kW 1.5 – 3 HP
IP 20/ Chassis	(380-480V)	110%	1.1 – 4.0 kW 1.5 – 5.5 HP

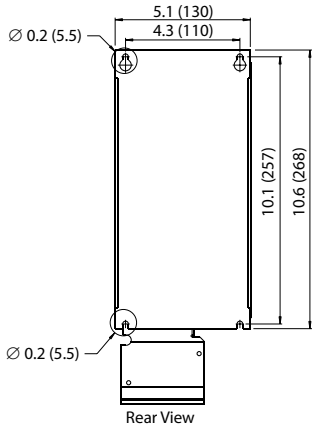
A2

A3 enclosures



Depth 8.7 mm with A/B-Options

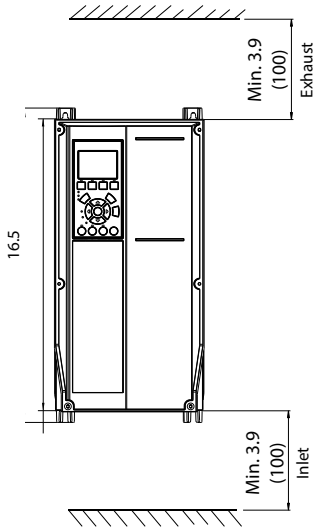


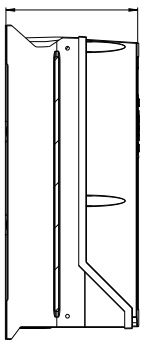


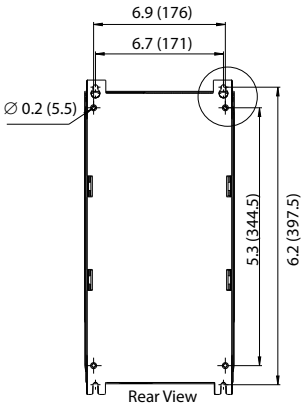
IP 20/ Chassis	(200-240V)	110%	3 – 3.7 kW 4 – 5 HP
IP 20/ Chassis	(380-480V)	110%	5.5 – 7.5 kW 7.5 – 10 HP
IP 20/Chassis IP 21/NEMA 1	(525-600V)	110%	1.1 – 7.5 kW 1.5 – 10 HP

A3

A4 enclosures







IP 55/NEMA 12 IP 66/NEMA 4X	(200-240V)	110%	1.1 – 2.2 kW 1.5 – 3 HP
IP 55/NEMA 12 IP 66/NEMA 4X	(380-480V)	110%	1.1 – 4.0 kW 1.5 – 5.5 HP

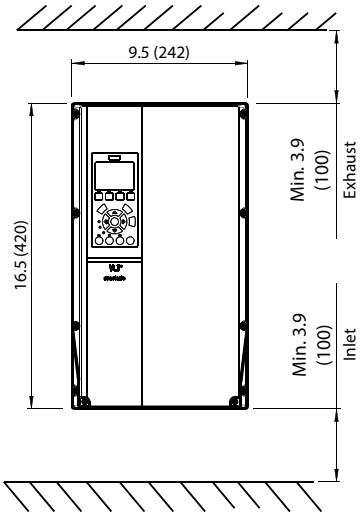
A4

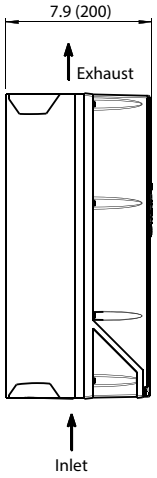
Dimensions VLT® Refrigeration Drive

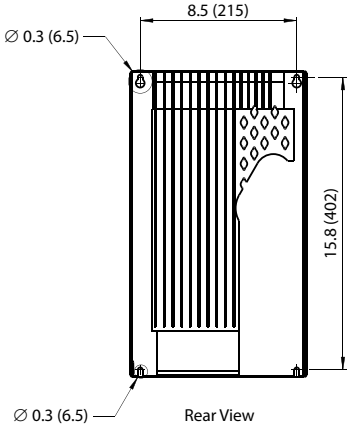
In inches (mm)

A5 enclosures

IP 55/NEMA 12 IP 66/NEMA 4X	(200-240V)	1.1 – 3.7 kW 1.5 – 5 HP
	110%	
IP 55/NEMA 12 IP 66/NEMA 4X	(380-480V)	1.1 – 7.5 kW 1.5 – 10 HP
	110%	
IP 55/NEMA 12 IP 66/NEMA 4X	(525-600V)	1.1 – 7.5 kW 1.5 – 10 HP
	110%	

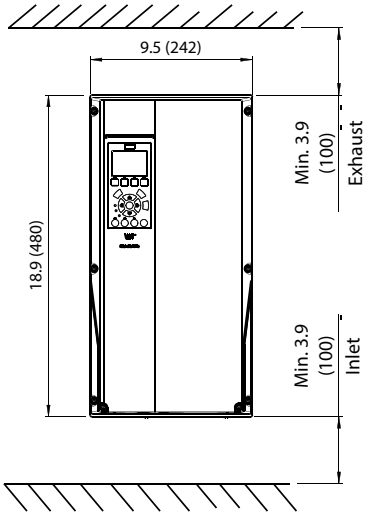


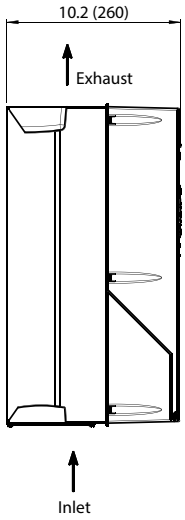


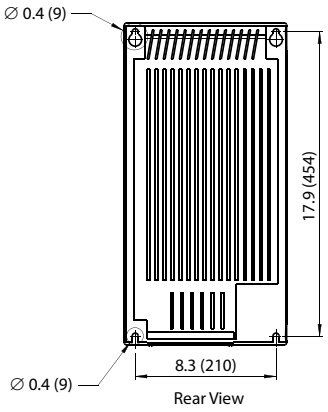


B1 enclosures

IP 55/NEMA 12 IP 66/NEMA 4X	(200-240V)	5.5 – 11 kW 7.5 – 15 HP
	110%	
IP 55/NEMA 12 IP 66/NEMA 4X	(380-480V)	11 – 18.5 kW 15 – 25 HP
	110%	
IP 21/NEMA 1 IP 55/NEMA 12 IP 66/NEMA 4X	(525-600V)	11 – 18.5 kW 15 – 25 HP
	110%	

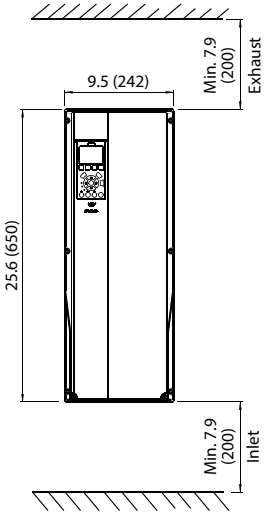


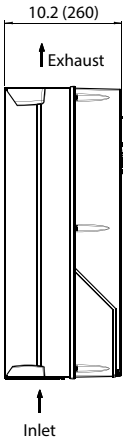


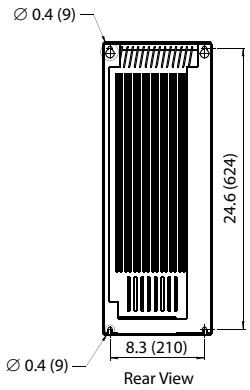


B2 enclosures

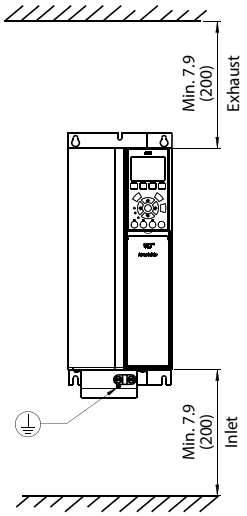
IP 20/ Chassis	(200-240V)	15 kW 20 HP
	110%	
IP 20/ Chassis	(380-480V)	22 – 30 kW 30 – 40 HP
	110%	
IP 20/ Chassis	(525-600V)	22 – 30 kW 30 – 50 HP
	110%	



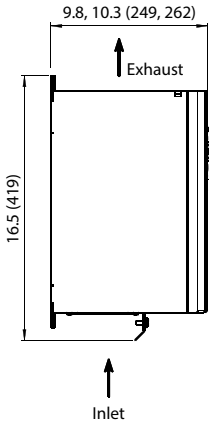


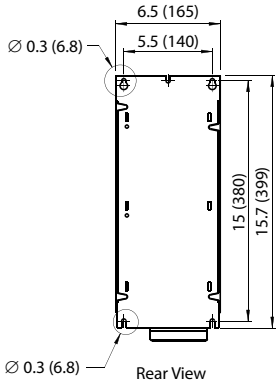


B3 enclosures



Depth 10.3 inches with A/B-Options

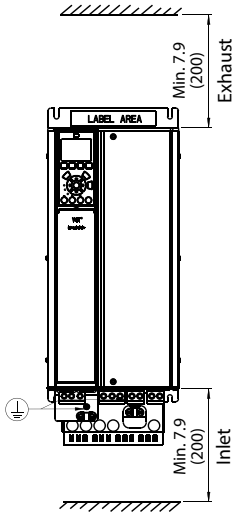


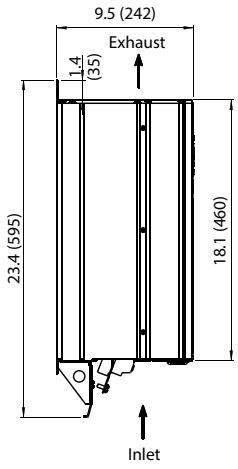


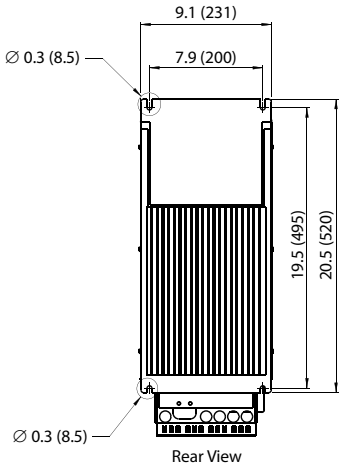
IP 20/ Chassis	(200-240V)	110%	5.5 – 11 kW 7.5 – 15 HP
IP 20/ Chassis	(380-480V)	110%	11 – 18.5 kW 15 – 25 HP
IP 20/ Chassis	(525-600V)	110%	11 – 18.5 kW 15 – 25 HP

B3

B4 enclosures



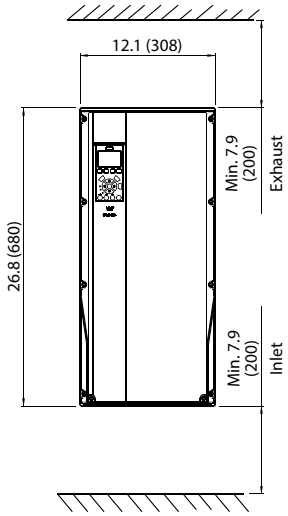


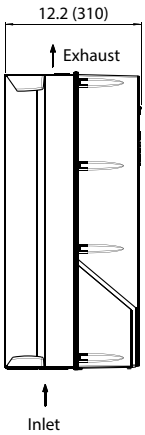


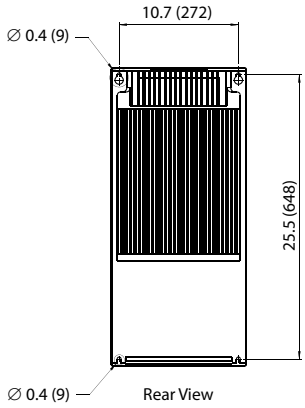
IP 20/ Chassis	(200-240V)	110%	15 – 18.5 kW 20 – 25 HP
IP 20/ Chassis	(380-480V)	110%	22 – 37 kW 30 – 50 HP
IP 20/ Chassis	(525-600V)	110%	22 – 37 kW 30 – 50 HP

B4

C1 enclosures







IP 55/NEMA 12 IP 66/NEMA 4X	(200-240V)	110%	18 – 30 kW 25 – 40 HP
IP 55/NEMA 12 IP 66/NEMA 4X	(380-480V)	110%	37 – 55 kW 50 – 75 HP
IP 21/NEMA 1 IP 55/NEMA 12 IP 66/NEMA 4X	(525-600V)	110%	37 – 55 kW 50 – 75 HP

C1

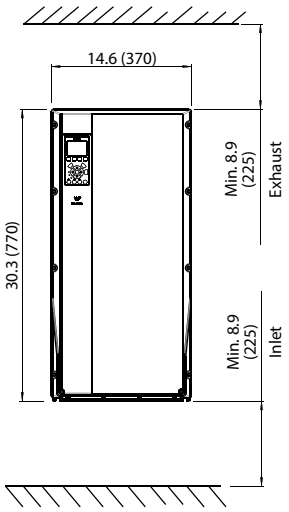
Dimensions VLT® Refrigeration Drive

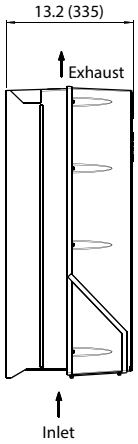
In inches (mm)

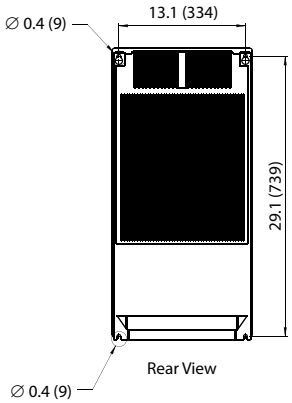
C2 enclosures

C2

IP 21/ NEMA 1	(200-240V)	110%	37 – 45 kW 50 – 60 HP
IP 55/NEMA 12 IP 66/NEMA 4X	(380-480V)	110%	75 – 90 kW 100 – 125 HP
IP 21/NEMA 1 IP 55/NEMA 12 IP 66/NEMA 4X	(525-600V)	110%	75 - 90 kW 100 – 125 HP



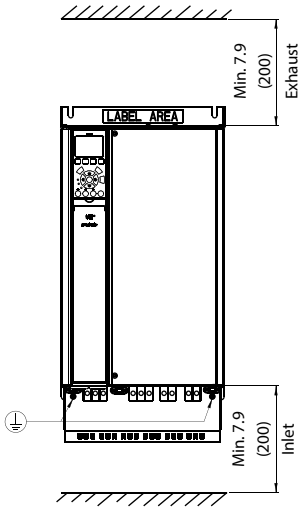


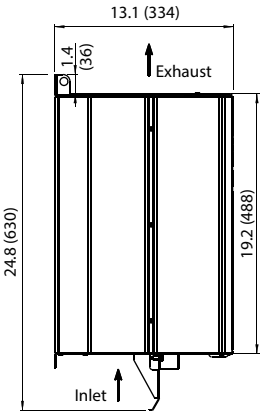


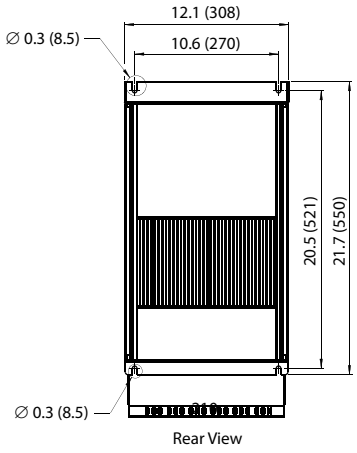
C3 enclosures

C3

IP 20/ Chassis	(200-240V)	110%	22 – 30 kW 30 – 40 HP
IP 20/ Chassis	(380-480V)	110%	45 – 55 kW 60 – 75 HP
IP 20/ Chassis	(525-600V)	110%	45 – 55 kW 60 – 75 HP



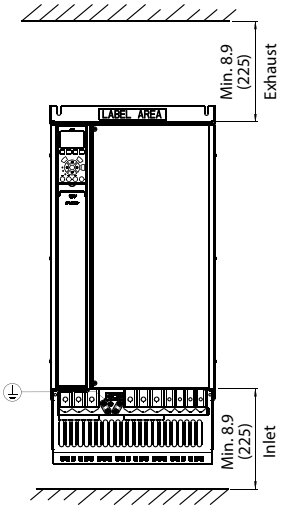


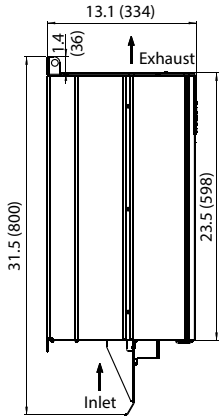


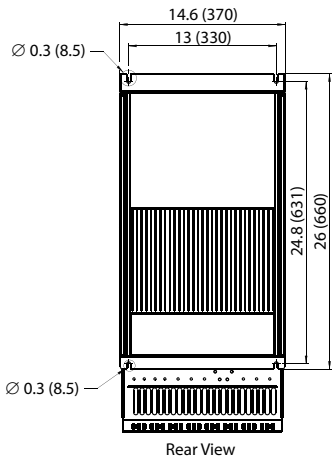
C4 enclosures

C4

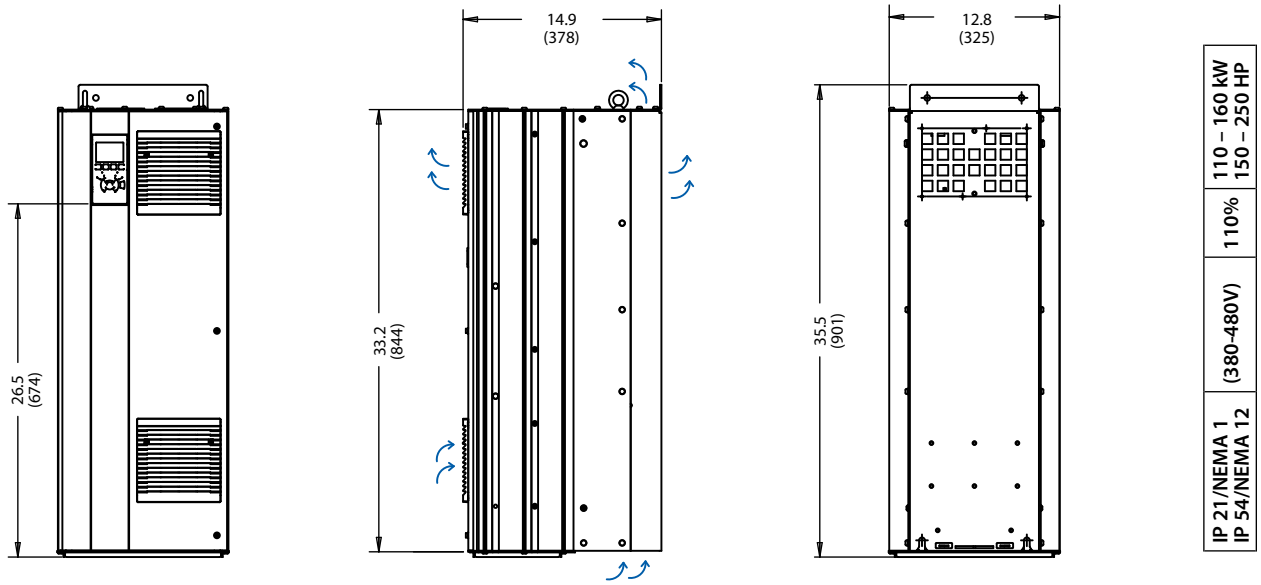
IP 20/ Chassis	(200-240V)	110%	37 – 45 kW 50 – 60 HP
IP 20/ Chassis	(380-480V)	110%	75 – 90 kW 100 – 125 HP
IP 20/ Chassis	(525-600V)	110%	75 – 90 kW 100 – 125 HP







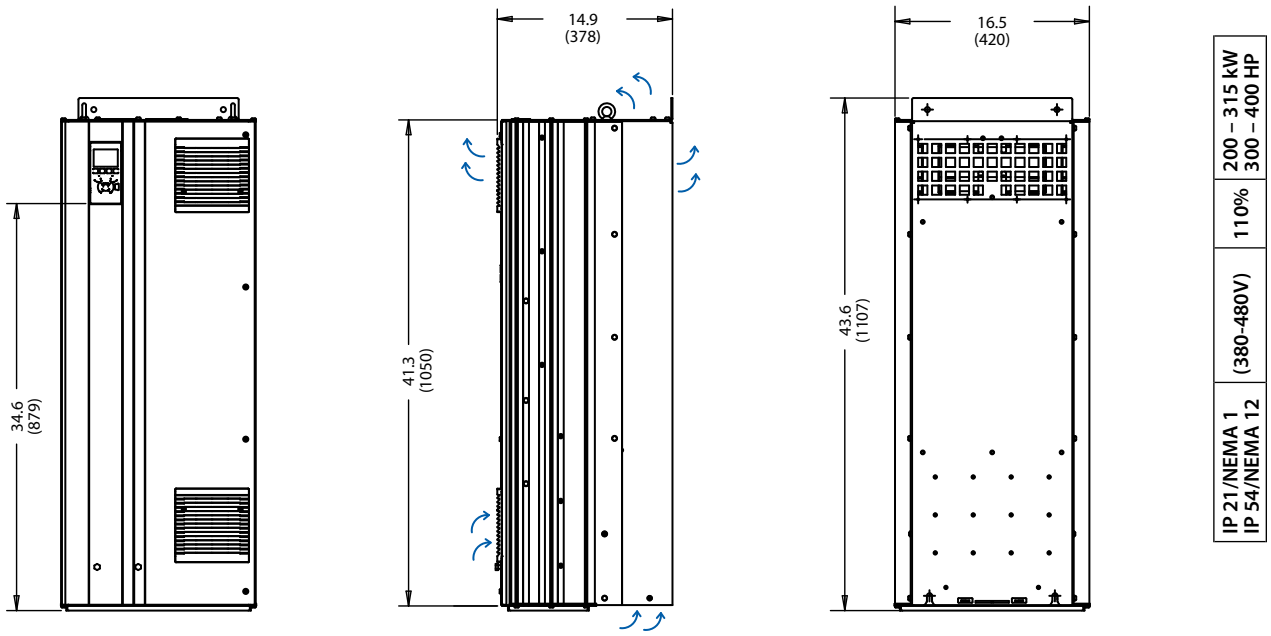
D1h enclosures (floor- or cabinet mount)



IP 21/NEMA 1 IP 54/NEMA 12	(380-480V)	110%	110 – 160 kW 150 – 250 HP

D1h

D2h enclosures (floor- or cabinet mount)



IP 21/NEMA 1 IP 54/NEMA 12	(380-480V)	110%	200 – 315 kW 300 – 400 HP

D2h

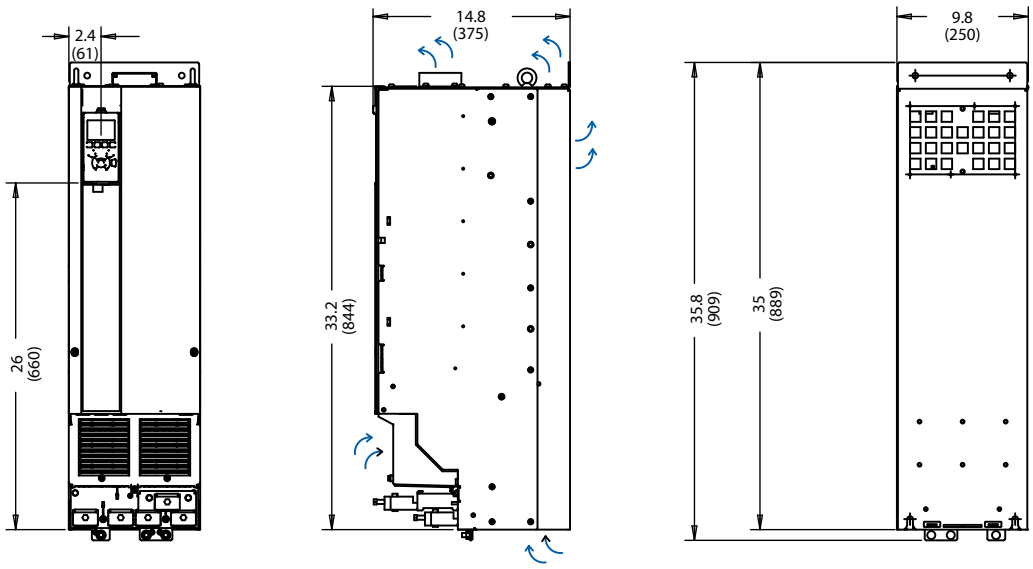
Dimensions VLT® Refrigeration Drive

In inches (mm)

D3h enclosures (cabinet mount)

D3h

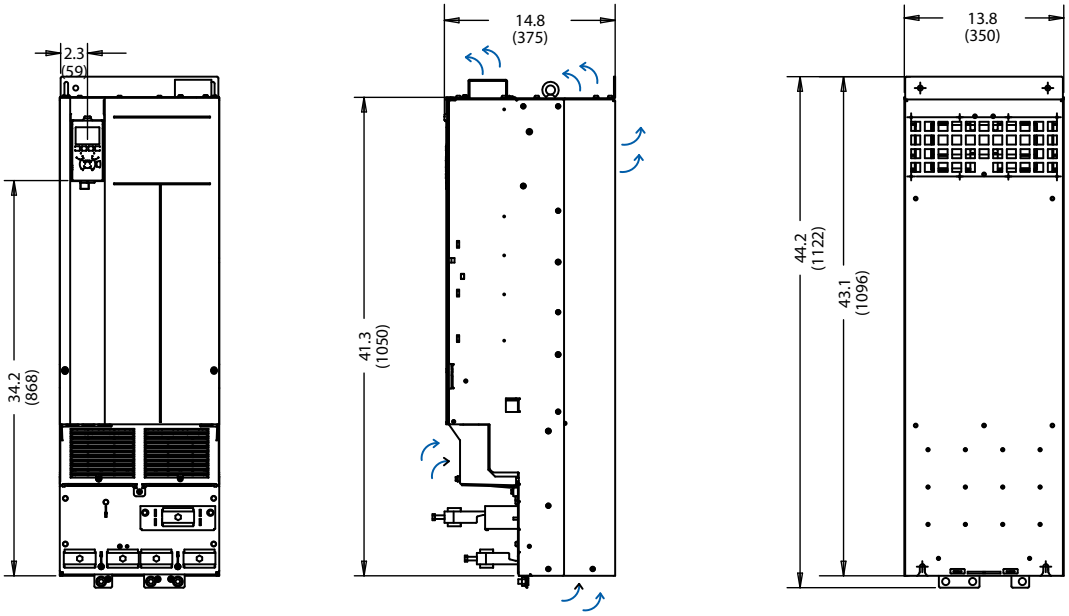
IP 20/ Chassis	(380-480V)	110%	110 – 160 kW 150 – 250 HP



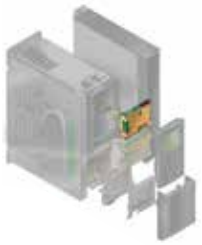
D4h enclosures (cabinet mount)

D4h

IP 20/ Chassis	(380-480V)	110%	200 – 315 kW 300 – 400 HP



VLT® Refrigeration Drive A & B Options



VLT® AK-LonWorks MCA 107

VLT® AK-LonWorks MCA 107 is a complete electronic refrigeration and control system for monitoring and controlling refrigeration plants. Connecting this drive to ADAP-KOOL® Lon network is really simple. After entering a network address, pressing a service pin starts the automatic configuration procedure.

Ordering number 130B1169 uncoated – 130B1269 coated (Class 3C3/IEC 60721-3-3)

13

VLT® General Purpose I/O MCB 101

The I/O option offers an extended number of control inputs and outputs.

- 3 digital inputs 0-24 V: Logic '0' < 5 V; Logic '1' > 10 V
- 2 analog inputs 0-10 V: Resolution 10 bit plus sign
- 2 digital outputs NPN/PNP push pull
- 1 analog output 0/4-20 mA
- Spring loaded connection
- Separate parameter settings

Ordering number 130B1125 uncoated – 130B1212 coated (Class 3C3/IEC 60721-3-3)

14

VLT® Relay Card MCB 105

Enables you extend relay functions with 3 additional relay outputs.

Max. terminal load:
AC-1 Resistive load .....240 V AC 2 A
AC-15 Inductive load @cos ϕ 0.4 .....240 V AC 0.2 A
DC-1 Resistive load .....24 V DC 1 A
DC-13 Inductive load @cos ϕ 0.4 .....24 V DC 0.1 A

Min. terminal load:
DC 5 V ..... 10 mA
Max switch rate at rated load/min. load ..... 6 min^{-1}/20 sec^{-1}

Ordering number 130B1110 uncoated – 130B1210 coated (Class 3C3/IEC 60721-3-3)

14

VLT® Analog I/O Option MCB 109

This analog input/output option is easily fitted in the frequency converter for upgrading to advanced performance and control using the additional in/outputs. The option also upgrades the frequency converter with a battery back-up supply for the clock built into the frequency converter. This provides stable use of all frequency converter clock functions as timed actions etc.

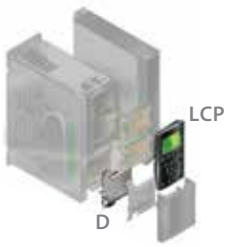
- 3 analog inputs, each configurable as both voltage and temperature input
- Connection of 0-10 V analog signals as well as PT1000 and NI1000 temperature inputs
- 3 analog outputs each configurable as 0-10 V outputs
- Incl. back-up supply for the standard clock function in the frequency converter

The back-up battery typically lasts for 10 years, depending on environment.

Ordering number 130B1143 uncoated – 130B1243 coated (Class 3C3/IEC 60721-3-3)

14

Installation of options is a simple matter of plug-and-play



VLT® Refrigeration Drive D Options & LCP

Typecode Position

18

VLT® 24 V Supply MCB 107

The option is used to connect an external DC supply to keep the control section and any installed option active when mains power is down.

- Input voltage range..... 24 V DC +/- 15% (max. 37 V in 10 sec.)
- Max. input current .....2.2 A
- Max. cable length .....75 m
- Input capitance load ..... < 10 uF
- Power-up delay ..... < 0.6 s
- Easy to install in drives in existing machines
- Keeps the control board and options active during power cuts
- Keeps fieldbuses active during power cuts

Ordering number 130B1108 uncoated – 130B1208 coated (Class 3C3/IEC 60721-3-3)

15 + 17

VLT® Control Panel LCP 102

- Multi-language display
- Status messages
- Quick Menu for easy commissioning
- Parameter setting and explanation of parameter function
- Adjustment of parameters
- Full parameter backup and copy function
- Alarm logging
- Info button – explains the function of the selected item on display
- Hand-operated start/stop or automatic mode selection
- Reset function
- Trend graph

Ordering number 130B1107

15

LCP Panel Mounting Kit

For easy installation of the LCP 101 and LCP 102 in e.g. a cabinet.

- IP 65/NEMA 12 (front)
- Thumb screws for tool-free installation
- Incl. 3 meters of cables of industrial quality (also available separately)
- With or without LCP operating unit
- Each time easy to install

Ordering number 130B1117 (Mounting kit for all LCP's including fasteners, 3 m cable and gasket).

Ordering number 130B1113 (Incl. graphical LCP, fasteners, 3 m cable and gasket).
Ordering number 130B1114 (Incl. numerical LCP, fasteners and gasket).
Ordering number 130B1129 (LCP front mounting IP 55/IP 66) – Ordering number 175Z0929 (cable only).
Ordering number 130B1170 (Panel Mouting Kit for all LCP w/o cable).

Installation of options is a simple matter of plug-and-play

VLT® Refrigeration Drive Accessories

IP 21/NEMA 1 Kit

The NEMA 1 kit is used for installation of VLT® drives in dry environments. The enclosure kits are available for frame sizes A1, A2, A3, B3, B4, C3 and C4.

- Supports VLT® drives from 1.5 HP to 125 HP
- Used on standard VLT® drives with or without mounted option modules
- IP 41 on top side
- PG 16 and PG 21 holes for glands

130B1122 for frame size A2, 130B1123 for frame size A3, 130B1187 for frame size B3, 130B1189 for frame size B4, 130B1191 for frame size C3, 130B1193 for frame size C4

VLT® Brake Resistors

Energy generated during braking is absorbed by the resistors, protecting electrical components from heating up.

Danfoss brake resistors cover the full power range.

- Quick braking of heavy loads
- Braking energy is only absorbed into the brake resistor
- External mounting makes it possible to use the generated heat
- All necessary approvals are available

USB Extension

USB extension for IP 55/NEMA 12 and IP 66/NEMA 4X enclosures. Makes the USB connector available outside the drive. The USB extension is designed for mounting in a cable gland in the bottom of the drive, which makes PC communication very easy, even in drives with high IP ratings.

USB extension for A5-B1 enclosures, 13.78" cable, ordering number 130B1155
USB extension for B2-C enclosures, 25.59" cable, ordering number130B1156

VLT® Advanced Harmonic Filter AHF 005/010

Easy, effective harmonic distortion reduction by connecting theVLT® Advanced Harmonic Filter AHF 005/010 harmonic filter in front of a Danfoss drive.

- AHF 005 reduces total harmonic current distortion to 5%
- AHF 010 reduces total harmonic current distortion to 10%
- Small compact housing that can be fitted into a panel
- Easy to use in retrofit applications
- User-friendly start-up – no adjustment necessary
- No routine maintenance required

VLT® Sine-Wave Filters

VLT® Sine-wave filters are placed between the drive and the motor to optimize the motor power current.

It provides a sinusoidal phase-to-phase motor voltage. The filters reduce motor insulation stress, acoustic noise from the motor and bearing currents (especially in large motors).

- Reduces motor insulation stress
- Reduces acoustic noise from the motor
- Reduces bearing currents (especially in large motors)
- Enables use of longer motor cables
- Reduces losses in the motor
- Prolongs service lifetime
- IP 20/Chassis; IP 21/NEMA 1

VLT® dV/dt Filters

VLT® dV/dt Filters are placed between the drive and the motor to eliminate very fast voltage changes.

The motor terminal phase-to-phase voltage is still pulse shaped but its dV/dt values are reduced.

- These filters reduce stress on the motor's insulation and are recommended in applications with older motors, aggressive environments or frequent braking which cause increased DC link voltage.
- IP 20/Chassis; IP21/NEMA 1

Please refer to the product and design manuals for selection and dimensioning
Note: *Missing numbers can be found in the design manual or can be delivered on request*

ENGINEERING
TOMORROW

What VLT® is all about

Danfoss VLT Drives is the world leader among dedicated drives providers – and still gaining market share.

Environmentally responsible

VLT® products are manufactured with respect for the safety and well-being of people and the environment.

All frequency converter factories are certified according to ISO 14001 and ISO 9001 standards.

All activities are planned and performed taking into account the individual employee, the work environment and the external environment. Production takes place with a minimum of noise, smoke or other pollution and environmentally safe disposal of the products is pre-prepared.

UN Global Compact

Danfoss has signed the UN Global Compact on social and environmental responsibility and our companies act responsibly towards local societies.

Impact on energy savings

One year's energy savings from our annual production of VLT® drives will save the energy equivalent to the energy production from a major power plant. Better process control at the same time improves product quality and reduces waste and wear on equipment.

Dedicated to drives

Dedication has been a key word since 1968, when Danfoss introduced the world's first mass produced variable speed drive for AC motors – and named it VLT®.

Twenty five hundred employees develop, manufacture, sell and service drives and soft starters in more than one hundred countries, focused only on drives and soft starters.

Intelligent and innovative

Developers at Danfoss VLT Drives have fully adopted modular principles in development as well as design, production and configuration.

Tomorrow's features are developed in parallel using dedicated technology platforms. This allows the development of all elements to take place in parallel, at the same time reducing time to market and ensuring that customers always enjoy the benefits of the latest features.

Rely on the experts

We take responsibility for every element of our products. The fact that we develop and produce our own features, hardware, software, power modules, printed circuit boards, and accessories is your guarantee of reliable products.

Local backup – globally

VLT® motor controllers are operating in applications all over the world and Danfoss VLT Drives' experts located in more than 100 countries are ready to support our customers with application advice and service wherever they may be.

Danfoss VLT Drives experts don't stop until the customer's drive challenges are solved.

Danfoss VLT Drives, 4401 N. Bell School Rd., Loves Park, IL 61111, Tel. +1 (815) 639-8600 (main),
Tel. +1 (800) 432-6367 (24 Hour Service for Drives), Fax +1 (815) 639-8000, www.danfossdrives.com, Email: salesinformation@danfoss.com

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