

ENGINEERING
TOMORROW

Danfoss

Reliable air-handling drives for clean-room applications

1.1kW – 1.4MW

SEMI 47 Certified
Full range VLT®
HVAC Drive, VLT®
AQUA Drive and
VLT® Automation
Drive has achieved
SEMI 47 certification.

www.danfoss.com/drives

VLT®
THE REAL DRIVE

Reliability is key

Reliability is a key requirement of the process equipment operating within clean-rooms and particularly the HVAC plant supplying the clean air.

Any failure for whatever reason can result in costly downtime and frequently the scrapping of work in progress at the time of the failure. For this reason, the drives powering the HVAC fans and chillers must be virtually immune to mains power aberrations short of a complete failure of supply.

Voltage sag

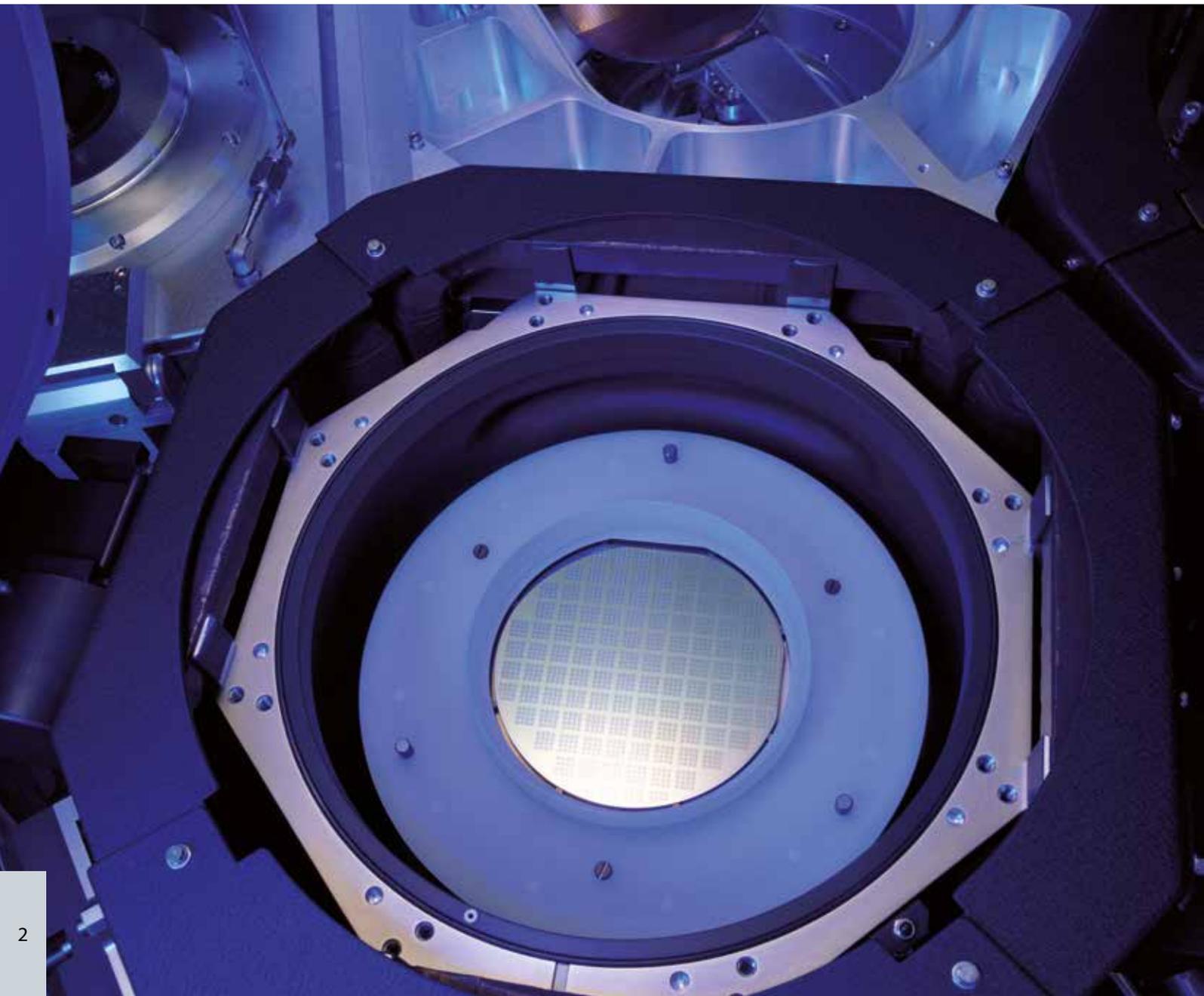
Danfoss VLT® HVAC Drive FC 102 drives are specifically designed to run through voltage sags with no degradation in performance.

Voltage sags are a common occurrence on utility mains supplies for a variety of reasons completely outside of the control of the customer but can also be caused by the starting of large loads within the plant itself. Local supply conditions govern the stability and reliability of the supply but

typically, voltage sags are of short duration, typically a voltage drop of 10-15% for 80-200 ms. This can be on all three phases but may be across only two phases. Whatever the case, the VLT® HVAC Drive FC 102 is certified to cope with short unstable power conditions and keep running.

Voltage interruption

Clearly, no electrically driven equipment will operate continuously if the supply is cut entirely but short



outages can be dealt with by the VLT® HVAC Drive FC 102 without nuisance tripping. Energy is stored within the drive's internal dc link capacitors and kinetic energy is also stored within the driven equipment itself.

In the event of a power outage, as the mains supply collapses, the VLT® HVAC Drive FC 102 is designed to draw on the stored energy, first from the capacitors, then by reducing the output frequency to cause regeneration and energy recovery from the load.

This allows the drive to remain in operation through mains outages of up to 500 ms, dependent upon load inertia and the level of the mains outage. This means the motor slows slightly but avoids unnecessary trips.

If the outage is too long, the drive can be programmed to auto-restart without operator intervention.

Voltage sag standards

There are many differing standards applying to performance of equipment under voltage sag conditions, each of which specifies different sag levels and durations and defines different performance requirements.

Compliance with one standard does not imply compliance with another. Danfoss VLT® HVAC Drive FC 102 complies with SEMI F47-0706 and extensive testing and simulation demonstrates that the drive dc link voltage will never drop to the trip level and that the drive will ride-

Power Standards Laboratory certifies that the above mentioned drives pass the requirements of SEMI F47-0706 for voltage sag immunity.

Automatic restart of the drive allows to continue a process without operator intervention.

through SEMI F47 voltage sags. This applies to VLT® driving fans or pumps of up to 1.4 MW at 690 V.

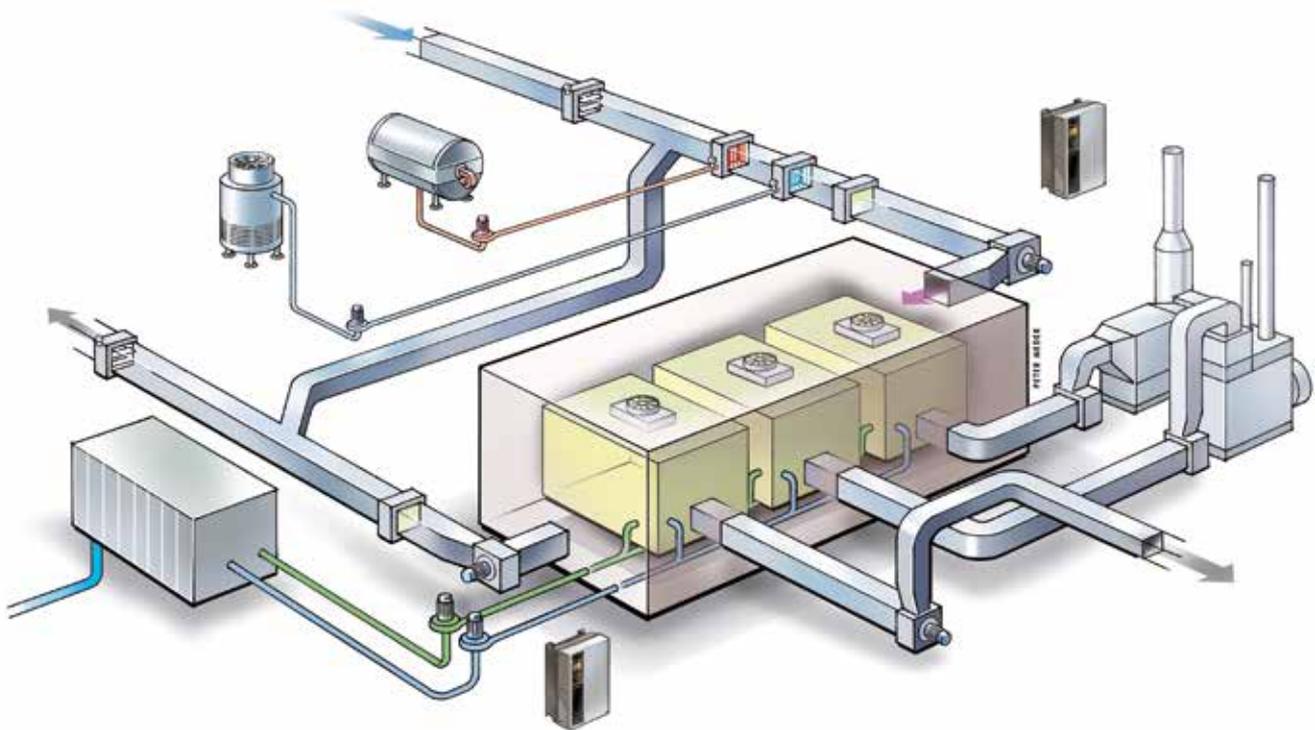
VLT® tolerates low quality power supplies

VLT® drives from Danfoss incorporate a number of features to improve tolerance to low quality power supplies and avoid un-necessary trips.

- High tolerance for nominal voltage
- Kinetic or battery back-up via common dc-bus
- Self protection from power failure by kinetic energy back-up
- Controlled, synchronised ramp-to-stop in extreme cases
- Tripless, extended voltage sag tolerance
- Internal DC chokes ensure near unity power factor and limited peak currents.



VLT[®] energy saving applications throughout the plant



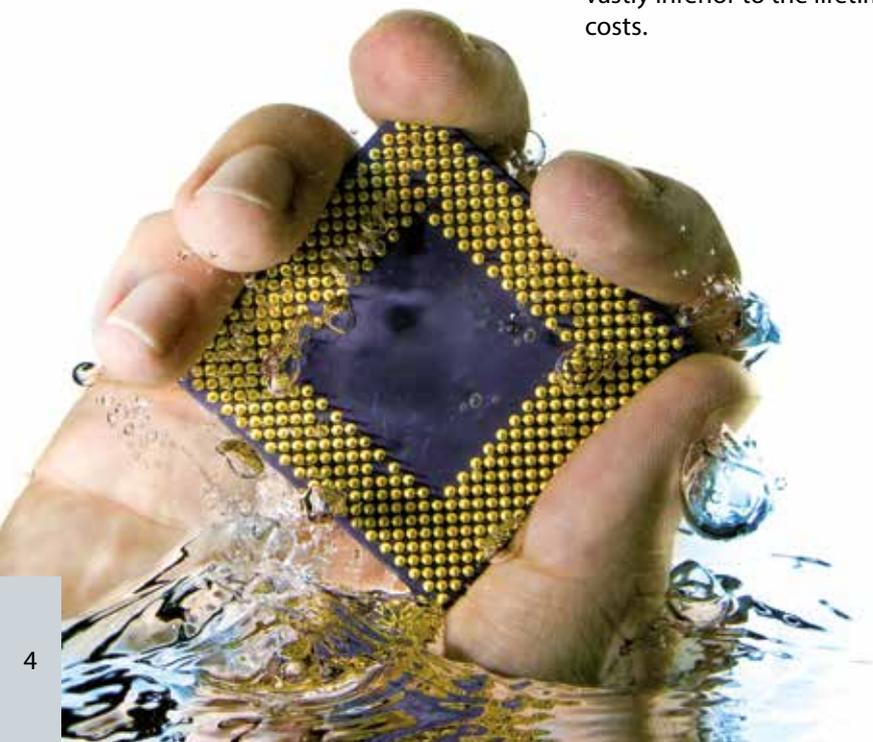
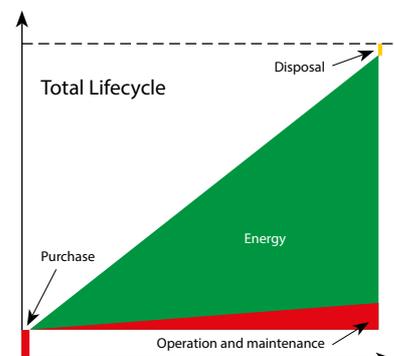
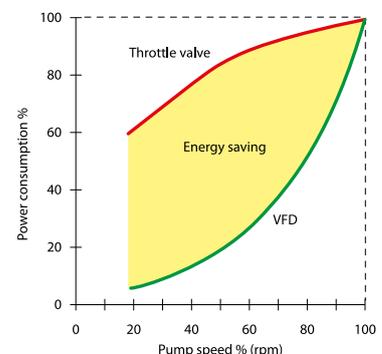
VLT[®]s save energy – reduce lifetime costs

Variable speed is the most cost effective way to control fan and pump operation in the long run. Traditional throttles and vane controls may be cheaper up-front but waste huge amounts of energy during operation.

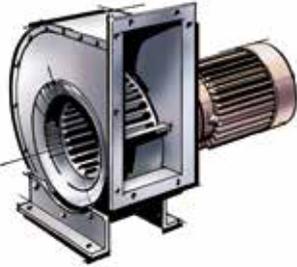
For centrifugal pumps and fans, the power consumed is proportional to the cube of the impeller speed.

Even a 20% reduction in delivered air or water volume (frequently the case because of operational demands or device over-sizing) can realise a 50% reduction in absorbed power, leading to vast cost savings over a relatively short period of time.

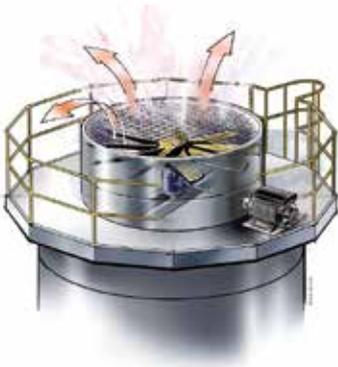
Energy efficiency is vital when considering the lifetime cost of plant. The purchase, installation and eventual disposal costs are inevitably vastly inferior to the lifetime energy costs.



Dedicated applications features save energy – enhance reliability



ID/FD fan features	TCO benefits
I/O points are available as remote I/O's	- Extends the system's capacity
Resonance monitoring	- Noise reduction
Cascaded P-PI for temperature control	- Maintenance free
Multi-zone pressure control	- Problem free operation in harsh environments
Flow balancing	- No external cooling or oversizing necessary
AEO using Cos phi algorithm	- Up to extra 10% savings
Flying start	- Can control "free-wheeling" fan in both directions – reduces equipment stress
Precise flow control	- Clean combustion in boilers



Cooling tower fan features	TCO benefits
Smart Logic Controller	- Lower installation cost - Valuable data points are saved
Auto-tune PID controller	- Reduced maintenance
I/O points are available as remote I/O's	- Extends the system's capacity
Resonance monitoring	- Noise & vibration reduction
AEO using Cos phi algorithm	- Up to extra 10% savings
Improved Floating Head pressure	- Reduced power consumption
Software algorithm to detect abnormal overall input power	- Eliminates need for multi motor klixon
VLT® pre-heat function	- Eliminates anti-condensation heater



Pump features	TCO benefits
Pump Cascade Controller	- Minimises wear and tear
Automatic Energy Optimisation (AEO)	- Saves energy
Dry Pump Detection	- Protects the pump - Saves energy
End of Curve control	- Protects the pump - Reduces energy consumption
Flow compensation	- Saves energy



Compressor features	TCO benefits
Over-capacity	- No need for larger compressor/drive
Reduced current limit	- Ensures functionality of cooling system - Protects the application
Running at current limit	- Extends the system's capacity
Minimum starts and stops	- Protects compressor - Reduces energy consumption
Setpoint in temperature	- Easy commissioning
Monitor running hours	- Schedule maintenance
Electronic control	- Less maintenance
Cascade control	- Stable pressure
Quick start up	- Protects compressor - Reduces energy consumption

VLT® control gives lowest total cost of ownership

Total Cost of Ownership (TCO) is an organisation's total cost of acquiring, operating and maintaining a system through a given lifecycle.

TCO includes initial acquisition cost and operating cost. Through its technology and experience, Danfoss can transform this into the "Benefit of Ownership".

We understand the needs of our customers operating their facilities in a competitive environment which requires total system cost effectiveness and highest efficiency in daily operation with environmental sustainability.

Reducing acquisition costs

- Fully integrated EMC & harmonic compliant solution
- IP 55/66
- Extensive functions to minimise external system components
- Extendable I/O to reduce total BAS costs
- Ease of installation and set-up

Reducing operating costs

- Minimum 98% efficiency
- Energy metering
- Automatic Energy Optimisation
- Design lifetime of 10 years
- Danfoss legacy and history in demanding industrial applications

- IP 66 enclosures and optional conformal coating to provide robust & reliable performance in the harshest of environments
- 50° C ambient temperature without derating
- Auto derate functions at temperatures above 50° C
- Broadest range of drive and motor protection
- Maintenance free drive
- Extensive system diagnostics

Save energy – save money

Efficiency is vital for High Power Drives

Efficiency was a major focus when Danfoss' developers designed the VLT® High Power Drives.

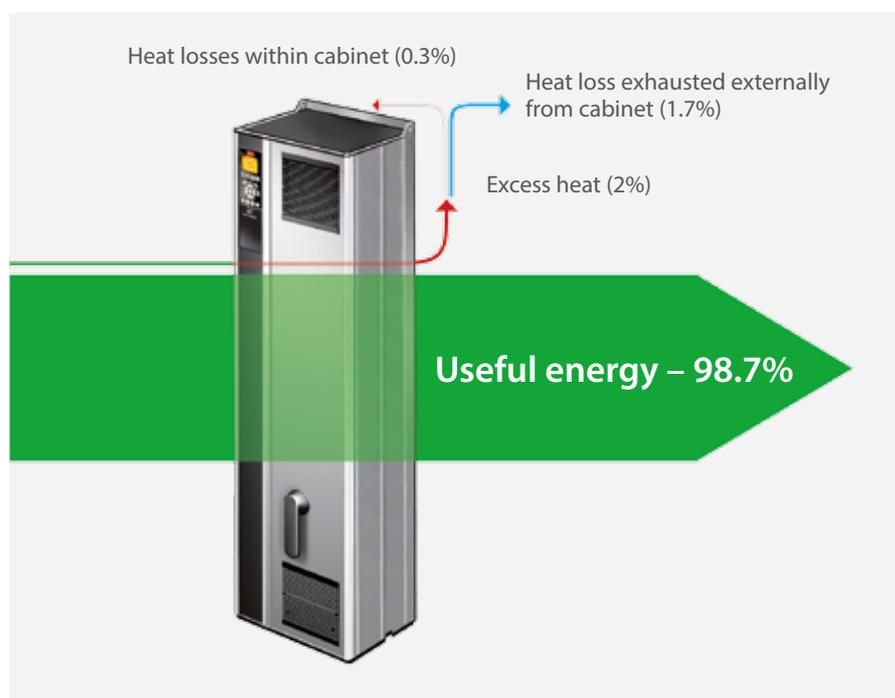
The electronic design and the quality of the components make for unsurpassed efficiency. VLT® drives pass 98% of the input electrical energy through to the motor.

Save 25,000 kWh a year

A half percent point better efficiency of a 1 MW VLT® drive will typically lower energy consumption by 25,000 kWh a year.

Makes motors efficient too

The VLT's Automatic Energy Optimisation vector technology ensures optimum magnetisation of the motor, minimising damaging passive currents and flux in the motor. This means that maximum electrical power provided to the drive is exploited in the application.



VLT® – designed for maximum up-time and lowest cost

Clean room applications

The unsurpassed VLT® experience developed in our organisation since 1968 ensures the ultimate quality in clean room solutions.

Enhanced advanced monitoring

Enhanced advanced application monitoring functionality allows you to keep track of the status of fans, pumps and compressors. This can mean increased lifetime, reduced maintenance costs, and less down-time.

Supporting software tool

Software tools are available to help design a system with minimal harmonics and best energy efficiency.

No-trip protection mode

As soon as the system detects a critical status (e.g. over-current or overvoltage) the frequency of the

VLT® drive will automatically be reduced and the modulation process adjusted.

Due to its ability to limit its switching operations, VLT® drives are extremely reliable and robust.

The protection mode will – if conditions allow – end after 10 seconds and the frequency will be restored under control.

Minimum 98% efficiency

The VLT® drives set new standards with a minimum 98% efficiency at full load. This reduces initial costs and operating costs due to the smaller heat load/air conditioning requirement in the switchroom/plantroom, thereby maximising energy efficiency. Every kW of losses typically requires another ~0.5 kW of energy to remove the heat.

Installed in an air conditioned switchroom, lower losses can easily result in operating cost savings >5% – 10%

of the cost of the drive every year (based on a typical load profile, with the drive operating 24/7). Energy consumption and CO₂ emissions are also reduced.

High ambient temperatures

VLT® drive is designed to operate in ambient temperatures up to 50°C with an autoderate capability for higher temperatures in order to maintain reduced operation in extreme climate conditions.

In most cases, the VLT® drive will handle the situation without needing attention.

VLT® drives 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 while keeping production running.



Danfoss – the drives specialist for 40 years

Danfoss has been at the forefront of the inverter drives industry for more than 40 years. VLT® drives meet the ever increasing demands for intelligent solutions and energy saving within clean-room applications.

In everything we do, Danfoss is a clean tech company.

VLT® drives include:

- > 98% basic energy efficiency
- Automatic Energy Optimisation
- User-friendly operation
- Programming in 27 languages

Easy commissioning

- Application menus
- Quick menu
- Motor Rotation Check
- PID-auto tuning

Save energy – save money – save CO₂ emissions

With losses at <2%, running costs are slashed. VLT® frequency converters save more than 20 million MWh of energy globally each year. This is equivalent to the annual electricity consumption of 5 million homes and 12 m tones of CO₂.

Save money up front

The modular design provides the flexibility to fit internally a range of functional performance modules at the best cost advantage for the application.

Save space

The compact design saves on installation real-estate while IP 66 enclosures up to 90 kW can eliminate the need for cabinets entirely.

- No need for costly external AC-coils
- Optional, built-in RFI filters across the whole power range

Save control costs and protect your system

- Overload trip protection
- Real-time clock
- Dry Run Detection
- End of curve detection
- Password protection
- Smart logic controller
- Motor alternation
- 2-step ramps (initial ramp)
- Safe stop
- Cascade controller

Save time

VLT® drives are designed to save time and cost on installation, commissioning and maintenance.

- Intuitive award-winning user interface...
- One drive type across the power range!
- Modular VLT® design enables fast installation of options.
- Auto-tuning of PI controllers
- Robust design and efficient monitoring makes VLT® drives maintenance free.
- Smart Start – an easy and simple commissioning tool available directly in the display.

Energy monitoring

VLT® HVAC Drives provide a complete range of energy consumption information. Choose to divide absolute energy consumption into hours, days or weeks or monitor a load profile for the application – you choose. If you can't measure it – you can't save it!

Proven reliability

The first VLT® drive – the VLT® 5 from 1968 – has proven the reliability of VLT® drives.

Original VLT® drives installed in 1968 are still functioning reliably more than 40 years later.





Danfoss commitment

Danfoss' long experience in applying drives in HVAC systems has enhanced its ability to offer a "Best in Class" technical expertise in extracting the maximum value from your initial investment and optimising operational savings.

Performance of the building

The overall performance of buildings is a prime focus today and this includes design, construction, efficiency, sustainability and the environmental impact of these buildings in the future. Energy efficient products like VLT® drives form part of this overall plan.

A wealth of knowledge

The various applications incorporated within high performance buildings are well understood by Danfoss and as global market leader we have developed products and technology to ensure we meet and determine future trends in this industry. VLT® is the premier drive in the market.

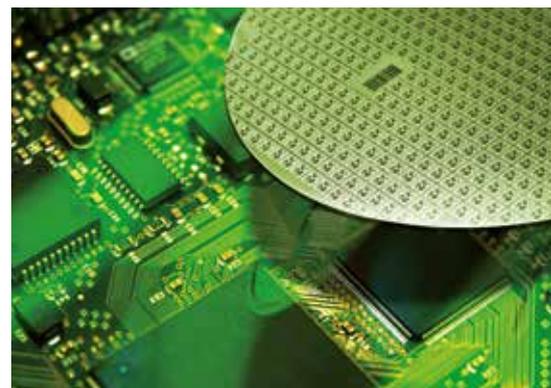
Reliable and cost effective

Correct drive selection is critical to reliability. Products that introduce unacceptable levels of RFI or harmonics into a building can prove highly problematic and costly in addition to breaking legislative regulations. Danfoss' years of experience in the application of VLT® drives has resulted in a global team focused on delivering the best drives solutions, ensuring total security of your investment.

High ambient temperature

VLT® drives are designed to work at maximum output in an ambient temperature up to 50° C. Beyond this, auto derating enables continued operation with reduced performance for a period of time without tripping.

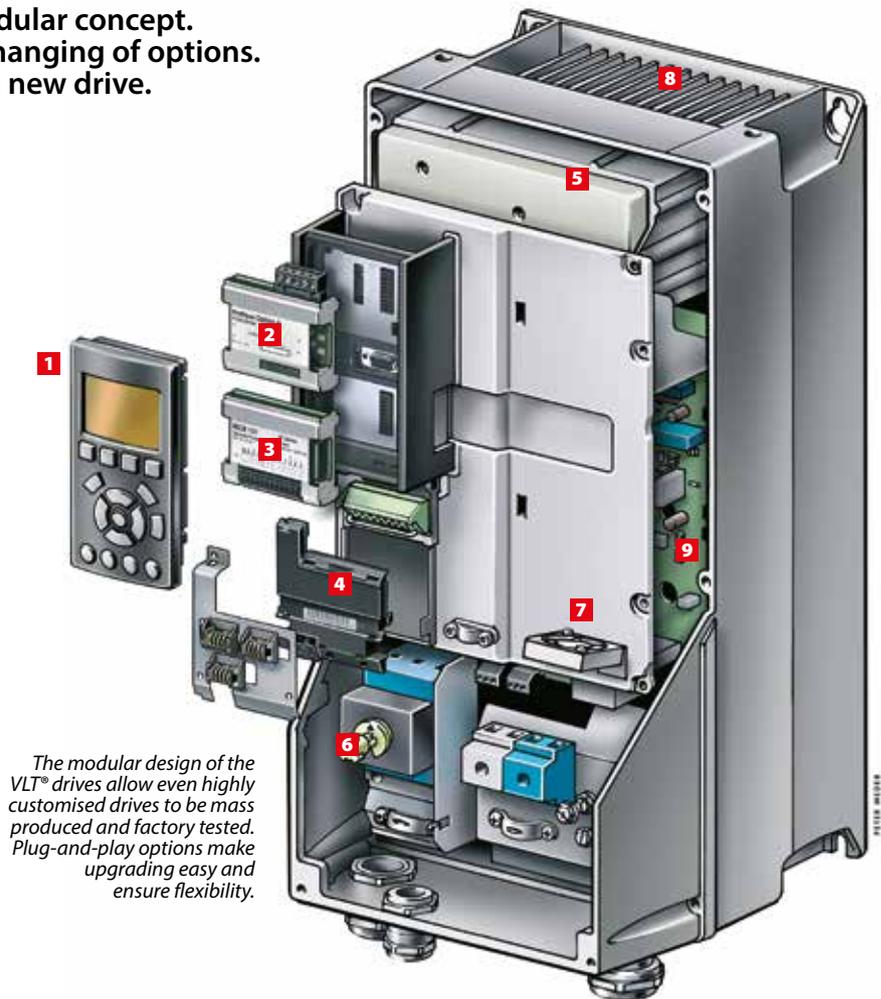
*Where temperature is critical
Industry facilities for the production of medicine
or micro electronics require special precautions.
VLT® drives can meticulously control and maintain
the correct temperature in the process under a
variety of operating conditions, including
continued operation during mains voltage
fluctuations.*



The modular VLT® drive

VLT® drives are built on Danfoss' modular concept. 'Real plug-and-play adding and exchanging of options. A simple upgrade saves the cost of a new drive.

- 1 Local Control Panel (LCP)**
Choose numerical, graphical or no display
- 2 Fieldbus option**
 - PROFINET
 - DeviceNet
 - Ethernet
- 3 I/O option**
 - General Purpose I/O (3DI + 2AI + 2DO + 1AO)
 - Analogue 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**
(Factory mounted option)
- 7 Input mains option**
Various input plate configurations are available including fuses, mains switch (disconnect), or RFI filter. Input plates are field adaptable if options need to be added after installation.



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

- 8 Unique cooling concept**
 - No ambient air flow over the electronics in models up to 90 kW
 - Above 90 kW IP 55, designed with back channel cooling (85% heat dissipated via back-channel)
- 9 Durable in aggressive environments**
In some applications, it is recommended to protect the drive with coated PCB's. VLT® drives are designed for level 3C2 according to IEC 60721-3-3. Protection level 3C3 is optionally delivered from factory.

VLT® quality up to 1.4 MW

VLT® drives are available from 1.1 kW to 1.4 MW.

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

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



Optimised EMC environment enhances total cost of ownership

Optimum EMC protection coupled with integrated harmonic filters ensures that the optimum EMC environment and cleanest power supplies are maintained throughout the operational lifetime of the system, enhancing the total cost of ownership.

VLT® drives meet the product standard EN 61800-3 regarding EMC without additional external components

even with long motor cables – and correspond to the EMC guidelines 2004/108/EC, offering 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), EN 55011, Class B (residential) and Class A1 (industrial area).

This ensures reliable plant operation through full compliance with all EMC

requirements and product standards, prescribed warnings and restrictions.

On the power side, integrated chokes minimise the network effects dramatically and thus maintain operation within the limits of EN 61000-3-12.

The fully dimensioned intermediate circuit makes the VLT® drives stable and highly dynamic even during short supply voltage drops or other poor network conditions.

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

Comparison of limits EN 55011/61800-3

Eliminate harmonic distortions

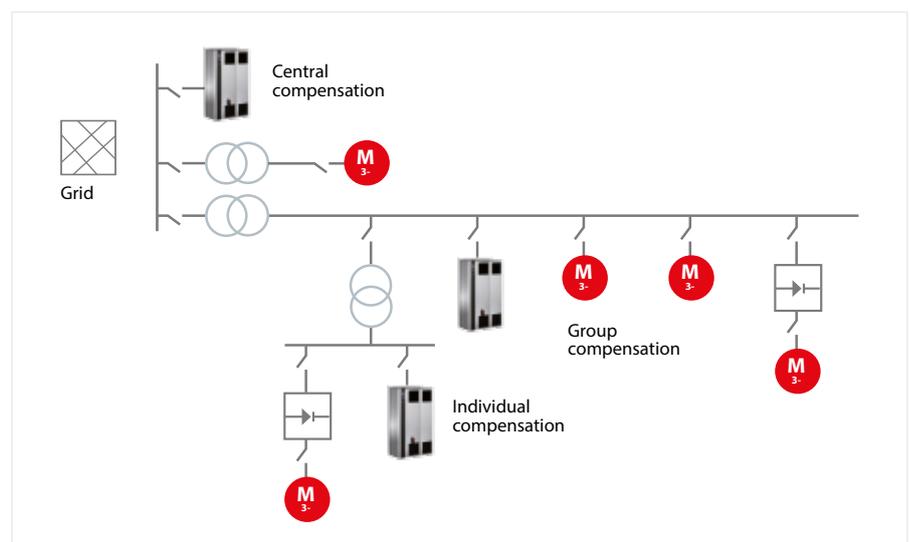
Active filters

VLT® Active Filter identifies harmonic distortion from non-linear loads and injects counter phased harmonic and reactive currents to re-establish optimal sinusoidal power. Danfoss active filters can compensate individual VLT® drives as a compact integrated solution or can be installed as a compact stand-alone solution at a common point of coupling compensating several loads simultaneously.

Passive filters

The Danfoss AHF 005 and AHF 010 are advanced harmonic filters, superior to traditional harmonic trap filters. Danfoss harmonic filters have been specially designed for operation with Danfoss VLT® drives.

AHF 010 reduces the harmonic current to less than 10% and the AHF 005 reduces the harmonic current to less than 5%.



Fully protected for longer life in all conditions

VLT® drives – available in enclosures from IP 20 through to IP 66

VLT® installation volumes and/or the mounting surfaces are reduced by up to 60% compared to the previous series, saving installation real-estate and costs.

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

Optimised design

Minimised heat losses 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 saving installation real-estate.

Save installation time and panel real-estate

The IP 20 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 of screened cables are included. The compact enclosures are easier to install. This is important especially within existing



installations with poor accessibility. An extensive range of options and accessories is available, optimising the drive for the respective application.

Intelligent heat management

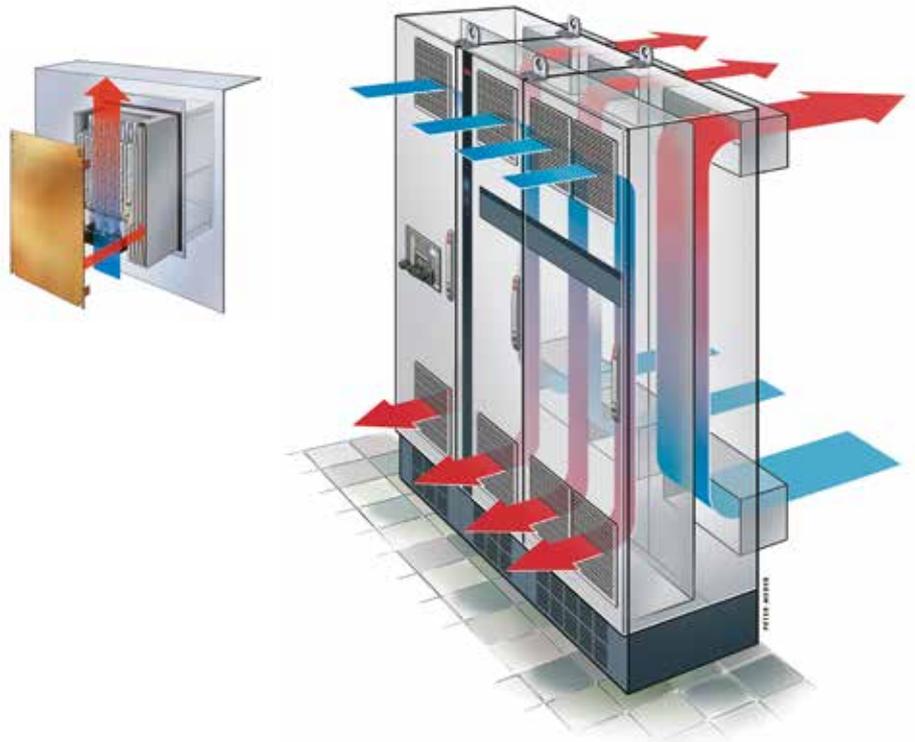
Variable cooling methods for life-cycle benefits

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

With VLT® drives, flanged heat sink kits are available for mounting the drives in the backplate of a cabinet without accessing the electronics.

Eliminating airflow over the electronics eliminates contaminants from the drive electronics, enhances drive reliability and extends the drive's lifetime.

Back-channel cooling minimises heat loss and increases energy efficiency, a significant benefit at high powers.



Common user interface across the range

– developed with drives users for drives users

1 Graphical display

- International letters and signs
- Graphical display with bar-charts
- Easy overview
- 27 languages selection
- iF awarded design

2 Menu structure

- Based on the well understood matrixsystem in today's VLT® drives
- Easy shortcuts
- Edit and operate in different set-ups simultaneously

3 Other benefits

- Demountable during operation
- Up- and download functionality
- IP 65 rating when mounted in a panel door
- 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
- Other LEDs indicate the status of the drive

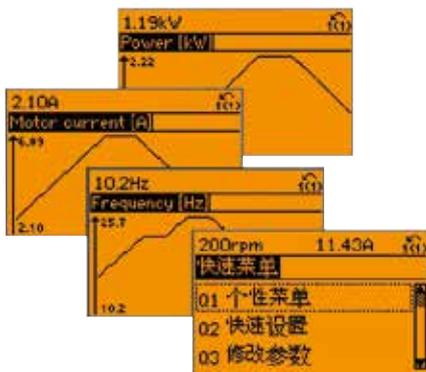
5 Quick Menu

- A Danfoss-defined Quick Menu
- A user-defined Quick Menu
- A Changes Made menu lists the parameters unique to your application
- A Function Setup menu provides quick and easy set-up for specific applications
- 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. This enables full advantage to be taken of the LCP, eliminating the need for additional switches and instrumentation.



Three panel options: Graphical, numerical, blind cover.

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

VLT® drives can be remotely-commissioned and monitored via a USB cable or fieldbus communication. Special software is available: Energy Box, Wizards, Data transfer tool, VLT® Set-up Software MCT 10, and Language changer.



Global 24/7 service maximises up-time

Sales and Service – Contacts worldwide

Helping to maximise your productivity, reduce your maintenance, and improve your finances.

- 24/7 availability
- Local hotlines, local language and local stock

The Danfoss service organisation is ready to respond whenever and wherever you need, around the clock, 7 days a week.

Find your local expert team on www.danfoss.com/drives

Pick your dedicated solution from the VLT® service menu:

Keep you running

- Drives update service
- Commissioning and regular adjustments
- Preventive maintenance

Keep you fit

- Training
- Stock maintenance & consignment
- Harmonic Survey
- Environmental Disposal

Fix your costs

- Fixed Price
- Post warranty service contract
- Transport insurance
- Response time

Service features	Benefits
24/7 availability	– The basis of efficient use of your resources and Danfoss VLT® drive assets
Hotline On-site repair	– Quick response time – Reduced production down-time down-time
Certified repair with warranty	– More reliable production – Reduced maintenance
Start-up and commissioning	– Increased performance with on-time failure-free operation
Application experts	– Optimise performance – Reduce lifecycle cost
Training	– Trained resources for optimal operation and maintenance
Harmonic survey	– Prevent failure – Maximise performance
Preventive inspection	– Reduce downtime – Reduce maintenance cost
Installed base evaluation	– Reduced capital and space allocation – Best availability
Stock maintenance and consignment	– Maximised availability with effective finance planning
Extended warranty	– Predictable budget for repair cost
Agreed response time	– Minimising downtime
Fixed repair and maintenance cost	– Effective finance planning for maintenance
Drives Upgrade Program	– Long-term finance planning for technology upgrade of drives

You're not the first – we've done it before



Albemarle Corporation, USA

Albemarle is a leading global manufacturer and supplier of polymer additives, catalysts and fine chemicals for consumer electronics, petroleum and petrochemical processing, pharmaceuticals, agricultural products, as well as transportation, industrial, construction and packaging materials.



AstraZeneca, United Kingdom

Danfoss VLT® HVAC Drives help to maintain clean sterile conditions reliably in the R&D and manufacturing environments of AstraZeneca, one of the world's leading pharmaceutical companies. It employs over 65,000 people in R&D and in the development and manufacture of high quality drugs and medicines worldwide.



Moser Baer India Ltd

In order to minimise harmonic corruption of their main supply, Moser Baer has, over the last 4 years, installed over 200 Danfoss VLT® drives and harmonics filters for their clean rooms. Total harmonic distortion is maintained at below 5%. Moser Baer is an OEM supplier to all of the 12 leading storage media brands in the world.



Chartered Semiconductor Manufacturing Ltd

Singaporean company Chartered, one of the world's leading semiconductor foundries, has installed over 300 Danfoss VLT® drives for various HVAC applications including clean room cooling and ventilation. It provides comprehensive wafer fabrication services and technologies to semiconductor suppliers and systems companies.



Microchip Technology Inc.

Danfoss Thailand has supplied over 100 VLT® HVAC Drives to Microchip Technology Inc. for clean room and air conditioning applications. Microchip Technology, headquartered in Chandler, Arizona, is a leading provider of microcontroller and analogue semiconductors, providing low-risk product development, lower total system cost and faster time to market for thousands of diverse customer applications worldwide.

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 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.

EU Directives

All factories are certified according to ISO 14001 standard. All products fulfil the EU Directives for General Product Safety and the Machinery directive. Danfoss VLT Drives is, in all product series, implementing the EU Directive concerning Hazardous Substances in Electrical and Electrical Equipment (RoHS) and is designing all new product series according to the EU Directive on Waste Electrical and Electronic Equipment (WEEE).

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.

