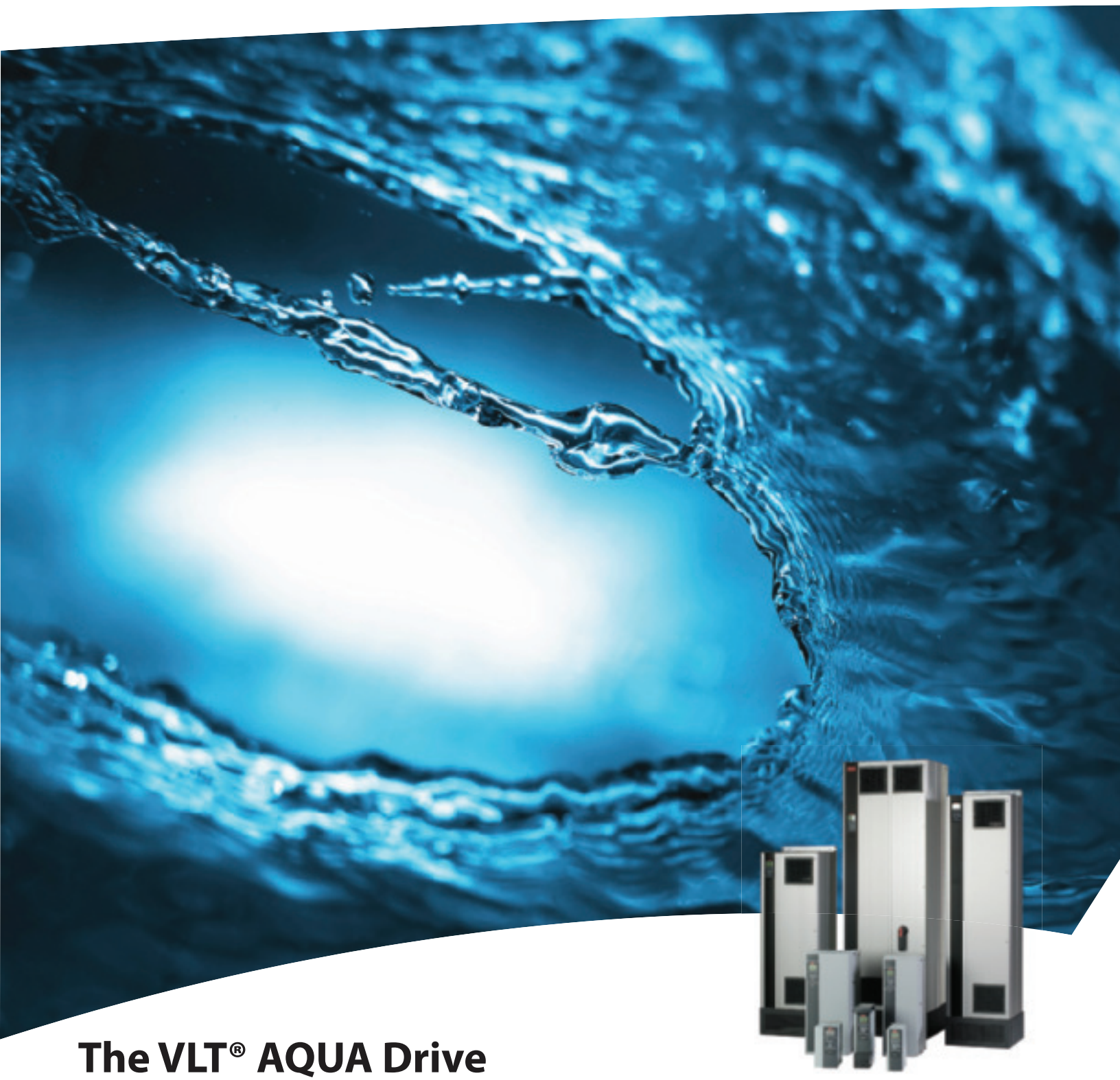


The VLT® AQUA Drive

Defining new standards for the Water/Wastewater market

VLT®
THE REAL DRIVE

Built-in intelligence for increased performance in all water and wastewater applications

Dedicated to water and wastewater

Danfoss Drives' unequalled experience was used to make the VLT® AQUA Drive the perfect match for pumps and blowers in water and wastewater systems. Water and Wastewater is a global business area for Danfoss Drives and you will find our dedicated sales and service staff all over the world, 24 hours a day.

With a wide range of powerful standard and optional features designed specifically for water and wastewater applications, the VLT AQUA Drive provides the lowest overall cost of ownership of any drive available.

Save energy

- High efficiency (>98%)
- Sleep Mode shuts off pumps when demand is low
- Automatic Energy Optimization produces typical savings of 3–5% (up to 15% possible)
- Flow compensation of setpoint
- Unique cooling concept

Save time

- Intuitive user interface with the new, award-winning local control panel (LCP)
- One drive type for the full power range
- Modular VLT design enables fast installation of options
- Automatic Motor Adaptation streamlines installation by automatically tuning the drive to the motor without spinning it or requiring the load to be decoupled
- Robust design and efficient monitoring significantly reduce maintenance requirements

Save space

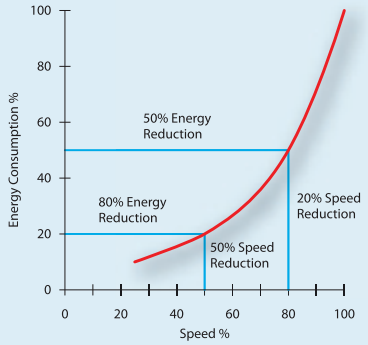
- Compact, modular design
- Built-in DC-link reactors for harmonic suppression—no need for external AC input line reactors
- Optional, integrated RFI filters throughout the power range
- Integrated disconnects and fusing

Save costs

Protect your system with a series of pump-specific features:

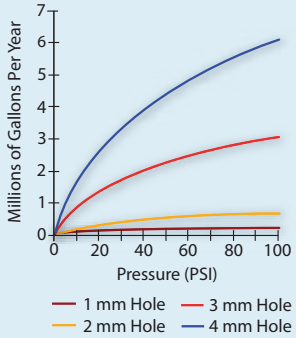
- Cascade controller
- Dry pump detection
- End of curve detection
- Motor alternation
- 2-step ramps (initial ramp)
- Pipe fill mode
- Real-time clock
- Password protection
- Overload trip protection
- Smart logic controller
- User-selectable variable or constant torque operation
- NEMA/UL Type 12 (IP 54/55) and IP66/NEMA 4X enclosures can eliminate the need for separate enclosures

Ideal Energy Consumption at Varying Speed



Energy savings using a VLT AQUA Drive are achieved with even a modest reduction in speed.

Distribution System Water Losses



Reducing water losses by lowering system pressure becomes increasingly effective as the size of line breaks increase.

Modular design platform

Unique cooling concept

- Improves efficiency
- Reduces contaminants in electronics

Fieldbus options (A-option)

- Select any of the common fieldbus protocols

Local Control Panel (LCP)

- Six-line graphical LCP display

I/O, relay or safety (B-option)

- I/O, Cascade Controller and relay functions

Advanced cascade controller option

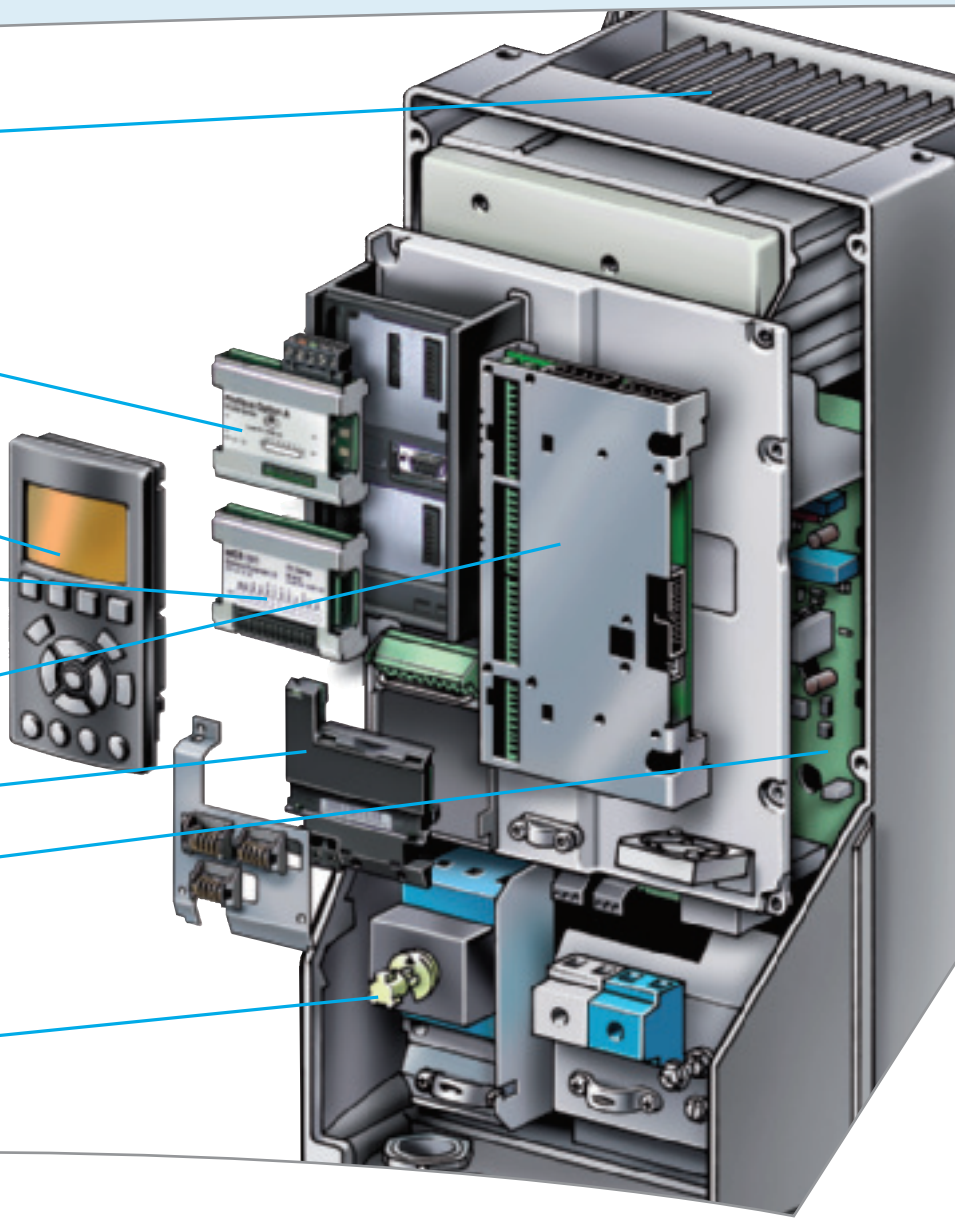
- (C-option)

24V supply option (D-option)

Conformally coated PCBs (optional)

- Durable in aggressive environments
- Additional higher level of conformal coating optional

AC mains disconnect and fusing (optional)



All VLT® AQUA Drives, regardless of horsepower size, have the same user interface and basic features.

Every VLT AQUA Drive is mass produced and factory tested with a load connected, as a complete assembly.

Modular plug-and-play options facilitate upgrading in the field.

Built-in DC-link reactors reduce harmonic noise and protect the drive. Integrated EMC filters are also available to minimize RFI interference (meets EN 55011 A2, A1 or B).

The VLT AQUA Drive can be remotely commissioned and monitored through a USB-pluggable cable using MCT 10 setup software.

Award-winning, user-friendly interface

Graphical display

- Informative overview
- Six lines of display
- Graphical or numerical display of information
- Readout in user-selectable engineering units
- Select from up to 27 languages as standard
- Backlit for increased visibility

Quick Menus

- Danfoss-defined Quick Menu
- My Personal Menu allows users to define their own menus of commonly accessed parameters
- Changes Made Menu displays the parameters to which changes have been made
- Function Setup Menu provides quick setup for specific applications
- Logging Menu provides access to operation history

Illumination

- Illuminated LEDs indicate which function is active

Menu structure

- Based on the field-proven matrix system used in previous VLT® Series drives
- Menu shortcuts access specific functions
- Edit and operate in different setups simultaneously

Other benefits

- The keypad is removable during operation
- Upload/download setups between drives using the keypad
- Remote mounting kit available for panel installation
- Hand / off / auto buttons for easy switching between manual and automatic control

Additional buttons

- Info: an "onboard manual" that provides specific information about each parameter
- Cancel: exits current parameter without saving changes
- Alarm log: easy access to a list of all previous alarm conditions

The VLT AQUA Drive has an award-winning Local Control Panel (LCP) that was designed based on user feedback. With a well-structured menu system, the VLT AQUA Drive ensures fast commissioning and easy access to its many powerful functions.

design award winner

Powerful control and flexibility

Modular application options

MCB 101 general purpose I/O

- Inputs: 3 digital; 3 analog (voltage)
- Outputs: 2 digital; 1 analog (current)

MCB 105 relay

- Provides three additional relay outputs

MCB 107 external 24 VDC supply

- 24 VDC external supply can be connected to supply backup power to control and option cards

MCB 109 advanced analog I/O

- 3 analog inputs, 3 analog outputs
- Backup power for real-time clock

Integrated fused disconnect

- Available in most sizes

Cascade Controllers

Provide additional relays for staging of additional pumps:

- MCO 101 extended cascade controller controls up to five pumps
- MCO 102 advanced cascade controller controls up to eight pumps

Cascade controller option cards extend the capabilities of the VLT® AQUA Drive, allowing the control of up to eight parallel pumps configured to appear to the sytem as a single larger pump. Individual pumps are automatically turned on (staged) and turned off (destaged) as needed to satisfy the required system output for flow or pressure. The speed of the pumps is also controlled to provide a continuous range of system output.

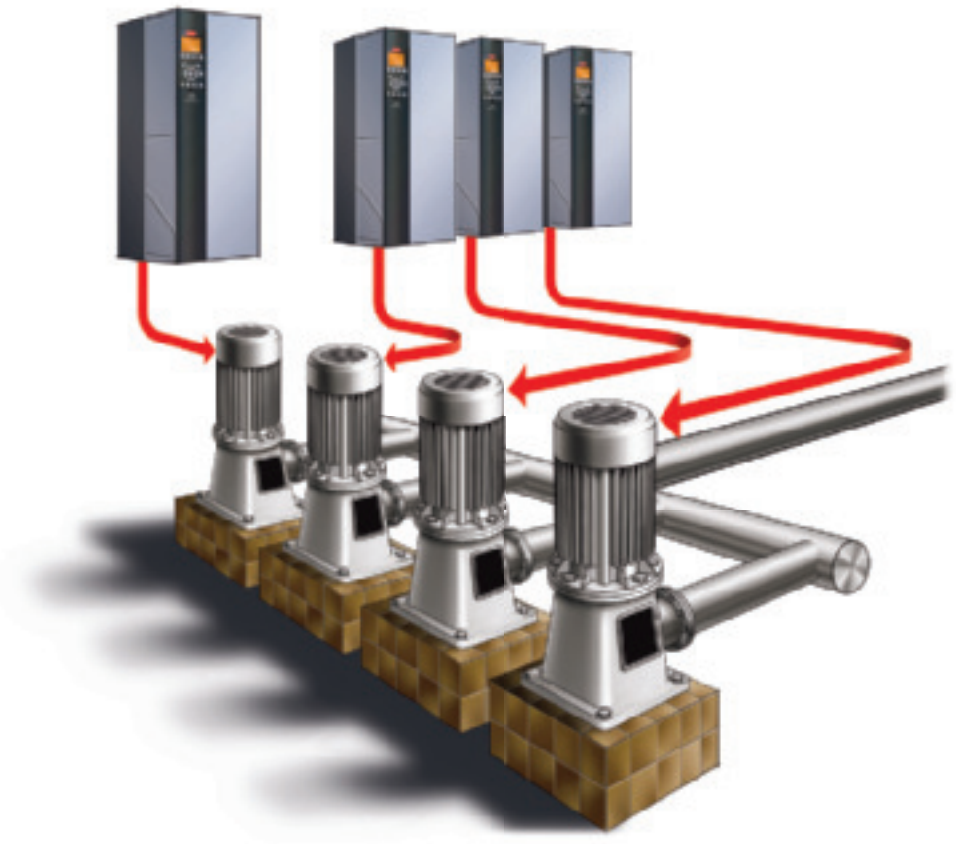
Available as a factory-installed option or a field-installed accessory, cascade controller option cards provide constant pressure or level control while reducing water hammer and energy consumption. They also eliminate the need for PLCs and external controllers.

Power accessories

- **Advanced Harmonic Solutions:** Filters anad low harmonics drives for applications where reducing harmonic distortion is critical
- **dV/dt filters:** For providing motor isolation protection
- **Sine filters** (LC filters): reduce motor noise

PC software tools

- **MCT 10:** provides powerful functionality for drive commissioning and servicing
- **VLT Energy Box:** Comprehensive energy analysis tool
- **MCT 31:** Harmonics calculation tool



A typical VLT AQUA Drive installation utilizing the Cascade Controller option in conjunction with three additional VLT AQUA Drives to operate one to four pumps as demand requires.

Designed with the user in mind

The VLT® AQUA Drive maximizes system reliability with built-in protection against:

- System overloads
- Motor failures
- Motor and drive overheating
- Voltage disturbances
- Power surges
- Loss of phase
- Phase-to-phase and phase-to-ground short circuit
- Ground fault
- Switching on input/output
- Electrical disturbances
- Overvoltage
- Overcurrent
- Undervoltage
- External fault
- Overtemperature

Minimize motor noise and heating with ASFM

With the ASFM (Adjustable Switching Frequency Modulation) function, the switching frequency is adjusted automatically in relation to the speed of the motor. As speed is reduced, the switching frequency increases to ensure optimally low motor noise and reduce motor heating.

Input line protection from extreme running conditions

Short circuit

The VLT AQUA Drive incorporates 3 hall affect sensors, one in each of the three motor phases to protect against short circuits. A short circuit between two output phases (or to ground) will shut down the drive as soon as the current exceeds the maximum value.

Line disturbances and transients

To protect itself from AC line voltage disturbances, the drive monitors all three phases and interrupts drive operation in the event of phase loss or imbalance. Transients on the AC line are suppressed by MOVs as well as zener diodes for extreme transients. Danfoss VLT AQUA Drives meet VDE 0160 (European standard—2.3 x line voltage for 1.3 msec) for transient protection.

Voltage sags and surges

The VLT AQUA Drive is designed for a wide range of operating conditions. The 480 volt drive will operate from 342–528 VAC. The 230 volt drives will operate on 180–264 VAC. 575 volt drives will operate on 495–660 VAC and 690 volt drives will operate on 472–759 VAC. Full rated motor voltage and torque can be delivered with voltage dips down to 10% under nominal AC line voltage. During an AC line drop-out, the VLT AQUA Drive continues until the intermediate circuit voltage drops below the minimum stop level, which is typically 15% below the VLT AQUA Drive's lowest rated supply voltage.

Ground fault

The VLT AQUA Drive provides complete protection from potentially damaging ground fault conditions on both the supply side and the motor side.

IP66/NEMA 4X rated enclosures

Available in IP66/NEMA 4X enclosures built to withstand harsh environments, the VLT AQUA Drive offers standard 1000-foot motor cable runs for maximum mounting flexibility. Since the drive can be installed directly at the equipment location without a protective enclosure, it's the perfect solution for lift stations, pump stations, irrigation system or any other installations that require protection against blowing dust and moisture or splashing water. All cast aluminium parts are powder coated with a durable epoxy that can stand up to most corrosive chemicals and ensure long-term reliability.

Output protection for longer motor life

VLT® AQUA Drives incorporate both DC-link reactors and motor output protection as standard design features. This provides short circuit protection and allows unlimited switching on the output without damage to the drive, eliminating the need for additional output reactors or switch interlocks.

The DC-link reactors improve overall efficiency by increasing the power factor and lowering the ripple current in the bus voltage providing an almost threefold increase in capacitor and drive life. As a result, motor operation is smooth and quiet and longer motor life can be expected.

Hall effect current transducers measure current flowing on all three motor phases. This provides highly responsive and accurate feedback to the VLT control circuit for optimum motor protection and performance.

VVC^{PLUS} output switching pattern

Unique digital VVC^{PLUS} voltage vector control provides:

- A nearly perfect output sine wave that reduces the overshooting and undershooting of voltage and current generated by standard PWM drives
- Fully rated motor voltage at rated frequency
- Increased efficiency for both drive and motor
- Full motor performance without derating; no additional heating of motor windings
- Motor cable lengths up to 1000' standard

Reduced installation cost

Dual DC-link reactors reduce the input RMS current to less than or equal to the output current. This greatly reduces the cable size requirement and the subsequent cost of installation.

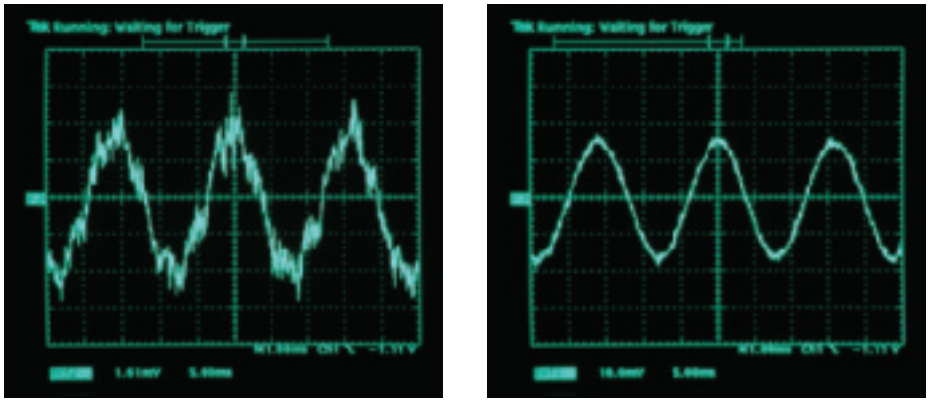
Minimal harmonic distortion/ maximum power factor

DC-link reactors reduce the harmonic distortion currents that a variable frequency drive injects back into the AC line. The properly sized reactors in a VLT AQUA Drive can reduce line harmonic currents by up to 40% of the fundamental current. This eliminates the need and cost of additional AC line reactors and their resultant line voltage reduction.

Thermal protection for the drive and motor

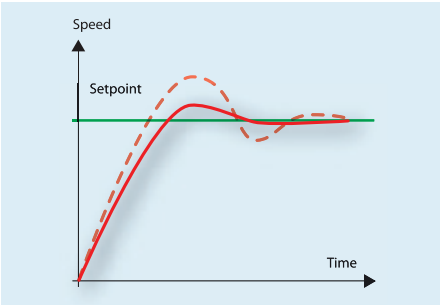
The ETR (Electronic Thermal Relay) is an open loop method built into the VLT AQUA Drive software to guard against motor overheating, requiring no additional sensors or wiring. This function is UL recognized (Class 20) as an effective guard against motor thermal overload.

The VLT AQUA Drive has built-in thermal protection and also accepts thermistor signal input from the motor to create closed loop thermal protection for the entire system.



Brand "X" PWM scope trace (left) compared to smoother VVC^{PLUS} scope trace (right).

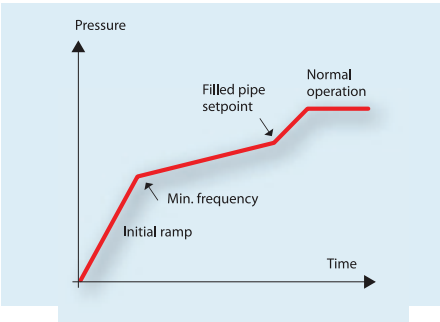
Dedicated features for water and wastewater applications



Automatic tuning of PI controllers

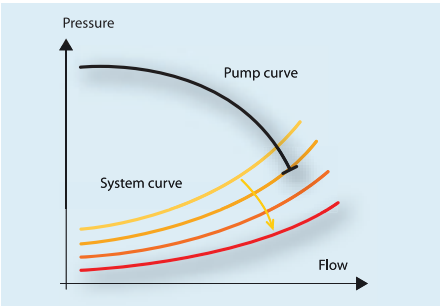
The VLT® AQUA Drive offers up to four separate PID loops for controlling multiple processes, each of which is automatically tuned to provide optimal performance.

The drive monitors how the system reacts to corrections and learns from this data to quickly achieve precise and stable operation. Gain factors for PI are continuously adjusted to compensate for changing characteristics of the loads. Knowing the exact P and I settings at startup is not necessary, making commissioning easier.



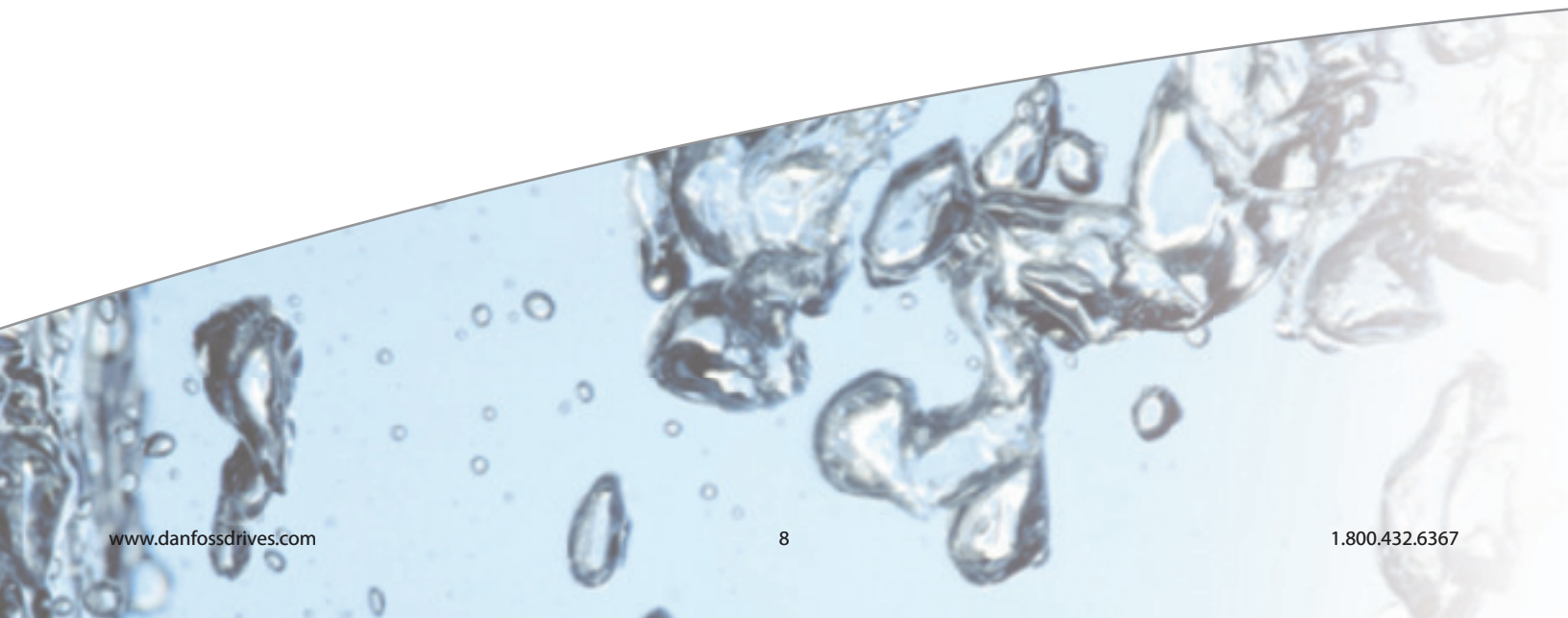
Pipe Fill Mode

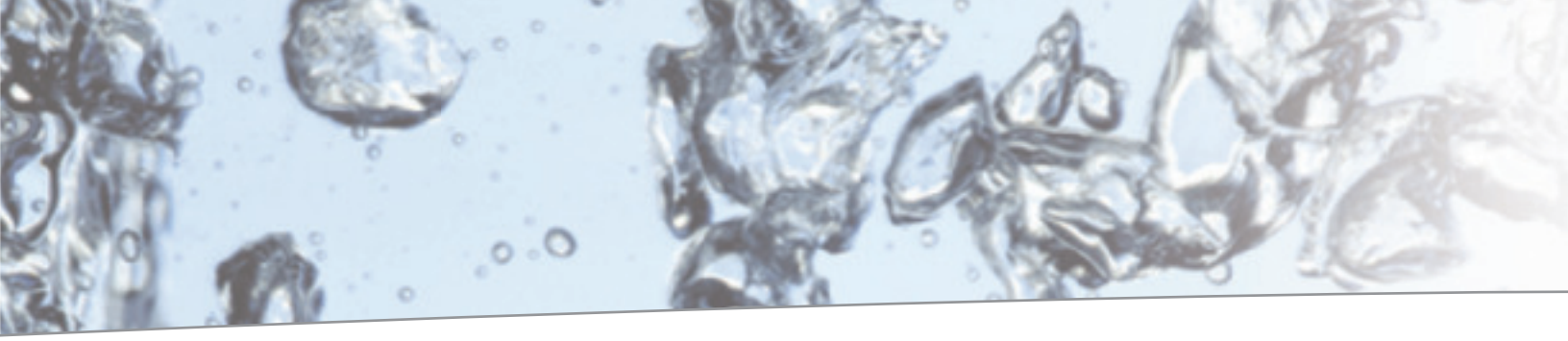
The VLT AQUA Drive can provide controlled (closed loop) filling of pipes, preventing water hammer, burst water pipes and damage to sprinkler heads. This feature is particularly valuable in applications that are vulnerable to these types of damage, such as irrigation systems and water supply systems.

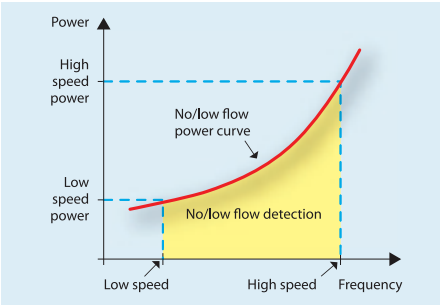


End of Pump Curve Detection

The VLT AQUA Drive can detect breaks and leakage in supply lines by comparing pump speed with the system pressure. The drive can be set to trigger an alarm, shut off the pump, or perform some other programmed action whenever a pump is found running at full speed without creating the desired pressure—a situation that usually indicates a break in the system.





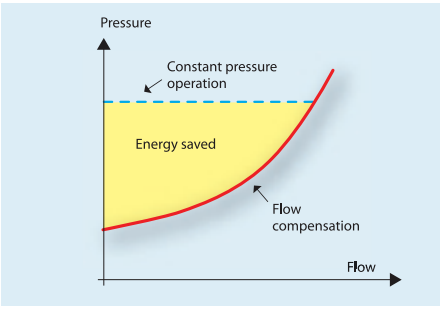


Dry Pump Protection

The VLT® AQUA Drive constantly evaluates the condition of the pump, based on internal frequency/power measurements. When power consumption drops too low—indicating a no or low flow situation—the VLT AQUA Drive will shut down the pump.

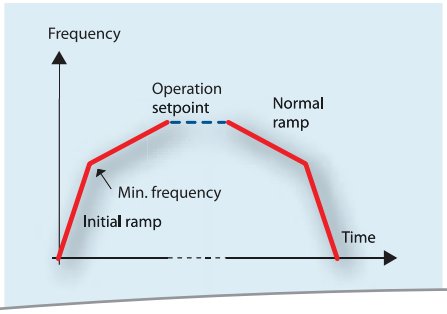
Sleep Mode

Sleep Mode keeps pump wear and power consumption to an absolute minimum. In low flow situations, the VLT AQUA Drive will boost the system pressure and then shut down the pump. It will continue to monitor the system pressure and restart when the pressure falls below the required level.



Flow compensation

The flow compensation feature of the VLT AQUA Drive takes advantage of the fact that flow resistance decreases with reduced flow. Using this information, the pressure setpoint is reduced as necessary, thereby saving energy.



Initial/Final Ramp

Initial ramp provides rapid acceleration of pumps to a desired minimum speed, at which time the normal ramp takes over. This prevents damage to thrust bearings and overheating of the pump.

The final ramp decelerates pumps to avoid unintended closure of check valves and water hammer.

Single-phase line supply

Single-phase VLT AQUA Drives can be wired to plug into a standard single-phase outlet. These drives can then be connected to three-phase pumps, fans, blowers, and more. It's just like getting three-phase power from a standard 220–240V power socket.

Payback time indication

One of the main reasons for using a VLT Series drive is the minimal payback time due to energy savings. The VLT AQUA Drive comes with a unique feature that continuously displays the time remaining before the drive pays for itself.

Motor Alternation

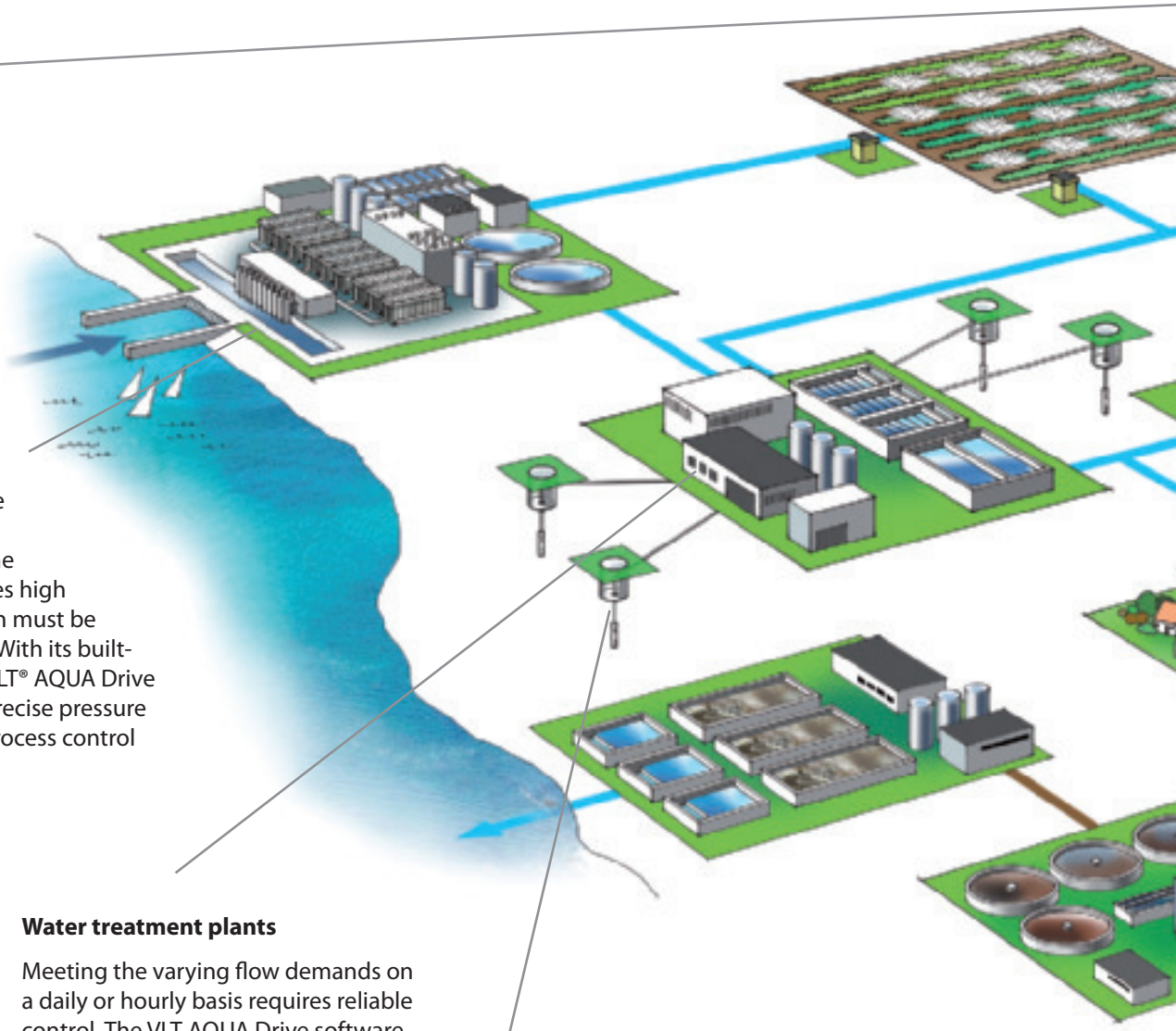
This built-in logic controls alternation between two pumps in duty/stand-by applications. Running the stand-by pump prevents sticking and lubricates the seals.

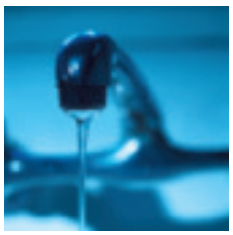
An internal timer assures equal usage of the pumps.

Designed for all water and wastewater applications

Desalination plants

Desalination plants are used to provide clean drinking water from the ocean. The process uses high pressure pumps, which must be accurately controlled. With its built-in PID controller, the VLT® AQUA Drive ensures reliable and precise pressure control, maximizing process control and efficiency.





Water treatment plants

Meeting the varying flow demands on a daily or hourly basis requires reliable control. The VLT AQUA Drive software provides unique pump control features that will help control even the most demanding applications.

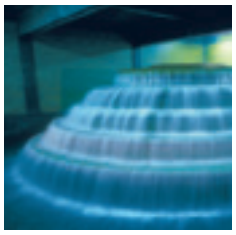
Groundwater pumps

Submersible deep well pumps need rapid start capability, precise control and protection against running dry. The built-in dry pump detection, initial ramp and multiple parameter input make the VLT AQUA Drive the perfect choice for these applications.

Irrigation systems

The irrigation market is focusing more and more on efficiency and energy savings for water management. Meeting these demands requires precise pressure and flow control.

The VLT® AQUA Drive offers a pipe fill function that prevents water hammer and reduces damage to pipes and components.



Water fountains and pools

Water fountains are used to enhance the aesthetics of buildings and parks nearly everywhere. In these applications, the VLT AQUA Drive can provide energy efficiency, accurate control and even meticulously timed sequencing for a dramatic effect.

Distribution

As areas become more populated, the increasing demand for reliable and precise pressure control becomes a challenge to many communities. The VLT AQUA Drive has innovative pumping functions to assist in maintaining precise pressure and flow while reducing system leakage and energy consumption. In many cases, it can also provide a cost-effective alternative to unsightly water towers.

Wastewater plants

Fluctuations in flow can disrupt efficient process control, increase costs and equipment wear due to a higher number of starts and stops, and adversely affect effluent quality.

Using the VLT AQUA Drive on pumps, blowers and other equipment will lead to better process control and reduce energy consumption. The AQUA Drive can also provide tighter control of chemical feed pumps, mixers and other equipment.

VLT® AQUA Drive specifications

Mains supply (L1, L2, L3):	
Supply voltage	200–240 V ±10%
Supply voltage	380–480 V ±10%
Supply voltage	525–690 V ±10%
Supply frequency	50/60 Hz
Max. imbalance temporary between line phases	3.0% of rated supply voltage
Displacement Power Factor (cosφ)	near unity (> 0.98)
True power factor (λ)	≥ 0.9
Switching on input supply L1, L2, L3	1–2 times/min.

Output data (U, V, W):	
Output voltage	0–100% of supply voltage
Output frequency	0–120 Hz
Rated motor frequency	50/60 Hz
Switching on output	Unlimited
Ramp times	1–3600 sec.
Closed loop	0–132 Hz
Maximum motor cable length	1000 ft.

VLT AQUA Drive can provide 110% current for 1 minute. Higher overload rating is achieved by oversizing the drive.

Torque Characteristics:	
Starting torque	maximum 110% for 1 min.*
Starting torque maximum	120% up to 0.5 sec.*
Overload torque	maximum 110% for 1 min.*

**Percentage relates to the nominal torque for the VLT AQUA Drive.*

Control Characteristics:	
Resolution of output frequency at 0–120 Hz	: +/- 0.003 Hz
System response time (terminals 18, 19, 27, 29, 32, 33)	: ≤ 2 ms
Speed control range (open-loop)	1:100 of synchronous speed
Speed accuracy (open-loop)	30 - 4000 rpm: Maximum error of ±8 rpm

All control characteristics are based on a 4-pole asynchronous motor.

Digital inputs:	
Programmable digital inputs (standard)	6**
Additional digital inputs available with MCB 101 general purpose I/O card (option)	3
Logic	PNP or NPN
Voltage level	0–24 V DC

*** 2 can be used as digital outputs*

Analog inputs:	
Analog inputs (standard)	2
Additional analog inputs available with MCB 101 general purpose I/O card (option)	2
Additional analog inputs available with MCB 109 advanced analog I/O card (option)	3
Modes	Voltage or current
Voltage level	0 to +10 V (scaleable)
Current level	0/4 to 20 mA (scaleable)