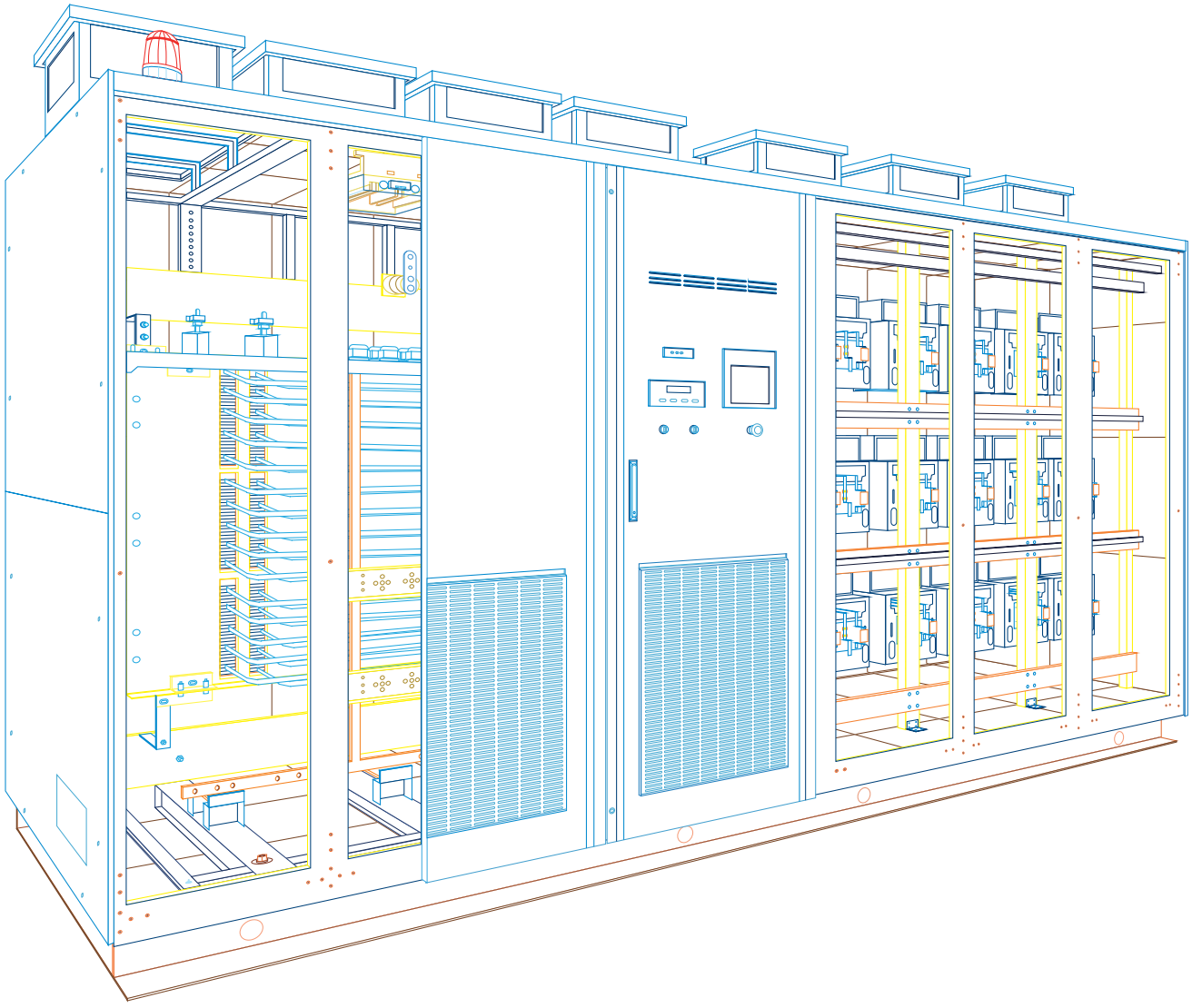
Medium voltage AC drive

DH1000



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DH1000 - General infomation

The DH1000 can be specified to control asynchronous or synchronous motors whether wound-rotor or permanent magnet.

The DH1000 provides speed and/or torque control for motor-driven applications in the medium and high power range from 200kW to 14 MW at motor voltages from 3.0kV to 13.8 kV.

It is available with air cooling in the lower power range and with optional water cooling in the medium to high power range. DH1000 drives are also available mounted within a customised container, with self-contained sealed cooling systems, providing the highest IP class ratings for hostile environments as well as providing greater convenience and ease of installation and commissioning.

The DH1000 family of drives is thus particularly suitable to retrofit applications as well as applications requiring long cables to the motor. The medium voltage output is achieved directly without the need for an output transformer, particularly important in order to achieve high motor torque at very low speeds.

On the motor side, the drives provide almost perfectly sinusoidal motor current such that there are no concerns regarding overheating in the motor or torque pulsations on the motor shaft. The output voltage waveform is multi-level PWM such that it is close to sinusoidal and compatible with standard motor and cable insulation systems. It also does not induce any significant stray currents in motor bearings which can otherwise cause early motor bearing failure. This is all achieved without the need for sinusoidal output filters in all but the most exceptional circumstances (extreme cable length).

Solution for a wide range of industries

The application of advanced technology variable speed drives to motor control results in significant energy savings over fixed speed in a wide variety of applications.
Since their introduction to the market in 2005, the DH1000 range of variable frequency drives have provided reliable and highly efficient control of medium voltage AC motors for many applications in a wide range of industries. The DH1000 series is the latest generation optimised for improved performance, reduced size and weight and even greater value for money.

Fields of application

Industries	Applications
Cement, mining and minerals	Grinding mills, conveyors, fans and pumps
Chemical, oil and gas	Compressors, extruders and pumps
Metals	Blast furnace blowers, fans and pumps
Pulp and paper	Fans and pumps
Power generation	Gas turbine starters, ID/FD fans and pumps
Water	Pumps
Renewable energy	Wind turbines, tidal and wave energy generation
Other applications	Test stands and wind tunnels

DH1000- Compact design and high performance

The DH1000 is designed for maximum reliability, efficiency and versatility – features that have a direct impact on the customer's cost of ownership.

Clean Power

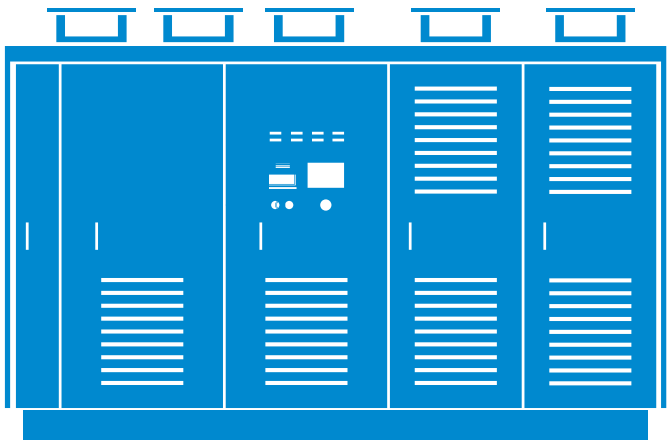
In the DH1000 converter, the medium voltage output is constructed by connecting the outputs of single-phase low-voltage IGBT-based inverters in series, with an equal number per phase. Each individual single-phase inverter power module is powered by an internal rectifier, itself supplied from separate phase-displaced secondary windings of the integrated transformer.

An inherent feature of this technology is that a high pulse number rectifier is created resulting in a significant reduction of input current harmonic distortion. In the example shown below for a 6kV output, the diode rectifier is 30-pulse. The input Power Factor is also high at a minimum of 0.95 regardless of speed and power.

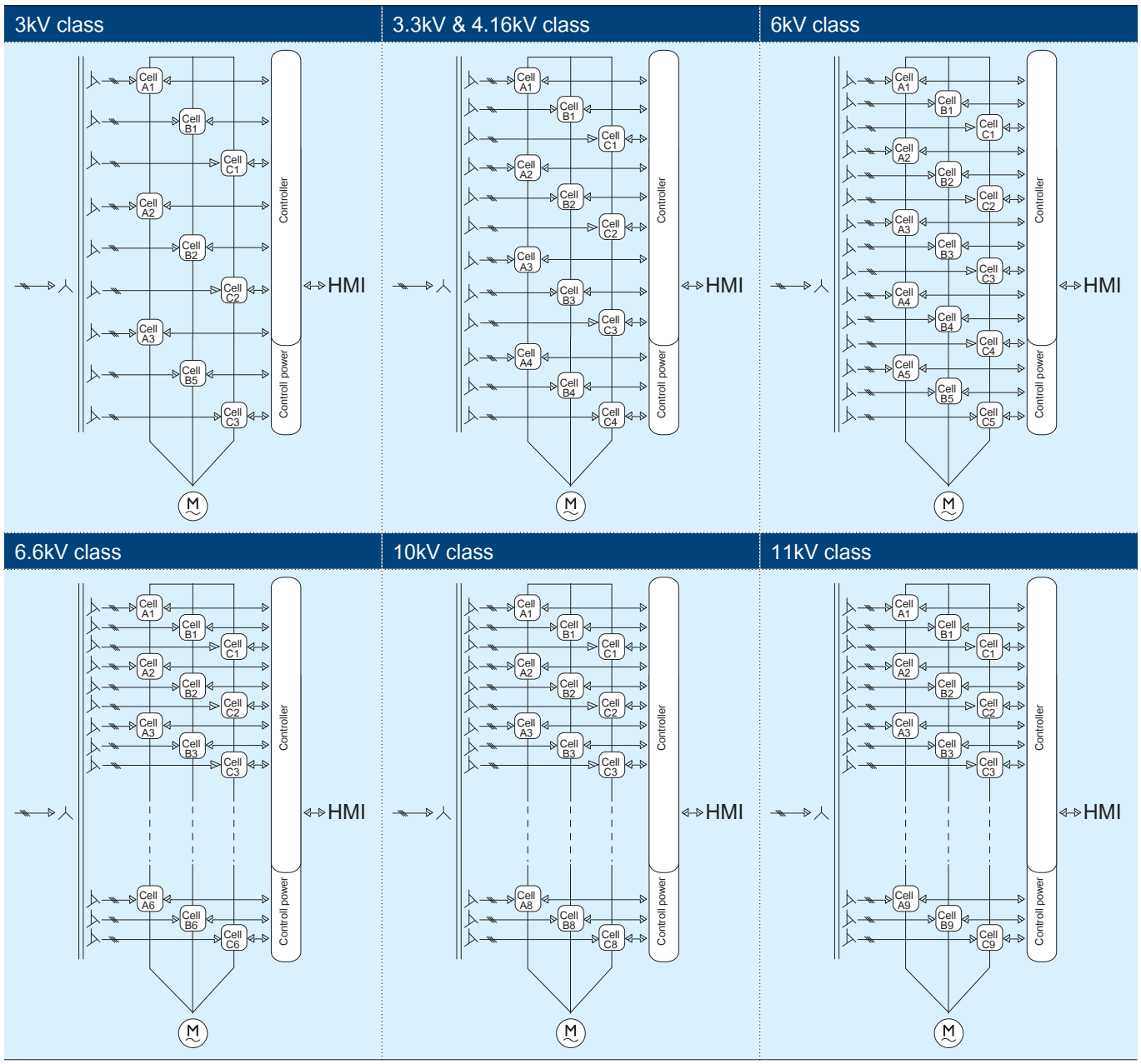
The PWM switching strategy ensures that sinusoidal current is supplied to the motor. The low levels of harmonic current in the motor ensure that both motor heating and shaft torque pulsations transmitted to the coupling and load are minimised.
Use of the multi-level PWM topology also results in a reduced size of voltage steps imposed on to the motor and cable insulation systems compared to 2 or 3-level inverters. The dV/dt is less than 1,000V/uS.

Multi-level features

- Very low levels of input current harmonics with high input power factor.
- Sinusoidal current output to motors – no significant temperature rise in the motor due to current harmonics.
- No significant motor shaft torque pulsations – kind to shaft coupling and mechanical load.
- Lower dV/dt voltage stress imposed on to the motor and cable insulation systems.
- Lower amplitude of PWM switching at the output significantly reduces potential transmission line effects when long output cables are used to the motor.
- Lower amplitude and frequency of PWM switching at the output significantly reduces potential for stray currents through the motor bearings.
- Use of low-voltage IGBTs which are easily obtainable, highly reliable and well-proven.
- Low losses since IGBTs do not need snubber circuits and require little switching power.
- Current can be switched off instantaneously in the event of a fault in the output circuit.
- Modular design.
- Medium voltage output achieved without output transformer



DH1000 Multi-level topology



External View

DH1000 : 6kV, 1250kVA

Compact design

- Transformer integrated within cabinet
- Modular power module design
- Front access only for easy maintenance and replacement

Fully equipped

- 7” HMI touch screen for status display6 and local control
- 30 min UPS to maintain control during a short-term power outage
- Internal cabinet lighting
- Visual and audible local alarm

Restricted access to medium voltage area

- Door interlock system prevents unauthorised access
- Special tools required to open doors
- Handle lock provided
- Fibre-optic communications for exchange of status and control between Medium Voltage Cabinets and Low Voltage Control Cabinet

Internal view

DH1000 10kV, 3150kVA

Transformer cabinet

Multi-winding phase-shift transformer

- Multi-winding phase-shift transformer (36 pulse/18 winding) is in place with taps for change in input voltage.
- Reducing power harmonics with multi-pulse filtering in compliance with IEEE standards
- Eliminating need for harmonic filter and power factor-improving condenser

Control cabinet

Master control module

- Master control module to control multi-level PWM output voltage with a total of 18 unit cells and fiber optic communication link.
- User-centric HMI to support system diagnostics and monitoring

Inverter cabinet

Cell drive module

- Six low-voltage single-phase drives in serial connection per phase, generating 25 level 3 phase output voltage. It is designed to ensure easy cell maintenance.
- Each cell performs PWM switching in distributed control mode and has default built-in cell protection and bypass functions.

Power module

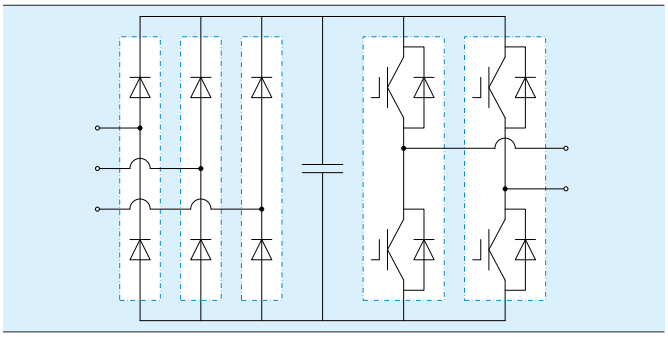
The inverter section within the drive is of a modular design using identical power modules connected in series to create the required medium voltage output. Each power module uses a well-proven low-voltage IGTB-based single-phase H-bridge architecture for added reliability, economy and ease of replacement.

The standard power module for two-quadrant control (bi-directional motor speed control without braking) uses a diode rectifier at the front end. An optional power module is available which uses an IGBT-based rectifier to allow power to be returned to the supply allowing full four-quadrant operation (motoring and braking in both directions). This “Active Front End” is modulated to draw sinusoidal current from the supply and control the input power factor to unity. The AFE version can also be used to continuously return power to the network for renewable energy generation applications such as for wind and tidal turbines.

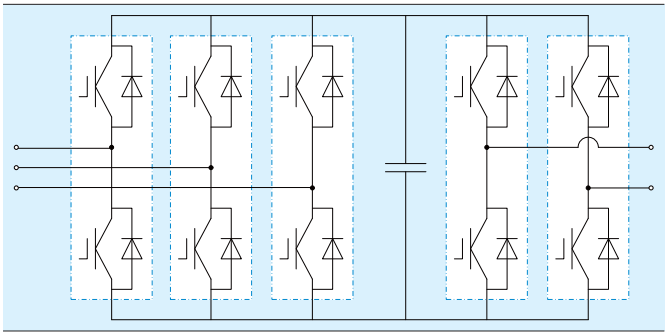
Features

- Front access design for easy maintenance of power modules that can be replaced in just a few minutes.
- Single power cell design for all modules allows reduced spare parts inventory cost.
- 2-Quadrant and 4-Quadrant versions available.
- Fibre-optic interface for safe control and feedback communication with controller.

Two quadrant topology



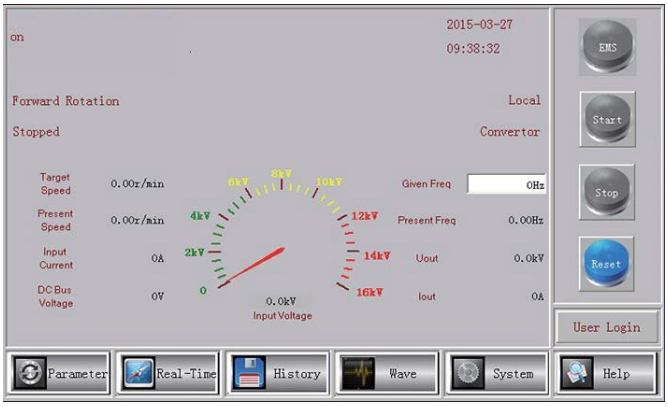
Four quadrant topology



Monitoring(HMI)

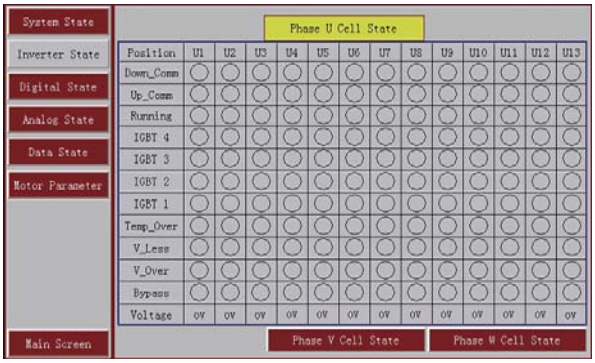
- Door-mounted easy-to-use 7-inch color LCD touch-screen
- User-friendly interface with operational data at your fingertips
- Virtual meters display main VFD parameters
- System and status monitoring and manual controls
- Power module status monitoring
- Data logging, trending displays, diagnostic information available
- Multiple languages available
- Parameter adjustment and operation records
- Dedicated multi-level menu to guide user with different access levels for service and commissioning engineers (Operator, Manager and Administrator)

Main panel

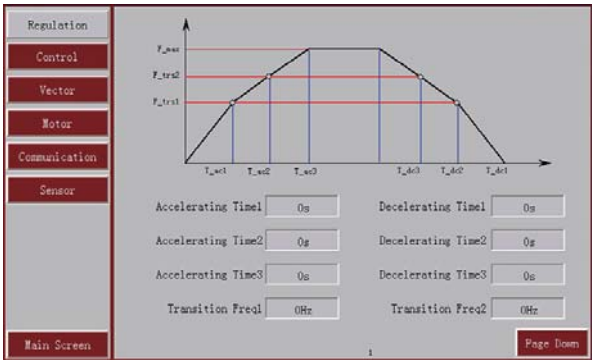


Standard HD HMI monitoring maximizes user convenience

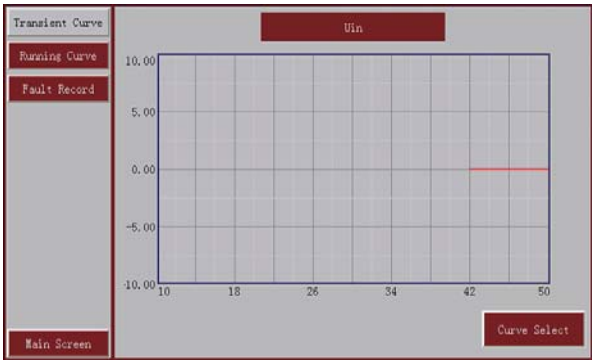
Inverter



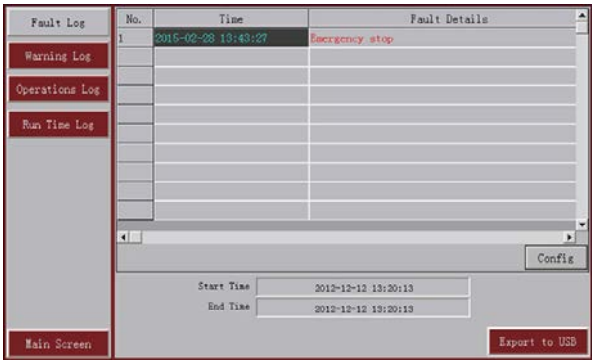
Speed

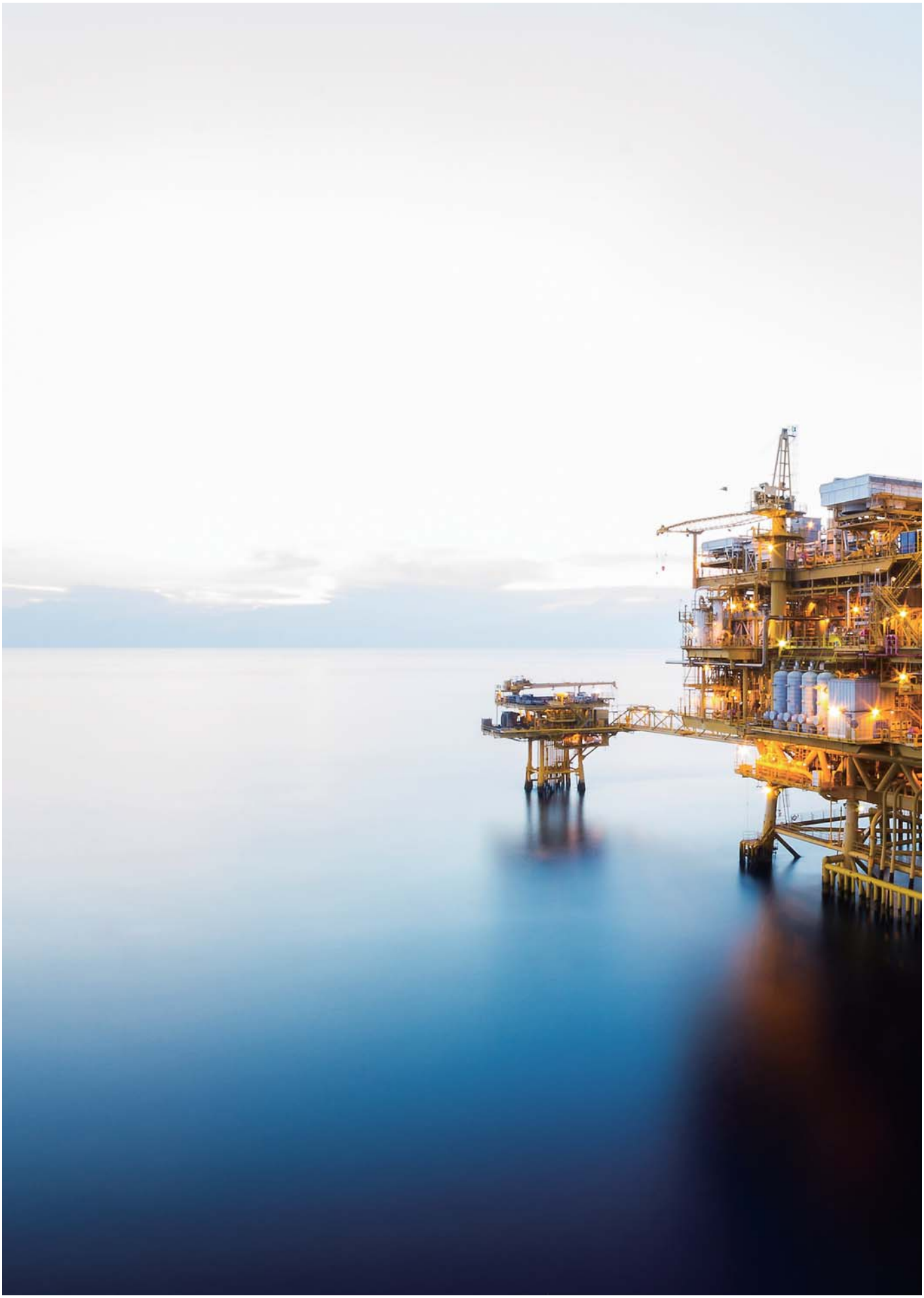


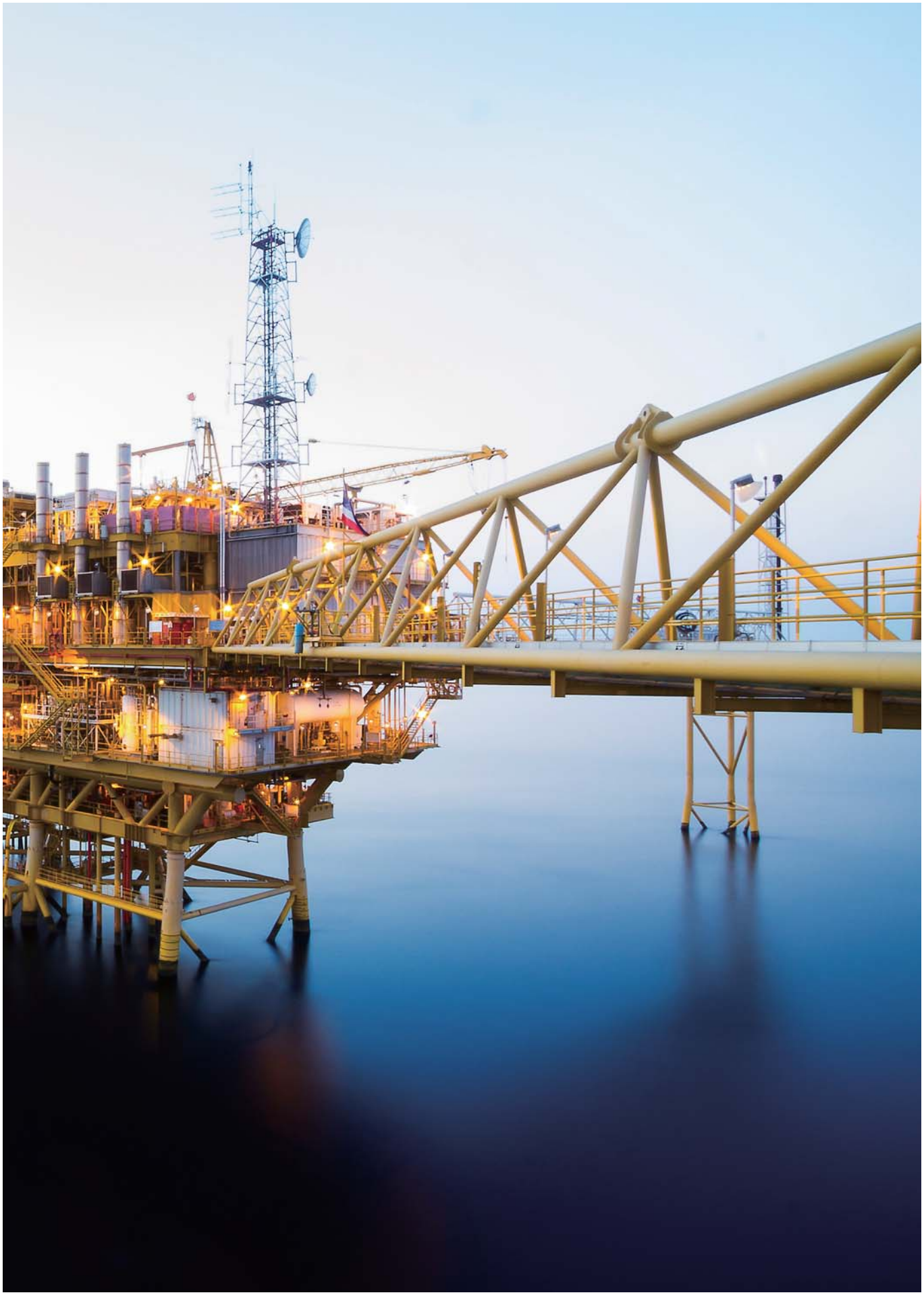
Trend



History







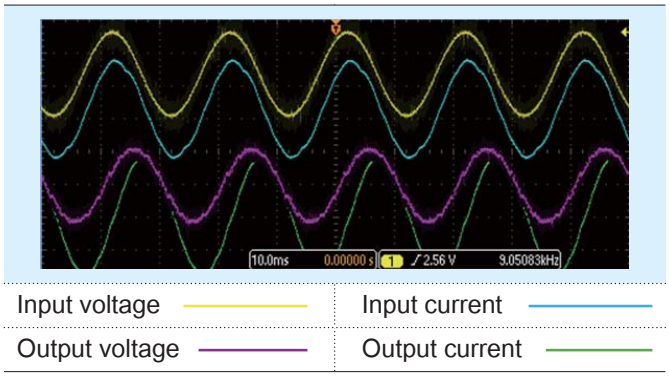
DH1000 - Benefits

DH1000 is designed to deliver value through reliable process control and low cost of ownership.

Improved power quality

- Almost sinusoidal input current eliminates the need for additional harmonic filters or active filters on the input side
- Compatible with older design of motors allowing retrofit to existing system designs.
- Minimal impact of voltage reflection, allowing longer cable length between motor and drive.
- Multi-level medium voltage drives minimise stress on motor windings, eliminating the need for additional sine wave filters

Input and output current and voltage waveform



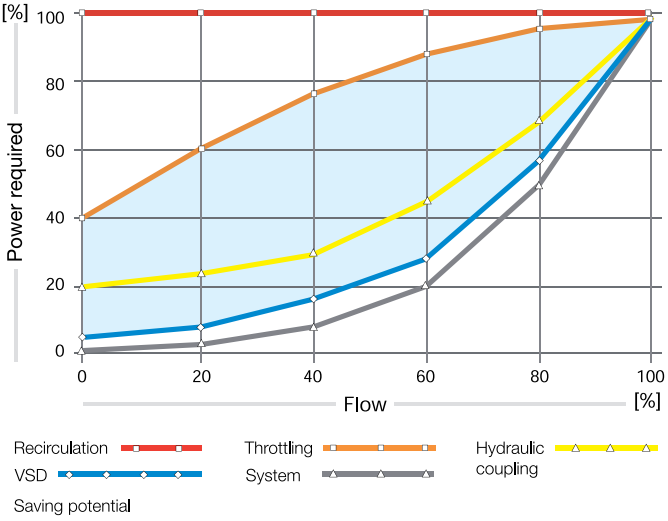
Energy saving

Fans, pumps and compressors have load characteristics whereby the power consumed increases as a cubic law with speed. The optimum way to save energy with this type of load is to control the motor speed with a VFD. This is far more effective as it avoids the waste of energy when fluid flow rate is controlled using a valve or damper.

Process control is improved by the use of more accurate, prompt and flexible control of the motor speed.

- The inherent soft starting ability of a VFD reduces the impact on the network (voltage dips) caused by high starting currents. Substantially greater starting torques can be achieved with a VFD than with a soft starter and with much lower starting current, reducing stress on the motor windings and saving energy.
- The controlled start-up acceleration rate also reduces the mechanical stress on the load equipment.
- The VFD operates at a higher input power factor than a directly connected asynchronous motor.
- The losses in the VFD converter are low, only 1.5% excluding the transformer.

Power consumption for various pump control methods



High Reliability and Easy Maintenance

DNH,such as the use of a modular multi-level topology design and use of IGBT power semiconductors, provide a low parts count, which extends the Mean Time Between Failures (MTBF) and increases reliability.

Front access

The DH1000 is designed to allow easy front access to the drives components thereby providing high availability.

Long lifetime

The DC bus capacitors provide an energy store and de-coupling buffer between the supply network and the load side converter. The high value of the capacitors almost eliminates the voltage ripple and stabilizes the DC bus voltage, suppressing disturbances caused by fluctuations of the load and supply side harmonics and switching transients.

Traditionally, the capacitors used for the DC bus have been of aluminium electrolytic type as the technology is mature and relatively low cost and also achieves a high energy density.

Disadvantages of electrolytic capacitors

However, electrolytic capacitors suffer from some disadvantages:

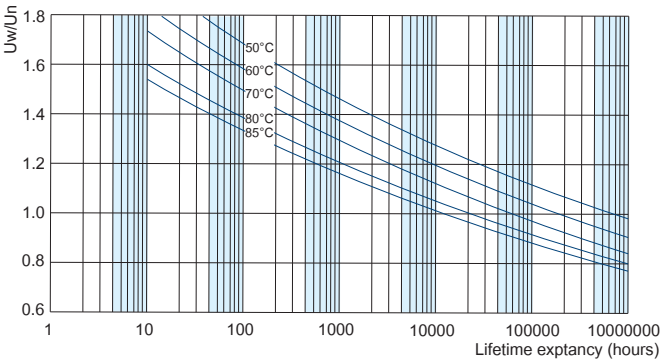
- Limited ability to handle large ripple current.
- Limited voltage rating and ability to handle voltage surges. It is necessary to connect capacitors in series and use voltage-sharing resistors, increasing system design complexity and reducing overall reliability.
- Limited lifetime.
- Unsuitability for long-term storage as spare parts.
- Failure modes may result in collateral damage to other components.

Advantages of metalized film capacitors

The DH1000 uses metalized film capacitors which have the following advantages, despite having a lower power density:

- Ability to handle high ripple current.
- Self-healing with longer natural life.
- Improved performance at low temperatures.
- Higher voltage capability such that it is not necessary to mount in series and also non-polarised – both these factors simplify bus bar and system design with reduced effects of stray parameters and improved resultant reliability.
- Lower internal losses and stray than electrolytic capacitors.
- Generally fail to open-circuit without causing collateral damage.
- Can be stored for long periods without the need for re-forming.

Lifetime expectancy vs Uw/Un



DH1000 - Functions

DH1000 offer highly reliable optimum solutions by providing spinning start, power cell bypass, sensorless vector control and many more functions.

Torque limiting function

The torque limit function is used to accurately control and limit the torque in order to prevent overload of the motor, electricity supply system or VFD itself. This prevents damage to the motor when stationary, for example, with a locked rotor, when starting with high inertia or high initial friction load.

The torque limit function can also be used to prevent or limit the return of power from the motor to the VFD in the event of an over-hauling load causing the motor speed to exceed the commanded speed.

Spinning start (Flying start)

The DH1000 can automatically identify that the motor is already spinning at the moment of the start request and institute a controlled sequence to enable the drive to pick up the spinning motor without the need to stop the motor or the risk of a system trip. The sequence requires an initial estimate of the spinning motor speed by scanning the motor voltage while changing the output frequency. Steps are taken to reduce the time needed to estimate the motor speed.

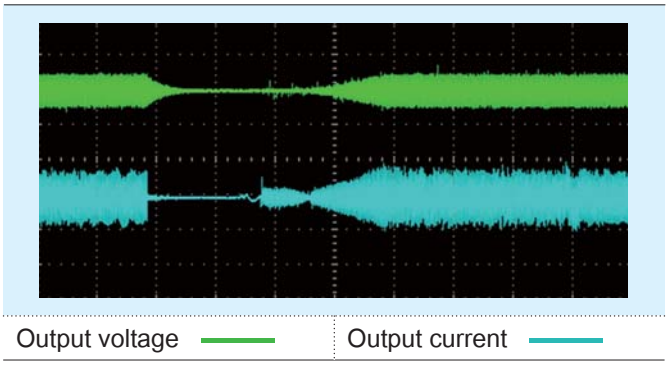
Examples of when a Flying Start would be used

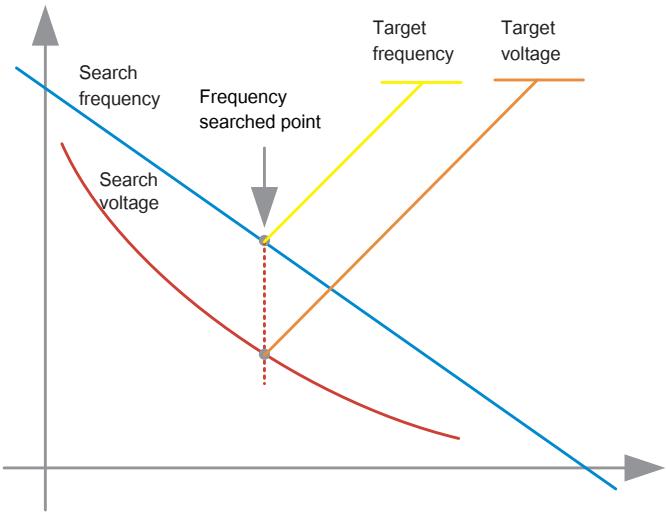
- The mechanical load causes the motor to be spinning, even though no electric power is applied to the motor.
- Manual reset after trip
- Automatic restart after a shutdown.
- Restart after Low-Voltage Ride-Through (temporary loss of supply power).
- Restart after an automatic Power Cell Bypass.

Rapid Speed Estimation

- Reduce speed estimation time by controlling the drive output frequency scanning rate
- Reduce estimation time by reducing output frequency
- Reducing estimation time by controlling voltage response

Spinning start waveform





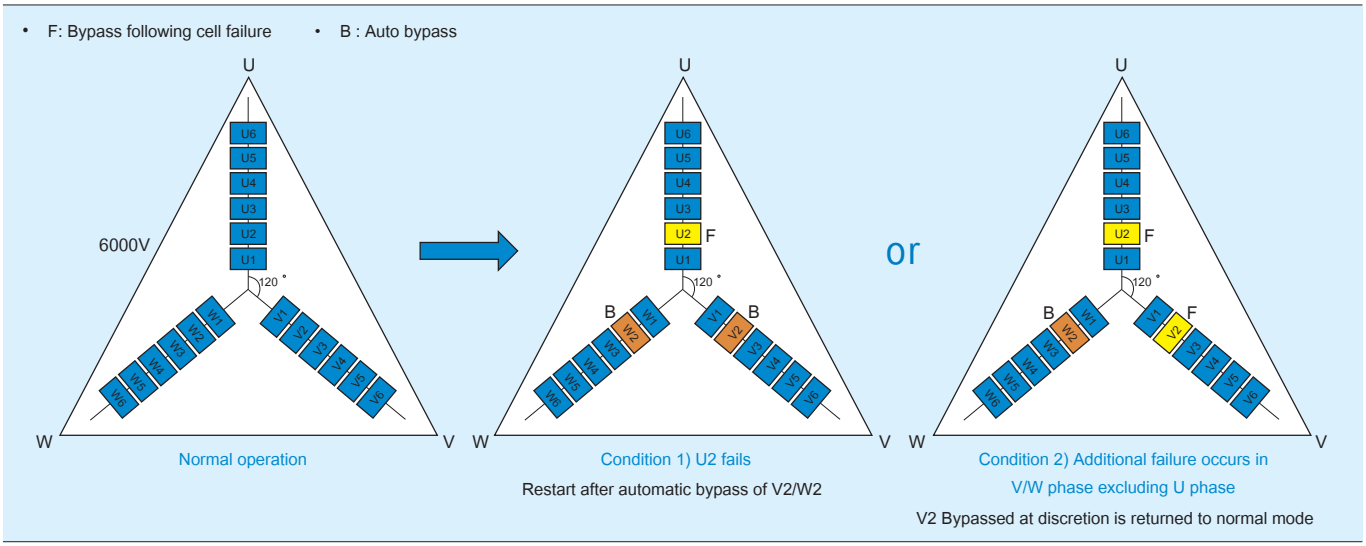
Automatic power cell bypass option

When a fault in a power module is detected, the DH1000 shuts off current to the motor, bypasses the identified faulty power module, bypasses the equivalent power module in the other phases in order to maintain voltage balance, and automatically restarts current to the motor. This allows operation to continue without intervention of the operator.

If a power module in another phase were to fail, the system automatically re-organises the bypass to achieve the highest working voltage possible.

Note: This function is optional.

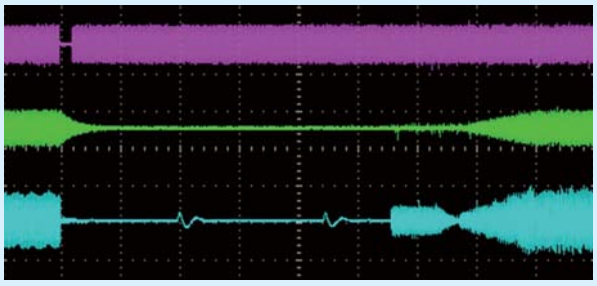
Operate cell bypass function (in auto setup)



Low voltage ride-through (LVRT)

In the event of a short-term dip in supply voltage, the vector control system maintains correct motor flux while allowing the motor to coast. If the supply voltage recovers within the stipulated period (e.g. up to 5 cycles of the supply power), normal speed and torque control are restored automatically. During the supply dip mechanical energy of the load may be regenerated in order to maintain the DC Link voltage, maintain control power and maintain control of the motor flux. The VFD is then able to ride through the under-voltage event and automatically continue normal operation without operator intervention. If the supply dip exceeds the stipulated period, the VFD will trip and a normal re-start is undertaken.

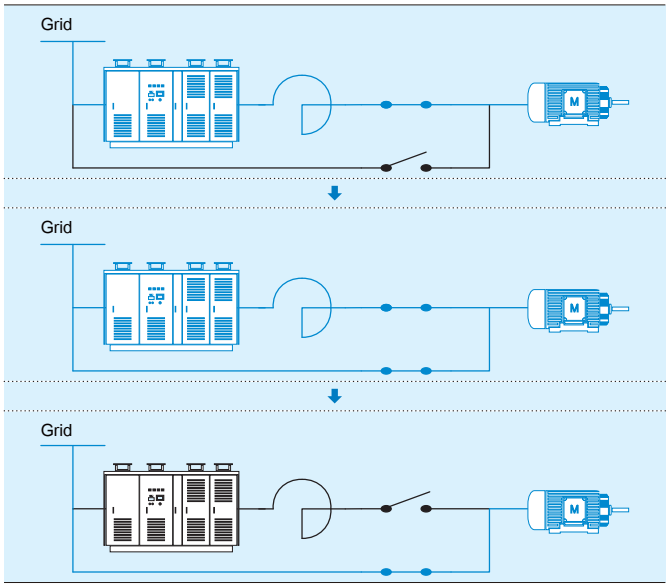
LVRT waveform



Synchronous transfer

- Seamless switching of the source of motor power from the VFD to the local supply network (Synchronous Transfer to Bypass mode) or vice versa (switch to VFD mode).
- Synchronous transfer function synchronises the VFD output frequency, voltage and phase with the local supply network before operating the Bypass circuit breaker, enabling power transfer without over-current or motor torque disturbance.
- For transfer back to VFD mode, the VFD output is first synchronised to the supply network before opening the Bypass circuit breaker and assuming VFD control of motor torque and speed.
- Multi-motor operation: Synchronous transfer can be arranged for a single VFD to be used as a starter for several motors that do not need variable speed operation. Once the transfer of a motor onto the supply network has been completed, the VFD is then available to start another motor. The final motor to be started can remain on the VFD if variable speed is required.

Drive mode to grid mode



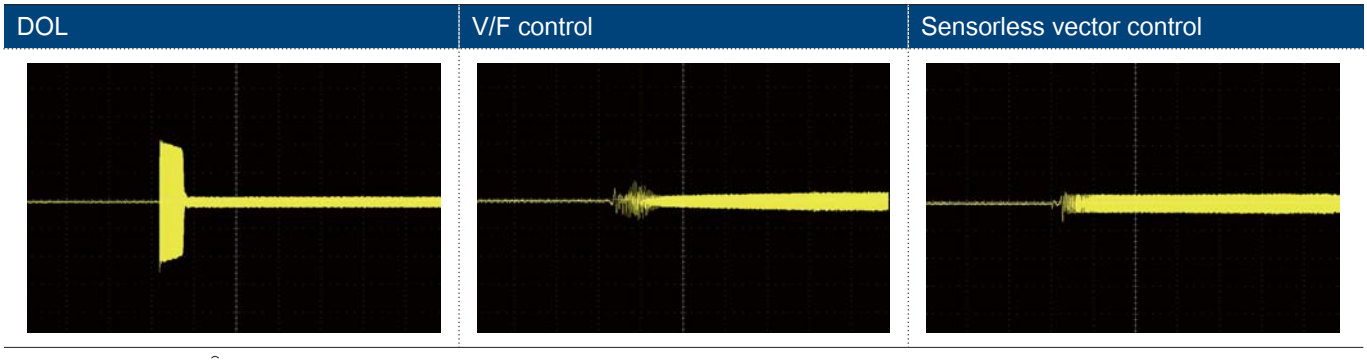
Sensorless vector control

A speed sensor can be a source of potential unreliability so is avoided if possible. Traditionally, the only alternative to closed-loop speed control with a speed sensor was to use V/f control with subsequent loss of accuracy, loss of ability to control and limit torque and inability to control at close to zero speed.

Advantage

Sensorless Vector Control (Open-loop control) now provides improved starting torque and accurate control of speed and torque at low speed. Low-speed performance now approaches that of closed-loop control without the need for a sensor with the attendant maintenance cost.

Starting current in different control mode

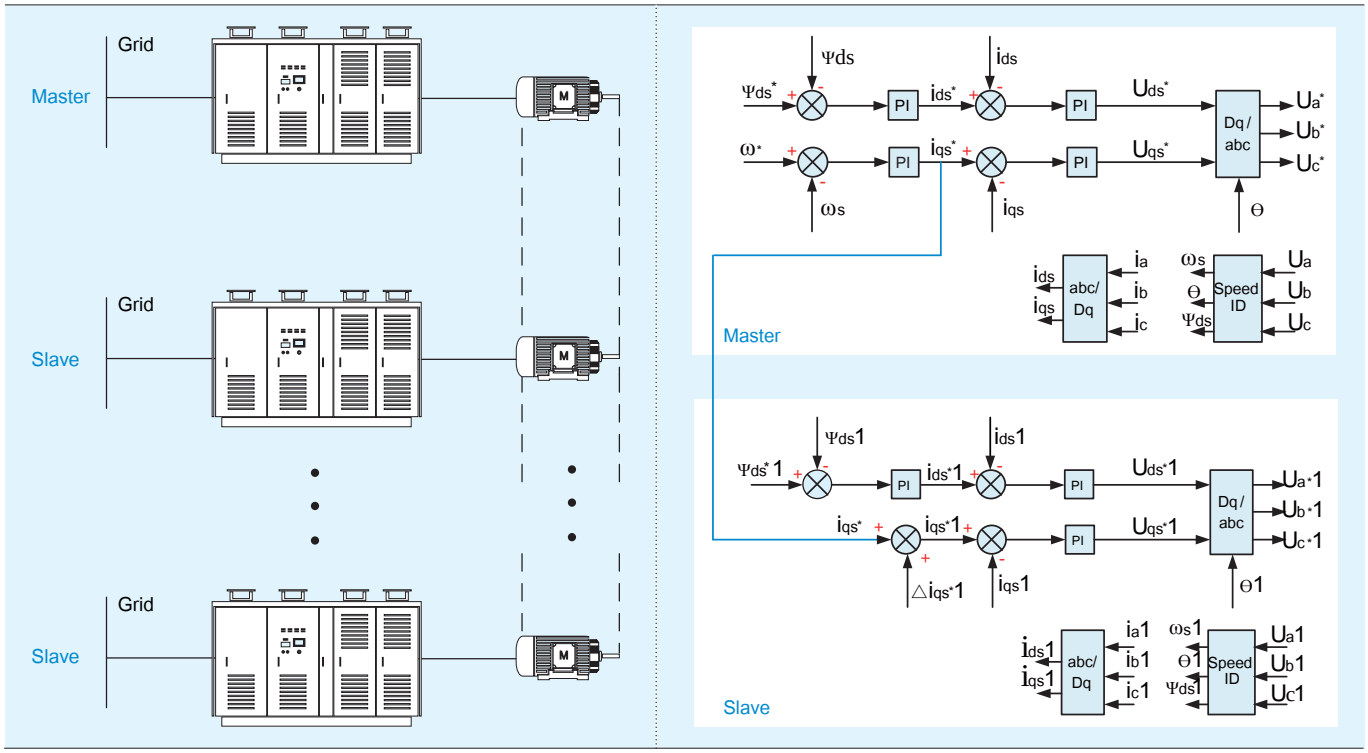


Master-Slave control

Some applications require that the load is driven by two or more motors that are mechanically coupled together. It is inherent that the motors run at the same speed but it is essential that they share the mechanical load equally or in a defined and stable manner. Even if each motor is driven from a separate VFD, only one speed regulator is required and steps must be taken to ensure that each motor takes the correct share of the mechanical load torque.

This requirement is satisfied by the Master-Slave system. VFD must be in Vector Control mode. One VFD is arbitrarily designated the Master and the Torque Command produced by the Speed Regulator in this Master VFD is transmitted to the other VFDs designated as Slaves. The Slave VFDs follow the Torque Command from the Master while their own Speed regulators are disabled. In the event that the Master VFD becomes unavailable, the system automatically re-assigns one of the former Slave VFDs to become the new Master. The medium used to transmit the Torque Command signal between the VFDs is either high-speed hard-wired analogue or via a high-speed digital network.

Vector logic drawing



Automatic parameter identification (Auto-tune)

The DH1000 can automatically identify the required motor parameters allowing accurate control of the motor at low speed without the need for a sensor (Open-loop Control).

DH1000 - Ordering Data

Technical spefication

Items	Parameter
Power supply	
Input voltage	3 phase, AC, 6kV/ 10kV
Input voltage fluctuation tolerance	±10%
Control voltage	3 phase, AC, 380V/ 400V / 415V / 480 V
Output	
Voltage	0 ~ 6kV /10kV
Current	0 ~ rated current
Frequency	0 ~ 50 / 60Hz (customized, maximum 120Hz)
Maximum length of cable permitted	1000m
Performance	
Input waveform	Current THD < 4%, input filter is not necessary
Output waveform	dv / dt < 1000V / us, output filter is not necessary
Effciency	> 98.5% at 100% speed (not including transformer)
Power factor	>0.96, (20% ～100% Speed) power factor compensator is not necessary
Ambient	
Installation	Indoor, no explosive and corrosive gas
Temperature	0 ~ 40 ˚C
Humidity	< 90%, no condensation
Above sea level	Less than 1000m (customized)
Storage / transportation temperature	-25 ˚C ~ +55 ˚C
Control	
Control mode	Sensor less vector control / sensor vector control / V/F control
Load type	Synchronous or asynchronous motor (slip ring motor)
Control chip	DSP, FPGA
PID function	Programmable
Control features	Duplicate supply, fault diagnostic, torque and current limit, low voltage ride-through, synchronous-transfer and drive bypass, power module bypass (option), flying start, master-slave control, skip frequencies, motor parameter estimation
Frequency resolution	0.01Hz
Communication	RS485, Modbus-RTU / Profibus-DP (optional:devicenet, profinet, ethernet)
HMI operation	Touch screen
HMI language	English / Russian / Chinese
Alarm annunciation	Audio visual
Noise level	<80dB
Protection	Over current, earth fault, over voltage,under voltage,phase loss, over temperature, fan failure, communication failure
Cell side road	Max. 2 of faulty cell bypass per phase (optional)
Enclosure	
Cooled mode	Air cooled (optional: water cooled)
Ingress protection	IP20 (optional: IP30, IP31, IP41, IP42)
Painting	RAL7035 (customized)

DH1000 - How to chose

Identification code

DH1000 - □□□ / □□□□ - □□□

Product series

DNH drive 5000 series

Input voltage

3.3 - 3.3kV
.....
6 - 6kV
.....

Output current

15 - 15A
.....
1300 - 1300A
.....

Customized function

B - cell bypass (option)

Cell type

T - two quadrant
F - four quadrant

Motor type

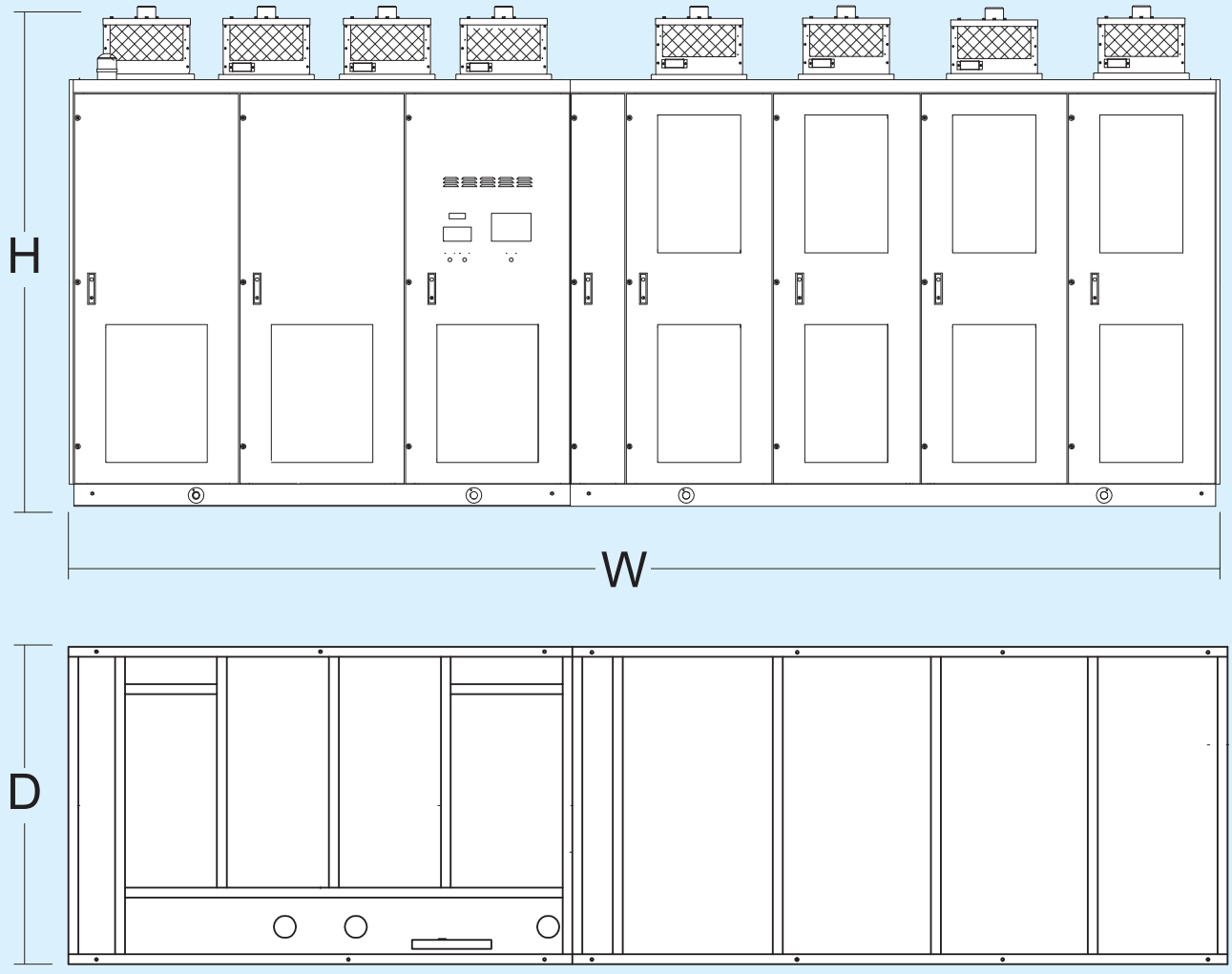
A - asynchronous
S - synchronous

Example

DH1000 - 10 / 280 - AT

DH1000 = DNH medium voltage drive 5000 series 10 = input voltage 10kV, 280 = output current 280A
A = asynchronous motor, T = two quadrant
Suitable for 4000kW motor.

Standard dimension drawing



6kV specification

Note:

1) ... Please contact DNH ELECTRIC for other combinations of input and output voltage.

2) ... For higher drive capacity please contact DNH

3) ... The specification is only suitable for 6kV standard air cooling drive, for water cooling system please contact DNH ELECTRIC.

Voltage	Current	Power	Type mode	Width	Depth	Height	Weight
kV	A	kW	Standard	mm	mm	mm	kg
6	25	200	DH1000-6/25	3052	1400	2722	3730
6	32	250	DH1000-6/32	3052	1400	2722	3730
6	39	315	DH1000-6/39	3052	1400	2722	3730
6	50	400	DH1000-6/50	3052	1400	2722	3730
6	63	500	DH1000-6/63	3052	1400	2722	3730
6	70	560	DH1000-6/70	3052	1400	2722	3730
6	79	630	DH1000-6/79	3052	1400	2722	3730
6	88	710	DH1000-6/88	3352	1400	2722	4230
6	96	800	DH1000-6/96	3352	1400	2722	4230
6	110	900	DH1000-6/110	3352	1400	2722	5395
6	120	1000	DH1000-6/120	3352	1400	2722	5395
6	150	1250	DH1000-6/150	3652	1400	2722	5395
6	170	1400	DH1000-6/170	3949	1500	2722	8013
6	195	1600	DH1000-6/195	4852	1500	2722	8013
6	240	2000	DH1000-6/240	4852	1500	2722	8013
6	270	2240	DH1000-6/270	4852	1500	2722	8013
6	305	2500	DH1000-6/305	6656	1700	2998	11400
6	338	2800	DH1000-6/338	6656	1700	2998	11400
6	360	3000	DH1000-6/360	6956	1700	2998	12050
6	380	3150	DH1000-6/380	6956	1700	2998	12050
6	430	3550	DH1000-6/430	7862	1700	2998	13550
6	458	3800	DH1000-6/458	7862	1700	2998	13550
6	480	4000	DH1000-6/480	7862	1700	2998	13550
6	545	4500	DH1000-6/545	8662	1700	3299	16000
6	600	5000	DH1000-6/600	8662	1700	3299	16000

10kV specification

Note:

1) ... Please contact DNH ELECTRIC for other combinations of input and output voltage.

2) ... For higher drive capacity please contact DNH ELECTRIC.

3) ... The specification is only suitable for 10kV standard air cooling drive, for water cooling system please contact DNH ELECTRIC.

Voltage	Current	Power	Type mode	Width	Depth	Height	Weight
kV	A	kW	Standard	mm	mm	mm	kg
10	29	400	DH1000-10/29	3954	1500	2722	5780
10	38	500	DH1000-10/38	3954	1500	2722	5780
10	42	560	DH1000-10/42	3954	1500	2722	5780
10	47	630	DH1000-10/47	3954	1500	2722	5780
10	53	710	DH1000-10/53	3954	1500	2722	5780
10	58	800	DH1000-10/58	3954	1500	2722	5780
10	66	900	DH1000-10/66	4254	1500	2722	6580
10	73	1000	DH1000-10/73	4254	1500	2722	6580
10	91	1250	DH1000-10/91	4254	1500	2722	6580
10	103	1400	DH1000-10/103	4254	1500	2722	8873
10	115	1600	DH1000-10/115	4852	1500	2722	8873
10	145	2000	DH1000-10/145	4852	1500	2722	8873
10	165	2240	DH1000-10/165	5154	1700	2722	9890
10	180	2500	DH1000-10/180	5154	1700	2722	9890
10	200	2800	DH1000-10/200	6257	1700	2722	9890
10	215	3000	DH1000-10/215	6557	1800	3052	12369
10	230	3150	DH1000-10/230	6557	1800	3052	12369
10	250	3550	DH1000-10/250	6557	1800	3052	12369
10	275	3800	DH1000-10/275	6557	1800	3052	12369
10	280	4000	DH1000-10/280	6557	1800	3052	12369
10	320	4500	DH1000-10/320	8160	1700	2998	18600
10	360	5000	DH1000-10/360	8160	1700	2998	18600
10	400	5600	DH1000-10/400	8160	1700	2998	18600
10	435	6000	DH1000-10/435	9968	1700	3299	21050
10	455	6300	DH1000-10/455	9968	1700	3299	21050
10	520	7100	DH1000-10/520	10768	1700	3299	24700
10	578	8000	DH1000-10/578	10768	1700	3299	24700

DH1000 - Installati

In order to ensure stable and reliable operation over the entire long lifetime of the VFD, attention should be paid to maintaining the correct environmental conditions.

Environmental conditions

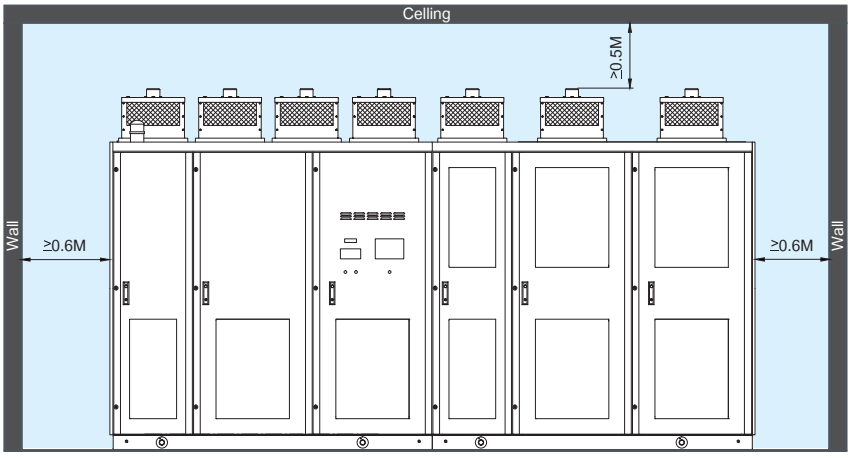
- Ambient temperature: 0~40°C
- Transportation / Storage temperature: -25°C~55°C
- Relative humidity: less than 90%, no condensation
- Free of corrosive gas or liquids
- Air supply free of dust and metallic dust
- Low levels of electric and magnetic field strength and of radiation
- Low levels of vibration

Installation space

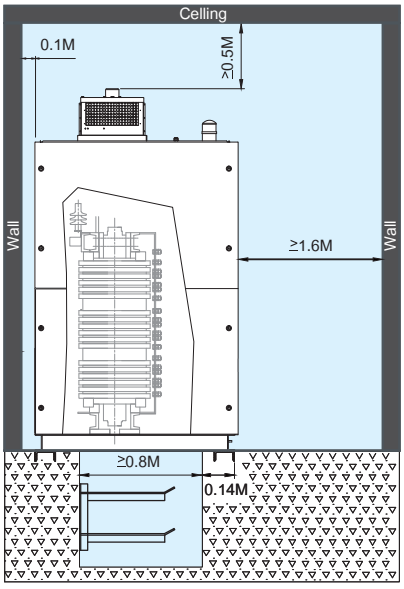
It is important to allow sufficient space around the VFD for heat dissipation, air circulation and convenient routine maintenance.
Please ensure that the following clearances are maintained as a strict minimum:

Diagram showing the installation space requirement.

View from front

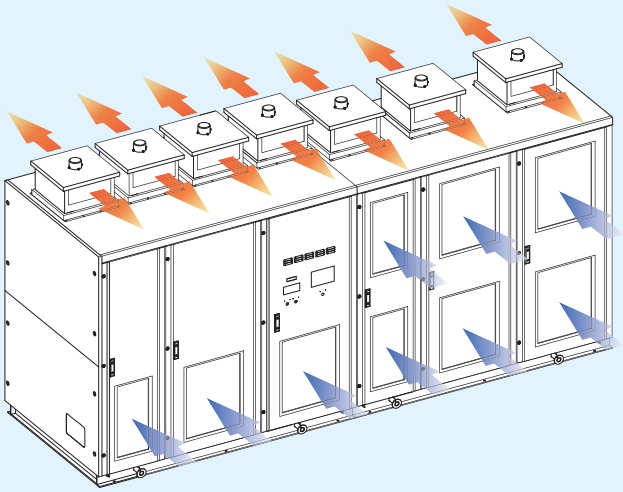
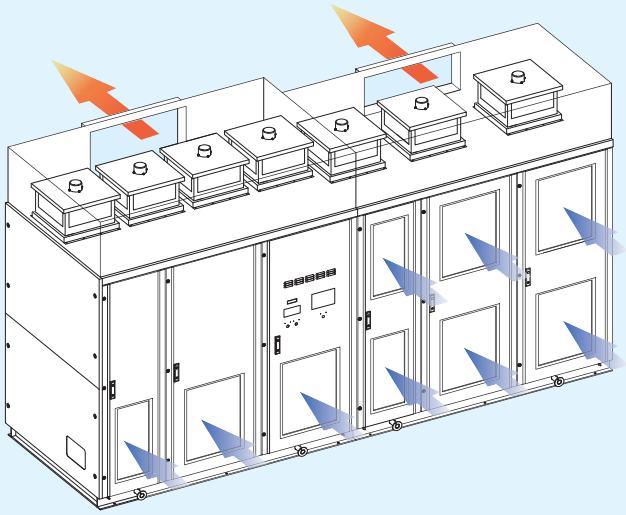


View from side

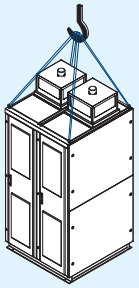
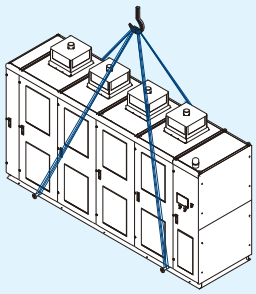
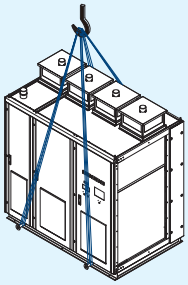
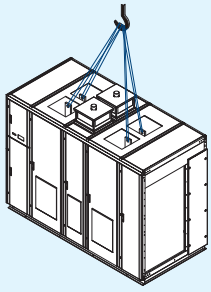


- Top of the cabinets to the ceiling 0.5m
- Space behind all of the cabinets to the rear wall 0.1m
- Space between cabinet sides and adjacent walls 0.6m
- Space in front of drive cabinets is at least 1.6m

Construction of duct for extracted air (optional)

Sketch of standard ventilation method	Sketch of optional duct for extracted air
	

Lifting methods

Lifting methods	Power and control cabinet	Lifting methods	Transformer
The width of the power cabinet and control cabinet sections for lifting must not exceed 900mm.		Here, the width of power cabinet and control cabinet section exceeds 900mm and is not allowed without a “spreader bar”.	
Where the size of transformer does not exceed 3500kVA, the cabinet may be lifted normally.		Where the size of transformer exceeds 3500kVA, use should be made of lifting rings which are fixed directly to the transformer and accessible by removing the access covers provided in the roof of the cabinet.	

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