ENGINEERING
TOMORROW

Selection Guide I VACON® NXP Grid Converter

Reduce emissions and **noise** in ports and on ships with **grid converter** technology

10%
fuel costs savings on shaft generator with VACON® NXP Grid Converter technology at M/V Bore Sea.

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Reduce emissions and improve efficiency

The limits of the worlds natural resources dominate our times, and the marine industry is taking on the same challenges as everybody else regarding energy usage. VACON® NXP Grid Converter technology helps ship owners and port authorities reduce fuel intake and improve efficiency. This will please investors and environmental legislators alike – after all, lower energy consumption equals lower costs.

Ships require power when at sea and when docked in the harbor. Power is not only required to propel ships around the world, it also provides electricity to operate equipment on board at all times.

Take a cruise ship for example. Passengers pay a great deal of money and expect to be treated accordingly. Karaoke, champagne bars and swimming pools all need a lot of electricity to power them, as do more fundamental components, such as propulsion machinery and winches. This also applies when a ship's docked in a city harbor, as on-board facilities still need to operate. Port authorities and local residents appreciate the use of grid converters, since they can practically eradicate CO_2 and NO_x emissions while the vessel is docked.

Eco-friendly sea travel

Providing clean energy and saving money for our customers is what drives us, and we develop environmentally sound solutions. VACON® NXP Grid Converter technology represents the next step, ensuring that ship and port owners can meet new stipulations while productivity increases and business prospers.

Using VACON® NXP Grid Converter in a shore supply solution enables ships to source energy from local grids on the shore, meaning that main ship generators can be switched off completely. Applying VACON® NXP Grid Converter to a shaft generator solution allows for optimum control of propulsion machinery at various speeds, thus saving plenty of energy. You can also rest assured that your products will be fully optimized for your particular solution with the help of VACON® Service.

How governments are focusing on cutting emissions

The International Maritime Organization (IMO) has made the Energy Efficiency Design Index (EEDI), which sets out to ensure new ships improve carbon efficiency by 20% in 2020 and 30% in 2030.

The IMO has also created the Ship Energy Efficiency Management Plan (SEEMP), which means all ships must seek to establish a means of improving energy efficiency.

Shore supply solution with VACON® NXP Grid Converter

Ships travel from port to port, sometimes stopping in a new country each day. Ports don't all use the same electrical frequencies, and ships have historically used a fuel-driven onboard generator to provide electrical power while docked. This is costly though, and city councils and local residents are reluctant to tolerate the noise and poor air quality that is often associated with a busy city harbor.

Many port authorities now prohibit, or at least strictly limit, the use of diesel generators while ships are docked. VACON® NXP Grid Converter technology ensures that the ship's frequency matches that of the local grid. This allows the ship's entire electrical network to be powered via a set of cables linking the vessel to the shore.

The main engine can be shut down, which prevents unnecessary carbon emissions and noise pollution, and allows maintenance work to take place when necessary. All in all, it's a far cleaner, more economical solution than before and is set to become a standard requirement in the future.

How it works

The shore side equipment typically includes an isolation transformer and either a 6/12 pulse or low harmonic Active Front End filter. The ship requires a VACON NXP Grid Converter, a filter and a connection interface. Shore side equipment is selected depending on the limit to total harmonic distortion (THDi) levels, which can be as low as <5% when an active front-end unit is installed.

Key benefits

Environmentally friendly

- Reduced CO_2 and NO_x emissions
- Reduced noise and vibration levels

High performance

- Improved efficiency
- Option of planned engine maintenance when docked

Cost savings

- Less running hours for main engine extends lifespan
- Significantly less fuel used

Case studies

Clean power for the largest port in the world

The port of Shanghai
Location: Shanghai, China

The Port of Shanghai is the busiest in the world in terms of cargo throughput, with nearly 170 large ships docking each day. Annual trade accounts for around ¼ of China's total foreign trade. This activity inevitably puts a strain on the local environment, which is why the port uses a movable 2000 kVA shore supply system to supply electricity from the national grid to ships that are docked.

VACON® NXP Grid Converter technology plays a key role in this design, ensuring 10 kV of shore power can be converted into 440 V/60 Hz or 380 V/50 Hz of high-quality clean power. The shore supply system has shown unprecedented technical benefits – if, and when, all large ships in the Port of Shanghai implement it, it will save 33,800 tons of harmful substances a year. Furthermore, a staggering 113,150 tons of CO_2 is saved, as is 366,000 tons of standard coal.

Land-based power supply for ships is on the increase

STX Europe
Location: Turku, Finland

STX Europe is a world leader in shipbuilding, with 14,000 employees and 6 shipyards in Finland, France and Norway. In 2010, a EU directive was passed making it compulsory to use extremely low sulphur fuel in port areas. It became apparent that electricity should be sourced from local grids in order to save costs, emissions and noise.

STX's Turku shipyard builds large cruise liners, historically supplying them with electricity via its own 1.5 MW diesel aggregate. When this power proved insufficient, the shipyard looked to source electricity from the national grid.

The grid converter solution produced was developed with VEO and featured two 4000+ VACON® NXP Liquid Cooled drives controlled by VACON® DriveSynch technology. The shore supply system came into operation in late 2008, and has resulted in major reductions in emissions and noise.

"The delivery took place during the economic boom and we had a very tight deadline, but the system was up and running on schedule. The land-based power supply system has met expectations. There have been some small problems in synchronizing the national grid network and the on-board network, but the team came up with a solution for this as well."

Timo Lahdenranta
Electrical Site Foreman
at STX Europe Turku

Shaft generator solution with VACON® NXP Grid Converter

The cruise liners and cargo ships of today tend to resemble mobile cities with vast infrastructures. They require a huge amount of electricity to maintain both their internal setup and the mechanical power that's needed to travel around the world.

Due to constant voltage and frequency requirements of the ship's electrical network, the main engine operates at a fixed speed. For a number of years now, shaft generators have been used to supplement this with variable amounts of electrical power. With VACON® NXP Grid Converter technology, the engine speed can be optimized while keeping 100% pitch for the propeller. This increases efficiency and, by delivering constant voltage and frequency, allows the electrical network to help the auxiliary engines.

It also makes it far easier to control the speed of the ship. This is especially useful for ships that require regular changes in speed mid-voyage due to dynamic traffic conditions. If the main engine encounters problems at sea, an alternative source of power means that ships can still make it to safety.

How it works

Since the frequency produced by the alternator is proportional to the speed of the engine, the engine must operate at a constant speed. The application consists of equipment on both the generator side and the ship grid side. The machine – which can be induction, permanent magnet (PM) or synchronous – is controlled either by a low-voltage inverter or Active Front End.

The shaft generator is coupled to the main engine and power is taken out to the ship's electrial network to support the auxilliary generators (Power Take off /PTO). It's also possible to boost propulsion by transferring power to the shaft generator (Power Take In /PTI).

Key benefits

Environmentally friendly

- Reduced fuel consumption
- Reduced CO_2 and NO_x emissions

Increased performance and efficiency

- Power Take Off (PTO) generates power to ship's electrical network
- Power Take In (PTI) boosts ship's speed
- Ship can be taken safely to harbour in case of main engine failure

Flexible solution

- Compatible with permanent magnet, induction or synchronous machines
- Available for both new-build and retrofit installations

Case studies

RoFlex® vessel with energy efficient shaft generator configuration

WE Tech / M/V Bore Sea
Location: Helsinki, Finland

M/V Bore Sea was one of two RoFlex vessels ordered by Rorel Ltd to transport Airbus components. After the enforcement of the SEEMP in January 2013, WE Tech Solutions Oy developed a solution which optimized main propulsion machinery and improved energy efficiency.

They chose a solution based on VACON® NXP Grid Converter technology. This is a system combining the shaft generator and the ship's electrical network which allows for large variation to the main engine's speed. This solution still delivers power with constant voltage and frequency, making it possible to optimize main engine efficiency and saving fuel.

Reducing carbon footprint on river cruises

Viking River
Location: Germany

River cruising is the hip younger brother of ocean cruises and has undergone something of a boom in the past decade. One challenge facing manufacturers is the limit on space for river-faring vessels, particularly when it comes to fitting diesel-electric propulsion equipment. Fortunately, VACON® NXP Grid Converter technology helps provide a solution via inverter-driven asynchronous generators.

Viking River Cruises are the world's largest river cruise company. Their boat MV Viking Legend made its maiden voyage in 2009, and was the world's first river cruise vessel to use a shaft generator network between main propulsion and the network.

The system connected VACON® NXP Grid Converter technology with 3 diesel generators, and was able to use a far smaller diesel engine than usual. This significantly reduced fuel consumption and emissions, noise and vibrations. It also meant the vessel was much easier to manoeuvre, allowing passengers to get up close to the historic cities and villages that border the Rhine and the Danube.

"We're very pleased with the improved energy efficiency achieved through various technical solutions used on M/V Bore Sea. Data analyses verify the WE Tech Solutions' shaft generator with VACON® AC drives brings savings of approximately 10% in fuel costs. Given that fuel costs are about €500 per tonne, the annual cost savings are significant, and on top of that CO_2 emissions are also cut by approximately 2000 tonnes."

Jörgen Mansnerus
VP Marine Management, Bore Ltd.

"At any given moment the ship's energy needs are automatically calculated and the engines produce and supply only as much energy as needed. This allows the ship to use 20 % less energy than a comparable ship."

Thomas Bogler
Viking River Cruises
Vice President of Nautical Operations

Ratings and dimensions

VACON® NXP Grid Converter 465-800 V DC, Type Open, liquid-cooled, EMC Class T

Product code	AC current			DC power				Power loss	Size/prot.	Dimensions	Weight
	Thermal I_{TH} [A]	Rated I_L [A]	Rated I_H [A]	400 V AC mains I_{TH} [kW]	500 V AC mains I_{TH} [kW]	400 V AC mains I_L [kW]	500 V AC mains I_L [kW]	c/a/T*) [kW]	CH/Type/IP	W x H x D [mm]	[kg]
NXA02615A0T02WVA1A2000000+MASG	261	237	174.0	176	220	160	200	4.0/0.4/4.4	CH5/IP00	246 x 553 x 264	40
NXA03855A0T02WGA1A2000000+MASG	385	350	256.7	259	324	236	295	5.5/0.5/6.0	CH61/IP00	246 x 658 x 374	55
NXA05205A0T02WGA1A2000000+MASG	520	473	346.7	350	438	319	398	6.5/0.5/7.0	CH62/IP00	246 x 658 x 374	55
NXA07305A0T02WGA1A2000000+MASG	730	664	486.7	492	615	448	559	10.0/0.7/10.7	CH62/IP00	246 x 658 x 374	55
NXA09205A0T02WGA1A2000000+MASG	920	836	613.3	620	775	563	704	14.4/0.9/15.3	CH63/IP00	505 x 923 x 375	120
NXA11505A0T02WGA1A2000000+MASG	1150	1045	766.7	775	969	704	880	18.4/1.1/19.5	CH63/IP00	505 x 923 x 375	120
NXA16405A0T02WGA1A2000000+MASG	1640	1491	1093.3	1105	1382	1005	1256	19.5/1.2/20.7	CH64/IP00	746 x 923 x 375	180
NXA23005A0T02WGA1A2000000+MASG	2300	2091	1533.3	1550	1938	1409	1762	29.6/1.7/31.3	CH64/IP00	746 x 923 x 375	180

VACON® NXP Grid Converter 640-1100 V DC, Type Open, liquid-cooled, EMC Class T

Product code	AC current			DC power				Power loss	Size/prot.	Dimensions	Weight
	Thermal I_{TH} [A]	Rated I_L [A]	Rated I_H [A]	525 V AC mains I_{TH} [kW]	690 V AC mains I_{TH} [kW]	525 V AC mains I_L [kW]	690 V AC mains I_L [kW]	c/a/T*) [kW]	CH/Type/IP	W x H x D [mm]	[kg]
NXA02616A0T02WGA1A2000000+MASG	261	237	174.0	231	303	210	276	5.4/0.3/5.7	CH61/IP00	246 x 658 x 374	55
NXA03856A0T02WGA1A2000000+MASG	385	350	257.0	341	448	310	407	7.5/0.4/7.9	CH62/IP00	246 x 658 x 374	55
NXA05026A0T02WGA1A2000000+MASG	502	456	335.0	444	584	403	530	9.8/0.5/10.3	CH62/IP00	246 x 658 x 374	55
NXA07506A0T02WGA1A2000000+MASG	750	682	500.0	663	872	603	793	14.4/0.8/15.2	CH63/IP00	505 x 923 x 375	120
NXA11806A0T02WGA1A2000000+MASG	1180	1073	787.0	1044	1372	949	1247	21.0/1.1/22.1	CH64/IP00	746 x 923 x 375	180
NXA15006A0T02WGA1A2000000+MASG	1500	1364	1000.0	1327	1744	1207	1586	28.0/1.5/29.5	CH64/IP00	746 x 923 x 375	180
NXA17006A0T02WGA1A2000000+MASG	1700	1545	1133.0	1504	1976	1367	1796	32.1/1.7/33.8	CH64/IP00	746 x 923 x 375	180

VACON® NXP Grid Converter 640-1200 VDC, IP00, liquid-cooled, EMC level T

Product code	AC current			DC power				Power loss	Size/prot.	Dimensions	Weight
	Thermal I_{TH} [A]	Rated I_L [A]	Rated I_H [A]	525 V AC mains I_{TH} [kW]	690 V AC mains I_{TH} [kW]	525 V AC mains I_L [kW]	690 V AC mains I_L [kW]	c/a/T*) [kW]	CH/Type/IP	W x H x D [mm]	[kg]
NXA02618A0T02WGA1A2000000+MASG	261	237	174.0	231	303	210	276	5.4/0.3/5.7	CH61/IP00	246 x 658 x 374	55
NXA03858A0T02WGA1A2000000+MASG	385	350	257.0	341	448	310	407	7.5/0.4/7.9	CH62/IP00	246 x 658 x 374	55
NXA05028A0T02WGA1A2000000+MASG	502	456	335.0	444	584	403	530	9.8/0.5/10.3	CH62/IP00	246 x 658 x 374	55
NXA07508A0T02WGA1A2000000+MASG	750	682	500.0	663	872	603	793	14.4/0.8/15.2	CH63/IP00	505 x 923 x 375	120
NXA11808A0T02WGA1A2000000+MASG	1180	1073	787.0	1044	1372	949	1247	21.0/1.1/22.1	CH64/IP00	746 x 923 x 375	180
NXA15008A0T02WGA1A2000000+MASG	1500	1364	1000.0	1327	1744	1207	1586	28.0/1.5/29.5	CH64/IP00	746 x 923 x 375	180
NXA17008A0T02WGA1A2000000+MASG	1700	1545	1133.0	1504	1976	1367	1796	32.1/1.7/33.8	CH64/IP00	746 x 923 x 375	180

I_{TH} = Thermal maximum continuous RMS current. Dimensioning can be done according to this current if the process does not require any overloadability or the process does not include any load variation or margin for overloadability.

I_L = Low overloadability current. Allows +10% load variation. 10% exceeding can be continuous.

I_H = High overloadability current. Allows +50% load variation. 50% exceeding can be continuous.

All values with cosφ = 0.83 and efficiency = 97%

*) c = Power loss into coolant;
a = Power loss into air;
T = Total power loss; power losses of input chokes not included.
All power losses obtained using max. supply voltage, I^{th} and switching frequency of 3.6 kHz and ClosedLoop control mode. All power losses are worst case losses.

If some other mains voltage is used, apply the formula P = √3 x Un x In x cosφ x eff% to calculate the NX Liquid-Cooled drive output power.

The enclosure class for all NX Liquid-Cooled frequency converters is IP00.

If the motor is continuously run at frequencies below 5 Hz (besides start and stop ramps), please pay attention to the drive dimensioning for low frequencies, i.e. maximum I = 0.66*I_{TH} or choose drive according to I_H. It is recommended to check the rating with your distributor or Vacon.

Drive overrating may also be necessary if the process requires high starting torque.

VACON® NXP Grid Converter 380-500 V, Type Open/IP00 air-cooled, EMC Class T

Product code	Low overload 110% / 40 °C		High overload 150% / 40 °C		DC power		Size/prot.	Dimensions	Weight
	$I_{L\text{-}cont}$ [A]	$I_{1\ min}$ [A]	$I_{H\text{-}cont}$ [A]	$I_{1\ min}$ [A]	400 V AC mains $P_{L\text{-}cont}$ [kW]	500 V AC mains $P_{L\text{-}cont}$ [kW]	FR/Type/IP	W x H x D [mm]	[kg]
NXA02615A0T02SGA1A2000000+MASG	261	287	205	308	176	220	FI9/TypeOpen/IP00	239 x 1030 x 372	67
NXA04605A0T02SGA1A2000000+MASG	460	506	385	578	310	388	FI10/TypeOpen/IP00	239 x 1032 x 552	100
NXA13005A0T02SGA1A2000000+MASG	1300	1430	1150	1725	876	1092	FI13/TypeOpen/IP00	708 x 1032 x 553	306

VACON® NXP Grid Converter 525-690 V, Type Open /IP00, air-cooled, EMC Class T

Product code	Low overload 110% / 40 °C		High overload 150% / 40 °C		DC power	Size/prot.	Dimensions	Weight
	$I_{L\text{-}cont}$ [A]	$I_{1\ min}$ [A]	$I_{H\text{-}cont}$ [A]	$I_{1\ min}$ [A]	600 V AC mains $P_{L\text{-}cont}$ [kW]	FR/Type/IP	W x H x D [mm]	[kg]
NXA01706A0T02SGA1A2000000+MASG	170	187	144	216	198	FI9/TypeOpen/IP00	239 x 1030 x 372	67
NXA03256A0T02SGA1A2000000+MASG	325	358	261	392	378	FI10/TypeOpen/IP00	239 x 1032 x 552	100
NXA10306A0T02SGA1A2000000+MASG	1030	1133	920	1380	1195	FI13/TypeOpen/IP00	708 x 1032 x 553	306

Type code key

GTCTA	NX	A	AAAA	V	A	2	T	0	C	S	S	A1 A2 00 00 00	+	PPPP

GTCTA — **Grid Converter**

NX — **Product generation**

A — **Module type A** = Based on Active Front End

AAAA — **Nominal current** (low overload)
0004 = 4 A
0520 = 520A, etc.

V — **Nominal mains voltage**
5 = 380...500 V AC / 465-800 V DC
6 = 525...690 V AC / 640-1100 V DC
8 = 525...690 VAC / 640...1200 VDC (Only Ch6x)

A — **Control keypad**
A = Standard alphanumeric
B = No local keypad
F = Dummy keypad
G = Graphic display

2 — **Enclosure class**
0 = IP00

T — **EMC emission level;**
T = IT networks (EN61800-3)

0 — **Brake chopper**
0 = No brake chopper

C — **2 = AFE module**

S — **S** = Standard air-cooled drive
W = Liquid cooled drive

S — **Hardware modifications; module type – S – Boards**
V = Direct connection, varnished boards, Ch5
G = Fiber connection, varnished boards
O = IP54 control box

A1 A2 00 00 00 — **Option boards; each slot is represented by two characters:**
A = Basic I/O boards,
B = Expander I/O boards
C = Fieldbus boards,
D = Special boards

+

PPPP — **+MASG** = Grid Converter Application

Shaft generator quick guide

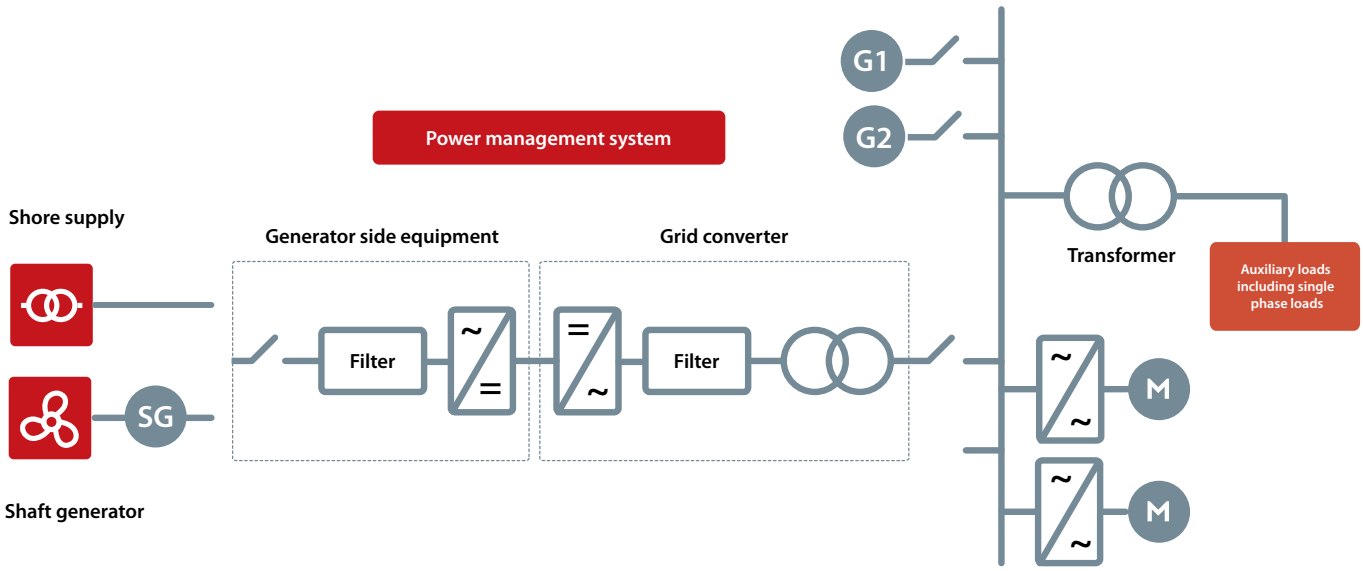
Generator type	Machine	Asynchronous	Permanent Magnet		Synchronous	
Generator side equipment	Power unit	INU	INU	AFE	INU	AFE
	Filter	dU/dt or none	dU/dt or none	SINE or LCL	dU/dt or none	SINE or LCL
	Encoder	Yes	Yes	No	Yes	No
	Software	Generator application ARFIFF03				
Ship grid equipment	Software	Grid converter application ARFIFF03				
	Power unit	Grid converter				
	Filter	SINE (LCL in case of paralleling)				
	Isolation	Transformer				

Shore supply quick guide

Shore grid harmonics requirement	Total current harmonics (THdi)	<5%	<15%	<30%
Shore grid equipment	Power unit	AFE	12-pulse NFE	6-pulse NFE
	Filter	LCL	Chokes	Choke
Ship grid equipment	Software	Grid converter application ARFIFF03		
	Power unit	Grid converter		
	Filter	SINE		
	Isolation	Transformer		

Grid converter configurations

This illustration shows the typical configurations for both shore supply and shaft generator applications.



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Danfoss Drives

Danfoss Drives is a world leader in variable speed control of electric motors. We aim to prove to you that a better tomorrow is driven by drives. It is as simple and as ambitious as that.

We offer you unparalleled competitive edge through quality, application-optimized products targeting your needs – and a comprehensive range of product lifecycle services.

You can rely on us to share your goals. Striving for the best possible performance in your applications is our focus. We achieve this by providing the innovative products and application know-how required to optimize efficiency, enhance usability, and reduce complexity.

From supplying individual drive components to planning and delivering complete drive systems; our experts are ready to support you all the way.

We draw on decades of experience within industries that include:

- Chemical
- Cranes and Hoists
- Food and Beverage
- HVAC
- Lifts and Escalators
- Marine and Offshore
- Material Handling
- Mining and Minerals
- Oil and Gas
- Packaging
- Pulp and Paper
- Refrigeration
- Water and Wastewater
- Wind

You will find it easy to do business with us. Online, and locally in more than 50 countries, our experts are never far away, reacting fast when you need them.

Since 1968, we have been pioneers in the drives business. In 2014, Vacon and Danfoss merged, forming one of the largest companies in the industry. Our AC drives can adapt to any motor technology and we supply products in a power range from 0.18 kW to 5.3 MW.

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