Shore-to-ship power Solutions
Static Frequency Conversion Platforms
Roberto Bernacchi, Global Product Manager
Agenda

Static Frequency Converters for Shore-to-ship power application
ACS6080 SFC
ACS880 SFC
PCS100 SFC
RFC vs SFC Case Study
Success stories
Summary
# Static frequency converters for Shore-to-Ship Power

## Applications and segments overview

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>RORO/Ferry</th>
<th>Container</th>
<th>Cruise</th>
<th>LNG / Tanker FSU / FPSO</th>
<th>Shipyards / Navy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>11 kV or low voltage</td>
<td>6.6 kV</td>
<td>6.6 &amp; 11 kV</td>
<td>6.6 kV</td>
<td>6.6 kV, 11 kV or low voltage</td>
</tr>
<tr>
<td>Max Power consumption</td>
<td>6.5 MVA</td>
<td>7.5 MVA</td>
<td>16/20 MVA</td>
<td>Approx. 10 MVA</td>
<td>Case by Case</td>
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<tr>
<td>Frequency</td>
<td>60 &amp; 50 Hz</td>
<td>60 mainly</td>
<td>60 mainly</td>
<td>60 Hz</td>
<td>50 &amp; 60 Hz</td>
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<tr>
<td>Plugs/cables (per connection)</td>
<td>1</td>
<td>2</td>
<td>4+1</td>
<td>2/3</td>
<td>Case by case</td>
</tr>
<tr>
<td>Transformer</td>
<td>onboard</td>
<td>onshore</td>
<td>onshore</td>
<td>onshore</td>
<td>Case by case</td>
</tr>
<tr>
<td>Layout</td>
<td>Not critical</td>
<td>critical</td>
<td>critical</td>
<td>critical</td>
<td>Not critical</td>
</tr>
<tr>
<td>Load profile</td>
<td>Partially controlled</td>
<td>Partially controlled</td>
<td>Flat profile</td>
<td>Not controlled</td>
<td>Case by case</td>
</tr>
<tr>
<td>Protect selectivity</td>
<td>critical</td>
<td>Not critical (if P=7.5 MVA)</td>
<td>critical</td>
<td>Case by case</td>
<td>Case by case</td>
</tr>
<tr>
<td>Cable management system</td>
<td>mid cost</td>
<td>low cost</td>
<td>high cost</td>
<td>Mid cost</td>
<td>Case by case</td>
</tr>
</tbody>
</table>
Static Frequency Converter for Shore-to-Ship Power

A complete portfolio

PCS100 SFC
0.1 – 2 MVA / unit
Low Voltage SFC (air cooled)

ACS880 SFC
0.5 – 5 MVA / unit

ACS6080 SFC
5 – 24 MVA / unit
Medium Voltage SFC (water cooled)

Higher power ratings can be achieved by paralleling units
# Static Frequency Converter for Shore-to-Ship Power

## Power converter portfolio

### Frequency converter | Rated power | Value proposition | Application details
--- | --- | --- | ---
PCS100 / ACS880 SFC | 0.1 MVA up to 5MVA | Lowest Opex
- LV IGBT technology
- Forced air cooling
- 0.1–2 MVA (PCS100)*
- 0.5–5 MVA (ACS880)* | Market segments
- Green port
- Cruise
- Container
- RORO ferry
- Shipyards
- FRSU/FSU
- Naval ports

ACS6080 SFC | 5MVA up to 24 MVA | Lowest Capex
- MV IGCT technology
- Closed loop liquid cooling
- 5–24 MVA | Standard Features:
- 50 or 60 Hz grid control
- Load side transformer pre-magnetization
- Synchronization and blackstart

* Higher power levels can be obtained by paralleling units

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AC6080 SFC
At a glance

**Highlights**

- Voltage source inverter, 3-level neutral point clamped topology
- Voltage range: 2.3-3.3kV
- Power range: up to 24 MVA
- Output frequency range: 50/60 Hz
- Parallelability and scalability
- Based on ABB’s well proven IGCT semiconductor platform
- Line Supply Unit (LSU) for two-quadrant operation with a constant power factor of 0.95
- Active Rectifier Unit (ARU) for four-quadrant operation and reduced harmonics, adjustable power factor
## ACS6080 SFC

Industrial converter for demanding applications

<table>
<thead>
<tr>
<th>Industries</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement, Mining and Minerals</td>
<td>Mine hoists, conveyors, crushers and mills</td>
</tr>
<tr>
<td>Chemical, oil and gas</td>
<td>Pumps, compressors, extruders, mixers and blowers</td>
</tr>
<tr>
<td>Marine</td>
<td>Main propulsion, thrusters (pumps and compressors)</td>
</tr>
<tr>
<td>Metals</td>
<td>Rolling mills, coilers</td>
</tr>
<tr>
<td>Pulp and paper</td>
<td>Fans, pumps, refiners and chippers</td>
</tr>
<tr>
<td>Power generation</td>
<td>Fans and pumps</td>
</tr>
<tr>
<td>Water</td>
<td>Pumps</td>
</tr>
<tr>
<td><strong>Special applications</strong></td>
<td><strong>Shore-to-ship power</strong></td>
</tr>
<tr>
<td></td>
<td>Static Frequency Conversion / Grid Intertie</td>
</tr>
<tr>
<td></td>
<td>Test stands</td>
</tr>
<tr>
<td></td>
<td>Wind tunnels</td>
</tr>
</tbody>
</table>
ACS6080

Benefits with modular design

All ACS6080 drives are configured of a combination of standardized modules: such modules can be arranged according to the required output power and application specific needs.

Benefits
- Optimal adaptation of converter rating according customer requirements
- Customer specific engineering can be taken into account with the flexible Control, Terminal and Interface units
- Each configuration consists of well-proven industrial components
- Compact, standardized design reduces space requirements
- Reduced installation and commissioning time
ACS6080 SFC

Product overview

- **Active Rectifier Unit (ARU)**
  - Self-commutated, 6-pulse, 3-level voltage source inverter with IGCT technology to rectify the line voltage from AC to DC

- **Terminal and Control Unit**
  - Contains the power terminals and the control swing frame

- **Inverter Unit (INU)**
  - Self-commutated, 6-pulse, 3-level voltage source inverter with IGCT technology to invert the voltage from DC to AC

- **Capacitor Bank Unit**
  - DC capacitors for smoothing the intermediate DC voltage

- **Water Cooling Unit**
  - Supplies deionized water for cooling the main power components
ACS6080 SFC

The right choice for high performance applications

**Modularity and flexibility**
- Built to order - every drive is tailored to fulfill your needs
- 2 or 4 quadrant, single or multi motor, wide range of customer-specific options in a very compact design

**Performance and usability**
- Part of the ABB drives all-compatible portfolio
- Smooth integration and easier operation throughout your entire installation
- Advanced process control

**Highest level of safety**
- Arc resistant design with fast arc elimination as standard
- Integrated DC grounding switch
- Electromechanically interlocked doors
- Certified functional safety

**Reliability and availability**
- ABB Ability™ condition monitoring for SFC to monitor your power converter condition every time, every where.
- Low parts count and fuseless design - ABB IGCT technology confirmed to be the best choice for high power applications
ACS6080 SFC

Model ratings & dimensions

**Double Power Unit**

**Triple Power Unit**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>NOMINAL RATING (c)</th>
<th>INTERFACE</th>
<th>HEAT LOSS</th>
<th>DIMENSION</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Configuration Name</td>
<td>Max continuous output power [MVA]</td>
<td>Overload capability [10 sec]</td>
<td>Short circuit limit [1 sec]</td>
<td>GRID SIDE</td>
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<tr>
<td>Double-A</td>
<td>Double-ACS6109_L12_2a05</td>
<td>7.5</td>
<td>135%</td>
<td>162%</td>
<td>DIODE (12p)</td>
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<tr>
<td></td>
<td>Double-ACS6107_A06_2a05</td>
<td>7.5</td>
<td>126%</td>
<td>180%</td>
<td>ACTIVE (6p)</td>
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<tr>
<td></td>
<td>Double-ACS6109_L12_2a7</td>
<td>7.5</td>
<td>226%</td>
<td>226%</td>
<td>DIODE (12p)</td>
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<tr>
<td>Double-B</td>
<td>Double-ACS6114_L12_2a7</td>
<td>13</td>
<td>130%</td>
<td>130%</td>
<td>DIODE (12p)</td>
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<tr>
<td></td>
<td>Double-ACS6207_A12_2a7</td>
<td>14</td>
<td>129%</td>
<td>134%</td>
<td>ACTIVE (2*6p)</td>
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<tr>
<td></td>
<td>Double-ACS6114_L12_2a9</td>
<td>14</td>
<td>127%</td>
<td>135%</td>
<td>DIODE (12p)</td>
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<tr>
<td></td>
<td>Double-ACS6209_A12_2a9</td>
<td>15</td>
<td>126%</td>
<td>151%</td>
<td>ACTIVE (2*6p)</td>
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<tr>
<td>Triple-A</td>
<td>Triple-ACS6209_L24_3a7</td>
<td>18</td>
<td>141%</td>
<td>141%</td>
<td>DIODE (24p)</td>
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<tr>
<td></td>
<td>Triple-ACS6209_A12_3a7</td>
<td>18</td>
<td>157%</td>
<td>157%</td>
<td>ACTIVE (2*6p)</td>
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<tr>
<td></td>
<td>Triple-ACS6214_L24_3a7</td>
<td>21</td>
<td>121%</td>
<td>121%</td>
<td>DIODE (24p)</td>
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<tr>
<td>Triple-B</td>
<td>Triple-ACS6214_L24_3a9</td>
<td>26</td>
<td>125%</td>
<td>125%</td>
<td>DIODE (24p)</td>
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<tr>
<td></td>
<td>Triple-ACS6309_A18_3a9</td>
<td>27</td>
<td>134%</td>
<td>134%</td>
<td>ACTIVE (3*6p)</td>
</tr>
</tbody>
</table>
ACS6080 SFC
Benefits that add value to your operations

Benefits and features

Tailor-made solutions
- Modular and expandable configuration.
- The modules can be arranged according to the required output power.
- Very compact and standardized design for reduced footprint.
- Flexible layout can be straight in line or fitted into the installation room with U, L or back-to-back setups.

Highest level of personal safety
- Arc resistant design (certified by 3rd party) with fast arc elimination.
- Integrated DC grounding switch.
- Electromechanically interlocked doors to all MV compartments.
- Certified functional safety features (E-off, E-stop, Safe Stop 1, STO, POUS).

High reliability and availability
- Each configuration consists of very well-proven components and simple power circuit.
- Low part count.
- Fuseless design.
- Self healing capacitors.
- Redundant configurations.
- ABB Ability and cloud connection for remote condition monitoring and remote assistance.

Increase productivity
- Part of ABB drives All-compatible family.
- Smoother integration and easier operation throughout your entire installation.
- Best-in-class control in terms of dynamic performance and power quality.
ACS6080 SFC
HMI Interface

**Same control interface**
- Easy navigation and monitoring
- Harmonized parameters and common shared functions
- Built-in USB connection to the PC tool

**Free entry level PC tool**
- Quick and harmonized access to drive settings
- Flexible monitoring capabilities
- Diagnostics support with one mouse click
- Additional settings in Pro version

**Universal connectivity**
- Many fieldbus options
- Standard customer interface

**Technical and commercial documentation**
- Full set of standard document for HW and SW
- Project specific document for SFC application
Highest safety for your people and equipment

Arc resistant design with fast arc elimination as standard offering

Description

Electric arcs represent a hazard source for people and equipment:

- ACS6080 offers the highest possible level of safety by detecting the arc and eliminating before it even occurs
- Every ACS6080 drive comes with an arc proof design as a standard and is certified according to IAC (internal arc classification)
- Optionally ACS6080 can be equipped with ABB’s Arc Guard System™ for even a superior protection function

No compromises
Certified functional safety features
For a safe and reliable system integration into your process

The ACS6080 is equipped with safety integrity level 3 (SIL3) and performance level e (PL e) and provides the following safety functions:

- **Emergency off** - stop category 0 according to IEC 60204-1
- **Emergency stop** - stop category 1 according to IEC 60204-1
- **Safe torque-off (STO)** - according to IEC 61800-5-2
The grounding switch is a safety switch to ground the DC bus of the drive. When the SFC is grounded, the door safety switches of the medium voltage units are released and the doors can be opened.

It is electromechanically interlocked with a discharge monitoring circuit that prevents the switch from closing when the DC-link capacitors are still charged.

Grounding the SFC is only possible after main power supply is disconnected and the DC link has been discharged.
ACS6080 SFC
Simple and efficient maintenance

Reliable components
- ABB drive technologies (IGCT semiconductors, multilevel-fuseless topology) provide low parts count, increasing reliability and availability

Easy access
- The ACS6080 allows easy front access to the drive’s components

Redundant cooling
- The cooling equipment is available with redundant pumps which increases availability
ACS6080 SFC
Worldwide service and support

- Supervision of installation and commissioning
- Training
- Remote diagnostics
- Customized maintenance contracts
- Local support
- 24 x 365 support line
- Spare parts and logistics network
- Worldwide service network
ABB Ability™ for ACS6080 SFC

Highlights

**ABB Ability™ Remote Assistance for Drives**

- Remote connectivity
- Expert support upon request

**ABB Ability™ Condition Monitoring for Drives**

- Remote or Local connectivity
- Condition Monitoring Portal

Rapid solution in case of problems

Should a fault be detected, ABB specialist provides rapid support by using ACS6080 SFC data which is stored remotely.

Alerts and information, for customer to react

ABB Ability Condition Monitoring is a service that delivers you accurate, real-time information about SFC condition and events to ensure your equipment is available, reliable and maintainable.
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ACS880 SFC - Grid Converter

Versatile converter platform

Wide power range
- Grid supply units from 200 kVA to 6,000 kVA
Available as power modules and cabinet-built solutions, air and liquid cooled variants

Value proposition in S2SP application
- Cost and quality benefit from existing high volume converter platform
- High power building blocks for competitive high power installations
- FRT, anti-islanding and off-grid functions available through Wind and Marine applications
- Validated virtual converter models available
ACS880 SFC - Grid Converter

Main features

Common ACS880 architecture
- Control panel
- Parameter menu structure
- Universal accessories and engineering tools

Integrated safety features, including
- Embedded STO as standard feature SIL 3

Compact size
- Increased power density and packing density
- Easy installation and maintenance

Reliability
- Coated boards as standard
- Long lifetime capacitors and cooling fans
ACS880 SFC - Grid Converter

R8i inverter module

Features and advantages

- Smart inverter concept
- Bookshelf design
- Only one core module size for 0.5 to 5 MVA
- Small dimensions, high output power
- Higher efficiency, with latest IGBT technology
- Plug in connectors—fast maintenance
- Advanced self diagnostic with redundancy in parallel connected units
- Self adjusting cooling according to conditions. Reduced noise level, extended life time, energy savings
- Embedded LCL filter for low harmonics performance
**ACS880 SFC - Grid Converter**

Introduction and key requirements

**Key requirements**

Grid Converter forms a 3-phase grid rectifying grid side AC at 50/60 Hz to DC voltage and then inverting DC voltage to load side AC at 60/50 Hz.

- Form a stable 3-phase grid with enough short circuit current to fulfill protection requirements.
- Supply the harmonic currents required by the load to keep voltage sinusoidal.
- Operate autonomously in parallel with multiple voltage sources using droop control.
- Allows seamless power transformer in both directions
**ACS880 SFC - Grid Converter**

**Optimal grid control principle**

**Optimal grid control**
- Creates 3-phase AC-network with 50/60 Hz frequency conversion

**Main functionality**
- ACS880 Off-grid converter hardware is a line converter (ISU) equipped with an LCL and voltage & current measurements at AC side.
- ACS880 Off-grid controls the AC-output voltage vessel side) while taking power from AC-grid side.
- ACS880 Off-grid acts as a “AC generator” providing the network voltage for a separate power distribution system. The line converter with Off grid control produces sinusoidal three-phase voltage with magnitude and frequency references defined by the user (e.g. 400V phase to phase, 50 or 60Hz).
- ACS880 Off-grid converter is used with a transformer (YNd), which allows three-phase four-wire systems to be supplied with the converter and enables single phase loads. In addition transformer decreases the common mode voltage.
ACS880 SFC - Grid Converter

Inverter Supply Unit and Optimal grid control principles

Line converter ISU controls DC

Optimal Grid control converter controls AC

Full 4 quadrant design: Power can always flow to both directions
ACS880 SFC - Grid Converter

Available ratings

<table>
<thead>
<tr>
<th>Type designation</th>
<th>kVA</th>
<th>I (AC)</th>
<th>I (AC)</th>
<th>kW</th>
<th>Frame size for grid and ship converter</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS880-207-1050A-7</td>
<td>1.000</td>
<td>837</td>
<td>1.474</td>
<td>63</td>
<td>2 pcs (2×R8i+BLCL-25-7)</td>
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<tr>
<td>ACS880-207-1570A-7</td>
<td>1.500</td>
<td>1.253</td>
<td>2.192</td>
<td>99</td>
<td>2 pcs (3×R8i+2×BLCL-24-7)</td>
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<tr>
<td>ACS880-207-2070A-7</td>
<td>2.000</td>
<td>1.677</td>
<td>2.898</td>
<td>125</td>
<td>2 pcs (4×R8i+2×BLCL-25-7)</td>
</tr>
<tr>
<td>ACS880-207-3080A-7</td>
<td>3.000</td>
<td>2.509</td>
<td>4.309</td>
<td>188</td>
<td>2 pcs (6×R8i+3×BLCL-25-7)</td>
</tr>
<tr>
<td>ACS880-207-4100A-7</td>
<td>4.000</td>
<td>3.345</td>
<td>5.746</td>
<td>251</td>
<td>2 pcs (8×R8i+4×BLCL-25-7)</td>
</tr>
<tr>
<td>ACS880-207-5130A-7</td>
<td>5.000</td>
<td>4.181</td>
<td>7.182</td>
<td>311</td>
<td>2 pcs (10×R8i+5×BLCL-25-7)</td>
</tr>
</tbody>
</table>

Notes

- Rated values with cos φ 1…0.85 inductive load
- The ratings above apply at 35 °C ambient temperature. At higher temperatures up to 50 °C the derating is 1%/1 °C.
- Overloadability is 140%, s.
- Active harmonic compensation (linear loading), total harmonic distortion THDI < 5 %.
The IGBT supply unit rectifies three-phase AC current to direct current for the intermediate DC link of the drive. The intermediate DC link supplies the inverter(s) that create the load side grid.

The LCL filter is an essential part of the ACS880-204 IGBT supply module and it does not work without the filter.

The IGBT supply module uses the filter to actively shape the AC line current to resemble sinusoidal waveform and to filter most of the current ripple at the switching frequency and higher frequencies.

The IGBT supply module used with the filter produces a low-harmonic input current.
ACS880 SFC - Grid Converter

ACS880-204 IGBT supply unit

- Benefits of ISU
  - DC-voltage boost
  - Nominal motor voltage available also during net voltage variations
  - No ripple in DC-voltage, => stable motor torque
  - Power factor 1.0 as default
  - Regenerative functionality => braking energy from motor(s) can be returned to the supply network
  - Reactive power compensation available
  - Low distortion, high quality of AC power
ACS880 SFC - Grid Converter

Static converter (Shore-to-Ship)

- A grid converter is used to convert harbor side 50 Hz grid to 60 Hz for ship.
- IGBT supply allows low harmonics contribution
- It also allows the installation of additional DC/DC converters on the DC bus, to allow an external source (such as batteries) power supply

IGBT supply

<table>
<thead>
<tr>
<th>IGBT—Supply unit</th>
<th>THDI</th>
<th>THDU_{RSC=20}</th>
<th>THDU_{RSC=100}</th>
<th>COS ( \phi _1 )</th>
<th>COS ( \phi _\text{total} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 %</td>
<td>3 %</td>
<td>0,8 %</td>
<td>1</td>
<td>0,99</td>
</tr>
</tbody>
</table>
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PCS100 SFC – product

The solution

- The ABB PCS100 SFC is a clean, efficient way to provide the frequency and voltage required
- Complete low voltage product range from 125 kVA to multi MVA
- Modular power electronic architecture
- Parallel capable
- Synchronizing and load limiting functions
PCS100 SFC – product

Modular construction 125 kVA to 2 MVA

- Housed in 800mm cabinets
- 125 kVA power modules
- Minimum spares required
- Fast replacement
## PCS100 SFC – product

### Ratings

<table>
<thead>
<tr>
<th>Model</th>
<th>Current Rating (A)</th>
<th>Load kVA @ 480V</th>
<th>Converter/Connection Cabinet</th>
<th>Transformer Cabinet</th>
<th>Number of Module Pairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFC-0125</td>
<td>150</td>
<td>125</td>
<td>2154 x 809 x 804</td>
<td>860</td>
<td>1</td>
</tr>
<tr>
<td>SFC-0250</td>
<td>300</td>
<td>250</td>
<td>2154 x 809 x 804</td>
<td>801</td>
<td>2</td>
</tr>
<tr>
<td>SFC-0375</td>
<td>450</td>
<td>375</td>
<td>2154 x 809 x 804</td>
<td>781</td>
<td>3</td>
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<tr>
<td>SFC-0500</td>
<td>600</td>
<td>500</td>
<td>2304 x 1609 x 804</td>
<td>1503</td>
<td>4</td>
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<tr>
<td>SFC-0625</td>
<td>750</td>
<td>525</td>
<td>2304 x 2009 x 804</td>
<td>1772</td>
<td>5</td>
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<td>SFC-0750</td>
<td>900</td>
<td>750</td>
<td>2304 x 2409 x 804</td>
<td>1932</td>
<td>6</td>
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<td>SFC-0875</td>
<td>1050</td>
<td>875</td>
<td>2304 x 2809 x 804</td>
<td>2308</td>
<td>7</td>
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<tr>
<td>SFC-1000</td>
<td>1200</td>
<td>1000</td>
<td>2304 x 3209 x 804</td>
<td>2686</td>
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<td>SFC-1125</td>
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<td>1125</td>
<td>2304 x 3609 x 804</td>
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<td>SFC-1250</td>
<td>1500</td>
<td>1250</td>
<td>2304 x 4409 x 804</td>
<td>3407</td>
<td>10</td>
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<td>SFC-1375</td>
<td>1850</td>
<td>1375</td>
<td>2304 x 4809 x 804</td>
<td>3700</td>
<td>11</td>
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<td>2000</td>
<td>1500</td>
<td>2304 x 4809 x 804</td>
<td>3880</td>
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<td>SFC-1625</td>
<td>1950</td>
<td>1625</td>
<td>2304 x 5209 x 804</td>
<td>4248</td>
<td>13</td>
</tr>
<tr>
<td>SFC-1750</td>
<td>2100</td>
<td>1750</td>
<td>2304 x 5609 x 804</td>
<td>4550</td>
<td>14</td>
</tr>
<tr>
<td>SFC-2000</td>
<td>2400</td>
<td>2000</td>
<td>2304 x 6009 x 804</td>
<td>5102</td>
<td>16</td>
</tr>
</tbody>
</table>

All specs are subject to change without prior notice.

- Parallel load sharing allows operation of multiple PCS100 SFC's up to 10MVA
- Dimensions are for side-by-side configuration. Back to back configuration dimensions will vary
- **Dimensions are for side-by-side configuration. Back to back configuration dimensions will vary.**
- **Weights are for LV transformers. For MV, transformers add 25% approx.**
- **IP23 + 100mm depth**
PCS100 SFC – How it works

Power module redundancy

Traditional FC

- Filter
- Inverter
- Rectifier

Available power 0 kVA / 0 %
MTTR many hours

Modular FC without redundancy

- R
- R
- R
- R
- R
- R

Available power 0 kVA / 0 % (fault with one module stops the whole system)
MTTR 30min

PCS100 SFC advanced redundancy

- R
- R
- R
- R
- R
- R

Available power 1875 kVA / 93.7 %
MTTR 30min or continue operation until scheduled maintenance
The PCS10 SFC includes a built in synchronizer

The synchronizer is used to automatically synchronize its output to a live AC bus before starting.

Synchronization procedure as follows:

- SFC is given a start command
  - SFC measures its output, as it is live it synchronizes the internal control loops to this voltage, frequency and phase.
- SFC starts running in parallel with the generator
- Generator can be unloaded and SFC used to supply the switchboard
PCS100 SFC – How it works

Parallel systems

Typical multi MVA system example
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Summary
SFC vs RFC – Case study

6 MVA RFC – Typical system

- Air insulated/SF6 MV feeder switchgear
- Feeder transformer: dry type transformer (20 kV / 6 ...15 kV)
  - Note: Feeder transformer may not be necessary for 15 kV
- Motor: 6 ...11 kV brushless excited 10-pole synchronous machine
- Generator: 6 ...11 kV brushless excited 12-pole synchronous machine
- Air insulated/SF6 MV load switchgear
SFC vs RFC – Case study

6 MVA RFC – Required space for installation

- Motor (6MVA):
  - Length: 4 m x Width: 1.8 m x Height: 3 ... 4.5 m
  - Weight: 23.4 tons
- Generator (6MVA):
  - Length: 4 m x Width: 1.8 m x Height: 3 ... 4.5 m
  - Weight: 27.3 tons
- System space req. including RFC, Control, Switchgear excluding transformer:
  - 9(+3) m x 1.5(+2.0) m x 4.5(+1) m → 211 m³
- Overall system weight including RFC, control, switchgear excluding transformers: Approx. 56 tons
**SFC vs RFC – Case study**

6 MVA RFC – Electrical characteristics

- Control system:
  - Sequences (start/stop/fault); motor/generator & switchgear supervision and voltage control (AVR), 2x excitation supervision and control
- Motor excitation system:
  - AC or DC brushless static (thyristor controlled appr. 50 kW) excitation system with crowbar protection circuitry.
- Generator excitation system:
  - AC or DC brushless excitation (thyristor controlled appr. 50 kW) excitation system with protection crowbar circuitry.
- Load side harmonics (voltage): < 5%
- MTBF: One transformer, two static excitation converters, motor, generator: ~4.4 years
SFC vs RFC – Case study

10 MVA SFC – Typical system

- Air insulated/SF6 MV feeder switchgear
- Feeder transformer: 12 pulse dry type transformer (xx kV/2x~1.7 kV)
- Converter: 3-level NPC MV converter with diode rectifier (at feeder side) and IGCT inverter at load side
- Load side transformer: 2 x 6 pulse dry type transformer (~3 kV / xx kV)
- Air insulated/SF6 MV load switchgear
**SFC vs RFC – Case study**

10 MVA SFC – Required space for installation

– Converter (10MVA):
  • Length: 9 m x Width: 1.2 m x Height: 2.2 m
  • Weight: 7.5 tons

– System space req. including SFC, control, switchgear, excluding transformers:
  • $9 (+3) \text{ m} \times 1.2 (+1.2) \text{ m} \times 2.5 \text{ m} = 72 \text{ m}^3$

– System weight including SFC, control, switchgear excluding transformer: Approx. 10 tons
SFC vs RFC – Case study

10 MVA SFC – Electrical characteristics

- Control:
  - Converter control and protection integrated in SFC

- Power factor feeder side: ~0.95
- Power factor load side: variable, 0.8 … 1.0

- Feeder side harmonics (current): according to IEC61000-2-4

- Load side harmonics (voltage): according to IEC/ISO/IEEE 80005-1
# SFC vs RFC – Case study

## Case study - Comparison table

<table>
<thead>
<tr>
<th>Item</th>
<th>RFC- 6 MVA</th>
<th>SFC-10 MVA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feeder and feeder protection components:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeder transformer</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Feeder aux. transformer</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Feeder main switchgear</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Feeder aux. Excitation switchgear</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Frequency conversion system:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>9m</td>
<td>9m</td>
</tr>
<tr>
<td>Width</td>
<td>1.5m</td>
<td>1.2m</td>
</tr>
<tr>
<td>Height</td>
<td>4.5m</td>
<td>2.2m</td>
</tr>
<tr>
<td>Weight RFC,SFC</td>
<td>56 tons</td>
<td>10 tons</td>
</tr>
<tr>
<td>Volume requirement excluding transformer</td>
<td>211m3</td>
<td>72 m3</td>
</tr>
<tr>
<td>Load side (V) harmonics</td>
<td>&lt;5%</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>MTBF (estimated)</td>
<td>~4.4 years</td>
<td>~5.7 years</td>
</tr>
<tr>
<td>Load side (V) harmonics</td>
<td>~95%</td>
<td>~96.5%</td>
</tr>
<tr>
<td><strong>Production time (typical):</strong></td>
<td>10 months</td>
<td>6 months</td>
</tr>
</tbody>
</table>
# SFC vs RFC – Case study

## Comparison table

<table>
<thead>
<tr>
<th></th>
<th>SFC</th>
<th>RFC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Noise and vibration</strong></td>
<td>Low, mainly cooling system (fans-air cooled, pumps-water cooled)</td>
<td>High, especially for large machines</td>
</tr>
<tr>
<td><strong>Frequency regulation</strong></td>
<td>Precise, electronically controlled</td>
<td>Can vary depending on the input frequency</td>
</tr>
<tr>
<td><strong>Serviceability/Maintenance</strong></td>
<td>Low MTTR due to modular construction Standard yearly maintenance plan (1/2 days)</td>
<td>Breakdowns can be time consuming (bearing replacement) Critical parts wearing</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td>High PCS100 ~95% ACS6080 ~98%</td>
<td>Lower than SFC especially at light/partial loads</td>
</tr>
<tr>
<td><strong>Overload capability</strong></td>
<td>PCS100 ( \rightarrow ) 200% x 2 s ( \rightarrow ) 150% x 30 s ACS6080 ( \rightarrow ) Depending on the model.</td>
<td>Good overload capability</td>
</tr>
<tr>
<td><strong>Technology, as perceived by end users</strong></td>
<td>New technology ( \rightarrow ) concerns on operation &amp; maintenance</td>
<td>Old, proven technology ( \rightarrow ) high reliability</td>
</tr>
</tbody>
</table>
Agenda

Static Frequency Converters for Shore-to-ship power application
ACS6080 SFC
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### Shore-to-ship power – Rotterdam, The Netherlands

One of the world’s largest S2SP installations

<table>
<thead>
<tr>
<th>Customer needs</th>
<th>ABB response</th>
<th>Customer benefits</th>
</tr>
</thead>
</table>
| Complete electrical infrastructure to simultaneously power several vessels while berthed in the port of Hoek van Holland | - Turnkey shore-to-ship power installation including design, engineering, project management, installation and commissioning  
- Complete substation and automation package based on PCS 6080 static frequency converters rated at 6 MVA | - Mitigation of negative impact of ferry operations on the local community and the environment  
- Reduction of fleet’s fuel consumption  
- Greenhouse gas emissions reduced by 98%  
- Less noise and vibrations |

- Customer  
Stena Line B.V., a subsidiary of Stena AB, one of the world’s largest ferry companies  
- Year of commissioning  
2012

The entire installation, both onshore and onboard the ships, was accomplished within a year and was activated at the Stena Line ferry terminal at the port of Rotterdam in June 2012.
ACS6080 - SFC
Knutsen FSO project

Customer needs

- Martin Linge O&G offshore facility (Norway) uses a floating, storage, and offloading unit (FSO) supplied by Knutsen NYK Offshore Tankers AS
- The Martin Linge field, including the FSO needs to be powered with electricity from shore through the world’s longest high voltage AC subsea cable. (approx. 180 km length)

ABB response

- ACS6080 SFC in double configuration performing 50 to 60 Hz frequency conversion at 6,6 kV
- Marine / off-shore certified system
- Island mode operation and bumpless switch between grid-to-island and vice versa

Customer benefits

- Martin Linge FSO represents an environmentally friendly installation with regards to CO2 emissions.
- Operating in parallel with diesel generator sets including active and reactive load management to optimize power consumption
**Shore-to-ship power – Gothenburg, Sweden**
First 50/60 Hz shore connection in Sweden

<table>
<thead>
<tr>
<th>Customer needs</th>
<th>ABB response</th>
<th>Customer benefits</th>
</tr>
</thead>
</table>
| Shoreside power supply to a vast number of Stena Line vessels while at berth | - Turnkey 11kV Grid Integration, including Safe+ GIS switchgear 6 bays 50Hz, 4 bays 60Hz, and 2 transformers type Resibloc  
- Two static frequency converters 1250kVA  
- PLC system type AC500 | - Dependable project execution from design to start-up, and state-of-the-art equipment  
- Reliable shoreside power supply to ferries  
- Reduced emissions, low-frequency noise and vibrations  
- Better environment for passengers, crew, dockworkers and local residents |

- Customer  
Processkontroll Elektriska AB Stenungsund  
- Year of commissioning  
2012
Shore-to-ship power – Fincantieri, Italy

Standard containerized solution for shipyards

Customer needs

- Shore power supply for Castellamare shipyard for newly built vessels
- Outdoor solution with minimized civil works
- Short delivery time of 15 weeks

ABB response

- Standard containerized solution, air-cooled, including frequency converter, isolation transformer, LV switchgear
- One static frequency converter PCS100, 1000kVA, rack-mounted

Customer benefits

- Scalable solution suitable for all shipyards
- Lower OPEX costs than 60 Hz diesel genset
- Improved efficiency at partial loads
- High reliability owing to converter redundancy
Agenda

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Summary

SFC dimensioning: Ask the right questions

1. Voltage and frequency
   - Grid side (U1, f1)
   - Ship side (U2, f2)

2. Power [MVA]
   - Nominal & Peak
   - Ship load profile, Single Line Diagram
   - Direct online motors
   - Transformer inrush
   - Overload (protection & selectivity)

3. Installation
   - Indoor / Outdoor

4. Environmental data
   - Minimum / maximum temperatures
   - Pollution levels
Summary

ACS6080 – ACS880 - PCS100 SFC Static Frequency Converters

ABB’s SFCs are the ideal solution for providing a different frequency and voltage.

ACS6080 – ACS880 - PCS100 SFC design provides the followings benefits:

- Energy savings compared to dynamic converters.
- High reliability static conversion.
- Rugged ratings and short circuit protection.
- Versatile configurations.
- High efficiency even at partial load
  \[ \sim 98.0\% \text{ (ACS6080 SFC)} \quad \sim 95.0\% \text{ (PCS100 SFC / ACS880 SFC)} \]

Advanced System Integration support

- Pre-engineered packages for fast lead time
- Customized solution for demanding requirements

ABB can deliver these benefits worldwide with performance and support you can trust.