ABB, JULY 2019

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

Characteristics	Vessel Type				
	RORO/Ferry	Container	Cruise	LNG / Tanker FSU / FPSO	Shipyards / Navy
					
Voltage	11 kV or low voltage	6,6 kV	6,6 & 11 kV	6,6 kV	6,6 kV, 11 kV or low voltage
Max Power consumption	6,5 MVA	7,5 MVA	16/20 MVA	Approx. 10 MVA	Case by Case
Frequency	60 & 50 Hz	60 mainly	60 mainly	60 Hz	50 & 60 Hz
Plugs/cables (per connection)	1	2	4+1	2/3	Case by case
Transformer	onboard	onshore	onshore	onshore	Case by case
Layout	Not critical	critical	critical	critical	Not critical
Load profile	Partially controlled	Partially controlled	Flat profile	Not controlled	Case by case
Protect selectivity	critical	Not critical (If P=7,5 MVA)	critical	Case by case	Case by case
Cable management system	mid cost	low cost	high cost	Mid cost	Case by case

Static Frequency Converter for Shore-to-Ship Power

A complete portfolio

PCS100 SFC

ACS880 SFC

ACS6080 SFC

0.1 – 2 MVA / unit

0.5 – 5 MVA / unit

5 – 24 MVA / unit

Low Voltage SFC (air cooled)

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 – LV IGBT technology – Forced air cooling – 0.1–2 MVA (PCS100)* – 0.5-5 MVA (ACS880)*	Lowest Opex • highest efficiency • highest availability • lowest maintenance costs Lowest Capex • Smallest weight and footprint • Scalable solution Lowest project execution & operation risk • Expert application know how available • Simulation models available ABB global footprint • Global Service organization • Global service support Benefits • Most economic solution (Opex and Capex) to make frequency fit	Market segments • Green port • Cruise • Container • RORO ferry • Shipyards • FRSU/FSU • Naval ports Standard Features: • 50 or 60 Hz grid control • Load side transformer pre-magnetization • Synchronization and blackstart Additional Optional Features: • Marine certification • NRTL certificates
ACS6080 SFC 	5MVA up to 24 MVA – MV IGCT technology – Closed loop liquid cooling – 5-24 MVA *		

* Higher power levels can be obtained by paralleling units

Agenda

Static Frequency Converters for Shore-to-ship power application

ACS6080 SFC

ACS880 SFC

PCS100 SFC

RFC vs SFC Case Study

Success stories

Summary

ACS6080 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

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

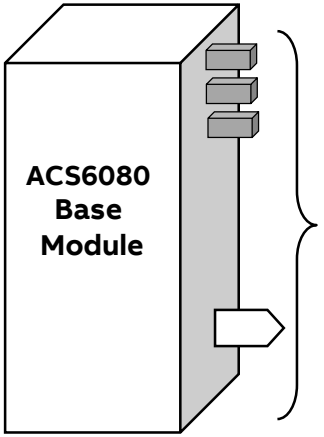
ACS6080

Benefits with modular design

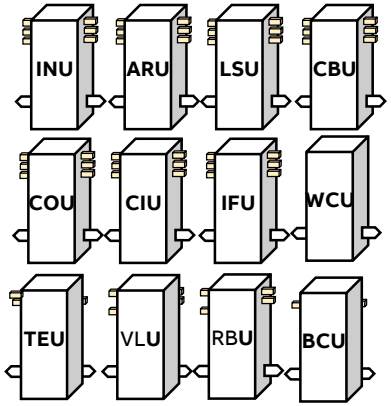
All ACS6080 drives are configured of a combination of standardized modules: such modules can be arranged according to the required output power and application specific needs

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

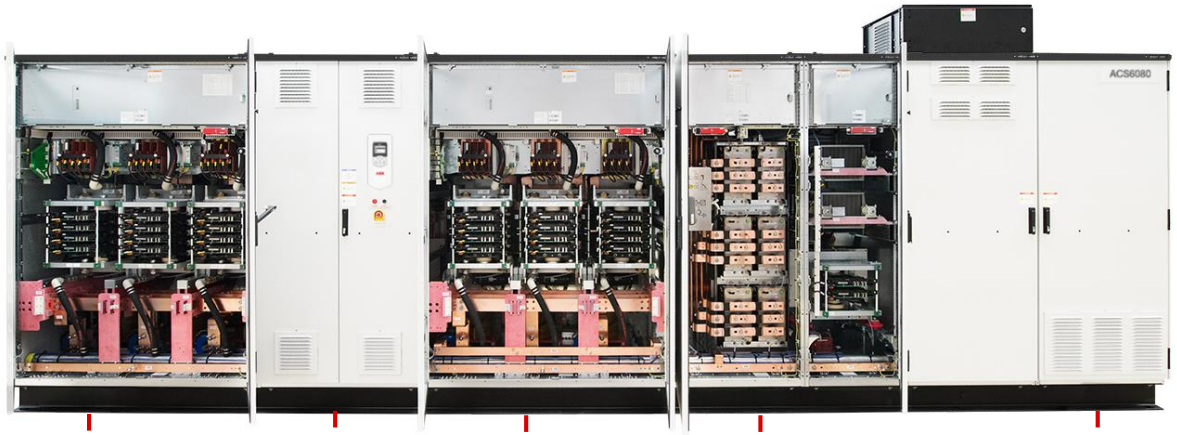


Pre-defined interfaces for power, cooling and control connections



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

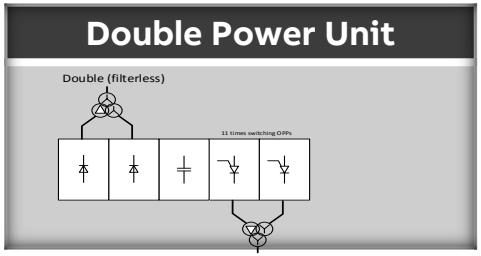
- Arc resistant design with fast arc elimination as standard
- Integrated DC grounding switch
- Electromechanically interlocked doors
- Certified functional safety

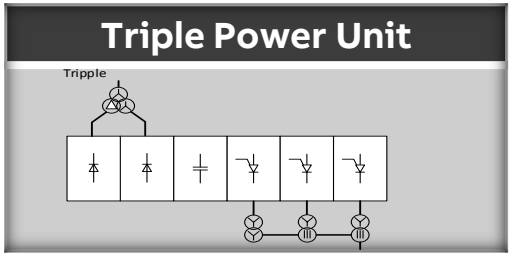
Reliability and availability

- 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





MODEL		NOMINAL RATING (c)			INTERFACE		HEAT LOSS	DIMENSION	WEIGHT
ID	Configuration Name	Max continuous output power [MVA]	Overload capability [10 sec]	Short circuit limit [1 sec]	GRID SIDE	LOAD SIDE	Into WATER [kW]	WxDxH [mm]	kg
Double-A	Double-ACS6109_L12_2a05	7,5	135%	162%	DIODE (12p)	2 UNITS (12p)	93	8830x1069x2162	7645
	Double-ACS6107_A06_2a05	7,5	126%	180%	ACTIVE (6p)	2 UNITS (12p)	134	9130x1069x2479	8395
	Double-ACS6109_L12_2a7	7,5	226%	226%	DIODE (12p)	2 UNITS (12p)	85	8830x1069x2162	7885
Double-B	Double-ACS6114_L12_2a7	13	130%	130%	DIODE (12p)	2 UNITS (12p)	149	9030x1069x2162	8015
	Double-ACS6207_A12_2a7	14	129%	134%	ACTIVE (2*6p)	2 UNITS (12p)	231	11830x1069x2479	10780
	Double-ACS6114_L12_2a9	14	127%	135%	DIODE (12p)	2 UNITS (12p)	163	9030x1069x2479	8195
	Double-ACS6209_A12_2a9	15	126%	151%	ACTIVE (2*6p)	2 UNITS (12p)	250	11830x1069x2479	10960
Triple-A	Triple-ACS6209_L24_3a7	18	141%	141%	DIODE (24p)	3 UNITS (18p)	201	13530x1069x2162	11940
	Triple-ACS6209_A12_3a7	18	157%	157%	ACTIVE (2*6p)	3 UNITS (18p)	307	14530x1069x2479	13575
	Triple-ACS6214_L24_3a7	21	121%	121%	DIODE (24p)	3 UNITS (18p)	242	14930x1069x2479	13185
Triple-B	Triple-ACS6214_L24_3a9	26	125%	125%	DIODE (24p)	3 UNITS (18p)	314	14930x1069x2479	13185
	Triple-ACS6309_A18_3a9	27	134%	134%	ACTIVE (3*6p)	3 UNITS (18p)	469	17030x1069x2479	15970

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

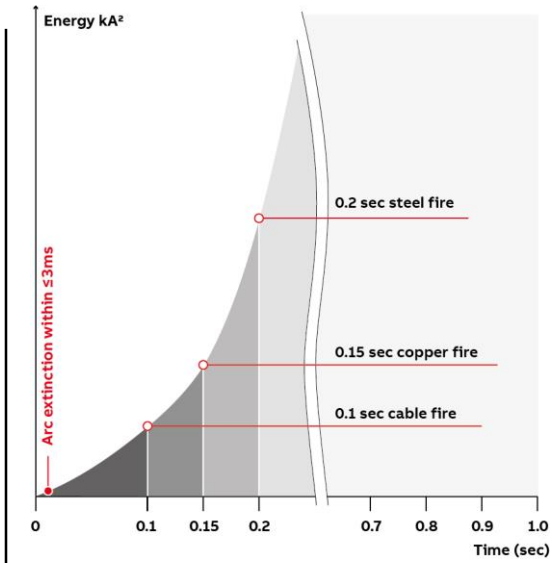
Arc resistant design with fast arc elimination as standard offering

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 come 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 SystemTM for even a superior protection function

No compromises



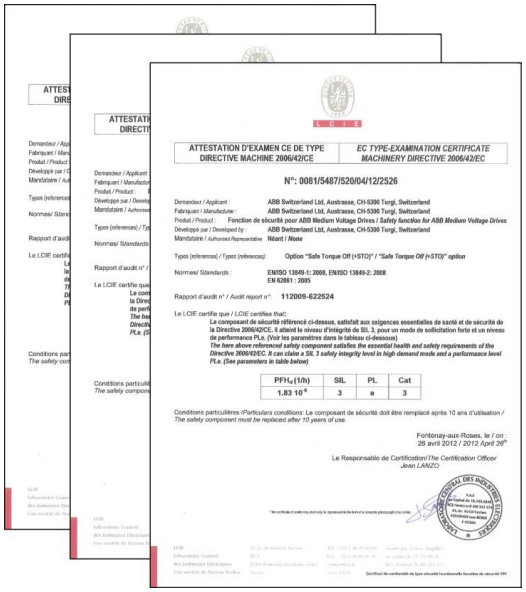
Arc extinction within ≤ 3 ms

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


ATTESTATION D'EXAMEN CE DE TYPE
DIRECTIVE MACHINE 2006/42/CE

EC TYPE-EXAMINATION CERTIFICATE
MACHINERY DIRECTIVE 2006/42/EC

N°: 0081/5487/520/04/12/2526

Demandeur / Applicant: ABB Switzerland Ltd, Austrasse, CH-5300 Turgi, Switzerland
Fabricant / Manufacturer: ABB Switzerland Ltd, Austrasse, CH-5300 Turgi, Switzerland
Produit / Product: Fonction de sécurité pour ABB Medium Voltage Drives / Safety function for ABB Medium Voltage Drives
Développé par / Developed by: ABB Switzerland Ltd, Austrasse, CH-5300 Turgi, Switzerland
Mandataire / Authorised Representative: Néant / None
Types (références) / Types (references): Option "Safe Torque Off (+STO)" / "Safe Torque Off (+STO)" option
Normes/ Standards: EN ISO 13849-1: 2008, EN ISO 13849-2: 2008
EN 62061 : 2005
Rapport d'audit n° / Audit report n°: 11200S-622524

Le LCIE certifie que / LCIE certifies that:
Le composant de sécurité référencé ci-dessus, satisfait aux exigences essentielles de santé et de sécurité de la Directive 2006/42/CE. Il atteint le niveau d'intégrité de SIL 3, pour un mode de sollicitation forte et un niveau de performance PLe. (Voir les paramètres dans le tableau ci-dessous)
The here above referenced safety component satisfies the essential health and safety requirements of the Directive 2006/42/EC. It can claim a SIL 3 safety integrity level in high demand mode and a performance level PLe. (See parameters in table below)

PFH_d (1/h)	SIL	PL	Cat
$1.83\ 10^{-8}$	3	e	3

Conditions particulières /Particulars conditions: Le composant de sécurité doit être remplacé après 10 ans d'utilisation / The safety component must be replaced after 10 years of use.

Fontenay-aux-Roses, le / on : 26 avril 2012 / 2012 April 26th

Le Responsable de Certification/The Certification Officer
Jean LANZO

Door interlocking system

Integrated DC grounding switch and door interlock

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

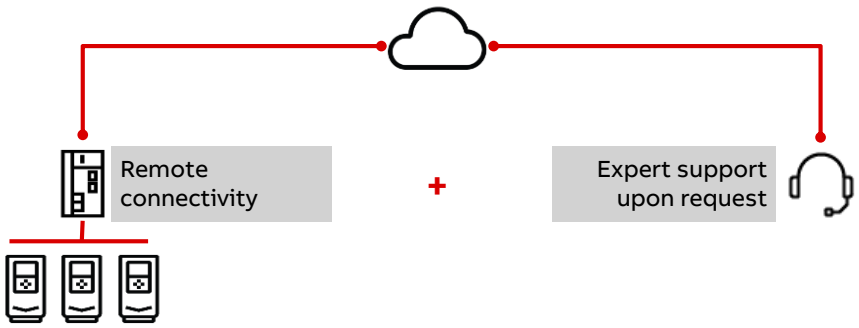
Worldwide service and support

- 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

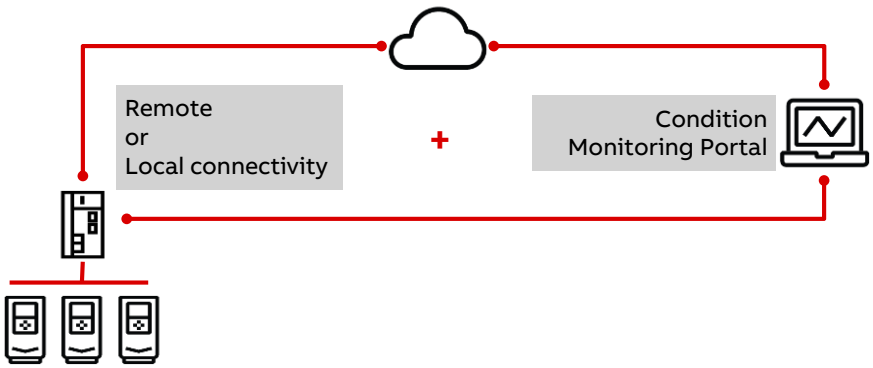
ABB Ability™ Remote Assistance for Drives



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.

ABB Ability™ Condition Monitoring for Drives



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.

Agenda

Static Frequency Converters for Shore-to-ship power application

ACS6080 SFC

ACS880 SFC

PCS100 SFC

RFC vs SFC Case Study

Success stories

Summary

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

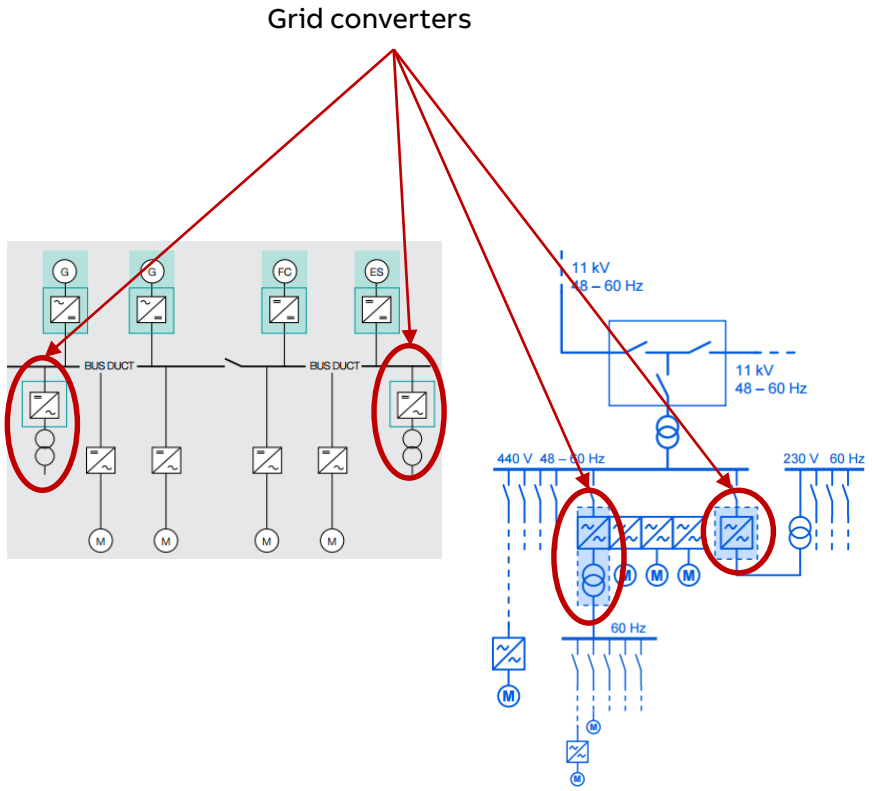
ACS880 SFC - Grid Converter

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

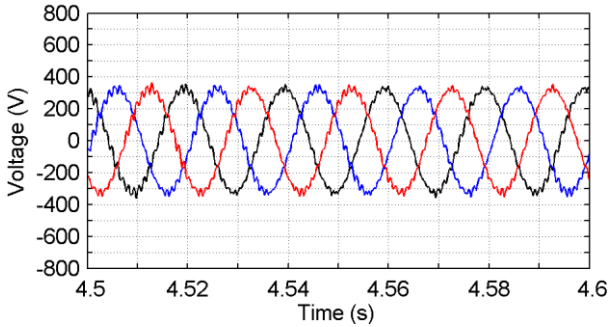


ACS880 SFC - Grid Converter

Optimal grid control principle

Optimal grid control

- Creates 3-phase AC-network with 50/60 Hz frequency conversion

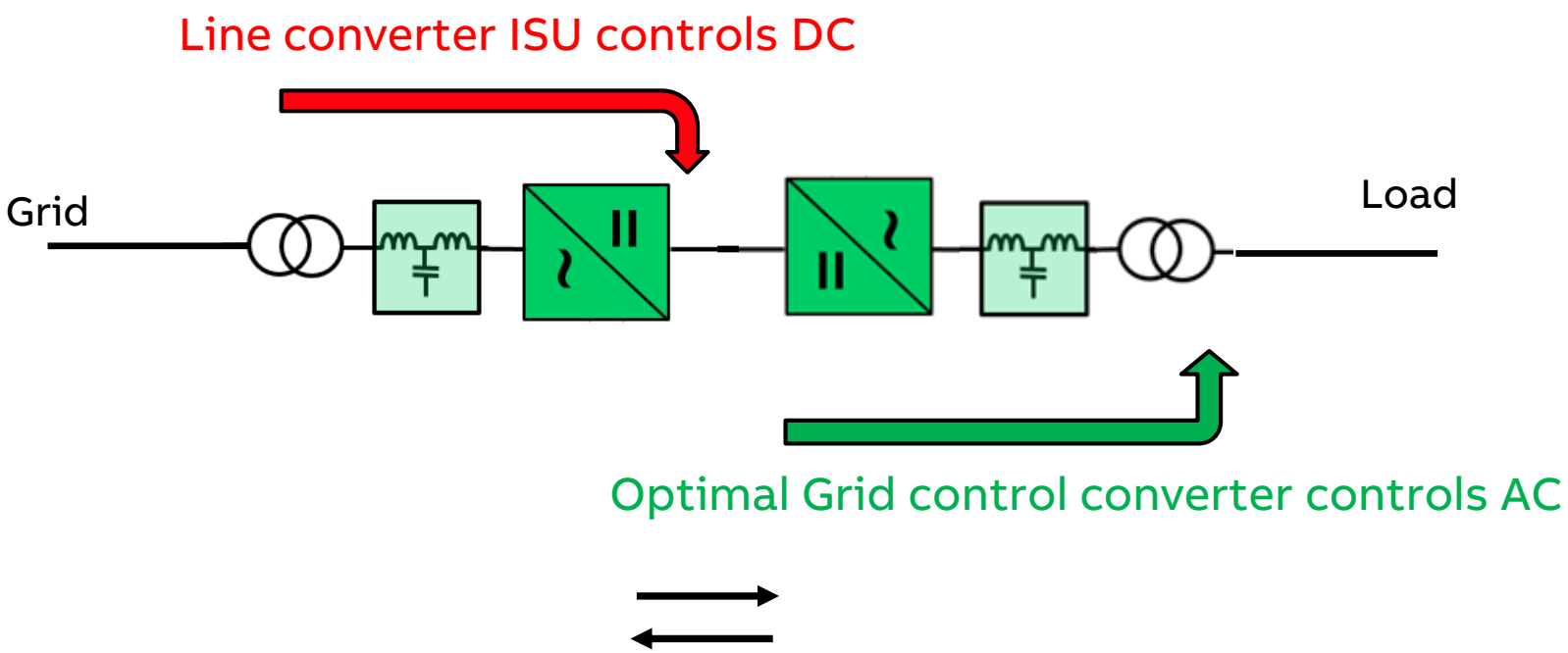


Main functionality

- 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



Full 4 quadrant design: Power can always flow to both directions

ACS880 SFC - Grid Converter

Available ratings

	Converter output nominal ratings		Overload capability	Heat dissipation	
	Power	Current	Current		
Type designation	**kVA**	**I (AC)**	**I (AC)**	**kW**	**Frame size for grid and ship converter**
ACS880-207-1050A-7	1.000	837	1.474	63	2 pcs (2×R8i+BLCL-25-7)
ACS880-207-1570A-7	1.500	1.253	2.192	99	2 pcs (3×R8i+2×BLCL-24-7)
ACS880-207-2070A-7	2.000	1.677	2.898	125	2 pcs (4×R8i+2×BLCL-25-7)
ACS880-207-3080A-7	3.000	2.509	4.309	188	2 pcs (6×R8i+3×BLCL-25-7)
ACS880-207-4100A-7	4.000	3.345	5.746	251	2 pcs (8×R8i+4×BLCL-25-7)
ACS880-207-5130A-7	5.000	4.181	7.182	311	2 pcs (10×R8i+5×BLCL-25-7)

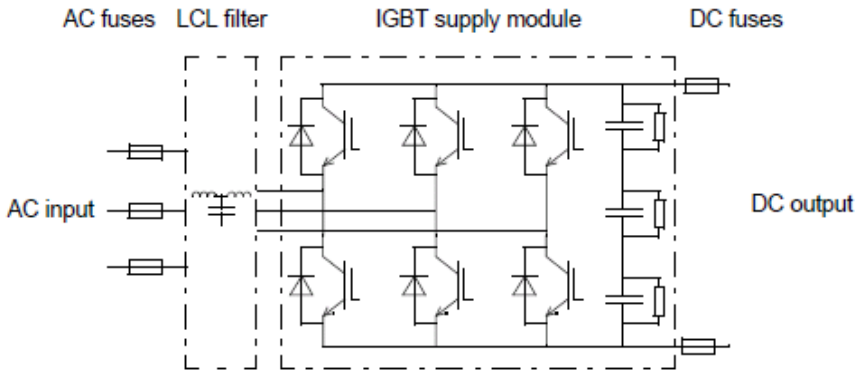
Notes

- Rated values with cos fi 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 %.

ACS880 SFC - Grid Converter

ACS880-204 IGBT supply unit

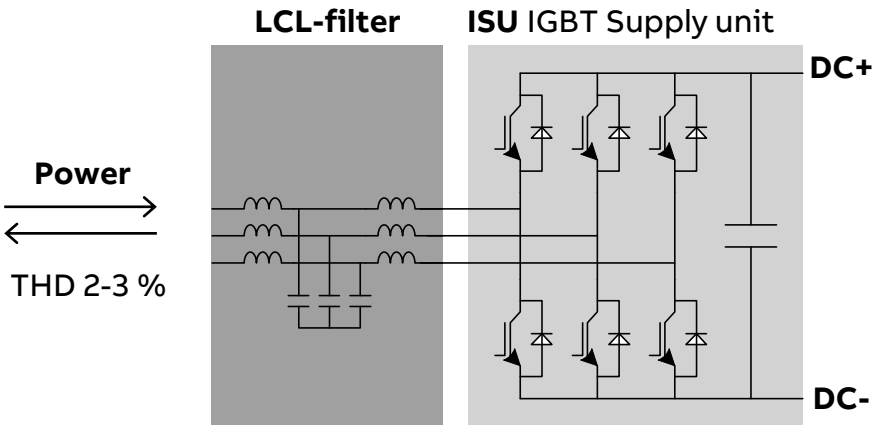
- The IGBT supply unit rectifies three-phase AC current to direct current for the intermediate DC link of the drive. The intermediate DC link supplies the inverter(s) that create the load side grid
- The LCL filter is an essential part of the ACS880-204 IGBT supply module and it does not work without 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

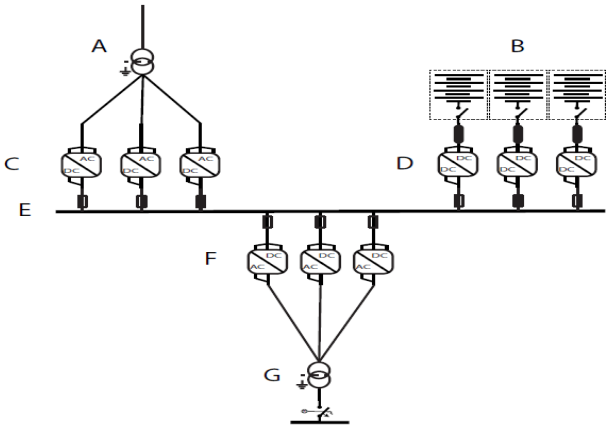
- Benefits of ISU
  - DC-voltage boost
  - Nominal motor voltage available also during net voltage variations
  - No ripple in DC-voltage, => stable motor torque
  - Power factor 1.0 as default
  - Regenerative functionality => braking energy from motor(s) can be returned to the supply network
  - Reactive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



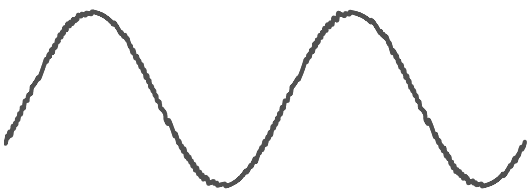
ACS880 SFC - Grid Converter

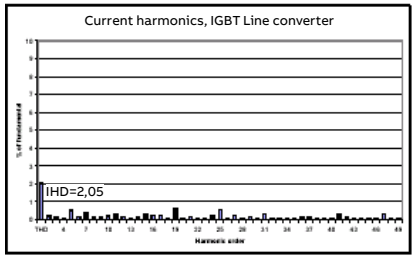
Static converter (Shore-to-Ship)

- 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





IGBT—Supply unit		
THDI	=	4 %
THDU $_{RSC= 20}$	=	3 %
THDU $_{RSC=100}$	=	0,8 %
COS φ_{1}	=	1
COS φ_{total}	=	0,99

Agenda

Static Frequency Converters for Shore-to-ship power application

ACS6080 SFC

ACS880 SFC

PCS100 SFC

RFC vs SFC Case Study

Success stories

Summary

PCS100 SFC – product

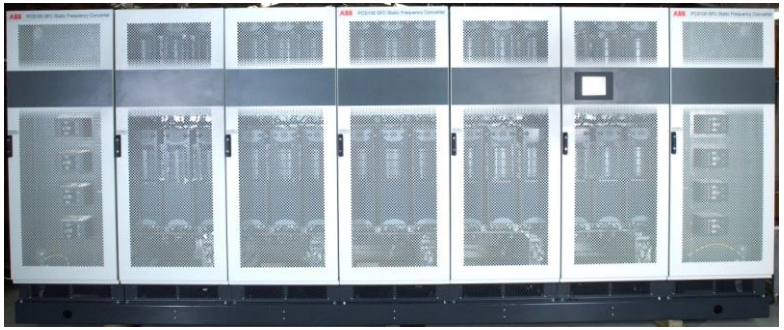
The solution

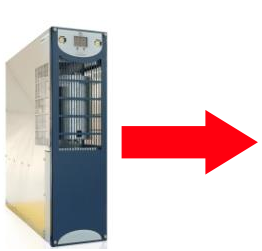
- The ABB PCS100 SFC is a clean, efficient way to provide the frequency and voltage required
- Complete low voltage product range from 125 kVA to multi MVA
- Modular power electronic architecture
- Parallel capable
- Synchronizing and load limiting functions

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

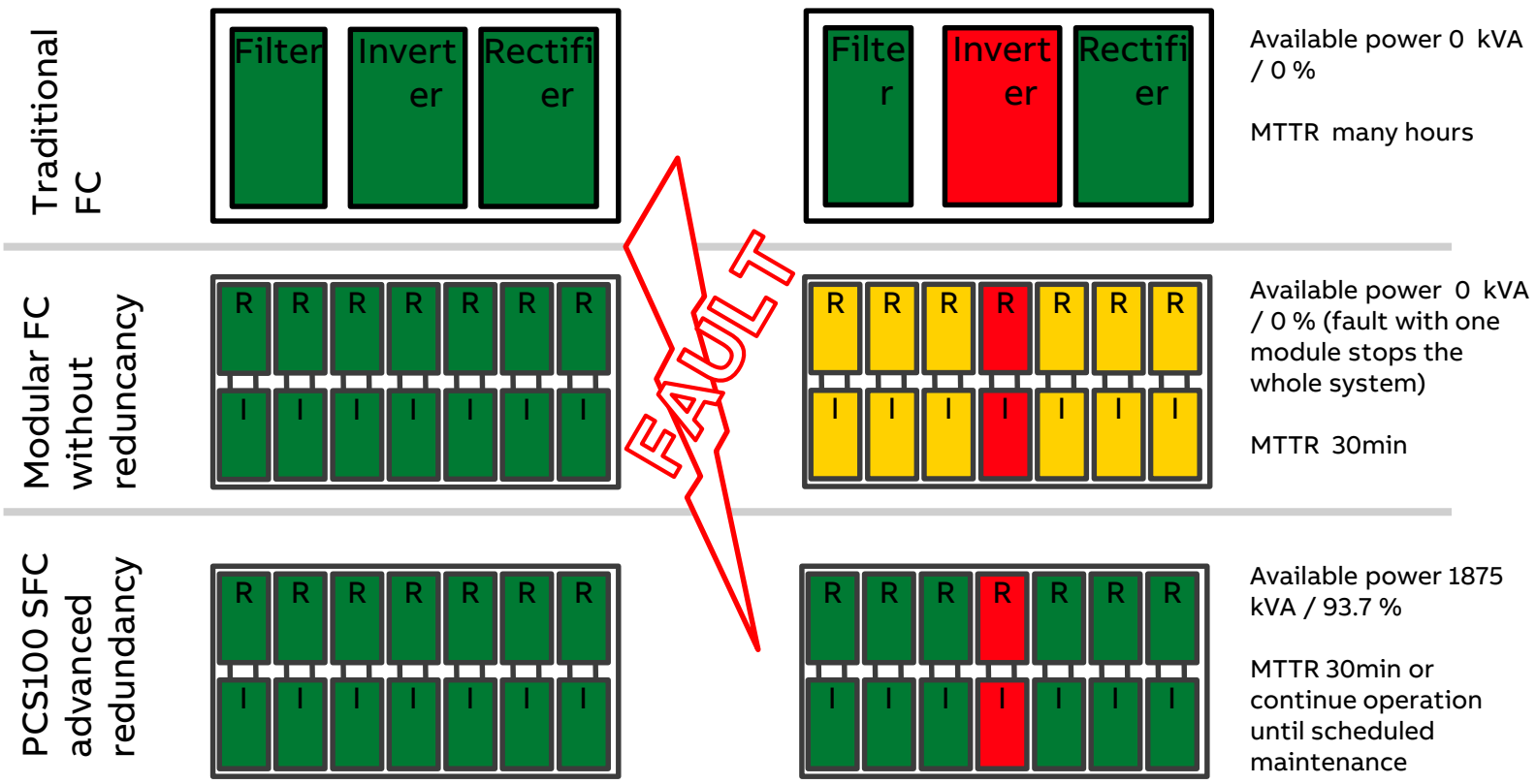
Model	Current Rating (A) @ 40°C	Load kVA @ 480V ↯	Converter/Connection Cabinet		Transformer Cabinet		Number of module pairs
			Dimensions HWD mm* xxx	Weight (Kg)	Dimensions HWD mm*	Weight (Kg)**	
SFC-0125	150	125	2154 x 809 x 804	860	Included in converter cabinet		1
SFC-0250	300	250	2154 x 809 x 804	601	2154 x 809 x 804	908	2
SFC-0375	450	375	2154 x 809 x 804	761	2154 x 1209 x 804	1510	3
SFC-0500	600	500	2304 x 1609 x 804	1503	2304 x 1209 x 804	1910	4
SFC-0625	750	625	2304 x 2009 x 804	1772	2304 x 1209 x 804	2310	5
SFC-0750	900	750	2304 x 2409 x 804	1932	2200 x 2250 x 1600	2800	6
SFC-0875	1050	875	2304 x 2809 x 804	2308	2200 x 2250 x 1600	3000	7
SFC-1000	1200	1000	2304 x 3209 x 804	2586	2200 x 2250 x 1600	3200	8
SFC-1125	1350	1125	2304 x 3209 x 804	2746	2200 x 2250 x 1600	3400	9
SFC-1250	1500	1250	2304 x 4409 x 804	3407	2350 x 2300 x 1600	3700	10
SFC-1375	1650	1375	2304 x 4809 x 804	3700	2350 x 2300 x 1600	3850	11
SFC-1500	1800	1500	2304 x 4809 x 804	3860	2350 x 2300 x 1600	4000	12
SFC-1625	1950	1625	2304 x 5209 x 804	4248	2350 x 2300 x 1600	4100	13
SFC-1750	2100	1750	2304 x 5609 x 804	4550	2350 x 2300 x 1600	4250	14
SFC-1875	2250	1875	2304 x 5609 x 804	4710	2350 x 2300 x 1600	4400	15
SFC-2000	2400	2000	2304 x 6009 x 804	5102	2350 x 2300 x 1600	4600	16

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
** Weights are for LV transformers. For MV, transformers add 25% approx
xxx IP23 + 100mm depth

PCS100 SFC – How it works

Power module redundancy



PCS100 SFC – How it works

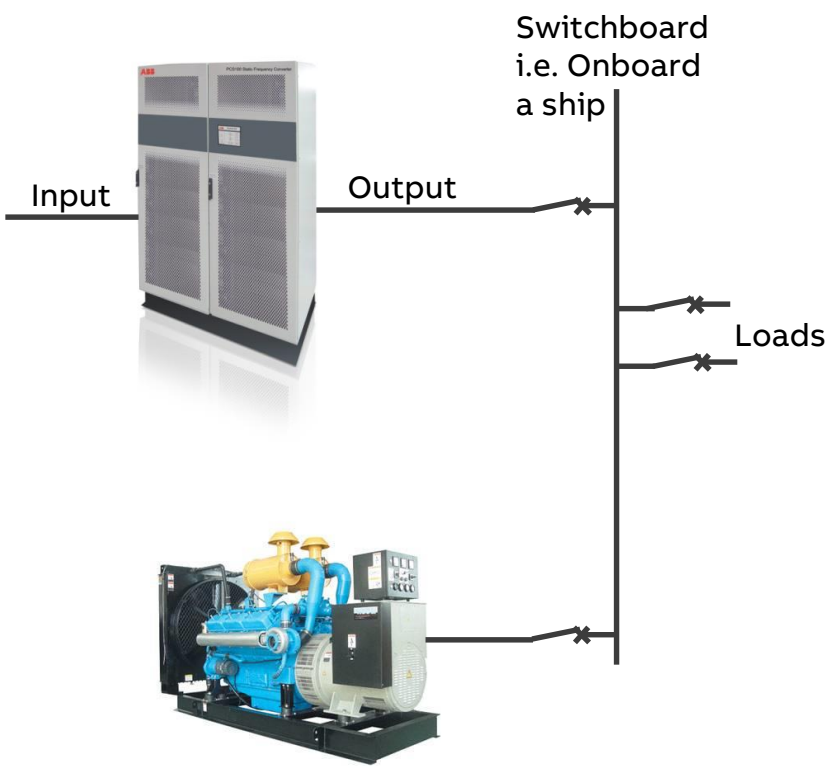
Automatic synchronizing

The PCS10 SFC includes a built in synchronizer

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

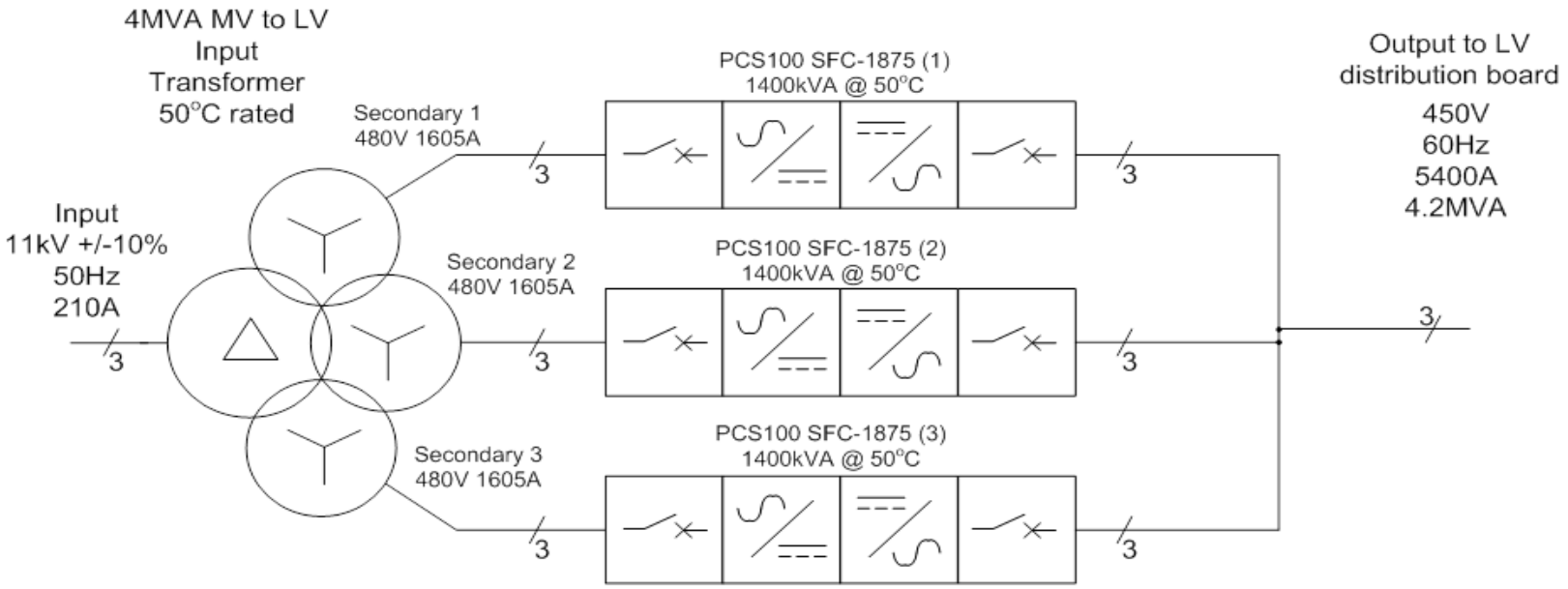
Synchronization procedure as follows:

- 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

Agenda

Static Frequency Converters for Shore-to-ship power application

ACS6080 SFC

ACS880 SFC

PCS100 SFC

RFC vs SFC Case Study

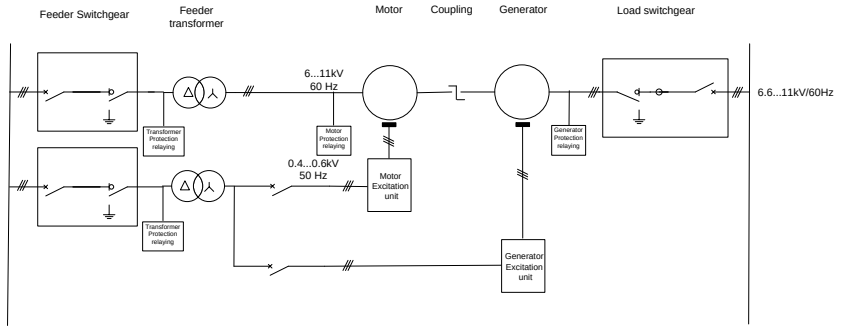
Success stories

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

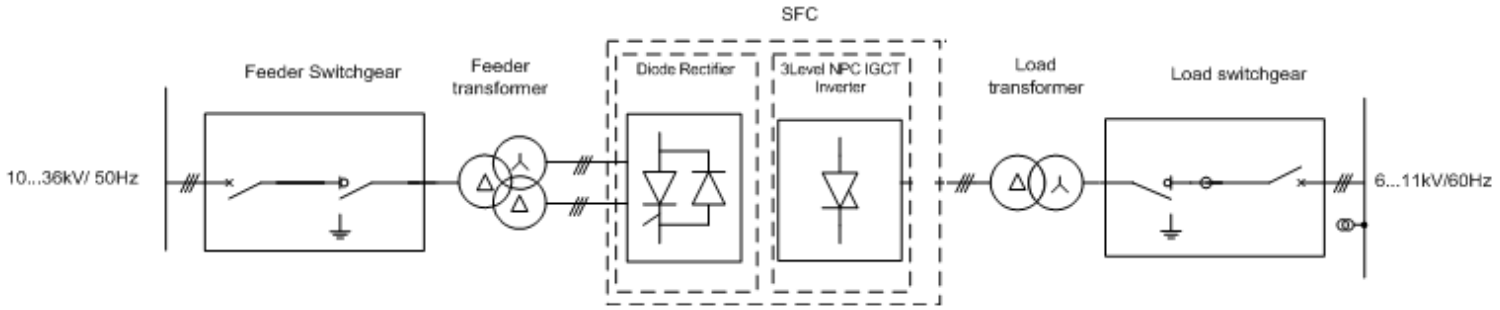
6 MVA RFC – Electrical characteristics

- 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) m x 1.2(+1.2) m x 2.5 m = 72 m3

- 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

Item	RFC- 6 MVA	SFC-10 MVA
Feeder and feeder protection components:		
Feeder transformer	1	1
Feeder aux. transformer	1	1
Feeder main switchgear	1	1
Feeder aux. Excitation switchgear	2	0
Frequency conversion system:		
Length	9m	9m
Width	1.5m	1.2m
Height	4.5m	2.2m
Weight RFC,SFC	56 tons	10 tons
Volume requirement excluding transformer	211m3	72 m3
Load side (V) harmonics	<5%	<2%
MTBF (estimated)	~4.4 years	~5.7 years
Load side (V) harmonics	~95%	~96.5%
Production time (typical):	10 months	6 months

SFC vs RFC – Case study

Comparison table

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

Agenda

Static Frequency Converters for Shore-to-ship power application

ACS6080 SFC

ACS880 SFC

PCS100 SFC

SFC vs RFC

Success stories

Summary

Shore-to-ship power – Rotterdam, The Netherlands

One of the world's largest S2SP installations

Customer needs

Complete electrical infrastructure to simultaneously power several vessels while berthed in the port of Hoek van Holland

- 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

ABB response

- 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

Customer benefits

- 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

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)

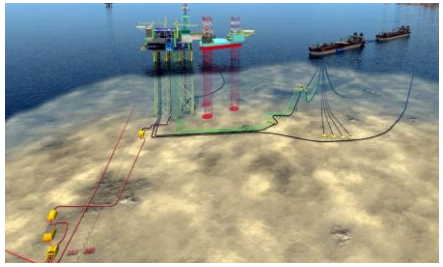


ABB response

- 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

Customer needs

Shoreside power supply to a vast number of Stena Line vessels while at berth

- Customer

Processkontroll Elektriska AB Stenungsund

- Year of commissioning

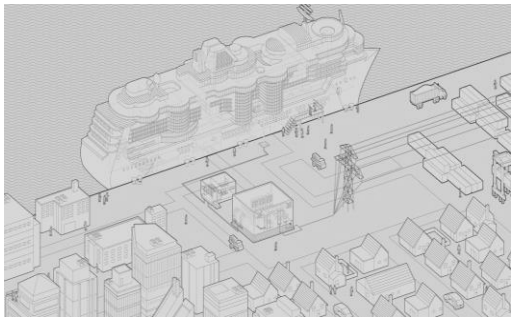
2012

ABB response

- 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

Customer benefits

- 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



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

- Customer

Fincantieri

- Year of commissioning

2014

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

Static Frequency Converters for Shore-to-ship power application

ACS6080 SFC

ACS880 SFC

PCS100 SFC

SFC vs RFC

Success stories

Summary

Summary

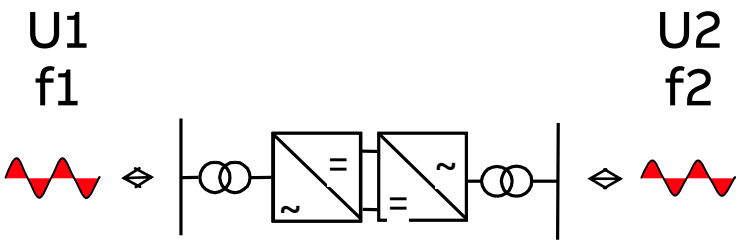
SFC dimensioning: Ask the right questions

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
  ~98.0 % (ACS6080 SFC) *~95.0 % (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.