STATIC FREQUENCY CONVERTER

SureWave SFC™
User Manual

ABB’s SureWave is the new generation of Static Frequency Converter (SFC) allows the connection of 60 Hz powered equipment to a 50 Hz supply network and 50 Hz powered equipment to a 60 Hz supply network.

Additionally, the SureWave SFC can stabilize the frequency and the voltage to allow the correct operation of sensitive equipment when the supply is not sufficiently regulated.

The SureWave’s high efficiency also contributes to sustainability, potentially represents a carbon emissions reduction of 351 tons over a typical 15-years lifespan

1 About this document

1.1 Document information

1.1.1 Copyright notice

1.1.2 Document identification

Ownership: ABB Ltd., Power Conditioning Products
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1.1.3 Contact information

Address: ABB Ltd. Napier 4110, 111, Main North Road. New Zealand
Web: https://new.abb.com/power-converters-inverters/grid-interconnections/industrial/pcs120-sfc

1.1.4 Equipment covered by the manual

This manual covers the standard SureWave SFC product and provides general information regarding:

- General functions of the SFC
- Operation
- Component enclosures
- Graphical Display Module (GDM)
- Control and adjustments

This manual does not claim to cover all variations and details of the SureWave SFC, nor to consider all eventualities that may arise during the operation of the product.

Installation, commissioning, and maintenance of the product are covered elsewhere. If the SureWave SFC is adapted to specific customer needs or applications, and handling, installation,

and operation of the product are affected by these modifications, the extra information required to cover these adaptions will be supplied in extra documentation.

If information is required beyond the instructions in this manual, please refer the matter to ABB

1.1.5 Target groups and required qualifications

The product presented in this manual is part of an industrial environment where voltages are present that contain a potential hazard of electric shock and/or burn. For this reason, only personnel who have a thorough knowledge of the SFC and the industrial environment and have obtained the required qualification may handle, install, operate, or maintain the product.

The manual addresses personnel who are responsible for operation and maintenance of the SureWave SFC. The personnel must carry out the listed tasks in a manner that does not cause physical harm or danger, and that ensures the safe and reliable functioning of the product.

“Commissioning of the SureWave SFC must only be performed by qualified and certified ABB personnel.”

Handling

The personnel must be skilled and experienced in unpacking and transporting heavy equipment.

Mechanical installation

The personnel must be qualified to prepare the installation site according to the site and equipment requirements and to perform the installation accordingly.

Electrical installation

The personnel must have a sound knowledge of the relevant electrical codes and specifications covering low voltage equipment, be experienced with electrical wiring principles, and know the electrical symbols typically used in wiring diagrams.

Operation

The personnel include all persons who operate the SureWave SFC from the HMI. Those people must know the functions of the GDM, be adequately trained for the SFC, and understand its operation process.

Maintenance

The personnel include all persons who:

- are qualified to carry out preventive and corrective maintenance on SureWave SFC as described in this manual.
- are thoroughly familiar with the product.
- have a sound knowledge of the relevant electrical codes and specifications covering low voltage equipment.
- are able to assess the hazards associated with the energy sources of the SureWave SFC system and act correspondingly.
- know the safe shutdown procedures for the SureWave SFC system

1.1.6 Responsibilities of the user

It is the responsibility of those in charge of the SureWave SFC to ensure that each person involved in the installation, operation or maintenance of the product has received the appropriate training and has thoroughly read and clearly understood the instructions in this manual and the relevant safety instructions

1.1.7 Intended use of equipment

Those in charge of the SureWave SFC must ensure that the product is only used as specified in the contractual documents, operated under the conditions stipulated in the technical specifications and on the rating plate of the product, and serviced in the intervals as specified by ABB.

Use outside the scope of the specifications, and unauthorized modifications and constructional changes of the SureWave SFC will render the warranty void

Intended equipment use also implies that only spare parts recommended and approved by ABB may be used.

1.1.8 Quality certificates and applicable Standards

The following certificates and conformity declarations are available from ABB:

– ISO 9001 certificates stating that ABB Ltd in Napier has implemented and maintains a management system that fulfils the requirements of the normative standards.

– EC conformity declaration.

– Individual IEC

Standard number	Standard name
IEC60146-1	Semiconductor converters – General requirements
IEC60146-2	Semiconductor converters – Self commutated semiconductor converters
IEC61000-6-2	EMC generic standards - Immunity standard for industrial environments
IEC6100-6-4	EMC generic standards - Emission standard for industrial environments
IEC/EN60947-1	Low voltage switchgear and control gear - General rules
IEC/EN60947-2	Low voltage switchgear and control gear - Circuit breakers
IEC62477-1	Safety requirements for power electronic converter systems and equipment - General
WEEE	Waste electrical and electronic equipment directive

Table 1-1: Summary of applicable standards

1.1.9 Items covered by delivery

Delivery of a SureWave SFC comprises the following items:

250 kVA to 750 kVA:

1 enclosure, identified as PE120-U1

This carries the universal controller (main), graphical display module (GDM) and power electronics building blocks (PEBBs) to make a complete static frequency converter.

Input and output circuit breakers are NOT supplied with these models and must be sourced separately.

1 MVA to 1.5 MVA

4 enclosures, as follows:

1. Input enclosure (Term. Enclosure-UAx) complete with circuit breaker
2. PE120-U1 enclosure (main), carrying the universal controller, GDM and PEBBs.
3. PE120-U2 enclosure (hub), carrying PEBBs, and universal controller.
4. Output enclosure (Term. Enclosure-UAx) complete with circuit breaker

1.75 MVA to 2.25 MVA:

5 enclosures, as follows:

1. Input enclosure (Term. Enclosure-UAx) complete with circuit breaker
2. PE120-U1 enclosure (main), carrying the universal controller (main), GDM and PEBBs.
3. PE120-U2 enclosure (hub), carrying PEBBs, and universal controller.
4. PE120-U3 enclosure (hub), carrying PEBBs, and universal controller.
5. Output enclosure (Term. Enclosure-UAx) complete with circuit breaker

1.1.10 Identifying the delivery

The SFC and accessories are identified by the type code printed on the rating label. The label is located on the back of the PE120-1 enclosure door.

The Label provides information on the SureWave SFC rated voltage, frequency, rated current and auxiliary power supply.

1.2 Abbreviations & Terms

The following table lists terms and abbreviations user should be familiar with when using this manual. Some of the terms and abbreviations used in the manual are unique to ABB and might differ from the common use.

Abbreviation / Term	Meaning
SFC	Static Frequency Converter
LV	Low Voltage. Voltage level up to 1000 Vac or 1500 Vdc.
LV PSU	24 Vdc internal power supply for fans and electronics
MV	Medium Voltage. Voltage level between 1 kVac and 35 kVac.
PCS120	Power Conversion System 120. The PCS120 is the product platform for the ABB power conditioning products.
PEBB	Power Electronic Building Block.
PE120-U<n>	Platform Enclosure 120. PE120 is the enclosure that contains several PEBB. The PE120 could be main controller or hub.
MC	Main Controller. UC120main controller located in the PE120-U1 enclosure.
HUB	HUB controllers are located in PE120-U2 and PE120-U3 cabinets respectively. The main function is to transfer the information to the main controller.
GDM	Graphical Display Module. Has the local Human Machine Interface (HMI) and it is located in the PE120-U1 enclosure.
HMI	Human Machine Interface
CB	Circuit Breaker
PE	Chassis Protective Earth.
PE-I	Inverter Earth.
PCC	Point of Common Coupling. The PCC is the point in the electrical power supply system where the responsibility of the utility changes to the industrial customer. The utility is responsible for providing clean voltage and current with respect to harmonic distortion up to the PCC. The industrial customer is responsible not to distort voltage and current by its electrical systems.
Line voltage	RMS line to line voltage of the main power supply of the input.
PCB	Printed Circuit Board.

Abbreviation / Term	Meaning
EMC	Electromagnetic Compatibility. All measures to suppress electromagnetic disturbances caused by different electrical equipment in the same electromagnetic environment, and to strengthen the immunity of the equipment to such disturbances.
RTD	Resistance Temperature Detector. The RTD is a temperature sensor where the change in electrical resistance is used to measure the temperature.

Table 1-2: Summary of abbreviations

1.3 Trademarks

Names that are believed to be trademarks of other companies and organizations are designated as such. The absence or presence of such a designation should however not be regarded as an offence of the legal status of any trademark. The following registrations and trademarks are used in this manual:

Abbreviation / Term	Meaning
Modbus™	Registered trademark of Schneider Electric USA, Inc
SureWave	Registered trademark of ABB Ltd

Table 1-3: Trademarks

1.4 Related documentation

Document type	Document title	Document Number
Drawings	250 kVA to 750kVA Layout drawings	2UCD42000E102
Drawings	1 MVA kVA to 1.5 MVA Layout drawings	2UCD42000E101
Drawings	1.75 MVA to 2.25 MVA Layout drawings	2UCD42000E103
Specifications	PCS120 SFC Technical Specifications	2UCD420000E002
Installation	PCS120 SFC Installation Manual	2UCD420000E003
Service	Service Manual	2UCD420000E400
Health & Safety	Health and Safety Risk Assessment	2UCD400000E601

Table 1-4: Summary of related documentation

2 Introduction

Thank you for selecting ABB as your preferred supplier of frequency conversion equipment and congratulations on your choice of the SureWave SFC to support your installation.

ABB's SureWave SFC is the latest Static Frequency Converter developed with ABB's years of experience with market trends and knowledge in the field.

The new generation of Static Frequency Converters allows connection of 60 Hz powered equipment to a 50 Hz supply network and 50 Hz powered equipment to a 60 Hz supply network.

Please carefully read this User Manual, which contains all the necessary information and describes all you need to know about the use of the SFC. The User Manual describes the function of the SFC, its operation, system components, the meaning of the system events related to the user interface and provides procedures for starting and stopping the equipment.

Please refer to the Installation Manual, for details on how to prepare the installation site, weight, dimensions, and procedures for moving, installing, and connecting the SFC.

While every care has been taken to ensure the completeness and accuracy of this manual, ABB assumes no responsibility or liability for any losses or damages resulting from the use of the information contained in this document.

Thank you for choosing ABB

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3 Safety

						
AR	تحذير: جهد كهربائي خطر ! راجع تعليمات التشغيل. افصل الكهرباء وقم بتأمينها قبل العمل في هذا الجهاز تنبيه! يجب عدم التركيب إلا من خلال شخص على دراية بمجال التقنية الكهربائية .
BG	Предупреждение: Опасно напрежение! Вижте инструкциите за работа. Изключете и блокирайте захранването преди да работите с устройството. Внимание! Да се монтира само от експерт електротехник.
CS	Varování: Nebezpečné napětí! Viz návod k obsluze. Před zahájením prací na tomto zařízení odpojte a uzamkněte napájení. Pozor! Toto zařízení smí instalovat pouze osoba s elektrotechnickou odborností.
DA	Advarsel: Farlig elektrisk spænding! Se betjeningsvejledningen. Frakobl enheden, og afbryd strømforsyningen, før du arbejder med denne enhed. Giv agt! Installation må kun foretages af personer med elektroteknisk ekspertise.
DE	Warnung: Gefährliche Spannung! Siehe Bedienungsanleitung. Vor dem Arbeiten Gerät ausschalten und von der Spannungsversorgung trennen. Achtung! Installation nur durch elektrotechnische Fachkraft.
EL	Προειδοποίηση: Επικίνδυνη τάση! Ανατρέξτε στις οδηγίες λειτουργίας. Αποσυνδέστε και απομονώστε την παροχή ισχύος προτού ξε κινήσετε τις εργασίες σε αυτήν τη συσκευή. Προσοχή! Η εγκατάσταση πρέπει να γίνεται μόνο από αδειούχο ηλεκτρολόγο εγκαταστάτη.
EN	Warning: Hazardous voltage! Refer to installation instructions. Disconnect and lock out power before working on this device. Attention! Installation by person with electrotechnical expertise only.
ES	Advertencia: ¡Tensión peligrosa! Consulte las instrucciones de funcionamiento. Antes de trabajar con este dispositivo, desconecte y bloquee la corriente. ¡Atención! La instalación debe ser realizada únicamente por un técnico electricista.
ET	Hoiatus: Elektrilöögi oht! Lisateavet vaadake kasutusjuhendist. Enne selle seadmega töötamist ühendage lahti ja lukustage toide. Tähelepanu! Seadet tohib paigaldada ainult elektrotehnilise kogemusega isik.
FI	Varoitus: Vaarallinen jännite! Katso käyttöohje. Katkaise virta ja estä virran kytkeminen lukituksella ennen töiden aloittamista. Huomio! Asennuksen saa suorittaa vain henkilö, jolla on kokemusta sähkötekniikasta.
FR	Avertissement: Tension dangereuse! Consultez les consignes d'utilisation. Débranchez et verrouillez l'alimentation électrique avant d'entreprendre des travaux sur cet appareil. Attention! L'installation doit être effectuée uniquement par une personne ayant une expertise en électrotechnique.
HR	Upozorenje: Opasan napon!

	Pogledajte upute za uporabu. Odspojite i isključite struju prije rada na ovom uređaju. Pažnja! Ugradnja je dopuštena samo osobama stručnim u području elektrotehnike.
HU	Figyelmeztetés: Veszélyes feszültség! Lásd a használati utasítást. Válassza le és zárja ki az áramellátást, mielőtt a berendezésen dolgozni kezd. Figyelem! Az üzembe helyezést csak elektrotechnikai szakértelemmel rendelkező személy végezheti el.
IT	Attenzione: Tensione pericolosa! Fare riferimento alle istruzioni per l'uso. Prima di intervenire su questo dispositivo, scollegare e isolare tutte le fonti di alimentazione. Attenzione! L'installazione deve essere eseguita esclusivamente da un installatore qualificato.
LT	Įspėjimas: Pavojinga įtampa! Žr. naudojimo instrukcijas. Atjunkite ir laikinai užblokuokite maitinimą prieš dirbdami su šiuo įrenginiu. Dėmesio! Įrengti gali tik asmuo, turintis elektrotechniko patirties.
LV	Brīdinājums: Bīstams spriegums! Skatiet darba norādījumus. Pirms sākat darbu ar šo ierīci, atvienojiet un bloķējiet strāvas padevi. Uzmanību! Uzstādīšanu drīkst veikt tikai persona ar zināšanām par elektrotehniku.
NL	Waarschuwing: Gevaarlijke spanning! Raadpleeg de bedieningsinstructies. Koppel dit apparaat los van de stroomvoorziening voordat u werkzaamheden uitvoert. Let op! Installatie mag alleen worden uitgevoerd door een monteur met elektrotechnische expertise.
NO	Advarsel: Farlig spenning! Se i bruksanvisningen. Koble fra og steng av strømmen før du arbeider på denne enheten. Forsiktig! Montering skal kun utføres av kvalifiserte personer med elektrokompetanse.
PL	Ostrzeżenie: Niebezpieczne napięcie! Patrz: instrukcja obsługi. Przed rozpoczęciem wykonywania pracy z tym urządzeniem odłącz i zablokuj zasilanie. Uwaga! Montaż może wykonywać wyłącznie osoba posiadająca doświadczenie elektrotechniczne.
PT	Aviso: Tensão perigosa! Consulte as instruções de operação. Desconecte e desligue a energia elétrica antes de trabalhar nesse dispositivo. Atenção! A instalação deve ser feita apenas por uma pessoa com especialidade eletrotécnica.
RO	Avertisment: Tensiune electrică periculoasă! Consultați instrucțiunile de utilizare. Deconectați și închideți sursa de energie înainte de a lucra cu acest dispozitiv. Atenție! Instalare
RU	Внимание: Опасное электрическое напряжение! Обратитесь к инструкциям по эксплуатации. Отключите питание и обесточьте устройство перед началом работ. Внимание! Установка должна выполняться только специалистом по электротехническим работам.
SK	Výstraha: Nebezpečné napätie! Pozrite si návod na použitie. Pred začatím prác na tomto zariadení odpojte a zablokujte napájanie. Pozor! Inštaláciu smie vykonávať len osoba s odbornými znalosťami v oblasti elektrotechniky.
SL	Opozorilo: Nevarna napetost! Glejte navodila za uporabo. Pred delom na tej napravi izklopite in zaklenite električno napajanje. Pozor! Namestitev sme izvesti samo elektrotehnični strokovnjak.
SV	Varning: Livsfarlig spänning! Se i bruksanvisningen. Frånkoppla och blockera anläggning eller en anläggningsdel innan arbeite utförs. Obs! Får endast installeras av behörig elektriker.
TR	Uyarı: Tehlikeli gerilim!

	Çalışma talimatlarına bakın. Bu cihaz üzerinde çalışmadan önce elektriği kesin ve kilitleyin. Dikkat! Yalnızca elektroteknik uzmanlığa sahip kişiler tarafından kurulabilir.
ZH	警告：高压危险! 请参见操作手册 操作本设备前请断开并锁定电源。 注意！安装仅限专业电工人员。

Table 3-1: Safety instructions

Safety instructions are used to highlight a potential hazard when working on the equipment. Safety instructions must be strictly followed! Non-compliance can jeopardize the safety of personnel, the equipment, and the environment.

This manual contains important information regarding the operation of the ABB SureWave SFC and provides technical and operational guidance for operators. The following safety instructions are to be observed.

3.1 Safety notices

Sign	Meaning
	DANGER This manual provides information for the safe operation of the SureWave SFC. It does NOT provide installation, commissioning or service information. For such information, refer to the appropriate manual.
	CAUTION – Trained operators All operations on the SureWave SFC must only be carried out by a trained operator familiar with the contents of this manual. Hazardous conditions could arise from incorrect adjustment.
	DANGER – Hazardous voltages An Operator must not open doors or panels marked as containing hazardous voltages. Many parts in this product, including printed circuit boards operate at lethal high voltages. Stored energy components such as batteries and capacitors can hold this voltage even after the opening of isolation switches. DO NOT TOUCH components or connections that may have voltage present.
 	DANGER – Stored charge Stored charge is present after the device is switched off. When the SFC is powered down, lethal voltages will remain in the energy storage elements and the complete SureWave SFC should be considered live. To remove this hazard, energy storage will need to be isolated and locked off, and filter capacitors discharged. This may only be done by trained technical personnel while following the stipulated isolation, grounding, and lockout procedures.
	DANGER – Protective covers Normal operation of this product requires all protective covers to be in place and all doors secured closed.

	DANGER – Personal Protective Equipment Ensure safety glasses and other appropriate PPE are worn while working if any part of the unit could be energized. Observe site requirements for PPE while operating this equipment.
	DANGER – Arc flash Arc flash is a dangerous phenomenon associated with operation at low voltages. It may be caused by switchgear failure, insulation breakdown or foreign object intrusion. It may result in severe burns, severe eye injury, blindness or death. To minimize the risk, keep all doors closed and covers in place while operating the equipment. Observe any arc flash protection boundaries that may be in place around the SFC enclosures.
	DANGER – Potential material hazard of batteries and capacitors If a capacitor is damaged electrically or physically, the resulting debris could represent a material hazard. Refer to the appropriate Material Safety Data Sheet for information on safe handling and disposal.

Table 3-2: Safety notices

Safety labels are attached to the enclosures to alert personnel of potential hazards when working on the equipment. The instructions on the safety labels must always be followed, and the labels must be kept in a perfectly legible condition.

3.2 General safety information

3.2.1 Operator duties

The scope of work for an operator of the SureWave SFC is to control and monitor the SFC from the GDM, digital I/O and or MODBUS interface, or from a remote web page. An operator is not normally authorized to undertake any maintenance, service, or repair work.

The operator may be authorized to provide assistance to a maintenance, service or repair technician, by performing his or her duties under the direction of a service team. If so, the operator must be wearing PPE to the same level as those of the service team.

3.2.2 Before energization

Before the SFC is energized, inspect to make sure:

- any maintenance work being done on the SFC has been completed and signed off, and all tools and equipment are removed.
- All covers on the SFC enclosures are securely fastened, and all doors are closed, locked, and/or bolted.

3.3 Possible residual risks

The following risks can arise from a SureWave SFC system and pose a hazard to people. These risks must therefore be considered by the system integrator and/or the plant owner when assessing the risks of the machinery.

The SFC is a high energy power conversion machine. Components may be dislodged or damaged during transport, or when being installed, commissioned, operated or serviced, due to, for example:

- Damage during transport,
- Incorrectly assembled or installed equipment,
- Wrongly connected cables,
- External influence on, or damage to the equipment,
- Wrong parameter settings,
- Operation of the equipment outside the scope of the specifications,
- Software errors,
- Faulty hardware.

Hazardous touch voltages can be present on SureWave SFC system components caused by, for example:

- Operation of the equipment outside the scope of the specifications,
- External influence on, or damage to the equipment,
- Induced voltages by external equipment,
- Condensation on equipment components or pollution,
- Faulty hardware,
- The used of inappropriate tools during servicing,

For all of the above reasons, always operate with all side and rear panels in place and all doors shut and latched

4 Cyber security

Overview

This product is designed to be connected to and to communicate information and data via network interface.

It is customer's sole responsibility to provide and continuously ensure a secure connection between the product and customer network or any other network (as the case may be). Customer shall establish and maintain any appropriate measures (such as but not limited to the installation of firewalls, application of authentication measures, encryption of data, installation of antivirus programs, etc.) to protect the product, the network, its system and the interface against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information.

ABB and its affiliates are not liable for damages and/or losses related to such security breaches, any unauthorized access, interference, intrusion, leakage and/or theft of data or information.

4.1 Deployment guidelines

The recommended Cyber Security deployment for the SureWave SFC is for it to be only used in a trusted network with restricted access. The user is responsible for creating a defense-in-depth protection by allocating firewall solutions to each network.

For secure remote access, use a VPN connection – the SureWave SFC is not approved by ABB for direct Internet connection. The user of the product should be aware that the unsecure nature of the Modbus TCP protocol exposes the communication between the product and the control system. Authentication and integrity of transmitted information is not provided by the proto-col. This enables certain types of attacks, such as man-in-the-middle attacks, eavesdropping attacks and replay attacks for instance. The main security is provided through monitoring the cyber security, topology (asset management) and correct operation of the data networks using the cyber security monitoring modules and features of the firewalls and managed switches

5 Product description

Overview

The ABB SureWave SFC is a high-performance high-efficiency static frequency converter system that provides a stable three-phase power supply with fixed voltage and frequency. The supply source is likely to be of different voltage and frequency to that required by the load.

A typical application of a frequency converter is the supply of electrical power to a ship when it is in harbor. The ship will be able to be supplied with electrical power without running any on-board generators. This has major benefits in reduction of noise and pollution, reduction in running time of shipboard generators, and overall energy savings.

The SureWave SFC uses ABB's new generation PCS120 power modules to convert the incoming utility to DC, then convert this DC back to 3-phase AC for supplying the load at the required frequency and voltage. The PCS120 power modules are compact and efficient, which contribute to the overall SureWave SFC being a compact powerful converter system with a fast-dynamic response to load changes and a high overload margin.

The SureWave SFC installation may be stand alone, operating the load without any parallel connected generating capacity. Or it may be connected in parallel with an existing generator bus, where it may be started to seamlessly take over the load from the generator(s). Alternatively, it may be connected in parallel to one or more SureWave SFC. Each of these possibilities is best catered for by selecting one of several operating modes.

5.1 Single line diagram

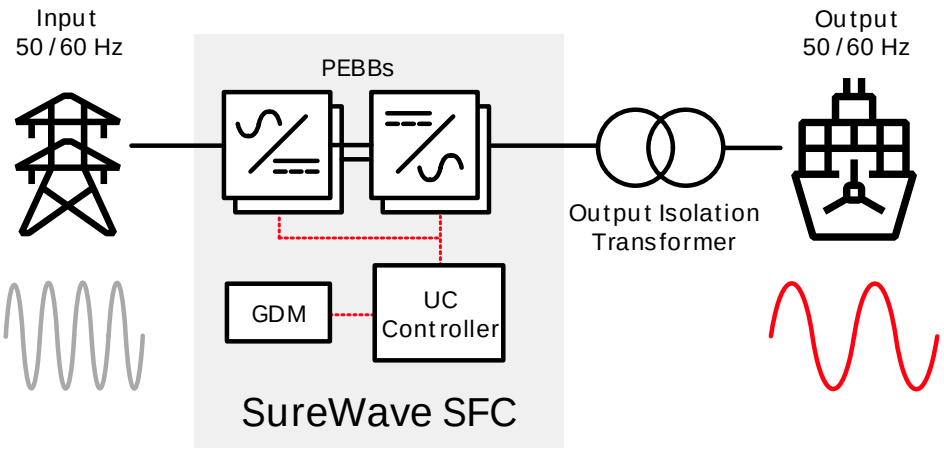


Figure 5-1: SureWave SFC SLD

5.2 Operating principle

Refer to Figure 5-1: SureWave SFC SLD. The SureWave SFC employs Power Electronics Building Blocks (PEBBs) in sets of two. The PEBB connected to the incoming utility is configured as an active rectifier, which converts the incoming AC to DC. The PEBB connected to the load functions as an inverter, to provide the load with clean power at the required voltage and frequency.

The PEBB pairs are then paralleled to give the required output rating, up to a maximum of 2.25MVA at 480Vac output. More than one SureWave SFC may be connected in parallel if the total required rating exceeds 2.25MVA.

The output of the SureWave SFC is at a fixed frequency and voltage, to suit the load requirements. Thanks to the double conversion architecture, the output voltage is tolerant to significant voltage distortion and transients from incoming voltage.

5.2.1 Generator mode

In generator mode (VGen) the SFC emulates the behavior of a real rotary generator and thus interacts with the power system in the same way as a traditional synchronous machine. This behavior is achieved purely through power electronic control and there are no large spinning masses.

In this mode the SFC can be configured to run as a standalone power source with tight tolerance voltage and frequency regulation (Isochronous) for a fixed application or as a power source running in parallel with other generators with voltage and frequency droop enabled.

In generator mode the bump less load transfer to and from another generator or generators.

The system can also synchronize to an external bus to connect another node to the output of the SureWave SFC.

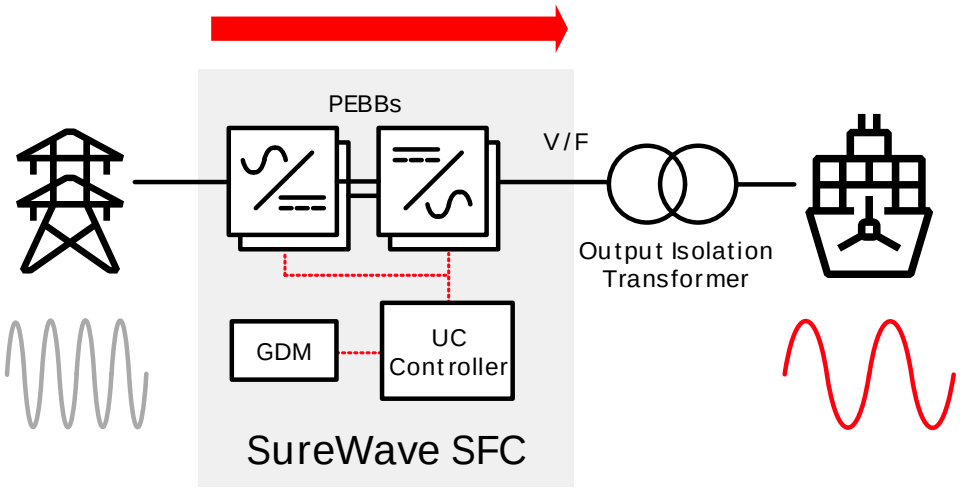


Figure 5-2: SureWave in Generator mode

5.2.2 Power flow control mode

In power flow control mode (Fix Power), when in parallel with another source the SFC has the ability to provide fixed P and Q power flow on the output. This is used when interfacing generators to a grid where power flow to and from the grid must be controlled.

Setpoints for both real power (P) and reactive power (Q) can be set.

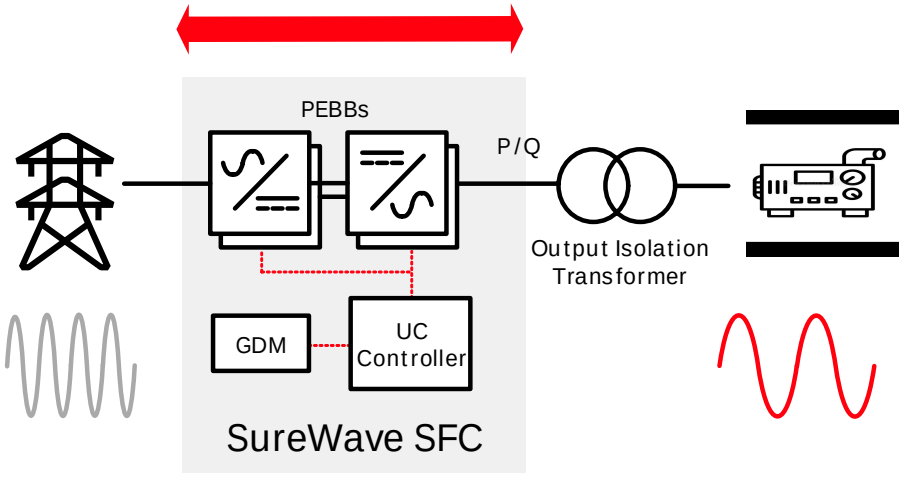


Figure 5-3: SureWave in Fix Power

5.3 User interface

The primary user interface is via a door mounted touch screen Graphical Display Module (GDM). The display is a 10” resistive touchscreen with a user-friendly intuitive interface.

The integrated navigation screen gives easy accessibility to any information on the SureWave SFC, it shows the system status and provides access to the operating parameters and event history. The mimic diagram gives the users a clear view of the status of the system.

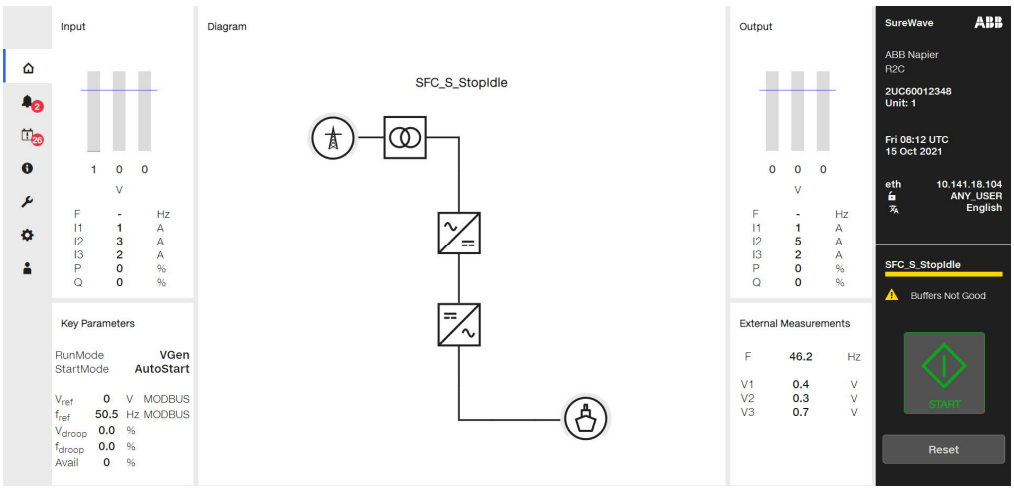


Figure 5-4: SureWave HMI

5.4 Major SFC components

This section introduces the main components of the SureWave SFC.

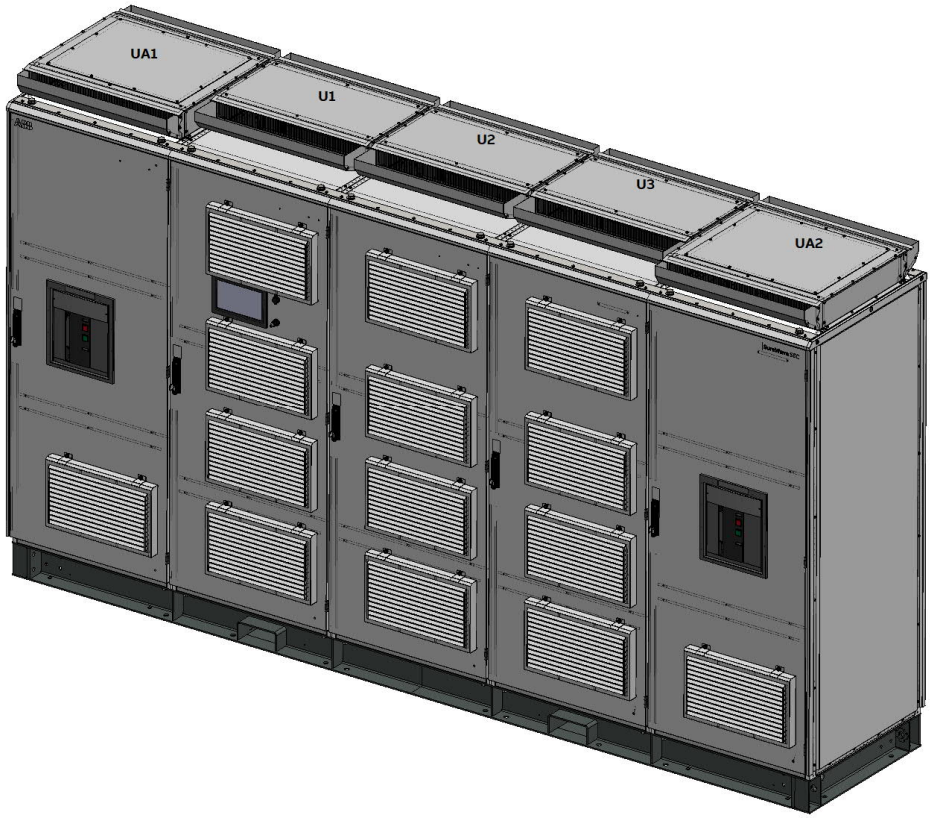


Figure 5-5: SureWave product overview

- Platform Enclosure (PE120-U1)
    - o Subcomponents:

      SureWave Power Electronic Building Blocks (PEBBs)
      Main controller (MC)
      Graphic Display Module (GDM)

- Platform Enclosure (PE120-U2, U3)
    - o Subcomponents:

      SureWave Power Electronic Building Blocks (PEBBs)
      Hub controller (hub)

- AC Termination Enclosure (Term. Enclosure-UAx)
    - o Subcomponents:

      AC input and output cable termination
      3-phase AC circuit breaker (ACB)

5.4.1 PE120 enclosures

Each PE120 can house up to six PEBBs and the enclosures are designated PE120-U1, PE120-U2 and PE120-3 (model dependent). Below the PEBBs in each cabinet, there is a control tray carrying the enclosure controller and associated circuits.

The PE120-U1 (main) is the enclosure that houses the Graphical Display Module (GDM) and the Main Controller (MC) of the SFC. The other two enclosures (PE120-U2 & PE120-U3) have HUB controllers to transfer the information between the main controller and their PEBBs.

The auxiliary supply in the control tray at the bottom of each PE120 enclosure may be externally feed from an independent 3-phase AC source. Generally, the auxiliary supply is feed from the input AC power terminals.

Figure 5-6: PE120 enclosure

5.4.1.1 SureWave SFC power electronic building blocks

The SureWave SFC can contain up to eighteen PEBBs. The Power Electronic Building Blocks are high efficiency three-level bi-directional power electronics IGBT-based converters.

Each PEBB is rated at 250 kVA and includes a sine filter. The PEBBs are plug-in modules with automatic smart firmware management and controlled via 2 x fiber optic cables (Tx, Rx) and auxiliary power provided by a 24 Vdc connection.

The power connections are at the back of the modules and are connected to busbars at the rear of the PE120 enclosures.

At the top-left front side of each PEBB, there are two LEDs. That indicates if 24 Vdc power supply is present, and the second one describes three main different states (Green = PEBB Ok, Yellow = Starting and Red.= Fault).

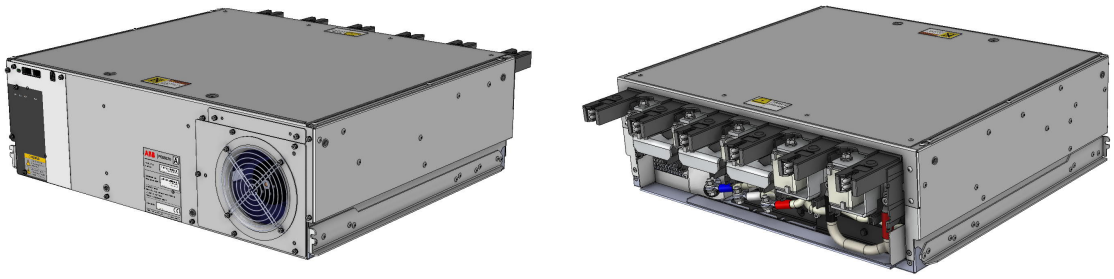


Figure 5-7: PEBBs

5.4.1.2 Graphic display module

The GDM is located in the PE120-U1 (main) enclosure. This user interface of the SureWave SFC is connected to the main controller. Through the GDM, it is possible to operate and monitor the SFC, read/edit its parameters, and reset faults.

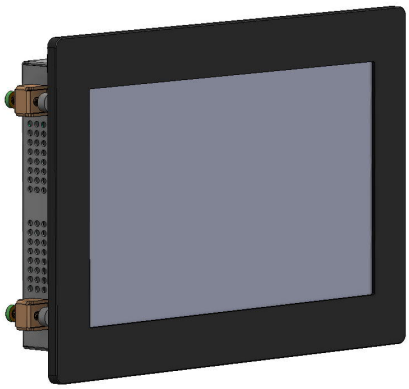


Figure 5-8: GDM

5.4.2 Termination enclosure (Term. Enclosure-UAx)

The termination enclosures have the AC termination bars where the input and output of the SFC is connected. The enclosure is designed to accommodate up to twelve terminal lugs (of each phase) with six M16 stud holes.

Note, termination enclosures are only present for > 750 kVA models.

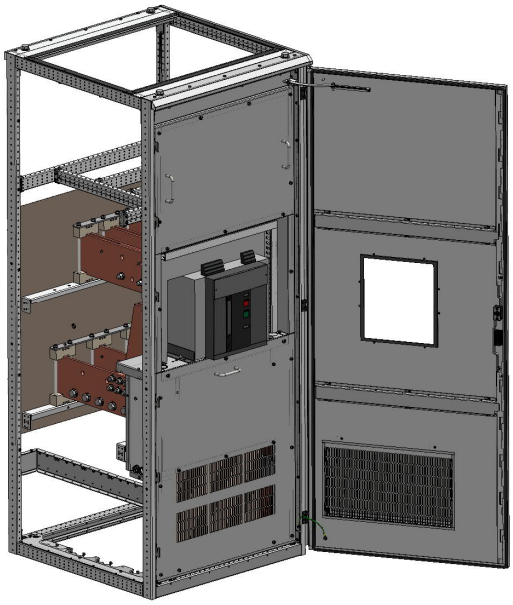


Figure 5-9: Termination enclosure

5.5 Cooling system

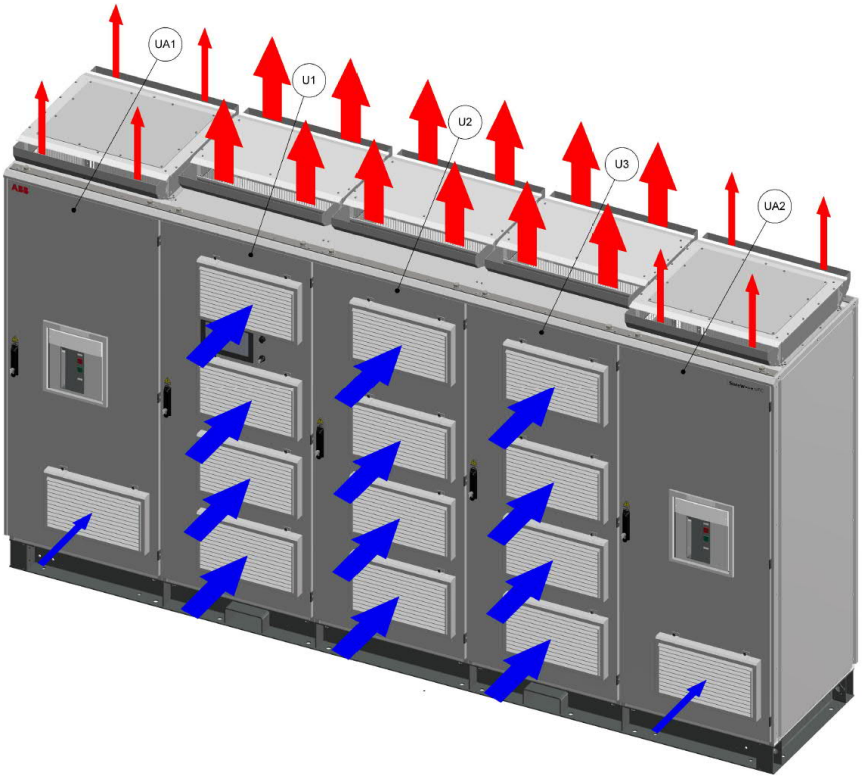


Figure 5-10: Air flow direction

The air enters the SureWave SFC enclosures through the louvre panels at the front and exits through the air outlet at the top.

The air intakes, including the louvers and filters, must be maintained and unobstructed when the SureWave SFC is operating. Figure 5-10: Air flow direction illustrate the air intake (blue arrows) and air out (red arrows). Please refer to the General Arrangement drawings for more information about the minimum recommended clearances for operation and maintenance purposes.

5.5.1 PE120 Enclosure air flow diagram

The enclosure airflow is managed as shown in Figure 5-11: Enclosure air flow diagram, where the air gets drawn from the enclosure front through the PEBBs fans and routed to the back and then upwards to the top exhaust.

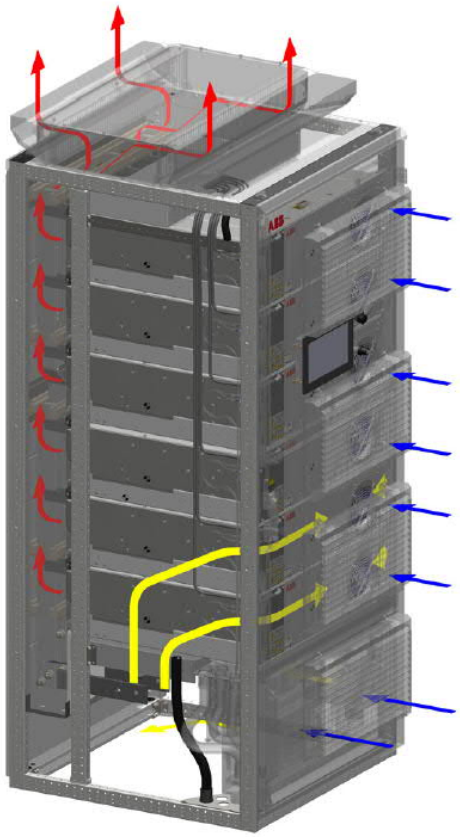


Figure 5-11: Enclosure air flow diagram.

6 Selecting transformer configuration

6.1 Industrial application

When the incoming supply voltage is between 380 Vac and 480 Vac from a TN power network, using an output transformer will give the most flexible output configuration. This will enable the customer to utilize either 3 wire or 4 wire output and give a choice of flexible earthing options.

An additional input transformer may be required if voltage matching is required, this must be Delta – Star with a solidly grounded star point to create a TN network supply. This is the best and recommended configuration for the SureWave SFC.

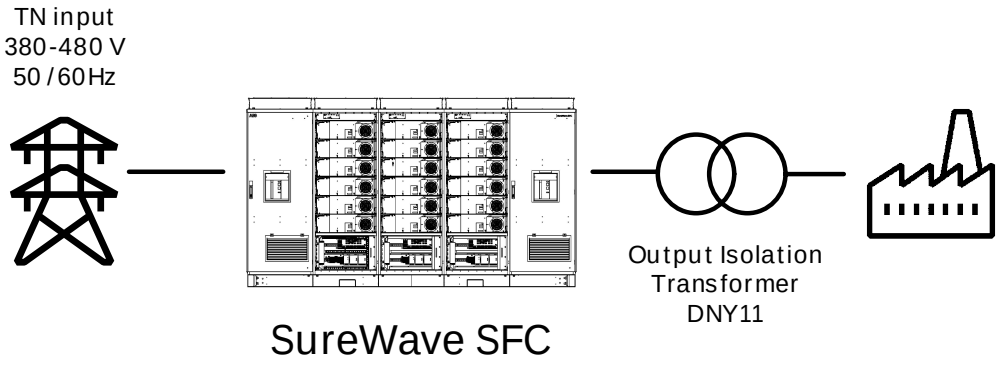


Figure 6-1: Industrial application example.

6.2 Shore to ship (Converter on shore side)

When supplying power to berthed vessels, it is recommended that the SFC has an output transformer. The transformer will not only provide voltage matching and isolation of the common mode voltages generated by the converter, but also very importantly galvanic isolation for the ship from the shore earth. The isolation is required to eliminate earth currents that cause galvanic corrosion.

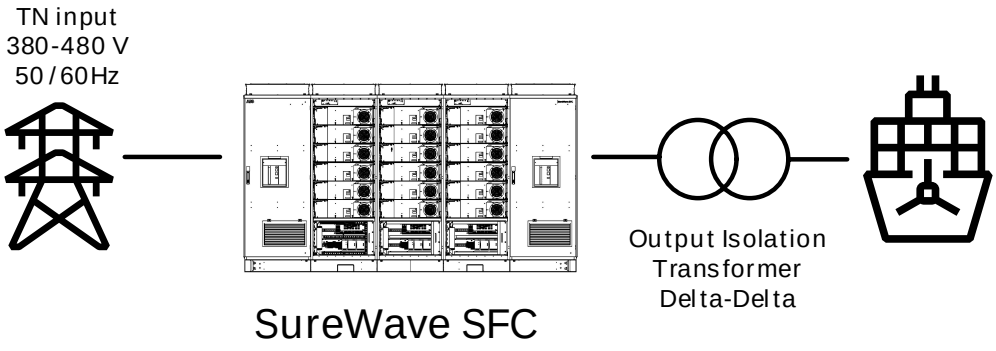


Figure 6-2: Shore to ship typical configuration.

6.3 On-board shore power

When the SureWave is installed on board to provide power conversion from the shore supply, a transformer must be provisioned on the input side of the frequency converter. The transformer will not only provide voltage matching and isolation of the common mode voltages generated by the converter, but also very importantly galvanic isolation from the shore earth. Galvanic isolation from the shore earth is required to eliminate the earth currents that cause galvanic corrosion between the ship's hull and other metal objects. An additional transformer may be required on the output if voltage matching, or a neutral point is required.

Note: unless a static balancer is employed on the output, in this configuration the SFC is not referenced to ground, therefore an earth leakage monitoring device will be required to trip the converter offline if earth faults are detected.

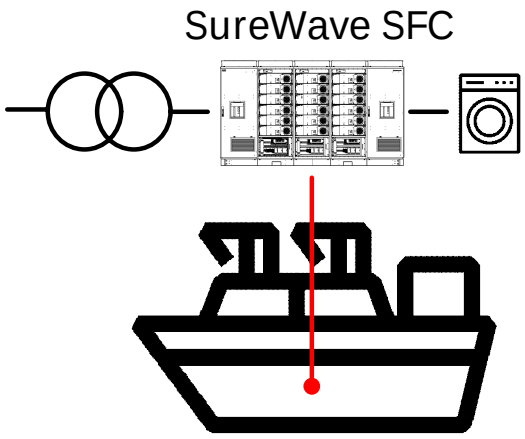


Figure 6-3: On board typical configuration.

6.4 Specifying transformer

The SureWave SFC requires a TN network. The most common and recommended transformer configuration is using an output transformer with DYN11 vector group, and the SFC with input RFI grounded. This gives the SFC a solid ground reference where no additional earth fault detection is required, and also allows single phase loads to utilize the converted power.

In general, there is nothing special about the SureWave SFC transformers, except for an EMC screen (shielding); any quality transformer manufacturer will be able to provide a suitable solution. Please see ABB document 2UCD030000E003 for more detailed information.

6.5 Sizing Transformers

When specifying a transformer, the engineering application team must be aware and take in to account the required power output of the SureWave SFC. If an input transformer is being used allowance must be made for the converter losses which will be around 4%. If both an input and output transformer is employed, allowance must also be made for the additional losses of the additional transformer.

If using an output transformer allowance must be made for internal transformer losses. Also, be aware the rated power is rated at the SureWave SFC output terminals, not after transformer losses.

7 Model definition

Product type code

The product type code defines the characteristics and features of the SureWave SFC. The type code is unique for each model of SureWave SFC and specifies all the parameters needed to order the product. Figure 7-1: SureWave product type code outlines the structure of the type code

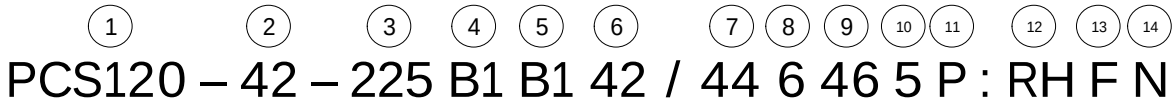


Figure 7-1: SureWave product type code

1	Platform code	6	Ingress protection	11	Operation
2	SureWave product code	7	Input voltage	12	Input termination side
3	Power rating	8	Input frequency	13	RFI configuration
4	Input cable routing & CB	9	Output voltage	14	External LV PSU feed
5	Output cable routing & CB	10	Output frequency		

7.1 Platform code

The SureWave SFC is part of the family of the high-efficiency power converters PCS120. The platform comprises different products for specific applications.

7.2 SureWave product code

Each product in the power conditioning portfolio has its own unique identifier. “42” designates the SureWave SFC static frequency converter product.

7.3 Power rating

Indicates the full load continuous power output rating of the converter. The code number represents the kVA output rating ÷10. For example, the type code indicated in Figure 7-1: SureWave

product type code represents a 2.25 MVA rated unit. Be aware that this rating can only be achieved with input and output voltages at (480 Vac).

Output rating	Code
250 kVA	025
500 kVA	050
750 kVA	075
1000 kVA	100
1250 kVA	125
1500 kVA	150
1750 kVA	175
2000 kVA	200
2250 kVA	225

Table 7-1: SureWave SFC power rating type code

7.4 Input cable routing & CB

The SureWave SFC is available with provision for top or bottom cable routing for the input termination. Models between 250 kVA and 750 kVA only provides bottom cable routing.

Note, termination enclosures are only available for > 750 kVA models.

For protection reasons, it is necessary to supply the SFC through a suitably rated low voltage circuit breaker. Models between 1 MVA and 2.25 MVA have circuit breaker installed by default from the factory.

Cable routing & circuit breaker	Code
Top entry, circuit breaker present	T1
Top entry, no circuit breaker	T0
Bottom entry, circuit breaker present	B1
Bottom entry, no circuit breaker	B0

Table 7-2: SureWave SFC input routing cable & CB type code

7.5 Output cable routing & CB

The SureWave SFC is available with provision for top or bottom cable routing for the output termination. Models between 250 kVA and 750 kVA are only bottom cable routing.

Note, termination enclosures are only available for > 750 kVA models.

Cable routing & circuit breaker	Code
Top entry, circuit breaker present	T1
Top entry, no circuit breaker	T0
Bottom entry, circuit breaker present	B1
Bottom entry, no circuit breaker	B0

Table 7-3: SureWave SFC output routing cable & CB type code

7.6 Ingress protection

IP21 models provide protection against touch and fingers greater than 12mm diameter. Additionally, protects against vertically falling drops of water.

IP42 models protect against tools and small wires greater than 1mm diameter, and against water spray at an angle less than 15 degrees from vertical.

Ingress protection	Code
IP21	21
IP42	42

Table 7-4: SureWave SFC ingress protection type code

7.7 Input voltage

The SureWave SFC covers a wide range of low voltage input levels. The voltage is referred to as the line-to-line RMS voltage. This value may be set through different sources by an operator with the correct log-in credentials.

Note, input voltage values lower than 380 V will need external 3-phase Ac supply the low voltage internal power supplies.

Input voltage	Code
380 V	38
400 V	40
420 V	42
440 V	44
460 V`	46
480 V	48

Table 7-5: SureWave SFC input voltage type code

7.8 Input frequency

The nominal supply input frequency to the SureWave SFC may be set through different sources by an operator with the correct log-in credentials.

Input frequency	Code
50 Hz	5
60 Hz	6

Table 7-6: SureWave SFC input frequency type code

7.9 Output voltage

The SureWave SFC covers a wide range of low voltage output levels. The voltage is referred to as the line-to-line RMS voltage. This value may be set through different sources by an operator with the correct log-in credentials.

Output voltage	Code
340 V	34
360 V	36
380 V	38
400 V	40
420 V	42
440 V	44
460 V`	46
480 V	48

Table 7-7: SureWave SFC output voltage type code

7.10 Output frequency

The nominal output frequency of the SureWave SFC may be set through different sources by an operator with the correct log-in credentials.

Output frequency	Code
50 Hz	5
60 Hz	6

Table 7-8: SureWave SFC output frequency type code

7.11 Operation

The SureWave SFC can be set to operate standalone or to share the load with other power sources e.g., a diesel generator or another SFC.

Operation	Code
Parallel (sharing)	P
Standalone	S

Table 7-9: SureWave SFC operation type code

7.12 Input termination side

It is possible to order the SureWave SFC with the input termination enclosure on the left or the right side (when viewed from front). This selection is made to best suit the layout of the installation location.

Note, termination enclosures are only available for > 750 kVA models.

Input termination side	Code
Left side	LH
Right side	RS

Table 7-10: SureWave SFC input termination side type code

7.13 RFI configuration

To adequately suppress radio frequency interference, the SureWave SFC must be RFI referenced to ground in one end, either input or output side. The recommended standard option for the SureWave is to be fed from a TN network supply using an output transformer and having RFI ground reference on the input side (rectifiers), which means the output side (inverters) is RFI floating. This will also ensure a clean (common-mode noise filtered) 3-phase voltage supply to the auxiliary supply.

As an option, the SureWave SFC's incoming supply can be from a network supply different to TN if required e.g., IT network using an input transformer, in this configuration the output side of the SFC (inverters) needs to be RFI grounded, and the auxiliary supply needs to be externally feed from a 3-phase supply clean of common-mode noise.

Note, for nonstandard use of the SureWave SFC in IT networks earth fault detection device is required.

RFI configuration	Code
Output side (inverter) is RFI floating, input side (rectifier) RFI grounded	F
Output side (inverter) is RFI grounded, input side (rectifier) RFI floating	E

Table 7-11: SureWave SFC RFI configuration type code

7.14 External LV PSU feed

The 3-phase feed to the 24 Vdc power supplies (LV PSU) are normally fed internally by the input supply for each cabinet as the expected incoming network supply is TN using output transformer (output side RFI floating).

In cases where the input side is not RFI grounded (e.g., no output isolation transformer), the supply will have to be externally fed from 3-phase supply clean of common-mode noise, as per LV PSU specifications.

External LV PSU feed	Code
Yes	Y
No	N

Table 7-12: SureWave SFC external LV PSU feed type code

8 Technical specifications

General product data

General	
AC voltage	380 – 480 V line-line
AC frequency range	50 – 60 Hz
Efficiency	96% (typical @ 100% load)
THDi at the input terminals	< 3% (at rated load)
THDv at the output terminals	< 2.5% (linear load)
Overload capability	250% for 2 seconds
Graphic Display Module (GDM)	Functional, high res., resistive 10” display
Acoustic noise	< 80 dBA @ 1 m
Cooling exhaust	Top hat
Input termination cabinet (only > 750 kVA)	Left or right
Cable entry (only for > 750 kVA)	Top or bottom
Communication	MODBUS TCP/IP, Ethernet

Table 8-1: SureWave SFC technical specifications summary

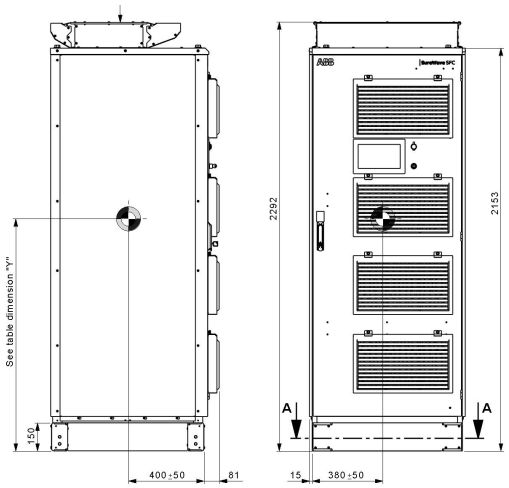
8.1 250 kVA to 2.25 MVA range specifications

	1 PE120			2 PE120			3 PE120		
Module pairs (PEBBs)	1	2	3	4	5	6	7	8	9
Termination Cabinet	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
I/O Breaker	N/A	N/A	N/A	E4.2 2000	E4.2 2000	E4.2 2000	E4.2 3200	E4.2 3200	E4.2 3200
Breaker rating current [A]	N/A	N/A	N/A	2000	2000	2000	3200	3200	3200
Nominal output current [A]	300	600	900	1200	1500	1800	2100	2400	2700
Nominal output power [kVA]	250	500	750	1000	1250	1500	1750	2000	2250
Max output power [kW]	225	450	675	900	1125	1350	1575	1800	2025

Table 8-2: SureWave SFC complete range specifications

8.2 Dimensional data

8.2.1 250 kVA to 750 kVA range

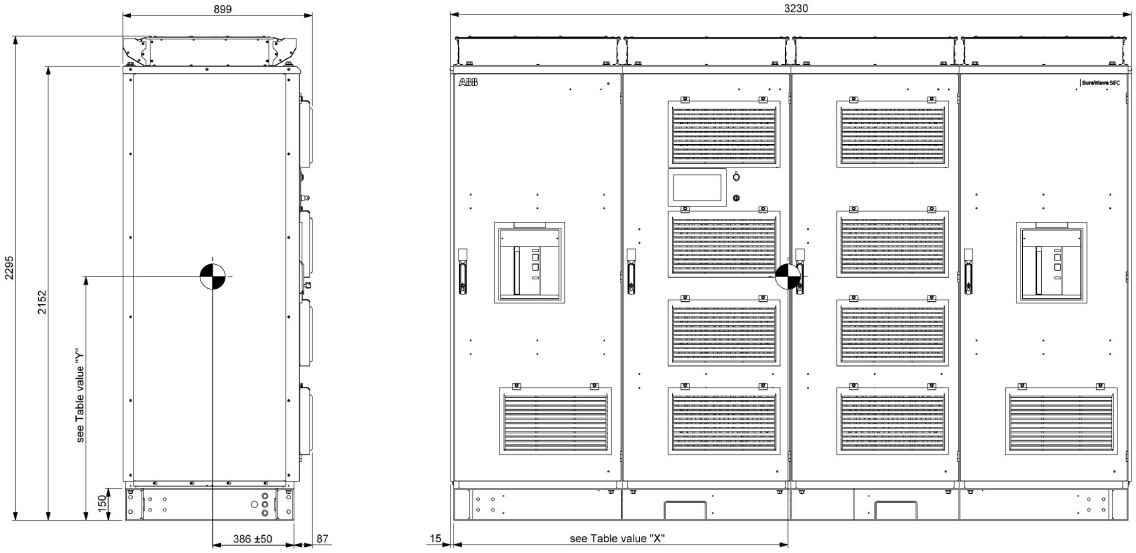


Dim (W x D x H)	830 x 899 x 2292 mm
Weight	1010 kg (fully populated)
Floor loading	1353 kg / m²

Table 8-3: SureWave 250 kVA to 750 kVA range

Refer to 2UCD42000E102_B for more detail

8.2.2 1.0 MVA to 1.5 MVA range

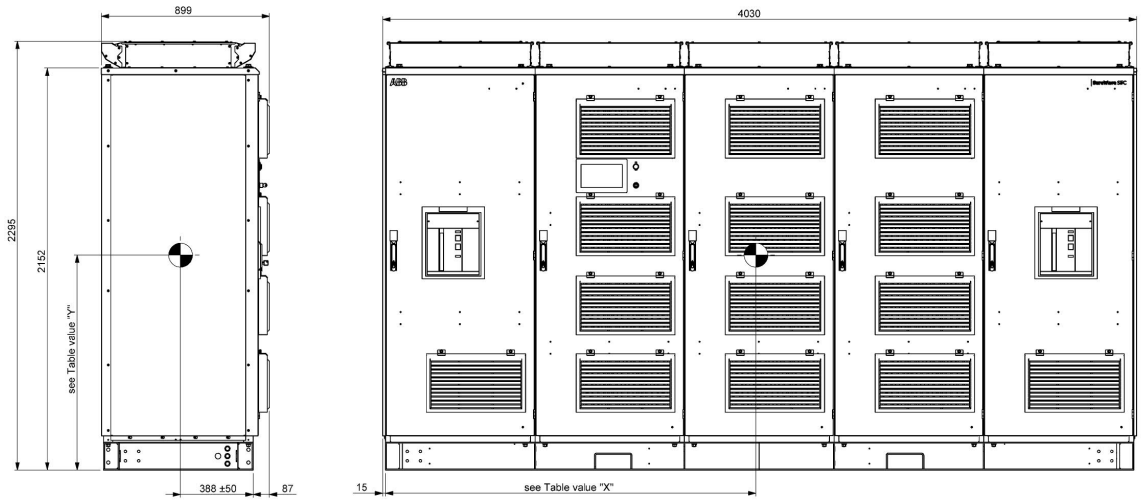


Dimensions (W x D x H)	3230 x 898 x 2295 mm
Weight	3300 kg (bottom entry fully populated)
Floor loading	1136 kg / m²

Table 8-4: SureWave 1.0 MVA to 1.5 MVA range

Refer to 2UCD42000E101_B for more detail

8.2.3 1.75 MVA to 2.25 MVA



Dimensions (W x D x H)	4030 x 899 x 2295 mm
Weight	4400 kg (bottom entry fully populated)
Floor loading	1214 kg/m²

Table 8-5: SureWave 1.75 MVA to 2.25 MVA

Refer to 2UCD42000E103_A for more detail

Note, for more information about the SureWave SFC technical specifications, please refer to 2UCD420000E002_a SureWave SFC Technical Data Sheet

8.3 Circuit breaker specifications

8.3.1 Input circuit protection

The SureWave SFC models < 1 MVA (single enclosure) relies upon upstream protection for current overload and short circuit protection. Upstream protection should be provided by a circuit breaker between the incoming supply and the SFC as per product specifications, please refer to 2UCD420000E002_a SureWave SFC Technical Data Sheet.

Rectifier modules (PEBBs) do not draw large inrush currents, nor do they consume current beyond about 250%. Therefore, upstream protection can be set quite closely. Fast, close protection should be applied. “Fast” protection refers to clearing times (always without delay / as fast as possible - for MCCBs typically 8 - 40ms). “Close” means setting the detection current to levels not much larger than the capability of the rectifier – typically 300%.

8.3.2 Output circuit protection

The SureWave SFC models < 1 MVA (single enclosure) relies upon downstream protection for current overload and short circuit protection when high fault capacities are present on both ends of the SFC. Downstream protection should be provided by a circuit breaker between the incoming supply and the SFC as per product specifications, please refer to 2UCD420000E002_a SureWave SFC Technical Data Sheet.

Inverter modules (PEBBs) do not draw large inrush currents, nor do they consume current beyond about 250%. Therefore, downstream protection can be set quite closely. Fast, close protection should be applied. “Fast” protection refers to clearing times (always without delay / as fast as possible - for MCCBs typically 8 - 40ms). “Close” means setting the detection current to levels not much larger than the capability of the rectifier – typically 300%.

9 Technical specifications

Overview

The following sections provide a general overview of the power and control connections. For detailed description, cable sizes, recommended torque, and information about installation requirements, please refer to the Installation Manual and project-specific documents.

9.1 Power connections to SFC

9.1.1 Single enclosure (250 kVA to 750 kVA)

Single enclosure models (PCS120-42-025xxxxxx, PCS120-42-050xxxxx, and PCS120-42-075xxxxxx) do not have circuit breakers or termination enclosures fitted. It is the responsibility of the customer or system integrator to supply and install these circuit breakers. Power wiring is made directly between these circuit breakers and the SureWave SFC input and output busbars.

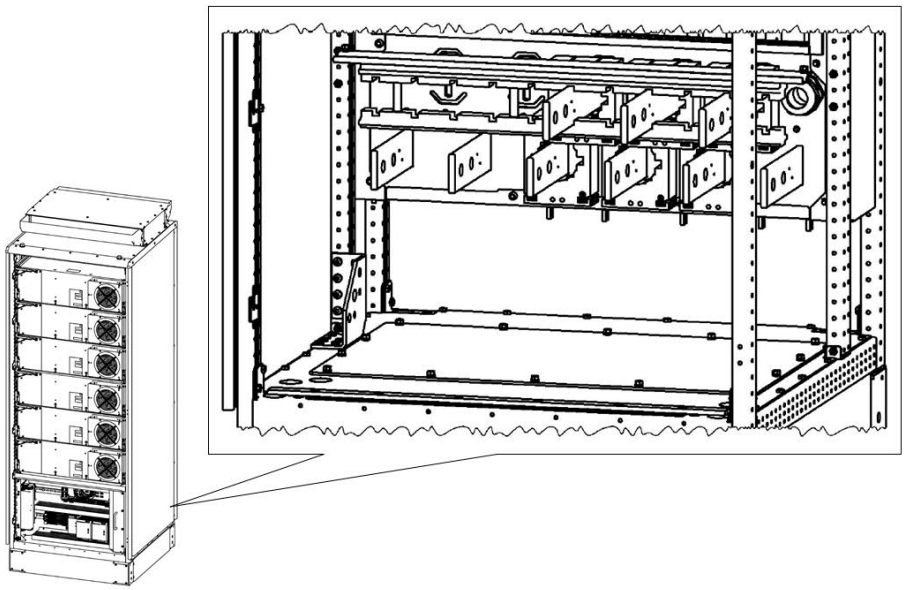


Figure 9-1: Single enclosure power cables connection

9.1.2 Multiple enclosures (1 MVA to 2.25 MVA)

Multiple enclosure models (PCS120-42-100xxxxxx, PCS120-42-125xxxxxx, PCS120-42- 150xxxxxx, PCS120-42-175xxxxxx, PCS120-42-200xxxxxx, PCS120-42-225xxxxxx) have input and output circuit breakers and power termination enclosures supplied by the factory for termination of the power cables.

By default, the input circuit breaker and termination enclosure are located on the left side (front view), and the output circuit breaker and termination enclosure are located on the right side of the plinth. These can be specified as reverse at the time of ordering.

Additionally, for models fitted with termination enclosure, the power cable routing could be from the top or the bottom of the termination enclosure. Single enclosure solution only provides bottom routing.

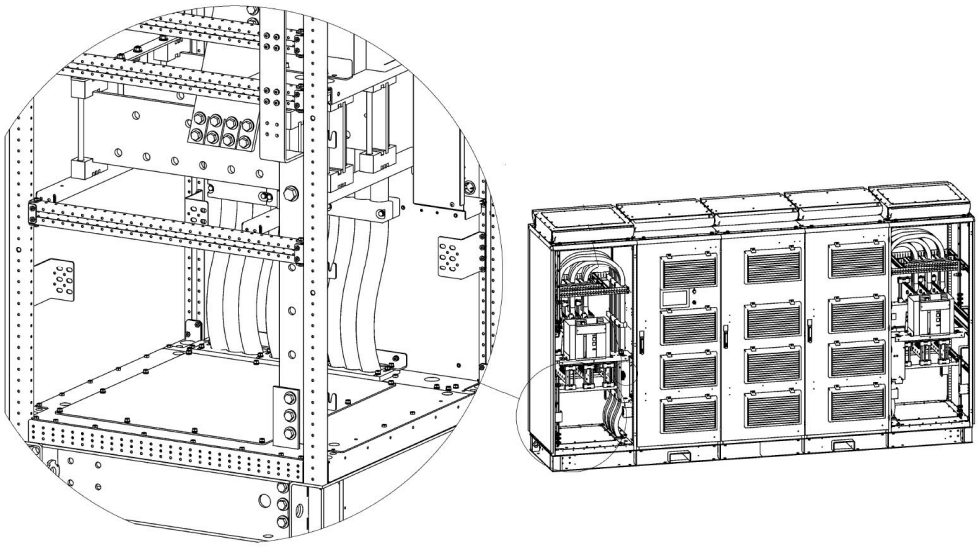


Figure 9-2: Multiple enclosures power cables connection

9.2 I/O interfaces

Multiple digital I/O and analogue I/O are available on the MC (main controller) for monitoring and control of the system.

The ethernet connection for remote webpage and MODBUS is provided for in the MC gear tray. This is routed to the main controller via the graphic display module (GDM), which provided the cyber security.

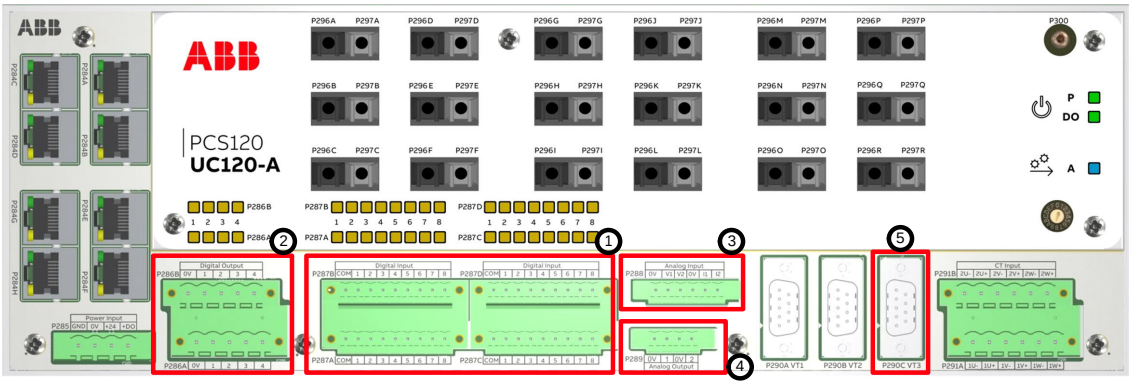


Figure 9-3: Universal controller – User interfaces

1. Digital inputs
2. Digital outputs
3. Analogue inputs
4. Analogue outputs
5. External voltage sync

9.2.1 Digital inputs

A number of digital inputs are provided for customer interface. The inputs are active high, with activation voltage being 24Vdc (supplied). These are summarized in Table 9-1: Summary of control inputs

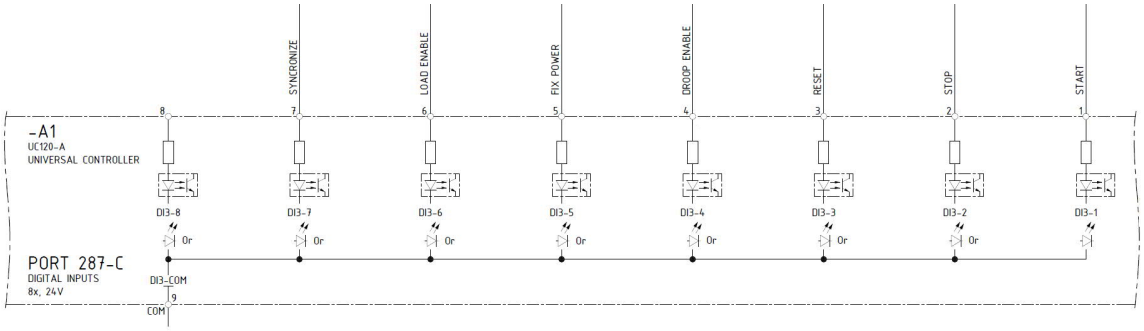


Figure 9-4: User digital inputs

Terminal no.	Name	Description
P287-A-1	Hard stop (EPO)	When system is running & this input goes low (opens), emergency trip is activated.
P287-A-5 (Internal)	Inhibit start (Door switch)	When system is not running, & this input is off, system is inhibited from starting. When system is running & this input goes low (opens), an emergency trip is activated.
P287-B-2	Customer DI-A	Configurable to be used as a warning or a trip, e.g. a transformer thermal warning or trip.
P287-B-3	Customer DI-B	Configurable to be used as a warning or a trip, e.g. a transformer thermal warning or trip.
P287-C-1	Start	Starts the system if not current faults are present

P287-C-2	Stop (Controlled)	Stops the system when running, when droop enabled, the system is first unloaded, when standalone the system will ramp down the output voltage prior to stopping.
P287-C-3	Reset	Rising edge will cause application & PEBB reset. Faults will not necessarily be cleared.
P287-C-4	Droop enable	When this input goes high (closes), system will transfer from isochronous to V_{droop}, F_{droop} mode for parallel operation. If fix power input is high, Droop enable input is overridden.
P287-C-5	Fix power	Applicable only in Virtual Generator mode. When enabled (high), output power and VARs are sourced based on P_{set} and Q_{set}.
P287-C-6	Load enable	Applicable only in Virtual Generator mode, used to bumplessly load or unload the SFC. When enabled (High) the load is ramped to the SFC at a fixed rate, when disabled (Low) the load is offloaded to the other sources.
P287-C-7	Synchronize	Used to synchronize system to another AC bus.
P287-C-8	NA	NA

Table 9-1: Summary of control inputs

9.2.2 Digital outputs

A number of digital outputs are provided, to provide status signals for the customer. Note that these outputs are electronic, rated at 24V 1A each. For remote signaling, suitable relays will need to be fitted and their coils wired to the respective digital outputs.

Table 9-2 summarizes these digital outputs.

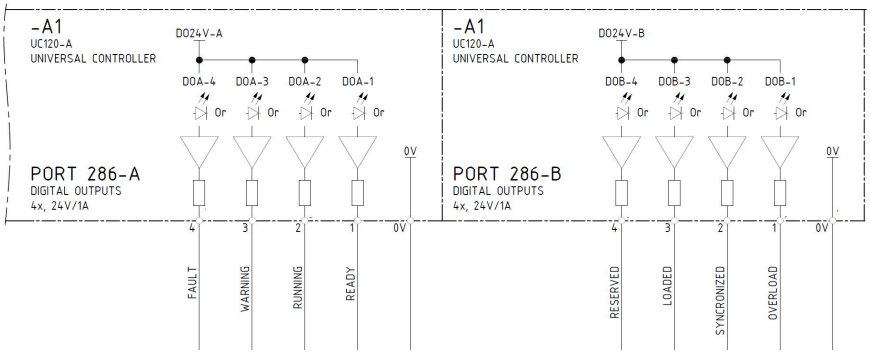


Figure 9-5: User digital outputs

Terminal no.	Name	Description
P286-A-1	Ready	High signal indicates that system is initialized, ready for commands
P286-A-2	Running	High signal indicates system is in final running state, on load and ramps complete, Signal is low during start-up, shutdown or stopped states
P286-A-3	Warning	High signal indicates a system warning is active. System will continue to run but investigation is needed.
P286-A-4	Fault	High signal indicates system in fault or trip, or emergency stop issued. System can only be restarted if fault no longer present and reset is issued to clear the trip.
P286-B-1	Overload	High signal indicates system is supplying more than overload current set point. If this overload persists, the system will eventually trip after configurable trip time.
P286-B-2	Synchronized	High signal indicates output power terminals are synchronized to external bus.
P286-B-3	Loaded	Only relevant in virtual generator mode. When set high, load ramp is at 100%, when low, load % is 0 or not yet reached 100%
P286-B-3	Reserved	

Table 9-2: Summary of status outputs

9.2.3 Analogue inputs

Four analogue inputs are provided, to enable customer input of setpoints. Depending on the output mode selected by the operator, one or more of these setpoints may be used to control the operation of the SFC. Alternatively, fixed setpoints as entered into the GDM may be used. The source for each setpoint may be individually configured from the GDM.

Table 9-3 summarizes these analogue inputs. Two inputs are for +/-10V and the other two are for 0-20mA or 4-20mA.

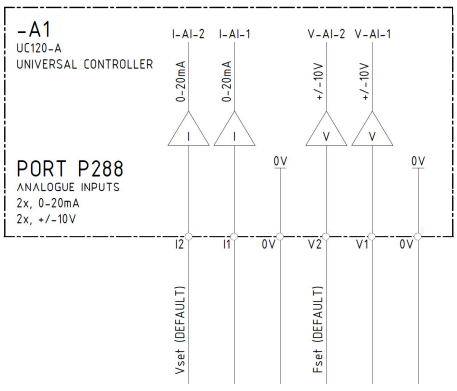


Figure 9-6: User analogue inputs

Terminal no.	Name	Description	Notes
P288-V1	V_{set} (default)	Can be configured to control the External output voltage setpoint	+/-10V
P288-V2	F_{set} (default)	Can be configured to control the External output frequency setpoint	+/-10V
P288-I1	V_{set} (default)	Can be configured to control the External output voltage setpoint	0-20mA or 4-20mA
P288-I2	F_{set} (default)	Can be configured to control the External output frequency setpoint	0-20mA or 4-20mA

Table 9-3: Summary of analogue inputs

9.2.4 Analogue outputs

Two analogue outputs are provided, to enable customer monitoring of various running parameters in the SFC. Table 9-4 summarizes these analogue outputs. Each analogue output may be configured as 0-20mA or 4-20mA or 0-10Vdc

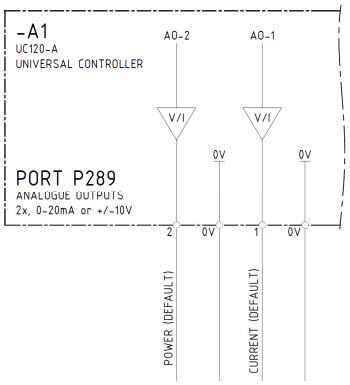


Figure 9-7: User analogue outputs

Terminal no.	Name	Description
P289-1	% of rated power	Output indicates output power delivered as % of its rating
P289-2	% of rated current	Output indicates output current delivered as % of its rating

Table 9-4: Summary of analogue outputs

9.2.5 External voltage sync

A DB9 male connector is provided to enable the SFC output voltage synchronization with an external AC bus. Measurements are taken through a external voltage sense board.

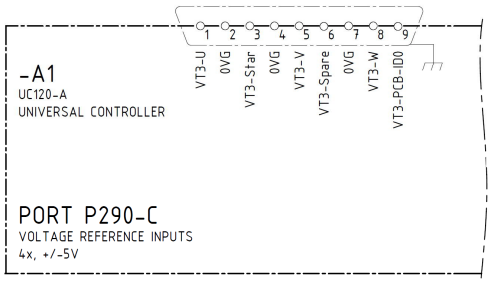
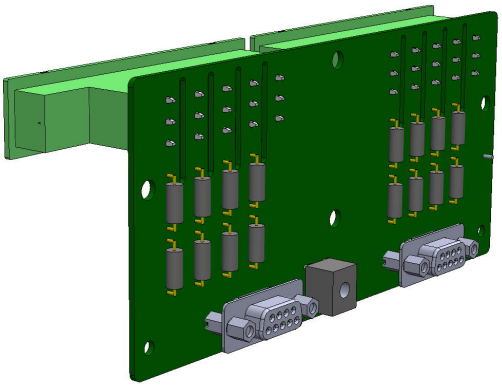


Figure 9-8: User DB9 external voltage sensing for sync

9.2.5.1 External voltage sense board

The external voltage sense board work without external circuitry and it is rated for 900 Vrms



9.2.6 Ethernet port

An ethernet port connection is provided for Modbus TCP and web interfaces can be physically accessed. The connection point is located on the bottom of the Main Enclosure's gear tray via the ethernet coupler "XF2" see Figure 9-9: User ethernet interface

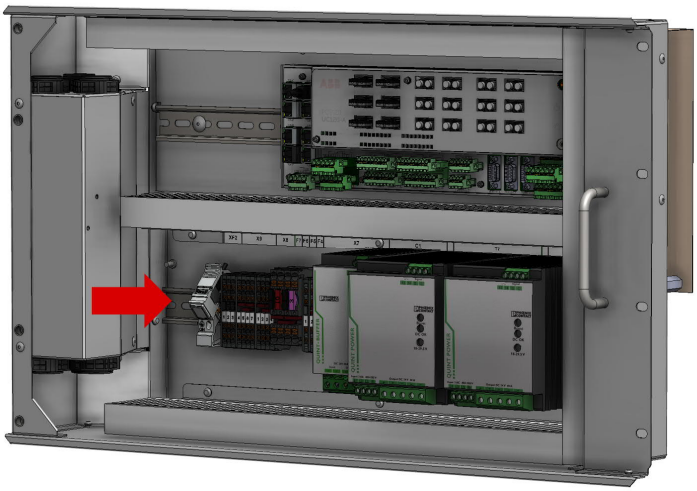


Figure 9-9: User ethernet interface

9.2.7 Webpage interface

A web server of the SureWave SFC is also accessible form the Local Area Network. The webpage interface can be accessed from any device with a web browser by entering the SureWave SFC's IP address into the address bar of the browser. The IP address can be obtained from the right-hand display column on the GDM dashboard page.

Note: There cannot be two devices with the same IP within the same network.

System status and events are accessible from the webpage interface. Start/Stop/Reset, setting of parameters and control are also available to those with the correct log-in credentials.

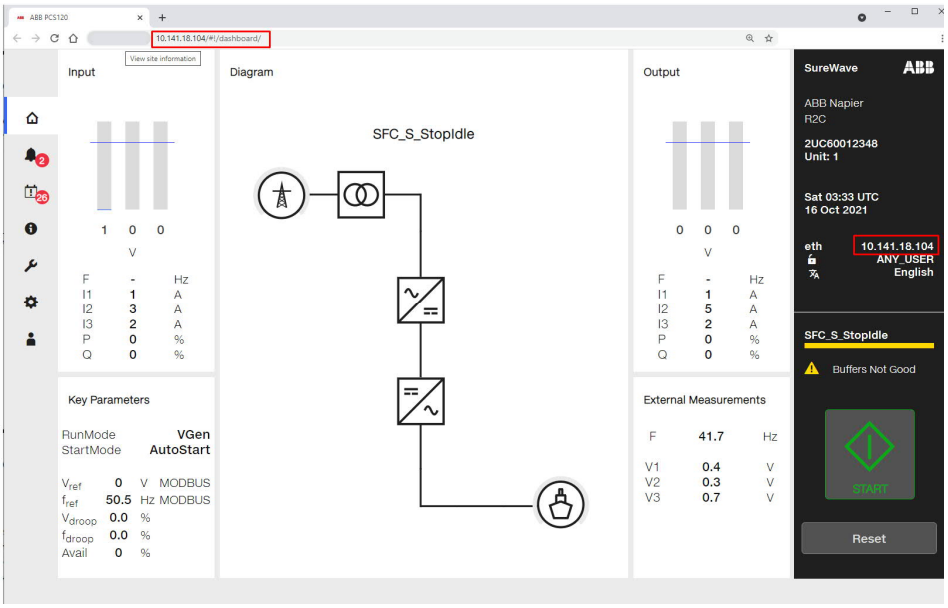


Figure 9-10: Remote webpage interface

9.2.7.1 List of user accounts

The SureWave SFC includes an ABB Service account which is accessible via Secure Shell (SSH). No other accounts are enabled for SSH access. Operator parameter setting to temporarily allow ABB access for Service actions.

SSH is disabled by default, however it can be enabled from the GDM through an Operator parameter setting to temporarily allow ABB access for Service actions.

Username	Interface	Password access	Enable by default
pcs120admin	SSH	No	No

9.2.7.2 Ports and services

- Modbus TCP (read-only registers) on port 502. This port is disabled by default. Enable this MODBUS TCP from the GDM services menu.
- Remote web interface for status/logs on port 443. This port is enabled by default.
- SSH interface for ABB Service on port 22. This port is disabled by default.

9.2.8 Modbus TCP

Ethernet standards support different physical media and topologies. Modbus TCP is a variant of the Modbus communication which uses Modbus messages over TCP connection in an IP network.

The SureWave SFC provides information including input/output voltages/frequencies/currents, and system status through the Modbus TCP communication port.

For a detailed description of Modbus registers, addresses and ranges, refer to SureWave SFC Modbus TCP Register Map (2UCD4200000E005)

9.3 Auxiliary AC power supply for LV PSU

The SureWave SFC's LV PSU can be externally feed if required from a 3-phase, 3-wire AC voltage (380 V to 480 V). The terminal locations are depending on the SFC model.

9.3.1 250 kVA to 750 kVA models

For SureWave SFC models between 250 kVA and 750 kVA the 3-phase terminals location is on the peripheral tray, in the bottom right corner of the PE120-U1 enclosure (when view from the front).

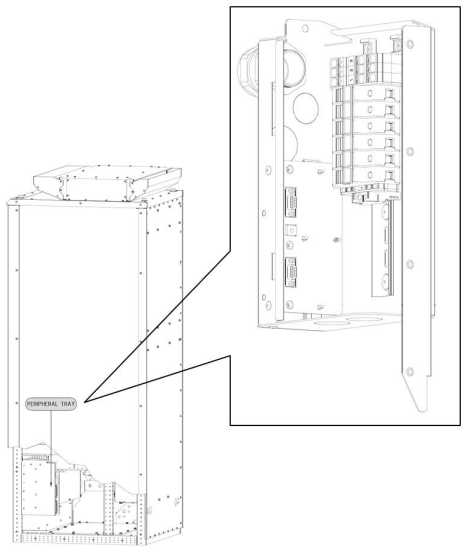


Figure 9-11: Peripheral tray for LV PSU external AC feeding (< 750 kVA)

9.3.2 1 MVA to 2.25 MVA models

For SureWave SFC models between 1 MVA and 2.25 MVA the 3-phase terminals location is on the left-hand termination enclosure, next the PE120-U1 (main).

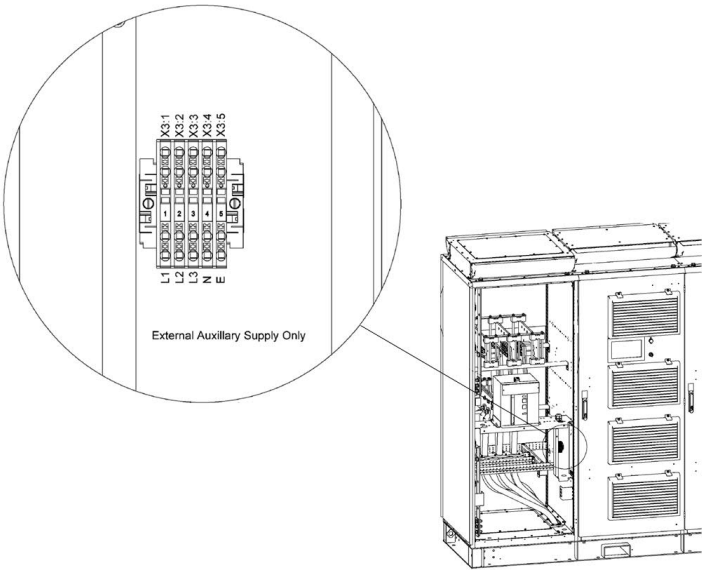


Figure 9-12: Terminal connection for external AC feeding (> 750 kVA models)

10 User Interface

Overview

10.1 Graphic Display Module (GDM)

The primary user interface for configuration of the SureWave SFC is via the Graphic Display Module (GDM) which is mounted on the door of the PE120-U1 enclosure. The HMI contained in it allows local control of the SureWave SFC showing the system status, providing access to the operating parameters, and event history.

The HMI has different screens and menus. The user can switch between them using the navigation buttons appearing on the left side of the GDM screen. On the right side of the GDM screen, the user can view product's main information (product number, access level, language, etc.) and the current system status bar. The Start / Stop and Reset buttons are also placed at the bottom righthand corner of the GDM screen.

The navigation buttons are always observable on the left side of the GDM screen. While the product information, control buttons and the status bar are always visible on the right side of the screen and on all pages.

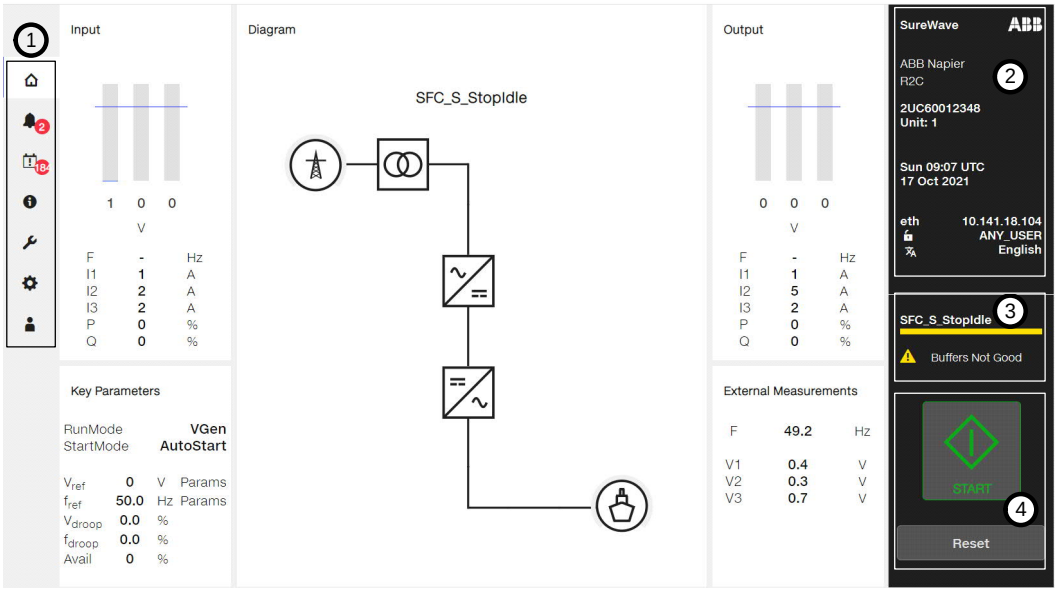


Figure 10-1: GDM screen

1 Navigation buttons

2 Product information

3 System status bar

4 Start/Stop and Reset buttons

To avoid an unintentional operation, after pressing the Start/Stop button, the GDM will show a confirmation window in the middle of the screen and the message "You are going to Start/Stop the SFC block. Please, confirm".

The user can confirm the operation by pressing "START/STOP" on the confirmation window or by pressing "Dismiss" to close the window and return to the previous screen with no changes on the SFC state. Please refer to 11 Operation of the SFC for more information about the system Start/Stop.

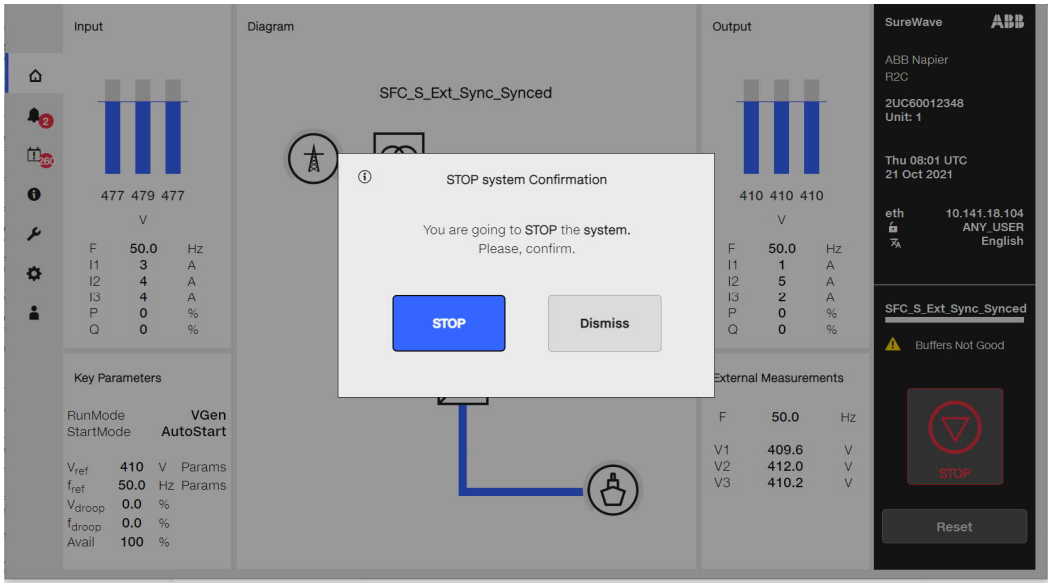


Figure 10-2: GDM – SFC stop confirmation screen

10.2 Navigation buttons

The navigation buttons provide all different main pages available in the SureWave SFC's HMI. These provide to the user a friendly and intuitive way to control and monitor the SureWave SFC.

Icon	Description
	Main - Dashboard
	Active Events
	Event Log
	Product Information
	Service
	Settings
	User

Table 10-1: Navigation buttons

10.2.1 Main Page

Refer to Figure 10-3: SureWave – Main page. This shows the dashboard screen, displaying the running state of the SFC. The screen can be divided into three different functional columns, as follows:

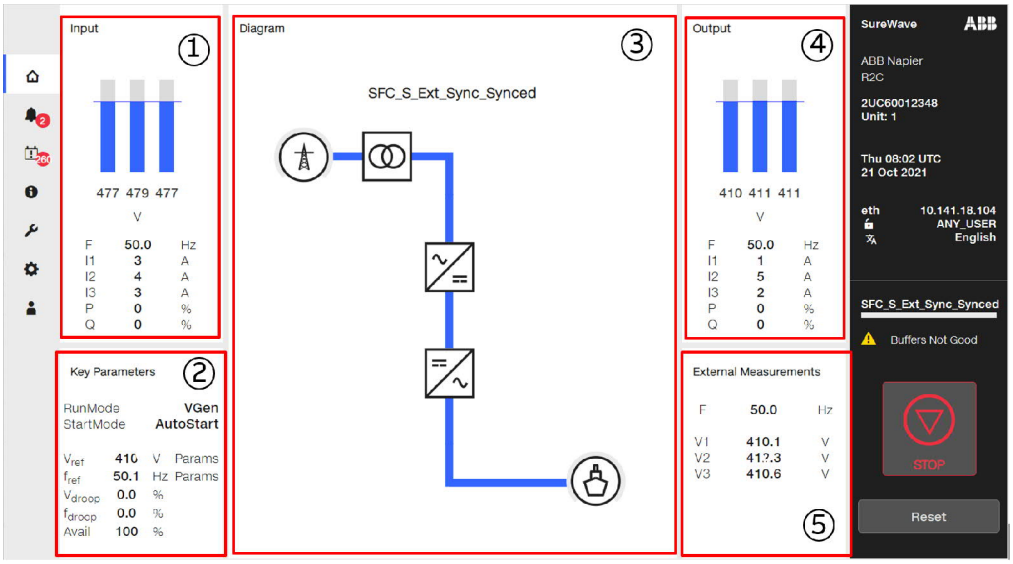


Figure 10-3: SureWave – Main page

10.2.1.1 Column 1- Input.

- Shows the line-to-line voltage (Vrms) of the incoming three-phase power supply
- Input line currents (A)
- Input frequency (Hz)
- Active (% of the power base) and reactive power (% of the power base).

The input voltages are represented by vertical bars at the input and output columns, and a horizontal line across the bars indicates the 100% mark (normalized to the nominal value of the voltage).

10.2.1.2 Colum 2 – Key parameters

- Operation mode
- Start mode
- V/F references (Vrms/Hz) or P and Q references (%)
- V/F droop (% of the base/% of the base)
- Availability (%)

10.2.1.3 Column 3 – Diagram

- Shows a single-line diagram indicating the present operating status of the SFC and indicates the power flow path (direction of power flow is not shown). See Chapter 11 Operation of the SFC for more detail.

The power flow in the SureWave SFC system can be summarized into two main states, Running and Stopped. The thick blue lines will indicate the energized sections.

For applications where the SFC is energized at both ends, the main difference between Running and Stopped states is the energization of the DC bus link between the inverter and the rectifier.

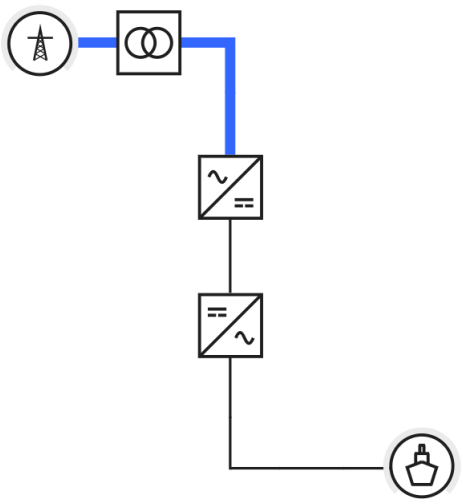
System states	SLD
Stopped	

Table 10-2: SFC power flow stopped state

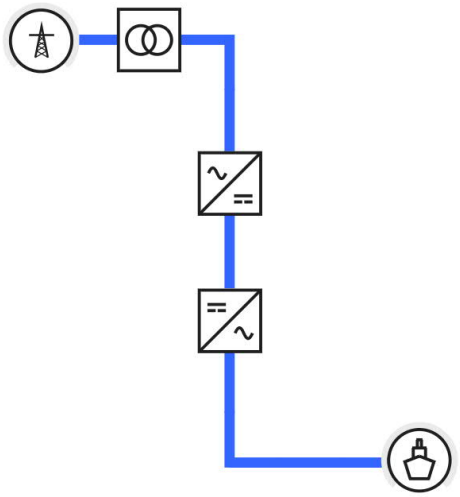
System states	SLD
Running	

Table 10-3: SFC power flow running state

10.2.1.4 Column 4- Output.

- Shows the line-to-line voltage (Vrms) of the outgoing three-phase power supply
- Output line currents (A)
- Output frequency (Hz)
- Active (% of the power base) and reactive power (% of the power base).

The output voltages are represented by vertical bars at the input and output columns, and a horizontal line across the bars indicates the 100% mark (normalized to the nominal value of the voltage).

10.2.1.5 Column – 5 External measurements

- Shows external three-phase line-to-line voltage (Vrms) and frequency (Hz) measurements of the AC external bus to synchronize with.

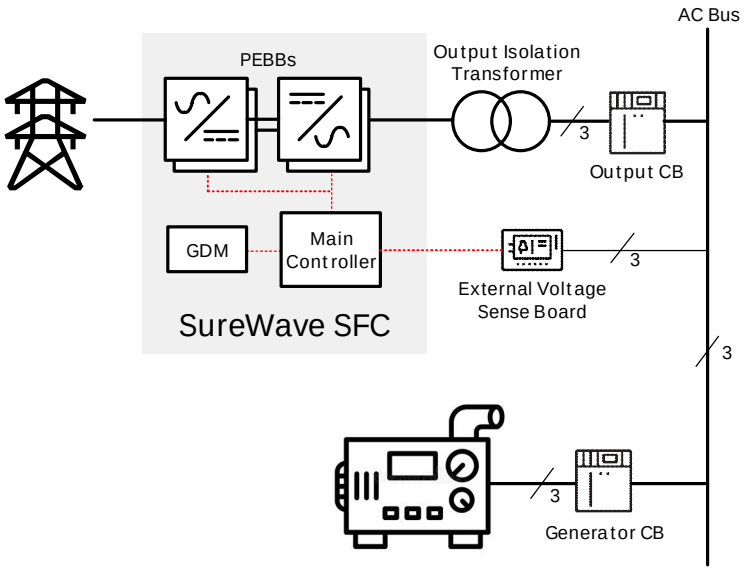


Figure 10-4: Example of an external measuring point

10.2.2 Active events page

This page shows a list of the system messages for currently active events like warnings and faults. When clicking on an active event on the left-hand side of the window, a description of the warning or fault is displayed in the events detail field.

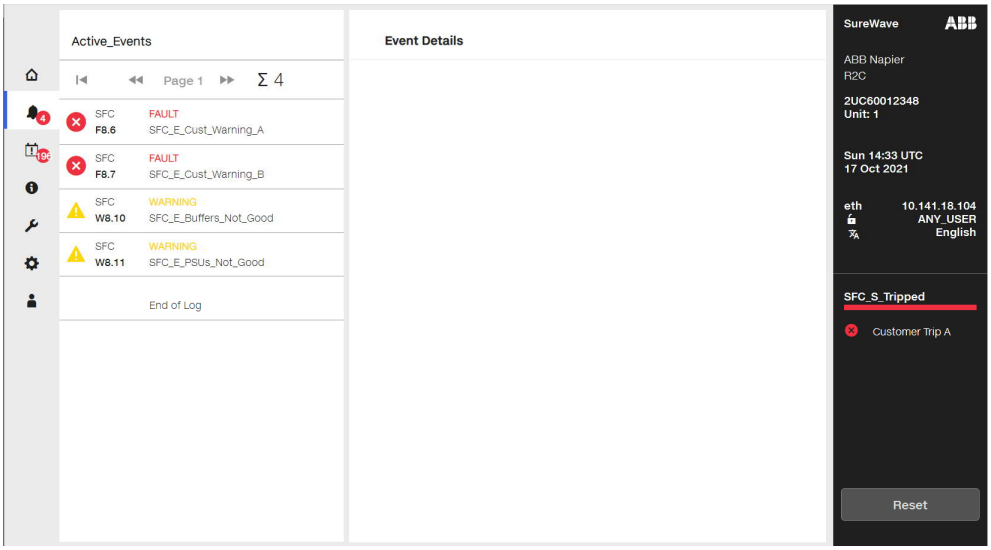


Figure 10-5: SureWave – Active events page

Description of all the icons found in the active events page is shown in Table 10-4: SureWave SFC active events icons

Icon	Description / Function
	Indicates the number of active events (can be seen from any page)
	Indicates an active fault
	Indicates a warning
∑	Indicates the total number of active events
▶▶	Move to the next active events page
◀◀	Return to the previous active events page
▏◀	Return to the first page (latest event)

Table 10-4: SureWave SFC active events icons

10.2.2.1 List of warnings

ID	Event	Description	Recommended Action
6	Customer Warning A	WARNING: Input A of two dedicated inputs trip / warning inputs is configured as a Warning. Typically used for transformer monitoring. This event has occurred.	Check the source of the warning and take action accordingly. In the case of a transformer overheat, shut the system down or reduce the load. Check inter-cabinet wiring. Check TX PTC connections are intact.
7	Customer Warning B	WARNING: Input B of two dedicated inputs trip / warning inputs is configured as a Warning. Typically used for transformer monitoring. This event has occurred.	Check the source of the warning and take action accordingly. In the case of a transformer overheat, shut the system down or reduce the load. Check inter-cabinet wiring. Check TX PTC connections are intact.
8	Chamber Hot	WARNING: One of the PE120s bus bar thermal switches has opened.	Check overload status, PEBB fan operation or exhaust obstruction.
9	Buffers Not Good	WARNING: Power supply buffers problem. Auxiliary power supply failure likely. SFC will soon stop.	Assess cause of power failure.
11	PSUs Not Good	WARNING OR TRIP: One or more of the auxiliary PSU output voltage < 90%, or output in overload. If one fails, fan speed will be reduced. If both fail, SFC will trip.	If SFC still running with reduced cooling, organize PSU Replacement. System can continue running for a time although hotter. If both have failed replace one or more of the PSUs as soon as possible.
37	Output Negative Sequence	WARNING: Output grid PLL has detected output grid is negative sequence.	Check for correct output grid phase sequence. Correct if necessary.

39	Uref Sat max	WARNING: Output Voltage reference exceeds the upper limit threshold.	Check set point parameter is within bounds
40	Uref Sat min	WARNING: Output Voltage reference set below the lower limit threshold.	Check set point parameter is within bounds
41	Freq ref Sat max	WARNING: Output Frequency reference exceeds the upper limit threshold.	Check set point parameter is within bounds
42	Freq ref Sat min	WARNING: Output Frequency reference set below the lower limit threshold.	Check set point parameter is within bounds
43	Vgen Q Sat max	WARNING: Virtual Generator Q loop output has been limited to Sat Max threshold.	AVR has wound up to its upper limit. If in Fixed power, check Qset set point maximum parameter is within bounds.
44	Vgen Q Sat min	WARNING: Virtual Generator Q loop output has been limited to Sat Min threshold.	AVR has wound down to its lower limit. If in Fixed power, check Qset set point minimum parameter is within bounds.
45	Vgen P Sat max	WARNING: Virtual Generator P loop output has been limited to Sat Max threshold.	Governor has wound up to its upper limit. If in Fixed power, check Pset set point maximum parameter is within bounds.
46	Vgen P Sat min	WARNING: Virtual Generator P loop output has been limited to Sat Min threshold.	Governor has wound down to its lower limit. If in Fixed power, check Pset set point minimum parameter is within bounds.
47	Vgen Vlim Sat max	WARNING: Virtual Generator output voltage has been limited to Sat Max threshold.	Voltage control has wound up to its upper limit. If in Fixed power, check Vlim set point maximum parameter is within bounds.
48	Vgen Vlim Sat min	WARNING: Virtual Generator output voltage has been limited to Sat Min threshold.	Voltage control has wound down to its lower limit. If in Fixed power, check Vlim set point minimum parameter is within bounds.
52	Thermal Overload Warning	WARNING: Internal temperature has been measured as higher than warning limit.	Check SFC fans and filters, and repair / clean as necessary. Check SFC load and reduce if necessary. Check cooling fans, filters, and repair / clean if necessary. Check ambient air temperature. Check for cooling air recirculation.
54	External Neg Sequence	WARNING: Negative Sequence detected on External bus.	Check phase rotations of output connections and Vsense measurements

Table 10-5: SureWave SFC active events icons

10.2.2.2 List of faults

ID	Event	Description	Recommended Action
2	EPO Engaged	TRIP: Emergency power off has been activated, 'Hard stop' triggered.	Assess the reason for EPO activation. Release the EPO & reset SFC.
3	Inhibit Engaged	INHIBIT: Inhibit is engaged, system is blocked from starting. Used for servicing the system.	Ensure system is safe to operate before releasing the Inhibit & starting the system.
4	Customer Trip A	TRIP: Input A of two dedicated trip/warning inputs for the customer is configured as a Trip. Typically used for transformer monitoring. This event has occurred, the SFC has tripped, and "Hard stop" triggered.	In the case of a transformer fault: Let transformer cool down before attempting to operate again. Check inter-cabinet wiring. Check TX PTC connections are intact. Check transformer cooling setup.
5	Customer Trip B	TRIP: Input B of two dedicated trip/warning inputs for the customer is configured as a Trip. Typically used for transformer monitoring. This event has occurred, the SFC has tripped, and "Hard stop" triggered.	In the case of a transformer fault: Let transformer cool down before attempting to operate again. Check inter-cabinet wiring. Check TX PTC connections are intact. Check transformer cooling setup.
11	PSUs Not Good	WARNING OR TRIP: One or more of the auxiliary PSU output voltage < 90%, or output in overload. If one fails, fan speed will be reduced. If both fail, SFC will trip.	If SFC still running with reduced cooling, organize PSU Replacement. System can continue running for a time although hotter. If both have failed replace one or more of the PSUs as soon as possible.
35	Input Grid Failure	TRIP: Input grid PLL unlocked or changed to negative sequence, while rectifiers already running.	Address grid issues, reset trip and restart.
49	Input Group Error	TRIP: The rectifier group has reported an error.	Contact Service. See PEBB or PEBB Group Level events and resolve.
50	Output Group Error	TRIP: The inverter group has reported an error	Contact Service. See PEBB or PEBB Group Level events and resolve.
53	Thermal Overload Trip	TRIP: Internal temperature has been measured as higher than trip limit.	Check SFC fans and filters, and repair / clean as necessary. Check ambient temperature. Check for cooling air recirculation.
62	Mode Change Error	TRIP: Mode Change request between VSI & Vgen while running has caused an error	Reset SFC. Change mode while stopped, then restart.

63	Max output voltage exceeded	TRIP: Output voltage has exceeded maximum level limit.	Contact ABB Service.
64	Min output voltage exceeded	TRIP: Output voltage has fallen below minimum level limit.	Contact ABB Service.
65	Max output freq exceeded	TRIP: Output frequency has exceeded maximum level limit.	Contact ABB Service.
66	Min output freq exceeded	TRIP: Output frequency has fallen below minimum level limit.	Contact ABB Service.

Table 10-6: SureWave SFC active events icons

10.2.3 Event Log

This page shows a list of the system messages for system events including origin, code, type, timestamp and basic description. The events are classified as information, warnings, or faults. Up to ten events are displayed on each page.

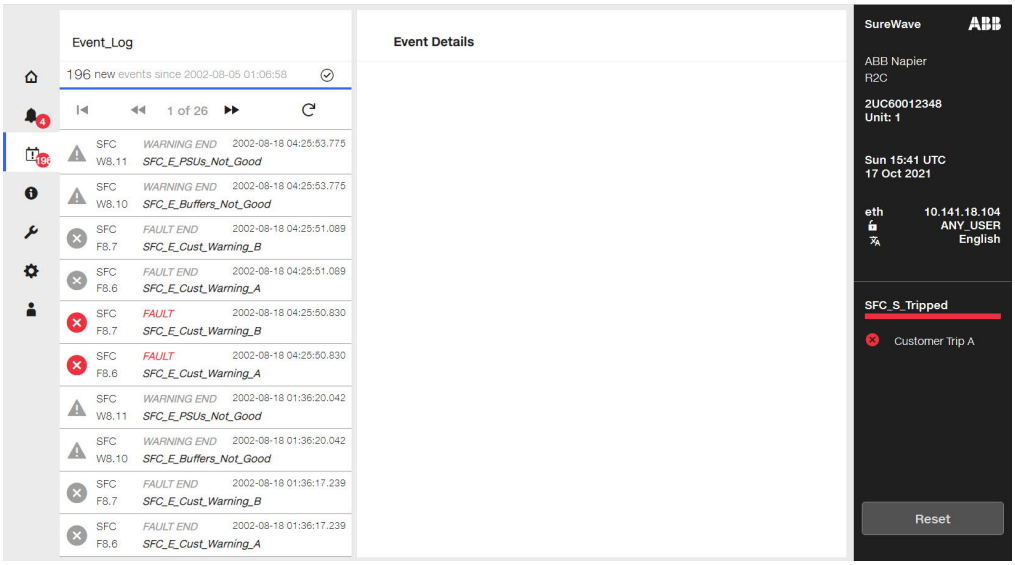


Figure 10-6: Event log page

Table 10-7: Event Log page icons, describes the function of each icon that may appear on the events Log page.

Icon	Description
	Indicates the number of new unacknowledged events (can be seen from any page)
	Indicates an fault
	Indicates a warning
	Move to the next active events page
	Return to the previous active events page
	Return to the first page (latest event)
	Acknowledge all events
	Update events list

Table 10-7: Event Log page icons

10.2.4 Product information page

This page includes all the software version for the different system components. Also, for access level higher than the default one “Any User” the option of “Service Log” is enable.

Figure 10-7: Product information page

10.2.5 Service page

This page is available for service trained authorized personnel that need special access requirements. The main service page includes several sub-pages such as test and calibration pages.

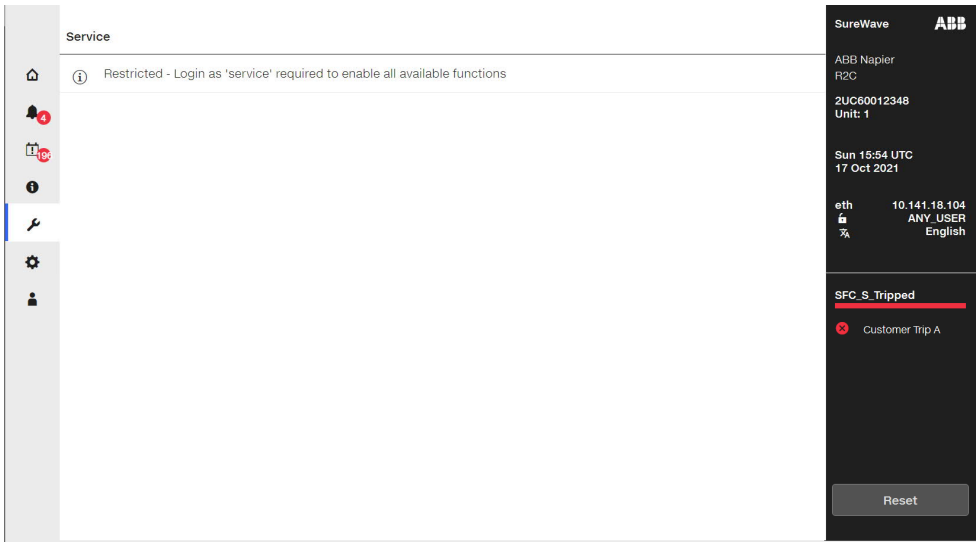


Figure 10-8: Service page

10.2.6 Settings page

The Settings page gives access to SureWave SFC system parameters based on the user log-in and their accessibility level. The parameters are organized into different groups, and each one has specific access rights.

Figure 10-9: Settings page

10.2.6.1 List of parameters

Parameter	Parameter Name	Access
0	Dashboard	w
3	Active Events	w
4	Event Log	w
7	Information	w
73	Service Log	w
74	Firmware Versions	w
8	Service	w
80	Restricted - Login as 'service' required to enable all available functions	r
9	Settings	w
90	General	w
900	Customer Name	w
901	Customer Tag Name	w
902	Site Name	w
903	Unit ID	r
904	Product Name	r
905	Model Name	r
906	Serial Number	r
907	Main Controller Reboot	w
908	PEBBs Reboot	w
91	Graphical Display	w
910	Display	w
9100	Color Theme	w
9101	GDM Reboot	w
9102	Screen Saver Time	w
911	Access	w
9110	Remote Access	w
9111	SSH Port	w
9113	Change Operator Password	w
9114	Service Access	w
912	Network Settings	w
913	Network Status	w
9130	Actual DHCP active	r
9131	Actual IP Address	r

9132	Actual IP Mask	r
9133	Actual IP Gateway	r
9134	MAC Address	r
9135	Ethernet Status	r
9136	Actual DNS 1	r
9137	Actual DNS 2	r
92	Nominal Settings	w
920	Input Nominal RMS Voltage	r
921	Output Nominal RMS Voltage	r
922	Output Nominal Freq Sel	r
93	Input Settings	w
930	Auto-Restart on Grid Drop	w
931	Reactive Current	r
94	Output Settings	w
940	Run Mode Sel	r
941	Start Coupling	w
942	Inductance Compensation	r
943	Resistance Compensation	r
944	Voltage Ref Ramp Rate	r
945	Voltage Trip Maximum	r
946	Voltage Trip Minimum	r
947	Frequency Ref Ramp Rate	r
948	Frequency Trip Maximum	r
949	Frequency Trip Minimum	r
94A	Droop Settings	w
94A0	Voltage Droop (Params Source)	w
94A1	Frequency Droop (Params Source)	w
94B	Virtual Generator	w
94B0	Inertia J	w
94B1	Synthetic Impedance L (VGen Mode Only)	r
94B2	Synthetic Impedance R (VGen Mode Only)	r
94B3	Virtual Generator lower P Limit	w
94B4	Virtual Generator upper P Limit	w
94B5	Virtual Generator lower Q Limit	w
94B6	Virtual Generator upper Q Limit	w
95	System Config	w
950	Breaker A Enable	w

951	Breaker B Enable	w
952	Cust DI A Severity	w
953	Cust DI B Severity	w
96	Commands (Params)	w
960	Droop Enable (Params Source)	w
961	Load Enable (Params Source)	w
962	Fix Power Enable (Params Source)	w
97	References (Params)	w
970	Output Voltage (Params Source)	w
971	Output Frequency (Params Source)	w
972	Fix P ref (Params Source)	w
973	Fix Q ref (Params Source)	w
98	CMD / Ref Sources	w
980	Output Voltage Source	r
981	Output Frequency Source	r
982	Droop Source	r
983	Droop Enable Source	r
984	Load Enable Source	r
985	Fix Power Enable Source	r
986	Fix P ref Source	r
987	Fix Q ref Source	r
99	PEBB Group Configs	w
990	Input Minimum Capacity	r
991	Input RFI Mode	r
992	Input Fan speed	r
993	Output Minimum Capacity	r
994	Output RFI Mode	r
995	Output Fan Speed	r
996	Input PEBB Bitmap	r
997	Output PEBB Bitmap	r

Table 10-8: SureWave SFC list of parameters

10.2.7 User log in page

The SureWave SFC has three levels of user roles available from the touch screen:

- Any User (default)
- Operator
- Service
- Factory

To log in, access the pin code entry screen from the main dashboard login icon.

Select the user role to access the virtual keyboard. This will appear as in Figure 10-10: User Log-in page. Then, enter the password. If no user is logged in, the SFC will remain at a reduced accessibility level of “Any User”.

Logging in prevents the unauthorized changing of parameters and/or the up-loading of firmware. The end-user must log in as operator to enable the SSH (Se-cure Shell) port and to enable the service log-in.

It is recommended that the end-user changes the Operator password from the factory default to improve security.

Warning: Store the password in a safe place, as ABB cannot reset the password on-site. A lost password will necessitate the returning of the GDM to the factory.

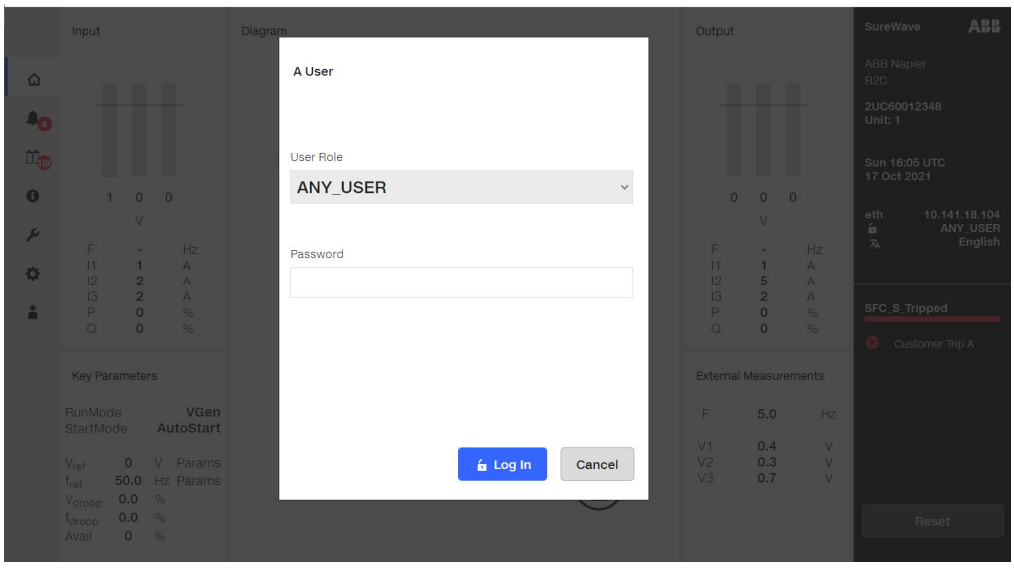


Figure 10-10: User Log-in page

11 Operation of the SFC

Safety

The SFC must be only operated by trained and authorized personnel, i.e., personnel who are familiar with the operation of the SureWave SFC and the hazards involved.

11.1 Machine state flow diagram

While the SureWave SFC system is operational, it has two basic modes of operation Isochronous and droop mode. This section explains the SureWave SFC machine different states transitioning between modes of operation and the logic driving the control of transitioning from one state to another.

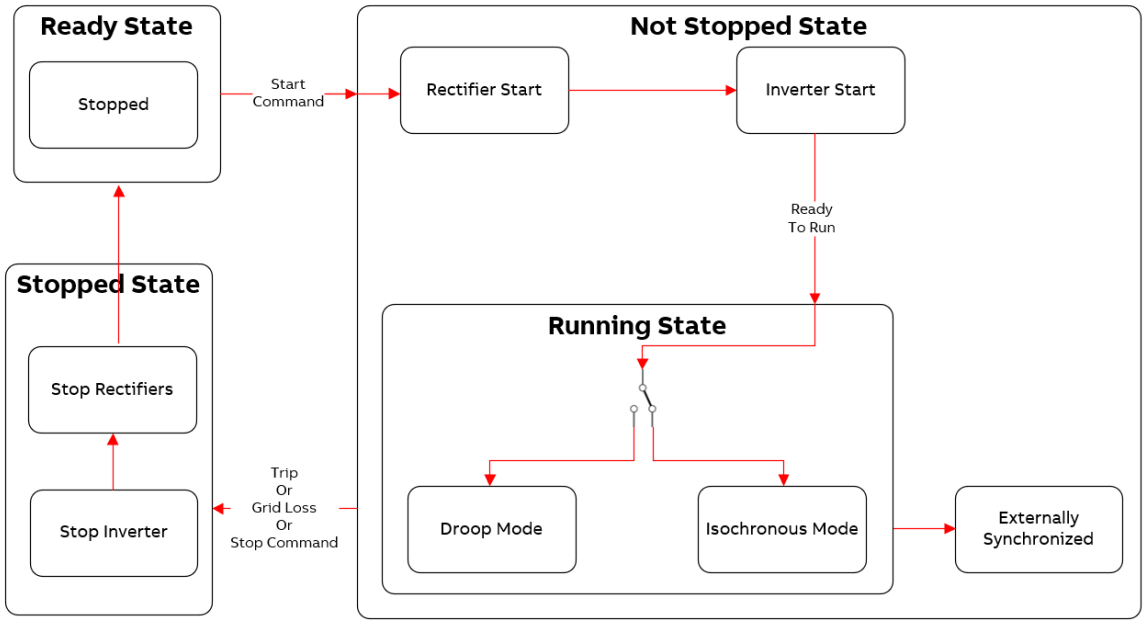


Figure 11-1: SureWave SFC state flow diagram

11.1.1 System states

11.1.1.1 Stopped

Idle - Ready for start command.

Inhibited - System inhibit is activated, all start commands are blocked, used for Service.

Tripped - System has been tripped, this state is latched, a reset command can attempt to unlatch it, if the fault is not still present.

11.1.1.2 Not stopped

Wait input grid - Assesses the input AC feed for voltage frequency and stability prior to starting the rectifiers.

Wait rectifier run -Waits for rectifiers to pre-charge, boost DC bus prior to starting inverters.

Live Bus detect (If Auto start or Coupled start selected) - Determines whether output bus is suitable for a couple start or if 'auto start' is selected determines whether to black start or to couple start.

Black start

Start inverters - Starts the output inverters with 0 volts as the output setpoint.

Ramp-up - Ramps the voltage up from 0 to the set point and a rate defined in the internal parameters.

Coupled start

Output PLL lock - Assesses output AC bus for suitable voltage, magnitude and stability prior to synching.

Sync voltage - Synchronizes internal voltage reference to the output bus.

Sync frequency - Synchronizes internal frequency reference to the output bus.

Sync phase - Synchronizes internal phase reference to the output bus.

Start inverters - Starts inverters a couples with references following the output bus.

RampRef - Transitions the voltage and frequency references to selected reference sources and set points.

Running

VF Isochronous - Output is set to stiff voltage and frequency

VF Droop - Output is set to V and F droop to share with a parallel source.

PQ Set - Fixed P and Q output, only can be used in VGen mode

External Sync - While the output is running, the output voltage, frequency and phase are adjusted to match the external measurements. During this transition the droop sharing is disabled, load enable is forced. When sync command is released the output will transition back to the selected output mode.

11.1.1.3 Stopping

Stop unload - When configured to share with droop or running fixed P and Q then the system will first unload the SFC and hand load off to other generators, prior to stopping the inverters

Stop ramp 0 - If stopping in from and Isochronous mode, the system will ramp the output voltage down to 0 prior to stopping the inverters.

Stop Inverters - Disconnects and stops the inverters

Stop rectifiers - Disconnects and stops the rectifiers

11.2 System start

To start the SureWave SFC the incoming supply needs to be present and the rectifiers AC terminals to be energized. Hence, the user has to check the system state e.g., confirming input voltage is at required levels through the GDM.

Once the input voltage is within nominal conditions and no faults are present, the system can be started via three sources:

- GDM – Via “Dashboard” page, the SFC can be started with the press of one button.
- Digital I/O – the SFC can be started after the “Start” digital signals is received.
- Modbus TCP – The SFC can be started after the “Start” command is received.

11.3 Operation modes

The SureWave SFC may have its output frequency and voltage controlled independently in a number of different ways, depending on the application.

- Stand-alone applications without any other generation equipment connected to the load. This typically require the output frequency and voltage to be fixed.
- Applications with a generator connected in parallel with the SureWave. This typically require the SFC to control its real power output by adjusting its output frequency. This enables seamless handover of load between generator and the SureWave SFC.
- Applications with more than one SureWave SFC in parallel to cover larger loads. Generally, the load sharing is successfully achieved by applying droop to the SureWave SFC output voltage.

11.3.1 Stand-alone (VSI) operation mode

11.3.1.1 VSI-V/F

This mode is typically used when the SFC either stands alone or is the largest unit on a grid. In this mode, the voltage and frequency are regulated very tightly in reaction to load changes.

11.3.1.2 VSI-V/F droop enable

Additionally, the SureWave can operate in parallel and share the load with other energy sources by enabling the frequency and voltage droops.

Note, when droop enable the frequency and the voltage will change depending on the load.

This is not a recommended operation. VGen with droop is the recommended mode of operation when running is parallel with other systems.

11.3.2 Virtual generator (VGen) operation mode

The ABB virtual generator mode is a unique operating mode for a power electronic converter whereby the converter emulates the behavior of a rotary generator and thus interacts with the power system in the same way as a traditional synchronous machine. This behavior is achieved purely through power electronic control and there are no large spinning masses.

When set to virtual generator mode, the SureWave SFC ca be operated in two control modes:

11.3.2.1 VGen-V/F

When operated in virtual generator V/F mode, the SFC run as a standalone power source by tightly controlling its own voltage and frequency. In this setting the SureWave supports the local loads with minimal disturbance.

In this mode, physical inertia is modeled in the SureWave SFC control system providing a damping response to the grid frequency via the energy provided by the incoming supply.

Note, the modelled inertia artificially limits the speed of the SFC, thus this mode is not recommended for applications where fast control is required.

11.3.2.2 VGen-V/F droop

The recommended mode when in parallel with other energy sources.

Note, when droop enable the frequency and the voltage will change and depending on the load.

11.3.2.3 VGen fix power (P/Q)

When operated in VGen fix power, the SFC has the ability to control power flow on the output . This is typically used when interfacing generators to a grid where power flow to and from the grid must be controlled. The SureWave SFC operates with setpoints for both real power (P) and reactive power (Q).

Note, switching between V/F and fix power control modes can be done while the system is running, which is particularly interesting for micro-grid applications.

11.4 VSI vs virtual generator

VSI mode is the simplest mode and can provide ‘stiff’ voltage and frequency. This has the fastest transient response. Although it can be used with droop it is not recommended.

Virtual generator mode is the most powerful when it comes to load sharing. It can be tuned to emulate the transient behavior of almost any type and size of generator. This allows even load

distribution during load steps. It also enables bump less loading or unloading of the SFC, so that parallel generators are not exposed to large load steps.

It also enables fixed real power and Var sourcing for advanced uses.

11.5 SureWave SFC performance

11.5.1 Step load capability

The step load capability of a power converter or generator is a measure of how much load can be applied to the converter or generator, without output voltage or frequency deviating from specification.

The step load capability of a generator is typically between 10% and 75% of its capacity, depending on the generator and type of prime mover. In contrast, the step load capacity of the SureWave SFC is 100% of its capacity.

Thus, depending on the parametrization of the SureWave SFC, if it is used in parallel with one or more generators, the step load capability of the overall system is substantially improved. Immediately on load application, the SureWave SFC typically will take on all the additional load, and then the load increase is gradually passed over to the generator(s).

11.5.2 Load rejection capability

A load rejection is a decrease in load. Load rejection capability is a measure of how much load can be removed from the output of a converter or generator while still providing output voltage and frequency within specifications.

The load rejection capability of a generator set is very dependent on its prime mover. Typical figures may be:

Steam turbine: 10 to 30% of its present loading.

Gas reciprocating: 50 to 100% of its present loading.

Diesel reciprocating: 90 to 100% of its present loading.

The SureWave SFC has a load rejection capability in excess of its present loading – that is, the SFC output power can briefly go negative by regenerating power into the source grid.

Thus, if the SureWave SFC is used in parallel with one or more energy sources, it can assist in handling load rejection by absorbing any energy transients and dissipating them by regenerating back into the grid. This can prevent the generator(s) from going into “reverse power” and tripping off. The decrease in load is then passed over to the other generator(s).

Note, for load rejection capability of the SureWave SFC, the real power (P) limits need to be considered.

11.6 Remote AC bus Synchronization

The SureWave SFC can connect to a live AC bus using its in-built synchronizer. This allows uninterrupted power to an AC bus while transferring from alternate AC power sources such as standby generators to the SFC.

The seamless transfer function is controlled by using the main controller digital I/O as described in 9.2 I/O interfaces.

11.6.1 Transfer generator to SFC

11.6.1.1 Generator to SFC installation SLD

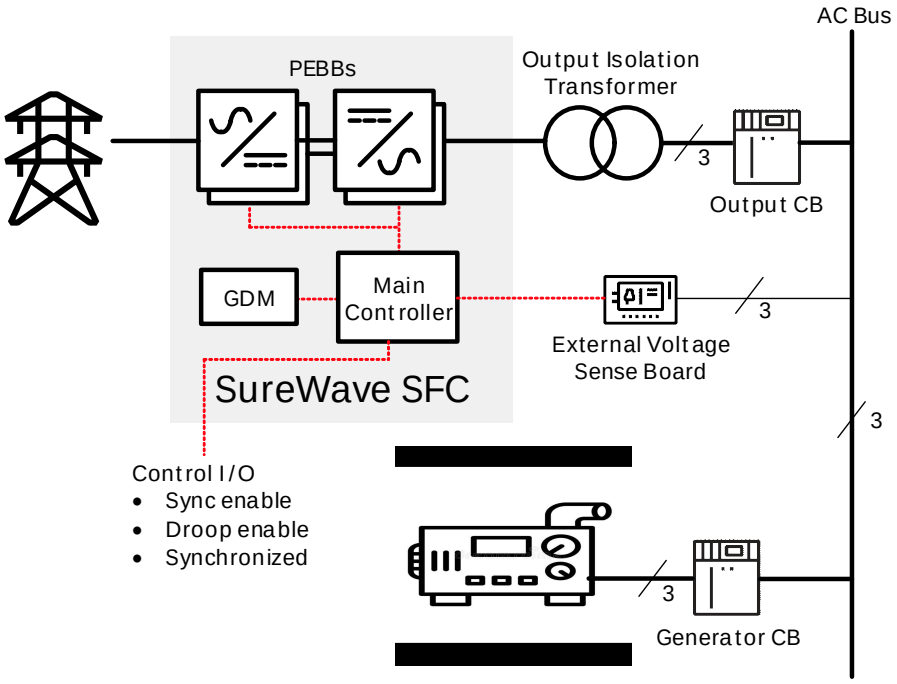


Figure 11-2: Seamless transfer from a generator to SFC

The installation and connection of the SureWave SFC to allow seamless transfer from a generator is shown in Figure 11-2: Seamless transfer from a generator to SFC.

Note, for proper operation the phase and voltage relationship between the voltages measured by the external voltage sense and the inverter terminals must be known. A neutral is not required for the synchronizing function and if present, does not need to be connected to the external voltage sense board.

11.6.1.2 Generator to SFC transfer procedure

The procedure for transferring from generator to SFC is as follows. Please refer to the SureWave commissioning manual for a complete detailed transfer procedure description.

Step	Description
1	With the output CB open, start the SureWave SFC
2	Enable V/F droops to allow the SFC to parallel with the generator
3	Command the SureWave SFC to synchronize to the reference as measured on the external voltage sense board.
5	Once the SFC is synchronized, the output CB can now be closed connecting the SFC to the AC bus.
6	Remove the synchronize command The SFC is now in parallel with the generator.
7	Once the generator is offline, disable the V/F droops. The AC bus is now being supplied from the SFC.

Table 11-1: Generator to SFC transfer procedure

11.6.1.3 Parallel operation with generator

If a long-term parallel operation and load sharing with a generator is required, ensure the generator has the identical voltage and frequency setpoints, as well as equal droop characteristic settings for both voltage and frequency. Follow the steps above until step 6. The SFC and generator will now be sharing the load.

The load may be transferred from either machine by setting the unload command on the SFC or unloading the Generator.

11.6.2 Transfer SFC to generator

Typically, generators will have their own synchronizer, which will perform the synchronization to the SFC supplied AC bus. If a generator is unstable when connected to the AC bus supplied by the SFC, enabling V/F droops on the SureWave SFC might help with stability.

11.6.2.1 SFC to generator installation SLD

The installation and connection of the SureWave SFC to allow seamless transfer from the SFC to generator is shown in Figure 11-3: Seamless transfer from the SFC to generator. In this scenario the external voltage sensing must be moved to sense the generator output voltage that is to be brought online. This could be done with a change-over relay to allow both connections to the external voltage sensing board.

Note, for proper operation the phase and voltage relationship between the voltages measured by the external voltage sense and the inverter terminals must be known. A neutral is not required for the synchronizing function and if present, does not need to be connected to the external voltage sense board.

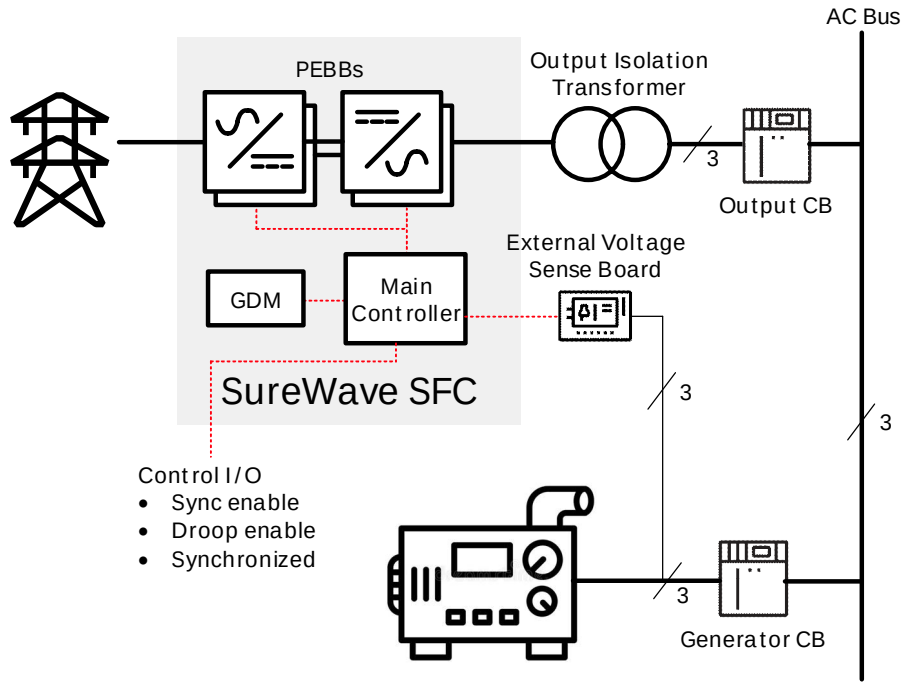


Figure 11-3: Seamless transfer from the SFC to generator

11.6.2.2 SFC to generator transfer procedure

The procedure for transferring from generator to SFC is as follows. Please refer to the SureWave commissioning manual for a complete detailed transfer procedure description.

Step	Description
1	With the generator contactor open, start the generator.
2	Once the generator output is stable and ready for loading, enable SureWave V/F droops to allow the SFC to parallel with the generator when the generator is online.
3	Command the SureWave SFC to synchronize to the reference as measured on the external voltage sense board.
4	Once the SFC is synchronized, the generator CB can now be closed connecting the generator to the AC bus.
6	Once the generator is online the SFC can be off loaded and switched off. The AC bus is now being supplied from the generator.

Table 11-2: SFC to generator transfer procedure

11.6.2.3 Parallel operation with generator

If a long-term parallel operation and load sharing with a generator is required, ensure the generator has the identical voltage and frequency setpoints, as well as equal droop characteristic settings for both voltage and frequency. Follow the steps above until step 6. The SFC and generator will now be sharing the load.

The load may be transferred from either machine by setting the unload command on the SFC or unloading the Generator.

11.6.3 External voltage sense board calibration

If the SFC has an output transformer, the transformers' output voltage and the voltage phase angle will be different to inverter output (transformer input). When the external voltage sense board is used for remote synchronization, these differences will need to be trimmed out. Please refer to the SureWave commissioning manual for a complete detailed transfer procedure description.

11.7 System EPO

The system Emergency Power Off (EPO) is a digital input linked to the site EPO and use to inhibit the SureWave SFC operation in case of emergency shut down. For larger systems > 750kVA the emergency inhibit action will not open the CBs located inside the termination enclosures.

11.8 Hard fault

Hard faults are extremely rare situations where multiple failures occur at the same time, and the system is not capable of keeping the correct operation any longer. In the case of hard fault the SureWave will stop operation and report accordingly. For larger systems > 750kVA a hard fault scenario will not open the CBs located inside the termination enclosures.

12 Maintenance schedule

Overview

The recommended intervals for maintenance and component replacement are based on the normal operating conditions of the SureWave SFC. The SFC should be checked at least annually by qualified personnel whose recommendations should be followed. Depending on the actual conditions of the SureWave SFC, maintenance work can be carried out before or after the recommended interval.

Item	Years from start up													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Power supply	-	-	-	-	-	-	I	I	I	R	-	-	-	-
PSU buffer	-	-	-	-	-	-	I	I	I	R	-	-	-	-
Busbar contact grease	-	-	-	-	-	R	-	-	-	I	I	R	-	-
PEBB fan	-	-	I	I	I	R	I	I	I	I	I	R	I	I
PEBB air filter kit	-	-	I	I	I	R	I	I	I	I	I	R	I	I
PEBB AC caps	-	-	-	-	-	-	I	I	I	R	-	-	-	-
Enclosure air filter kit	I	I	R	I	I	R	I	I	R	I	I	R	I	I
Input/output breakers*														

Table 12-1: SFC to generator transfer procedure

Key:

I = Inspection (visual inspection, corrective measures, repair and/or replacement of component if needed).

R = Replacement of component.

- = No action

* Refer to ABB library document 1SDH001000R0002

https://to.abb/RH91iGe3

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