2UCD190000E001 rev. J

PCS100 ESS
Grid Connect Interface for Energy Storage Systems
User Manual

Introduction

ABB's PCS100 ESS converter is a grid connect interface for energy storage systems that allows energy to be stored or accessed exactly when it is required. Able to connect to any battery type or energy storage medium, the PCS100 ESS brings together decades of grid interconnection experience and leadership in power conversion to provide seamless system integration and battery control.

The PCS100 ESS' modular design and advanced control maximize the availability, value and performance of both large and small energy storage systems in a variety of applications. With this optimized use of the energy storage system, the PCS100 ESS helps to deliver exceptional returns on investment.

The PCS100 ESS allows control of both real power (P) and reactive power (Q), enabling it to cover a wide range of system requirements.

Moreover, advanced control features in the Virtual Generator mode of operation allow this storage system to emulate generator behavior and thus act as a true power system component.

With these advanced features the PCS100 ESS is the perfect solution for applications requiring power system load levelling, grid stabilization, grid loss detection, grid compliance for renewable and generation systems and power quality improvement.

For a comprehensive overview of publications available for the PCS100 ESS, refer to the inside cover of this publication. Web links and QR code are also included.

The Company

We are an established world force in the design and manufacture of power electronics and power protection equipment.

As a part of ABB, a world leader in electrical technology, we offer customers application expertise, service and support worldwide.

We are committed to teamwork, high quality manufacturing, advanced technology and unrivalled service and support.

The quality, accuracy and performance of the Company's products result from over 100 years of experience, combined with a continuous program of innovative design and development to incorporate the latest technology.

Quality Control

The products listed in this catalogue are manufactured in an ISO 9001 accredited facility.

TELARC REGISTERED ISO 9001

Registration No. 2469

For more information…

Further publications for the PCS100 ESS are available for free download from https://new.abb.com/power-converters-inverters/power-converters-and-inverters/pcs100-ess or by scanning this code:

Overview of this Manual

About this Manual

This manual contains information regarding:

- the general functions of the PCS100 ESS
- the user interface, control and possible adjustments of the PCS100 ESS
- installation and commissioning of the PCS100 ESS

Usage

This manual should be used during operation and adjustment of the PCS100 ESS. It should be referenced when:

- integrating the PCS100 ESS into a complete BESS system
- operating and adjusting the PCS100 ESS
- commissioning the PCS100 ESS

Who should read this manual?

This manual is intended for:

- integrators of the PCS100 ESS
- installation personnel
- operators

Prerequisites

An installation/repair/operator person working with the PCS100 ESS must:

- be trained by ABB and have electrical operational and safety knowledge
- have sufficient training to operate in an accidentally touch safe service environment

Software Revision

This User Manual applies to PCS100 ESS systems with software revision **R2M2**.

Note: To locate the current software release number, on the GDM's Control Panel, press Product. The release number is labeled *"Release: …"*.

Safety Notices

This manual contains important information regarding the operation of the ABB PCS100 ESS. This manual provides technical and operational guidance for operators. The following safety instructions are to be observed.

DANGER
This manual does not provide sufficient information for safe service of the PCS100 ESS. For such service information refer to appropriate manual.

Please pay due regard to safety as the PCS100 ESSs are high energy devices and require strict precautions to be taken.

CAUTION – Trained Operators
All operations on the PCS100 ESS must only be carried out by a trained Operator familiar with the contents of this manual. Hazardous conditions could arise from incorrect adjustment.

Ensure power to the product is isolated and locked off before attempting any work on it.

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 voltages. DO NOT TOUCH components or connections that have voltage present.

DANGER – Stored Charge
Stored charge is present after the device is switched off.

DANGER – Arc Flash
Shorted terminals can cause arc flash resulting in severe burns, severe eye injury or blindness. Use insulated tools and do not short any terminals.

DANGER – High Leakage Current
The leakage current that is produced during normal operation of an ESS rack system exceeds 3.5 mAac. The ESS rack system is required to be installed in a fixed connection for protection.

DANGER – Protective Covers
Normal operation of this product requires any protective covers in place and doors secured closed.

DANGER – Personal Protection Equipment
Ensure safety glasses are worn while working if any part of the unit could be energized.

DANGER – Personal Protection Equipment
Ensure appropriate safety footwear is worn if inserting or removing modules or components from the product.

Table of Contents

1 Overview

In today's power systems energy storage devices such as new generation batteries, flywheels and super capacitors provide the opportunity to store energy from the electricity grid and return it when required. This offers a huge range of options to strengthen and enhance the performance, quality and reliability of smart electricity grids. Providing the grid connect interface for all types of energy storage devices, the PCS100 ESS is the perfect solution to connect such energy storage devices to the grid.

The PCS100 ESS is based on a LV converter platform especially developed for power quality issues and characterized by wide bandwidth performance and great flexibility thanks to its modular power electronic configuration. It offers two main modes of operation, namely Current Source mode and Virtual Generator mode, which enables the PCS100 ESS to cover a wide range of applications and power system requirements. Both modes offer independent control of both real power (P) and reactive power (Q) providing the highest possible flexibility to the operator. In addition, advanced control features in the Virtual Generator mode allow the PCS100 ESS to emulate generator behavior and thus to interact with the power system in the same way as a traditional synchronous machine. Such behavior is achieved purely through power electronic control and there are no large spinning masses.

In case the grid supply is lost the system can be set to shut down according to anti-islanding standards or to operate in island mode, where the PCS100 ESS operates disconnected from the main grid but continues to supply local loads. When operating in island mode, the PCS100 ESS can automatically re-synchronize the islanded network with the main grid, allowing a seamless transfer back to grid connect mode.

1.1 User Benefits

- Supports power system load levelling and thus helps defer network and generation investment
- Increases network stability and transmission capacity and thus facilitates increased use of renewables
- Delivers grid compliance for renewable and other generation systems
- Damps disturbances and oscillations in critical system configurations
- Modular design for highest availability
- Based on LV converter platform especially developed for power quality issues

1.2 Features

- Modular design providing high reliability and typically 30 minutes mean time to repair (MTTR)
- Grid fault detection
- Islanding and anti-islanding options
- Ratings from 100 kVA to 4000 kVA and voltages from 150 Vac to 480 Vac
- Allows a range of energy storage devices to be coupled to the grid
- Dynamic real power control (P)
- Dynamic reactive power control (Q)
- Generator emulating control mode
- Grid stabilization features including synthetic inertia and active damping
- Low voltage ride through (LVRT)
- Voltage and frequency dynamic envelope/regulation functions
- Voltage clamping for reactive power grid support
- Black start option

1.3 Applications

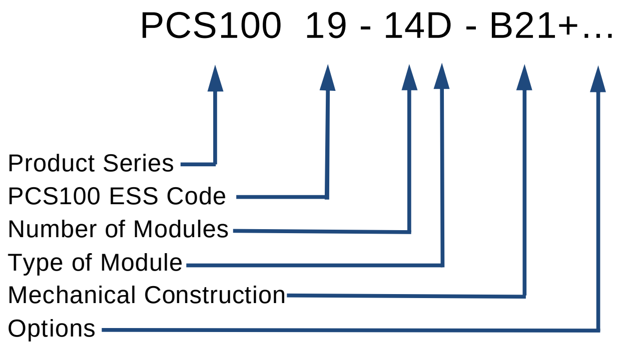
- Integration of renewable energy (to meet grid codes regarding LVRT, ZVRT)
- Load levelling for optimized generation utilization
- Spinning reserve in case of line loss
- Frequency regulation
- Peak shaving (end user)
- Micro grids, Islanding and Anti-Islanding

2 Model Definition

2.1 Type Code

The PCS100 ESS type code is given in the product tables. The type code is a unique code for the specific PCS100 ESS model and specifies all the components that are used to construct the model. To the type code given in the product tables options can be added, which are called plus (+) codes.

The diagram on the right outlines the structure of the type code:



2.1.1 Number of Power Modules

This is the number of modules used in the PCS100 ESS system, which depends on the load kVA.
One PCS100 ESS cabinet can have up to 6 PCS100 power modules and one PCS100 ESS rack converter up to 32 modules. In case a bigger system is required multiple PCS100 ESS can be connected in parallel. In this case, the units must be tied together with separate transformers or multi-winding transformers.

2.1.2 Type of Power Module

There are two types of power modules available for the PCS100 ESS, which differ in their DC voltage range. The D-type module is suitable for DC voltages up to 820 Vdc. For higher DC voltages the C-type module has to be used, which can run up to 1120 Vdc.

Parameters	D-Type Module	C-Type Module
Rated DC voltage[1]	750Vdc (250 – 820 Vdc)	1000Vdc (250 – 1120 Vdc)
Rated AC voltage[2]	480 Vac (150 – 480 Vac)	480 Vac (150 – 480 Vac)
Current at rated AC voltage	150 Aac	105 Aac
Nominal frequency	50/60 Hz	50/60 Hz
DC side grounding	DC side RFI grounded	DC side RFI grounded
AC side grounding	Floating (AC transformer coupled)	Floating (AC transformer coupled)

Note: [1] Power derating is required for continuous operation above 780 Vdc and 1065 Vdc as illustrated in Figure 2-1.
[2] This is the standard rated AC voltage. Other operating voltages (as indicated in brackets) can be achieved based on sizing criteria and software settings. The product will be delivered set up for the voltage specified in the sizing tool.

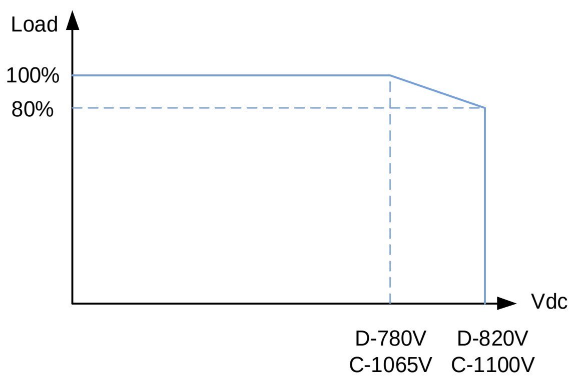
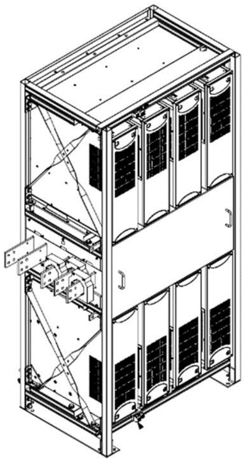


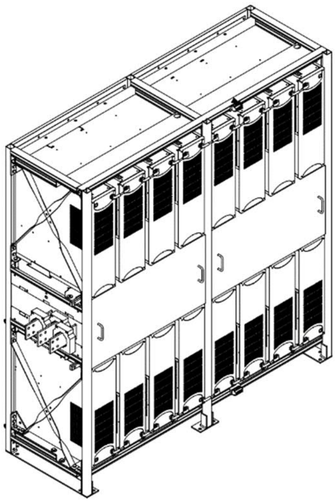
Figure 2-1: Derating curve for continuous operation at high DC voltages

2.1.3 Mechanical Construction

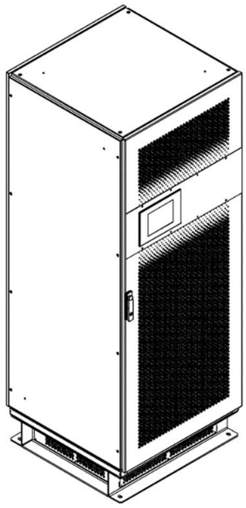
This specifies the type of mechanical construction, with A10 denoting the standard cabinet and Bxx the standard rack. For some cases the letter Cxx[1] will be used, denoting a specific application or duty cycles.



8-Modules rack section



16-Modules rack section



Cabinet

A10 - Standard cabinet solution (800W x 800D)
Bxx - Standard rack solution
B**x**x - Number of 8-modules sections:

- **B1** = 8-modules rack
- **B2** = 16-modules rack
- **B3** = 16-modules + 8-modules racks
- **B4** = 16-modules + 16-modules racks
- **C2** = 16-modules rack[1]
- **C3** = 16-modules + 8-modules racks[1]
- **C4** = 16-modules + 16-modules racks[1]

Bx**x** – Busbar requirements:

- **1** = AC/DC left - (up to 16 modules)
- **2** = AC/DC right - (up to 16 modules)
- **3** = AC left, DC right - (up to 16 modules)
- **4** = AC right, DC left - (up to 16 modules)
- **C** = Center fed 16-modules rack RH side (16 < modules < 25) [2]
- **D** = Center fed 16-modules rack LH side (16 < modules < 25)

Overview modules and racks:

Cabinets		Rack with D-Type Modules		Rack with C-Type Modules	
		B1x	1-8 modules		
		B2x	9-14 modules	B1x	1-8 modules
		C2x	15-16 modules[1]	B2x	9-16 modules
A10	1-6 modules	B3x	15-22 modules	B3x	17-24 modules
		C3x	23-24 modules[1]	B4x	25-32 modules
		B4x	25-28 modules		
		C4x	29-32 modules[1]		

Note: [1] For racks with D-type modules typically a maximum of 14 modules can be placed into one rack (two sections of 8 modules) due to current limitations on the DC bus. Contact factory in case you require more than 14 modules on a single rack (two sections of 8 modules) for specific applications with continuous DC currents below 2500 Adc, or specific duty-cycles applications.

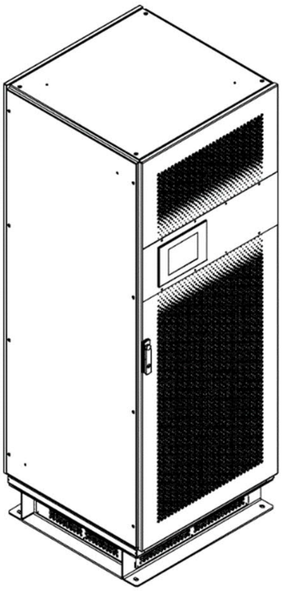
[2] For racks over 24 modules, two sections of 16-modules are required. Therefore, there is not distinction where it is located. By default, the code for busbar requirement will be **C**

2.1.4 Options

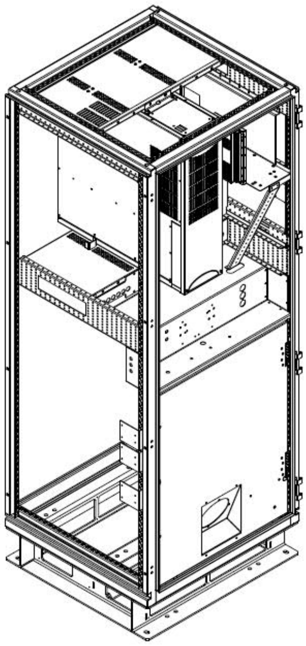
This specifies the different options available for the PCS100 ESS either cabinet or rack solution. Any other configuration not specified in this document will be denoted with a **+C**.

+T000 = Tx ready (1 and 2 modules cabinet only)
+C = Customized solution (contact factory)
VR1 Remote synch input:
+480x3 = 480 V, 3 wire
+480x4 = 480 V, 4 wire
+110x4 = 110 V, 4 wire
+110x3 = 110 V, 3 wire

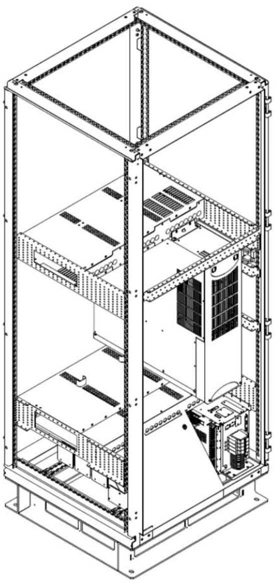
2.2 Examples of PCS100 ESS Type Codes



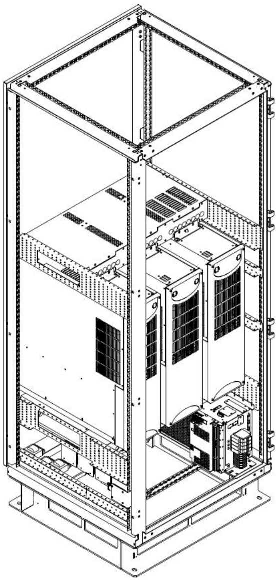
PCS100 19-01D-A10 … PCS100 19-06D-A10



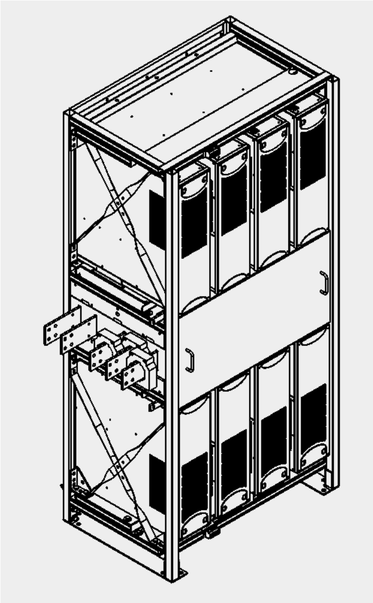
PCS100 19-01C-A10+T000



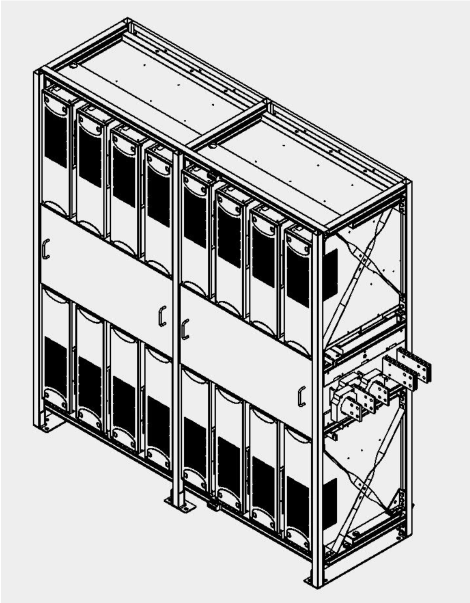
PCS100 19-01C-A10



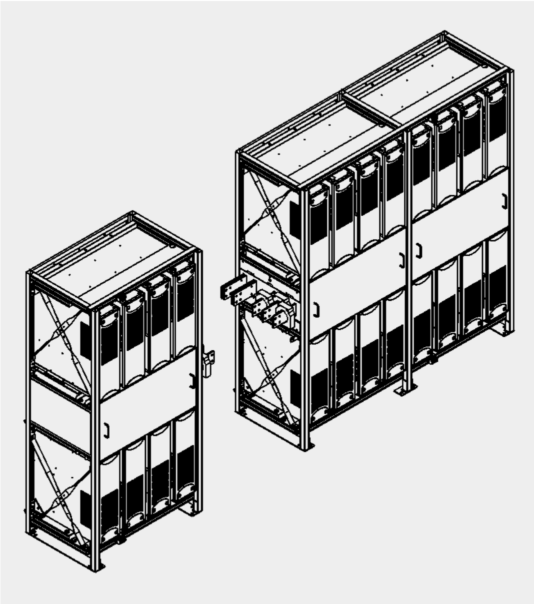
PCS100 19-03D-A10



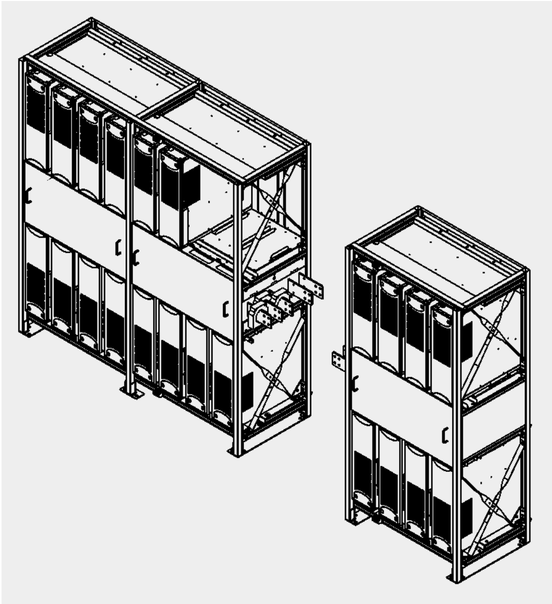
PCS100 19-08D-B11



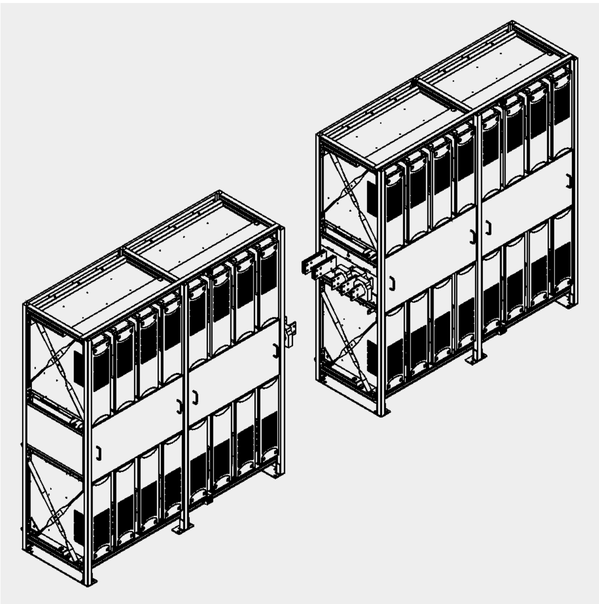
PCS100 19-16C-B22



PCS100 19-24C-B3C



PCS100 19-22C-B3D



PCS100 19-32C-B4C

Further information about rack's components connection can be found in the PCS100 ESS Wiring Diagram, 2UCD190xxxE301.

Any other configuration not specified in this document will be a customized solution (contact factory)

2.3 PCS100 ESS Model Range

The model ratings of the PCS100 ESS are defined by the number of power modules used to construct the system. The PCS100 ESS product range is summarized in section 2.3.1 for D-type modules and in section 2.3.2 for C-type modules.

The ratings are given for a typical PCS100 ESS system under nominal conditions.

Note: Operation at different voltages than nominal will affect the power rating. Consult **2UCD190000E025 PCS100 ESS Detailed Sizing Tool** for the exact rating according to your operating conditions.

2.3.1 PCS100 ESS D-Type Model Range

Number of Modules	**Dimensions** H x W x D (mm)	**Weight** kg	**Rated Current** Iac (A)	**Heat dissipation** kW (Typical)	**Airflow** (m^3/min)	**Type Code**
1	2154x809x804	790	150	4.9[1]	14	PCS100 19-01D-A10+T000[2]
2	2154x809x804	920	300	8.8[1]	24	PCS100 19-02D-A10+T000[2]
1	2154x809x804	330	150	2.9	10	PCS100 19-01D-A10
2	2154x809x804	410	300	5.8	20	PCS100 19-02D-A10
3	2154x809x804	490	450	8.7	30	PCS100 19-03D-A10
4	2154x809x804	570	600	11.6	40	PCS100 19-04D-A10
5	2154x809x804	650	750	14.4	50	PCS100 19-05D-A10
6	2154x809x804	730	900	17.3	60	PCS100 19-06D-A10
4	2200x1041x703	560	600	11.5	40	PCS100 19-04D-B1x[3]
5	2200x1041x703	630	750	14.4	50	PCS100 19-05D-B1x[3]
6	2200x1041x703	700	900	17.3	60	PCS100 19-06D-B1x[3]
7	2200x1041x703	770	1050	20.1	70	PCS100 19-07D-B1x[3]
8	2200x1041x703	840	1200	23.0	80	PCS100 19-08D-B1x[3]
9	2200x2041x703	1020	1350	25.9	90	PCS100 19-09D-B2x[3]
10	2200x2041x703	1080	1500	28.8	100	PCS100 19-10D-B2x[3]
11	2200x2041x703	1150	1650	31.6	110	PCS100 19-11D-B2x[3]
12	2200x2041x703	1220	1800	34.5	120	PCS100 19-12D-B2x[3]
13	2200x2041x703	1300	1950	37.4	130	PCS100 19-13D-B2x[3]
14	2200x2041x703	1370	2100	40.3	140	PCS100 19-14D-B2x[3]
15	2200x(1041+2041)x703	1710	2250	43.1	150	PCS100 19-15D-C[5]2x[3]
16	2200x(1041+2041)x703	1780	2400	46.0	160	PCS100 19-16D-C[5]2x[3]
17	2200x(1041+2041)x703	1850	2550	48.9	170	PCS100 19-17D-B3x[4]
18	2200x(1041+2041)x703	1920	2700	51.8	180	PCS100 19-18D-B3x[4]
19	2200x(1041+2041)x703	1990	2850	54.6	190	PCS100 19-19D-B3x[4]
20	2200x(1041+2041)x703	2070	3000	57.5	200	PCS100 19-20D-B3x[4]
21	2200x(1041+2041)x703	2140	3150	60.4	210	PCS100 19-21D-B3x[4]
22	2200x(1041+2041)x703	2210	3300	63.3	220	PCS100 19-22D-B3x[4]
23	2200x(2041+2041)x703	2280	3450	66.1	230	PCS100 19-23D-C[5]3x[4]
24	2200x(2041+2041)x703	2350	3600	69.0	240	PCS100 19-24D-C[5]3x[4]
25	2200x(2041+2041)x703	2520	3750	71.9	250	PCS100 19-25D-B4C
26	2200x(2041+2041)x703	2590	3900	74.8	260	PCS100 19-26D-B4C
27	2200x(2041+2041)x703	2660	4050	77.6	270	PCS100 19-27D-B4C
28	2200x(2041+2041)x703	2730	4200	80.5	280	PCS100 19-28D-B4C
29	2200x(2041+2041)x703	2800	4350	83.4	290	PCS100 19-29D-C[5]4C
30	2200x(2041+2041)x703	2870	4500	86.3	300	PCS100 19-30D-C[5]4C
31	2200x(2041+2041)x703	2940	4650	89.1	310	PCS100 19-31D-C[5]4C
32	2200x(2041+2041)x703	3010	4800	92.0	320	PCS100 19-32D-C[5]4C

Note: [1] Assuming typical additional heating from coupling transformer.
[2] T000 option with free space for customer coupling transformer inside the cabinet (does not include transformer).
[3] Refer to section 2.1.3 for the right code according the bus bars termination
[4] Place C for center termination (2 m rack on the right) or D for center termination (2 m rack on the left)
[5] Please consult factory for any systems with over 14 D-type modules on a single two-section rack. Refer to 2.1.3

2.3.2 PCS100 ESS C-Type Model Range

Number of Modules	**Dimensions** H x W x D (mm)	**Weight** (approx.) kg	**Rated Current** Iac (A)	**Heat dissipation** kW (Typical)	**Airflow** (m^3/min)	**Type Code**
1	2154x809x804	780	105	4.4[1]	14	PCS100 19-01C-A10+T000[2]
2	2154x809x804	900	210	7.7[1]	24	PCS100 19-02C-A10+T000[2]
1	2154x809x804	330	105	2.4	10	PCS100 19-01C-A10
2	2154x809x804	410	210	4.7	20	PCS100 19-02C-A10
3	2154x809x804	490	315	7.1	30	PCS100 19-03C-A10
4	2154x809x804	570	420	9.4	40	PCS100 19-04C-A10
5	2154x809x804	650	525	11.8	50	PCS100 19-05C-A10
6	2154x809x804	730	630	14.1	60	PCS100 19-06C-A10
4	2200x1041x703	560	420	9.4	40	PCS100 19-04C-B1x[3]
5	2200x1041x703	630	525	11.8	50	PCS100 19-05C-B1x[3]
6	2200x1041x703	700	630	14.1	60	PCS100 19-06C-B1x[3]
7	2200x1041x703	770	735	16.5	70	PCS100 19-07C-B1x[3]
8	2200x1041x703	840	840	18.8	80	PCS100 19-08C-B1x[3]
9	2200x2041x703	1020	945	21.2	90	PCS100 19-09C-B2x[3]
10	2200x2041x703	1080	1050	23.5	100	PCS100 19-10C-B2x[3]
11	2200x2041x703	1150	1155	25.9	110	PCS100 19-11C-B2x[3]
12	2200x2041x703	1220	1260	28.2	120	PCS100 19-12C-B2x[3]
13	2200x2041x703	1300	1365	30.6	130	PCS100 19-13C-B2x[3]
14	2200x2041x703	1370	1470	32.9	140	PCS100 19-14C-B2x[3]
15	2200x2041x703	1440	1575	35.3	150	PCS100 19-15C-B2x[3]
16	2200x2041x703	1510	1680	37.6	160	PCS100 19-16C-B2x[3]
17	2200x(1041+2041)x703	1850	1785	40.0	170	PCS100 19-17C-B3x[4]
18	2200x(1041+2041)x703	1920	1890	42.3	180	PCS100 19-18C-B3x[4]
19	2200x(1041+2041)x703	1990	1995	44.7	190	PCS100 19-19C-B3x[4]
20	2200x(1041+2041)x703	2070	2100	47.0	200	PCS100 19-20C-B3x[4]
21	2200x(1041+2041)x703	2140	2205	49.4	210	PCS100 19-21C-B3x[4]
22	2200x(1041+2041)x703	2210	2310	51.7	220	PCS100 19-22C-B3x[4]
23	2200x(1041+2041)x703	2280	2415	54.1	230	PCS100 19-23C-B3x[4]
24	2200x(1041+2041)x703	2350	2520	56.4	240	PCS100 19-24C-B3x[4]
25	2200x(2041+2041)x703	2520	2625	58.8	250	PCS100 19-25C-B4C
26	2200x(2041+2041)x703	2590	2730	61.1	260	PCS100 19-26C-B4C
27	2200x(2041+2041)x703	2660	2835	63.5	270	PCS100 19-27C-B4C
28	2200x(2041+2041)x703	2730	2940	65.8	280	PCS100 19-28C-B4C
29	2200x(2041+2041)x703	2800	3045	68.2	290	PCS100 19-29C-B4C
30	2200x(2041+2041)x703	2870	3150	70.5	300	PCS100 19-30C-B4C
31	2200x(2041+2041)x703	2950	3255	72.9	310	PCS100 19-31C-B4C
32	2200x(2041+2041)x703	3020	3360	75.2	320	PCS100 19-32C-B4C

Note: [1] Assuming typical additional heating from coupling transformer.
[2] T000 option with free space for customer coupling transformer inside the cabinet (does not include transformer).
[3] Refer to section 2.1.3 for the right code according the bus bars termination
[4] Place C for center termination (2 m rack on the right) or D for center termination (2 m rack on the left)

3 Technical Specification

3.1 Model Range

AC Rating	150A – 4800A D-type module 105A – 3360A C-type module Note: Higher power available by paralleling multiple PCS100 ESS systems.

3.2 Utility Side (AC)

Rated voltage	150 - 480 V
Voltage tolerance	± 10 %
Nominal frequency	50 Hz or 60 Hz
Frequency tolerance	± 5 %
Power system	3-phase center ground referenced (TN-S) - coupling transformer required[1]. 3-phase floating system (IT) - insulation monitoring required[2]. Note: [1]For transformer requirements refer to ABB document 2UCD190000E006 ESS Transformer . Requirements. [2]For more information refers to section 7.2 in this manual.
Overvoltage category	III – 4kV (IEC 60664)
Fault capacity	25 kA (cabinet), 65 kA (rack)
Achievable efficiency	98 %
Overload capability	200 % for 2 seconds[1] 150 % for 30 seconds 120 % for 600 seconds[1] Note: [1] From 75% preload, refer to document 2UCD190000E013 PCS100 ESS Overload.
Circuit protection	Circuit breaker or fuse (not included)
Voltage harmonic compatibility	IEC 61000-2-4 Class 2 (Utility THDv < 8%) Note: For THDv > 8%, please refer to factory. For applications where THDv is above 10% lifetime of components may be significantly affected, please refer to factory.
Power module voltage harmonic distortion	THDv < 2.5% for linear loads

3.3 Energy Storage Side (DC)

Rated voltage	+/- 125Vdc up to +/- 560Vdc (250 up to 1120 Vdc) for C-type +/- 125Vdc up to +/- 410Vdc (250 up to 820 Vdc) for D-type
Supply earth referencing	DC center referenced
Overvoltage category	II (IEC 60664) 4kV D-type module 6kV C-type module Note: The PCS100 ESS system is rated for use in systems which will not be subject to impulse voltages exceeding their overvoltage rating. Suitably rated surge protection devices (SPDs) should be connected from + and - to earth in applications where surge voltage may exceed the overvoltage rating (e.g.: remote connected DC sources).

Maximum, voltage to ground	+/- 600Vdc Note: The PCS100 ESS system is in systems which will not be subject to impulse voltages exceeding their over-voltage rating. Suitably rated surge protection devices (SPDs) should be connected from + and - to earth in applications where surge voltage may exceed the overvoltage rating (e.g.: remote connected DC sources).
Circuit protection	Circuit breaker or fuse (not included)

3.4 Standards and Certifications

Quality	ISO 9001
Marking	CE c UL us Refer to 2UCD200000E801 for UL recognized PCS100 components.
Safety	IEC 62103
Electromagnetic compatibility	Emissions CISPR 11 Class A Group 1 Immunity IEC 61000-6-2 Note: Minimum requirements must be met to achieve the EMC claimed performance at the ESS demarcation point. For-More information please refer to ABB document. 2UCD190000E006 ESS Transformer Requirements
Performance (Aligned with)	IEEE 519 IEEE 1031-2000
Grid connection/monitoring (Aligned with)	IEEE 1547 Japanese Grid Code

3.5 Environmental

Operating temperature range	0 °C to 50 °C
Temperature derating	Above 40 °C, derate at 2 % load per °C
Operating altitude	< 1000 m without derating
Capacity derating with altitude	1 % every 100 m above 1000 m, 2000 m maximum
Inverter cooling	forced ventilation
Humidity	< 95 %, non-condensing
Pollution degree rating	2
Noise	< 85 dBA @ 2 m Note: Average from measurements taken all around of a 32 type-C . modules rack @ fully loaded.
Seismic rating	Designed to UBC zone 4 (rack only)

3.6 Protection Rating

Rack / Cabinet rating	IP20 / NEMA 1 Note: On Rack systems, the IP rating is characterized by the inverter modules only. Final protection degree dependent on application.

3.7 Service

MTTR	30 min typical by module exchange
Diagnostics	Non-volatile event & service log

3.8 User Interface

User interface	8.4” color touch panel
Touch panel	Full parameter control, system event log
Control inputs	10 digital inputs 24 Vdc (< 50ms) - Start / Stop / Reset (Master Module) - 7 programmable inputs
	2 analog inputs on the extended I/O board -10…+10 V / 4…20 mA, (< 2ms) Resolution 0.1 %, Accuracy ± 2 %
	2 PTC inputs
Control outputs	7 digital relay outputs, 250 V/1~, 30 Vdc (1 A) - Running, warning, fault relays (Master Module) - 4 programmable outputs on the extended I/O board
	2 analog outputs on the extended I/O board -10…+10 V / 4…20 mA (< 50ms) Accuracy ± 2 %
Communication	Ethernet Modbus TCP/IP RS485, Modbus RTU

3.9 Auxiliary Power

In case of rack systems two types of auxiliary power have to be provided from an external source[1]:

- 26.5 Vdc safety extra low voltage dc for control
- 230 Vac 50/60 Hz fan supply

It must be ensured that these external power supplies are suitable for industrial use and that cables are dimensioned appropriately. Attention should also be given to the grounding of the supplies: The 0Vdc of the 26.5 Vdc supply must be tied to ground at one point and the 230 Vac fan supply should be configured as a TN (hard grounded) supply. Furthermore, it is not recommended to connect other loads to the 26.5 Vdc supply or to interconnect +26.5 Vdc or 0 V lines when multiple supplies are used in larger systems.

More detailed information about the dimensioning of the auxiliary supplies can be found in the application note 2UCD000420E003 “Auxiliary Power Supplies for PCS100 Rack Systems”.

Note: [1] In case of cabinet systems the control auxiliary power is provided by an internal 26.5 Vdc power supply located in the Auxiliary Master Module and the only external supply is the 110 or 230 Vac 50/60 Hz as described in this section. It is worth noting that on cabinet versions the Auxiliary Master Module is 230Vac 50/60Hz, but is always supplied by an auxiliary “Z” transformer which allows customers to provide power either on 110Vac or 230Vac depending on the connection of the primary windings of such auxiliary transformer.

4 Sub-Assemblies

The PCS100 ESS consists of the following parts:

- PCS100 Rack or Cabinet
- PCS100 Module
- PCS100 Master Module
- PCS100 Metering Interface
- PCS100 GDM Display

Together these sub-assemblies are referred to as the PCS100 ESS System.

4.1 PCS100 ESS Rack and Cabinet

The PCS100 ESS system contains an appropriate number of PCS100 modules for the rating of the product. Each module has a unique identification number (1 - 32), which is displayed on the front of the module as shown in more detail in section 5.2.

Depending on the requirements of an application, the modules can be placed either in a rack or in a cabinet. If cabinet construction is selected, all parts will be delivered fully assembled in a cabinet. To be ready for use only the cabinets need to be connected in parallel in case more than one cabinet is needed for the application. On the other hand, if rack construction is selected, the certain parts are shipped separately and will have to be assembled into the rack system before the PCS100 ESS system can be used.

As shown in more detail in section **Error! Reference source not found.**, the maximum number of modules varies between rack and cabinet systems: A single cabinet can contain up to 6 modules. In case of one or two modules a transformer can also be included in the cabinet enclosure as detailed in the product range in section 2.3. A single rack can contain up to two rack sections of 1000 mm, giving a maximum of 16 modules (max. 8 modules per rack section). For PCS100 ESS systems requiring more than 16 modules, two racks can be connected with a center termination as explained in more detail in section **Error! Reference source not found.**.

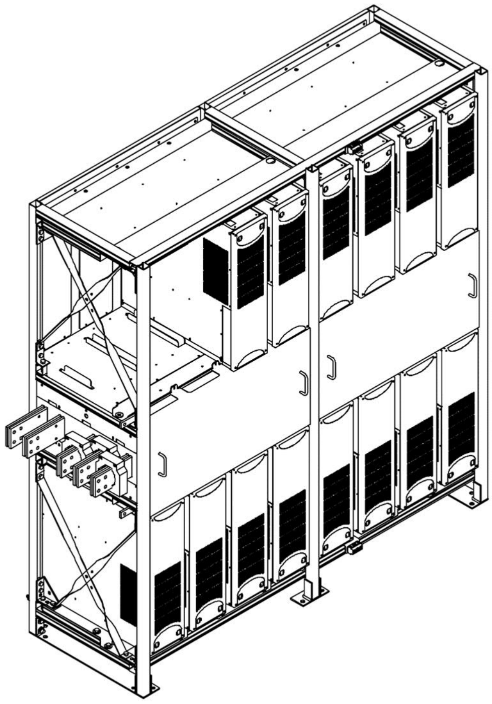


Figure 4-1: PCS100 ESS Rack

DANGER – Hazardous Voltages
Many parts in this product, including printed circuit boards operate at lethal voltages.
DO NOT TOUCH components or connections that have voltage present

4.2 PCS100 Modules

The PCS100 modules are the link between the energy storage and the main grid. They present a regulated three phase AC voltage (in Virtual Generator VSI mode) or a regulated three phase AC current (in CSI mode) to the grid and transfer power from the grid to the energy storage and vice versa.

As shown in Figure 4-2, the PCS100 modules include a sine filter and a RFI filter as part of the assembly, meaning the power electronics and filters are integrated into one module. Thanks to this and the use of state of the art IGBT technology the PCS100 modules have minimum impact on power quality of the supply network (harmonics and power factor). They are delivered in the compact package shown in Figure 4-3.

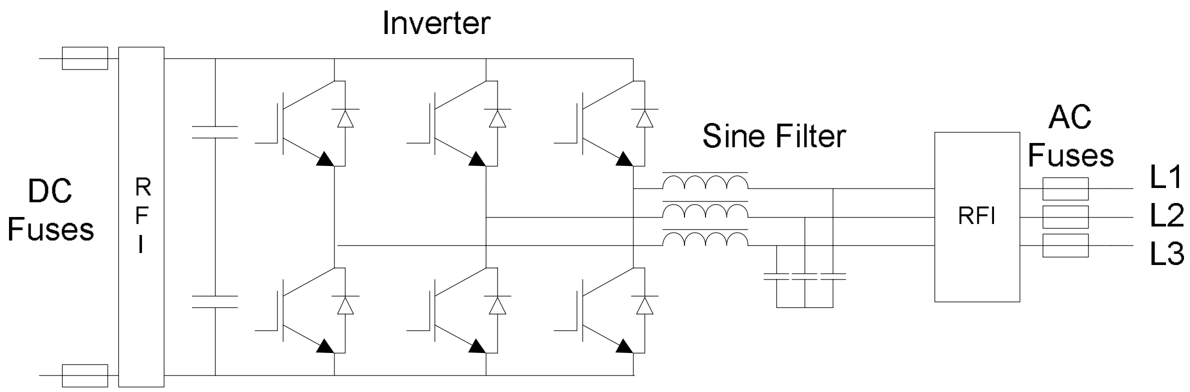


Figure 4-2: Diagram of a PCS100 module

Figure 4-3: PCS100 Power Module

4.3 PCS100 Master Module

Each PCS100 ESS system has one Master Module that controls the overall system operation from a central point by coordinating the function of all PCS100 modules.

The Master Module controls the operating state of the overall system and combines the measurements and feedback from all the PCS100 modules into a single data set. It also identifies significant events in the system (e.g. a fault state of a module) and stores them in an event log. Furthermore, it performs the system-wide input voltage sensing and calculates the reference values for the PCS100 modules based on the system-wide reference values set by the operator.

In case of cabinet systems, the Master Module is called the Auxiliary Master Module and includes an internal 26.5 Vdc power supply and a 600ms hold-up circuit in case of AC supply failure. The master module is fed via a 230V 50/60Hz Supply. In addition, the power for the fan supply (230Vac) also is provided from an external source.

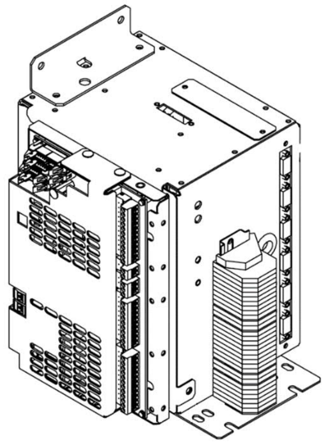


Figure 4-4: PCS100 Compact Master Module

In case of rack systems, the Master Module is referred to as PCS100 Compact Master Module and does not contain an internal power supply. Figure 4-4 shows a Compact Master Module.

4.3.1 Connections on the Master Module

The PCS100 ESS includes several control and control power connections for local and remote control and monitoring of the system. All terminals are located on the PCS100 Master Module and are suitable for wires up to 2.5 mm^2 cross section.

The following sections describe these connections in more detail. It includes some information on cabinet systems, however, the main focus is on rack systems as they still have to be assembled during installation.

4.3.1.1 Digital I/Os and Power Terminals

On the PCS100 Compact Master Module (rack systems) shown in Figure 4-5 there are digital input and output terminals to activate remote control and monitor the status of the system, as well as power terminals to supply the compact master from an external 26.5Vdc source.[1] The numbering of these terminals is shown in Figure 4-6 together with a short description in Table 4-1. In comparison the Auxiliary Master Module used in cabinet systems is shown in Figure 4-7.

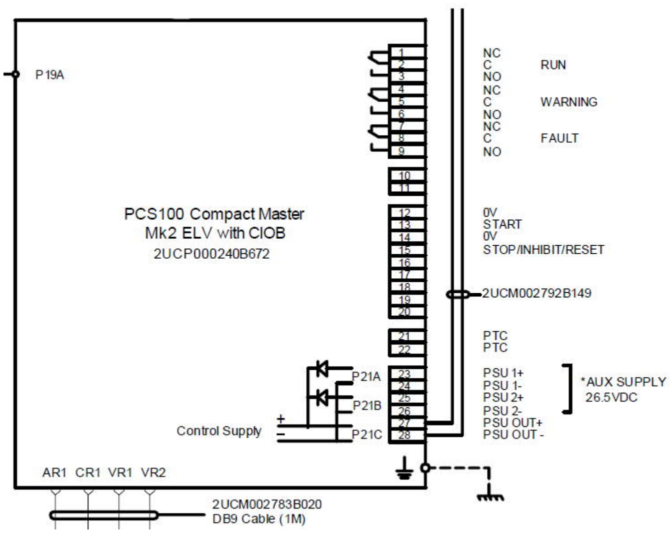


Figure 4-5: PCS100 Compact Master Module

Note: [1] In case of cabinet systems the master module is fed from an internal 26.5Vdc power supply.

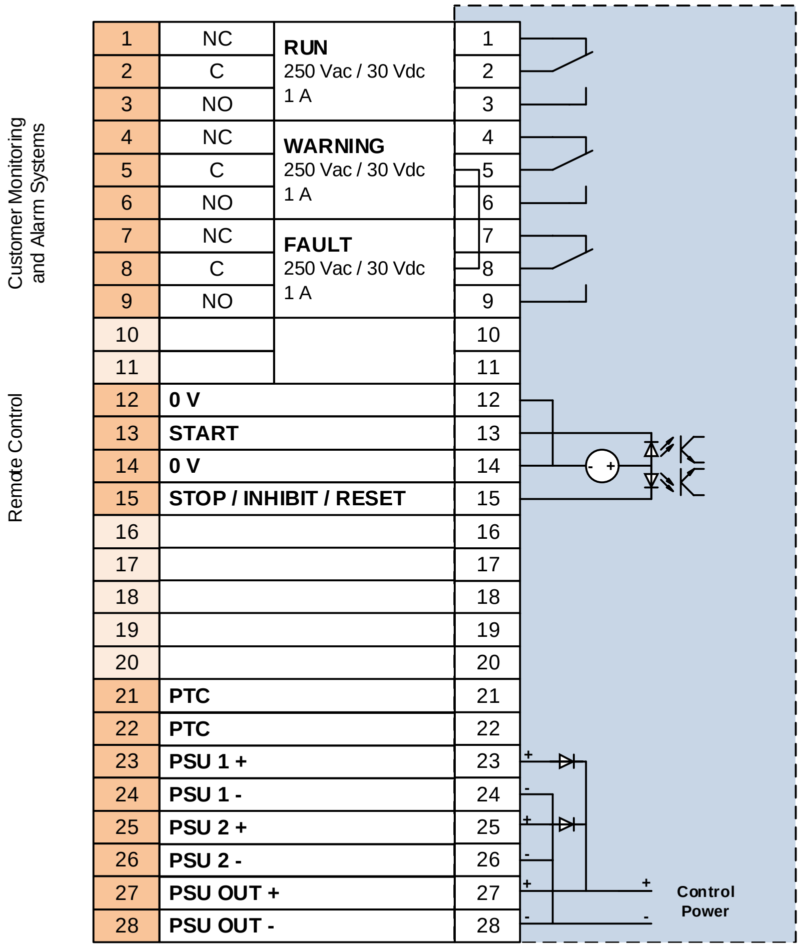


Figure 4-6: Remote Control, Monitoring and Control Power Terminals on the PCS100 Compact Master Module

Terminal Number	Description	Name
1	Relay output / 250 Vac/30 Vdc, 1 A / NC	RUN Status (Normally Closed)
2	Relay output / 250 Vac/30 Vdc , 1 A / C	RUN Status (Common)
3	Relay output / 250 Vac/30 Vdc , 1 A / NO	RUN Status (Normally Open)
4	Relay output / 250 Vac/30 Vdc , 1 A / NC	WARNING Status (Normally Closed)
5	Relay output / 250 Vac/30 Vdc , 1 A / C	WARNING Status (Common)
6	Relay output / 250 Vac/30 Vdc , 1 A / NO	WARNING Status (Normally Open)
7	Relay output / 250 Vac/30 Vdc , 1 A / NC	FAULT Status (Normally Closed)
8	Relay output / 250 Vac/30 Vdc , 1 A / C	FAULT Status (Common)
9	Relay output / 250 Vac/30 Vdc , 1 A / NO	FAULT Status (Normally Open)
10	NA	10
11	NA	11
12	Dry contact only: Return Wire	0V Start Input – return
13	Dry contact only: Start on closing edge	START Start Input – only used if remote Start is required
14	Dry contact only: Return Wire	0V Stop/Inhibit/Reset - return
15	Dry contact only: Stop on open edge: Inhibit while open; Reset on open edge	Stop/Inhibit/Reset – input
16	NA	16
17	NA	17
18	NA	18
19	NA	19
20	NA	20
21	PTC input (e.g. for transformer supervision)	PTC
22	PTC input (e.g. for transformer supervision)	PTC

23[1]	DC control power supply, positive input 1	PSU1+
24[1]	DC control power supply, negative input 1	PSU1-
25[1]	DC control power supply, positive input 2	PSU2+
26[1]	DC control power supply, negative input 2	PSU2-
27[1]	DC ctrl power positive output to extended I/O board	PSU OUT+
28[1]	DC ctrl power negative output to extended I/O board	PSU OUT-

Table 4-1: PCS100 Compact Master Terminals

Note: [1] Not fitted in the Auxiliary Master Module for cabinet systems as can be seen in Figure 4-7.

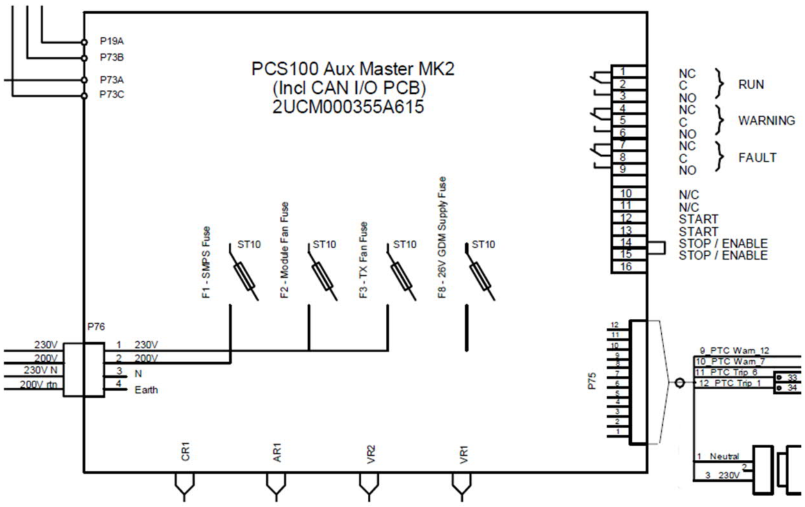


Figure 4-7: PCS100 Auxiliary Master Module

Remote Control Inputs

The following control connections are available for the wired remote control or monitoring of the PCS100 ESS. If not otherwise specified, the “No remote control” link is fitted in the factory by standard.

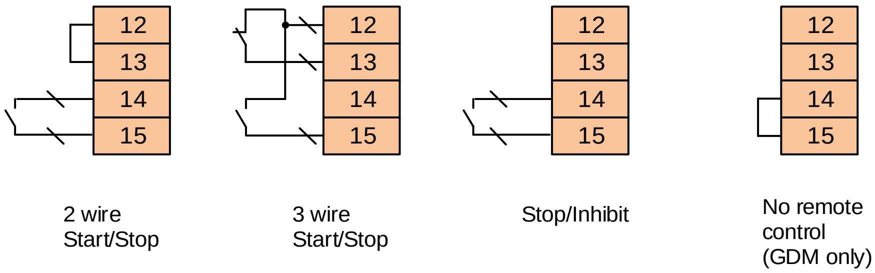


Figure 4-8: Wiring options for remote control

Status Monitoring Outputs

The product status is indicated by the relay outputs mounted on the front of the Master Module, and may be used for external monitoring by the customer.

Relay	Product status or description
RUN	Active in RUN, STARTING, STOPPING. Not active in FAULT
WARNING	Active if user WARNING condition is present (temperature or overload warnings) and during power up.
FAULT	Not active if FAULT condition is present or the PCS100 ESS is powered down.

Table 4-2: Relay outputs for status monitoring

Control Power Terminals and Thermal Sensor (PTC) Connection

DC control power of 26.5 Vdc needs to be connected to terminals 23 (PSU1+) and 24 (PSU1-) to power the PCS100 Compact Master Module, whose power consumption is approximately 2 A. A redundant power supply input is available on terminals 25 (PSU2+) and 26 (PSU2-).

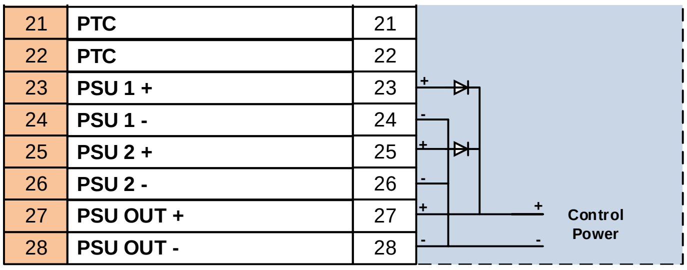


Figure 4-9: Control power terminals and terminals for optional thermal sensor (PTC)

Terminals 27 (PSU OUT+) and 28 (PSU OUT-) are connected to the auxiliary power input of the extended I/O board fitted on the side of the PCS100 Compact Master Module.

Note: For further information about the requirements for the auxiliary power for PCS100 ESS rack systems, please refer to 2UCD000420E003, 26.5 Vdc Auxiliary Power Supplies for PCS100 Rack Systems.

Terminals 21 and 22 offer the possibility to connect an additional thermal sensor (PTC) for further protection of the PCS100 ESS system.

4.3.1.2 Ground Connection

The PCS100 Compact Master must be connected to ground with a cable lug on the M5 earth connection next to the terminal block as shown in Figure 4-10.

4.3.1.3 DB9 Connections

The DB9 connections on the PCS100 Compact Master are connected to the PCS100 Compact Metering Interface, which is described in more detail in section 4.4. The voltage signal levels on these connections are 0Vdc…+2.5Vdc for the AR inputs and -8Vdc…+8Vdc for the CR and VR inputs.

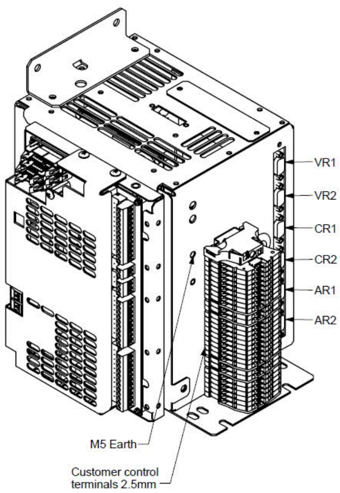
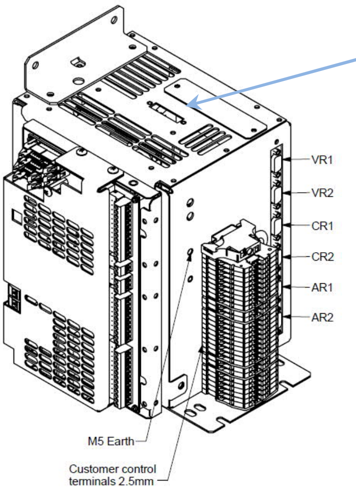


Figure 4-10: Ground and DB9 connections on the PCS100 Compact Master Module

Description	Hardware Name	Name in Software
External (Grid) AC voltage sensing	VR1	VT1
PCS100 ESS AC voltage sensing	VR2	VT2
PCS100 ESS AC current sensing	CR1	CT1
Not used on PCS100 ESS	CR2	CT2
PCS100 ESS DC voltage sensing	AR1	AT1
Not used on PCS100 ESS	AR2	AT2

Table 4-3: PCS100 DB9 connections

4.3.1.4 CAN Bus Connection of the Compact Master



The CAN Bus connection (20 pin) is located on the top of the PCS100 Compact Master and is typically the start/ first node on the PCS100 CAN bus. The bus connects the PCS100 Compact Master with the Extended I/O Board, PCS100 GDM and all the PCS100 modules.

4.3.2 The PCS100 Extended I/O Board

For both rack and cabinet systems, an extended I/O board is fitted on the side of the Master Module providing additional I/Os. The board is powered via the Master Module and contains the connections shown in Figure 4-11.

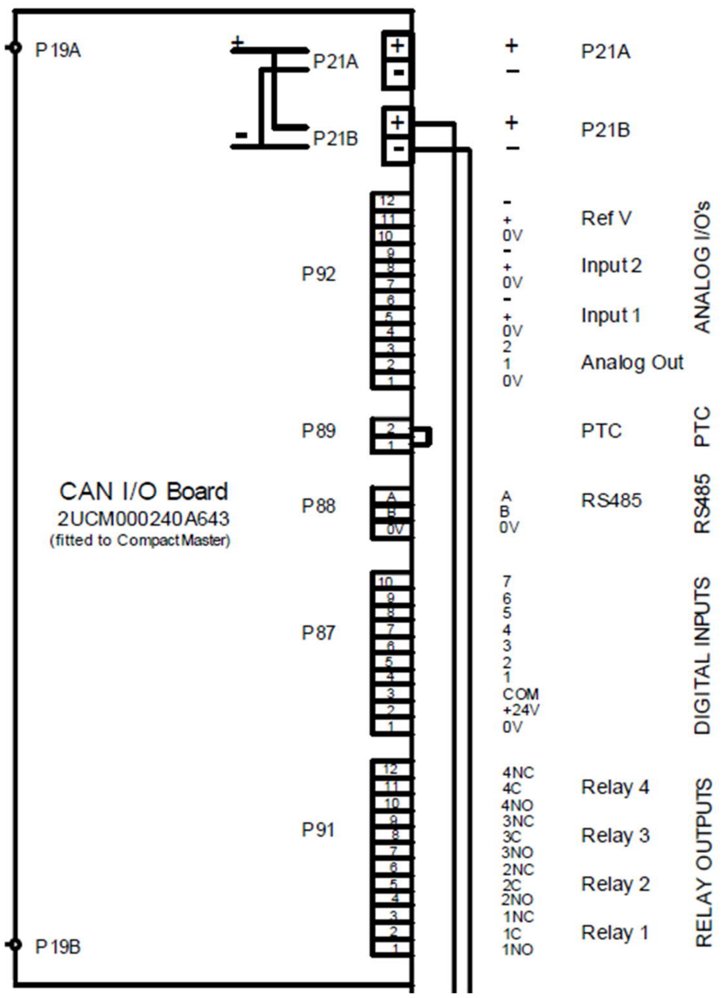


Figure 4-11: Connections on the PCS100 Extended I/O Board

Note: Figure 4-11 shows the terminal layout for a rack system. In case of cabinet systems, the board has the same connections, but a slightly different arrangement of the terminals.

4.3.2.1 Connections on the PCS100 Extended I/O Board

The names of the connections on the PCS100 Extended I/O Board can be found in Table 4-4 together with a short description.

Terminal Block	Terminal Number	Description	Name	
P91	1	Relay output 1/ 250 Vac/30 Vdc, 1 A / NO	1NO	Relay1
	2	Relay output 1/ 250 Vac/30 Vdc , 1 A / C	1C	Relay1
	3	Relay output 1/ 250 Vac/30 Vdc , 1 A / NC	1NC	Relay1
	4	Relay output 2/ 250 Vac/30 Vdc , 1 A / NO	2NO	Relay2
	5	Relay output 2/ 250 Vac/30 Vdc , 1 A / C	2C	Relay2
	6	Relay output 2/ 250 Vac/30 Vdc , 1 A / NC	2NC	Relay2
	7	Relay output 3/ 250 Vac/30 Vdc , 1 A / NO	3NO	Relay3
	8	Relay output 3/ 250 Vac/30 Vdc , 1 A / C	3C	Relay3
	9	Relay output 3/ 250 Vac/30 Vdc , 1 A / NC	3NC	Relay3
	10	Relay output 4/ 250 Vac/30 Vdc , 1 A / NO	4NO	Relay4
	11	Relay output 4/ 250 Vac/30 Vdc , 1 A / C	4C	Relay4
	12	Relay output 4/ 250 Vac/30 Vdc , 1 A / NC	4NC	Relay4
P87	1	Digital input 0 V reference	0V	Digital Input
	2	Digital input +24 V reference	+24V	Digital Input
	3	Digital input common	COM	Digital Input
	4	Digital input 1	1	Digital Input
	5	Digital input 2	2	Digital Input
	6	Digital input 3	3	Digital Input
	7	Digital input 4	4	Digital Input
	8	Digital input 5	5	Digital Input
	9	Digital input 6	6	Digital Input
	10	Digital input 7	7	Digital Input
P88	A	Modbus RTU, RS485, signal A	A	RS485
	B	Modbus RTU, RS485, signal B	B	RS485
	0V	Modbus RTU, RS485, 0 V	0V	RS485
P89	1	PTC input (e.g. for transformer supervision)	PTC	
	2	PTC input (e.g. for transformer supervision)	PTC	
P92	1	Analog output 0 V reference	0V	Analog Out
	2	Analog output 1	1	Analog Out
	3	Analog output 2	2	Analog Out
	4	Analog input 1 0 V reference	0V	Analog Input 1
	5	Analog input 1 positive	+	Analog Input 1
	6	Analog input 1 negative	-	Analog Input 1
	7	Analog input 2 0 V reference	0V	Analog Input 2
	8	Analog input 2 positive	+	Analog Input 2
	9	Analog input 2 negative	-	Analog Input 2
	10	Analog output 0 V reference	0V	Ref V
	11	Analog positive voltage reference	+	Ref V
	12	Analog negative voltage reference	-	Ref V
P21A	+	DC control power supply, positive input 1	P21A +	
	-	DC control power supply, negative input 1	P21A-	
P21B	+	DC control power supply, positive input 2	P21B+	
	-	DC control power supply, negative input 2	P21B-	
P19A	1..20	CAN bus connection A	P19A CAN bus	
P19B	1..20	CAN bus connection B	P19B CAN bus	

Table 4-4: PCS100 Extended I/O Board terminals

Relay Outputs

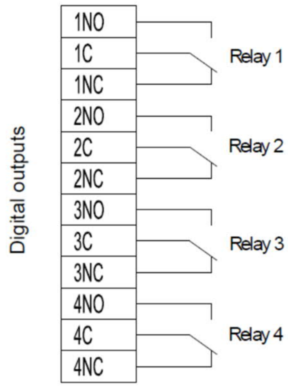


Figure 4-12: Digital outputs on the PCS100 Extended I/O Board

Digital Control Inputs

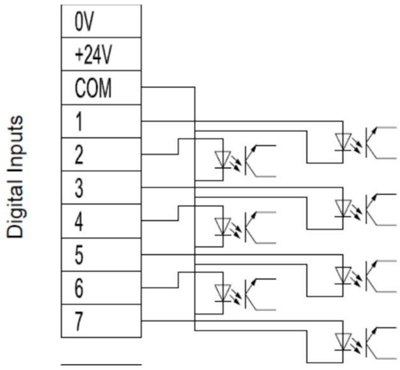


Figure 4-13: Digital inputs on the PCS100 Extended I/O Board

Analog Inputs and Outputs

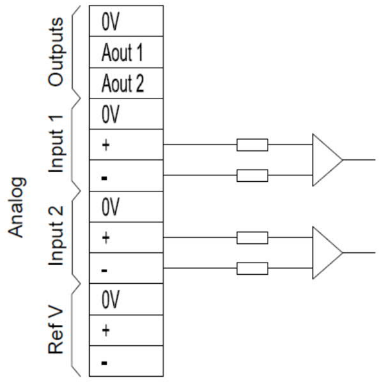


Figure 4-14: Analog inputs and output on the PCS100 Extended I/O Board

Control Power Terminals

Terminals P21B+ and P21B- are connected to the auxiliary power output of the Master Module (terminals 27 PSU OUT+ and 28 PSU OUT- in case of rack systems). In rack systems, terminals P21A+ and P21A- can be used to loop the control power to the PCS100 GDM (in cabinet systems, the GDM is fed directly by the Master Module).

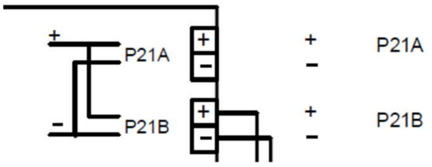
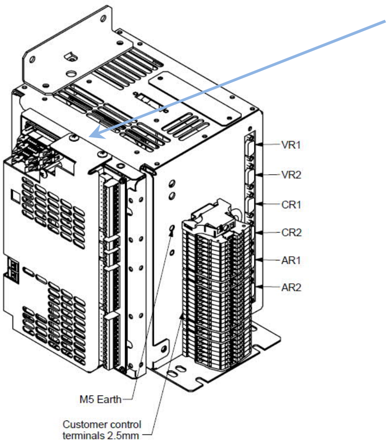


Figure 4-15: Control power connections on the PCS100 Extended I/O Board

4.3.2.2 CAN Bus Connection of the PCS100 Extended I/O Board



The CAN Bus connection (2x 20pin) of the PCS100 Extended I/O Board connects the PCS100 Extended I/O Board to the PCS100 Compact Master, PCS100 GDM and all the PCS100 modules.

4.4 Metering Interface

The metering interface is the connection between the Master Module and the sensors used to measure the parameters needed to ensure proper operation of the PCS100 ESS system.

4.4.1 Measurements

The following measurements are used by the PCS100 ESS system:

- External (grid) voltages
- Voltages on PCS100 ESS AC side
- Currents on PCS100 ESS AC side
- Voltage on PCS100 ESS DC side

4.4.1.1 External (Grid) AC Voltages

This measurement is optional and only used in connection with islanding and anti-islanding operation to detect a grid fault and to re-synchronize back to the grid after islanding. This voltage sensing input must be protected by fuses (e.g. 1 A) close to the point of the sensing. Four different options are available:

- 480V, 3 Wire
- 110V, 3 Wire
- 480V, 4 Wire
- 110V, 4 Wire

Note: This measurement needs to be connected to the DB9 connection VR1 on the Master Module.

4.4.1.2 PCS100 ESS AC Voltages

This measurement provides the voltages on the AC side of the ESS system. This voltage sensing input must be protected by fuses (e.g. 1 A) close to the point of the sensing.

Note: This measurement needs to be connected to the DB9 connection VR2 on the Master Module.

4.4.1.3 PCS100 ESS AC Currents

This measurement provides the currents on the AC side of the ESS system. There is 5 A CT input (standard) or a 1 A CT input (on request) version available.

Note: [1] This measurement needs to be connected to the DB9 connection CR1 on the Master Module.
[2] Refer to the project specific PCS100 ESS Wiring Diagram, 2UCD190xxxE301, for further information regarding the DIP switch settings of the current sensing PCB.

4.4.1.4 PCS100 ESS DC Voltage

This measurement provides the voltages on the DC side of the ESS system. This voltage sensing input must be protected by fuses (e.g. 1 A) close to the point of the sensing.

Note: This measurement needs to be connected to the DB9 connection AR1 on the Master Module.

4.4.2 Metering Interface for Cabinet Systems

In case of cabinet systems each sensor is connected to a small PCBA which in turn is connected to the DB9 terminals on the Auxiliary Master Module as shown in Figure 4-16.

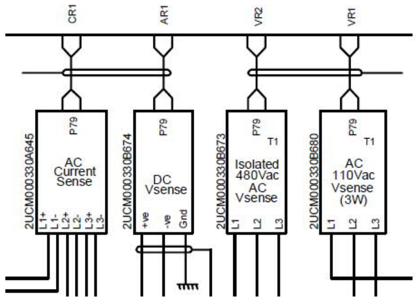


Figure 4-16: Metering Interface for cabinet systems

Note: The PCBA of the DC voltage sensor needs to be grounded.

4.4.3 Metering Interface for Rack Systems

For rack systems the Metering Interface has been integrated into the PCS100 Compact Metering Interface shown in Figure 4-17 and Figure 4-18. The DB9 Cables on the PCS100 Compact Metering Interface (VR1, VR2, CR1 and AR1) must be connected to the PCS100 Compact Master Module as explained in more detail in section 4.3.1.3.

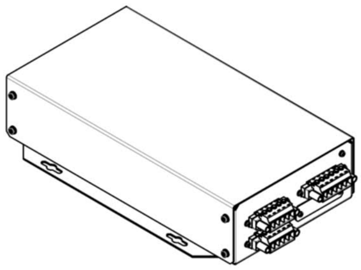


Figure 4-17: PCS100 Compact Metering Interface

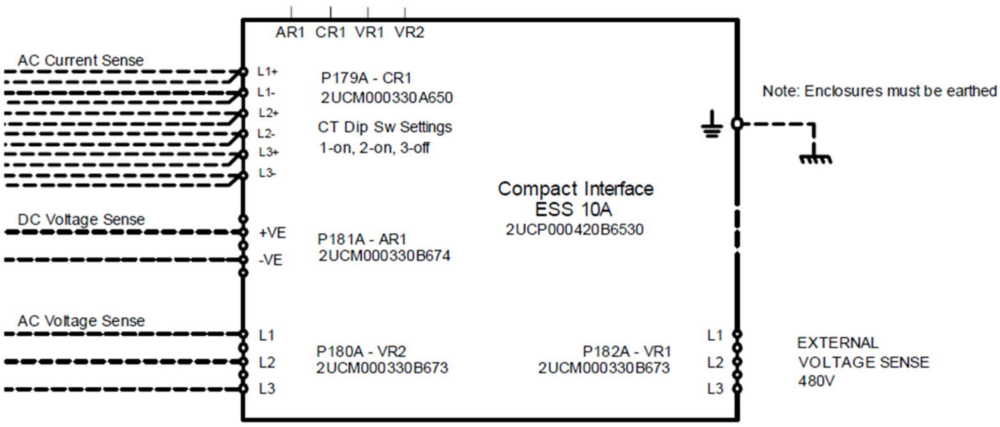


Figure 4-18: PCS100 Compact Metering Interface connections (standard 5A CT input)

Description	Name
External (Grid) AC voltage sensing	VR1 *P182A*
PCS100 ESS AC voltage sensing	VR2 *P180A*
PCS100 ESS AC current sensing, 5 A (1 A option)	CR1 *P179A*
PCS100 ESS DC voltage sensing	AR1 *P181A*

Note: The PCS100 Compact Metering Interface must be connected to ground with a cable lug on the M5 earth connection as indicated in Figure 4-18.

4.5 Graphic Display Module (GDM)

The primary user interface for configuration of the PCS100 ESS is via the Graphic Display Module (GDM). It allows local control of the PCS100 ESS, shows the system status and provides access to the operating parameters and event history. The look and functions of the GDM are explained in detail in section 5.1.

Table 4-5 describes the general features of the GDM:

Feature	GDM
Display resolution	1024 x 600 pixels
Display size	10.1"
Color graphic display	yes
Touch sensitive display	yes
Full descriptions of status and faults	yes
Local Start/Stop Reset Control	yes
Status Display	yes
Parameter adjustment	yes
Number of Event Log records stored	10000
Event log can be downloaded to a PC	yes
Remote Web Pages	yes
Modbus TCP connection	yes
Multilanguage selection	no

Table 4-5: PCS100 ESS GDM features

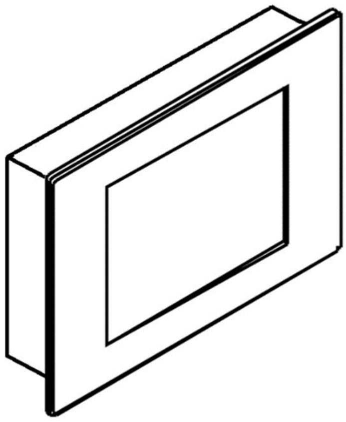


Figure 4-19: PCS100 Graphic Display Module (GDM)

The GDM needs to be connected to the 26.5Vdc auxiliary power at its power terminals see **Figure 4-20**.The internal communication with the PCS100 Master Module can be done using the CAN termination bard via a three-wire cable*. Location of CAN bus and power connections are shown in Figure 4-20.Even when the GDM is energized by extra low voltage its frame is internally earthed through the negative of the DC supply connection (-0V).

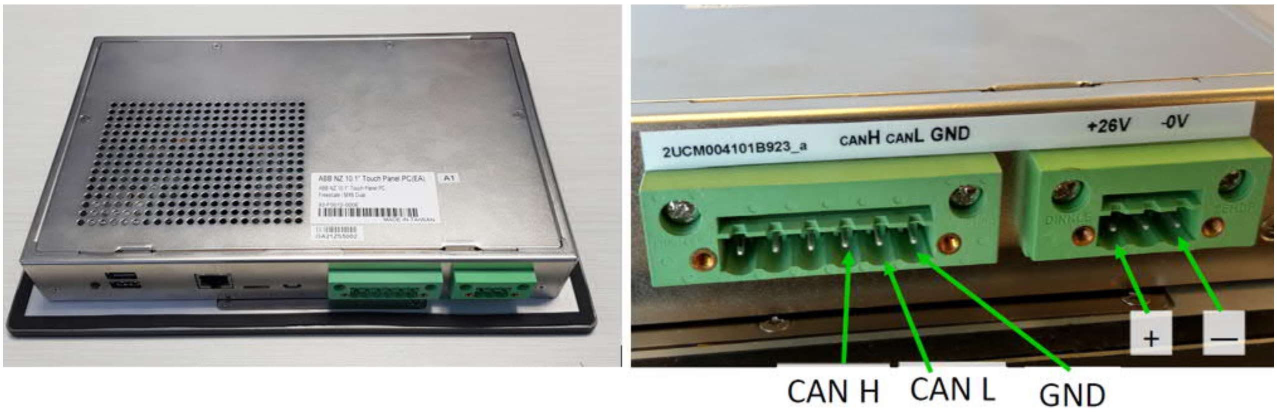


Figure 4-20: PCS100 GDM back panel

*Note: Further information on how to connect the PCS100 ESS GDM can be found in the PCS100 ESS Wiring Diagram, 2UCD190xxxE301.

5 The User Interface

5.1 Graphic Display Module (GDM)

The primary user interface for configuration of the PCS100 ESS is the Graphic Display Module (GDM). It allows local control of the PCS100 ESS, shows the system status and provides access to the operating parameters and event history.

The GDM interface consists of several pages that can be selected by the user. Each page has the Navigation & Control Panel and the Status Bar at the top as shown in Figure 5-1, which are displayed at all times. The Navigation & Control Panel consists of buttons allowing page selection and a Start (I) / Stop (O) / Reset button allowing local control of the product. The Status Bar displays the current system status and any warning or fault condition that may be present.

The GDM's touch screen is divided into the following parts:

1. Navigation & Control Panel
2. Status Bar
3. Page (selectable)

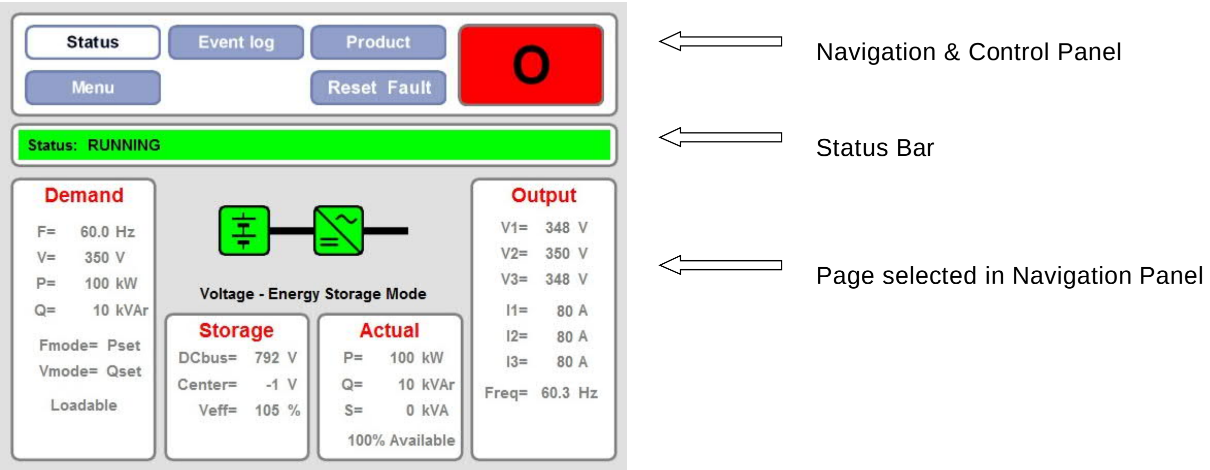


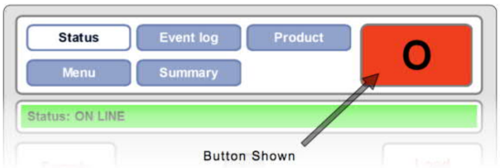
Figure 5-1: GDM display showing Navigation & Control Panel, Status Bar and selected Page

5.1.1 Hiding / Showing the Control Button

If it is preferable to control the PCS100 ESS from another device, the control buttons (Start, Stop and Reset buttons) can be removed from the GDM's touch screen.

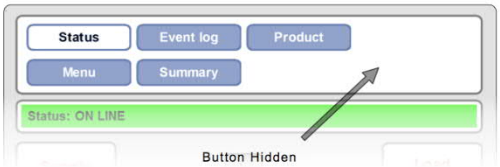
To show the control buttons:

Set parameter A31 "Control Enable" to true.



To hide the control buttons:

Set parameter "A31 Control Enable" to false.



5.1.2 Navigation Panel

The blue navigation buttons are displayed at all times at the top of the screen. When selected, the navigation buttons is turn to white. The following four pages can be accessed by pressing the corresponding navigation button:

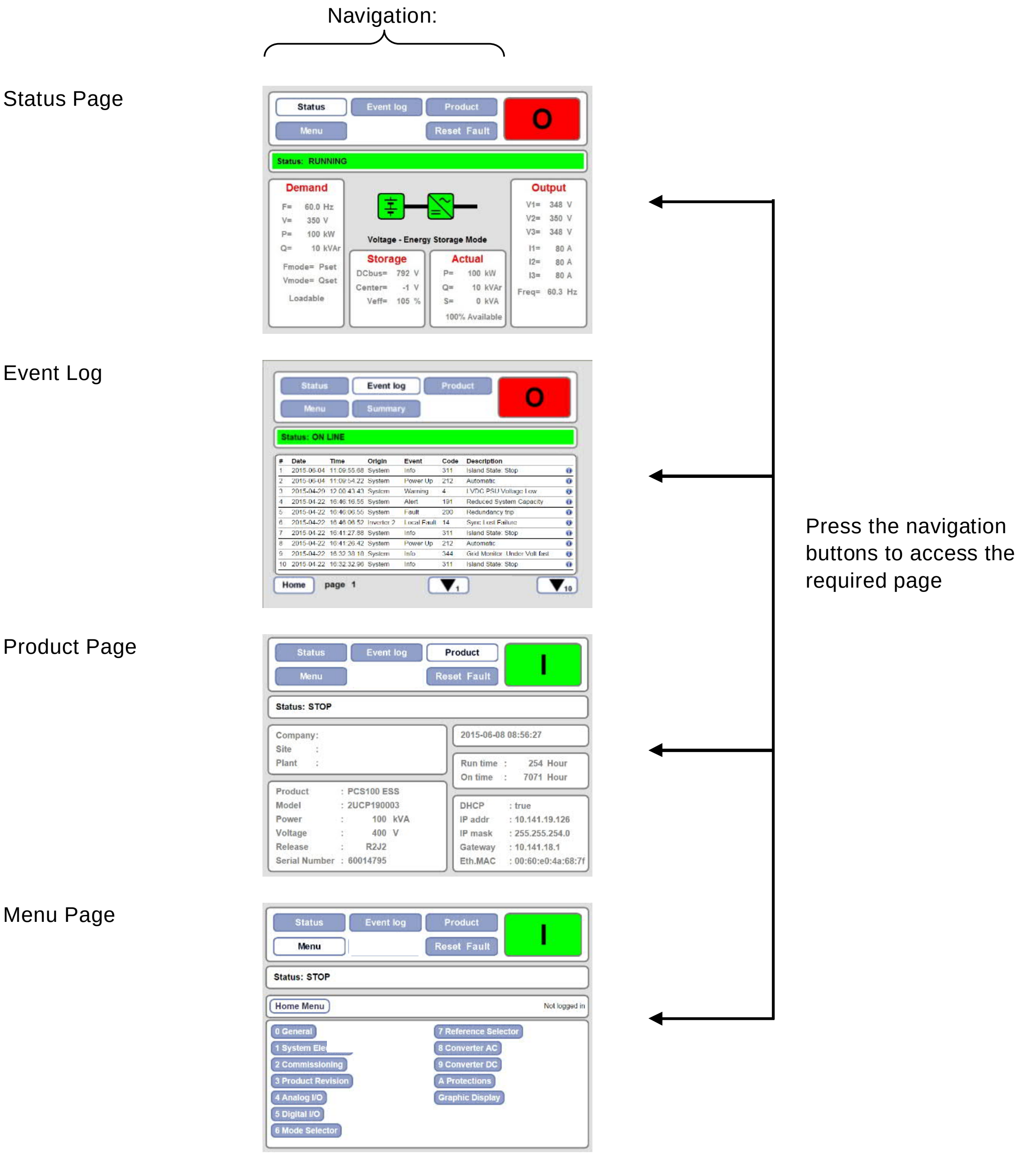
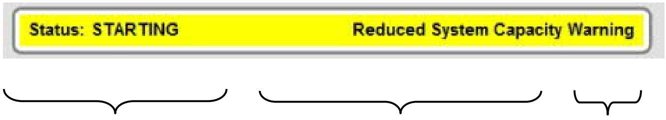


Figure 5-2: Pages available on the GDM

5.1.3 Status Bar

The Status Bar displays the PCS100 ESS status and, if present, any warning or fault code.



1. Status 2. Event Description 3. Warning or Fault Condition

1. PCS100 ESS status. Refer to Table 5-2 for a complete list of status messages.
2. Fault of Warning description. The event code number can be found in the event log. Refer to Table 5-2 for a complete event description.
3. “Warning” or “Fault” is displayed if any warning or fault condition exists.

Note: The Status Bar will only display the most recent event or what is considered the most important event. Touch the status bar and a list of all faults and warnings presently active will be displayed.

The Status Bar changes color depending on the system status. The meaning of each color is listed in Table 5-1.

Status Bar Color	Status
Green	PCS100 unit running with no warning
Green with yellow flashing warning cell	ESS running with warning present
White	ESS stopped with no warning
White with yellow flashing warning cell	ESS unit stopped with warning present
Red and white flashing	ESS unit stopped with fault present
Yellow	ESS unit is starting

Table 5-1: Status Bar colors and their meaning

The following status messages are displayed on the Status Bar of the GDM and in the event log.

Status Display	Description
Black Start	PCS100 ESS is starting without AC Voltage on an island grid.
Booting or System Down	PCS100 ESS is booting up or initializing or there is no response from the master this could be due to the GDM CAN cable disconnected.
Fault	PCS100 ESS has tripped.
Generator active	PCS100 ESS has synchronized to the grid after startup in Virtual Generator mode.
Generator connect	PCS100 ESS is waiting for grid tie breaker feedback closed. After having synchronized to the grid and activated the grid tie breaker output after being running in islanding
Inverter Not Ready	One of the PCS100 ESS inverters is not ready.
Ramp down	PCS100 ESS is ramping down voltage, power and frequency.
Ramp up	PCS100 ESS is ramping up voltage, power and frequency.
Reconnect	PCS100 ESS is reconnecting to the grid after having been running in islanding and grid voltage is back.
Running	PCS100 ESS running normal
Running Islanded	PCS10 ESS is running islanded (no main grid)
Standby	PCS100 ESS is in standby: Outputs are not switching, and the system will restart when unload or standby command is released.
Standby Islanded	PCS100 ESS island avoidance caused system to go into standby.
Standby unload	System is unloading, prior to going into standby.
Starting	PCS100 ESS is waiting until power is present and the controller is locked to the grid AC voltage.

Starting on Grid	PCS100 ESS is starting on grid
Stop	PCS100 ESS has stopped, inverters are not active or system is booting/initializing.
Synchronized	PCS100 ESS received synchronizing command and has synchronized to the external voltage, frequency and phase.
Syncing…	PCS100 ESS is synchronizing voltage, frequency and phase to the gird.
Testmode run	Test mode has been activated. See parameter 24 “Test Mode”

Table 5-2: PCS100 ESS status messages

5.1.4 Status Page

The Status Page is the default page after powering up the system and displays various system status parameters as shown in

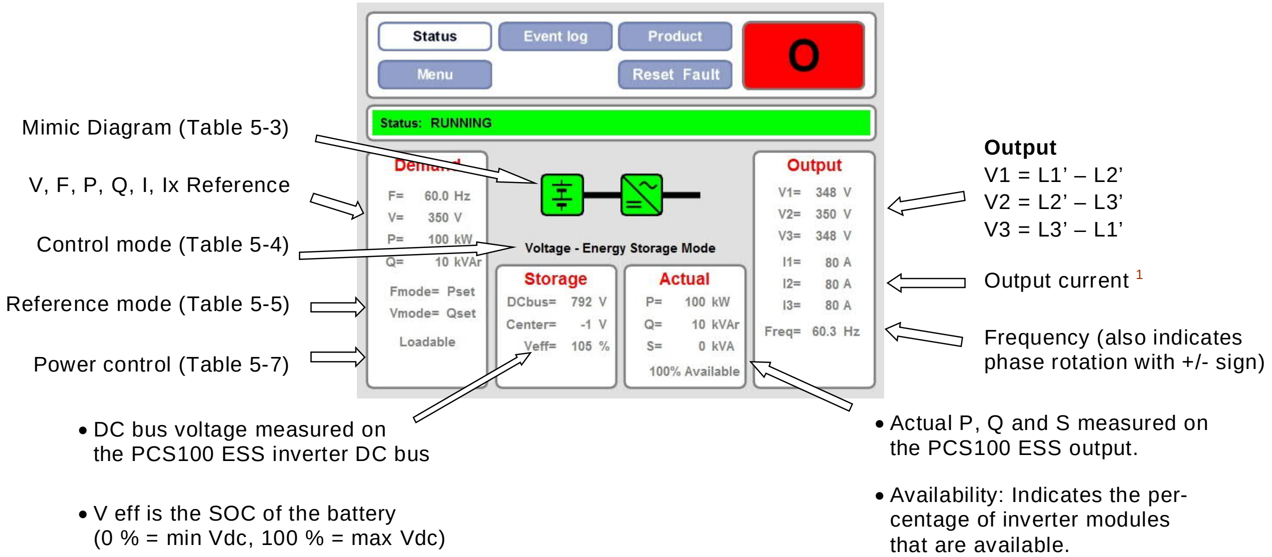


Figure 5-3: GDM Status Page (when PCS100 ESS is running)

Note: [1] At no load the current displayed is the combination of coupling transformer magnetizing current and the PWM filter current. This current is mainly capacitive and is generally useful for plants which have a lagging power factor.

Mimic Diagram Icon Color	Description
Battery Green	SOC of battery is > 50 %
Battery Orange	SOC of battery is < 50 %
Battery Red	SOC of battery is < 10 %
Inverter Green	run/on/no fault/no warning
Inverter Orange	warning
Inverter Red	fault

Table 5-3: Mimic diagram descriptions

Message	Mode
Voltage – Energy Storage Mode	Voltage Source Mode
Current – Energy Storage Mode	Current Source Mode
Rectifier & Equalization Mode	Mode to adjust PCS100 ESS DC voltage to the energy storage voltage before connecting.

Table 5-4: Control Mode descriptions

Message	Description
Fmode =	Frequency Mode:
Fset	Frequency reference
Pset	Active power reference
Fdroop	Frequency reference with droop enabling parallel operation of ESS with generators, etc.
Fsync	Synching to the grid
Vmode =	Voltage Mode:
Vset	Voltage reference
Qset	Reactive power reference
Vdroop	Voltage reference with droop enabling parallel operation of ESS with generators, etc.
Vsync	Synching to the grid

Table 5-5: Reference Mode descriptions

Selection of such modes is done based on the “Mode Selector” command inputs on menu 6. Particularly when in VSI, the configurations are achieved based on Table 5-6 (simplified).

Droop (66 and 67)	Fixed P (68 and 69)	Result
Disabled	Disabled	Fset, Vset
Enabled	Disabled	Fdroop, Vdroop
Enabled	Enabled	Pset, Qset

Table 5-6: Mode Selection

Message	Description (also see parameter 63 “Conv Load”)
Loadable	Power flow enabled
Unloading	Power ramping down to 0
Unloaded	Power flow disabled
Loading	Power ramping up to setpoint
Load Halt	Power ramping on hold

Table 5-7: Power Control descriptions

The icons on the Status Page change color depending on their status according to Table 5-8. An example is shown in Figure 5-4 for the case when the PCS100 ESS is starting.

Status	Icon color
Run (on)	Green
Off	Grey
Yellow	Warning
Red	Fault

Table 5-8: Colors of the icons on the Status Page and their meaning

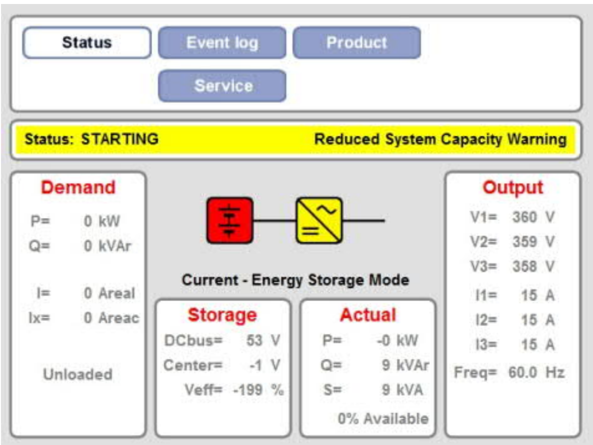


Figure 5-4: Status Page – icon colors when PCS100 ESS is starting

5.1.5 Event Log Page

The PCS100 ESS also incorporates an Event Log Page that stores a chronological list of events, which is useful for diagnosing PCS100 ESS operation.

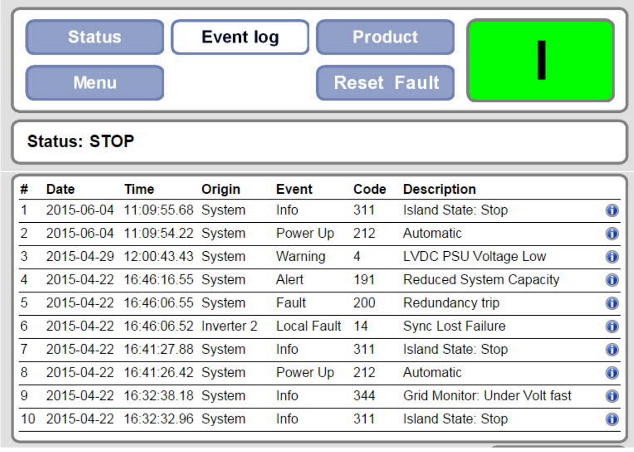


Figure 5-5: GDM Event Log Page

When accessed the Event Log Page uploads the ten most recent event records. The most recent event is shown at the top and each event record is referenced by date and time. Each system event is displayed on a single line which displays the information listed in Table 5-9.

Information Type	Description
Date	The date the event occurred.
Time	The time the event occurred (to 10ms resolution).
Origin	Fault and Warning events may originate from the Master (system) or Inverter modules.
Event	The event type.
Code	The unique numerical code for the event.
Description	For a system event this column shows a description of any Fault or Warning.

Table 5-9: Event Log columns

More detail information on the event can be accessed by clicking on the blue information button on a specific event. The event log records can be scrolled through using the paging buttons “up 1”, “down 1”, “up 10” and “down 10” at the bottom of the page as illustrated in Figure 5-6. The page number is shown at the bottom of the screen. Pressing the home button will return to page 1 and upload the most recent event records in the system. A maximum of 10,000 events can be recorded. When more than 10,000 events occur the new events replace the oldest events. The event log cannot be cleared.

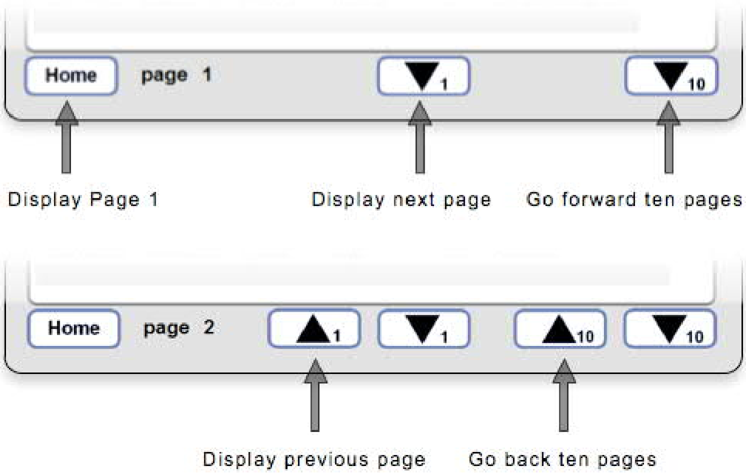


Figure 5-6: Paging buttons on the Log Event Page

5.1.6 Product Page

The Product Page records information about the product and site as shown in Figure 5-7 and summarized in more detail in Table 5-10.

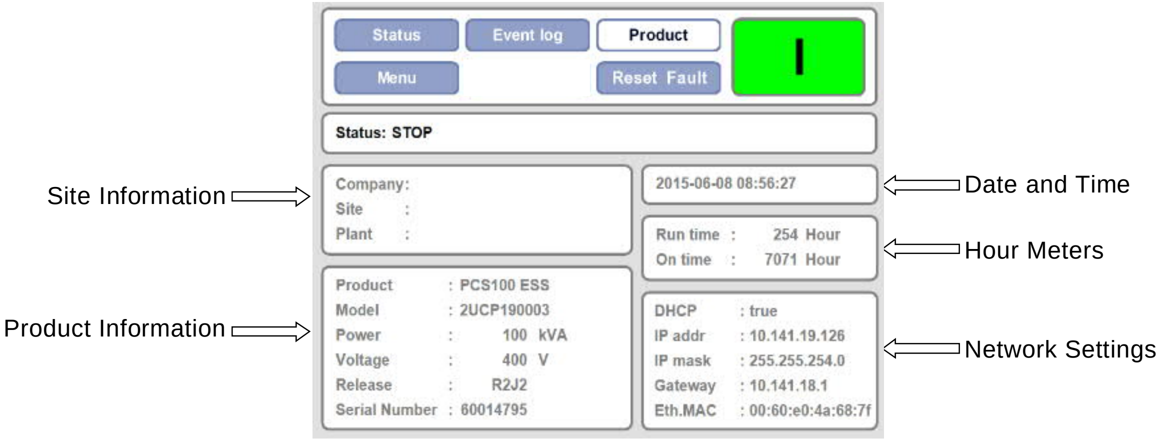


Figure 5-7: GDM Product Page

Item	Description
Site Information	Name of Company, Site and Plant Entered during commissioning in Menus: *03 Customer Name,* *04 Plant Name,* *05 Site Name.*
Product Information	Product Name and Model Power and Voltage rating SW version and Serial No. Entered during production
Date and Time	Current Date and Time Entered in menu: *02 Date and Time*
Hour Meters	Total hours running an total hours on (powered up)
Network Settings	Ethernet network parameters Entered in Menu *GDM B00 Network Settings*

Table 5-10: GDM Product Page information

5.1.7 Menu Page

The Menu Page provides access to the PCS100 ESS parameters for viewing and/or adjustment. It is organized into menus and sub menus which contain the parameters. Each folder and parameter is indexed by up to four characters to the left of the name and the current position in the menu is shown on the Navigation Panel.

A full listing and description of the parameters can be found in Appendix A – GDM Menu Reference.

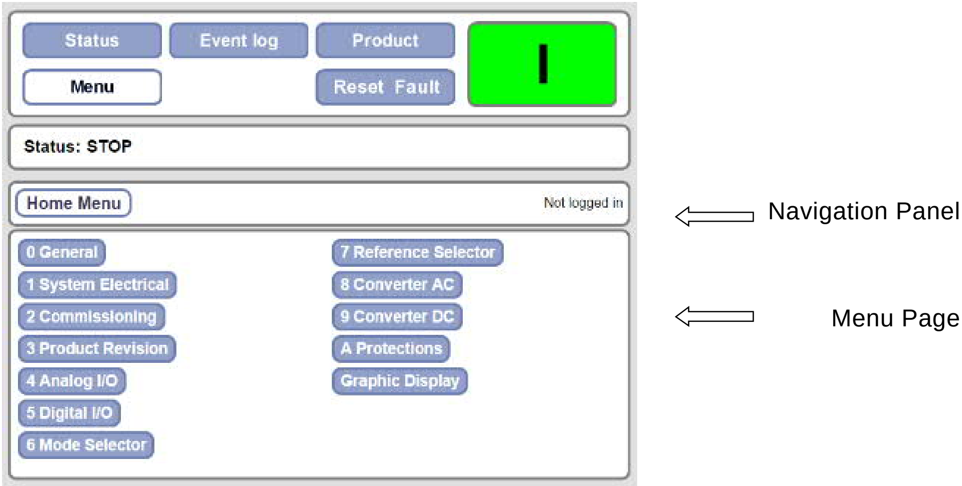


Figure 5-8: GDM Menu Page

5.1.8 Starting and Stopping the PCS100 ESS

Starting the PCS100 ESS takes it online. When stopped, the PCS100 ESS is not online.
The following table outlines the general behavior of the control button and the state of the PCS100 ESS.

When the Control Button is…	The PCS100 ESS is…	Press the Button…
I	…off	…to start the PCS100 ESS. When prompted, press Yes.
O	…on	…to stop the PCS100 ESS. When prompted, press Yes.

Steps to Start or Stop the PCS100 ESS:

1. **On the Control Panel, press the control button.**
   Note: Pressing [I] *(green button) starts the PCS100 ESS. Pressing* [O] *(red button) stops the PCS100 ESS.*
   Result: You will be asked to confirm that you want to run or stop the PCS100 ESS.
2. **Press YES.**
   Result:
   If starting the PCS100 ESS, the PCS100 ESS's status is updated to Run and the control button has changed from green [I] *to red* [O].
   If stopping the PCS100 ESS, the PCS100 ESS is not operational and the control button has changed from red [O] *to green* [I].

Reset and Inhibited Buttons

The following buttons are sometimes displayed as well.

When the Control Button is…	The PCS100 ESS…	What's Next?
Reset	…is stopped. There is a fault that needs to be resolved before the PCS100 ESS can be started.	Press Reset. If the Reset button reappears, see 'Resolving a Fault (Red)' in section 9.1.
Inhibited	…is stopped. The Inhibit switch inside the inverter's door is open or the stop/reset digital input is in open circuit.	Ensure the stop/reset digital input is closed. Note: When closed, the green Start button is displayed.

No Button Displayed?

If no button is displayed, the buttons may be hidden. When hidden, the PCS100 ESS is usually controlled from another location. For more information, please refer to section 5.1.1.

5.1.9 Logging in to the GDM

You have to log in to the GDM in order to modify most settings of the PCS100 ESS. A comprehensive overview of the settings that can be changed with "operator" and "technician" permissions can be found in Appendix A – GDM Menu Reference

Note: If you are not logged in to the GDM you can still use the GDM's touch screen to display information. However, some menu items and information will not be displayed, and you will not be able to modify any settings, nor conduct any tests.

User Codes

There are two user codes with which you can log in to the GDM:

1. "Operator": Access to the User Menu to operate the PCS100 ESS Login code **159**
2. "Technician": Access to the Tech Menu to maintain the PCS100 ESS Login code **265**

Before You Begin

Before logging in to the GDM, ensure that you have authorization and adequate training to perform the tasks that you need to perform.

Caution: *Modifying settings without adequate training may affect the operation of the PCS100 ESS; leaving the grid unprotected. Do not change settings without authorization.*

Steps to Log In

1. **On the Control Panel, press Menu.**
2. **Press Home Menu.**
3. **Press <u>0 General</u>.**
   Result: The 00 Login button is displayed.
4. **Press <u>00 Login</u>.**
   Result: A numeric keypad is displayed.
5. **Type in the login code.**
   For an operators user the login code is 159. For technicians the login code is 265.
6. **Press Apply.**
   Result: You will be logged into the GDM.
   If you are logged in as an operator user, 'User Access OK' is displayed in the Status Bar.
   If you are logged in as a technical user, 'Tech Access OK' is displayed in the Status Bar.

After successful login, you can now modify a range of settings. The settings open for modification depend on the user code used to log in to the GDM and are summarized in Appendix A – GDM Menu Reference.

Time Out

Your session will automatically time out 30 minutes after logging in. Any changes that have not been applied (by pressing Apply) will be lost when a session times out.

Note: The touch screen may go to sleep sooner. If asleep, activate the touch screen by pressing it.

5.2 Module Display Boards

Each PCS100 ESS module has its own display board as shown in Figure 5-9, which contains RUN and OK LEDs, as well as two 7 segment LED displays.

The RUN and OK LEDs indicate whether the module is running or not and whether there is a fault or warning present. The two 7 segment displays show the individual module identification number (1-32). They are also used to indicate the states during the start-up sequence (L0 and L1) and in case of a fault, they alternately flash the corresponding error code and the module identification number.

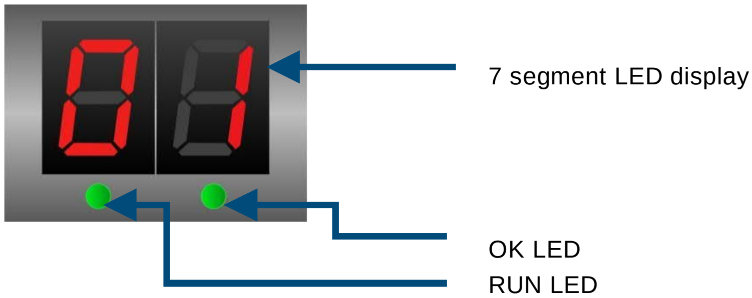


Figure 5-9: Module display board with OK and RUN LEDs and two 7 segment LEDs

RUN LED	Product Status or Description
OFF	Module stopped
ON	Module active
FLASH	Module starting

Table 5-11: RUN LED states and their meaning

OK LED	Product Status or Description
OFF	Not powered
ON	No fault present and microprocessor is functioning
FLASH (50% duty, 1sec period)	FAULT, WARNING (temperature or overload warnings) or module boot up stage

Table 5-12: OK LED states and their meaning

7 Segment LED Display	Product Status or Description
Blank	Not powered.
Module number (1…32)	PCS100 ESS is running.
L0 and module number FLASH (50% duty, 1sec period)	Booting. This is normal during start up.
L1 and module number FLASH (50% duty, 1sec period)	Configuring. This is normal during start up.
E0 and module number FLASH (50% duty, 1sec period)	A fault has occurred in the module. See error message on GDM.
E1 and module number FLASH (50% duty, 1sec period)	No communication with the main DSP (digital signal processor) controller in the auxiliary master module. Possible DSP hardware failure.
E2 and module number FLASH (50% duty, 1sec period)	Problem starting the module – invalid module configuration or invalid module parameter/s.
E3 and module number FLASH (50% duty, 1sec period)	Communications error.
E7 and module number FLASH (50% duty, 1sec period)	RFI relay error. Switched RFI relays off.
E9 and module number FLASH (50% duty, 1sec period)	High address or used with older bootloader or older application.
u0 and module number FLASH (50% duty, 1sec period)	Module operating mode = using internal module dip switch setting.
rE and module number FLASH (50% duty, 1sec period)	The module is running and it has been configured as rectifier. This is displayed for about 2 minutes after configuration (L1) is completed.
ou and module number FLASH (50% duty, 1sec period)	The module is running and it has been configured as inverter. This is displayed for about 2 minutes after configuration (L1) is completed.

Table 5-13: 7 segment LED displays

6 Functional Description and Setup

6.1 How it Works

The PCS100 ESS connects energy storage systems to the grid, in most cases via a dedicated coupling transformer as shown in Figure 6-1. The PCS100 ESS controls the power flow between the storage system and the grid and thus helps to provide various regulating tasks. If grid power is lost, it can also be used to power an islanded grid.

Figure 6-1 also shows the location of the PCS100 ESS system voltage, which is one of the system's main parameters. It depends on the PCS100 module type, DC operating range of the storage and the grid voltage tolerance and is specified during the ordering process. The product will then be delivered with the corresponding functional and protection settings.

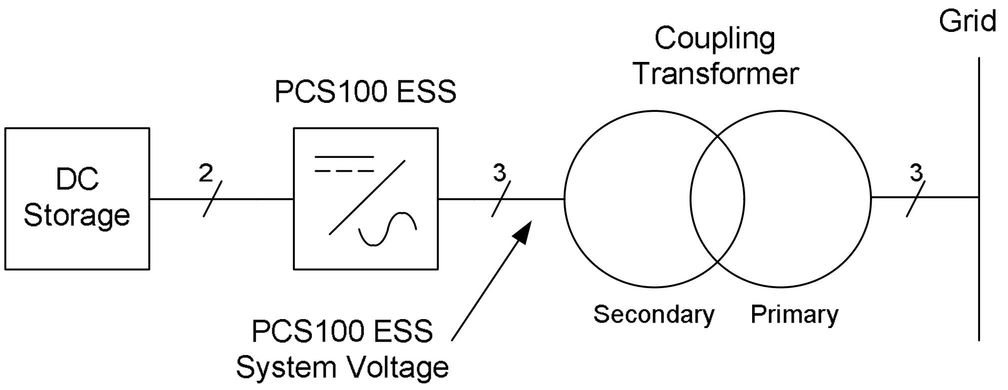


Figure 6-1: PCS100 ESS with coupling transformer (control and protection circuits not shown)

The PCS100 ESS can be configured to operate in different modes and sub-modes depending on the application, making the PCS100 ESS extremely flexible and suitable for all common energy storage applications. The two system modes available are the Virtual Generator and Current Source Inverter modes, which are presented in more detail in sections 6.2 and 6.3, respectively. The currently active system mode is always displayed on the GDM Status Page.

Note: Switching between system modes is only possible when the PCS100 ESS system is stopped.

6.2 Virtual Generator Mode (VSI)

The ABB Virtual Generator mode is a unique operating mode for a power electronic converter whereby the converter mimics 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. Physical inertia is modeled in the PCS100 ESS control system, providing a damping response to the grid frequency via the energy storage connected to the PCS100 ESS.[1]

In this mode the PCS100 ESS presents a low impedance voltage source to the AC grid, providing a balanced 3-phase voltage, i.e. the PCS100 ESS operates as a voltage source inverter (VSI). This mode is particularly useful for small grids, where the Virtual Generator voltage source provides stability in the network.

Moreover, when operated in Virtual Generator mode, the PCS100 ESS can also create a micro or islanded grid (island), by controlling its own voltage and frequency. In this setting the PCS100 ESS supports the local loads with minimal disturbance. Operation in parallel with other voltage sources is also possible without any problem thanks to the inbuilt voltage and frequency droop control options. After the return of the main grid, it automatically re-synchronizes the island to the grid for seamless reconnection. The monitoring and indication of a grid failure can be done externally or by internal supervision based on frequency and voltage monitoring.

Thus, when set to Virtual Generator mode, the PCS100 ESS can be operated in two control modes[2]:

- PQ power flow control, where the converter operates with set-points for active and reactive power
- Vf control, where the converter operates with fixed voltage and frequency set-points enabling islanding

Note: [1] This inertia artificially limits the speed of the converter and this mode is thus not recommended for applications where fast control is required.
[2] Switching between these control modes can be done while the system is running, which is particularly interesting for micro-grid applications. More details of these control modes is found in section 0.

6.3 Current Source Inverter Mode (CSI)

In the current source inverter (CSI) mode the PCS100 ESS presents a high impedance current source to the AC grid, which provides a balanced 3-phase sinusoidal current to the grid regardless of grid conditions such as imbalance or harmonics.

Compared to the Virtual Generator mode the CSI mode offers lower current ripple demand on the DC energy storage as it does not try to correct any imbalance or harmonics in the grid. Furthermore, a faster response to changes in the active and reactive power set-points can be achieved since the generator model, and thus the physical inertia modeled in it, is not present in the control loop of the CSI mode. Thanks to this the current source inverter mode is particularly useful in highly dynamic applications where sub-cycle response to power commands is required.

Thus, typical applications for the CSI mode include:

- Frequency regulation (P)
- Voltage regulation (Q)
- Load levelling / peak shaving (P)
- Renewable generation smoothing (P and Q)
- Power factor control (Q)
- Voltage clamping (Q)

6.4 Selecting the System Mode (VSI or CSI)

The system mode (Virtual Generator or CSI) of the PCS100 ESS can be selected either via MODBUS, CAN I/O Board digital input, or manually by setting parameter 60 “Sys Mode Source” accordingly. In case of manual selection, the system mode can be set with parameter 61 “Sys Mode Manual”: if set to true the PCS100 ESS will operate in Virtual Generator mode and if set to false the system will operate in CSI mode.

Note: The system mode can only be changed when the PCS100 ESS is not running.

6.5 Control Setup in Virtual Generator Mode

Figure 6-2 shows a simplified control block diagram for the PCS100 ESS when operating in Virtual Generator system mode. A summary of the most relevant parameters is given in Table 6-1, and a detailed description of all parameters can be found in Appendix A – GDM Menu Reference.

It can be seen that the converter is controlled based on the voltage reference output V_{out} of the generator model, which is at the core of the control in Virtual Generator mode. The generator model uses P and Q reference values which are either derived from the power set-points directly set in PQ control mode or calculated from the voltage and frequency set-points used in Vf control mode. The control mode is selected by setting parameter PQ mode accordingly (true = PQ control mode). In Vf control mode, synchronization with the grid voltage VR1 and grid frequency can be selected by setting parameter sync. In this case the system will remain synchronized with the grid independent of other possibly available voltage and frequency set-points.

When operating in Vf control mode a voltage and frequency droop can be set as well to enable problem-free power sharing when operating in parallel with other PCS100 ESS systems or other generator sources.

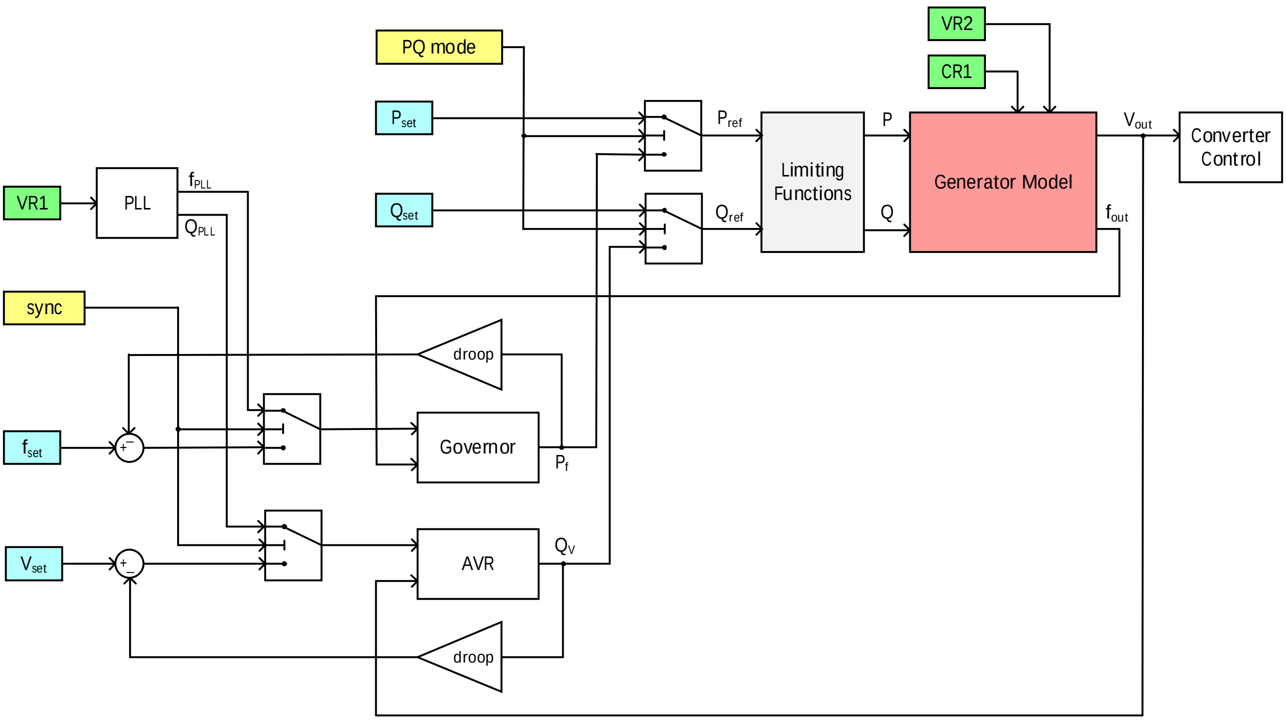


Figure 6-2: Simplified control block diagram for Virtual Generator system mode

Parameter	Number	Description
P_{set}	700	Active power set-point used in PQ (power flow) control mode
Q_{set}	704	Reactive power set-point used in PQ (power flow) control mode
V_{set}	714	Voltage set-point used in Vf control mode
f_{set}	710	Frequency set-point used in Vf control mode
PQ mode	68	Selects between PQ and Vf control mode[1]
sync	64	Enables synchronization with the grid voltage VR1 when in Vf control mode[2]
droop (f)	81	Frequency droop control[3]
droop (V)	82	Voltage droop control[3]

Table 6-1: Main parameters in Virtual Generator system mode

Before feeding the P and Q set-points into the generator model, they are checked and if necessary adjusted in a limiting control block that contains several limiting functions. These functions are the same for all operating modes and are explained in more detail in section 6.8.

The green input blocks represent the voltage and current measurements taken by the system. They are described in more detail in section 4.4.1.

Note: [1] More details can be found in section 6.5.1.
[2] More details can be found in section 6.9.4.
[3] More details can be found in section 6.5.2.

6.5.1 Fixed Power Mode and V/F mode

Parameter 68 “Fixed P Source” provides an input to switch from PQ control mode to Vf control mode and vice versa. PQ operation is usually used for grid connect applications, whereas Vf control is needed if the PCS100 ESS is supplying an islanded grid. To activate PQ control mode this parameter has to be set to true, which is also the default value.

Note: Switching between PQ and Vf control mode while in Virtual Generator mode is possible while the system is running.

6.5.2 Frequency and Voltage Droop

Parameter 66 “Droop Source” provides an input to activate or deactivate the frequency and voltage droops set in parameters 81 “Freq Droop” and 82 “Volt Droop” respectively. It is recommended to activate droop in Vf control mode when power is shared between parallel PCS100 ESS converters or other generators, as it adds compliance to the output voltage and frequency of the converter to ensure stability and power sharing in this setup. Droop is enabled when this input is set to true. The default value for this parameter is false.

Setpoints for voltage and frequency droops will be sourced automatically according to parameter 66 “Droop Source”. E.g. when parameter 66 “Droop Source” = Auto, parameters 81 & 82 will be listening the Modbus command ignoring any other possible source such as, GDM manual inputs. Please refer to Appendix A – GDM Menu Reference, page 100 for Droop sources.

6.5.3 Generator Settings

The behavior of the generator model used in Virtual Generator mode can be modified by adjusting the parameters listed in Table 6-2. The setting of these parameters determines how the PCS100 ESS system will interact with other systems in the grid.

Generator Setting	Parameter
Inertia time constant	840
Synthetic output resistance	841
Synthetic output inductance	842

Table 6-2: Parameters for adjusting the generator model

6.6 Control Setup in CSI Mode

When operated in current source inverter mode the PCS100 ESS is always operated in PQ power flow control mode and thus the control loop of this system mode is slightly simpler than the one for Virtual Generator mode.

Instead of the inertia-based generator model, a high-speed control of the real and reactive current is employed in this mode, as is shown in

Figure 6-3. These current set-points are then used as input commands for the converter control.

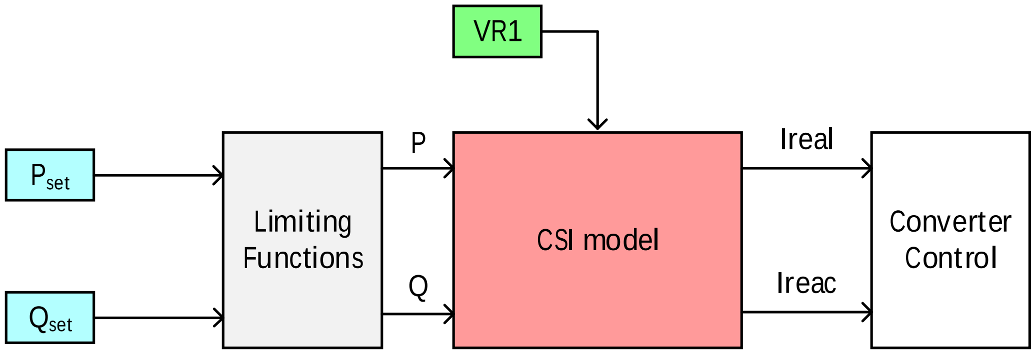


Figure 6-3: Control block diagram for CSI mode

6.7 Inputs and Measurements

6.7.1 Source Selection for Input References

Each input reference, including the set-points for P, Q, V and f and the P and Q limits, can be configured to be received either over MODBUS, an analog input on the Can I/O Board or manually through the GDM Menu Page.[1] The selection of the input reference is done using the multiplexer shown in Figure 6-4.

The input source has to be specified for each input reference and if the analog input source is selected, the gain and offset values need to be set as well. An overview of the relevant control parameters is given in Table 6-3 and a more detailed description of these parameters can also be found in Appendix A – GDM Menu Reference.

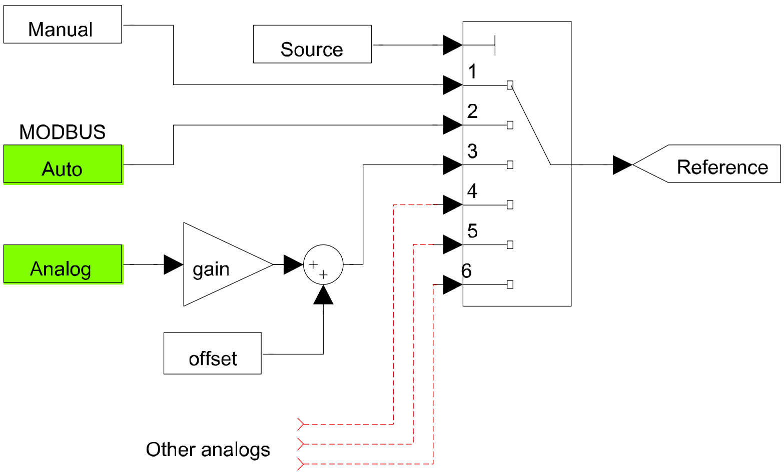


Figure 6-4: Input reference multiplexer

Input Reference	Parameter
P set-point	700 – 703
Q set-point	704 – 707
f set-point	710 – 713
V set-point	714 – 717
Positive P limit[2]	8590 – 8593
Negative P limit[2]	8594 – 8597
Positive Q limit[2]	85A0 – 85A3
Negative Q limit[2]	85A4 – 85A7
S limit[2]	85B0 – 85B3

Table 6-3: Parameters for input reference selection[3]

Note: [1] The actual set-point values are always shown on the GDM Status page.
[2] These limits must be set within the overall power limits of the PCS100 ESS as outlined in section 6.8.6.
[3] All these set-points and limits relate to power on the AC terminals of the converter.

6.7.2 DC Voltage Sensing

There are several options for connecting the DC voltage measurement from the energy storage to the PCS100 ESS. The most common method is to use the sensing circuits included with the PCS100 ESS (AR1), however, it is also possible to configure other sources for this voltage. The desired option can be selected by setting parameter 96 "Sense Method" accordingly.

6.7.3 Grid Voltage Sensing – VR1

The sync VT (voltage transducer) on the VR1 measurement input is used in Virtual Generator mode to detect a grid failure and to re-synchronize to the grid after having operated as an islanded grid.

For proper operation the phase and voltage relationship between the voltages measured by the sync VT[1,2] and the inverter terminals must be known. Typically, a Yd transformer is employed to couple the converter to the grid as shown in Figure 6-5. Therefore, using the sync VT requires measuring the phase relationship across the grid tie breaker to ensure the magnitude and phase relationship is correct. Failure to do so will cause synchronization faults and a large inrush currents.

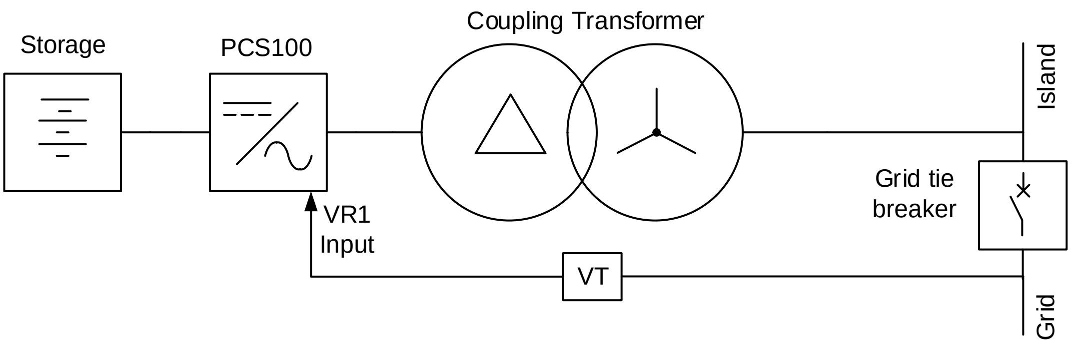


Figure 6-5: System overview with sync VT

To trim the phase and the amplitude of the VR1 sync input, stop the system and apply AC power to inverter terminals closing the AC grid tie breaker. Then adjust angle trim first using parameter 890 "Trim Sync Phase" until angle error =0, confirm it monitoring 892 "Sync Phase error". Afterward, adjust magnitude trim using parameter 891 "Trim Sync Volt" until mag error = 0, confirm it monitoring 893 "Sync Volt error".
More information about these parameters can be found in Appendix A – GDM Menu Reference.

Note: [1] The maximum voltage for the PCS100 voltage transducer is 480Vac. For higher voltages a step down voltage transformer must be used.
[2] The phase relationship includes all transformer phase shifts between the sync VT and the inverter.

6.8 Limiting Control Functions

This section presents the limiting functions used in both the Virtual Generator and CSI control. Figure 6-6 shows a simplified graphical representation of these functions.

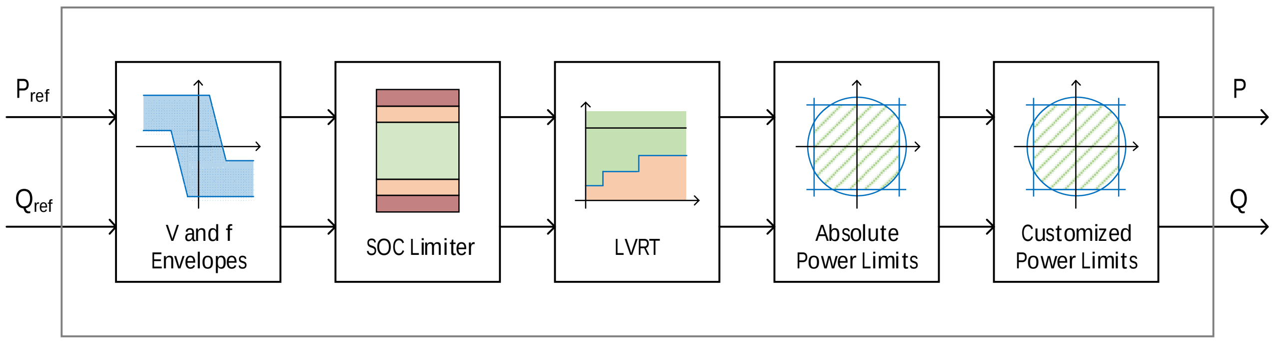


Figure 6-6: Limiting functions

Note: The SOC (State of Charge) Limiter and Absolute Power Limits always need to be defined.

6.8.1 Frequency Envelope

When operating in PQ control mode and a grid connection is suddenly lost, it is possible that the frequency of the system goes out of range due to unbalance in power. In such cases it is desirable that the PCS100 ESS limits its P output to support the grid and keep the frequency within tolerances, i.e. reduce P in case of over frequency and increase P in case of under frequency.

In the PCS100 ESS this frequency control is done using the frequency envelope shown in Figure 6-7, which can be enabled with parameter 8840 “Env Freq Mode” and is usually only used in PQ control mode. The envelope can be adjusted using the parameters listed in Table 6-4 (also refer to Appendix A – GDM Menu Reference).

In Figure 6-7 it can also be seen that there is a dead band[2] present, within which the P set-point is not adjusted even if the frequency deviates from the nominal grid frequency f_0. This is to avoid constantly changing P for slight variations in frequency.

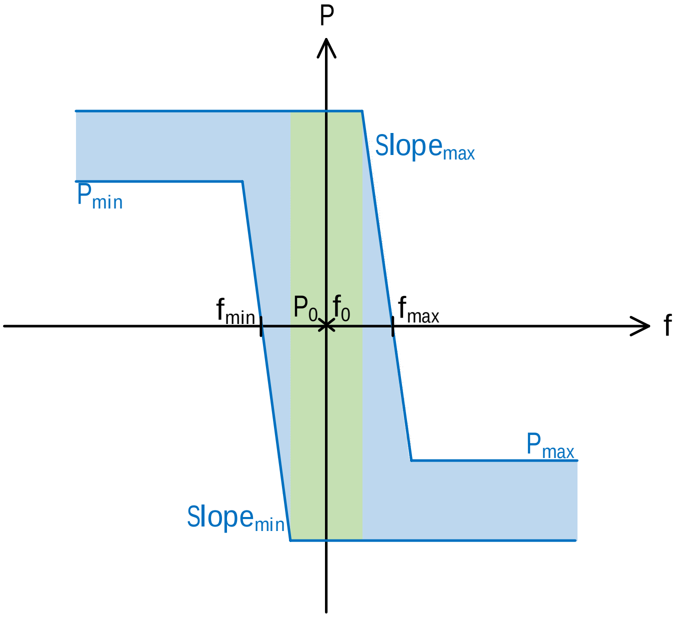


Figure 6-7: Frequency envelope

Parameter	Number	In Figure 6-7	Description
Env Freq Max	8841	f_{max}	Max frequency for Pmax
Env Freq Min	8842	f_{min}	Min frequency for Pmin
Env Freq Max Slope[3]	8843	$Slope_{max}$	Slope for Pmax
Env Freq Min Slope [3]	8844	$Slope_{min}$	Slope for Pmin
Over Freq P Min	8845	P_{max}	Lowest level to where the Pmax can drop
Under Freq P Max	8846	P_{min}	Highest level to where the Pmin can rise

Table 6-4: Parameters for adjusting the frequency envelope

When operating in Virtual Generator mode the frequency envelope is mainly used to contain the converter output frequency during various fault scenarios in the main grid. When operating in CSI mode, however, this control can also be used to actively regulate the frequency (sub-cycle fast response to power commands). In this case the envelope would typically be set narrowly around the targeted frequency.

Note: [1] It is not recommended to use the frequency envelope in Vf mode.
[2] The dead band is set by the factory and cannot be adjusted via the GDM.
[3] A hysteresis is used to ensure control stability on the frequency slopes. I.e. if the frequency increases above the allowed frequency, the power is limited to the corresponding P on the P slope. The power can only be increased again once the frequency has fallen by at least a given Δf below the frequency that triggered the slope limitation. The same principle applies for the minimum frequency slope.

6.8.2 Voltage Envelope

When operating in PQ control mode, it is possible that the voltage goes out of range. In such cases it is desirable that the PCS100 ESS adjusts its Q output to support the grid, i.e. reduce Q in case of over voltage and increase Q in case of under voltage.

In the PCS100 ESS this voltage control is done using the voltage envelope shown in Figure 6-8, which can be enabled with parameter 8850 “Env Volt Mode” and is usually only used in PQ control mode.1 The envelope can be adjusted using the parameters listed in Table 6-5 (also refer to Appendix A – GDM Menu Reference).

In Figure 6-8 it can also be seen that there is a dead band[2] present, within which the Q set-point is not adjusted even if the voltage deviates from the nominal voltage V_0. This is to avoid constantly changing Q for slight variations in voltage.

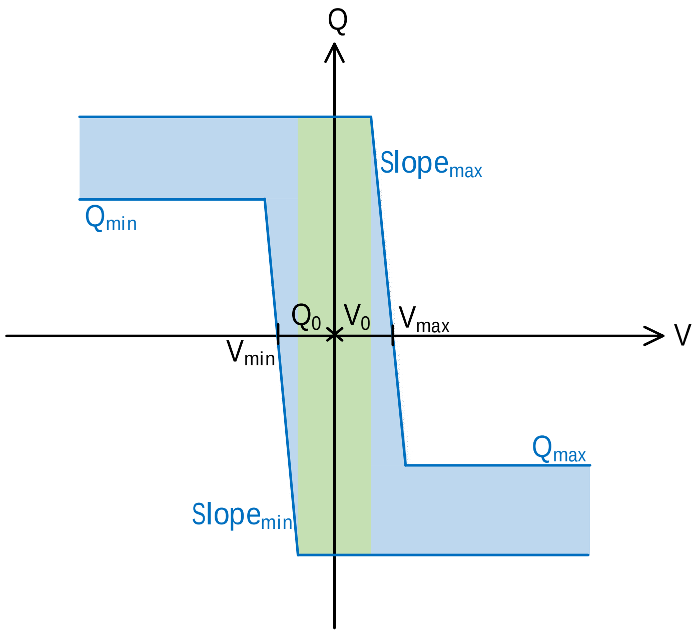


Figure 6-8: Voltage envelope

Parameter	Number	In Figure 6-8	Description
Env Volt Max	8851	V_{max}	Max voltage for Qmax
Env Volt Min	8852	V_{min}	Min voltage for Qmin
Env Volt Max Slope[3]	8853	$Slope_{max}$	Slope for Qmax
Env Volt Min Slope [3]	8854	$Slope_{min}$	Slope for Qmin
Over Volt Q Min	8855	Q_{max}	Lowest level to where the Qmax can drop
Under Volt Q Max	8856	Q_{min}	Highest level to where the Qmin can rise

Table 6-5: Parameters for adjusting the voltage envelope

When operating in Virtual Generator mode the voltage envelope is mainly used to contain the converter output voltage during various fault scenarios in the main grid. When operating in CSI mode, however, this control can also be used to actively regulate the voltage (fast control). In this case the envelope would be set narrowly around the targeted voltage.

Note: [1] It is not recommended to use the voltage envelope in Vf mode.
[2] The dead band is set by the factory and cannot be adjusted via the GDM.
[3] A hysteresis is used to ensure control stability on the voltage slopes. I.e. if the voltage increases above allowed voltage, the reactive power is limited to the corresponding Q on the Q slope. The reactive power can only be increased again once the voltage has fallen by at least a given ΔV below the voltage that triggered the slope limitation. The same principle applies for the minimum voltage slope.

6.8.3 SOC Limiter

Energy storage state of charge (SOC) management is a feature typically inherent of BMSs (Battery Management Systems). Nonetheless, the PCS100 ESS has inbuilt a SOC limiting function which is designed to provide internal protection of the PCS100 product from DC low-voltage and high-voltage operating conditions, called “SOC Limiter”.

When the SOC Limiter functionality is enabled, the PCS100 ESS system only allows full power operation in a preset range of DC voltages. By setting this voltage range to the nominal voltage range of the energy storage system the SOC Limiter can be used as a protection mechanism for the energy storage system in addition to its internal protections: If for any reason the power set-point given to the PCS100 ESS is such that the energy storage element would be operated outside its nominal voltage range, the PCS100 ESS SOC Limiter takes control and adjusts the power reference to avoid potentially damaging voltages occurring on the DC side.[1]

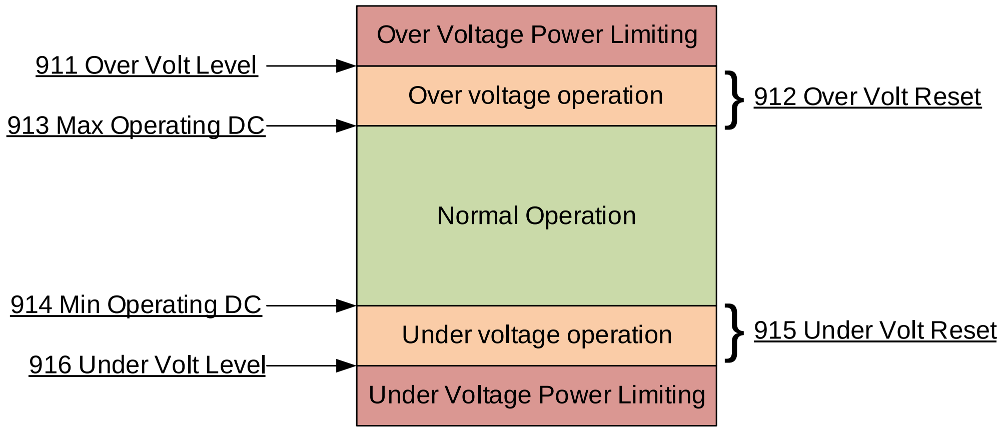


Figure 6-9: Illustration of the SOC Limiter

As can be seen in Figure 6-9 three parameters are used to define the protection for over voltage and under voltage. Parameters 913 “Max operating DC” and 914 “Min operating DC” define the limits of normal operation of the energy storage system.[2] The activation levels for the SOC Limiter are set by parameters 911 “Over Volt Level” and 916 “Under Volt Level”. If the voltage exceeds these activation limits, the SOC Limiter will start overriding existing power commands via a slope until the voltage is back within the deactivation levels, which can be adjusted by parameters 912 “ Over Volt Reset” and 915 “Under Volt Reset”.[3] An overview of these parameters is given in Table 6-6 and a more detailed description can be found in Appendix A – GDM Menu Reference.

Setting	Parameter
Maximum allowed voltage level for storage (= 100% SOC)	913
Minimum allowed voltage level for storage (= 0% SOC)	914
Over voltage level	911
Under voltage level	916
Reset level after over voltage	912
Reset level after under voltage	915

Table 6-6: Parameters for setting SOC Limiter

Note: [1] While these settings allow the DC bus operating range to be moved, they do not change the inverter voltage protection limits.
[2] These values are used as 0% and 100% SOC on the GDM Status Page.
[3] The deactivation levels must be set between the limits for normal operation and the activation levels.

6.8.4 Low Voltage Ride Through (LVRT)

The PCS100 ESS low voltage ride through (LVRT) function is typically used in CSI mode and allows the user to customize the low voltage ride through behavior of the PCS100 ESS to meet grid code specifications that require the PCS100 ESS to not trip during certain low voltage events, by means of a limiting PQ algorithm.

The LVRT function is enabled with parameter 870 “Allow LVRT” and defined by a main voltage threshold, below which the real power reference is overridden to 0%. In this way the current through the PCS100 ESS is reduced below this voltage threshold, helping the system to avoid tripping due to over current. The voltage threshold is set through parameter 871 “Vac Pset 0” and illustrated in Figure 6-10 with a red line. If LVRT is enabled the Q limits will also be internally limited in proportion to the grid voltage below 40%. This allows continued limited support of the grid voltage by injecting VAR

Furthermore, two voltage levels with corresponding time thresholds can be programmed via the GDM or Modbus, resulting in the various LVRT zones illustrated in Figure 6-10. The behavior of the PCS100 ESS in each of these zones is shortly described below:

- Zone 1: LVRT zone, where the PCS100 ESS operates continuously, respecting the voltage threshold where P is set to zero.
- Zone 2: PLL unlocked zone, where the PCS100 ESS stops switching, as the voltage is insufficient to keep the system synchronized to the grid voltage. Operation in this zone still allows for a fast recovery as soon as the voltage is back above the PLL threshold, which is at 10%, in order to meet typical grid code requirements.
- Zone 3A: LVRT off zone defined by the first set of voltage limit and time threshold, which can be set through parameters 873 “Level Vac min 1” and 874 “Time Vac min 1”. In this zone the converter stops switching and disconnects from the grid. Once the grid voltage is back, the PCS100 ESS automatically starts the restart sequence.
- Zone 3B: LVRT off zone defined by the second set of voltage limit and time threshold, which can be set through parameters 875 “Level Vac min 2” and 876 “Time Vac min 2”. In this zone the converter stops switching and disconnects from the grid. Once the grid voltage is back, the PCS100 ESS automatically starts the restart sequence.

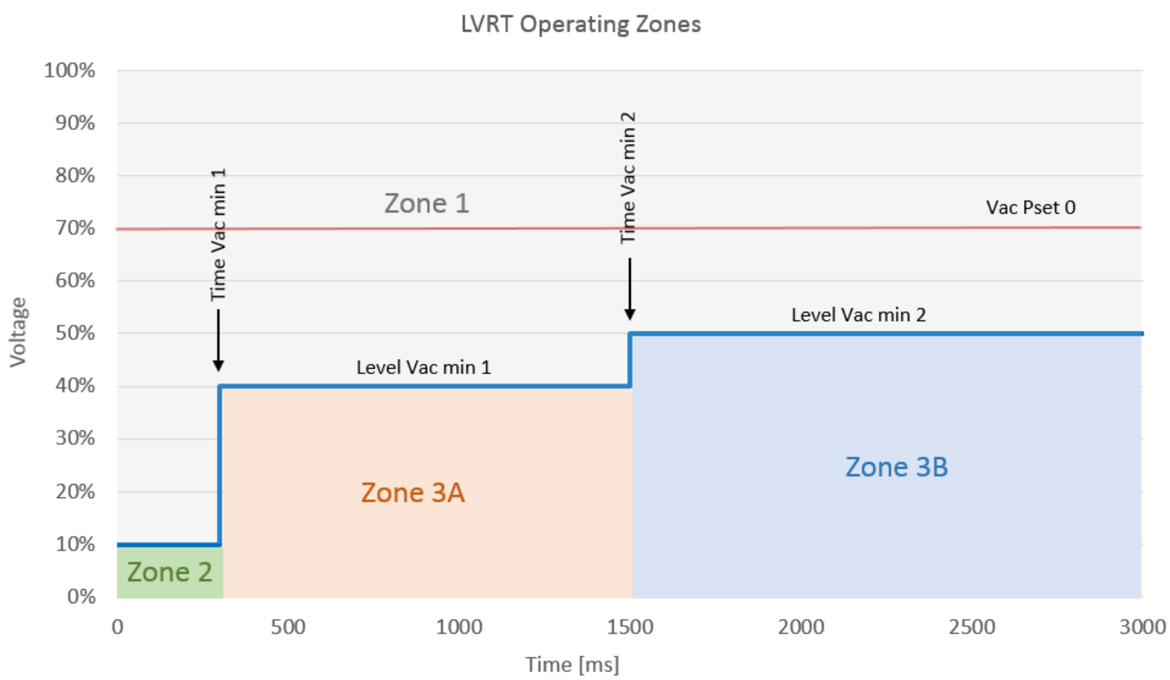


Figure 6-10: Illustration of the LVRT operating zones

Note: Details about all parameters can be found in Appendix A – GDM Menu Reference.

6.8.5 Absolute Power Limits

The PCS100 ESS contains advanced power limiting algorithms to ensure the AC power is always within desired limits. Through parameters 850 – 854 (refer to Appendix A – GDM Menu Reference for more detail) it is possible to set P and Q limits for all four quadrants of operation as well as an overall apparent (S) power limit.

The interaction of these power limits is illustrated in Figure 6-11, where the green hatched area corresponds to the possible power operation levels for the depicted limits.

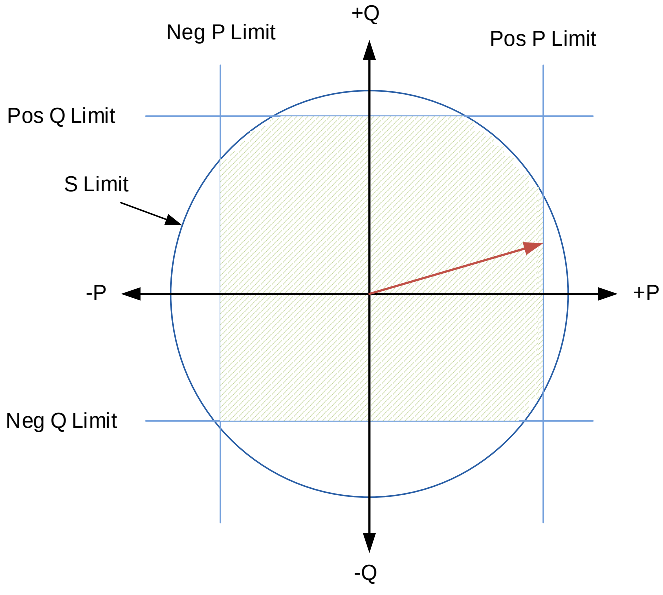


Figure 6-11: Interaction of the P, Q and S power limits

The apparent power (S) limit is able to operate in two modes, which can be selected with parameter 855 “S Limit mode” and which determine the behavior of the system in case the S limit is exceeded. The default mode is “Limit Q”, whereby the PCS100 ESS first reduces the reactive power set-point to maintain the apparent power within its limit, without changing the active power set-point P. The second mode “Limit PQ”, on the other hand, reduces both the P and Q power set-points at the same time in order to keep the apparent power within its limit.

Note: All limits relate to power on the AC terminals of the converter.

6.8.6 Customized Power Limits

In addition to the absolute power limits discussed in section 6.8.5 customized power limits can also be defined.[1] These limits interact in the same way as the absolute power limits (see Figure 6-11) and have to be set within the absolute power limits. They can be set through the parameters in Table 6-7, which are also explained in more detail in Appendix A – GDM Menu Reference.

Limit	Parameter
P limit[2]	8590 – 8597
Q limit[2]	85A0 – 85A7
S limit[2]	85B0 – 85B3

Table 6-7: Parameters for setting customized power limits

Note: [1] Such limits can for example be imposed by the battery management system and may be more restrictive than the limits given by the PCS100 ESS's capabilities.
[2] All limits relate to power on the AC terminals of the converter.

6.9 Islanding and Anti-Islanding

In an electrical network an “island” is a situation in which a generator is powering a part of the network even though power from the electrical utility network has been cut off. Islanding can be dangerous to people working with the network and not realizing that the circuit is still powered. For that reason, many grid codes require distributed power generators to immediately stop producing power to the network, as soon as an island is detected. Regulatory requirements dictate the thresholds and timing of the various protections that are required to detect grid loss. Detection of an islanded condition is carried out by a combination of grid monitoring and island detection methods which are discussed in the following sections.
When a grid loss or island condition is detected, the action to be taken by the system depends on both the requirements of the application and the local grid codes. The following actions are available on the PCS100 ESS and can be selected by setting parameter 8A03 “Grid Loss Action” accordingly.

- Disabled — Grid monitoring is disabled.
- Monitor — A “grid loss” output is generated, but no action is taken by the system.
- Run on Island — System runs as an island when grid loss is detected.
- Trip on Island — System issues a trip when grid loss is detected.
- Stop on Island — System goes into standby when grid loss is detected.

A detailed description of these options can be found in section 6.9.3.

6.9.1 Grid Monitoring

In order to detect a grid loss the grid has to be monitored by the system. A grid monitoring function is already implemented in the PCS100 ESS and parameter 8A01 “Enable Src” provides an input to enable or disable this function. When set to true, which is the default value, the grid is monitored using the passive and active detection methods summarized in Table 6-8.

Methods		Control Parameters
Passive detection	Under voltage detection[1,2]	8A10 – 8A13
	Over voltage detection[1,2]	8A14 – 8A17
	Under frequency detection	8A20 – 8A23
	Over frequency detection	8A24 – 8A27
Passive Anti-island.	Frequency rate of change	8A28 – 8A29
	Phase loss detection	8A30 – 8A31
Active Anti-island	Reactive power variation	8A40 – 8A41

Table 6-8: Methods used for grid monitoring

Each detection method consists of a detection threshold and timer that allows the methods to be fine-tuned so as to prevent nuisance activation. A more detailed description of each parameter can also be found in Appendix A – GDM Menu Reference.

Note: [1] Voltage sensing can be done externally (VR1) or internally (VR2) by setting parameter 8A04 “Utility Feedback Src” accordingly. For islanding operation VR1 must be selected to enable re-synchronization with the main grid.
[2] Important to note that the frequency used on grid monitoring signed (+ or -), so phase rotation needs to be checked.

6.9.2 Islanding Control Overview

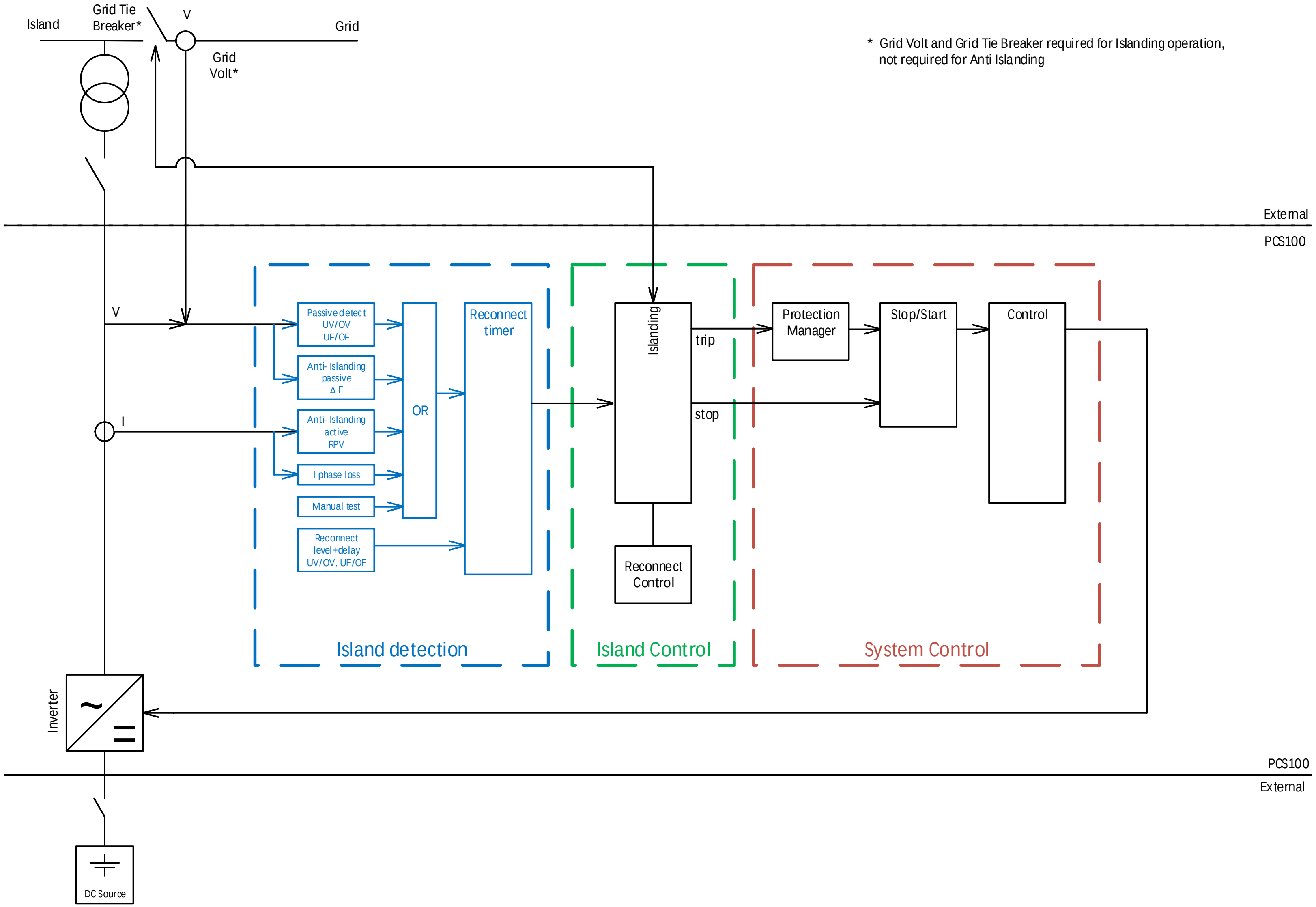


Figure 6-12: Overview of the PCS100 ESS Islanding Control

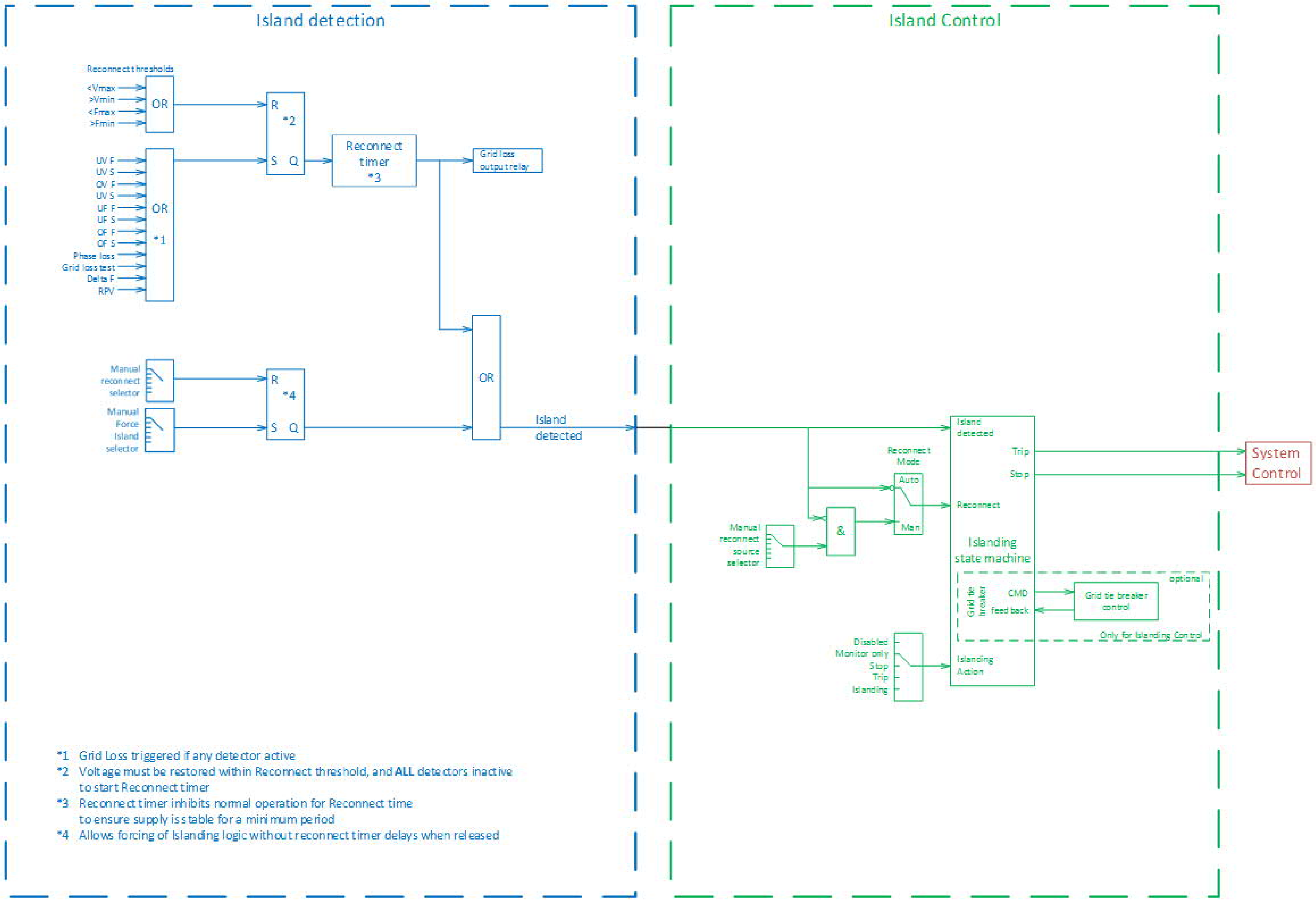


Figure 6-13: Overview of PCS100 ESS Island Detection and Island Control

Note: More information about parameters 8Axx can be found in Appendix A – GDM Menu Reference.

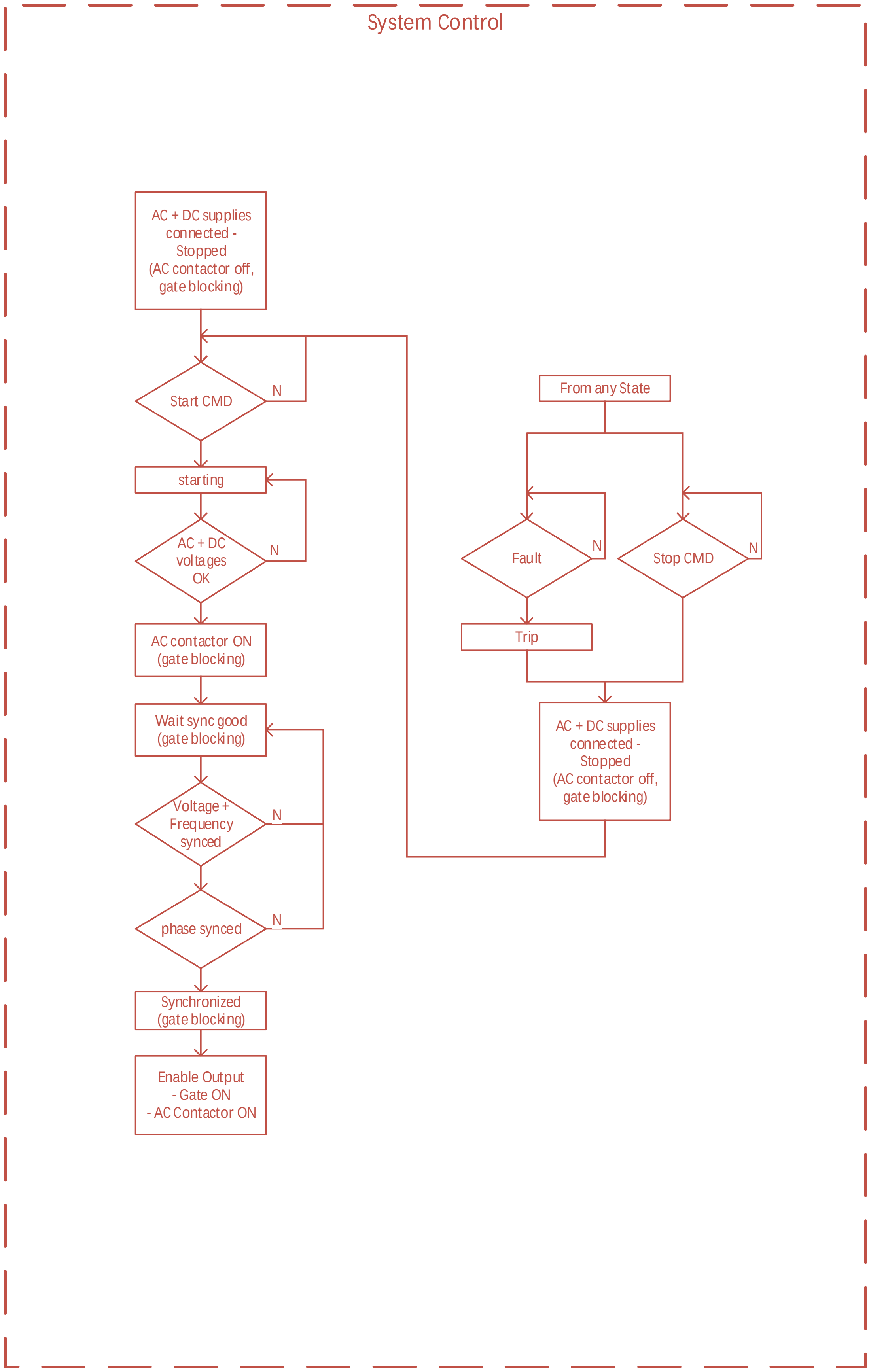


Figure 6-14: Overview of the PCS100 ESS System Control

6.9.3 Grid Loss Action

The PCS100 ESS offers several options for what the PCS100 ESS should do when a grid loss is detected by the monitoring function. Besides monitoring only, there are three possible reactions, “Run on Island”, “Trip on Island” and “Stop on Island”, which are presented in more detail in this section.

6.9.3.1 Run On Island

If parameter 8A03 “Grid Loss Action” is set to “Run on Island”, the PCS100 ESS starts running as an island when a grid loss is detected. The flow chart for this case is shown in Figure 6-15.

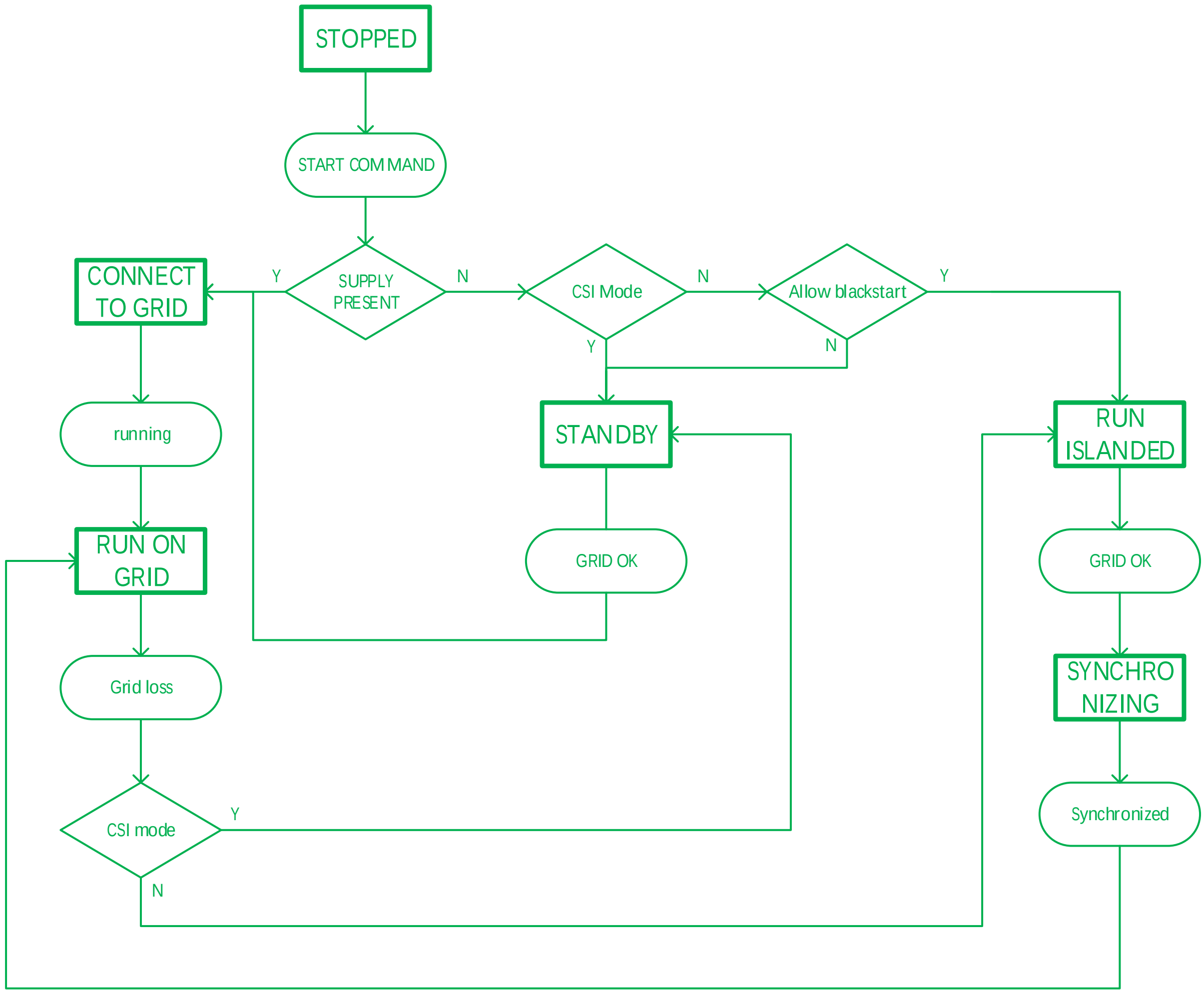


Figure 6-15: Flow chart when “Run on Island” is selected

6.9.3.2 Trip on Island

If parameter 8A03 “Grid Loss Action” is set to “Trip on Island”, the PCS100 ESS trips when a grid loss is detected. The flow chart for this case is shown in Figure 6-16.

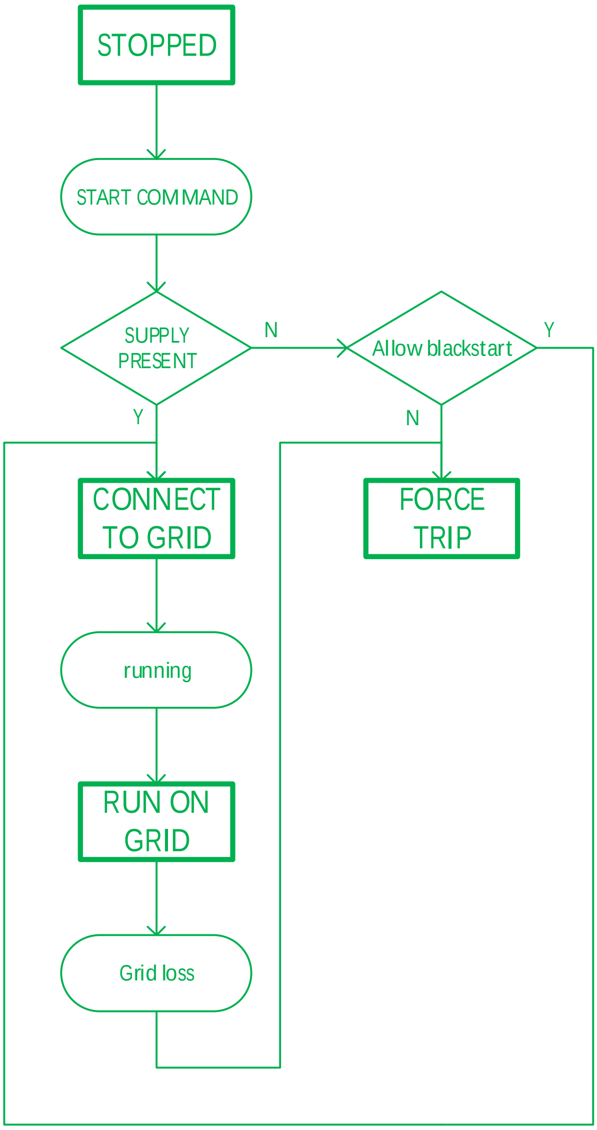


Figure 6-16: Flow chart when “Trip on Island” is selected

6.9.3.3 Stop on Island

If parameter 8A03 “Grid Loss Action” is set to “Stop on Island”, the PCS100 ESS goes into standby when a grid loss is detected. The flow chart for this case is shown in Figure 6-17.

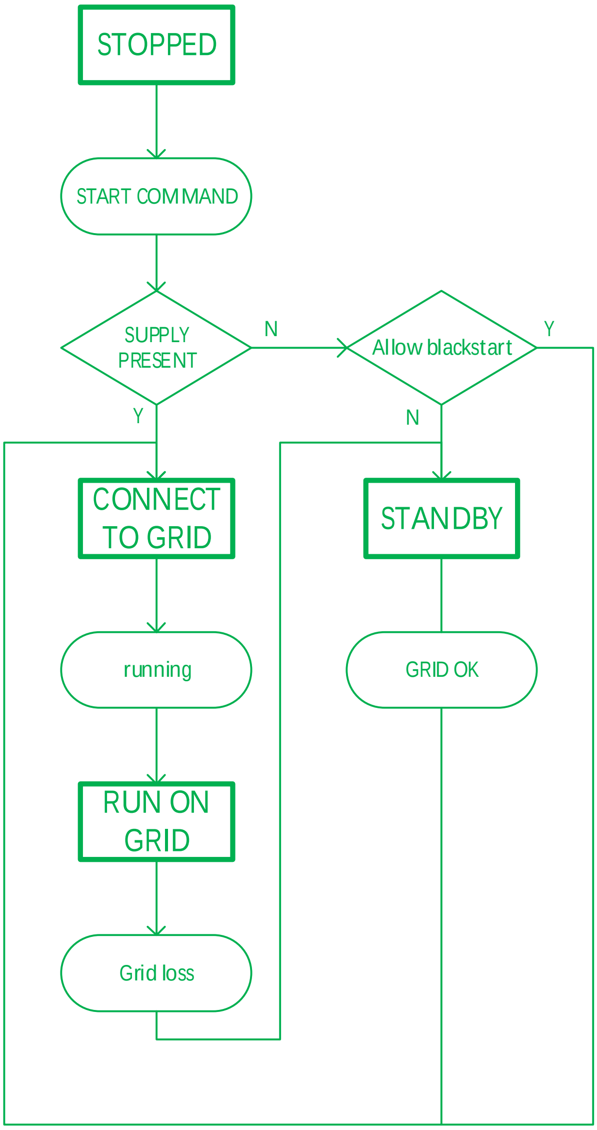


Figure 6-17: Flow chart when “Stop on Island” is selected

6.9.4 Re-Synchronization with the Grid

When running as an island the PCS100 ESS must re-synchronize with the main grid once the grid power has come back. Only after successful re-synchronization can the load be seamlessly transferred back to the main grid.

Parameter 64 “Conv Sync Source” provides an input to command the converter to synchronize to an external voltage reference. Setting this input to true will cause the output of the PCS100 ESS to align its voltage, frequency and phase with the voltage measured on the VR1 input (also refer to section 4.4.1). For normal grid connected operation this input must be set to false, which is also the default value.

6.10 Using the Converter Loading Feature

Parameter 62 “Conv Load Source” provides an input to command the converter to take up load or to unload. For normal operation this parameter must be set to true, as setting to false will cause the output power of the PCS100 ESS to ramp down to zero. The default value for this parameter is true.

6.11 Using the Energy Saving Standby Feature

The PCS100 ESS incorporates an energy saving standby function, which greatly reduces idle losses by blocking the power module IGBT switching if both the P and Q power set-points are below a pre-set threshold.[1] Thus, the converter losses are reduced to auxiliary power only when in energy saving standby. Should the P or Q references rise above the threshold the PCS100 ESS will restart providing the demanded power.

This function is activated by setting parameter 860 “Standby on low PQ” to true and can be adjusted to an application’s needs by setting the threshold and timeout parameters in Table 6-9. More information about these parameters can be found in Appendix A – GDM Menu Reference.

Setting	Parameter
P threshold to enter standby[2]	861
P threshold to exit standby[2]	862
Q threshold to enter standby[2]	863
Q threshold to exit standby[2]	864
Standby when “unload” activated	865
Enter timeout	866
Exit timeout	867

Table 6-9: Parameters for programming the energy saving standby function

Note: [1] The reactive current from the internal capacitors still flows when the system is in energy saving standby.
[2] The thresholds for entering energy saving standby must be lower than the thresholds for exiting energy saving standby, providing a hysteresis band.

6.12 Using the Voltage Clamping Feature

When operating in CSI mode the PCS100 ESS offers a Voltage Clamping feature, which allows the PCS100 ESS to support the grid voltage during low voltage events.

The ability of the PCS100 ESS to help restore the voltage at the point of common coupling, Vpcc, depends on the network short circuit capacity relative to the PCS100 ESS’ nominal current and the relative impedances within the network as illustrated in Figure 6-18. Given typical relative network impedances, the PCS100 ESS is usually able to move the Vpcc a few per cent at full current.

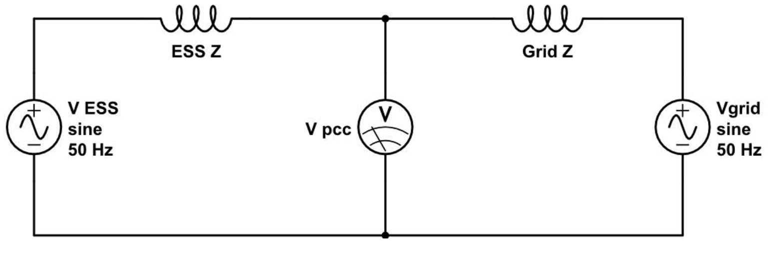


Figure 6-18: Network equivalent for voltage clamping feature

During steady state conditions an external PLC will continuously adjust the PQ commands to the PCS100 ESS in order to manage both the voltage Vpcc and the net power flow into the network. As long as Vpcc remains within a defined dead band the transient clamping algorithm will not interfere with normal operation.

When the voltage Vpcc moves outside the defined dead band, the transient clamping algorithm will inject a reactive current Ix into the network to bring the voltage back within the dead band. During such clamping events, the limiting function reduces the P command so that more Ix is available for voltage clamping. The maximum current the system will deliver into the system can be adjusted to the needs of the application.

The main difference between the voltage clamping feature and the voltage envelope is that the voltage clamping feature is not bound to a slope, but limited only by the product reactive power limits and a maximum current parameter.

The voltage clamping feature is enabled with parameter 8B0 “Volt Clamp Ena” and can be adjusted with parameters listed in Table 6-10. A more detailed description can be found in Appendix A – GDM Menu Reference.

Setting	Parameter
Limit for over voltage	8B2
Limit for under voltage	8B3
Response rate for correction	8B4
Maximum current used for voltage clamping	8B5

Table 6-10: Parameters for programming the voltage clamping feature

6.13 Using the DC Equalize Feature

The PCS100 ESS includes a DC pre-charge feature called DC Equalize to allow the seamless connection of the converters to a charged energy storage by ensuring that the DC breaker is only closed once the internal DC bus capacitors of the PCS100 modules are charged to the correct voltage. Without this feature large inrush currents can be experienced and even damage to DC side circuit protection is possible. This feature is controlled manually via the GDM or automatically via the Modbus communication port. To use it the AC grid must be present.

Note: The DC Equalize feature must be used whenever the PCS100 ESS DC bus is disconnected from the energy storage and reconnection is required. However, this is NOT a continuous operation mode.

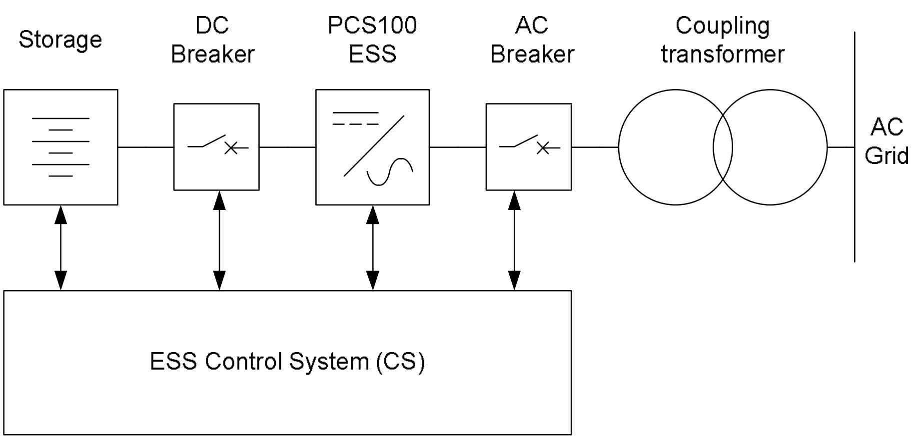


Figure 6-19: System overview when using the DC Equalize feature

Steps to equalize and connect the DC bus to the charged energy storage:

1. Close the AC breaker and supply auxiliary power to the PCS100 modules.
2. Close the inhibit digital input on the PCS100 master controller.
3. Set the PCS100 into DC Bus Equalization mode via parameter 20 “Inverter Mode” or by setting Modbus parameter 215 to true.

4. Measure the storage voltage and set this value into the PCS100 ESS DC bus equalization voltage reference, parameter 21 “DC Equalize V”. Or by writing the scaled value to Modbus parameter 103 (refer to Modbus tables in Appendix B – MODBUS Parameters & Error Codes for scaling).
5. Start the PCS100 ESS via the Green GDM start button or by momentarily setting Modbus parameter 203 to true.
6. Once the DC bus on the PCS100 ESS reaches the voltage set-point the DC breaker can be closed.
   Note: The DC bus value is shown on the GDM and is also available on Modbus parameter 33.
7. The PCS100 ESS must be stopped with the DC breaker remaining closed to exit the equalize mode. Stop the PCS100 ESS via the GDM red stop button or by momentarily setting Modbus parameter 200 to true.
8. Turn off the DC bus equalize mode via setting parameter 20 “Inverter Mode” to None or by setting Modbus parameter 215 to false.

The PCS100 ESS is now ready to operate in PQ or Vf mode with the DC bus connected to the energy storage. Should the energy storage be disconnected from the PCS100 ESS repeat the above procedure to re-connect.

6.14 DC Voltage Imbalance and Ripple Protection

The PCS100 ESS includes an imbalance and high frequency ripple voltage protection on the DC side, which ensures that the converter is operated within its insulation ratings and that all internal components are protected from potential over voltages. The imbalance protection monitors the voltage to ground from the “virtual” mid-point of the DC voltage and the ripple protection detects any high frequency PWM voltages on the DC-link to ground.

Note: Incorrect settings can deactivate this protection. Therefore, factory only settings are usually used, which should only be adjusted with instruction from the factory.

7 Protection Requirements

7.1 Input Circuit Protection

The PCS100 ESS relies upon upstream protection for current overload and short circuit protection. Upstream protection should be provided by a circuit breaker between isolation transformer and the PCS100 ESS.

PCS100 inverters do not draw large inrush currents, nor do they consume current beyond about 200% so supply 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; for ACBs 40 – 80ms). “Close” means setting the detection current to levels not much larger than the capability of the inverter – typically 300%.

Ungrounded power systems are also generally more exposed to coupled transient disturbances, so the use of appropriately sized surge protective devices (SPDs) is recommended. Note that SPDs should be rated to 480Vac or higher to ground (e.g. 480/690Vac, not 277/480Vac) due to possible common mode offset and PWM voltages. Grounded electrostatic shields between the MV and LV windings, where fitted, provide equivalent protection, obviating the need for SPDs

7.2 Insulation Monitoring

IT power systems has all active parts isolated from the earth or one point of the network grounded via a high impedance. Even when ungrounded systems increase the operational reliability and human safety, an unattended non-critical first fault can lead to a much more serious event.

When PCS100 ESS integrated in ungrounded power systems (IT) it requires the use of insulation monitoring equipment. While in resistance grounded and distributed earth systems (no direct connection of protective earth conductor throughout the power system - TT power systems) residual current protection is required.

An insulation monitoring device will monitor the ungrounded system among the active phase conductors and earth. It is intended alert or disconnect the power supply when the resistance between the two conductors drops below a set.

7.3 Arc Fault Hazards and Protection

7.3.1 Arc Fault and Standards

Arc faults may happen due to unexpected occurrences and are often triggered by a service person with consequently high risk of harm from the arc. Arcs can cause lethal injury from burns, pressure and flying debris. Generally, the risk is in proportion to the energy of the fault current and time of exposure.

Safety issues in respect or arc faults are considered in the USA National Fire Protection Association NFPA 70E Standard for Electrical Safety in the Workplace. Currently there is no equivalent European standard.

In the USA, NFPA 70E (and associated standards) mandates:

- Assessment of whether there are arc flash hazards (if the electrical equipment was de-energized, for example, the hazard would not be present)
- Calculation of the energy released by the arc, if present
- Determination the flash protection boundary
- Provision of appropriate personal protective equipment (PPE) for the personnel working within the flash protection boundary
- Appropriate labelling of the equipment. These warning labels are placed on the equipment by the plant owner and not by the manufacturer. The labels shall indicate the minimum protective distance, the energy level which can be released and the required personal protective equipment (PPE).

Such study is required for all US installations.

NFPA 70E Annex D (referencing references IEEE Std. 1584-2002 - IEEE Guide for Performing Arc Flash Hazard Calculations) provides guidance on calculation of fault energies, protection boundaries, PPE and labelling.

7.3.2 Arc Fault Protection Recommendation

Electrical arcs propagate through air and equals between 30 and 50 % of the bolted short circuit current depending on arc distance. Released energy is proportional to current and time so protection must be designed to minimize both. ABB highly recommends MCCB or ACB for arc protection.

7.3.2.1 MCCBs

Fast molded case circuit breakers (MCCBs) are the highly preferable choice for protection of PCS100 ESS systems. Such MCCBs, such as ABB Tmax series use magnetic repulsion to successfully clear fault currents of 10 - 15 times the nominal current within about 6ms. But note that below about 10 times the nominal current, the breakers revert to the electronic trip and are specified as taking < 40ms to trip.

7.3.2.2 ACBs

Mechanical air circuit breakers (ACBs) do not provide any sub-cyclic current limitation in short circuits and are usually slower than MCCBs. The ABB Emax series is specified to clear in 70ms, but EMax2 is specified to clear in only 40ms. Other ACBs may be slower than this and protection relays may add to the time. ACBs are applied to systems from about 1500A and above, where MCCBs are less commonly available. As with MCCBs, to minimize arc fault energy, it is critical to choose instantaneous tripping under lowest expected arc current (typically the ACB instantaneous trip level can be set to about 300% of the PCS100 ESS full load current rating).

To minimize arc fault energy, it is critical to choose instantaneous protection (no delay) and a tripping level less than the lowest expected arc current.

7.3.2.3 Fuses

Careful attention must be paid when choosing to use fuse for arc protection. Current limiting fuses are useful when the minimum arc current is in their current limiting range (e.g. 20 times or more). Fuses are not useful at reducing arc energy when the arc current is a low multiple of their rating (e.g. 10 times or less). When choosing fuses it is important to check that the melt time of the fuse is suitably short (e.g. 10ms) under minimum arc current conditions. Note that particularly in high current applications, fuse melt times are so long that fuses are unsuitable for providing arc fault protection.

Protection on the MV side with systems with dedicated transformer will result in increased arc fault energy for various reasons, such as MV breakers generally being slower than LV breakers.

7.3.3 Personal protective equipment

Due to the high levels of released energy and excessive heat it is highly recommended that the personal protective equipment is used when working around live equipment.

NFPA 70E sections (14) and (15) provide guidance on the selection of suitable personal protective equipment and ratings.

This can be summarized as:

Hazard Risk Category (HRC)	Incident Energy Minimum cal/cm2	Required FR Work Wear PPE
0	2	Non-melting Clothing
1	4	FR Shirt and FR Trousers (or FR coveralls) and PPE
2	8	FR Shirt and FR Trousers (or FR Coveralls), Cotton Underwear and PPE
3	25	FR Shirt and FR Trousers, FR Coveralls (in addition to FR Shirt and FR Trousers), Cotton Underwear d PPE
4	40	FR Shirt and FR Trousers, FR Coveralls (in addition to FR Shirt and FR Trousers), Cotton Underwear, Full Coverage Arc Flash Suit and PPE

NFPA 70E does not have a Hazard Risk Category (HRC) above 40 cal/cm2. Working in environments above 40 cal/cm2 should be avoided because of the blast hazards caused by electric arc flash. Arc flash levels above 40 cal/cm2 can be fatal and usually result in a massive pressurized blast with sound waves and projectiles. PPE is available for 100 cal/cm2 however the force from the pressurized blast can be fatal regardless of the PPE.

8 Maintenance

Recommended maintenance intervals and component replacements are based on specified operational and environmental conditions. ABB recommends product inspections according to list below to ensure the highest reliability and optimum performance. More detailed maintenance information can be found on the detailed maintenance instructions.

The design lifetime of the PCS100 ES product is 15 years with operation in specified operational and environmental conditions, and maintenance performed according to recommended schedule.

For more information consult ABB Service: NZ-powerconditioningservice@abb.com

	Legend
R	**R**eplacement of component
I	**I**nspection (visual inspection, correction and replacement if needed)
S	On-**S**ite work (tests, measurements, etc.)

Recommended maintenance actions	**Activity**	**Period**
Cooling		
Air ducts	**I**	**1 year**
All fans and filters	**I**	**1 year**
Connections and surroundings		
Thermal scan	**I**	**1 year**
Tightness of terminals	**I**	**1 year**
Dust, corrosion and temperature	**I**	**1 year**
Communications cables and connections	**I**	**1 year**
Aging		
AC filter capacitors	**S**	**1 year**
Spare Parts		
Spare parts	**I**	**1 year**
PCS100 power module DC bus capacitor reforming	**S**	**3 years**
Improvements		
Software upgrades	**I**	**1 year**

Note: For critical applications and applications where there is the possibility of poor environmental conditions it is recommended to shorten the above recommended periods.

Schedule of component replacement for product operation in environmental conditions up to 40° C			
		Years from start-up	
Component	**Note**	**5**	**10**
Cooling			
PCS100 power module fan		**R**	**R**
Transformer cooling fans	If fitted	**R**	**R**
Aging			
CANbus cable replacement*			**R**
AC filter capacitors **			**R**
Auxiliary module power supply	not applicable to systems with a compact master	**R**	**R**
SCM board	SCM rev F and earlier, systems built before 18/6/2015		**R**
SCM board battery	SCM rev G and later, systems built after 18/6/2015		**R**
Compact master module	Rack systems only		**R**

* If for any reason there is the need to replace a module from year 8 onward, we recommend that the opportunity is taken to replace the CANbus cables at this time.

** Valid for THDv <8%. For THDv >8% components' life time is likely to be reduced.

Consult ABB Service for maintenance recommendations at: NZ-powerconditioningservice@abb.com

9 Faults, Warnings and other Events

Faults, warnings and other events are displayed on the GDM in the Status Panel. There may be more than one fault or warning to resolve at any one time, however, the Status Panel only displays the most recent or most important fault or warning. All other events can be accessed through the Event Log Panel as described in section 5.1.5.

Depending on the status of the PCS100 ESS the Status Panel changes color. Table 9-1 lists all fault and warning conditions (for an overview of all statuses see Table 5-1):

Status Panel	Meaning
Flashing red and white	There is a fault that requires immediate action. The PCS100 ESS is stopped and cannot be started until the fault is resolved. Note: Refer to section 9.1.
White with a flashing yellow warning	There is a warning that may require attention. The PCS100 is stopped but can be restarted. Note: Refer to section 9.2.
Green with a flashing yellow warning	There is a warning that may require attention. The PCS100 ESS is operational and the problem may correct itself or may require fixing. Note: Refer to section 9.2.

Table 9-1: Fault and warning conditions

9.1 Resolving a Fault

When a fault prevents the PCS100 ESS from operating the Reset button shown on the right is displayed and a fault message is shown on the Status Panel.

Important: *The PCS100 ESS cannot be started (operate) until the Reset button is dismissed. The reset button cannot be dismissed until the fault is resolved.*

Note: Press the Reset button before attempting to resolve a fault. This might already solve the problem, as some faults, e.g. temperature related faults, resolve themselves.

Steps to Resolve a Fault:

1. **If the Event Log is not already displayed, press Event Log on the Control Panel**
   Result: A list of events is displayed.
   Note: More information about the fault is available in the event log.
2. **Resolve the fault**
   Note: Refer to Table 9-2 to resolve the fault. If you are unable to resolve the fault or you are unsure about how to resolve it, please contact ABB for assistance.
3. **When resolved, press Reset**
   Note: If displayed, you can instead press the smaller Reset Fault button.

Faults and How to Resolve Them

Table 9-2 gives an overview of the faults that can prevent the PCS100 ESS from operating and the actions required to resolve each fault.

Danger: *Before opening the PCS100 ESS cabinet to check cables and connections, ensure that you have authority to do so. Follow your companies Health and Safety procedures at all times.*

DO NOT TOUCH components or connections that have voltage present. Touching the components or connections will result in severe injury or death.

Many parts in this product, including printed circuit boards operate at lethal voltages.

Code	Message	Description	Resolution
1	Module Start Failure	The module failed to start because of an error with the NVRAM, the FPGA (Field Programmable Gate Array) or the configuration ID.	Power down and restart the PCS100 ESS.
2	IGBT Desat	The fault may be caused by one of the following: - The Inverter's IGBT (Insulated Gate Bipolar Transistor) is faulty. - The Inverter IGBT is overloaded. - The IGBT driver's PCB (Printed Circuit Board) is faulty.	Power down and restart the PCS100 ESS. If the fault is not resolved, contact your ABB Service Agent to have the affected module replaced.
3	Desat Cooling Time	A reset was attempted too soon.	Wait for 15min before pressing Reset.
4	LVDC PSU Voltage low	Control low voltage power supply failure.	Check AC supply voltage is correct.
5	Internal Fault	Two of the IGBTs (Insulated Gate Bipolar Transistor) from the same bridge are activated. Note: Only one should be activated at any time.	Contact your ABB Service Agent to have the faulty module replaced.
6	Internal Fault	There is an SPI (Serial Peripheral Interface Bus) watchdog error.	Power down and restart the PCS100 ESS. If damaged, contact your ABB Service Agent to have the cables replaced.
7	Internal Fault	There is a generic FPGA (Field-Programmable Gate Array) fault.	Check all communication cables.
8	DC Bus Overvoltage	There is an over voltage on the DC bus because of one of the following: - There is an earth fault on the coupling transformer primary winding. - There is excessive load regeneration. Note: [1] This fault will trip the coupling transformer circuit breaker. [2] The over voltage limit is set by the hardware.	Power down and restart the PCS100 ESS.
12	Internal Fault	Inverter module zero sequence current is too high.	Contact your ABB Service Agent to have the fault resolved.

Code	Message	Description	Resolution
13	Internal Fault	The PCS100 module's absolute zero sequence currents are too high.	Contact your ABB Service Agent to have the fault resolved.
14	Internal Fault	The inverter lost synchronization with the master.	Check all communication cables.
15	Internal Fault	The inverter cannot synchronize with the master within the timeout period.	Ensure all communication cables are connected and not damaged. If damaged, contact your ABB Service Agent to have the cables replaced.
19	Internal Error	There was an internal error.	Press Reset. If the fault is not resolved, power down and restart the PCS100 ESS.
21	Contactor Activate T/O	The pre-charge or bypass contactor has not opened within the required time-out period.	Contact your ABB Service Agent to have the fault resolved.
22	Contactor Deactivate T/O	The pre-charge or bypass contactor has not de-activated (auxiliary contact detection) within the required time-out period.	Contact your ABB Service Agent to have the fault resolved.
23	Precharge Timeout	Precharge relay & softcharge resistor is enabled for too long.	Contact your ABB Service Agent to have the fault resolved.
24	Softcharge Error	Errors indicated by the softcharge manager.	Contact your ABB Service Agent to have the fault resolved.
29	Contactor Recharge Error	Second contactor activation before recharge delay has timed out.	Contact your ABB Service Agent to have the fault resolved.
30	Bus Not Charging	Softcharge error if the DCV < 0.15 PU after 200 ms, bus not charging.	Contact your ABB Service Agent to have the fault resolved.
31	FPGA Reset	Either, the FPGA (Field-Programmable Gate Array) has not been reset, or did not initialize.	Press Reset. If the fault is not resolved, power down and restart the PCS100 ESS.
39	Out of Regulation Error	Inverter output voltage out of regulation error.	Contact your ABB Service Agent to have the fault resolved.
40	SDI Cmd Error	The Streaming Data Interface error count is too high.	Contact your ABB Service Agent to have the fault resolved.
42	Initialization Failure	A setting is out of range.	Contact your ABB Service Agent to have the fault resolved.
43	Fault Reset Timeout	The master was not able to reset a fault in an inverter module.	Ensure all communication cables are connected and not damaged. If damaged, contact your ABB Service Agent to have the cables replaced. If there is no damage and the fault is not resolved, power down and restart the PCS100 ESS.
44	Internal Fault	The master could not access a setting from within the inverter	Ensure all communication cables are connected and not damaged. If damaged, contact your ABB Service Agent to have the cables replaced. If there is no damage and the fault is not resolved, power down and restart the PCS100 ESS.

Code	Message	Description	Resolution
47	DC bus unequal	Difference in DC Bus voltages between rectifier and inverter is above threshold.	Contact your ABB Service Agent to have the fault resolved.
50	HW Overcurrent	The long-duration transistor is over current. This may be caused by a short circuit in the load. Note: The limit is set by the hardware.	Investigate the load for short circuits.
55	Sin Filter Over Temp	The temperature sensor in module sine filter choke indicates temperature is too high.	Ensure all module fans are operating and that the ambient temperature is not too high.
57	Heat sink Over Temp	The inverter's heat sink is too hot Note: A sensor is mounted on the heat sink.	Ensure all module fans are operating and that the ambient temperature is not too high.
59	Enclosure Over Temp	The inverter enclosure's internal temperature is above the limit. Note: The temperature is monitored by a thermistor in enclosure.	Ensure all module fans are operating and that the ambient temperature is not too high.
63	Copper Hot	Copper model hot due to high average current.	Reduce the load on the PCS100 ESS.
64	Copper Over Temp	The choke winding/copper is too hot. Note: The temperature is calculated using a thermal model.	Ensure all module fans are operating and that the ambient temperature is not too high.
66	Transformer Hot	Transformer is too hot. Note: The temperature is detected by a thermistor in transformer winding.	Ensure all module fans are operating. Ensure the ambient temperature is not too high.
68	VCAN Error	There was a non-recoverable communications error between the master and the inverter	Ensure all communication ribbon cables are connected and not damaged. If damaged, contact your ABB Service Agent to have the cables replaced.
69	Rectifier Lost	The Master controller lost communications with Rectifier module.	Check ribbon cables between modules Call service agent
70	Inverter Lost	The master controller lost communication with the inverter module.	Ensure all communication ribbon cables are connected and not damaged. If damaged, contact your ABB Service Agent to have the cables replaced.
71	Master Lost	The rectifier or inverter lost communication with master module.	Ensure all communication ribbon cables are connected and not damaged. If damaged, contact your ABB Service Agent to have the cables replaced.
73	Module Coms Fault	Data loss in the internal bus Master-Module communication.	Ensure all communication ribbon cables are connected and not damaged. If damaged, contact your ABB Service Agent to have the cables replaced.
75	PC Comms Lost	Master lost communications with critical TCPM (PC).	Check the connections.

Code	Message	Description	Resolution
76	GDM/UIM Lost	Master lost communications with critical GDM/UIM.	Check the connections.
78	Module Number Mis-match	Number of rectifier and inverter modules is unequal.	Ensure identifier are set correctly Call service agent
80	Module Display Error	There were unsustainable module inter-nal communication errors.	Ensure the module display board is plugged firmly into interface board.
83	IOM Testmode	Commissioning test mode has been acti-vated. Setting: 915 Relay Test Modes	Contact your ABB Service Agent to have the fault resolved.
86	Not Passed Tester	This fault occurs when a module has not passed the factory test or failed since leaving the factory.	Contact your ABB Service Agent to have the faulty module re-placed.
87	IRQ Frequency Error	Software task IRQ not occurring at cor-rect frequency.	Contact your ABB Service Agent to have the faulty module re-placed.
88	Serial No Error	The system (product) serial number in SCM and DSPE are different.	Replace the whole master auxil-iary module as a complete unit.
106	Stop button override	The following scenarios have occurred: The GDM's Stop button is pressed when the ESS is started from another location, e.g. control room. Note: This sequence of events causes a trip.	Contact your ABB Service Agent to have the start/stop logic cor-rected.
108	RFI Lead Misconfigu-ration	The RFI configuration in the power mod-ules does not match the Master map.	Check the part numbers of the power modules are correct for this machine.
109	Protection Message Error	Protection Message Error.	Check cables.
167	CIOB Lost	Master lost communications with Can I/O Board	Check cables and connections
168	CIOB Module Error	CIOB has an internal error preventing it from running.	Contact your ABB Service Agent
170	CIOB PTC Overtemp	CIOB external PTC over temperature	
171	Output Freq Too Low	Output frequency is too low	
172	Output Freq Too High	Output frequency is too high	
173	Output Volt Too Low	Output voltage is too low	
174	Output Volt Too High	Output voltage is too high	
175	System SW Overcur-rent	Software overcurrent detection	Reduce the systems load, check load.
195	CIOB RS485 Timeout	Expansion I/O board (CIOB) RS485 Com-munications timeout (MODBUS)	
197	Output Volt Too High Timed	The output voltage has been too high for a specified time.	Contact your ABB Service Agent
200	Redundancy Trip	Too many of the inverters have faults.	Contact your ABB Service Agent to repair the inverters.
202	Transistor Junction OverTemp	Rectifier or Inverter Transistor Junction model hot.	Check all module fans are operat-ing properly and that the ambient temperature is not too high

Code	Message	Description	Resolution
204	Dcbus center ripple high	There is high frequency ripple voltage on the DC link. This is an indication of a phase to ground fault on the inverter AC side.	
276	Rfi relay error	RFI relay or driver indicated a problem. Power cycle system and if problem persists contact ABB service.	Power cycle system and if problem persists contact ABB service.
277	Ground Shift too high	Ground fault. System detected ground shift indicating a possible earth fault on DC link.	Check for ground faults and earth referencing on DC storage. Note: DC bus should be center earth referenced
278	Common mode voltage too high	Ground shift detection; System detected abnormal high frequency common-mode indicating a possible earth fault on AC connections.	Check for ground faults or internal module faults.
283	Many contactor activations	The contactor is switching too often.	Contact your ABB Service Agent
284	Battery Params Config Error	One or more of the battery parameters are not set correctly.	Configure the system correctly
285	Sequence Mismatch Error	A slave has detected that its phase sequence differs from the master. Voltage sensor phase rotation is incorrect.	Check grid voltage phase rotation is correct and check voltage sensing wiring. Contact your ABB Service Agent
324	Island Breaker Fail	Feedback did not match command within timeout period. The islanding breaker failed to open during an islanding event. For safety the system was tripped.	Inspect the wiring to/from the breaker and check the breakers operation.
343	Island State: Trip on Island	System tripped because Island condition was detected.	Check event log for reason code.

Table 9-2: List of faults and how to resolve them

9.2 Resolving a Warning

When a warning is present a warning message is displayed on the Status Panel.

Caution: *While a warning will not prevent the PCS100 ESS from operating, it is important to resolve the problem before further damage (if any) is caused.*

The load may not be fully protected.

Warnings and How to Resolve Them

Table 9-3 gives an overview of the warnings that can be displayed, and the actions required to resolve them.

Danger: *Before opening the PC100 ESS cabinet to check cables and connections, ensure that you have authority to do so. Follow your companies Health and Safety procedures at all times.*

DO NOT TOUCH components or connections that have voltage present. Touching the components or connections will result in severe injury or death.

Many parts in this product, including printed circuit boards operate at lethal voltages.

Code	Message	Description	Resolution
4	LVDC PSU Voltage Low	One of the following scenarios has occurred: - The control power supply has failed - The auxiliary module is faulty.	Check the AC supply voltage is correct. If the warning is not resolved, contact your ABB Service Agent to have the auxiliary module replaced.
8	DC Bus Overvoltage	The DC Bus is over voltage because of one of the following scenarios: • There is an earth fault on the coupling transformer primary winding. • There is excessive load regeneration. Note: The over voltage limit is set by the hardware.	Power down and restart.
9	DC Bus Voltage High	The DC bus voltage is high. There may be an earth fault in the supply or excessive load regeneration.	Wait until the DC voltage has returned to normal. If the warning is not resolved, contact your ABB Service Agent.
10	DC Bus Voltage Low	Storage voltage is low.	No action is required. The PCS100 ESS will automatically recover when the input power returns to normal.
11	DC Bus Undervoltage	The storage voltage is too low to protect the load. Note: This fault is not recorded in the event log when the PCS100 ESS is offline.	If not already online, start the PCS100 ESS and confirm that the energy storage is charging. Note: The energy storage charges when the PCS100 ESS is online.
18	Internal Warning	Sustainable internal condition. Control loop processing result late.	Press Reset. If the warning is not resolved, power down and restart the PCS100 ESS.

Code	Message	Description	Resolution
20	Internal – Warning	DSP stack has reached 75% threshold level.	Power down and restart the PCS100 ESS. Notify your ABB Service Agent.
25	Softcharge Timeout	The softcharge sequence takes too long, causing restart sequence.	Contact your ABB Service Agent to have the fault resolved.
26	DC Bus Ripple High	DC Bus ripple voltage high.	Check all three phases are present.
27	Input Voltage Low	The phase lock loop is not locked to the input voltage. This usually occurs when the supply to the PCS100 ESS is switched off.	Check the utility supply. If the warning is not resolved, contact your ABB service agent to have the utility and load voltage sense connection checked.
28	Control Model Unstable	Model control loop parameters out of range.	Contact your ABB Service Agent to have the fault resolved.
38	Internal	There is a sustainable internal condition.	No action required.
46	Inverter Unbalanced	There is a variation in current level between inverter modules above threshold.	Check all inverters are operating.
48	DC Bus Uncontrolled	DC Bus undervoltage - lower than URMS*sqrt(2)*correction - the control loop does not have enough headroom to control inductor voltages.	Check the incoming AC voltage is not too high.
49	HW Current High	The short duration transistor current is too high. Note: This limit is set by the hardware.	Reduce the load's current to maintain full protection.
51	Current Limit	The inverter's current exceeds 110% of its rating.	Reduce the load's current to maintain full protection.
53	System Overload	The load's current exceeds the rating of the PCS100 ESS. There may be short term transient over currents. Note: This limit is set by the hardware.	Ensure that the load is suitable for the PCS100 ESS.
54	System Overload (SW).	The load current is near the limit. The limit is 160% of the PCS100 ESS rating. Note: This limit is set by the software.	Reduce system loading.
56	Heat sink Hot	The inverter's heat sink is too hot Note: A sensor is mounted on the heat sink.	Ensure all module fans are operating and that the ambient temperature is not too high.
58	Enclosure Hot	The inverter enclosure's internal temperature is too hot (near the limit). Note: The temperature is monitored by a thermistor in enclosure.	Ensure all module fans are operating and that the ambient temperature is not too high.
62	Transistor Junction Hot	The IGBT junction is too hot (near limit). Note: The temperature is calculated using a thermal model.	Ensure all module fans are operating and that the ambient temperature is not too high.
63	Copper Hot	The choke winding is too hot (near limit). Note: The temperature is calculated using a thermal model.	Ensure all module fans are operating and that the ambient temperature is not too high.
67	VCAN Warning	There is sustainable interference in the module communications cables.	Ensure all communication ribbon cables are connected and not damaged. If damaged, contact your ABB Service Agent to have the cables replaced.

Code	Message	Description	Resolution
70	Inverter Lost	The master controller lost communication with the inverter module.	Ensure all communication ribbon cables are connected and not damaged. If damaged, contact your ABB Service Agent to have the cables replaced.
72	Module Coms Warning	Two consecutive frames have been lost from the Streaming Data Interface.	Ensure all communication ribbon cables are connected and not damaged. If damaged, contact your ABB Service Agent to have the cables replaced.
77	Module Number Changed	A module has been replaced. The replacement's number was not recognized.	If a module has been replaced check the module ID number is set to the same as the replaced module.
79	Module Display Warning	There are sustainable communication errors between the module display board and Digital Signal Processor Engine (DSPE).	Ensure the module display board is firmly plugged into interface board.
81	Utility Voltage Low	The PCS100 ESS input voltage is below the operation threshold. Note: This is normal when the input voltage is removed or applied.	Check the utility voltage is within the thresholds.
82	Utility Open Source	Utility open source detected. Input has been switched off.	Check the input breaker.
84	Negative Phase Rotation	Negative phase rotation detected.	Correct the phase sequence.
90	Heatsink Cold	Rectifier or Inverter heatsink sensor error or too cold.	Check ambient temperature is > 5 degrees C.
91	Enclosure Cold	Rectifier or Inverter enclosure sensor error or too cold.	Check ambient temperature is > 5 degrees C.
104	Umagnitude sync to low	The voltage reference for synchronization is too low to allow synchronization.	Check the mains.
105	Uzeroseq sync to high	There is too much zero sequence voltage to allow synchronization.	Check connections and voltages.
107	Umain low timeout	The input AC voltage has been too low and the converter timed out.	Reconnect the mains supply
149	Tx Zero Seq Current High	The neutral current is too high.	Check the load current imbalance.
167	CIOB Lost	Master lost communications with Can IO board.	Check connections and fix faulty CIOB if necessary.
169	CIOB Analog IP Overrange	CIOB analog input signal is overrange (5%)	Possible open circuit 4-20mA loop.
173	Output Volt Too Low	Output voltage is too low.	Adjust corresponding parameter.
176	System Overload	The load on the PCS100 ESS is above 100%.	To avoid activating the PCS100 ESS thermal protection the load should be reduced.
179	Local override	Local operation, only manual settings are used, no external control is available	Set up the system as required
191	Reduced System Capacity	One or more power modules are not operating, possibly due to a dual supply system losing one feed.	

Code	Message	Description	Resolution
192	External Trans-former	External transformer warning input is ac-tive	Repair the source of the external transformer warning.
195	CIOB RS485 Timeout	CIOB RS485 Communications timeout (MODBUS)	
201	Unbalanced DC bus	The DC bus voltage from mid-bus to ground is outside the threshold set by parameter 68 Max unbalance. There may be a ground fault on the DC.	Ensure DC-bus is balanced.
203	Zero Sequence Voltage High	The zero-sequence voltage of the in-verter output is higher than expected. Not common for PCS100 ESS converters as the inverter connection is 3 wires floating.	
205	Battery Full Power Limiting	The maximum battery voltage as defined by parameter 61 Over volt level has been reached. The PCS100 ESS is now limit-ing the incoming power to avoid over-charging the battery.	Stop charging the battery.
206	Battery Empty Power Limiting	The minimum battery voltage as defined by parameter 916 Under volt level has been reached. The PCS100 ESS is now limiting the outgoing power to avoid over-discharging the battery.	Charge the battery to restore nor-mal operation.
300	Dcbus setpoint wrong	DC bus set-point voltage is outside of range, because the DC bus set-point pa-rameter has either been set outside of range or the system ratings have been set outside of the DC bus set-point.	Change DC bus set-point value to sensible level within system rat-ings.
328	SCM Lost	The Auxiliary Master Module has failed to receive a response to a status request from the SCM.	(1) The SCM is faulty. (2) There is a cable/connector fault between the Auxiliary Master Module and the SCM
331	SCM Fault	The System Configuration Module (SCM) has detected a fault in the SCM or the System.	SD card failure.
344	Grid Monitor: Under Volt fast	Grid monitoring: Utility voltage less than grid monitoring under voltage fast thresh-old.	info only
345	Grid Monitor: Under Volt slow	Grid monitoring: Utility voltage less than grid monitoring under voltage slow threshold.	info only
346	Grid Monitor: Over Volt fast	Grid monitoring: Utility voltage greater than grid monitoring over voltage fast threshold.	info only
347	Grid Monitor: Over Volt slow	Grid monitoring: Utility voltage greater than grid monitoring over voltage slow threshold.	info only
348	Grid Monitor: Under Freq fast	Grid monitoring: Utility frequency less than grid monitoring under frequency fast threshold.	info only
349	Grid Monitor: Under Freq slow	Grid monitoring: Utility frequency less than grid monitoring under frequency slow threshold.	info only

Code	Message	Description	Resolution
350	Grid Monitor: Over Freq fast	Grid monitoring: Utility frequency greater than grid monitoring over frequency fast threshold.	info only
351	Grid Monitor: Over Freq slow	Grid monitoring: Utility frequency greater than grid monitoring over frequency slow threshold.	info only
352	Grid Monitor: I Phase Loss	Grid monitoring: Output phase current unbalance exceeds phase loss thresh-olds.	info only
353	Grid Monitor: Delta Freq	Grid monitoring: Utility frequency change exceeds delta frequency threshold.	info only
354	Grid Monitor: Re-connect wait	Grid monitoring: Supply not trusted, wait-ing for utility to be within voltage/fre-quency thresholds and for reconnect time to expire (auto) or manual recon-nect input.	info only
355	Grid Monitor: Im-pedance	Grid monitoring: RPV has detected that utility Impedance exceeds threshold.	info only
356	Grid Monitor: User Forced	Grid monitoring: User has activated grid loss test or external force island inputs.	info only
357	Grid Monitor: Re-connect V Fail	Grid monitoring: Utility voltage is outside the reconnect voltage thresholds.	info only
358	Grid Monitor: Re-connect F Fail	Grid monitoring: Utility frequency is out-side the reconnect frequency thresholds.	info only
359	Grid Monitor: Disa-bled	Grid monitoring: The Grid detectors have been disabled by user input.	info only

Table 9-3: List of warnings and how to resolve them

9.3 Events during Normal Operation

When there are no faults and warnings present, the Status Panel displays the normal-operation events listed in Table 9-4. The corresponding color code is as follows:

- Status Panel is white: PCS100 ESS is offline, i.e. not operational
- Status Panel is green: PCS100 ESS is online, i.e. operational
- Status Panel is yellow: PCS100 ESS is either starting or stopping

Code	Message	Description
125	System Stop	The ESS inverters and charger are off.
126	System Starting	The system has received a start command and the system is starting.
135	Test Mode	A test mode has been activated.
210	Start/Stop/Reset	A start, stop or reset command has been received from the remote terminal.
211	Start/Stop/Reset	A start, stop or reset command has been received from the GDM.
212	Power Up/Stop/Fault Reset	The system has received an automatic stop command. Note: This typically occurs after a reset.

Table 9-4: List of events during normal operation

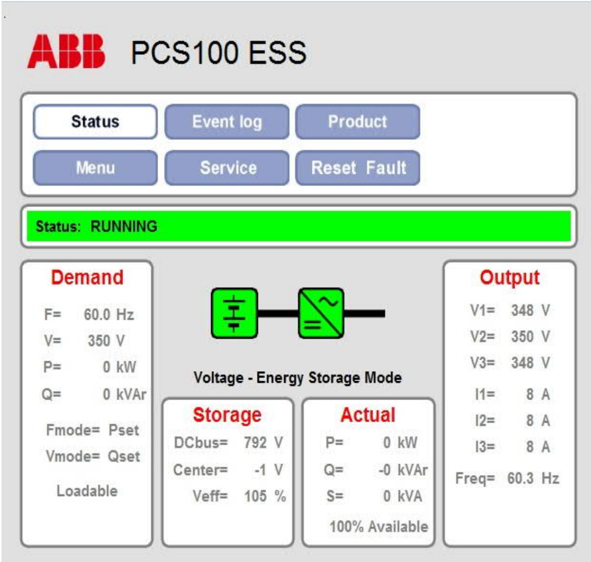
10 Remote Monitoring

If the GDM of your PCS100 ESS is connected to your Ethernet network, it can be accessed for monitoring purposes using a browser such as Internet Explorer, Firefox or Safari.

Once connected you can click:
- Status, to display up-to-date utility and load information
- Event Log, to display faults, warnings and other events
- Product, to display the product overview

Depending on the device you are using, you can also use your browser to download a copy of the event log and the PCS100 ESS service information.

If set up, read-only data from the Status Panel can also be accessed using Modbus TCP. More information about this can be found in Appendix B – Modbus TCP Parameters & Error Codes.



Note: For security reasons start/stop control and parameter menus are disabled default. However, they can be enabled through parameter settings on the unit.

10.1 List of Ports

Communication Type	Communication Type	Port	Connector
Remote Web pages	Webserver via HTTP, Ethernet	80	Standard RJ45
Remote Web pages	SW upgrade via SSH	22	Standard RJ45
Monitoring system	Modus TCP	502	Standard RJ45

10.2 Cyber Security Information

10.2.1 Cyber Security Disclaimer

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 anti-virus 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.

10.2.2 List of User/System accounts in ABB delivery

Linux root account is only available as a service account used with SSH. SSH port is disabled by default, however, it can be enabled through parameter settings.

Steps to Enable Full Remote Access

1. **Press Menu on the Control Panel**
2. **Press Home Menu**
3. **Press 2 Commissioning**
   Result: A list of menu items is displayed.
4. **Press 22 GDM Remote Menus**
   Result: True / False options are displayed.
5. **Select true to enable full remote menus**
6. **Press Apply**
   Result: The setting will show the value you specified.

10.3 Displaying the GDM in a Web Browser

Before You Begin

Before displaying the GDM in a browser window, ensure that you have the GDM's IP address. If there is no shortcut to the GDM in your browser, you can obtain the GDM's IP address from the GDM's touch screen. To do this, on the touch screen, press Product. The GDM's IP address is located in the bottom-right panel. For future access, you can add the GDM's IP address to your browser's list of bookmarks.

Steps to Display the GDM Screen in a Web Browser

1. **In the browser's address field, type the GDM's IP address**
   Note: *Use the format* http://##.###.##.## *where ##.###.##.## is the IP address of the GDM.*
   Example: http://10.123.12.12 (this is only an example and not a valid IP address)
2. **Press Enter**
   The GDM's Status panel is displayed.

Unable to Display the GDM's Screen?

If you are unable to display the GDM's screen in a browser, ensure that:

- the GDM is connected to the network
  Before opening a PCS100 ESS cabinet, see 'Danger' below.
- the GDM has been assigned an IP address
  For more information, see 'Configuring the GDM's Network Settings', earlier in this manual.
- you have the correct IP address for the GDM
- the IP address is formatted correctly when entered in the browser's address field

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Danger: *Before opening the PCS100 ESS cabinet to check cables and connections, ensure that you have authority to do so. Follow your company's Health and Safety procedures at all times.*

DO NOT TOUCH components or connections that have voltage present. Touching the components or connections will result in severe injury or death.

Many parts in this product, including printed circuit boards operate at lethal voltages.

10.4 Downloading the Event Log

Using a network connected device, e.g., a computer, you can use the device's browser to access the GDM and download a record of the most recent events or the entire event log.

Note: Before downloading the event log, ensure that the GDM's screen is displayed in the browser's window. Refer to section 10.3 for explanations on how to display the GDM in your browser.

Steps to Download Some or All of the Event Log

1. **Click Event Log on the Control Panel**
   Result: *The Event Log is displayed.*
2. **Below the list of events, click the number of most recent records that you want to download**
   Note: *You can download the 100, 1000, or 5000 most recent event records, or you can download all event records.*
3. **When prompted by your browser, save the file to the relevant location on your device**
   Hint: *When you have the opportunity, prepend the file name with the date and time of the download using the format yyyy-mm-dd HH-MM. This ensures that files are displayed in chronological order.*
   Result: *The file is downloaded and saved.*

Note: If requested, please email the file to ABB.

10.5 Downloading Service Information

In order to have ABB resolve any faults or issues that you cannot resolve, you may be requested to download the PCS100 ESS's service information and email the downloaded file to ABB. Service information can be downloaded with a computer that is connected to the same Ethernet network as the PCS100 ESS's GDM.

Note: Before downloading the service information, ensure that the GDM's screen is displayed in the browser's window. Refer to section 10.3 for explanations on how to display the GDM in your browser.

Steps to Download Service Information

1. **Click Service on the Control Panel**
2. **Click Service Information**

   Result: You will be informed that a service file is being created. Creating a service file is a five-step process, which may take some time, e.g. five minutes. You will then be informed that the service information is ready to download.
3. **When prompted by your browser, save the file to the relevant location on your device.**

   Hint: When you have the opportunity, prepend the file name with the date and time of the download using the format yyyy-mm-dd HH-MM. This ensures that files are displayed in chronological order.

   Result: The file is downloaded and saved.

Note: If requested, please email the file to ABB.

11 Commissioning

The PCS100 ESS is only part of a bigger system, typically a BESS system. The below only describes a systematic checklist recommended to perform the PCS100 ESS system commissioning. Nevertheless, it’s required to be completed by a suitably qualified engineer who has been trained in the use of power systems, electrical safety, and ABB Power Quality products.

Customer:	Site:
Model:	
Serial Number:	
Date:	Engineer:

11.1 Pre-Power Visual Checks

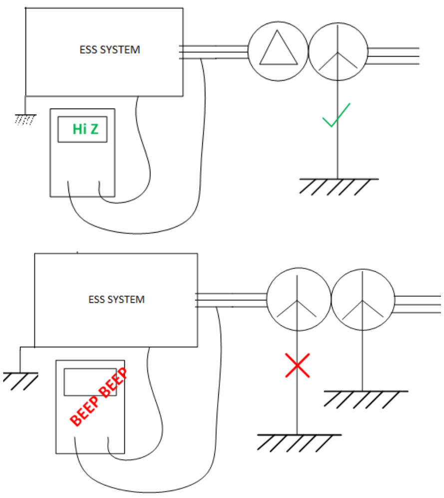
No	Description	Check
11.1.1	Check power to the unit is safely isolated and locked off.	
11.1.2	Confirm power is off with a proper voltage tester (like Duspol Expert or equivalent).	
11.1.3	Check upstream power protection if applicable (see section 7.1 of the ESS manual version I)	
11.1.4	Check mechanical installation:	
11.1.5	Check there is no physical damage to unit and internal parts.	
11.1.6	Check there is no insulation damage or signs of exposure to water or conductive dust during transport and storage.	
11.1.7	Check the supply and load cable or bus-work used is adequate for system load rating.	
11.1.8	Check all inverter modules are correctly connected to the power wiring and the communications and control ribbon cables are fully bedded.	
11.1.9	Check the auxiliary module is correctly connected to the power wiring and the communications ribbon cable is fully bedded.	
11.1.10	Check the GDM is correctly connected to the power wiring and the communications ribbon cable is fully bedded.	
11.1.11	Check there is no cooling air path blockage at front and rear (at least 200mm)	
11.1.12	Check adequate room ventilation and cooling meets the power dissipation and airflow requirements refer section 2.3	
11.1.13	Check fuses (cabinets with Aux master) F1 12A auxiliary module F2 12A auxiliary module F3 3A auxiliary module F8 6A auxiliary module	

11.2 Power Connection Checks

No	Description	Check
11.2.1	Check all power connections are assembled and tightened correctly.	
11.2.2	Perform a point to point wiring check as per installation wiring diagram to determine the transformer is correctly connected and phased.	
11.2.3	Ensure the correct DC polarity wiring	

11.3 Isolation transformer check list

The ESS must be used with an isolation transformer at its output.

No	Description	Check
11.3.1	Check the latest version of the document 2UCD190000E006 PCS100 ESS Transformer Requirements and verify that your installation meets the requirements. (basically, EMC and power cabling sections)	
11.3.2	Using a DMM (Digital Multimeter) set to continuity and test between the inverter output terminals and ground to ensure there is an open circuit. 	
11.3.3	Make sure there is nothing else connected between the ESS's output terminals and the isolation transformer. The presence of common-mode voltage at inverters terminals could be harmful to electric/electronic devices.	

11.4 Earth (Ground) Checks

No	Description	Check
11.4.1	Check the system is earthed to the utility supply at the main Earth Stud. Check the connection is appropriate and capable of carrying potential fault currents.	

11.5 Initial Power Up (Low Power)

In some situations, the system may be powered up at low power, before powering up from the utility supply to the unit.

No	Description	Check
11.5.1	Connect the low power supply to the system (fans and control)	
11.5.2	Apply power.	
11.5.3	Verify that all fans are running (if possible, check the air flowing at the back of the modules)	
11.5.4	Verify the GDM powers up. It will initially show the default start-up screens. Verify modules are powered up by checking the module identification numbers on the 7-segment LED displays of the modules are on. Check the module identification numbers are correct, especially if for some reason modules were swapped. Successful configuration check will be indicated by the GDM displaying the status page, and no configuration errors being reported.	
11.5.5	Check the GDM s/w image revision is up to date using the GDM Software Upgrade Tool. Please refer to section 5 on 2UCD200000E463 PCS100 GDM MK3 replacement procedure version c or above.	
11.5.6	Power down and resolve any start-up error conditions and repeat the process to confirm the start-up and configuration check for the PCS100 ESS has been successful.	

11.6 Initial Power Up (Utility Power)

All loads should remain disconnected at this stage.

No	Description	Check
11.6.1	Check all protective covers are in place.	11.6.2
11.6.2	Apply utility power to the system and verify the system has energized correctly.	
11.6.3	Be aware of the AC filter capacitor current, as soon as voltage is present at the ESS terminals, capacitive current will start flowing (about 12kVAr or 15Amps per module)	
11.6.4	Verify the GDM powers up. It will initially show the default start-up screens. • Verify modules are powered up by checking the module identification numbers on the 7-segment LED displays of the modules are on. • Check the module identification numbers are correct, especially if for some reason modules were swapped. Successful configuration check will be indicated by the GDM displaying the status page, and no configuration errors being reported.	
11.6.5	Power down and resolve any start-up error conditions and repeat the process to confirm the start-up and configuration check for the PCS100 ESS has been successful.	
11.6.6	Once start-up and configuration check for the PCS100 ESS has been performed verify there are no other faults present in the system. If any faults are present and reported on the display, then resolve these faults before continuing.	
11.6.7	Verify the AC voltage and frequency measurements shown on the GDM status screen are correct against to a true RMS meter.	

11.7 Initial Run (No Load)

This stage verifies correct function of the PCS100 ESS.

No	Description	Check
11.7.1	Start the system. Verify the system runs and no faults exist.	
11.7.2	Measure the output voltage and frequency. Verify it is as expected and matches that shown on the GDM.	
11.7.3	Stop the system. Verify the system returns to the STOP mode and no faults exist.	
11.7.4	Test the inhibit switch if fitted	

11.8 Load Test

No	Description	Check
11.8.1	Switch the load on. Start the system. Verify the system runs and no faults exist.	
11.8.2	Check the load currents on the GDM status screen match the actual measured load currents within tolerance. Ensure at least greater than 5% load current is applied for this check. PCS100 ESS claimed accuracy 1%	
11.8.3	Check all the values shown in the GDM are consistent	
11.8.4	If possible, increase the load as close as possible to 100% and check that no overload is reported by the ESS	

11.9 Documentation and Handover

No	Description	Check
11.9.1	Download and save the event log via a PC connection.	
11.9.2	Record any parameters changed during commissioning and keep a record with the commissioning documentation.	
11.9.3	Ensure staff knows the PCS100 ESS is now in service.	
11.9.4	Send the downloaded service log to the factory. NZ-PowerConditioningService@abb.com	

11.10 Parameters change record

Parameter	Original Value	New Value	Comments

12 Appendices

Appendix A – GDM Menu Reference
Appendix B – Modbus Parameters & Error Codes
Appendix C – Open Source Software
Appendix D – Wiring Information
Appendix E – Torque Settings and Bolt Oder
Appendix F – Installation Requirements
Appendix G – General Disclaimer
Appendix H – Waste Electrical and Electronic Equipment Information (WEEE)
Appendix I – Glossary

Appendix A – GDM Menu Reference

The following is an overview of the settings that can be accessed using the GDM's menu.

Note: To display the GDM's menu, on the Control Panel, press Menu, then press Home Menu.

Once logged into the GDM, you can modify a range of settings.

If you are not logged in:

- you can still use the GDM's touch screen to display information, however
- some menu items will not be displayed, and
- you will not be able to modify any settings.

GDM Parameter Index

Parameter Number	Parameter GDM Text	Login: Not	Login: Operator	Login: Technician	page
0	General	○	○	○	90
00	Login	●	●	●	90
01	Start Mode	○	●	●	90
02	Date and Time	○	●	●	90
03	Customer name	○	●	●	90
04	Plant Name	○	●	●	90
05	Site Name	○	●	●	90
06	Sys SW Version	○	○	●	90
07	Set Parameter	●	●	●	90
08	System Reboot	○	●	●	90
09	Show Faults	●	●	●	90
0A	GDM Services	○	○	○	90
0A0	Webserver Status	○	○	○	90
0A1	Vcanserver Status	○	○	○	91
0A2	Modbus Status	○	○	○	91
0A3	NTP Status	○	○	○	91
0A4	NTP Server	○	○	●	91
0A5	NTP Time Zone	○	○	●	91
1	System Electrical	○	○	○	91
10	System Voltage	○	○	○	91
11	System Current	○	○	○	91
12	Module Voltage			○	91
14	Inverter Voltage	○	○	○	91
18	System I Base			○	91
19	System Frequency	○	○	○	91
1A	Minimum Availability	○	○	●	91
2	Commissioning	○	○	○	91
20	Inverter Mode	○	●	●	91
21	DC Equalize V	○	●	●	92

○ read only

● read and write

Parameter Number	Parameter GDM Text	Login: Not	Login: Operator	Login: Technician	page
22	GDM Remote Menus	○	○	●	92
23	Fan Control	○	○	○	92
230	Fan Operation	○	○	●	92
231	Start temperature	○	○	●	92
232	Stop temperature	○	○	●	92
233	Fan run time	○	○	●	92
24	Test Mode			●	92
25	Test Voltage			●	92
26	Test Frequency			●	92
27	Relay Test Mode			●	92
28	DC Soak I Real	○	●	●	93
29	AC Soak I Reactive	○	●	●	93
2A	Output Temp Grp	○	○	●	93
3	Product Revision	○	○	○	93
30	System Product	○	○	○	93
31	System Revision	○	○	○	93
32	SCM Boot Product			○	93
33	SCM Boot Revision			○	93
34	SCM Product	○	○	○	93
35	SCM Revision	○	○	○	93
36	CGI Revision		○	○	93
37	Modbus Revision		○	○	93
38	NTP Revision	○	○	○	93
4	Analog I/O	○	○	○	93
40	Ain 1 mode	○	●	●	93
41	Ain 2 mode	○	●	●	93
42	Analog Outputs	○	○	○	93
420	Aout 1 mode	○	●	●	93
421	Aout 2 mode	○	●	●	93
422	Aout 1 Source	○	●	●	94
423	Aout 2 Source	○	●	●	94
424	Aout 1 gain	○	●	●	94
425	Aout 2 gain	○	●	●	94
426	Aout 1 offset	○	●	●	94
427	Aout 2 offset	○	●	●	94
43	Analog Status	○	○	○	94
430	Analog IP 1	○	○	○	94
431	Analog IP 2	○	○	○	94
432	Analog OP 1	○	○	○	94
433	Analog OP 2	○	○	○	95
5	Digital I/O	○	○	○	95

○ read only
● read and write

Parameter Number	Parameter GDM Text	Login: Not	Login: Operator	Login: Technician	page
50	System Enable	○	○	●	95
51	Fault Reset	○	○	●	95
52	Soft Stop	○	○	●	95
53	System Permit	○	○	●	96
56	Digital Outputs	○	○	○	96
560	Dout 1 source	○	○	●	96
561	Dout 2 source	○	○	●	96
562	Dout 3 source	○	○	●	96
563	Dout 4 source	○	○	●	97
57	Digital Status	○	○	○	97
570	Digital IP 1	○	○	○	97
571	Digital IP 2	○	○	○	97
572	Digital IP 3	○	○	○	97
573	Digital IP 4	○	○	○	97
574	Digital IP 5	○	○	○	97
575	Digital IP 6	○	○	○	97
576	Digital IP 7	○	○	○	97
577	Digital OP 1	○	○	○	97
578	Digital OP 2	○	○	○	97
579	Digital OP 3	○	○	○	97
57A	Digital OP 4	○	○	○	97
58	Serial Communication	○	○	○	97
580	Modbus Address	○	●	●	97
581	RS485 Baud Rate	○	●	●	97
582	RS485 Parity	○	●	●	98
583	RS485 Timeout	○	●	●	98
584	RS485 Timeout Alert Mask	○	●	●	98
585	RS485 Timeout Trip Mask	○	●	●	98
6	Mode Selector	○	○	○	98
60	Sys Mode Source	○	●	●	98
61	Sys Mode Manual	○	●	●	99
62	Conv Load Source	○	●	●	99
63	Conv Load Manual	○	●	●	99
64	Conv Sync Source	○	●	●	100
65	Conv Sync Manual	○	●	●	100
66	Droop Source	○	●	●	100
67	Droop Manual	○	●	●	101
68	Fixed P Source	○	●	●	101
69	Fixed P Manual	○	●	●	101
7	Reference Selector	○	○	○	101
70	P and Q	○	●	●	101

○ read only
● read and write

Parameter Number	Parameter GDM Text	Login: Not	Login: Operator	Login: Technician	page
700	P set Source	○	●	●	101
701	P set Manual	○	●	●	102
702	P Analog Gain	○	●	●	102
703	P Analog Offset	○	●	●	102
704	Q set Source	○	●	●	102
705	Q set Manual	○	●	●	102
706	Q Analog Gain	○	●	●	102
707	Q Analog Offset	○	●	●	102
71	V and F	○	○	○	102
710	F set Source	○	●	●	102
711	F set Manual	○	●	●	102
712	F Analog Gain	○	●	●	103
713	F Analog Offset	○	●	●	103
714	V set Source	○	●	●	103
715	V set Manual	○	●	●	103
716	V Analog Gain	○	●	●	103
717	V Analog Offset	○	●	●	103
8	Converter AC	○	○	○	103
80	Start Mode	○	○	●	103
81	Freq Droop	○	●	●	103
82	Volt Droop	○	●	●	103
83	Volt Droop Iso	○	●	●	104
84	Impedances	○	○	○	104
840	Inertia	○	○	●	104
841	Output R	○	○	●	104
842	Output L	○	○	●	104
843	Damping	○	○	●	104
85	Power Limits	○	○	○	104
850	Pos P Limit	○	●	●	104
851	Neg P Limit	○	●	●	104
852	Pos Q Limit	○	●	●	104
853	Neg Q Limit	○	●	●	104
854	Total S Limit	○	●	●	104
855	S Limit mode	○	●	●	105
859	Volatile P Limits	○	○	○	105
8590	Pos P Lim Source	○	●	●	105
8591	Pos P Lim Manual	○	●	●	105
8592	Pos P Lim Ana Gain	○	●	●	105
8593	Pos P Lim Ana Offset	○	●	●	105
8594	Neg P Lim Source	○	●	●	105
8595	Neg P Lim Manual	○	●	●	106

○ read only
● read and write

Parameter Number	Parameter GDM Text	Login: Not	Login: Operator	Login: Technician	page
8596	Neg P Lim Ana Gain	○	●	●	106
8597	Neg P Lim Ana Offset	○	●	●	106
85A	Volatile Q Limits	○	○	○	106
85A0	Pos Q Lim Source	○	●	●	106
85A1	Pos Q Lim Manual	○	●	●	106
85A2	Pos Q Lim Ana Gain	○	●	●	106
85A3	Pos Q Lim Ana Offset	○	●	●	106
85A4	Neg Q Lim Source	○	●	●	106
85A5	Neg Q Lim Manual	○	●	●	107
85A6	Neg Q Lim Ana Gain	○	●	●	107
85A7	Neg Q Lim Ana Offset	○	●	●	107
85B	Volatile S Limit	○	○	○	107
85B0	S Lim Source	○	●	●	107
85B1	S Lim Manual	○	●	●	107
85B2	S Lim Ana Gain	○	●	●	107
85B3	S Lim Ana Offset	○	●	●	107
85B4	S Lim Therm Backoff	○	●	●	107
86	Standby	○	○	○	108
860	Standby on low PQ	○	●	●	108
861	P Enter Standby	○	●	●	108
862	Q Enter Standby	○	●	●	108
863	P Exit Standby	○	●	●	108
864	Q Exit Standby	○	●	●	108
865	Standby on Unload	○	●	●	108
866	Standby Time To On	○	●	●	108
867	Standby Time To Off	○	●	●	108
87	LV Ride Through	○	○	○	108
870	Allow LVRT	○	●	●	108
871	Vac Pset 0	○	●	●	108
872	Vac Pset normal	○	●	●	108
873	Level Vac min 1	○	●	●	109
874	Time Vac min 1	○	●	●	109
875	Level Vac min 2	○	●	●	109
876	Time Vac min 2	○	●	●	109
877	Level Vac Restart	○	●	●	109
878	Time Vac Restart	○	●	●	109
88	Envelope Limits	○	○	○	109
884	Frequency Envelope	○	○	●	109
8840	Env Freq Mode	○	○	●	109
8841	Env Freq Max	○	○	●	109
8842	Env Freq Min	○	○	●	110

○ read only
● read and write

Parameter Number	Parameter GDM Text	Login: Not	Login: Operator	Login: Technician	page
8843	Env Freq Max Slope	○	○	●	110
8844	Env Freq Min Slope	○	○	●	110
8845	Over Freq P Min	○	○	●	110
8846	Under Freq P Max	○	○	●	110
885	Voltage Envelope	○	○	●	110
8850	Env Volt Mode	○	○	●	110
8851	Env Volt Max	○	○	●	110
8852	Env Volt Min	○	○	●	110
8853	Env Volt Max Slope	○	○	●	110
8854	Env Volt Min Slope	○	○	●	110
8855	Over Volt Q Min	○	○	●	110
8856	Under Volt Q Max	○	○	●	110
89	Sync Input Trim	○	○	○	111
890	Trim Sync Phase	○	○	●	111
891	Trim Sync Volt	○	○	●	111
892	Sync Phase error			○	111
893	Sync Volt error			○	111
8A	Grid Monitoring	○	○	○	111
8A0	Configuration	○	○	●	111
8A01	Enable Src	○	○	●	111
8A02	Enable Manual	○	○	●	111
8A03	Grid Loss Action	○	○	●	111
8A04	Utility Feedback Src	○	○	●	112
8A05	Use Pos Seqence	○	○	●	112
8A1	Passive Voltage Detect	○	○	○	112
8A10	Under Volt Fast Level	○	○	●	113
8A11	Under Volt Fast Delay	○	○	●	113
8A12	Under Volt Slow Level	○	○	●	113
8A13	Under Volt Slow Delay	○	○	●	113
8A14	Over Volt Fast Level	○	○	●	113
8A15	Over Volt Fast Delay	○	○	●	113
8A16	Over Volt Slow Level	○	○	●	113
8A17	Over Volt Slow Delay	○	○	●	114
8A2	Passive Freq Detect	○	○	○	114
8A20	Under Freq Fast Level	○	○	●	114
8A21	Under Freq Fast Delay	○	○	●	114
8A22	Under Freq Slow Level	○	○	●	114
8A23	Under Freq Slow Delay	○	○	●	114
8A24	Over Freq Fast Level	○	○	●	114
8A25	Over Freq Fast Delay	○	○	●	115
8A26	Over Freq Slow Level	○	○	●	115

○ read only
● read and write

Parameter Number	Parameter GDM Text	Login: Not	Login: Operator	Login: Technician	page
8A27	Over Freq Slow Delay	○	○	●	115
8A28	Delta F Level	○	○	●	115
8A29	Delta F Delay	○	○	●	116
8A3	Phase Loss Detect	○	○	○	116
8A30	Unbalance Level	○	○	●	116
8A31	Unbalance Delay	○	○	●	116
8A4	Active Island Detect	○	○	○	116
8A40	RPV Enable	○	○	●	117
8A41	RPV Inject Level	○	○	●	117
8A5	Islanding Control	○	○	○	117
8A50	Allow Black Start	○	○	●	117
8A51	Breaker Feedback Fitted	○	○	●	117
8A52	Breaker Feedback Src	○	○	●	117
8A53	Breaker Feedback Time	○	○	●	118
8A54	Ext Grid Loss Source	○	○	●	118
8A55	Ext Grid Loss Manual	○	○	●	119
8A56	Force Island Source	○	○	●	119
8A57	Force Island Manual	○	○	●	119
8A6	Reconnect Control	○	○	○	119
8A60	Auto Reconnect	○	○	●	119
8A61	Reconnect Delay	○	○	●	120
8A62	Reconnect Source	○	○	●	120
8A63	Reconnect Manual	○	○	●	120
8A64	Reconnect Min Volt	○	○	●	120
8A65	Reconnect Max Volt	○	○	●	121
8A66	Reconnect Min Freq	○	○	●	121
8A67	Reconnect Max Freq	○	○	●	121
8B	Over/Under Voltage Clamp	○	○	○	121
8B0	Volt Clamp Ena	○	○	●	121
8B1	Volt FB Src	○	○	●	121
8B2	Over Voltage Limit	○	○	●	121
8B3	Under Voltage Limit	○	○	●	121
8B4	Clamping Gain	○	○	●	121
8B5	Clamp I limit	○	○	●	121
9	Converter DC	○	○	○	122
91	Converter SOC	○	○	○	122
911	Over Volt Level	○	●	●	122
912	Over Volt Reset	○	●	●	122
913	Max operating DC	○	●	●	122
914	Min operating DC	○	●	●	122
915	Under Volt Reset	○	●	●	122

○ read only
● read and write

Parameter Number	Parameter GDM Text	Not	Operator	Technician	page
		Login			
916	Under Volt Level	○	●	●	122
917	Over Volt Slope	○	●	●	122
918	Under Volt Slope	○	●	●	122
919	Under Volt Charge Max	○	●	●	122
91A	Over Volt Discharge Max	○	●	●	122
96	Sense Method	○	●	●	122
A	Protections	○	○	○	123
A0	Unbalance Check	○	○	●	123
A1	Max Unbalance Level	○	○	●	123
A2	Max Ripple Level	○	○	●	123
A3	Unbalance Trips	○	○	●	123
A4	Ripple Trips	○	○	●	123
					123
GDM	Graphic Display	○	○	○	123
A00	Display	○	○	○	123
A31	GDM Control Enable	○	○	○	123
A62	Screen Saver Time	○	○	○	123
A63	........SSH Port Enable	○	○	●	123
B00	Network Settings	○	○	○	123
B11	Dynamic IP DHCP	○	○	●	124
B12	Static IP address	○	○	●	124
B13	Static IP mask	○	○	●	124
B14	Static IP gateway	○	○	●	124
B15	Apply settings	○	○	●	124
C00	Network Status	○	○	○	124
C11	Actual DHCP active	○	○	○	124
C12	Actual IP address	○	○	○	124
C13	Actual IP mask	○	○	○	125
C14	Actual IP gateway	○	○	○	125
C15	Mac address	○	○	○	125
C16	Ethernet Status	○	○	○	125
D00	Product Revision	○	○	○	125
D11	GDMIB Boot Product		○	○	125
D12	GDMIB Boot Revision		○	○	125
D13	GDMIB Product	○	○	○	125
D14	GDMIB Revision	○	○	○	125
D21	GDM Revision	○	○	○	125
D31	Vcanserver name	○	○	○	125
D32	Vcanserver revision	○	○	○	125

○ read only
● read and write

GDM Parameter

Menu Number	Parameter Name	Selection/Range default value	Description
0	General		
00	Login		Log in to the GDM to display and modify a range of settings. Note: For user access the login is 159
01	Start Mode		If system auto starts at power on. Mem Autostart means after power-cycle that system starts if it was previously running.
02	Date and Time	Format: YYYY-MM-DD HH:MM:SS Example: 2015-11-19 15:30:00	When modified, the time that is displayed on the Product panel is updated. Note: Include one space between the date and the time.
03	Customer name		Modify to update the customer name that is displayed on the Product Panel.
04	Plant Name		Modify to update the plant name that is displayed on the Product Panel.
05	Site Name		Modify to update the site name that is displayed on the Product Panel.
06	Sys SW Version		Allow system software to be locked to a particular version. Unless specified, leave as a star: "*"
07	Set Parameter		Entering a code supplied by ABB, you can modify a specific setting, including a factory setting. (refer to section 0) Note: Type in the code supplied by ABB and Press Apply. You will be informed that the setting has been applied. After pressing Apply, you may be informed that the setting (value entered) was not correct. This may be because: 1) The code was not entered correctly. If this is the case, repeat the step above. 2) The code that was entered was not written for this ESS unit. Some codes are written for just 1 ESS identified by its serial number. Please contact ABB for a code that is specifically written for this ESS unit. 3) Some codes have an expiry date. For security reasons, these codes can only be entered within a specified date range. In this case, please contact ABB for another code. Codes are case sensitive. Ensure that you enter the code exactly as it is supplied by ABB. Some characters are similar in appearance, e.g. the letter 'O' and zero '0'
08	System Reboot		Reboot system.
09	Show Faults		When activated, all current faults and warnings are displayed Note: only the most critical fault is displayed in the Status Panel.
0A	GDM Services		Shows the status of the GDM services.
0A0	Webserver Status		

Menu Number	Parameter Name	Selection/Range default value	Description
0A1	Vcanserver Status		
0A2	Modbus Status		
0A3	NTP Status		
0A4	NTP Server		NTP time server address.
0A5	NTP Time Zone		NTP time server time zone.
1	System Electrical		
10	System Voltage	150 V to 480 V	The rated AC coupling voltage of the system Volts RMS line-to-line Note: The system voltage is factory set to the ESS coupling voltage.
11	System Current	105 A to 4200 A	The total rated current of the system (Line RMS). Amps RMS Note: The system current is factory set to the ESS rated current.
12	Module Voltage	480 V / 690 V	PCS100 Internal Module Type Voltage: C-Type = 690 V D-Type = 480 V
14	Inverter Voltage	150 V to 480 V	The rated voltage of the inverter modules Volts RMS line-to-line
18	System I Base	105 A ... 4200 A	PCS100 Internal system current: C-Type = 105A x Modules D-Type = 150A x Modules
19	System Frequency	50 Hz / 60 Hz Default: Nameplate frequency rating of ESS	The supply (utility) frequency.
1A	Minimum Availability	-1% ... 150 % Default: 40%	Sets the minimum number of inverter modules the system will remain running with.
2	Commissioning		Caution: Damage to the ESS may occur if the test mode is set incorrectly. Factory Use Only.
20	Inverter Mode	None DC bus equalization Batt Resistance AC Soak-Battery AC Soak-No Batt DC Soak-No Batt Default: None	Sets the inverter to special commissioning modes None: regular operation DC bus equalization: Set the inverter to generate a fixed DC bus voltage prior to connecting storage to the inverter. Batt Resistance: Battery resistance test AC Soak-Battery: AC reactive current soak with battery connected. AC Soak-No Batt: AC reactive current soak without battery connected

Menu Number	Parameter Name	Selection/Range default value	Description
			DC Soak-No Batt: Reactive and real current soak without battery connected.
21	DC Equalize V	150 to 1100 Vdc	The DC bus voltage to regulate to when in DC bus equalize mode
22	GDM Remote Menus	False/True Default: False	Allow access to the ESS parameters via Ethernet
23	Fan Control		
230	Fan Operation	Temp Run_on On Off Default: On	Select fan control mode Temp: Controlled by module temperature Run on: Always on when system running On: Always on Off: Always off
231	Start temperature	0 … 50 deg Celsius	The module temperature for the fans to start when temperature controlled (230 set to "Temp")
232	Stop temperature	0 … 50 deg Celsius	The module temperature for the fans to stop when temperature controlled (230 set to "Temp")
233	Fan run time	0 … minutes	The minimum time for fans to run once started when temperature controlled (230 set to "Temp")
24	Test Mode	NONE OUTWAVE ABWAVE OUTWAVEPLL ABWAVEPLL Default: NONE	
25	Test Voltage	-4 pu … 3.9999 pu Default: 0 pu	
26	Test Frequency	-4 pu … 3.9999 pu Default: 1 pu	
27	Relay Test Mode	off relays off relay 1 = run on relays off relay 2 = warning on	

Menu Number	Parameter Name	Selection/Range default value	Description
		relays off relay 3 = not fault on relays off Default: off	
28	DC Soak I Real	0 to 2pu	The per-unit real current for “DC soak-no batt” test mode
29	AC Soak I Reactive	0 to 2pu	The per-unit reactive current for all soak modes
2A	Output Temp Grp	Selectable bits for each inverter module number in the system. Module0 … Module31	The bitmap to set the Inverter modules that are in Temperature Group 1 (readable via MODBUS) Note: Module ID on display is 1..32, where as Module Number in Output Temp Grp is 0..31.
3	Product Revision		Displays the system product revision numbers.
30	System Product		
31	System Revision		
32	SCM Boot Product		
33	SCM Boot Revision		
34	SCM Product		
35	SCM Revision		
36	CGI Revision		
37	Modbus Revision		
38	NTP Revision		
4	Analog I/O		
40	Ain 1 mode	VOLTAGE CURRENT Default: VOLTAGE	Mode for CAN IO Board analog input 1 - Voltage (±10V) - Current (4 to 20mA)
41	Ain 2 mode	VOLTAGE CURRENT Default: VOLTAGE	Mode for CAN IO Board analog input 2 - Voltage (±10V) - Current (4 to 20mA)
42	Analog Outputs		
420	Aout 1 mode	VOLTAGE CURRENT Default: VOLTAGE	Mode for CAN IO Board analog output 1 - Voltage (±10V) - Current (4 to 20mA)
421	Aout 2 mode	VOLTAGE CURRENT	Mode for CAN IO Board analog output 2 - Voltage (±10V)

Menu Number	Parameter Name	Selection/Range default value	Description
		Default: VOLTAGE	- Current (4 to 20mA)
422	Aout 1 Source	Set 0 % (Used for testing) Set -100 % (Used for testing) Set +100 % (Used for testing) Test Value (Used for testing) Output Cord 0 Current Output Cord 1 Current Output Cord 2 Current Output Cord 0 Voltage Output Cord 1 Voltage Output Cord 2 Voltage Default: Set 0 %	Access internal variables on CAN IO Board analog output 1
423	Aout 2 Source	Set 0 % (Used for testing) Set -100 % (Used for testing) Set +100 % (Used for testing) Test Value (Used for testing) Output Cord 0 Current Output Cord 1 Current Output Cord 2 Current Output Cord 0 Voltage Output Cord 1 Voltage Output Cord 2 Voltage Default: Set 0 %	Access internal variables on CAN IO Board analog output 2
424	Aout 1 gain	-4 pu … 4 pu Default: 1 pu	Output gain for CAN IO Board analog output 1
425	Aout 2 gain	-4 pu … 4 pu Default: 1 pu	Output gain for CAN IO Board analog output 2
426	Aout 1 offset	-4 pu … 4 pu Default: 1 pu	Output offset for CAN IO Board analog output 1
427	Aout 2 offset	-4 pu … 4 pu Default: 1 pu	Output offset for CAN IO Board analog output 2
43	Analog Status		
430	Analog IP 1	-4 pu … 4 pu	Shows actual status of Analog Input 1
431	Analog IP 2	-4 pu … 4 pu	Shows actual status of Analog Input 2
432	Analog OP 1	-4 pu … 4 pu	Shows actual status of Analog Output 1

Menu Number	Parameter Name	Selection/Range default value	Description
433	Analog OP 2	-4 pu ... 4 pu	Shows actual status of Analog Output 2
5	Digital I/O		

50	System Enable	MANUAL = system enabled
		AUTO = Modbus
		CIOB1 DIGI IP1 = Ext.I/O Digital Input 1
		CIOB1 DIGI IP2 = Ext.I/O Digital Input 2
		CIOB1 DIGI IP3 = Ext.I/O Digital Input 3
		CIOB1 DIGI IP4 = Ext.I/O Digital Input 4
		CIOB1 DIGI IP5 = Ext.I/O Digital Input 5
		CIOB1 DIGI IP6 = Ext.I/O Digital Input 6
		CIOB1 DIGI IP7 = Ext.I/O Digital Input 7
		CIOB1 DIGI PTC = Ext.I/O PTC Input
		MSIB AR1-1 = Master DC Voltage +/GND
		MSIB AR1-2 = Master DC Voltage -/GND
		MSIB AR2-1 = Master Analogue Input 2-1
		MSIB AR2-2 = Master Analogue Input 2-2
		
		Default = MANUAL (GDM)
			Selects source for Enabling System.
			
			Digital input on Extended I/O board: Active = System Enabled
			
			- PTC Input on Extended IO board cannot be used for this function.
			- AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for enabling System Enable).
			- AR2-1 and AR2-2 could be used to System Enable.
			  - If the input signal is higher than 1.25V, System is ENABLED,
			  - If the input signal is lower than 1.25V, System is disabled.
			
			Note: .Please leave as per default factory setting: MANUAL!

51	Fault Reset	MANUAL = Fault Reset via GDM AUTO = Modbus CIOB1 DIGI IP1 = Ext.I/O Digital Input 1 CIOB1 DIGI IP2 = Ext.I/O Digital Input 2 CIOB1 DIGI IP3 = Ext.I/O Digital Input 3 CIOB1 DIGI IP4 = Ext.I/O Digital Input 4 CIOB1 DIGI IP5 = Ext.I/O Digital Input 5 CIOB1 DIGI IP6 = Ext.I/O Digital Input 6 CIOB1 DIGI IP7 = Ext.I/O Digital Input 7 CIOB1 DIGI PTC = Ext.I/O PTC Input MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Selects source for Fault Reset. Digital input on Extended I/O board: edge 0 - 1 = Fault Reset - PTC Input on Extended IO board cannot be used for this function. - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). - AR2-1 and AR2-2 could be used for this function. - If the input signal is higher than 1.25V = Fault Reset.
52	Soft Stop	MANUAL = Soft Stop via GDM	Selects source for Soft Stop.

Menu Number	Parameter Name	Selection/Range default value	Description
		AUTO = Modbus CIOB1 DIGI IP1 = Ext.I/O Digital Input 1 CIOB1 DIGI IP2 = Ext.I/O Digital Input 2 CIOB1 DIGI IP3 = Ext.I/O Digital Input 3 CIOB1 DIGI IP4 = Ext.I/O Digital Input 4 CIOB1 DIGI IP5 = Ext.I/O Digital Input 5 CIOB1 DIGI IP6 = Ext.I/O Digital Input 6 CIOB1 DIGI IP7 = Ext.I/O Digital Input 7 CIOB1 DIGI PTC = Ext.I/O PTC Input MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Digital input on Extended I/O board: Active = Soft Stop - PTC Input on Extended IO board cannot be used for this function. - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). - AR2-1 and AR2-2 could be used for this function. If the input signal is higher than 1.25V = Soft Stop.
53	System Permit	MANUAL = System Permit AUTO = Modbus CIOB1 DIGI IP1 = Ext.I/O Digital Input 1 CIOB1 DIGI IP2 = Ext.I/O Digital Input 2 CIOB1 DIGI IP3 = Ext.I/O Digital Input 3 CIOB1 DIGI IP4 = Ext.I/O Digital Input 4 CIOB1 DIGI IP5 = Ext.I/O Digital Input 5 CIOB1 DIGI IP6 = Ext.I/O Digital Input 6 CIOB1 DIGI IP7 = Ext.I/O Digital Input 7 CIOB1 DIGI PTC = Ext.I/O PTC Input MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Selects source for System Permit. Digital input on Extended I/O board: Active = System Permit - PTC Input on Extended IO board cannot be used for this function. - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). - AR2-1 and AR2-2 could be used for this function. If the input signal is higher than 1.25V = System Permit.
56	Digital Outputs	Set 0 (used for testing) Set 1 (used for testing) System Ready Sync OK System Mode (see parameter 60 & 61)	
560	Dout 1 source		Select digital output 1 source
561	Dout 2 source		Select digital output 2 source
562	Dout 3 source		Select digital output 3 source

Menu Number	Parameter Name	Selection/Range default value	Description
563	Dout 4 source	Over Load Warning Alert Generator On Line Rectifiers On Line Module Hot Auto Parameter Standby Active Grid Outside Limits Close Island Breaker[1] Syncronise Mode Isocronous Mode Droop Mode (see parameter 66 and 67) Power Set Point Mode Open Grid Tie[2] Default: Set 0	Select digital output4 source [1]Only to be used in IEEE1547 operation mode (OBSOLETED). [2]For grid-tie breaker controlling using NC contact on the CIOB (CIOB relay energises to open grid tie breaker.
57	Digital Status		Shows input and output status of Digital I/Os (read only)
570	Digital IP 1	0 / 1	
571	Digital IP 2	0 / 1	
572	Digital IP 3	0 / 1	
573	Digital IP 4	0 / 1	
574	Digital IP 5	0 / 1	
575	Digital IP 6	0 / 1	
576	Digital IP 7	0 / 1	
577	Digital OP 1	0 / 1	
578	Digital OP 2	0 / 1	
579	Digital OP 3	0 / 1	
57A	Digital OP 4	0 / 1	
58	Serial Communication		
580	Modbus Address	1 … 247 Default: 10	MODBUS RTU server address
581	RS485 Baud Rate	300	RS-485 serial baud rate

Menu Number	Parameter Name	Selection/Range default value	Description
		600 1200 2400 4800 9600 19200 38400 57600 115200 Default: 115200	
582	RS485 Parity	NONE EVEN ODD Default: EVEN	RS-485 serial parity
583	RS485 Timeout	0 … 327670 ms Default: 5000 ms	RS-485 timeout
584	RS485 Timeout Alert Mask	CIOB1 CIOB2 CIOB3 CIOB4 CIOB5 CIOB6 CIOB7 CIOB8 Default: CIOB1	Bitmap for selecting which CAN I/O Boards can cause a Timeout Alert. Usually only one CAN I/O Board is present
585	RS485 Timeout Trip Mask	CIOB1 CIOB2 CIOB3 CIOB4 CIOB5 CIOB6 CIOB7 CIOB8 Default: CIOB1	Bitmap for selecting which CAN I/O Boards can cause a unit Timeout Trip. Usually only one CAN I/O Board is present.
6	Mode Selector		
60	Sys Mode Source	MANUAL = GDM (61)	Selects source for System Mode.

Menu Number	Parameter Name	Selection/Range default value	Description
		AUTO = Modbus CIOB1 DIGI IP1 = Ext.I/O Digital Input 1 CIOB1 DIGI IP2 = Ext.I/O Digital Input 2 CIOB1 DIGI IP3 = Ext.I/O Digital Input 3 CIOB1 DIGI IP4 = Ext.I/O Digital Input 4 CIOB1 DIGI IP5 = Ext.I/O Digital Input 5 CIOB1 DIGI IP6 = Ext.I/O Digital Input 6 CIOB1 DIGI IP7 = Ext.I/O Digital Input 7 CIOB1 DIGI PTC = Ext.I/O PTC Input MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Digital input on Extended I/O board: Active = VSI Mode Not active = CSI Mode - PTC Input on Extended IO board cannot be used for this function. - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). - AR2-1 and AR2-2 could be used for this function. If the input signal is higher than 1.25V = Mode1 (VSI Mode).
61	Sys Mode Manual	False= System Mode0 (CSI Mode) True = System Mode1 (VSI Mode) Default = false (Mode0, CSI Mode)	If "60, Sys Mode Source" is set to 'Manual' this parameter selects the System Mode
62	Conv Load Source	MANUAL = GDM (63) AUTO = Modbus CIOB1 DIGI IP1 = Ext.I/O Digital Input 1 CIOB1 DIGI IP2 = Ext.I/O Digital Input 2 CIOB1 DIGI IP3 = Ext.I/O Digital Input 3 CIOB1 DIGI IP4 = Ext.I/O Digital Input 4 CIOB1 DIGI IP5 = Ext.I/O Digital Input 5 CIOB1 DIGI IP6 = Ext.I/O Digital Input 6 CIOB1 DIGI IP7 = Ext.I/O Digital Input 7 CIOB1 DIGI PTC = Ext.I/O PTC Input MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Selects source for converter load enable. Digital input on Extended I/O board: Active = converter load enable - PTC Input on Extended IO board cannot be used for this function. - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). - AR2-1 and AR2-2 could be used for this function. If the input signal is higher than 1.25V = converter load enabled
63	Conv Load Manual	False (Unloaded – 0 power) True (Normal Operation)	If "62, Conv Load Source" is set to 'Manual' this parameter enables the system to accept set points other than zero.

Menu Number	Parameter Name	Selection/Range default value	Description
		Default: True	
64	Conv Sync Source	MANUAL = GDM (65) AUTO = Modbus CIOB1 DIGI IP1 = Ext.I/O Digital Input 1 CIOB1 DIGI IP2 = Ext.I/O Digital Input 2 CIOB1 DIGI IP3 = Ext.I/O Digital Input 3 CIOB1 DIGI IP4 = Ext.I/O Digital Input 4 CIOB1 DIGI IP5 = Ext.I/O Digital Input 5 CIOB1 DIGI IP6 = Ext.I/O Digital Input 6 CIOB1 DIGI IP7 = Ext.I/O Digital Input 7 CIOB1 DIGI PTC = Ext.I/O PTC Input MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Selects source for converter synchronize enable. Digital input on Extended I/O board: Active = synchronize - PTC Input on Extended IO board cannot be used for this function. - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). - AR2-1 and AR2-2 could be used for this function. If the input signal is higher than 1.25V = synchronize
65	Conv Sync Manual	false true (synchronize) Default: false	If "64, Conv Sync Source" is set to 'Manual' this parameter enables the system to synchronize to VR1 Sync VT.
66	Droop Source	MANUAL = GDM (67) AUTO = Modbus CIOB1 DIGI IP1 = Ext.I/O Digital Input 1 CIOB1 DIGI IP2 = Ext.I/O Digital Input 2 CIOB1 DIGI IP3 = Ext.I/O Digital Input 3 CIOB1 DIGI IP4 = Ext.I/O Digital Input 4 CIOB1 DIGI IP5 = Ext.I/O Digital Input 5 CIOB1 DIGI IP6 = Ext.I/O Digital Input 6 CIOB1 DIGI IP7 = Ext.I/O Digital Input 7 CIOB1 DIGI PTC = Ext.I/O PTC Input MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2	Selects source for converter droop enable. Digital input on Extended I/O board: Active = droop enabled - PTC Input on Extended IO board cannot be used for this function. - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). - AR2-1 and AR2-2 could be used for this function. If the input signal is higher than 1.25V = droop enabled

Menu Number	Parameter Name	Selection/Range default value	Description
		Default = MANUAL (GDM)	
67	Droop Manual	false true (f/V droop enabled) Default: true	If “66, Droop Source” is set to ‘Manual’ this parameter enables frequency and voltage droop.
68	Fixed P Source	MANUAL = GDM (69) AUTO = Modbus CIOB1 DIGI IP1 = Ext.I/O Digital Input 1 CIOB1 DIGI IP2 = Ext.I/O Digital Input 2 CIOB1 DIGI IP3 = Ext.I/O Digital Input 3 CIOB1 DIGI IP4 = Ext.I/O Digital Input 4 CIOB1 DIGI IP5 = Ext.I/O Digital Input 5 CIOB1 DIGI IP6 = Ext.I/O Digital Input 6 CIOB1 DIGI IP7 = Ext.I/O Digital Input 7 CIOB1 DIGI PTC = Ext.I/O PTC Input MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Selects source to change from V/f mode to P/Q mode Digital input on Extended I/O board: Active = P/Q setpoint enabled - PTC Input on Extended IO board cannot be used for this function. - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). - AR2-1 and AR2-2 could be used for this function. If the input signal is higher than 1.25V = P/Q setpoint enabled
69	Fixed P Manual	false (V/f setpoints enabled) true (P/Q setpoints enabled) Default: true	If “68, Fixed P Source” is set to ‘Manual’ this parameter selects between P/Q set points or V/F set points
7	Reference Selector		Reference sources for all control modes.
70	P and Q		
700	P set Source	MANUAL = GDM (701) AUTO = Modbus CIOB1 ANA IP1 = Ext.I/O Analog Input 1 CIOB1 ANA IP2 = Ext.I/O Analog Input 2 MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2	Selects source for P setpoint Analog input Extended I/O board: 10..+10V or 4..20mA (see GDM 40, 41) = -400..+400% P setpoint - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). - AR2-1 and AR2-2 could be used for this function.

Menu Number	Parameter Name	Selection/Range default value	Description
		Default = MANUAL (GDM)	
701	P set Manual	-400 to +400 % Default: 0 %	If "700, P set Source" is set to 'Manual' this parameter is used for P setpoint.
702	P Analog Gain	-4.00 to +3.99 Default: 2	Gain for the analog input when source is any of the analog inputs.
703	P Analog Offset	-4.00 to +3.99 Default: 0	Offset for the analog input when source is any of the analog inputs.
704	Q set Source	MANUAL = GDM (705) AUTO = Modbus CIOB1 ANA IP1 = Ext.I/O Analog Input 1 CIOB1 ANA IP2 = Ext.I/O Analog Input 2 MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Selects source for Q setpoint Analog input Extended I/O board: 10..+10V or 4..20mA (see GDM 40, 41) = -400..+400% Q setpoint - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). AR2-1 and AR2-2 could be used for this function.
705	Q set Manual	-400 to +400 % Default: 0 %	If "704, Q set Source" is set to 'Manual' this parameter is used for Q setpoint.
706	Q Analog Gain	-4.00 to +3.99 Default: 2	Gain for the analog input when source is any of the analog inputs.
707	Q Analog Offset	-4.00 to +3.99 Default: 0	Offset for the analog input when source is any of the analog inputs.
71	V and F		
710	F set Source	MANUAL = GDM (711) AUTO = Modbus CIOB1 ANA IP1 = Ext.I/O Analog Input 1 CIOB1 ANA IP2 = Ext.I/O Analog Input 2 MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Selects source for F setpoint Analog input Extended I/O board: 10..+10V or 4..20mA (see GDM 40, 41) = -400..+400% F setpoint - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). AR2-1 and AR2-2 could be used for this function.
711	F set Manual	-400 to +400 % Default: 0 %	If "710, F set Source" is set to 'Manual' this parameter is used for F setpoint.

Menu Number	Parameter Name	Selection/Range default value	Description
712	F Analog Gain	-4.00 to +3.99 Default: 2	Gain for the analog input when source is any of the analog inputs.
713	F Analog Offset	-4.00 to +3.99 Default: 0	Offset for the analog input when source is any of the analog inputs.
714	V set Source	MANUAL = GDM (715) AUTO = Modbus CIOB1 ANA IP1 = Ext.I/O Analog Input 1 CIOB1 ANA IP2 = Ext.I/O Analog Input 2 MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Selects source for V setpoint Analog input Extended I/O board: 10..+10V or 4..20mA (see GDM 40, 41) = -400..+400% V setpoint - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). AR2-1 and AR2-2 could be used for this function.
715	V set Manual	-400 to +400 % Default: 0 %	If “714, V set Source” is set to ‘Manual’ this parameter is used for V setpoint.
716	V Analog Gain	-4.00 to +3.99 Default: 2	Gain for the analog input when source is any of the analog inputs.
717	V Analog Offset	-4.00 to +3.99 Default: 0	Offset for the analog input when source is any of the analog inputs.
8	Converter AC		
80	Start Mode	Always black start Always coupled start Uinv depending Shared/droop depending Default: Uinv depending	System mode source: - Always black start - Always start coupled, even when inverter terminal voltage is not correct - Do black start or coupled start based on inverter terminal voltage - If droop is active, then start in coupled mode, otherwise black start
81	Freq Droop	-100 .. 100 % Default: 2 %	Frequency droop when droop enabled Base = 19 System Frequency Typical: 0 .. 5 %
82	Volt Droop	-100 .. 100 %	Voltage droop when droop enabled

Menu Number	Parameter Name	Selection/Range default value	Description
		Default: 5 %	Base = 10 System Voltage Typical: 0 .. 20 %
83	Volt Droop Iso	-100 .. 100 % Default: 1 %	Voltage droop when not operating in shared mode Base = 10 System Voltage Typical: 0 .. -8 % for transformer compensation
84	Impedances		
840	Inertia	10 .. 32000 ms Default: 500 ms	Modeled generator inertia time constant
841	Output R	-4.00 ... +3.99 pu Default 0.1 pu	Modeled generator synthetic output resistance
842	Output L	-4.00 ... +3.99 pu Default 0.1 pu	Modeled generator synthetic output inductance
843	Damping	-4.00 ... +3.99 pu Default 1 pu	Current Source-mode, active resistive damping
85	Power Limits		
850	Pos P Limit	0 ... 399 % Default: 120 %	Absolute PCS100 Machine Positive P Limit Base = √3 x “10 System Voltage” x “11 System Current”
851	Neg P Limit	0 ... 399 % Default: 120 %	Absolute PCS100 Machine Negative P Limit Base = √3 x “10 System Voltage” x “11 System Current”
852	Pos Q Limit	0 ... 399 % Default: 180 %	Absolute PCS100 Machine Positive Q Limit Base = √3 x “10 System Voltage” x “11 System Current”
853	Neg Q Limit	-400 ... 0 % Default: -180 %	Absolute PCS100 Machine Negative Q Limit Base = √3 x “10 System Voltage” x “11 System Current”
854	Total S Limit	0 ... 399 % Default: 180 %	Absolute PCS100 Machine Total S Limit Base = √3 x “10 System Voltage” x “11 System Current”

Menu Number	Parameter Name	Selection/Range default value	Description
			Note: Can be disabled on 855!
855	S Limit mode	Disabled Limit Q Limit PQ Default: LimitQ	Set the operating mode of the S limit - Disabled (No limit) - Limit Q (Q will be reduced first to limit S) - Limit PQ (Both P and Q will be reduced to limit S)
859	Volatile P Limits		These volatile power limits (859x) are in addition to the Absolute PCS100 Machine Power Limits (850…854) and can be set from remote over analogue input or MODBUS.
8590	Pos P Lim Source	MANUAL = GDM (8591) AUTO = Modbus CIOB1 ANA IP1 = Ext.I/O Analog Input 1 CIOB1 ANA IP2 = Ext.I/O Analog Input 2 MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Selects source for Positive P limit Analog input Extended I/O board: -10..+10V or 4..20mA (see GDM 40, 41) - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). AR2-1 and AR2-2 could be used for this function.
8591	Pos P Lim Manual	0 to 399 % Default: 150 %	If "8590, Pos P Lim Source" is set to 'Manual' this parameter is used for Positive P Limit. Base = √3 x "10 System Voltage" x "11 System Current"
8592	Pos P Lim Ana Gain	-4.00 to +3.99 Default: 1	Gain for the analog input when source is any of the analog inputs.
8593	Pos P Lim Ana Offset	-4.00 to +3.99 Default: 1	Offset for the analog input when source is any of the analog inputs.
8594	Neg P Lim Source	MANUAL = GDM (8595) AUTO = Modbus CIOB1 ANA IP1 = Ext.I/O Analog Input 1 CIOB1 ANA IP2 = Ext.I/O Analog Input 2 MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1	Selects source for Negative P limit Analog input Extended I/O board: -10..+10V or 4..20mA (see GDM 40, 41) - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). AR2-1 and AR2-2 could be used for this function.

Menu Number	Parameter Name	Selection/Range default value	Description
		MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	
8595	Neg P Lim Manual	0 to 399 % Default: 150 %	If "8594, Neg P Lim Source" is set to 'Manual' this parameter is used for Negative P Limit. Base = √3 x "10 System Voltage" x "11 System Current"
8596	Neg P Lim Ana Gain	-4.00 to +3.99 Default: 1	Gain for the analog input when source is any of the analog inputs.
8597	Neg P Lim Ana Offset	-4.00 to +3.99 Default: 1	Offset for the analog input when source is any of the analog inputs.
85A	Volatile Q Limits		
85A0	Pos Q Lim Source	MANUAL = GDM (85A1) AUTO = Modbus CIOB1 ANA IP1 = Ext.I/O Analog Input 1 CIOB1 ANA IP2 = Ext.I/O Analog Input 2 MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Selects source for Positive Q limit Analog input Extended I/O board: -10..+10V or 4..20mA (see GDM 40, 41) - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). AR2-1 and AR2-2 could be used for this function.
85A1	Pos Q Lim Manual	0 to 399 % Default: 399 %	If "85A0, Pos Q Lim Source" is set to 'Manual' this parameter is used for Positive Q Limit. Base = √3 x "10 System Voltage" x "11 System Current"
85A2	Pos Q Lim Ana Gain	-4.00 to +3.99 Default: 1	Gain for the analog input when source is any of the analog inputs.
85A3	Pos Q Lim Ana Offset	-4.00 to +3.99 Default: 1	Offset for the analog input when source is any of the analog inputs.
85A4	Neg Q Lim Source	MANUAL = GDM (85A5) AUTO = Modbus CIOB1 ANA IP1 = Ext.I/O Analog Input 1 CIOB1 ANA IP2 = Ext.I/O Analog Input 2 MSIB AR1-1 = Master DC Voltage +/GND	Selects source for Negative Q limit Analog input Extended I/O board: -10..+10V or 4..20mA (see GDM 40, 41)

Menu Number	Parameter Name	Selection/Range default value	Description
		MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	- AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). AR2-1 and AR2-2 could be used for this function.
85A5	Neg Q Lim Manual	-400 to 0 % Default: -400 %	If "85A4, Neg Q Lim Source" is set to 'Manual' this parameter is used for Negative Q Limit. Base = √3 x "10 System Voltage" x "11 System Current"
85A6	Neg Q Lim Ana Gain	-4.00 to +3.99 Default: 1	Gain for the analog input when source is any of the analog inputs.
85A7	Neg Q Lim Ana Offset	-4.00 to +3.99 Default: 1	Offset for the analog input when source is any of the analog inputs.
85B	Volatile S Limit		
85B0	S Lim Source	MANUAL = GDM (85B1) AUTO = Modbus CIOB1 ANA IP1 = Ext.I/O Analog Input 1 CIOB1 ANA IP2 = Ext.I/O Analog Input 2 MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Selects source for S limit Analog input Extended I/O board: -10..+10V or 4..20mA (see GDM 40, 41) - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for this function). AR2-1 and AR2-2 could be used for this function.
85B1	S Lim Manual	0 to 399 % Default: 399 %	If "85B0, S Lim Source" is set to 'Manual' this parameter is used for S Limit. Base = √3 x "10 System Voltage" x "11 System Current"
85B2	S Lim Ana Gain	-4.00 to +3.99 Default: 1	Gain for the analog input when source is any of the analog inputs.
85B3	S Lim Ana Offset	-4.00 to +3.99 Default: 1	Offset for the analog input when source is any of the analog inputs.
85B4	S Lim Therm Backoff	Disable Enable Default: disable	If 85B4, "S Lim Therm Backoff" is set to 'enable', the Power will be re-duced once the thermal limits of the system are reached.

Menu Number	Parameter Name	Selection/Range default value	Description
86	Standby		
860	Standby on low PQ	Disable Enable Default: disable	Enable or disable standby feature
861	P Enter Standby	0 to 399 % Default: 5 %	P threshold where converter enters standby Base = √3 x "10 System Voltage" x "11 System Current"
862	Q Enter Standby	0 to 399 % Default: 5 %	Q threshold where converter enters standby Base = √3 x "10 System Voltage" x "11 System Current"
863	P Exit Standby	0 to 399 % Default: 6.99 %	P threshold where converter exits standby Base = √3 x "10 System Voltage" x "11 System Current"
864	Q Exit Standby	0 to 399 % Default: 6.99 %	Q threshold where converter exits standby Base = √3 x "10 System Voltage" x "11 System Current"
865	Standby on Unload	False True Default: false	If set to 'true' system goes into standby when generator is unloaded
866	Standby Time To On	0 … 32767 ms Default: 100 ms	Minimum time for system loading to be above P and Q thresholds (863 and 864) before coming out of standby
867	Standby Time To Off	0 … 32767 ms Default: 1000 ms	Minimum time for system loading to be below P and Q thresholds (861 and 862) before going into standby
87	LV Ride Through		
870	Allow LVRT		Enable or disable LVRT features
871	Vac Pset 0	0 to 480V Default: 278 V	AC voltage threshold where for voltages below threshold real power setpoint is overridden to 0%
872	Vac Pset normal	0 to 480 V Default: 320 V	AC voltage threshold where for voltages above threshold real power set-point is reverted to normal Note: This value must be greater than 871 Vac Pset 0

Menu Number	Parameter Name	Selection/Range default value	Description
873	Level Vac min 1	-1 to 3.99 pu Default: 0.15 pu	AC voltage threshold where for voltages below threshold a timeout is evoked. Base = 10 System Voltage
874	Time Vac min 1	0 … 32767 ms Default: 200 ms	Timeout for “Level Vac min 1”.
875	Level Vac min 2	-1 to 3.99 pu Default: 0.4 pu	AC voltage threshold where for voltages below threshold a timeout is evoked. Base = 10 System Voltage
876	Time Vac min 2	0 … 32767 ms Default: 1500 ms	Timeout for “Level Vac min 2”.
877	Level Vac Restart	-1 … 3.99 pu Default: 0.7 pu	AC voltage threshold where for voltages above threshold converter can restart. Base = 10 System Voltage
878	Time Vac Restart	0 … 32767 ms Default: 1000 ms	Timeout for “Level Vac Restart”.
88	Envelope Limits		
884	Frequency Envelope		
8840	Env Freq Mode	• Disabled No frequency envelope • PQ mode only Frequency envelope enabled when in PQ mode. • Enabled Frequency envelope enabled in all modes (Not recommended)	Enable frequency envelope clamp.
8841	Env Freq Max	Tech: Set upper frequency for envelope mode. Units: per unit (Base = 19 System Frequency) Range: 0 to 3.9	Note: If 8840 Env Freq Mode is enabled and this frequency is exceeded the ESS will automatically reduce it’s output power to bring the frequency within this limit. Can be used to prevent an over frequency trip when in Pset mode and the mains is lost.

Menu Number	Parameter Name	Selection/Range default value	Description
8842	Env Freq Min	Tech: Set lower frequency for envelope mode. Units: per unit (Base = 19 System Frequency)Range: 0 to 3.9	Note: If 8840 Env Freq Mode is enabled and this frequency is exceeded the ESS will automatically increase it's output power to bring the frequency within this limit. Can be used to prevent an under frequency trip when in Pset mode and the mains is lost.
8843	Env Freq Max Slope		Slope for Pmax
8844	Env Freq Min Slope		Slope for Pmin
8845	Over Freq P Min		Lowest level to where the Pmax can drop
8846	Under Freq P Max		Highest level to where the Pmin can rise
885	Voltage Envelope		
8850	Env Volt Mode		
8851	Env Volt Max	Tech: Set upper voltage for envelope mode. Units: per unit (Base = 10 System Voltage) Range: 0 to 3.9	Note: If 8850 Env Volt Mode is enabled and this voltage is exceeded the ESS will automatically reduce it's reactive power output to bring the voltage within this limit. Can be used to prevent an over voltage trip when in Qset mode and the mains is lost.
8852	Env Volt Min	Tech: Set lower voltage for envelope mode. Units: per unit (Base = 10 System Voltage) Range: 0 to 3.9	Note: If 8850 Env Volt Mode is enabled and this voltage is exceeded the ESS will automatically increase it's reactive power output to bring the voltage within this limit. Can be used to prevent an under voltage trip when in Qset mode and the mains is lost.
8853	Env Volt Max Slope		Slope for Qmax
8854	Env Volt Min Slope		Slope for Qmin
8855	Over Volt Q Min		Lowest level to where the Qmax can drop
8856	Under Volt Q Max		Highest level to where the Qmin can rise
89	Sync Input Trim		
890	Trim Sync Phase	Units: degrees Range: -180° to 179.9°	Phase correction parameter between sync VR1 and inverter terminals.
891	Trim Sync Volt	Units: percentage (Base = 10 System Voltage) Range: 30% to 300%	Voltage trim parameter between sync VR1 and inverter terminals.
892	Sync Phase error	Units: degrees Range: -180° to 179.9°	Phase error between sync VR1 and inverter terminals.

Menu Number	Parameter Name	Selection/Range default value	Description
893	Sync Volt error	Units: percentage (Base = 10 System Voltage) Range: 30% to 300%	Voltage amplitude error between sync VR1 and inverter terminals.
8A	Grid Monitoring		
8A0	Configuration		

8A01	Enable Src	MANUAL = GDM (8A02)
		AUTO = Modbus (230)
		CIOB1 DIGI IP1 = Ext.I/O Digital Input 1
		CIOB1 DIGI IP2 = Ext.I/O Digital Input 2
		CIOB1 DIGI IP3 = Ext.I/O Digital Input 3
		CIOB1 DIGI IP4 = Ext.I/O Digital Input 4
		CIOB1 DIGI IP5 = Ext.I/O Digital Input 5
		CIOB1 DIGI IP6 = Ext.I/O Digital Input 6
		CIOB1 DIGI IP7 = Ext.I/O Digital Input 7
		CIOB1 DIGI PTC = Ext.I/O PTC Input
		MSIB AR1-1 = Master DC Voltage +/GND
		MSIB AR1-2 = Master DC Voltage -/GND
		MSIB AR2-1 = Master Analogue Input 2-1
		MSIB AR2-2 = Master Analogue Input 2-2
		
		Default = MANUAL (GDM)
			Selects source for Enabling Grid Monitoring.
			
			Digital input on Extended I/O board: Active = Grid Monitoring ON
			
			- PTC Input on Extended IO board cannot be used for this function.
			- AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for enabling Gird Monitoring).
			- AR2-1 and AR2-2 could be used to Enable Grid Monitoring.
			  - If the input signal is higher than 1.25V, Grid Monitoring is ENABLED,
			  - If the input signal is lower than 1.25V, grid monitoring is disabled.

8A02	Enable Manual	False= Grid Monitoring OFF, True = Grid Monitoring ON Default = True (Grid Monitoring ON)	If “8A01, Enable Src” is set to ‘Manual’ this parameter enables or disables the Grid Monitoring Function
8A03	Grid Loss Action	Disabled Monitor Stop on Island Trip on Island Run on Island	Disables the grid monitoring/island detection functions Enables the grid monitoring function and generates a "Grid Loss" output only. Enables the grid monitoring function, goes into standby when grid loss detected Enables the grid monitoring function, issues trip when grid loss detected

Menu Number	Parameter Name	Selection/Range default value	Description
		Default = Disabled (no action)	Enables the grid monitoring function, Runs as an island when grid loss detected
8A04	Utility Feedback Src	VR1	PCS100 ESS external voltage sensing is used for grid monitoring. For islanding applications VR1 must be selected and wired to the utility side of the grid tie breaker This is required to enable the PCS100 ESS to synchronize to the grid after having been running in an Island.
		VR2 Default = VR2 (PCS100 ESS master internal voltage sensing)	PCS100 ESS internal master voltage sensing is used for grid monitoring.
8A05	Use Pos Sequence	False	RMS voltage
		True Default = False (use RMS voltage for Grid monitoring)	pos. sequence voltage Positive sequence voltages are used if the supply voltage contains lots of negative sequence (unbalance voltages), the negative sequence causes a ripple in the signals which can cause the detectors to trigger prematurely.
8A1	Passive Voltage Detect		Fast detection has minimal filtering (TC 10ms) and hence has slightly higher ripple content (+/-5%). It is intended to be used to detect large signal disturbances with a minimal delay. Slow detection has additional filtering (TC 100ms) and hence has less ripple content (+/-0.5%). It is intended to be used to detect small signal disturbances. Delay timers are used to ensure that the grid voltage has been outside range for a minimum time, this delay is adjustable over the range 10ms...5min, 0ms disables this protection.
8A10	Under Volt Fast Level	Default 50.00 % Min 0.00 %	Voltage Level (in percent of “10 System Voltage”) for triggering grid fault fast/deep Voltage disturbance on the grid.

Menu Number	Parameter Name	Selection/Range default value	Description
		Max 399.99% Step 0.01 %	*If “8A11 Under Volt Fast Delay” is set to 0 ms, Fast Under Voltage detection is disabled!*
8A11	Under Volt Fast Delay	Default 160 ms Min 10 ms* Max 327670 ms (5min 27.67sec) Step 10 ms ** 0ms = Fast Under Volt detection OFF*	Time delay (in Milliseconds) for triggering grid fault by fast/deep Voltage disturbance on the grid.
8A12	Under Volt Slow Level	Default 88.00 % Min 0.00 % Max 399.99% Step 0.01 %	Voltage Level (in percent of “10 System Voltage”) for triggering grid fault slow/small- Voltage disturbance on the grid. *If “8A13 Under Volt Slow Delay” is set to 0 ms, Slow Under Voltage detection is disabled!*
8A13	Under Volt Slow Delay	Default 2000 ms Min 10 ms* Max 327670 ms (5min 27.67sec) Step 10 ms ** 0ms = Slow Under Volt detection OFF*	Time delay (in Milliseconds) for triggering grid fault by slow/small Voltage disturbance on the grid.
8A14	Over Volt Fast Level	Default 120.00 % Min 0.00 % Max 399.99% Step 0.01 %	Voltage Level (in percent of “10 System Voltage”) for triggering grid fault fast/high Voltage disturbance on the grid. *If “8A15 Over Volt Fast Delay” is set to 0 ms, Fast Over Voltage detection is disabled!*
8A15	Over Volt Fast Delay	Default 160 ms Min 10 ms* Max 327670 ms (5min 27.67sec) Step 10 ms ** 0ms = Fast Over Volt detection OFF*	Time delay (in Milliseconds) for triggering grid fault by fast/high Voltage disturbance on the grid.
8A16	Over Volt Slow Level	Default 110.00 % Min 0.00 % Max 399.99% Step 0.01 %	Voltage Level (in percent of “10 System Voltage”) for triggering grid fault slow/small- Voltage disturbance on the grid. *If “8A17 Over Volt Slow Delay” is set to 0 ms, Slow Over Voltage detection is disabled!*
8A17	Over Volt Slow Delay	Default 1000 ms Min 10 ms* Max 327670 ms (5min 27.67sec) Step 10 ms	Time delay (in Milliseconds) for triggering grid fault by slow/small Voltage disturbance on the grid.

Menu Number	Parameter Name	Selection/Range default value	Description
		** 0ms = Slow Under Volt detection OFF*	
8A2	Passive Freq Detect		The frequency is derived from the filtered output of a local PLL. There is only one output frequency filter, the filter setting is a compromise between fast responses for these detections and the slower response required for delta frequency detection. Delay timers are used to ensure that the grid voltage has been less than the set level for a minimum time.
8A20	Under Freq Fast Level	Default 95.00 % Min 0.00 % Max 399.99 % Step 0.01 %	Frequency (in percent of "19 System Frequency") for triggering grid fault fast/big Under Frequency disturbance on the grid. *If "8A21 Under Freq Fast Delay" is set to 0 ms, Fast Under Frequency detection is disabled!*
8A21	Under Freq Fast Delay	Default 160 ms Min 10 ms* Max 327670 ms (5min 27.67sec) Step 10 ms ** 0ms = Fast Under Freq. detection OFF*	Time delay (in Milliseconds) for triggering grid fault by fast/big Under Frequency disturbance on the grid.
8A22	Under Freq Slow Level	Default 99.67 % Min 0.00 % Max 399.99 % Step 0.01 %	Frequency (in percent of "19 System Frequency") for triggering grid fault slow/small Under Frequency disturbance on the grid. *If "8A23 Under Freq Slow Delay" is set to 0 ms, Slow Under Frequency detection is disabled!*
8A23	Under Freq Slow Delay	Default 300000 ms (5 min) Min 10 ms* Max 327670 ms (5min 27.67sec) Step 10 ms ** 0ms = Slow Under Freq. detection OFF*	Time delay (in Milliseconds) for triggering grid fault by slow/small Under Frequency disturbance on the grid.
8A24	Over Freq Fast Level	Default 100.83 % Min 0.00 % Max 399.99 % Step 0.01 %	Frequency (in percent of "19 System Frequency") for triggering grid fault fast/big Over Frequency disturbance on the grid. *If "8A25 Over Freq Fast Delay" is set to 0 ms, Fast Over Frequency detection is disabled!*
8A25	Over Freq Fast Delay	Default 160 ms Min 10 ms* Max 327670 ms (5min 27.67sec)	Time delay (in Milliseconds) for triggering grid fault by fast/big Over Frequency disturbance on the grid.

Menu Number	Parameter Name	Selection/Range default value	Description
		Step 10 ms ** 0ms = Fast Over Freq. detection OFF*	
8A26	Over Freq Slow Level	Default 0.00 % Min 0.00 % Max 399.99% Step 0.01 %	Frequency (in percent of "19 System Frequency") for triggering grid fault slow/small Over Frequency disturbance on the grid. *If "8A27 Over Freq Slow Delay" is set to 0 ms, Slow Over Frequency detection is disabled!*
8A27	Over Freq Slow Delay	Default 0 ms (disabled) Min 10 ms* Max 327670 ms (5min 27.67sec) Step 10 ms ** 0ms = Slow Over Freq. detection OFF*	Time delay (in Milliseconds) for triggering grid fault by slow/small Over Frequency disturbance on the grid.
8A28	Delta F Level	Default 0.0628 %/cycle Min 0.0000 %/cycle Max 1.2271 %/cycle Step 0.0001 %/cycle	The grid monitor provides an adjustable frequency rate of change (ROC) protection and delay timer. Frequency rate of change (in percent per cycle, %/c) for triggering grid fault by Changing Frequency on the grid. <u>Example1</u> 50Hz grid (19 System Frequency): f rate of change 2.5 Hz/sec, in 1 cycle: 2.5Hz/50cycles = 0.05Hz/cycle in % of 50Hz: 0.05Hz/50Hz*100 = 0.1%/cycle <u>Example2</u> 60Hz grid (19 System Frequency): f rate of change 0.3%/cycle in Hz/cycle 0.003*60Hz = 0.18Hz/cycle in Hz/sec 0.18 * 60cycles =10.8Hz/sec *If "8A29 Delta F Delay" is set to 0 ms, Frequency rate of change detection is disabled!*
8A29	Delta F Delay	Default 500 ms Min 10 ms* Max 327670 ms (5min 27.67sec) Step 10 ms ** 0ms = Changing Freq. detection OFF*	Time delay (in Milliseconds) for triggering grid fault by Changing Frequency on the grid.

Menu Number	Parameter Name	Selection/Range default value	Description
8A3	Phase Loss Detect		The grid monitor provides an adjustable unbalance current level and delay timer to allow the detection of an open circuit output phase connection as described in the IEEE1547.1 - section 5.9 Open Phase test. Delay timers are used to ensure that the output current unbalance has been more than the set level for a minimum time. If the unbalanced current is bigger than the unbalance level threshold, unbalance detection will be activated.
8A30	Unbalance Level	Default 80.00 % Min 20.00 % Max 399.99 % Step 0.01 %	Phase loss unbalance current (in percent of maximal current minus minimal current, divided by maximal current of the three phase). $unbalance = \frac{max - min}{max}\ x\ 100\%$ <u>Example</u> L1 = 50A, L2 = 364A, L3 = 385A max. phase current = 385A min. phase current = 50A Unbalance level = (385A – 50A)/385A = 87% *If "8A31 Unbalance Delay" is set to 0 ms, Unbalance detection is disabled!*
8A31	Unbalance Delay	Default 2000 ms Min 10 ms* Max 327670 ms (5min 27.67sec) Step 10 ms ** 0ms = Unbalance detection OFF*	Time delay (in Milliseconds) for triggering grid fault by Current Unbalance.
8A4	Active Island Detect		
8A40	RPV Enable	False= Grid Impedance Monitoring OFF True = Grid Impedance Monitoring ON, Default = False (RPV off)	Enables/disables reactive power injection Notes: RPV active island detection is not applicable for all grid circumstances. Hence, the impedance calculation delay has been hidden from GDM Menu and set to zero by default. Contact the factory for its activation.

Menu Number	Parameter Name	Selection/Range default value	Description
			The interval of injection is by default 100ms and it is not adjustable
8A41	RPV Inject Level	Default 0.1000 pu Min 0.0000 pu Max 1.0000 pu Step 0.0001 pu	Max. reactive power inject level (in pu of product of rated reactive power: “11 System Current” x “10 System Voltage” x √3) <u>Example:</u> 8A41: set to 0.1 pu 400Vac PCS100 ESS inverter, rated 2400A (16x D-Type modules) 0.1 x 400V x 2.4kA x √3 = 166 kVA random amount up to 166 kVAr reactive power will be injected to the grid to detect a grid fault (changing impedance/admittance of the grid).
8A5	Islanding Control		
8A50	Allow Black Start	False = PCS100 ESS can start on existing AC grid only. True = PCS100 can start in Islanding (no grid present), Default = true	Allows system to start as an island under black start condition (no grid present) if set to TRUE
8A51	Breaker Feedback	Not fitted = NO breaker feedback Fitted = breaker feedback connected Default = Fitted	Grid tie breaker feedback is recommended for islanded operation, this will trip the system if the grid tie breaker fails to open within a specified time. . To be able to use this function, 8A52 needs to be set accordingly, other-wise the unit will trip!
8A52	Breaker Feedback Src	MANUAL* (not applicable) AUTO = Modbus (227) CIOB1 DIGI IP1 = Ext.I/O Digital Input 1 CIOB1 DIGI IP2 = Ext.I/O Digital Input 2 CIOB1 DIGI IP3 = Ext.I/O Digital Input 3 CIOB1 DIGI IP4 = Ext.I/O Digital Input 4 CIOB1 DIGI IP5 = Ext.I/O Digital Input 5 CIOB1 DIGI IP6 = Ext.I/O Digital Input 6	Islanding breaker feedback input Digital input on Extended I/O board: Active = Breaker CLOSED feedback

Menu Number	Parameter Name	Selection/Range default value	Description

		CIOB1 DIGI IP7 = Ext.I/O Digital Input 7
		CIOB1 DIGI PTC = Ext.I/O PTC Input
		MSIB AR1-1 = Master DC Voltage +/GND
		MSIB AR1-2 = Master DC Voltage -/GND
		MSIB AR2-1 = Master Analogue Input 2-1
		MSIB AR2-2 = Master Analogue Input 2-2
		
		Default = MANUAL*
			- PTC Input on Extended IO board cannot be used for this function.
			- AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for Breaker Feedback).
			- AR2-1 and AR2-2 could be used for the Breaker Feedback.
			  - If the input signal is higher than 1.25V, Breaker CLOSED Feed-back,
			  - If the input signal is lower than 1.25V, Breaker OPEN Feedback.
			
			* to be able to use the breaker feedback the setting must be changed during commissioning.

8A53	Breaker Feedback Time	Default 300 ms Min 0 ms Max 327670 ms (5min 27.67sec) Step 10 ms	Grid tie breaker feedback timeout After the delay of 8A53 the grid tie breaker feedback must be the same as the grid tie command, otherwise the PCS100 ESS will trip

8A54	Ext Grid Loss Source	MANUAL = GDM (8A55)
		AUTO = Modbus (228)
		CIOB1 DIGI IP1 = Ext.I/O Digital Input 1
		CIOB1 DIGI IP2 = Ext.I/O Digital Input 2
		CIOB1 DIGI IP3 = Ext.I/O Digital Input 3
		CIOB1 DIGI IP4 = Ext.I/O Digital Input 4
		CIOB1 DIGI IP5 = Ext.I/O Digital Input 5
		CIOB1 DIGI IP6 = Ext.I/O Digital Input 6
		CIOB1 DIGI IP7 = Ext.I/O Digital Input 7
		CIOB1 DIGI PTC = Ext.I/O PTC Input
		MSIB AR1-1 = Master DC Voltage +/GND
		MSIB AR1-2 = Master DC Voltage -/GND
		MSIB AR2-1 = Master Analogue Input 2-1
		MSIB AR2-2 = Master Analogue Input 2-2
		
		Default = MANUAL (GDM)
			This parameter can be used to connect external devices, e.g. reverse power relay.
			Grid monitoring loss input; includes the reconnect delay timer, which means that the PCS100 ESS will connect only back to the grid only once the reconnection time (8A61) has elapsed.
			
			Digital input on Extended I/O board: Active = grid fault simulation
			
			- PTC Input on Extended IO board cannot be used for this function.
			- AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for Grid Loss Test).
			- AR2-1 and AR2-2 could be used for the Grid Loss Test.
			  - If the input signal is higher than 1.25V, Grid Loss Test is acti-vated,
			  - if the input signal is lower than 1.25V, Grid Loss Test is not ac-tive.

Menu Number	Parameter Name	Selection/Range default value	Description
8A55	Ext Grid Loss Manual	True = grid fault active False= no grid fault Default = False	Grid monitoring loss test, includes reconnect timer True = simulates a grid fault and triggers the reconnection delay timers. False = grid fault simulation is disabled.

8A56	Force Island Source	MANUAL = GDM (8A57)
		AUTO = Modbus (229)
		CIOB1 DIGI IP1 = Ext.I/O Digital Input 1
		CIOB1 DIGI IP2 = Ext.I/O Digital Input 2
		CIOB1 DIGI IP3 = Ext.I/O Digital Input 3
		CIOB1 DIGI IP4 = Ext.I/O Digital Input 4
		CIOB1 DIGI IP5 = Ext.I/O Digital Input 5
		CIOB1 DIGI IP6 = Ext.I/O Digital Input 6
		CIOB1 DIGI IP7 = Ext.I/O Digital Input 7
		CIOB1 DIGI PTC = Ext.I/O PTC Input
		MSIB AR1-1 = Master DC Voltage +/GND
		MSIB AR1-2 = Master DC Voltage -/GND
		MSIB AR2-1 = Master Analogue Input 2-1
		MSIB AR2-2 = Master Analogue Input 2-2
		
		Default = MANUAL (GDM)
			Grid monitoring force island will force the system immediately into island, without reconnect timer, and only manual reconnection is possible.
			
			Digital input on Extended I/O board: Active = Forcing Island command
			
			- PTC Input on Extended IO board cannot be used for this function.
			- AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for Forcing Island).
			- AR2-1 and AR2-2 could be used for Forcing Island.
			  - If the input signal is higher than 1.25V, Forcing Island command,
			  - If the input signal is lower than 1.25V, Forcing Islanding is not active.

8A57	Force Island Manual	False= Forcing Island not active True = Forcing Island command Default = False	Grid monitoring force island, without reconnect timer. Uses manual reconnect
8A6	Reconnect Control		
8A60	Auto Reconnect	False = Manual reconnection to Grid (see 8A62 Reconnect Source) True = automatic reconnection to Grid	After the PCS100 ESS is running in Island, the grid is up and running again and “8A61 Reconnect Delay” time has elapsed, - the PCS100 ESS needs to be manually reconnected back to the Grid. or

Menu Number	Parameter Name	Selection/Range default value	Description
		Default = False	- the PCS100 ESS reconnects automatically back to the Grid.
8A61	Reconnect Delay	Default 300 s Min 0 s Max 32767 s Step 1 s	Grid Loss reconnect time – seconds After Grid Loss causing the PCS100 ESS to run in island it will wait for X seconds after the Grid Voltage and Grid Frequency are within the reconnect thresholds (8A64 – 8A67) until it allows to be reconnected to the Gird.
8A62	Reconnect Source	MANUAL = GDM (8A63) AUTO = Modbus (226) CIOB1 DIGI IP1 = Ext.I/O Digital Input 1 CIOB1 DIGI IP2 = Ext.I/O Digital Input 2 CIOB1 DIGI IP3 = Ext.I/O Digital Input 3 CIOB1 DIGI IP4 = Ext.I/O Digital Input 4 CIOB1 DIGI IP5 = Ext.I/O Digital Input 5 CIOB1 DIGI IP6 = Ext.I/O Digital Input 6 CIOB1 DIGI IP7 = Ext.I/O Digital Input 7 CIOB1 DIGI PTC = Ext.I/O PTC Input MSIB AR1-1 = Master DC Voltage +/GND MSIB AR1-2 = Master DC Voltage -/GND MSIB AR2-1 = Master Analogue Input 2-1 MSIB AR2-2 = Master Analogue Input 2-2 Default = MANUAL (GDM)	Digital input on Extended I/O board: Active = reconnection command - PTC Input on Extended IO board cannot be used for this function. - AR1-1 and AR1-2 on the Master controller are used for DC voltage sensing (cannot be used for Reconnect). - AR2-1 and AR2-2 could be used for Reconnect. - If the input signal is higher than 1.25V, the PCS100 ESS will reconnect, - if the input signal is lower than 1.25V, the PCS100 ESSS will not reconnect.
8A63	Reconnect Manual	False= manual reconnection inactive True = manual reconnection active Default = False	Manual 'reconnection to the grid' command on GDM, when PCS100 ESS is running in Island. e.g. after manual test of "8A57 Force Island Manual" The Manual reconnection on the GDM can be used only if: - 8A60 Reconnect Mode = Manual and - 8A62 Reconnect Source = MANUAL.
8A64	Reconnect Min Volt	Default 91.7 % Min 0 %	Voltage low threshold to allow reconnection of PCS100 ESS to the grid.

Menu Number	Parameter Name	Selection/Range default value	Description
		Max 399.99 % Step 0.01 %	
8A65	Reconnect Max Volt	Default 105.8 % Min 0 % Max 399.99 % Step 0.01 %	Voltage high threshold to allow reconnection of PCS100 ESS to the grid.
8A66	Reconnect Min Freq	Default 98.83 % Min 0 % Max 399.99 % Step 0.01 %	Frequency low threshold to allow reconnection of PCS100 ESS to the grid.
8A67	Reconnect Max Freq	Default 100.83 % Min 0 % Max 399.99 % Step 0.01 %	Frequency high threshold to allow reconnection of PCS100 ESS to the grid.
8B	Over/Under Voltage Clamp		
8B0	Volt Clamp Ena	False/True	Enables Voltage Clamping. Note only available in CSI mode
8B1	Volt FB Src		Selects the feedback source for the voltage clamping controller. Note: Typically this would be the VR2 (inverter) terminals, but the VR1 input can be used to measure the voltage at some other point on the network e.g. PCC. Note: if VR1is used as the feedback source it is important that the magnitude and phase of this signal is adjusted to match the VR2 signal. See the following section on adjustment of the sync trim values.
8B2	Over Voltage Limit	0 to 3.9 pu (Base = 10 System Voltage)	Over Voltage limit for Voltage clamping
8B3	Under Voltage Limit	0 to 3.9 pu (Base = 10 System Voltage)	Under Voltage limit for Voltage clamping
8B4	Clamping Gain	-4 to +3.9 pu	response rate for correction Note: Higher gains will produce a faster correction response but may cause an oscillation, lower gains are typically more stable but the correction is slower. Lower gains are typically needed for high impedance networks. The default value of 1 is provides a good starting point, but this must be verified over a range of network grid impedances.
8B5	Clamp I limit	-4 to +3.9 pu	Absolute maximum current the system provides for Voltage clamping.

Menu Number	Parameter Name	Selection/Range default value	Description
			Note: Due to the relative impedances of the ESS system and the Grid, it is likely that the ESS will only be able to correct the utility voltage @ PCC by only a few percent at full rated current. If this correction is not limited it would easily exceed the maximum available from the system and cause the system to trip on overload in less than 2 seconds. Setting a lower current limit value will give a longer overload time. When 8B0 Volt Clamp Ena = enabled, 8B5 Clamp I limit sets the maximum current the system will deliver and this will override all the normal P/Q reference and limit sources. The current limit will sacrifice the real power (P) in favor of reactive power (Q) to maintain the current within limits.
91	Converter SOC		
911	Over Volt Level	0 to 1140 V	Over voltage level. If DC voltage exceeds this level the P setpoint will be overridden to discharge storage until voltage is at 913 Max Operating DC
912	Over Volt Reset	0 to 1140 V	DC voltage where protection control is deactivated Note: Must be set below 911 Over Volt Level and above 913 Max Operating DC
913	Max operating DC	0 to 1140 V	Maximum operating DC level for storage. This is also the 100% State Of Charge value as indicated by the Veff parameter on the GDM Status page. Note: Must be set below the 912 Over Volt Reset
914	Min operating DC	0 to 1140 V	Minimum operating DC level for storage. This is also the 0% State Of Charge value as indicated by the Veff parameter on the GDM Status page. Note: Must be set below 913 Max Operating DC
915	Under Volt Reset	0 to 1140 V	Dc voltage where protection control is deactivated. Note: Must be set above 916 Under Volt Level
916	Under Volt Level	0 to 1140 V	Under voltage level. If DC voltage goes below this level the P setpoint will be overridden to charge storage until voltage is at Min Operating DC. Note: Must be set below Min Operating DC
917	Over Volt Slope		
918	Under Volt Slope		
919	Under Volt Charge Max		
91A	Over Volt Discharge Max		
96	Sense Method	 DISABLED	Specifies where the converter DC sensing comes from: - No DC Voltage sensing

Menu Number	Parameter Name	Selection/Range default value	Description
		MUX_SOC MUX_DCBUS MODULE_DCBUS	- - PCS100 Master DC Voltage sensing Input AR1 - Module Internal Voltage sensing
A	Protections		
A0	Unbalance Check	False/True	Enables or disables DC center balance checking.
A1	Max Unbalance Level	0 to 1000 V	Alert/Trip level of DC voltage from the midpoint of the DC bus to ground.
A2	Max Ripple Level	0 to 1000 V	Alert/Trip level of high frequency voltage ripple on DC bus.
A3	Unbalance Trips	False/True	DC center balance protection set to trip (true), or warning (false)
A4	Ripple Trips	False/True	Ripple protection/high frequency voltage ripple on DC bus. Set to trip (true), or warning (false)
GDM	Graphic Display		
A00	Display		
A31	GDM Control Enable	False/True Default: True	Enables or disables the local Start, Stop, Reset control. Setting to True displays the Control buttons (Start / Stop / Reset buttons) on the GDM's touch screen. Setting to False removes the Control buttons (Start / Stop / Reset buttons) from the GDM's touch screen.
A62	Screen Saver Time	Range: 0 to 999 min Default: 15 min	Sets the time for the screen saver (black screen) to activate. Note: If you specify 0, the touch screen will go to sleep 15 seconds after being touched.
A63	SSH Port Enable	False /True Default: True	Enables SSH access
B00	Network Settings		

Menu Number	Parameter Name	Selection/Range default value	Description
B11	Dynamic IP DHCP	True dynamic IP address (enable (DHCP) False static IP address (disable DHCP)	The network may be configured using either static or dynamic configuration methods. The static method is the simplest for a direct connection to a PC. The IP address for the GDM is manually configured via parameter B12 Static IP address. The PC IP address in Windows may also need adjusting. The Dynamic method is when the computer's IP address is assigned automatically, in which case parameters B12 Static IP address and B13 Static IP mask does not need to be entered. Dynamic IP addresses are most frequently assigned on LANs and broadband networks by a Dynamic Host Configuration Protocol (DHCP) server. On any but the simplest network the network administrator’s assistance will probably be required. Parameter B15 Apply Settings must be set to TRUE to save this setting.
B12	Static IP address	###.###.###.### (where ### = 1 to 255)	Configures the GDM Static IP address. Parameter B15 Apply Settings must be set to TRUE to activate this setting. This is not required if DHCP is in use.
B13	Static IP mask	###.###.###.### (where ### = 1 to 255 Example: 255.255.254.0	Configures the GDM Static IP mask. Parameter B15 Apply Settings must be set to TRUE to save this setting. Ensure that you have the correct subnet mask for the GDM. The example provided above is for formatting purposes only and may not be valid for your network. If you are unsure, see your IT System Administrator for assistance. This is not required if DHCP is in use.
B14	Static IP gateway	###.###.###.### (where ### = 1 to 255) Example: 192.168.4.1	Configures the GDM Static IP gateway. Parameter B15 Apply Settings must be set to TRUE to save this setting. Ensure that you have the correct IP gateway / router address for the GDM. The example provided above is for formatting purposes only and may not be valid for your network. If you are unsure, see your IT System Administrator for assistance.
B15	Apply settings	True / False	Applies the network settings B11 Dynamic IP DHCP, B12 Static IP address, B13 Static IP mask and B14 Static IP gateway. Select True to update the configuration. To view the actual settings currently used by the PCS100 ESS see the Product Page
C00	Network Status		
C11	Actual DHCP active	True / False	Displays the status of Actual DHCP. Useful for debugging network connection problems.
C12	Actual IP address	###.###.###.### (where ### = 1 to 255)	Displays the actual IP address. Useful for debugging network connection problems.

Menu Number	Parameter Name	Selection/Range default value	Description
C13	Actual IP mask	###.###.###.### (where ### = 1 to 255)	Displays the actual IP mask. Useful for debugging network connection problems.
C14	Actual IP gateway	###.###.###.### (where ### = 1 to 255)	Displays the actual IP gateway. Useful for debugging network connection problems.
C15	Mac address	##:##:##:##:##:## (where ## = 01 to FF)	Displays the product's MAC address. Useful for debugging network connection problems.
C16	Ethernet Status	UP	Displays the status of Ethernet connection. "Up" when active Useful for debugging network connection problems.
D00	Product Revision		Displays GDM and Vcan-server revision information.
D11	GDMIB Boot Product		
D12	GDMIB Boot Revision		
D13	GDMIB Product		
D14	GDMIB Revision		
D21	GDM Revision		
D31	Vcanserver name		
D32	Vcanserver revision		

Appendix B – MODBUS Parameters & Error Codes

The MODBUS protocol is:

- an open messaging structure developed by Modicon in 1979
- used to establish master-slave (client/server) communication between intelligent devices.
- truly open, and
- the most widely used network protocol in the industrial manufacturing environment

The MODBUS TCP/IP specification (available from www.modbus-ida.org) was developed in 1999, combining the physical network (Ethernet) with a networking standard (TCP/IP) and a vendor neutral data representation (MODBUS) giving an open, accessible network for exchange of process data.

MODBUS TCP is accessed using an Ethernet cable connected to the Ethernet port on the underside of the PCS100 ESS Graphical Display Module.

MODBUS TCP embeds a MODBUS frame into a TCP frame in a simple manner.

MODBUS TCP Supported Functions

The following MODBUS functions are supported:

- Function 3 – Read multiple registers
- Function 4 – Read input registers
- Function 8 – Diagnostic request

The MODBUS server has the following characteristics:

- Maximum registers per request =16
- Maximum TCP connections = 5
- MODBUS server port = 502

Note: For information on the GDM's network settings, see "Section 4 – System Information & Settings".

MODBUS RTU RS-485 Supported Functions

The following MODBUS functions are supported over the RS-485 port:

- Function 3 – Read multiple registers
- Function 6 – Write output registers
- Function 8 – Diagnostic request
- Function 16 – Write multiple registers
- Function 23 – Read/Write multiple registers

The MODBUS server has groups of high speed and low speed registers. The parameter addresses specify which the access speed used. The two speed modes have the following characteristics:

- MODBUS RTU
- Slow speed maximum read registers per request = 5
- Slow speed maximum write registers per request = 5
- No high speed read access
- High speed maximum write registers per request = 2
- Low speed message processing time ~50ms per frame
- High speed message processing time < 10ms

General Status and Measurements Registers

The following table lists the read-only user parameters available from the ESS.

Note: The address listed is the offset (raw) address. Each address refers to a 16 bit, register.

Offset Address	Name	Access	Type	Raw Value & Scaling
1	Product Status	ro	Enum	Detailed product status. Values and description are in section "0 below.
2	Warning Indication (same as warning relay)	ro	Enum	0 – NOT WARNING 1 – WARNING
3	Inhibit Indication. (same as inhibit switch)	ro	Enum	0 – NOT INHIBIT 1 – INHIBIT
4	Utility Voltage	ro	Signed	Voltage (line-to-line RMS volts) = raw value e.g. raw value = 480 Voltage = 480V
5	Utility Frequency	ro	Signed	$F(Hz) = \frac{Raw\_Value}{32}$ e.g. If the raw value = 1920 the frequency = 60Hz
6	Rated Current (greater accuracy at register 57)	ro	Signed	Current (RMS Amps) = raw value e.g. raw value = 500 Current = 500A
7	Sync VoltageL1-2	ro	Signed	Voltage (line-to-line RMS) $V_{LLrms} = \frac{Raw\_Value \times Sys\_base\_V}{8192}$ e.g. raw value = 8000 Sys base voltage = 480V (parameter 4) Voltage (line-to-line RMS) = 468.75V Voltage (% of rated voltage) Voltage (% of rated voltage) = (raw value * 100) / 8192 e.g. raw value = 8000 Voltage (% of rated voltage) = 97.65%
8	Sync VoltageL2-3	ro	Signed	
9	Sync Voltage L3-1	ro	Signed	
10	Output Voltage L1-2	ro	Signed	
11	Output Voltage L2-3	ro	Signed	
12	Output Voltage L3-1	ro	Signed	
13	Load Current I1	ro	Signed	Phase Current (RMS Amps) $I_{rms} = \frac{Raw\_Value \times Rated\_Current}{8192}$ e.g. raw value = 5792 rated current = 500A (parameter 6)
14	Load Current I2	ro	Signed	

Offset Address	Name	Access	Type	Raw Value & Scaling
15	Load Current I3	ro	Signed	Current = 354A Current (% of rated current) = (raw value * 100) / 8192 e.g. raw value = 5792 Current = 71%
16-18	Not use			
19	Actual Frequency	ro	Signed	Frequency (Hz) = raw value x rated frequency / 8192 e.g. raw value = 8192 rated frequency = 60Hz Frequency = 60.0Hz
20-25	Not used			
26	AC Real Power	ro	Signed	$Base\_P = Base\_Voltage \times Rated\_Current \times \sqrt{3}$ $P(kW) = \frac{Raw\_Value \times Base\_P}{8192}$
27	AC Reactive Power	ro	Signed	$Q(kVAr) = \frac{Raw\_Value \times Base\_P}{8192}$
28	AC Apparent Power	ro	Signed	$S(kVA) = \frac{Raw\_Value \times Base\_P}{8192}$
29	Active Event Code (From GDM Status Bar)	ro	Signed	For more information, see "Section 2 – Faults, Warnings and Other Events" earlier in this manual.
30	Synchronization Confirmation	ro	Enum	0 = Not Synchronised 1 = Synchronised
31	Converter Ready Confirmation	ro	Enum	0 = Not Ready 1 = Ready
32-33	Not used			
34	Availability of rated power (rate limited)	ro	Signed	$Aval\,\% = \frac{Raw\_Value \times 100\,\%}{8192}$
35	Availability of rated power	ro	Signed	$Aval\,\% = \frac{Raw\_Value \times 100\,\%}{8192}$
36	Negative reactive power limit	ro	Signed	$-Q\lim = \frac{Raw\_Value \times Base\_P}{8192}$
37	Positive reactive power limit	ro	Signed	$+Q\lim = \frac{Raw\_Value \times Base\_P}{8192}$
38	Negative real power limit	ro	Signed	$-P\lim = \frac{Raw\_Value \times Base\_P}{8192}$

Offset Address	Name	Access	Type	Raw Value & Scaling
39	Positive real power limit	ro	Signed	$+P\lim = \frac{Raw\_Value \times Base\_P}{8192}$
40	Power module base voltage	ro	Signed	Module_Base_V = raw value
41	DC bus voltage minimum inverter	ro	Signed	$V_{DC} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
42	DC bus voltage maximum inverter	ro	Signed	$V_{DC} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
43	DC bus voltage sensed by master	ro	Signed	$V_{DC} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
44	Centre DC bus voltage sensed by master	ro	Signed	$V_{DC} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
45	Offset in DC bus center voltage	ro	Signed	$V_{DC} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
46	DC bus center ripple voltage	ro	Signed	$V_{DC} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
47	System operating mode	ro	Enum	0 = Mode 0 (usually Current Source Mode) 1 = Mode 1 (usually Virtual Generator Mode)
48	Not used			
49	Warning of any module hot	ro	Enum	0 = No warning 1 = Warning active
50	Not used			
51	Availability of system to start	ro	Signed	$Aval\,\% = \frac{Raw\_Value \times 100\,\%}{8192}$

Offset Address	Name	Access	Type	Raw Value & Scaling
52	Status Register 1	ro	Enum	0000 0000 0000 0001 = Fault 0000 0000 0000 0010 = Stop 0000 0000 0000 0100 = Starting 0000 0000 0000 1000 = Run 0000 0000 0001 0000 = Stopping 0000 0000 0010 0000 = Ready 0000 0000 0100 0000 = Synchronized 0000 0000 1000 0000 = System Mode 0000 0001 0000 0000 = Equalize mode 0000 0010 0000 0000 = Overload 0000 0100 0000 0000 = Warning 0000 1000 0000 0000 = Alert 0001 0000 0000 0000 = Virtual Generator mode ready 0010 0000 0000 0000 = Rectifiers online 0100 0000 0000 0000 = Module Hot 1000 0000 0000 0000 = Availability not 100%
53	Number of command errors	ro	Signed	Number of command errors, eg writing stop and start at the same time. Counter resets on reboot.
54	Status Register 2	ro	Enum	0000 0000 0000 0001 = Inhibit 0000 0000 0000 0010 = Local mode 0000 0000 0000 0100 = Warning Master 0000 0000 0000 1000 = Local trip 0000 0000 0001 0000 = In Standby 0000 0000 0010 0000 = System Loadable 0000 0000 0100 0000 = Load Ramping 0000 0000 1000 0000 = Island V or F limit detected 0000 0001 0000 0000 = Voltage clamping active 0000 0010 0000 0000 = External island forced active 0000 0100 0000 0000 = Grid loss detected 0000 1000 0000 0000 = Gird islanded (forced or grid loss) 0001 0000 0000 0000 = Isochronous mode (Fset/Vset) 0010 0000 0000 0000 = VF droop mode (Fdroop/Udroop) 0100 0000 0000 0000 = Fixed power mode (Pset/Qset) 1000 0000 0000 0000 = Sync mode (Fsync/Usync)
55	System Current Rating (no de-rating)	ro	Signed	Total current rating of the system without any derating. $Current = Raw\_Value$

Offset Address	Name	Access	Type	Raw Value & Scaling
56	System Current with deratings (Deprecated, use register 59)	ro	Signed	$Current = \frac{Raw\_Value}{8}$
57	Rated Current (same as address 6 but with higher accuracy) (Deprecated, use register 60)	ro	Signed	$Current = \frac{Raw\_Value}{8}$
58	Master Copper Model Current Value	ro	Signed	$Heating\ Model\ \% = \frac{Raw\ value * 100}{2048}$ Indicates the equivalent heating so value is proportional to current squared. i.e. 110% current will result in 121% heating.
59	System Current with deratings	ro	Signed	$Current = \frac{Raw\_Value}{4}$
60	Rated Current (same as address 6 but with higher accuracy)	ro	Signed	$Current = \frac{Raw\_Value}{4}$
61-62	Not used.			
63	VSI or GEN frequency synced to PLL	ro	Enum	0 = Not synced 1 = Synced
64	Phase angle synced to PLL	ro	Enum	0 = Not synced 1 = Synced
65	Generator voltage synced to PLL	ro	Enum	0 = Not synced 1 = Synced

Configuration Parameters

As these parameters are stored in Non-Volatile Memory they **must only** be written to on power-up or reset of the system. Continuous writing will in time will **destroy the memory**. They are also able to be accessed from the GDM menus.

Offset Address	Name	Access	Type	Raw Value & Scaling
100	Voltage Droop Value	rw	Signed	$Droop\ (\%) = \frac{Raw\_Value \times 100\,\%}{8192}$
101	Frequency Droop Value	rw	Signed	$Droop\ (\%) = \frac{Raw\_Value \times 100\,\%}{8192}$
102	Total apparent power limit	rw	Signed	$S\lim = \frac{Raw\_Value \times Base\_P}{8192}$
103	DC Voltage setpoint for DC bus equalization	rw	Signed	$V_{DC\_eq} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
104	Positive real power limit	rw	Signed	$+P\lim = \frac{Raw\_Value \times Base\_P}{8192}$
105	Negative real power limit	rw	Signed	$-P\lim = \frac{Raw\_Value \times Base\_P}{8192}$
106	Positive reactive power limit	rw	Signed	$+Q\lim = \frac{Raw\_Value \times Base\_P}{8192}$
107	Negative reactive power limit	rw	Signed	$-Q\lim = \frac{Raw\_Value \times Base\_P}{8192}$
108	Minimum operating DC voltage (0% SOC)	rw	Signed	$V_{DC\_min} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
109	Maximum operating DC voltage (100% SOC)	rw	Signed	Slope the charge power reduces when reaching end of charge. $V_{DC\_max} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
110	End of charge slope	rw	Signed	Slope the charge power reduces when reaching end of charge. $Slope = \frac{Raw\_Value}{256}$
111	End of discharge slope	rw	Signed	Slope the discharge power reduces when reaching end of discharge. $Slope = \frac{Raw\_Value}{256}$
112	Power Max Reverse Min	rw	Signed	Lowest level to where the P_MAX can drop $Level = \frac{Raw\_Value}{8192}$
113	Power Min Reverse Max	rw	Signed	Highest level to where the P_MIN can rise. $Level = \frac{Raw\_Value}{8192}$

Offset Address	Name	Access	Type	Raw Value & Scaling
114	SOC DC-undervoltage	rw	Signed	SOC undervolt enable threshold, enables the SOC discharge slope limiting. $V_{DC} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
115	SOC DC-undervoltage reset	rw	Signed	SOC undervolt disable threshold, disables the SOC discharge slope limiting $V_{DC} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
116	SOC DC-overvoltage	rw	Signed	SOC overvolt enable threshold, enables the SOC charge slope limiting $V_{DC} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
117	SOC DC-overvoltage reset	rw	Signed	SOC overvolt disable threshold, disable the SOC charge slope limiting $V_{DC} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
118	Env Freq Mode	rw	Signed	Enable frequency envelope clamp 0- Disable 1- PQ mode only 2- Enable
119	Env Freq Max	rw	Signed	Max frequency for Pmax $Freq(Hz) = \frac{Raw\_Value\ x\ Rated\ Frequency}{8192}$ e.g. raw value = 6000 rated frequency = 60Hz Frequency = 43.94Hz
120	Env Freq Min	rw	Signed	Min frequency for Pmin $Freq(Hz) = \frac{Raw\_Value\ x\ Rated\ Frequency}{8192}$ e.g. raw value = 6000 rated frequency = 60Hz Frequency = 43.94Hz
121	Env Freq Max Slope	rw	Signed	Slope for Pmax $Slope = \frac{Raw\_Value}{256}$ e.g. raw value = 2560 slope = 10
122	Env Freq Min Slope	rw	Signed	Slope for Pmin $Slope = \frac{Raw\_Value}{256}$ e.g. raw value = 2560 slope = 10
123	Over Freq P Min	rw	Signed	Lowest level to where the Pmax can drop $Over\ Freq\ P\ Min = \frac{Raw\_Value \times Base\_P}{8192}$
124	Under Freq P Max	rw	Signed	Highest level to where the Pmin can rise $Under\ Freq\ P\ Max = \frac{Raw\_Value \times Base\_P}{8192}$

Offset Address	Name	Access	Type	Raw Value & Scaling
125	Env Volt Mode	rw	Signed	Enable voltage envelope clamp 0- Disable 1- PQ mode only 2- Enable
126	Env Volt Max	rw	Signed	Max voltage for Qmax $V_{LLrms} = \frac{Raw\_Value \times Sys\_base\_V}{8192}$ e.g. raw value = 8000 Sys base voltage = 480V (parameter 4) Voltage (line-to-line RMS) = 468.75V
127	Env Volt Min	rw	Signed	Min voltage for Qmax $V_{LLrms} = \frac{Raw\_Value \times Sys\_base\_V}{8192}$ e.g. raw value = 8000 Sys base voltage = 480V (parameter 4) Voltage (line-to-line RMS) = 468.75V
128	Env Volt Max Slope	rw	Signed	Slope for Qmax $Slope = \frac{Raw\_Value}{256}$ e.g. raw value = 2560 slope = 10
129	Env Volt Min Slope	rw	Signed	Slope for Qmin $Slope = \frac{Raw\_Value}{256}$ e.g. raw value = 2560 slope = 10
130	Over Volt Q Min	rw	Signed	Lowest level to where the Qmax can drop $Over\ Volt\ Q\ Min = \frac{Raw\_Value \times Base\_P}{8192}$
131	Under Volt Q Max	rw	Signed	Highest level to where the Qmin can rise $Over\ Volt\ Q\ Max = \frac{Raw\_Value \times Base\_P}{8192}$
132	Thermal backoff enable	rw	Signed	Enables thermal backoff which sets lower S limits when active

Control Parameters

As these parameters are stored RAM and as such are volatile. They can be written to on a continuous basis.

Offset Address	Name	Access	Type	Raw Value & Scaling
200	Stop Command	rw	enum	0 = No action 1 = Stop
201	Soft-stop Command	rw	enum	0 = No action 1 = Unload then stop
202	Reset Command	rw	enum	0 = No action 1 = Reset
203	Start Command	rw	enum	0 = No action 1 = Start
204	Real Power (P) setpoint	rw	Signed	$Base\_P = Base\_Voltage \times Rated\_Current \times \sqrt{3}$ $P(kW) = \frac{Raw\_Value \times Base\_P}{8192}$
205	Reactive Power (Q) setpoint	rw	Signed	$Q(kVAr) = \frac{Raw\_Value \times Base\_P}{8192}$
206	Voltage setpoint	rw	Signed	$V_{LLrms} = \frac{Raw\_Value \times Base\_Voltage}{8192}$
207	Frequency setpoint	rw	Signed	$F(Hz) = \frac{Raw\_Value \times Base\_Frequency}{8192}$
208	Dynamic positive real power limit	rw	Signed	$P(kW) = \frac{Raw\_Value \times Base\_P}{8192}$
209	Mode Selection. V/F or P/Q	rw	Enum	0 = Voltage and Frequency mode 1 = P and Q mode
210	Remote Sync Command	rw	Enum	0 = unsync 1 = sync
211	Droop enable	rw	Enum	0 = no droop 1 = droop enabled
212	Load enable command	rw	Enum	0 = unload 1 = load
213	External State of Charge input to PCS	rw	Signed	$SOC(\%) = \frac{Raw\_Value \times 100\%}{8192}$
214	External Battery voltage input to PCS	rw	Signed	$V_{DC} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
215	Operation mode	rw	Enum	0 = normal operation 1 = DC Bus equalization
216	Not used			
217	Test register	rw	Signed	Dummy register
218	Auto increment register	rw	Signed	Read = register automatically increments by 1 Write = sets the value of the register

Offset Address	Name	Access	Type	Raw Value & Scaling
219	Command register	rw	Enum	0000 0000 0000 0001 = Hard Stop 0000 0000 0000 0010 = Soft Stop 0000 0000 0000 0100 = Run 0000 0000 0000 1000 = Fault Reset 0000 0000 0001 0000 = Sys Mode 0 (usually Current Source Mode) 0000 0000 0010 0000 = Sys Mode 1 (usually Virtual Generator Mode) 0000 0000 0100 0000 = Equalise Mode 0000 0000 1000 0000 = Not used 0000 0001 0000 0000 = Not used 0000 0010 0000 0000 = Synchronise activate 0000 0100 0000 0000 = Synchronise deactivate 0000 1000 0000 0000 = Unload command 0001 0000 0000 0000 = Load command 0010 0000 0000 0000 = Virtual Generator Iso 0100 0000 0000 0000 = Virtual Generator Droop 1000 0000 0000 0000 = Power flow mode
220	Not used			
221	P max volatile limit	rw	Signed	$+P\lim = \frac{Raw\_Value \times Base\_P}{8192}$
222	P min volatile limit	rw	Signed	$-P\lim = \frac{Raw\_Value \times Base\_P}{8192}$
223	Q max volatile limit	rw	Signed	$+Q\lim = \frac{Raw\_Value \times Base\_P}{8192}$
224	Q min volatile limit	rw	Signed	$-Q\lim = \frac{Raw\_Value \times Base\_P}{8192}$
225	S volatile limit	rw	Signed	$S\lim = \frac{Raw\_Value \times Base\_P}{8192}$
226	Island Connect	rw	Enum	Manual reconnect command for islanding state machine.
227	Island Breaker feedback	rw	Enum	Grid tie breaker feedback input
228	Grid loss test	rw	Enum	Simulates a grid loss detection
229	External force island	rw	Enum	Force Island digital input
230	Grid monitoring enable	rw	Enum	Enable the Grid detection algorithms (Grid loss action is separate)

Setpoint Status

These are the actual active setpoint values.

Offset Address	Name	Access	Type	Raw Value & Scaling
600	Frequency setpoint	ro	Signed	$F(Hz) = \frac{Raw\_Value \times Base\_Frequency}{8192}$
601	Voltage setpoint	ro	Signed	$V_{LLrms} = \frac{Raw\_Value \times Base\_Voltage}{8192}$
602	Real power setpoint	ro	Signed	$P(kW) = \frac{Raw\_Value \times Base\_P}{8192}$
603	Reactive power setpoint	ro	Signed	$Q(kVAr) = \frac{Raw\_Value \times Base\_P}{8192}$
604	Real power limit	ro	Signed	$+P\lim = \frac{Raw\_Value \times Base\_P}{8192}$
605	DC bus value	ro	Signed	$V_{DC} = \frac{Raw\_Value \times Module\_Base\_V}{10033}$
606	DC bus mid value	ro	Signed	$V_{DC} = \frac{Raw\_Value \times Module\_base\_V}{10033}$
607	SOC	ro	Signed	$SOC(\%) = \frac{Raw\_Value \times 100\%}{8192}$
650	Load enable	ro	Enum	0 = Unload (can be used to unload when paralleled) 1 = Load Enable (converter will supply the load)
651	Remote synchronize status	ro	Enum	0 = Un-synchronise 1 = Synchronise
652	Droop Enable status	ro	Enum	0 = No Droop 1 = Droop Enabled (required for paralleling)
653	Mode Selection status Voltage & Frequency or Power Flow Control	ro	Enum	0 = Voltage and Frequency Control Mode 1 = Power Flow Control Mode
654	System mode	ro	Enum	0 = Mode selection 0 1 = Mode selection 1
655	Soft stop	ro	Enum	0 = Not soft stopping 1 = Soft stopping
656	System able to start	ro	Enum	0 = Output inverters not able to start yet 1 = Output inverters able to start.

CAN IO Board Status

These are the CAN IO Board analog and digital values.

Offset Address	Name	Access	Type	Raw Value & Scaling
700	Digital input 1	ro	Enum	0 = Inactive 1 = Active
701	Digital input 2	ro	Enum	0 = Inactive 1 = Active
702	Digital input 3	ro	Enum	0 = Inactive 1 = Active
703	Digital input 4	ro	Enum	0 = Inactive 1 = Active
704	Digital input 5	ro	Enum	0 = Inactive 1 = Active
705	Digital input 6	ro	Enum	0 = Inactive 1 = Active
706	Digital input 7	ro	Enum	0 = Inactive 1 = Active
707	PTC input	ro	Enum	0 = Inactive 1 = Active
708	Analog input 1	ro	Signed	$Ain1(\%) = \frac{Raw\_Value \times 100\%}{8192}$
709	Analog input 2	ro	Signed	$Ain2(\%) = \frac{Raw\_Value \times 100\%}{8192}$
710	Analog output 1	ro	Signed	$Aout1(\%) = \frac{Raw\_Value \times 100\%}{8192}$
711	Analog output 2	ro	Signed	$Aout2(\%) = \frac{Raw\_Value \times 100\%}{8192}$
712	Digital output 1	ro	Enum	0 = Inactive 1 = Active
713	Digital output 2	ro	Enum	0 = Inactive 1 = Active
714	Digital output 3	ro	Enum	0 = Inactive 1 = Active
715	Digital output 4	ro	Enum	0 = Inactive 1 = Active
750	Auto Value for Analog output 1	ro	Signed	$Aout1(\%) = \frac{Raw\_Value \times 100\%}{8192}$

Offset Address	Name	Access	Type	Raw Value & Scaling
751	Auto value for Analog output 2	ro	Signed	$Aout\ 2(\%) = \frac{Raw\_Value \times 100\,\%}{8192}$
752	Auto value for Digital outputs	ro	Enum	0000 0000 0000 0001 = Relay 1 set 0000 0000 0000 0010 = Relay 2 set 0000 0000 0000 0100 = Relay 3 set 0000 0000 0000 1000 = Relay 4 set

Power Module Internal Temperatures

These are the actual temperatures.

Offset Address	Name	Access	Type	Raw Value & Scaling
800	Heatsink temp Module 1	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
801	Heatsink temp Module 2	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
802	Heatsink temp Module 3	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
803	Heatsink temp Module 4	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
804	Heatsink temp Module 5	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
805	Heatsink temp Module 6	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
806	Heatsink temp Module 7	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
807	Heatsink temp Module 8	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
808	Heatsink temp Module 9	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
809	Heatsink temp Module 10	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
810	Heatsink temp Module 11	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
811	Heatsink temp Module 12	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
812	Heatsink temp Module 13	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
813	Heatsink temp Module 14	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
814	Heatsink temp Module 15	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
815	Heatsink temp Module 16	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$

Offset Address	Name	Access	Type	Raw Value & Scaling
816	Heatsink temp Module 17	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
817	Heatsink temp Module 18	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
818	Heatsink temp Module 19	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
819	Heatsink temp Module 20	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
820	Heatsink temp Module 21	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
821	Heatsink temp Module 22	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
822	Heatsink temp Module 23	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
823	Heatsink temp Module 24	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
824	Heatsink temp Module 25	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
825	Heatsink temp Module 26	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
826	Heatsink temp Module 27	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
827	Heatsink temp Module 28	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
828	Heatsink temp Module 29	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
829	Heatsink temp Module 30	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
830	Heatsink temp Module 31	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$
831	Heatsink temp Module 32	ro	Signed	$Temp\ (^{o}C) = \frac{Raw\_value}{32}$

Rack Module Internal Temperatures

These are the actual temperatures.

Offset Address	Name	Access	Type	Raw Value & Scaling
900	Average heatsink temp group 1	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
901	Minimum heatsink temp group 1	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
902	Maximum heatsink temp group 1	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
903	Average enclosure temp group 1	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
904	Minimum enclosure temp group 1	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
905	Maximum enclosure temp group 1	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
906	Average heatsink temp group 2	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
907	Minimum heatsink temp group 2	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
908	Maximum heatsink temp group 2	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
909	Average enclosure temp group 2	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
910	Minimum enclosure temp group 2	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
911	Maximum enclosure temp group 2	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
920	Maximum heatsink temp	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
921	Maximum enclosure temp	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
922	Minimum heatsink temp	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$
923	Minimum enclosure temp	ro	Signed	$Temp\,(^oC) = \frac{Raw\_value}{32}$

Frequency and Voltage Envelopes' Parameters

Group to allow the envelopes' slopes and references to be wrote simultaneously.

Offset Address	Name	Access	Type	Raw Value & Scaling
1100	Env Freq Max	rw	Signed	Refer to 119 register
1101	Env Freq Max Slope	rw	Signed	Refer to 121 register
1102	Gen P set	rw	Signed	Refer to 204 register
1103	Env Freq Min Slope	rw	Signed	Refer to 122 register
1104	Env Freq Min	rw	Signed	Refer to 120 register
1200	Env Volt Max	rw	Signed	Refer to 126 register
1201	Env Volt Max Slope	rw	Signed	Refer to 128 register
1202	Gen Q set	rw	Signed	Refer to 205 register
1203	Env Volt Min Slope	rw	Signed	Refer to 129 register
1204	Env Volt Min	rw	Signed	Refer to 127 register

Grouped Parameters

Register mirrors grouped together to make efficient use of only being able to read up to 5 registers at a time.

5000	Rated Current adjusted with the system derating	ro		Mirror of address 6
5001	Base voltage modules	ro		Mirror of address 40
5002	Rated Voltage	ro		Mirror of address 4
5003	Base Frequency	ro		Mirror of address 5
5004	System current with any derating	ro		Mirror of address 56
5005	Output Voltage L1-2 RMS	ro		Mirror of address 10
5006	Output Voltage L2-3 RMS	ro		Mirror of address 11
5007	Output Voltage L3-1 RMS	ro		Mirror of address 12
5008	Load Current phase 1 RMS	ro		Mirror of address 13
5009	Load Current phase 2 RMS	ro		Mirror of address 14
5010	Load Current phase 3 RMS	ro		Mirror of address 15
5011	Measured frequency	ro		Mirror of address 19
5012	Measured real power	ro		Mirror of address 26
5013	Measured reactive power	ro		Mirror of address 27
5014	Measured apparent power	ro		Mirror of address 28
5015	Availability while mains good	ro		Mirror of address 51
5016	Status word 0	ro		Mirror of address 52
5017	Status word 1	ro		Mirror of address 54
5018	Currently active event code	ro		Mirror of address 29
5019	Incrementing register	rw		Mirror of address 218
5500	P setpoint	rw		Mirror of address 204
5501	Q setpoint	rw		Mirror of address 205
5502	Remote command word	rw		Mirror of address 219

Modbus Error Codes

One of the following codes may be returned by the MODBUS server following an error.

Code	Name	Description
1	Illegal Function	Function code received in the query is not supported by this MODBUS server or the query is badly formatted.
2	Illegal Data Address	The data address received in the query is not a valid address in the MODBUS server. Specifically the combination of address and number of registers is not valid. Register not known by the ESS Register is not in MODBUS config table Not all registers of a single parameter accessed Register / length mismatch
3	Illegal Data Value	The value received in the query is not an allowable value for this register or the implied length is invalid. Value out of range for parameter Number of registers requested exceeds max.
4	Slave Device Failure	An unrecoverable error occurred while server attempted to perform requested action. Read/Write access violation GDM hardware issues Insufficient access privileges
6	Slave device Busy	The MODBUS server is unable to process this command at present. Retry this command again later. GDM VCAN server busy or unavailable

Detailed Product Status Codes

These are the status codes for MODBUS register offset 1.

Value	Display Name	Description
0	INIT	System is booting up/initializing
1	FAULT	System has tripped out.
2	CLEAR	Clearing tripped system
3	STOP	Stopped
4	STARTING	Wait till voltage OK, wait rectifier input modules
5	RUN	System running
6	STOPPING	Ramp down system
151	GEN_OFF	Stop
152	GEN_RAMP_OFF	Ramp down
153	GEN_RAMPUP_EXT	Ramp up
154	GEN_OFF_SYNC_WAIT	Wait sync good, no output
155	GEN_OFF_SYNC_RAMP	Syncing voltage/freq, no output
156	GEN_OFF_SYNC_PHASE	Syncing phase no output
158	GEN_OFF_SYNC	Synchronized, no output
159	GEN_OFF_SYNC_TO_EXT	Generator mode, output enabled
160	GEN_EXT_SYNC_WAIT	Wait sync good
161	GEN_EXT_SYNC_RAMP	Syncing voltage/freq
162	GEN_EXT_SYNC_PHASE	Syncing phase correction
163	GEN_EXT_SYNC	Synchronized
164	GEN_EXT_SYNC_TO_EXT	Enable generator mode
165	GEN_EXTERN	Generator mode
166	GEN_EXT_SYNC_LOST	Bus out of spec, go to sync wait off state
167	GEN_STANDBY_UNLOAD	Standby unload
168	GEN_STANDBY	Standby
169	GEN_SYNC_RAMP	Synchronized, ramping up
170	ISLAND_RUN_ISLANDED	Running Islanded
171	ISLAND_RECONNECT	Reconnect
172	ISLAND_STANDBY_ISLANDED	Standby islanded
173	ISLAND_START_COUPLED	Starting on Grid
174	ISLAND_START_DECOUPLED	Black start
175	ISLAND_GEN_CONNECT	Generator connect

Appendix C – Open Source Software

This product incorporates software from open source communities. For more information refer to the document 2UCD200000E041 PCS100 Open Source Software Information

Appendix D – Wiring Information

Maximum CAN Bus Length

The official maximum CAN bus length is 25 meters.

> Note: Due to the effect of noise in different configurations, all tested systems shipped from ABB are checked to ensure the cable length is adequate.

Analog AR1 and AR2 Inputs

For high speed (under 1 ms) set-points the AR1 and AR2 inputs on the Control Module can be used. There are, however, some implications of using these ports.

The ports are 9-pin DIN connectors with two analog inputs per connector, which allows selection of analog input AR1-1, AR1-2, AR2-1 and AR2-2.

Wiring

The analog inputs are unipolar and have a voltage range between **0 and +2.5V.**

> Note: Exceeding these voltages may cause damage to the Control Module.

The 9-pin DIN pin-out is:

Pin 1	ARx-1 positive.
Pin 2	ARx-1 negative (should be connected to ground).
Pin 3	ARx-2 positive.
Pin 4	ARx-2 negative (should be connected to ground).
Pins 5 to 7	Control module analog ground.
Pin 8	+15V. To be used as a reference only.
Pin 9	-15V. To be used as a reference only.

It is heavily recommended to provide differential RC filtering on the analog inputs. A recommended filter is to have a 1k-ohm resistor in line with both the positive and negative inputs, with a 10pF capacitor across the ARx input pins.
A current-source input can be achieved by placing an additional burden resistor before in the input RC filter. Use a 125-ohm resistor to achieve a 4-20mA operation.

Input Resolution

The analog inputs have a useful analog resolution of 10-bits. If a differential set-point over a ±200% range is re-quired, the achievable 0 to 100% range resolution will only be 8-bit.

Failure Modes

The failure modes of using the ARx inputs must be considered. Although the DIN plugs have screw-locking posts, if the connector is disconnected the reference voltage will drop to 0V. If differential scaling is used this would likely correspond to a full-negative reference, which may produce undesirable results. Checks should be put in place to detect the occurrence of this happening.

Appendix E - Torque settings and Bolt order

Following table shows torque settings recommended for the power connections.

Tightening Torque for Standard Bolts and Nuts

Diameter (mm)	Pitch (mm)	Torque Nm (lbf ft) Use only high tensile bolts
M5	0.8	4.5 (3.6)
M6	1.0	7.2 (5.3)
M8	1.0	16 (11.8)
M10	1.25	28 (20.7)
M12	1.25	45 (33.2)

Table 12-1: Tightening torques

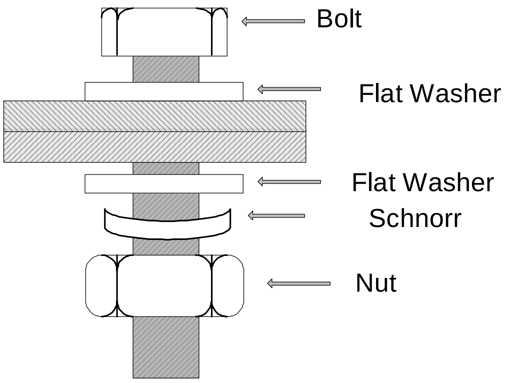


Table 12-2: Bolt order

Appendix F – Installation requirements

Floor Requirements

- All enclosures must be installed on a horizontal fireproof surface.
- Do not exceed ± 0.2° change in slope between adjacent enclosures
- Do not exceed ± 5 mm in elevation between adjacent enclosures.

Note: Additional precaution should be taken for PCS100 system weight.

Location

- The PCS100 is designed for location in a restricted access location only.
- The PCS100 is designed for connection by fixed wiring.
- PCS100 system location should be clean electrical room with controlled environment temperature and humidity according the requirements under 3.5 Environmental

Dedicated Transformer

A dedicated (“coupling”) transformer is used to connect the PCS100 power electronics to the grid. The transformer isolates the DC power system and PWM switching noise from the mains supply. There are some particular requirements of the transformer that are necessary for the ESS to meet claimed emc performance – refer to 2UCD190000E006_E PCS100 ESS Transformer Requirements for more detailed information.

Appendix G – General Disclaimer

The manufacturer shall have no obligation with respect to any product which (i) has been improperly repaired or altered; (ii) has been subjected to misuse, negligence or accident; (iii) has been used in a manner contrary to the manufacturer’s instructions; (iv) has failed as a result of ordinary wear and tear, or (v) has not been serviced and maintained as per the manufacturers maintenance schedule and associated procedures.

Appendix H – Waste Electrical and Electronic Equipment Information (WEEE)

The crossed-out wheeled bin symbol on the product(s) and / or accompanying documents means that used electrical and electronic equipment (WEEE) should not be mixed with general household waste.
If you wish to discard electrical and electronic equipment (EEE), please contact your dealer or supplier for further information.
Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

Appendix I – Glossary

Term	Description
CB	Circuit Breaker
CGI	Common Gateway Interface. CGI software is used when passing data between the Vcan serial communications bus and the remote web pages.
CSI	Current Source Inverter
CT	Current Transformer
DSPE	Digital signal processing engine. Control processor board. Fits on top of the MSIB and VSIB
GDM	Graphic Display Module. The main HMI (Human Machine Interface) for the PCS100 products
GDMIB	Graphics Display Module Interface Board. A small circuit board inside the GDM. It's main function is an interface between Vcan and the GDM.
MSIB	Master Stack Interface Board (located in the master module)
NC	Normally closed (Relay)
NO	Normally open (Relay)
PCS100	A generic range of ABB power converter products.
PTC	Positive Temperature Coefficient temperature sensor.
SCM	System Configuration Module. A small circuit board located inside the master module. When the PCS100 product powers up the SCM checks the SW revisions and the hardware configuration (i.e. the number of inverter and rectifier modules).
Vcan	The name of the high speed serial communications bus protocol used by the different modules in the PCS100 products to communicate to each other. These modules are the Master Module, Inverter Module, Rectifier Module, SCM and GDM.
Vcanserver	The name of the driver software for the Vcan bus
VSI	Voltage Source Inverter
VSIB	Slave Stack Interface Board (located in a inverter module)
VT	Voltage Transformer or potential transformers (PT) for metering and protection in high/medium-voltage circuits

Table 12-3: Glossary

13 List of Related Documentation

Document Number	Document Name
2UCD190000E006	PCS100 ESS Transformer Requirements
2UCD190000E013	PCS100 ESS Overload Curves
2UCD190000E018	PCS100 ESS Product Release Document
2UCD200000E430	PCS100 SCM Diagnostics
2UCD000420E003	Auxiliary Power Supplies for PCS100 Rack Systems AN

Contact us

To find the contact person for your region please refer top our webpage:

www.abb.com/pcs100-power-converters

Note

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