

Stabiliti™ – Modbus Guide



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1. About This Document

This document is CE+T America proprietary. It is a customer facing document aimed to serve as an operational guide for Stabiliti converter's modbus communication.

Document Revision History:

Date	Revision	Notes
Oct 14 th , 2021	A	Initial draft
Nov 14 th , 2021	B	Adding more graphics to clarify concepts
April 22 nd , 2022	C	Updates on modbus map instructions
May 25, 2022	D	Updates on port methods

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2. Glossary of Terms

Acronym of Term	Full Expression
AWG	American wire gauge
CEC	California Energy Commission
GFDI	Ground fault detection current
IMI	Isolation monitor interrupter
BESS	Battery energy storage system, specifically e-ON's. Based on context in the manual, BESS may refer to complete system including eON batteries and PCS.
PCS	Power conversion system, specially Stabiliti 30C3
PV	Photovoltaic
LCD	Liquid Crystal Display
RSS	Rapid shutdown system
RSE	Rapid shutdown equipment
BoS	Balance of system components
BAMS	Battery array management system
MBMS	Master battery management system
CAN	Communication protocol
Modbus	Communication protocol
SoC	State of charge of batteries, specified in percentage.
UPS	Uninterrupted power supply
HMI	Human machine interface, touch screen or web interface
PPE	Personal Protective Equipment
CCS	Customer Control System
EMS	Energy Management System
PMS	Power Management System

3. Important Safety Instructions

The following safety symbols are used in this manual:



Danger – Procedure or situations that require action to prevent personal injury/death or damage to equipment/environment.



Warning – Indicates a potentially hazardous situation that, if not avoided, can result in serious injury or death.



Important Information: Includes key information for the operation of this equipment or specific instructions to maintain the warranty.



Personal Protective Equipment: This symbol means that use of personal protective equipment is highly recommended. This includes insulated gloves, steel toed boots, hard hat, reflective fire-resistant vests, and protective eye goggles.

Note that the equipment must be handled, installed, and operated by qualified engineer/technician with proper training on handling high/medium voltage electrical equipment. Local and national electrical code must be used during installation and operations. Failure to observe safety standards could result in personal injury or damage to equipment/environment.



Danger - This product includes Ground Fault Protection for both grounded and ungrounded operation of PV systems. All instructions regarding the configuration of this device must be followed. Failure to follow may result in injury, death, or damage to equipment. All GFDI related information will be marked with the symbol below:



Danger - To avoid an electric shock, verify that the Converter's external AC and DC Disconnects are open (off). A minimum wait time of five (5) minutes is required after opening AC and DC Disconnects to assure that the Converter's internal capacitors have discharged to zero voltage before performing any work on the Converter. Utilize lockout procedures to ensure that both AC and DC Disconnects remain in the off position during all service periods.



Warning - This photovoltaic rapid shutdown equipment (RSE) does not perform all the functions of a rapid shutdown system (RSS). This RSE must be installed with other equipment to form a complete RSS that meets the requirements of NEC (NFPA 70) section 690.12 for controlled conductors outside the array. Other equipment installed in or on this PV system may adversely affect the operation of the PVRSS. It is the responsibility of the installer to ensure that the completed PV system meets the rapid shut down functional requirements. This equipment must be installed according to the manufacturer's installation instructions.



Danger – The enclosure contains exposed high voltage conductors. The enclosure front access door must remain closed, except during installation, commissioning, or maintenance by trained service personnel. Do not remove the front doors if extreme moisture is present (rain, snow, or heavy dew).



Danger – To avoid an electric shock, verify that the Converter’s external AC and DC Disconnects are open (off). A minimum wait time of five (5) minutes is required after opening AC and DC Disconnects to assure that the Converter’s internal capacitors have discharged to zero voltage before performing any work on the Converter. Utilize lockout procedures to ensure that both AC and DC Disconnects remain in the off position during all service periods.



Warning – These instructions DO NOT contain any information on the operation of battery systems outside of this product. Refer the manufacturer for the battery system for installation and servicing instructions.



Danger – Ensure that the equipment is adequately installed and grounded per this manual and all applicable codes.



Danger – Do not leave foreign objects in the Converter enclosure. Keep the area around the enclosure clear of trash, debris, and other combustible materials.



Warning – Personnel Qualification: Inspections and operations requiring access to lethal AC or DC voltages, should only be performed by qualified personnel.



Warning – All field wiring must conform to the codes set forth in the National Electric Code ANSI/NFPA 70.



Warning – Electrostatic Discharge (ESD) Damage: The Converter contains ESD-sensitive equipment. Failure to use ESD control measures while servicing the equipment may result in component damage and void the warranty.



Warning – Service and maintain the Converter in accordance with applicable CE+T Power procedures. Discontinue Converter use until all equipment defects and safety hazard have been cured. Replace damaged warning and precautionary labels.



Warning – The 30C3 and 30C Converters weigh approximately 135 pounds. They are designed to be transported and wall-mounted by two people, without the use of lift or power equipment. If lift or power equipment is used to move, or lift the Converter, follow all safety rules. Failure to do so could result in personal injury or equipment damage.



Warning – An unpacked Converter should be stored on its back, prior to vertical mounting installation.



Warning – After a prolonged use of system, note that even after disconnecting AC/DC cables, high voltage can persist on terminals. Always allow long enough wait time before proceeding to touch exposed metal parts/connectors of BESS, PCS or BoS components.



Refer to “Reference Documents” section of this manual for details on manuals/documents that should be read first before proceeding.

4. Overview

This document serves as a quick start guide to Stabiliti 's modbus communication interface. Stabiliti supports both Modbus RTU (serial) and Modbus TCP (ethernet). This document will go over details of the communications. This document will also cover basic understanding of different Stabiliti port methods.

5. Reference Document

5.1. MAN - 00115 – Stabiliti Series 30 KW – Installation and Operation Manual – V1.0

5.2. MAN - 00114 – Stabiliti Series 30 KW – Quick Start Guide – V1.0

Also refer to PCS' modbus map for details. All safety precautions mentioned in the above two manuals must be followed before proceeding

6. Stabiliti Modbus Specification

Stabiliti supports Modbus RTU (serial) and Modbus TCP interface for communication with higher level monitoring/control system like an EMS or PMS (also known as site controller). There are some limits and communication design details that must be considered. The specs are shown below:

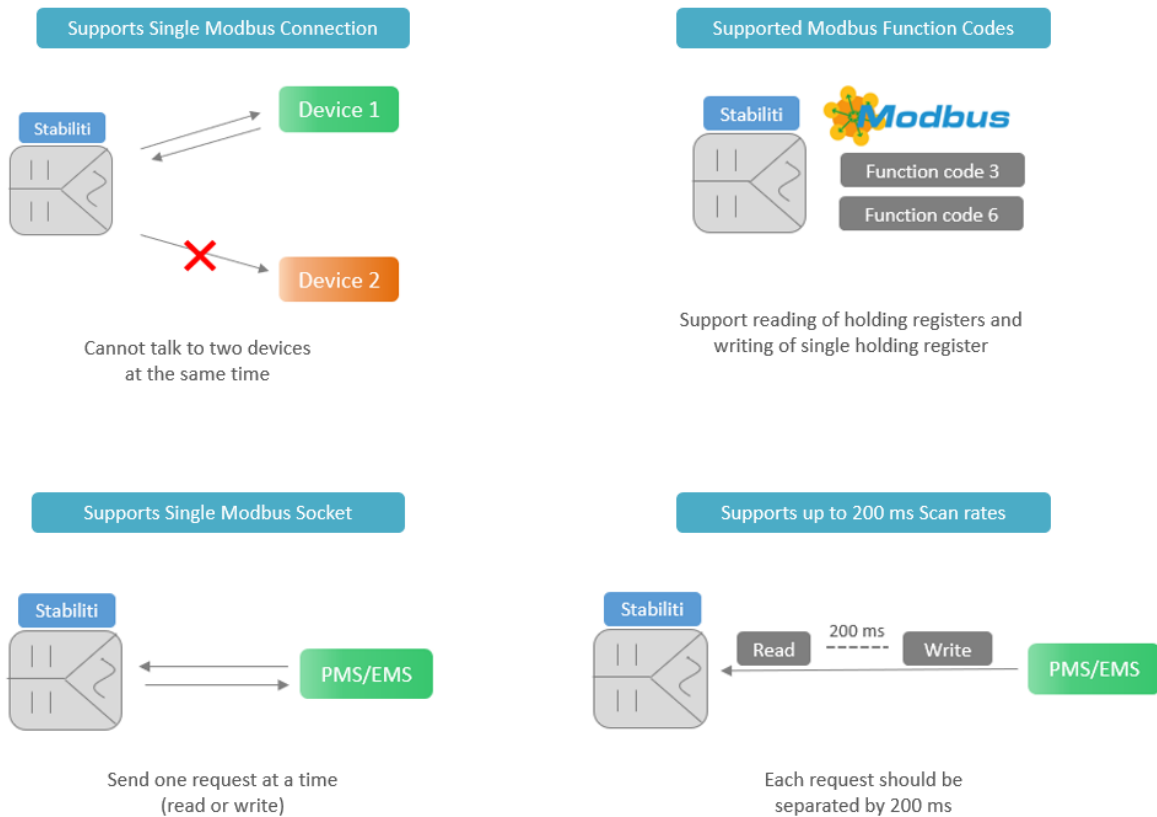


Figure 1 - Stabiliti Modbus Spec

7. Connecting to a Stabiliti

Once Stabiliti is powered up (using either 480 vac or a dedicated 24 Vdc applied to “Aux 24” and “Gnd”), the Stabiliti display will show its current IP address and modbus ID. Set your PC or controller’s IP address to be within the same network and you should be able to connect. “240” is default modbus ID.

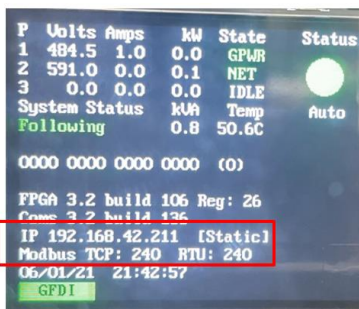


Figure 2 - Stabiliti Display

8. Stabiliti Monitoring Via Modbus

Stabiliti report a lot of data relevant to its operation but not all of it is needed for monitoring done by a higher-level controller/monitor. Shown below are four different register groups that provide various information about the Stabiliti operations and configuration. Register block starting at address 834 is more than sufficient for majority monitoring applications. Some control systems also prefer reading current setpoints and configurable parameters and those are grouped into “Intermediate Monitoring parameters as shown below. And then there are advanced parameters as well.

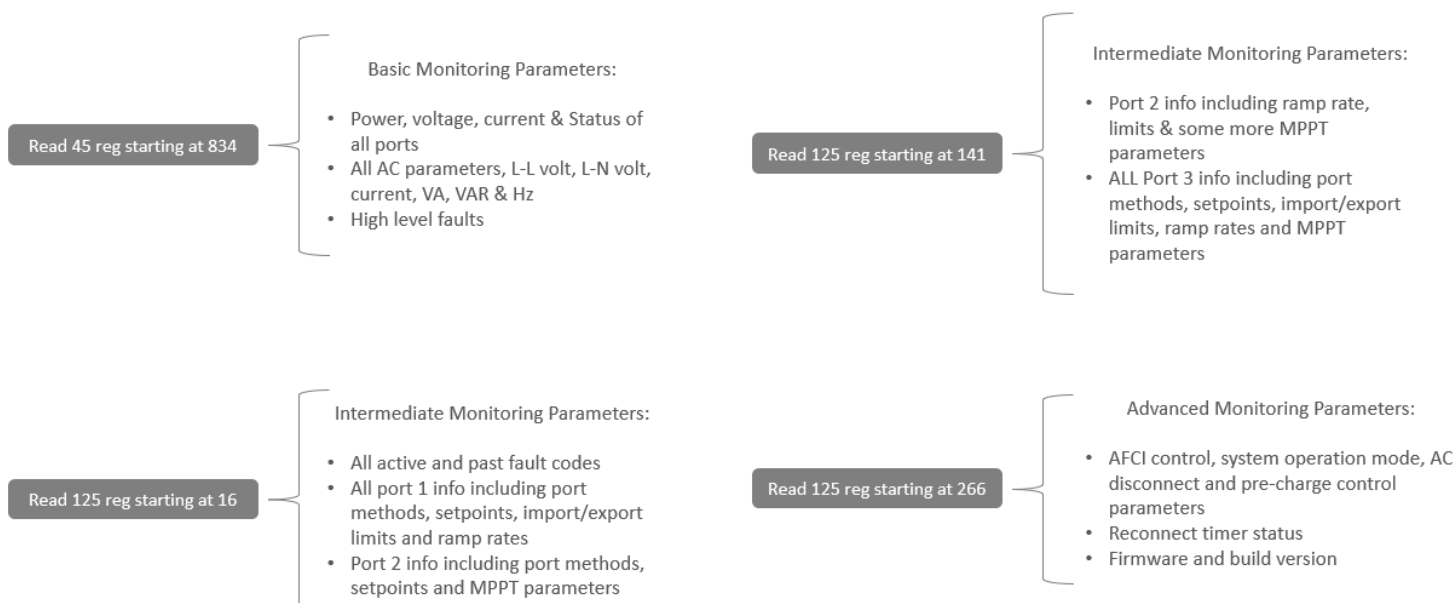


Figure 3 - Stabiliti - Monitoring Parameters

9. Stabiliti Control Via Modbus

Stabiliti can operate in various modes: PV inverter, voltage source, current source, constant power mode, DC bus, Microgrid etc. So, it must be configured properly to achieve the desired functionality. The first set of parameters is port methods. This sets the main behavior of the power converter. These parameters are set once at the beginning and usually not changed during normal operation. However, some advanced control systems might prefer to change port methods dynamically to optimize overall system performance.

Next comes setpoints. Based on selected port methods, Stabiliti looks for either power, or voltage or current setpoints. Apart from voltage setpoint, power and current setpoints will be changed dynamically by a higher-level control system to achieve desired system level functionality.

Next comes limits. On top of power setpoints, additional limits can be imposed to limit power output. For instance, an AC port with a power setpoint of 20 kw but an export limit of 10 kw will only export 10 kw. At this point, if setpoint drops to 5 kw while keeping limit to 10 kw, the output will drop to 5 kw.

Shown in the Figure below are all details:

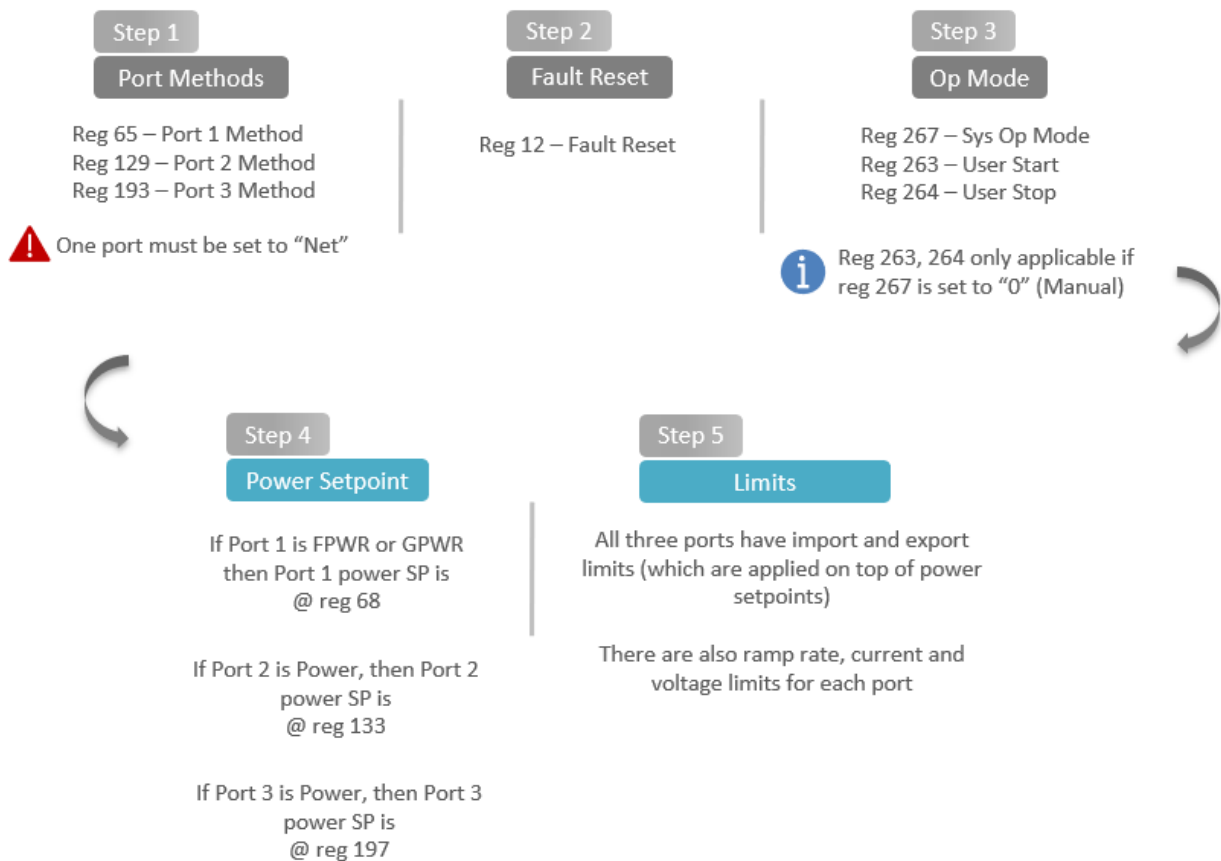


Figure 4 - Stabiliti - Control Parameters

System Op Mode:

Stabiliti Op mode or “sys Op mode” defines how Stabiliti starts. If set in Auto mode (register 267, value of 1) then as long as no faults are present, Stabiliti will start on its own and wait for user to send a setpoint (if configured to wait to receive a setpoint). If set in Manual mode (register 267, value of 0) then Stabiliti waits for control system to send a “user start” command (register 263, value of 1) to start up. Note that Stabiliti will only start if there are no active faults. Control system can also send a “user stop” command (register 264, value of 1) to stop Stabiliti from running. This is helpful to reduce auxiliary load losses that Stabiliti incur while its running. In Auto mode, Stabiliti keeps running as long as there are no faults.

Fault Reset:

When Faults are present, they can be cleared by sending a “1” to Fault reset register (register 12).

Watchdog:

Stabiliti also has a watchdog (register 40). By default, its disabled (register 40, value of 0). If a control system writes a positive value, Stabiliti will start counting down from that value every second. For instance, if a value of 60 is written, Stabiliti will countdown from 60 all the way to “-1”. If a new value is not received by then, Stabiliti will shut down and throw a “Watchdog fault” (register 18 or register 26, value of 1024). This is helpful when it is desired to have Stabiliti shutdown on loss of communication with a higher-level controller.

Sign Convention:

Note that any power going into Stabiliti is negative and any power coming out is positive. So, if batteries are being charged from AC, AC port power will be reported as negative and DC port will be positive. Setpoints follow the same convention as well.

10. Stabiliti Faults

Stabiliti reports both “Active” and “Occurred” faults. Active faults are faults which are currently being active. Occurred faults are faults which occurred in the past and may or may not be present currently.

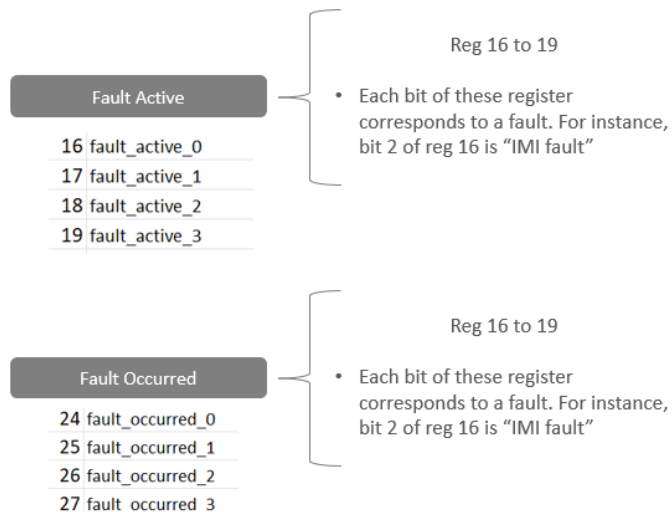
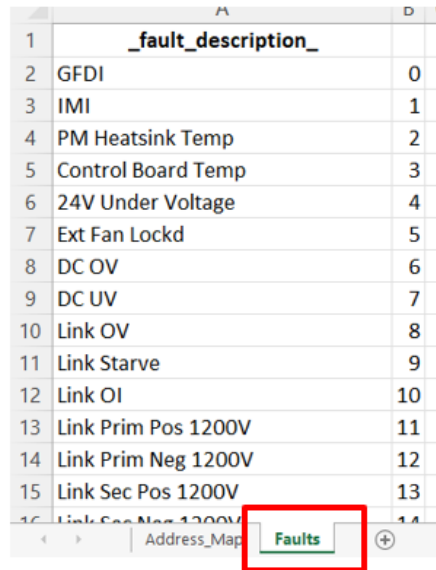


Figure 5 - Stabiliti - Fault Registers

The faults description can be found within “faults” sheet of stabiliti:



	A	D
1	_fault_description_	
2	GFDI	0
3	IMI	1
4	PM Heatsink Temp	2
5	Control Board Temp	3
6	24V Under Voltage	4
7	Ext Fan Lockd	5
8	DC OV	6
9	DC UV	7
10	Link OV	8
11	Link Starve	9
12	Link OI	10
13	Link Prim Pos 1200V	11
14	Link Prim Neg 1200V	12
15	Link Sec Pos 1200V	13
16	Link Sec Neg 1200V	14

Figure 6 - Stabiliti - Fault Sheet

11. Stabiliti Faults Decoder

The fault sheet within the modbus map file contains an inbuilt fault decoder. All you need to do is enter the decimal value captured over modbus on register 16 to 19 or register 24 to 27 in the correct field. For instance, if you read a value of 256 in “fault_active_1” (which is register 17) then enter it in fault decoder and it will display current active fault.

1	_fault_description_		Status	Fault 0	Fault 1	Fault 2	Fault 3
2	GFDI	0	FALSE	0	256	0	0
24	Link State Timeout	22	FALSE				
25	Bad Link Start	23	FALSE				
26	Bad Control Method	24	TRUE				
27	AC1 Island Detected	25	FALSE				

Figure 7 - Stabiliti - Fault Decoder Sheet

12. Commonly Occurring Faults

12.1. Bad Control Method Fault

There are few faults customers can resolve/troubleshoot on their own. One of such faults is “Bad Control Method”. This fault goes active if either none of the port is set to “Net” or more than one port is set to “Net” or more than one port is set to “Idle”. It’s very common for this fault to appear right after sending port configuration to the Stabiliti. Set the port methods right and issue a “Reset” command (register 12, send a value of 1).

12.2. DC UV Fault

DC UV or DC under voltage fault goes active if either DC2 or DC3 voltage is below specified Vmin voltage. For DC2, Vmin setpoint is at register 142 and for DC3 Vmin is at 206. If PV is connected to DC3 then make sure to set Vmin to “0” or “-10”. This way, at night, when PV goes down, it will not force Stabiliti to throw fault and shutdown. If the battery is connected to DC2 then make sure to set Vmin to minimum voltage batteries can sustain. That way if batteries drop below that voltage, Stabiliti will shut down and prevent “over discharge” condition on the battery.

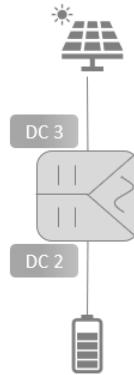


Figure 8 - Stabiliti DC UV Faults

12.3. DC OV Fault

DC OV or DC over voltage fault goes active if voltage on either DC2 or DC3 goes above Vmax value. For DC2, Vmax setpoint is at register 141 and for DC3 Vmax is at 205. It's common if Vmax is not set correctly as per batteries max voltage rating. Make sure Vmax is set correctly to prevent batteries from “over charge” conditions.

12.4. E-Stop Fault

Stabiliti is shipped with an “E-stop” jumper in place to prevent unintended operation. Before operation, this jumper must be removed as Stabiliti will keep throwing this fault and prevent Stabiliti from Starting up.

13. Stabiliti Port Methods

Stabiliti is a highly configurable power converter which allows the user to define different behavior using various “port methods”. For each port, there is a method that can be defined. “Idle” and “Net” are two methods shared among all ports.



At any time, no more than one port can be set as idle or net. One port MUST be set as net. AC port must not be idle, this has not been tested yet.

13.1. AC1 Port Methods

AC port can be set as “idle”, “Net”, “GPWR” or “FPWR”. Set it to “GPWR” when the project does NOT require grid form or microgrid. Set it to “FPWR” when the project requires grid form or microgrid. Here is more description on this:

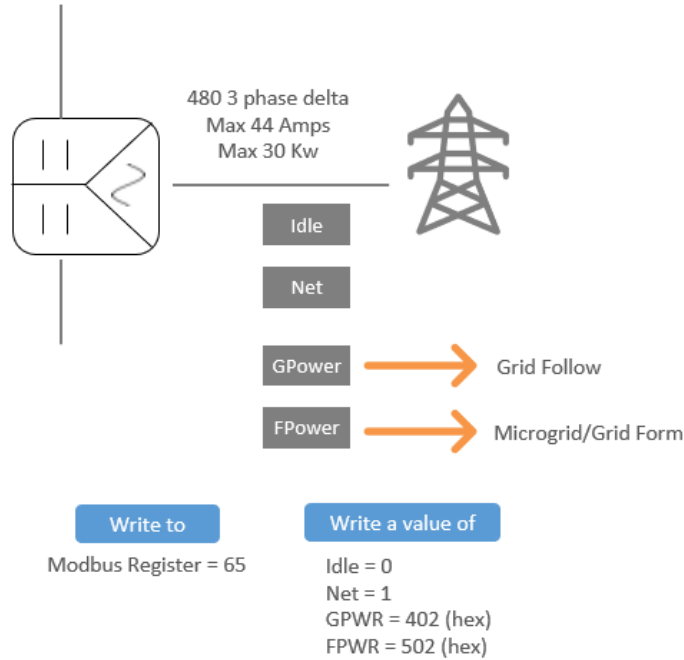


Figure 9 - AC Port Methods

While in “GPWR” or “FPWR”, user can define a power setpoint (modbus register 68) and Stabiliti will try to obey the setpoint if there is available capacity on DC2 or DC3 (or both). Note that in FPWR mode, if Stabiliti is being commanded to form microgrid then power flow is dictated by connected AC loads and available capacity, not by the AC setpoint.

		Modbus Register for AC
Control Method		65
Maintain constant output power based on power setpoint. →	FPWR	Power Setpoint 68
	GPWR	
For completely off grid sites where SEL relay is not required, setting this bit to 0 will force Stabiliti to form microgrid without waiting for SEL commands →	Off grid microgrid control bit	Reg 95, bit 0
When Stabiliti is actively forming microgrid, this bit will be high →	Microgrid Form Status bit	Reg 848, bit 12
These limits takes priority over all other setpoints →	Import Limit	93
	Export Limit	89

Figure 10 - AC Port - Control Description

13.2. DC2 or DC3 Port Methods

DC ports can be set as “idle”, “Net”, “MPPT”, “PWR”, “Current”, “Volts” or “DC Bus”. Depending on what is connected on the DC port, that dictates the port method that must be set to achieve desired functionality. For instance, for managing the batteries, DC port must be set to either “net”, “PWR” or “current”. In this mode, Stabiliti does not maintain a specific voltage all the time but simply follows power or current setpoint (based on selected method). Here is more description on this:

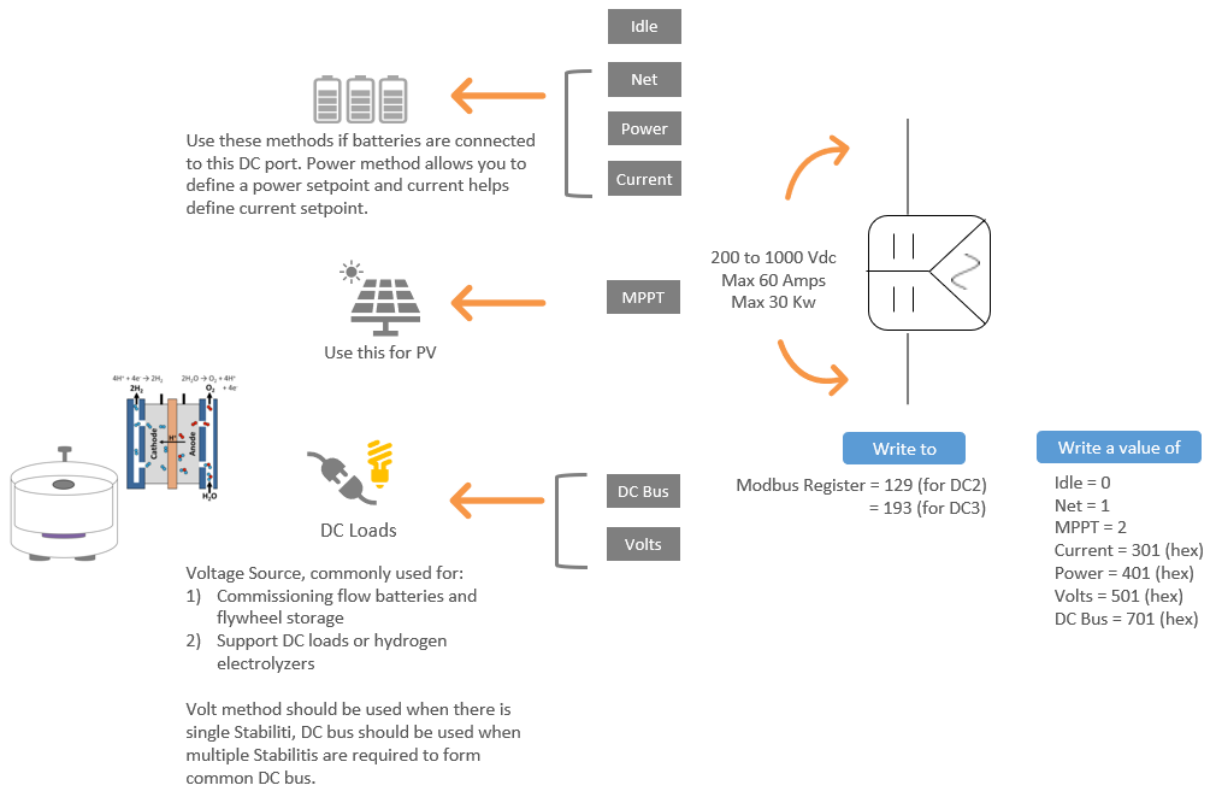


Figure 11 - DC Port Methods

DC port method also defines the setpoint Stabiliti will follow. For instance, while in “Power” method, Stabiliti will follow a power setpoint (modbus register 133 for DC2, 197 for DC3). Similarly, while in “current” method Stabiliti will follow “current” setpoint (modbus register 132 for DC2, 196 for DC3). While in “DC Bus” or “Volts” method, Stabiliti will follow a voltage setpoint (modbus register 134 for DC2, 198 for DC3) and a voltage offset (modbus register 146 for DC2, 210 for DC3). It will ignore the power and current setpoint. MPPT mode does not have a setpoint associated with it but there are several MPPT related parameters. Refer to Stabiliti’s modbus map for details.

		Modbus Register for DC2	Modbus Register for DC3	
		Control Method	129	193
Maintain constant output power based on power setpoint.	← Power	Power Setpoint	133	197
Maintain constant output current based on current setpoint.	← Current	Current Setpoint	132	196
Maintain output voltage based on voltage setpoint and voltage offset	← DC Bus Volts	Voltage Setpoint	134	198
		Voltage Offset	146	210
These limits takes priority over all other setpoints	←	Import Limit	152	216
		Export Limit	153	217

Figure 12 - DC Port Control Description

13.3. “Net” Method

Net method is a **required** method for Stabiliti operation. One and only one port **must** be set as “Net”. When either setpoint is lower than capacity or higher than available capacity, Net port helps absorb the excess power or supply power to make up for the lack of capacity. A net port will not obey power, voltage or current setpoint due to this reason. The power flow to/from the net port is based on setpoint and available capacity of other two ports.

Let’s consider a use case when PV is connected to one of the ports and battery to another port. In this case, one DC port will be set to MPPT (PV) and the other to the net. In this configuration, only AC port can command a power setpoint. If AC setpoint is 20 but PV is generating 30, the 10-kw excess will automatically go to the net port to charge the batteries. Note that site controller (or PMS/EMS) does not have to make any decision here.

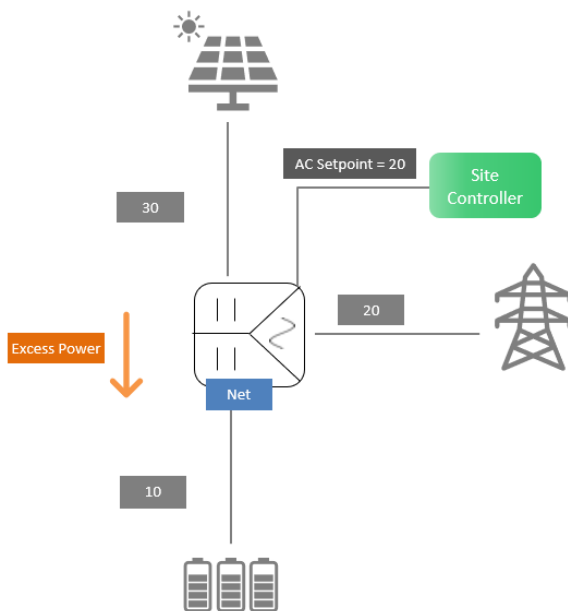


Figure 13 - Net Port - Absorbing Access Power

Let's consider a case when demand is higher than PV generation now. In this case battery or net port will supply power to make up for the difference:

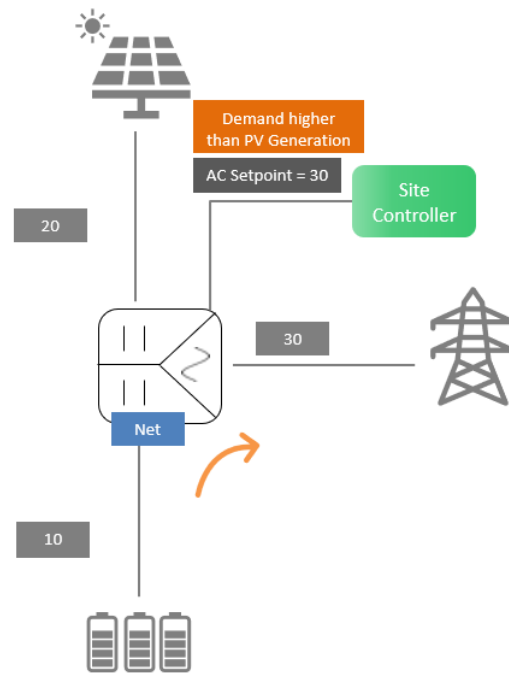


Figure 14 - Net Port - Supplying Power to make up for the difference

13.4. “Net” Method - “Throttle” Port Setting

In cases where Net port is unable to support the “Net” port functions as described in previous section, Stabiliti must know what to do when there is excess or lack of power. This is where Throttle port comes into play. Every port gives you an option to define throttle port. For AC, the register is 67, a value of 0 will throttle to DC2 and a value of 1 will throttle to DC3. Note that this setting is only applicable if AC port is set to Net (register 65 values of 1). For DC2 port, throttle port setting is at register 131, for DC3 its at 195.

Let's consider a scenario where Net port is unable to fulfil the functions of Net port. In the event when there is excess power, as explained earlier the excess power will automatically go to the battery port which in our example is set to Net. Now if the batteries are fully charged, a site controller must set the “Export Limit” to “0”. This will force Net port NOT to absorb the excess power. Now what happens with excess power depends on the “Throttle port Setpoint”. If Throttle port is set to AC (modbus register 131, value of 1), excess power will be forced to AC port and Stabiliti will ignore the AC port setpoint in this operation:

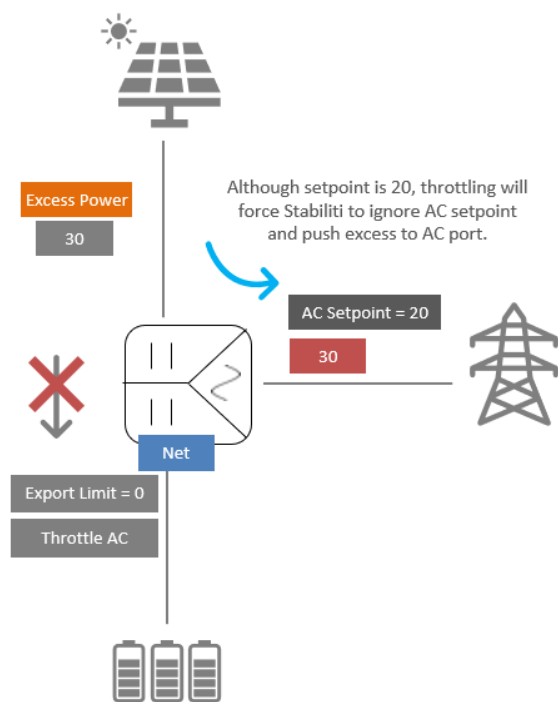


Figure 15 - Net Port - Throttling - Forcing Excess Power to Another Port

If Throttle port is set to DC3 (modbus register 131, value of 1), then Stabiliti will force PV to generate less.

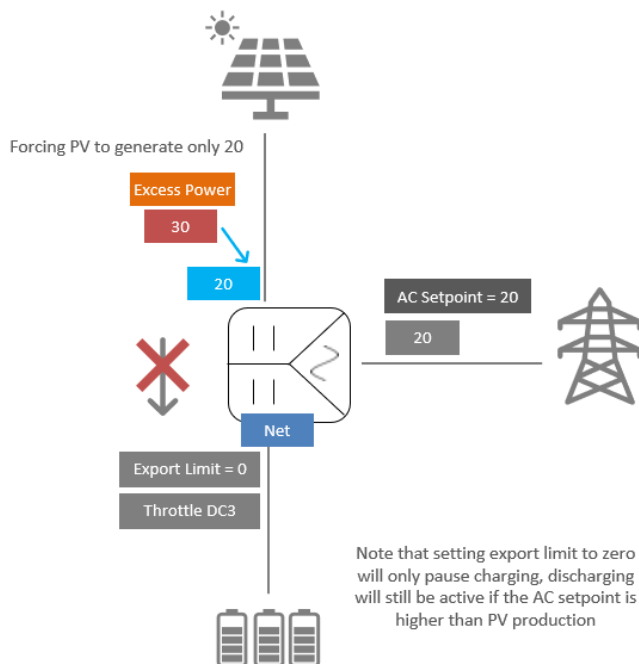


Figure 16 - Net Port - Throttling - Curtailing Excess Power

As mentioned in the note, setting export limit of DC2 to zero only pauses charging, discharging can continue if the condition warrants it.

13.5. “Throttle” Port Setting – Special Use Case – Two Power Ports

In most use cases, the power flow of Stabiliti will be driven based on setpoint (power or current or voltage) of a single port in conjunction with the throttle port setpoint. There are special use cases where two ports could have possible power setpoint. One case is where DC3 is set to power, DC2 is set to Net and AC is GPWR (or FPWR). In this case, if AC is set to throttle then DC2 will give preference to DC3 when it comes to supplying (or absorbing) power and vice versa.

13.6. “Throttle” Port Setting – Special Use Case – Volts/DC Bus Method

If one of the ports is set to Volts (let say DC3) then throttling to DC3 will force Stabiliti to collapse the voltage on DC3.

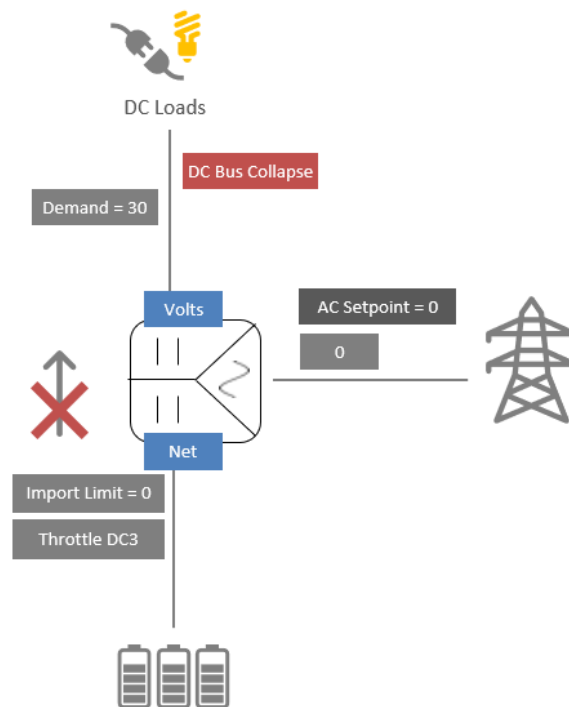


Figure 17 - Net Port - Throttling - Special Case

Throttle to AC will force AC port to supply power (or absorb) power to maintain voltage.

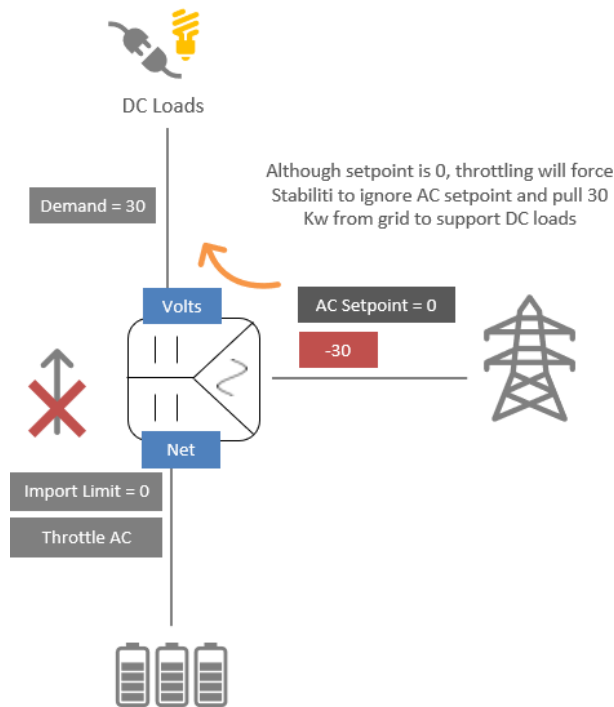


Figure 18 - Net Port - Throttling - Special Case

14. Stabiliti Monitoring Tool

To help customers learn Stabiliti, CE+T has developed a LabView based HMI tool to help control/monitor Stabiliti. The LabView runtime and executable files can be downloaded here:

https://drive.google.com/file/d/1waciCnldR8IJ7QAbhfL_pEd8yDOoPA-y/view?usp=sharing

This tool is not required as customers can use their own modbus tool or their own controller to control and monitor Stabiliti.

We have also developed a node-red tool to help monitor Stabiliti. It is also posted on the link above. Note that support for both LabVIEW and node-red will be limited as they are free tools.

Contact CE+T on how to use the tool if interested.

End of Document