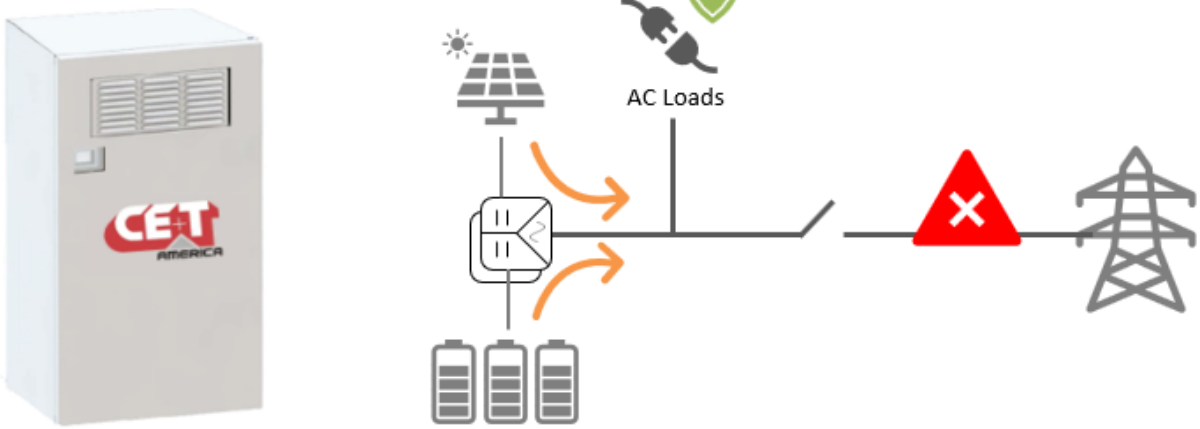
Leading Conversion and Storage Technology for Energy Saving and Power Resilience

Stabiliti™ – Microgrid Operation



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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 microgrid operation.

Document Revision History:

Date	Revision	Notes
Sept 15th, 2021	A	Initial draft

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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

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 - All instructions regarding the configuration of this device must be followed. Failure to follow may result in injury, death, or damage to equipment.

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.

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 NFPA and all applicable NEC codes.

Danger – Do not leave foreign objects in the 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 –Replace damaged warning and precautionary labels.

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 microgrid operation. There are different ways Stabiliti s can be commanded to form grid (i.e., microgrid operation) and this guide will cover all different methods and their pros and cons. This document is aimed at providing a "bird's eye view" only for all different microgrid operation method. Refer to applicable detailed app notes for further details.

5. System Rating

Note that the max number of Stabiliti that can be used to form microgrid is 8 (240 kw total as one Stabiliti is 30 kw). There is no minimum limit though. Microgrid function can be achieved via a single Stabiliti as well.

6. Reference Document

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

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

6.3. DOC - 00063 – App Note – Single Wire Microgrid Guide

6.4. DOC – 000xx – App Note – Islanding Switchgear Guide

6.5. DOC – 503 – App Note – Rapid Backup Power Solution Guide

6.6. DOC - 00033 – App Note – Transformer & Interconnection

Also refer to PCS' modbus map for details.

7. Microgrid Operation – Synchronous Vs Asynchronous

In essence, microgrid operation means that the Stabiliti will form grid and keep the loads running even when the grid is lost. For Stabiliti to be able to do so, there are specific software settings and specific ways to set the whole system up from wiring standpoint. The exact settings depend on desired microgrid operation. Before we go into further details, its important to understand the difference between synchronous and asynchronous microgrid function.

Synchronous means that upon receipt of appropriate commands (and grid conditions), ALL Stabiliti s in the system will start forming (or following) the grid at the exact same time. Such operation is required when the load that needs to be powered up is exactly equal to the size of Stabiliti installation. To achieve this, a use of islanding switchgear or following "single wire microgrid" method is crucial. This of course adds cost and adds some complexity to the overall control.

If the load that is supposed to be protected is controllable, meaning it can be gradually brought online then an asynchronous way of controlling microgrid is a cheaper alternative. In asynchronous mode, individual Stabiliti are brought online one by one. They may all receive "microgrid command" at the same time but there might be a slight delay for individual units to start forming microgrid. Due to this limitation, this method is ideally suited for completely off grid applications.

8. Microgrid Operation

There are three different ways of achieving microgrid operation. Each one has their own pros and cons. Note that there is a max limit of 8 converters while forming microgrid. Refer to the table below for details:

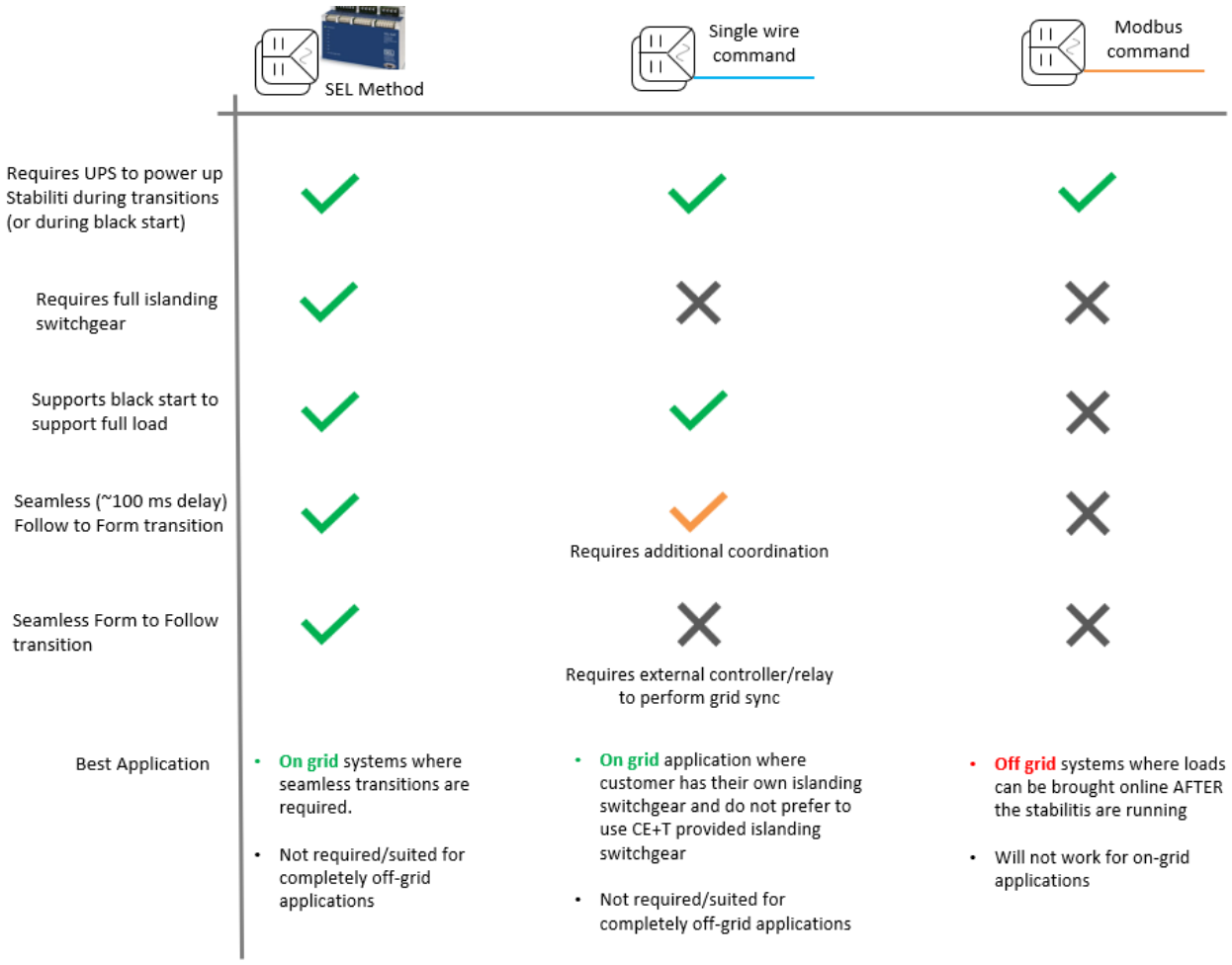


Figure 1 - Microgrid Operation - Three Ways

Refer to the section below to gain better understanding of each term used in the table above.

Definitions:

- On grid means system is normally connected to grid. But when grid is lost, the Stabiliti system is required to form microgrid to support the loads.
- Off grid means the system has no connection to the grid at all and there will never be an actual grid connection.
- Black start refers to a mode of operation where the load is required to be brought online from a completely offline state.

Here is a summary of pros and cons of all three methods:

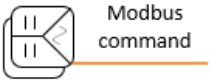
	 SEL Method	 Single wire command	 Modbus command
Pros	• Fully automated transitions which do not require any coordination from Customer's Control System. • Seamless (~100ms) Follow to form transition • Ready to use box supplied by CE+T with detailed field wiring instructions. • Full CE+T Support on commissioning and operation	• No need to buy CE+T Islanding Switchgear, saves cost.	• No need to buy CE+T Islanding Switchgear, saves cost. • No special field wiring required.
Cons	• Adds cost to the project.	• Requires customer to taken on a lot of design items including but not limited to designing "Islanding Assist box" and all related field wiring. • Requires customer to source components including but not limited to UPS and Grid Interconnect Relay (GIC). • Requires customer to modify their control system to control both "Islanding Assist box" and GIC	• Can only be used in completely off grid applications. • Does not support black start in certain cases. The load must be brought online once the Stabilitis are already running • Still requires UPS powered 24-volt DC power supply.

Figure 2 - Pros and Cons of Different Microgrid Operation Methods

9. Microgrid Operation – SEL Method

This is how the system shall be interconnected when using CE+ T supplied islanding switchgear:

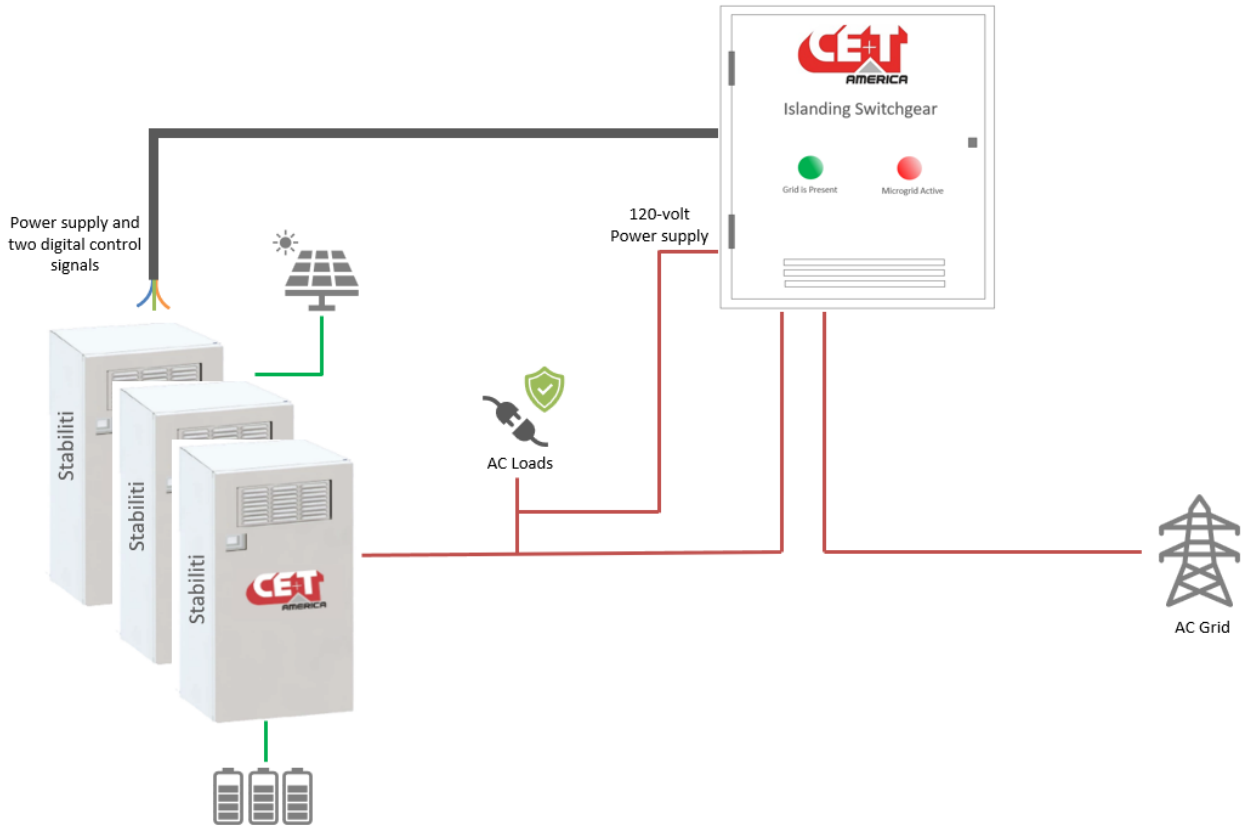


Figure 3 - Microgrid Operation - SEL Method

Field Wiring:

The AC connection from Stabiliti will go into an AC distribution panel (not shown above) and then into "Islanding Switchgear". From there, it will connect to the grid. Note that the "power supply and digital control signals will go from "Islanding switchgear" to one Stabiliti and then connection to subsequent Stabiliti will be daisy chained from this Stabiliti. Note that the "Islanding Switchgear" design may look different (look and feel) than the one shown in figure above. The field connections and functionality will remain the same. This is the most recommended mode of operation for all "on grid" applications.

System Startup – Initial Start of System:

The system must be set up when the grid is present. Upon interconnecting everything, the SEL relay will engage 24 volts to the two digital signals connected to Stabiliti and at the same time it will energize/close the Grid Interconnect Contactor (GIC). At this time the load is powered via the grid. Now each stabiliti should be manually commissioned and brought online. Note that Stabiliti's AC port must be set in "FPWR" mode. When grid is present and SEL relay is not commanding the Stabiliti to form the grid, Stabiliti will wait for a Customer Control System (CCS) to send a power command to support the load.

Follow to Form Operation – Loss of Grid:

When the grid is lost, the SEL relay detects the loss of grid and notifies the Stabiliti to start getting ready to form the microgrid. After this, SEL relay opens the GIC. Upon successful GIC operation, SEL reports back to Stabiliti that its ok to form microgrid now. This whole process takes around 100 ms. Note that once Stabiliti are forming the grid, they will ignore power command sent by CCS and will keep the loads on by appropriately taking power from the two DC ports.

The Stabiliti's on board control systems are normally powered via the 480-vac connection. During the "following to forming" transition, the UPS within the Islanding switchgear provides power to keep the internal Stabiliti controls running.

Form to Follow Operation – Grid is Back:

When the grid is back, SEL ensures that the grid formed by Stabiliti is in sync (phase, voltage, frequency) with the grid and upon successful sync, SEL relay closes the GIC and releases both microgrid command signals from Stabiliti. This transition is almost seamless.

Application:

Using this method adds cost to the system but it greatly automates the microgrid function. A customer control system will have to make no decision to enable any of "forming to follow" or "follow to forming" transitions. This is best suited for all "on grid" applications.

Refer to "DOC – 000xx – App Note – Islanding Switchgear Guide" for additional details.

10. Microgrid Operation – Single Wire Command Method

This is how the system shall be interconnected when using "Single Wire Method":

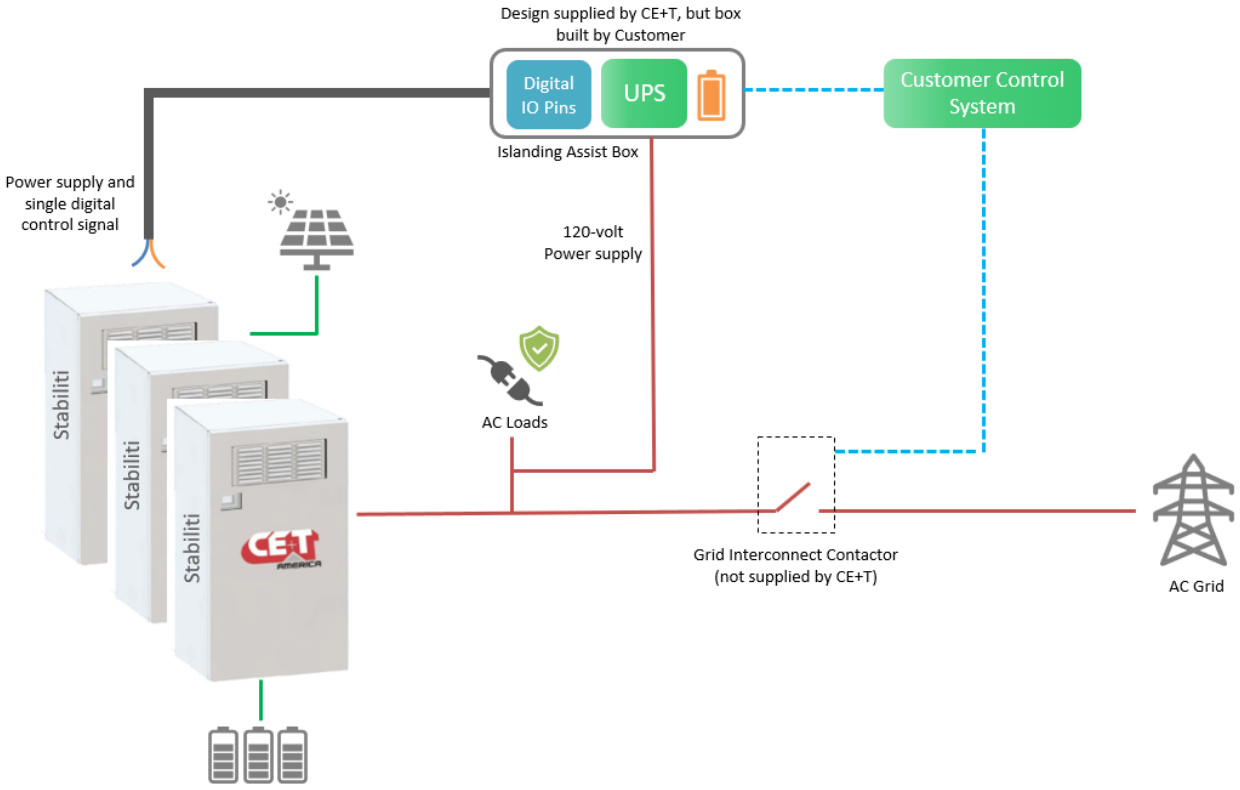


Figure 4 - Microgrid Operation - Single Wire Method

Field Wiring:

The "power supply and digital control signals will go from "Islanding Assist Box" to one Stabiliti and then connection to subsequent Stabiliti will be daisy chained from this Stabiliti. CCS must control both the "Islanding Assist Box" and the GIC to achieve the same operation as performed by CE+T supplied Islanding Switchgear (as described in the previous section). It is customer's responsibility to design appropriate wiring and control algorithm to achieve the same. The figure above serves as a guide to achieve required field wiring.

Note: Regarding the "Islanding Assist Box", CE+T can provide design documentation but will not be able to have one built for the customer. It will be customer's responsibility to build one as per provided documentation. It is also customer responsibility to design the CCS to control the "Islanding Assist Box".

Refer to "DOC – 503 – App Note – Rapid Backup Power Solution Guide" for additional details.

System Startup – Initial Start of System:

The system must be set up when the grid is present. Upon interconnecting everything, the CCS shall engage 24 volts to the one digital signal connected to Stabiliti and at the same time it shall energize/close the Grid Interconnect Contactor (GIC). At this time the load is powered via the grid. Now each stabiliti should be manually commissioned and brought online. Note that Stabiliti's AC port must be set in "FPWR" mode. When grid is present and CCS is not commanding the Stabiliti to form the grid, Stabiliti will wait for CCS to send a power command to support the load.

Follow to Form Operation – Loss of Grid:

When the grid is lost, the CCS must detect the loss of grid and before commanding the Stabiliti to form microgrid, it must ensure the system is isolated from the grid by opening up GIC. Upon successful GIC operation, it must command Stabiliti to form microgrid. Note that if CCS is not fast enough to make these decisions, the load may be dropped, and additional coordination will be required to black start the loads. This will be solely customer's responsibility to ensure reliable Stabiliti operation.

The Stabiliti's on board control systems are normally powered via the 480-vac connection. During the "following to forming" transition, the UPS within the Islanding switchgear provides power to keep the internal Stabiliti controls running.

Form to Follow Operation – Grid is Back:

When the grid is back, CCS **must** ensure that the grid formed by Stabiliti is in sync (phase, voltage, frequency) with the grid and upon successful sync, CCS can close the GIC and release the microgrid command signal from Stabiliti. Again, this will be solely customer's responsibility to ensure reliable Stabiliti operation

Application:

This method is best suited for customers who do not wish to use CE+T provided islanding switchgear. While this method saves upfront cost (no cost added for Islanding Switchgear) it adds significant amount of work for the customer to build the ""Islanding Assist Box" and also make changes to CCS to control "Islanding Assist Box" and GIC.

Disclaimer:
Note that in this case, the full operation is solely controlled by "Customer Control System". CE+T shall not be held liable for damage or harm caused to equipment or personnel due to incorrect system operation.

Refer to "DOC – 00063 – App Note – Single Wire Microgrid Guide" for additional details.

11. Microgrid Operation – Modbus Command Method

This is how the system shall be interconnected when using “Modbus Method”:

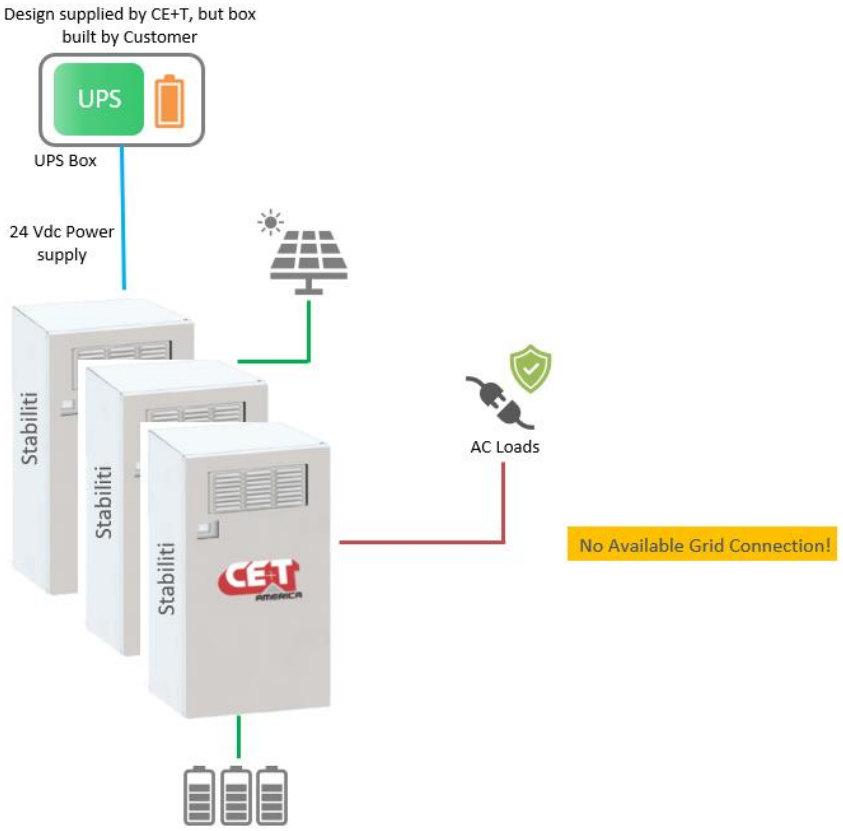


Figure 5 - Microgrid Operation - Modbus Method

Field Wiring:

The UPS box must be connected to 24 volts dc power supply pins within Stabiliti. Apart from this, there is no additional/special field wiring.

Note: Regarding the “UPS Box”, CE+T can provide design documentation but will not be able to have one built for the customer. It will be customer’s responsibility to build one as per provided documentation.

System Startup – Initial Start of System:

Before reaching the project site, the UPS box must be fully charged. Ensure the load is physically disconnected from the Stabiliti system. Use the “UPS box” to power up Stabiliti. Once Stabiliti is on, the AC port must be set to “FPWR”. Once set, start Stabilitis one by one. Once all the Stabilitis are on, ensure they are all reporting “Forming” status on the LCD panel. Once this is confirmed, then provided there is

enough PV, storage or DC power sources (connected to Stabiliti's DC port), the Stabiliti system can now be connected to the load.

Follow to Form Operation – Loss of Grid:

Not applicable.

Form to Follow Operation – Grid is Back:

Not applicable.

Application:

This method is best suited for projects which are completely off grid.

Disclaimer:

Note that in this case, the full operation is solely controlled by "Customer Control System". CCS must control all DERs appropriately to ensure reliable operation. CE+T shall not be held liable for damage or harm caused to equipment or personnel due to incorrect system operation.

End of Document