APPLICATION NOTE 503

Rapid Backup Power Utilizing the Stabiliti™ Series Power Conversion Systems

1.0 PURPOSE AND SCOPE

The Stabiliti™ Series 30 kW bi-directional Power Conversion System (PCS) is for commercial and industrial energy storage system (ESS) applications. The PCS may be purchased with either one or two DC power ports, both of which may be used with either solar PV or a battery.

When used in standalone microgrid applications, the AC1 power port will form a 3-phase AC output at 380/480 Vac and 50/60 Hz supporting real, as well as reactive microgrid loads up to their nominal nameplate ratings of 30 kW and 18 kVAR. In grid-interactive voltage-following applications, the AC1 port will source or sink power into a utility interconnection, with the same AC characteristics as described above.

Supporting both modes of operation at a customer facility delivers greater value than traditional grid-tied only systems. Typically, the Stabiliti™ Series PCS operates in voltage-following mode, sourcing or sinking power to and from the grid, utilizing PV and a large battery as its DC energy sources. If/when the grid fails, the PCS will immediately re-configure itself to voltage-forming mode, enabling backup support of facility critical loads.

This application note provides hardware, control recommendations and utility interconnection considerations for using a Stabiliti™ PCS for backup power applications. One key difference between the Stabiliti™ Series PCS, and earlier generation Ideal Power converters, such as the 125B2 and the 30B3, is its ability to move rapid between the modes of operation described above, providing blinkless support to critical loads. Additionally, the Stabiliti™Series PCS is capable of parallel operation, while in either voltage-following or voltage-forming. The 30B3 and 125B2 do not support parallel operation while in voltage-forming mode.

This is an overview document meant to introduce the key concepts and required components to support rapid backup. For detailed implementation please refer to the more advanced Application Note 504: Rapid Backup Power Implementation Guide-Stablit™Series Power Conversion System with SEL-547, Application Note DOC-00030.

2.0 SAFETY CONSIDERATIONS

This application note should be used in conjunction with other product and safety documentation provided by Ideal Power. The intended audience is engineering and lab personnel familiar with high-voltage/high-power systems and the general safety issues related to the wiring and use of 3-phase AC electricity, battery systems, and PV energy sources.

Additionally, this document does not purport to make recommendations regarding conformance with applicable electrical codes. A qualified electrical engineer should be engaged to do detailed system design and ensure conformance with local code requirements. Refer to the product datasheet for detailed specifications upon which to base any detailed designs. Lastly, this document assumes that the reader is already familiar with the Modbus interface, and is comfortable using that interface to configure, monitor and command PCS operation.

3.0 STABILITI™ SERIES PCS BACKUP CAPABILITIES

- Once installed with appropriate external islanding hardware and controls introduced later in this document, the PCS will move immediately from voltage-following to voltage-forming modes without site controller intervention.
- While the transition to backup power with the PCS is essentially seamless, it is not an uninterruptable power supply and should not be depended upon to support highly sensitive equipment. The system described herein does not conform to UL 1778 (Uninterruptible Power Systems).
- While in voltage-following or voltage-forming mode, the PCS utilizes a 3-wire delta output: all power is made phase leg to phase leg when exporting, or importing power to/from the grid.
- While in voltage-forming mode, the PCS requires an external transformer to support unbalanced phase-to-neutral loads.
- The PCS can operate at 380 Vac or 480 Vac and 50 Hz or 60 Hz to support most international grid standards. Supporting other grid interconnect voltages, such as 208 Vac or 600 Vac requires an external step-down or step-up transformer.
- The PCS must have appropriate and sufficient energy storage to enable voltage-forming mode and to support critical loads. PV-only based microgrids are NOT supported.

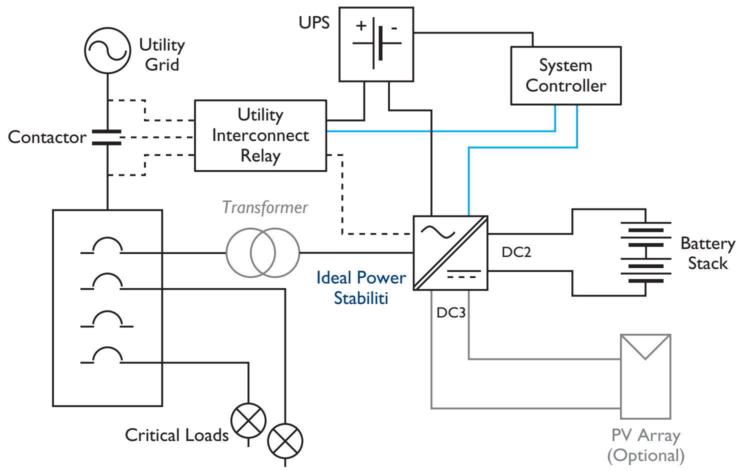
4.0 SYSTEM LAYOUT & COMPONENTS

A backup power system is typically comprised of nine primary elements, as shown in Figure 1. Note this conceptual schematic neglects standard circuit safety devices such as disconnects. An electrical engineer should be engaged to do the detailed system design and ensure conformance with applicable electrical codes.

1. Primary utility grid
2. Utility line isolation device, typically a 3-phase contactor
3. Utility interconnect relay
4. Critical loads electrical subpanel
5. Ideal Power Stabiliti™ Series PCS (Shown with optional second DC port)
6. Battery System
7. PV Array
8. System Site Controller
9. 24 Vdc Uninterruptible Power Supply (UPS)

FIGURE 1: Backup Power with Stabiliti™ Series PCS

Blue lines indicate software communication; dotted lines indicate hardware control or sensing.



Primary Utility Grid – Interconnection Requirements

Although IEEE1547 is a common interconnection standard, utilities across the U.S. often adopt and enforce variations of it. Furthermore, utilities will typically stipulate validation and test requirements for a distributed energy resource ("DER") interconnection, utilizing a relay and contactor for islanding purposes. This may require reports from the relay manufacturer and in-person commissioning witness tests by a utility personnel or other authorized representative.

Utility Isolation Device – Contactor

The contactor is used to electrically disconnect and reconnect a segment of the local facility's electrical system from the main utility grid. It will separate and isolate the electrical subpanel that is wired to the facility's critical loads. It is controlled by the utility interconnection relay.

Utility Interconnection Relay

In a grid-tied only application of the ESS, the Stabiliti™ PCS handles conformance with interconnection and safety requirements in accordance with its UL1741 listing. This includes anti-islanding provisions which prevents the PCS from energizing a dead electrical grid. No interconnection relay is required in such voltage-following only applications.

However, to support back-up power applications, the PCS must have its anti-islanding disabled, allowing it to energize in-building wiring, specifically wiring that is connected to the critical loads subpanel.

For such backup power applications, the utility interconnection relay and contactor are added to the system design. The relay is responsible for managing conformance with utility interconnect requirements such as IEEE1547 near the Point of Common Coupling (PCC) where it will issue a grid disconnect (contactor open) signal if the grid goes outside code mandated voltage and frequency limits. Contactor open and close command signals from the relay are also mirrored and transmitted to the PCS which reacts accordingly and automatically to transition from grid following to grid forming mode of operation.

Common utility interconnect relays include:

SEL-547	www.selinc.com/products/547/
Basler Electric BE1-11i	www.basler.com/Product/BE1-11i-Intertie-Protection-System

The utility interconnection relay controls the contactor and senses the AC voltage on both sides of the contactor. Broadly, it should be programmed to operate on the following logic:

- If the contactor is closed, the relay senses the grid voltage and will open the contactor when the grid goes out of the mandated voltage/frequency range.
- If the contactor is open, the relay senses the grid voltage and load bus voltage and will only close the contactor when these conditions are met: the grid voltage has been in range for at least five minutes (per IEEE 1547) and the critical load bus is either synchronized with the grid or not energized.
- In some cases, a secondary redundant relay may be required. Ideal Power highly recommends engaging a utility interconnection representative as early as possible in the process of designing rapid backup solutions to determine local utility interconnection requirements.

  Detailed software and hardware control advice are beyond the scope of this overview document. For detailed implementation please refer to the more advanced Application Note 504: Rapid Backup Power Implementation Guide-Stabliti™Series Power Conversion System with SEL-547, Application Note DOC-00030.

Critical Loads Subpanel

Critical loads to be supported by the PCS during grid-forming operation should be identified and their load profiles characterized by the end user and must never exceed the nominal 30 kW nameplate rating of the Stabiliti™ Series PCS.

Ideal Power Stabiliti™ Series PCS

With the support of a battery system, and PV array, the PCS will form a 3-phase grid on its AC1 port and rapidly support critical loads. It supports the critical load subpanel, while the external islanding switchgear and contactor ensure grid safety (contactor confirmed open; ensuring that no grid backfeed occurs). This rapid transfer capability is supported only when the AC1 Control Method is set to FPWR (Facility Power): rapid backup is NOT supported when AC1's Control Method is set to GPWR (Grid Power), or to NET.

Battery System

Stores electrical energy and allows bi-directional DC power flows to charge the battery from the grid and/or PV; as well as discharging the battery to the grid as desired. Usually incorporates its own battery management system along with DC contactors to handle self-protection. The battery must be connected to the DC2 bidirectional power port and DC2's Control Method must be NET.

PV Array

PV is typically connected to the DC3 port, which must have its Control Method set to MPPT. Note that the PCS is capable of creating a microgrid without PV, but it must always have a battery attached to operate as a voltage-forming device.

Site System Controller

The system controller is responsible for monitoring and managing the overall status and health of the ESS, as well as the PCS operating state: which may be either voltage-following mode or voltage-forming mode. The system controller operates in concert with the interconnection relay to ensure that the ESS operating mode is appropriate and safe, given grid conditions.

Uninterruptible Power Supply

The 24 Vdc UPS is required to sustain power to the system controller, PCS, utility interconnection relay, and any low-voltage contactor control power during the brief transition between loss of the utility grid and formation of the backup grid by the PCS. Note that the UPS should be powered by the critical loads subpanel to ensure that its batteries remain charged during a backup power event.

5.0 OPERATION AND CONTROL SEQUENCE

The following sequences of operations are indicative samples and are not comprehensive. Refer to the advanced application note for more detail.

Loss of Grid

1. The PCS should be pre-configured with AC1 port as FPWR and DC2 port as NET.

2. The utility voltage or frequency goes out of acceptable range.

3. The interconnection relay senses this excursion and triggers the contactor to open.

4. The contactor and PCS receive a mirrored low voltage control signal. As the contactor opens, the PCS immediately transitions to grid forming mode.

5. The site system controller should periodically poll the interconnection relay and PCS to register the grid and system state.

6. The critical loads will be automatically supported during and after the move to voltage-forming from voltage-following.

Off-grid Operation

- Any PV tied to port DC3 will contribute to supporting the critical loads, and will charge the battery whenever the available PV resource is greater than the loads. The system controller will monitor and curtail the PV whenever the battery reaches its maximum state of charge (SoC). This curtailment is easily made via a "softpower" command to the DC2 port on the PCS.
- If the battery SoC reaches its minimum, the system controller should disable the converter to protect the battery from damage. This will immediately drop support of all critical loads.

Return of Grid

1. At some time during backup power mode the utility grid returns.
2. The interconnection relay waits the required five minutes ensuring the grid remains within range. It then waits until the voltage, frequency and phase are synchronized on the facility and utility sides of the contactor. Upon synchronization the interconnection relay triggers the contactor to close. Natural variations in the phase may result in a delay of less than ten seconds before synchronization occurs.
3. The contactor and PCS receive a mirrored low voltage control signal. As the contactor closes, the PCS transitions to grid following mode.
4. The PCS will resume grid-following operation and power transfer as it had been commanded prior to the grid outage.

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