Application Note
AN-0004

Considerations for Operating Multiple OZpcs-RS40 in Parallel

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ABSTRACT

The OZpcs-RS40 is a 40kW Power Conversion System (PCS) intended for battery-based energy storage applications. The OZpcs-RS40 can operate in both grid-following and grid-forming modes and has been designed to be easily paralleled. This application note describes the hardware and functional features to be considered when designing systems with multiple OZpcs-RS40's.

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1. Introduction

The OZpcs-RS40 is a 40kW Power Conversion System (PCS) intended for battery-based energy storage applications. The OZpcs-RS40 is designed to be mounted in a standard 19" rack and easily paralleled to scale power capability. This application note provides some of the technical details that should be considered when designing systems that involve paralleling multiple OZpcs-RS40's. More detailed product information, including control register details, can be found in the User's Manual, UM-0061.

2. Safety

The information contained in this application note is intended be used in conjunction with other product and safety documentation provided by Oztek. It is assumed readers are familiar with high-voltage/high-power systems and the general safety considerations related to the wiring and use of 3-phase AC electricity, battery systems, and PV energy sources. Oztek strongly suggests that a qualified engineer be engaged to do detailed system design and ensure conformance with local codes. UM-0061 should be consulted for OZpcs-RS40 product specifications upon which to base any detailed designs.

3. Hardware Interfaces

The OZpcs-RS40 hardware has been designed to easily parallel multiple units. All interfaces are provided on the front panel, as shown below in Figure 1.

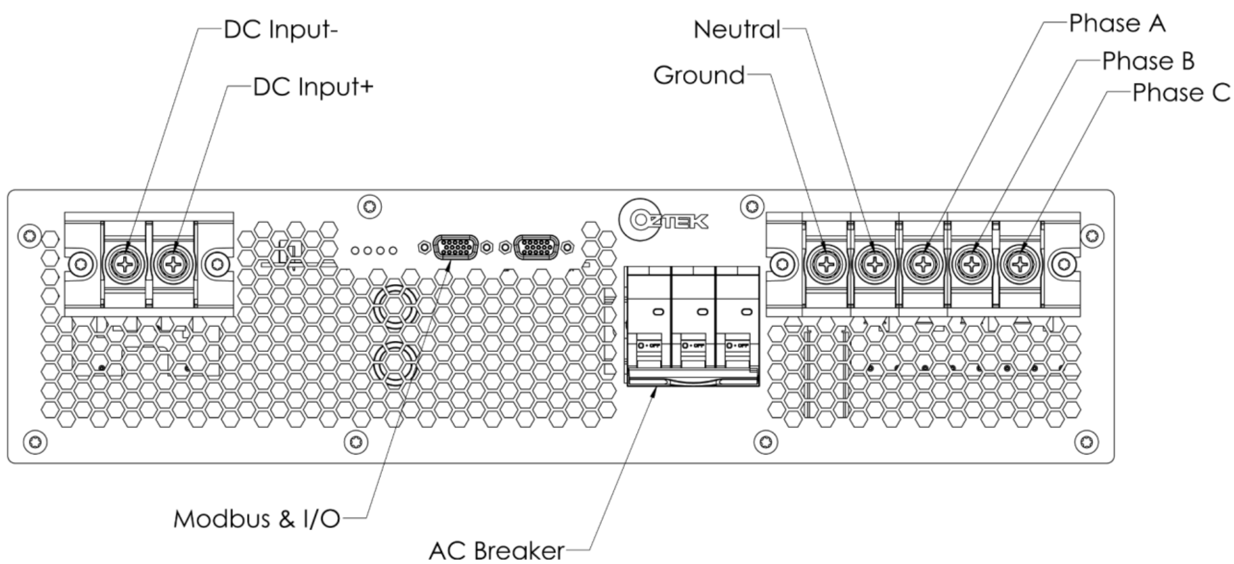

Figure 1 - Front Panel Interface

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3.1 DC and AC Power Interfaces

The DC and AC connections are made using pass-through type terminal blocks. This interface style allows for simple daisy chain connections between units using cable or bus bars as shown below in Figure 2.

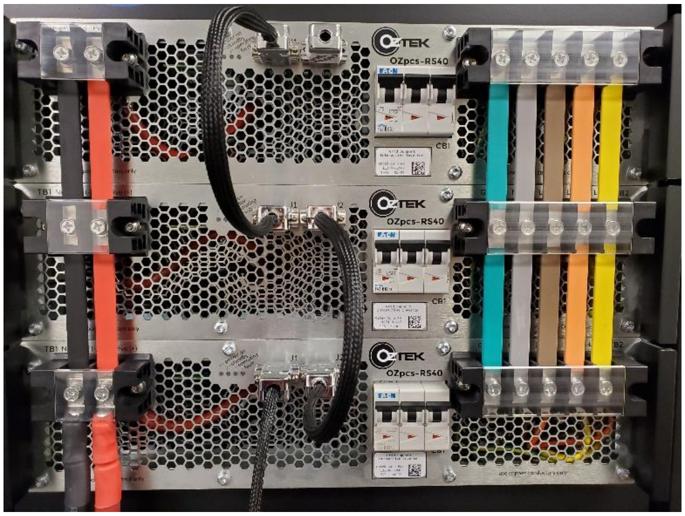

Figure 2 - DC and AC Power Cabling

When designing the interface cabling solution, the total current of all paralleled units must be accounted for. For example, noting that the maximum DC current of the OZpcs-RS40 is 75A, in the figure above, the DC battery cables must support the sum of all three PCS devices, or a total of 225A.

3.2 Signal Interface

All isolated, low voltage I/O signals are provided on two standard High Density, D-Sub, 15-pin, female connectors. The pinout is identical for the two connectors provided in the table below. Providing two connectors simplifies cabling by allowing one point to point cable between the system controller and PCS #1, and short daisy chain cables to connect #1 to #2, and #2 to #3. This is illustrated in Figure 2. The host cable is routed from the bottom to the left connector on the lower PCS. Daisy chain cables are used to connect the bottom to the middle PCS, and the middle to the top. The connector on the top right PCS implements the terminating jumpers, as described in section 3.3.

Table 1 - I/O D-Sub 15 Pinout

Pin #	Name	Description
1	ESTOP_C	Opto-Isolated Emergency Stop - Cathode Input
2	ESTOP_A	Opto-Isolated Emergency Stop - Anode Input
3	DOUT1_C	Opto-Isolated Output #1 – Collector
4	TERM_A	RS-485 Termination Resistor (A – connection)
5	RS485A	RS-485 A Signal

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Pin #	Name	Description
6	DIN_A	Opto-Isolated Input – Anode Input
7	BIAS_EN_A	Opto-Isolated Bias Enable – Anode Input
8	DOUT2_C	Opto-Isolated Output #2 – Collector
9	DOUT1_E	Opto-Isolated Output #1 – Emitter
10	RS485_GND	Isolated Ground for RS-485 interface
11	DIN_C	Opto-Isolated Input – Cathode Input
12	BIAS_EN_C	Opto-Isolated Bias Enable – Cathode Input
13	DOUT2_E	Opto-Isolated Output #2 – Emitter
14	TERM_B	RS-485 Termination Resistor (B – connection)
15	RS485B	RS-485 B Signal

3.3 RS-485 Termination

The RS-485 data bus must be terminated for reliable communications. Do NOT terminate every device on the bus, as this will degrade the signals and overload the transceivers. Only the devices physically located at the end of the wires should have termination. The OZpcs-RS40 provides an internal termination resistor that may be enabled by shorting pins 4 & 5, and 14 & 15 on the last PCS in the daisy chain, as illustrated in Figure 3.

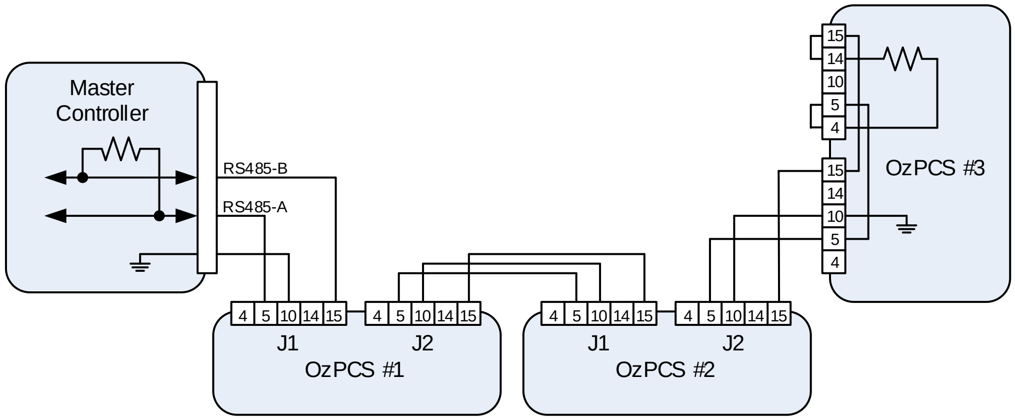

Figure 3 - Modbus Serial Interface Wiring

4. Modbus Configuration

The OZpcs-RS40 provides Modbus RTU serial communications over an RS-485, multi-drop, hardware interface. Modbus RTU is a Master/Slave protocol where only one node, assigned as the Master, may initiate a command. All other devices are Slaves and respond to requests and commands from the Master. The OZpcs-RS40 is designed to operate as a Slave device. To prevent contention all devices communicating on a Modbus network must have a unique address.

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4.1 Slave Addresses

Whenever two or more units are paralleled on the same RS-485 serial bus, each PCS must be assigned a unique Modbus Device Address so it can be individually addressed by the system controller. The configuration register ***REG 40069 – Modbus Device Address*** is used to set the address of each PCS. The factory default setting for this register is 1 and it supports an address range of 1 to 247. Each PCS must be assigned a unique address by writing to this register ***before*** attempting to connect and operate it in parallel with others. The register is non-volatile, so the register only needs to be written once; its value is retained when power is removed.

NOTE: This register is unique in that it requires a power cycle to take effect. For example, if a value of 2 is written to this register, the PCS will continue to respond to the default address of 1 until the PCS is powered off and then on again.

WARNING

Firmware updates may reset configuration registers to factory defaults. Care should be taken when upgrading firmware "in-system" with paralleled units.

It is recommended that you do NOT use the default ID of "1" in a system with paralleled PCS's, (i.e. start with 2, 3 …). That way, when updating firmware, it's possible to recommission the newly reset unit without needing to isolate it from the others – i.e. you eliminate the issue of having two PCS's on the bus with an ID = 1.

4.2 Broadcast Messages

The Modbus protocol defines a broadcast write mechanism that uses the Modbus Device Address value of zero to indicate that all slaves should respond to the write message regardless of their unique slave address. This is useful if you want to turn multiple, similar devices on or off, or change their operating setpoints simultaneously.

For example, assume you have a system with three OZpcs-RS40's with Modbus addresses of 2, 3 and 4. You can set the power output of each one individually by writing to each PCS, i.e., one Modbus write to Address 2, another to 3, and a third to 4. Alternatively, they can all be set simultaneously by a single Modbus write to Address 0.

NOTE: Slave devices do not send a reply message to a broadcast command as they would upon receipt of a command addressed specifically to them.

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5. Functional Considerations

5.1 Grid Following Mode

When operating in grid following mode, also referred to as grid tie, each PCS can be turned on and controlled independently from the others. Because each PCS operates in power control mode, it is acceptable to turn one unit on and give it a 75% power command and then turn a second unit on and give it a power command that is different than 75% - i.e., each unit independently controls the power seen at its AC terminals.

5.2 Grid Forming Mode

When operating in grid forming mode, with a valid microgrid already present, i.e., powered by some other resource, each PCS can be turned on independently from the others. Each PCS will begin operating in Grid Forming mode using the voltage and frequency sensed at the AC terminals, and then ramp to the user's commanded setpoints (***REG 42795 - 42796***) using the ramp rates configured in ***REG 42801 & 42804***.

If the local microgrid happens to be dead, it can be black started using the full power capability of multiple PCS's operating in parallel. To do so, all the PCS need to be started at the exact same point in time. To meet this requirement, each PCS must be tied to the same physical RS-485 serial bus, and the dedicated Modbus broadcast device address of zero must be used when turning the PCS on (writing a "4" to ***REG 41123 – Set Operation***).

In addition, we recommend that ***REG 42812 – Grid Form Startup Voltage Slew Rate*** be configured for the default slew rate or slower when black starting multiple PCS's at the same time. When ramping at extremely fast rates, slight voltage mismatches can cause noticeable currents to circulate between units. These currents will not harm the PCS, but when combined with local loads at startup, they could cause nuisance over-current trips and fail to reliably black start the microgrid.

Parallel black start is not possible if all PCS units cannot be attached to the same physical RS-485 serial bus. In this case, black starting the microgrid is still possible, but requires a manual black start process by the operator. In this scenario, a single PCS must first be black started by itself. If the local loads are greater than the power ratings of a single unit, they must be disconnected during the manual black start procedure. Once the first unit has finished black starting and the local voltage has been established, the remaining PCS units will synchronize to the first unit and may then be individually turned on. Once all units are operating, the local loads may then be attached.

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