Using OutBack Inverters for 3-Phase 480V Applications

Introduction

This application note will discuss how to adapt OutBack Power 230V single phase inverters for 60 Hz 480V three-phase applications using 3-phase autotransformers in a step-down/step-up configuration. The single-phase Radian GS7048E inverter is the best choice. The "split phase" Radian GS8048A will not work in 3-phase applications as each power module is configured for 120V/240V operation. The FXR 120V inverters can be configured directly for 120V/208Y applications, but the maximum 32 kVA is only half as much power as nine of the 7 kVA GS7048E inverters that can be stacked (three per phase) for a total of 63 kVA.

Solution

A single 3-phase autotransformer can be used to step down the incoming 277V per phase (480V 3-phase) to 230V per phase for the GS7048E AC inputs. The 230V inverter outputs are then stepped up through another 3-phase autotransformer to 277V per phase (480V 3-phase). An autotransformer uses a single core and winding as it is only stepping up or down the difference between input and output volts — in this case 47 Vac (see Figure 1). In the step-down configuration, the source is across the entire winding while the load (inverter input) is across a portion of the winding, while the opposite is true in a step-up configuration where the source (inverter output) is across part of the winding while the load is across the entire winding.

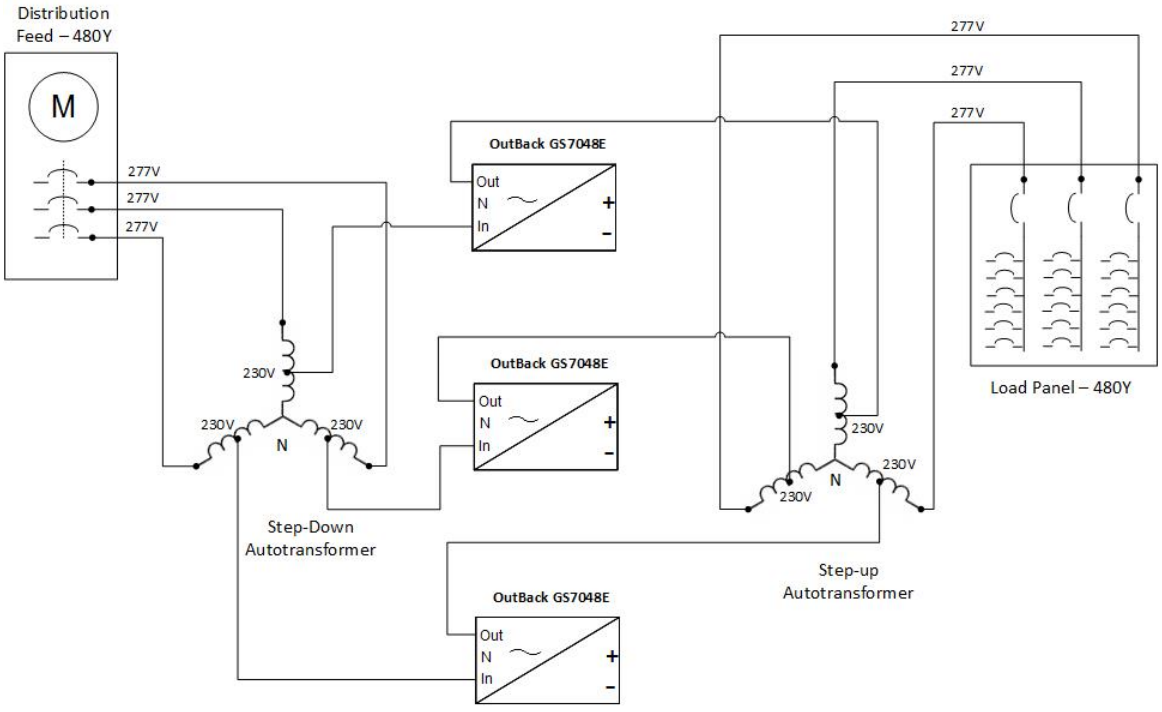

Figure 1: Single line diagram for 480V 3-phase system with Radian 230V inverters and autotransformers.

The tradeoff of an autotransformer over an isolation transformer is less power loss, reduced size and weight for the same volt amps, which also makes it less costly. However, since most of the input and output current of the autotransformer is not isolated, a newly derived ground cannot be created on the output as with an isolation transformer. For many applications, the size and cost benefits of the autotransformer outweigh the need for an isolated ground.

Most grid connected installations in North America require a UL or CSA listing for interconnection to the local utility grid. While the GS7048E meets most, if not all of the UL and CSA requirements, it has a CE listing to meet the European electrical standards. Depending on local electrical requirements, the CE listing could limit this solution to Off-Grid, Mini-Grid and Industrial/Commercial applications where exceptions may exist for using a CE listed inverter instead of a UL/CSA listed inverter.

Sizing the System

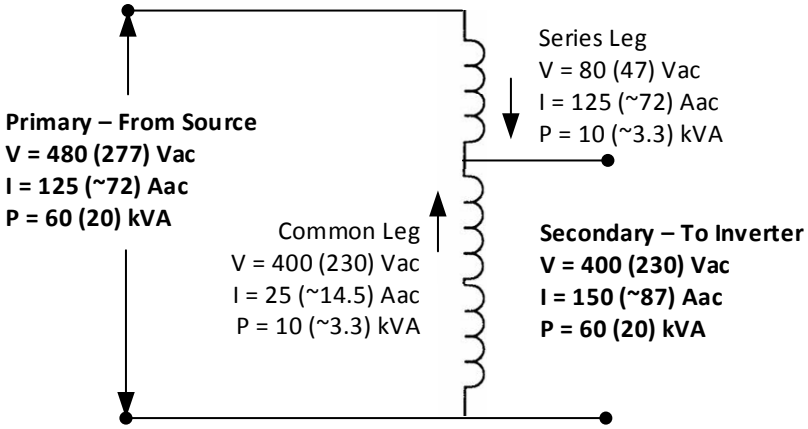

Figure 2: Single diagram representation of 3-phase autotransformer (single-phase values on each transformer leg)

1. With up to three 7 kVA inverters per phase, the 3-phase system sizes are 21, 42 or 64 kVA. In the example in Figure 2 with a 60 kVA source and load, there is approximately 87 Aac per phase. This means that at least two inverters per phase would be required as each inverter can pass through up to 50 amps.
2. Size the 3-phase autotransformer to the load kVA and integrate into the AC bussing scheme. Additional de-rating (oversizing) is advisable to accommodate surge loads, power factor and harmonic load currents.
3. Size the battery bank to the load, and design the DC bussing scheme.
4. If using solar (PV), size the array to the battery bank for hours or days of autonomy and depth of discharge.

NOTE: the system sizing tool and multi-inverter application notes on OutBack Power's website can provide more details to assist with the aforementioned steps.

Application Case Study

One of OutBack Power's customers, the Saskatchewan Research Council (SRC), has implemented a variation of the solution discussed above for remote, off-grid industrial sites requiring 480V 3-phase power called the Hybrid Energy Container (HEC). The HEC was originally designed for the cleanup of abandoned mining sites in remote areas of Canada, but it's also well suited for industrial sites, disaster relief areas, remote communities as well as research and exploration camps. Some benefits of the project are summarized in the following paragraphs taken from their case study of the mining site.

A generator, by principle, follows the electrical load, which leads to inefficiencies as the engine operates outside of its optimal range. This results in excessive fuel consumption, increased pollution and more frequent maintenance. Such a need to improve efficiency was identified at one of the mine sites that the Saskatchewan Research Council (SRC) is remediating, the former Gunnar uranium mine and mill site, as part of Project CLEANS (CLEanup of Abandoned Northern Sites). An operating camp has been established at Gunnar, which is located on the north shore of Lake Athabasca. The camp operates during the summer months and accommodates up to 100 people. All power needs for the camp were met by 2 legacy 500-kW generators, which were sized to meet the requirements of the initial demolition phase of the remediation effort, but were oversized for current operation at the camp.

Diesel represented a major operating expense for the camp, as approximately 460 L/day of diesel was consumed to support the small camp. The fuel cost is approximately $2.30/L, including delivery to the site from the nearest bulk fuel station. To reduce the diesel consumption for the Gunnar camp, SRC developed the Hybrid Energy Container power system. SRC conducted extensive site monitoring of the camp to characterize the site's load and then designed the customized hybrid system to maximize the fuel savings over the life of the remediation effort. All aspects, including battery chemistry, inverter technology, generator type and hybrid construction were considered. The system was constructed in the spring of 2015, received ETL certification and was then transported from Saskatoon to the Gunnar camp via truck and barge.

The customized Hybrid Energy Container was integrated into a single modular container, which accommodates a generator, a battery, a photovoltaic array and an inverter system equipped with remote control and monitoring systems. This design makes the system portable and rugged, while allowing multiple systems to be stacked to achieve higher generation and storage capacities, as well as to increase reliability through redundancy.

Throughout the first summer of operation, the Hybrid Energy Container met all SRC's goals by reducing diesel fuel costs, providing reliable power and reducing overall maintenance. The system is fully automated and can be monitored and controlled remotely. During operation at Gunnar, SRC's Hybrid Energy Container reduced generator runtime by over 70%, and is expected to save 86% of the site's fuel consumption, providing approximately CAD$93,000 in savings during its first 4 months of operation and a payback period of less than 12 months of operation.

Figure 3: The Saskatchewan Research Council Hybrid Energy Container (HEC-60) at installation.

The HEC-60 comes in a standard 20-foot ISO shipping container with a 60-kVA diesel generator, a 259-kWh battery bank, 42-kVA OutBack inverters and an 8-panel solar array. Other features include: integrated HVAC, online monitoring, automated control, input for auxiliary energy sources (wind, solar, grid) and microgrid controller.

While the standard HEC-60 configuration is for an off-grid diesel generator based power system that is offset by batteries and solar power, other configurations are possible, such as local power grid connections as well as other renewable sources like wind and micro-hydro. The HEC-60 system below the standard configuration using a 400V 3-phase generator that will direct-feed the 3-phase 230V wye inverter configuration. Since the input is already configured for the native 230V/400Y power feed, there is only one 3-phase setup autotransformer from 400V 3-phase to 480V 3-phase power.

More information is available on SRC's website: www.src.sk.ca

About OutBack Power Technologies

OutBack Power Technologies is a leader in advanced energy conversion technology. OutBack products include true sine wave inverter/chargers, maximum power point tracking charge controllers, and system communication components, as well as circuit breakers, batteries, accessories, and assembled systems.

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Other

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