VERTIV WHITE PAPER

Safe capacity test:

Innovation and savings

Summary

Executive Summary

Optimizing energy consumption and improving system efficiency is the main goal for every UPS system installation.

With this in mind, Vertiv™ medium and high power UPS have now been endowed with an embedded functionality to process a closed-loop circulation of power through their own rectifier and inverter, acting as an internal load bank.

This eco-friendly and low risk test of UPS performances is called "Safe Capacity Test" and guarantees significant savings in terms of time, money and set-up operations, thanks to the ability to perform the burn-in test directly on site and without the need for an external load bank.

Traditional Load Bank Testing

UPS are critical to business continuity and load bank tests are usually performed to ensure that the UPS can meet their own specification as it is a way of validating the correct operational performance of the overall system. Traditional load bank tests, however, tend to be complex and expensive because, in addition to the excessive amount of energy wasted, they require hundreds of meters of costly copper cable and thousands of dollars in case the load banks need to be rented. Moreover, the presence of an external load bank creates a hazardous environment due to the large amount of operations and activities during cable connections.

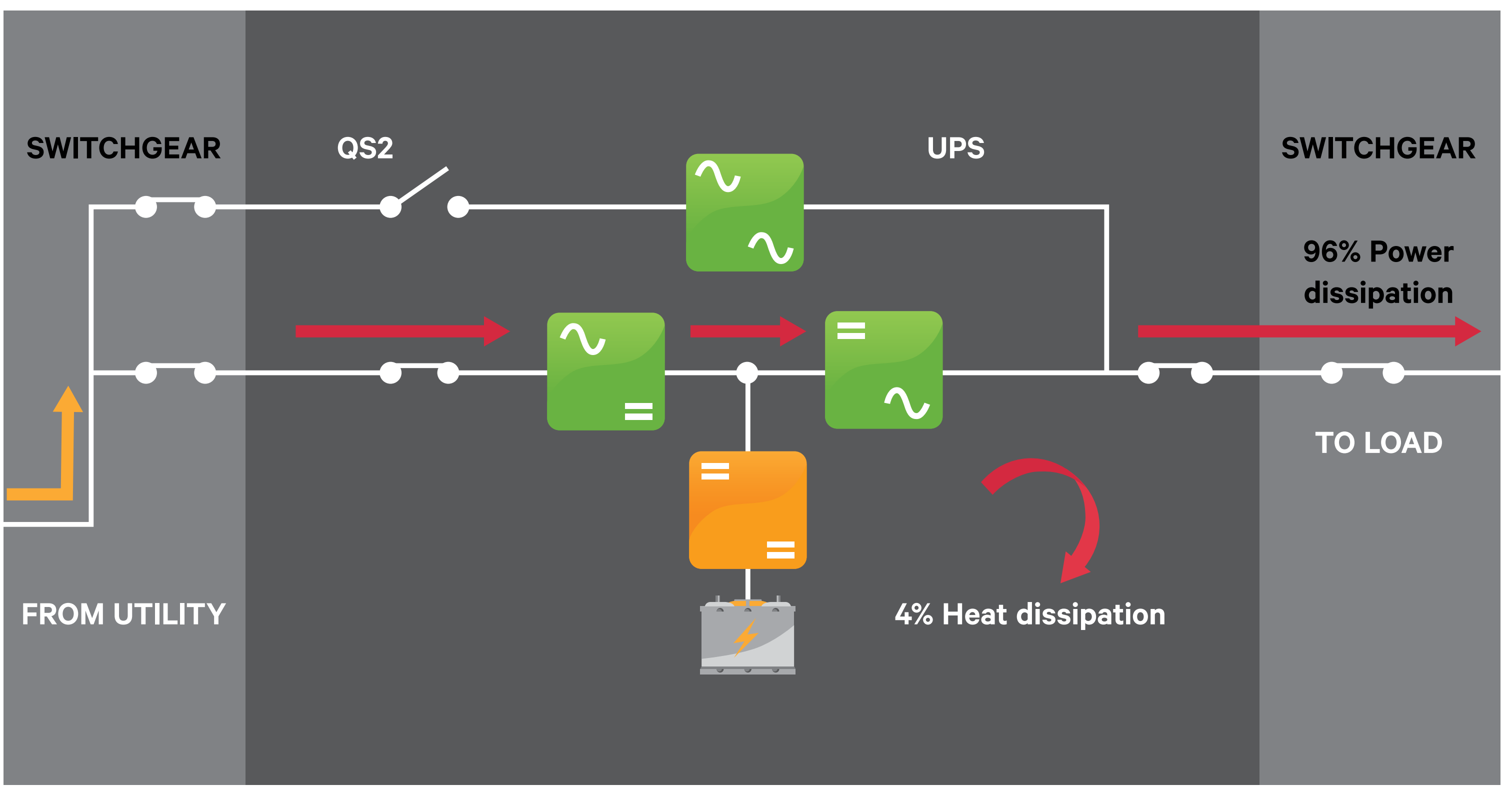

Figure 1: *Traditional Load Bank Test*

The Safe Capacity Test: Innovation and Savings

With the safe capacity test, on the other hand, the UPS can test its entire power train, including the rectifier, inverter, contactors, fuses, power busses, cabling, bypass static switch, magnetics and filter capacitors, all without an external load connected.

This feature saves time and money during startup, commissioning tests and also after a system upgrade or repair, thanks to the ability to use the rectifier and inverter in a closed loop power circulation that allows the UPS to perform the safe capacity test at full load.

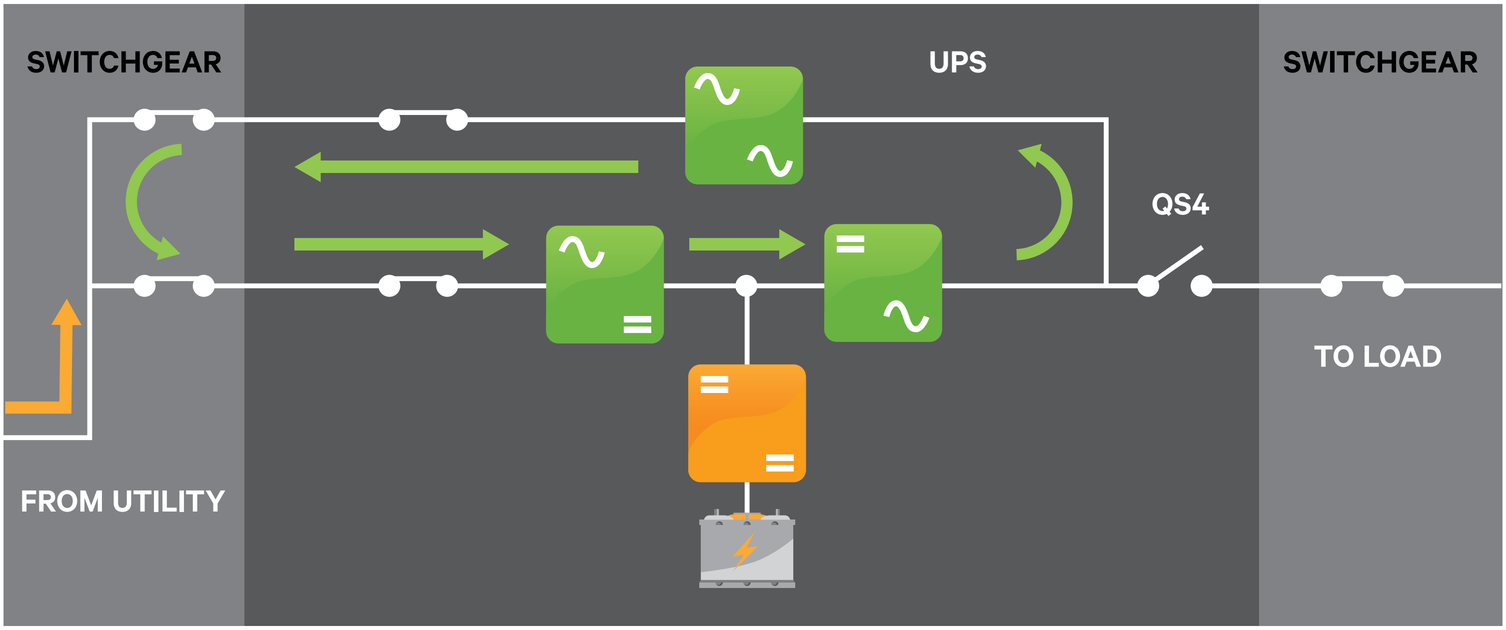

Figure 2: *Safe Capacity Test*

Vertiv service technical field engineers are trained to perform the safe capacity test easily and quickly during commissioning or preventive maintenance with disconnectable loads to ensure optimum calibration, maximum efficiency and inherent redundancy.

The safe capacity test is available for the Vertiv state-of-the-art Vertiv™ Liebert® Trinergy™ Cube large modular UPS and Vertiv™ Liebert® EXL S1 large monolithic UPS.

Liebert® Trinergy™ Cube

Liebert® EXL S1

Tradition vs Innovation

Assuming that a 1 MW system is tested using a traditional load bank test and compared to a safe capacity test, the differences in terms of money and time for load bank connections and burn-in tests can be seen in the table and graphs below:

Operation	Traditional Test	Safe Capacity Test
Cable Connection to Load Bank [1]	8 h	0 h
Burn-In Test	24 h	24 h
Load Bank Rental (weekly)	4000 ÷ 7000 €	0 €
Electrician Expense for Cable Connection [2]	80 €/h	0 €
Energy Waste [3][4]	2.40 €	100 €
Total Time	32h	24 h
Total Money [5]	> 8000 €	100 €

1 Installation and dismantling by an electrician
2 Labour hours referred to the load bank connection
3 Considering 24 hours operation at full load at an average electrical utility rate of 0.1 €/kWh
4 Considering an AC/AC UPS efficiency of 96%
5 Considering an average weekly rental cost of 5,000 €

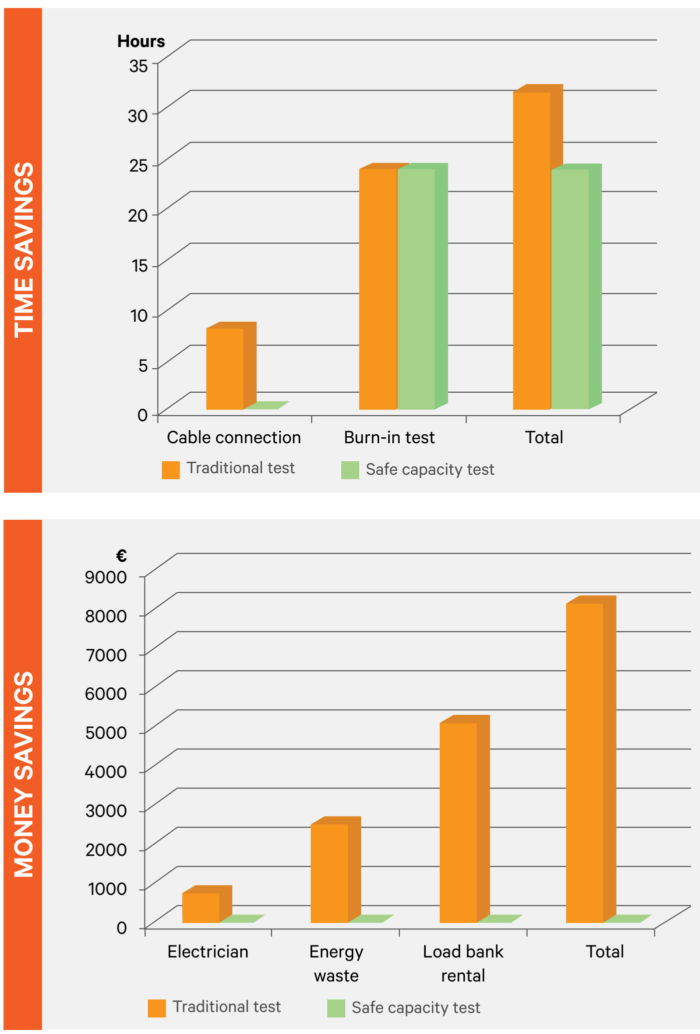

Figure 3: *Comparison Charts – Traditional Test vs Safe Capacity Test*

The end results of the safe capacity test vs traditional load bank test are:

- Cost savings: no load banks to rent
- Quick operation: no temporary load connections to make
- Green operation: no wasted energy
- Safe operation: less hazardous due to minor electrical activities

The Safe Capacity Test: Working Principle

Understanding how the safe capacity test works is simple: instead of flowing directly from the double conversion chain to the load, power is forced to follow a closed loop circulation from the inverter back to the rectifier through the static bypass.

This continuous circulation of power allows the converters to be loaded and energized as if the UPS were connected to a traditional load bank test, but with the enormous advantages of energy consumption being maintained at a minimum level. In fact, energy dissipation during circulation is just that related to the UPS AC/AC efficiency which is dissipated into heat.

State-of-the-art UPS have an average double conversion efficiency higher than 96%, thus, the energy dissipated is less than 4% of the overall power circulating into the loop, which makes the safe capacity test an eco-friendly and energy saving solution.

In order to allow the continuous circulation of power, the UPS software uses a digital control technique to adjust and modify the phase angle of the inverter output. This is feasible because the inverter and the static bypass are in parallel and the power flow between parallel voltage sources is easily manipulated by varying their phase angle. If one of the sources has a wider phase angle than the other, it is in a leading state and in a condition of delivering power.

This is the situation we can find during the safe capacity test. Initially, when the power is introduced from the mains, the double conversion mode starts operating normally, but when the test begins, the static switch is opened and the inverter - now in parallel with utility - varies its output phase angle to deliver power to the static switch and allow a closed loop. The wider the phase angle, the higher the power delivered by the inverter. At this point, in order to avoid the reintroduction of power into the mains, the rectifier absorbs power and produces direct current to support the inverter and complete the power circulation.

During this entire process, the UPS is capable of testing its own power train and components because the calibrations and measurements are the same as if the test were performed with an external and expensive load bank.

From an operational standpoint, when the test is performed, the appointed service technical field engineer opens the output switch of the UPS and activates the safe capacity test by simply setting a dedicated UPS parameter. Subsequently, the technician sets up the active (P) and reactive (Q) power that must be supplied (thus indirectly setting up the phase angle as well). This couple (P & Q) will simulate the load.

In particular:

- Active power parameter (P): when enabled, it defines the active power amount in kW supplied to the bypass line by the inverter and is available only when the inverter is started.
- For this parameter, the minimum value is 0 kW while the maximum is equal to 120% of the maximum UPS active power.
- Reactive power parameter (Q): when enabled, it defines the reactive power in kVAr supplied to the bypass line by the inverter and is available only when the inverter is started. For this parameter, the minimum and maximum values are saturated at ± 120% of maximum UPS apparent power. A negative value means the generation of lagging reactive power while a positive value means the generation of leading reactive power.

Consequently, the two parameters above can be used to test the UPS at different load percentages (e.g.: 25%, 50%, 75%, 100%) up to an overload condition of 120%. The inverter, bypass and rectifier, indeed, simply let the energy flow as if they were powering a real load connected to the output of the UPS.

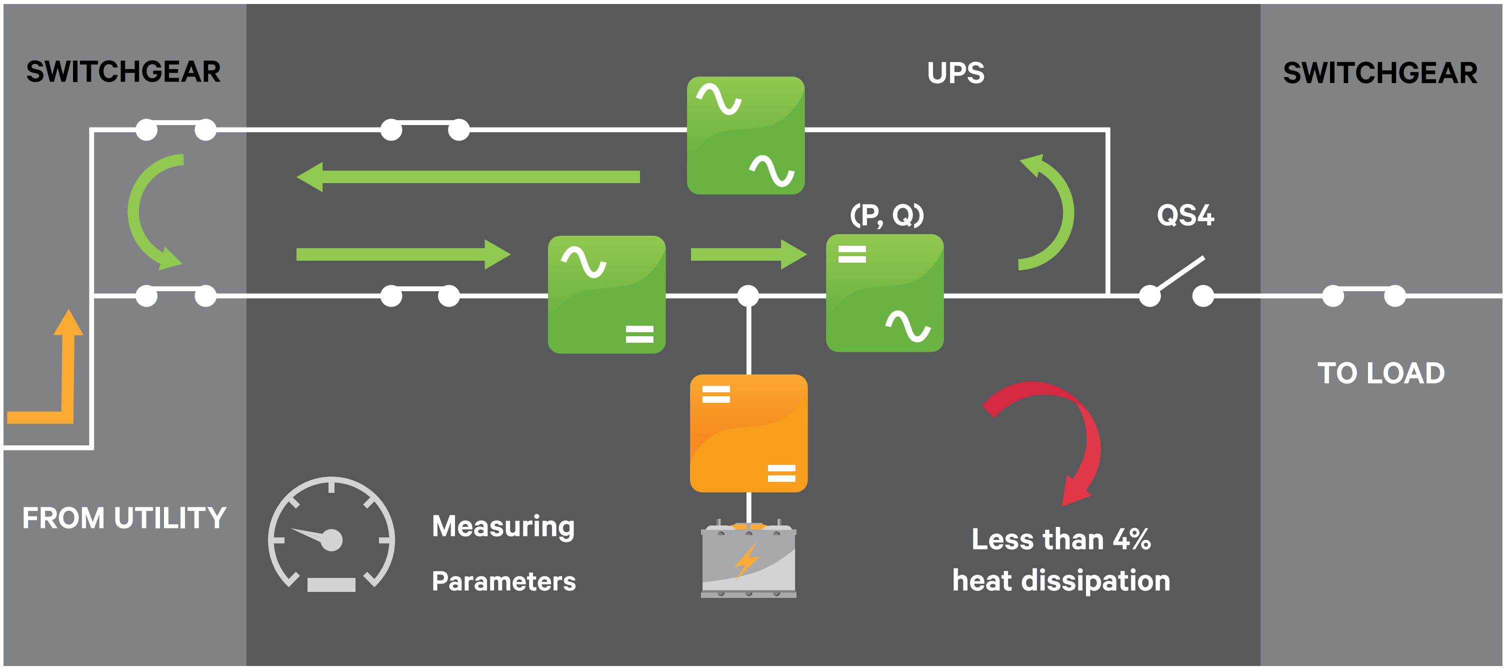

Figure 4: *Working Details of a Safe Capacity Test*

Safe Capacity Test: Typologies and Modes

1) Safe Capacity Test on a Vertiv™ Liebert® EXL S1

This test typology occurs when the inverter runs in parallel with the mains through the static bypass switch and energy circulates between the inverter and the rectifier in a closed loop. The safe capacity test is performed on all the Liebert® EXL S1 distributed parallel systems.

2) Safe Capacity Test on a Vertiv™ Liebert® Trinergy™ Cube

This safe capacity test described is also available with a multiple module system, such as Liebert® Trinergy™ Cube. The safe capacity test is performed on one Single core or on a Multiple core Liebert Trinergy Cube system.

3) Safe Capacity Test Modes

There are two safe capacity test modes of operation. They are referred to as burn in mode and battery discharge mode. Burn in mode refers to the mode of UPS energy circulation between the inverter, rectifier, and static switch reflected in Figures 5, 6 and 7 below. Battery discharge mode refers to the mode of UPS energy circulation between the battery, DC/DC converter, inverter, static switch and back to the utility feed as shown in Figure 8 below. Note: Battery discharge mode requires energy back feed into the utility. Other loads connected to the utility will be impacted by this mode of operation. The customer shall confirm that this is acceptable with the utility supplier prior to activating this mode of operation.

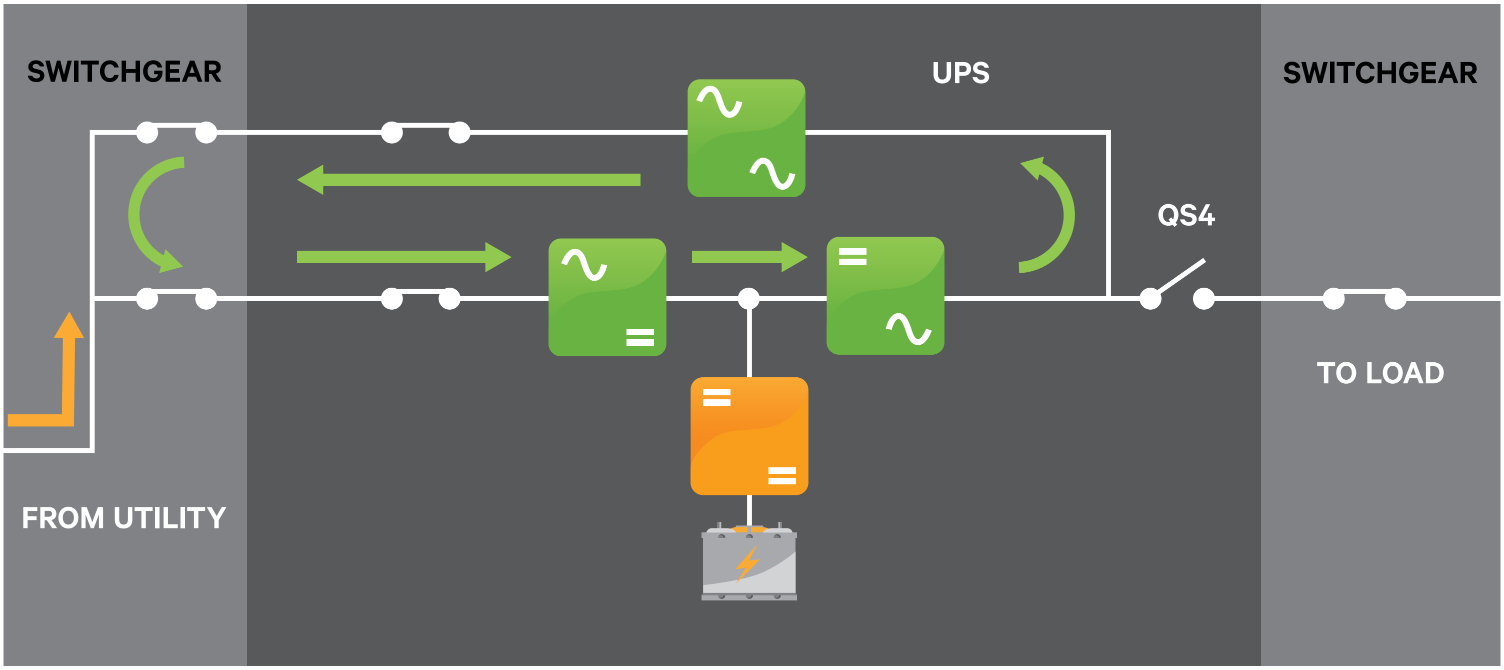

Figure 5: *Safe Capacity Test on a Liebert® EXL S1 System*

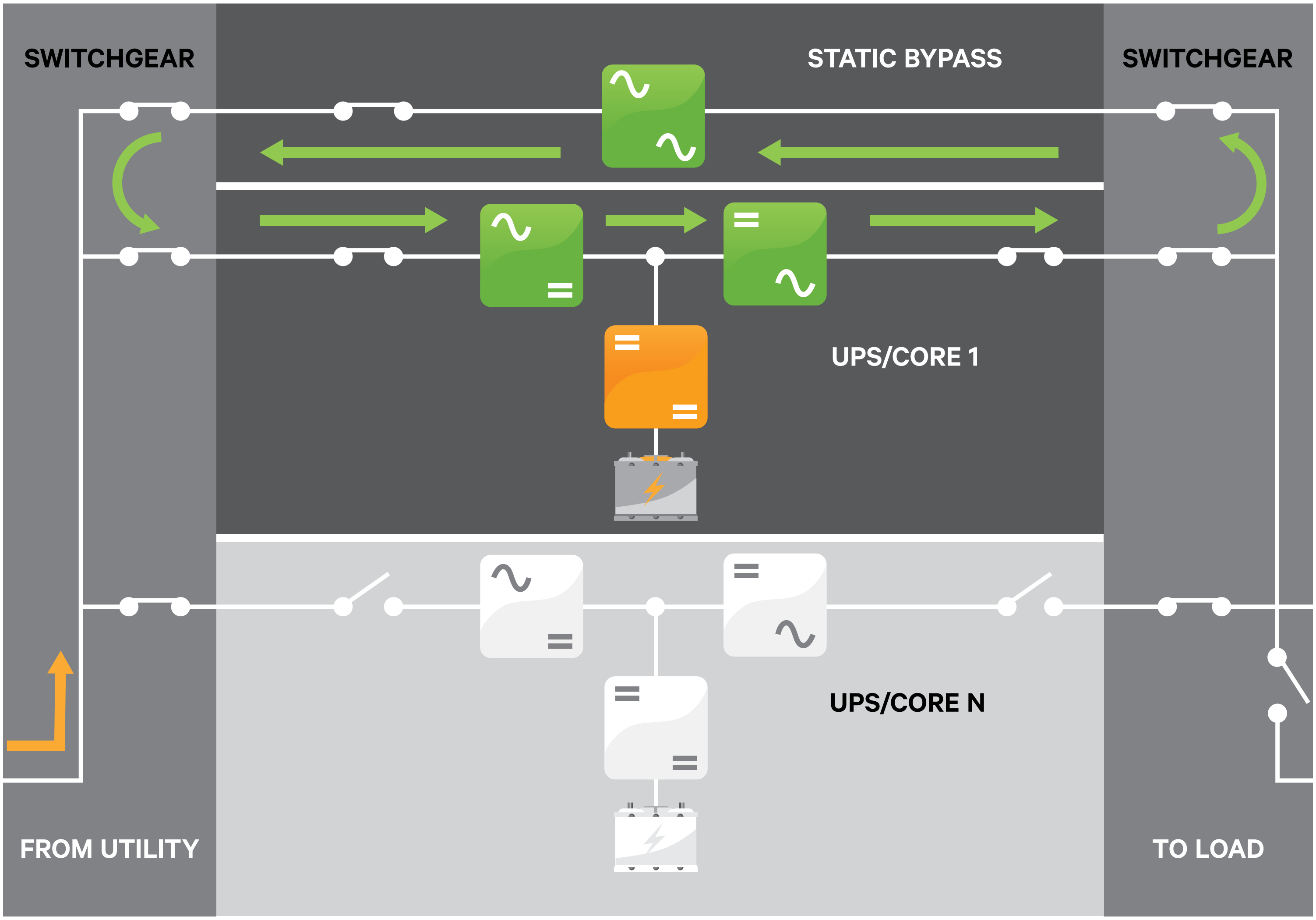

Figure 6: *Single Core Safe Capacity Test on a Liebert® Trinergy™ Cube System*

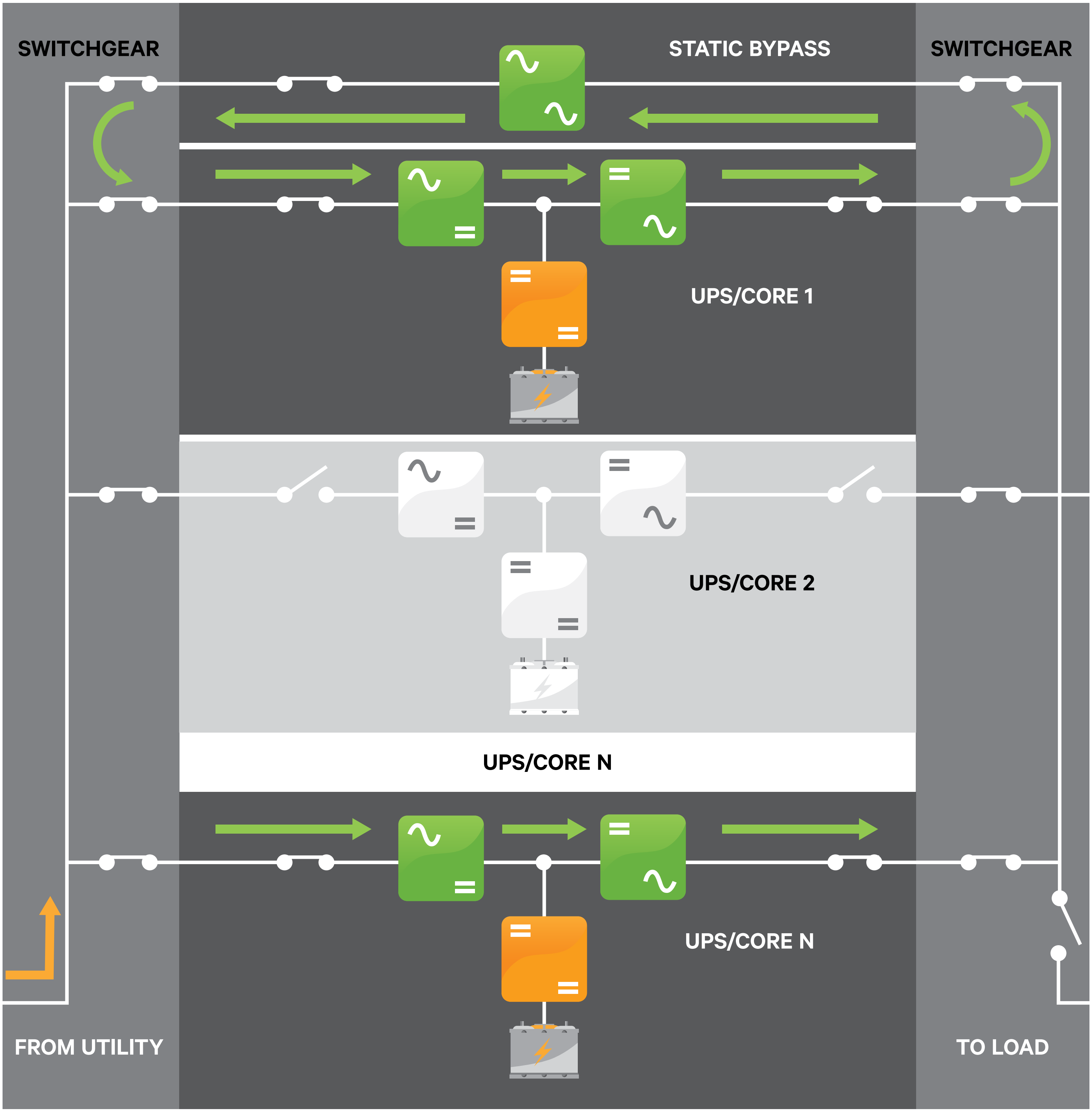

Figure 7: *Multiple Core Safe Capacity Test on a Liebert® Trinergy™ Cube System*

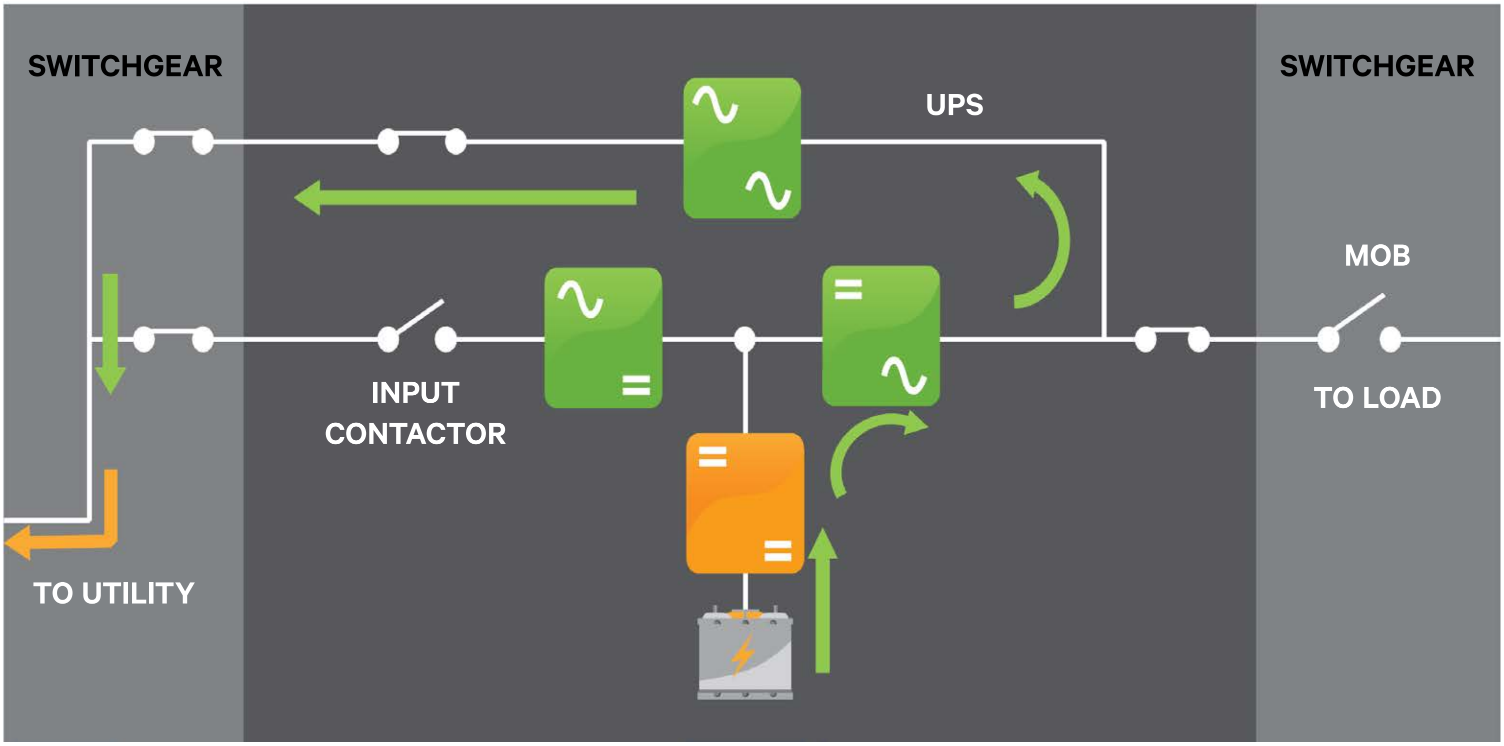

Figure 8: *Safe Capacity Test Battery Discharge Mode*

Safe Capacity Test: Benefits

Money Savings
The safe capacity test eliminates the need to rent a load bank and the waste of energy related to its use.

Time Savings
The safe capacity test can be performed easily and swiftly by a service technical field engineer without requiring special equipment, saving time needed to install, connect and further dismantle the load banks to the UPS output.

Energy Savings
The safe capacity test is an eco-friendly approach, since the only energy losses come from the heat dissipation of converters. As a consequence, energy consumption is highly reduced if compared to a traditional load bank test.

Risk Savings
The safe capacity test eliminates all hazards and risks associated to the use of load banks, such as their movement, noise and temporary connections.

Flexibility
The safe capacity test can easily be performed directly on-site during commissioning, after a system repair or upgrade, as well as during preventive maintenance. The test does not require special equipment and, above all, it avoids the possibility of hard and laborious cable connection through doors and panels.

Safe Capacity Test: Conclusions

The safe capacity test is an alternative and more effective method of testing the capabilities of a UPS by simply allowing the circulation of power in a closed loop inside the unit, then from the inverter and back to the rectifier through the static bypass. Moreover, the test eliminates all expenses in terms of time, money and energy consumption associated with traditional load bank testing. All these features, combined with the substantial reduction in terms of risks and complexity during operations, make the safe capacity test a highly flexible and practical testing methodology.

Vertiv.com | **Vertiv Headquarters,** 1050 Dearborn Drive, Columbus, OH, 43085, USA

SL-70855 (R09/22)