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Modular Power Protection Concept for Mission and Business Critical Application

Abstract

This document describes a new *Modular Power Protection Concept (MPPC)* for mission and business critical applications that enhances the overall availability of the power supply. High availability of uninterruptible power supplies is of paramount importance for continuous operation of data-centers, telecom equipment, health care equipment, traffic control, banking transactions etc. The new MPPC is based on the latest modular (rack-mount) three-phase transformer-less Uninterruptible Power Supplies (UPS) technology.

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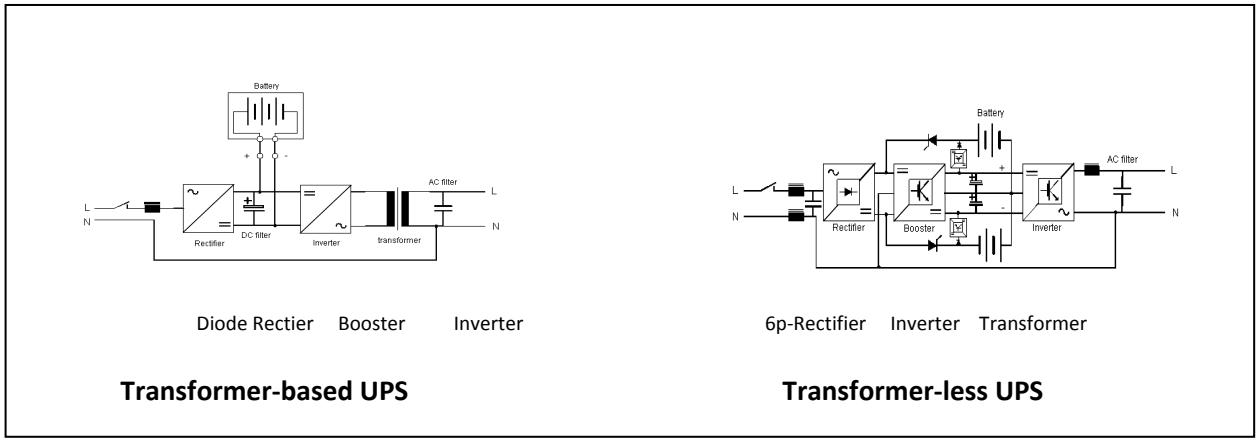
Introduction

The traditional transformer-based UPS-technology has achieved its limits in terms of further technological improvement. With the exception of minor hardware and software corrections the transformer-based UPS-technology does not allow additional technological developments that would provide true benefits. The integrated bulky output transformer, the obsolete controlled SCR input rectifier stage and the traditional PWM-inverter switching technology are the limiting factors. The obvious step forward in qualitative development of the UPS-technology was to design a new three-phase UPS-technology *without the output transformer, with a non-controlled diode rectifier stage followed by an advanced booster stage and a new energy saving inverter switching technology* (see Fig. 1)

Fig. 1 Block-diagram of Transformer-based and Transformer-less UPS-technology



Modular Power Protection Concept

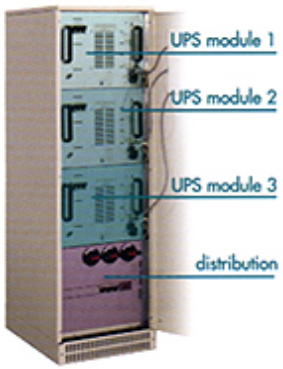
The transformer-less UPS-technology has opened new ways for the development of a new *Modular Power Protection Concept* with considerable beneficial effects. The high power density of the new transformer-less design has set new standards in the future of power protection systems. The MPPC is composed of the following key features: *Modularity, Redundancy, Upgradeability, Environmentally Friendly, Serviceability.*

Modularity

The high power density of the transformer-less design has provided the opportunity to develop hot-swappable 19”- rack-mountable 3-phase modules with nominal power of up to 45kVA and with a maximum weight of 60kg. Up to 5 modules can vertically be fitted in floor-saving racks reaching a maximum power of 225 kVA per rack (see Fig. 2 shows 120 kVA unit with 3 modules à 40 kVA).

Fig. 2. Photograph of a Module and Rack with 3 modules

40KVA UPS module



Redundancy

In order to reach higher availability of the power supply, modules are paralleled in (n +1)-redundant configurations. The *Availability (A)* of the power supply of a UPS-system depends on the MTBF (Mean Time Between Failure) and MTTR (Mean Time To Repair) of the UPS (see Eq.1).

$$A = \frac{MTBF}{MTBF + MTTR} \qquad \text{(Eq.1)}$$

The impact of MTTR on Availability is very high. The Availability (5-nines) of a Modular UPS system with MTTR=0.5[h] is higher than the Availability (4-nines) of a stand-alone non-modular UPS with MTTR=6h. See example in Table1.

Table 1. Comparison of Power Supply Availability of a Non-Modular and a Modular (Hot-Swappable) UPS-systems.

Type of UPS	Modular (Hot-Swap)	Non-Modular (Stand-alone)
MTBF [h]	100’000	100’000
MTTR[h]	0.5	6
Availability	0.999995	0.99994

Furthermore the replacement (repair) of a hot-swappable redundant is achieved without the need to transfer the load to bypass and therefore exposing it to unreliable raw mains power supply.

Upgradeability

The modular (hot-swap) design allows easy *upgrading* of the power by just adding modules into the Rack. The addition of modules is achieved without the need to transfer the load to bypass and therefore exposing it to unreliable raw mains power supply. This feature allows the step-by-step growth of the power protection depending on the growing computer power.

Environmentally Friendly

The elimination of the transformer and the new Energy Saving Inverter Switching (ESIS) Technology increases the efficiency of the new design by 5% as opposed to traditional transformer-based UPS-systems. This reduces the heat-emission to the environment of the transformer-less UPS by up to 50% with regard to the traditional transformer-based UPS-systems (see Table 2). Furthermore by eliminating the transformer from the UPS the total weight of the UPS is reduced by approximately 50%. The low heat emission and the reduced use of natural resources results makes the transformer-less design an *environmentally friendly* design.

Table 2. Comparison of UPS-losses of transformer-less and transformer-based UPS-systems

Type of UPS	Transformer-less	Transformer-based
NominalPower [kVA/kW]	100/80	100/80
Efficiency [%]	94%	89%
Losses [kW]	5.1	9.9
5-Years Cost (US$)	33’507	65’043

Serviceability

The IGBT-Booster stage corrects the input P.F. to almost unity and reduces the input current THD to a value of 8%. This circuit replaces the need for additional bulky and inefficient 12pulse rectifiers and/or passive filters that often generate more problems than they help to solve.

Serviceability is substantially improved by the modular technology, because modules can be swapped out for service, even by lower qualified electricians. thanks to the hot-swap design the MTTR is massively improved to less than 15 minutes. Access to the module is always via the front so that utilization of floor space can be optimized (see Fig. 3).
A further feature of the Modular Design is the capability to parallel and operate Modules with different power ratings 10, 15, 20, 30, 40 or 45kVA. If there are UPS-configurations with different modules in different sites, it is sufficient to keep in stock just the largest Module of 45kVA, because the 45kVA can replace any other module. This dramatically reduces the spare parts stock.

Fig.3 How a module can be extracted from the rack via the front access.

Conclusion

The transformer-less UPS-technology has opened new ways for the development of new Power Protection Concepts. The Modular Power Protection Concept is one of the important steps in the development of UPS-technology and its adaptation to the needs of modern IT, Telecom and other critical equipments. As opposed to transformer-based technology the transformer-less technology is not limited in its technological development and therefore we can expect in future, higher availability, reduction in size, higher efficiencies and better electrical performance.

References:

[1] Reliability Engineering Theory and Practice, *A. BIROLINI ,Prof. Dr. ETHZ*
[2] Uninterruptible Power Supplies Handbook, *Peter Bentley EING MIIE, David Bond*