ADVANTAGES OF A TRANSFORMER-BASED UPS SYSTEM

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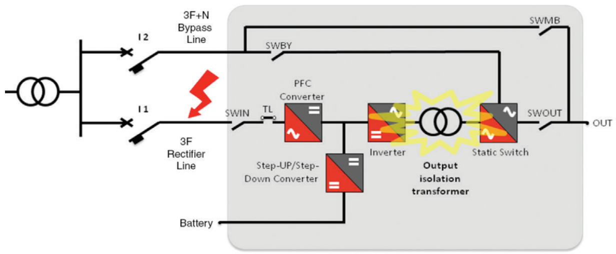
Introduction

Recent Whitepapers have point out the advantages of transformerless UPS: less weight, flexible installation, energy efficiency, money savings.
However, transformerless UPS are better suited for large energy efficient applications where the tolerance for downtime is acceptable under certain circumstances and where there is a transformer installed somewhere else in the electric path.
This literature has made it sound like transformer-based technology in UPSs is obsolete and should be avoided.
Nonetheless, there are still critical applications requiring a nine nines rate which in turn need a transformer-based UPS.
For that reason, we are listing below the advantages of transformer-based UPS:

- Galvanic isolation
- Independent mains power supplies
- Dual load protection from DC voltage
- Providing galvanic isolation and recreation of a fixed TN-S System (grounding system) without reducing operating efficiency
- Providing a higher phase-neutral inverter short circuit current than a phase-phase short circuit current
- Superior power protection when presented with power quality problems
- Greater robustness with respect to back feed protection

1 Galvanic Isolation

The diagram shows a single transformer-based UPS system in its standard configuration. The UPS system has two alternating current (AC) power inputs: the rectifier (l1) and the bypass (l2) supplied from a single connection to the mains power supply (or a generator).

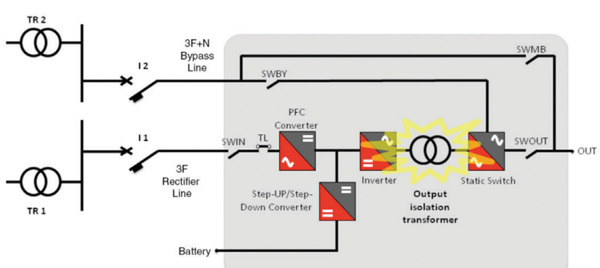


With an AC power supply present (I1), the power supply to the load comes from the Static Switch from the secondary winding of the Output Isolation Transformer. The Rectifier/PFC Converter is connected to the AC power source (I1) and is used to generate the direct current (DC), which in turn charges the Battery and powers the Inverter.
When the primary AC power supply fails (I1), the Inverter receives the power supply directly from the Battery. If a fault occurs the load is automatically transferred to the Bypass (I2), if available, through the Static Switch. With Galvanic isolation between the two AC power sources (I1 and I2) – the Rectifier and the Bypass – the load is protected from electrical faults (or fault migration) on either AC power source and receives a continuous AC supply.
Transformerless UPS do not include an Isolation Transformer as part of their standard design – hence the name. To achieve the same level of AC supply isolation and fault tolerance, transformerless UPS must be installed with an additional Isolation Transformer; either on their output or input. This can lead to a larger initial investment and higher Total Costs of Ownership (TCO) due to a higher installation cost.

In a transformer-based UPS, the Rectifier AC supply (I1) only requires a Delta three-phase, three-wire AC supply (with no neutral). This is because the Inverter output is referenced to the incoming neutral on the secondary side of the Output Isolation Transformer. The Bypass AC supply (I2) must be a three-phase, four-wire (with neutral). This configuration allows the transformer-based UPS to receive the power supply from two separate earthing arrangements and prevent input earth or Rectifier/Battery faults from disrupting Bypass operation. In contrast, a transformerless UPS requires a neutral from (i) the AC supply as part of Rectifier/Booster circuit and mid-point battery bank configuration and (ii) the bypass supply.

2 Independent mains power supplies

The Output Isolation Transformer allows the UPS to be connected to two separate inputs (for the Rectifier and Bypass) and even two independent power sources (TR1 and TR2). This can further increase UPS system resilience and improve availability of the load.



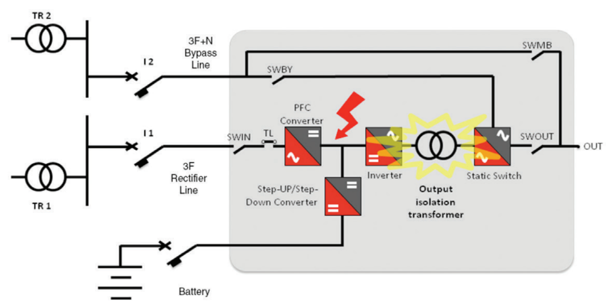
3 Dual load protection from DC voltage

The inherent Galvanic isolation of the Output Isolation Transformer provides a dual protection. Connected UPS loads and the UPS Battery Bank are protected from the potential damage that can result from:

• Internal UPS DC faults, which could affect the output supply to connected loads.

• The potential for DC voltage disruption of the AC Inverter output waveform, following a component failure.

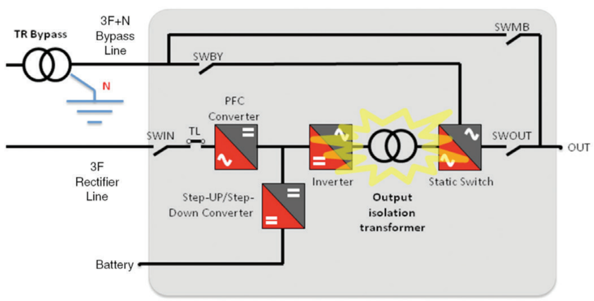
The UPS output is an AC waveform generated from a DC source, from within the UPS itself. Potential DC sources include the Rectifier/PFC Converter and Battery Bank (and/or DC Flywheel or Super Capacitor Bank).



Any DC voltage present on the Inverter output AC waveform (due to a fault) can lead to damages on the connected IT equipment or to the activation of their internal protection systems. This is a rare but potentially detrimental problem for connected loads. Its severity can be limited by active monitoring of the UPS Inverter waveform for DC voltage and IGBT (Insulated Gate Bipolar Transistor) failure within the UPS itself. In either scenario, a transformerless UPS will immediately transfer the load from the Static Switch to the Bypass supply. In fact, the transformerless UPS has a higher potential for letting DC voltage pass through than a transformer-based UPS because DC voltage cannot pass through the transformer itself.

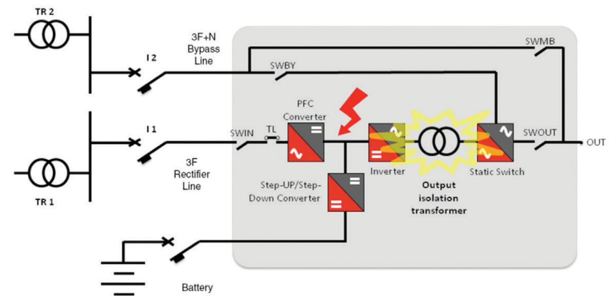
4 Providing galvanic isolation and recreation of a fixed TN-S system (grounding system) without reducing operating efficiency

The Inverter Isolation Transformer provides the opportunity for full Galvanic isolation between the mains and the load via the installation of a Bypass Isolation Transformer (TR) upstream of the bypass line.



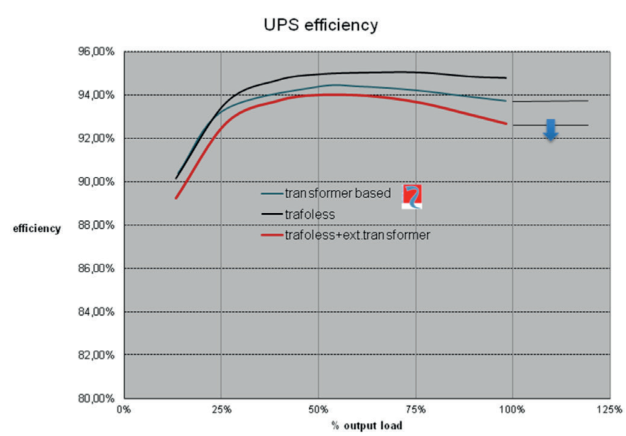
UPS with Inverter Output Isolation Transformer and Bypass Isolation Transformer

With the Bypass Isolation Transformer upstream of the bypass connection, full power does not pass through except when the load is transferred from Inverter output to the Bypass and back. The only additional efficiency losses (during normal system operation) are those related to the bypass supply being available – but not under load. Achieving the same design configuration using a transformerless UPS requires the installation of an additional Isolation Transformer (at the input or output) with full power running through and under all operating conditions.
The addition of a separate Isolation Transformer to a transformerless UPS design introduces two further issues:
• The overall system efficiency can decrease by 2-3% on average and up to 1.5% at best.
• The transformer can introduce a single point of failure into the UPS design as the load cannot be directly connected to the Bypass supply.



Transformerless UPS with output isolation transformer

A comparison between the two systems shows how the overall AC/AC efficiency of a transformer-based UPS with an Isolation Transformer on the inverter output is greater than that of a transformerless UPS with an additional Isolation Transformer (even when no-load losses of the transformer upstream of the bypass are taken into consideration).



Other issues resulting from the addition of an external Isolation Transformer to a transformerless UPS installation include:
• poorer dynamic response and output voltage distortion (on load) than a transformer-based UPS with a built-in Output Isolation Transformer.
• an overall lower short circuit current than the design rate because the external Isolation Transformer reduces amplitude towards the load.
• reduced output power from the UPS, due to additional transformer losses.
• a larger overall footprint than that of a transformer-based UPS with its built-in transformer.

5 Providing a higher phase-neutral inverter short circuit current than a phase-phase short circuit current

In a transformerless UPS, the short circuit current set by the Inverter usually has the same value whether the downstream short circuit is Phase-Phase or Phase-Neutral. In a transformer-based UPS, the short circuit current value set by the Inverter is greater if the downstream short circuit is Phase-Neutral, as opposed to Phase-Phase. This higher short circuit current provides improved protection downstream of the UPS, even when the UPS is operating without a mains or bypass supply.
In its standard configuration, a transformer-based UPS is therefore more suited to installations with long cable runs and several protection levels.

6 Superior power protection when presented with power quality problems

Both transformerless and transformer- based UPS are designed to protect their loads from power quality problems. A transformer-based UPS provides a higher degree of power protection, especially when installed in one of the configurations described in sections 1, 2 and 4. This is predominantly due to the Galvanic isolation of the Isolation transformer described above, which is more suited to tackling mains disturbances on the supply phases and provides a more robust design.
To match the power protection and electrical performance of a transformer-based UPS design, a transformerless UPS must be installed with an external Isolation Transformer. The downsides include a largest initial investment and a lower overall operating efficiency.

7 Greater Robustness with respect to back feed protection

In a transformer-based UPS, the Output Isolation Transformer allows the UPS to power loads, such as motors (with four-quadrant drive systems) and industrial devices without disruption.

Even when this type of loads is installed with back feed protection, they can disrupt transformerless UPS operation and force a transfer to bypass. For a transformer-based UPS, the only requirement is to size it correctly to cope with the power demands and waveforms of this machinery.

Conclusion

When you install a transformer-based UPS, you know the efficiency, operating costs, active power, and footprint from day one. In other words, you don’t get surprises.
In fact, to achieve the same robustness and protection of a transformed-based design with a transformerless UPS you must install an external Isolation Transformer.
As a result, you may end up with higher operation costs, a greater initial investment, a largest footprint and less efficiency. Also, you may introduce new single points of failure.
Therefore, if you cannot afford downtime in your critical facility and want to avoid installing an external isolation transformer (and, in turn, preventing all the potential problems), you need a transformer-based UPS to achieve a higher degree of power protection.

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