White paper

BLIXT X-Verter® Technical Introduction

Background

While Blixt's solid state circuit breaker technology enables full control of the current flow, the X-Verter® addresses voltage control. It allows electricity conversion to be controlled by software only, and not by hardwiring static conversion systems as it is done today.

While the power conversion market has developed over the past decade, there is still no conversion technology that enables an efficient and scalable volume production, extendable power conversion systems, with high efficiency levels across the entire load spectrum, and is adaptable to all types of use cases and voltage levels (low, medium, and high voltage). Existing systems also lack system modularity and observability to adapt to the surrounding environment and do not support integration of multiple energy storage technologies to provide built-in storage.

Our solution, the X-Verter® technology, is a generic voltage control technology. This technology combines the modularity of modular multilevel converters (MMC), with the flexibility of next generation reconfigurable battery system (RBS), and the advantages of solid-state transformers.

How it works

The X-Verter® is a switching power conversion technology that is developed by BLIXT. It shares similarities with modular multilevel power converters, reconfigurable battery systems and solid-state transformers.

Battery Energy Storage Systems (BESS)

Batteries are widely applied for energy storage, power supply, transportation, power systems, communication networks, etc. With new emerging technologies, such as vehicle electrification and renewable energy integration, the demand for batteries has skyrocketed the past few years. To meet various voltage, power, and energy requirements in large-scale applications, multiple battery cells have to be connected in series and/or parallel.

While battery technology has advanced significantly in the past decade, existing battery management systems (BMS) mainly focus on state monitoring and control of battery systems packed in fixed configurations. In fixed configurations, though, the battery system

performance is in principle limited by the weakest cells, which can leave large parts severely underutilized.

In addition, when deploying these systems, they all require inverters, rectifiers, cooling and additional monitoring systems. If the required input or output voltages change or the system needs to switch from AC to DC, the supporting hardware cannot be upgraded but needs to be completely replaced.

Reconfigurable Battery Systems (RBS)

A reconfigurable battery system has several benefits, as every cell can be addressed individually.

- **Enhanced Fault Tolerance:** Defect or malfunctioning cells can be isolated immediately without impacting the battery as a whole.
- **Charge and Temperature Balancing:** Charging and discharging can be optimized on a cell level, improving lifetime of a cell and also minimizing the required thermal management solutions.
- **Extended Energy Delivery:** Charging and discharging can be optimized on a per cell level, and taking the temperature into account, each cell can give it maximum power output or charged at a maximum level.
- **Coordinating Batteries of Different Age or Chemistry:** Battery cells of different chemistry or age can be combined into the same system, and their usage optimized based on their individual parameters.
- **Customized Terminal Ranges:** An RBS system can feed a different voltage to each terminal, depending on the requirement of the load, and only implemented by the software configuration of the system.

Modular multilevel converters (MMC)

Modular multilevel converters (MMC) describe an architecture, that consists of basic building blocks and are stack able and therefore scalable and can be used to build systems for any voltage level.

The MMC technology is already used in high voltage DC (HVDC) applications, but its use in low voltage and other application areas, for example in EV batteries, is still an unexplored area.

Unique properties of the X-Verter® technology

Software based Configuration Management

The X-Verter® supports any power input (AC or DC) and can be configured in real time (runtime) to provide any voltage and ampere output – far more flexible than any traditional inverter or rectifier. All conversion paths are bi-directional conversion paths. Every terminal can have a custom output voltage, based on its software configuration.

Modularity

The fundamental building block for the X-Verter® is the cell. This results in several advantages regarding production, product design, but also technical functionality. The control software manages the cells to control the output voltage and current, and cells of different types can be mixed to deliver the optimal power output. By adding more cells the X-Verter® capacity can be upgraded, making it a flexible system.

Storage

Each X-Verter® cell contains an energy core, which can be a battery cell, a capacitor, or a transformer. Using batteries as a core means the X-Verter® has built-in storage and replaces the need for inverters, rectifiers - as well as batteries. Unlike any other battery system, the X-Verter® can bypass defect cells and allows for cells of different types to be mixed.

Unmatched Conversion Efficiency

Critically, the X-Verter® does not use traditional pulse width modulation. Unlike the current state-of-the-art switching converters, the X-Verter® has no switching and deadtime losses, due to its unique design. It delivers near maximum efficiency at all power ranges, which significantly improves the performance compared to normal inverters.

Flexible and Fast

Voltage in/output can be modified by the X-Verter® in less than 5µs (microseconds). Voltage amplitude and frequency output is determined by the X-Verter®'s control software and can range from low to high voltage without any additional efficiency losses.

Application Areas

A more efficient and flexible voltage converter technology brings advantages to several areas within power conversion and storage. For example, being able to charge and discharge each battery cell in an optimal way will increase the efficiency, quality and lifetime of a battery. Additional benefits include reduced power losses and a modular and flexible system that can adapt to all in- and output levels, while also reducing the need for active cooling.

Sub stations: Full control over the power flow providing high power quality, while integrating storage in the same system.

Battery: Mix cells with different chemistries, bypass defect cells, optimize charging /discharging and less active cooling needs.

Solar: Unmatched conversion efficiency and better utilisation of the solar installation, more compact design and modular upgradable system.

EV charging: Enables V2G systems with its bi-directional conversion system and reduces the conversion losses during fast charging cycles.

UPS: Full insight of power flow, responds to power quality issues immediately and able to run like a micro-gird in island mode.

E-mobility: Removes the need for rectifies and inverters and active cooling while integrating storage in the same system.

Use case: Grid scale solar

Solar inverter with unmatched efficiency, built-in storage and compact design.

The high volatility in solar power production results in several challenges. A solar installation without storage might need to reduce the production if the energy cannot be consumed, which is a waste of energy. Adding grid storage requires an additional building site, large investments and results in additional conversion stages and power losses. But what is we could offer a distributed battery with inverter?

Any X-Verter® based system can contain storage. This means no external battery is needed. Replacing the inverters in a grid scale solar installation would not only provide superior conversion efficiency, but also onside storage without adding more conversion stages.

Through its modular design, defect battery cells can be bypassed, and therefore not impacting the whole system. The system becomes more reliable, with build in redundancy, leading to higher availability but also less unscheduled system maintenance.

Additionally, the cell-based structure of the X-Verter® means we can build up any kind of inverter-storage system, from grid scale down to residential solar installations.

Market Size:

- Grid Scale Energy Storage: $40 Billion by 2030 Market Size [1]
- Residential Energy Storage: $6.3 billion in 2019, to $17.5 billion by 2024 [2]
- Solar Inverters: $8.4 billion in 2019 (residential and utility scale) [3]

Use case: Distribution transformers

Substation with increased conversion efficiency and energy storage on the local distribution level.

With increased electrification transformer stations are facing new load profiles they were not built for, resulting in transmission losses and additional severe challenges for the grid infrastructure.

Transmission and distribution network losses are important because they represent a global economic loss of more than US$61 billion annually and annual greenhouse gas emissions of more than 700 million tons. And one third of network losses occur in transformers, and of these transformer losses, seventy per cent occur in distribution transformers. [4]

The new X-Verter® based distribution transformer can solve much of this by equalizing the phases, reducing harmonics, and controlling the power factor in real time - supporting the grid in ways not possible before.

With zero switching and deadtime losses and constant high efficiency it can also contribute to reduced transmission losses. Moreover, it can act as a battery to store excess electricity from local solar and balance peak loads. Real time monitoring provides insights to network operators who can manage the system remotely by software programming. It is a future proof system that supports both AC and DC without any hardware changes - only a software configuration away.

Market Size: Distribution transformer market is estimated to $32.58 billion by 2028 [5]

References

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[4] https://www.aceee.org/files/proceedings/2002/data/papers/SS02_Panel3_Paper27.pdf

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