

Novel 3-Phase Unfolder Converter Architecture | USU Ref. C26004

Regan A Zane, Mahmoud Mansour, Sanat Rakesh Poddar

09/23/2026



Novel 3-Phase Unfolder Converter Architecture

Electrical and Computer Engineering

Abstract

This technology presents a novel solid-state transformer architecture that efficiently converts three-phase AC input into multiple output ports, including both AC and DC. The design addresses unique challenges posed by time-varying input voltages to achieve high efficiency, modularity, and reliable voltage sharing, making it suitable for advanced power distribution applications.

What It Is

Problem: Rising energy demand and integration of high-power loads strain existing grid-tied power converters, which face efficiency, reliability, and cost challenges with traditional multi-stage designs.

Solution: This technology overcomes efficiency and integration challenges by enabling modular, high-performance multi-port power conversion with natural voltage sharing and reactive power control using a streamlined single-frequency stage.

Value Proposition

This technology delivers higher efficiency, improved reliability, and cost savings in medium-voltage power conversion, enabling compact, flexible, and scalable grid-connected systems for modern energy demands.

Applicable Markets

Electric vehicle charging, renewable energy, and data centers – providing fast, compact, multiport charging architectures alongside enhanced efficiency and reduced infrastructure costs.

Benefit

Conventional three-phase AC-to-AC power conversion architectures often require multiple stages, leading to increased system complexity, lower efficiency, and higher hardware costs. Additionally, existing solutions typically do not provide both AC and DC outputs from a single architecture, limiting their ability to interface with diverse loads and reducing hardware utilization. Furthermore, modular converter topologies typically require complex active control to achieve voltage and power sharing among modules, thereby increasing system cost and control complexity. There is also a lack of straightforward solutions to enable reactive power control in unfold-based topologies, which limits the ability to support grid stability and power quality requirements. The proposed architecture uses an unfold-based power conversion stage to directly convert three-phase AC input to three-phase AC output with a single high-frequency AC-AC conversion step (referred to as DCX-stage), thereby improving overall system efficiency compared to conventional multi-stage converters. The design also provides simultaneous AC and DC outputs, allowing multiple loads to be connected and improving hardware utilization. Additionally, the architecture incorporates an auxiliary converter for reactive power control, enabling grid support. When the DCX stage is used in a modular input-series-output-parallel structure, it achieves natural voltage sharing among modules, eliminating the complexity of active power-sharing controls. This novel 3-phase unfold converter architecture efficiently converts three-phase AC power with built-in electrical isolation while operating at a single frequency. Unlike conventional multi-stage converters that add complexity and reduce efficiency, it uses a high-frequency AC-AC conversion step to boost power density and system performance. Its modular design enables natural voltage sharing between units without complex controls, making it easier and cheaper to

scale for medium-voltage grid applications. By providing both AC and DC outputs simultaneously and integrating reactive power control, it improves hardware utilization and supports grid stability. This makes it a versatile and scalable solution for modern power conversion needs.

Market Application

This technology could be applied in the electric vehicle charging market as a tool to develop fast, compact charging architecture that supports high-power, multiport charging stations. It could also support the renewable energy market or data centers by providing enhanced efficiency, and a reduction in infrastructure costs.

Researchers

[Regan A Zane](#)

Mahmoud Mansour

Sanat Rakesh Poddar

USU Department: **USU College of Engineering: Power Electronics Lab (ASPIRE)**

Funding

This invention was made with government support awarded by the National Science Foundation. The government has certain rights in the invention.

USU Reference No. C26004

Intellectual Property

Provisional Patent Application Filed November 2025
(Status: Filed)