Skysong Innovations
Advancing the Arizona State University Knowledge Enterprise

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High Efficiency, Wide Voltage Gain Power Converter System

Power converters convert electrical energy (e.g., convert alternating current (AC) into direct current (DC) and vice versa, change the voltage or frequency of current, or do some combination thereof). Transformers are key components in power converters and transfer electrical energy from one electrical circuit to another circuit or multiple circuits. Transformers are used in power converters to incorporate electrical isolation and voltage step-up or step-down. Power converters requiring wide input and/or output voltage ranges with high step-up or step-down ratios are bottlenecked by the size and efficiency of their transformers. Here, the key challenge is that wide conversion ratios impose highly disparate operating waveforms on the transformer, yielding wide changes in copper loss and core loss over the operating regime. Thus, there is a need for better waveshape control on the transformer that also mitigates loss and allows for smaller power converter design.

A researcher at Arizona State University has developed a system for high efficiency, wide voltage gain power conversion. This power converter system is able to convert power with wide input and/or output voltage ranges having high step-up or step-down ratios with greater efficiency and in smaller sizes than conventional power converter technologies. This system can include a variable-inverter-rectifier-transformer (VIRT). The VIRT is a hybrid electronic and magnetic structure that enables a transformer with fractional and reconfigurable effective turns ratios. The VIRT has variable operating modes to assist with gain variation, but typically achieves wide operating voltage. This system allows the VIRT to operate with wide voltage ranges without also introducing a wide variation in core loss (i.e., loss in the magnetic material of the magnetic component). By controlling the switching operations of the VIRT, this system manipulates the applied voltage waveshape to achieve different output voltages rather than having to connect frequency and voltage gain directly. This innovation results in wide output voltage converters being significantly more efficient and potentially smaller.

Potential Applications:

- A high-efficiency low volume power converter system for use in, for example:
  - datacenters
  - electric vehicles (e.g., in an auxiliary power unit)
  - grid interface chargers
  - grid interface inverters
  - uninterruptible power supplies

Benefits and Advantages:

- Switching architecture connecting transformer gain to waveshape to best utilize properties of magnetic material
- Improve the size and efficiency of power converters requiring wide input and/or output voltage ranges with high step-up or step-down ratios
- Achieve arbitrary waveshape control on a transformer and connect this control to the gain of the transformer
- Greatly mitigate loss and provide simpler design for high performance