

"AC Cube": A Single-Stage PV/Battery/Grid Energy Router

System Overview:

✓ Objective

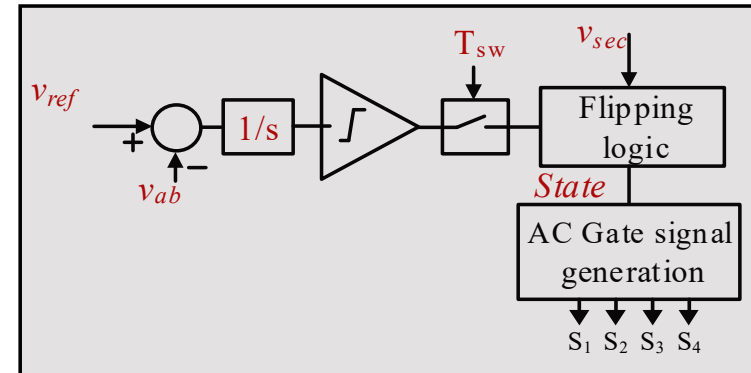
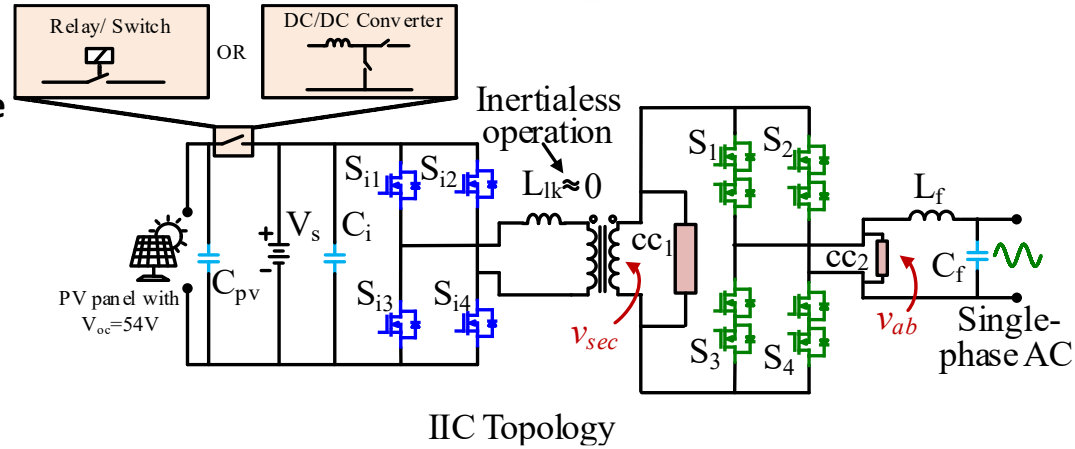
- Address the critical need for a **single-stage bidirectional isolated DC/AC converters** presenting low cost and simple control for off-grid DER applications

✓ System

- Inertia-less Isolated Converter (IIC) achieves single-stage bidirectional power conversion through an ultra-low leakage, coaxially wound transformer, and eliminates intermediate energy storage

✓ Power Sources

- Multiport operability directly from PV panels and/or battery pack



IIC Control

Operating Principle - Overview

✓ “DC Bridge” Operation

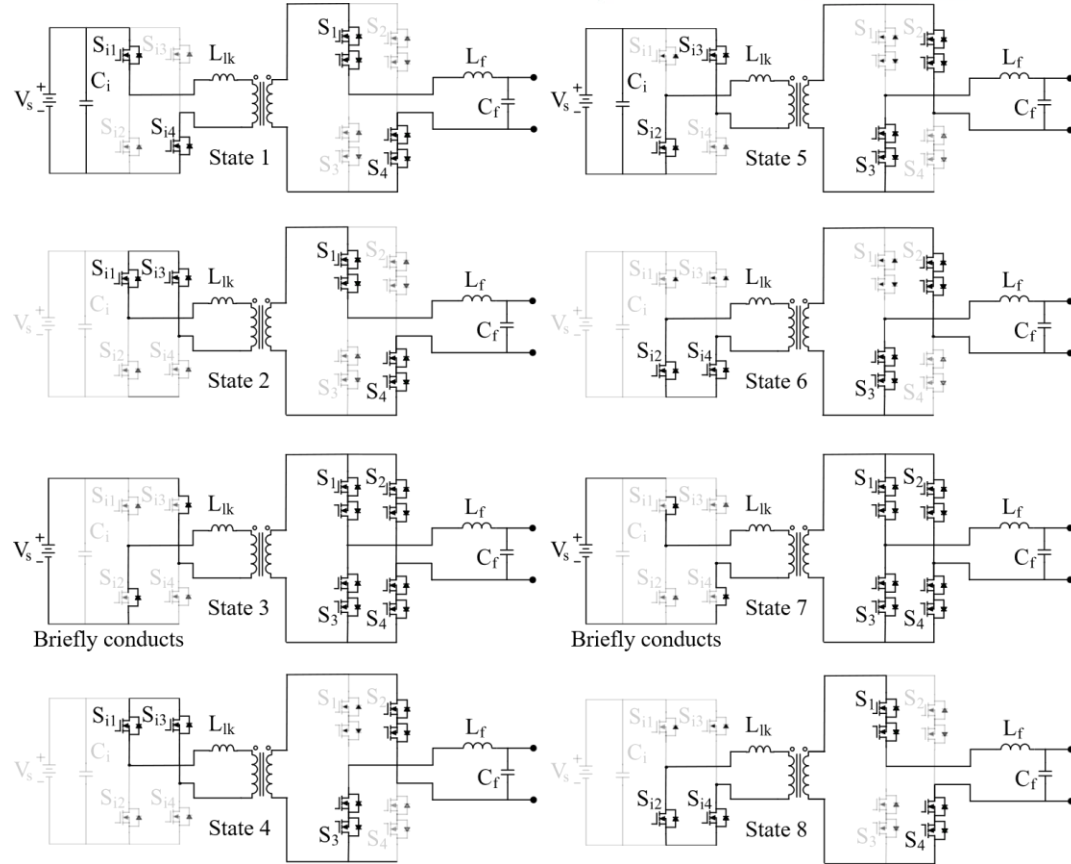
- High-frequency, quasi-square-wave with a zero-voltage duration forms a high-frequency link

✓ “AC Bridge” Operation

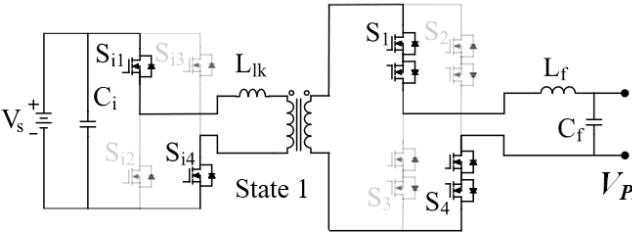
- Inertia-less Isolated Converter (IIC) achieves single-stage bidirectional power conversion through an ultra-low leakage, coaxially wound transformer, and eliminates intermediate energy storage

✓ ZVS/ZCS Operation

- The AC bridge zero-state (3, 8) enables ZVS switching transitions for all AC bridge devices, this transition state also enables the DC bridge to dissipate the leakage current and each ZCS switching transitions.

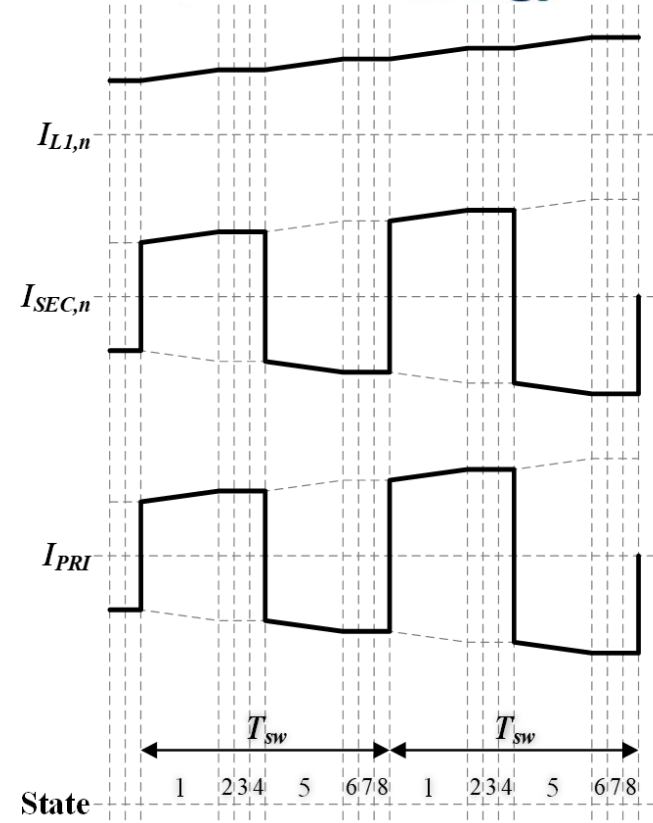
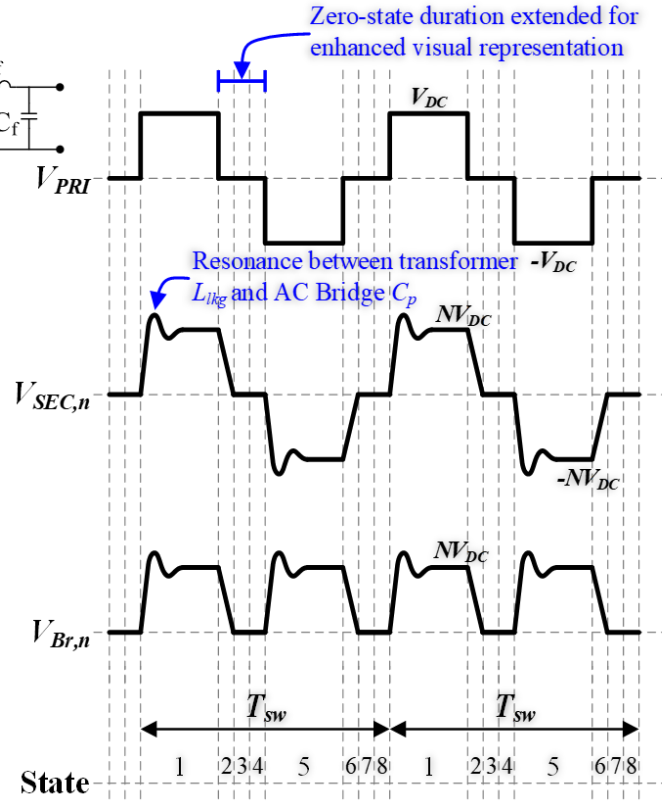


Operating Principle - Parasitic Consideration

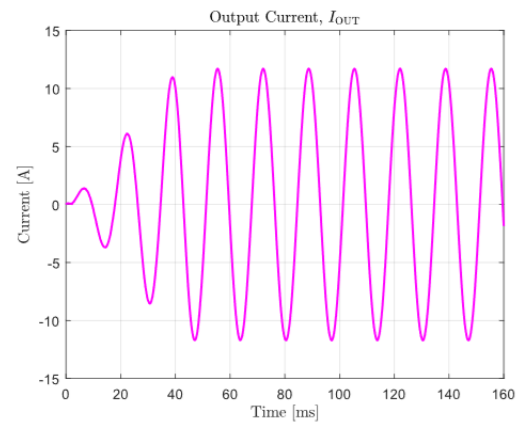
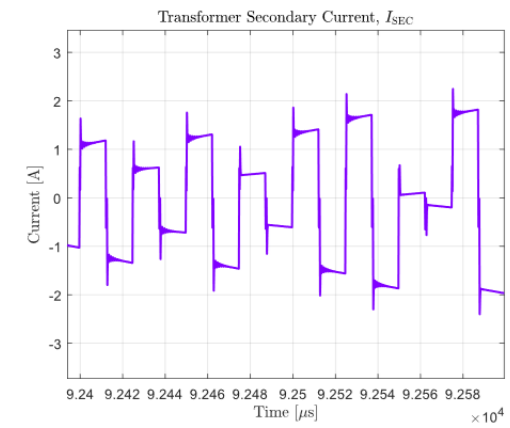
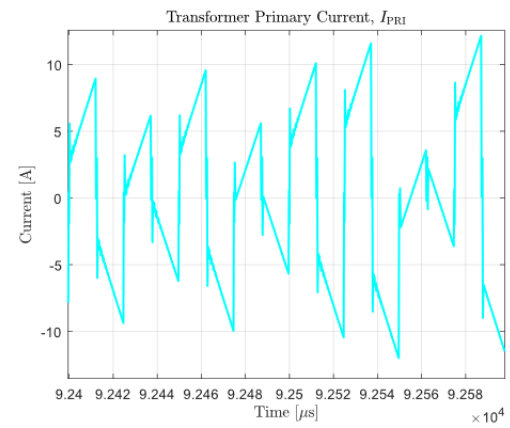
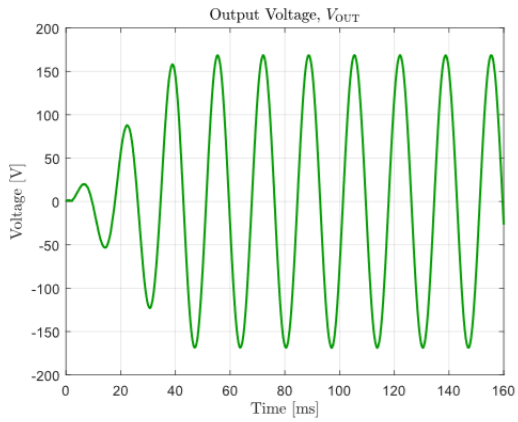
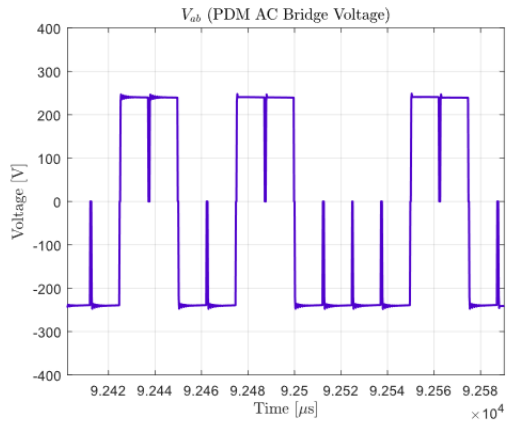
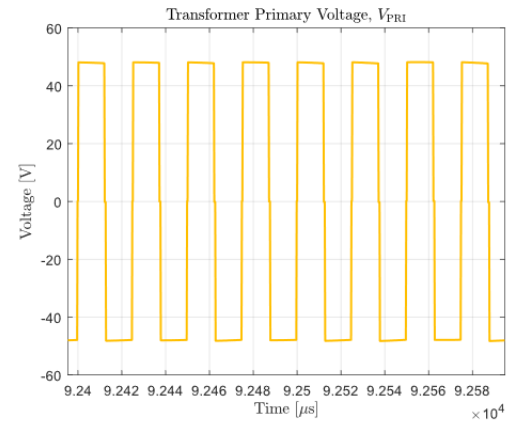


$$F_{res} = \frac{1}{2\pi\sqrt{(L_{lkg} \times N^2)C_p}}$$

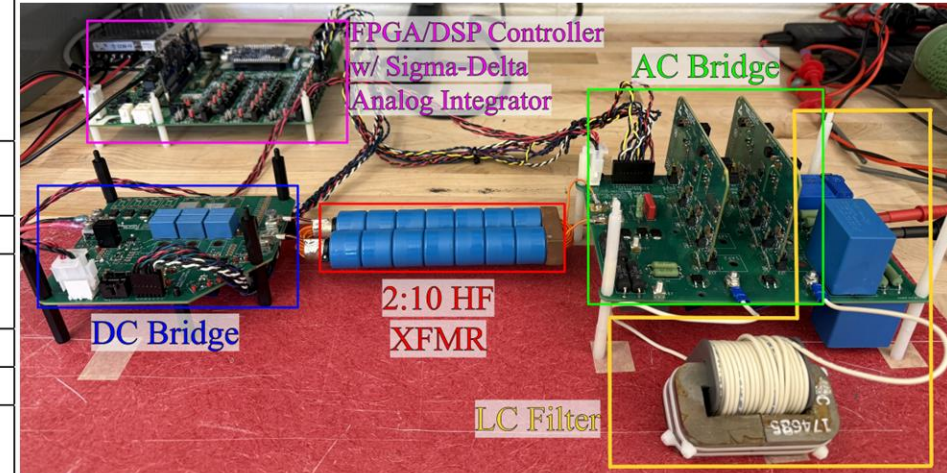
$$Z_0 = \sqrt{\frac{(L_{lkg} \times N^2)}{C_p}}$$

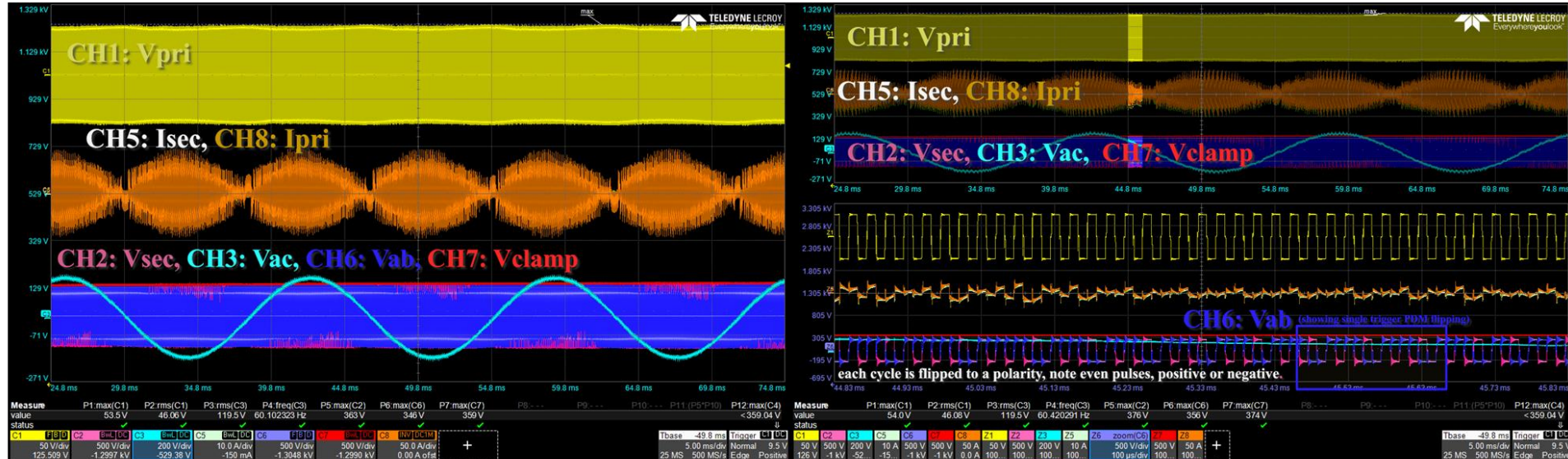


Simulation of AC Cube: $V_{batt} = 48V$, $V_{AC} = 120V_{rms}$, $P_{out} = 1kW$



Parameter	Value
Power Converter General Specs	$P_{\text{rated}} = 1 \text{ kW}$, $V_{\text{DC}} = 48 \text{ V}$, $f_{\text{sw}} = 40 \text{ kHz}$, $V_o = 240/120 \text{ V}_{LL} \pm 10\%$, 60 Hz , $\eta_{2kW} \geq 97.7\%$
Transformer	$N = 1 : 5$, $L_m = 350 \mu\text{H}$, $L_{\text{lk}} = 150 \text{ nH}$
LC Filter	$L_f = 2 \text{ mH}$, $C_f = 20 \mu\text{F}$
AC Bridge Parasitic Capacitance	$C_p = 500 \text{ pF}$
DC Bridge Power Devices	IPP018N10N5, 100 V Si MOSFET
AC Bridge Power Devices	G3F25MT06K, 650 V SiC JFET
Clamp	Diode: FFSD0665B, 650 V SiC $C_{\text{clamp}} = 10 \mu\text{F}$





- Experimental results show steady-state single-phase AC operation
- The zoomed waveform (right), taken near the peak of the AC reference, validates the operation of the sigma-delta pulse density modulation scheme in single trigger mode
 - Double trigger mode would enable more fine waveform generation at effectively double switching frequency

