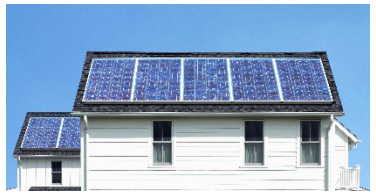
A Hybrid Switched-Capacitor Solar Microinverter Utilizing a Fixed-ratio Resonant DC-DC Stage and Flying Capacitor Multi-level DC-AC Stage

Berkeley Power and Energy Center

Motivation and Application

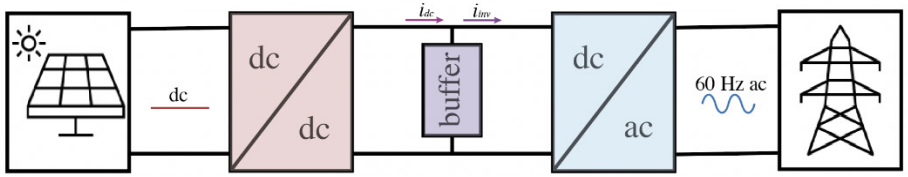
Hybrid Switched-Capacitor Converters

- The Cascaded Series-Parallel converter (CaSP) has been used as a power-dense dc-dc step-down solution in the 48V application space but is being adapted use as a boost stage [1].
- The flying capacitor multilevel converter (FCML) can be used to step down the



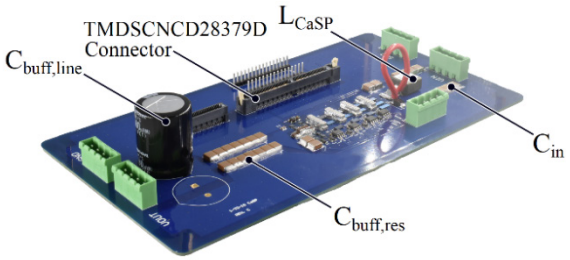
Rooftop solar requires **efficient** and **power dense** solutions to convert power for use in homes and at the grid.

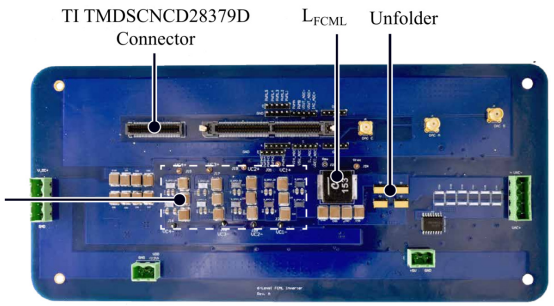
Example inverter: Enphase IQ8



Full microinverter concept.

Hardware





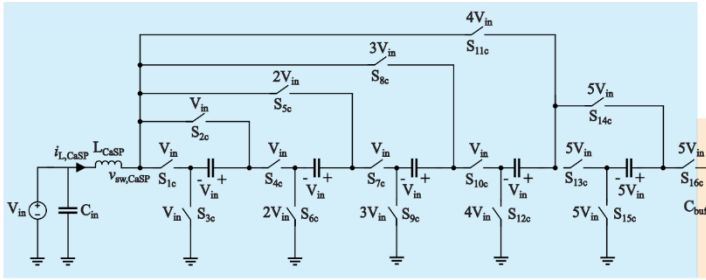
CaSP System Specifications

- 35-40V input
- 350-400V, 500W output

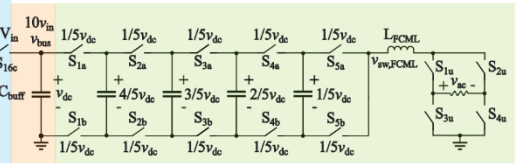
FCML System Specifications

- 350-400V input, 500W+
- Sensing for control included on this board.
- 2nd revision coming soon

System Architecture

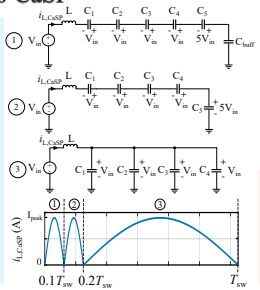


1-to-10 CaSP

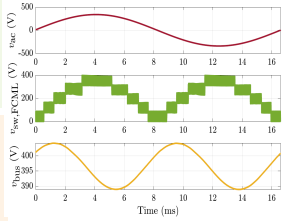


Buffer 6-Level FCML + Unfolder

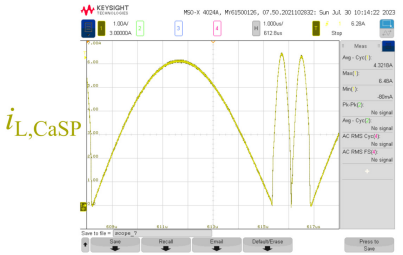
- Three sub-intervals of one switching cycle, each with a unique resonant LC tank impedance [2].
- Achieves ZCS, partial ZVS.
- Can be used as stand-alone startup circuitry.

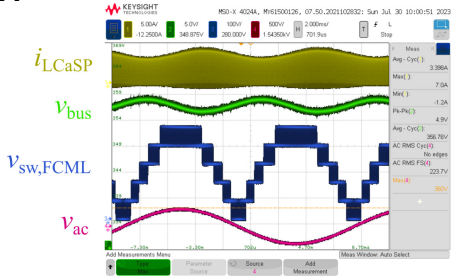


- 400V to 240Vac. Voltage at output of inductor is rectified sine wave that is unfolded by H-bridge.
- HV buffer allows for reduction of capacitance due to smaller current ripple



Experimental Validation





System waveforms with 240 V_{ac} output

Peak efficiency with 255 Vac output at light load: **93.5%**

- System able to produce 240 Vac output at light load
- CaSP achieves ZCS during full system operation at 240 Vac output

References:
[1] R. A. Abramson, Z. Ye, T. Ge and R. C. N. Pilawa-Podgurski, "A High Performance 48-to-6 V Multi-Resonant Cascaded Series-Parallel (CaSP) Switched-Capacitor Converter," 2021 IEEE Applied Power Electronics Conference and Exposition (APEC), Phoenix, AZ, USA, 2021
[2] K. Fernandez and R. C. N. Pilawa-Podgurski, "A 1-to-10 Fixed-Ratio Step-up Multi-Resonant Cascaded Series-Parallel (CaSP) Switched-Capacitor Converter with Zero-Current Switching," *2023 11th International Conference on Power Electronics and ECCE Asia (ICPE 2023 - ECCE Asia)*, 2023

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