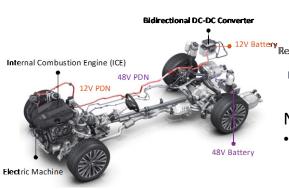
# Bidirectional Power Transfer in Hybrid Switched-Capacitor Converter for 48V/12V Regulated Automotive Applications



# Motivation and Application



Dual Battery System in Mild Hybrid Electric Vehicle (MHEV) (Source: Audi A8 Powertrain)

# AC Compressor AC Compressor Regenerative Braking Infotainment Lighting Integrated Starter Generator (ISG) Integrated Starter Generator (ISG)

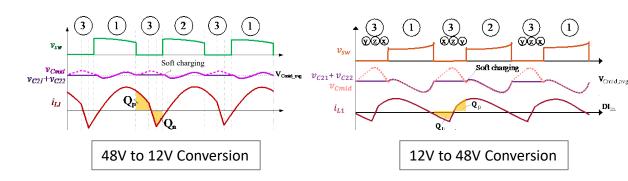
#### Need:

 48V battery should be able to deliver extra power to 12V battery based on increased load demand and vice-versa.

#### Challenges:

 Delivery of high current with high efficiency and high power density in both directions

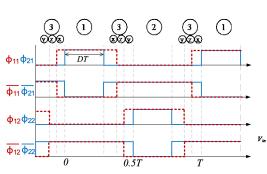
## Advantages of Proposed Control Technique

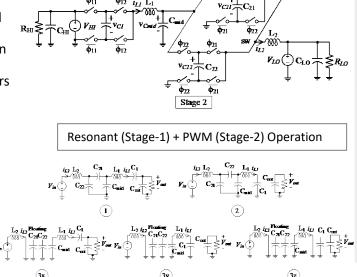


- Implements Natural Balancing of all flying capacitors.
- Achieves Soft-charging and soft-switching .
- Minimizes the size of the intermediate capacitor  $C_{mid}$ .

# Converter Topology

- 48V-to-12V regulated cascaded hybrid resonant-PWM converter [1]
- 1<sup>st</sup> stage uses a conventional doubler in resonant mode
- 2<sup>nd</sup> stage used two interleaved doublers operating in PWM mode.

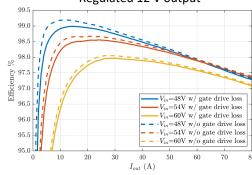




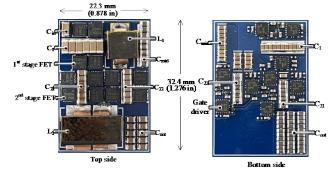
### Hardware Demonstration and Results

#### Measured Efficiency at:

- Input voltage: 48 60V
- 80 A full-load current
- Regulated 12 V output



[1] T. Ge, et. al., "A Regulated Cascaded Hybrid Switched-Capacitor Converter with Soft-Charging and Zero Voltage Switching for 48-to-12-V," 2023 IEEE APEC.



- 80A, 99% peak eff. 3115 W/in<sup>3</sup> power density
- 21% loss and 63% size reduction over SOTA

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