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Experimental Evaluation of EMI and Efficiency in a Hybrid T-Type Wide-Bandgap Converter

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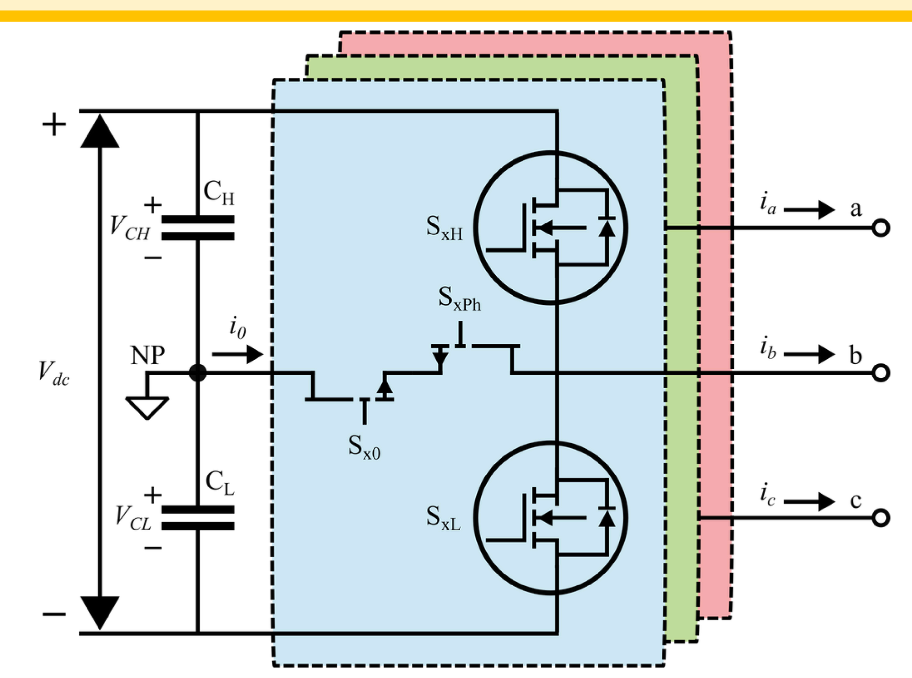
Abstract

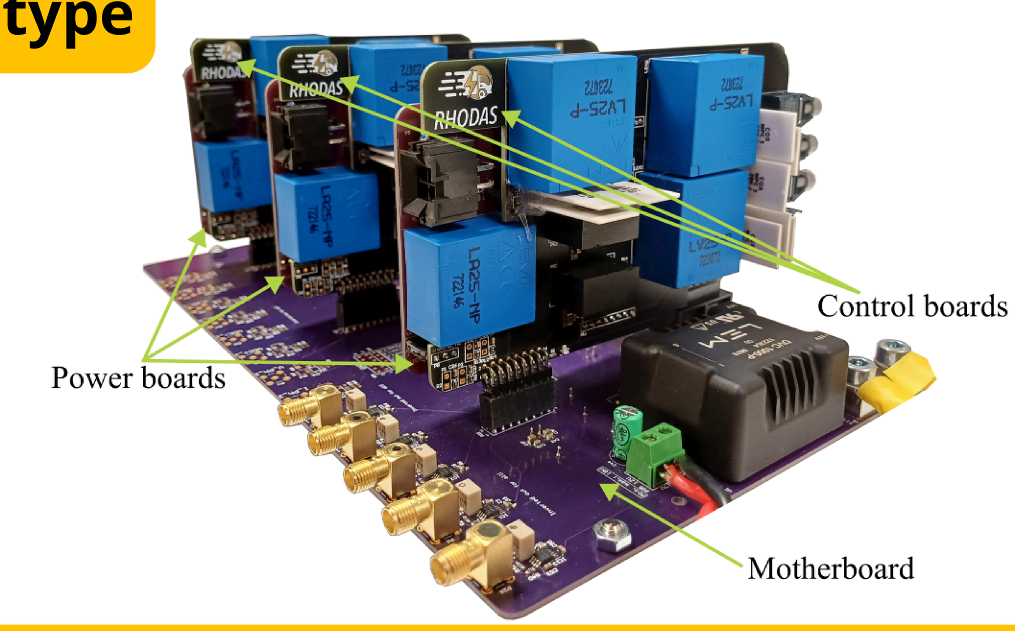
This work presents an experimental study of a hybrid T-type converter using wide-bandgap (WBG) devices, combining the low switching losses of gallium nitride (GaN) with the high-voltage capability of silicon carbide (SiC). Furthermore, an adaptive level-shift algorithm is introduced, enabling operation in both two- and three-level modes, improving fault tolerance and current capability. Experimental validation demonstrates high efficiency, minimal EMI impact at high switching frequencies, and improved THD, confirming the converter as a robust solution for high-performance applications.

Hybrid T-Type Converter

- SiC MOSFETs withstand full DC bus voltage
- GaN e-HEMTs minimise switching losses
- Adaptive level-shift algorithm enables 2L / 3L operation
- Enhanced current capability and fault tolerance



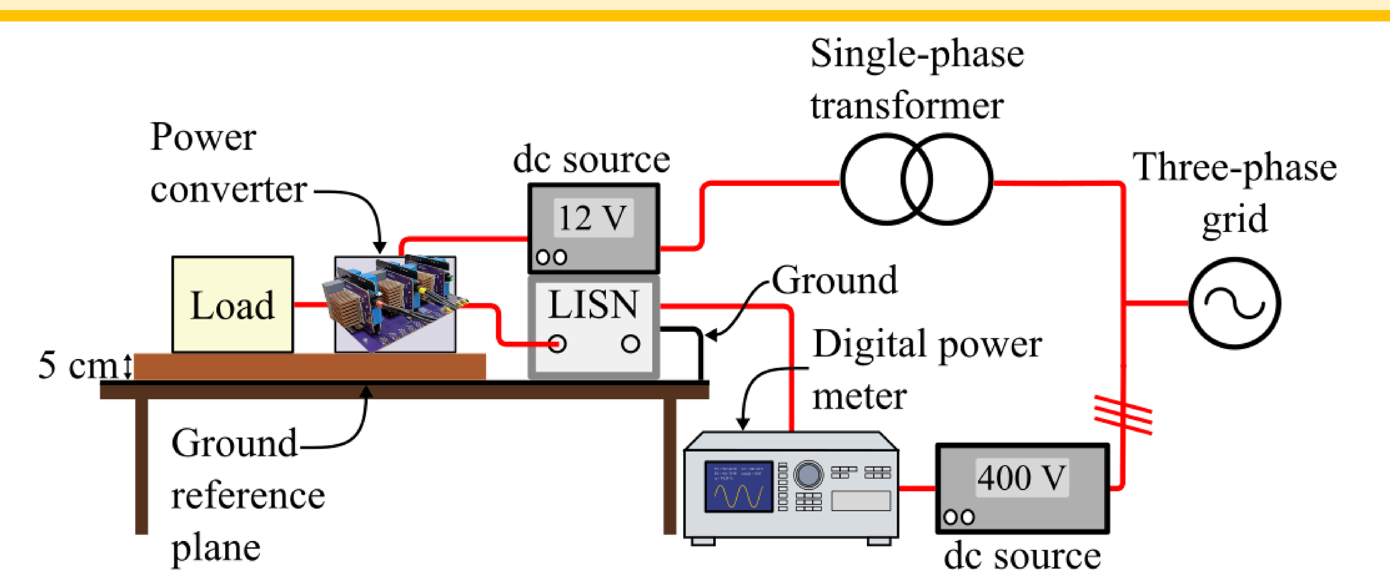
Prototype



Experimental Setup

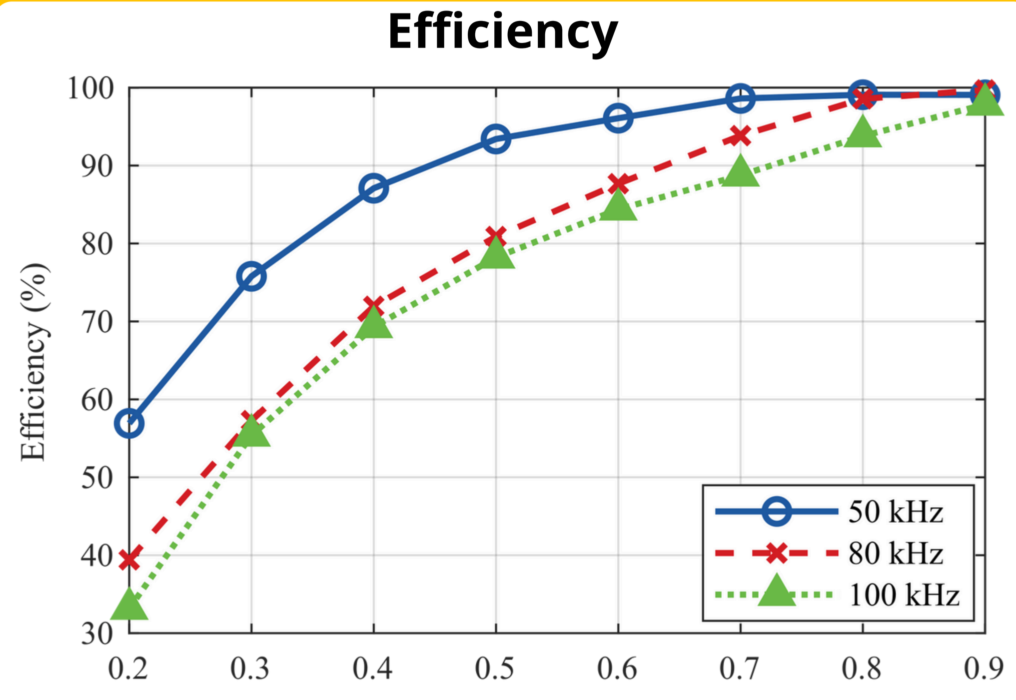
- **Prototype**: Modular hybrid T-type converter, 15 kW
- **Transistors:** SiC MOSFETs (1200 V, 90 A) + GaN e-HEMTs (650 V, 60 A)
- **Modulation:** SVPWM and CB-PWM
- **Loads:** 3-phase RL, R = 68 Ω, L = 1.55 mH
- **DC source:** 400 Vdc
- **Switching frequencies:** 50, 80, 100 kHz

Schematic

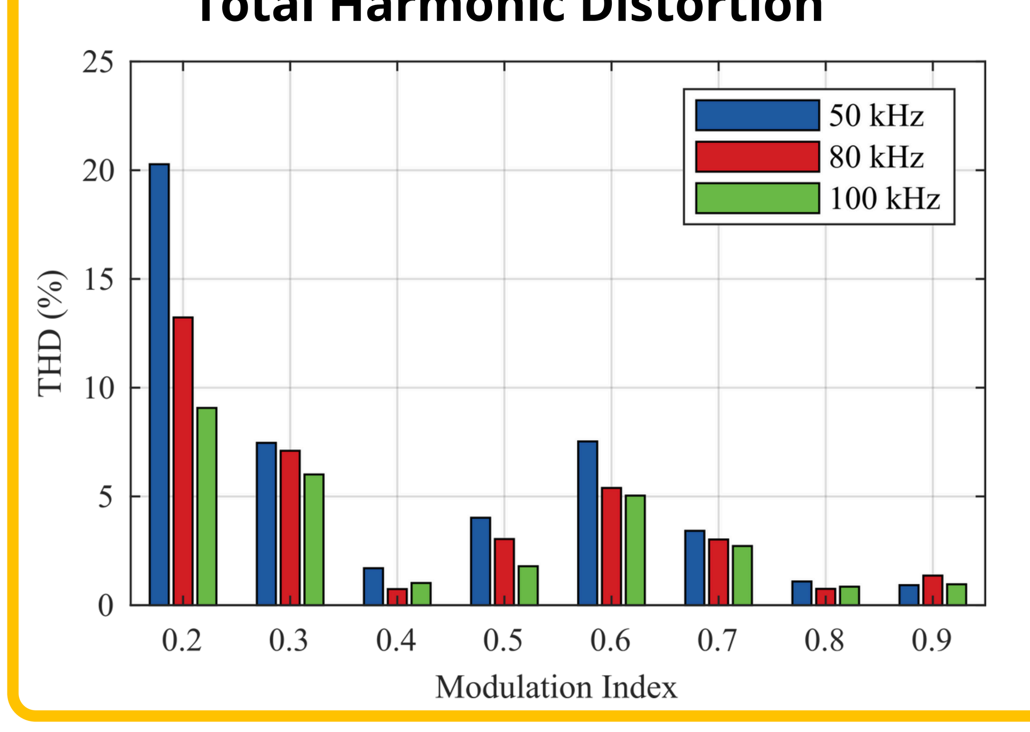


Experimental Results

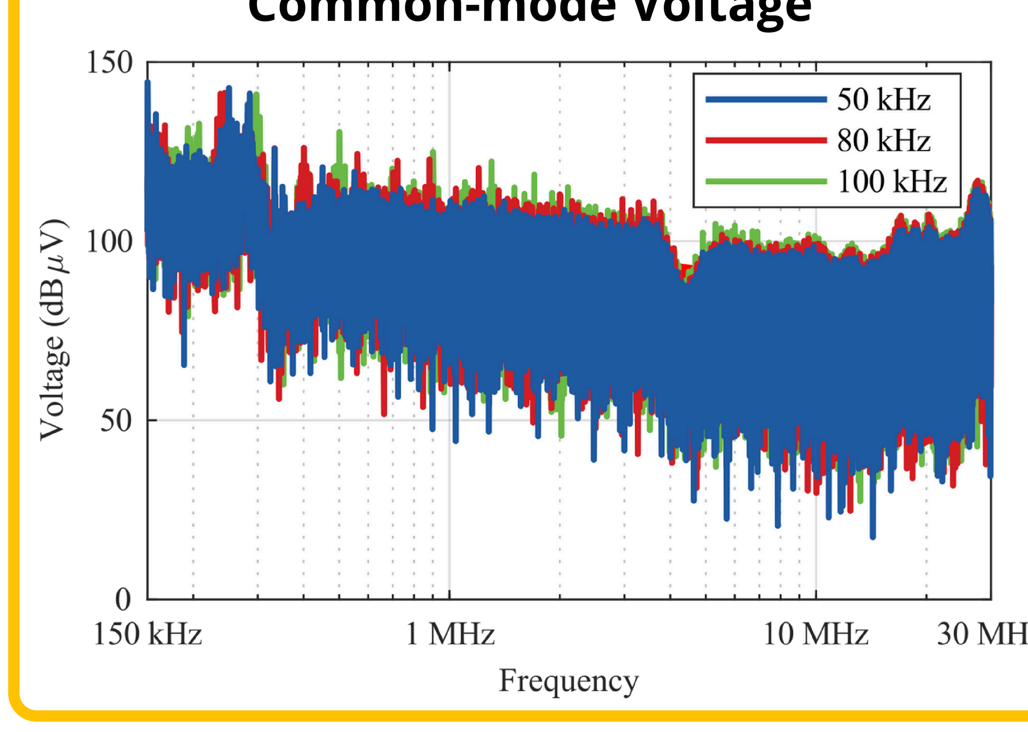
Efficiency



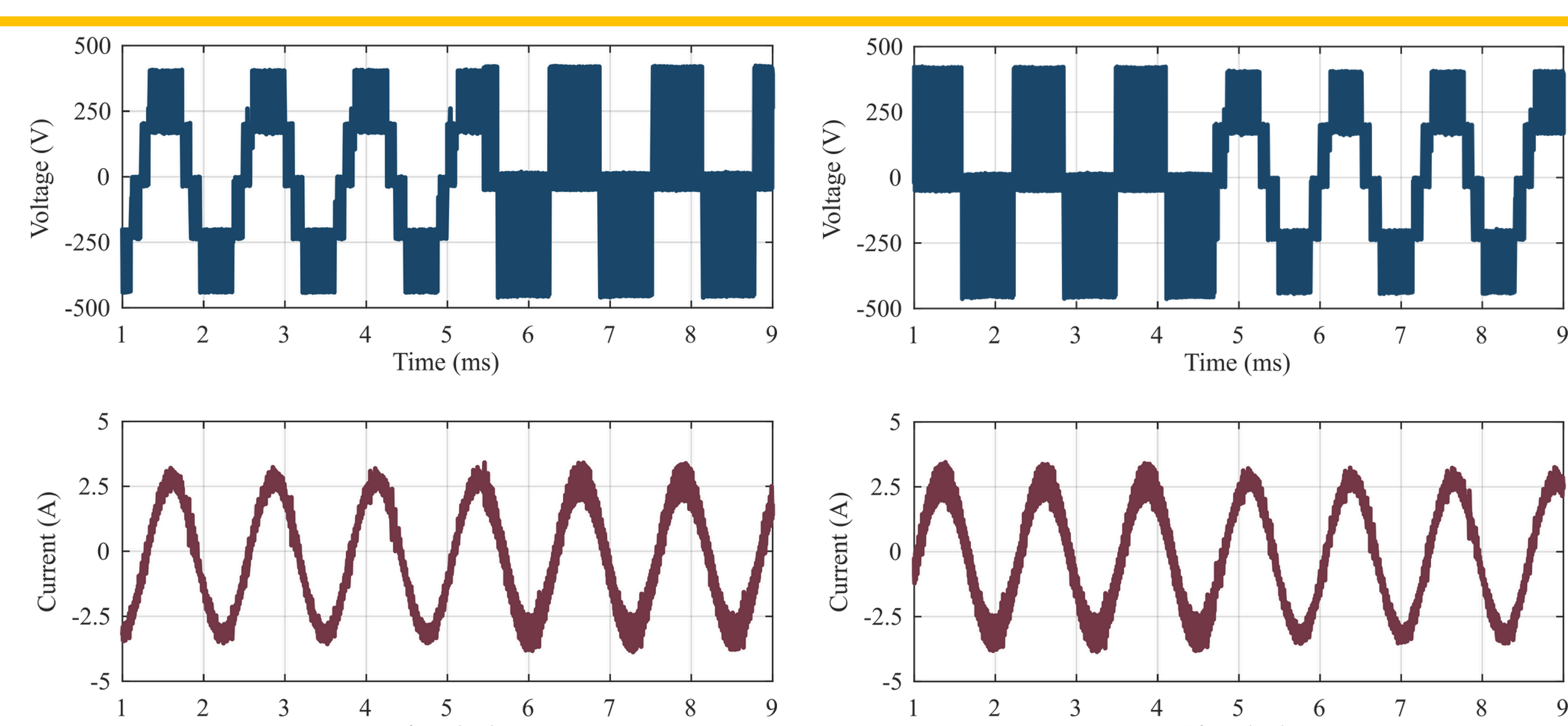
Total Harmonic Distortion



Common-mode Voltage



Adaptative Level-Shift Algorithm



- Test at m = 0.9, 50 kHz, injecting 787.5 Hz current.
- Transition 3L → 2L:
  - GaN devices turned off. SVPWM with SiC.
  - Line voltage becomes less sinusoidal.
  - Current ripple increases.
- Transition 2L → 3L:
  - GaN reactivated. CB-PWM with SiC + GaN.
  - Three voltage levels.
  - Current remain sinusoidal with reduced ripple.

Conclusions

The proposed hybrid three-level T-type converter, combining SiC and GaN, has been experimentally validated. An adaptive level-shift algorithm enables smooth transitions between two- and three-level modes, improving fault tolerance and current handling. Results confirm that high switching frequencies, enabled by WBG devices, have minimal impact on power losses, THD, and EMI; differences appear mainly at low modulation indices, where higher frequencies increase losses but reduce THD. Overall, the hybrid T-type converter proves to be a reliable and efficient solution for high-performance applications requiring efficiency, flexibility, and robustness.