UNIVERSITY OF MINNESOTA

Wide bandgap devices in Power Electronics

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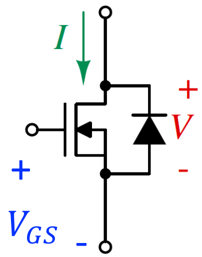
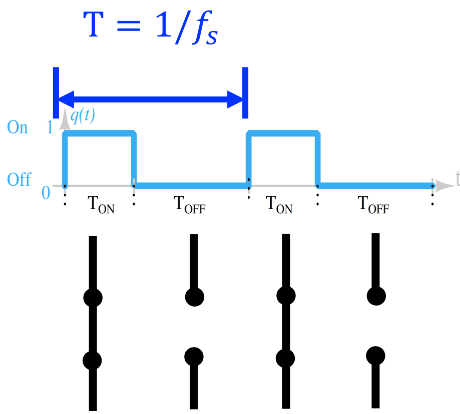
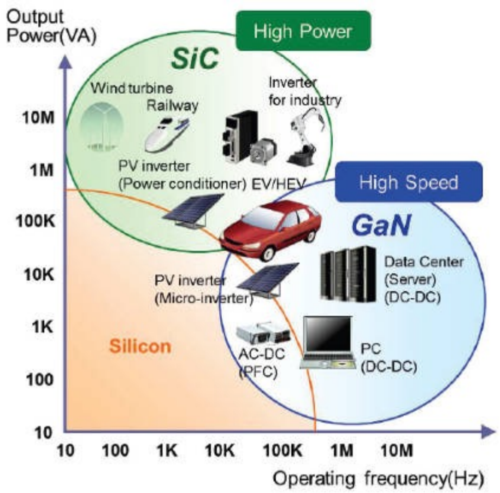




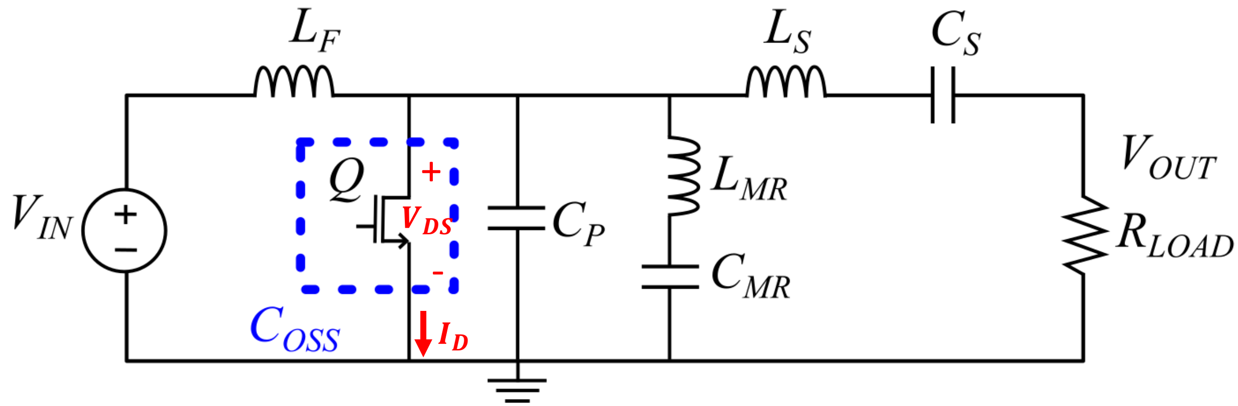


SiC for high power voltages (>1kV) with high current
= niche market

GaN on Si for high frequency at midrange voltages (<1kV, up to 100A)
= mass market

- Wide band gap devices such as eGaN FETs or SiC MOSFETs have a lot of potential to improve performance of high-frequency, high-power converters.
- GaN FET
  - Lower C_{iss} and $R_{DS,ON}$
  - Higher $V_{DS,MAX}$
  - Higher switching frequency

Challenges in High-power, High-frequency Operation



- However, the GaN device is limited by its uniquely small packaging and structure in high-frequency, high-power applications ***(10's MHz, >1kW).***

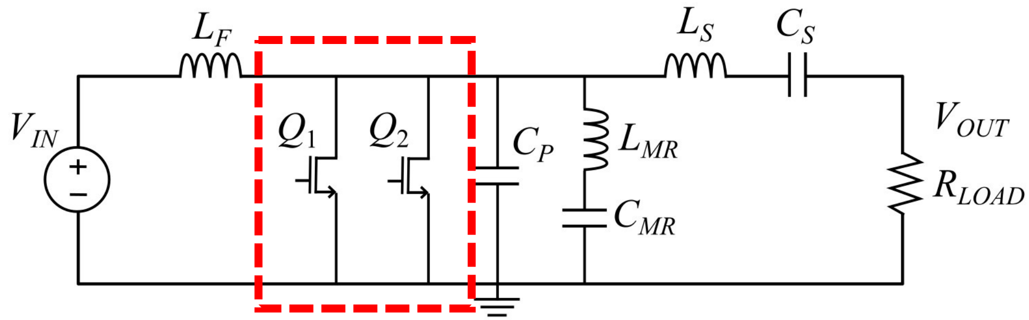
Assuming Zero Voltage Switching (ZVS) during turn-on transition is achieved in the resonant inverter, the switching losses mainly consist of

- Losses due to $R_{DS,ON}$
- Losses due to charging and discharging of device output capacitance, C_{OSS}

Solution → **Parallel GaN Devices** to reduce conduction loss, increase power capability and increase device reliability.

Keerti Palanisamy, Kamlesh Sawant, Jungwon Choi, "Paralleling GaN Devices in a 13.56 MHz Class Φ^2 Inverter for High-Power Applications," IEEE Workshop on Wide Bandgap Power Devices and Applications (WiPDA), 2021.

Resonant Inverter Design with Multiple devices

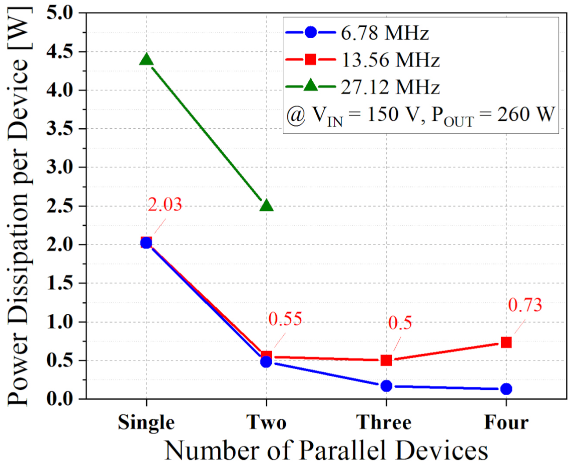


Initial Parameters

- Same as single device inverter

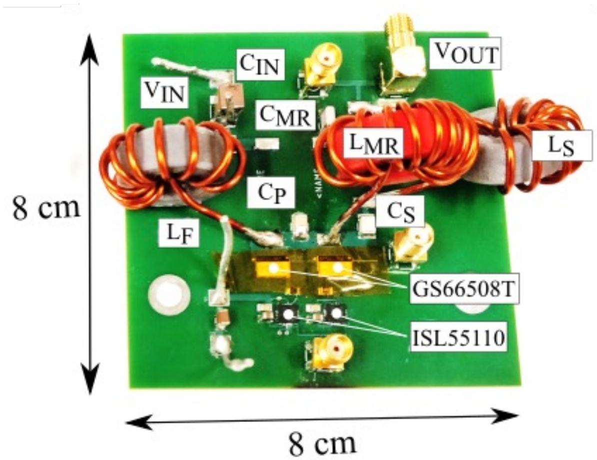
Tuning circuit

- Change C_p for every additional device added. Modify L_F if required to absorb capacitance.

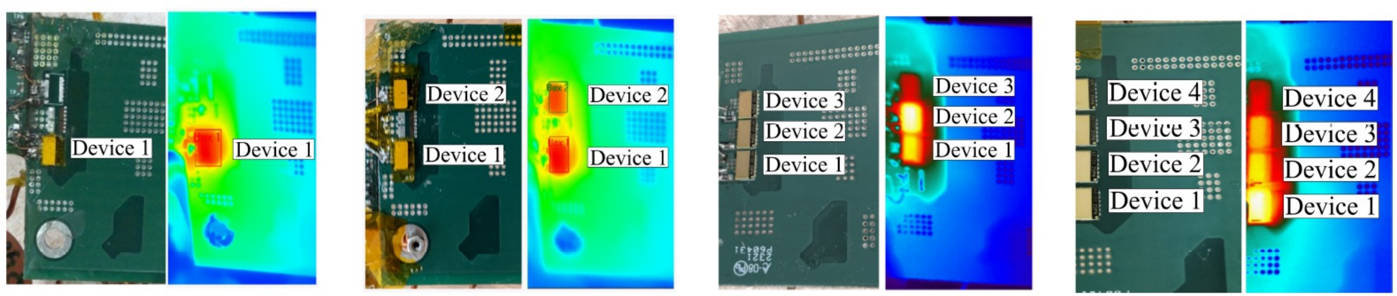


Ratio of non-linear capacitance to externally added C_p affects turn-off losses

Prototype of Resonant Inverter with Multiple Devices



Parameter	Value	Type
V_{IN}	150 V-240 V	DC Power Supply
Frequency	13.56 MHz	Pulse Generator
L_F	240 nH	Custom inductor with Air-Core
C_P	210 pF	Ceramic C0G
L_{MR} C_{MR}	605 nH 57 pF	Custom inductor with Air-Core Ceramic C0G
L_S C_S	305 nH 4.4 nF	Custom inductor with Air-Core Ceramic C0G
R_{LOAD}	50 Ω	MFJ-264 Dummy Load
Gate Driver *Gate Resistor*	ISL55110 2 Ω	Intersil Chip Resistor
Switching Device	GS66508T	GaN Systems



V_{IN}	Steady-State Case Temperature									
	One-Device	**Two-Device**		**Three-Device**			**Four-Device**			
	Device 1	Device 1	Device 2	Device 1	Device 2	Device 3	Device 1	Device 2	Device 3	Device 4
150 V	82.1°C	57.1°C	54.5°C	51.4°C	54.9°C	45.6°C	54°C	49.5°C	48.8°C	45.2°C
170 V	>110°C	67°C	63.1°C	60.1°C	63.3°C	51.1°C	64.8°C	57.7°C	56.4°C	51.5°C

Thank you!

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