High-frequency Power Electronics with eGaN Devices

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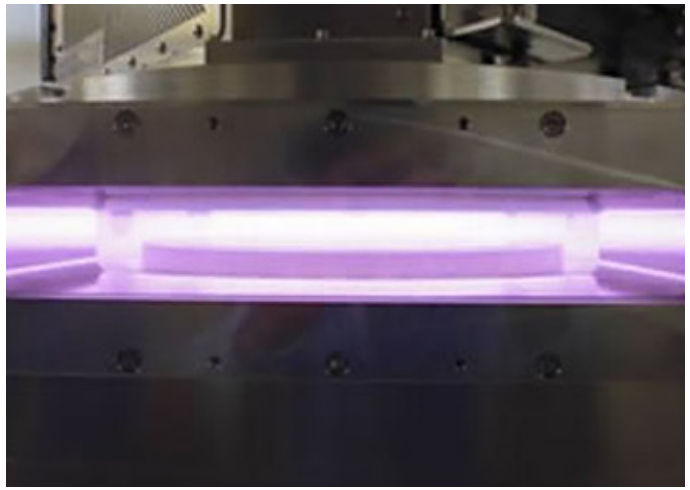
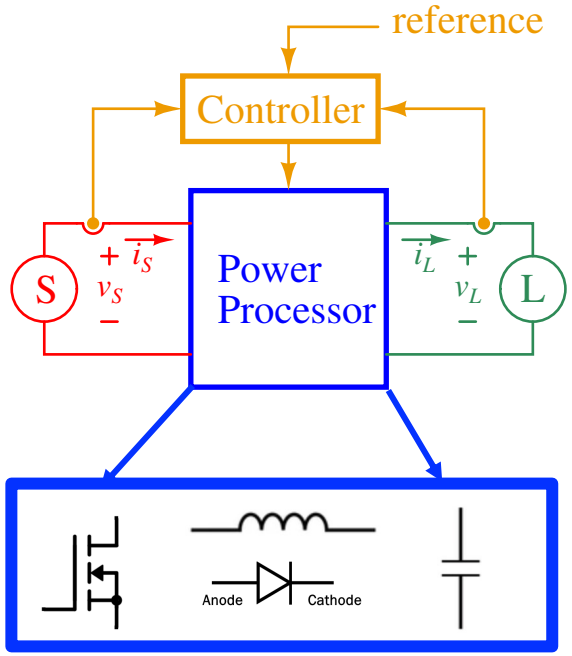
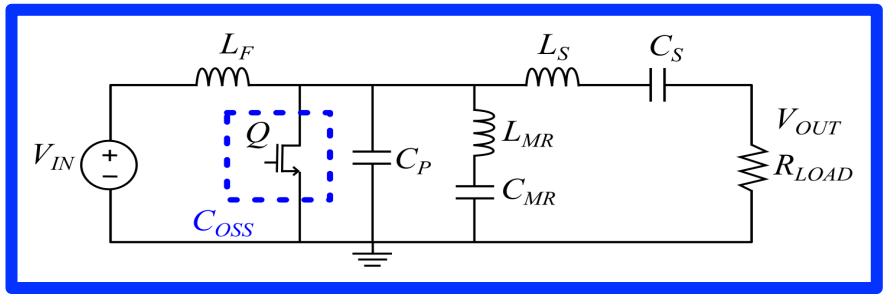
Plasma Generation

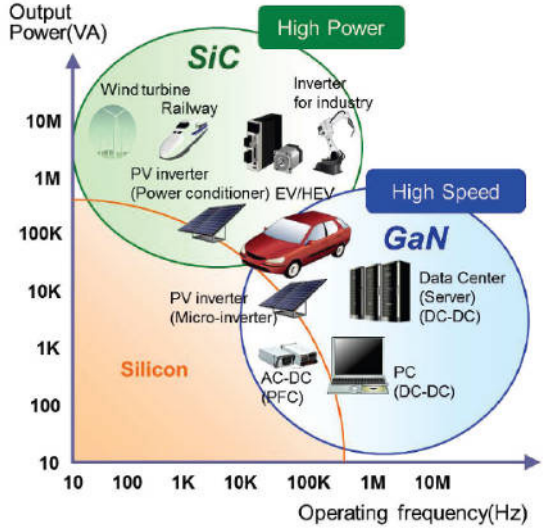


- Radio-frequency (RF) power amplifiers (PA) are used in plasma generation processes
  - High (3-30 MHz) or very high (30-300 MHz) frequency ranges
  - Over 1 kW output power
- Need to provide constant output power with load variations (resistive, inductive or capacitive).

Resonant Converter with Wide Bandgap Devices







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

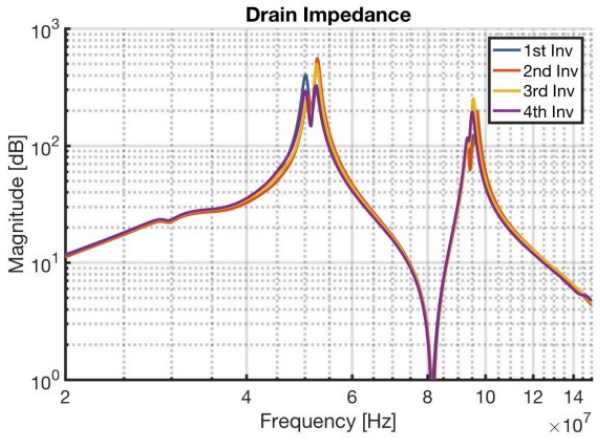
GaN on Si for high frequency at midrange voltages (<1kV, up to 100A)
= mass market

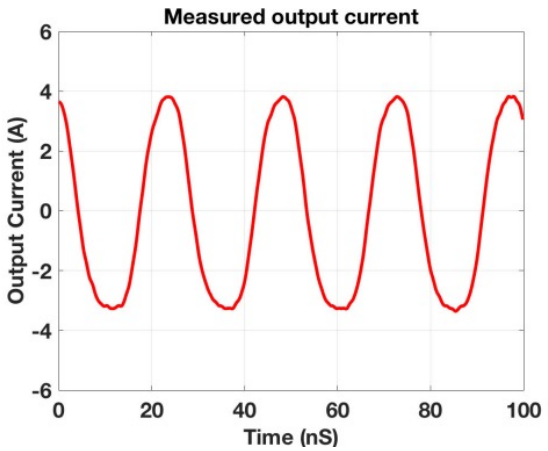
❑ Challenges

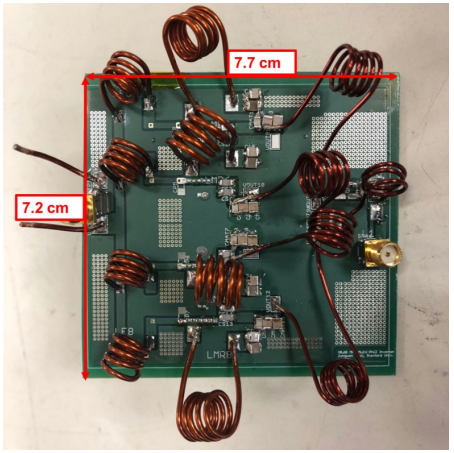
- ❑ Limited by its uniquely small packaging and structure in high-frequency, high-power applications.
- ❑ Switching losses in eGaN Devices.

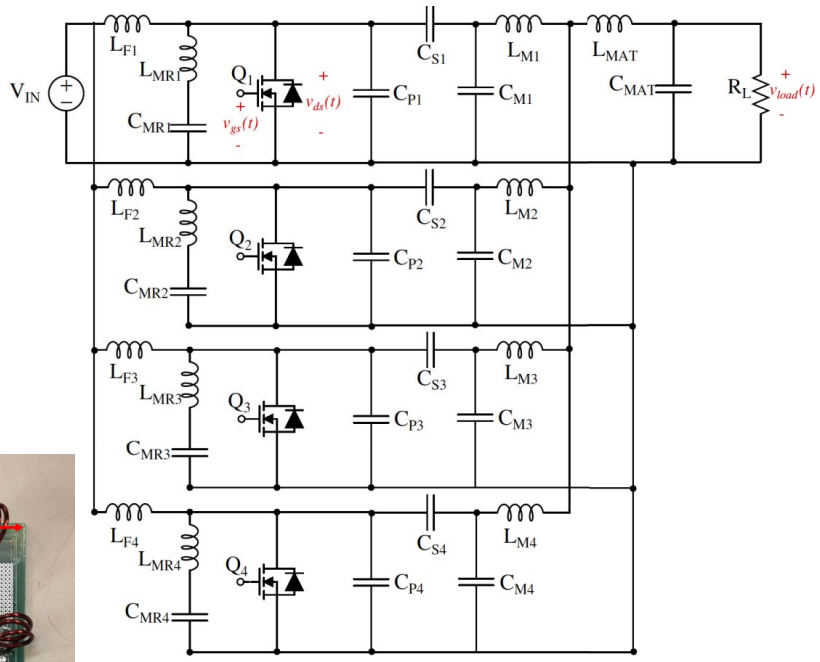
40.68 MHz, 1.2 kW Power Combining Resonant Inverter

- Four eGaN FETS (GS66506T) with four gate drivers (ISL55110).
- 195 V of input voltage, 1174 W of output voltage with 83% of efficiency (higher than conventional linear amplifier).

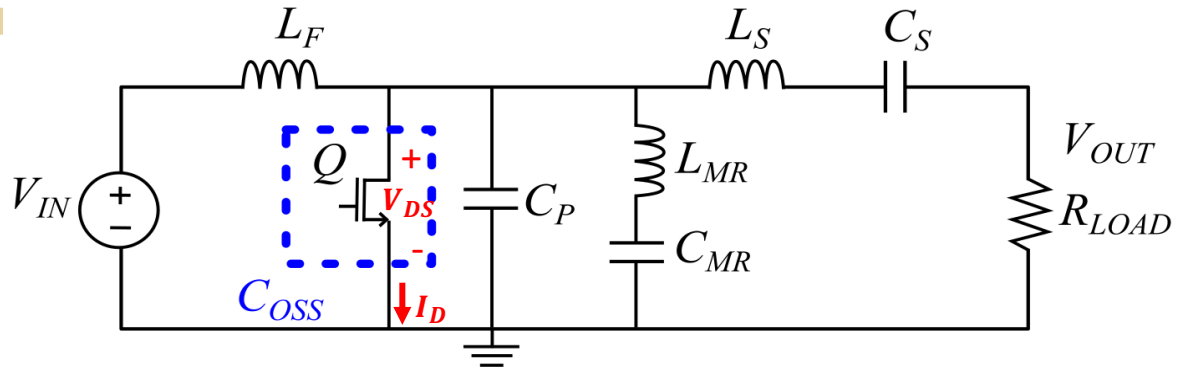








GaN Devices in Resonant Inverter



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

High-power + high-frequency operation → **Higher device losses**

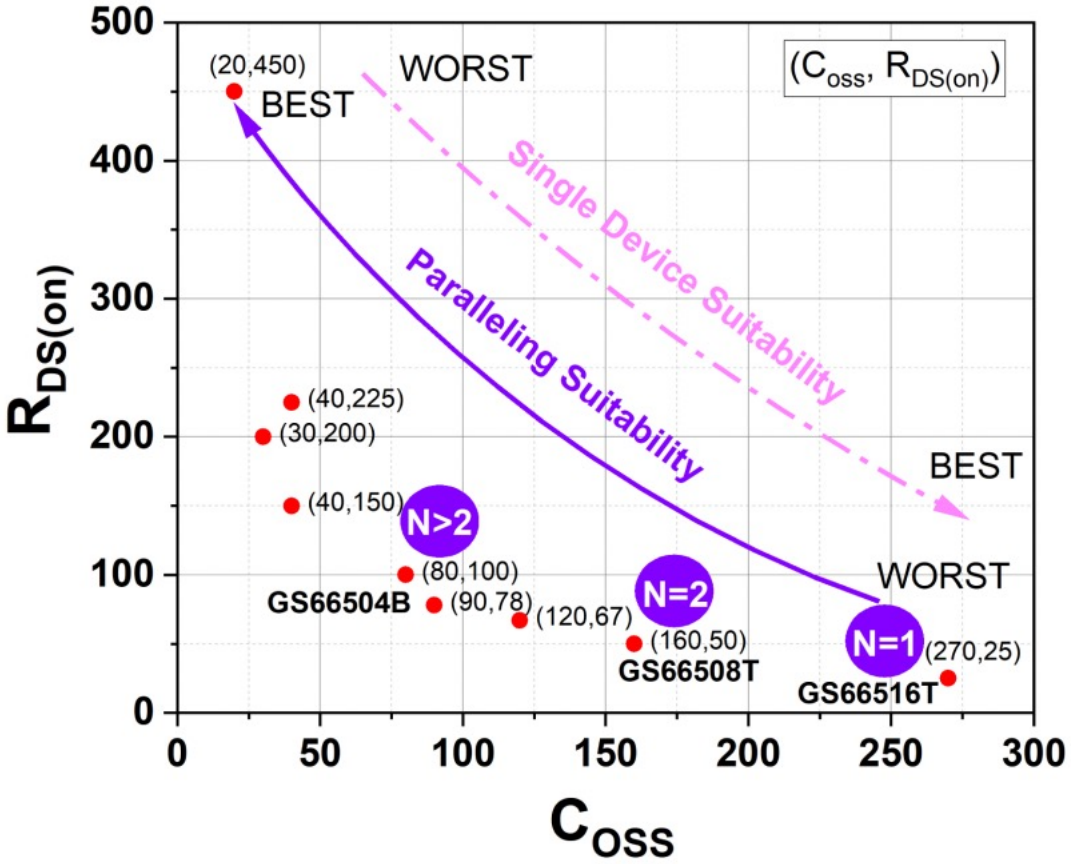
Assuming ZVS is achieved in the resonant inverter, the switching losses mainly consist of

- Losses due to $R_{DS,ON}$
- Losses due to turn-off transition
- 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.

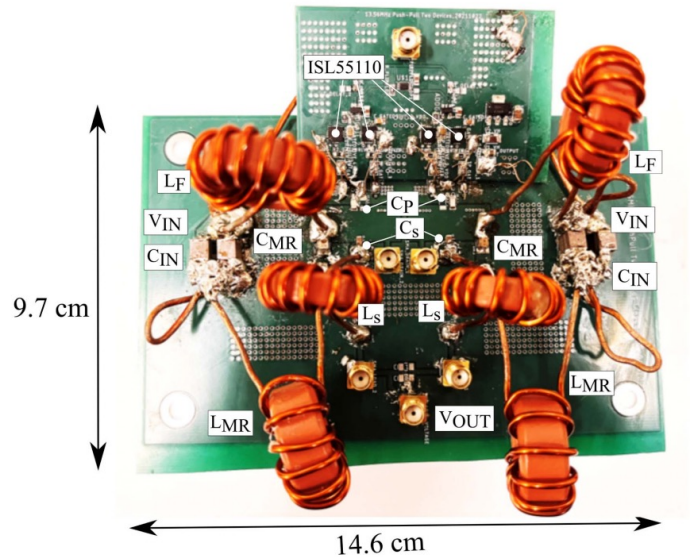
Keerti Palanisamy, Kamlesh Sawant, Jungwon Choi, "Paralleling GaN Devices in a 13.56 MHz Class Φ_2 Inverter for High-Power Applications," IEEE WiPDA, 2021.

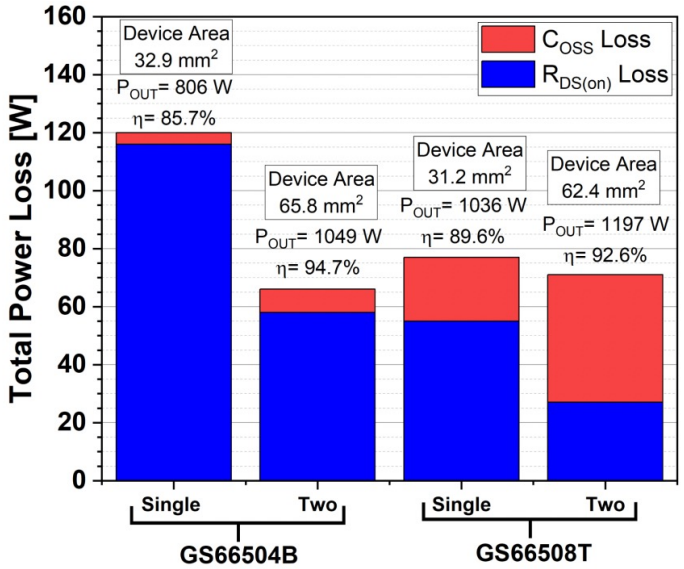
Optimum Number of Parallel Devices

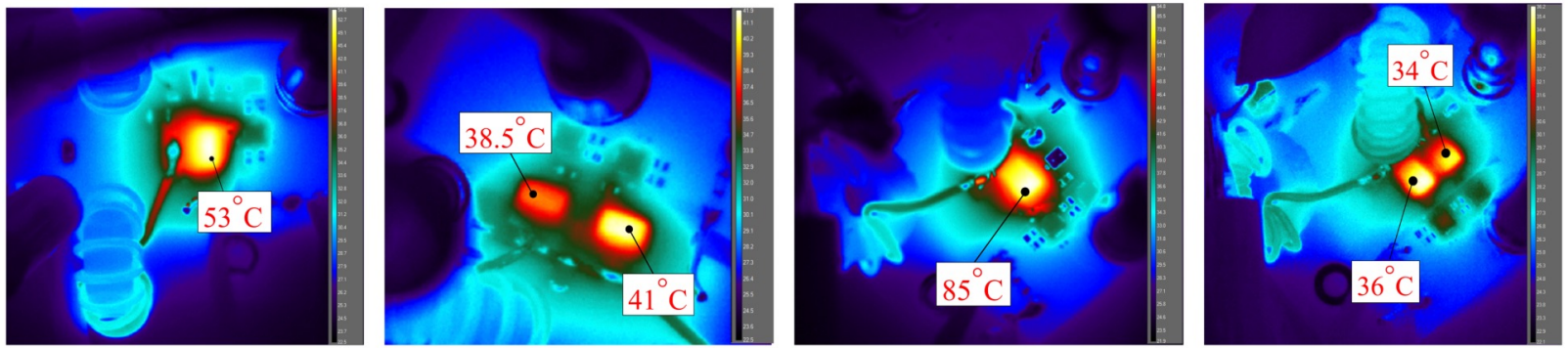


Device	Parameter	One	Two	Three	Four
GS66504B	C_P $[pF]$	430	350	280	200
	$(Total)P_{Device\_Loss}$ $[W]$	7.3	4.4	3.6	3.6
	P_{OUT} $[W]$	920	970	980	1000
	η $[\%]$	95.8	96.4	96.4	96.3
GS66508T	C_P $[pF]$	330	180	0	–
	$(Total)P_{Device\_Loss}$ $[W]$	5.1	3.8	4.2	–
	P_{OUT} $[W]$	970	1000	1100	–
	η $[\%]$	96.3	96.2	96.0	–

Prototype of Resonant Inverter with Multiple Devices







Thank you!