GaN Devices

Vertical Silicon Power MOSFET

- No body diode (reverse conduction due to $V_{gd} > V_{gd,th} \approx 2V$)
  - Use antiparallel (schottky) diode or precise dead time
  - Significantly faster switching

Lateral GaN HEMT

Designing with GaN

- Because of high electric breakdown field and high electron velocity, GaN devices with comparable $R_{on}$ can be significantly smaller and switch must faster.
- Need very good layout to prevent ringing from causing overvoltage and device failure.
- More information:

How to GaN: Simplifying Design with DrGaN
GaN Design Issues

1. Reverse conduction mechanism
2. Sensitivity to parasitics
3. Gate robustness
4. Small size -> Thermal, soldering difficult

Reverse Conduction
Bridge Layout

Half Bridge Layout: Example

Lateral  Vertical  “Optimal”

D. Reusch & J Strydom, “Understanding the Effect of PCB Layout on Circuit Performance in a High-Frequency Gallium-Nitride-Based Point of Load Converter”
Kelvin Measurement

ZVS Assist Circuits
Remaining Switching Losses

Switching-related losses:
1. $C_{sw} \rightarrow$ reduced ($2^{nd}$ function)
2. Overlap $\rightarrow$ turn-on $\rightarrow$ reduced
   $\rightarrow$ turn-off $\rightarrow$ reduced $\rightarrow$ recovery increase (?)
3. Reverse Recovery $\rightarrow$ eliminated
4. $Q_g \rightarrow$ no effect
5. Body diode conduction $\rightarrow$ reduced (at setting)
6. Short-through $\rightarrow$ alleviated
7. Additional parasitics ($L_p$) ?

Idealized Switching Waveforms

- $V_{gs}$
- $I_d$
Class-E Amplifier

Fig 2—Schematic of a low-order Class-E amplifier.

Fig 3—Actual transistor voltage and current waveforms in a low-order Class-E amplifier.

Class $\Phi_2$ Inverter

Fig 4—Drain to Source Voltage ($f=30$ MHz).

Fig 5—Inverter Performance vs. Input Voltage.