High voltage integrated Smart GaN boosting consumer applications

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Content

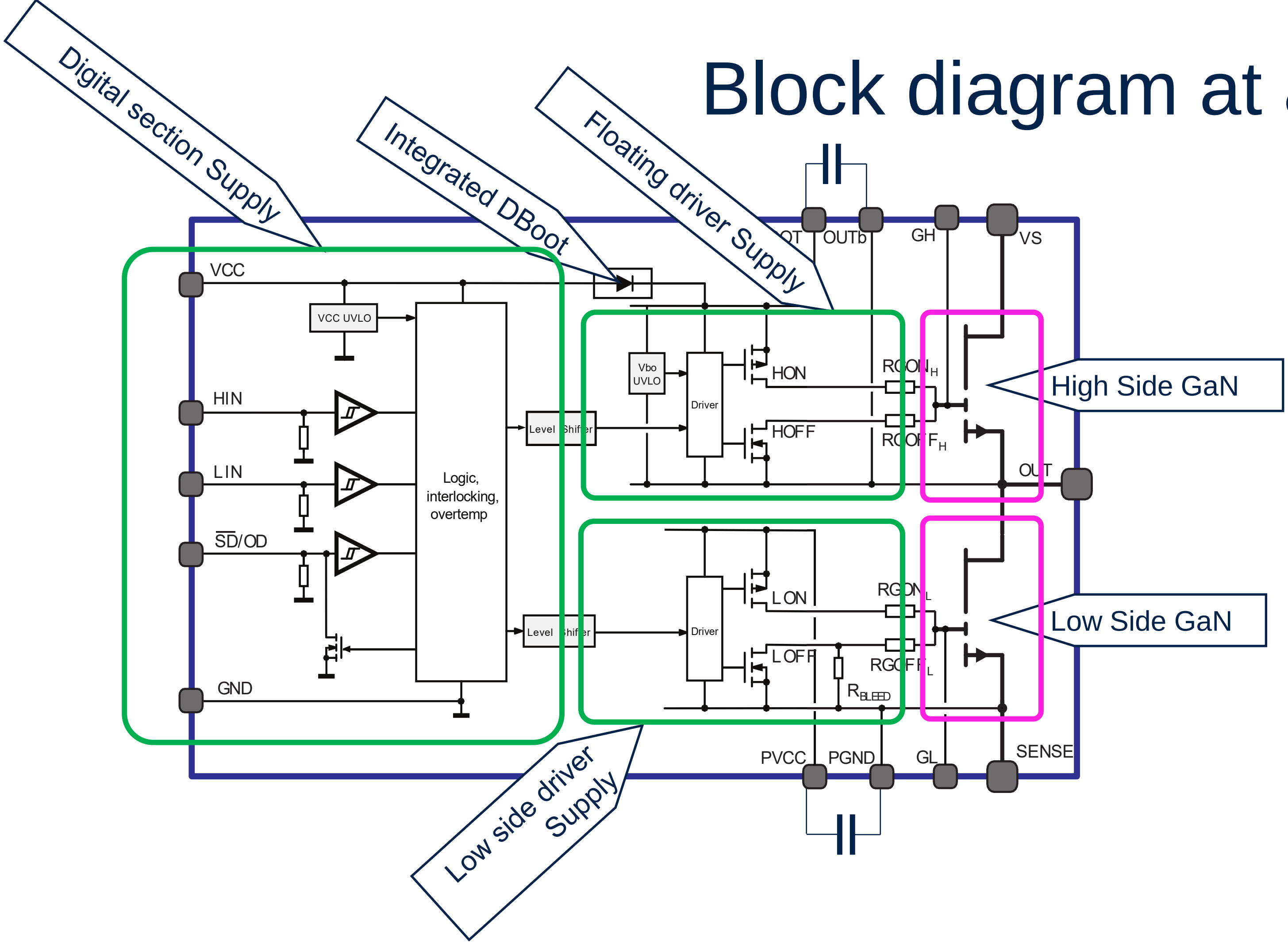
Introduction

- High-performance power converters need Smart power integrated devices
- Need for simplification
- Power system-in-package devices integrate gate drivers and half-bridge enhancement mode GaN transistors
- No need for additional external components

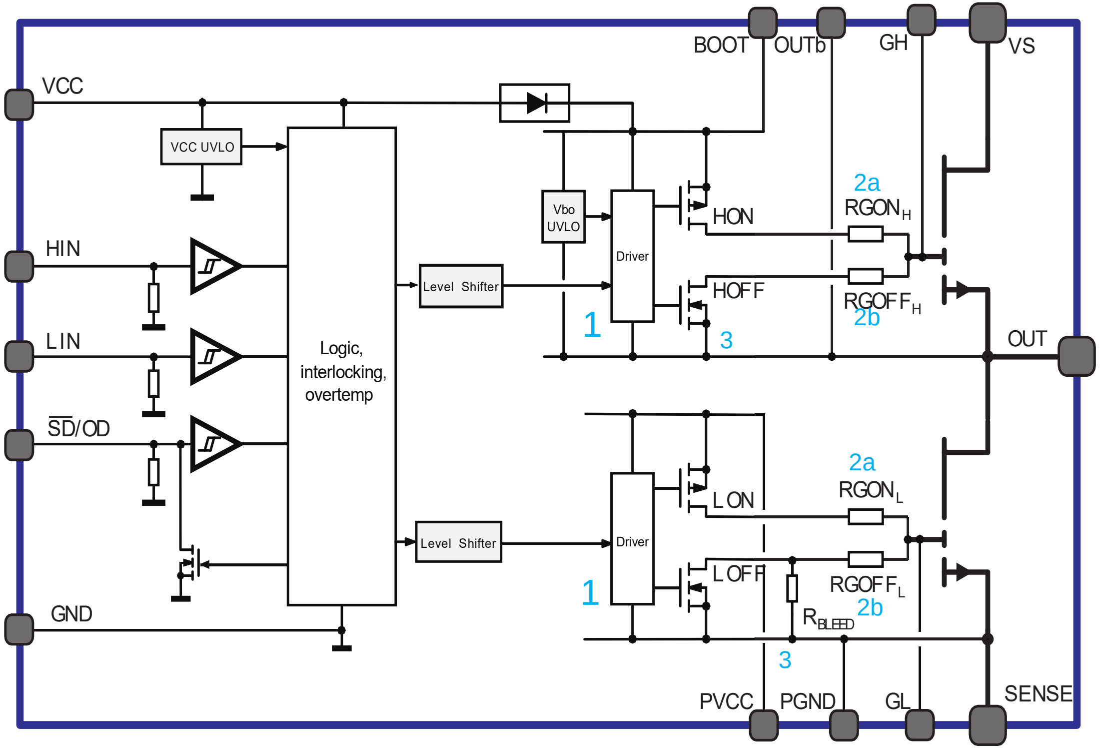
Integrated Smart GaN

- The structure of the gate driver ensures more effective driving of each transistor by minimizing current loops
- Thermal management is easier
- The integrated power GaN switches are enhanced mode transistors fully exploiting the zero-recovery characteristic of the HEMT

Block diagram at a glance



GaN drivers



1. Level shifters are implemented
2. Different turn-on and off current capability
3. Prevention of accidental GaN turn-on when PVCC and VBO are below turn on threshold.

Reverse conduction operation

- GaN FET’s channel can operate in direct or reverse conduction mode
- The reverse conduction results in large reverse voltage drop across source to drain terminals
- The reverse conduction is typical in resonant topologies

- Large voltage can create large dissipation → dead time optimization is important to reduce the power dissipation on both Low side and High side
- Reverse conduction of low side generates negative voltage on OUT pin

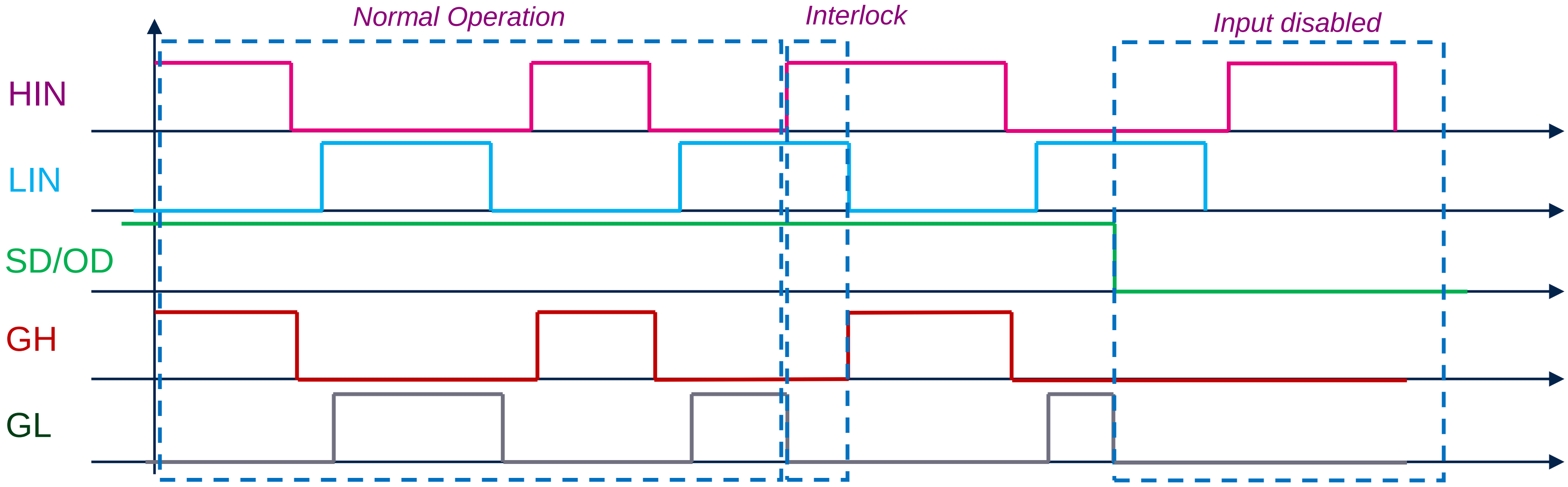
Supply sources - consumptions

- Input logic section has quiescent current < than 900µA
- Low side driver, when there is no switching activity and gate is low, exhibits negligible power consumption
- High side driver – with no switching activity and low gate - exhibits an extremely low power consumption: 220µA
- Low voltage rail compatibility (6V typ) allows low power consumption

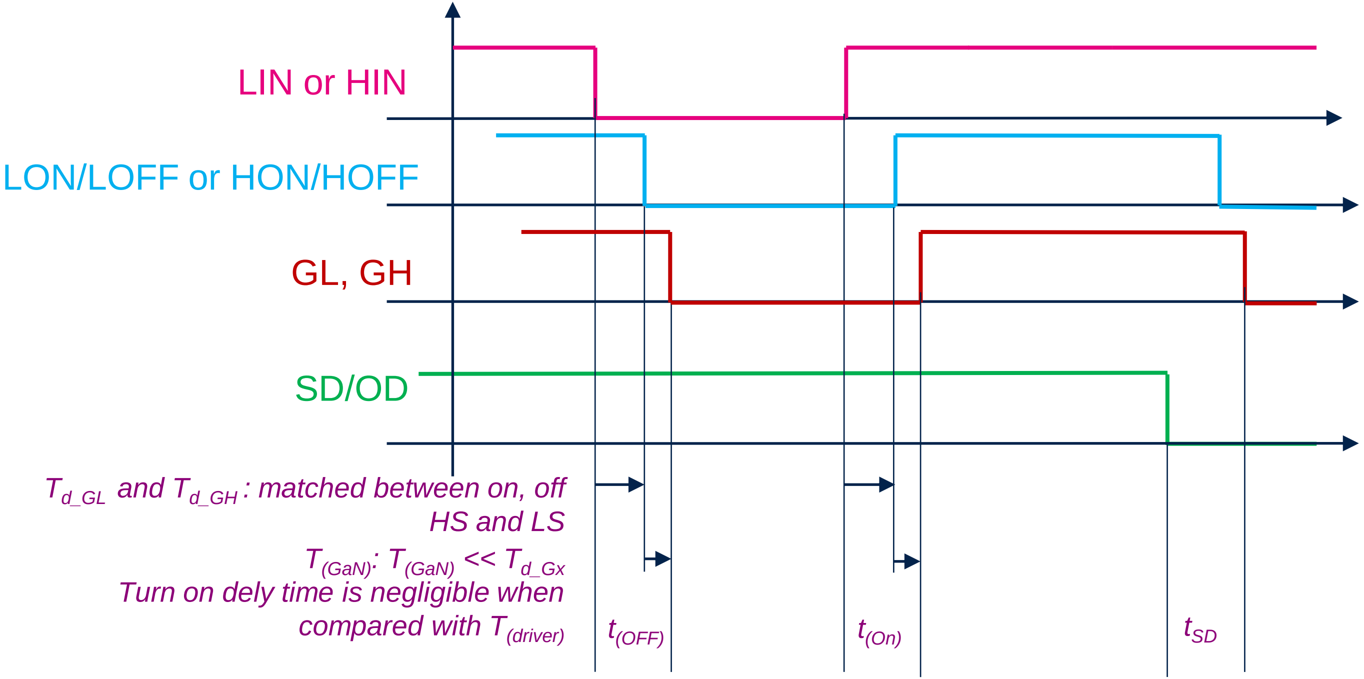
Logic inputs – truth table

	Input pins			GaN transistors status	
	$\overline{SD}$/OD	LIN	HIN	LS	HS
Disabled input port	L	X	X	OFF	OFF
Normal Operation Configurations	H	L	L	OFF	OFF
	H	L	H	OFF	**ON**
	H	H	L	**ON**	OFF
Interlocking	H	H	H	OFF	OFF

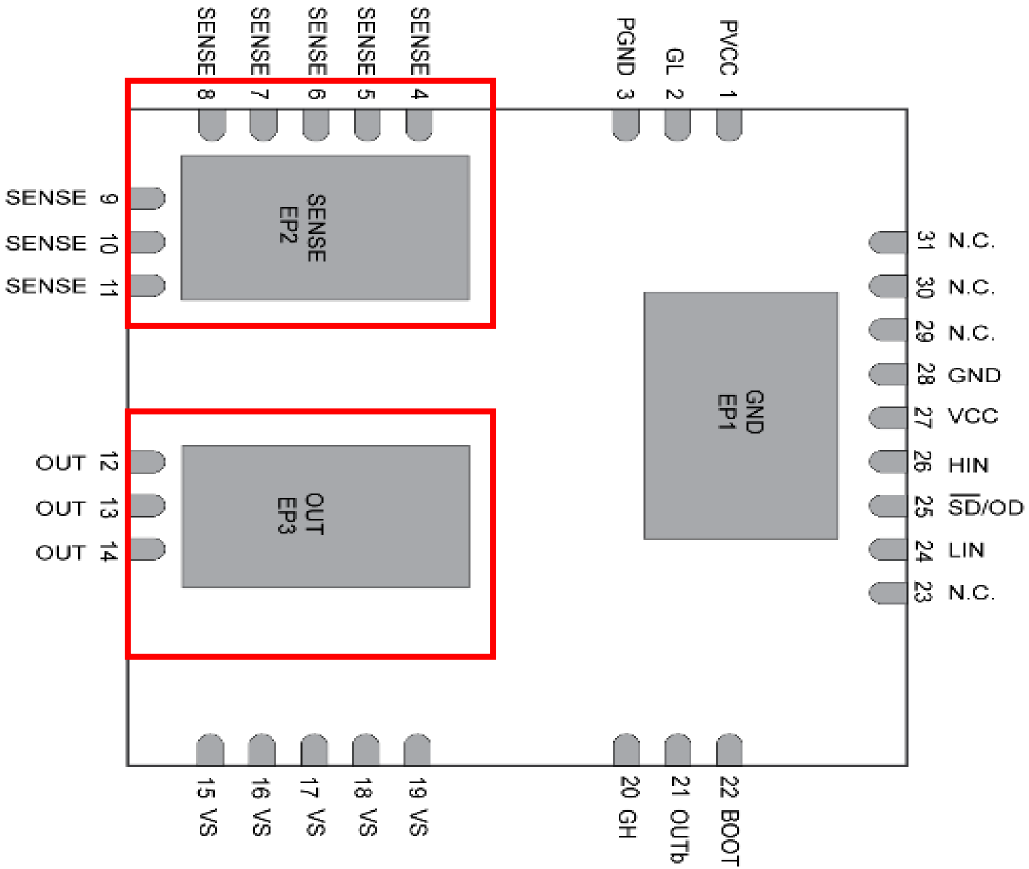
1. X: Don't care



Logic inputs – propagation delays

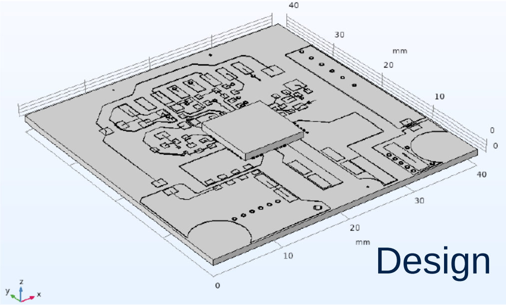


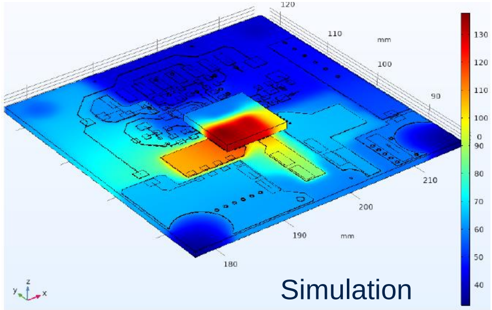
Thermal management



How to prepare a PCB for heatsink application

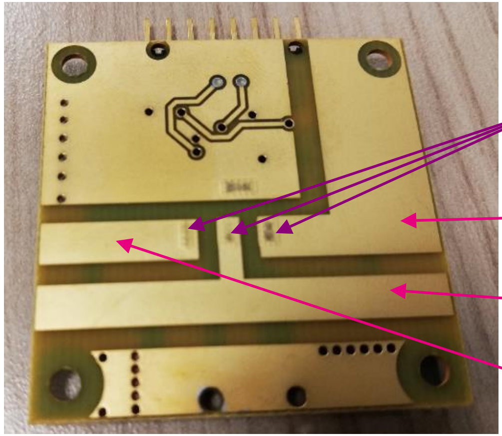
Board: 40mm x 40mm x 1mm FR4
Copper: 2 layers 70µm
Vias: Filled with CU





Esitmated
Rth,j-bot =9.5°C/W
Rth,j-a = 59°C/W
(ideal case with no external pins)

Real board - Top



Copper Vias

Sense

OUT

VS

Real board – Bottom
(Heatsink interface)

Typical applications

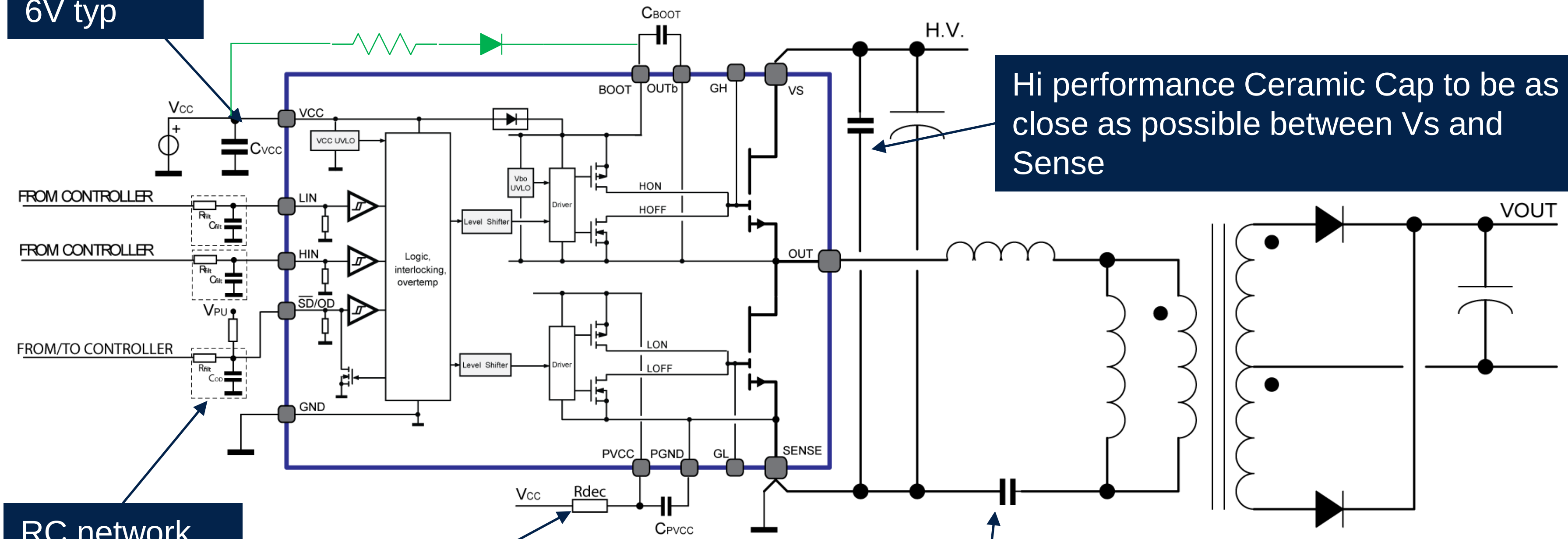
Typical examples of topology for consumer applications
- low to high output power levels up to 500W

Active Clamp Flyback (ACF)

Resonant LLC converter (LLC)

Typical topologies

LLC resonant



Suggested 6V typ

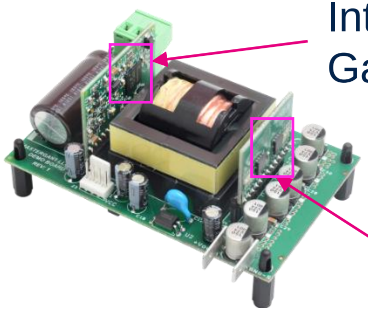
Hi performance Ceramic Cap to be as close as possible between Vs and Sense

RC network for OTP extended time constant

Suggested 10Ω

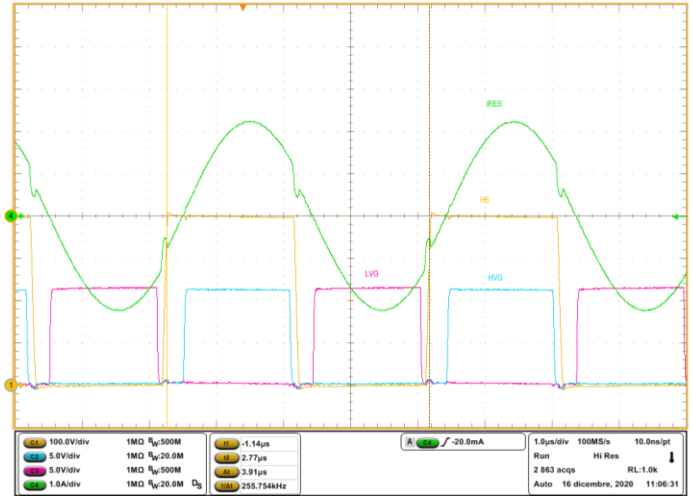
Shunt is optional: lossless Capacitive divider on resonant capacitor is normally used

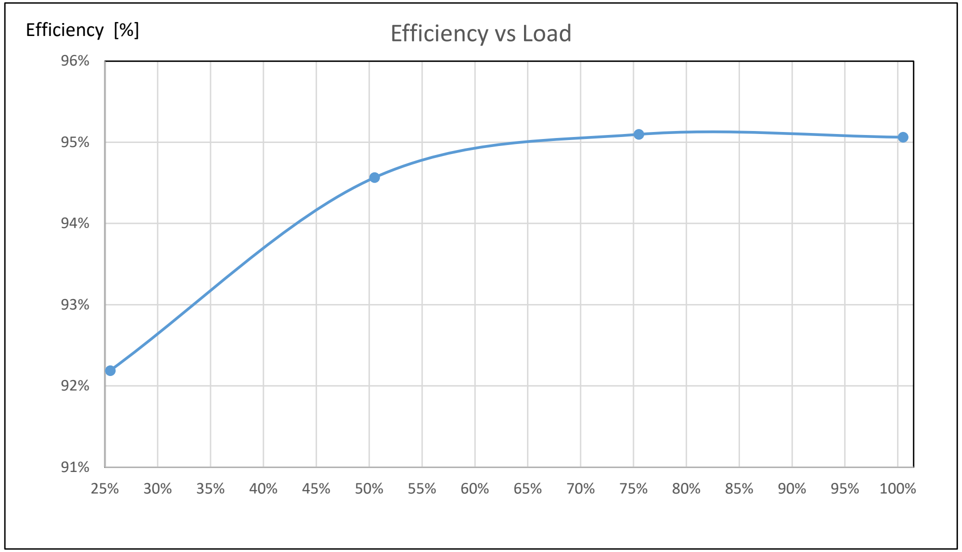
250W LLC converter

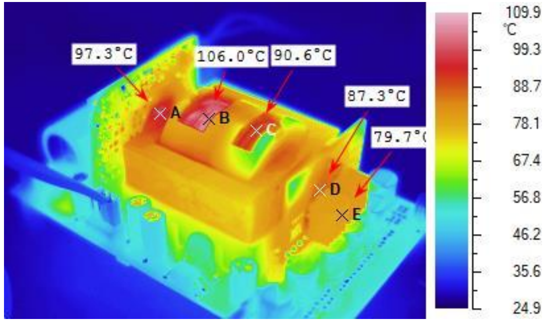


Integrated Smart GaN

Synchronous rectification

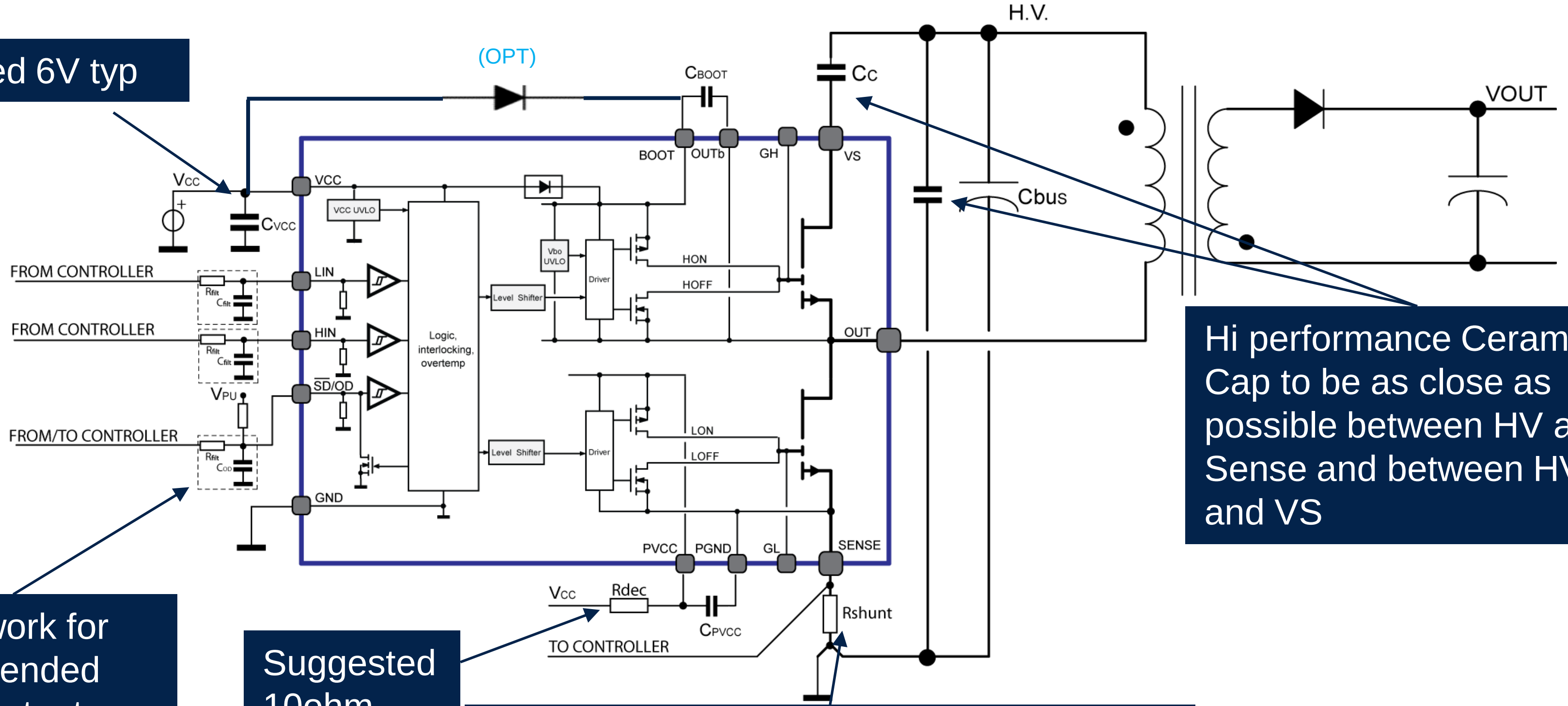






Typical topologies
Active clamp flyback

Suggested 6V typ



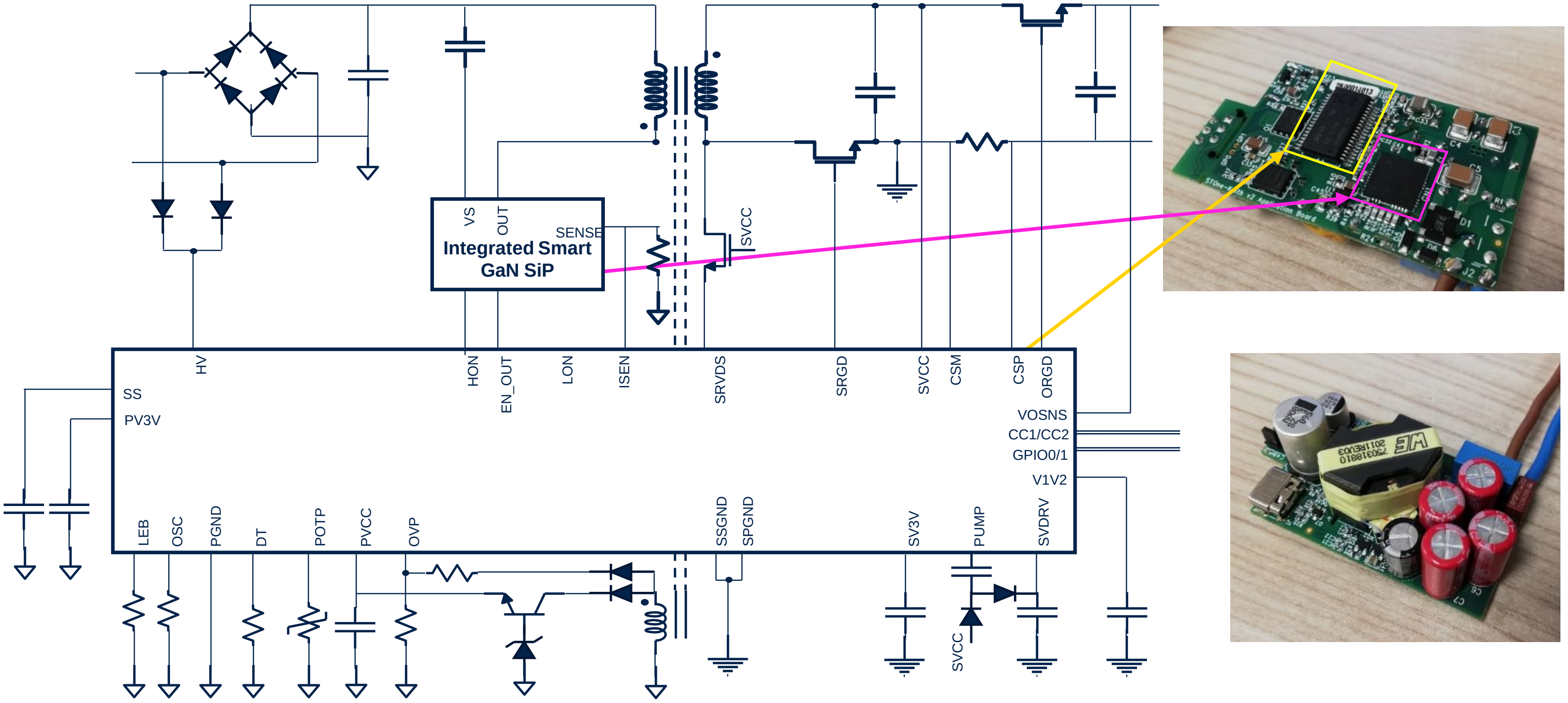
Hi performance Ceramic Cap to be as close as possible between HV and Sense and between HV and VS

RC network for OTP extended time constant

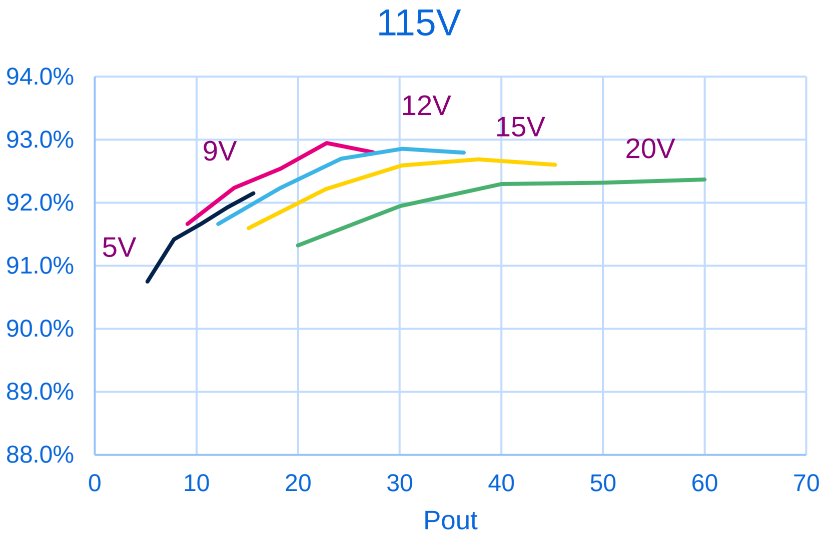
Suggested 10ohm

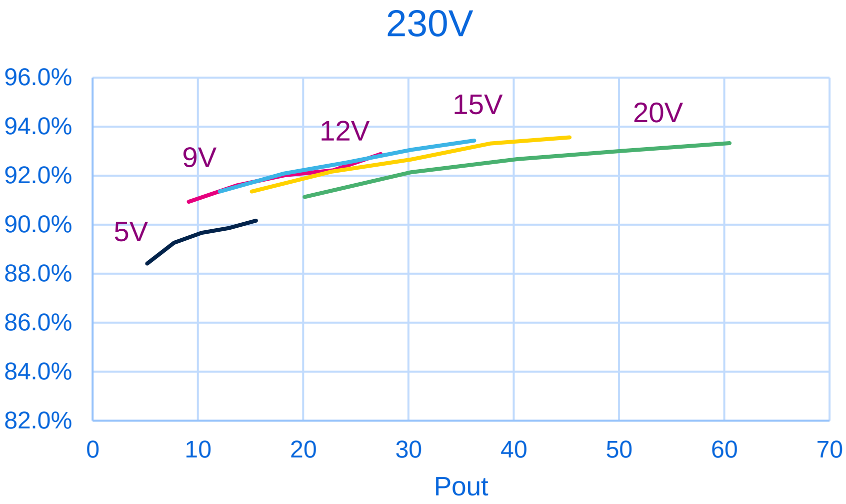
Shunt is very common: LS driving is guaranteed until the voltage difference between PGND and GND is within +/-2V ☺

Application example – ACF with SR



Application example – ACF with SR





Efficiency measurements

Conclusion

- The integrated Smart GaN device in half-bridge configuration is a viable solution for easy and safe design of low power building blocks for power converters
- Thanks to the integration both electrical and thermal designs are straightforward and robust
- The high voltage integrated approach is fully exploited in **consumer applications** where performance, size and cost are the key selection criteria

THANK YOU!