The Application of Miniature Planar Gate Drive Transformers

Rosemary O'Keeffe, Senior Applications Engineer, Bourns

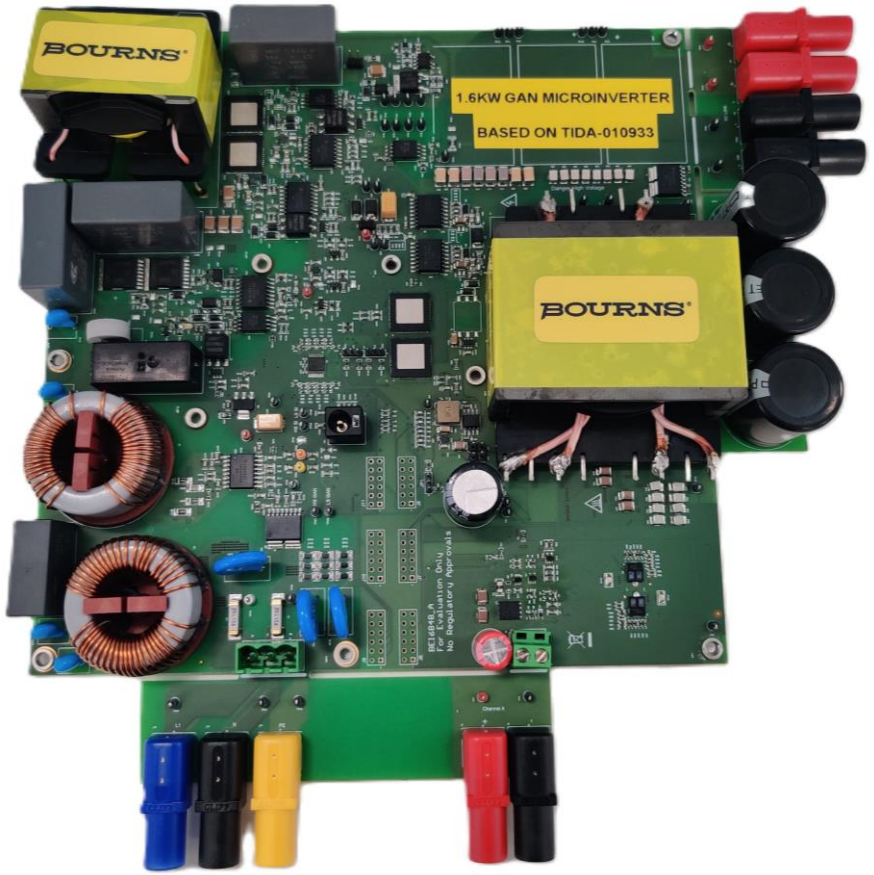
Bodo's Wide Bandgap Event 2025

Making WBG Designs Happen

SiC

About Bourns

- Applications Focus
  - SiC and GaN Converters
- Power Electronics Design
- Expertise in PCB Design
- CAD Tools (Ansys Maxwell, HFSS, CST Studio, SolidWorks, Altium)
- Automotive Manufacturing

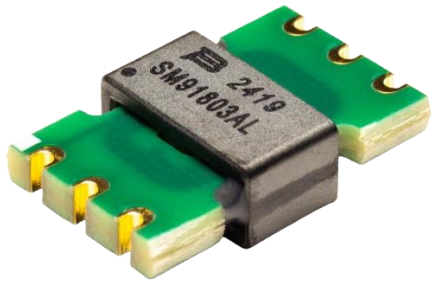


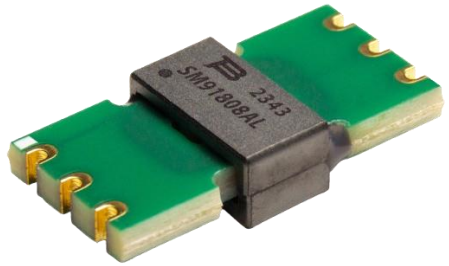
Agenda

- Background
- Criterion
- Objectives
- Product Overview
- Test Results
- Conclusion

Expertise in Miniature Planar Magnetics

- High-volume planar BMS transformers already in automotive production
- Proven capability with low-profile, PCB-integrated magnetics
- Strong background in isolation, EMI, and AEC-Q200 qualification





Part Numbers [1]
SM91801AL
SM91803AL
SM91806AL
SM91808AL

Key Design Criteria for SiC Magnetic Component

Gate drive transformer requires:

- High Power Density
- High Isolation
- Miniature Size and low profile
- Low impact on EMI

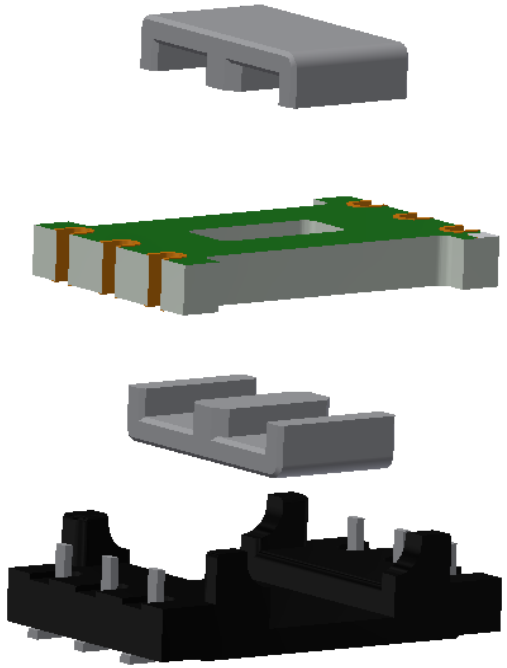
Resonant Frequency

- BMS transformer uses high frequency core material with high Q factor
- Excellent for low losses at 1MHz

Can Planar Meet These Requirements?

How to meet these criteria

- High Switching Frequency
- Transformer used as LLC drivers
- Planar Windings



Goal of this study

Evaluate planar magnetic performance under real 1 MHz SiC gate-drive loading conditions

Introducing the SM9127x Series Power Transformer

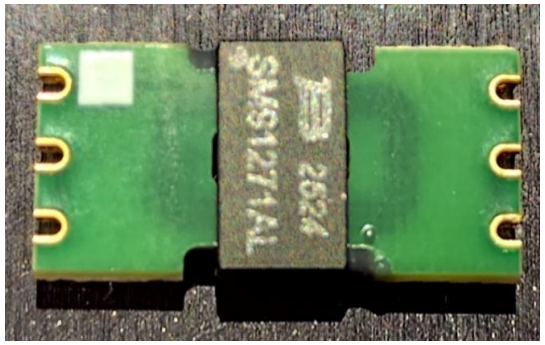
Compact and Low Profile

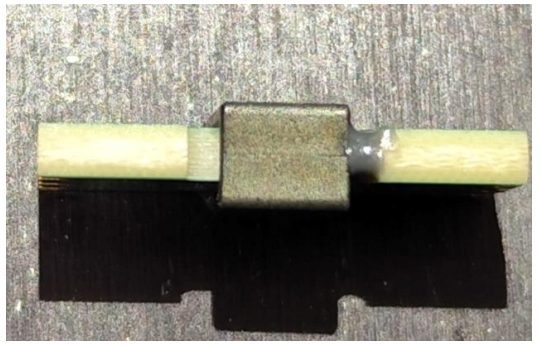
- Dimensions: 17.4mm x 8.5mmx 4.05mm
- Designed for PCB mounting with a slot cutout, only 3.2mm above the board surface
- 4KV Isolation, 850Vdc working voltage

Variants Tested

- High Power Density (4W at 1MHz (LLC transformer)
- Aimed at Isolated Power (gate drive)

SM91270AL	**SM91271AL**	**SM91272AL**
Turns Ratio	Turns Ratio	Turns Ratio
Np:Ns = 1:1	Np:Ns = 1:1.14	Np:Ns = 1:2





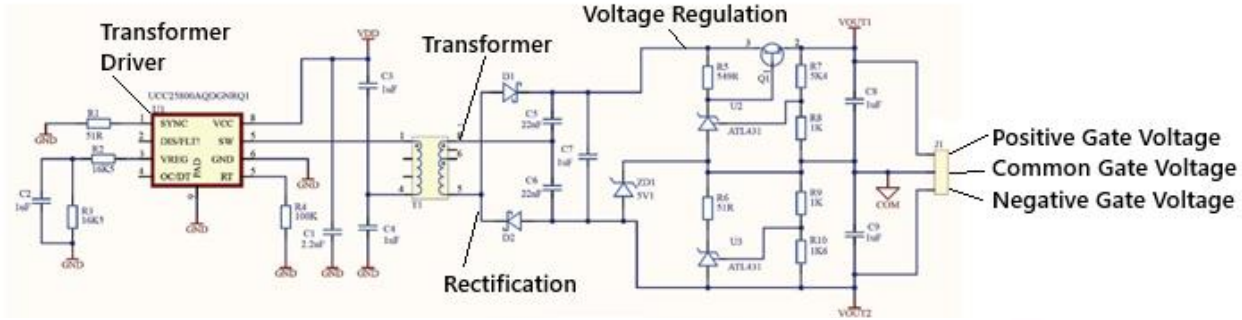
Transformer Characteristics

Characteristic	SM91270AL	SM91271AL	SM91272AL
Primary Inductance, L_m	45.20µH	36.50µH	22.46µH
Leakage Inductance, L_L	861nH	723nH	490nH
Primary DCR	469mΩ	408mΩ	277mΩ
Secondary DCR	457mΩ	516mΩ	1.68Ω
Interwinding Capacitance, C_{ww}	3.29pF	3.35pF	3.79pF
Turns Ratio Np : Ns	1 : 1	1 : 1.14	1 : 2
V-s Product	7.2 V-µs	6.3 V-µs	3.6 V-µs
Designed For	24V Systems	24V Systems	12V Systems

Test Setup & Methodology

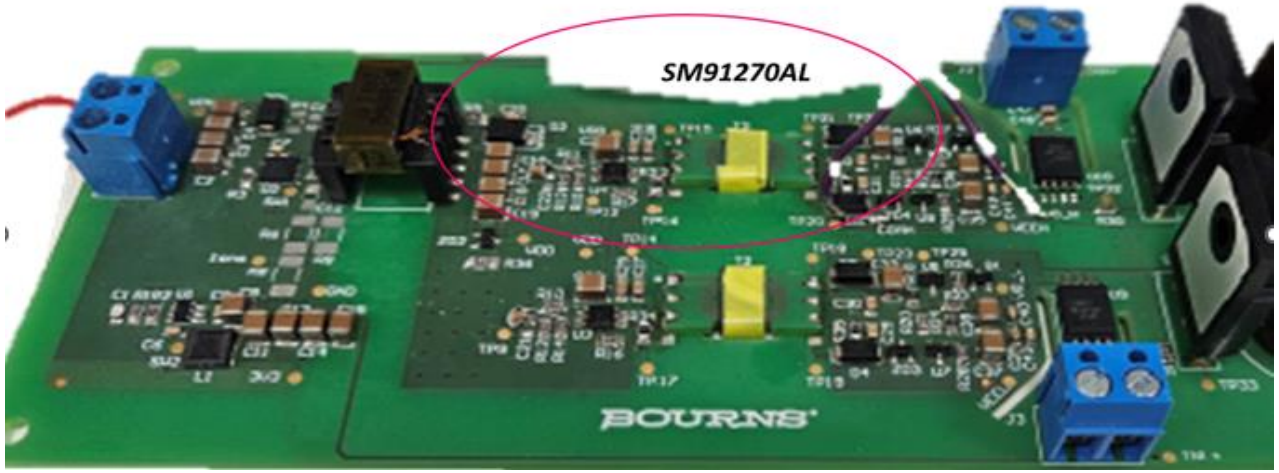
Circuit Conditions

- Driver: LLC Transformer Driver(up to 6W)
- Switching Frequency: 1MHz
- Output: +16V/-4V gate voltage



Measurements Taken

- Input Current
- Rectified Output Voltage
- Regulated Output Voltage



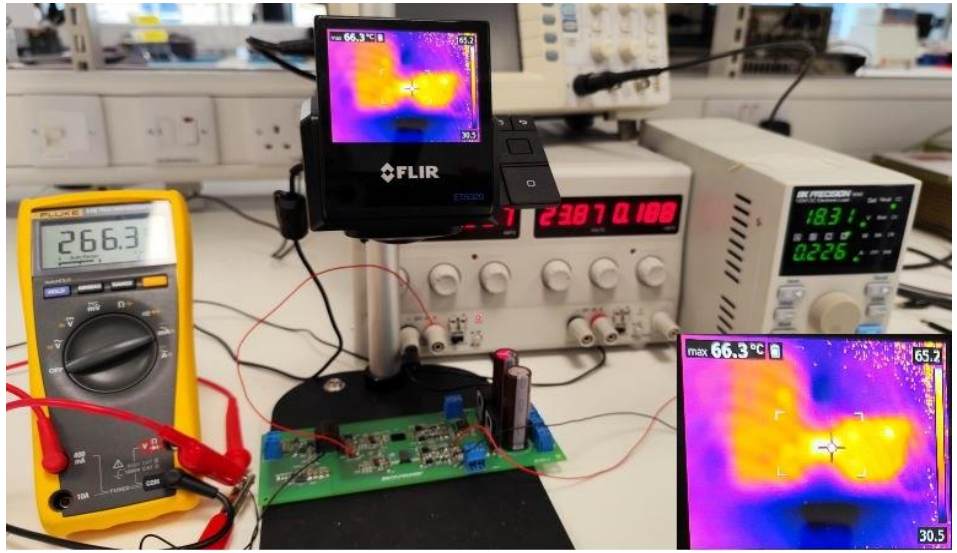
Results: SM91270AL (1:1 Ratio, 24V Input)

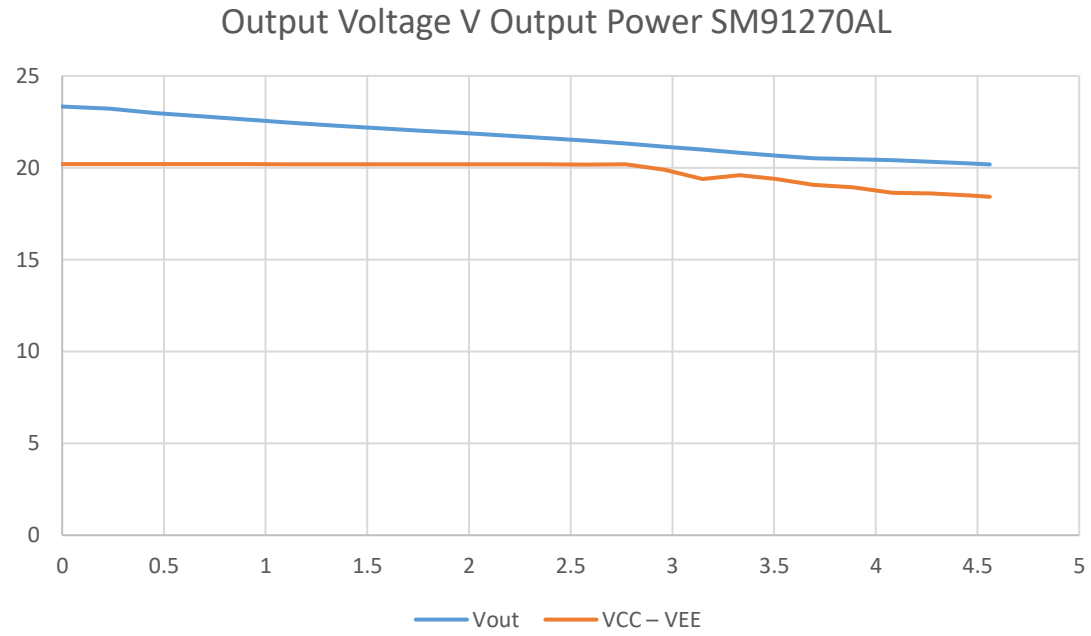
Performance

- 3W output power at Max gate drive voltage
- Slightly reducing the gate drive voltage increases maximum power to 4.5W
- Driver IC's overcurrent protection, which triggered at 226mA, limited the output power

Thermal Rise

A temperature rise of 26°C was recorded at maximum power

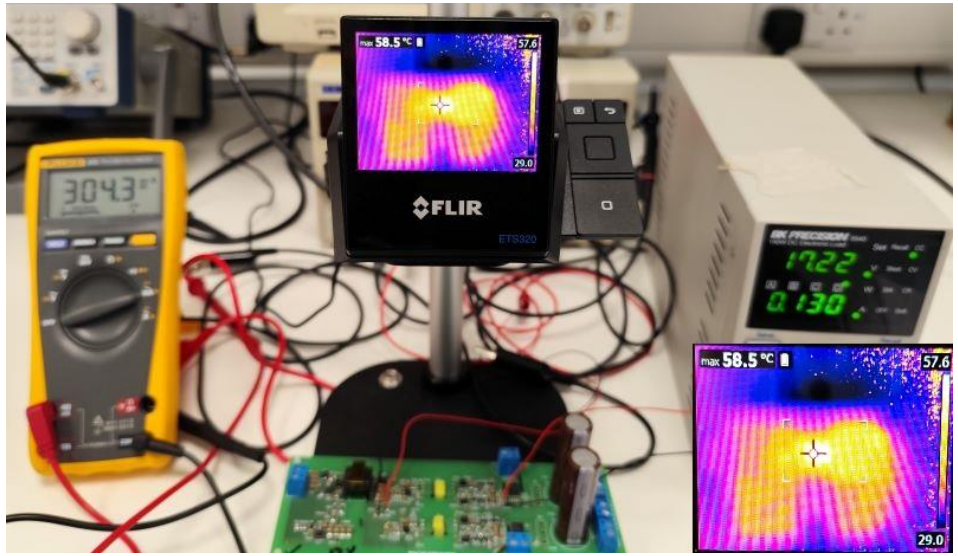




Results: SM91271AL (1:1.14 Ratio, 24V Input)

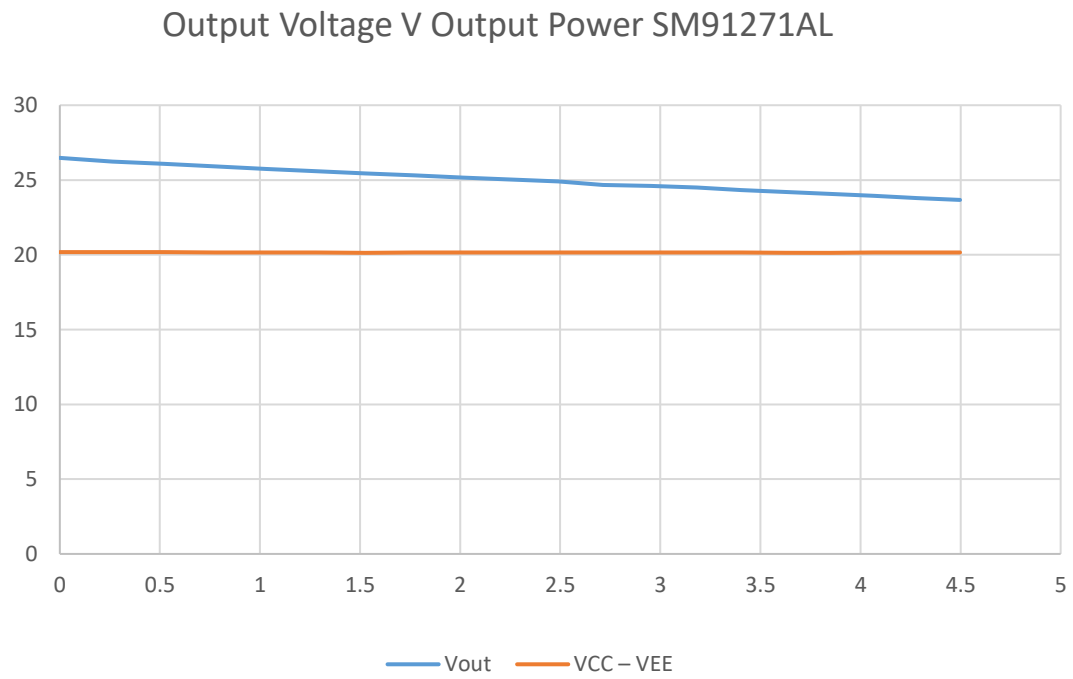
Performance

- This transformer demonstrated excellent performance, delivering up to 4.5W without any loss of regulation
- Maximum power was limited not by the transformer but by the driver IC's overcurrent protection, which triggered at 192mA



Thermal Rise

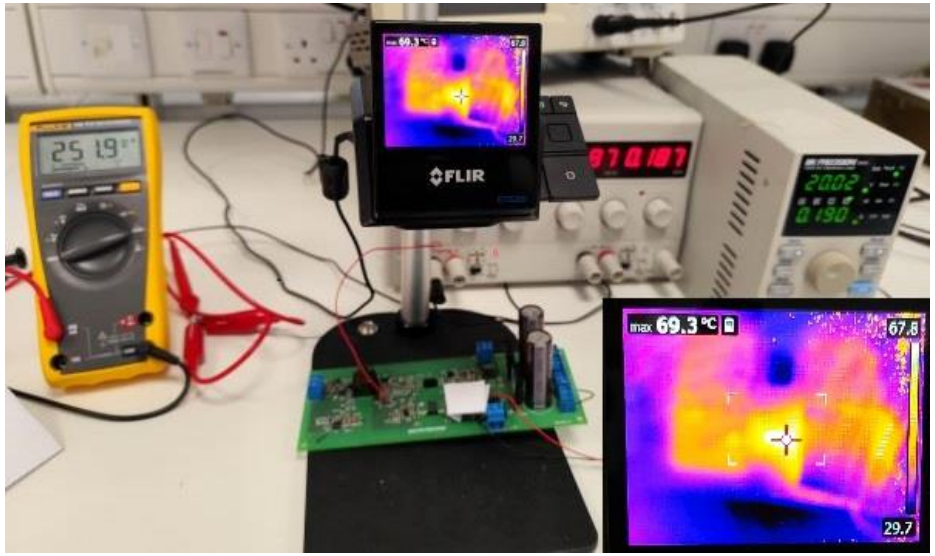
The temperature rise was slightly higher at 30°C



Results: SM91272AL (1:2 Ratio, 12V Input)

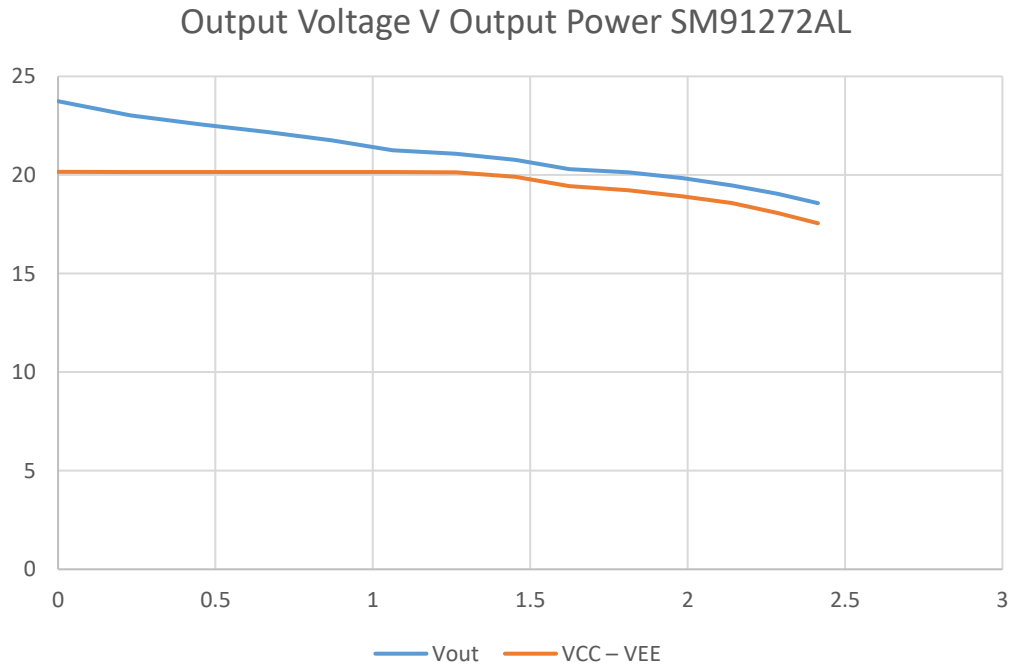
Performance

- Regulation is lost at 1.5W power
- Transformer continues to operate up to 2W of output power
- Reduction is output power is due to the large step up

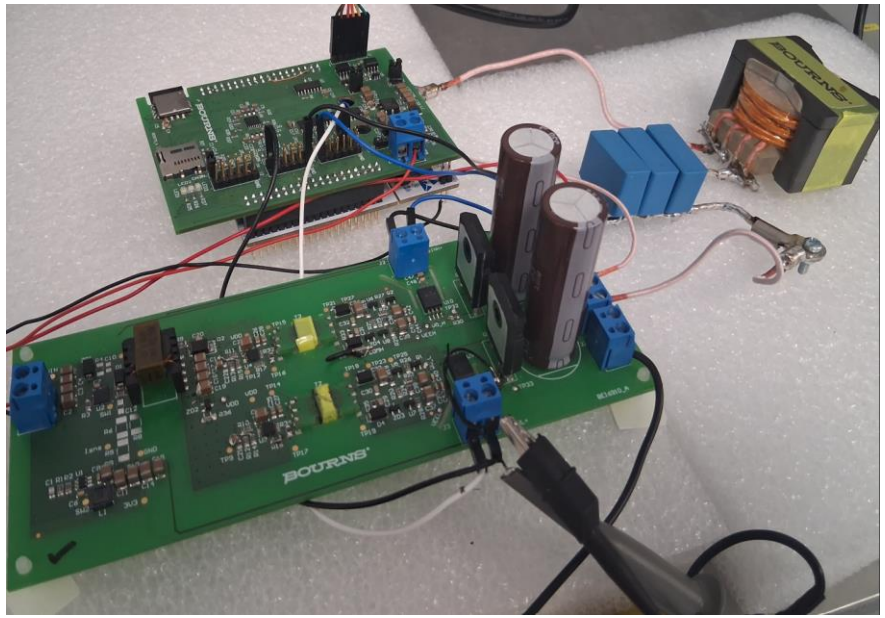


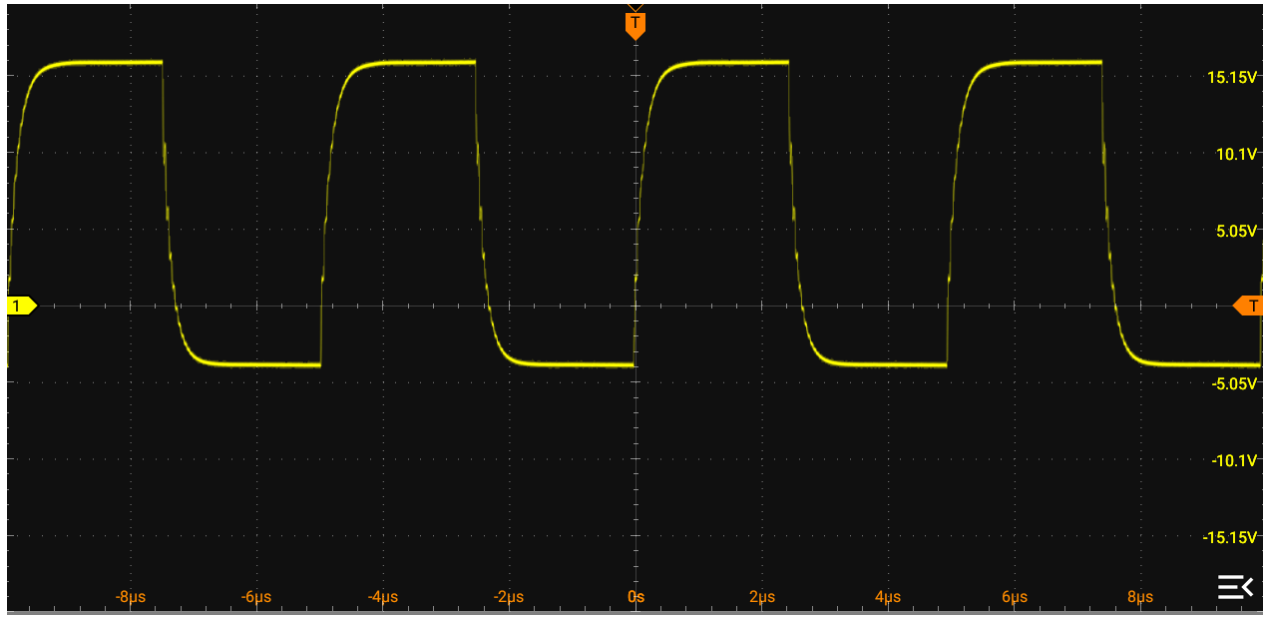
Thermal Rise

The temperature rise was slightly higher at 30°C



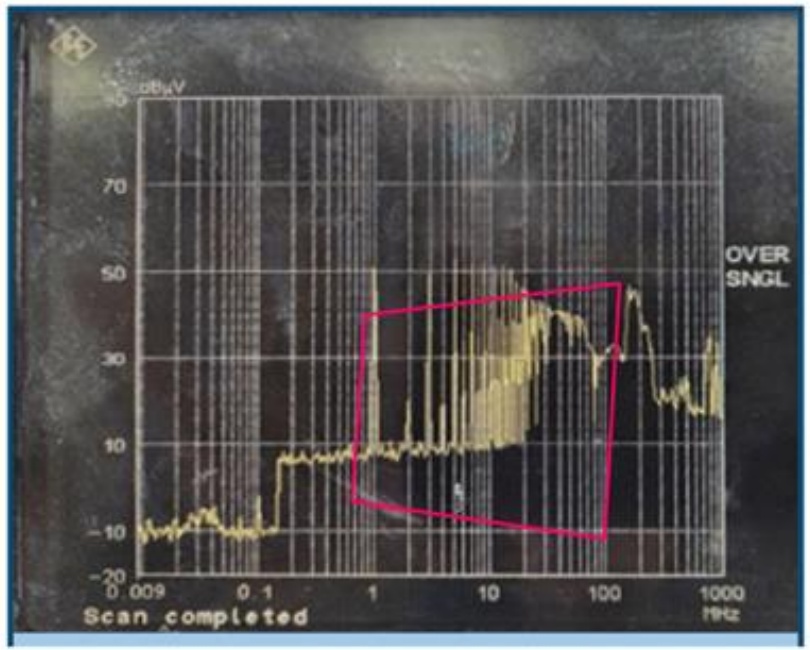
Results: SM91270AL Gate Drive Signal



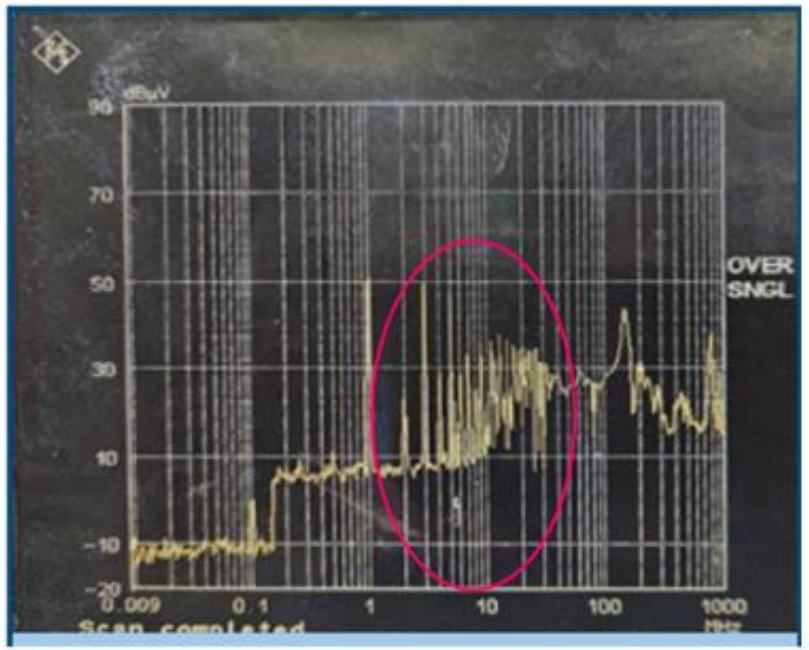


- Figure shows half-bridge setup with SiC FETs driving a LLC transformer with the output short circuited
- Gate drive signal is very clean, demonstrating low parasitics

Results: EMI



Concentric Wound



SM91270AL Planar

- Lower Emissions compared to a concentric wound transformer [2]
- In particular 1MHz to 100MHz

[2] bourns_emi_testing_white_paper.pdf

Conclusion: High Power in a Small Package

High Power Density

Their suitability for high-frequency switching (tested at 1MHz) allows them to deliver a large amount of power relative to their small physical size

Low Profile

The low-profile design is a significant advantage in applications with height constraints, enabling more compact power systems

EMI Advantages

Beyond power delivery, the planar configuration offers well-controlled, low interwinding capacitance, which helps reduce common-mode noise and improve EMI performance

Bourns' miniature planar transformers are highly suitable for providing power for gate drives in high-frequency LLC topologies

Key Takeaways

- The SM9127X family of transformers offers excellent performance
  - ✓ Achieves up to 4.5W of output power
  - ✓ Compact and low-profile package
  - ✓ Input voltages of 12V and 24V
  - ✓ Operates reliably up to 1MHz switching frequency
  - ✓ Reinforced Insulation up to 850V
  - ✓ AEC-Q200 qualified for demanding applications
- EMI advantage
- More variants planned to be added to the SM9127X family
- Samples available on request, custom version also available (turns ratio on request). Send us an email at Custom Magnetics Enquiry

Any questions?

Appendix

[1] Signal BMS Planar Transformers: https://bourns.com/products/magnetic-products/signal-isolation-transformers

[2] Bourns EMI Testing white paper: https://www.bourns.com/docs/technical-documents/technical-library/inductive-components/publications/bourns_emi_testing_white_paper.pdf?sfvrsn=27cb29f6_11

[3] Reference Designs: https://bourns.com/resources/reference-design