High-Frequency High-Efficiency LLC Module with Planar Matrix Transformer for CPRS Application Using GaN Power IC

Bin Li, Director of Application

May 11th, 2023

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Efficient Power Supply for Data Center and AI

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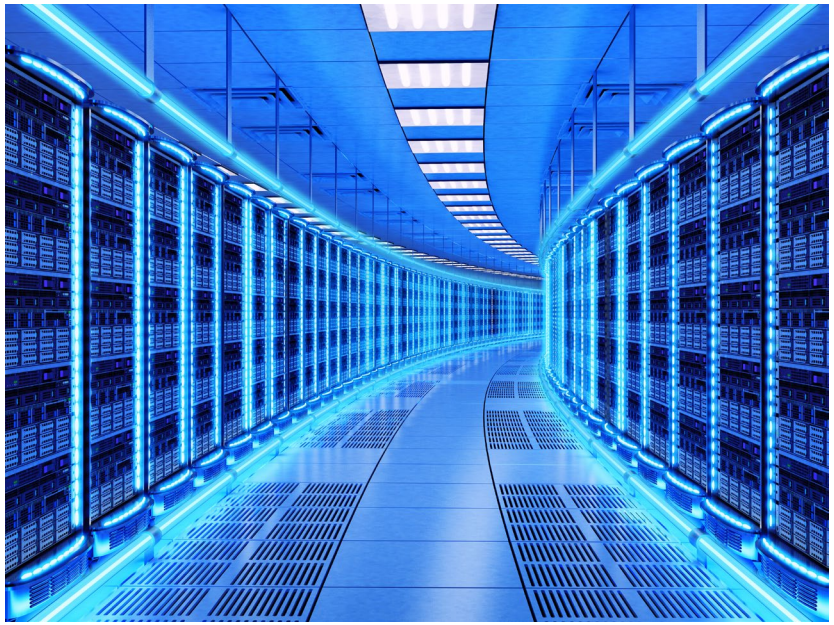
- Data Center



- Artificial Intelligence

- Data center consumed about **1.5%** electricity globally, which is around **300TWh** [1]. It accounts for **23** nuclear power plants [2].
- ChatGPT uses **10GWh** electricity in Jan. 2023 to response to inquiries [3].
- One training ChatGPT (GPT-3) consumed around **1.3GWh** electricity [4].

[1] https://www.iea.org/reports/data-centres-and-data-transmission-networks
[2] https://www.energy.gov/ne/articles/5-fast-facts-about-nuclear-energy
[3] https://towardsdatascience.com/chatgpts-electricity-consumption-7873483feac4
[4] https://arxiv.org/ftp/arxiv/papers/2204/2204.05149.pdf

1% efficiency improve = 1/4 Nuclear power plant ~3GTon of Co2

High Power Density for Data Center and AI

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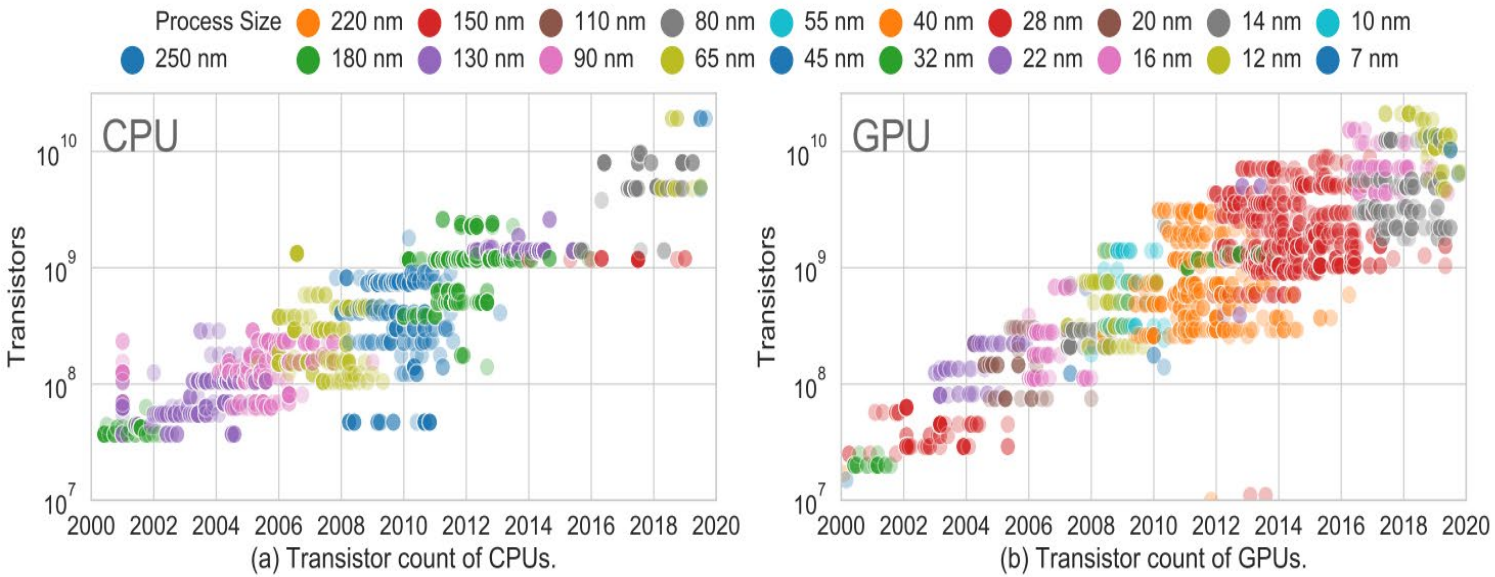
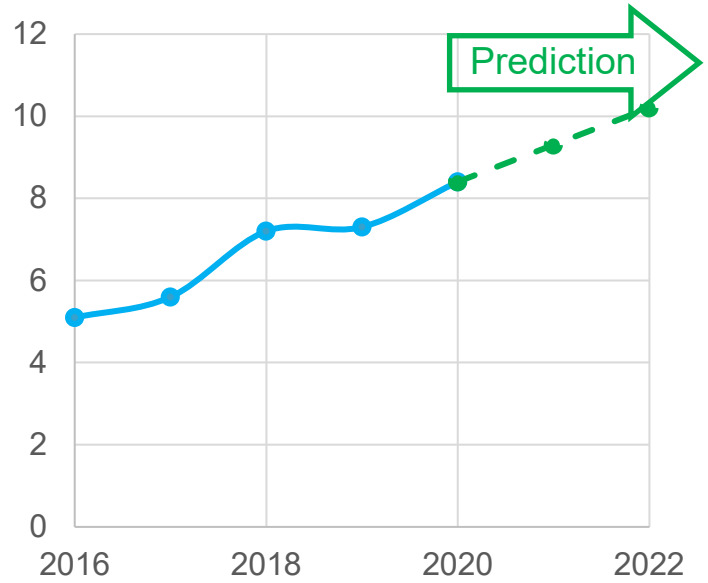
- Moore's Law for CPUs and GPUs [1]



- Average Server Rack Density [2]

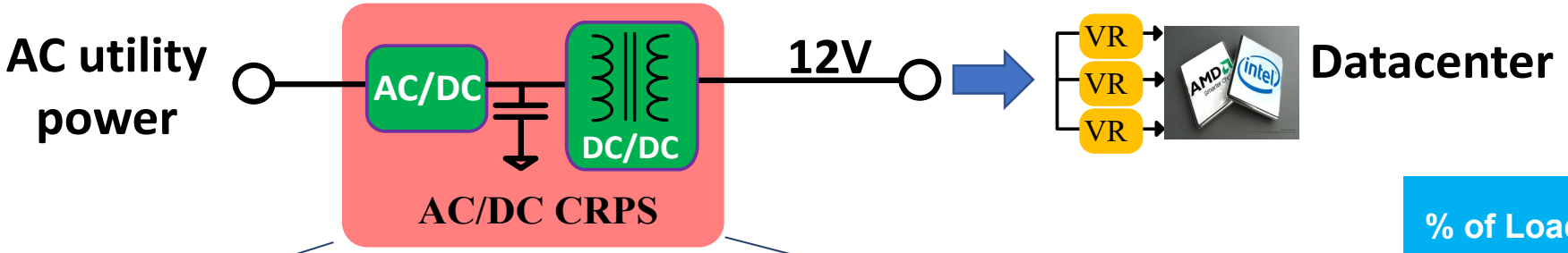


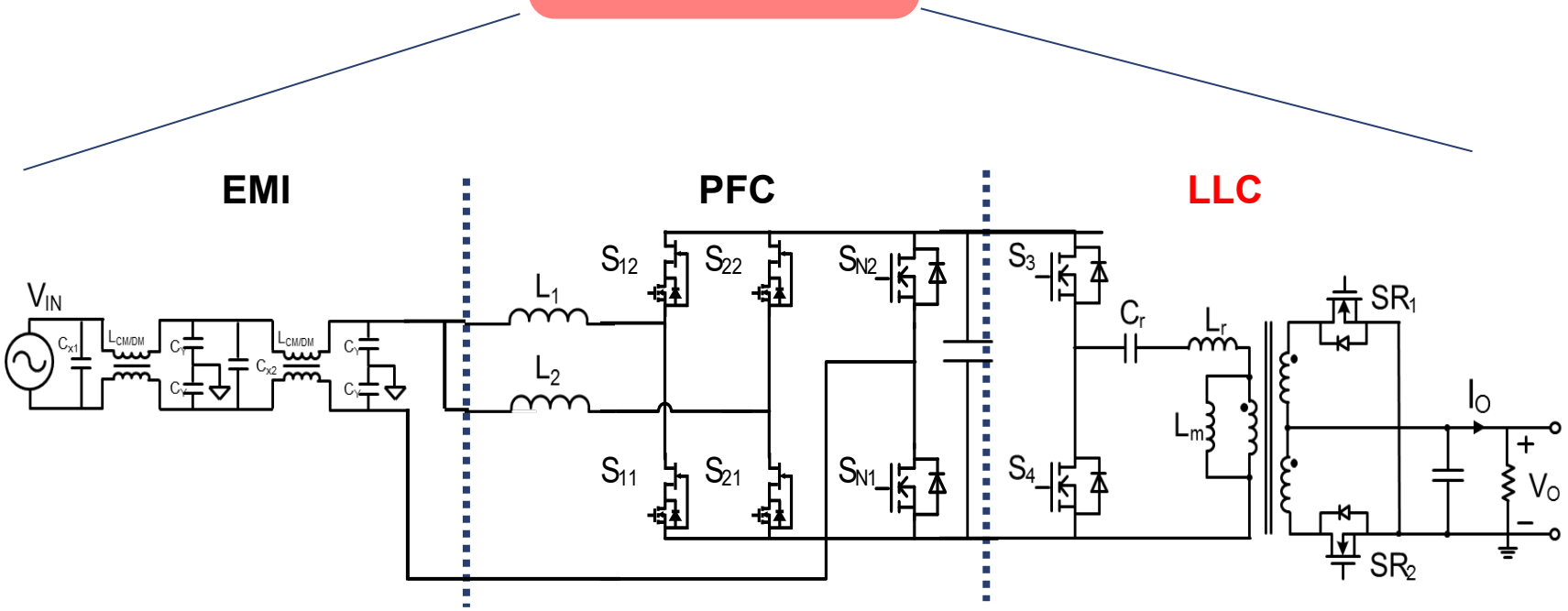
- Power consumption for GPU and CPU keeps increasing according to Moore's Law.
- AI requires more powerful processors for machine learning.
- Higher server rack power density is required.

High power density power supply is required!

[1] https://arxiv.org/pdf/1911.11313.pdf
[2] https://phoenixnap.com/blog/rack-density-increasing

Data Center Power Supply Structure





80 PLUS™

% of Load	10%	20%	50%	100%
Titanium	90%	94%	96%	91%
Platinum		90%	94%	91%
Gold		88%	92%	88%
Silver		85%	89%	85%
Bronze		81%	85%	81%

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Integrated GaN Power IC from Navitas

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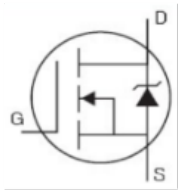
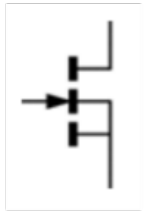
Silicon FET



- High Qg
- High Qrr
- High C_{OSS}
- F_{SW} < 100 kHz

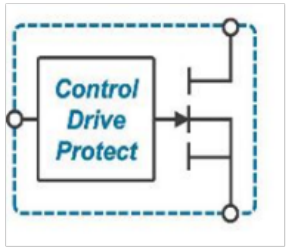
Discrete GaN



- ✓ Low Qg, Qrr and Coss
- ✓ Fast switching

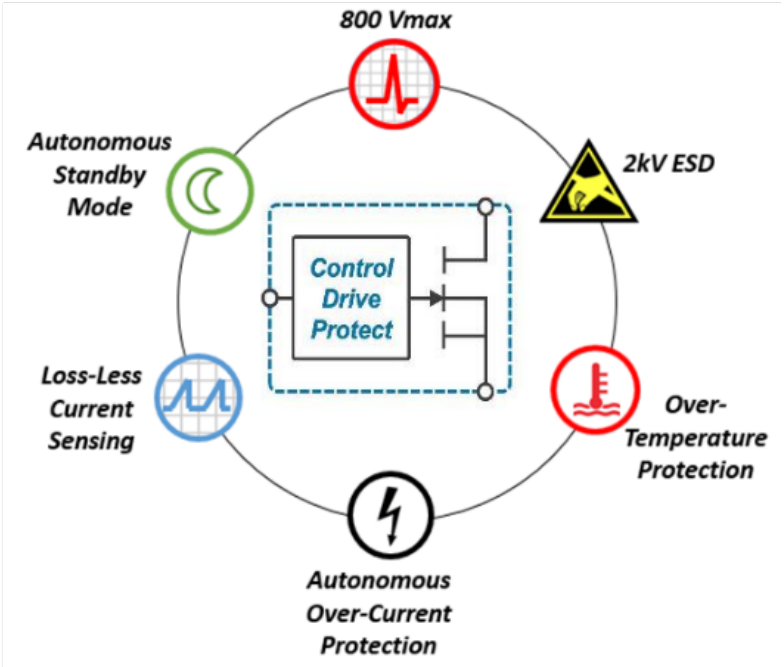
- Sensitive gate drive
- Additional gate drive
- Additional ESD protection
- High quality layout

500 kHz GaNFast™



- ✓ Integrated gate driver
- ✓ High dV/dt immunity
- ✓ Easy layout
- ✓ Turn on dv/dt control
- ✓ 2 kV ESD protection

GaNSense™



GaNSense with GaNSafe:

- ✓ Integrated gate driver
- ✓ Short circuit protection
- ✓ Over temperature protection
- ✓ Turn on/off dv/dt control

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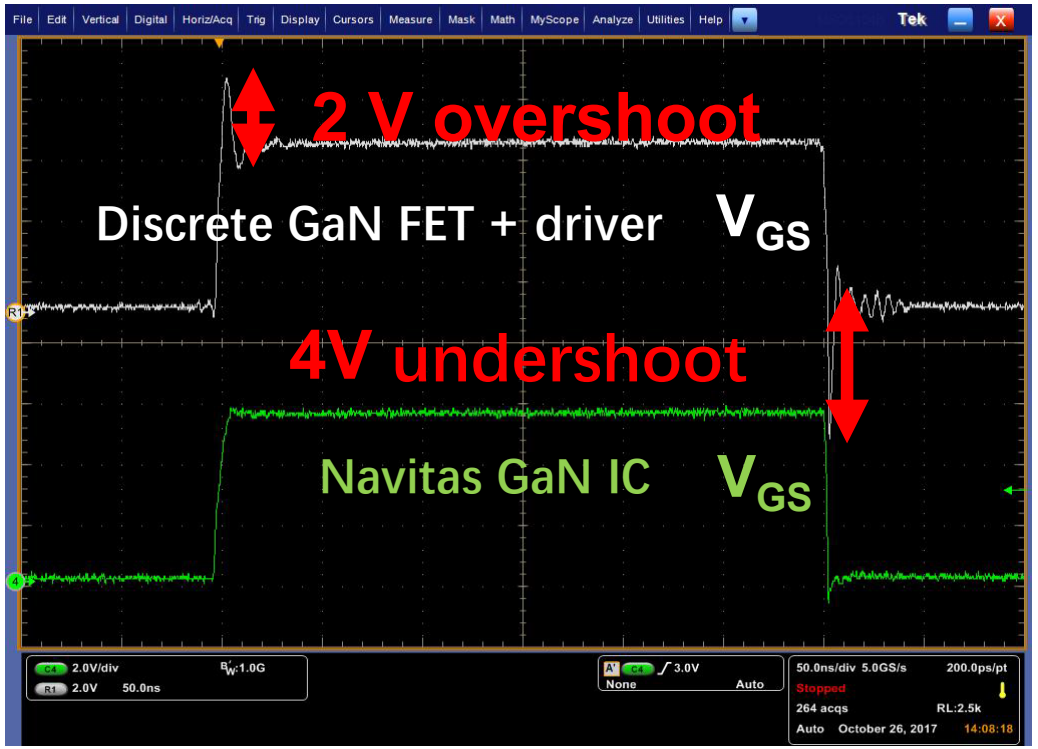
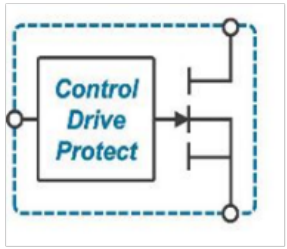
Integrated GaN Power IC from Navitas



500 kHz

GaNFast™



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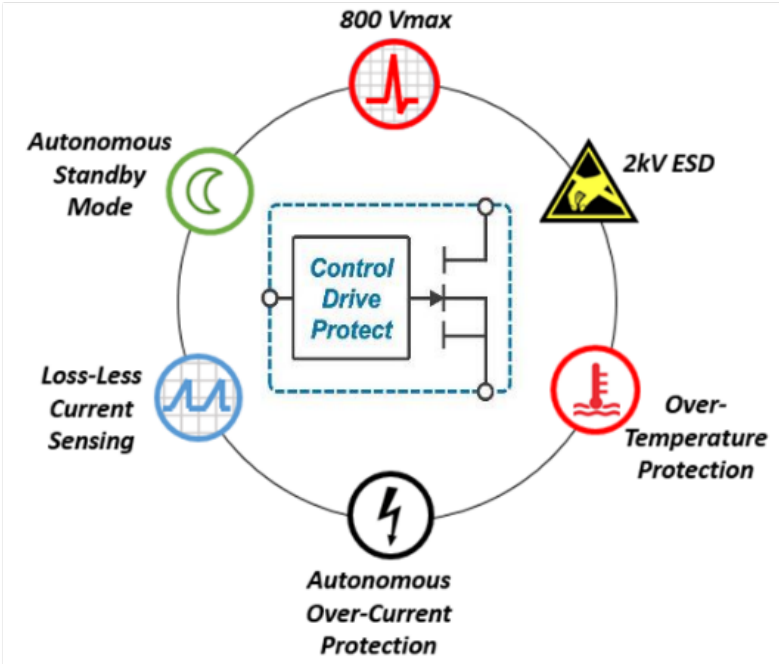

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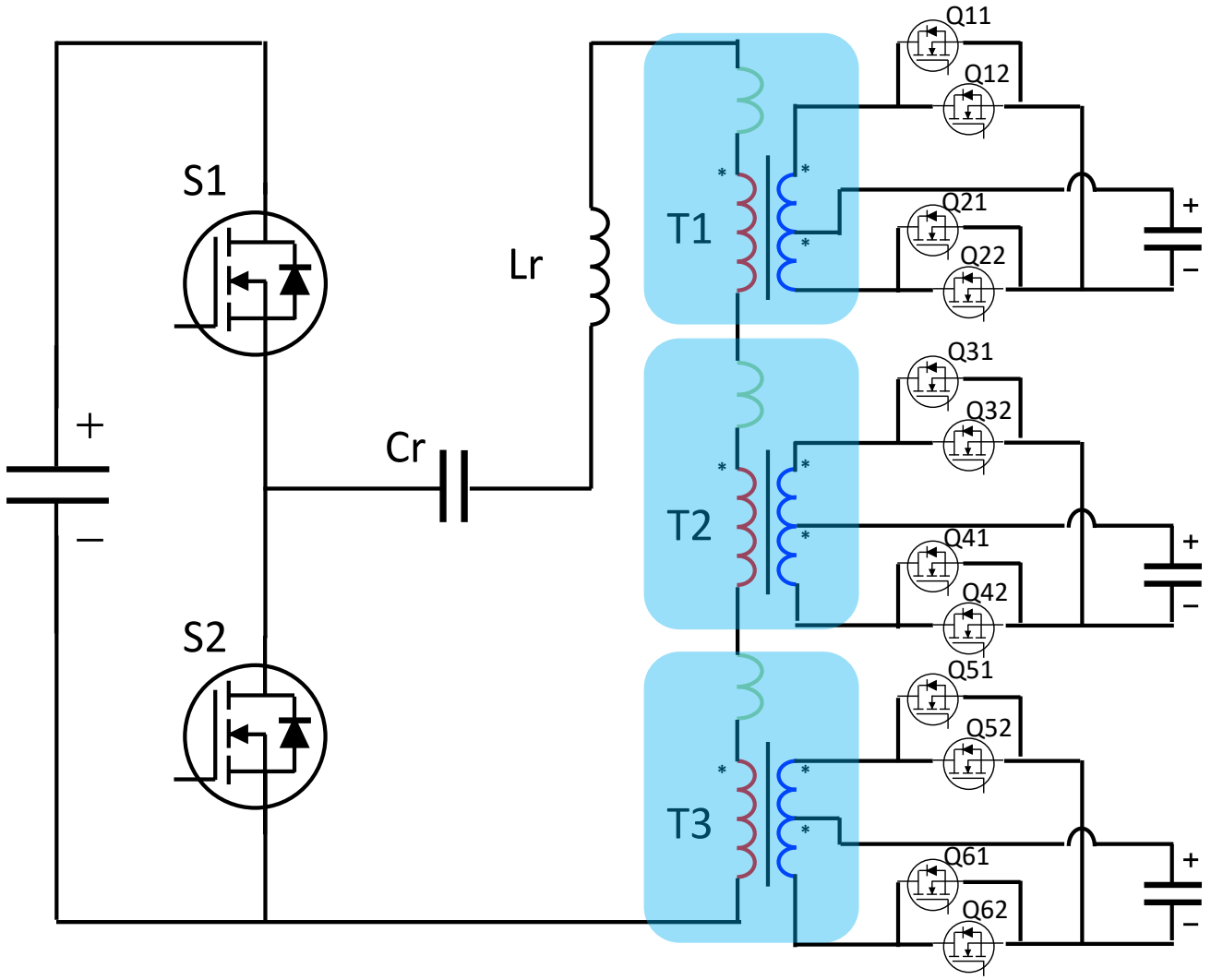
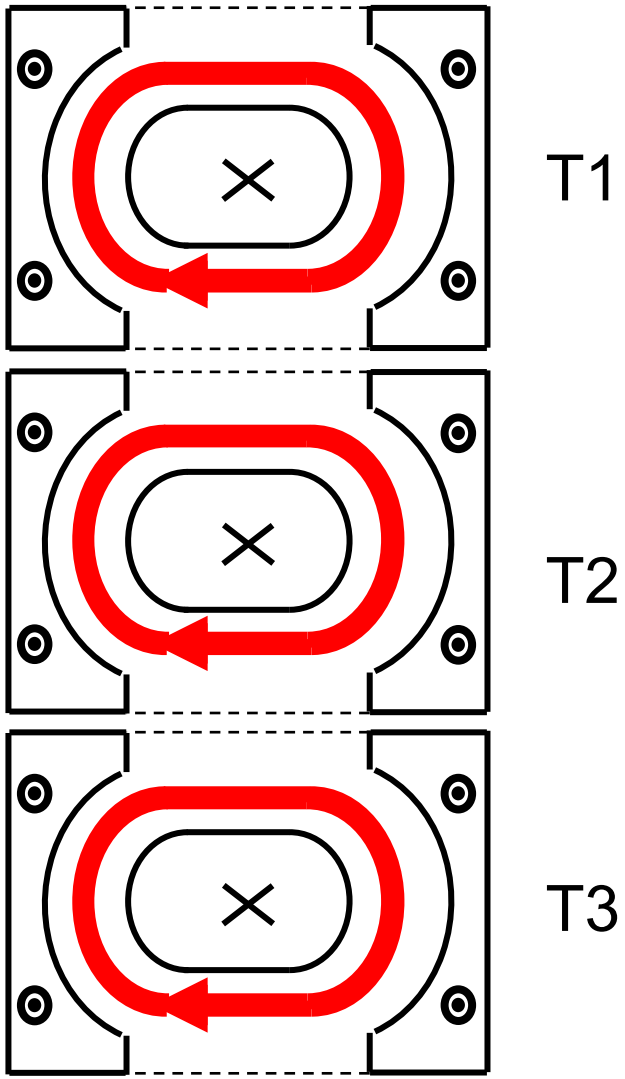
Matrix Transformer Structure for LLC





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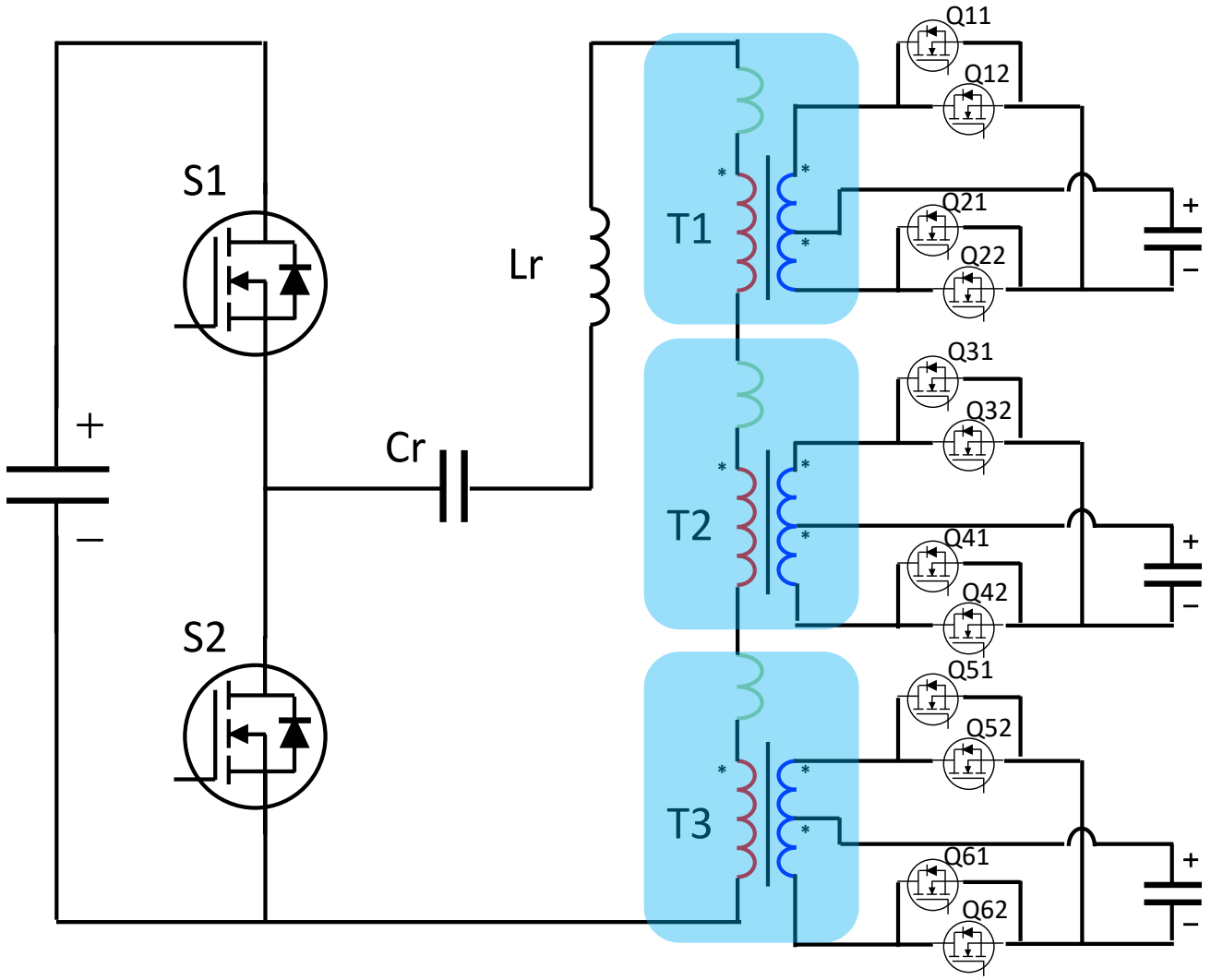

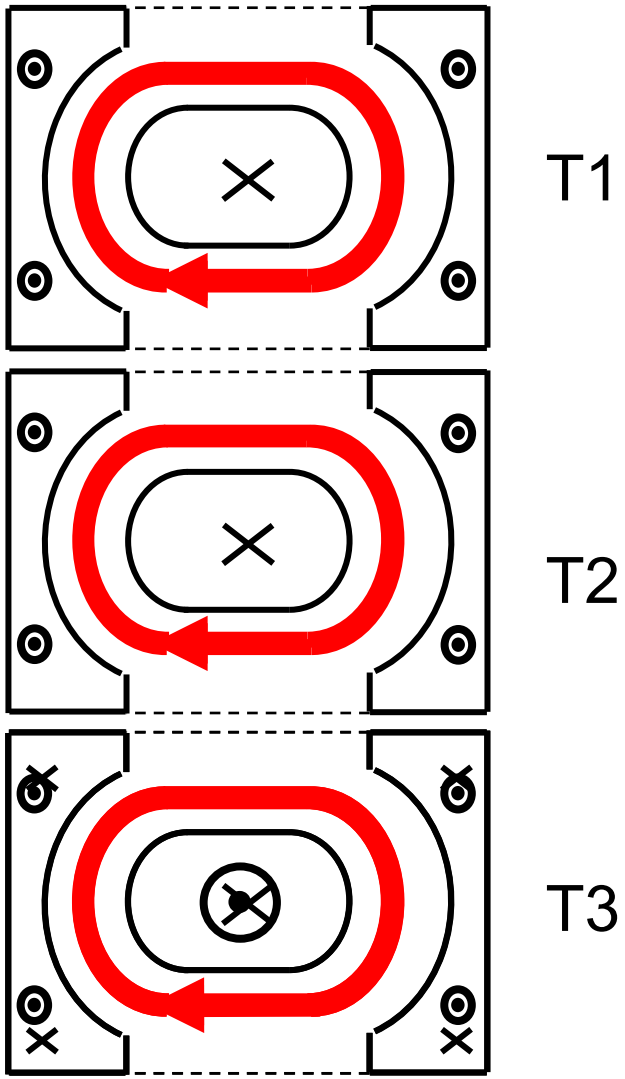

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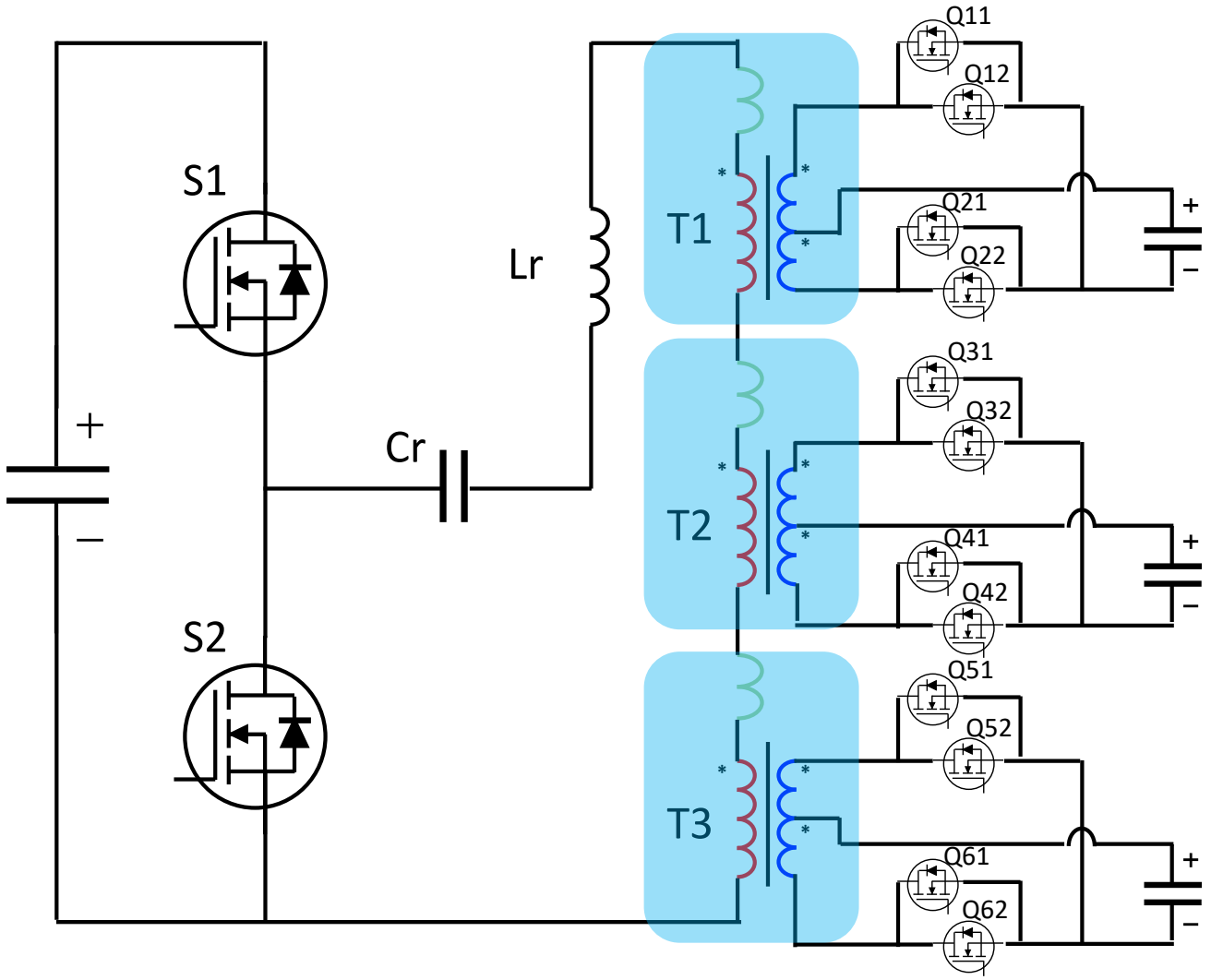

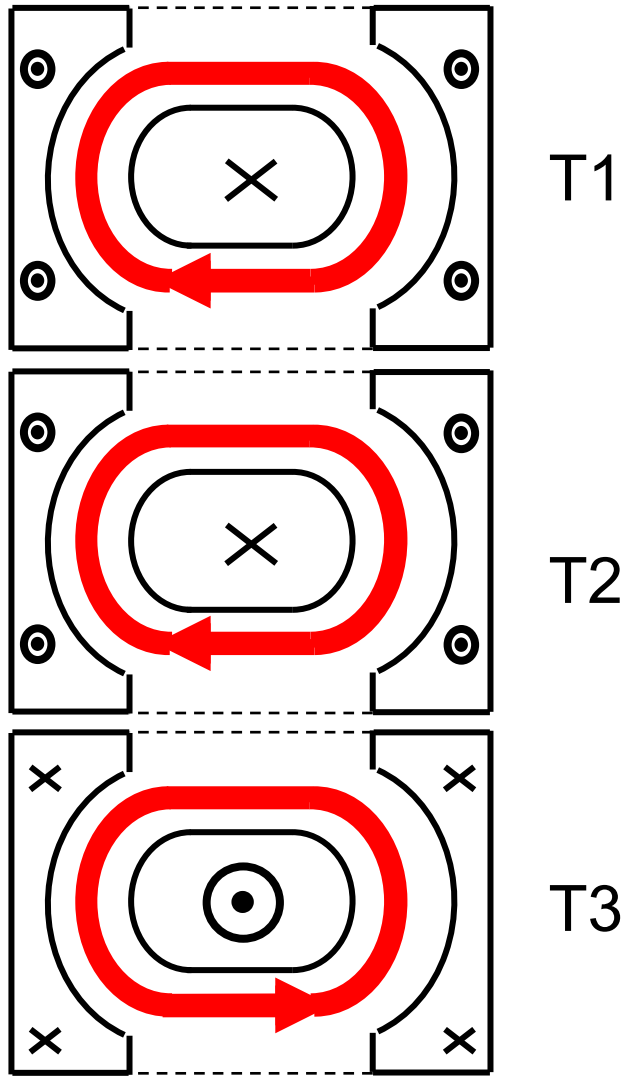

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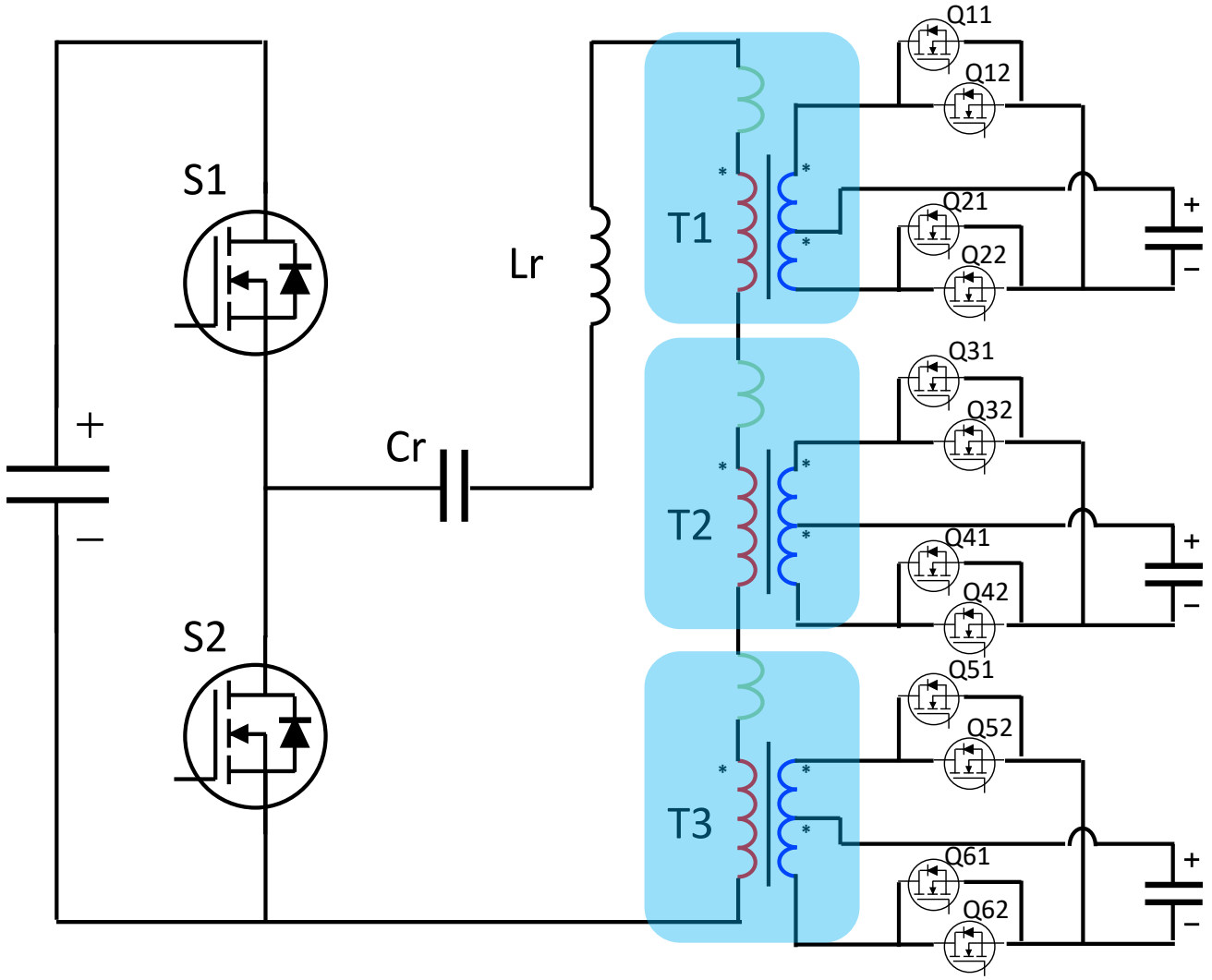

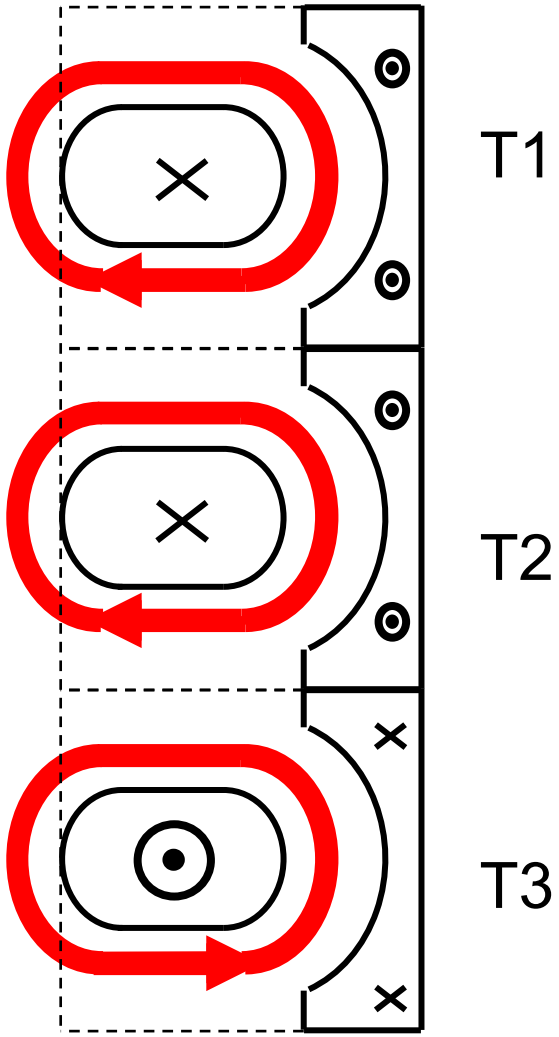

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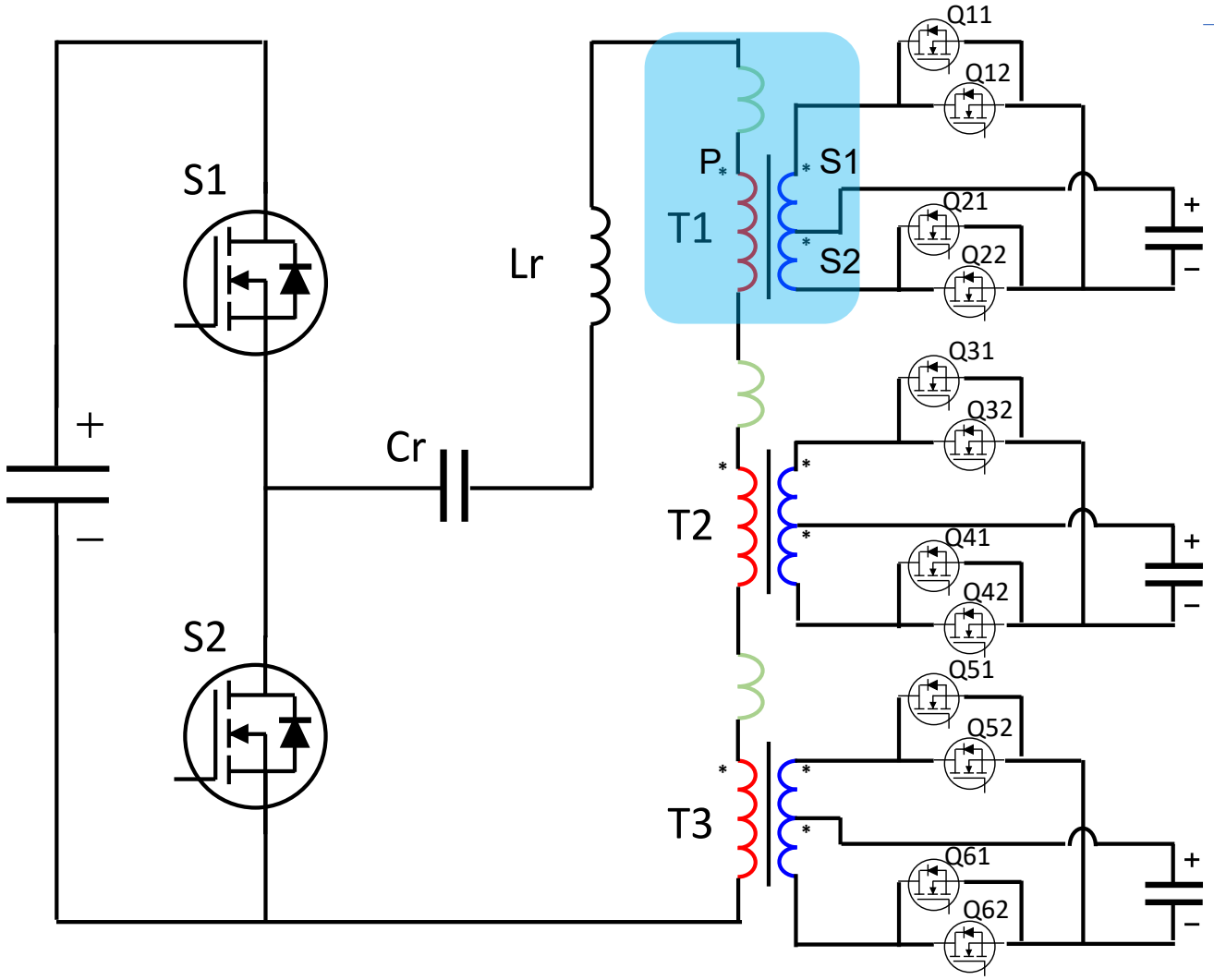
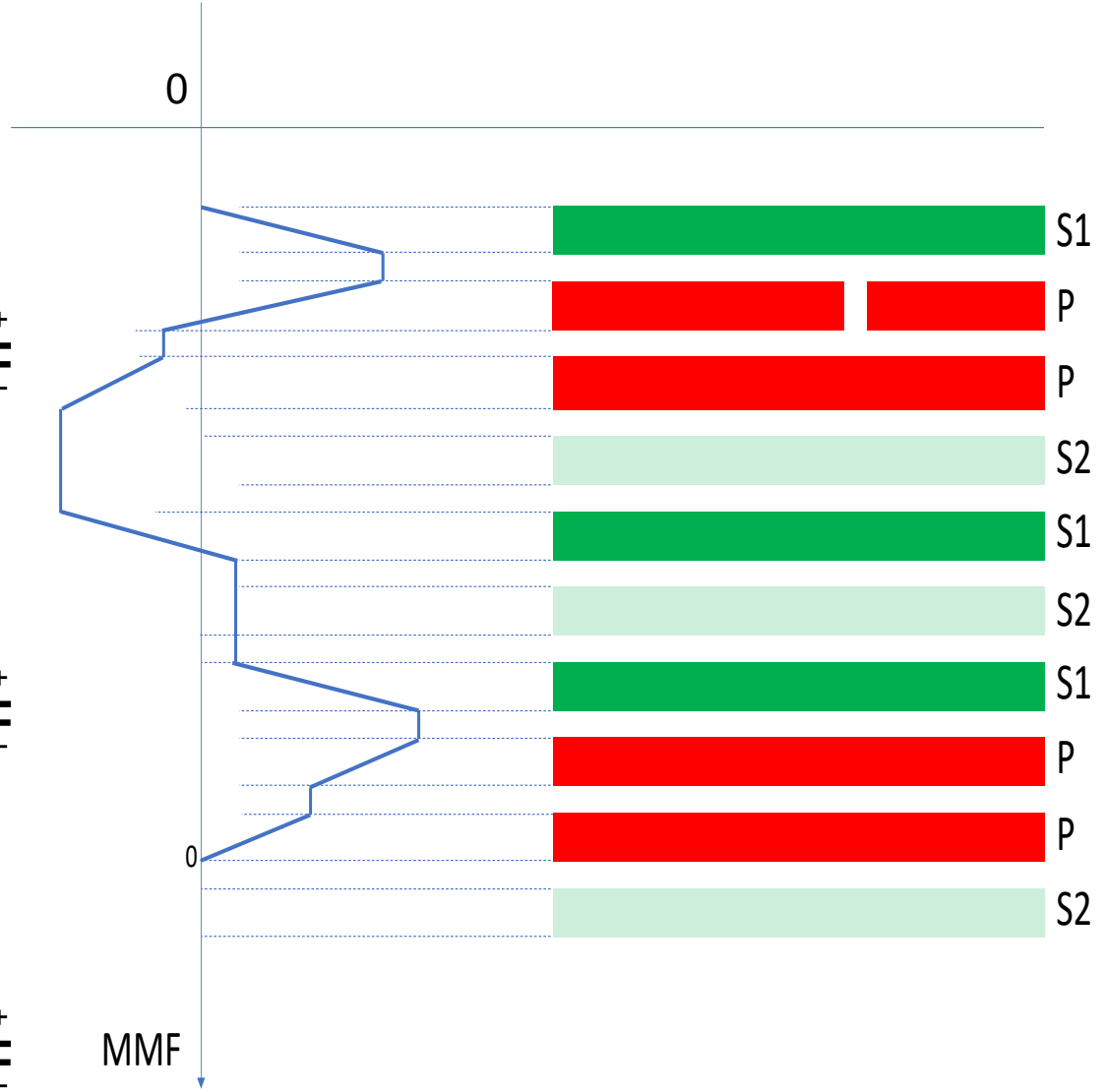
Winding Distribution





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Flux Distribution Simulation

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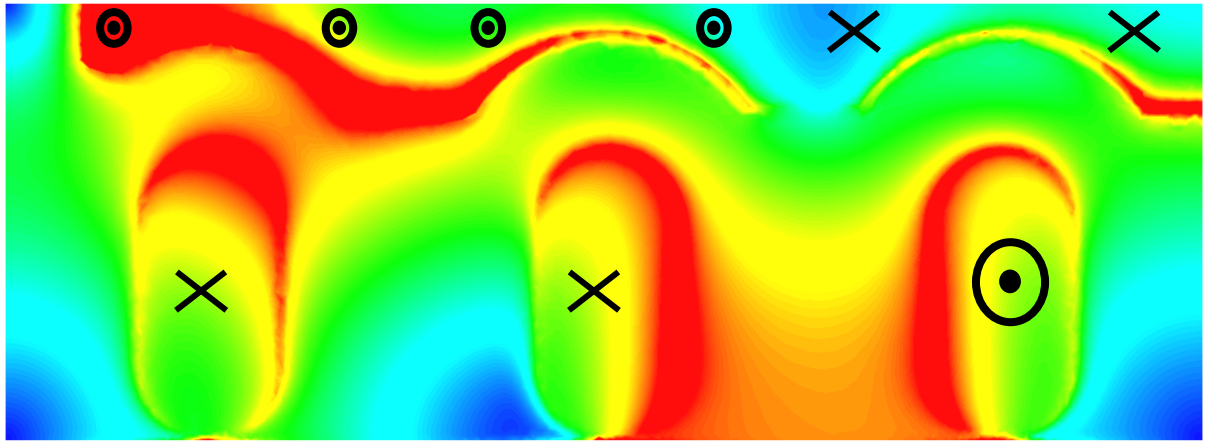
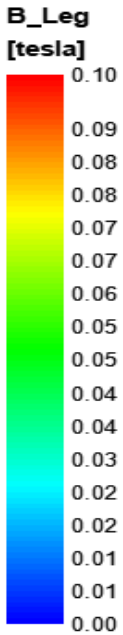
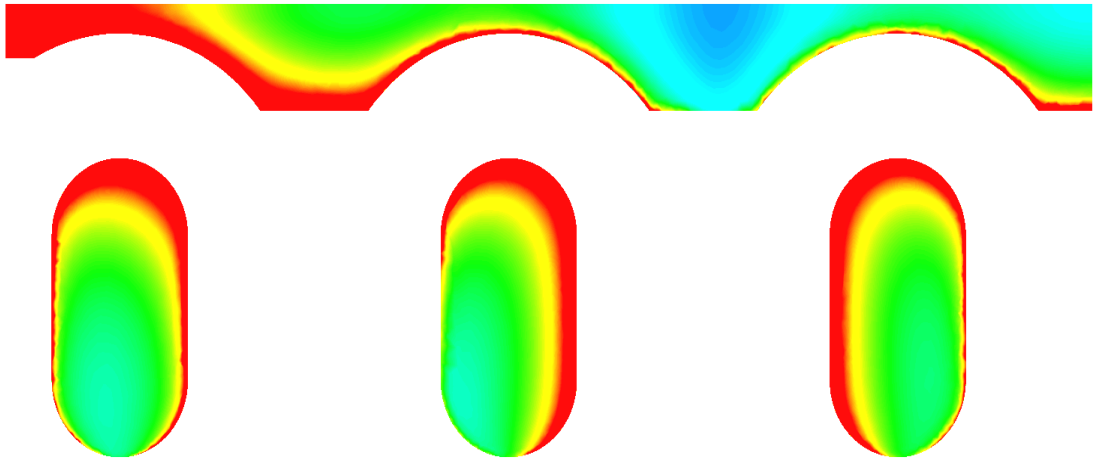
Top Plate





Core Post



Flux Cancellation is effective

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Hardware Prototype and Experimental Results

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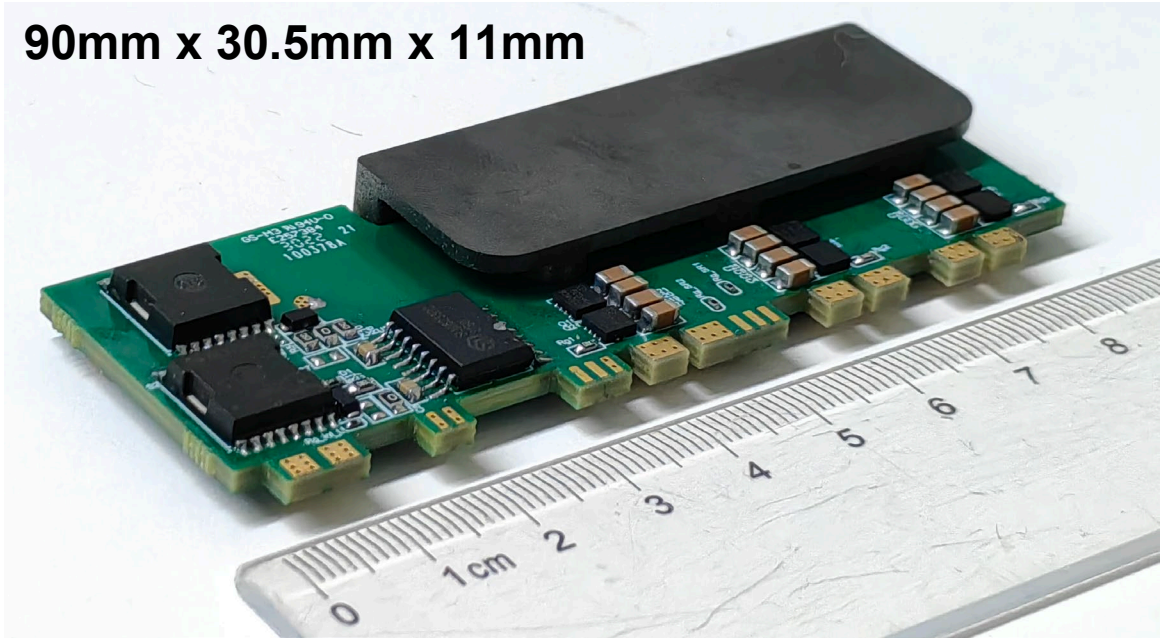
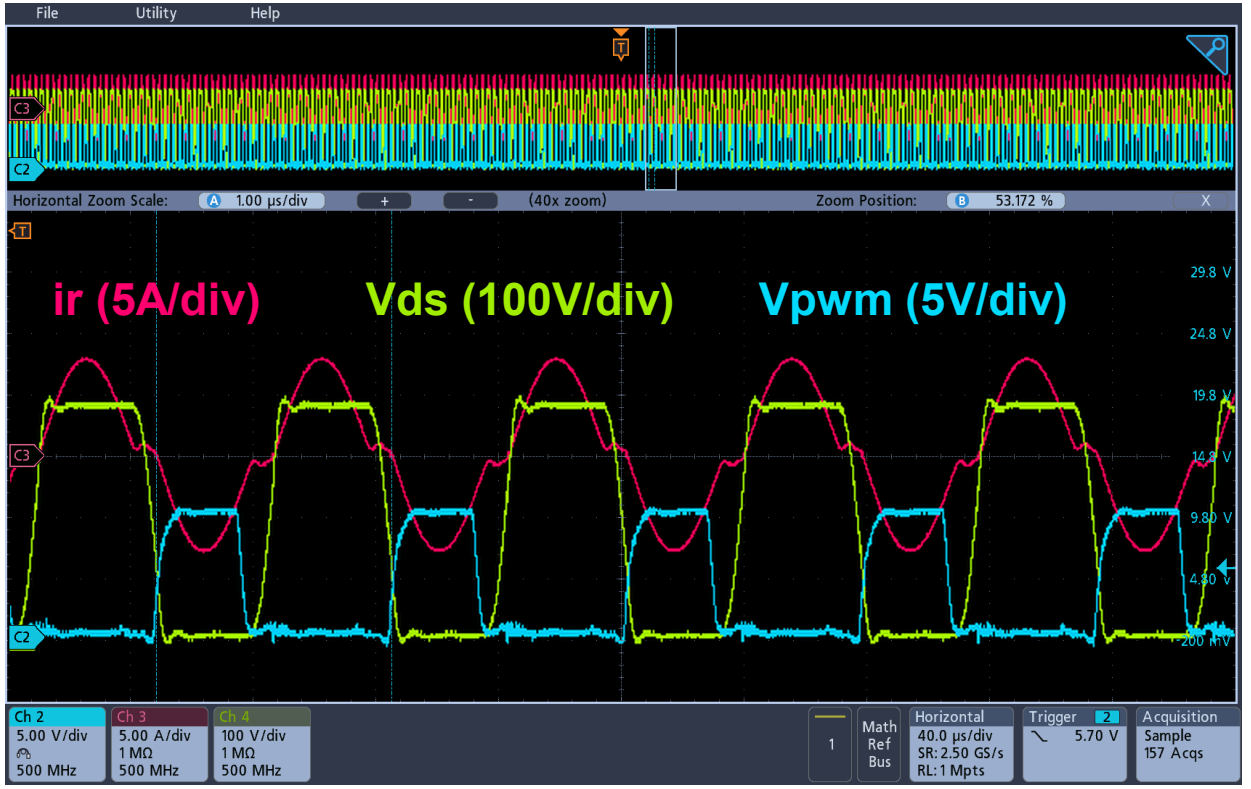


600kHz Switching



High frequency enables high power density and PCB winding

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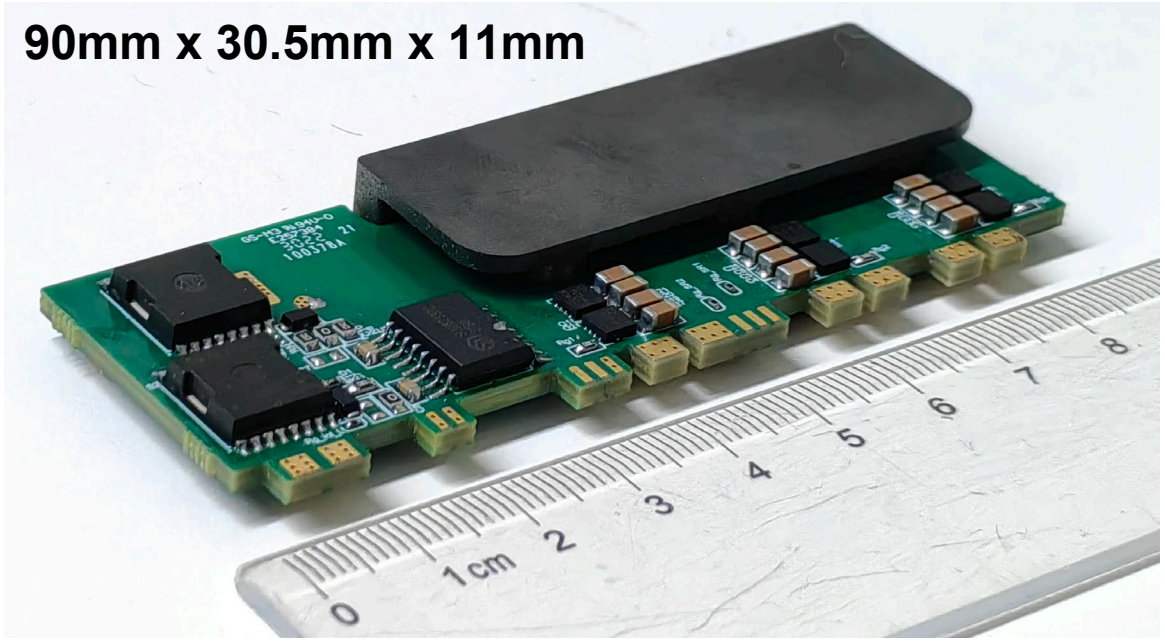
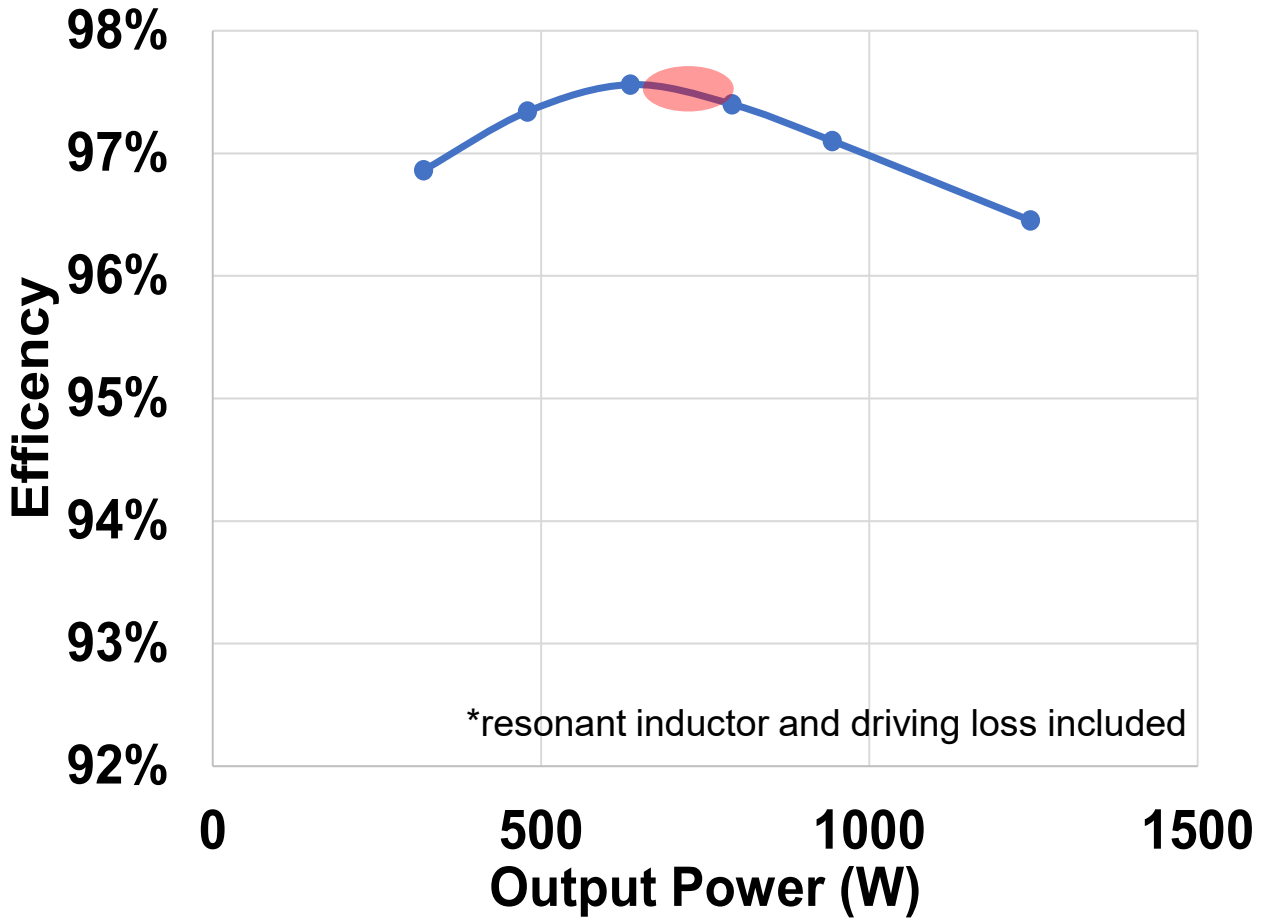
Hardware Prototype and Experimental Results





➢ **Peak efficiency @half load is over 97.5%**

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Summary

- ✓ Data Center and AI needs high-efficiency and high-power density power supply.
- ✓ Integrated GaN power IC from Navitas provide reliable gate drive as well as robust protection for industrial application.
- ✓ A matrix transformer is proposed utilizing flux cancellation to reduce core size and loss.
- ✓ High-frequency operation using GaN power IC help to future reduce the transformer size and make it possible to utilize PCB winding.
- ✓ 1.5kW LLC module prototype with the size of 90mm x 30.5mm x 11mm is built and peak efficiency of 97.5% @half load is achieved.

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“Navitas is a pure-play, next-generation power semiconductor company and drives to Electrify Our World™”

Thank you

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