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ECEN 404 Final Presentation
Team URS-1_Enjeti Matrix Converter

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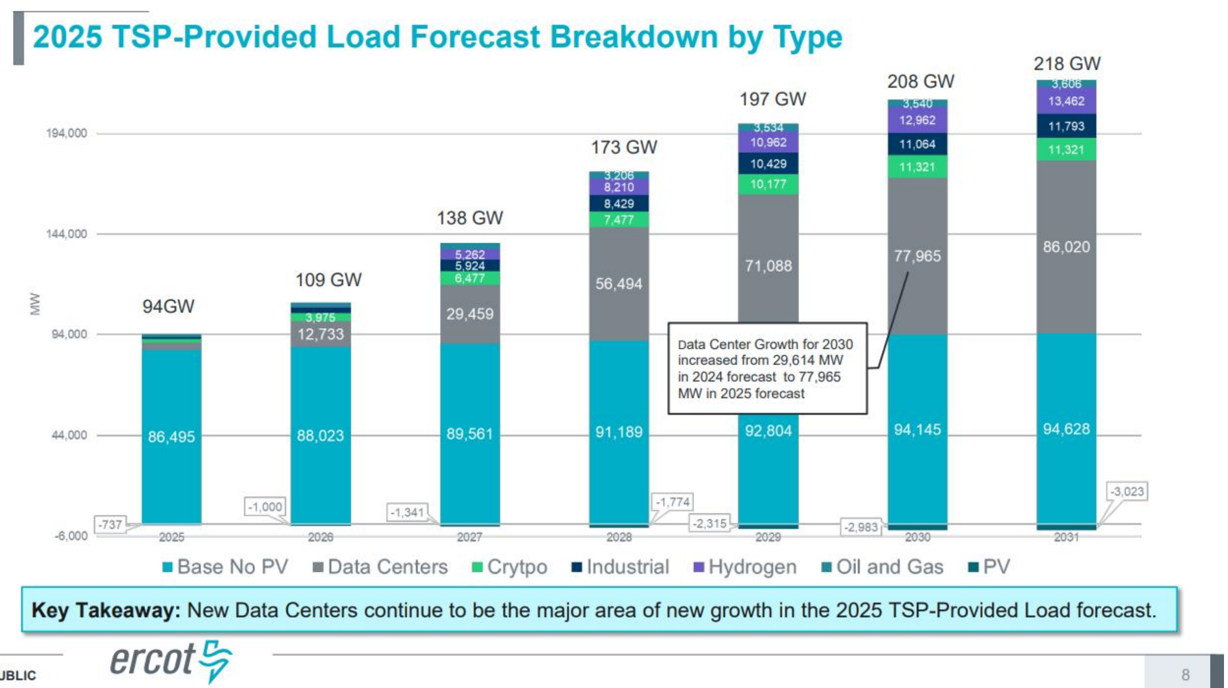
Problem Overview

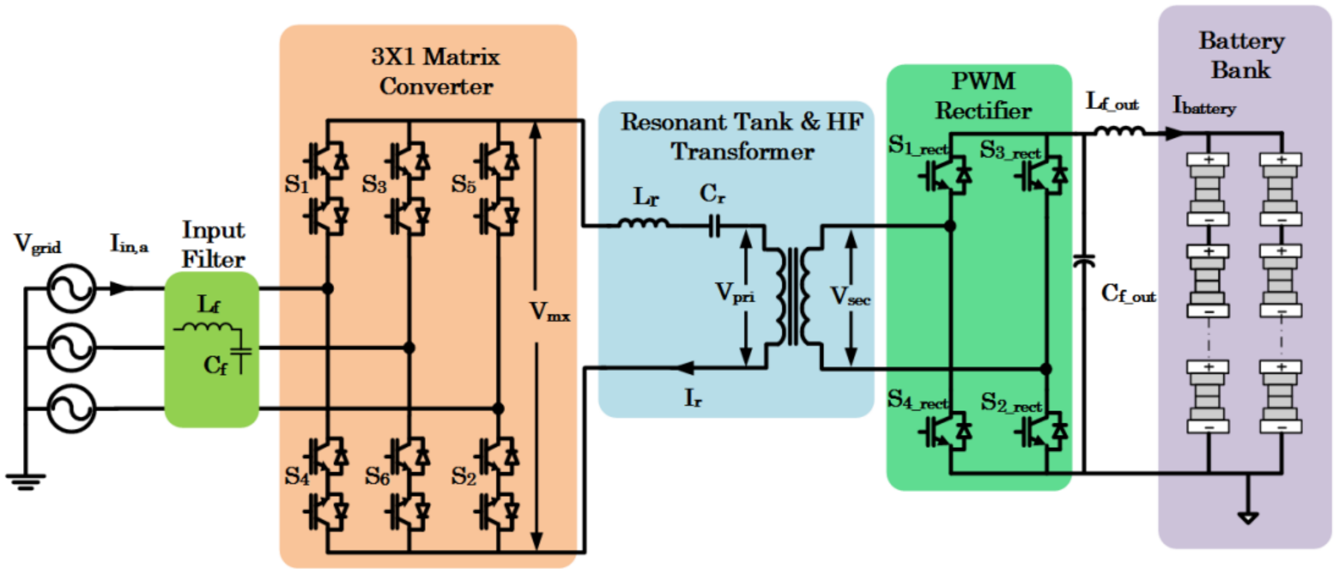
Energy demand is being driven by industrial computing operations (data centers, cryptomining, cloud computing, etc.)

Improved power conversion systems can reduce the burden placed on our aging energy infrastructure



ERCOT Public. (2025, April 7-8). Slide 8. *Item 8.1: Long-Term Load Forecast Update (2025-2031) and Methodology Changes* [PowerPoint slides]. https://www.ercot.com/files/docs/2025/04/07/8.1-Long-Term-Load-Forecast-Update-2025-2031-and-Methodology-Changes.pdf

Integrated Project Diagram



J. J. Sandoval, S. Essakiappan and P. Enjeti, “A bidirectional series resonant matrix converter topology for electric vehicle DC fast charging,” 2015 IEEE Applied Power Electronics Conference and Exposition (APEC), Charlotte, NC, USA. 2015, pp. 3109- 3116, doi: 10.1109/APEC.2015.7104795.

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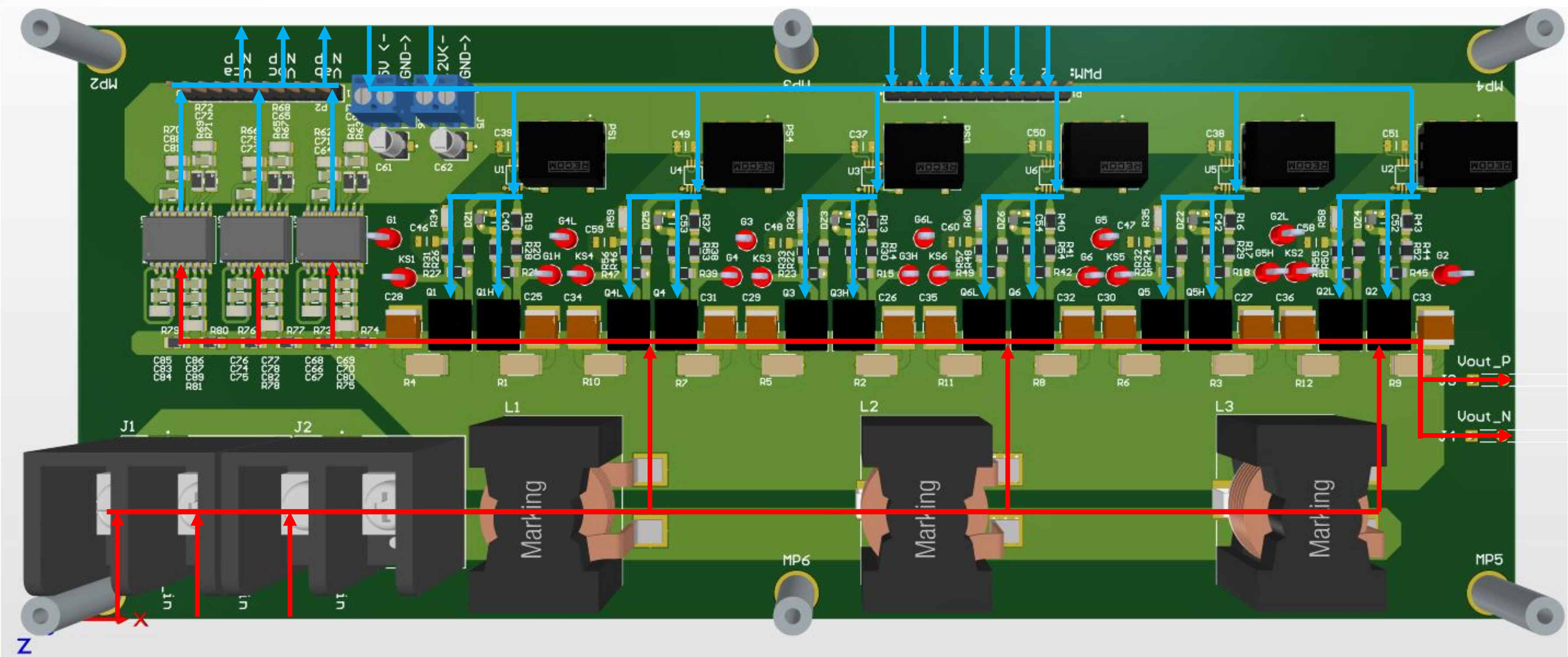
Engineering Design Accomplishments

3-Phase Matrix Converter

Board layout keeps LV nets (blue) on the north side and HV nets (red) to the south



3-Phase Matrix Converter

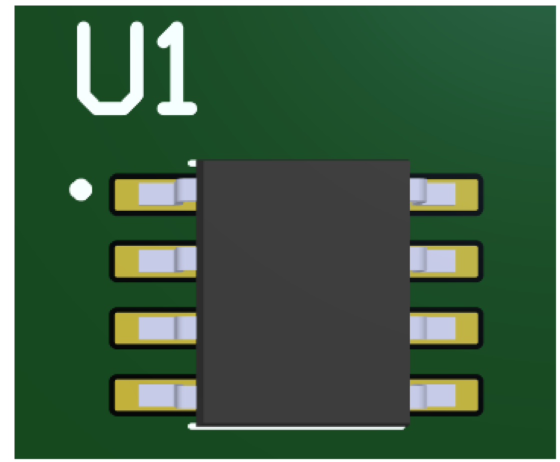
- Verified 421 board connections (100% continuity)
- Verified 200 component connections (47% continuity)
- Voltage sensors operational

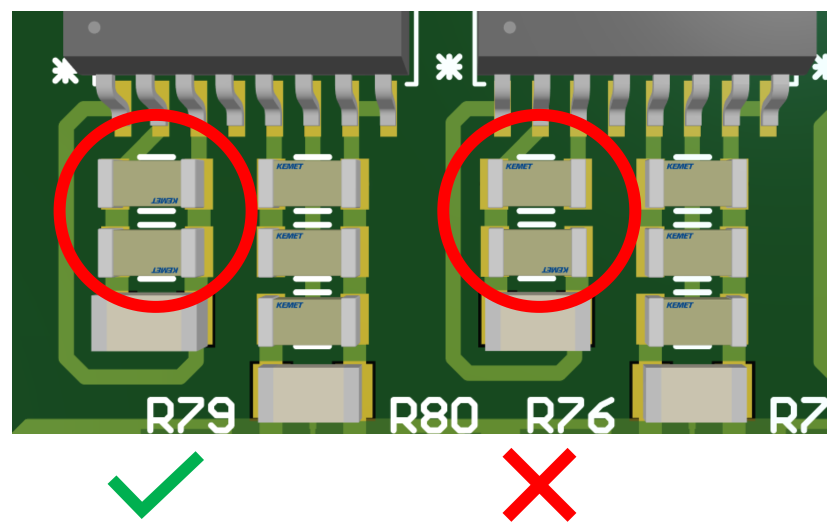
Board Continuity (100%)				
Section	Net	Designator 1	Designator 2	Connection?
Gate driver	12	J5	C62	TRUE
Gate driver	12	J5	PS1	TRUE
Gate driver	12	J5	PS2	TRUE
Gate driver	12	J5	PS3	TRUE
Gate driver	12	J5	PS4	TRUE
Gate driver	12	J5	PS5	TRUE
Gate driver	12	J5	PS6	TRUE
Voltage sensor	A	R80	R73	TRUE
FET	A	R73	Q1	TRUE
FET	A	Q1	R4	TRUE
FET	A	Q1	C6	TRUE
FET	A	Q1	Q4	TRUE
FET	A	Q4	R7	TRUE
FET	A	Q4	L1	TRUE
FET	A	Q4	C21	TRUE
FET	A	Q4	C20	TRUE
Input filter	A	C6	C7	TRUE
Input filter	A	C6	C8	TRUE
Input filter	A	C6	C1	TRUE

Component Continuity (40.86%)				
Section	Designator	Part Number	Net	Connection?
Voltage sensor	R79	CRCW1206845KFKEA	C	TRUE
Voltage sensor	R79	CRCW1206845KFKEA	Vca_P	TRUE
Voltage sensor	U9	AMC3330DWER	NetC81_1	TRUE
Voltage sensor	U9	AMC3330DWER	GND	TRUE
Voltage sensor	U9	AMC3330DWER	NetC81_1	TRUE
Voltage sensor	U9	AMC3330DWER	SENca_P	TRUE
Voltage sensor	U9	AMC3330DWER	EN	TRUE
Voltage sensor	U9	AMC3330DWER	SENca_N	TRUE
Voltage sensor	U9	AMC3330DWER	GND	TRUE
Voltage sensor	U9	AMC3330DWER	NetC83_1	TRUE
Voltage sensor	U9	AMC3330DWER	Vca_N	TRUE
Voltage sensor	U9	AMC3330DWER	NetC85_2	TRUE
Voltage sensor	U9	AMC3330DWER	NetC86_1	TRUE
Voltage sensor	U9	AMC3330DWER	Vca_P	TRUE
Voltage sensor	U9	AMC3330DWER	Vca_N	TRUE
Voltage sensor	U9	AMC3330DWER	Vca_N	TRUE
Voltage sensor	R73	CRCW1206845KFKEA	A	TRUE
Voltage sensor	R73	CRCW1206845KFKEA	Vab_P	TRUE
Voltage sensor	R74	CRCW1206845KFKEA	Vab_N	TRUE

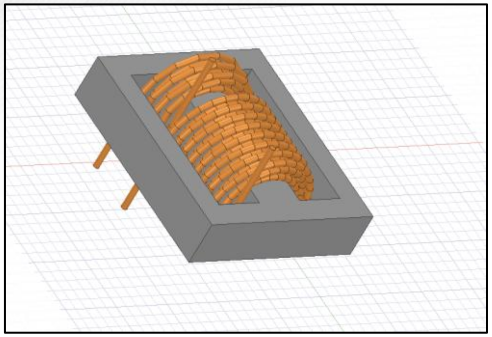
3-Phase Matrix Converter

- Proposed using cheaper GaN FET
- Incorrect gate driver footprint (will jump)
- Incorrect voltage sensor tracing; circumvented by soldering parts together

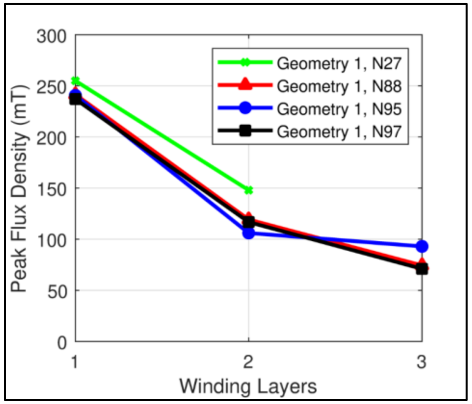




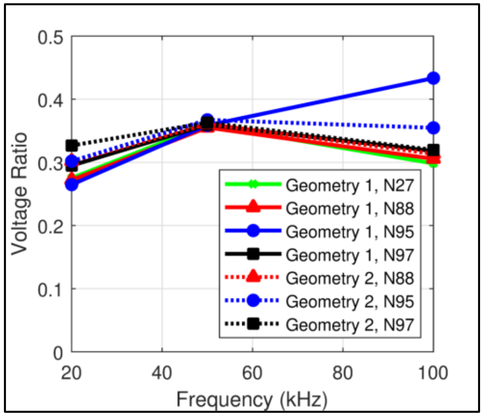
High Frequency Transformer



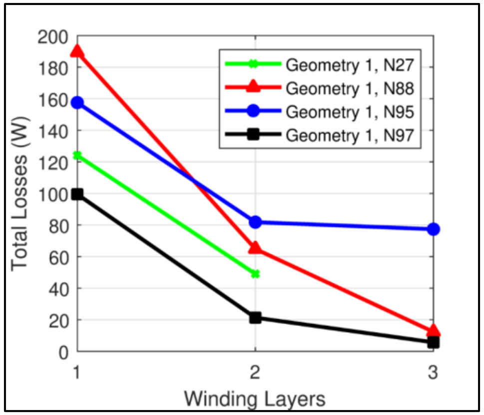
Parameterized Transformer Model for Mass Simulation



Peak Flux Density Results

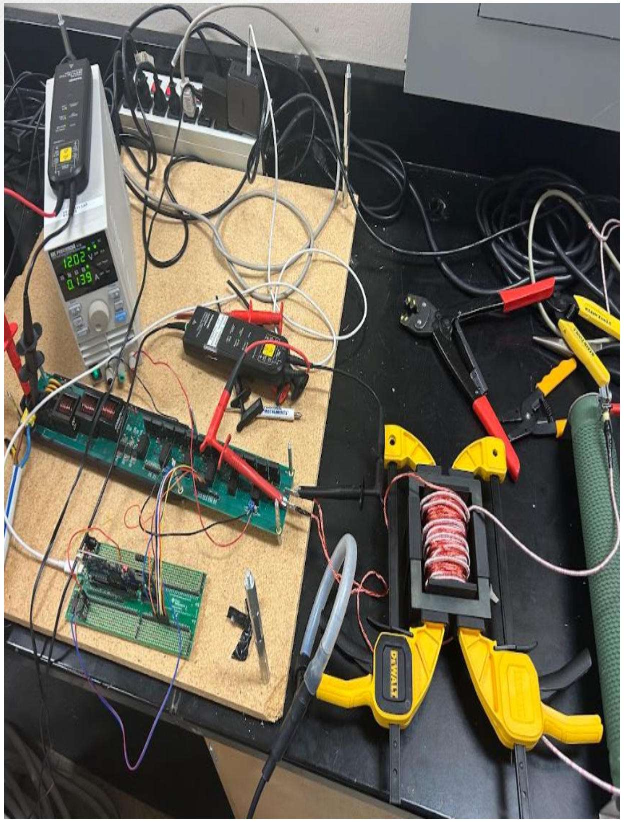


Voltage Step Down Results



Loss Results

High Frequency Transformer



Testing Setup

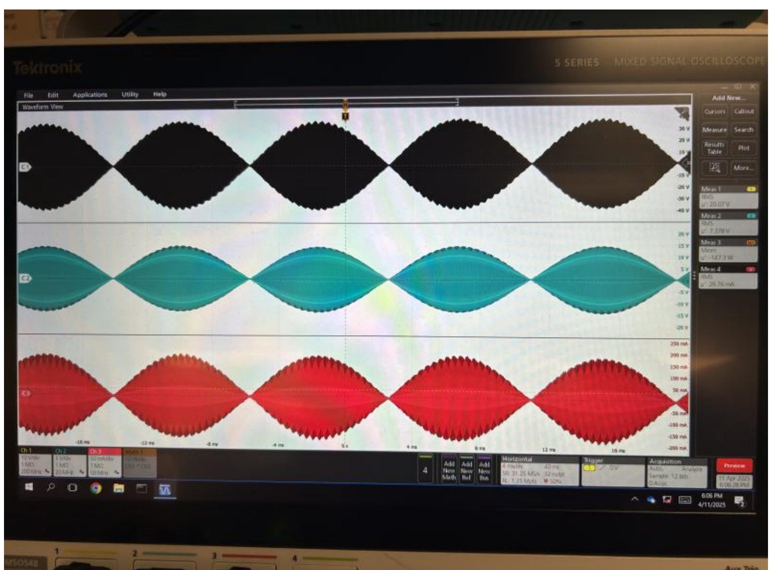
- 3D printed coil former as TDK part was not available
- Transformer wound with Litz wire
- 260 strands of 38 AWG wire on the primary side; 600 strands of 38 AWG wire on secondary

High Frequency Transformer

$$P_{in} = I_{in}V_{in} = (20.07\ \text{Vrms})(0.02976\ \text{Arm}) = 0.597\ \text{W}$$

$$P_{out} = \frac{V_{out}^2}{R_{out}} = \frac{(7.378\ Vrms)^2}{100\ \Omega} = 0.544\ \text{W}$$

$$\eta = 0.911$$

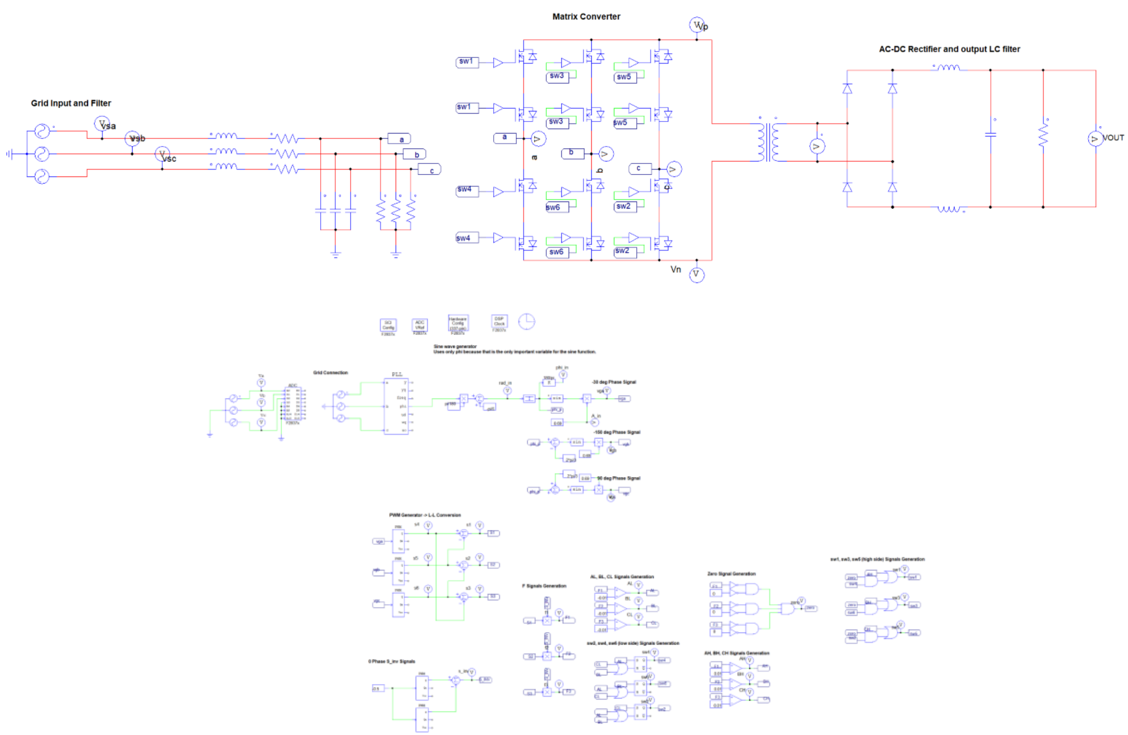


Testing results at 100 kHz, 20 Vrms input

Vin	Vout	Iin
20.07 Vrms	7.378 Vrms	29.76 mArms

Controls Scheme

- Designed control system and validated functionality in PowerSim software



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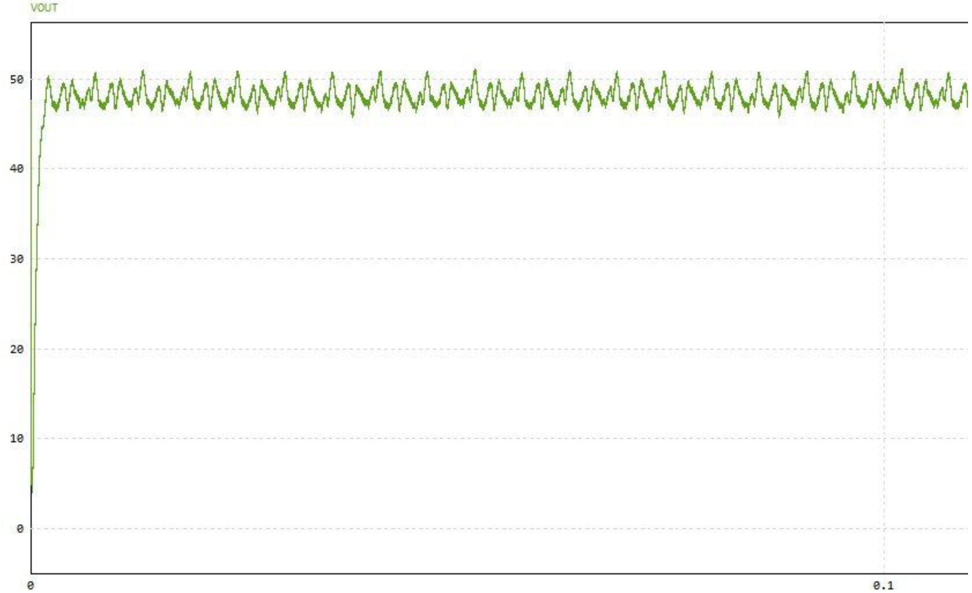
Controls Scheme

- TI F28379D controlCARD is used to input the voltage signal and output switching signals to the gate drivers.
- Utilized Typhoon HIL 602+ for hardware-in-the-loop testing of the controls system.

Controls Scheme

- Validated control scheme in software using PowerSim
- Validation using HIL testing



Conclusions

- An updated PCB uses cheaper FETs and corrects gate driver/voltage sensor errors
- For the current board, voltage sensors work, gate drivers being tested next
- Controls system output validated
- Transformer successfully transfers power at >90% efficiency when tested at low voltages. Future testing with higher voltages to be done