U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

PACE
ACCELERATING ELECTRIFICATION

Project Title: Multi-Port Modular Medium-Voltage (M3) Transactive Power Electronics Energy Hub

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Project Status: Completed June 2022 **Project Term: June 2020 to June 2022** **Award Amount: $100K** **Partners: Brian Rowden, ORNL**

Project Summary

As power electronics systems on the grid are increasing due to integration of new distributed energy resources coupled with the evolution of loads such as electric vehicle charging, smart homes, and server farms, there is increased pressure on electric utilities to interface, control, coordinate, and optimize these various systems. The overall intent of this project is to design, develop, and demonstrate foundational technologies and capabilities for multiport power electronics energy hubs (a.k.a. HUB) that can serve as intelligent devices to coordinate and control several different sources and loads.

UTK supports one primary aspect of the HUB hardware. It is the development and demonstration of a 20-kV insulated auxiliary power supply for a 10 kV H-bridge power stage to support the MV HUB concept.

Technical Approach

- Simulate the electric field of the transformer to identify isolation weak points
- Utilize isolation material with high breakdown voltage and vacuum pressure potting process
- Simplify the winding and core structure basic geometry to estimate parasitic capacitance
- Minimize the winding turns and increase the distance between the primary windings and secondary windings to reduce capacitance

Accomplishments

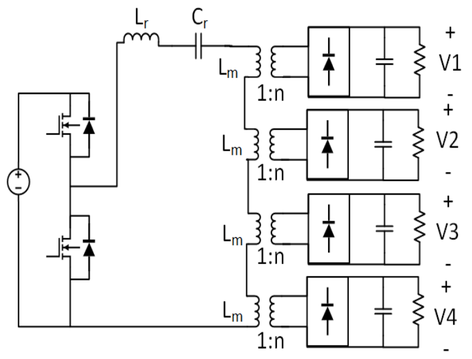
An LLC topology with four secondary outputs to support power to four separate gate drivers in one H bridge is implemented. Full power operation is conducted with balanced voltage across four terminals. A secondary protection is developed to prevent short circuit fault at one output from interfering with other outputs.

Impact/Commercialization

The LLC topology can be extended to more outputs for auxiliary power supplies. Potting the transformer with high voltage insulation material reduces the clearance distance and maintains system integrity in high voltage environment.

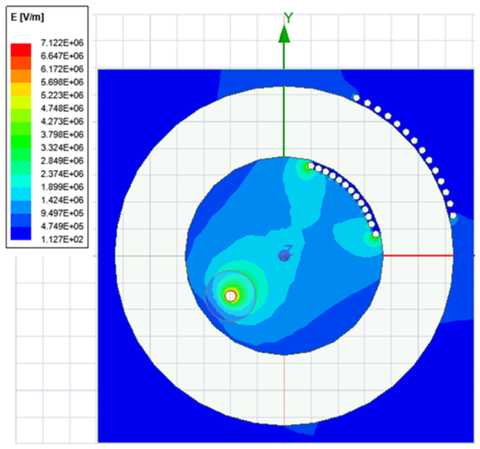
Future Work

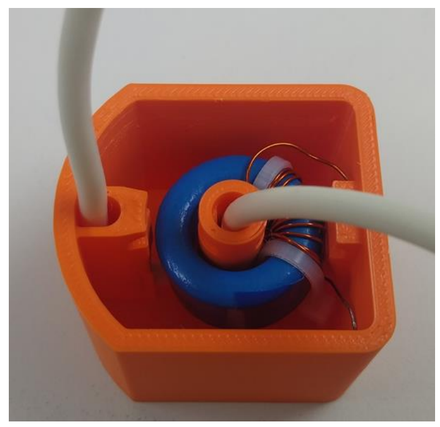
- Higher switching frequency to reduce core size and volume
- Integration with 10 kV H-bridge gate drivers
- Common mode current reduction under high EMI environment



Specifications	Values
V_{in}	15 V
V_{out}	24 V
P_{out}	7.5 W
f_{sw}	260 kHz
L_r	1.2 uH
C_r	423 nF
L_m	3.12 uH
n	1:14

LLC topology with four secondary outputs





Electric field distribution

P_{out}(W)	V_{out1}(V)	V_{out2}(V)	V_{out3}(V)	V_{out4}(V)
2.2	25.61	25.57	25.69	25.62
4.2	25.09	25.01	25.08	25.01
6	24.55	24.52	24.56	24.55
7.8	24.21	24.18	24.23	24.19

Balanced output voltage at different loading conditions