



## Background

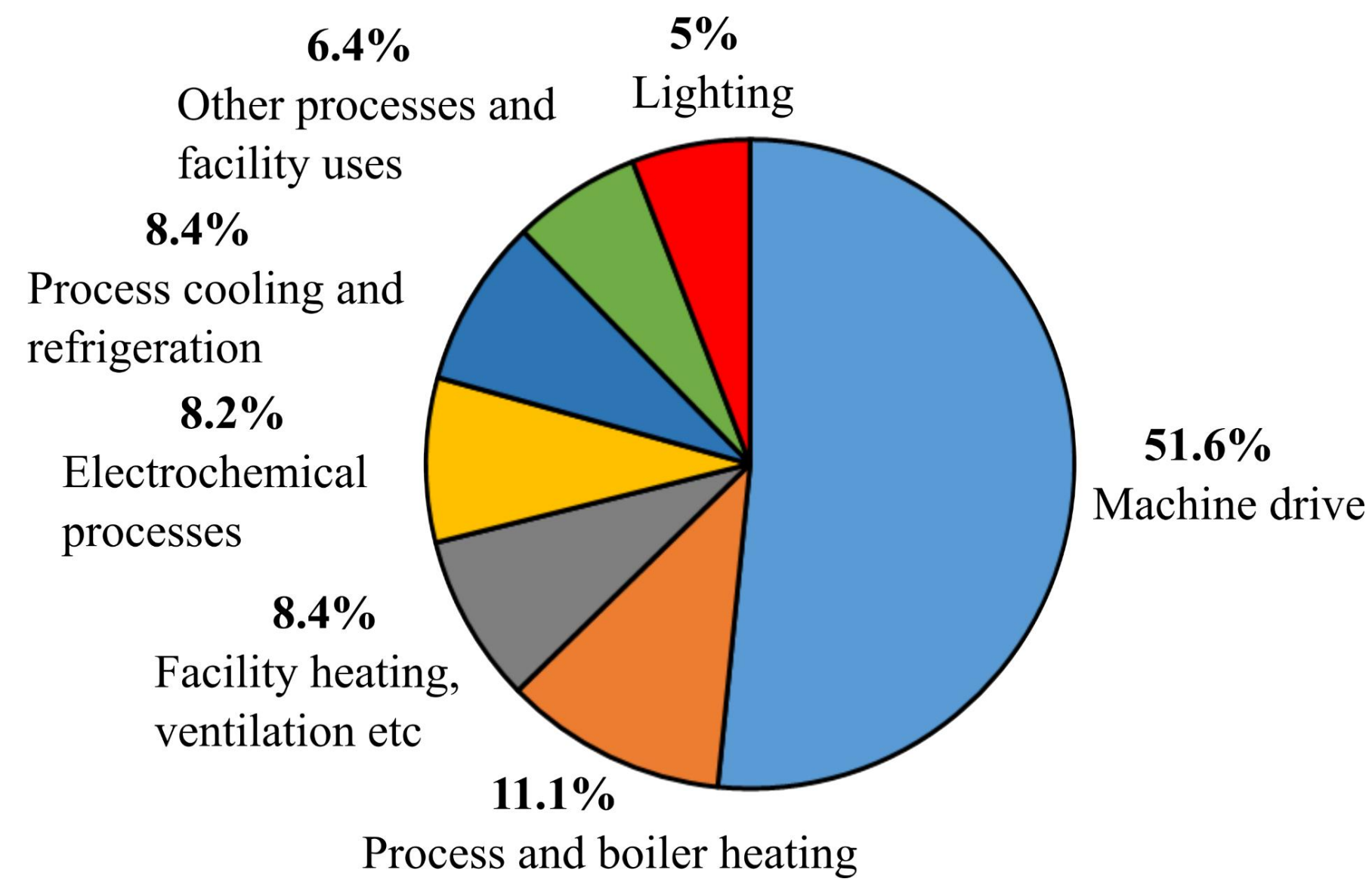
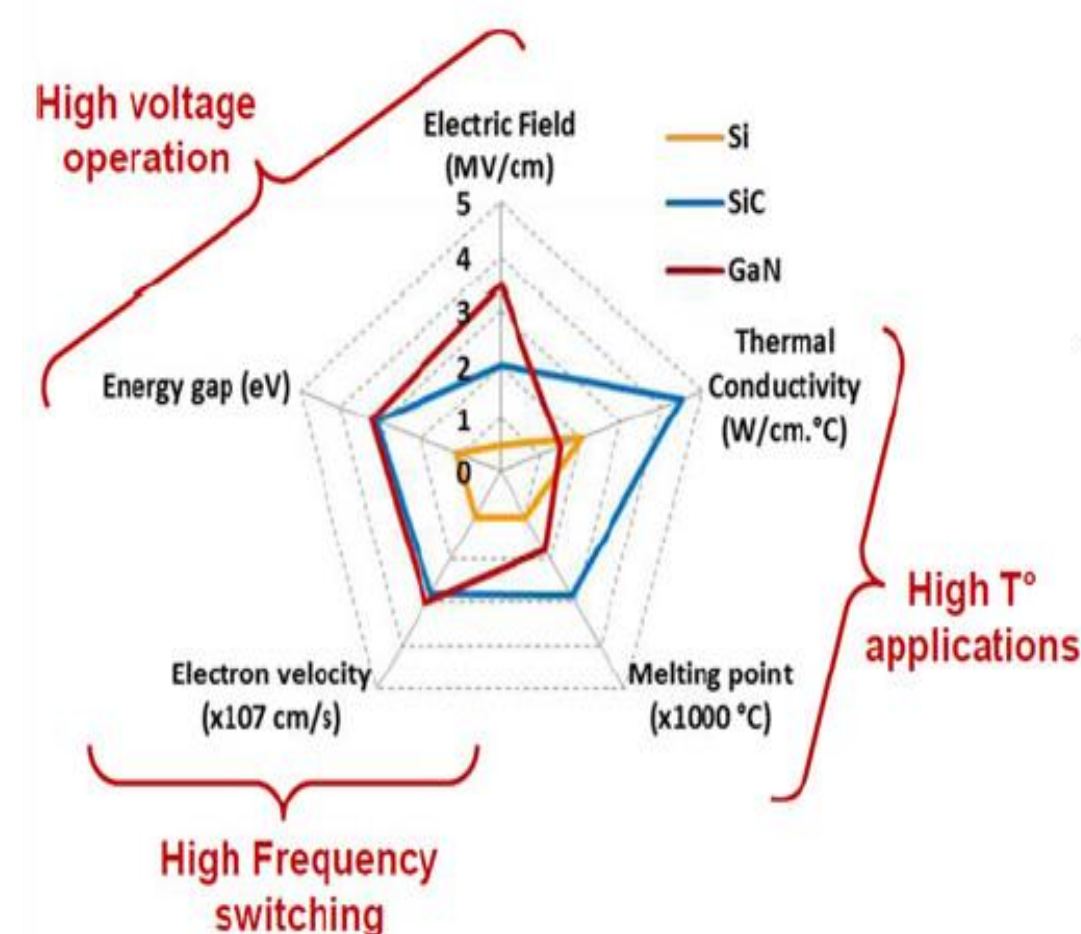


Fig.1. - Summary of the manufacturing electricity consumption in the U.S. by major end users [1].

- Fixed speed drives - **30% to 80% potential wastage** due to the mechanical throttle.
- Variable speed drive (VSD) - Control the speed and torque of the motor by varying the voltage and frequency.
- Medium Voltage (MV) systems (>1kV) reduce copper losses.
- Only 13% of MV motors** are integrated into VSDs.



**Market Barriers** - high capital cost, large footprint, low switching frequency, and high losses for Si-based VSDs.

**Wide band-gap devices (WBG)** are a step to address the market barriers.

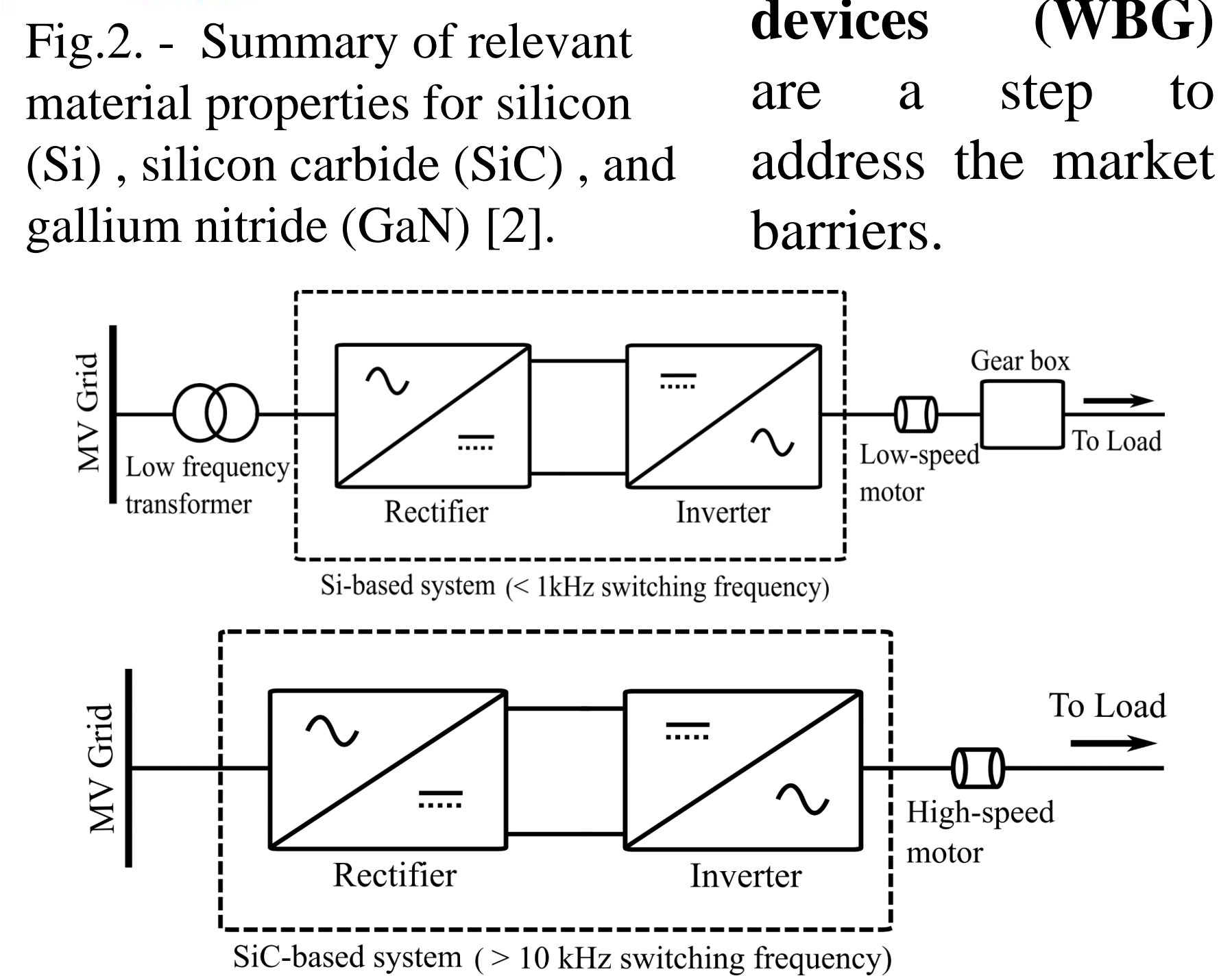


Fig.3. - Schematic of (a) an MV Si-based and (b) an MV SiC-based inverter for high-speed motor drive application.

**Applications** - Pumps, Fans, Compressors, Oil, and Gas, Aircraft Propulsion Systems, Wind Energy Systems

## Medium Voltage Motor Drives

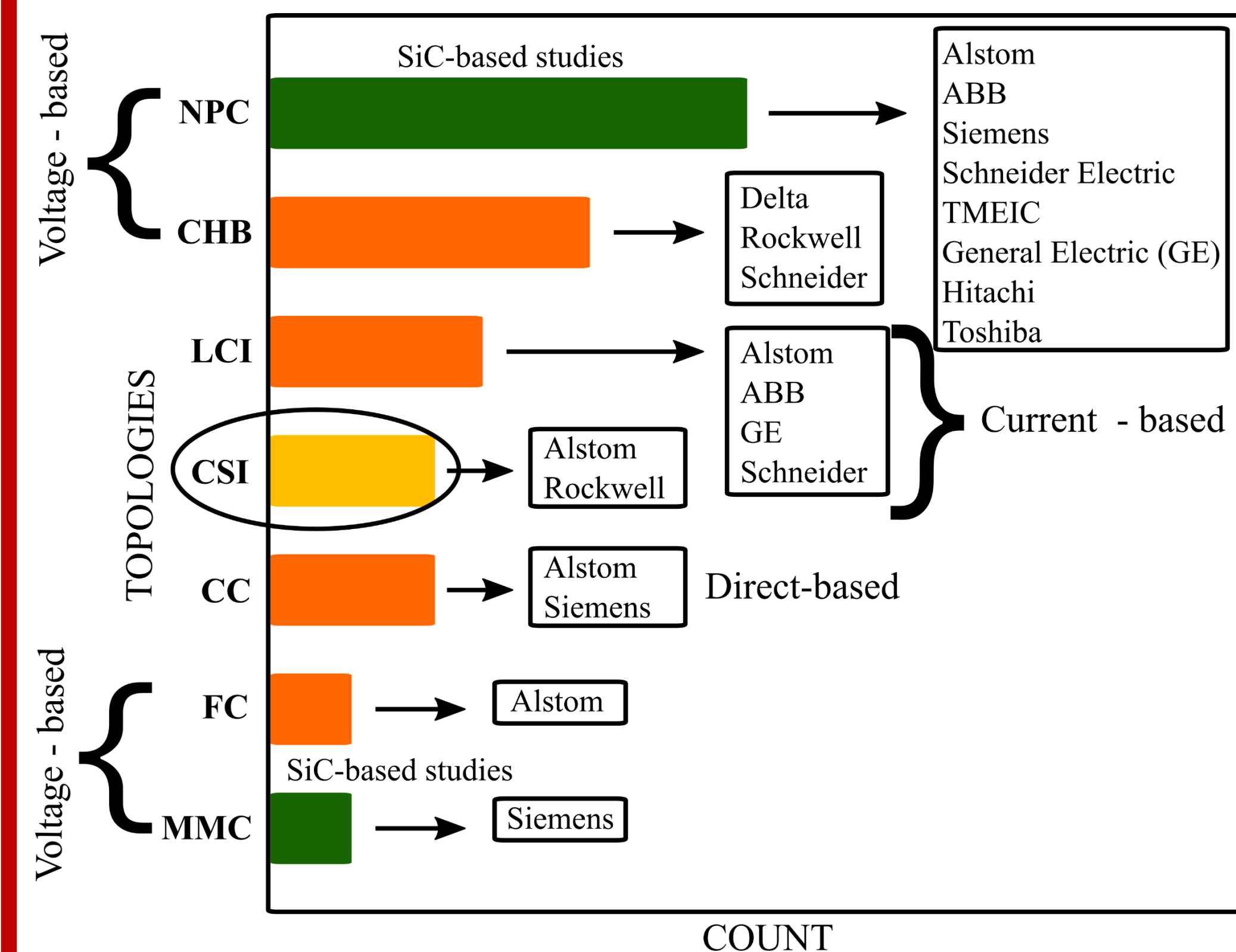


Fig.4. - Overview of existing Si-based MV drives in the market.

**Research Statement: Investigate SiC-based devices for CSIs**

- SiC-based devices - 3.3 kV, 6.5 kV, and 10 kV.
- Neutral Point Clamped (NPC) and Modular Multilevel Converter (MMC) topologies have been studied using SiC devices.
- Concerns** - Large filters, Component counts, Complex structure
- Current Source Inverters (CSI)**: Low Output Voltage Total Harmonic Distortion, Conducted Emissions, 4-Quadrant Operation.

## SiC-based Current Source Inverter

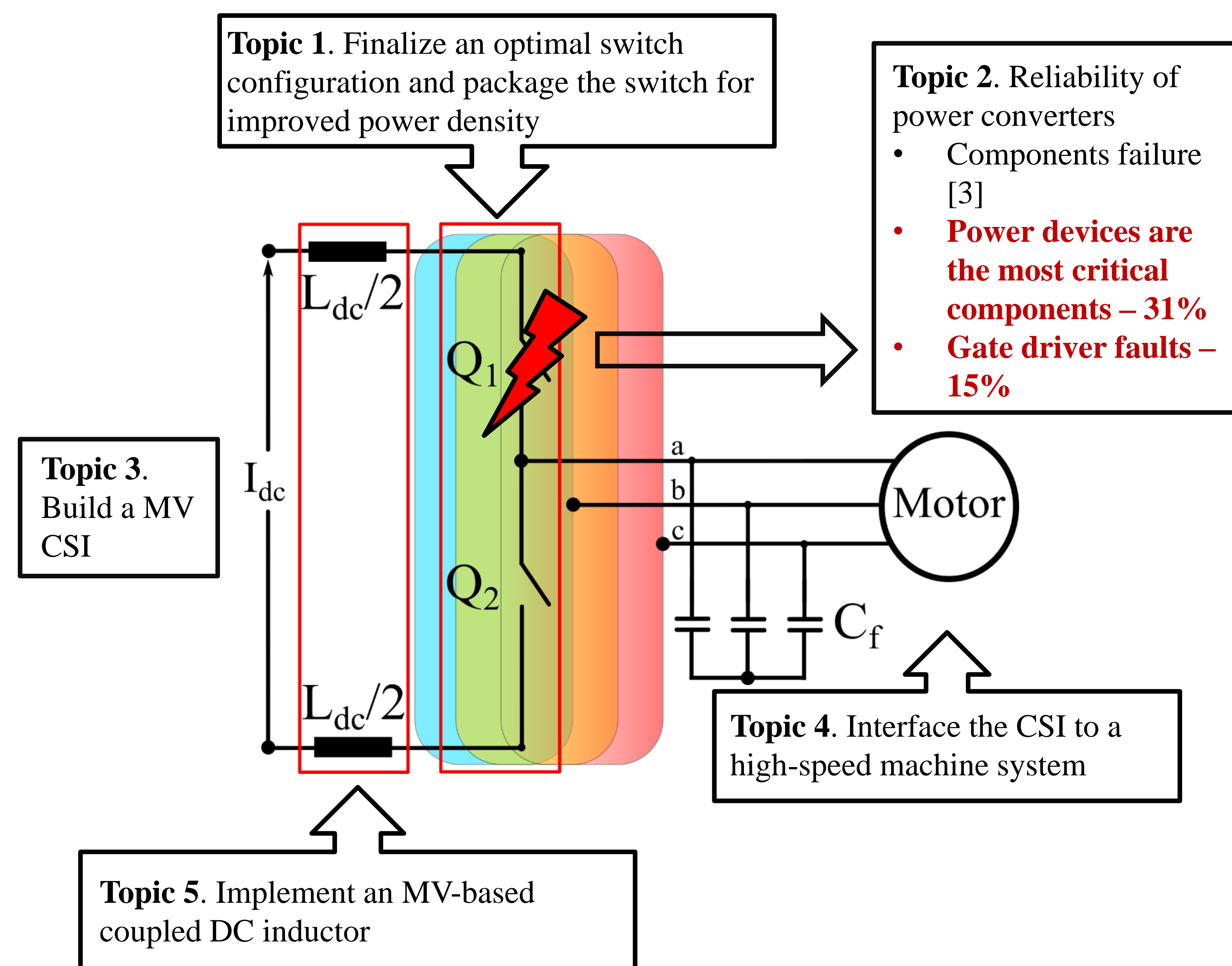
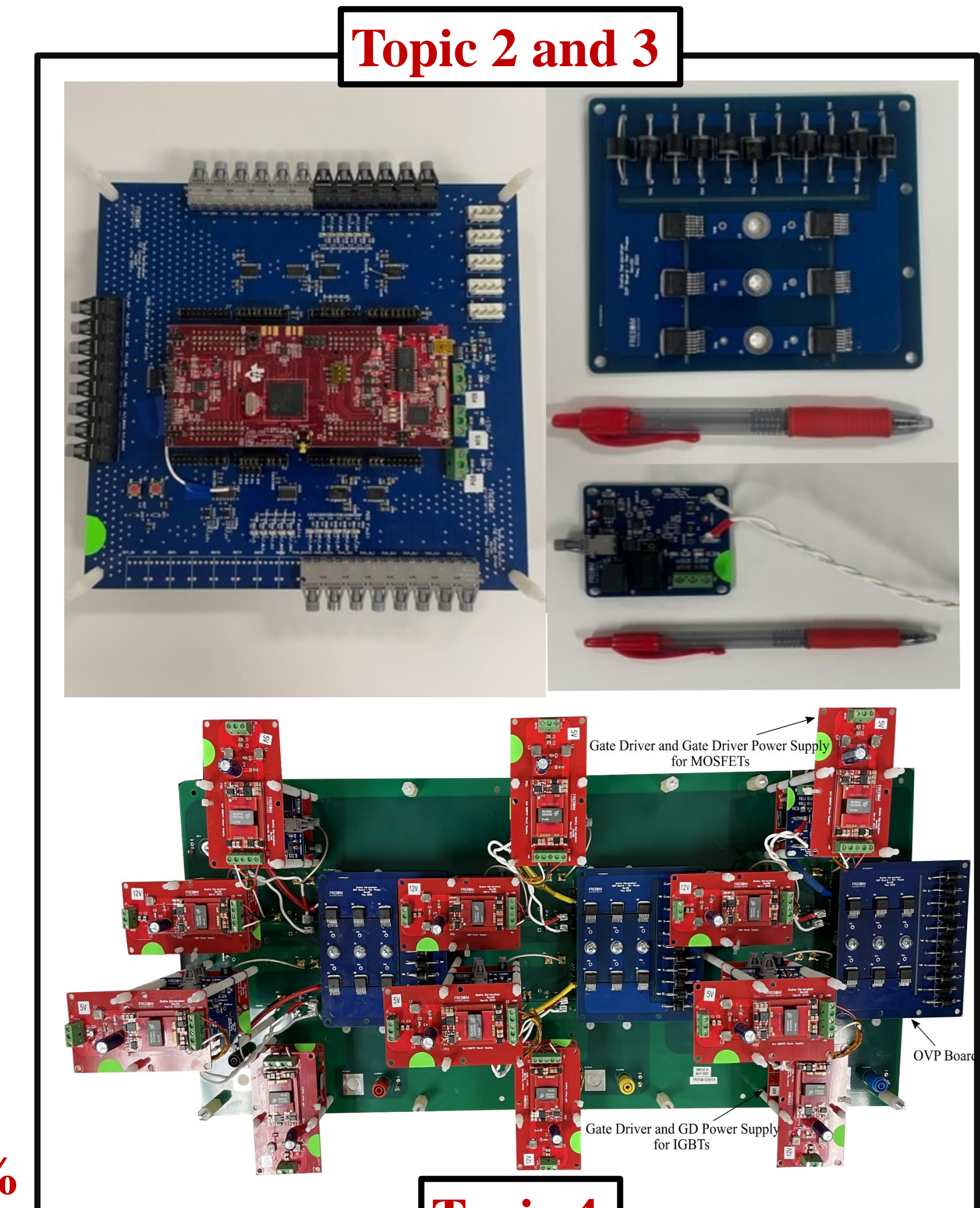
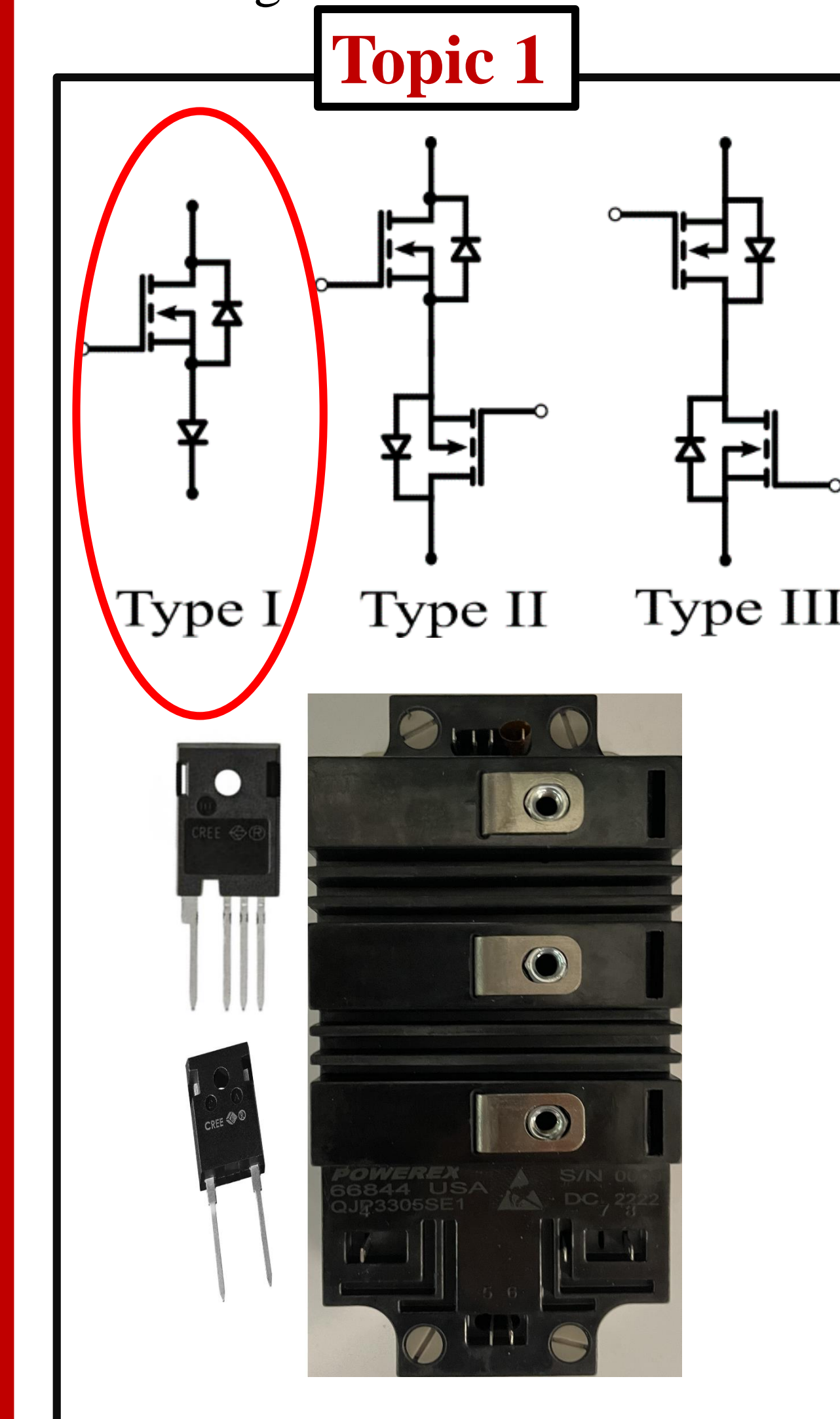


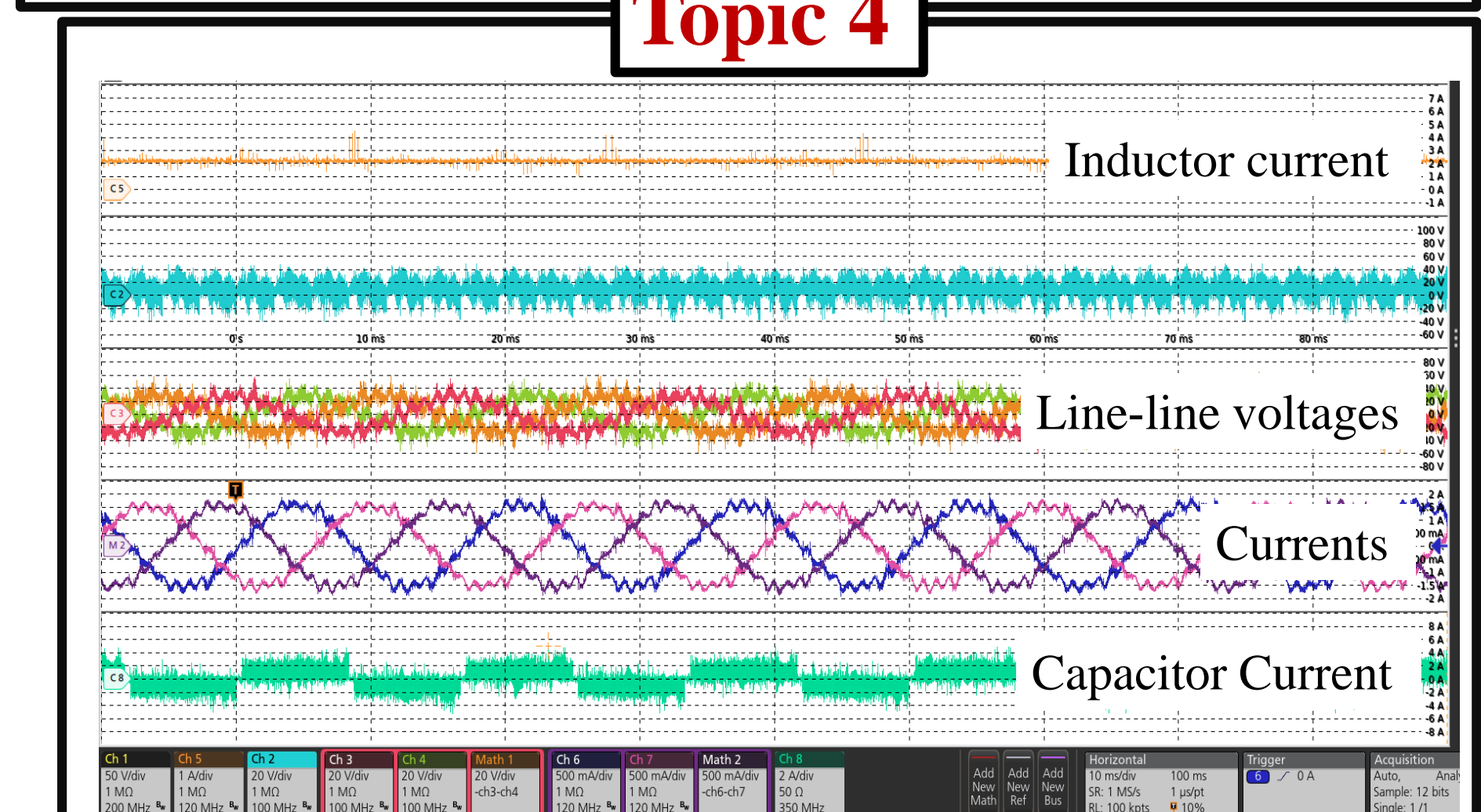
Fig.5. - Research aspects of the three-phase CSI for motor drive applications

## Results

- 3.3 kV SiC devices** were used for this research, and results can be extended for higher voltages.



- Power density > 40 %** compared to baseline.
- Efficiency increases by ~ 3%.**
- Operated at **higher fundamental frequencies** greater than 60 Hz.
- Fault detected within **two fundamental cycles.**



## Future Work

- Operate the CSI at full voltage and power ratings.
- Implement an optimized MV-based coupled DC inductor design.

## References

- U. EIA, "Electricity explained - use of electricity," <https://www.eia.gov/energyexplained/electricity/use-of-electricity.php>.
- L. Tolbert and M. Chinthavali, "Wide bandgap semiconductors for utility applications," 2003.
- S. Yang, A. Bryant, P. Mawby, D. Xiang, L. Ran, and P. Tavner, "An industry-based survey of reliability in power electronic converters," IEEE Transactions on Industry Applications, vol. 47, no. 3, pp. 1441-1451, 2011.

