

Traction Inverter Technology

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U.S. DEPARTMENT OF
ENERGY

US DOE Electric Drive Technologies R&D Targets

Our roadmap defines the pathway to achieving 2025 targets

Current Status

\$1800*

(\$12/kW 2015 Target)



Chevrolet Bolt

2025+

\$900

(\$6/kW 2025 Target)



Future Mobility Design Concept

2025 Targets		2015
Cost (\$/kW)	\$6/kW	\$12/kW
Power Density (kW/L)	33 kW/L	3.5 kW/L
Power Level	100 kW	55 kW
Reliability/lifetime	300,000 miles	150,000 miles

* Based on 2016 Bolt 150 kW system

Draft – Electric Drive Tech Team Technical Targets

Electric Drive

Year	2025	2030	2035
Peak Power Level (kW_peak)	100	150	225
Voltage (V)	600	800	800
Cost (\$/kW_peak)	6	4	2.67
Power Density (kW_peak/L)	33.3	50	75

Power Electronics

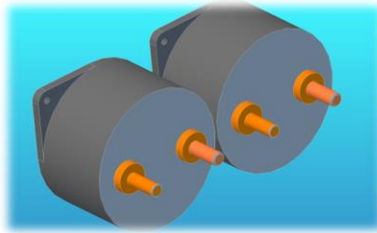
Year	2025	2030	2035
Cost (\$/kW_peak)	2.70	1.80	1.20
Power Density (kW_peak/L)	100	150	225

Electric Motor

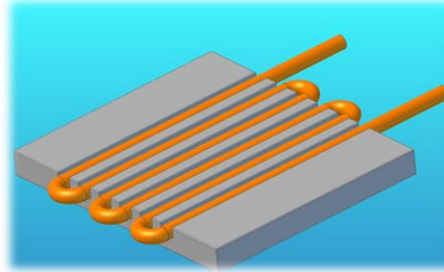
Year	2025	2030	2035
Cost (\$/kW_peak)	3.30	2.20	1.47
Power Density (kW_peak/L)	50	75	112.5

Components of an inverter

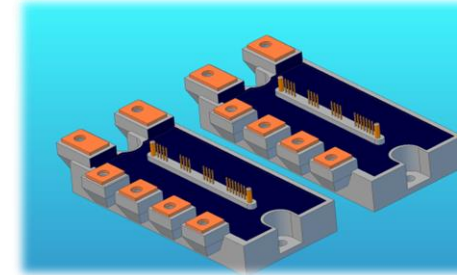
DC link capacitors



Heat sink



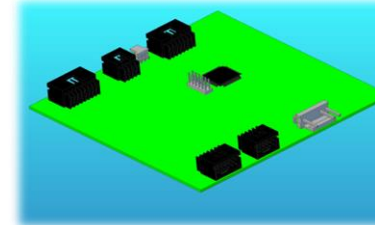
Power modules



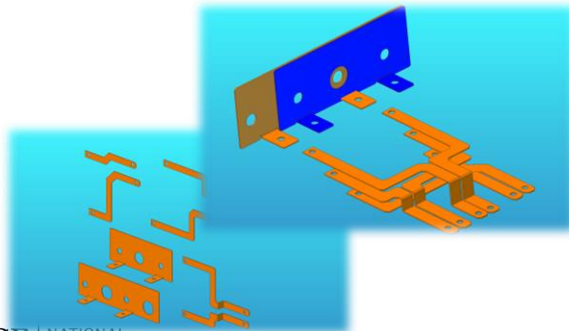
Major power density impact

- DC Link Capacitors
- Heat sink
- Power Modules

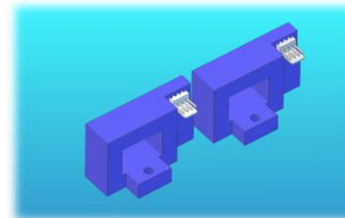
Controller/DSP board



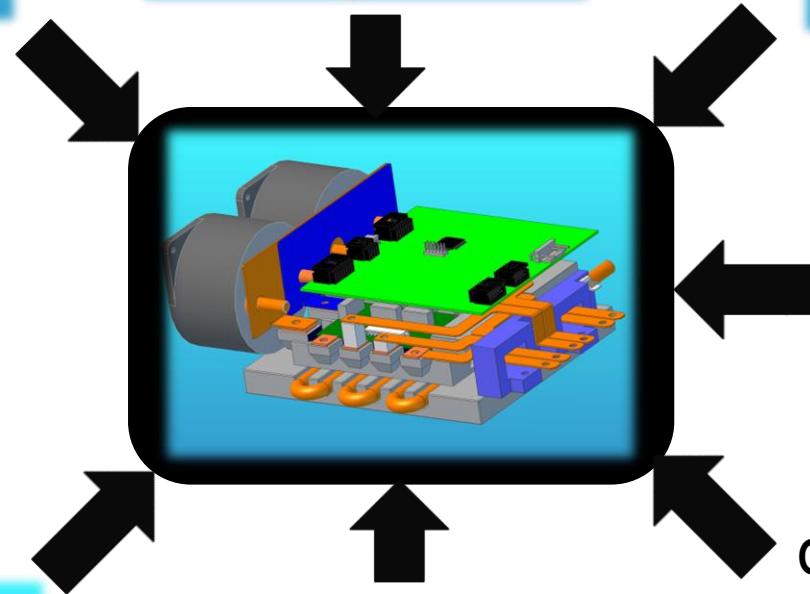
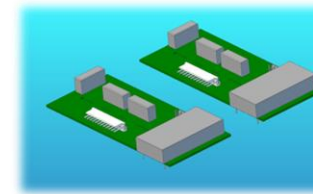
Busbars



Sensors



Gate driver boards

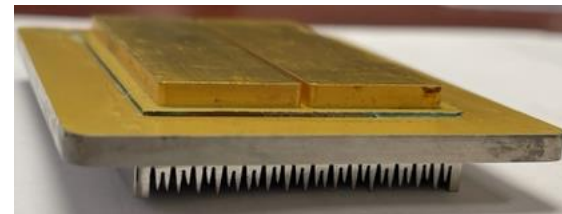
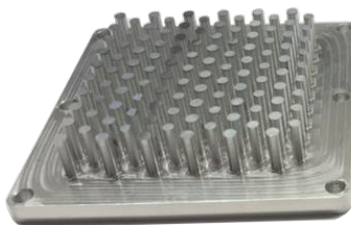
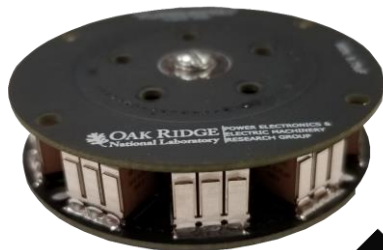


Focus on Components of an Inverter

DC link capacitors

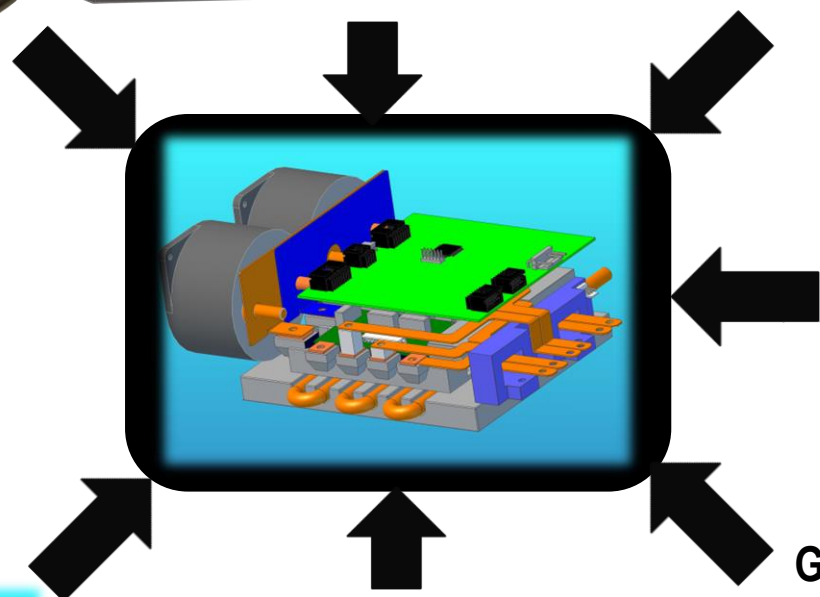
Heat sink

Power modules

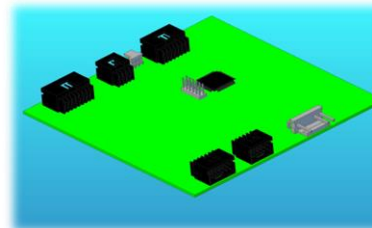


Major power density impact

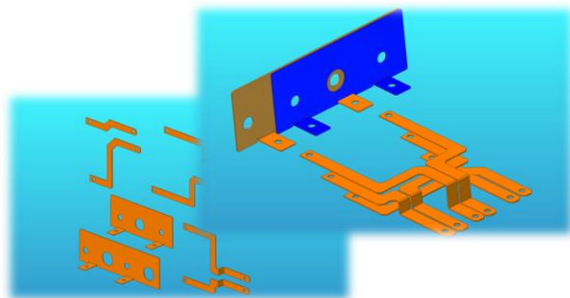
- DC Link Capacitors
- Heat sink
- Power Modules



Controller/DSP board



Busbars

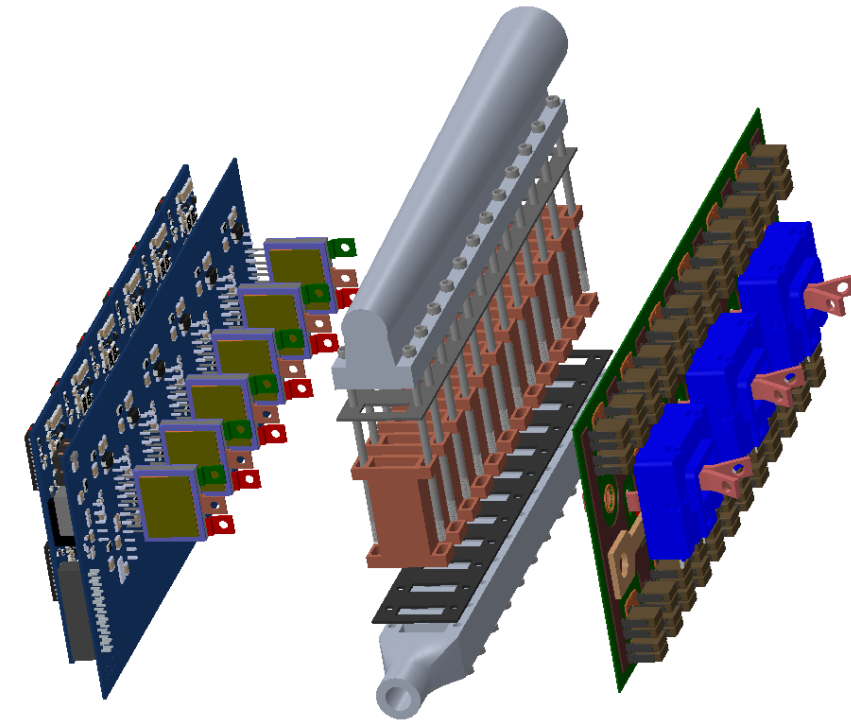
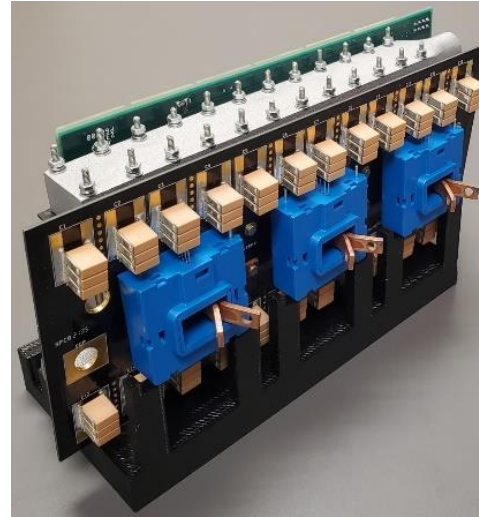
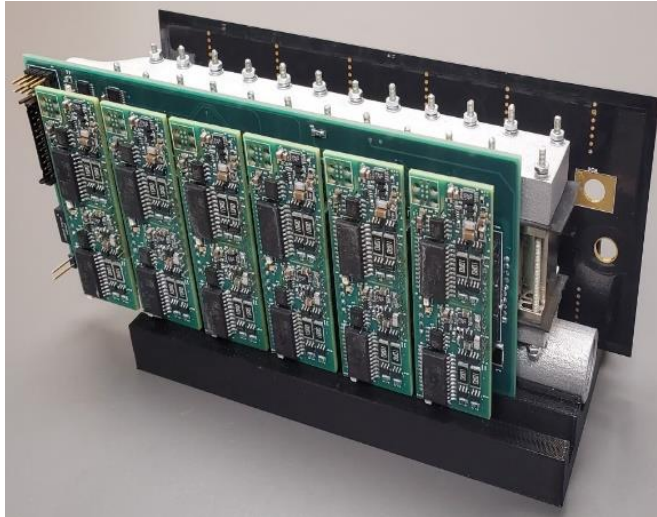
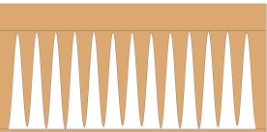
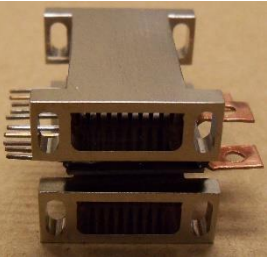
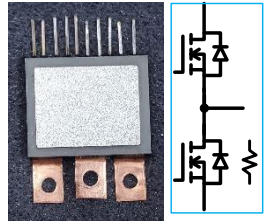


Sensors

Gate driver boards

Inverter Power Density Target 100kW/L

The 1st Gen 100kW inverter design using the Virginia Tech Phase leg Modules



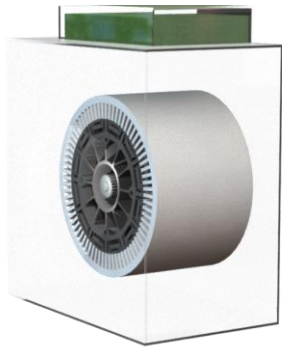
Exploded view

Photos of the inverter prototype using VT power modules and heatsinks using ORNL genetic algorithm (GA) based optimization tools

100 kW/143 kVA segmented inverter @0.98L meets the 2025 targets

Integrated Electric Drive

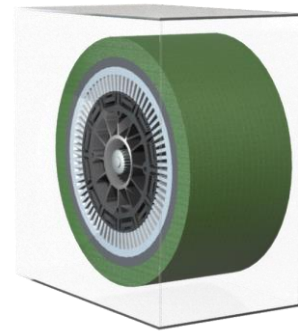
Conventional Motor Drive



- Easy mounting
- Detachable for debugging
- Separate cold plate
- Separate casing
- Low power density due to the geometry

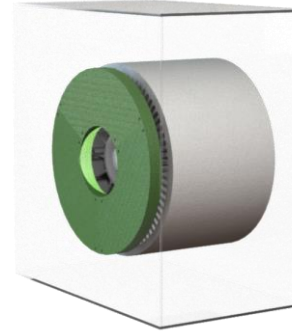
Integrated Drive

Radial Stator Mount



- Shared cooling jacket
- Shared casing
- Debugging is difficult

Axial Stator Mount



- Easy mounting
- Detachable for debugging
- Shared casing
- Can be shared or separate cold plate

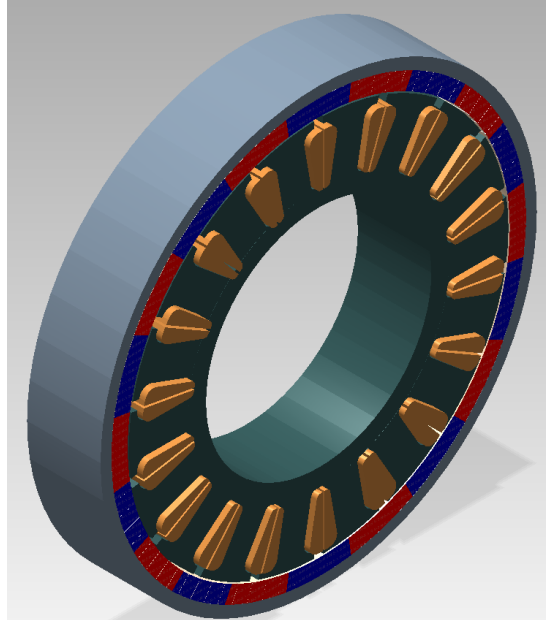
 Motor  Power electronics

Current ORNL approach

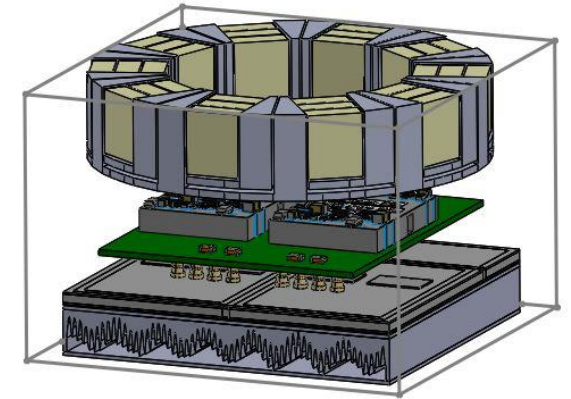
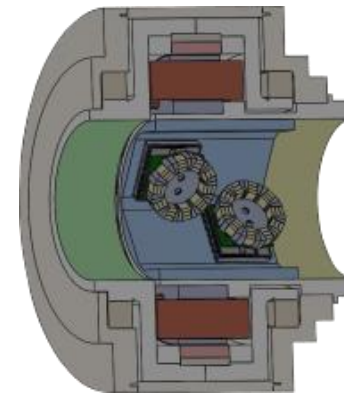
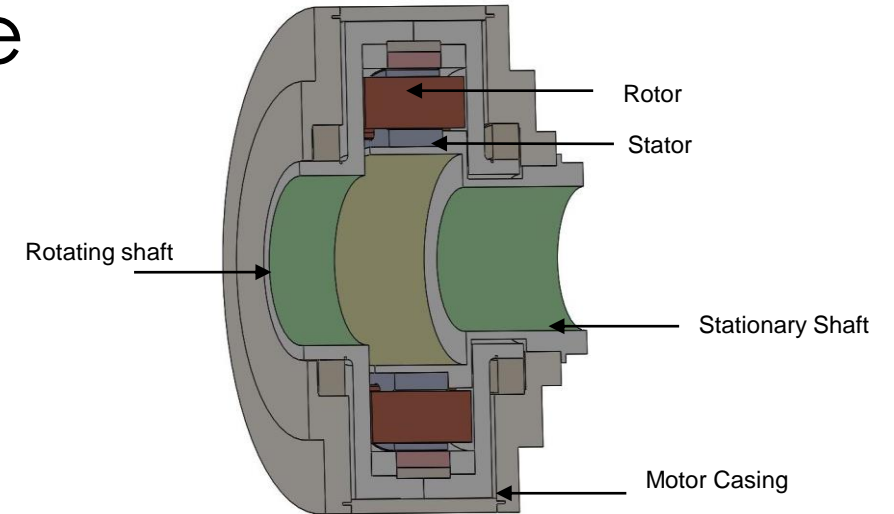
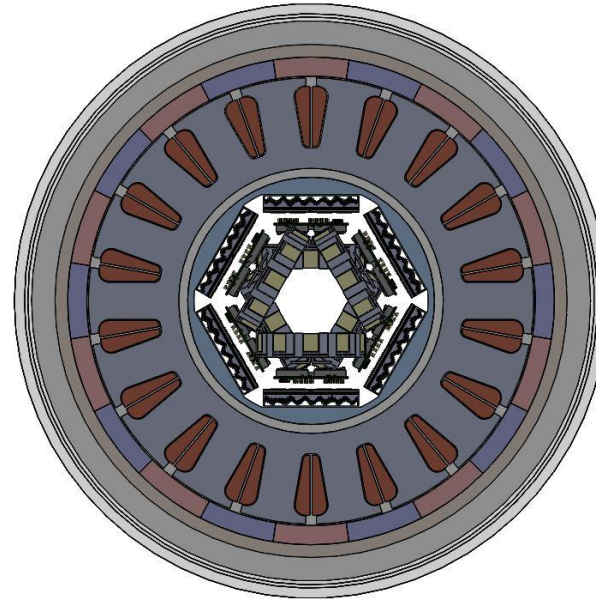


- Outer rotor motor has higher power density than the other variants
- Inverter can be embedded inside the motor
- Shared casing and cooling for tight integration

Outer Rotor Motor Integrated Drive



Outer rotor Surface Permanent Magnet
Concentrated tooth winding



Outer rotor motor is selected to achieve higher power density and due to the availability of the inner hollow space for inverter integration

Questions

