

Comparison of IGBT and SiC power electronics in inverters for electric vehicle three phase electric traction motor

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OSCar eO (2012)

the first electric car to finish Dakar rally



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eO PP03 (2015)

the first electric car to win Pikes Peak Hill Climb



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Electric Fox (2016)

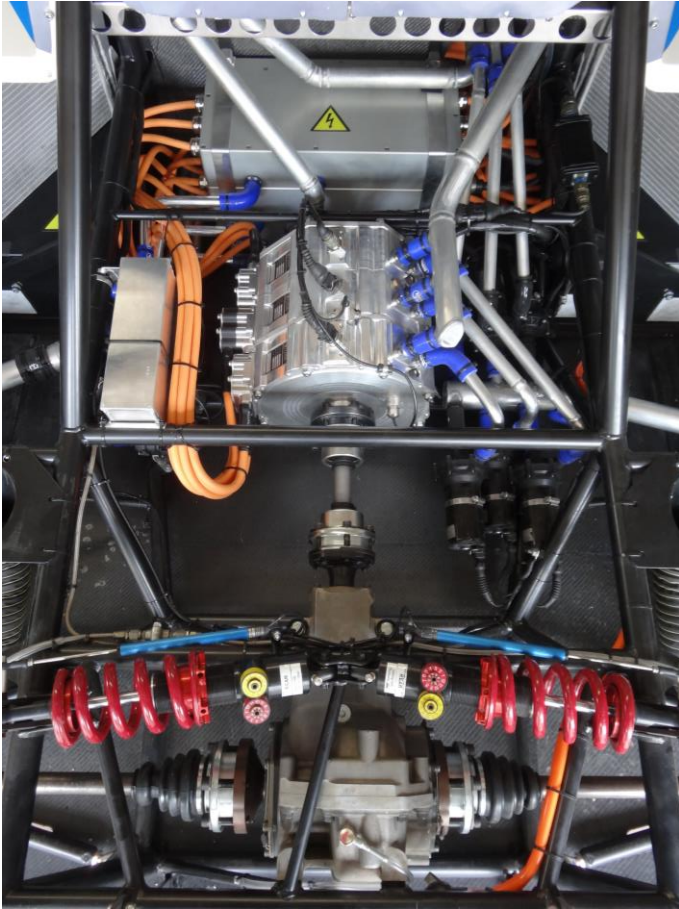
the fastest electric dragster in Europe – ¼ mile in 7.6 sec



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Prototype EV development



- computer aided design and simulation
- electric motor and controller integration
- bespoke lithium ion battery packs
- high voltage and low voltage wiring looms
- thermal management solutions
- charging infrastructure
- dynamometer and road testing
- machining, fabrication, composite shops

Generic electric drive system



Motor drive inverter / controller



High power density

- operational voltage 500 – 800 VDC
- output current nominal 240 / peak 450 ARMS
- mass 11 kg, volume 8 litres

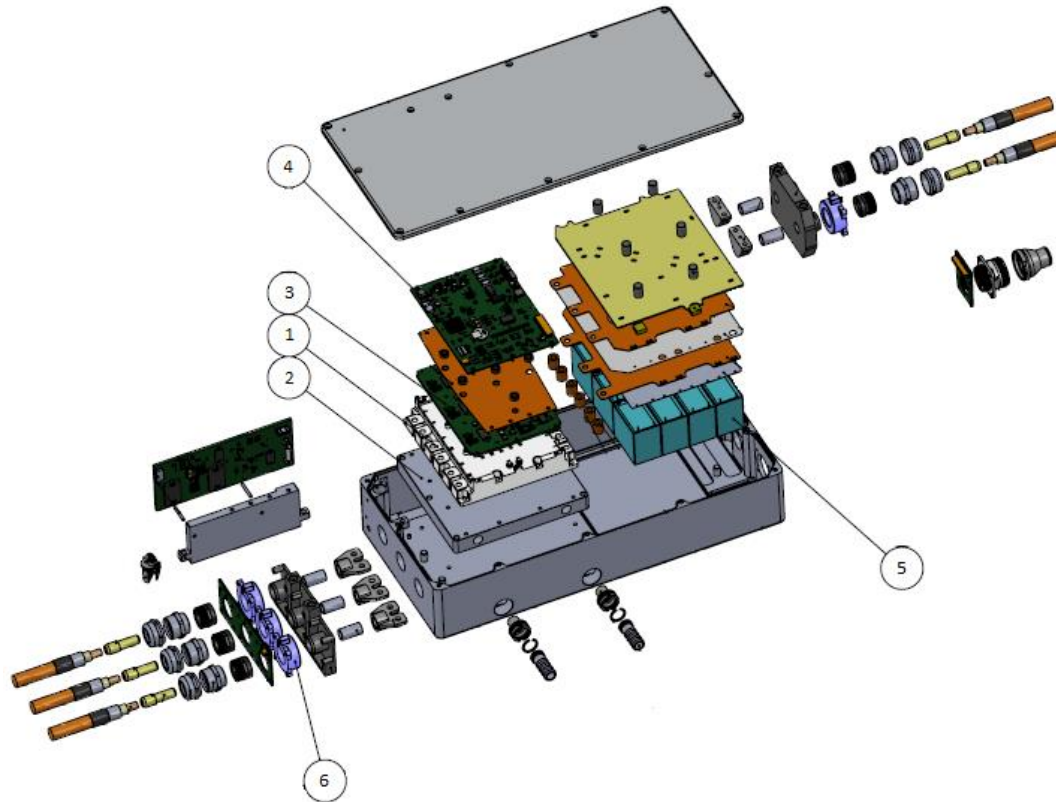
Versatile integration options

- 2× CAN interface
- multi-motor axle support
- numerous and adaptable signal I/O
- single power supply

Rugged hardware



Motor drive inverter / controller



- (1) power module (2) cold plate (3) gate driver PCB
(4) μ -controller PCB (5) DC capacitor (6) current sensors

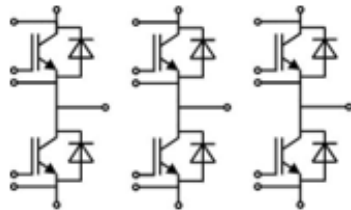
Pilot demonstrator



Demonstrate advantages of wide bandgap power electronics by integrating a SiC power module and comparing the efficiency and output parameters



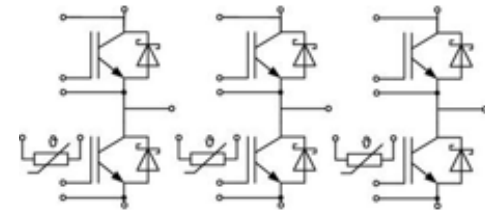
Power module



Si diodes

production IGBT module

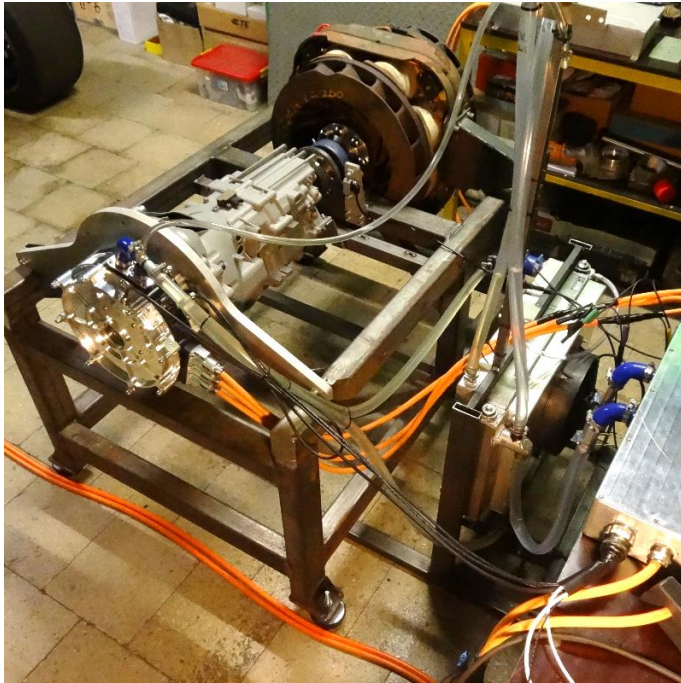
vs.



SiC Schottky diodes

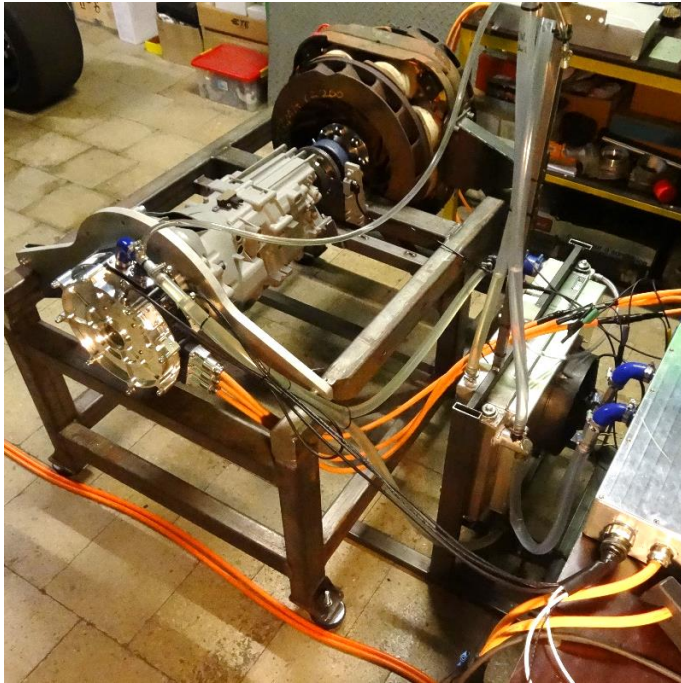
experimental sample

Dynamometric motor test bench



- electromagnetic brake load
- permanent magnet synchronous electric machine YASA-400 (power output nominal 80 kW / peak 160 kW at 700 V_{DC})
- DC power supply
- test inverter
- liquid cooling system
- power meter HIOKI-3194
- Tektronix MSO3000 series oscilloscope
- analogue signal converter L-Card E-502
- data logging software PowerGraph

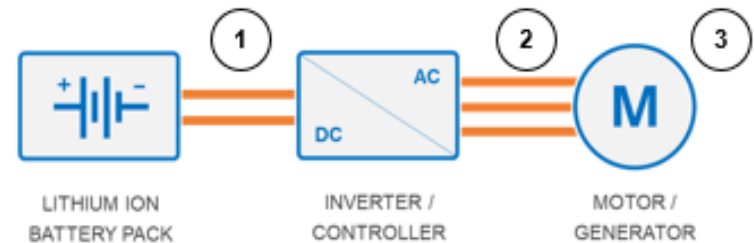
Test conditions



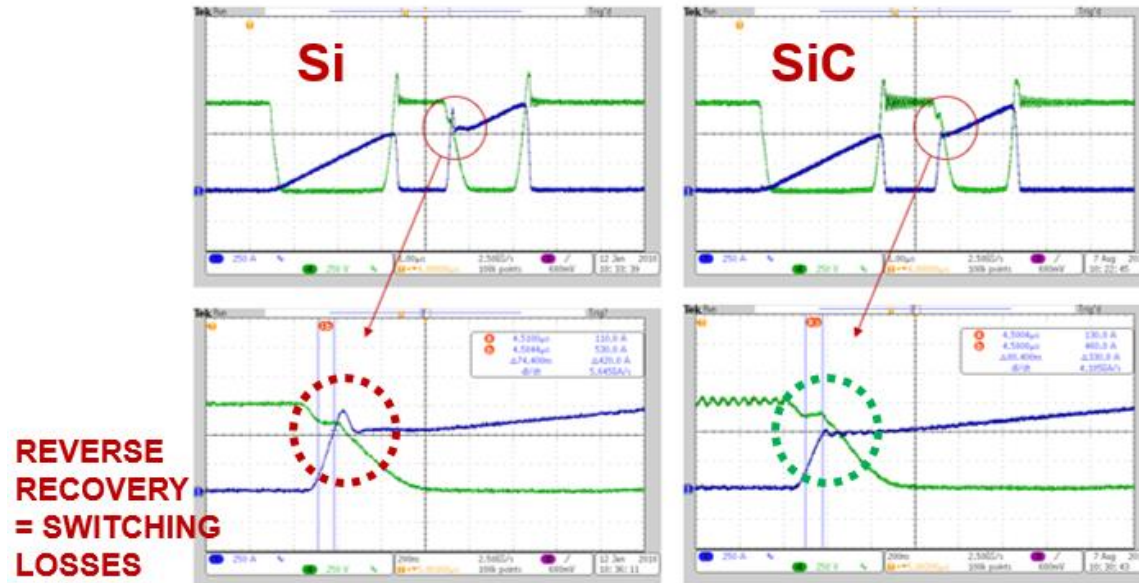
- motor angular speed 2000 RPM
- inverter input voltage 660 V_{dc}
- inverter output current 200 A_{rms}
- mechanical power 40 kW
- module and winding dT/dt = 0

Results

	Switching f [kHz]	Module temp [C]	Efficiency [%]		
			1-2	2-3	1-3
Si power module	10	48	92.2	88.5	81.7
SiC power module	10	44	95.6	88.4	84.6
	15	44	95.0	88.8	84.4

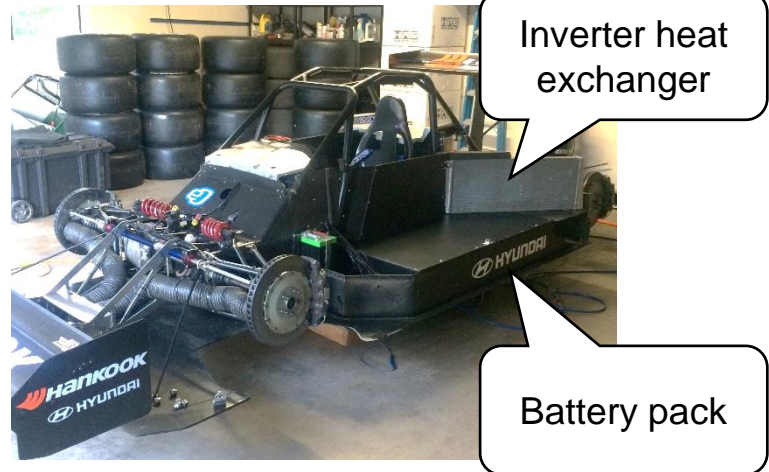


Results



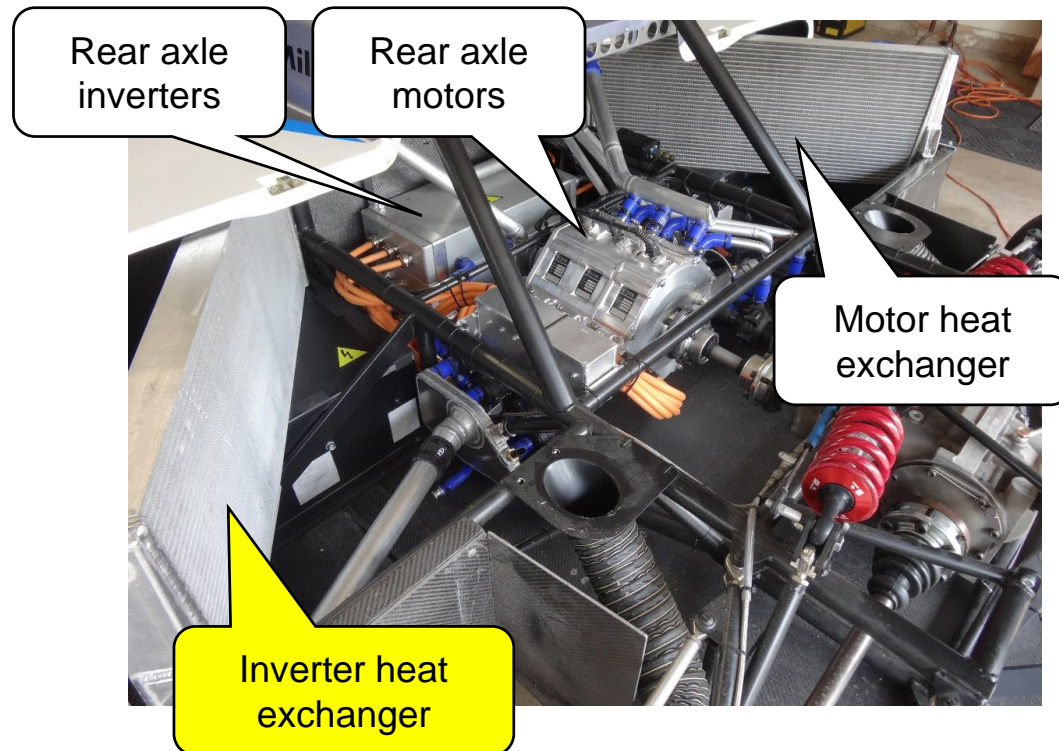
Double pulse test: power module switching time and energy dissipation;
SiC diode module exhibit virtually no reverse recovery → higher efficiency
(and switching frequency, if required)

Application



Higher system efficiency allows downsizing
the battery pack and inverter heat exchanger
→ lower vehicle mass and aerodynamic resistance
= better outright performance

Application



Application





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