Power Conditioning Systems for High-Megawatt Fuel Cell Plants

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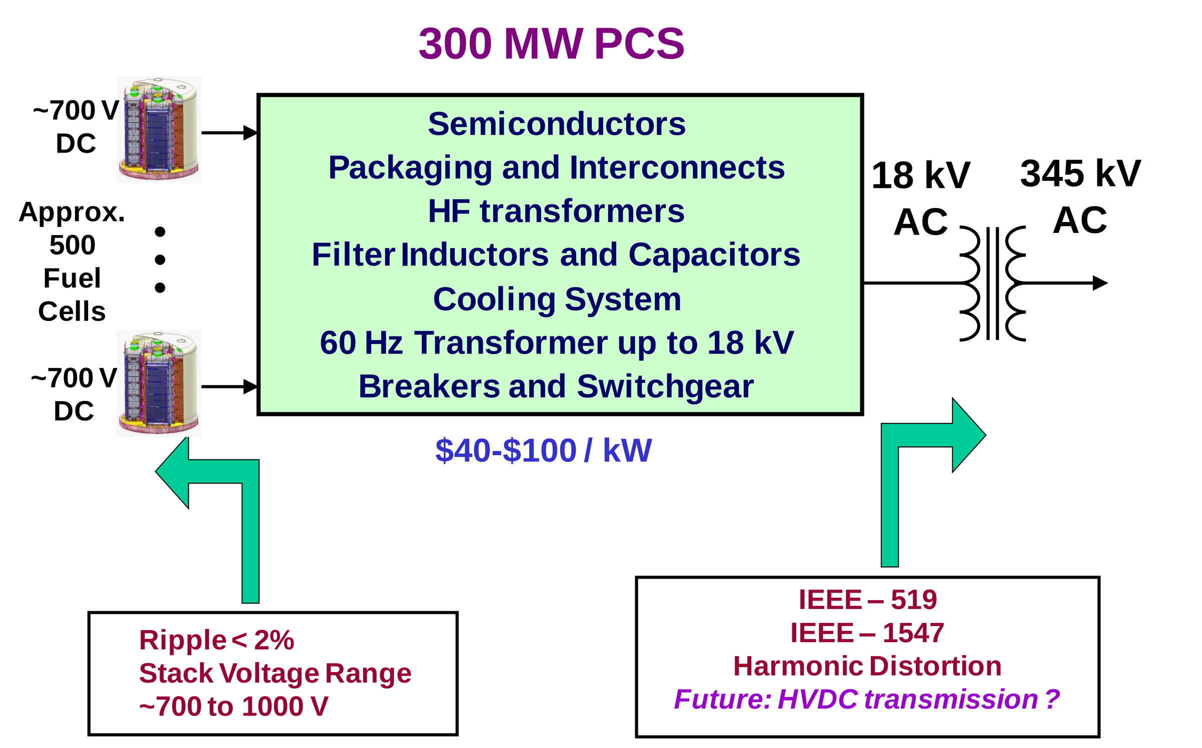
Abstract:
High-megawatt Power Conditioning Systems (PCS) are required to convert the low voltage power produced by fuel cell modules in central station scale plants to the very much higher voltage levels required for delivery to the grid. The SECA power plant PCS cost goal of $40 - $100/kW is generally recognized as a difficult stretch goal that cannot be met with today's technology. To address this challenge, DOE and NIST have entered into an Interagency Agreement to evaluate various advanced technology options for the PCS and to identify technologies requiring development to meet the SECA cost and efficiency goals. For example, direct grid-connected inverters using high-voltage, high-frequency (HV-HF) SiC devices result in reduced cost of the passive components, cooling system, and switchgear. Prototypes of advanced HV-HF SiC devices have been developed, characterized, and compared with Silicon devices, and circuit simulation models have been developed to simulate the performance of advanced PCS approaches using these devices.

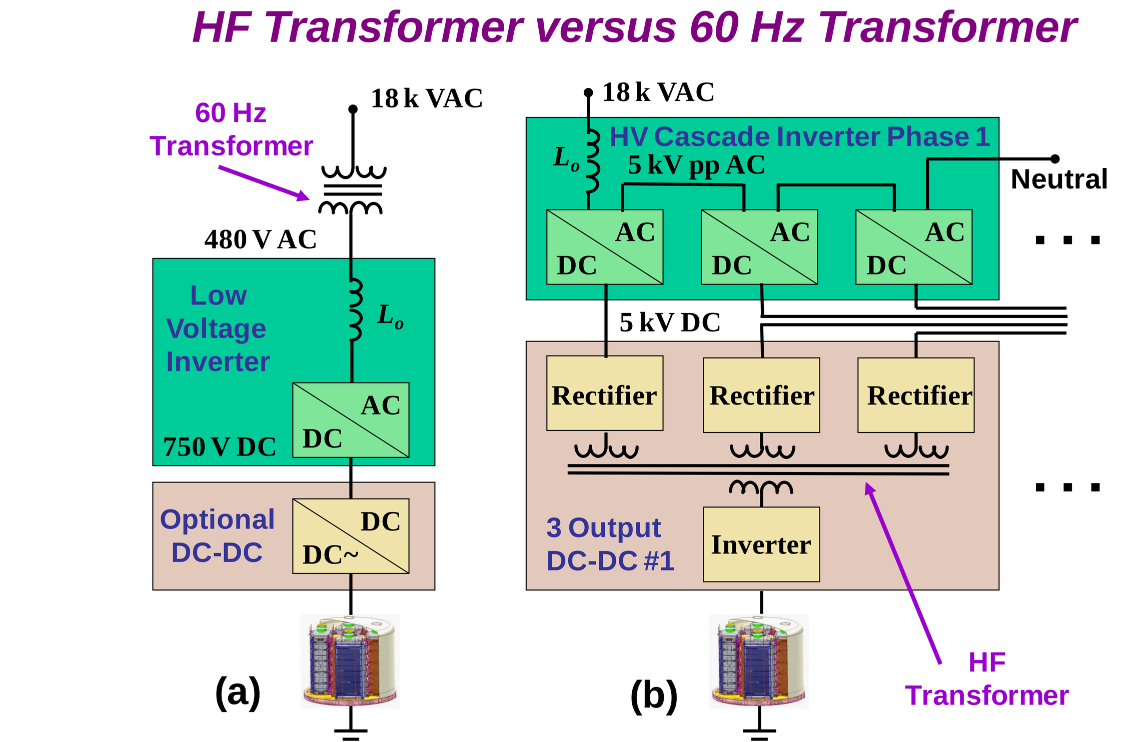
Objectives

- Identify advanced technologies that may significantly reduce the cost of the power conditioning systems (PCS) required for future high-megawatt fuel cell power plants.
- Determine fuel cell power plant PCS performance requirements, including requirements for fuel cell interface and for Smart Grid interconnection.
- Develop simulation models for advanced PCS architectures, circuit topologies, and component technologies and perform simulations required to determine overall cost and performance benefits of advanced technologies.
- Coordinate with related industry and federal government programs to enable the development of advanced high-megawatt PCS technologies necessary to meet the Solid State Energy Conversion Alliance (SECA) high-megawatt fuel cell power plant PCS goals.



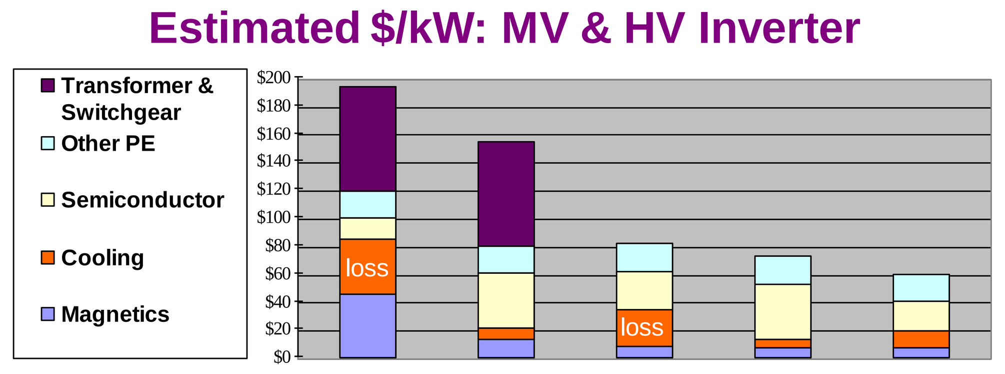
Fuel cell power plant requirements for High-megawatt Power Conditioning System (PCS) indicating the component technologies included in PCS cost

HF Transformer versus 60 Hz Transformer



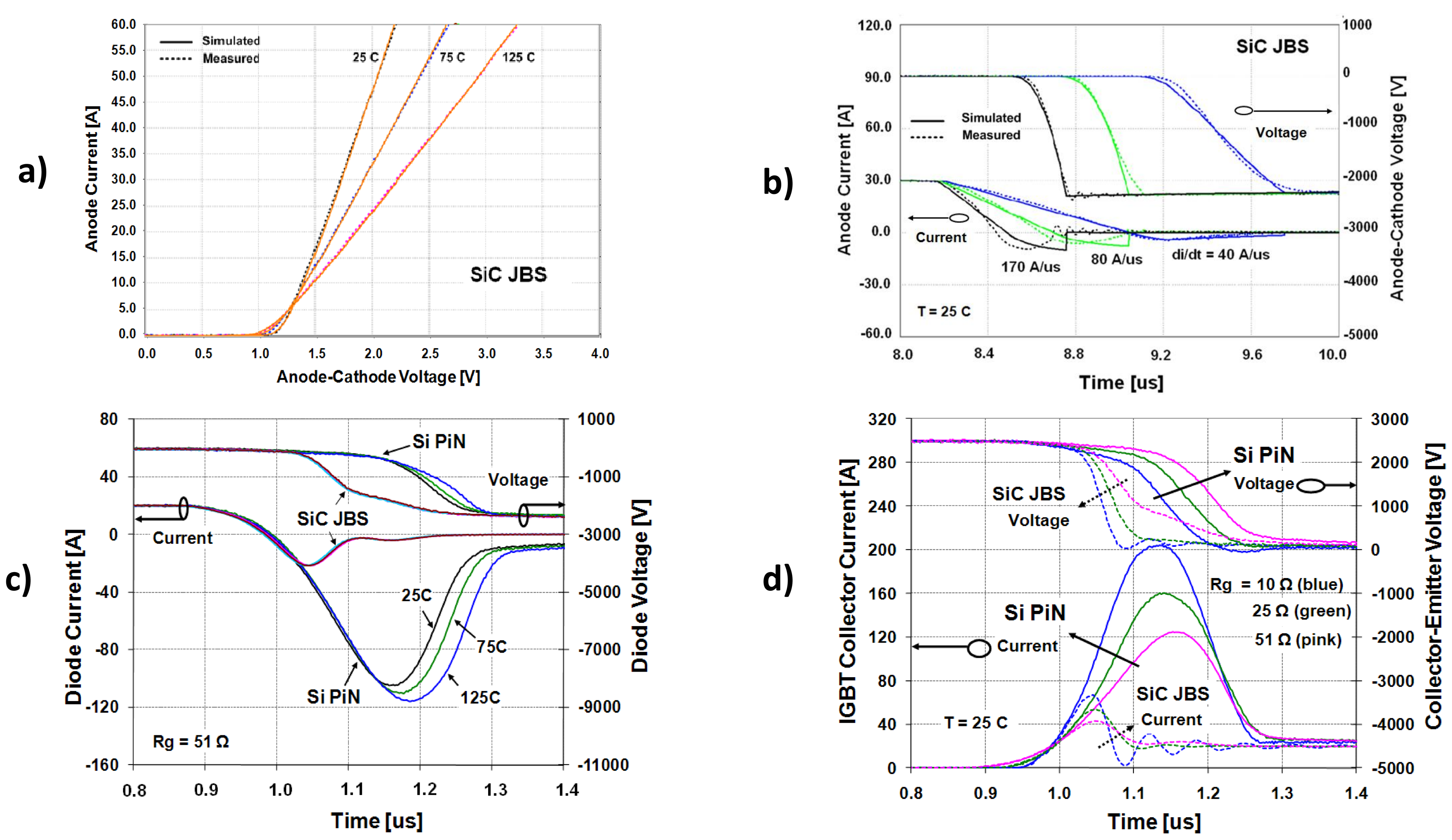
(a) 480 V AC inverter and a 60 Hz transformer to raise the output voltage to 18 kV AC for plant distribution and **(b)** multiple fuel cells each having a three output DC-DC converter that steps the voltage up to 5 kV, followed by a high voltage three phase cascade inverter connected directly to the 18 kV AC power plant distribution.

Estimated $/kW: MV & HV Inverter

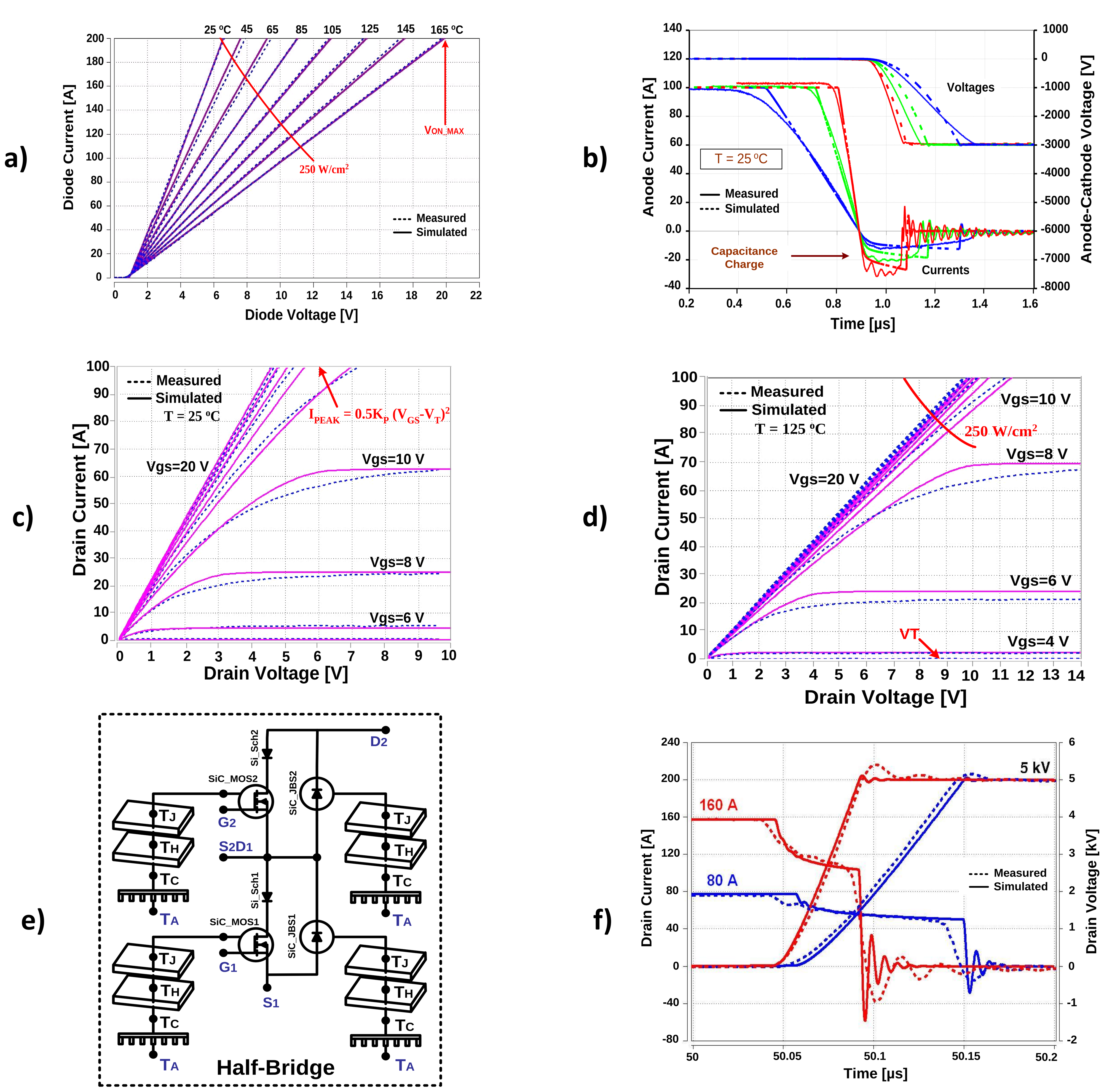


Inverter Voltage	Medium	Medium	High	High	High
HV-SiC Diode		Schottky	Schottky	Schottky	PiN
HV-SiC Switch		MOSFET		MOSFET	IGBT
HF Transformer	Nano	Nano	Nano	Nano	Nano
60 Hz Transformer	yes	yes			

Risk Level: Low | Moderate | Considerable | High



4.5 kV Si-IGBT/SiC-JBS hybrid module development: a) Forward characteristic of SiC JBS; b) Reverse recovery of SiC JBS for different di/dt; c) Comparison of reverse recovery vs. temperature for Si PiN and SiC JBS diodes; d) Gate resistor dependence of Si IGBT turn-on for Si PiN and SiC JBS anti-parallel diodes.



10 kV SiC MOSFET/JBS half-bridge module: a) Forward characteristic of SiC JBS; b) Reverse recovery of SiC JBS for different di/dt; c) Output characteristics of SiC MOSFET at 25 C; d) Output characteristics of SiC MOSFET at 125 C; e) 10 kV SiC MOSFET/JBS half-bridge module model; f) Current dependence of inductive load turn-off for SiC MOSFET module.