# Modeling Silicon Carbide Devices for Power Supply Performance Evaluation

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## A. Project Summary

This project will concentrate on **compact circuit simulation models for Silicon Carbide (SiC) devices**. Namely, the power MPS diode, PiN diode, BJT, MOSFET, and npnp thyristor and MTO devices will be investigated. **Specifically, the project objectives are to:**

- ✧ **Physically characterize MPS, PiN, BJT, MOSFET, and thyristor SiC devices**
- ✧ **Design & develop circuit simulation models for these devices**
- ✧ **Validate the SiC power device models against actual device measurements**
- ✧ **Demonstrate and validate SiC power device models in key power electronic applications**

Compact circuit simulation models enable designers to more effectively utilize a technology in circuits and systems. Power electronic designers rely on computer simulation for insight into the details of the operation of their circuits. In addition to nominal operating conditions, the designer analyzes the robustness of the design through a number of studies such as dynamic thermal analysis, worst case analysis, statistical variations in circuit performance due manufacturing tolerances on parts, and failure modes and effects to determine the safe operating area of the circuit. In order to perform these simulations, models are required. Such analysis cannot practically be performed using hardware prototypes.

Silicon carbide is capable of operating temperatures of 500°C because of its unique electrical and mechanical properties. Other advantages compared to silicon-based devices exist regarding reliability, higher immunity to thermal runaway, reduced switching losses, and higher current density. Due to SiC’s high thermal conductivity, significant savings in system cooling requirements, mass, and cost are likely for many aircraft, shipboard, vehicle, and utility power conversion applications.

SiC’s higher breakdown electric field allows the design of SiC power devices with thinner (1/10th that of silicon devices) and more highly doped (more than 10 times higher) voltage blocking layers. For majority carrier power devices such as power Schottky diodes and MOSFETs, the combination of 1/10th the blocking layer thickness with 10 times the doping concentration can yield a SiC device with a factor of 100 advantage in resistance compared to that of Si majority carrier devices. For minority carrier conductivity modulated devices such as PiN diodes, BJTs, and thyristors a blocking layer of 1/10th the thickness of a Si device can result in a factor of 100 faster switching speed.

Now that SiC power devices are becoming more reliable and reproducible, it is time for research and development of accurate, physical-based models to commence. As the number of commercially available SiC devices increase, designers will require an increasing number of component models (characterized parts) for use in circuit simulators. Since it takes on the order of two years to correctly construct and validate an accurate model, it is imperative that SiC device models be developed somewhat in parallel with the device technologies.

Collaborators at two federal agencies, National Institute of Standards and Technology (NIST) and NASA Glenn, will provide access to SiC devices, facilities, and summer employment to the UA researchers throughout the duration of the project.