



NASA SBIR 2016 Phase I Solicitation

Z1.01 High Power/Voltage Electronics

Lead Center: GSFC

Participating Center(s): GRC, LaRC

NASA is seeking performance improvements to Power Management and Distribution (PMAD) systems through increases to the operating voltages and temperatures of these electrical components. Although many parts exist in the commercial market place that would represent significant improvements over the state of the art space qualified components, these parts have failed to pass critical tests related to space qualification, most importantly in terms of their radiation tolerance. It is believed that the development and integration of high voltage/high temperature components that can be space qualified will lead to increases in system level performance as they will tend to increase efficiency and decrease mass at the system architecture level. Such performance improvements are necessary if NASA is to realize several operational concepts such as very high power Solar Electric Propulsion (SEP) that undergird their future mission architectures. For example, SEP is a key technology supporting NASA's deep space asteroid retrieval mission. This SEP mission requires total power on the order of 50 kW with a thruster power processing unit that steps up voltages to 700 V or more. These parameters are not truly negotiable and in turn dictate certain design choices for current and voltage regulation across the system. Given the space qualified electronic parts available today, system engineers are frequently required to make sub-optimal design choices. In a simplistic but specific realization, higher voltage parts allow power generation at higher voltages on the arrays themselves, this higher voltage allows for the same power to be transferred at lower current thereby reducing cable mass at the system level. At a more general level within the PMAD architecture, the use of presently available parts forces design choices that end in lower operating efficiency and increased heat generation within the electronic system, which in turn drive overall system mass.

The premise of this solicitation is that there have been recent improvements to semi-conductor devices at the material level, e.g., SiC and GaN, which have enabled higher efficiency, voltage and temperature regimes for parts and systems working terrestrially. However the first generation devices have proven unsatisfactory for use in space applications due to radiation-induced early failures after exposure to heavy-ion fluences of concern to most space missions. Further research and development effort must be accomplished to fully understand the failure mechanisms within devices made of these advanced materials and iterative design cycles must then be conducted to develop components that have the performance characteristics required for future NASA missions.

The types of components coming under this topic include:

- Semiconductor switches, e.g., the design of Wide Band Gap semiconductors such as switches and diodes using GaN or SiC, with minimum voltage and current ratings of 1200 V and 12 A.
- Switch driver diodes.
- High temperature capacitors.
- Interconnection wires for switchgears.
- Associated control electronics.

This solicitation topic seeks proposals that address each of the following points:

- Analysis and research into the failure modes related to heavy-ion radiation exposure, as well as high temperature operation of GaN and SiC devices.
- Design and development of "next-generation" components.

It is important to note that technologies of interest to NASA under this topic must not simply provide an incremental improvement as the solution but must have the potential to significantly improve upon device operating points, thermal range, heavy-ion single-event effect tolerance, and the mass and volume characteristics. Proposals submitted in response to this topic must state the initial component state of the art and justify the expected final performance metrics.

Target performance levels include:

- Radiation hardness:
 - 300 krad(Si) total ionizing dose tolerance, and
 - For vertical-field power devices: No heavy-ion induced permanent destructive effects upon irradiation with ions having a silicon-equivalent surface-incident linear energy transfer (LET) of 40 MeV-cm²/mg and sufficient energy to fully penetrate the epitaxial layer(s) prior to the ions reaching their maximum LET (Bragg peak)
 - For all other devices: No heavy-ion induced permanent destructive effects upon irradiation with ions having a silicon-equivalent surface-incident linear energy transfer (LET) of 75 MeV-cm²/mg and sufficient energy to fully penetrate the active volume prior to the ions reaching their maximum LET (Bragg peak).
- Thermal range: 150 °C or greater junction temperature.