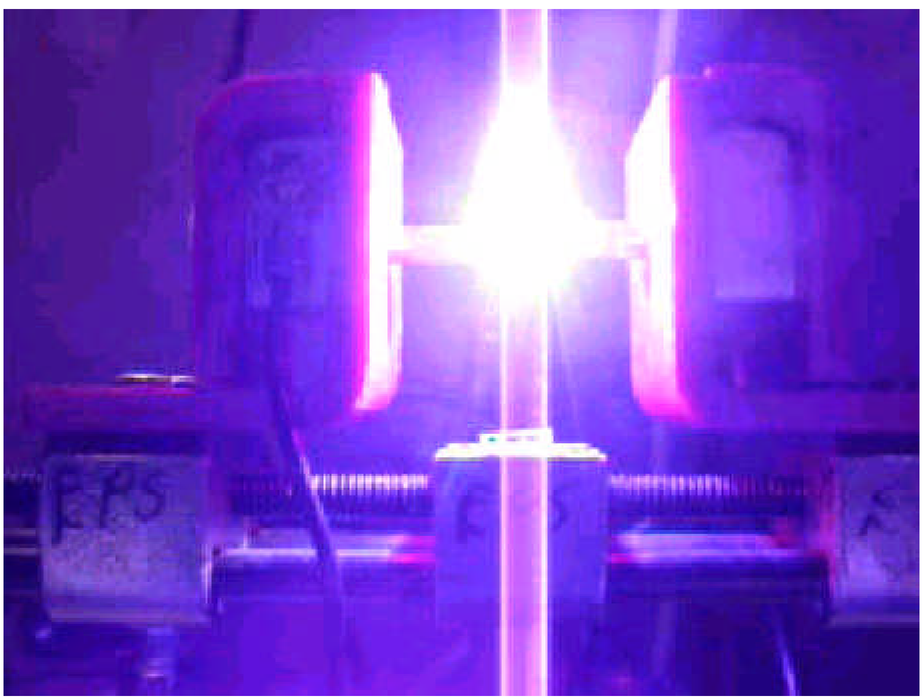
Soft-Fault Detection Technologies Developed for Electrical Power Systems

The NASA Glenn Research Center, partner universities, and defense contractors are working to develop intelligent power management and distribution (PMAD) technologies for future spacecraft and launch vehicles. The goals are to provide higher performance (efficiency, transient response, and stability), higher fault tolerance, and higher reliability through the application of digital control and communication technologies. It is also expected that these technologies will eventually reduce the design, development, manufacturing, and integration costs for large, electrical power systems for space vehicles.

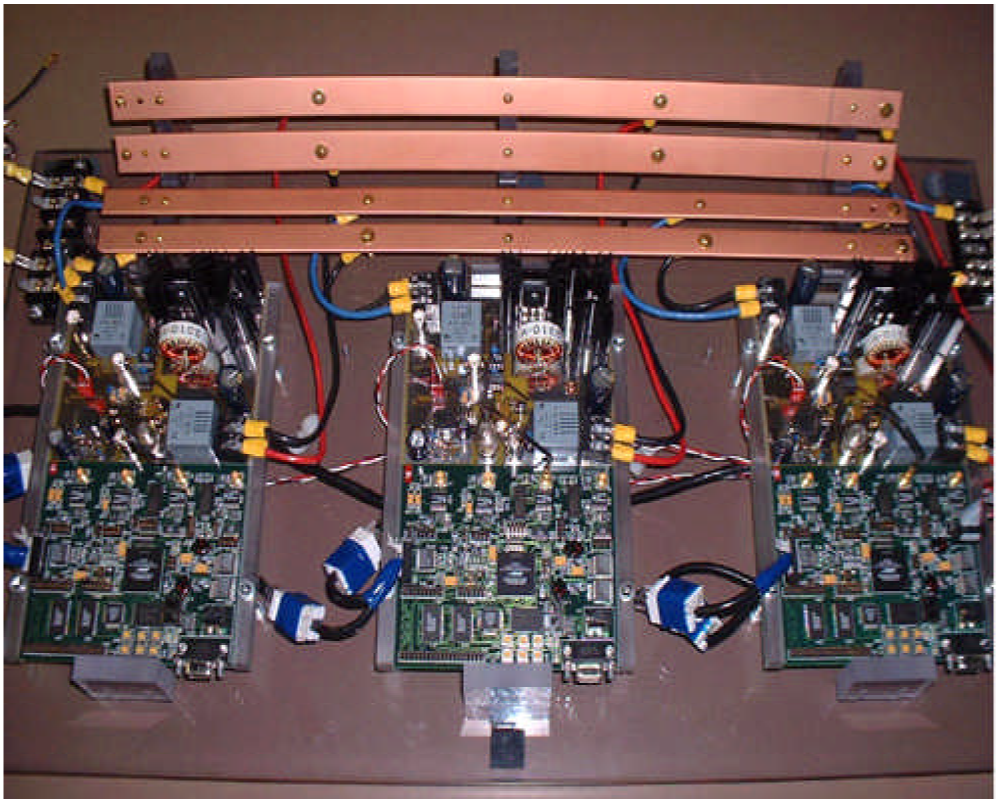
The main focus of this research has been to incorporate digital control, communications, and intelligent algorithms into power electronic devices such as direct-current to direct-current (dc-dc) converters and protective switchgear. These technologies, in turn, will enable revolutionary changes in the way electrical power systems are designed, developed, configured, and integrated in aerospace vehicles and satellites. Initial successes in integrating modern, digital controllers have proven that transient response performance can be improved using advanced nonlinear control algorithms.



Arc fault detection research.
This research uses a test rig that produces low-current electrical arcs.

One technology being developed includes the detection of "soft faults," those not typically covered by current systems in use today. Soft faults include arcing faults, corona discharge faults, and undetected leakage currents. Using digital control and advanced signal analysis algorithms, we have shown that it is possible to reliably detect arcing faults in high-voltage dc power distribution systems (see the preceding photograph). Another research effort has shown that low-level leakage faults and cable degradation can be detected by analyzing power system parameters over time. This additional fault detection capability will result in higher reliability for long-lived power systems such as reusable launch vehicles and space exploration missions.

An extension of the digital technology being developed is to provide active "collaboration" among modular components to improve performance and enable the use of common modules, thereby reducing costs. The performance improvement goals include active current sharing, load efficiency optimization, and active power quality control. The challenge is to make these modules truly stand alone with no central controllerthereby eliminating sources of single-point failures. The current technology demonstrator (see the following photograph) has high-speed serial communication between the modular controllers, and it can actively control the switching phase between three paralleled dc-dc converters, thereby greatly improving power quality.



Multimodule, digital control of dc-dc converters.
The three DC-DC converters are connected in parallel.

Future technologies to be developed include active stability control, health monitoring, and prognostics of power electronic hardware. Finally a highly reconfigurable distribution topology is being developed that will greatly increase system reliability and enable autonomous reconfiguration of the electrical power system in response to system failures or changes in mission priorities.

Find out more about this research: http://powerweb.grc.nasa.gov/elecsys/

Glenn contact: Robert M. Button, 216-433-8010, Robert.M.Button@nasa.gov
Author: Robert M. Button
Headquarters program office: OAT
Programs/Projects: Enabling Concepts & Technologies, Energetics