



### **Integral Battery Power Limiting Circuit for Intrinsically Safe Applications**

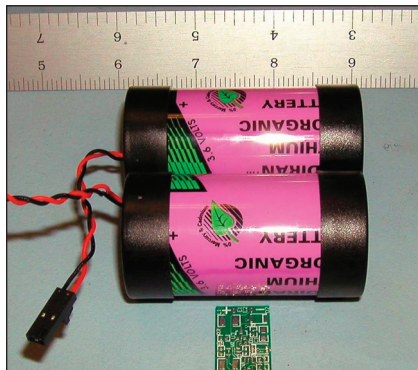
**This circuit is designed for low-voltage batteries, but is valid for any DC power source.**

*John F. Kennedy Space Center, Florida*

A circuit topology has been designed to guarantee the output of intrinsically safe power for the operation of electrical devices in a hazardous environment. This design uses a MOSFET (metal-oxide-semiconductor field-effect transistor) as a switch to connect and disconnect power to a load. A test current is provided through a separate path to the load for monitoring by a comparator against a preset threshold level. The circuit is configured so that the test current will detect a fault in the load and open the switch before the main current can respond. The main current passes through the switch and then an inductor. When a fault occurs in the load, the current through the inductor cannot change immediately, but the voltage drops immediately to safe levels.

The comparator detects this drop and opens the switch before the current in the inductor has a chance to respond. This circuit protects both the current and voltage from exceeding safe levels. Typically, this type of protection is accomplished by a fuse or a circuit breaker, but in order for a fuse or a circuit breaker to blow or trip, the current must exceed the safe levels momentarily, which may be just enough time to ignite anything in a hazardous environment. To prevent this from happening, a fuse

is typically current-limited by the addition of the resistor to keep the current within safe levels while the fuse reacts. The use of a resistor is acceptable for non-battery applications where the wasted energy and voltage drop across the resistor can be tolerated.



The **Battery Power Limiting Circuit** minimizes the voltage drop to the load, and current drain on the battery.

The use of the switch and inductor minimizes the wasted energy. For example, a circuit runs from a 3.6-V battery that must be current-limited to 200 mA. If the circuit normally draws 10 mA, then an 18-ohm resistor would drop 180 mV during normal operation, while a typical switch (0.02 ohm) and inductor (0.97 ohm) would only drop 9.9 mV. From a

power standpoint, the current-limiting resistor protection circuit wastes about 18 times more power than the switch and the inductor configuration. In the fault condition, both the resistor and the inductor react immediately. The resistor reacts by allowing more current to flow and dropping the voltage. Initially, the inductor reacts by dropping the voltage, and then by not allowing the current to change. When the comparator detects the drop in voltage, it opens the switch, thus preventing any further current flow. The inductor alone is not sufficient protection, because after the voltage drop has settled, the inductor would then allow the current to change, in this example, the current would be 3.7 A.

In the fault condition, the resistor is flowing 200 mA until the fuse blows (anywhere from 1 ms to 100 s), while the switch and inductor combination is flowing about 2  $\mu$ A test current while monitoring for the fault to be corrected. Finally, as an additional safety feature, the circuit can be configured to hold the switch opened until both the load and source are disconnected.

*This work was done by Bradley M. Burns of ASRC, Inc. and Norman N. Blalock of Sierra Lobo, Inc. for Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-12703*

### **Configurable Multi-Purpose Processor**

**This small processor board can be used in applications requiring substantial processing power in a flexible platform and in high vibration environments.**

*John F. Kennedy Space Center, Florida*

Advancements in technology have allowed the miniaturization of systems used in aerospace vehicles. This technology is driven by the need for next-generation systems that provide reliable, responsive, and cost-effective range operations while providing increased capabilities such as simultaneous mission support, increased

launch trajectories, improved launch, and landing opportunities, etc.

Leveraging the newest technologies, the command and telemetry processor (CTP) concept provides for a compact, flexible, and integrated solution for flight command and telemetry systems and range systems. The CTP is a rela-

tively small circuit board that serves as a processing platform for high dynamic, high vibration environments. The CTP can be reconfigured and reprogrammed, allowing it to be adapted for many different applications. The design is centered around a configurable field-programmable gate array (FPGA) device