Electronics/Computers

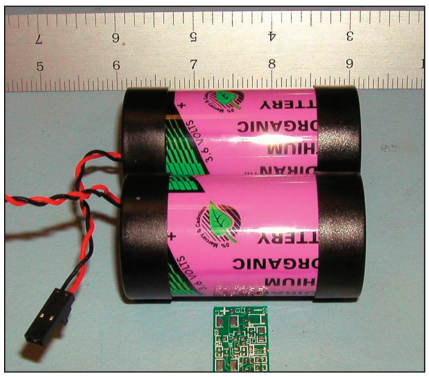
Integral Battery Power Limiting Circuit for Intrinsically Safe Applications

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 μA 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 relatively 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 that contains numerous logic cells that can be used to implement traditional integrated circuits. The FPGA contains two PowerPC processors running the VxWorks real-time operating system and are used to execute software programs specific to each application.

The CTP was designed and developed specifically to provide telemetry functions; namely, the command processing, telemetry processing, and GPS metric tracking of a flight vehicle. However, it can be used as a general-purpose processor board to perform numerous functions implemented in either hardware or software using the FPGA's processors and/or logic cells.

Functionally, the CTP was designed for range safety applications where it would ultimately become part of a vehicle's flight termination system. Consequently, the major functions of the CTP are to perform the forward link command processing, GPS metric tracking, return link telemetry data processing, error detection and correction, data encryption/decryption, and initiate flight termination action commands. Also, the CTP had to be designed to survive and operate in a launch environment.

Additionally, the CTP was designed to interface with the WFF (Wallops Flight Facility) custom-designed transceiver board which is used in the Low Cost TDRSS Transceiver (LCT2) also developed by WFF. The LCT2's transceiver board demodulates commands received from the ground via the forward link and sends them to the CTP, where they are processed. The CTP inputs and processes data from the inertial measurement unit (IMU) and the GPS receiver board, generates status data, and then sends the data to the transceiver board where it is modulated and sent to the ground via the return link.

Overall, the CTP has combined processing with the ability to interface to a GPS receiver, an IMU, and a pulse code modulation (PCM) communication link, while providing the capability to support common interfaces including Ethernet and serial interfaces boarding a relatively small-sized, lightweight package.

This work was done by J. Emilio Valencia, Christopher Forney, Robert Morrison, and Richard Birr of Kennedy Space Center. For further information, contact the Kennedy Innovative Partnerships Program Office at (321) 861-7158. KSC-13324

Squeezing Alters Frequency Tuning of WGM Optical Resonator

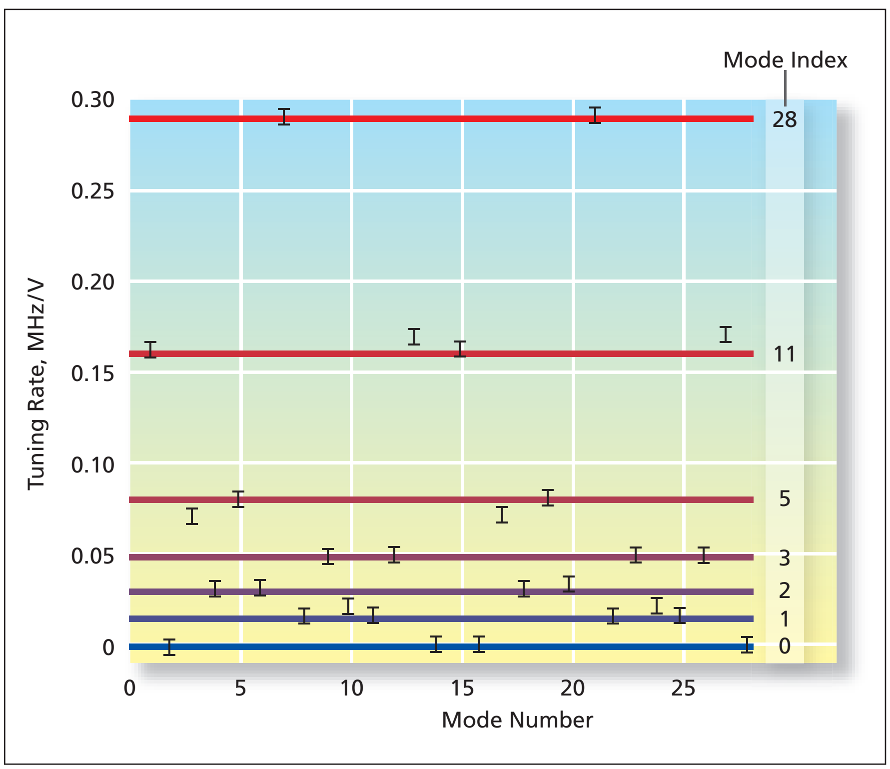
Tuning rates for modes of different indices can be made to differ.

NASA's Jet Propulsion Laboratory, Pasadena, California

Mechanical squeezing has been found to alter the frequency tuning of a whispering-gallery-mode (WGM) optical resonator that has an elliptical shape and is made of lithium niobate. It may be possible to exploit this effect to design reconfigurable optical filters for optical communications and for scientific experiments involving quantum electrodynamics.

Some background information is prerequisite to a meaningful description of the squeezing-induced alteration of frequency tuning: The spectrum of a WGM resonator is represented by a comblike plot of intensity versus frequency. Each peak of the comblike plot corresponds to an electromagnetic mode represented by an integer mode number, and the modes are grouped into sets represented by integer mode indices. Because lithium niobate is an electro-optically active material, the WGM resonator can be tuned (that is, the resonance frequencies can be shifted) by applying a suitable bias potential. The frequency shift of each mode is quantified by a tuning rate defined as the ratio between the frequency shift and the applied potential. In the absence of squeezing, all modes exhibit the same tuning rate. This concludes the background information.

It has been demonstrated experimentally that when the resonator is squeezed along part of either of its two principal axes, tuning rates differ among the groups of modes represented by different indices (see figure). The differences in tuning rates could be utilized to configure the resonance spectrum to obtain a desired effect; for example, through a combination of squeezing and electrical biasing, two resonances represented by different mode indices could be set at a



Tuning Rates were calculated from resonance-frequency-vs.-voltage measurements on an elliptical WGM resonator squeezed along its semimajor axis.