

# AVIONICS magazine **TECH REPORT**

## Ground Fault Protection

The wear and tear of wiring harnesses can create a safety issue in commercial aircraft, particularly in the aging ones. However, an approved, and proven,



technology exists that can detect and isolate the electrical faults, which otherwise can escape the harnesses and create hazardous situations in the aircraft's fuel tanks.

**A** major challenge confronting aircraft operators today is not new technology, but rather the aging of their fleets. As aircraft age, the complex wiring harnesses within them age, too. Harness deterioration can result in ground faults that could cause significant damage to wiring and equipment. One answer to this problem is ground sensing relays and contactors that can detect and isolate faults within fuel tanks.

### Threat

Every day, the wiring harnesses within an aircraft are subject to wear and tear. This occurs from swaying during flight or changes in the harness's chemical makeup due to aging. Over time, ground faults can occur as electrical current escapes these harnesses and seeks easier paths. A humble ground fault inside a fuel tank can become a catastrophic event in a commercial aircraft.

Ground faults aren't the only problem facing aircraft operators; cost control is another major factor. The challenge is to attain reliable ground fault prevention with minimal aircraft downtime, and maximum safety.

In May 2001 the U.S. Federal Aviation Administration (FAA) issued special federal aviation regulation (SFAR) -88, which requires transport-category aircraft manufacturers to modify fuel systems to eliminate the possibility of an ignition source developing within a fuel tank. In response, Leach International Corp. developed its

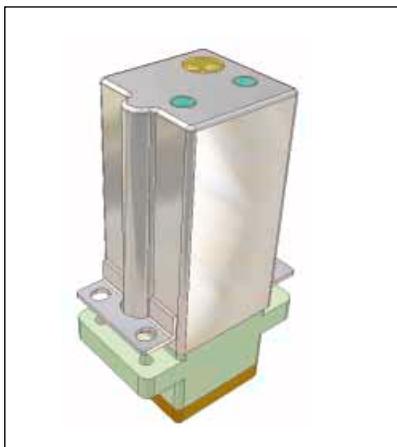
ground fault isolation solutions that meet SFAR-88 requirements. These products are compatible with the wiring interfaces, footprints and form factors of the components that they replace. Although no protection system is perfect, the ground fault detection technology substantially reduces the chance of electrically induced combustion within aircraft fuel tanks.

### Concept

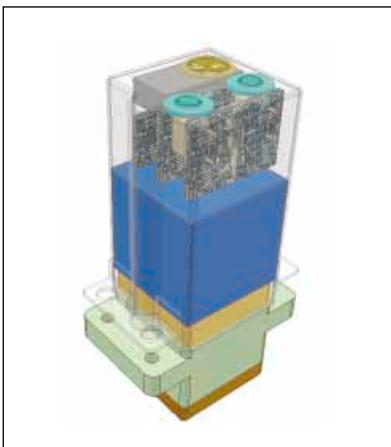
The ground fault isolation unit employs a fundamentally simple and proven technique to detect and isolate electrical faults in fuel tanks. The detection technology compares the total electrical current flowing to the load, or device consuming electrical power, with the current returning from the load. A difference between these two values indicates that the current is returning to the source through an unexpected path, such as a ground fault. Should this happen, the ground fault isolation component automatically and rapidly trips its relay, protecting the aircraft's electrical and wiring system from significant damage.

### Theory

The science that underlies this ground fault isolation technology is outlined in the white paper, "Ground Fault Protection," by Mark Thek and M. Critchley of Leach International. (It can be found online at [www.leachintl.com/PDF/Ground\\_Fault\\_Protection\\_Paper.pdf](http://www.leachintl.com/PDF/Ground_Fault_Protection_Paper.pdf).)

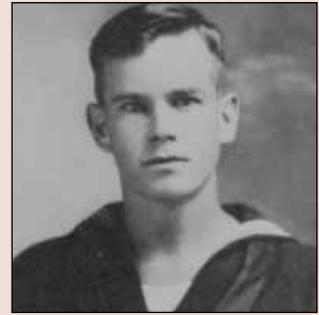


Leach's K series relay uses a standard GFI packaging approach.



### About Leach International

Val Leach, a World War I radio operator in the U.S. Navy, founded Leach International in 1919 as a one-product company. During his service, Leach (shown below) became frustrated with the erratic nature of early two-way radio communications. This irritation inspired him to invent an automatic antenna switch and power relay, the company's first product.



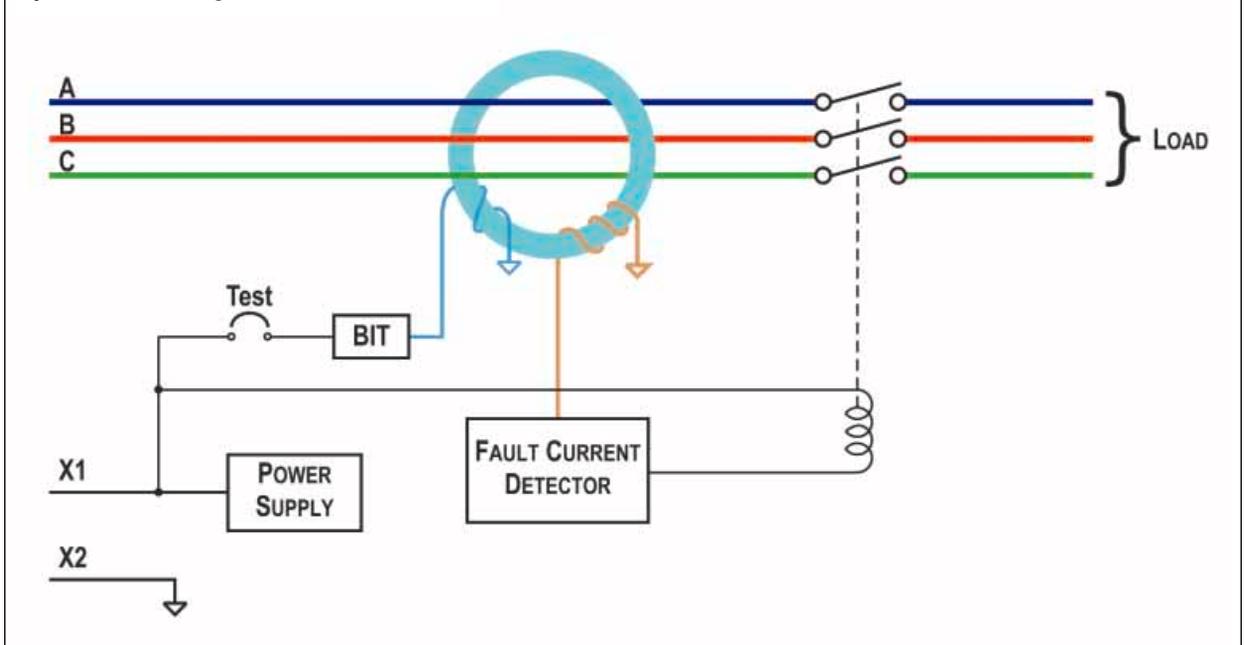
After moving to Los Angeles in 1929, Leach Relay Co. Inc. (as it was then called) began a 10-year expansion of its product line. Leach subsequently developed products for aircraft power switching, as well as for aircraft communications.

When the United States entered World War II in 1941, Leach expanded to the military aircraft market. Val Leach died that same year, at which time company ownership passed through various hands until its present owners acquired it in 1949. During the following years Leach made various achievements, including the invention of "balanced armature" and "balanced force" relays.

In the early 1970s Leach engineers further reduced the size of the "balanced-force" relays by 60 percent. Later in the decade the company applied its new hybrid technology to develop miniaturized timing circuits for time delay relays. In the 1980s, Leach pioneered the development of solid state power controllers and designed and built the first aircraft automated electrical power management system using this technology.

Today, Leach International has more than 1,000 employees and representatives in over 21 countries. It continues its 85-year history with its ground fault interrupter technology.

## System Block Diagram



This schematic diagram of the Leach GFI solution shows the relay's main circuit features.

The white paper explains how a ground fault current is formed in three-phase, AC powered loads. It further explains that, with a balanced load, the vector sum of the currents drawn from the three-phase lines will be zero.

### What It Must Do

However, a non-zero sum of the current indicates an unbalanced load and that a current is returning to the generator, or current source, via an unintended path.

An effective isolation relay must include a fast contact opening to reduce the fault duration. It also must include accurate sensing in a fault current environment. And the relay must be able to operate in adverse environmental conditions, including power line interference, high-intensity radiated fields (HIRF), and induced surges due to lightning strike.

Finally, to be of practical and economic value to aircraft operators, ground fault isolation relays must physically match the form, fit and function of the original equipment manufacturer (OEM) relays they are replacing. They must do so to keep the operator's maintenance intervals and material costs to a minimum.

### Application

When it comes to ground faults and fuel tanks, two vulnerable areas need to be protected from electrical mishaps. The first is the fuel pump's circuitry. The second is the wiring "upstream" from the pump.

Leach International's ground fault interrupt (GFI) relays protect the first area by detecting and isolating fuel pump ground faults. The company's fault current detection (FCD) relays protect the upstream wiring by detecting fuel pump ground faults and phase-to-phase shorts in the fuel pump and downstream wiring.

Through the use of a proprietary electronic circuit design, the GFI and FCD relays trip affected circuits to open positions within 10 milliseconds. They thereby minimize the potential of combustion inside the fuel tank.

To aid in troubleshooting, all of Leach International's FCD and GFI components come with a built-in test (BIT) feature, which allows aircraft mechanics to verify that the fault sensing is functional. A visual trip indicator on each device also alerts mechanics that a ground fault has occurred.

### GFI H-Type Contactor

Leach International's H-type contac-

tors are power-switching devices used throughout the Boeing family of aircraft. This includes B727 through B777 and DC-10, MD-10 and MD-11 aircraft. (Boeing selected Leach International as the exclusive supplier of FCD and GFI relays in December 2003.) It therefore was natural for Leach International to produce an H-type contactor with ground fault interrupt protection, which is virtually identical to the original H contactor. Currently, other aircraft manufacturers are evaluating Leach International's technology.



A relay with GFI (right) is a drop-in replacement of the the standard Leach International balanced armature relay (left).

The only difference between the original H-type contactor the GFI-enhanced version is that the latter is 0.40 inch (1 cm) taller and weighs approximately 2 ounces (0.05 kg)

more. A multilayer printed circuit board holds all necessary protection circuits, other than the current transformer.

### Installation and Replacement

As for installation: the GFI-enhanced H contactor maintains the same interface and footprint as the original H contactor. The 60-ampere GFI-protected H contactor can detect ground fault currents as low as a half ampere. It will activate the trip relay in less than 10 milliseconds without any degradation in the H contactor's performance.

The H series is not the only product with GFI circuitry. The ground fault interrupt feature has been incorporated into other Leach International products, including the subminiature K and a balanced armature series. These, too, maintain the original device's footprint and capabilities.

Since Leach International relays and contactors are on Boeing air-

craft, satisfying SFAR-88 requirements on existing aircraft will be a direct replacement process. The relays and contactors also will be Federal Aviation Administration-certified and PMA [parts manufacturer approval] -certified as the retrofit solution.

### Minimizing Danger

Leach International's ground fault detection and isolation technology was designed to minimize the dangers posed by aging wiring harnesses in a manner that is both proven and practical. The ability of components such as Leach International's GFI-enhanced H contactors to replace original parts using the same connections and space allows aircraft operators to bring their fleets up to SFAR-88 standards during a fast-turnaround. Upgrades were designed to not cut substantially into aircraft availability, nor significantly increase the workload of maintenance, repair and overhaul mechanics.

## Leach International Products

Leach International Corp. manufactures aerospace electrical switching components, including the following:

### Relays

Military-qualified subminiature and half-crystal, hermetically sealed, can relays for both commercial and military applications. These relays are available in power handling capability, from low level to 75 amps AC or DC. They also include ground fault interrupt (GFI) models.

### Contactors

High-power contactors, sealed and unsealed, for primary power control, ranging from 25 to 1,000 amps. These units include GFI, smart and busbar mount contactors.

### Control Devices

Control devices built for timing purposes, sensing and protection of current, voltage, frequency and phase are available in fixed and adjustable AC/DC versions.

### Solid State Power Controllers

Computer controllable, field effect transistor-based, solid state power controllers with integral protection, device/load status and infinite switching life. These controllers provide enabling technology for future electrical power systems, including data bus compatibility.

### Sockets

A variety of sockets are available for Leach relays, time delays and rail devices in PC board mount, solder, crimp, snap-in, and track mount styles.

### Custom Equipment/Other Products

Lighted switches, indicators, keyboards, panels and custom modules, manufactured to military and aerospace specifications. Custom equipment includes primary and secondary power distribution units, changeover units, logic control, load switching and control/protection units.

For more information, go to [www.leachintl.com](http://www.leachintl.com).

## Leach GFI Solution...



Relay

- Drop-in replacement eliminates wiring modifications
- Built-in test and trip indicator for visual verification
- Various contact ratings and styles suitable for other aircraft circuit applications

These Boeing approved devices will be FAA certified for fuel pump applications

**LEACH**<sup>®</sup>

Leach GFI relays...ready and qualified for the Boeing Fleet in 2005

(714) 736-7599 • [www.leachintl.com](http://www.leachintl.com)