

AVIONICS magazine TECH REPORT

Secure Power With Next-Generation SPDUs

Computer-controlled advances in avionics, such as fly by wire, along with added onboard electrical features, including in-seat, passenger entertainment systems, are boosting electrical demand on board aircraft. Standard thermal circuit breakers



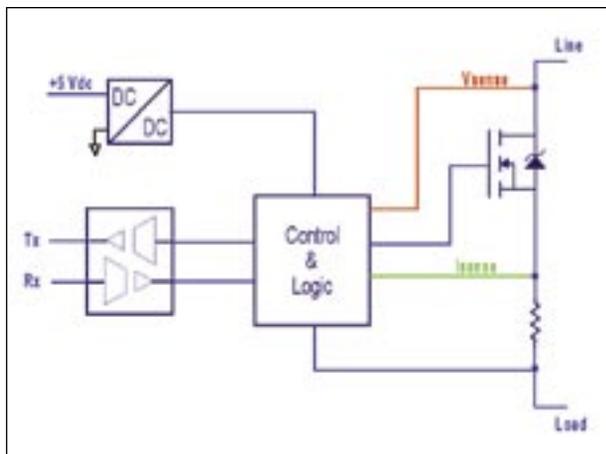
and relay systems are carrying ever more current-dense wiring cables to provide this extra electrical power. In a legacy configuration, all related wiring runs directly between the circuit breakers and electrical devices. As a result, the as much as 100 miles (161 km) of wiring in a commercial passenger aircraft can be vulnerable to ground and arc faults, whether series or parallel, or actual current and voltage overload. This much wiring (as many as 50 circuit wires in a single wiring bundle) encompasses a huge maze for maintenance personnel to traverse. It also creates one of the greatest sources of heat in an aircraft cockpit.



Enter SSPCs

Traditional circuit breakers are not designed to be computer controlled. One answer, therefore, to providing circuit, wiring and device protection comes via solid state power controllers (SSPCs). SSPCs have been in use since the mid-1980s and are designed to replace thermal/mechanical circuit breaker and relay systems. By using low-level electrical signals that do not need protection, transmitted or received, SSPCs are more reliable and accurate in detecting genuine faults and overloads. In addition, SSPCs offer size and weight savings over traditional circuit breakers and direct wiring.

Another critical performance aspect of SSPCs, especially when dealing with an arc fault, is the faster response time. The response time of electromechanical circuit breakers is measured in milliseconds, while the response time of SSPCs is measured in microseconds. Further, since SSPCs are not dependent on temperature changes, they can offer more predictable performance. And this accuracy may permit the aircraft designer to use smaller-gauge electrical cables.



Block diagram of the Next Generation DC SSPC.

Nuisance Trips

Because of their thermal dependence, conventional circuit breakers will not react to a mild arc fault, for example, one that could signal a genuine arc or overload in the making. As a result, the mechanical circuit may only trip when the more damaging surge of current occurs.

The false positives for a circuit failure truly can be a complex nuisance. If a circuit protection system trips when there is no excessive charge on the circuit, the trip looks the same as if it had been caused by a potentially dangerous overload condition. Since most circuit breaker and relay systems offer little or no diagnostic data on the overload, or even status information in some cases—whether a switch has been turned on, off or tripped—the failure may be ignored and the circuit assumed to be capable. This may explain why

Features in the Next-Generation SSPCs

Key Features

- ▶ Low voltage drop and power dissipation
- ▶ Backup wire protection
- ▶ Optional arc fault protection
- ▶ Data bus UART ARINC 485, CAN (Controller Area Network) standard (at no extra cost)
- ▶ ARINC 429 and Mil-Std-1553 data buses optional
- ▶ Configurability via software-based design
- ▶ Full integration and interface with avionics

Design Benefits

- ▶ Reduced part count (elimination of connectors, junction boxes, wires, circuit breakers, and other components)
- ▶ Reduced overall volume (wire length and size)
- ▶ Increased accuracy and repeatability
- ▶ Improved arc fault protection

Reporting

- ▶ Switch status (on, off, tripped overcurrent, tripped arc fault)
- ▶ Current reading @ 100 mA resolution
- ▶ Output voltage
- ▶ Presence or absence of load
- ▶ Switch failure mode (open or closed)
- ▶ Overcurrent I²t trip curve

Testing

Built-in testing (BIT) includes:

- ▶ Startup built-in testing (SBIT)
 - ▶ Memory check
 - ▶ Power supply check
 - ▶ Trip circuit check
 - ▶ Gate signal check
- ▶ Continuous built-in testing (CBIT)
 - ▶ Temperature monitoring
 - ▶ Memory checksum
 - ▶ Signal integrity check
- ▶ Initiated built-in testing (IBIT)

industry sources report at least one “smoke in the cockpit” incident per week in the United States on commercial aircraft.

Integrating Electrical Management

In his report about development of new circuit protection technology by Boeing Phantom Works, David Evans makes the point that SSPCs in electric architecture have the potential to reduce the total number of components needed for electrical power management. Evans is editor of *Air Safety Week* and a columnist for *Avionics Magazine*.

Other advantages he cites include SSPC configurability at distributed sites, where they are near relevant devices, yet outside the cockpit. Evans states that SSPCs “can serve the functional equivalent of built-in test equipment to check wiring integrity in the ‘electric jets’ of today and tomorrow.”

Buena Park, Calif.-based equipment provider, Leach International, a subsidiary of Esterline Corp., agrees with Evans’ assessment. Over 20 years the company has manufactured more than 250,000 SSPCs and 1,000 secondary power distribution units (SPDUs) within its line of electronic equipment. Leach International SSPCs were used in the world’s first automated power management systems on board the Lockheed C-130J and Bombardier Global Express aircraft in 1995. By continually evolving compact, low impedance SPDUs since 1994, and hermetically sealed, thick-film hybrid SSPCs since 1986, Leach International sees a cost- and performance-effective, SSPC-based, secondary distribution system on the near horizon.

Adopted by A380 and B787

The company is focused on combining multichannel, next-generation SSPCs into compact, microprocessor-controlled SPDU enclosures that can be installed on an aircraft, wherever they fit best. This is designed to yield circuit protection that does just what Evans suggests: provide distributed site (or remote) location and built-in testing

to check wiring integrity, plus considerably more.

The latest, 28-channel SPDU uses a field effect transistor (FET)-based microprocessor approach to control and monitor current, so all those miles of direct wiring are significantly lessened and smaller-gauge cables can be used. This will decrease heat in the cockpit, as well as reduce the wiring maze that confronts maintenance crews. The maximum time to “turn around” an aircraft due to a fault in the new secondary distribution systems is estimated to be within minutes. Currently, it can take hours to find a fault.

New aircraft, such as the Airbus A380 superjumbo jet and Boeing 787 Dreamliner, are adopting this approach. The new Leach 28-channel SPDUs are designed to switch 28 volts DC. (Leach International also is designing 115 volts AC and 270 volts DC SPDUs.) The bus interface and input/output (I/O) module allow communication from the company’s next-generation SSPCs, which can accept commands to turn on, turn off or reset in the event of a trip due to overload. In addition, the communication to and from the SSPCs provides health and status of loads and the device itself.

Custom Configuration

Each SSPC can be configured to trip at different thresholds and time delays, though the hardware does determine a maximum programmable load rating, according to Jim Cearns, Leach’s vice president of marketing and business development. Each SSPC channel is connected to a separate load and is configured to handle the maximum safe rating of that load within the “smoke curve” rating of the associated cable. This is meant to translate to a more flexible, standardized

and adaptable means of achieving a safer, higher-integrity electrical distribution system.

However, diagnostics is perhaps most helpful for current overload detection and electrical system protection with these products. Software now exists that can be externally programmed and customized to end-user power requirements (see sidebar, opposite page).

Size Matters

The mantra of “form, fit and function” when replacing electrical components means maximizing existing space with new designs that offer added performance at no cost or size tradeoffs. This also applies to the utilization of SPDU/next-generation SSPCs. Different-sized aircraft need different electrical load capacity, which will determine the number of next-generation SSPCs and the number of SPDU boxes. Small aircraft, such as business jets and helicopters, with 70- to 80-DC loads, may require three to four SPDUs, while a mid-sized aircraft, such as a Boeing 737 or Airbus A320, is more likely to use eight SPDUs. Each SPDU box may include as few as 18 to 20 SSPCs or as many as 40 to 50 SSPCs.

The enclosures can be customized and are designed to be modular, says Cearns. They therefore can accommodate the different power requirements of new aircraft models and optimize the space required for the SPDUs. Finally, the size, design and placement of the boxes will optimize ease of removal and replacement for maintenance.

A significant advantage of the new SPDUs is their low heat dissipation in representative aircraft configurations. A typical DC SPDU would, in practice, have a normal temperature rise that is less than 25 percent of

that from the equivalent relay/thermal circuit breaker assembly.

About Leach International

Founded in 1919 with a “break in” relay as its first product, Leach International was known for about 20 years as Leach Relay Co. Now nearly 90 percent of all commercial jets and the vast majority of military jets, helicopters and other aircraft, as well as a number of military ground vehicles, use Leach components and assemblies. The equipment provider manufactures 10,000 variations of more than 50 basic types of relays for the aerospace and rail industries. A typical relay assembly may be comprised of 70 to 130 parts.

The Leach product line has expanded to include power switching and control components for aircraft communications. The company’s achievements include invention of the balanced armature relay (1952) and balanced force relay (1962), the miniaturized hybrid timing circuits for time delay relays, rotary solenoid and power contactors, and pioneering solid state power controllers (SSPCs).

Leach International designed and built the first aircraft automated electrical power management system using SSPC technology in 1995 for the Bombardier Global Express, and has also participated in developing SSPC components for space applications. The manufacturer produces 28-volt DC, 270-volt DC and 115-volt AC SSPCs, with ratings to 225 amps.

Leach facilities include the 112,000-square-foot (10,405-m²) Buena Park, Calif., headquarters, as well as manufacturing plants in Tijuana, Mexico; Saralbe and Niort, France; and in Zunyi, China. Leach employs about 1,200 persons worldwide.

In 2004, to satisfy the FAA safety regulation SFAR 88 regarding fuel tank safety, Boeing selected Leach Fault Current Detection (FCD) and Ground Fault Interrupt (GFI) relays for retrofit as well as for new production 727, 737, 747, 757, 767 and 777 aircraft, and FCD relays to retrofit all DC-10, MD-10 and MD-11 aircraft. In January 2005, Toulouse-based aircraft manufacturer Airbus contracted Leach to design and manufacture customized ground fault interrupt (GFI) relays to comply with FAA SFAR 88 safety regulations regarding fuel pump safety on its new 500-plus passenger aircraft, the A380. Among its other customers, Leach has supplied products to Bell Helicopter Textron, Dassault Aviation, Honeywell, Lockheed Martin Corp., NASA, Raytheon Co. and Rockwell International Corp. In addition, Leach equipment is installed on the Boeing Co.’s 727, 737, 747, 767 and 777 aircraft.

For more information, visit www.leachintl.com.

Control Panel Interface

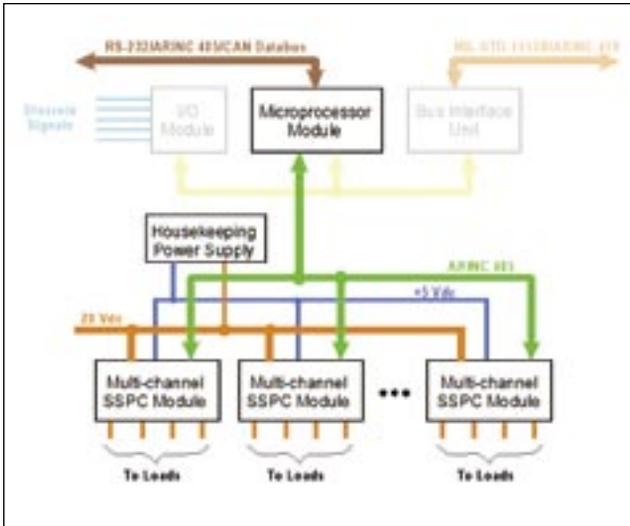
With the new SPDUs and an interface to the aircraft systems’ display/computers, an original equipment manufacturer (OEM) can display what it wants the flight crews to know about the performance of the wiring and circuitry protection systems. “Load can be identified on a display to ascertain what tripped,” Cearns states. “A pilot will be able to tell whether the failure is an overload trip, a short circuit, an arc fault, an SSPC failure or if there is no load connected. And this is observed in real time.”

“The last thing you want a flight crew to be concerned with is having to take some action on the electrical system without complete information,” he adds. “This is how aircraft can be lost, ultimately by fire in the wiring systems.”

Getting to COTS

Can SPDUs be made commercial off the shelf (COTS) to reduce costs? COTS could cut expenses by an estimated two to 2.5 times. However, some hurdles exist.

“One has to consider that SSPCs inherently exhibit current leakage, albeit low, for



The architecture for solid state power controllers

each load," Cearn's explains. A few circuits, therefore, may require positive isolation by using a traditional relay or circuit breaker. Leach International uses standard circular connectors on the SPDU and will have a dual-redundant data bus to the box and integrated power supplies. But Cearn's admits redundancy isn't easy to provide.

"Avionics are packaged for redundancy," he explains. "For electrics, which are the heart of every system on board, it's more difficult to build in redundancy since each OEM has different goals

for its overall aircraft, avionics and electrical systems designs and certification. So at this point, the very nature of SPDUs calls for customization."

Leach International's goal is to have both the enclosures and the SSPCs become COTS. Initially, it probably will be easier to achieve COTS status at the SSPC card level; enclosures may take longer. But COTS can reduce the OEM's need for spares on hand and the related cost of those spares.

Realistic Time Lines

So how soon can an OEM implement next-generation SSPCs? Cearn's estimates that Leach International could deliver evaluation or preproduction units in 20 weeks. After final configuration, and possibly a second round of evaluation units, production units probably would be available by first quarter 2006. These small SPDUs would have optimum application in helicopters, trainers, business aircraft, and smaller attack aircraft and military ground vehicles.

Ultimately, the elements of this electrical architecture are expected to reduce mean time between failures (MTBF) and mean time for aircraft turnaround (MTTR). Such reductions can significantly affect the amount of on-ground time when an aircraft has an electrical problem. In addition, the reduction in cockpit heat and cable bundles can be dramatic. Finally, these products lead the way from a component-based electrical architecture to a fully integrated electrical power management system.

Making the Leap to NEXT GENERATION SSPCs

LEACH®

Leach International's new SSPCs, designed for multi-channel Secondary Power Distribution Units (SPDUs), feature:

- Low voltage drop and power dissipation
- "Hard wired" PLUS data bus* control and reporting
- Comprehensive SBIT, CBIT and IBIT diagnostics
- Optional arc fault protection

This "COTS" solution gives you greater flexibility and reliability.

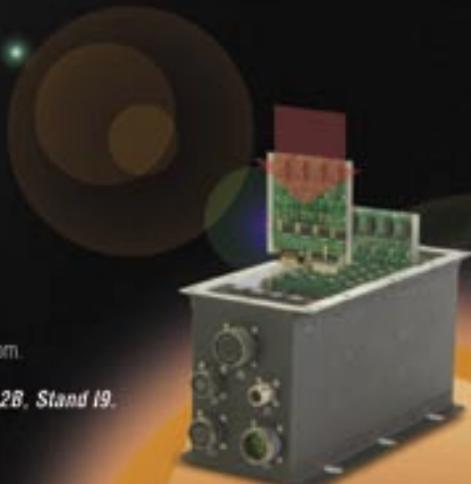
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See us at the Paris Air Show, Hall 2B, Stand 19.



*ARINC 429 MIL-STD-1553 CAN, etc