

AVIONICS magazine TECH REPORT

270-VOLT DC CONTACTOR Solves Cost vs Performance Problems

Aircraft requiring greater electrical power for an increasing number of critical electrical loads are employing 270Vdc power. But to make, break or change the connection of electric circuits for the high voltage poses a significant challenge for the manufacturers of relays and contactors. Various solutions exist, but one contactor technology succeeds in resolving all of the obstacles: weight, high heat, safety, cost and performance.



The “more electric aircraft” is rapidly evolving. New aircraft designs are increasingly forsaking heavy, maintenance-intensive and (in combat) vulnerable hydraulic and pneumatic subsystems in favor of electrohydrostatic actuators (EHAs). EHAs, which combine electric and hydraulic power, are control systems designed to enhance aircraft performance while reducing weight by eliminating miles of tubing, pumps and valves required for aircraft with traditional controls.

These subsystems generally have built-in test capability and require much less maintenance than hydraulics and pneumatics. For commercial carriers that means less aircraft downtime, and for military aircraft, a shorter logistics tail.

Electrics for control surfaces, such as flaps and ailerons, are the most demanding and critical, but other subsystems require greater electrical power, as well. For example, air conditioning in the cabin and rotor blade deicing on a helicopter. It all adds up to a much greater demand for electrical power: 270 volts DC (direct current), electrical power is more efficient in achieving this greater electrical demand. With this, less total energy is required from the aircraft engines. Add to this the fact that this greater power at 270Vdc results in smaller wires, and it becomes readily apparent how high-voltage DC contributes to optimizing the power-to-weight ratio of an aircraft.

Growing Demand for Power

Applications of high-voltage DC power at 270 volts and higher are not new and go back as far as Thomas Edison, himself. Trains and industrial facilities have long used high-voltage DC. Aircraft have used DC power since World War II, but the onboard generation and distribution has been limited to 28 volts for many years.

When larger, commercial airliners entered the skies in the early 1960s, the demand for power became greater, and to avoid the considerable weight of larger 28Vdc generators and cables, aircraft began using 115 volts, 400Hz AC

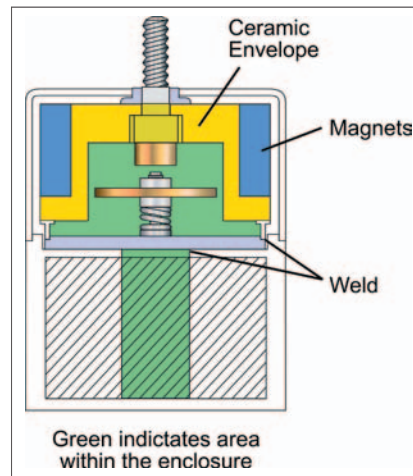
(alternating current). But AC power has its own limitations. For example, multi-engine aircraft would require multiple power generators, and this posed the problem of either coordinating frequencies, or using the alternating current from the generators for separate and isolated busbars—not an elegant solution! DC power, which is constant, does not require devices that synchronize power sources, which is why applications such as fuel cells, solar power systems, and electric & hybrid vehicles other than in aviation also are turning more and more to high-voltage DC.

AC voltage in its raw form still is used for nonessential systems on board aircraft; however, it doesn’t meet the requirements of EHAs, etc., which demand sufficient power delivery that is consistent and highly controlled. The

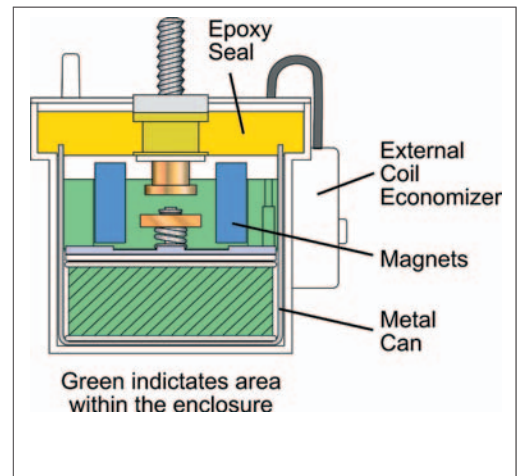
applications, which are not weight- or size-sensitive. For instance, scaling up AC technology to accommodate electrohydrostatic actuators in place of hydraulics and pneumatics isn’t a viable option. On, say, a Boeing 737, converting to EHAs and sufficiently enhancing the existing 60-kilo-volt-ampere (kVA) fixed frequency per channel would probably cause power generation and distribution to be heavier and much more costly. The viable option is to employ 270 volts DC power derived from variable frequency AC generators.

High-voltage 270Vdc contactors were first used on the International Space Station. High-voltage DC is now employed in the F-22 combat aircraft and will be used increasingly in the F-35 Joint Strike Fighter. The Airbus

Previous Sealing Technology



Left drawing Ceramic envelope—Costly, large, and hard to shape. Allows for high pressure internal gases for optimal switching. Auxiliary contacts are not on main armature and coil economizer must be outside the sealed enclosure.



Right Drawing Epoxy Seal—Large, less rugged, lower temperature rated, and cannot use hydrogen gas for optimal switching. Auxiliary contacts are not on main armature and coil economizer is outside the sealed enclosure.

more electric aircraft, therefore, relies more and more on high-voltage DC.

DC power also provides an additional advantage for aircraft that have onboard batteries, which are employed as redundant power sources, should the primary source fail. DC power can be used to charge the batteries, with no need to convert the voltage from AC to DC, as was required in the past.

Contactors Applications

The challenge, however, has been to adapt to aircraft the high-voltage DC power long enjoyed for ground-based

A380 is introducing high-voltage DC to the commercial marketplace and the Boeing 787 makes much greater use of this power source. Future aircraft on the drawing board will take the use of 270 volts DC to an even higher level. The trend is obvious.

Challenge in Contactors

However, this trend poses a challenge to the manufacturers of contactors that must switch the power. (Contactors are similar to electrical relays but are larger and have the higher overload rating needed for most critical

aircraft components.)

Any arc that occurs when switching DC current must somehow be extinguished. The higher the voltage, the more difficult this is to achieve. (The problem does not exist when switching AC because the voltage passes through zero volts every cycle; hence any arc is quickly extinguished automatically.)

Most ground-based applications of high-voltage DC haven't had to face the challenge because, in managing the higher voltage, they do not have to be concerned about the contactor's weight and size. Light rail systems, therefore, can use open-air contactors, which are not sealed and allow the heat generated from the discharge of an electric arc. These contactors are large and heavy, employing arc chutes, or baffles, that split the electric arc into metal plates to reduce the voltage. (The arc in a contactor is an electrical discharge through a gas producing the voltage drop required to interrupt the current.)

Contactors for aircraft must closely manage and seal the arc to prevent interference, yet also provide DC switching at an acceptable heat level and be small, lightweight and reasonably priced. In an attempt to provide these features, various technologies have been employed. All have limitations—except one.

Other Designs

Contactors for aircraft must be sealed to prevent electrical leakage and interference, and the electric arc must be isolated, as well as the magnets that move the arc. One solution is to

produce an impervious ceramic, switching chamber. Ceramic material, used to produce contactors for the International Space Station, can seal off all types of gases accompanying the arc, including hydrogen, which is the best gas to break a high-voltage DC current (see chart).

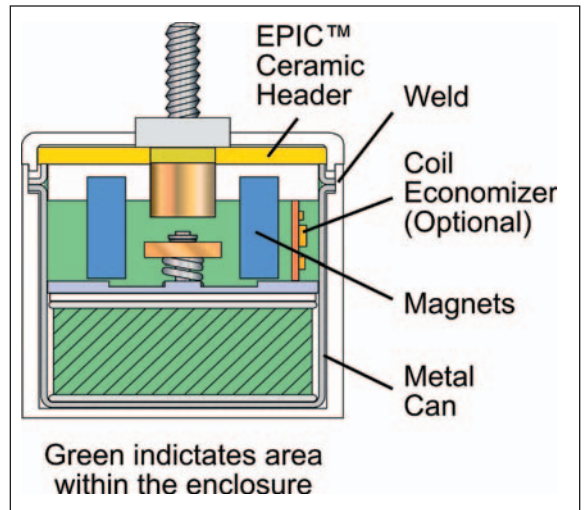
But ceramics also can be cost prohibitive; it initially takes on a semi-liquid form, so making an exact-shaped chamber to manage the arc can be tricky. The chambers don't always come out as planned.

An alternate solution is with an epoxy sealed contactor and use of high-temperature plastics in the area that manages the arc. While much less expensive, this type of contactor has its own limitations. The seal is not as good as ceramic, so the contactor cannot use hydrogen gas, which provides the best switching environment for 270 volts DC power management. And the epoxy seal is temperature-limited (to about 150 degrees C) and susceptible to failure in severe over-current situations.

The EPIC™ Solution

A new sealing technology exists that produces a contactor combining the benefits of high-temperature sealing quality of ceramics with the low cost arc management of high-temperature

New Higher-Performance EPIC Technology



EPIC Ceramic Header Low cost, rugged, high temperature rated ceramic header allows high pressure internal gases for optimal switching. Auxiliary contacts are on main armature and coil economizer is within the sealed enclosure.

plastics. It allows the use of high-pressure gases and remains small in size and weight. Called EPIC™ (Extended Performance Impervious Ceramic), this new technology has been applied to a high-voltage contactor design over the past two years by aircraft electrical component and equipment manufacturer Leach International and GIGAVAC, a maker of high-voltage relays.

The EPIC high-voltage DC contactor includes a ceramic header that is welded to a can with high-temperature plastics inside for the arc management. No thick layer of epoxy is required, yet the EPIC contactor has a seal sufficient to contain high-pressure gases such as hydrogen.

EPIC Benefits

The EPIC high-voltage DC contactor provides all the benefits of an all-ceramic contactor but at less than half the weight and about one-tenth the cost. Specifically, it offers the following advantages over other high-voltage contactors:

- The inert gas in the controlled environment of a sealed switching chamber will not cause oxidation, and this allows the use of low resistance copper contacts. With the excellent conductivity of copper, the contactor therefore can be made smaller and lighter and able to operate with less coil power than with other metals.
- The low leakage of the contactor's

Gas and Contact Material Performance Comparisons for Switching Applications

Application	H2 (Hydrogen)		N2 (Nitrogen)	
	Copper	Moly/Copper	Copper	Moly/Copper
Carry Only	BEST	Good <small>But not as good as all copper</small>	Better	Fair <small>But not as good as all copper</small>
Make Only Life	Good <small>But not as good as Moly/Copper</small>	BEST	Fair <small>But not as good as Moly/Copper</small>	Better
Make & Break Life	Good <small>But not as good as Moly/Copper</small>	BEST	Fair <small>But not as good as Moly/Copper</small>	Better
Very High Overload Make & Break	Good <small>But not as good as Moly/Copper</small>	BEST	Fair <small>But not as good as Moly/Copper</small>	Better

ceramic seal, compared to epoxy, means all types of gases, including highly desirable hydrogen, can be used for high-current interrupts. It also allows various combinations of different gases and contact materials, to accommodate difficult switching applications.

- The new contactor has a higher temperature rating than contactors sealed with epoxy. Initial EPIC technology products are rated at 175 degrees C, but a header can reach well over 250 degrees C without damage to the seal or risk of failure.
- With a higher temperature rating, there is much less risk of a contactor failure or a fire, should a downstream circuit breaker fail in an abnormal over-current situation.
- The thinner seal leaves room in the contactor for built-in, double-throw, auxiliary contacts that are driven off the same armature as the main contacts, and for a cutthroat, dual-coil economizer when required. (With the epoxy-seal contactor, the auxiliary contact is a secondary activated micro switch and the economizer is located outside the chamber.)

EPIC™ is a registered trademark of GIGAVAC.

A Collaborative Effort

This next generation of high-voltage DC contactors was jointly developed by Leach International, considered the “father” of aerospace relays, a Buena Park, Calif.-based division of Esterline, and GIGAVAC, considered today’s expert in high-voltage relays, based in Santa Barbara, Calif. A long relationship has existed among officials in the two companies.

Leach International is a manufacturer of electrical power distribution assemblies and components, such as relays and contactors, and of fault current detectors. It manufactures components for various applications, including lower-current 270Vdc solid state relays and power controllers for 270Vdc switching. To produce an affordable, lightweight, high-voltage contactor for military and aerospace applications that can accommodate over 10 times greater amperage, Leach teamed with GIGAVAC. The team then developed the Extended Performance Impervious Ceramic (EPIC™) technology that can be used with high-voltage DC power that resolves the problems of weight, safety, high heat and cost while improving performance.

- In addition to increased coil efficiency, the cutthroat, dual-coil economizer can be used to increase contact pressures in order to gain additional contact current-carrying capabilities. They also can be used to offset larger return springs to handle higher contact current, make or break, fault conditions.

Early Uses

Extensive qualification testing has been completed on the EPIC technol-

ogy contactors for 270 volts DC. The contactors meet all military and aerospace standards.

According to the companies that jointly developed the EPIC technology contactor, the first air vehicle to use the new contactors will be an unmanned air vehicle (UAV). In addition to use in aircraft, potential applications for the 270 volts DC contactors range from missiles to naval ships to a hybrid Humvee for the U.S. Army.

LEACH® 270Vdc Contactor —

Higher Performance at a Lower Cost

Leach’s new 270Vdc contactor, designed in conjunction with GIGAVAC™, an industry leader in high-voltage relays, features the revolutionary sealing technology EPIC™ (Extended Performance Impervious Ceramic) to provide superior performance in severe aerospace environments.

Rated to carry current up to 175°C and at altitudes exceeding 50,000’, these completely sealed, compact devices offer:

- **Lowest cost**
- **Smallest size**
- **Lightest weight**
- **Highest temperature operation**
- **Best power switching & overload capabilities**

When cost, weight and performance are critical, count on Leach for all your aerospace and military switching needs.



Esterline Leach International

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