VISHAY PRECISION GROUP

Facts at a Glance

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Precision Resistors (EEE-INST-002 and COTS) for More Electric Aircraft (MEA) and Fly by Wire (FBW): From the Drawing Board to Reality

Commercial and military aircraft manufacturers are promoting the replacement of older hydraulic and pneumatic control systems by lighter and more efficient electrically-driven systems through a trend known as MEA, or More Electric Aircraft. The electrically-driven systems can be supplemented with multiple distributed redundancy for added reliability and faster response while reducing aircraft weight and increasing fuel efficiency. The systems of cables, pulleys, and hydraulic lines routed through the aircraft have greater vulnerability to damage as well as being much heavier than their electrical counterparts. Aviation design experts are convinced the newer electrical systems are more reliable and more efficient; they are encouraging many countries to invest in this direction and transfer more resources to it.

The shift to MEA is expected to reduce the cost of production, reduce the cost of the final product, improve propulsion efficiency, contribute to global green energy efforts, and reduce the environmental impact of aviation. By giving a direct input through electrical signals, commands can become sharper and more precise with less noise – providing overall safety to the passengers and more confidence to the pilots and crew.

Vishay Foil Resistors (VFR) identified this trend several years ago and began to invest in the development of cost-effective high-precision resistors for the MEA (see table #1) based on two options. First is the commercial off-the-shelf (COTS) concept with the addition of extra tests to ensure more stable and reliable performance when COTS alone isn't sufficient. The second option is the EEE-INST-002 screening method which can be purchased for ground units with the "U" –option (Group A only) or with the full test protocol (Group B +C testing).

Many universities and research institutes are also working on the development and improvement of such electrical systems with the goal of greater safety and reliability. They are investigating electrical, electronic, and mechanical components, and looking for safe and reliable ways to choose, screen, assemble, protect, and monitor these components throughout the operating life of the systems they need to support.

Both hydraulic and pneumatic systems are subject to replacement. Hydraulic systems can be found in several flight controls such as secondary flight control systems, environmental control systems, landing gears, brakes, steering, doors, and many other actuation functions. Pneumatic methods can be found in systems for flight controls, cabin pressurization, cabin energy recovery, the engine, wing ice protection, and engine ignition.

Table 1: COTS, DSCC, EEE-INST-002, EPPL ESA and CECC Foil Resistors

TYPE	CONFIGURATION	COTS	DLA (1)	EEE-INST-002 (2)	EPPL (3)	ESA (4)	CECC (5)	QPL – ER (6)
PRND	Custom Hermetically Sealed Precision Resistor Network Device	√		√				√
VSMP Series (0805-2512)	Wrap-around Surface Mount	√	√					
VSM Series (0805-2512)		√	√					
FRSM Series (0603-2512)	Wrap-around Surface Mount with improved long term stability and for higher temperature	√		Per request				**2013**
SMR1DZ	Molded, flexible terminations with robust construction	√	√	√				
SMR3DZ		√	√	√				
VCS1625Z	Current sense with Kelvin connections for high accuracy	√	√	√				
VCS1625		√	√	√	√			
CSM2512		√	√	√				
CSM3637		√	√	√				
Z201	Through-hole	√		√				
RCK HR 02, 02A		√				√		
RS92N, RS92NA, AN		√					√	
S102		√	√					√
300144Z	Through-hole Voltage divider	√	√					
1240	Trimmer	√	√					√

Notes:
(1) DLA (Defense Logistics Agency)
(2) EEE-INST-002 (Instruction for EEE Parts Selection, Screening, Qualification, and Derating)
(3) EPPL (European Preferred Parts List)
(4) ESA -European Space Agency

(5) CECC- CENELEC Electronic Components Committee-European Committee for Electro-technical Standardization
(6) ER (Establish Reliability) , QPL (Qualified Part List)
(7) * Screen/Test Flow per S-311-P813

Another component of MEA is FBW (fly by wire), a class of control systems that are now becoming standard and common in many commercial and military aircraft. A fly by wire system replaces the manual flight controls of an aircraft with electronic interfaces. Fly by wire aircraft controls allow for the replacement of traditional control yokes with computer flight controls that can be easily customized for different aircraft models. But designers must be careful to select passive components that are not sensitive to ESD damage, including the possible latent defects characteristic of some resistor technologies.

With the proper component selection, reliability and flight safety are actually increased using fly by wire. And the weight saved by switching to FBW systems can be re-allocated to additional revenue-generating passengers and cargo while reducing maintenance costs and improving passenger satisfaction through fewer repair-related flight delays.

Certainly, technological developments have reached the point where the values of control and system safety are well understood and have been applied to the flight control systems of many popular aircraft by Airbus and Boeing. These companies are working to reduce aircraft operating costs, reduce fuel costs (a particular concern when pricing in the petroleum market is so volatile) and, hopefully, make air travel an affordable option for passengers who must now rely on slower and possibly less safe means of transportation.

But additional study is required on the analog side of the MEA/FBW to provide a suitable analog platform based on the most-suitable precision resistors and other components for secure and reliable service. We should also remember that the complexity of this process has increased as designers work to solve conflicting interactions between several equipment systems by enhancing the efficiency of each.

Research in the last several years in the alternative energy and smart grid technologies has shown electrical systems tend to be more energy efficient and environmentally friendly than their hydraulic counterparts. To achieve the right solutions, each application and function on the aircraft must be considered on its own merits. Performance, reliability, and long-term cost reductions all need to be taken into account.

In the component area several resistor technologies are available for use in various flight controls. Different resistor technologies perform at different levels with different consequences for each circuit. For example, electrical systems may be switched on and off as required and that can create power surges in the resistors. Similarly, temperature coefficient of resistance (TCR) and TCR tracking (ratio stability through temperature changes) vary considerably by technology.

To achieve the reliability required for flight certification, the complex nature of the electric motor drive and control should be taken into consideration. Vishay Foil Resistors (VFR) has developed several new products in through-hole and SMD configurations that are based on its Z and Z1-Foil technologies to enable the production of units capable of exceeding the reliability levels required with the best TCR over a wide range of temperature. Although electronic control and drive systems introduce a level of complexity that does not exist in current hydraulic controls, the use of complex electronics in flight-critical

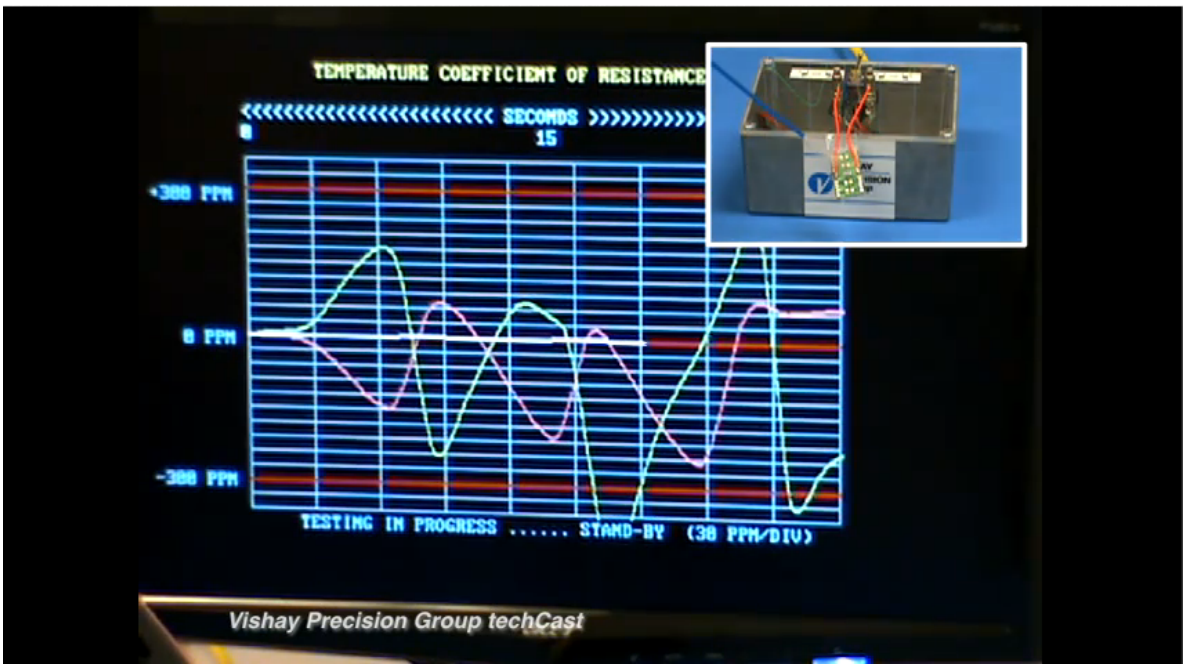
applications is well understood by VFR, whose Bulk Metal® Foil resistors have been serving the avionics and aerospace industries for 50 years.

Using the best-quality precision resistors in the MEA will contribute to greater efficiency, as the electrical systems will use less energy or waste less energy than their conventional counterparts, and losses in electrical cabling are certainly lower than those in hydraulic or pneumatic piping.

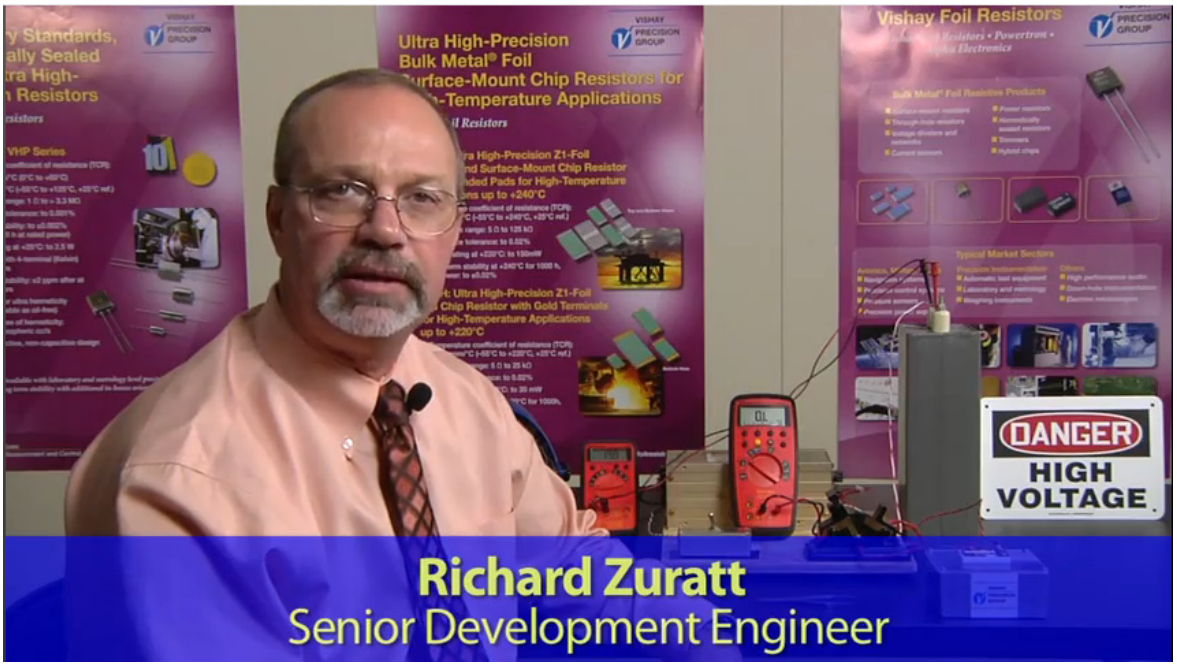
With respect to individual actuator development, VFR has successfully proven resistors in flight demonstrations. Research activity has indicated some technical challenges that are now being addressed in more detail. Additional research programs have also started to the point where electronic performance is being pushed close to the limit of today's available precision resistors technologies, especially for high temperature and electrostatic discharge (ESD). So, in what direction does electric actuation technology move now? Further advances in resistor development will bring incremental performance benefits, but the really important advancements must be derived from system-level studies. Performance analysis and electronic optimization studies for electric actuation will help establish the technical priorities for the next stage of systems development.

Videos about 3 resistors characteristics: **ESD, TCR and Pulses** *(Click to watch):*

Video 1: Undetectable ESD Damage (http://www.vishaypg.com/foil-resistors/videos/?video=3)



Video 2: Bulk Metal® Foil Resistor TCR Performance
(http://www.vishaypg.com/foil-resistors/videos/?video=10)



Video 3: High Energy Pulse, Performance Comparison
(http://www.vishaypg.com/foil-resistors/videos/?video=2)

Further information about Vishay Foil Resistors products is available at: **www.vishayfoilresistors.com**

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