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What's all this DO-160 Stuff Anyhow?

Bob, am building a couple pieces of avionics - just some simple things, not critical to flight - and was re-reading your essay on doing without the avionics master switch, which I agree with and will adopt in my plane.

In the essay, you mention that it is trivial to add a couple of components to make a piece of gear DO-160 compliant. Since I am the builder of my experimental avionics, I know it doesn't meet the DO-160, but I would like for it to. I am hoping there are one or two inexpensive components I can lay across the +12 and ground to accomplish this. Could you tell me what components, part numbers, etc. would do this?

Thanks!

Gary,

It's a tad more complicated. I've been contemplating an extensive article to boil down the more meaningful parts of DO-160 for folks building non-certified stuff. In a nutshell . . .

First, DO-160 is not a REQUIREMENT, rather a listing of various tests recommended to show any particular piece of equipment is (1) not subject to damage from the aircraft's expected and very predictable operating environment and (2) does not itself generate noises unacceptable to other system in the airplane. A large committee of representatives from industry, aviation user groups, and of course government crafted DO-160. The document is a well considered, middle-of-the-road recommendation for tests that do a good job of balancing what is NEEDED against what is POSSIBLE and PRACTICAL.

When a manufacturer tests to DO-160, they may not (and in fact probably won't) do EVERY test described. There is a coding scheme by which the product can be labeled as tested to DO-160, what tests were conducted and to what levels of stress. Tests performed will address the following issues:

(A) Power input: Try to make your gizmo work as specified over the range of 13.0 to 15.0 volts and function with perhaps degraded but still useful performance down to 10.5 volts (end of battery life). Double these numbers for 28v systems.

(B) Bus Noise: Expect noise on the bus ranging from 10 to 100 Hz ramping upward zero volts pk-pk to 1.5 volts pk-pk. Then from 100 Hz to 1000 Hz, at 1.5 volts pk-pk constant. Finally 1000Hz to 10,000 Hz with the amplitude ramping downward from 1.5 volts pk-pk to zero at 10KHz. A sine wave "noise" is satisfactory for testing. Double these numbers for 28V systems.

(C)Interruptions: Test for all manner of interruption and brownout. Your gizmo should not be damaged by any downward excursions of power supply for any duration and any levels down to and including zero volts. The gizmo can fail to function below 10.5 volts but should come back to normal operation in an orderly manner and without pilot intervention when the bus returns to normal voltage levels.

(D) Surges: Can you take 20 volts for 1 second with no damage to your product? Can you take 40 volts for 100 milliseconds? For small electro-whizzies a simple shunt regulated zener or active device (FET or Transistor) supply can be configured to take these hits. For larger current draws, you might have to add an active pass transistor, or other power supply designed to handle at least 40 volts. Double these numbers but same times for a 28v system.

My first full-blown DO-160 qual was about 25 years ago for the first multi-speed pitch trim systems to go on a GA bizjet. First for the new model 55 Learjet and ultimately retrofitted to the Learjet fleet. In a 28-volt system I had to stand off 80 volts for 100 MILLISECONDS. With a little judicious selection of parts, I demonstrated this portion of the test by cranking up the power supply from 28v nominal to 80 volts while the trim system was running . . . the motor speed didn't change a bit.

I turned to the FAA inspector who came over to

witness the test and asked, "okay, is that long enough?" The supply was 80 volts for several seconds and well over 28 volts for 10 SECONDS during the demonstration. I got no arguments about the 80-volt surge test.

(E) 300V Spike: There's a test you can conduct that feeds a short duration spike of up to 300 volts of a few millijoules delivered through a 50-ohm source impedance into the 14V input of your gizmo . . . it's easy to pass this test with a 10uF capacitor (rated for 40v surge of course) right across the input. Double these numbers for 28v systems.

(F) Temperature Altitude: There are LOTS of categories but cabin mounted gizmos for our airplanes would be typically rated and tested for up to 15,000 feet and operating temperatures of -40 to +55 degrees C. Other than issues surrounding forced air cooling, I've never had a concern about altitude effects. This used to be BIG deal when avionics ran from 300 to 1000 volt power supplies. The biggest stumbling block today is adequate cooling for high temp ops and those are short lived . . (sun-soak on ramp in Phoenix . . . cools rapidly once airborne).

(G) Vibration: There are lots of categories here too . . . but unless you're going to mount the gizmo directly on the engine or landing gear, very ordinary fabrication techniques will suffice. In this day of surface mount components, it's REALLY easy to build for robustness.

I did a solid state power distribution assembly for a new target at RAC that launches at 30 g's linear acceleration and subjects me to 10-20 g's of acoustic noise vibration in flight. But because I'm now all solid state and surface mounted, it's going the be about the easiest qualification I've ever done.

If you have any components that stand up from an etched circuit board on little solid wire leads, it's a good idea to tack the critters to the board with adhesive (Sho-Goo, Leech F-26 liquid nails, electronic grade RTV are all good possibilities. NO garden variety epoxies . . .)

(H) Gunks, goos, grit bad gas and death by athlete's foot: Consider all forms of wetness. Water, hydraulic fluid, fuel, oil. Gonna keep it out or always mount it where it doesn't matter? How about sand/dust? If you're under the cowl and have any moving parts, this should be considered. There's also a test for fungus. This is routinely bought off with a statement in the qualification document that there are, "no materials that are nutrients to fungus used in the fabrication of this device." How about ozone . . . lots of it under the cowl that will eat up many forms of plastic finishes and insulation.

(I) Radio Emissions: You can spend big bux having the full range of frequencies tested in a lab but you can do a quick look-see with a handheld vhf comm and gps receiver. Do any of these critters complain or seem to hear noise when operated in close proximity to your product? If your gizmo is processor based or has any kind of electronic 'hummer', let's talk about shielding via enclosure and i/o filters so as to avoid RFI issues and still not have to test in the lab.

(J) Radio Susceptibility: Key up the handheld transmitter while holding it's antenna about 12" away from your gizmo and its interconnecting wires. Does this upset its normal operation?

(K) Electo-Static Discharge: Can you hold your gizmo in hand and shuffle across the carpet and safely draw a body-static spark to any pin in your input/output connector? This isn't hard to design for and I generally don't bother to test for it any more . . if you have potentially vulnerable pins, let's talk about it.

(L) Lightning: This is a BIG thing with the FAA now which I choose to ignore for amateur built aircraft projects. It's not terribly difficult to design for lighting protection but it drives up costs and parts count. Further, I figure if a pilot has gotten himself into a high lightning (or ice) risk, whether or not MY gizmo works is the least of his problems. But if you choose to run the gauntlet for lightning, you may have to stand off as much as 600 volt pulses delivered to you through a 25 ohm resistor (24 amps max).

(M) HIRF: This is also a BIG thing with the FAA. Seems you can fly by high powered ground based systems or get painted by both ground and airborne radar capable of delivering very high levels of RF energy (albeit for short periods of time). Potentially vulnerable systems are taken to the lab and radiated at anywhere from 20v/m to 200v/m of RF at 100Mhz to perhaps 18GHz. For simple, non-radio systems this is not a hard test to pass.

A recent episode of Mythbusters on television tried to address an urban myth concerning operation of a cell phone aboard an aircraft resulting in bent metal and perhaps bent people too. They crafted some experiments to radiate on-board systems in two aircraft; a single engine light plane and a bizjet using both a barefoot cell phone and then with a signal generator purported to radiate at many times greater levels than the cell phone. Of course, they observed no effects to on board systems of either airplane. Had they studied and understood the real hazards to on-board systems and the testing done to mitigate them, they would have realized that their experiment

> ***was bad science. The worst thing is that folks watching the show got a completely erroneous "enlightenment" with respect to the science.***

This is an off-the-top-of-the-head, 25-cent tour of DO-160 as it might apply to your project. In the trade, we can figure about $100,000 in round numbers to write a test plan, built test fixtures, do a DO-160 sweep of a product's characteristics and vulnerabilities, write a test report and then shepherd the work through a growing maze of bureaucratic hoop jumping and sand-pounding.

An interesting feature of exercise is that people who have designed products in this venue for years are 99% capable of passing every qualification test first time because they have experience and they've done their homework with engineering tests (Have I ever mentioned the value of "repeatable experiments" or "recipes for success"?). Nonetheless, every new product is treated as if regulators haven't a clue as to what designers do for a living (most don't). The safe thing is to treat every new task as if the designer is fresh out of school and the company they work for didn't exist yesterday. The net result is a CYA mode of operation where certification is so expensive that engineering testing done before qual tests is minimized. This increases risks of failure during qual, which only re-enforces the regulator's dim view of the designer's competence. This regulation-induced-incompetence justifies the regulator's notion that every new project gets the whole book thrown at it every time. It's a case of policies and procedures being placed above experience and common sense. Of course, the above opinion may well be tainted by fundamental attribution error . . . but this is what my observations and current experience tell me right now.

If you'd care to share a schematic of your product with me, I can scratch some recommendations onto it based upon a whole lot of smoke I've smelled in the lab . . . no sense in letting any smoke out of your parts if it's easy to avoid.

While not DO-160 recommendations, my personal suggestions for i/o is use D-sub connectors for as much of your wiring needs as possible. The solid state power distribution assembly for the new target is ALL d-sub connectors in spite of the fact that three outputs are rated at over 20A continuous and one input is rated for 40A continuous. There are ways to make this work that allow you to take advantage of a wide variety of relatively low cost connectors and tools with military qualified pins at the critical junctures in the connector.

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