Generating and measuring 400 Hz AC power for Military and Avionics Instrument manufacturers can be quite challenging

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Designers of electronic equipment that must operate in land vehicles, onboard ships, and in aircraft face many serious challenges when it comes to designing equipment that can withstand the rigors of real power problems. Dropouts, surges, and transients are all common occurrences and can cause your equipment to operate incorrectly, or even worse, may cause catastrophic failures.

To ensure that your equipment will survive and recover from these power problems, you need to test it under many types of AC power transients. The easiest way to do this is with Agilent's 6800 Series AC Power Source/ Analyzers. These integrated instruments use state of the art technology. Digital Signal Processing (DSP) coupled with 16-bit A/D and D/A converters accurately generate nearly any type of AC power transient imaginable. These products can test electronic instruments that are powered from 400 Hz, and single-phase (as well as DC systems) commonly found in military and commercial vehicles. In addition, the Agilent 6812B and 6813B models can also supply the DC voltages (up to ±425 DC) needed to test 28 Vdc and 270 Vdc equipment.

Military and Commercial Specifications

To guide you in developing tests to ensure the proper operation of your equipment, many government regulated agencies as well as individual instrument manufacturers publish testing standards for your reference. An example of two such documents are: MIL-STD-704E and RTCA/DO-160D MIL-STD-704E, "Aircraft Electric Power Characteristics," is maintained by the US Department of Defense. RTCA/DO160D refers to "Environmental Conditions and Test Procedures for Airborne Equipment" and is maintained by the Radio Technical Commission for Aeronautics. Both standards refer to AC and DC power systems aboard aircraft. These standards also specify limits for normal, emergency, and abnormal power operating conditions.

RTCA/DO-160D applies to commercial avionics and there are four equipment categories: A,B,E, and Z. Category A refers to equipment that is connected to fixed frequency AC systems and/or transformed/rectified DC. Category B refers to equipment that is connected to alternator/rectifiers, or DC generators. Category E is for equipment that is connected and powered only by AC. Category Z is a catch all category for all other equipment that uses electrical power (example, powered from batteries).

The test procedures include tests at high and low voltage limits, tests at high and low frequency limits, surge tests, and power-interruption tests.

In addition to these standards, many companies have developed their own in-house test procedures. In many cases, these test procedures are tougher than the conditions specified in the standards. Quite often, companies will perform these tests during the design phase to ensure that their equipment will pass the official standards tests. But even more importantly, they perform these tests to ensure that their equipment will operate reliably and safely in the field.

To perform official standards tests or in-house tests, you need a high performance and flexible AC power source capable of generating many different power conditions. In the past, this meant purchasing several standalone test instruments, including an arbitrary waveform generator, bi-polar amplifier, and a personal computer to control the setup. To measure input power characteristics, you would use a current probe/scope combination or purchase an expensive power analyzer.

There are many disadvantages to this approach. Test setups using many different instruments take up a lot of space and cost a lot of money. In fact, for many remote test locations, rack space is a premium and in some cases, all of the equipment that needs to be used cannot be 'racked and stacked' easily. So, you must find space for them in a custom enclosure and build cables to hook them all together. You're also responsible for making sure that the instruments will all work together. Writing a test program to synchronize the operation of the instruments in this type of test setup can become quite complex. There's also a reliability issue - with many instruments in a test setup, there are more opportunities for something to go wrong.

There is, fortunately, a solution to all these potential problems: the compact Agilent 6800 series AC Power Source/Analyzers. These products greatly simplify the test setup. The 6800 series not only precisely generates power, it also has the ability to make many different types of power measurements, including rms voltage, rms current, peak current, frequency, phase, real power, apparent power, power factor, and harmonic content. It makes these measurements with an accurate, 16-bit analog-to-digital converter, suitable for even the most demanding applications. This measurement capability eliminates the need for expensive power analyzers.

Finally, the Agilent 6800 series offers great flexibility, allowing users to control the instrument from the front panel for lab/bench applications and via computer for ATE applications (built in RS-232 and GPIB interfaces come standard at no additional cost). In short, the Agilent 6800 series provides an easy to program, reliable, and compact integrated solution for your Military and Commercial power testing needs.

Agilent AC Power Source/Analyzers Provide MIL-STD Power

As an example of how the Agilent 6800 series meets your power-source test needs, let's look at a test for compliance to MIL-STD-704E. The purpose of this test is to ensure that aircraft electronics can withstand the voltage and frequency transients that can occur under normal operation, emergency power operation, and power transfers.

For one typical test procedure - for testing a device which uses 115 Vac, 400 Hz input power - there are 17 different voltage and frequency conditions based on normal voltage and frequency limits **(see Figures 1 and 2)**. The voltage during the first part of this test varies from a low of 80 Vac up to 180 Vac, while the frequency stays constant at 400 Hz. During the second part of the test, the voltage remains a constant 115 Vac, while the frequency varies from 400 Hz up to 425 Hz, then down to 375 Hz and back to a nominal 400 Hz.

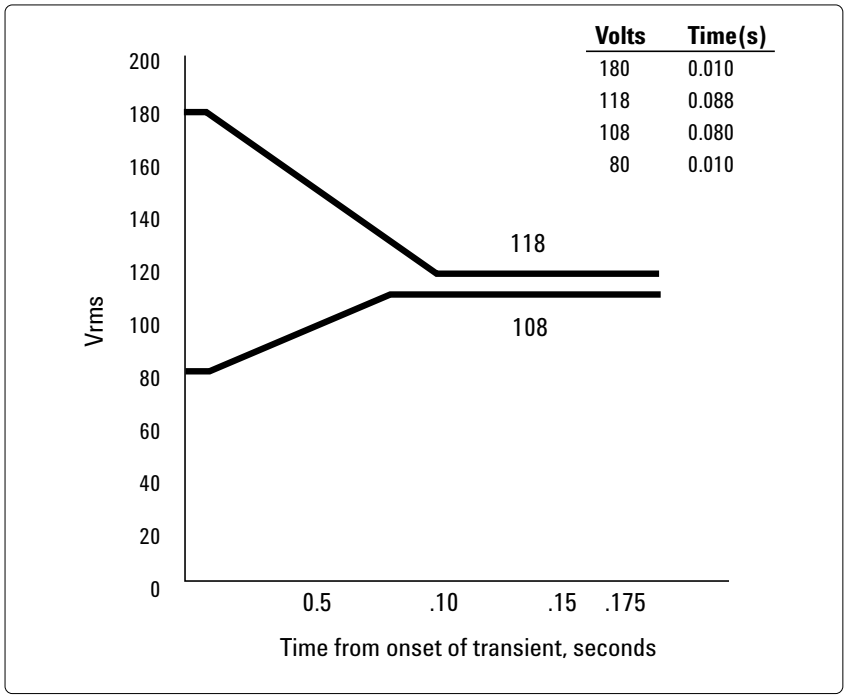

Figure 1 Envelope of normal AC voltage limits

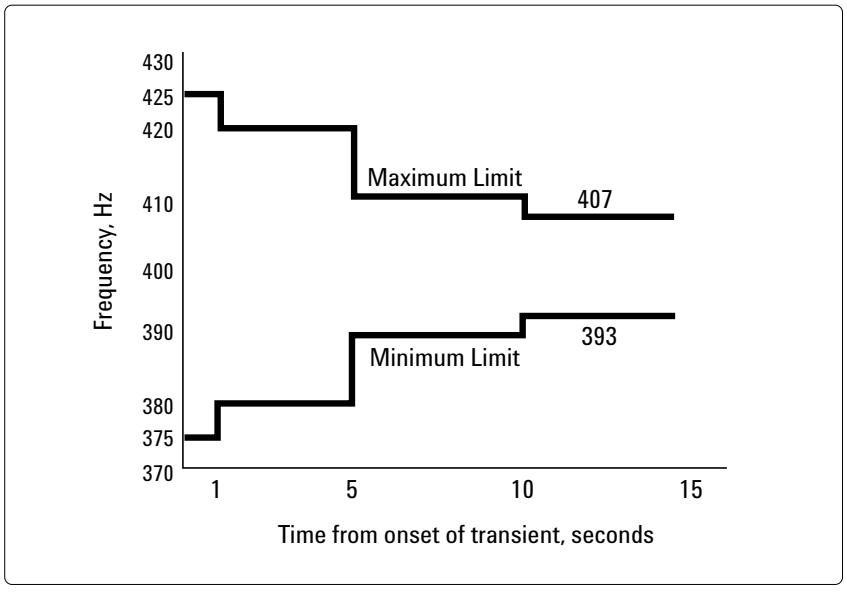

Figure 2 Envelope of normal AC frequency limits

The Agilent 6800 AC power source/analyzers have transient generation feature which is just perfect for combining these two tests, it is called the LIST mode. The LIST mode allows users to program the instrument with a sequence of up to 100 output changes. For each List point, up to 11 parameters can be controlled. These include waveshape, voltage, current, frequency and, time parameters.

For this example, we will use a subset of the List parameters. The test begins when the instrument receives a trigger from the system controller or from some other instrument. The **Table 1** shows the LIST parameters for the generating the voltage and frequency limits specified by MIL-STD-704E.

List Point	Vrms	Freq	Vrms Slew (V/sec)	Dwell Time(sec)
1	115	400	INF	60
2	180	400	INF	0.01
3	118	400	800	0.07
4	115	400	INF	60
5	80	400	INF	0.01
6	108	400	400	0.07
7	115	400	INF	60
8	115	425	INF	1
9	115	420	INF	4
10	115	410	INF	5
11	115	407	INF	4
12	115	400	INF	60
13	115	375	INF	1
14	115	380	INF	4
15	115	390	INF	5
16	115	393	INF	4
17	115	400	INF	60

Table 1. List setup for a MIL-STD-704E test.

The LIST feature greatly simplifies test programming. The test programmer need only send this list of AC source output settings to the instrument once during the initialization sequence. The instrument stores this sequence in non-volatile memory and runs the sequence for each successive test directly from this memory. The controller can then be off doing other things besides instrument control.

The pass/fail criteria for this test depends on the type of equipment under test (EUT). Some EUT's are allowed to lose some functions, while others may quit functioning altogether, and still pass the test. The criteria for pass/fail is determined by the manufacturer and is representative of it's intended operation. No equipment can, however, produce a damaging or unsafe condition during the test, and the unit must return to normal functioning when the input power returns to normal.

Avionics Manufacturer Improves Reliability of Cockpit Electronics

One major avionics manufacturer recently began using Agilent AC power source/analyzers to improve the reliability of the radios, light control products, displays, and warning devices they make. They use the Agilent 6800 AC sources in their laboratories and service centers, and in the ATE systems they sell to major airlines for use in local service centers.

One interesting test challenge that they had was to accurately reproduce the AC power transient that occurred when the aircraft switched over from ground power to aircraft power. This power transfer generates both voltage and current transients, as well as voltage dropouts.

To simulate the power interruptions, the avionics manufacturer needed a flexible AC source it could easily program to generate a wide range of power interruptions. They also needed to make AC measurements so that they could characterize the operation of the cockpit controls under these extreme conditions. The arbitrary-waveform generation capability of the Agilent 6800 series, along with the high-accuracy measurement functions were a perfect fit.

Earlier test systems had limited transient generation capability and lacked the flexibility to control the test parameters. In addition. the test setup required multiple test instruments which make it difficult to accurately repeat the power transients. The problem was that their customers would reject instruments and send them back to the manufacturer for repairs. When the manufacturer would test the units, however, they would work fine. The result was a lot of equipment shuttling back and forth between the manufacturer and its customers with no real resolution.

Once the manufacturer began using Agilent AC source/analyzers the situation changed dramatically. Now, technicians can simulate the transients and pinpoint problems with malfunctioning units at the local service centers. When the unit is returned to the manufacturer, it can run the same test to verify the failure and then fix the problem once and for all.

In addition to the ability to generate nearly any waveform, the manufacturer also found another feature which made the Agilent 6800 series highly desirable: Remote Inhibit (RI). Remote Inhibit adds an extra level of safety needed in ATE systems. When necessary, a technician operating the ATE system can hit an emergency switch which is wired to the RI input of the Agilent AC power source/analyzer and disables the output immediately.

In the engineering lab, designers can use exactly the same AC source to generate the transient waveform and recreate the problem. With this capability, they can then modify the design to make the equipment more immune to these types of power transients.

Instrument designers can also easily program the Agilent 6800 series AC sources to stress their designs by generating power conditions and transients that are even tougher than the tests called out by the standards. The result is a much more reliable design - and safer air travel for airline passengers, pilots and their crew.

Summary

Agilent 6800 Series offer many advantages for testing military and commercial electronic equipment:

- **Accurately generate transients**
  Uses state of the art technology to accurately generate real world transients.
- **Easy to program**
  Either from the front panel or over the RS-232 or GP-IB bus.
- **Single box solution**
  An integrated, compact solution that contains several high performance instruments in a single box.
- **Reliability**
  Single-instrument solutions are inherently more reliable than multiple instrument setups.
- **Flexibility**
  The ability to generate custom waveforms and combine tests, which will meet your test requirements now and in the future.
- **World-wide support**
  Agilent has offices around the world to provide both application support as well as instrument service.

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