

# New EMC Requirements For Commercial Avionics: RTCA/DO-160G

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**R**TCA/DO-160G, Environmental Conditions and Test Procedures for Airborne Equipment, prepared by RTCA Special Committee 135, was issued on Dec. 8, 2010, superseding the previous version, DO-160F [1].

DO-160G covers standard procedures and environmental test criteria for testing airborne electrical and electronic equipment (avionics). The tests specified in DO-160G are typically performed to meet Federal Aviation Administration (FAA) or other international regulations covering electrical or electronic equipment that is installed on commercial aircraft.

The tests and test levels/limits (also referred to as "Equipment Categories") found in DO-160G are applicable to virtually every type of aircraft in use today, including small general aviation aircraft, business jets, helicopters, regional jets, and "Jumbo Jets," such as the newest airliners from Airbus (the A350XWB) and Boeing (the 747-8).

The document includes 26 sections and three Appendices, but it is Sections 15 through 23 and also Section 25 that cover EMC. Examples of other tests covered in DO-160G are: temperature, altitude, vibration, sand/dust, power input, radio frequency susceptibility, lightning, and electrostatic discharge.

Creation and revision of DO-160G is coordinated with the European Union sister organization to RTCA, EUROCAE. As a result of this trans-Atlantic cooperation

and joint effort by the two organizations, RTCA/DO-160G and its European twin, EUROCAE/ED-14G, are identically worded.

The purpose of this article is to provide an overview of each of the sections that deal with EMC in DO-160G. Changes in each section since the release of DO-160F will be summarized. Finally, we will look at the future direction of SC-135, and the timetable for future revisions to DO-160, and the DO-160 Users Guide.

## SECTIONS 1-3

The first three sections cover the Purpose and Applicability (Section 1) of DO-160, provide a Definition of Terms (Section 2) used throughout the document, and give Conditions of Tests (Section 3). These first three sections are referenced in all of the subsequent sections of DO-160, and provide the general information and guidance needed to properly perform the specified tests.

## *What's new for DO-160G?*

- In Section 1, a discussion of the Users Guide material found in an appendix after many sections, and the confirmation that any information found in the Users Guide is GUIDANCE ONLY (emphasis added).
- In Section 2, additional guidance covering "Category Tests and Declarations". In particular, Section 2.8 now states that if equipment is qualified to a particular category, the equipment can be considered to be qualified to any other category that is less severe.
- In Section 3, additional guidance covering "EUT Configuration for Susceptibility Tests", with special attention given to the firmware

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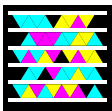
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and/or software used during testing.

### SECTION 15: MAGNETIC EFFECT

This “MC” (for “Magnetic Compatibility” as opposed to “EMC” for Electromagnetic Compatibility) test is performed to determine how much the Equipment Under Test (EUT) will deflect a compass needle, or affect the indication from a magnetic field sensor, also known as a “Flux Gate”.

A standard compass that has a large enough dial to read one degree of needle deflection, or an “equivalent magnetic sensor” (electronic compass) is the only test equipment required. The EUT is simply moved closer to the compass on an East-West line until one degree of deflection away from magnetic North is observed. The separation distance is then measured and the “Equipment Category” is determined.

#### Equipment classes

There are five Equipment Categories (Y, Z, A, B, and C) that apply to installation separation distances between the EUT and compass (or compass sensor) of less than 30 centimeters to more than 300 centimeters.

#### What’s new for DO-160G?

- Figure 15-1, showing the Test Installation and Procedure, was revised to better show how the EUT and compass (sensor) are to be properly set up for testing, and how to correctly determine the distance at which one degree of needle deflection is observed.

### SECTION 16: POWER INPUT

Although an argument can be made that “Power Input” (or “Power Quality” as they are referred to in other standards) tests are not truly EMC tests, they are included here for two reasons:

- 1) Power Input/Quality tests are often performed in the EMC lab by the EMC test personnel.
- 2) In the latest versions of DO-160, the frequency ranges for some of the tests fall well within the realm of typical EMC tests, and the test equipment used is similar to many other “true” EMC tests found elsewhere in DO-160 and other EMC standards.

The tests in Section 16 are performed to determine that the EUT can operate as required during all of the different conditions of AC and/or DC power variations that occur during normal and emergency aircraft operation. In addition, Section 16 contains tests to verify that the EUT does not have a negative influence on the aircraft power system that would be harmful or otherwise cause degraded performance in other installed equipment.

One interesting note about Section 16 is the fact that it is the only section of DO-160 that contains requirements and tests that cover both the susceptibility of the EUT (such as surge, dropout, frequency transients, etc.), and the generation of harmful interference (emissions) from the EUT (such as current harmonics, re-generated energy, power factor, etc.). This fact, along with the increasing complexity and variety of

modern aircraft power systems, and the sheer size of Section 16 (69 pages in DO-160G), is spurring some discussion on SC-135 about the possibility of splitting off the Power Input/Quality requirements to a completely different document; although no immediate change is being considered.

In order to keep pace with the “state-of-the-art” in aircraft power system design, Section 16 has seen dramatic changes over the last decade, but (thankfully) the changes made for DO-160G, are not as extensive as previous revisions, and with a couple of exceptions, fall more under the heading of clarification and improvements for ease of use.

Change 2 to DO-160D, issued June 12, 2001, revised Section 16 fairly dramatically, by including new tests, and modifications to existing testing, to address the issues of AC Harmonic Current Content and Variable Frequency AC power systems [2].

In DO-160E, the entire section was re-ordered so that all the AC tests were in one subsection, and all DC tests were in another subsection, making Section 16 easier to use and understand. DO-160E also introduced some new tests, such as a DC Content test for AC powered equipment, and a new sub-section covering “Load Equipment Influence on Aircraft Electrical Power Systems”.

In DO-160F, even more tests were added, for both AC and DC powered equipment. In addition, a whole series of new tests and test levels to cover 270 Volt DC power systems, and a greatly expanded list of tests to cover the EUT influence on the aircraft electrical power systems was instituted.

DO-160G does not contain any new tests, but does add some clarification of the applicability of some tests.

#### DC input tests

On DC inputs, there are tests that cover:

- Steady-state over- and under-voltage conditions
- Ripple voltage
- Momentary power interruption
- Momentary sags and surges
- Exposed voltage decay time (270 Volt only)
- Inrush current

#### AC input tests

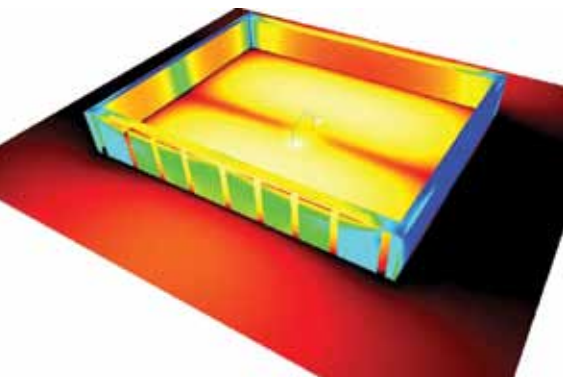
AC inputs are subjected to the following tests:

- Steady-state over- and under-voltage conditions
- Steady-state over- and under-frequency conditions
- Steady-state phase unbalance (three-phase power)
- Voltage and frequency modulation
- Voltage and frequency transients
- Momentary power interruption
- Momentary sags and surges
- DC offset and voltage distortion
- Harmonic current emissions
- Phase unbalance (3 phase inputs)
- DC current content
- Inrush current
- Current modulation
- Power factor

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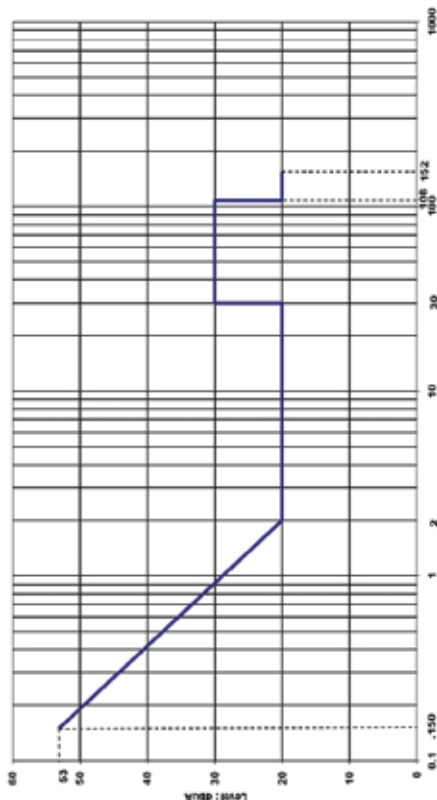
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CHANGING THE STANDARDS



**Figure 1.** Category Q conducted RF emissions limit - power leads.

### Equipment categories

There are four Equipment Categories (A, B, D, or Z) that indicate the type of power used by the equipment and the type of AC and/or DC power source with which the equipment is compatible. For AC powered equipment, an additional designator, placed in parenthesis following the Category designator, is a two character code indicating that the equipment has been tested for use with Constant Frequency (CF), Narrow Variable Frequency (NF), or Wide Variable Frequency (WF).

Up to four additional category designators are used to indicate testing for:

- AC current harmonics (H)
- AC current modulation (L)
- AC power factor (P)
- DC current ripple (R)
- AC or DC inrush (I)

### What's New for DO-160G

- Directions regarding the testing process for equipment with multiple power sources.
- The requirement to test all AC powered equipment (regardless of whether

they contain "Digital Circuits") to the Momentary Power Interruptions given in Table 16-1 (and 16-2 if the equipment uses "Narrow" or "Wide" Variable Frequency AC power).

- Abnormal Surge test is now specified for each individual phase of 3 phase AC powered EUTs.
- Tolerances for some test voltage levels have been added or modified to make the test easier to perform, and also more accurately simulate the intended conditions that would be seen on the aircraft.
- Revisions to Momentary Interruptions Tables 16-1, 16-2, and 16-3, to make it much easier to understand the test requirements.

### SECTION 17: VOLTAGE SPIKE

This test determines whether the EUT can operate as required during and/or after voltage spikes are applied to the AC and/or DC power input(s). Any method of generating the spike may be used, provided that the pulse produced has a duration of at least 10 microseconds, a rise-time of less than 2 microseconds, and a source impedance of 50 ohms. A minimum of 50 voltage spikes are applied within 1 minute. This test is very similar to MIL-STD-461F test method CS106 [3].

### Equipment categories

There are two Equipment Categories. The Category B test level is twice the AC (rms) and/or DC line voltage (or 200 volts, whichever is less). The Category A test level is 600 volts.

### What's new for DO-160G?

- Clarification that a minimum of 50 spikes in positive polarity, and 50 spikes in negative polarity, are required.

### SECTION 18: AUDIO FREQUENCY CONDUCTED SUSCEPTIBILITY - POWER INPUTS

This test is performed to determine that the EUT will operate as specified when audio frequency interference is applied to the AC and/or DC power input. The test setup and procedure are nearly identical to MIL-STD 461F test

method CS101, with the only difference being the actual test level and frequency range. The audio frequency interference is transformer coupled onto each power input lead, and the peak-to-peak voltage level of the interference signal is measured across the power input and return leads. Test levels are up to 8% of the nominal AC input voltage, and the frequency range is as broad as 10 Hz to 150 kHz.

The EUT must be tested while operating at both minimum and maximum current draw (if applicable), and at the AC power frequency extremes if designated for use with Variable Frequency systems. The frequency scan rate is 30 steps per decade, with a 1 minute dwell time at each frequency.

### Equipment categories

There are three DC power Equipment Categories (R, B, and Z) that indicate the type of power used by the equipment and the type of DC power source with which the equipment is compatible.

Two AC power Equipment Categories are specified (R & K). Category R is used with an additional designation (a two character code), placed in parenthesis following the Category designator, indicating that the equipment has been tested for use with Constant Frequency (CF), Narrow Variable Frequency (NF), or Wide Variable Frequency (WF). Category K designates that the EUT has been tested for use with any type of AC power input, and tested to a higher level of voltage distortion than category R.

### What's new for DO-160G?

- Users Guide has been added to the end of the section, resulting in many comments and remarks being moved from the requirements section to the new Users Guide.
- The allowance to limit applied power (of the test signal) to 100 watts has been removed and replaced by a 36 Amp peak-to-peak test current limit. Test setup figures have been modified to show the "Optional AC Current Monitor" in the proper location.
- The 0.6 ohm output impedance specification for the coupling transformer has been deleted.

## SECTION 19: INDUCED SIGNAL SUSCEPTIBILITY

The tests in this section are performed to determine that the EUT can operate as required when the equipment and interconnecting cables are subjected to audio frequency electric fields, magnetic fields and transient voltage spikes.

The test levels for the interconnecting cable tests are determined by the length of wire that is exposed to the radiating wire. For the Inductive Switching Transients (induced spikes) test, the exposed length is either 1.2 or 3.0 meters, with the amplitude of the spikes applied to the radiating wire being at least 600 Volts peak-to-peak.

For the magnetic and electric fields induced into cables, the test level is defined as the product of the length of interconnecting cable that is exposed to the radiating wire and the rms voltage or current applied to the wire. This test level is given as "volts x meters" (V-m), or "amps x meters" (A-m). For example, category Z requires an electric field test level of 1800 V-m, which is typically obtained by exposing 3 meters of cable to a radiating wire with 600 volts rms applied to it. If less than 3 meters of cable is exposed to the radiating wire (due to space restrictions, for example), the voltage applied to the wire must be increased so that the test level of 1800 V-m is achieved. The exception to this requirement is when the actual length of the cable in the final installation is known to be less than 3 meters. In this case, the test level

may be reduced in proportion to the ratio of the reduced coupling length.

The frequency ranges for the swept frequency tests are determined by the Equipment Category specified. The frequency scan rate is 30 steps per decade, with a 10 second dwell time at each frequency.

### Equipment categories

The Equipment Categories are comprised of two characters. The first character (A, B, C, or Z) indicates the tests performed and severity level of the tests. The second character (C, N, or W) indicates the AC power system operating frequency (Constant, Narrow Variable, or Wide Variable) with which the EUT is compatible.

### What's new for DO-160G?

- Clarification that these tests are not applicable to Power Input cables/leads.
- An "Electric Fields Induced Into the Equipment" test has been added. This test is very similar to the existing "Magnetic Fields Induced Into the Equipment" test, and a single test level of 170 Vrms (400 Hz) is used for all Equipment Categories. Corresponding Test Setup Figure also added.
- The requirement to sweep the radiating wire across the face of the equipment in both the Magnetic and Electric

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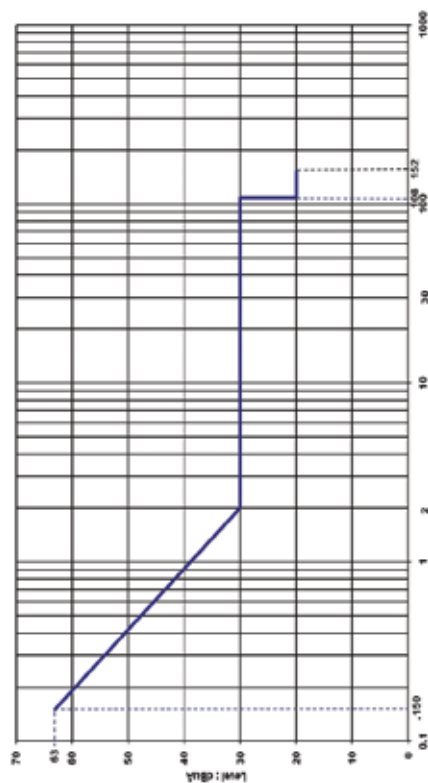
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**Figure 2.** Category Q conducted RF emissions limit - Interconnecting cables.

Fields Induced Into the Equipment tests.

- Clarification added to the Inductive Switching Transients (Induced Spikes) figure, to allow for the fact that spikes of varying amplitude will be produced during the test, and that some spikes will be less than the indicated 600 Vpp amplitude.

## SECTION 20: RADIO FREQUENCY SUSCEPTIBILITY (RADIATED AND CONDUCTED)

These tests are performed to determine that equipment will operate as specified when the EUT and its interconnecting cables are exposed to Radio Frequency interference. Continuous Wave (CW), Square Wave AM (SW), and Pulse Modulated (PM) RF signals are required. A Line Impedance Stabilization Network (LISN) must be inserted in series with each power lead and ungrounded power return lead, with a 10  $\mu$ F capacitor connected between the power input of the LISN and the ground plane. Unless otherwise specified, interconnecting cables shall be at least 3.3 meters in length, and power

leads will be no more than 1 meter in length for these tests.

### Conducted susceptibility

The RF conducted susceptibility test procedure is similar to MIL-STD-461F test method CS114. RF interference is coupled into the EUT interconnecting cables and power leads using an injection probe that is calibrated (in a 50 ohm fixture) to the required test level prior to performing the test. The amount of RF power applied to the injection probe that is required to achieve the specified RF current in the fixture is recorded for each test frequency. This calibration table, showing RF power required at a given frequency, is then used during the actual test.

During testing, the RF current that is induced into the cable or lead under test is monitored with a calibrated RF current probe, and the RF power applied to the injection probe is increased until the appropriate current level (as defined by the applicable Equipment Category used) is reached. The amount of RF applied to the injection probe is limited to no more than 6 dB above the power level recorded during calibration in the 50 ohm calibration fixture. The test frequency range is 10 kHz to 400 MHz, and 2 scans are typically required for each test - once with a CW signal, and then again with a SW modulated signal.

### Radiated susceptibility

The RF radiated susceptibility test procedure is similar to MIL-STD-461F test method RS103. The EUT and its interconnecting cables and power leads are exposed to RF radiated fields in the frequency range of 100 MHz to 18 GHz. There are two RF radiated susceptibility test methods specified in Section 20.

The first uses a standard semi-anechoic chamber as in MIL-STD-461F test method RS103. The chamber must be lined with RF absorber, and the minimum performance of the absorber is specified. The minimum antenna distance is normally 1 meter, and multiple antenna positions are required when the beamwidth of the antenna does not totally cover the system. If the EUT has apertures, connectors,

seams, or other points of penetration in the EUT enclosure, all of these must be directly exposed to the test antenna, requiring multiple EUT positions during testing.

Calibration of the RF field prior to placement of the EUT is required. The RF power required to achieve the specified test level is applied to the antenna input and this power level is recorded at each calibration frequency, for each antenna used. During EUT testing, the calibrated power level for each test frequency is applied to the antenna.

The second method uses a Reverberation Chamber, which requires a Field Uniformity Validation and Maximum Chamber Loading Verification prior to the first use of the chamber, or after any modifications. Field Uniformity measurements are performed with a 3-axis E-Field probe at up to nine different positions within the chamber. In addition, a passive, linear, monitor antenna is moved to different positions within the chamber to calibrate the monitor antenna for use prior to each test. This calibration allows the monitor antenna to be used to measure Chamber Q, Time Constant, and Test Level determination, during EUT testing.

The RF power level required to achieve the desired test level for each test frequency is determined by injecting a known RF power level (typically 1 watt) into the chamber, and then measuring the field level inside the Reverb Chamber with the monitor antenna, after the EUT installed in the chamber.

### Equipment categories

Equipment Category designation for Section 20 consists of two letters. Conducted susceptibility test levels are designated with the first category character and radiated susceptibility test levels with the second category character. There are 7 Equipment Categories for conducted susceptibility, and 10 Equipment Categories for radiated susceptibility. These categories indicate the severity level of the tests performed, and/or the type of modulation used. Category S is the least severe at 1 V/m, and Category L is the most severe, with test levels as high as 7200 V/m.

### What's new for DO-160G?

- Users Guide added.
  - Wording throughout the section has been revised or added to align Section 20 with the requirements of the new FAA HIRF Rule, FAA Advisory Circular 20-158, and SAE document ARP5583A (HIRF Users Guide).
  - The requirement that when using the Anechoic Chamber method for Radiated Susceptibility, all faces of the EUT must be directly exposed to the test antenna, and if any face of the EUT is not directly exposed to the test antenna, the justification for this decision must be included in the Test Report.
  - Clarification that the distance between the test antenna and the EUT must be the same for calibration and test.
  - The Reverberation Chamber test method has been modified from a "Mode-Tuned" process to a "Mode-Stirred" process. This change has resulted in a major re-write of Section 20.6, to such an extent that it cannot be discussed in sufficient detail in this article, but a few highlights can be provided:
1. Field Uniformity determination using 3-axes E-Field probes is still required.
  2. Test Level is determined by measuring the power received by a monitor antenna (with the EUT installed), and then calculating the field based on the maximum received level on the monitor antenna, over one tuner rotation.
  3. Tuner speed is 4 rpm below 1 GHz, and 2 rpm above 1 GHz, or slower (usually a slower speed is needed).

### SECTION 21: EMISSION OF RADIO FREQUENCY

The tests in this section are performed to determine that the EUT does not emit radio frequency interference in excess of the specified limits. Conducted RF emissions appearing on interconnecting cables and power leads are measured. Radiated RF emissions from the EUT, interconnecting cables, and power leads are also measured.

Measurements must be made with an instrument using a peak detector, and with IF bandwidths, frequency step size, and dwell time as specified in Section 21, Table 1, for the frequency range being scanned.

A LISN must be inserted in series with each power lead and ungrounded power return lead, with a 10  $\mu$ F capacitor connected between the power input of the LISN and the ground plane. Unless otherwise specified, interconnecting cables shall be at least 3.3 meters in length, and power leads will be no more than 1 meter in length for these tests.

Ambient emission levels must be at least 6 dB below the applicable limit, and must be measured and recorded if any signals are found to be within 3 dB of the applicable limit.

#### Conducted emissions

Conducted RF currents on interconnecting cables and power leads are measured with a clamp-on current probe. The probe is positioned 5 centimeters from the EUT and measurements are made over the frequency range of 150 kHz to 152 MHz.

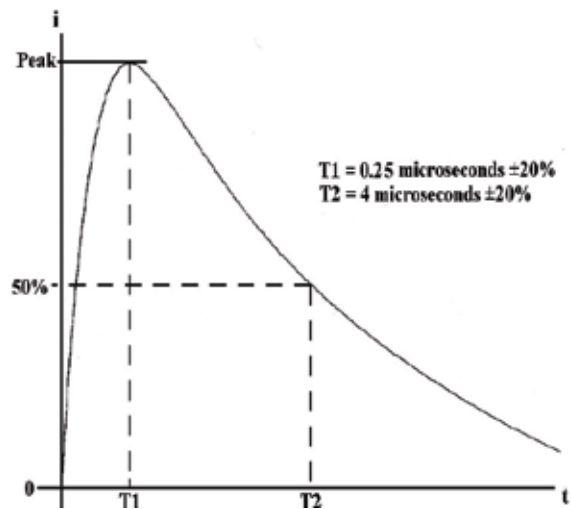


Figure 3. Waveform 6.

#### Radiated emissions

Radiated RF fields are measured with a linearly polarized antenna over the frequency range of 100 MHz to 6 GHz. As with RF radiated susceptibility testing in Section 20, there are two RF radiated emissions test methods allowed in Section

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21: the Anechoic Chamber method, and the Reverberation Chamber method.

The Anechoic Chamber method requires a chamber lined with RF absorber, and the minimum performance of the absorber is specified. The measurement antenna distance is 1 meter, and multiple antenna positions are required when the beamwidth of the antenna does not totally cover the system. If the EUT has apertures, connectors, seams, or other points of penetration in the EUT enclosure, all of these must be directly exposed to the test antenna, requiring multiple EUT positions during testing.

The second method uses a Reverberation Chamber, which requires a Field Uniformity Validation from Section 20. EUT Loading is measured after the EUT is installed in the chamber, and this data is used as a correction factor for the radiated emissions measurement. A minimum of 200 sweeps of the analyzer or measurement receiver is required over one rotation of the tuner, for each measured frequency range.

### Equipment categories

There are 6 Equipment Categories (B, L, M, H, P, and Q) that indicate the location of the equipment and the separation between the equipment and aircraft antennas. In general, the closer the equipment is to an aircraft antenna, and the more it approaches a "direct view" of an aircraft antenna, the tighter the emissions limits.

### What's new for DO-160G?

- Users Guide.
- A new limit category has been added - Category Q - to provide added protection for VHF and GPS receivers, but without the Conducted Emissions "HF notch" used in Category P (see Figure 1 and Figure 2).
- Change in the frequency for the bandwidth step from 100 kHz to 1 MHz. Previous versions had this step at 1 GHz. DO-160G has the step at 960 MHz.
- Removal of the option to use a 10 kHz bandwidth to measure in the notches above 960 MHz, and instead, a note that a high-gain pre-amplifier may (will) be required.

## SECTION 22: LIGHTNING INDUCED TRANSIENT SUSCEPTIBILITY

These tests determine whether the EUT can operate as specified during and/or after various lightning induced transient waveforms are injected into connector pins, interconnecting cables, and power leads using pin injection, and/or cable bundle tests. The pin injection method is normally used to show damage tolerance, while the cable bundle tests are normally used to show upset tolerance.

Change 3 to DO-160D, issued December 5, 2002, was a major revision of Section 22, primarily to add procedures, waveforms, and test levels for Multiple Burst and Multiple Stroke Cable Bundle test methods. New Waveform Set designators (G through K) were also added to cover the Multiple Burst and Multiple Stroke tests.

### Pin injection

During pin injection testing, the EUT is normally powered, so that the circuits being tested are biased as they would be in normal operation. The test level is defined as an open circuit voltage (Voc) with a specified source impedance from the generator. For example, waveform 3, test level 2 specifies Voc as 250 volts, with a short circuit current (Isc) of 10 amps. The ratio of Voc to Isc yields a generator source impedance requirement of 25 ohms. The generator is adjusted to produce waveform 3 with these specified characteristics, and the transient waveform is then applied directly to the interface pins. After the pins have been tested, the EUT is evaluated to determine if its performance has been degraded.

### Cable bundle tests

Cable Bundle Tests are performed using either Cable Induction or Ground Injection to couple the transient waveforms into the interconnecting cable bundles and power leads.

The cable induction test method uses an injection probe to induce the transient waveforms into interconnecting cables and power leads. The ground injection method is very similar to the cable induction method, except that the

transient waveform is applied between the EUT case and the ground plane. The EUT is isolated from the ground plane by lifting all local grounds and returns, and insulating the case from the ground plane, which forces the injected transient into the cable shields and any other return paths back to the ground plane.

A Line Impedance Stabilization Network (LISN) must be inserted in series with each power lead and ungrounded power return lead, with a 10 uF capacitor connected between the power input of the LISN and the ground plane for AC powered equipment, or with a 33,000 uF capacitor connected across the power inputs of the LISNs for DC powered equipment. Unless otherwise specified, interconnecting cables shall be at least 3.3 meters in length, and power leads will be no more than 1 meter in length for these tests.

For each waveform, either a voltage or current test level is given, along with a current or voltage limit. For example, waveform 2, test level 3, specifies a voltage test level (VT) of 300 volts, and current limit (IL) of 600 amps. This means that during the test, the generator level is increased until the peak voltage measured on a single turn monitor loop placed thru the injection probe reaches 300 volts, or the monitored induced current in the cable or lead reaches the 600 amp limit.

Cable Bundle tests may be performed using the Single Stroke method only, or using a combination of the Single Stroke, Multiple Stroke, and Multiple Burst methods.

The Single Stroke test method is designed to represent the internal aircraft wiring response to the most severe external aircraft lightning strike. A single occurrence (stroke) of the specified test waveform is applied to the cable bundle or wire under test, and repeated for a total of 10 applications in each polarity.

The Multiple Stroke test method is designed to represent the induced effects to internal aircraft wiring in response to an external aircraft lightning strike that is composed of a first return stroke immediately followed by multiple return strokes (see Figure 5).

The Multiple Burst test method is

designed to represent the induced effects to internal aircraft wiring in response to an external aircraft lightning strike of a multiple burst nature (see Figure 6). The specified test waveform is applied to the cable bundle or wire under test, and repeated for at least 5 minutes in each polarity.

### Equipment categories

Category designations consist of six characters that describe the pin and cable test Waveform Sets and test levels.

The 3 Pin Injection test waveforms are grouped together in two Waveform Sets (A & B). The 6 Cable Bundle test waveforms are grouped together in four Single Stroke Waveform Sets (C through F), and four combined Single Stroke and Multiple Stroke (G through K), and two Multiple Burst Waveform Sets (L & M).

### What's new for DO-160G?

- Users Guide added, resulting in many notes and remarks being moved from the requirements section to the Users Guide. A vast amount of additional (helpful) information is included in the Section 22 Users Guide.
- The "resistor method" for determining the source impedance of the Pin-Injection test waveforms has been eliminated.
- Cable Bundle test Waveform 6 was added, for the Multiple-Burst test only. See Figure 3.
- Pin-Injection calibration and test setup figures were revised for clarity.

## SECTION 23: LIGHTNING DIRECT EFFECTS

The tests in this section are performed to determine the ability of externally mounted electrical and electronic equipment to withstand the direct effects of a severe lightning strike. The equipment will not normally be powered during the test, and these tests usually cause damage (sometimes spectacular damage) to the EUT. High voltage and/or high current tests at levels of thousands of kilo-Volts and/or hundreds of kilo-Amps are required.

### Equipment categories

Category designations consist of four

characters that describe the nature and severity of the test waveforms applied. The first 2 characters designate the High Voltage Strike Attachment test category, and the last two characters designate the High Current Physical Damage test category. The designated test category for the EUT should correspond to the lightning strike zone in which the EUT will be installed on the aircraft.

### What's new for DO-160G?

- No changes.

## SECTION 25: ELECTROSTATIC DISCHARGE (ESD)

This test determines whether the EUT can operate as specified during and after being subjected to an electrostatic air discharge event. The test procedure and test generator used is similar to most other international ESD standards, except that the EUT is bonded to the ground plane and only air discharge is specified. Test points are chosen based on their accessibility to personnel, with 10 positive and 10 negative polarity discharges at 15 kV applied to each one.

### Equipment categories

There is only one category (A), with a test level of 15 kV.

### What's new for DO-160G?

- Clarification of applicability of test points, in particular, stating that connector pins are not to be tested.

## THE LATEST FROM SC-135

At the most recent meeting of the RTCA Program Management Committee (which directs the activities of SC-135), where Revision G of DO-160 was approved, the decision was made to allow for a minimum of 5 years until another revision of DO-160 was released. The Program Management Committee revised the "Terms of Reference" for SC-135 to create a "stand-alone" document (possibly in the form of an appendix) that would contain all the Users Guide material for all sections of DO-160. Although no target date was given for the release of this new Users Guide, it is to be completed before the

committee resumes work on the next revision of DO-160 (DO-160H).

## SUMMARY

RTCA/DO-160, and its European twin, EUROCAE/ED-14, are truly the world standards for Electromagnetic Compatibility requirements for aircraft electronic equipment.

The test levels, requirements, and procedures are intended to reflect the "state-of-the-art" in aviation technology and EMC testing methodology.

Since both aviation technology and EMC testing methodology are evolving at a rapid rate, work is continuing on a comprehensive Users Guide covering all sections of RTCA/DO-160G and eventually, the next revision, DO-160H.

## REFERENCES

- [1] RTCA/DO-160F, "Environmental Conditions and Test Procedures for Airborne Equipment," RTCA, Incorporated, December 2007.
- [2] RTCA/DO-160D, "Environmental Conditions and Test Procedures for Airborne Equipment," RTCA, Incorporated, July 1997.
- [3] MIL-STD-461F, "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment," Dept. of Defense Interface Standard, December 2007.

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