U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: The Certification of Aircraft Electrical and Electronic Systems for Operation in the High-intensity Radiated Fields (HIRF) Environment

Date: 05/30/14
Initiated by: AIR-130
AC No: 20-158A

1. Purpose.

a. This advisory circular (AC) will provide you with information and guidance on how to show compliance with Title 14, Code of Federal Regulations (14 CFR) 23.1308, 25.1317, 27.1317, and 29.1317, High-intensity Radiated Fields (HIRF) Protection.

b. This AC is not mandatory and does not constitute a regulation. It describes an acceptable means, but not the only means, for you to show compliance with the requirements for protection of the operation of electrical and electronic systems on an aircraft when the aircraft is exposed to an external HIRF environment. If you use the means described in this AC, you must follow it entirely to comply with this AC. The term "must" is used to indicate mandatory requirements when following the guidance in this AC. The term "should" is used when following the guidance is recommended but not required to comply with this AC.

c. This AC updates AC 20-158 to include the latest revision of SAE ARP 5583A (and EUROCAE document ED-107A), *Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment*, June 2010.

d. AC 20-158, *The Certification of Aircraft Electrical and Electronic Systems for Operation in a High-Intensity Radiated Field (HIRF) Environment*, dated July 30, 2007, is cancelled.

2. Applicability. This AC applies to all applicants for a new type certificate (TC) or a change to an existing TC when the certification basis requires you to address the HIRF certification requirements of 14 CFR 23.1308, 25.1317, 27.1317, and 29.1317.

3. Related Material.

a. 14 CFR. Sections 23.1308, 25.1317, 27.1317, and 29.1317, High-intensity Radiated Fields (HIRF) protection; §§ 23.1309, 25.1309, 27.1309, and 29.1309, Equipment, systems, and installations; §§ 23.1529, 25.1529, 27.1529, and 29.1529, Instructions for Continued Airworthiness; § 25.1729, Instructions for Continued Airworthiness: EWIS; and § 26.11, Electrical Wiring Interconnection Systems (EWIS) Maintenance Program, (when the latest regulation is not required). You can get copies of the above 14 CFR sections from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402-9325, telephone 202-512-1800, fax 202-512-2250. You can also get copies from the Government Printing Office (GPO) website at www.access.gpo.gov.

b. European Aviation Safety Agency (EASA). Certification Specifications (CS)-23, *Normal, utility, aerobatic & commuter aeroplanes*, CS-25, *Large aeroplanes*, CS-27, *Small rotorcraft*, and CS-29, *Large rotorcraft*. You can get copies of these documents from the European Aviation Safety Agency, Postfach 10 12 53, D-50452 Köln, Germany; telephone +49 221 8999 000; fax: +49 221 8999 099; website: http://www.easa.eu.int.

c. FAA ACs. AC 23.1309-1E, *System Safety Analysis and Assessment for Part 23 Airplanes*; AC 25.1309-1A, *System Design and Analysis*; AC-27-1B, *Certification of Normal Category Rotorcraft;* and AC-29-2C, *Certification of Transport Category Rotorcraft*, or later revisions. You can view and download copies from our web based Regulatory and Guidance Library (RGL) at www.airweb.faa.gov. On the RGL website, select "Advisory Circular", then select "By Number". ACs are also available on the FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/.

d. RTCA, Inc. RTCA/DO-160, *Environmental Conditions and Test Procedures for Airborne Equipment*, Revision E or later. You can order copies of this document from RTCA, Inc., 1150 18th St. NW, Suite 910, Washington, DC 20036; telephone: (202) 833-9339 or fax (202) 833-9434. You can also order copies online at http:/www.rtca.org. This document is technically equivalent to EUROCAE ED-14. You may use RTCA/DO-160 whenever there is a reference to EUROCAE ED-14 in this AC.

e. European Organization for Civil Aviation Equipment (EUROCAE). You can order copies of the following documents from EUROCAE, 102 rue Etienne Dolet, 92240 Malakoff, France; Telephone: +33 1 40 92 79 30; Fax: +33 1 46 55 62 65; website: http://www.eurocae.net.

(1) EUROCAE ED-107A, *Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment*, July 2010. ED-107A and SAE ARP 5583A, referenced in paragraph 3f(1) below, are technically equivalent. Either document may serve as the "User's Guide" referred to in this AC.

(2) EUROCAE ED-14, *Environmental Conditions and Test Procedures for Airborne Equipment*, Revision E or later. This document is technically equivalent to RTCA/DO-160. You may use EUROCAE ED-14 whenever there is a reference to RTCA/DO-160 in this AC.

f. SAE International. You can order copies of the following documents from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001; telephone (724) 776-4970; fax 724-776-0790; web site: http://www.sae.org.

(1) SAE Aerospace Recommended Practice (ARP) 5583A, *Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment*, June 2010. SAE ARP 5583A

and ED-107A, referenced in paragraph 3.e(1) above, are technically equivalent. Either document may serve as the "User's Guide" referred to in this AC.

(2) SAE ARP 4754A, *Guidelines for Development of Civil Aircraft and Systems*, December 2010.

(3) SAE ARP 4761, *Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment*, December 1996.

4. Background.

a. Aircraft Protection. Concern for the protection of aircraft electrical and electronic systems has increased substantially in recent years for the following reasons:

(1) Greater dependence on electrical and electronic systems performing functions required for continued safe flight and landing of an aircraft;

(2) Reduced electromagnetic shielding afforded by some composite materials used in aircraft designs;

(3) Increased susceptibility of electrical and electronic systems to HIRF because of increased data bus and processor operating speeds, higher density integrated circuits and cards, and greater sensitivities of electronic equipment;

(4) Expanded frequency usage, especially above 1 gigahertz (GHz);

(5) Increased severity of the HIRF environment because of an increase in the number and radiated power of radio frequency (RF) transmitters; and

(6) Adverse effects experienced by some aircraft when exposed to HIRF.

b. HIRF Environment. The electromagnetic HIRF environment exists because of the transmission of electromagnetic RF energy from radar, radio, television, and other ground-based, shipborne, or airborne RF transmitters. The User's Guide (SAE ARP 5583A/EUROCAE ED-107A) provides a detailed description of the derivation of these HIRF environments.

5. Definitions.

a. Adverse Effect. HIRF effect that results in system failure, malfunction, or misleading information to a degree that is unacceptable for the specific aircraft function or system addressed in the HIRF regulations. A determination of whether a system or function is adversely affected should consider the HIRF effect in relation to the overall aircraft and its operation.

b. Attenuation. Term used to denote a decrease in electromagnetic field strength in transmission from one point to another. Attenuation may be expressed as a scalar ratio of the input magnitude to the output magnitude or in decibels (dB).

c. Automatically Recover. Return to normal operations without pilot action.

d. Bulk Current Injection (BCI). Method of electromagnetic interference (EMI) testing that involves injecting current into wire bundles through a current injection probe.

e. Continued Safe Flight and Landing. Capability for continued controlled flight and landing at a suitable location, possibly using emergency procedures, but without requiring exceptional pilot skill or strength. Some aircraft damage may be associated with a failure condition during flight or upon landing.

f. Continuous Wave (CW). RF signal consisting of only the fundamental frequency with no modulation in amplitude, frequency, or phase.

g. Coupling. Process whereby electromagnetic energy is induced in a system by radiation produced by an RF source.

h. Current Injection Probe. Inductive device designed to inject RF signals directly into wire bundles when clamped around them.

i. Direct Drive Test. EMI test that involves electrically connecting a signal source directly to the unit being tested.

j. Equipment. Component of an electrical or electronic system with interconnecting electrical conductors.

k. Equipment Electrical Interface. Location on a piece of equipment where an electrical connection is made to the other equipment in a system of which it is a part. The electrical interface may consist of individual wires or wire bundles that connect the equipment.

l. External HIRF Environment. Electromagnetic RF fields at the exterior of an aircraft.

m. Field Strength. Magnitude of the electromagnetic energy propagating in free space expressed in volts per meter (V/m).

n. HIRF Environment. Electromagnetic environment that exists from the transmission of high power RF energy into free space.

o. HIRF Vulnerability. Susceptibility characteristics of a system that cause it to suffer adverse effects when performing its intended function as a result of having been subjected to a HIRF environment.

p. Immunity. Capacity of a system or piece of equipment to continue to perform its intended function, in an acceptable manner, in the presence of RF fields.

q. Interface Circuit. Electrical or electronic device connecting the electrical inputs and outputs of equipment to other equipment or devices in an aircraft.

r. Internal HIRF Environment. The RF environment inside an airframe, equipment enclosure, or cavity. The internal RF environment is described in terms of the internal RF field strength or wire bundle current.

s. Margin. Difference between equipment susceptibility or qualification levels and the aircraft internal HIRF environment. Margin requirements may be specified to account for uncertainties in design, analysis, or test.

t. Modulation. Process whereby certain characteristics of a wave, often called the carrier wave, are varied in accordance with an applied function.

u. Normal Operation. A status where the system is performing its intended function. Specifically in the context of §§ 23.1308(a)(2), 25.1317(a)(2), 27.1317(a)(2), and 29.1317(a)(2) normal operation is defined as the ability to perform functions to the extent necessary to continue safe flight and landing, but not necessarily full functional performance.

v. Radio Frequency (RF). Frequency useful for radio transmission. The present practical limits of RF transmissions are roughly 10 kilohertz (kHz) to 100 gigahertz (GHz). Within this frequency range, electromagnetic energy may be detected and amplified as an electric current at the wave frequency.

w. Reflection Plane. Conducting plate that reflects RF signals.

x. Similarity. Process of using existing HIRF compliance documentation and data from a system or aircraft to demonstrate HIRF compliance for a nearly identical system or aircraft of equivalent design, construction, and installation.

y. Susceptibility. Property of a piece of equipment that describes its inability to function acceptably when subjected to unwanted electromagnetic energy.

z. Susceptibility Level. Level where the effects of interference from electromagnetic energy become apparent.

aa. System. Piece of equipment connected via electrical conductors to another piece of equipment, both of which are required to make a system function. A system may contain pieces of equipment, components, parts, and wire bundles.

bb. Transfer Function. Ratio of the electrical output of a system to the electrical input of a system, expressed in the frequency domain. For HIRF, a typical transfer function is the ratio of the current on a wire bundle to the external HIRF field strength, as a function of frequency.

cc. Upset. Impairment of system operation, either permanent or momentary. For example, a change of digital or analog state that may or may not require a manual reset.

dd. User's Guide. Refers to SAE document ARP 5583A or EUROCAE document ED-107A.

6. Approaches to Compliance.

a. General. The following activities should be elements of a proper HIRF certification program. Adherence to the sequence shown is not necessary. More detailed information on HIRF certification compliance is provided in the User's Guide. You should:

(1) Identify the systems to be assessed;

(2) Establish the applicable aircraft external HIRF environment;

(3) Establish the test environment for installed systems;

(4) Apply the appropriate method of HIRF compliance verification; and,

(5) Verify HIRF protection effectiveness.

b. Identify the Systems to be Assessed.

(1) General. You must identify aircraft systems requiring HIRF assessment. You should define the elements of the system performing a function, considering redundant or backup equipment that makes up the system. The process used for identifying these systems should be similar to the process for showing compliance with 14 CFR 23.1309, 25.1309, 27.1309, and 29.1309, as applicable. These sections address any system failure that may cause or contribute to an effect on the safety of flight of an aircraft. The effects of a HIRF encounter should be assessed to determine the degree to which the aircraft and its systems safety may be affected. The operation of the aircraft systems should be assessed separately and in combination with, or in relation to, other systems. This assessment should cover:

(a) All normal aircraft operating modes, stages of flight, and operating conditions;

(b) All failure conditions and their subsequent effect on aircraft operations and the flightcrew; and

(c) Any corrective actions required.

(2) Safety Assessment. A safety assessment related to HIRF must be performed to establish and classify the equipment or system failure condition. Table **1** provides the corresponding failure condition classification and system HIRF certification level for the appropriate HIRF regulations. The failure condition classifications and terms used in this AC are similar to those used in AC 23.1309-1E, AC 25.1309-1A, AC-27-1B, and AC-29-2C, as applicable. Only those systems identified as performing or contributing to functions whose failure would result in catastrophic, hazardous, or major failure conditions are subject to HIRF regulations. Based on the failure condition classification established by the safety assessment, the systems should be assigned appropriate HIRF certification levels, as shown in table 1. The safety assessment should consider the common cause effects of HIRF, particularly for highly integrated systems and systems with redundant elements. Further guidance on performing the safety assessment can be found in AC 23.1309-1E, AC 25.1309-1A, AC-27-1B, AC-29-2C, SAE ARP 4754A, SAE ARP 4761, and ARP 5583A.

Table 1. HIRF Failure Conditions and System HIRF Certification Levels

HIRF REQUIREMENTS EXCERPTS FROM §§ 23.1308, 25.1317, 27.1317, AND 29.1317	FAILURE CONDITION	SYSTEM HIRF CERTIFICATION LEVEL
Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the rotorcraft/airplane	Catastrophic	A
Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the rotorcraft/airplane or the ability of the flightcrew to respond to an adverse operating condition	Hazardous	B
Each electrical and electronic system that performs a function whose failure would reduce the capability of the rotorcraft/airplane or the ability of the flightcrew to respond to an adverse operating condition	Major	C

(3) Failure Conditions. Your safety assessment should consider all potential adverse effects due to system failures, malfunctions, or misleading information. The safety assessment may show some systems have different failure conditions in different phases of flight; therefore, different HIRF requirements may have to be applied to the system for different phases of flight. For example, an automatic flight control system may have a catastrophic failure condition for autoland, while automatic flight control system operations in cruise may have a hazardous failure condition.

c. Establish the Applicable Aircraft External HIRF Environment. The external HIRF environments I, II, and III, as published in 14 CFR 23.1308, 25.1317, 27.1317, and 29.1317, are shown in tables 2, 3, and 4, respectively. The field strength values for the HIRF environments and test levels are expressed in root-mean-square (rms) units measured during the peak of the modulation cycle.

Table 2. HIRF Environment I

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	**AVERAGE**
10 kHz - 2 MHz	50	50
2 MHz - 30 MHz	100	100
30 MHz - 100 MHz	50	50
100 MHz – 400 MHz	100	100
400 MHz – 700 MHz	700	50
700 MHz - 1 GHz	700	100
1 GHz - 2 GHz	2,000	200
2 GHz - 6 GHz	3,000	200
6 GHz - 8 GHz	1,000	200
8 GHz - 12 GHz	3,000	300
12 GHz - 18 GHz	2,000	200
18 GHz - 40 GHz	600	200
In this table, the higher field strength applies at the frequency band edges.		

Table 3. HIRF Environment II

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 500 kHz	20	20
500 kHz - 2 MHz	30	30
2 MHz - 30 MHz	100	100
30 MHz – 100 MHz	10	10
100 MHz – 200 MHz	30	10
200 MHz – 400 MHz	10	10
400 MHz - 1 GHz	700	40
1 GHz - 2 GHz	1,300	160
2 GHz - 4 GHz	3,000	120
4 GHz - 6 GHz	3,000	160
6 GHz - 8 GHz	400	170
8 GHz - 12 GHz	1,230	230
12 GHz - 18 GHz	730	190
18 GHz - 40 GHz	600	150
In this table, the higher field strength applies at the frequency band edges.		

Table 4. HIRF Environment III

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 100 kHz	150	150
100 kHz – 400 MHz	200	200
400 MHz – 700 MHz	730	200
700 MHz - 1 GHz	1,400	240
1 GHz - 2 GHz	5,000	250
2 GHz - 4 GHz	6,000	490
4 GHz - 6 GHz	7,200	400
6 GHz - 8 GHz	1,100	170
8 GHz - 12 GHz	5,000	330
12 GHz - 18 GHz	2,000	330
18 GHz - 40 GHz	1,000	420
In this table, the higher field strength applies at the frequency band edges.		

d. Establish the Test Environment for Installed Systems.

(1) General. The external HIRF environment will penetrate the aircraft and establish an internal RF environment to which installed electrical and electronic systems will be exposed. The resultant internal RF environment is caused by a combination of factors, such as aircraft seams and apertures, reradiation from the internal aircraft structure and wiring, and characteristic aircraft electrical resonance.

(2) Level A Systems. The resulting internal HIRF environments for level A systems are determined by aircraft attenuation to the external HIRF environments I, II, or III, as defined in 14 CFR part 23 appendix J, 14 CFR part 25 appendix L, 14 CFR part 27 appendix D, and 14 CFR part 29 appendix E, as applicable. The attenuation is aircraft- and zone-specific and should be established by aircraft test, analysis, or similarity. The steps for showing level A HIRF compliance are presented in paragraph 9 of this AC.

(3) Level B Systems. The internal RF environments for level B systems are defined in 14 CFR part 23 appendix J, 14 CFR part 25 appendix L, 14 CFR part 27 appendix D, and 14

CFR part 29 appendix E, as applicable, as equipment HIRF test levels 1 or 2. The steps for showing level B HIRF compliance are presented in paragraph 10 of this AC.

(4) Level C Systems. The internal RF environment for level C systems is defined in 14 CFR part 23 appendix J, 14 CFR part 25 appendix L, 14 CFR part 27 appendix D, and 14 CFR part 29 appendix E, as applicable, as equipment HIRF test level 3. The steps for showing level C HIRF compliance are also presented in paragraph 10 of this AC.

e. Apply the Appropriate Method of HIRF Compliance Verification.

(1) General. Table 5 summarizes the relationship between the aircraft performance requirements in the HIRF regulations (sections (a), (b) and (c)), and the HIRF environments and test levels. The process for showing compliance with section (d) of the HIRF regulations is discussed in paragraph 6g below.

(2) Pass/Fail Criteria. Establish specific HIRF compliance pass/fail criteria for each system as it relates to the applicable HIRF regulation performance criteria. The definitions of “normal operation” and “automatically recover” in paragraph 5 this AC are provided in the context of §§ 23.1308(a)(2), 25.1317(a)(2), 27.1317(a)(2), and 29.1317(a)(2). These pass/fail criteria should be presented to the FAA for approval. The means for monitoring system performance relative to these criteria should be established by the applicant and approved by the FAA. All effects defining the pass/fail criteria should be the result of identifiable and traceable analysis that includes both the separate and interdependent operational characteristics of the systems. The analysis should evaluate the failures, either singularly or in combination, which could adversely affect system performance. This should include failures which could negate any system redundancy or influence more than one system performing the same function.

Table 5. HIRF Certification Requirements Summary

HIRF FAILURE CONDITION FROM §§ 23.1308, 25.1317, 27.1317, AND 29.1317	PERFORMANCE CRITERIA	ITEM THE ENVIRONMENT OR TEST LEVEL APPLIES TO	HIRF ENVIRONMENT OR TEST LEVEL
Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the airplane/rotorcraft must be designed and installed so that—	Each function is not adversely affected during and after the time…	the airplane/rotorcraft…	is exposed to HIRF environment I.
	Each electrical and electronic system automatically recovers normal operation of that function, in a timely manner after…	the airplane/rotorcraft…	is exposed to HIRF environment I, unless this conflicts with other operational or functional requirements of that system.
	Each electrical and electronic system is not adversely affected during and after…	the airplane/rotorcraft…	is exposed to HIRF environment II.
	Each function required during operation under visual flight rules is not adversely affected during and after…	the rotorcraft…	is exposed to HIRF environment III (Parts 27 and 29 only).
Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the airplane/rotorcraft or the ability of the flightcrew to respond to an adverse operating condition must be designed and installed so that—	The system is not adversely affected when…	the equipment providing these functions…	is exposed to equipment HIRF test level 1 or 2.
Each electrical and electronic system that performs such a function whose failure would reduce the capability of the airplane/rotorcraft or the ability of the flightcrew to respond to an adverse operating condition must be designed and installed so that—	The system is not adversely affected when…	the equipment providing these functions…	is exposed to equipment HIRF test level 3.

f. Verify HIRF Protection Effectiveness. You should show the RF current on system and equipment wire bundles and the RF fields on the system, created by the HIRF environment, are lower than the equipment or system HIRF qualification test levels.

g. Compliance Based on Previously Issued HIRF Special Conditions. The installation of a level A electrical or electronic system, until December 1, 2012, was allowed under section (d) of the HIRF regulation, when it could be shown the system intended for installation previously complied with HIRF special conditions prescribed under 14 CFR 21.16 and issued before December 1, 2007. Since December 1, 2012, section (d) of the HIRF regulations and paragraph 6.g of this AC were no longer applicable.

7. Margins. Margins are not required if your HIRF compliance is based on tests of the specific aircraft model and system undergoing certification. Margins are also not required if your HIRF compliance is based on analysis or similarity if the process validation is robust and the data well substantiated. Where data have limited substantiation, a margin may be required depending on the available justifications. When a margin is required, include a justification for the selected margin in the HIRF Compliance Plan, as discussed in paragraph 8.

8. HIRF Compliance.

a. HIRF Compliance Plan. An overall HIRF compliance plan should be established to clearly identify and define HIRF certification requirements, HIRF protection development, and the design, test, and analysis activities intended to be part of the compliance effort. This plan should provide definitions of the aircraft systems, installations, and protective features against which HIRF compliance will be assessed. The HIRF compliance plan should be discussed with, and submitted to, the FAA for approval before initiating HIRF compliance activities. If the aircraft, system, or installation design changes after approval, a revised HIRF compliance plan should be submitted to the FAA for approval. The HIRF compliance plan should include the following:

(1) A HIRF compliance plan summary;

(2) Identification of the aircraft systems, with classification based on the safety assessment as it relates to HIRF (see paragraph 6.b(2));

(3) The HIRF environment for the aircraft and installed systems; and

(4) The verification methods, such as test, analysis, or similarity.

b. HIRF Verification Test, Analysis, or Similarity Plan. Test, analysis and similarity are all acceptable methods. The applicant must choose the method most appropriate for their project. See paragraphs 9 and 10 of this AC, and SAE ARP5583A for additional guidance for selecting the appropriate method. Specific HIRF test, analysis, or similarity plans should be prepared to describe specific verification activities. One or more verification plans may be necessary. For example, there may be several systems or equipment laboratory test plans, an aircraft test plan, or a similarity plan for selected systems on an aircraft.

(1) Test Plan.

(a) A HIRF compliance test plan should include the equipment, system, and aircraft test objectives for the acquisition of data to support HIRF compliance verification. The plan should provide an overview of the factors being addressed for each system test requirement. The test plan should include:

_1_ The purpose of the test;

_2_ A description of the aircraft and/or system being tested;

_3_ System configuration drawings;

_4_ The proposed test setup and methods;

_5_ Intended test levels, modulations, and frequency bands;

_6_ Pass/fail criteria; and

_7_ The test schedule and test location.

(b) The test plan should cover level A, B, and C systems and equipment, as appropriate. Level A systems may require both integrated systems laboratory tests and aircraft tests. Level B and level C systems and equipment require only equipment laboratory testing.

(c) The test plan should describe the appropriate aspects of the systems to be tested and their installation. Additionally, the test plan should reflect the results of any analysis performed in the overall process of the HIRF compliance evaluation.

(2) Analysis Plan. A HIRF compliance analysis plan should include the objectives, both at the system and equipment level, for generating data to support HIRF compliance verification. Comprehensive modeling and analysis for RF field coupling to aircraft systems and structures is an emerging technology; therefore, the analysis plan should be coordinated with the FAA to determine an acceptable scope for the analysis. The analysis plan should include:

(a) The purpose and scope of the analysis;

(b) A description of the aircraft and/or system addressed by the analysis;

(c) System configuration descriptions;

(d) Proposed analysis methods;

(e) The approach for validating the analysis results; and

(f) Pass/fail criteria, including margins to account for analysis uncertainty.

(3) Similarity Plan. A similarity plan should describe the approach undertaken to use the certification data from previously certified systems, equipment, and aircraft in the proposed HIRF compliance program. The similarity plan should include:

(a) The purpose and scope of the similarity assessment;

(b) Specific systems addressed by the similarity assessment;

(c) Data used from the previously certified systems, equipment, and aircraft;

(d) Details on significant differences between the aircraft and system being certified and the similar aircraft and system from which the data will be used; and

(e) When data have limited substantiation, a description and justification for margins to account for similarity uncertainty. See paragraph 7 for additional information on margins.

c. Compliance Reports. One or more compliance reports may be necessary to document the results of your test, analysis, or similarity assessments. For new or significantly modified aircraft, HIRF compliance reports include many system and equipment test reports, aircraft test reports, and HIRF vulnerability analysis reports. For these types of HIRF certification programs, a compliance summary report may be useful to summarize the results of tests and analysis. For HIRF certification programs of relatively simple systems, a single compliance report is adequate.

(1) Test Reports. Comprehensive test reports should be produced at the conclusion of HIRF compliance testing. The test reports should include descriptions of the salient aspects of equipment or system performance during the test, details of any area of noncompliance with HIRF requirements, actions taken to correct the noncompliance, and any similarity declarations. You should also provide supporting rationale for any deviations from system performance observed during testing.

(2) Analysis Reports. Analysis reports should describe the details of the analytical model, the methods used to perform the analysis, and the results of the analysis. The reports should identify any modeling uncertainty and justify the margins established in the analysis plan.

(3) Similarity Reports. Similarity reports should document the significant aircraft, system, equipment, and installation features common between the aircraft or system that is the subject of the similarity analysis and the aircraft or system that previously was certified for HIRF. Identify all significant differences encountered, along with the assessment of the impact of these differences on HIRF compliance. These reports should also justify the margins established in the similarity plan.

d. Methods of Compliance Verification.

(1) Various methods are available to aid in demonstrating HIRF compliance. Methods acceptable to the FAA are described in paragraphs 9 and 10 of this AC. Figures 1 and 2 below outline the steps to HIRF compliance for systems requiring level A HIRF certification. Figure 3 below outlines the steps to HIRF compliance for systems requiring level B or C HIRF

certification. The steps in these figures are not necessarily accomplished sequentially. Wherever a decision point is indicated on these figures, you should complete the steps in that path as described in paragraphs 9 and 10 of this AC.

(2) Other HIRF compliance techniques may be used to demonstrate system performance in the HIRF environment; however those techniques should be approved by the FAA before using them.

Figure 1. Routes to HIRF Compliance – Level A Systems

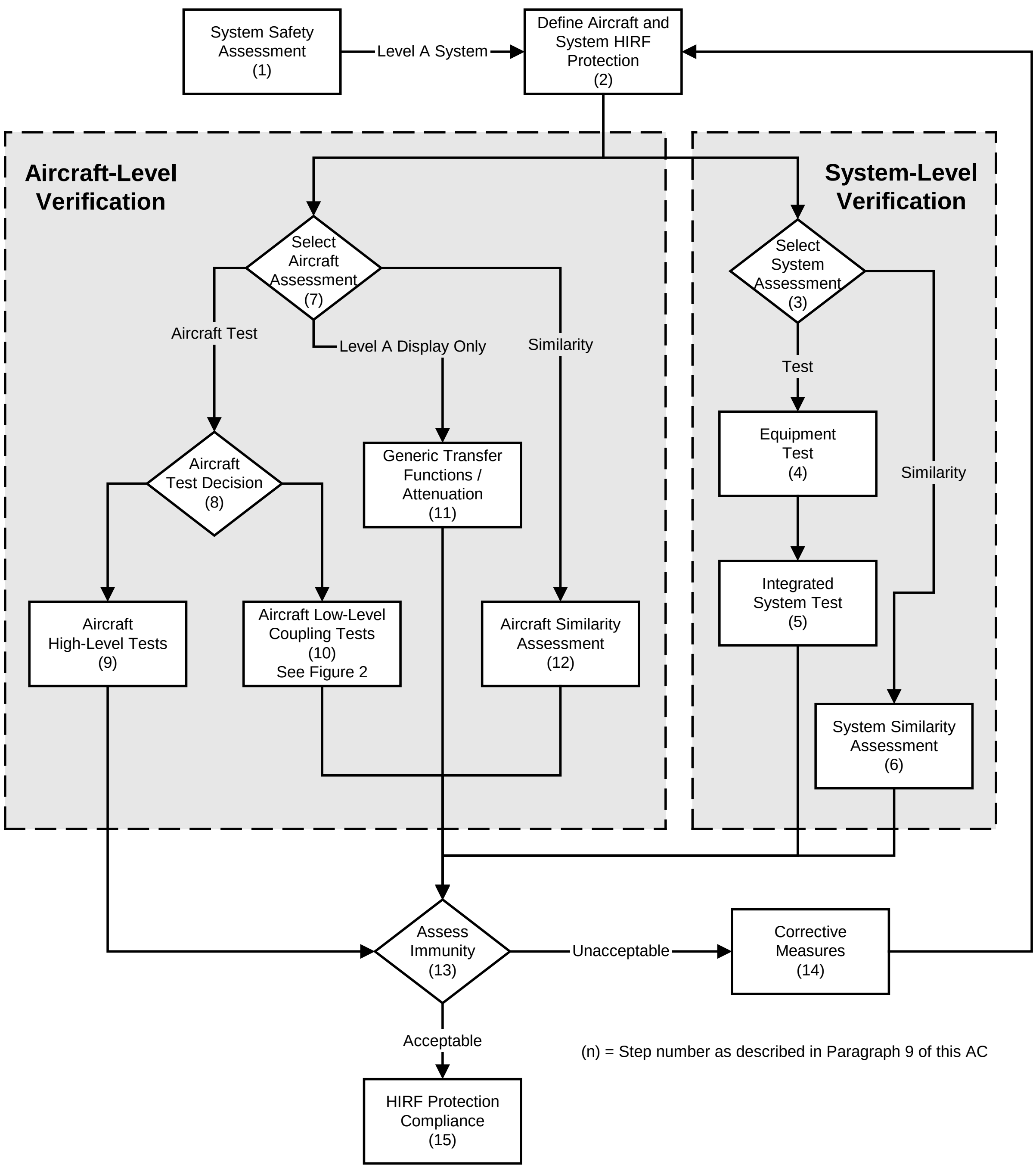
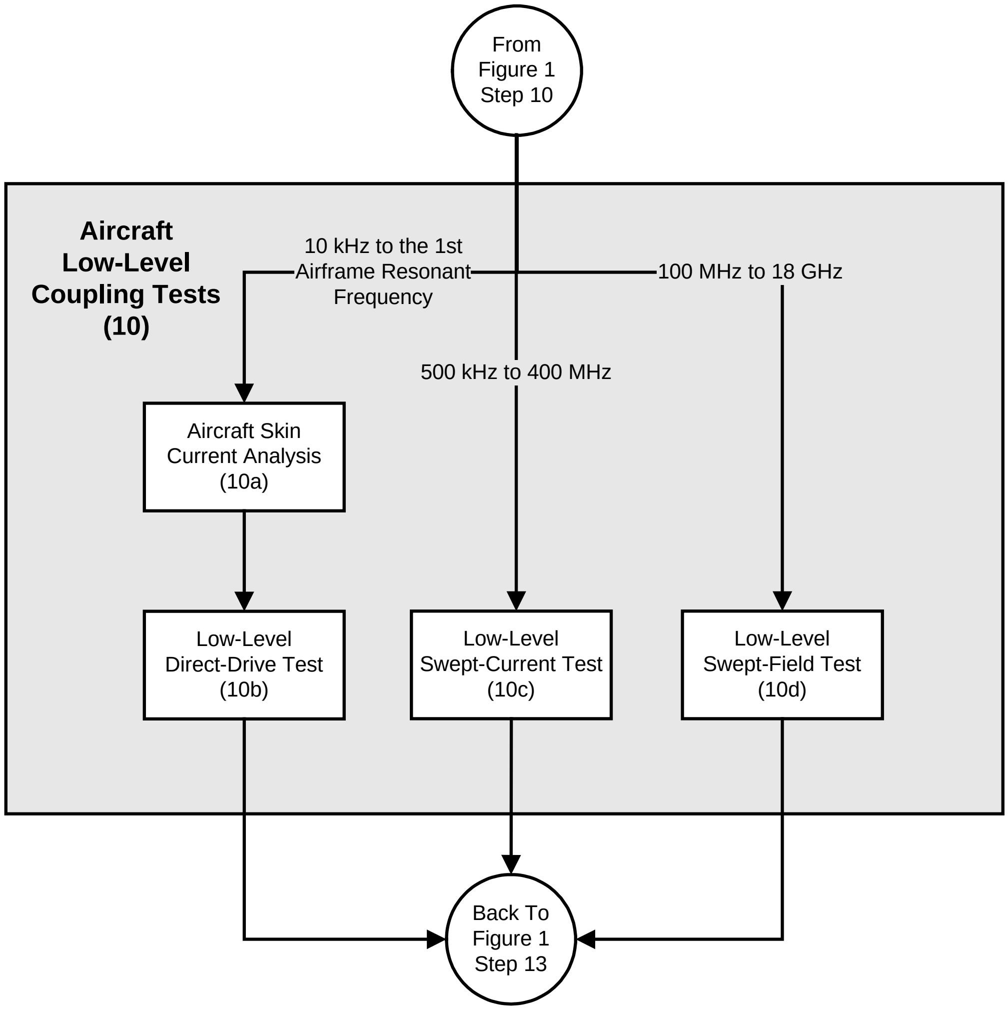
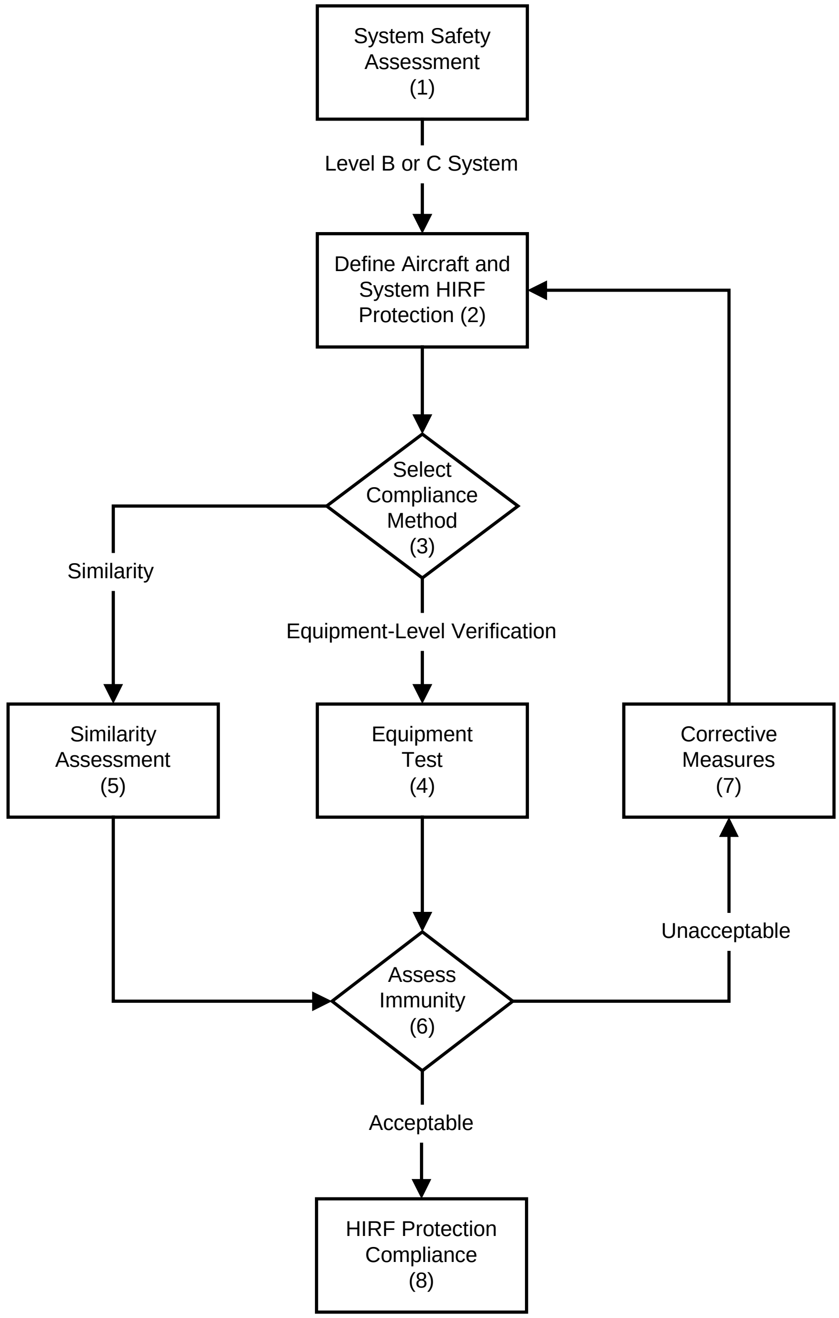


Figure 2. Aircraft Low-Level Coupling Tests – Level A Systems



(n) = Step number as described in Paragraph 9 of this AC

Figure 3. Routes to HIRF Compliance – Level B and C Systems



(n) = Step number as described in Paragraph 10 of this AC

9. Steps to Level A System HIRF Compliance.

a. Step 1 — System Safety Assessment. Determine the system failure condition classification for the systems being certified on your aircraft, using a system safety assessment as discussed in paragraph 6b(2). For systems classified with catastrophic failure conditions (Level A systems), follow compliance steps 2 through 15 listed below, as appropriate. These compliance steps are also depicted in figures 1 and 2 of this AC, and are not necessarily accomplished sequentially. Systems classified with hazardous or major failure conditions (Level B and C systems) should follow the compliance steps outlined in paragraph 10.

b. Step 2 — Define Aircraft and System HIRF Protection. Define the HIRF protection features to be incorporated into the aircraft and system designs, based on the HIRF environments that are applicable to your aircraft and its level A systems. Equipment, system, and aircraft HIRF protection design may occur before aircraft-level tests are performed, and before the actual internal HIRF environment is determined. Therefore, the equipment, system and aircraft HIRF protection design should be based on an estimate of the expected internal HIRF environment. Consider all aircraft configurations that may affect HIRF protection, such as open landing gear doors (see step 7).

c. Step 3 — System Assessment Decision. Determine if you will perform integrated system HIRF tests on the level A system, or if you will base the system verification on previous integrated system HIRF tests performed on a similar system. Aircraft and system tests and assessments need not be performed for the HIRF environments above 18 GHz if data and design analysis show the integrated system tests results (see step 5) satisfy the pass criteria from 12 GHz to 18 GHz, and the systems have no circuits that operate in the 18 GHz to 40 GHz frequency range.

d. Step 4 — Equipment Test.

(1) Radiated and conducted RF susceptibility laboratory tests of RTCA/DO-160E (or latest version), Section 20, may be used to build confidence in the equipment's HIRF immunity before conducting integrated system laboratory tests in step 5. The equipment should be tested in accordance with the test levels (wire bundle currents and RF field strengths) of RTCA/DO-160, Section 20 or to a level estimated for the aircraft and equipment installation using the applicable external HIRF environment.

(2) Equipment HIRF tests may be used to augment the integrated system HIRF tests where appropriate. For equipment whose HIRF immunity is evaluated as part of the integrated system-level HIRF tests discussed in step 5, the individual equipment's HIRF testing described in this step is optional.

e. Step 5 — Integrated System Test.

(1) Radiated and conducted RF susceptibility laboratory tests on an integrated system should be performed for level A systems. The HIRF field strengths and wire bundle currents selected for this test should be based on the attenuated external HIRF environment determined in

the aircraft assessment (see Steps 10, 11, or 12). In many cases, the integrated system test is performed before the aircraft assessment is complete. In these cases, the integrated system test field strengths and currents should be selected based on the expected aircraft attenuation or transfer function.

(2) The installation details for the laboratory integrated system tests should be similar to the installation in the aircraft. For example, the bonding and grounding of the system, wire size, routing, arrangement (whether parallel or twisted wires), connector types, wire shields, and shield terminations, and the relative position of the elements to each other and the ground plane in the laboratory should closely match the system installation on the aircraft to be certificated. For this reason, the laboratory integrated system rig should have an FAA conformity inspection prior to conducting any FAA certification credit testing.

(3) The integrated system should be tested with the system operating, to include connected displays, sensors, actuators, and other equipment. Place the system in various operating modes to ensure the integrated system is tested when operating at its maximum sensitivity. If the connected equipment is not related to the functions with catastrophic failures, these items may be simulated by test sets, if the test sets accurately represent the terminating circuit impedance of the sensor. However, the connected equipment should meet the appropriate HIRF requirements required for their failure condition classification.

(4) The test levels should be selected based on the expected aircraft internal HIRF environment determined through aircraft tests (see step 10), generic transfer functions “for level A display systems only” and attenuation (see step 11), or aircraft similarity assessment (see step 12), using the applicable external HIRF environment. Integrated system test procedures are described in detail in the User's Guide (SAE ARP 5583A/EUROCAE ED-107A).

(5) Wire bundle current injection should be used for frequencies from 10 kHz to 400 megahertz (MHz). RF currents are injected into the integrated system wiring via a current transformer. Each wire bundle in the system should be injected and the induced wire bundle current measured. If a system wire bundle branches, then each wire bundle branch should also be tested. Simultaneous multi-bundle current injection may be necessary on systems with redundant or multi-channel architectures.

(6) High-level radiated susceptibility tests should be used at frequencies greater than 100 MHz. The radiating antenna should be far enough away to ensure the total volume of the equipment and at least half a wavelength of the wiring is simultaneously and uniformly illuminated during the test.

(7) Define appropriate pass/fail criteria for the system, based on the system safety assessment and the appropriate HIRF regulation. Any system susceptibility, including system malfunctions such as displaying hazardously misleading information, upset, or damage should be recorded and evaluated based on these previously defined pass/fail criteria.

(8) Using only the modulation to which the system under evaluation is most sensitive may minimize the test time. The User's Guide provides guidance on modulation selection and suggested default modulations and dwell times.

(9) The equipment tests in step 4, using the techniques in RTCA/DO-160E (or latest version), Section 20, normally are not sufficient to show HIRF compliance for step 5. However, these standard RTCA/DO-160, Section 20 tests may be sufficient if paragraphs 9e(2) and (3) of this step are met.

f. Step 6 — System Similarity Assessment.

(1) The integrated system HIRF tests performed for a system previously certified on one aircraft model may be used to demonstrate system verification for a similar system. Each system considered under the similarity approach needs to be assessed independently even if it may use equipment and installation techniques from previous certification projects.

(2) The system used as the basis for similarity must have successfully completed integrated system HIRF tests. Similarity assessment requires comparison of both equipment and installation differences that could adversely effect HIRF immunity. The assessment should evaluate the differences between the previously HIRF certified system and the equipment circuit interfaces, wiring, grounding, bonding, connectors, and wire-shielding practices of the equipment that comprise the new system.

(3) If the assessment finds only minimal differences between the previously certified system and the new system to be certified, similarity may be used as the basis for system-level verification without the need for additional integrated system tests, providing there are no unresolved in-service HIRF problems related to the previously certified system. If there is uncertainty about the effects of the differences, additional tests and analysis should be conducted as necessary and appropriate to resolve the uncertainty. The amount of additional testing should be commensurate with the degree of difference identified between the new system and the system previously certified. If significant differences are found, similarity should not be used as the basis for system-level verification.

g. Step 7 — Aircraft Assessment Decision.

(1) Level A systems require an aircraft assessment. The aircraft assessment should determine the actual internal HIRF environment where the level A systems are installed in the aircraft. You should choose whether you will use aircraft tests, previous coupling/attenuation data from similar aircraft types (similarity). For level A display systems only, use the generic transfer functions and attenuation in appendix 1 to this AC. Alternately, the aircraft assessment may be a test that exposes the entire aircraft with operating level A systems to external HIRF environments I, II, or III (tables 2, 3, and 4, respectively), as appropriate, to demonstrate acceptable level A system performance.

(2) Integrated display systems include the display equipment, control panels, and the sensors that provide information to the displays. In some systems, the sensors also provide information to level A systems that are not displays. For example, if the sensors also provide

information to Level A flight controls, you must use actual transfer functions and attenuation when demonstrating compliance for these sensors and the flight controls.

(3) Other methods for aircraft HIRF assessment, such as analysis, may be acceptable. However, comprehensive modeling and analysis for RF field coupling to the aircraft structure is an emerging technology. Therefore, analysis alone is currently not adequate to show HIRF compliance for level A systems and should be augmented by testing.

(4) If analysis is used to determine aircraft attenuation and transfer function characteristics, test data should be provided to support this analysis. Any analysis results should take into account the quality and accuracy of the analysis. Significant testing, including aircraft level testing, is required to support the analysis.

(5) Aircraft and system tests and assessments need not be performed for the HIRF environments above 18 GHz if data and design analysis show the integrated system tests results (see step 5) satisfy the pass criteria from 12 GHz to 18 GHz, and the systems have no circuits operating in the 18 GHz to 40 GHz frequency range.

h. Step 8 — Aircraft Test Decision.

(1) Various aircraft test procedures are available and accepted for collecting data for aircraft HIRF verification. The two main approaches to aircraft testing are the aircraft high-level test (see step 9) and the aircraft low-level coupling test (see step 10). The aircraft high-level field-illumination test involves radiating the aircraft at test levels equal to the applicable external HIRF environment in the HIRF regulations. Aircraft low-level coupling tests involve measuring the airframe attenuation and transfer functions, so that the internal HIRF electric fields and currents can be compared to the integrated system test levels.

(2) Some test procedures may be more appropriate than others because of the size of the aircraft and the practicality of illuminating the entire aircraft with the appropriate external HIRF environment. The aircraft low-level coupling tests (see step 10) may be more suitable for testing large aircraft than the high-level field-illumination test in step 9, which requires illumination of the entire aircraft with the external HIRF environment.

i. Step 9 — Aircraft High-Level Tests.

(1) The aircraft high-level field-illumination test requires generating RF fields external to an aircraft at a level equal to the applicable external HIRF environment.

(2) At frequencies below 400 MHz, the distance between the aircraft and the transmitting antenna should be sufficient to ensure the aircraft is illuminated uniformly by the external HIRF environment. The transmit antenna should be placed in at least four positions around the aircraft. For airplanes, the antenna is typically placed to illuminate the nose, tail, and each wingtip. For rotorcraft, the antenna is typically placed to illuminate the nose, tail, and each side. The aircraft should be illuminated by the antenna at each position while sweeping the frequency range. Perform separate frequency sweeps with the transmit antenna oriented for

horizontal and vertical polarization. The RF field should be calibrated by measuring the RF field strength in the center of the test volume before the aircraft is placed there.

(3) At frequencies above 400 MHz, the RF illumination should be localized to the system under test, provided all parts of the system and at least one wavelength of any associated wiring (or the total length if less than one wavelength) are illuminated uniformly by the RF field. You may need reflection planes to illuminate relevant apertures on the bottom and top of the aircraft.

(4) To ensure the systems are tested when operating at their maximum sensitivity, level A systems should be fully operational and the aircraft should be placed in various simulated operating modes.

(5) The test time can be minimized by using only the modulation to which the system under evaluation is most sensitive. If you do this, the rationale used to select the most sensitive modulation should be documented in the HIRF test plan as discussed in paragraph 8b(1). The User's Guide provides guidance on modulation selection and suggested default modulations and dwell times.

(6) As an alternative to testing at frequencies below the first airframe resonant frequency, it is possible to inject high-level currents directly into the airframe using aircraft high-level direct-drive test methods. Aircraft skin current analysis should be performed as described in the User's Guide, or low-level swept-current measurements should be made to determine the skin current distribution that will exist for different RF field polarizations and aircraft illumination angles so that these can be simulated accurately during this test. Aircraft high-level direct-drive testing, although applicable only from 10 kHz to the first airframe resonant frequency, is advantageous because it is possible to test all systems simultaneously.

j. Step 10 — Aircraft Low-Level Coupling Tests.

(1) General.

(a) The aircraft low-level coupling tests include three different tests that cover the frequency range of 10 kHz to 18 GHz (see figure 2). Detailed descriptions are available in the User's Guide. Other techniques may be valid, but must be discussed with and approved by the FAA before being used.

(b) The low-level direct-drive test (see step 10b, figure 2) and the low-level swept-current test (see Step 10c) are used for frequencies at or below 400 MHz. The low-level swept-field test (see Step 10d) is used for frequencies at and above 100 MHz. There is an overlap of test frequencies from 100 MHz to 400 MHz in the low-level swept-current test and the low-level swept-field test. The division at 400 MHz is not absolute but rather depends on when HIRF penetration of the equipment case becomes a significant factor.

(2) Steps 10a and 10b — Aircraft Skin Current Analysis and Low-Level Direct-Drive Test. Low level direct-drive tests in conjunction with skin current analysis should be used to determine the transfer function between the skin current and individual equipment wire bundle

currents. The low-level direct-drive test is typically used for frequencies from 10 kHz to the first airframe resonant frequency. For the low-level direct-drive test to be applied successfully, a three dimensional model of the aircraft should be derived using aircraft skin current analysis. The three dimensional model can then be used to derive the aircraft's skin current pattern for the applicable external HIRF environment. Guidance on skin current analysis is in the User’s Guide. If the relationship between the external HIRF environment and the skin current is known for all illumination angles and polarization, either because of aircraft skin current analysis or the use of the low-level swept-current test, the skin current can be set up by direct injection into the airframe. The resultant currents on the system wire bundles are measured with a current probe and normalized to 1 V/m electric field strength so they can be scaled to the appropriate external HIRF environment. The low-level direct-drive test is more effective than low-level swept-current tests for frequencies from 10 kHz to the first airframe resonant frequency, and may be necessary for small aircraft or aircraft with high levels of airframe shielding.

(3) Step 10c — Low-Level Swept-Current Test.

(a) The low-level swept-current test involves illuminating the aircraft with a low-level external HIRF field to measure the transfer function between the external field and the aircraft and equipment wire bundle currents. This test is typically used in the frequency range of 500 kHz to 400 MHz. The transfer function is resonant in nature and is dependent on both the aircraft structure and the system installation. Because the transfer function relates wire bundle currents to the external field, the induced bulk current injection test levels can be related to an external HIRF environment.

(b) The transmit antenna should be placed in at least four positions around the aircraft, with the distance between the aircraft and the transmitting antenna sufficient to ensure the aircraft is illuminated uniformly. For airplanes, the antenna is typically placed to illuminate the nose, tail, and each wingtip. For rotorcraft, the antenna is typically placed to illuminate the nose, tail, and each side. The aircraft should be illuminated by the antenna at each position while sweeping the frequencies in the range of 500 kHz to 400 MHz. Perform separate frequency sweeps with the transmit antenna oriented for horizontal and vertical polarization. Measure the currents induced on the aircraft wire bundles.

(c) Calculate the ratio between the induced wire bundle current and the illuminating antenna field strength and normalize this ratio to 1 V/m. This provides the transfer function in terms of induced current per unit external field strength. Then the current induced by the applicable external HIRF environment can be calculated by multiplying the transfer function by the external HIRF field strength. The calculated HIRF currents for all transmit antenna positions for each aircraft wire bundle being assessed should be overlaid to produce worst-case induced current for each wire bundle. These worst-case induced currents can be compared with the current used during the integrated system test in step 5.

(4) Step 10d — Low-Level Swept-Field Test. Low-level swept-field testing is typically used from 100 MHz to 18 GHz. The test procedures for the low-level swept-field test are similar to those used for the low-level swept-current test; however, in the low-level swept-field test, the internal RF fields in the vicinity of the equipment are measured instead of the wire

bundle currents. Various techniques can be used to ensure the maximum internal field in the vicinity of the equipment is measured. Depending on the size of the aircraft and the size of the aircraft cabin, flight deck, and equipment bays, multipoint measurement or mode stirring can be used to maximize the internal field in the vicinity of the equipment. See the User's Guide for detailed low-level swept-field test procedures.

k. Step 11 — Generic Transfer Functions and Attenuation - Level A Display Systems Only.

(1) Level A displays involve functions for which system information is displayed directly to the pilot. For level A display systems, the aircraft attenuation data may be determined using generic attenuation and transfer function data. This approach should not be used for other level A systems, such as control systems, because failures and malfunctions of those systems can more directly and abruptly contribute to a catastrophic failure event than display system failures and malfunctions; therefore, other level A systems should have a more rigorous HIRF compliance verification program.

(2) The integrated system test levels specified in step 5 may be derived from the generic transfer functions and attenuation for different types of aircraft. Acceptable transfer functions for calculating the test levels are given in appendix 1 to this AC. Appendix 1 to this AC also contains guidelines for selecting the proper generic attenuation. The generic transfer functions show the envelope of the currents that might be expected to be induced in the types of aircraft in an external HIRF environment of 1 V/m. The current levels should be multiplied linearly by HIRF environment I, II, or III, as appropriate, to determine the integrated system test levels.

(3) The internal HIRF electric field levels are the external HIRF environment divided by the appropriate attenuation, in linear units. For example, 20 dB or a 10:1 attenuation means the test level is the applicable external HIRF environment electric field strength reduced by a factor of 10.

(4) The internal HIRF environments for level A display systems can also be measured using on-aircraft low-level coupling measurements of the actual system installation (see step 10). This procedure should provide more accurate information to the user, and the test levels may be lower than the generic transfer functions or attenuation, which are worst-case estimates.

l. Step 12 — Aircraft Similarity Assessment.

(1) The aircraft attenuation and transfer functions tests performed for a previously certified aircraft may be used to support aircraft-level verification for a similar aircraft model. The aircraft used as the basis for similarity must have been previously certified for HIRF compliance, using HIRF attenuation and transfer functions determined by tests on that aircraft.

(2) The similarity assessment for the new aircraft should consider the aircraft differences that could impact the internal HIRF environment affecting the level A systems and associated wiring. The comparison should consider equipment and wiring locations, airframe materials and construction, and apertures that could affect attenuation for the external HIRF environment.

(3) If the assessment finds only minimal differences between the previously certified aircraft and the new aircraft to be certified, similarity may be used to determine aircraft attenuation and transfer functions without the need for additional aircraft tests, providing there are no unresolved in-service HIRF problems related to the existing aircraft. If there is uncertainty about the effects of the differences, additional tests and analysis should be conducted as necessary and appropriate to resolve the uncertainty. The amount of additional testing should be commensurate with the degree of difference identified between the new aircraft and the aircraft previously certified. If significant differences are found, similarity should not be used as the basis for aircraft-level verification.

m. Step 13 — Assess Immunity.

(1) Compare the test levels used for the integrated system test of step 5 with the internal RF current or RF fields determined by the aircraft low-level coupling tests (see step 10), the generic transfer functions and attenuation (see step 11), or the aircraft similarity assessment (see step 12). The actual aircraft internal RF currents and RF fields should be lower than the integrated system test levels. Your comparison method should be included in the HIRF compliance plan. The method should enable a direct comparison between the system test level and the aircraft internal HIRF environment at the equipment or system location, using current for frequencies from 10 kHz through 400 MHz, and using electric field strength for frequencies from 100 MHz through 18 GHz.

(2) If the conducted RF susceptibility test levels used for the integrated system test (see step 5) were too low when compared with the aircraft-induced currents determined in steps 10b, 10c, 11 or 12, then corrective measures are needed (see step 14). If the radiated RF susceptibility test levels used for integrated system tests (see step 5) were too low when compared with the aircraft internal fields determined in steps 10d, 11 or 12, then corrective measures are needed (see step 14).

(3) When comparing the current measured during low-level swept-current tests in step 10c with the current used during the integrated system tests in step 5, there may be differences. These differences may be due to variations between the actual aircraft installation and the integrated system laboratory installation, such as wire bundle lengths, shielding and bonding, and wire bundle composition. The worst-case current signature for a particular wire bundle should be compared to the current induced at the particular test level or equipment malfunction over discrete frequency ranges such as 50 kHz to 500 kHz, 500 kHz to 30 MHz, and 30 MHz to 100 MHz. This comparison should be broken into discrete frequency ranges because the resonant frequencies may differ between the integrated system tests and the aircraft tests.

(4) If you used aircraft high-level tests (see step 9) for aircraft HIRF verification, you should determine if there were any level A system susceptibilities. Any level A system susceptibilities should be evaluated based on the pass/fail criteria as established in the test plan (see paragraphs 8b(1)). If the HIRF susceptibilities are not acceptable, then corrective measures may be needed (see step 14).

(5) HIRF susceptibilities that were not anticipated or defined in the test plan pass/fail criteria may be observed during aircraft high-level tests or integrated system laboratory tests. The pass/fail criteria may be modified if the effects neither cause nor contribute to conditions that adversely affect the aircraft functions or systems in the HIRF regulations. You should provide an assessment and supporting rationale for any modifications to the pass/fail criteria to the FAA for approval. If the HIRF susceptibilities are not acceptable, then corrective measures may be needed (see Step 14).

(6) If the level A systems show no adverse effects when tested to levels derived from the applicable HIRF environment I or III, this also demonstrates compliance of the system with HIRF environment II.

(7) If the integrated system tests results (see step 5) satisfy the pass criteria from 12 GHz to 18 GHz, and design analysis shows the system has no circuits operating in the 18 GHz to 40 GHz frequency range, this demonstrates by analysis the system is not adversely affected when exposed to HIRF environments above 18 GHz. If these conditions are satisfied, further aircraft and system tests and assessments above 18 GHz are not necessary.

(8) Review the actual system installation in the aircraft and the system configuration used for the integrated system test (see step 5). If significant configuration differences are identified, corrective measures may be needed (see step 14).

(9) Certain RF receivers with antennas connected should not be expected to perform without effects during exposure to the HIRF environments, particularly in the RF receiver operating band. Because the definition of adverse effects and the RF response at particular portions of the spectrum depends on the RF receiver system function, refer to the individual RF receiver minimum performance standards for additional guidance. However, because many RF receiver minimum performance standards were prepared before implementation of HIRF requirements, the RF receiver pass/fail criteria should be coordinated with the FAA.

(10) You should provide the similarity assessment and supporting rationale to the FAA for approval.

n. Step 14 — Corrective Measures. Take corrective measures if the system fails to satisfy the HIRF immunity assessment of step 13. If changes or modifications to the aircraft, equipment, system or system installation are required, then additional tests may be necessary to verify the effectiveness of the changes. The RTCA/DO-160E or latest version, Section 20 equipment tests, integrated system tests, and aircraft tests, in whole or in part, may need to be repeated to show HIRF compliance.

o. Step 15 — HIRF Protection Compliance. Submit the test results and compliance report to the cognizant FAA aircraft certification office for approval as part of the overall aircraft type certification or supplemental type certification process.

10. Steps to Level B and C System HIRF Compliance.

a. Step 1 — System Safety Assessment. Determine the system failure condition classification for the systems being certified on your aircraft, using a system safety assessment as discussed in paragraph 6b(2). For systems classified with hazardous or major failure conditions (Level B and C systems), follow compliance steps 2 through 8 listed below, as appropriate. These compliance steps are also depicted in figure 3 of this AC, and are not necessarily accomplished sequentially. Systems classified with catastrophic failure conditions (Level A systems) should follow the compliance steps outlined in paragraph 9.

b. Step 2 — Define Aircraft and System HIRF Protection. Define the HIRF protection features incorporated into the aircraft and system designs, based on the HIRF test levels applicable to your aircraft and its level B and C systems. Equipment, system, and aircraft HIRF protection design may occur before aircraft-level tests are performed, and before the actual internal HIRF environment is determined. Therefore the equipment, system and aircraft HIRF protection design should be based on an estimate of the expected internal HIRF environment.

c. Step 3 — Select Compliance Method. Determine if you will perform equipment HIRF tests on the level B and C systems, or if you will base the compliance on previous equipment tests performed for a similar system.

d. Step 4 — Equipment Test.

(1) Level B and level C systems do not require the same degree of HIRF compliance testing as level A systems, and therefore do not require aircraft-level testing. RTCA/DO-160E or latest version, Section 20 laboratory test procedures should be used, using equipment test levels defined in the regulations. The test levels used depend on whether the system is categorized as level B or C. Equipment HIRF test level 1 or 2, as applicable, should be used for level B systems. RTCA/DO-160 Section 20, Category RR (using the alternative modulation for radiated susceptibility), satisfies the requirements of equipment HIRF test level 1. For equipment HIRF test level 2, you may use the approach in paragraph 9k to help determine acceptable aircraft transfer function and attenuation curves for your level B system. Equipment HIRF test level 3 should only be used for level C systems. RTCA/DO-160 Section 20, Category TT, satisfies the requirements of equipment HIRF test level 3. When applying modulated signals, the test levels are given in terms of the peak of the test signal as measured by a root-mean-square (rms)-indicating spectrum analyzer's peak detector. See the User's Guide (SAE ARP 5583A/ EUROCAE ED-107A) for more details on modulation.

(2) Define appropriate pass/fail criteria for the system, based on the system safety assessment and the appropriate HIRF regulation (see paragraph 6b(2)). Any susceptibility noted during the equipment tests, including equipment malfunctions, upset, or damage, should be recorded and evaluated based on the defined pass/fail criteria.

e. Step 5 — Similarity Assessment.

(1) The equipment HIRF tests performed for a system previously certified on one aircraft model may be used to show compliance for a similar system. Each system considered for similarity needs to be assessed independently even if it used equipment and installation techniques from a previous certification.

(2) The system used as the basis for certification by similarity must have successfully completed equipment HIRF tests and previously certified for HIRF compliance on another aircraft model. Similarity assessment requires comparison of both equipment and installation differences that could adversely effect HIRF immunity. An assessment of a new system should consider the differences in the equipment circuit interfaces, wiring, grounding, bonding, connectors, and wire-shielding practices.

(3) If the assessment finds only minimal differences between the previously certified system and the new system to be certified, similarity may be used for HIRF compliance without the need for additional equipment HIRF tests, providing there are no unresolved in-service HIRF problems related to the previously certified system. If there is uncertainty about the effects of the differences, additional tests and analysis should be conducted as necessary and appropriate to resolve the uncertainty. The amount of additional testing should be commensurate with the degree of difference identified between the new system and the system previously certified. If significant differences are found, similarity should not be used as the basis for HIRF compliance.

f. Step 6 — Assess Immunity.

(1) Review the results of the equipment test to determine if the pass/fail criteria are satisfied. HIRF susceptibilities not anticipated or defined in the test plan pass/fail criteria may be observed during equipment HIRF tests. The pass/fail criteria may be modified if the effects neither cause nor contribute to conditions that adversely affect the aircraft functions or systems, as applicable, in the HIRF regulations. You should provide an assessment of, and supporting rationale for, any modifications to the pass/fail criteria to the FAA for approval. If the HIRF susceptibilities are not acceptable, then corrective measures may be needed (see step 7).

(2) Review the actual system installation in the aircraft and the configuration used for the equipment tests (see step 4). If significant differences in grounding, shielding, connectors, or wiring are identified, corrective measures may be needed (see step 7).

(3) Certain RF receivers with antennas connected should not be expected to perform without effects during exposure to the HIRF environments, particularly in the RF receiver operating band. Because the definition of adverse effects and the RF response at particular portions of the spectrum depends on the RF receiver system function, refer to the individual RF receiver minimum performance standards for additional guidance. However, because many RF receiver minimum performance standards were prepared before implementation of HIRF requirements, the RF receiver pass/fail criteria should be coordinated with the FAA. Future modifications of the minimum performance standards should reflect HIRF performance requirements.

g. Step 7 — Corrective Measures. Take corrective measures if the system fails to satisfy the HIRF immunity assessment of step 6. If changes or modifications to the equipment, system, or system installation are required, then additional tests may be necessary to verify the effectiveness of the changes. The RTCA/DO-160E or latest version, Section 20 equipment tests, in whole or in part, may need to be repeated to show HIRF compliance.

h. Step 8 — HIRF Protection Compliance. Submit the test results and compliance report to the cognizant FAA aircraft certification office for approval as part of the overall aircraft type certification or supplemental type certification process.

11. Maintenance, Protection Assurance, and Modifications.

a. The minimum maintenance required to support HIRF certification should be identified in instructions for continued airworthiness as specified in 14 CFR 23.1529, 25.1529, 25.1729, 26.11, 27.1529, and 29.1529, as appropriate. Dedicated devices or specific features may be required to provide HIRF protection for an equipment or system installation. Appropriate maintenance procedures should be defined for these devices and features to ensure in-service protection integrity. A HIRF protection assurance program may be necessary to verify that the maintenance procedures are adequate. The User's Guide (SAE ARP 5583A/EUROCAE ED-107A) provides further information on these topics.

b. The maintenance procedures should consider the effects of corrosion, fretting, flexing cycles, or other causes that could degrade these HIRF protection devices. Whenever applicable, specific replacement times of these devices and features should be identified.

c. Aircraft or system modifications should be assessed for the impact any changes will have on the HIRF protection. This assessment should be based on analysis and/or measurement.

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Airworthiness Division
Aircraft Certification Service

Appendix 1. Generic Transfer Functions and Attenuation

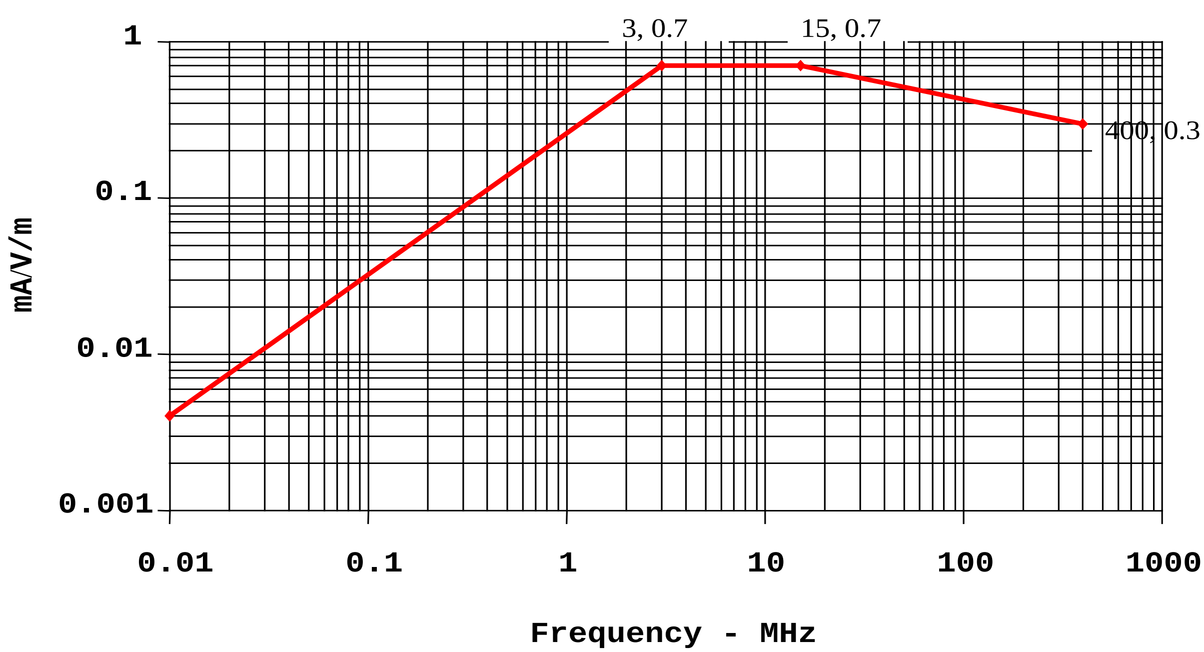
1. Generic Transfer Functions.

a. Suitable transfer functions for calculating the bulk current injection test levels for level A display systems (see paragraph 9k) are given in figures A1-1 through A1-5. These are derived generic transfer functions acquired from test results obtained from a significant number of aircraft. The test results were processed to establish a 95 percent population probability.

b. The transfer functions are normalized to a 1 V/m HIRF environment and may be multiplied linearly by the external HIRF environment to establish the bulk current injection test level requirements in the frequency range from 10 kHz up to 400 MHz. For example, if the HIRF environment is 100 V/m at 3 MHz, then using figure A1-1, multiple 0.7 mA/V/m by 100 V/m to establish a test level of 70 milliamperes (mA).

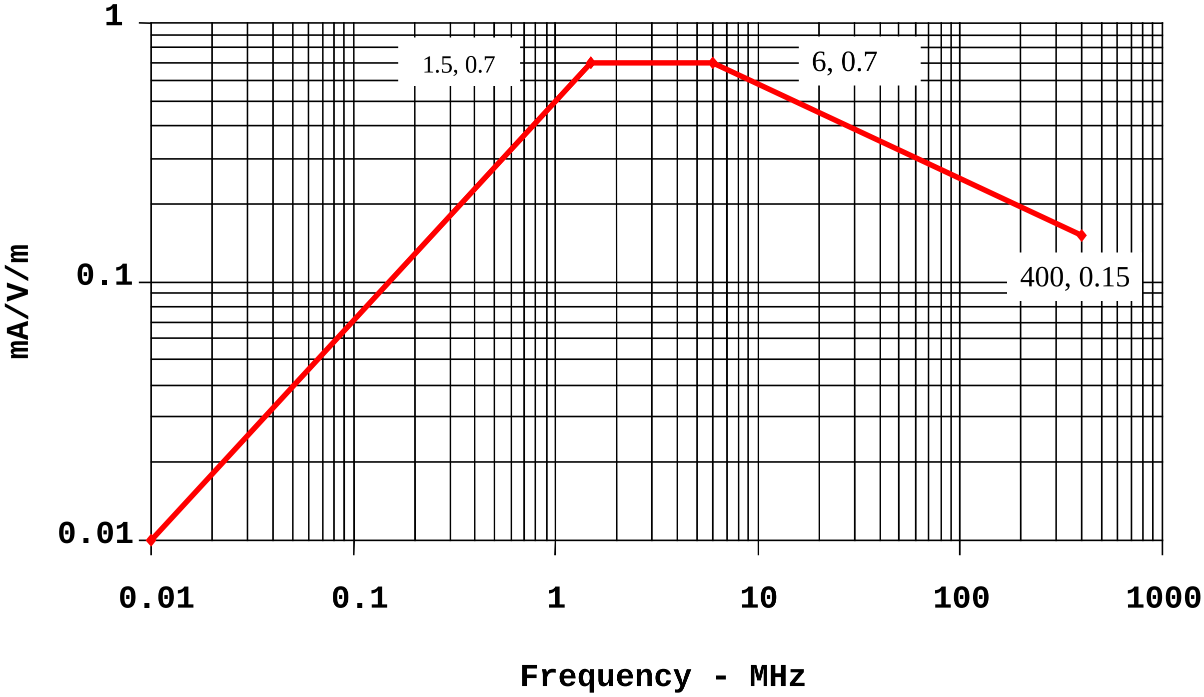
c. Consult the User's Guide (SAE ARP 5583A/EUROCAE ED-107A) for details on the use of generic transfer functions.

FIGURE A1-1 — Generic Transfer Function - Airplane



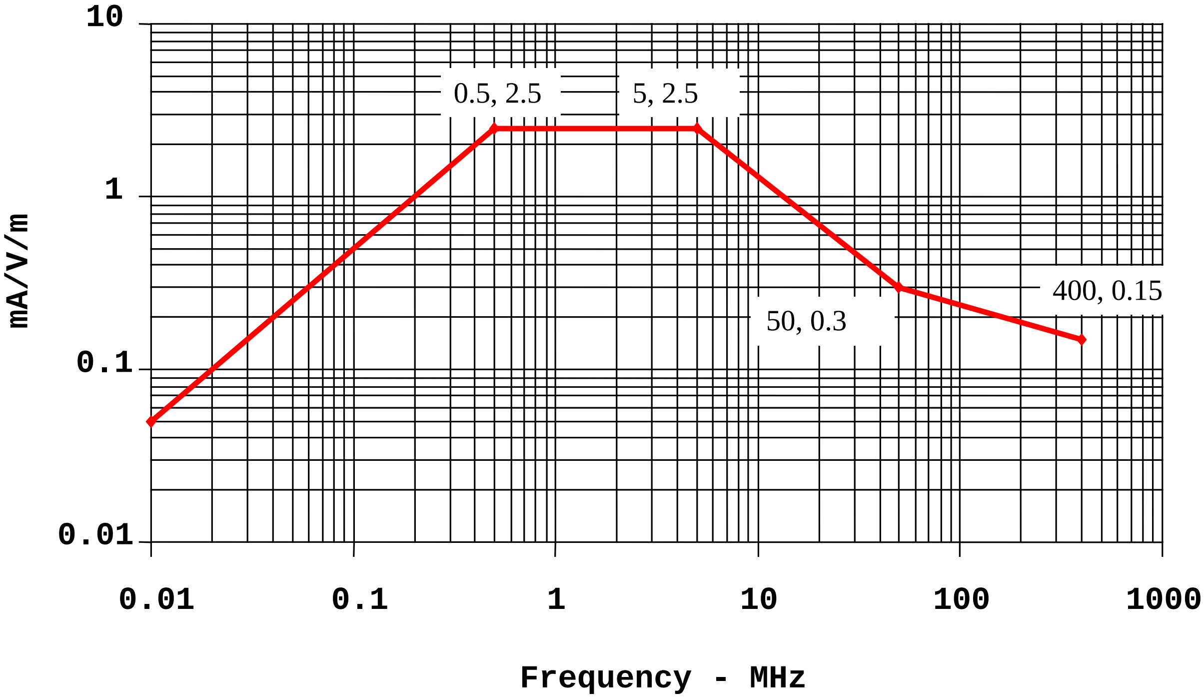
Note: Generic transfer function normalized to 1 V/m for an airplane with a fuselage length of ≤ 25m.

FIGURE A1-2 — Generic Transfer Function - Airplane



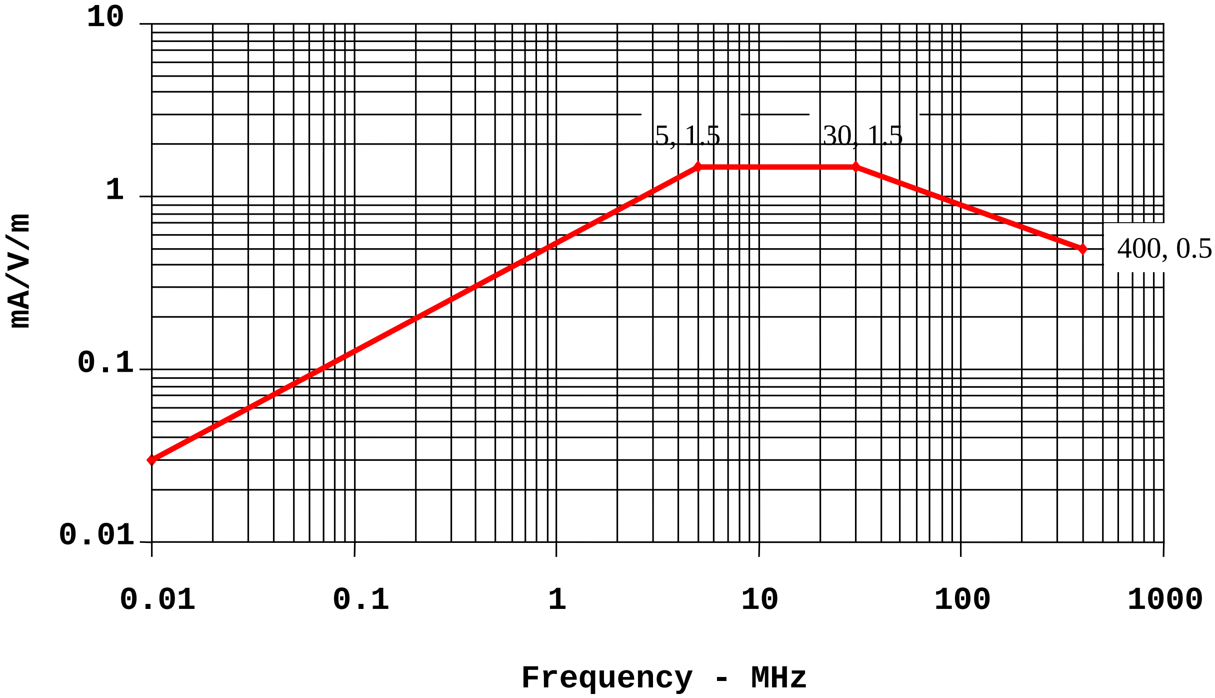
Note: Generic transfer function normalized to 1 V/m for an airplane with a fuselage length of > 25m and ≤ 50m.

FIGURE A1-3 — Generic Transfer Function - Airplane



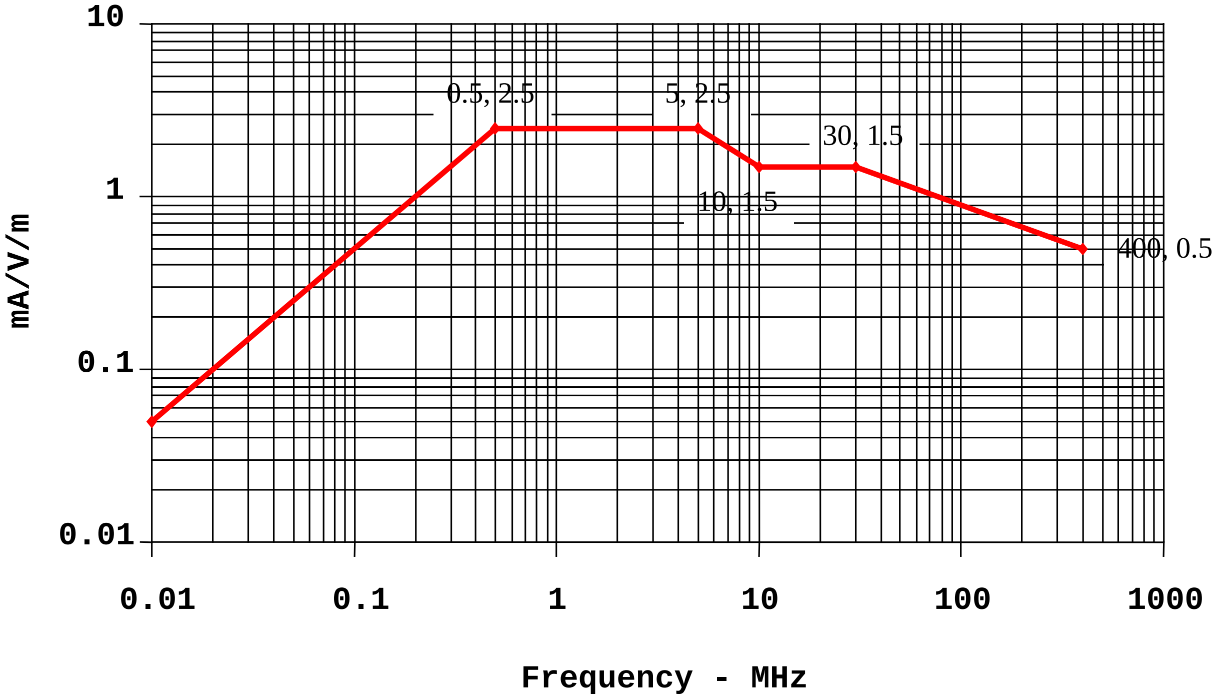
Note: Generic transfer function normalized to 1 V/m for an airplane with a fuselage length of > 50m.

FIGURE A1-4 — Generic Transfer Function - Rotorcraft



Note: Generic transfer function normalized to 1 V/m for a rotorcraft.

FIGURE A1-5 — Generic Transfer Function – All Aircraft



Note: Generic transfer function normalized to 1 V/m for all aircraft.

2. Generic Attenuation.

a. Figure A1-6 shows the generic attenuation for frequencies from 100 MHz to 18 GHz that can be used for determining the internal HIRF environment where equipment and associated wiring for level A display systems (see paragraph 9k) are installed. This internal HIRF environment provides the test level for the integrated system radiated susceptibility laboratory test. The external HIRF environment should be divided by the appropriate attenuation, in linear units, to determine the internal HIRF environment. For example, 12 dB or a 4:1 attenuation means the test level is the applicable external HIRF environment electric field strength reduced by a factor of 4.

b. Guidance on the use of the generic attenuation is given below:

(1) No Attenuation. No attenuation credit can be used when the level A display equipment and associated wiring are located in aircraft areas with no HIRF shielding, such as areas with unprotected nonconductive composite structures, areas where there is no guarantee of structural bonding, or other open areas where no shielding is provided. You may choose to use no attenuation for equipment that may be installed in a broad range of aircraft areas.

(2) 6 dB Attenuation. This attenuation is appropriate when the level A display equipment and associated wiring are located in aircraft areas with minimal HIRF shielding, such as a cockpit in a nonconductive composite fuselage with minimal additional shielding, or areas on the wing leading or trailing edges, or in wheel wells.

(3) 12 dB Attenuation. This attenuation is appropriate when the level A display equipment and associated wiring are located entirely within aircraft areas with some HIRF shielding, in aircraft with a metal fuselage or a composite fuselage with shielding effectiveness equivalent to metal. Examples of such areas are avionics bays not enclosed by bulkheads, cockpits, and areas near windows, access panels, and doors without EMI gaskets. Current-carrying conductors in this area, such as hydraulic tubing, control cables, wire bundles, and metal wire trays, are not all electrically bonded to bulkheads they pass through.

(4) 20 dB Attenuation. This attenuation is appropriate when the level A display equipment and associated wiring are located entirely within aircraft areas with moderate HIRF shielding, in aircraft with a metal fuselage or a composite fuselage with shielding effectiveness equivalent to metal. In addition, wire bundles passing through bulkheads in these areas have shields electrically bonded to the bulkheads. Wire bundles are installed close to metal structure and take advantage of other inherent shielding characteristics provided by metal structure. Current-carrying conductors, such as hydraulic tubing, cables, and metal wire trays are electrically bonded to all bulkheads they pass through.

(5) 32 dB Attenuation. This attenuation is appropriate when the level A display equipment and all associated wiring to and from equipment are located entirely within areas with very effective HIRF shielding to form an electromagnetic enclosure.

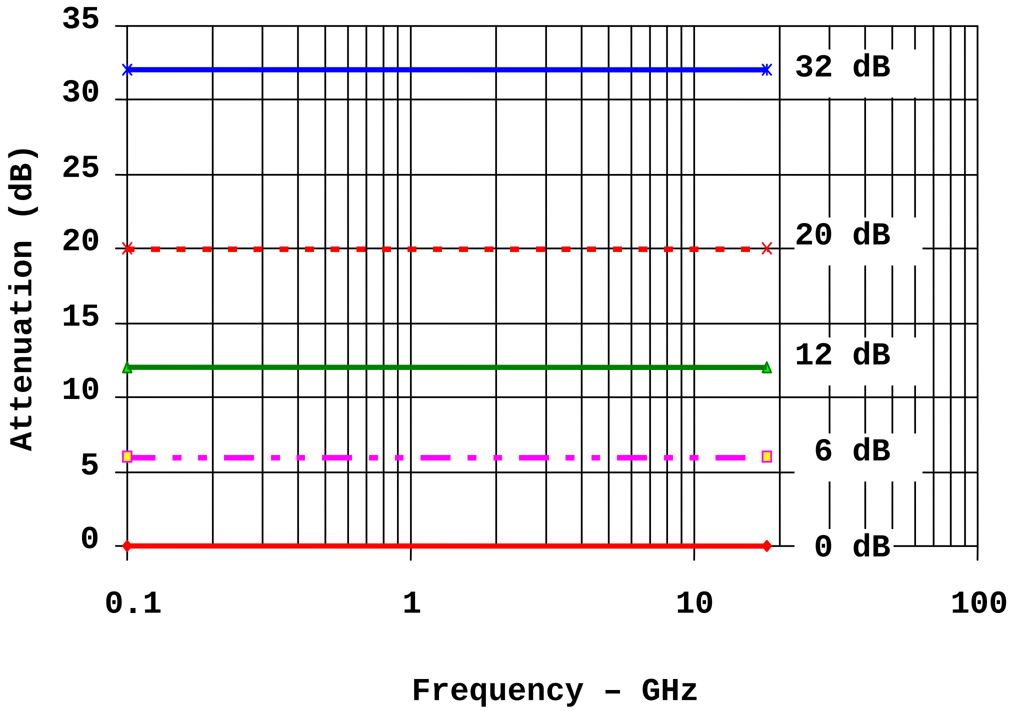
(6) Generic Attenuation for Rotorcraft. Display units installed in rotorcraft typically have minimal attenuation unless specific shielding is provided in the bulkhead, glare shield, panel, and doors.

c. Different attenuation values may be appropriate for different frequency ranges. For example, 0 dB attenuation may be used for the frequency range of 100 MHz to 400 MHz, 6 dB attenuation for the frequency range of 400 MHz to 1 GHz, and 12 dB attenuation for the frequency range of 1 GHz to 18 GHz. If you intend to use different attenuation values for various frequency ranges, then you should also provide the supporting rationale.

d. Consult the User's Guide for details on the use of generic attenuation.

3. Measured Transfer Functions or Attenuation. You can produce your own generic transfer functions and attenuation for your level A display systems (see paragraph 9k) based on actual measurements on your aircraft models. These transfer functions and attenuation can then be used in your HIRF compliance submission in place of the generic transfer functions and attenuation specified in this appendix. The FAA encourages this approach because it provides a more accurate reflection of the true internal HIRF environment for your aircraft models. However, if you intend to produce your own generic transfer functions and attenuation, then this approach should also be addressed in the HIRF compliance plan (see paragraph 8a) that is submitted to the FAA for approval.

FIGURE A1-6 — GENERIC ATTENUATION VALUES — All Aircraft
100 MHz to 18 GHz



Appendix 2. Advisory Circular Feedback Information

If you have comments or recommendations for improving this advisory circular (AC), or suggestions for new items or subjects to be added, or if you find an error, you may let us know about by using this page as a template and 1) emailing it to 9-AWA-AVS-AIR500-Coord@faa.gov or 2) faxing it to the attention of the AIR Directives Management Officer at 202-267-3983.

Subject: (insert AC number and title) Date: (insert date)

Comment/Recommendation/Error: (Please fill out all that apply)

An error has been noted:

Paragraph ____________________

Page ______

Type of error (check all that apply): Editorial:----- Procedural-----

Conceptual____

Description/Comments:____

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Recommend paragraph ______ on page ______ be changed as follows:
(attach separate sheets if necessary)

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In a future change to this advisory circular, please include coverage on the following subject: (briefly describe what you want added attaching separate sheets if necessary)

____

Name: ________________________