The NASA High Intensity Radiated Fields Laboratory

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ABSTRACT

High Intensity Radiated Fields (HIRF) are the result of a multitude of intentional and non-intentional electromagnetic sources that currently exists in the world. Many of today's digital systems are susceptible to electronic upset if subjected to certain electromagnetic environments (EME). Modern aerospace designers and manufacturers increasingly rely on sophisticated digital electronic systems to provide critical flight control in both military, commercial, and general aviation aircraft. In an effort to understand and emulate the undesired environment that high energy RF provides modern electronics, the Electromagnetics Research Branch (ERB) of the Flight Electronics and Technology Division (FETD) conducts research on RF and microwave measurement methods related to the understanding of HIRF. In the High Intensity Radiated Fields Laboratory, the effects of high energy radiating electromagnetic fields on avionics and electronic systems are tested and studied.

BACKGROUND

During the fall of 1992 it was determined that a capability to perform HIRF susceptibility evaluation of aircraft was required. After consultations with members of the appropriate standards committees, a determination was made that this capability should include Reverberation Chambers, Transverse Electromagnetic (TEM) and Gigahertz Transverse Electromagnetic (GTEM) Cells. The shielded rooms would conform to, or exceed, NSA 65-6 (RF Shielded Enclosures for Communications Equipment), MIL-STD-220A (Method of Insertion Loss Measurement), MIL-STD-285 (Attenuation Measurements for Enclosures Test Methods and related specifications for the containment, attenuation and control of radio frequency energy.

Figure 1: HIRF Lab NASA Langley

DESIGN

The design of NASA's HIRF Facility was a collaborative effort of NASA Langley, the National Institute of Standards and Technology [1], and the Naval Surface Warfare Center, Dalghren Virginia. After thorough consideration of the requirements, site limitations, and monetary constraints, a preliminary design was formulated. For the Reverberation Chambers the desired characteristics were High Q chambers with exceptional repeatability and field uniformity. The GTEM Cell would provide plane waves at frequencies not supported by the Reverberation Chambers. Capability to do true distributed testing was also desired. Therefore, the design included three Reverberation Chambers co-located to provide the capability to have three distinctly different RF environments. This would allow the simulation of the fields in any location in an aircraft such as a cockpit, passenger cabin and equipment bay simultaneously. A determination was made that to be a viable facility in the twenty first century the capability to perform evaluations up to 40 GHz would be required. This decision was result of the announcement by the FCC that licenses to operate in the 20 to 40 GHz range would be granted. It was not the intent for the facility to be a commercial certification lab, but to assist in the development of comprehensive standards and techniques for the evaluation of avionics systems, for both commercial and general aviation.

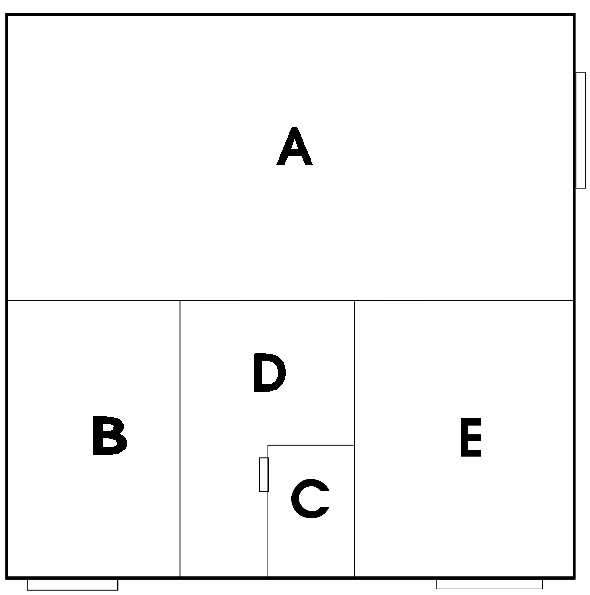

Figure 2: Reverberation Chamber Layout

DESCRIPTION

The HIRF Lab is located in building 1220 at NASA Langley Research Center Hampton, Virginia as seen in figure 1. The lab consists of five steel welded RF shielded rooms a GTEM and two TEM cells. Three of the rooms are test chambers, one is the amplifier room and the other a control room. The layout of the Reverberation Chambers is shown in figure 2. The three test chambers have attenuation to magnetic field of 120 db between 10Khz and 100 MHz. The attenuation to electric field is 120 dB between 10 kHz and 25 MHz and attenuation to plane waves of 120 db between 100Mhz and 40 GHz. The minimum operational frequencies of the test chambers are as shown in Figure 3.

CHAMBER	L	W	H	FREQ
A	47’	23’	9.5’	80 MHz
B	23’	13’	9.5’	150MHz
C	9’	7’	9.5’	250 MHz

Figure 3: Reverberation Chamber Operational Frequencies

Reverberation Chambers are basically a larger version of a consumer grade microwave oven. RF is transmitted into the chamber and is stirred by metallic paddles. The point at which 60 modes are achieved has been determined to be the minimum operational frequency. One of the unique features of these chambers is the corner located, floor to ceiling stirring mechanisms. This design provides enhanced stirring of RF energy providing greater field uniformity and repeatability.

Stirrers

The stirrer paddles are fabricated from machined 2” thick foam board. The board is bonded to aluminum rod with epoxy and the union of the two halves is secured with a layered fiberglass sheet. Each paddle is covered with .004” aluminum. All edges are covered with conductive aluminum tape .The paddles are then mounted in an aluminum hub attached to a steel shaft. There are two sets of four paddles for each of the stirrer assemblies in chambers A and B. Chamber C has a single set of four paddles. Stepper motors drive the paddles. These motors have the capability of 200,000 steps per revolution or to run continuously. A typical rate is one revolution per ten seconds. The stirrers are pictured in figure 4.

Figure 4: Stirrers in Chamber A

Experiment Control

The HIRF Lab uses Visual Engineering Environment for stirrer and test equipment control. The equipment is attached to a personal computer through a GPIB interface. Programmers generate graphical user interfaces for chamber calibration and experiment execution. Excell and Access are used for data manipulation, storage and retrieval.

Shielded Doors

Fully pneumatic sliding shielded doors are installed on all five rooms. The doors are equipped with auto-reverse bars and sliding thresholds. The sliding doors are steel, all-welded assemblies with pneumatic bladders. The doors are welded into a pocket assembly, and the doorframes are comprised of an internal frame covered with two shielding skins, that are mechanically attached to the leaf frame. The perimeter of the shielded skins mates with the two doorframes and all mating surfaces are coated with pure tin. Actuation of the doors to the closed position inflates the bladder, causing the shielded skins to expand outward within the confines of the steel frame. The doors have sliding thresholds that fold up during door closure.

Figure 5: Pneumatic doors

Power and Signal Filters

Each room is equipped with 220 VAC 3 phase 60 Hz, 110VAC 60Hz, 120VAC 400 Hz, 12VDC, 28 VDC, +- 15 VDC and +- 5VDC. Each outlet or circuit is individually filtered. The rational for individual filters was two fold, to prevent feedback and eliminate a single point of failure. All power is run to its appropriate filter, then into steel-welded trays that run under the shielded rooms. Access panels for all power are provided in the floors of all rooms. Grounding for all power is provided through a grounding stud located near chamber A. This stud is connected to grid which runs throughout the lab and then to earth ground.

Safety

Each door is equipped with an automatic reversing switch to prevent personnel from being injured during door closure. Once the doors are closed, a pneumatic visual indicator changes from green to red to indicate proper inflation. When proper inflation is achieved, approximately 60 Psi, a pneumatic switch is activated which allows operation of all high power amplifiers through an interlock system. A pneumatic emergency release valve is located inside each chamber to provide egress in the event of a door malfunction. Access to the shielded doors is computer controlled incorporating a Card Key system.
Included in the interlock system are 3 sets of NARDA SMARTS Area RF Monitors, which cover a frequency range of from 10 MHz to 40 GHz. When activated, these monitors provide an audible alarm and also place the amplifiers into standby mode. General Microwave personal RF monitors are provided for the lab staff to wear during operation of the facility.

PROJECT AND RESEARCH UTILIZATION

The HIRF Facility has been used for the illumination of production flight control computers, aircraft engine data processor systems and optical communications networks. High power isotropic field probes used in the health and safety industry were evaluated and modifications made to prevent failure. The facility has also been utilized for the electromagnetic radiated emissions testing of experiments flown on NASA's Space Shuttle and Russia's Space Station MIR (MIDAS and MDIM). The Facility is currently supporting the upset detection and analysis of a quad redundant flight control computer. The guidelines for the RF field levels used to illuminate the computer are from the recommendations by the SAE-AE4R advisory committee to the FAA for certification of aircraft electrical and electronic systems for operation in the high intensity radiated field's (HIRF) environment [2]

NIST CHARACTERIZATION

In the spring of 1996 during a six week period, the national Institute of Standards and Technology (NIST) performed various measurements in the three reverberation chambers located a NASA Langley Research Center. These measurements were compared to measurements taken in other reverberation chambers, including the chamber at NIST. In a preliminary report it was stated that as a result of their experience at the HIRF Lab, that stirrer design criteria quoted in past reports is not adequate. The data analysis of the measurements taken in the HIRF lab chambers indicates superior stirring when the mechanical size of the stirrers occupies a significant part of the room dimensions. It was also stated that the field uniformity and repeatability of the HIRF lab chambers was the best ever measured by NIST. It was recommended that other mode-stirred chamber operators seriously consider the design of the NASA stirrers when developing new facilities or modifying existing facilities. [3]

FACILITY MILESTONES

GTEM Delivery	March 93
Reverb Chamber Design Complete	March 93
Chamber Construction Complete	March94
Stirrers Installed	August 95
NIST Evaluation of Chambers	June 96

CONCLUSION

Reverberation Chambers are rapidly becoming an accepted method for the evaluation of electrical and electronic systems. [4] The method is not only used by government agencies but private industry as well. This method has also proven to be more cost effective and efficient than anechoic methods. [1] The facilities at NASA Langley's HIRF Lab are state of the art and have verified performance characteristics that set them apart from previous designs. The HIRF Lab is the only know facility capable of performing true distributed testing.

REFERENCES

1. M. L. Crawford, G. H. Koepke, NBS Technical Note 1092, April 1986

2. SAE-AE4R Committee report on proposed FAA Advisory Circular, Draft #16, August 9, 1993

3. Electromagnetic Fields Division, NIST, Summary memo on NASA Reverberation Chamber evaluation, 12 June, 1997

4. RTCA/DO-160D Environmental Conditions and Test Procedures for Airborne Equipment, Draft, July 12, 1996