Electromagnetic Compatibility Program to Accommodate a Spacecraft Magnetic Search Coil 1 Experiment

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ABSTRACT

A search coil is a very sensitive instrument that measures low frequency magnetic field radiation. in order for the search coil 10 achieve its objectives, an electromagnetic clean environment must be provided. On the spacecraft, there are many potential sources of low frequency magnetic field emitter. Consequently, a very stringent program is needed to control the emission from these sources. This paper describes the details of such a program.

SUMMARY

A search coil measures low frequency time varying magnetic fields. For deep space science applications, the main purpose of a search coil is to measure the: magnetic field component of the plasma waves that exist in a deep space environment. Due. to the tenuous nature of the space plasma, these plasma waves are usually of low frequencies (<100 kHz), and arc of low amplitude. The amplitude of the magnetic field component of these waves could be in the picoTesla range. in order to detect magnetic fields at very low amplitudes, the search coil must be of high sensitivity. A typical search coil consists of a solenoid with several thousand turns wound around a high permeability core.

The challenge for accommodating a search coil experiment onboard a spacecraft is to maintain the spacecraft free of electromagnetic interference such that the ambient low frequency AC magnetic emission noise level produced by spacecraft electrical and electromechanical subsystems is low compared to the expected signals from the space plasma. To illustrate the lightness of electromagnetic cleanliness control that is needed with a search coil, the allowable emission level from a source that is 3 meters away from the search coil is compared with the standard MIL_STD 4611) RE101 magnetic field allowable level (both

refer to the field measured at 0.5 meter from the source). Notice that the allowable levels driven by the search coil experiment are 100 dB lower than MIL_STD 4611) levels.

On the spat'cxrafl, magnetic field emitters can be divided into two categories. They are: (1) electromechanical devices, and (2) electronic circuits. Electromechanical devices, such as motors, shutters and scan actuators, arc. intense sources of AC magnetic field emissions. 1 'or example, a typical motor consists of magnets arranged in a multipole configuration. The configuration usually leads to a small but non-negligible leakage of steady state magnetic field. The magnitude of this leakage field could be in the range of ~1000 p']' (~1 nT) at a distance of 1 meter away from the motor. During the operation of the motor, the leakage magnetic field from the rotating magnets becomes a time varying (AC) magnetic field. The dominant frequency of this AC magnetic field is directly proportional to the angular speed of rotation and the number of poles in the motor. The peak amplitude of ibis AC field is essentially given by the steady leakage magnetic field. Referring to Figure 1, this field is usually substantially higher than the allowable levels (nT as opposed to p']').

The aluminum enclosures of electronics in a typical spacecraft subsystem provides inadequate or negligible attenuation to magnetic fields at frequencies below 1 k] Iz. For this mason, electronic circuits (primarily power converters) become sources of AC magnetic field emission if the current flowing in the circuits have AC components at frequencies less than 1 kl Iz. The current needed to drive a motor and the current drawn by a data 1/() board usually have these low frequency components. The most intense emitters of AC magnetic fields within electronic circuits are (1) magnetic components (e.g. transformers, inductors and chokes) and (2) current loops with large areas formed by circuit traces on the circuit boards. All these items have large magnetic dipole moments.

With potentially numerous AC magnetic field sources on board a spacecraft, a vigorous program must be in place to control emissions from all possible sources. This paper describes the activities that are in progress for the accommodation of a search coil experiment on the Cassini spacecraft. This program consists of early developmental testing 10 identify the sources, and the development of proper design guidelines for circuit and cable layout to minimize magnetic field emissions. The selection of the proper shielding materials and the

tradeoffs between different shielding techniques will also be discussed in Ibis paper.

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COMPARISON OF MIL-STD 461 RE101
vs.
SEARCH COIL ALLOWABLE LEVELS

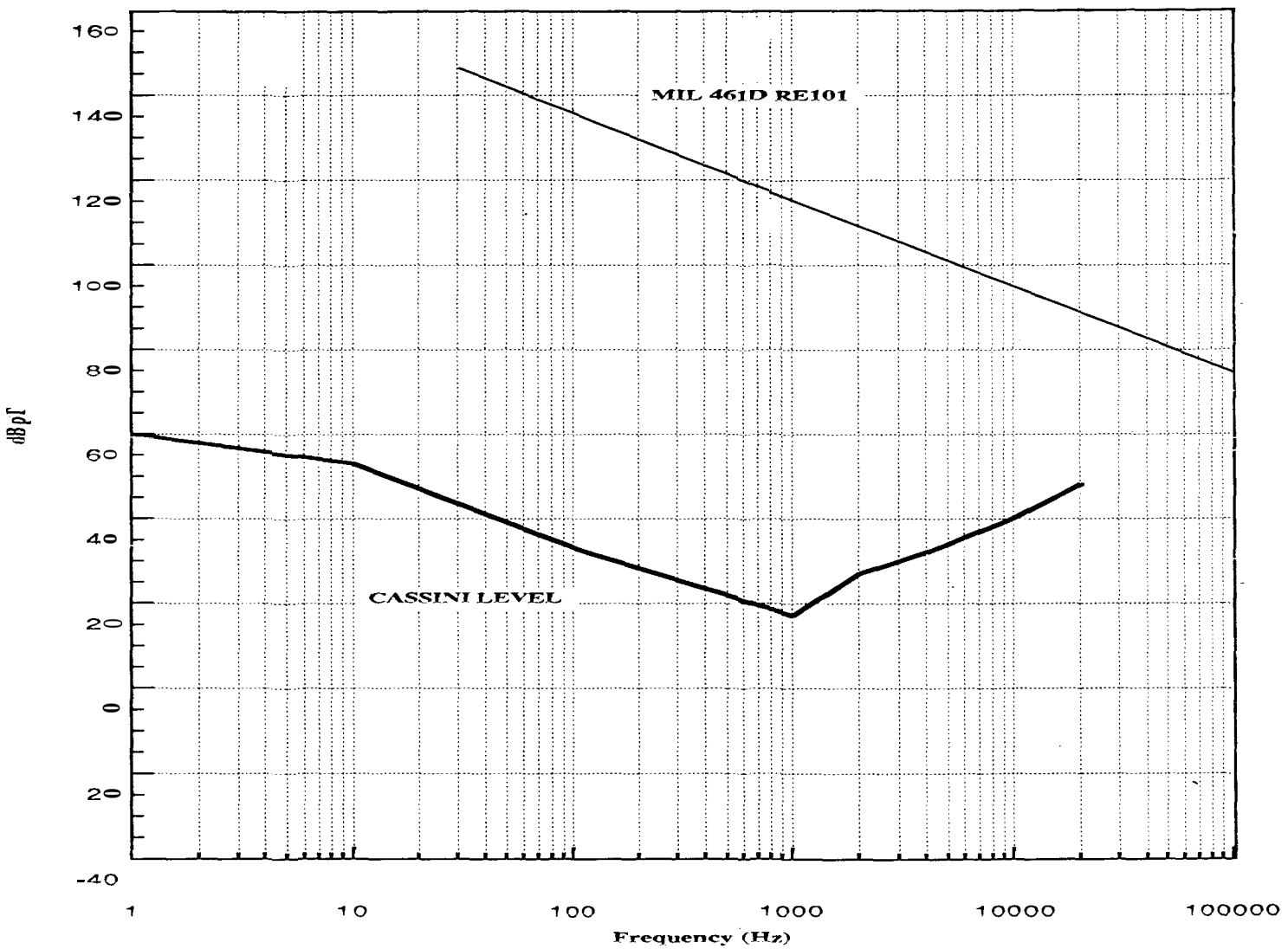

Figure 1. Allowable LFH emission levels vs MIL-STD 461 RE101 AC magnetic field levels at 0.5 meter away from the test article.