EMP Protection and Testing of HF Systems An Overview

Walter J. Scott
Analytic & Advisory Services
TASC, Inc.
Lorton, Virginia, USA

Michael R. Rooney
Survivability Assessments Branch
Defense Threat Reduction Agency
Ft. Belvoir, Virginia, USA

Abstract—**High Frequency (HF) communications are widely used for government, military and civilian infrastructure applications including emergency services. Survivable HF communications systems must be able to function after subjection to High Power Electromagnetic (HPEM) threats such as lightning and nuclear EMP. This paper presents an overview of a systematic method that can be used to Electromagnetic Pulse (EMP) harden and test typical unhardened HF transceiver systems. It begins with a basic analytical approach for determining the EMP-induced voltages and currents in HF antennas from an unclassified 50kV/m EMP environment[1]. These EMP-induced currents are usually sufficient to cause damage to HF equipment, so the next step in achieving a survivable system is to select a protection scheme that is capable of shunting these large currents to an Earth grounding point. There are many protection selection and implementation considerations that must be carefully dealt with in order to avoid adverse affects to normal HF transmit and receive functions, and even to avoid damage to the protective devices by the HF system itself. Finally there is a need to test the system in a high fidelity, threat-level EMP simulator to assess the performance of the hardening design and, for certain applications, to verify compliance with regulatory standards. For example, certain US military HF systems must meet the pass/fail requirements in MIL-STD-188-125-1[2] or MIL-STD-188-125-2[3].**

Keywords-HPEM, HF, system, EMP, hardening, testing, standards, antenna

I. INTRODUCTION

The paper begins with a discussion of the nuclear EMP threat waveform and employs the concept of antenna effective aperture and simple antenna reception equations to calculate the received power from the EMP waveform by the HF antenna's effective aperture. To simplify the analysis, local field reflections are ignored and a matched condition between the antenna and its load is assumed. The antenna manufacturer's literature can be consulted to provide the antenna's gain vs. frequency plot and, since HF antennas operate in the same bandwidth as an EMP, the flat part of the antenna spectrum may be used to specify antenna gain. With the foregoing data, the voltage at the antenna terminals can be calculated and used in the system hardening design.

II. HF SYSTEM HARDENING

Basic antenna equations are used to determine the antenna terminal voltage and current when it is illuminated by an EMP threat waveform. Using Thevenin's Theorem the open circuit voltage and short circuit current are found; short circuit current is then used as the worse-case current that the antenna protection scheme must shunt to Earth ground. An examination of the time history profile of the current indicates

that a device is needed with very low capacitance to handle the initial fast leading edge transition of the current waveform, and it also must be capable of diverting currents on the order of thousands of amperes. Consulting the product literature on fast, high current surge arresters indicates that a Gas Discharge Tube (GDT) is best suited for this application. Several GDT options available from one manufacturer are discussed in detail. The second part of the paper is concerned with hardening the electronics equipment: the transceiver, power amplifier, equalizer (flattener) and other typical HF system components. A brief discussion on shielded cabinets and point of entry treatments completes the hardening design.

III. HARDNESS VALIDATION

The final part of the paper discusses ways to validate the effectiveness of the hardening design through testing the hardened HF system in a threat-level EMP simulator. Measurement points in the system are identified and testing for compliance to certain military EMP protection standards is described. An example system will be described.

REFERENCES

[1] MIL-STD-464 Electromagnetic Environmental Effects Requirements For Systems, December 2010

[2] MIL-STD-188-125-1 High-Altitude Electromagnetic Pulse (HEMP) Protection For Ground-Based C^4I Facilities Performing Critical, Time-Urgent Missions, Part 1 Fixed Facilities, 17 July 1998

[3] MIL-STD-188-125-2 High-Altitude Electromagnetic Pulse (HEMP) Protection for Ground-Based C^4I Facilities Performing Critical, Time-Urgent Missions, Part 2 Transportable Systems, 3 March 1999