COMPUTER AIDED EMC ANALYSIS FOR ELECTRONIC SYSTEMS

EMC/IAP SUPPORT CENTER

The Electromagnetic Compatibility Intrasystem Analysis Program (EMC/IAP) Support Center, a government-funded Center run under contract to IIT Research Institute, is in its fourth year of operation under the aegis of the Rome Air Development Center, Compatibility Techniques Section (RADC/RBCT). The Support Center, located at Griffiss AFB, can deal with all government agencies, as well as contractors, with emphasis on the promotion of information transfer between the research and development community and the EMC-user community.

The Center's charter is to update and maintain IAP software codes which have been developed by the government. The primary code being maintained is the Intrasystem Electromagnetic Compatibility Analysis Program (IEMCAP), which was developed by an aircraft company in the early 70s.

IEMCAP is a system level code which permits prediction of possible interference at any designated receptor point (called a port) through calculation of the average power present at that port caused by all identified emitters. This power is then compared to the designated susceptibility. The following IEMCAP modifications and enhancements are being developed for inclusion in future versions of the code.

a) incorporation of a line-printer graphics option that will plot received signal power levels vs. receiver sensitivity;
b) an EMC/EMI interference matrix as part of the standard output which will summarize the port-pair integrated margin results;
c) incorporation of additional modulation models (e.g., phase modulation and related subsets);
d) antenna-to-antenna propagation model allowing for coupling through the fuselage skin for in-board ports;
e) new capability for nonlinear analysis models;
f) new port spectral models (replaces port spectrum quantization).

Other codes supported by the Center include the General Electromagnetic Model for the Analysis of Complex Systems (GEMACS), which uses a method of moments technique to analyze a wire grid representation of a conducting surface; Nonlinear Circuit Analysis Program (NCAP), which will determine nonlinear transfer functions for electronic circuits using Gaussian elimination techniques; Wire Coupling, which provides a capability for determining crosstalk in uniform multiconductor transmission lines caused by a reference conductor or a steady state single frequency EM field; the Precipitation Static Electricity Analysis Program (PSTAT), which predicts noise fields and short circuit antenna currents caused by corona streamer discharges in airborne avionics systems; an antenna plotting routine (ANTPLT), which helps verify the geometry of antenna positions in the input data for IEMCAP; a supplemental computer program (IMOD), which may be used to enable an EMC engineer to calculate possible intermodulation frequency situations within systems; and Advanced Composite Shielding Experiment Simulations (ACSESS), which employs transmission line analysis to compute the fields that penetrate a stratified system of advanced composite materials irradiated by a normally incident uniform plane wave.

Other facets of the Support Center include:

- training courses for IAP Users;
- IAP workshops (intensified mini-courses) on IEMCAP and other IAP codes;
- computer related assistance in both the use and installation of the programs for the different computer environments;
- technical assistance and liaison for contractors and the product divisions (SPOs);
- providing detailed customer oriented analysis on a case-by-case basis, utilizing the IAP on a system(s) to analyze specific results;
- establishing a database library consisting primarily of physical and electrical data for specific systems as they are developed. The Support Center now has on hand in its library over 20 different databases.

As the state-of-the-art progresses and new IAP codes are developed while older ones are refined, the Support Center will perform a greater role in disseminating this material and providing training in the use of these codes. The Air Force R&D efforts currently underway include new computer codes to access and organize the widely disbursed data already generated, and apply these data to current and future codes through a tailored translator program.

Though primarily an arm of the Air Force, the user community which the Support Center services already spans the Army, Navy, NASA, and commercial users.

To better serve our users, the Support Center is initialing a three-tiered subscription service which will provide a range of services to accommodate casual to comprehensive users. For further information on the Support Center, call (315) 330-7168.

This article was prepared for ITEM '82 by John J. Dobmeier, Program Manager, and Donna R. Crossland, Administrative Assistant, IIT Research Institute, Griffiss AFB, NY 13441.

SEMCAP—VERSION 8

Introduction

SEMCAP (Specification and Electromagnetic Compatibility Analysis Program) is a large scale computer program for intrasystem EMC analysis, and has been in use since 1968, when it was developed as a spacecraft oriented intrasystem analysis program for NASA's Manned Space Center (later Johnson Space Center) in Houston, Texas. Numerous articles* have been written about the subject of intrasystem compatibility and about the original version of SEMCAP. Basically, this program performs an EMC analysis between modeled interference generators and modeled interference receptors for various interference transfer functions. The generators and receptors are modeled in

*Articles by A.K. Thomas, W.R. Johnson, and J.A. Spagon in the 1968 IEEE Symposium Record, and in the 1969 IEEE Symposium Records, and by J.A. Spagon in the 1976 IEEE Symposium Records, and in previous issues of ITEM.

terms of their electrical and physical parameters. The system's physical characteristics are also modeled so that transfer functions can be computed. The computer calculates the spectrum of the generator circuits and transfers the energy via the transfer function to the receptor terminals. The received spectrum is limited by the receptor bandwidth and integrated over the complete frequency range from 10 Hz to 10 GHz (or higher, at the user's option). The integral then represents the voltage available at the receptor terminals. This received voltage is compared to the threshold of the particular circuits to determine compatibility status. In addition, the computer stores the voltage received from a particular generator and proceeds through the complete generator list until the contribution of each generator is determined. These contributions are summed to determine if the receptor is compatible with the sum of all generating sources modeled. The purpose of this article is to acquaint the EMC community with the latest version of SEMCAP (Version 8), which has considerably more capabilities than earlier versions.

SEMCAP Version 8

SEMCAP was developed to perform EMC analyses of spacecraft, where the major problems are in the area of wire-to-wire coupling in complex cable harnesses. Antenna to antenna radiation on most satellites does not represent a serious analysis problem because, unlike an airplane, there are few antennas on most satellites, and these usually operate in the GHz frequency range. Therefore, the emphasis was placed on what happens inside the spacecraft. Consequently, SEMCAP models are virtually unconstrained by the complexity of cable harnesses regardless of the number of different wires or types of wires used, the number of harness segments, unequal spacing of wires in the harness, different heights above ground, different pigtail lengths, etc. A unique feature of SEMCAP is that the model may simultaneously define a large number of different separation distances between wires in the same harness, or between wires in different harnesses. The metric system is used throughout. In addition to handling the effects of shielded wires, SEMCAP simultaneously can deal with the effects of group shields, bulkhead shielding, various values of ground return resistances, various values of common return paths, etc.

However, because it is recognized that not all problems deal with wire-to-wire coupling, a flexible method was developed for modeling antenna to antenna, antenna to wire, and field to wire coupling. This method requires definition of the field rather than definition of typical antenna parameters. In fact, the antenna coupling capability of SEMCAP has been used very little because of the nature of the analytical problems to which it has been addressed. On the other hand, coupling from external fields originating from arc discharges and EMP has been analyzed using the E and H-field models. A feature of this flexibility is that any number of various internal and external fields can be modeled simultaneously, in either the time or frequency domains, and a large number of different structural shielding characteristics can be modeled simultaneously, with the shielding factors being either constant or variable as a function of frequency.

Another unique feature of SEMCAP is that it generates its own frequency base using as many points as necessary to define the spectrums, and has a standard frequency base of 1801 points which are logarithmically spaced to give 1% resolution. On the other hand, if the user wishes to select frequencies as in frequency amplitude pairs, he is virtually unlimited as to the number he may use.

SEMCAP models for generators are described in either the time or frequency domains. In the time domain, it accepts models for sinewaves, single pulses, pulse trains, and ramp steps. In the frequency domain, there is no practical limit to the number of frequency amplitude pairs that may be used. Voltage sources and current sources are defined independently. E and H-field sources are derived from the voltage and current sources, or may be entered independently, at the user's option. Filters may be used for each source and may be defined in either the frequency domain or by standard parameters such as cutoff frequency, slope, inband insertion loss, etc. Two filters may be cascaded for each source. The use of generator filters is optional, and in practice is used infrequently.

SEMCAP models for receptors are modeled as voltage thresholds combined with a frequency response curve. This allows a reasonably accurate representation of both analog and digital (or bi-level) circuits. The frequency response curve can be defined in the frequency domain or by standard filter parameters. If desired, two filters can be cascaded for each receptor.

Because SEMCAP does not assume compatibility except within a black box, all generators are played against all receptors. As stated previously, there is no actual limit as to the number of generators and the number of receptors, although there are practical limits based on engineering time and computer time. Figure 2 shows the actual amount of CPU time as a function of G-R interactions for a CDC 6600 computer. Each interaction is called a "cell" in the G-R matrix. For example, an analysis of 100 generators and 100 receptors would result in a 10000 cell matrix, and would use between 500 and 600 CPU seconds.

The standard printout of a SEMCAP run shows, in addition to all the input data, a list of all the models, the integrated voltage received and margin for each generator-receptor interaction (including a breakdown by coupling mode, i.e., capacitive, inductive, E-field, H-field), the total voltage received and margin for each receptor versus all generators, and a compatibility matrix of all receptors and generators coded to identify ranges of margins. This last item is useful in providing a "quick look" at the results of an analysis.

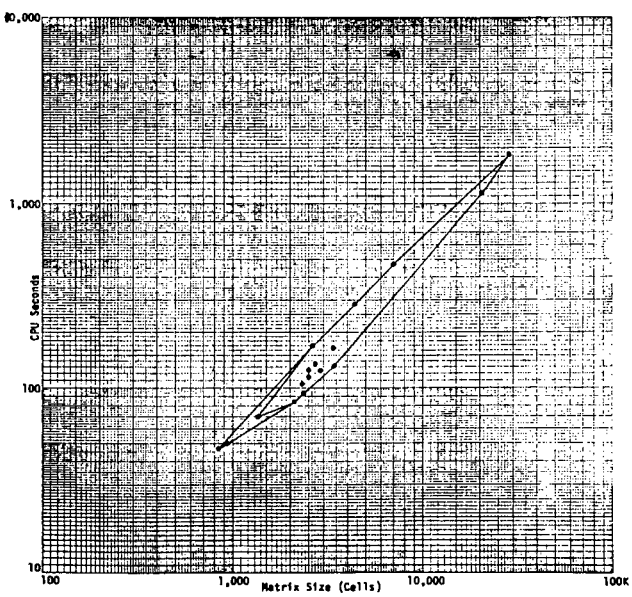

Figure 2. SEMCAP Running Time Matrix Size versus CPU Seconds

Conclusion

The developmentof SEMCAP V8 provides an enhanced version of a proven system level EMC analysis program which has been successfully used for many years by a number of well known aerospace organizations.

The above material was reprinted with permission of TRW Defense and Space Systems Group.