SOFTWARE AS A TOOL FOR CONTROLLING EMI/EMC

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ABSTRACT

TRADITIONAL METHODS of controlling Electromagnetic Interference (EMI) typically deal with hardware based solutions such as: grounding, bonding, shielding, filtering, and equipment placement. With the evolution of microprocessor and computer controlled systems, system flexibility and effectiveness increase up to a point where ambiguities reduce effectiveness and introduce the potential for a new form of EMI. Software, however, can become a tool for system designers, E³ and software engineers to use in controlling EMI and managing system EMC.

BACKGROUNDHistorical Perspective

1950 to 1970: Early electronic systems were typically manually controlled with limited hardware functions and performance windows. A search antenna, for example, would rotate physically, spending a large percentage of its scanning time looking at sectors of no particular interest.

1970 to Present: In the last 20 years there has been a proliferation of microprocessor controlled systems with manual input and control only as needed. Coincident with this, black box functions and system performance have become more dynamic. Phased array antennas now efficiently scan only areas that are desired and direct single pulses at will with no wasted time required for physically moving the antenna between angles.

Looking Ahead

As this trend continues, it appears that future systems will be highly dynamic, with virtually unlimited performance windows and flexibility. This flexibility, however, is not without a price. As system flexibility increases, there is a point where ambiguities may enter with a corresponding decrease in system effectiveness, as shown in Figure 1.

Figure 1. System Effectiveness as a Function of System Flexibility.

IMPACT OF SOFTWARE ON EMI HARDNESSLaboratory Example

Background: In the early 1980's, a retest of a weapon system revealed an 80 dB deviation from previous results. Engineers reviewed test procedures, configurations and test sample exhausting all known explanations with no results.

Software Suspected: Discussions with the manufacturer revealed that an upgrade to the software had been installed. Lab personnel and manufacturer both agreed this change should not affect EMI hardness, but agreed to reinstall the original version to eliminate this possibility.

Software EMI Confirmed: The retest with the original version of software was accomplished successfully, with the original baseline tests results repeatable within acceptable lab test limits. Subsequent testing on a modified configuration, with both software versions, confirmed that, in fact the software changes produced similar results of greater than 80 dB variation in EMI hardness.

Engineering Investigation

As a result of a paper given¹ highlighting this issue, a study was funded to investigate this phenomena further.² The study identified certain efforts instrumental in minimizing the negative impact software development and/or software changes have on system EMC.

SOFTWARE DESIGN--AN EMC TOOLTraditional EMC Tools

Traditionally the System Designer, relying on the E³ engineer, has been limited to hardware methods of EMI control [i.e., grounding, bonding, shielding, filtering, spatial placement of hardware, etc.). EMC solutions have often taxed the weight, size and cost budgets heavily. In an era of increasing restrictions on physical (i.e., weight and size) budgets and financial resources, the System Design engineer needs creative alternatives to produce designs that are consistent with increasingly restrictive requirements.

Concurrent Engineering Required

E³ and Software Engineers: Specialized disciplines like E³ and Software engineering have traditionally been segmented within the design process. Little, if any, communication between them has made the System Designer's job very difficult. More recently, however, there has been an emphasis on *concurrent engineering* which has resulted in increased communication between a number of specialized disciplines.

System Design Engineer's Responsibility: Since the System Designer is responsible for the overall allocation of resources to meet requirements, having additional "tools" should become more and more important, especially as the distinctions between the "hardware" world and the "software" world become less obvious.

Figure 2. Application of Software and Hardware EMI Controls in Typical RF System.

Software, A New EMC Tool

If software control is thought of as an extension of "manual" control techniques (i.e., switches set, dials turned, shutters opened, antennas pointed, etc.), it becomes apparent how software can control EMI.

Typical RF System: To illustrate this, Figure 2 depicts a typical RF system with a source (A), possibly some software controlled processing (B) and an RF subsystem (C), radiating a signal which is picked up by a receiver (D). The receiver may process the information (E) using a combination of microprocessors, User Data Files (UDF), and software code or logic. For example, Figure 3 shows logic for determining if received signal frequency (f), pulse width (PW) and pulse repetition interval (PRI) match a record in a predefined UDF. Depending on the result of this match, some action or function (F) is performed.

Example: To illustrate this, assume a received signal with characteristics:

$$f' = 13 \text{ MHz}, \text{PW}' = 0.15 \mu\text{s} \text{ and } \text{PRI}' = 60 \mu\text{s}.$$

If, the processor finds a record in the UDF with the profile:

$$f'' = 12.5\text{-}14.1 \text{ MHz}, \text{PW}'' = 0.2 \pm 0.05 \mu\text{s} \text{ and } \text{PRI} = \text{'agile' with range } 20\text{-}100 \mu\text{s}$$

the processing algorithm (Fig. 3 Case A) will find a match for frequency, pulse width, and pulse repetition interval, even though the two PRI's are, in fact, different.

Ambiguity Results in EMI: If the action performed for criteria α (say a match) is defined as initiation of a function α' (say a TRACK), and the action performed for criteria β (say no match) defined as initiation of a function β' (say a SEARCH function), it becomes obvious that the ambiguity results in a misidentification not unlike that which can be experienced under EMI. If the signal entering the receiver is a 'friendly' system, and if the UDF characteristics describe a 'threat' system, the receiver could begin tracking a 'friendly' with the intent of performing action intended for a 'threat'—an EMI condition with potentially disastrous consequences.

Figure 3. Basic Processing Logic and Enhanced Logic Incorporating Software EMI Control.

Software Fix Achieves EMC: If we now take the basic algorithm of Figure 3 Case A and modify the software code as shown in Figure 3 Case B, the PRI ambiguity is reduced with a corresponding effective reduction in EMI potential. Using this information, one can increase the scope of EMI tools, as shown in Figure 2, adding software enhancements in the processing stages of the receiver. By similarity, transmitter processing can also be augmented in the processing stage.

CONCLUSION

The contribution of software as a tool in eliminating EMI is a significant step forward in the overall effort to manage EMC in the system design and engineering/software change process. The advantages of using software to control EMI are most apparent in achieving EMC with no physical weight or size gains. In addition, system upgrades and changes (ECP's) can be accomplished with virtually no impact on the physical redesign of the system.

Software changes can, however, become a source for system degradation if not supervised properly. Proper use, however, can provide an additional tool for eliminating EMI and proper EMC management during the lifetime of a system.

This advancement depends on: 1) the forward thinking of E³ engineers; 2) the degree to which E³ engineers can expand typical "tools" beyond "hardware only" concepts; and 3) the ability of E³ and Software Engineers to work concurrently with Systems Designers to maximize system EMC using these software "tools."

[1] T. G. Boone and D. Laack, *Achieving EMI Control In Advanced Highly Integrated Systems*, presented at the Naval Air Systems Command (NAVAIR) Air Systems Electromagnetic Interference Corrective Action Program (ASEMICAP) Progress Review, Oakridge National Laboratory, Tennessee, May 1989.

[2] T. G. Boone, D. Laack and E. Walker, Technical Report *Engineering Investigation of Software Impacts on Electromagnetic Compatibility (EMC)*, 31 October 1990, prepared for Space and Naval Warfare Systems Command (SPAWARSSYSCOM) under Task No. 90-1-RD-255.