

EMC Expert Systems for Evaluating Automotive Designs

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Abstract—The automobiles of the future are being designed on computers and a significant amount of performance and safety testing is done using computer models. By the time the first hardware prototype is built, many critical design decisions affecting intersystem and intra-system electromagnetic compatibility (EMC) have been made. Therefore, it is becoming increasingly important to perform the first EMC design review well before any hardware is available to test. Automotive EMC expert systems examine the relevant aspects of an automotive design while it is still on the computer to spot design features that are likely to cause EMC problems.

Keywords—vehicular electronics; expert system; electromagnetic interference; electromagnetic compatibility

I. INTRODUCTION

Today's automobiles rely heavily on electronics to monitor and control everything from the engine ignition, steering and braking to the entertainment, navigation and communication systems. A typical new automobile has dozens of microprocessors and the number of independent electronic systems on automobiles grows significantly each year. Ensuring that all of these electronic systems operate reliably without producing or being susceptible to electromagnetic interference is a significant challenge. More than ever, it is important to catch potential EMC design problems early, while it is still possible to identify an effective low-cost solution.

Identifying EMC problems (even relatively obvious problems) in an automotive design that hasn't been built can be challenging. The various electronic systems in an automobile are developed by many different engineering groups, often at different companies. These groups are usually unfamiliar with the other electronic systems that will share a vehicle (or even a wire harness) with their own system. As an automotive design evolves, features are added, component specifications change, and wire harnesses are rerouted. Keeping up with all of these changes and evaluating their impact on EMC is a daunting task. However failure to identify potential problems before they appear in a full vehicle test can result in costly delays and/or retrofits.

Automotive EMC expert system software monitors the design of an automobile to identify potential EMC problems as soon as they arise [1]. Like a human EMC expert, the software looks for potential sources and victims of electromagnetic interference and evaluates potential coupling paths between

them. Unlike a human expert, expert system software is capable of investigating thousands of possible system interactions and can easily repeat the entire process every time the design is updated.

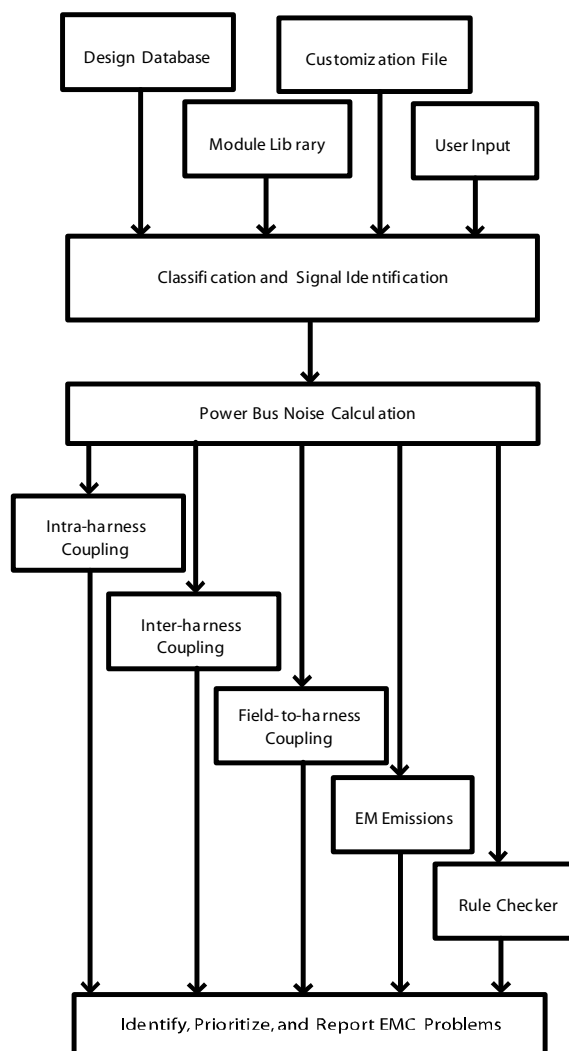


Figure 1. Automotive EMC Expert System Flowchart

II. EXPERT SYSTEM STRUCTURE

Figure 1 shows a basic outline of tasks performed by an automotive expert system. Input is obtained from four possible sources. The primary source of information is the computer database that contains information about the mechanical and electrical design of the automobile. Information about the individual electronic modules that is relevant to an EMC analysis, but not available in the database is stored in a *module library*. The module library may contain default specifications for modules that are missing from the database as well as design specifications, signal definitions, test results and other data that is not part of the normal database structure. A *customization file* provides special instructions that pertain to a particular vehicle manufacturer or model. For example, instructions to treat a specific component differently than it would be by default based on previous experience with that component. Finally, any information critical to the operation of the expert system that is not available from any other source must be provided by the user. User input should be optional and function only to provide the user with some degree of control over how the analysis is performed.

A. Classification & Signal Identification

Identifying and prioritizing potential EMC problems requires the system to be familiar with all wired and wireless electrical signals used to communicate between components in the vehicle. Unfortunately, this information is generally unavailable in vehicle design databases. Therefore, the first step in the analysis process is to examine the information that is available and attempt to describe all of these signals to the degree necessary to evaluate their impact on EMC. Classification and signal identification algorithms convert database information related to the components and component interfaces into signal amplitudes, frequencies and noise margins. They also identify the relative potential of the various signals to act as sources or victims of interference. A separate power bus noise calculation is performed in order to characterize the noise voltages and currents present on all power supply wiring.

B. Coupling Algorithms

The coupling algorithms quantify the worse-case coupling between all potential EMC sources and all potential victims. These algorithms can be divided into four categories; intra-harness coupling, inter-harness coupling, field coupling and EM emissions.

1) Intra-harness Coupling

Intra-harness coupling algorithms evaluate the crosstalk between systems with wires that share the same wiring harness. Common impedance coupling, electric field coupling and magnetic field coupling are all evaluated independently. The levels of crosstalk in the final vehicle design will depend on many factors (e.g. the exact positioning of wires in a harness, exact impedance of connections, etc...) that are not available in the computer database. Therefore, a worse-case analysis is performed that is intended to alert the user of a potential problem even though a specific implementation may not exhibit that problem [2].

2) Inter-harness Coupling

Inter-harness coupling algorithms evaluate the crosstalk between two wiring harnesses due to common impedance coupling, electric field coupling or magnetic field coupling. They employ information regarding the relative placement of harnesses and harness connectors in the vehicle. Like the intra-harness algorithms, they perform a worse-case coupling analysis.

3) Field Coupling

Field coupling algorithms evaluate the noise coupled to wire harnesses and receiving antennas due to electric and magnetic fields generated within or external to the vehicle. These algorithms employ various methods to estimate this coupling depending on the nature of the exciting field. External field strengths and frequencies are derived from component or vehicle EMC test specifications. Internal field information is obtained from the EM emissions algorithms.

4) EM Emissions

The electromagnetic emissions algorithms quantify the worse-case field emissions from the various electronic systems on a vehicle. Both intentional and unintentional emission sources are evaluated.

5) Rule Checking

Rule checking algorithms look for design features that violate basic EMC design rules. In this case no attempt is made to quantify the effect of the violation.

III. THE FUTURE OF AUTOMOTIVE EMC EXPERT SYSTEMS

EMC expert systems are capable of analyzing complex systems relatively quickly and thoroughly. They perform tasks that would be relatively monotonous and time-consuming for a human EMC expert and are therefore capable of finding problems that a human is likely to miss.

Although the expert system described above has yet to be implemented in software, a similar expert system for analyzing printed circuit board layouts has demonstrated the potential value of this approach [3]. Expert system EMC software does not replace the need for EMC testing nor is it a substitute for involving qualified EMC engineers in major design decisions. However, it excels at identifying potential problems early in the design process, when these problems can usually be avoided at little or no cost. As the importance and complexity of vehicular electronics increases, EMC expert system tools are sure to play an increasingly important role in the automotive design process.

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