Method of Systemic EMC Evaluation

Gao Wanfeng  Su Donglin  DaiFei  WangBingQie  CaoCheng
( School of Electronic and Information Engineering, BUAA, Beijing 100083, China )

Abstract: Systemic electromagnetic compatibility (EMC) evaluation method is presented in the paper. Firstly, the relative of all sensitive sub-systems and mathematical models of systemic EMC performance EMC(s) are provided. Secondly, this paper proposes a series, parallel, three basic hybrid sensitive ports electromagnetic compatibility prediction model and its mathematical model. Based on these models, the compatibility probability of all sensitive sub-systems can be analyzed and computed so as that systemic EMC performance EMC(s) can be computed successfully. Finally, systemic EMC(s) evaluation of a kind of Military Computer is provided as a typical application.

Keywords: system EMC Prediction Evaluation

1. Introduction

Suitable design and prediction of Electromagnetic Compatibility (EMC) are reliable guarantee of system-level EMC.

EMC Prediction analyzes and evaluates EMC degree of electronic equipment and system-level by theoretic calculation. It carries out with EMC design and covers the whole process of system development. It has become the essential part in modern EMC design. Generally when it carries on the system-level EMC forecast, the system may be divided into three or four-layer patterns logical diagram. The three patterns are system-level, equipment level (subsystem-level) and primary device level (board level), and the four patterns are system-level, equipment level (subsystem level),primary device level (board level) and chip level. This paper forecasts in term of three patterns.

2. EMC Prediction Probability Model

When carrying out the system-level EMC forecast, system-level EMC prediction models are necessary to deal with the EMC probability questions by reliability analysis. Series models are often adopted. Equipment and subsystem-level EMC prediction can adopt series models, parallel models, hybrid models, m/n (select m in n) models, etc, to forecast.

2.1 Series l EMC Prediction Model

\[
\begin{align*}
C_i(t,f,s) &= C_i(t,f,s) \\
C_s(t,f,s) &= \prod_{i=1}^{n} C_i(t,f,s) \\
C_s(t,f,s) &= \text{system-level EMC probability} \\
C_i(t,f,s) &= \text{systematic EMC probability of i unit}
\end{align*}
\]

As far as analyzing series model knows, EMC of independent series model is equal to product of EMC of each unit. Systematic EMC is equal to product of EMC of the various units.

Because of \(0<C_i(t,f,s)<1\), from formula (1) we know, the more series units the system is constituted, the lower system-level EMC is.

2.2 Parallel EMC Prediction Model

Authorized licensed use limited to: HARBIN ENGINEERING UNIV LIBRARY. Downloaded on March 05,2010 at 00:23:17 EST from IEEE Xplore. Restrictions apply.
Supposing system is composed of n parallel connection structural unit models, the system appears electromagnetic interference meanwhile each unit must have EMI questions. Supposing each unit is mutually independent and EMC of each unit is $C_i(t,f,s)$, probability of each unit appearing EMI (appear electromagnetic incompatibility) question is $F_i(t,f,s)$. According to the definition of parallel connection structure and the multiplication principle, the mathematical model is:

$$F_s(t,f,s) = F_i(t,f,s)F_2(t,f,s)\cdots F_n(t,f,s) = \prod_{i=1}^{n} F_i(t,f,s)$$  \hspace{1cm} (2)

Electromagnetic compatibility is:

$$C_s(t,f,s) = 1 - F_s(t,f,s) = 1 - \prod_{i=1}^{n} F_i(t,f,s) = 1 - \prod_{i=1}^{n} 1 - C_i(t,f,s)$$ \hspace{1cm} (3)

In the above two formulas:

$F_s(t,f,s)$ — system appearing probability of EMI problems

$C_s(t,f,s)$ — system EMC

$C_i(t,f,s)$ — system EMC of i unit

As far as analyzing parallel model knows, system-level EMC $C_s(t,f,s)$ increases gradually with parallel unit increasing. Parallel unit increases one while the system will increase one pack up, therefore system EMC can improve.

In the actual systems, various sub-systems, the equipment and the primary device realize different functions and may be series-parallel structure, adopting the different mix model computation when carrying on all levels EMC prediction. Generally military system often uses the series connected model.

### 3. A method of expert-score and prediction of system-level EMC

Because the system-level EMC and the system reliability have the similarity, carrying on the system-level EMC forecast by using the system reliability prediction method and obtaining the whole system EMC forecast result in terms of the primary device, the equipment and the subsystem progressive judging the level EMC. This is a comprehensive process from partial to whole, from bottom to top.

When carrying on the system-level EMC forecast in the electronic products preliminary design and the detailed design stage, the EMC data may extremely lack. Introducing the method based on the reliability estimated theory to gain EMC data.

This method depends upon the experienced engineers and technicians' project experience, carrying on grading according to several kinds of factors. According to the grading result, figuring out the EMI probability other units appears by the EMI probability known some unit appears and the grading coefficient. This method is large influenced by man, therefore, in application time, visiting experts to grade as many as possible so as to guarantee the objectivity of grading, and enhances the accuracy of system forecast.

### 4. Examples of System-Level EMC Model Prediction Law

Take some military computer as an example to explain expert-score application. Don’t consider EMC problems of the system software in the prediction, that is, supposing the system software can’t appear the EMI problems. Figure 3 and figure 4 are EMC prediction models.
It is assumed that interference signal which goes through the electric filter of the main engine power source is conducted by a power line, and it can not generate the EMI to the main engine of the military computer and any EMI problems to other units of subsystems, but can transfer the EMI to the display power source. If any units receive the EMI, then the EMC of this unit is 0; but if all units can work normally without being influenced by the EMI, then the EMC of this unit is 1. According to Table 1, see table 2 using the grading law to calculate system EMC.

When using expert-score-method to predict EMC for the military computer system, the first thing is to judge the EMC of each unit $C_i$ depending on the system EMC. It is complex to judge $C_i$ value. Carried on forecast, EMC value of each unit must be known. The second is to calculate the EMC of each subsystem separately. Finally according to the EMC of each subsystem, the system EMC forecast result is $C_s=0.7980$. From Table 2, the EMC rank of the forecast result is the critical state.

### 5. Conclusion

The application of expert-score-method is quite simple, but appears some shortcomings: This method’s result is artificially influenced, evaluating system-level EMC and its evaluating factor proportion is also different. The evaluating factors and the objective of grading are of equal importance. Therefore, when using expert-score-method carries on system-level EMC forecast grading, inviting many experts as many as possible to guarantee the objectivity of grading and to enhance the accuracy of the system forecast.

The system EMC forecast provides the basis for design decision as EMC design method. Therefore, the work of forecast should carry on in time, generally in deferent design stage and different system-level, adopting the different forecast method. When carrying on the system EMC forecast, pay attention to the following four points:

1. It is necessary to carry on system EMC prediction as soon as possible. When any level EMC predicted value does not achieve system place value, paying more attention to technique and administration and adopting necessary action.
2. In various stage of product development, EMC prediction should be carried on repeatedly. In the stage of the plan provided and preliminary designed prediction only offer the approximate estimated value and the effective feedback information which meets EMC requirements for the designer and the administrator. With the progress of design work, the product definition is further defined and the system model is refined, the work of EMC forecast also should carry on repeatedly.
3. The relative meaning of system EMC forecast result is more important than the absolute value. Finding the vulnerable area of system EMC design and improve it through EMC forecast; when carrying on the optimization to the different design proposal, EMC forecast result is the important basis of the plan optimal and the adjustment.
4. The forecast value of system EMC should be higher than the specified value of the mature period before the system-level EMC can be guaranteed.

### Reference

Table 1 some model military computer electromagnetic compatibility expert score chart

<table>
<thead>
<tr>
<th>Grading standard</th>
<th>Complex degree</th>
<th>Technical maturity degree</th>
<th>Work electromagnetic environment synthesis</th>
<th>Weight proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High 1-3</td>
<td>general 4-6</td>
<td>Low 7-10</td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>0.0695</td>
</tr>
<tr>
<td>S2</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>0.0695</td>
</tr>
<tr>
<td>S3</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td>0.1070</td>
</tr>
<tr>
<td>S4</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>0.1283</td>
</tr>
<tr>
<td></td>
<td>Low 7-10</td>
<td>general 4-6</td>
<td>Low 1-3</td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>0.0909</td>
</tr>
<tr>
<td>S2</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>0.0963</td>
</tr>
<tr>
<td>S3</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>0.1070</td>
</tr>
<tr>
<td>S4</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>0.1444</td>
</tr>
</tbody>
</table>

Table 2 using expert-score-method to forecast military computer system EMC data sheet

<table>
<thead>
<tr>
<th>Grading standard</th>
<th>Weight proportion</th>
<th>Each unit EMC</th>
<th>Subsystem EMC probability</th>
<th>System EMC probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0.0695</td>
<td>0.991</td>
<td>$C_{S_i} = \sum_{k=1}^{n} W_{ik} \cdot C_{ik}$</td>
<td>$C_S = \sum_{i=1}^{4} C_{S_i}$</td>
</tr>
<tr>
<td>S2</td>
<td>0.0695</td>
<td>0.925</td>
<td>$C_{S_i} = \sum_{k=1}^{4} W_{ik} \cdot C_{ik}$</td>
<td>$C_S = \sum_{i=1}^{4} C_{S_i} \cdot W_{j}$</td>
</tr>
<tr>
<td>S3</td>
<td>0.1070</td>
<td>0.786</td>
<td>$C_{S_i} = \sum_{k=1}^{2} W_{ik} \cdot C_{ik}$</td>
<td>$= C_{S_1} + C_{S_2} + C_{S_3} + C_{S_4}$</td>
</tr>
<tr>
<td>S4</td>
<td>0.1283</td>
<td>0.459</td>
<td>$C_{S_i} = \sum_{k=1}^{3} W_{ik} \cdot C_{ik}$</td>
<td>$= 0.7980$</td>
</tr>
</tbody>
</table>


射频和天线设计培训课程推荐

易迪拓培训(www.edatop.com)由数名来自于研发第一线的资深工程师发起成立，致力于专注于微波、射频、天线设计研发人才的培养。我们于2006年整合合并微波EDA网(www.mweda.com)，现已发展成为国内最大的微波射频和天线设计人才培养基地，成功推出多套微波射频以及天线设计经典培训课程和ADS、HFSS等专业软件使用培训课程，广受客户好评，并先后与人民邮电出版社、电子工业出版社合作出版了多本专业图书，帮助数万名工程师提升了专业技术能力。客户遍布中兴通讯、研通高频、埃威航电、国人通信等多家国内知名公司，以及台湾工业技术研究院、永业科技、全一电子等多家台湾地区企业。

易迪拓培训课程列表：http://www.edatop.com/peixun/rfe/129.html

射频工程师养成培训课程套装

该套装精选了射频专业基础培训课程、射频仿真设计培训课程和射频电路测量培训课程三个类别共30门视频培训课程和3本图书教材，旨在引领学员全面学习一个射频工程师需要熟悉、理解和掌握的专业知识和研发设计能力。通过套装的学习，能够让学员完全达到和胜任一个合格的射频工程师的要求…

课程网址：http://www.edatop.com/peixun/rfe/110.html

ADS学习培训课程套装

该套装是迄今国内最全面、最权威的ADS培训教程，共包含10门ADS学习培训课程。课程是由具有多年ADS使用经验的微波射频与通信系统设计领域资深专家讲解，并多结合设计实例，由浅入深、详细而又全面地讲解了ADS在微波射频电路设计、通信系统设计和电磁仿真设计方面的内容。能让您在最短的时间内学会使用ADS，迅速提升个人技术能力，把ADS真正应用到实际研发工作中去，成为ADS设计专家…


HFSS学习培训课程套装

该套课程套装包含了本站全部HFSS培训课程，是迄今国内最全面、最专业的HFSS培训课程套装，可以帮助您从零开始，全面深入学习HFSS的各项功能和在多个方面的工程应用。购买套装，更可超值赠送3个月免费学习答疑，随时解答您学习过程中遇到的棘手问题，让您的HFSS学习更加轻松顺畅…

课程网址：http://www.edatop.com/peixun/hfss/11.html
CST 学习培训课程套装

该培训套装由易迪拓培训联合微波EDA网共同推出，是最全面、系统、专业的CST微波工作室培训课程套装，所有课程都由经验丰富的专家授课，视频教学，可以帮助您从零开始，全面系统地学习CST微波工作的各项功能及其在微波射频、天线设计等领域的设计应用。且购买该套装，还可超值赠送3个月免费学习答疑…


HFSS天线设计培训课程套装

套装包含6门视频课程和1本图书，课程从基础讲起，内容由浅入深，理论介绍和实际操作讲解相结合，全面系统的讲解了HFSS天线设计的全过程。是国内最全面、最专业的HFSS天线设计课程，可以帮助您快速学习掌握如何使用HFSS设计天线，让天线设计不再难…

课程网址：http://www.edatop.com/peixun/hfss/122.html

13.56MHz NFC/RFID线圈天线设计培训课程套装

套装包含4门视频培训课程，培训将13.56MHz线圈天线设计原理和仿真设计实践相结合，全面系统地讲解了13.56MHz线圈天线的工作原理、设计方法、设计考量以及使用HFSS和CST仿真分析线圈天线的具体操作，同时还介绍了13.56MHz线圈天线匹配电路的设计和调试。通过该套课程的学习，可以帮助您快速学习掌握13.56MHz线圈天线及其匹配电路的原理、设计和调试…


我们的课程优势：

※ 成立于2004年，10多年丰富的行业经验，
※ 一直致力并专注于微波射频和天线设计工程师的培养，更了解该行业对人才的要求
※ 经验丰富的一线资深工程师讲授，结合实际工程案例，直观、实用、易学

联系我们：

※ 易迪拓培训官网：http://www.edatop.com
※ 微波EDA网：http://www.mweda.com
※ 官方淘宝店：http://shop36920890.taobao.com