Method of Systemic EMC Evaluation

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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.

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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

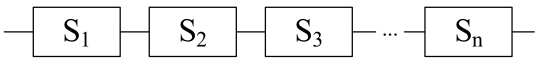

Fig1: series connection structural EMC prediction model

Supposing n units are mutually independent in series model, EMC of each unit is $C_i(t,f,s)$. According to the multiplication principle in the theory of probability, the mathematical model is:

$$C_S(t,f,s) = C_1(t,f,s)\cdot C_2(t,f,s)\Lambda\, C_n(t,f,s) = \prod_{i=1}^{n} C_i(t,f,s) \qquad (1)$$

$C_S(t,f,s)$ — system-level EMC probability

$C_i(t,f,s)$ — systematic EMC probability of i unit

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

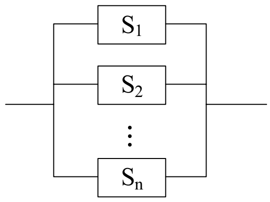

Fig2: Parallel Connection Structural EMC Prediction Model

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:

$$F_S(t,f,s) = F_1(t,f,s)F_2(t,f,s)\Lambda\ F_n(t,f,s) = \prod_{i=1}^{n} F_i(t,f,s) \quad (2)$$

Electromagnetic compatibility is:

$$C_S(t,f,s)=1-F_S(t,f,s)=1-\prod_{i=1}^{n}F_i(t,f,s)=1-\prod_{i=1}^{n}[1-C_i(t,f,s)] \quad (3)$$

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.

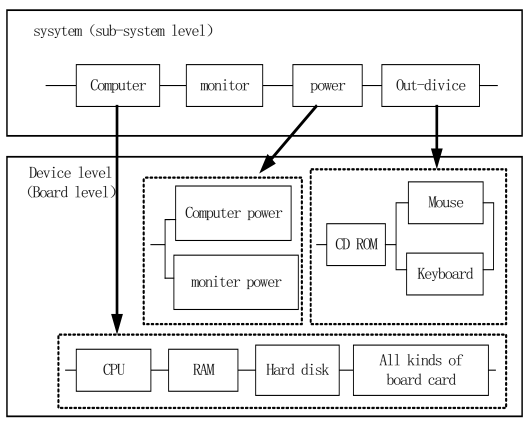

Fig3 Military Computer System-level EMC Model

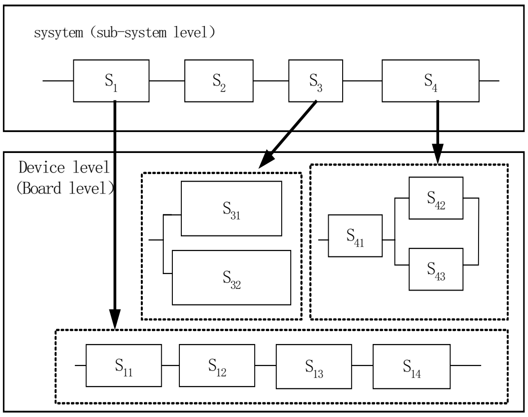

Fig4 Military Computer System-level EMC Mathematical Model

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.

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Table 1 some model military computer electromagnetic compatibility expert score chart

Grading standard		Complex degree			Technical maturity degree			Work electromagnetic environment			synthesis	Weight proportion
		High 1-3	general 4-6	Low 7-10	Low 1-3	General 4-6	High 7-10	Bad 1-3	General 4-6	good 7-10		
S_1	S_{11}	3				5			5		13	0.0695
	S_{12}		6			6			5		17	0.0909
	S_{13}		6			6			6		18	0.0963
	S_{14}	1			3			4			8	0.0428
S_2	S_2	3				5			5		13	0.0695
S_3	S_{31}			9		6			5		20	0.1070
	S_{32}			9		6			5		20	0.1070
S_4	S_{41}			7			8			9	24	0.1283
	S_{42}			9			9			9	27	0.1444
	S_{43}			9			9			9	27	0.1444

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

Grading standard		Weight proportion W_{ik}	Each unit EMC C_{ik}	Subsystem EMC probability $C_{S_i} = \sum_{k=1}^{n} W_{ik} \cdot C_{ik}$	System EMC probability $C_S = \sum_{i=1}^{4} C_{S_i}$
S_1	S_{11}	0.0695	0.991	$C_{S_1} = \sum_{k=1}^{4} W_{1k} \cdot C_{1k} = 0.2746$	$C_S = \sum_{i=1}^{4} C_{S_i} \cdot W_i = C_{S_1} + C_{S_2} + C_{S_3} + C_{S_4} = 0.7980$
	S_{12}	0.0909	0.976		
	S_{13}	0.0963	0.854		
	S_{14}	0.0428	0.813		
S_2	S_2	0.0695	0.925	$C_{S_2} = W_2 \cdot C_2 = 0.0643$	
S_3	S_{31}	0.1070	0.786	$C_{S_3} = \sum_{k=1}^{2} W_{3k} \cdot C_{3k} = 0.1799$	
	S_{32}	0.1070	0.895		
S_4	S_{41}	0.1283	0.459	$C_{S_4} = \sum_{k=1}^{3} W_{4k} \cdot C_{4k} = 0.2792$	
	S_{42}	0.1444	0.629		
	S_{43}	0.1444	0.897		

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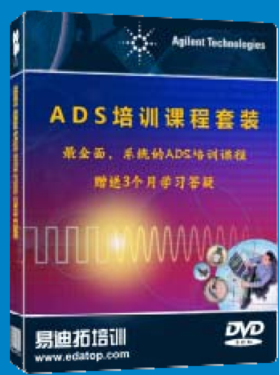

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