EMC Simulation of Automotive Safety System

Chun-Chih Lin, Jason Chiang
Automotive Research & Testing Center (ARTC)
No.6, Lugong S. 7th Rd., Lukang, Changhua County 50544, Taiwan
cclin@artc.org.tw
jasonchiang@artc.org.tw

Abstract—A design challenge in automobile electronic system is the compliance to electromagnetic compatibility (EMC) requirements. Traditionally, EMC issues are not detected until a prototype has been built, it will require many procedures and time to rectify these issues. In this paper we present an EMC simulation process including board-level S-parameter extraction, transient analysis and near-field simulation. Finally, the simulation results are compared with measurement data.

I. INTRODUCTION

With the rapid development of automotive industry and electronic technology, more and more new technologies in modern cars have been widely used, especially micro-electronics technology, and effectively promoted the automotive industry to the high value-added direction [1–3]. However, these new technologies also put forward higher requirements for the reliability of the entire vehicle system, which means all electronic devices and electronic control systems must adapt to each other. Therefore, automotive electronics applications will be related to a common problem — the automotive EMC [4–9]

Electromagnetic compatibility (EMC) is a characteristic of electrical and electronic equipment that permits it to operate as intended in the presence of other electrical and electronic equipment, and not to adversely interfere with other equipment. All such equipment emits electrical energy, and some of that emitted energy may interact and interfere with other equipment. Equally, equipment may be susceptible to receiving energy emitted from other sources.

Since the majority of the innovative trends in automotive industry are based on advanced electronics technology, mastering the EMI (Electromagnetic Interference) between embedded electronic subsystem and the EMC (Electromagnetic Compatibility) features of a vehicle in its early design phase becomes one of the crucial technical challenges for all automotive manufacturers.

Traditionally, the EMC issues are debugged in the EMC laboratory, but in a complex electronic system, it is difficult to locate the noise source of EMC issues. Consequently, an accurate analysis of EMC issues in the development process is important. By using EM Simulation, the EMC issues can be predicted in earlier stages of development process. Especially, the EM simulation is possible to run many design alternatives to avoid time-consuming and expensive redesign.

In this paper apply EMC simulation technology to execute EPB (Electric Parking Brake) system troubleshooting including board-level S-parameter extraction, transient analysis and near-field simulation.

II. EMC SIMULATION PROCESS

Generally, EMC issues are debugged in EMC laboratory, often without clarifying the root causes in design stage. In this paper will adopt the EMC simulation technology to clarify the root causes of EMC issues. The EMC simulation process is shown in Figure 1. The general S-parameter model of PCB will extract in the first stage, the next stage will combine the S-parameter model and circuit topology to do time-domain transient analysis. Finally, the near-field and far-field analysis will help us to determine the compliance with EMC standards.

![Fig.1 EMC simulation process](image)

III. THE EPB SYSTEM

The EPB (Electric Parking Brake) system is designed to enhance vehicle safety and driver comfort, which is used the push button to control the parking brake easily. The EPB system is accomplished by an electronic control unit and an actuator mechanism as shown in Fig. 2.

The ECU (electronic control unit) of EPB (Electric Parking Brake) system is shown in Fig. 3; the implementation of the control logic for the actuators is carried out by using a standalone ECU, so this component EMC (Electromagnetic Compatibility) feature of a vehicle in its early design stage becomes one of the crucial technical challenges for all automotive manufacturers.
Electromagnetic compatibility issues of automobile electronic system become increasingly complex. When multiple devices arrange in the same Printed Circuit Board, the electromagnetic fields can couple between them, and generates EMC issues, such as resonances, crosstalk and radiation are difficult to debug from the measurement process, therefore, this paper will use the simulation technology to predict this issue.

The S-parameter simulation can help designer to determine whether the poor design of printed circuit board to resonate effect at the particular frequency. The S-parameter simulation result of CAN bus transceiver is shown in Fig. 4. The resonance frequency is 100MHz to 300MHz, it will produce the antenna effect and radiate the interference signal.

V. NEAR-FIELD SIMULATION AND MEASUREMENT

The near-field simulation and measurement result is shown in Fig. 5 and Fig. 6, respectively. Compared with these results, we can find the hotspot at the same position. The hotspot is caused from the poor design of return current path of printed circuit board, as shown in Fig. 7.
VI. VOLTAGE SWING SIMULATION

As mentioned in the previous section, the EMC simulation is focused on the frequency-domain and near-field analysis. This section will perform the time-domain transient simulation to analysis the power and ground design of CAN bus transceiver. The voltage swing simulation result is shown in Fig. 8. The voltage swing is violent by interference from the return current path. According to the simulation results, the EMC issue can be solved by improving the return current path of printed circuit board. The modified method is based on the hotspot position of near-field simulation to improve the return current path. The simulation result of modified design is shown in Fig. 9. The voltage swing is smaller when the return current is modified. This example demonstrates the EMC simulation technology is usefully.

VII. FAR-FIELD MEASURED

The Far-Field measurement result is shown in Fig. 10. The original design of CAN bus transceiver exceeds the automotive EMI standard limit, but the modified design passes the automotive EMI standard limit.

VIII. CONCLUSIONS

This paper presents an EMC simulation process including board-level S-parameter extraction, transient analysis and near-field simulation. By using the EMC simulation technology, the root causes of EMC issues are easy to clarify. Although, EMC simulation cannot replace the final validation by measurements, it is a virtual validation process and possible to run many design alternatives to avoid time-consuming and expensive redesign.

REFERENCES