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Analysis of Radio Frequency Interference for a Biomimetic Chassis Mode Antenna

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Abstract: In this paper, we propose a method to analyze radio frequency interference (RFI) from a device's internal noise. To provide a well-fitted analysis for a biomimetic chassis-mode antenna, RFI is analyzed based on characteristic mode theory (CMT). The relationship between CMT and RFI is derived using a reaction theorem.

Keywords: Characteristic mode theory, radio frequency interference, reaction theorem.

1. INTRODUCTION

Radio frequency interference (RFI) worsens the sensitivity of the radio frequency receiver caused by the coupling of integrated circuit chip noise to the victim antenna. As the digital circuits become faster and the number of antennas in the device increases, the RFI problem becomes more severe. In this paper, we propose an analysis of RFI, mainly caused by conductive coupling, based on characteristic mode theory (CMT) for a chassis mode antenna.

2. RADIO FREQUENCY INTERFERENCE ANALYSIS BASED ON CHARACTERISTIC MODE THEORY

The coupling from a noise to a victim antenna can be analyzed using a reaction theorem. Assuming the antenna is already designed as described in [1], the source to excite antenna, $\mathbf{J}_a$ (or $\mathbf{M}_a$), and the generated E-field and H-field, $\mathbf{E}_a$ and $\mathbf{H}_a$, are known. As shown in Fig. 1, an arbitrary noise can be modeled with the sum of the infinitesimal dipoles. Thus, the equivalent infinitesimal dipole noise source $\mathbf{J}_b$ (or $\mathbf{M}_b$), and the generated incident E-field and H-field, $\mathbf{E}_b$ and $\mathbf{H}_b$, are specified. Assuming that most of the coupling path is via the conductor, the reaction between the noise and the antenna can be calculated based on CMT. This is because CMT provides the basis of the currents on the conductor [2]. The derived reaction is:

$$\begin{aligned} I_{sc} &= \langle \mathbf{H}_a, \mathbf{M}_b \rangle = \int \mathbf{M}_b \cdot \mathbf{H}_a \, dv \\ &= \int \mathbf{M}_b \cdot \sum_n \left(\alpha_a^{(n)} \mathbf{H}_a^{(n)} \right) dv \\ &= \sum_n \left(\alpha_a^{(n)} \int \mathbf{M}_b \cdot \mathbf{H}_a^{(n)} dv \right) \\ &= \sum_n \left(\alpha_a^{(n)} \mathrm{MEC}_b^{(n)} \right) \\ &= \sum_n \left(\frac{\mathrm{MEC}_a^{(n)} \mathrm{MEC}_b^{(n)}}{1 + j\lambda^{(n)}} \right) \end{aligned} \quad (1)$$

where MEC is the modal excitation coefficient of the characteristic mode [2], superscript (n) denotes the value corresponding to the nth characteristic mode, and $\mathbf{M}_b$ is an unit magnetic loop current source.

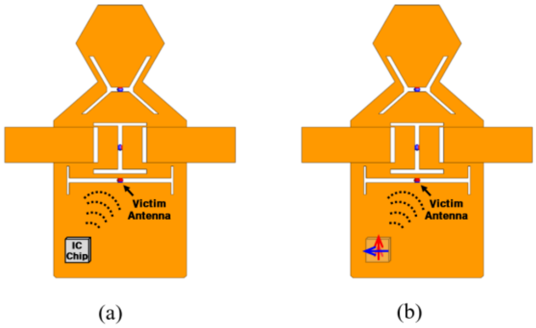

Fig. 1 Illustration of the RFI problem. (a) Original problem; (b) Equivalent problem with modeled noise source.

Thus, the coupled power created by the noise is:

$$P_r = \frac{1}{2} I_{sc}^2 \frac{R_L}{R_A + R_L} = \frac{1}{4} I_{sc}^2 = \frac{1}{4} \left[\sum_n \left(\frac{\mathrm{MEC}_a^{(n)} \mathrm{MEC}_n^{(n)}}{1 + j\lambda^{(n)}} \right) \right]^2 \quad (2)$$

3. CONCLUSION

The RFI problem is analyzed for a biomimetic chassis mode antenna. Based on the reaction theorem, we derived the received noise power in terms of the parameters of the characteristic modes. Future work will address how to optimally minimize the noise coupling.

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