Noise immune antenna (NIA) – a novel approach to mitigate desense for on-board antennas

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***Abstract*— Conventional de-sense mitigation techniques mainly tackle aggressor and coupling path to the antenna. However, very little work has been done to realize antennas with minimal reverse fields. This paper highlights a novel noise immune antenna design that can meet wireless specifications while being immune to noise leading to cost reduction by effectively removing shield can.**

Keywords- Noise immune antenna (NIA), Desense, Aggressors.

I. Introduction

Current market of consumer electronics emphasizes on developing miniaturized feature packed ergonomic devices. Desense/EMI and antenna work streams have become an integral part of wireless product development process (PDP). With numerous sensors and noise aggressors packed into small form factor devices, designing a multi radio antenna system with good radiated and conducted performance in becomes challenging. Current de-sense solutions are catered towards tackling aggressor and coupling path (using shield can, filters etc) [1-2]; however, very little development has been made from antenna point of view. This paper emphasizes on suppressing desense/EMI issues by developing novel noise immune antenna (NIA) that features minimal coupling to the noise aggressors.

II. Antenna Conceptualization and Design

Consumer electronics typically use PCB (etch) antenna on same MLB as the radio chipset due to cost effectiveness. Printed inverted F-antennas (PIFA) are one of the most common structure for Bluetooth (BT) and Wi-Fi. To minimize PCB size, and reduce RF front end path length, the antenna keep-out is typically located on the MLB edge, near several noise aggressors, such as the SOC-DDR. In such situation conventionally, a shield can is placed on top of the SOC-DDR along with shielded flexes to mitigate the noise coupling to the antenna. Both the shield can and shielded flexes are cost adder to the product. As an alternative to PIFA, we developed a novel ground independent antenna (Fig. 1), that helps in localizing ground current distribution and reduce noise coupling between antenna and SOC-DDR, thereby facilitating shield can removal without affecting desense performance and hence realizing a more cost-effective solution.

The proposed ground independent antenna is a folded loop with two legs (Fig. 1); the first leg is the antenna feeding pin while the other leg is for antenna ground. The antenna is inspired from the dual band antenna structure patented in [3]. The folded loop antenna dominant mode is a common current mode with current propagating in the same direction on both legs (Fig. 2a). The drawback of common mode excitations is that the current distribution on the ground plane can be strongly excited and hence can reach to the system noise aggressors such as the SOC-DDR.

On the contrary, the folded loop antenna second order mode has a differential current mode with localized ground current distribution around the antenna feed (Fig. 2b). The benefit of this

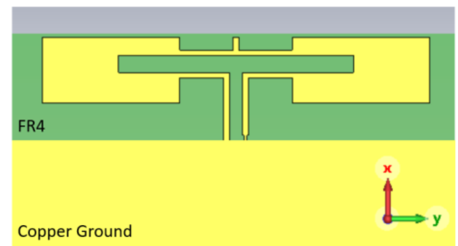

Fig. 1. Folded loop PCB antenna.

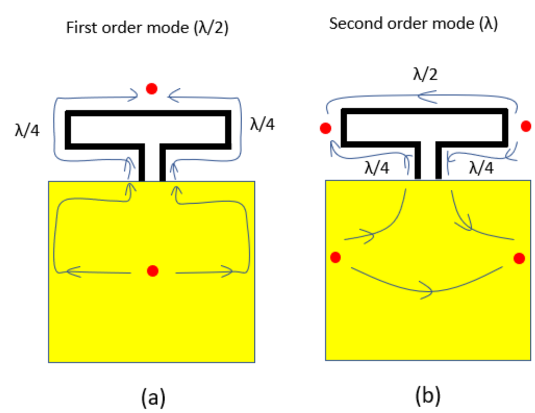

Fig. 2. Schematic current pattern distribution on folded loop antenna and adjacent ground plane. (a) Current pattern at first order mode. (b) Current pattern at second order mode.

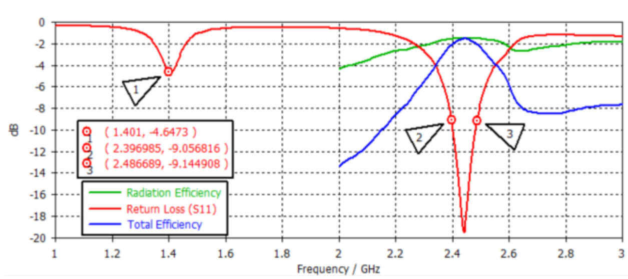

Fig. 3. Simulated return loss, radiation efficieny, and total efficiency of folded loop antenna.

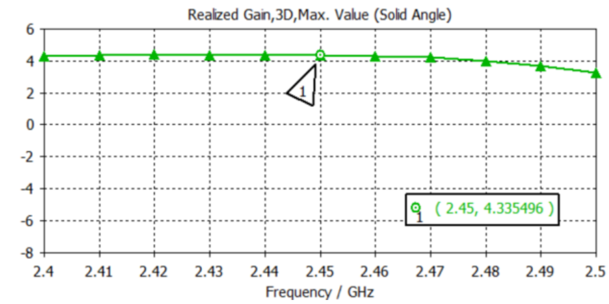

Fig. 4. Maximum gain over Bluetooth frequency band.

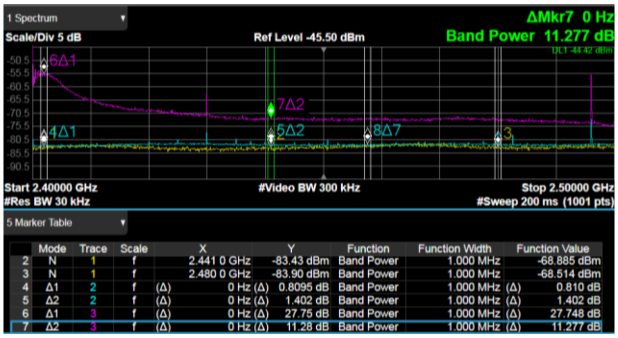

Fig. 5. Spectrum capture of NIA (green) and PIFA (purple) antennas without shield can

localized ground current distribution is that less current can reach system aggressors, which can help to decouple the antenna from its noise aggressors.

III. Results

The antenna was designed and simulated in CST time domain solver. Figure 3 red curve plots the return loss which shows two distinct resonances; first resonance at 1.4 GHz corresponding to common mode current as in Fig. 2a; the second resonance at 2.45 GHz is the desired mode with differential current as in Fig. 2b. The second resonance is properly matched in BT band with return loss S11< -9 dB, radiation efficiency > -1.5 dB, and total efficiency > -2 dB.

Figure 4 shows the simulated maximum 3D realized gain over the BT band while the antenna is integrated in an Echo device. The radiation pattern satisfies wireless specifications, with a peak realized gain of 4.33 dBi at 2.45 GHz.

Figure 5. compares the experimental spectrum capture for BT desense results for NIA without shield cans versus PIFA without shield cans. NIA without shield cans shows very good BT desense of 1.4 dB and qualifies the desense target. Whereas PIFA without shield cans shows worst BT desense of 27.7 dB, and it fails the desense target.

This excellent desense result was achieved by favorable magnetic field polarity of NIA and good control over ground current. As an evidence, Figure 6 (a) and (b) plots the reverse H_y-field and the current distribution respectively of the PIFA antenna in comparison with that of the folded loop antenna. It is clear from those two graphs that the folded loop antenna has less current distribution near the SOC-DDR. Also, the magnetic field polarity of folded loop antenna second order mode is orthogonal to the magnetic field polarity of the noise source (SOC-DDR) dipole moment. Thus, both the reverse H_y and surface current altogether provides the folded loop antenna immunity to the aggressor noise.

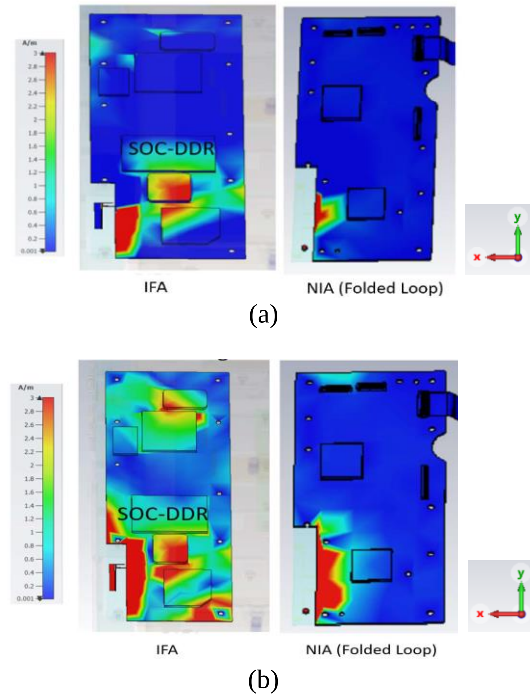

Fig. 6. Comparing IFA vs NIA (folded loop) antenna desense mitigation in terms of (a) Reverse H_y and (b) tangential surface current distribution.

IV. Conclusion and Discussion

In this study we presented a PCB based Noise immune antenna (NIA) concept, where the novel design and judicious choice of antenna mode can be employed to control the ground current distribution in the vicinity of the antenna. By creating such an antenna design, we were able to alleviate the need of external shield can and shielded flex for noise aggressor, and hence realizing a cost minimizing solution.

References

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[2] L. Zhang et al., "Radio-Frequency Interference Estimation for Multiple Random Noise Sources," in IEEE Transactions on Electromagnetic Compatibility, vol. 64, no. 2, pp. 358-366, April 2022, doi: 10.1109/TEMC.2021.3117845.

[3] Dual Band Antenna With A First Order Mode and A Second Order Mode: US patent (US 9,653,821 B1).