An Isolation Technique for Closely Stacked MIMO Antennas

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***Abstract* – In this paper, an isolation technique between two closely stacked conventional Inverted-L antennas (ILAs) is proposed for canceling the induced coupling current between adjacent antenna structures. Two ILAs are sharing the common ground plane and oriented with the same polarization. To improve isolation characteristic, the Ground Well Structure (GWS) is inserted between two ILA layers. The GWS delays the current path up to $\lambda_r/2$ which can cancel the coupling effect between two closely placed feeding ports. The isolation characteristic is enhanced while maintaining the radiation characteristics of each ILA in LTE 2300 band (2300 ~ 2400 MHz). The envelope correlation coefficient (ECC) is calculated in a multiple-input-multiple-output (MIMO) antenna system, and the ECC is less than 0.26 in the whole frequency band.**

***Index Terms* — Isolation technique, LTE MIMO system.**

1. Introduction

With a rapid development of a wireless mobile communication techniques to provide good quality of mobile service, a multiple-input-multiple-output (MIMO) antenna technology has drawn attention in a Long Term Evolution (LTE) system. Recently, many diversity antennas are demanded to increase mobile data rate and requisite MIMO system is 4x4, 8x8 and even more. However, antenna co-location in small mobile device becomes harder and the coupling effect among the antennas is the problem for maintaining the antenna diversity performance [1]. As studied in [2], the decoupling network between two antennas is used in order to improve isolation. However, this technique is demanded additional space for implementing an isolation structure and considered co-located MIMO antennas in the same system ground which is already integrated with many RF components.

In this paper, an isolation technique for closely stacked MIMO antennas which have small volume within 3-layers is proposed to achieve high isolation by inducing decoupling signal in LTE 2300 band (2300 ~ 2400 MHz). The GWS (Ground Well Structure) which has different ground height in the middle layer is applied to improve isolation performance between two stacked ILAs. The proposed structure is designed without additional patterns for isolation and can be expected the solution of the enhanced MIMO system by practically using the system ground in the mobile device.

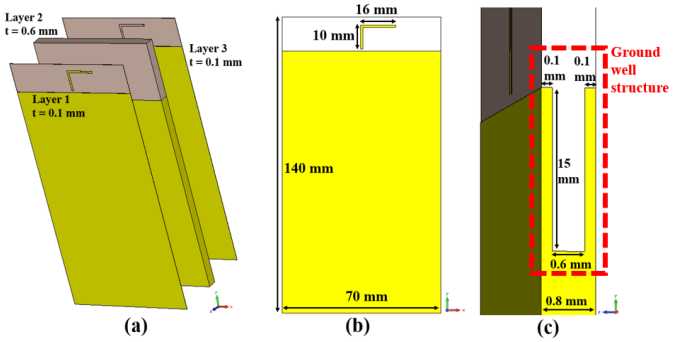

Fig. 1. Proposed structure configurations of (a) each layer, (b) front and (c) side view.

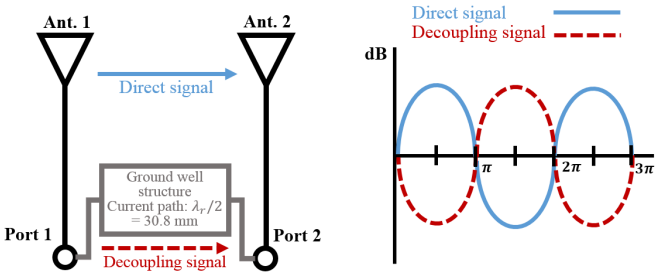

Fig. 2. The concept diagram of DWS-layer between two inverted-L antennas.

2. Design of Proposed Structures

The configurations of proposed structure are shown in Fig. 1. As represented in Fig. 1 (b), the overall dimension is 70 mm * 140 mm and in Fig. 1 (a), the proposed structure consists of three layers and the layer 1 and layer 3 (t = 0.1 mm) are printed the conventional inverted-L antennas respectively. Between the layer 1 and layer 3, the layer 2 (t = 0.6 mm) is added with different ground height which compose the GWS. All of the layers are printed on FR-4 substrate (ε_r = 4.3 and tan δ = 0.025) with overall thickness of 0.8 mm. The isolation characteristic is enhanced with making a GWS as shown in Fig. 1 (c). The concept diagram of proposed structure is represented in Fig. 2. By coordinating the ground height of the layer 2, the current path between the input port 1 and port 2 is increased which corresponds to half wavelength ($\lambda_r/2$ = 30.8 mm) to induce

the anti-phase decoupling signal. The performance of proposed isolation technique will be discussed in the next section as compared with the result of without applying the GWS.

3. Measurement Result

The fabricated proposed structures which consist of three layers are shown in Fig. 3 and the result of simulated and measured s-parameter characteristics are presented in Fig 4. The conventional ILAs are designed to operate at LTE 2300 band. Each ILA is supposed to operate at target frequency band. However, the operating frequency is shifted to lower frequency band and the transmission coefficient is quite high (over -5 dB) due to the severe correlation between two antenna structures as shown in Fig. 4 (a). To suppress the coupling effect, the proposed isolation technique is applied. As represented in Fig 4 (b), each ILA operates well and coupling effect which degrades the antenna performances reduces remarkably in the target frequency band. The Envelope Correlation Coefficient (ECC) is defined for evaluating diversity characteristics in MIMO system [3]. The ECC equation can be approximated with regard to the scattering parameters as follow.

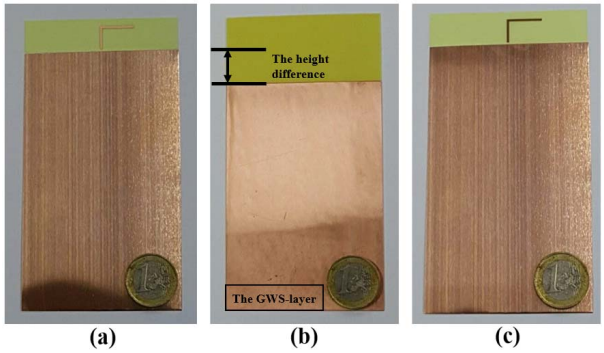

Fig. 3. Fabricated proposed structures (a) layer 1 (t = 0.1 mm), (b) layer 2 (t = 0.6 mm), (c) layer 3 (t = 0.1 mm).

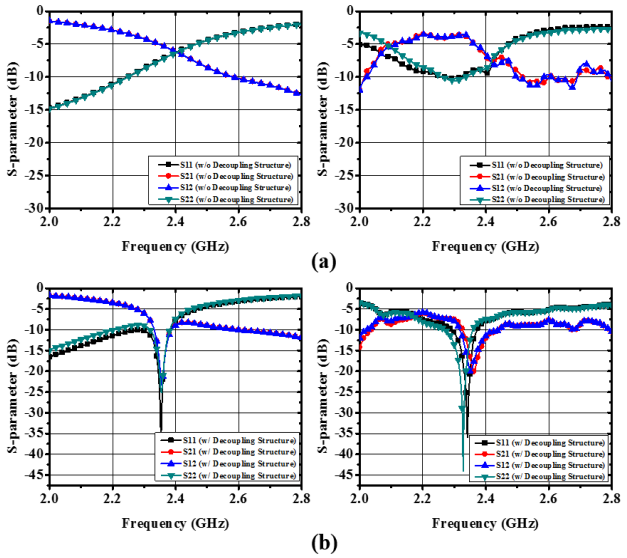

Fig. 4. Simulated and measured s-parameter characteristics (a) w/o decoupling structure, (b) w/ decoupling structure.

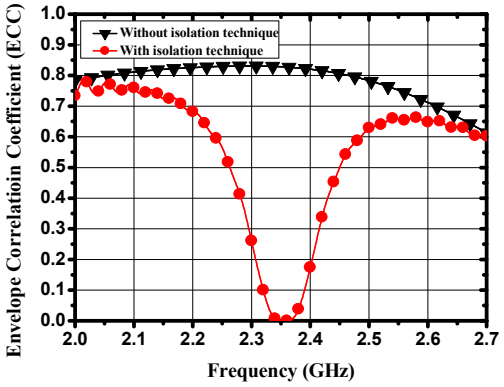

Fig. 5. The comparison of calculated envelope correlation coefficients (ECCs).

$$\rho_{12} = \frac{\left|S_{11}^{*}S_{12} + S_{12}^{*}S_{22}\right|^{2}}{\left(1-\left|S_{11}\right|^{2}-\left|S_{21}\right|^{2}\right)\left(1-\left|S_{22}\right|^{2}-\left|S_{12}\right|^{2}\right)} \quad (1)$$

As represented in Fig 5, in the whole LTE 2300 band (2300 ~ 2400 MHz), the calculated ECC is less than 0.26 which is much lower than the case of without applying proposed isolation technique. From the low ECC value, the isolation performance can be enhanced by applying proposed structure in the MIMO systems.

4. Conclusion

In this paper, an isolation technique for closely stacked two conventional ILAs is proposed in order to achieve high isolation performance in MIMO antenna system. The GWS of common substrate delays the current path between two ILAs for canceling the coupling current. As a result, the ILAs well operate in the LTE 2300 band with low correlation without additional pattern for the isolating structure. Therefore, the proposed isolation technique is expected to apply in the MIMO system to provide high isolation performance.

Acknowledgment

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References

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