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A DECOUPLING METHOD FOR INCREASING THE ISOLATION BETWEEN COUPLED ANTENNAS USING METAMATERIAL SCREEN

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Abstract— A *decoupling technique is able to reach high-level isolation ratio because it isolates two antennas in near-field region. The isolation screen sandwiched between closely placed two monopole antennas proposed. The designed structure with dimension of 220 mm by 140 mm simulated. The transmission coefficient between the monopoles without metamaterial structure is about -26.49 dB. When the metamaterial Omega structure is inserted between the monopole antenna, high isolation of -134 dB is achieved. Consequently, it provides high degree of isolation of 107.51 dB which reduce the mutual coupling between the radiators. This isolation is valid from 1.0 GHz to 3 GHz.*

Keywords*— Near-field region, mutual coupling in antenna, Omega structured metamaterial screen.*

I. Introduction

It is well known that mutual coupling between elements has long been a serious problem for multiple-antenna Systems [1]. Reduced the mutual coupling between closely placed antennas in near field region is not easy but important for many applications. A small number of technologies are invented to resolve this trouble. Following natural idea, the artificial magnetic conductors of the split ring type SRRs can play a significant role to suppressed the mutual coupling and improve the performance of antenna arrays [2]. A decoupling technique using the circuit approach for getting better the isolation between two closely placed antennas of the same frequency using two transmissions Lines and a shunt reactive component [3]. A double-layer mushroom structure is used to improve the inter-element isolation of a four-element antenna system is configured for multiple-input multiple-output (MIMO) applications[4].Recently, using multiple tunable metamaterial structures to improve high-level isolation in narrow band[5], [6]. Basic theory is introduced in Section II. In Section III, the design of the screen as well as the unit cell and model of simulated decoupling system are described.

This model consist antenna A and antenna B (monopole antennas) with tunable metamaterial screen in the middle. Theoretical signal model for near-field transmission between two strongly coupled antenna elements with resonators in the middle, shown in fig.1

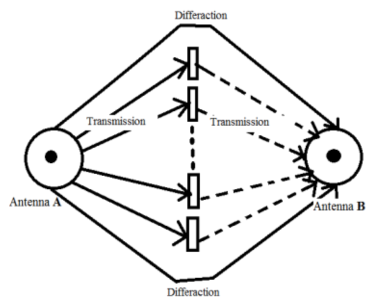
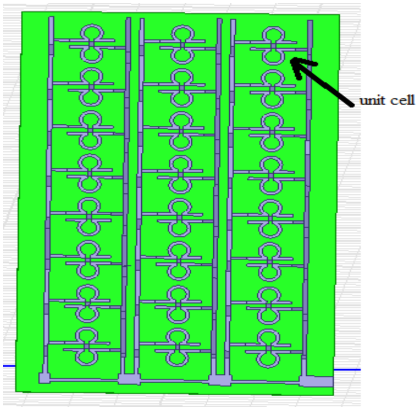


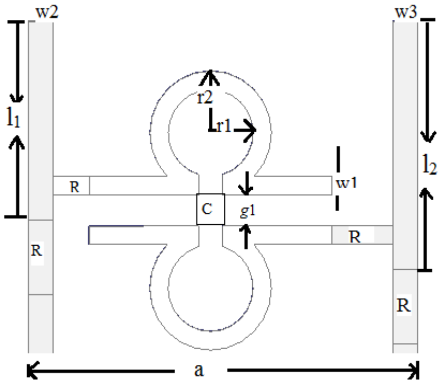
Fig: 1. Basic signal model of near field region

Antenna A transmits the signal to reaches the resonator rows and re-emits to antenna B, here tunable metamaterial screen act as a isolator. It decreases the mutual coupling between the two antennas. When the signals received by antenna B are totally cancelled, high-level isolation can be realized.

II. DESIGN OF THE SCREEN



(a)



(b)

Fig: 2. Designed structure of (a) screen and (b) single unit cell

The dimensions are as follows: r1 = 8.5, r2=10.5mm, a = 30 mm, l1 = 8 mm, l2 = 10 mm, W1 =1mm, W2 = W3 = 1.5 mm, and g1 = 1.5 mm. where R,C denote the resister and capacitance.

III. DESIGN OF MODEL

3.1. Modelling of proposed structure

The stimulated structure is shown in Fig.3. Two straight up positioned same monopoles are designed uniformly with respect to a resonator screen. A monopole is a ground plane dependent antenna that must be feed single-ended. The monopole antenna should have a ground plane to be efficient, and the ground plane must spread out at least a 1/4 wavelength, or more, approximately the feed-point of the antenna. The size of the ground plane influences the gain, resonance frequency and impedance of the antenna. The height and radius of the monopoles is respectively 30.6 mm, 9mm and they resonate at 2.4 GHz. Their distance is equal being at the center of the tunable screen. The distance between these monopoles is 10 cm at 2.4 GHz. A circular ground plate with a radius of 20 mm is added for getting a more stable matching.

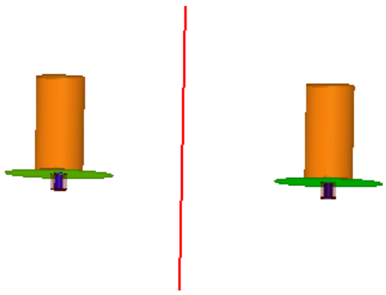
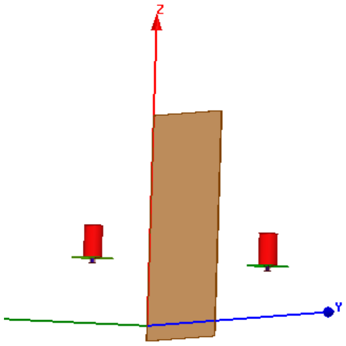
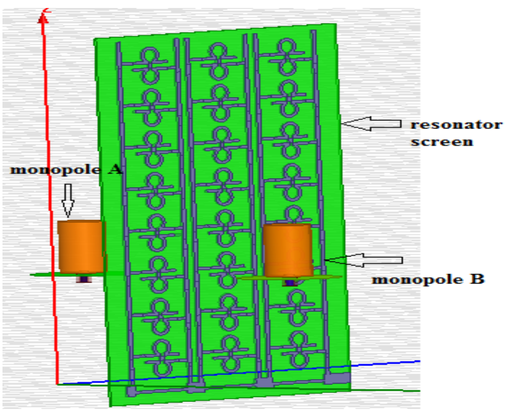


Fig: 3.Monopole antenna without screen

The stimulated structure is using a single sheet FR4 board. An additional bias grid is added proximate to the patches to supply controlling voltage for the varactors.10 K-Ohm resistors are added on the bias grid for the purpose of choking the high frequency signals on the bias grid. At the resonant frequency, the surface current flows along the inner edge of the metallic patch, and the majority of current flows through the varactor. The magnetic field forms a ring around the screen at the centre, which stores EM energy and prevents the transmitting of a plane wave. Evidently, the change of varactor capacitance would consequently tune the resonant frequency.



(a)



(b)

Fig: 4. (a) Monopole antenna with metal screen, (b) proposed structure

The resonator screen and the structure is shown in Fig. 2. In early, The original design of this patch can be traced back and it is also known as the electric-LC (ELC) resonator. It is later successfully modified into an (AFSS) active frequency selective surface. The simulated structure is sensitive to steep (vertical) polarized incident wave. In this work, it is realized on a single layer FR4 board.

A very large metallic screen is required to achieve a high isolation ratio. A decoupling networks/circuits use feedback signal to cancel the coupling signal. When the signals received by antenna B are totally cancelled, high-level isolation can be realized.

IV. RESULT AND ANALYSIS

4.1 S-Parameter

Simulated results (Frequency Vs Transmission Coefficients for various distances) are shown in Fig. 5. The resonant frequency can be tuned from 1.0 GHz to 3.0 GHz which covers the working band of the monopoles. After optimization procedure, S21 reach -134 dB. This result is close to the sensitivity limit of the VNA. The direct transmission (nothing is between the monopoles) is -26.49 dB. We replace the resonator screen with a metal board having the same dimension (220 mm by 140 mm), the transmission coefficient is about -134.0 dB.

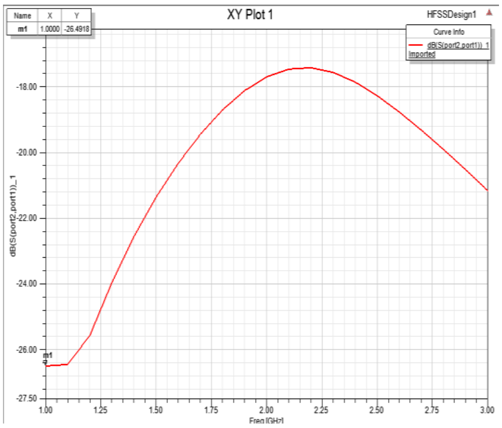
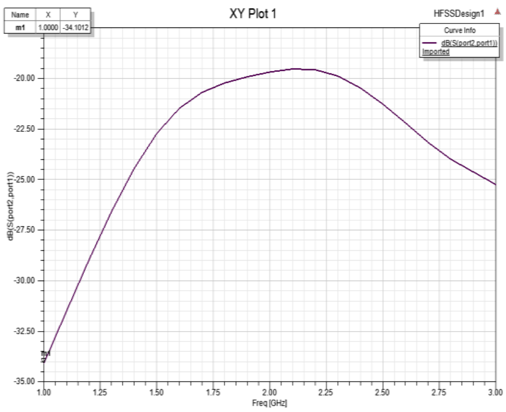
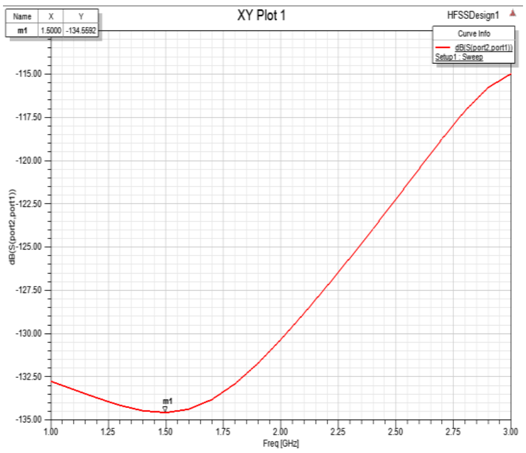


Fig: 5. Frequency Vs Transmission Coefficients for dual monopole antenna without metamaterial screen

At the frequencies, the transmission coefficients are −134 dB, for distance between the antenna 10cm. Here shown the comparison between the graph of dual monopole antenna without screen, with metal screen and with metamaterial screen.



(a)



(b)

Fig: 6. Frequency Vs Transmission Coefficients for dual monopole antenna (a)with metal screen (b) with metamaterial screen

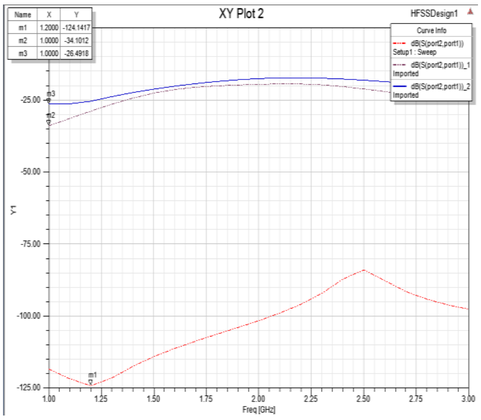


Fig: 7. Frequency Vs Transmission Coefficients for dual monopole antenna without screen, with metal screen, with metamaterial screen

The dual monopole antenna system, the distance between the antenna is 10 cm .Fig.7 gives the result of -134 dB, -34.10 dB and -26.49 dB at the targeting frequencies for 1.2 ghz,1.0 ghz and 1.0 ghz respectively.

4.2 Radiation Pattern

Radiation pattern is get from 10 cm distance between the monopole antenna A and B. Fig 8. is shown the result for the distance 10cm.

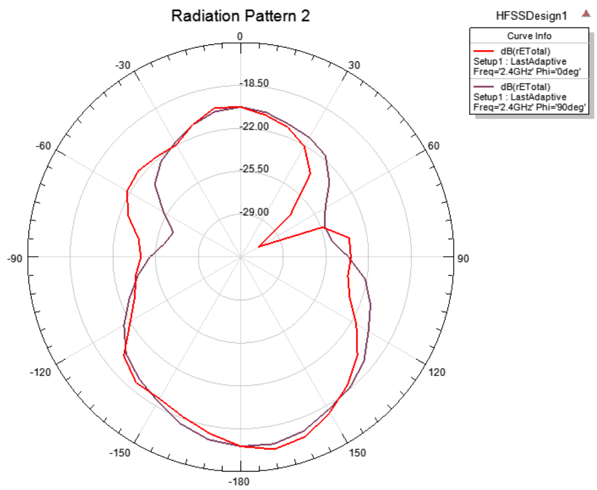


Fig : 8. Radiation pattern for proposed system.

V. CONCLUSION

A decoupling method for increasing the isolation has been achieved by using a metamaterial (omega structure) screen structure. The results show that this method can offer a very high-level isolation. Additionally, the isolation frequency is tunable over the resonators' tunable range. Compared to other decoupling techniques, the proposed decoupling scheme provides good coupling suppression level for MIMO applications. This technique can be used in various areas such as MIMO antennas, two closely positioned antennas of different systems like Wi-Fi and Bluetooth, or the decoupling between transmitting and receiving antennas.

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