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ELECTROMAGNETIC INTERFERENCE (EMI) SUPPRESSION IN CO-LOCATED RADIATING SYSTEM USING COMPLEMENTARY SPLIT RING RESONATOR (CSRR)

J. Mangaiyarkarasi[1], N. Sureshkumar[2] and R. Parthasarathy[3]
[1]Department of Electronics and Communication Engineering, Anna University, Regional office Madurai, Tamilnadu, India
[2]Department of Electronics and Communication Engineering, Velammal College of Engineering and Technology, Madurai, Tamilnadu, India
[3]Department of Electronics and Communication Engineering, St. Josesh's College of Engineering, Chennai, Tamilnadu, India
E-Mail: j_mangaiyarkarasi@yahoo.com

ABSTRACT

Electromagnetic Interference (EMI) suppression in co-located radiating systems is presented and this is accomplished by incorporating circular complementary split ring resonator (CSRR) under the feed line of the low frequency antenna. The first harmonic of the low frequency antenna which coincides with the high frequency antenna is suppressed by 8.2dB. The proposed method enables simultaneous operation of 2GHz and 4GHz antenna sharing the common ground.

Keywords: complementary split ring resonator (CSRR), electromagnetic interference (EMI), microstrip patch antenna.

1. INTRODUCTION

The integration of different radio modules into a single device is one of the vital developments in the wireless communication domain over the past decade. Integration of GPS with cellular communications is one classic example. Consequently demand for multiband antennas [15] that support different functionalities has increased. Multiband antennas that include GPS functionality along with cellular communication have been proposed in the literature [1]-[4]. Apparently integrating GPS and cellular based antennas increases the risk of interference between the two functional antennas, which eventually impacts the accuracy and availability of GPS. Adequate isolation between collocated cellular based and GPS antennas must be established in order to minimize the risk [5].In order to suppress the interference, band pass filters (BPF) are used in the front end of the receivers, and since the problem was solved not much research has been reported addressing the interference issues in collocated antennas.

Inclusion of BPF in the RF chain adds additional circuitry and insertion loss in the channel which is not desired. Instead a novel approach has been presented which makes the use of BPF redundant. BPF [13] was passed the desired range of signal from transmitter to receiver. With the inclusion of a complimentary split-ring resonator (CSRR) in the antenna, harmonics can be suppressed [6], [9]-[12], which mean filtering activity is done at the antenna stage, making the BPF redundant. Although our discussion appears more to be on the telemetric applications the proposed method can be generalized to address the interference issues in any integrated radio modules with printed antennas [7].For demonstrating the approach, two patch antennas resonating at 2GHz and 4GHz are printed on a single PCB with independent feeds. The patch radiating at 2GHz has its first harmonic at 4 GHz which is the operating band of the other patch antenna. This harmonic is suppressed by the inclusion of CSRR in the ground plane [11], [14] of the 2GHz antenna. The idea that single negative media does not allow the signal transmission is applied here.

Split ring resonator (SRR) consists of two concentric metal rings separated by a gap and both having splits at opposite sides. Magnetic resonance is induced by splits at the rings and by the gap between the inner and outer rings. SRR produces negative permeability at the designed resonant frequency. The application of babinet principle leads to the implementation of its complementary counterpart CSRR. In the CSRR the rings are etched on a metallic surface and its electric and magnetic properties are interchanged with respect to SRR. This CSRR acts as a single negative media which allows us to perform the filtering activity [8].

2. CO-LOCATED RADIATING SYSTEMS

The structure of co-located radiating system without CSRR is shown in Figure-1 the two microstrip patch antennas and the ground plate are separated substrate, whose thickness is h=1.58mm(in this paper we used Rogers/RT duroid 5880(tm)). The CSRR is created by etching the ground plane under the interference making antennas feed. This CSRR in ground plane act as a stop band which suppress the out of band radiation present in the co-located antenna system. The Figure-1 shows the top view of antenna structure the design values of CSRR are, inner radius r_1=2.09mm, second ring radius r_2=3.59mm, width of the split w=0.75mm, split gap g=0.75mm, ring separation t=0.75. This design values are used to provide the stop band at 3.8GHz to 4.1GHz. At antenna band width of 0.3GHz.The permittivity of substrate ε_r =2.

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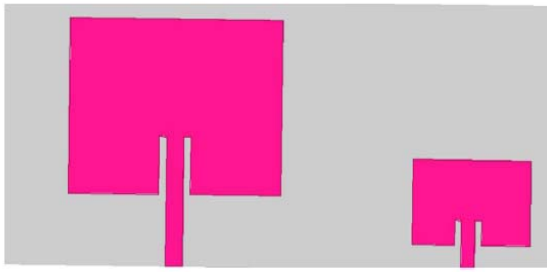

Figure-1. Top view co-located radiating system without CSRR.

3. EMI ANALYSIS

The analysis of co-located radiating system is done based one the application of metamaterial CSRR. Which have the properties of stop band and band pass using this property we proposed the novel method to suppress the out band radiation. Strong rejection characteristics are observed for the CSRR, where the band-gap zone is clearly seen within the designed frequency range. Here the CSRR act as a band stop filter in the frequency range of 3.8GHz to 4.2 GHz.

A. Configuration

The electromagnetic interference is analyzed from the Figure-2 and the simulated result of the co-located radiating antenna is shown in Figure-3. Form this Figure we can clearly understand the EMI interference. In this Figure-2 the low frequency radiating antenna is designed to operate at 2GHz and another antenna designed to operate at 4GHz, but the low frequency antenna also radiating at out of band radiation at 3.95GHz so this antenna introducing the interference and the s11-parameter at 3.95GHZ is -9.5dB is noted.

In order to suppression this out of band radiation by CSRR etching under the feed line of 2GHz antenna. The design arrangement of co-located radiating system with CSRRs is shown in Figure-3.

The setup model used to demonstrate the EMI reduction is shown in Figure-3 where two identical microstrip antennas having a resonant frequency of 2 GHz, 4GHz and placed $0.5\lambda_0$ apart, where λ_0 is the free-space wavelength. So the CSRR disrupt the property of microstrip feed and create the stop b and for the out of band radiation Figure-4 shows the suppression out band radiation.

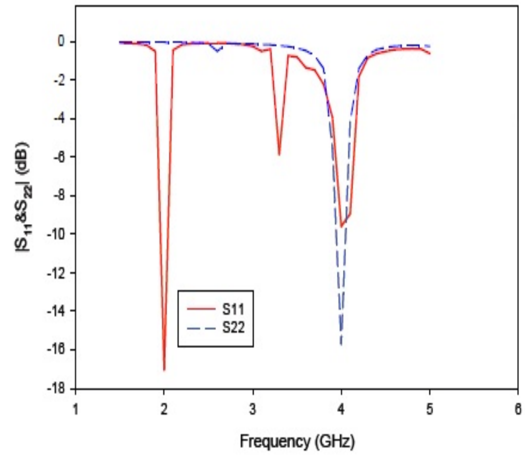

Figure-2. Reflection coefficient S_{11}&s_{22} of the microstrip patch antenna without CSRR.

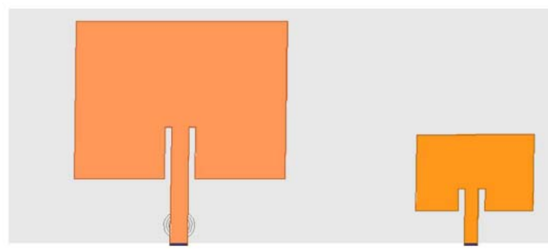

Figure-3. Top view co-located radiating system with CSRR.

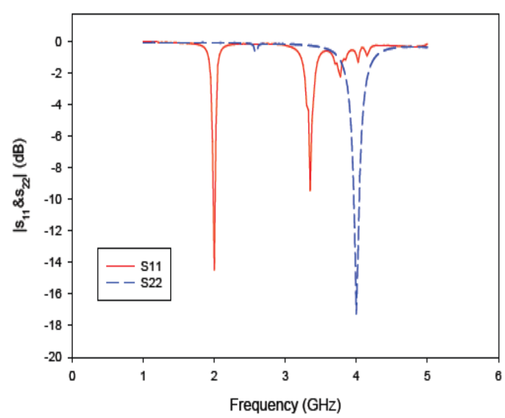

Figure-4. Reflection coefficient S_{11}&s_{22} of the micro strip patch antenna with CSRRs.

The configuration of microstrip line loaded with CSRR was simulated using Finite element based full wave solver Ansoft HFSS. This simulated result is shown in Figure-4. From this result we demonstrate the EMI reduction in the out of band 4GHz radiating element therefore the s_{11} -14.5 dB resonating at 2GHz and also resonating at 3.4GHz is -8dB (another narrow band

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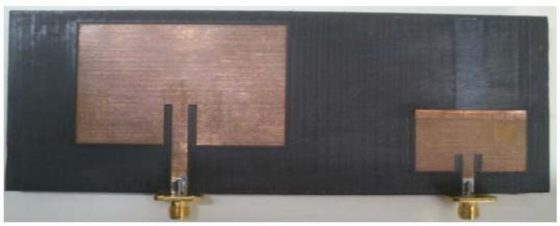
interference) s_{22} -16.5 dB achieved without EMI interference. A reduction of about -1.8dB in the interference between the antennas is observed.

B. Measured results

The structure is then realized on Duriod 5880 substrate using standard fabrication procedures. The photograph of the top and bottom view of fabricated structure is shown in Figure-5.



(a)

(b)

Figure-5. Photograph of the fabricated structure (a) Top view (b) Bottom view.

The measured result is taken with the help of network analyzer. A stop band observed from 3.8GHz to 4.2GHz with s_{11} above -1.3dB in Figure-7. In case of the unloaded microstrip patch the s_{11} remains below -9.5dB over the band in Figure-3. The simulated s_{11} shows a peak of -16.5DB at 2GHz while the measured s_{11} shows -14.5dB. This is attributed to the fabricated tolerances. Similarly the s_{22} shows a peak of - 17.3dB at 4GHz while the measured s_{22} shows -15dB.The out of band radiation of low frequency radiating element is suppressed in simulated s_{11} shows -0.98dB and the measured result s_{11} shows -1.58dB. Form this observation the EMI is completely suppressed.

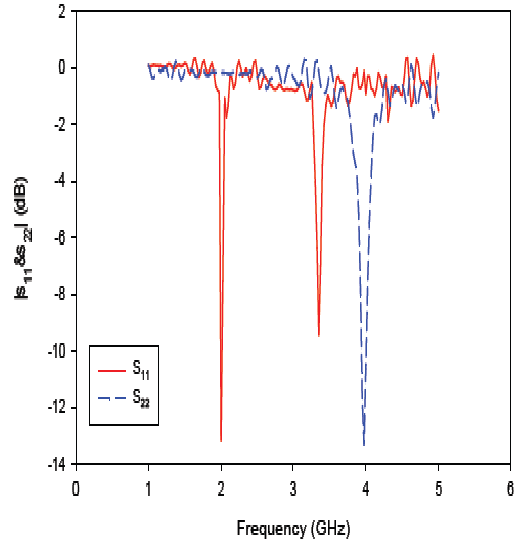


Figure-6. Measured result of Reflection coefficient s_{11}&s_{22} of microstrip patch antenna with CSRR.

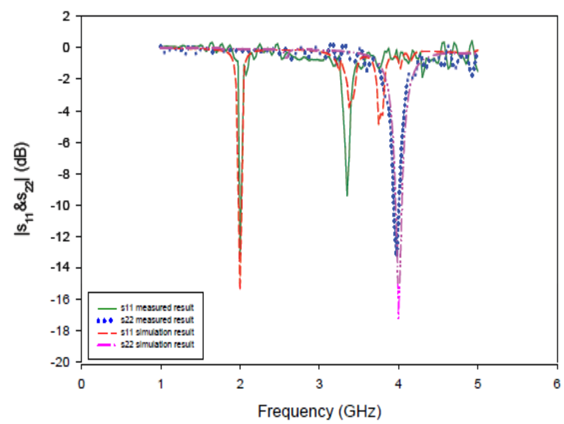


Figure-7. Comparison of simulated and measured results of CSRR loaded under the microstrip feed line.

6. CONCLUSIONS

In this paper we proposed novel electromagnetic interference suppression by etching a ground pane to create stop band to stop the out of band radiation using CSRR. The proposed structure is simulated in Ansoft HFSS and measured using Agilent E8363b PNA Series Vector Network Analyzer. Although the out of band rejection is good, it cerate stop band only in the narrow band range (only in the second antenna operating frequency range). So near to this stop band some sub pass band is present this will create interference. In order to stop this band we need increase number of cells and it should load in the ground plane. If increase the number of cells with different size of CSRR then it act as a stop band for a wide range band (by array etching CSRR). The antennas which are designed above structure all are narrow band if we want increase by using the different feeding technique in patch antenna.

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