Design of MIMO Antenna with High Isolation using Split Ring Resonator

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Abstract - *A MIMO antenna with two different antenna elements of different operational bandwidth is proposed in the design. the whole configuration consists of circular monopole antenna of UWB region operates at 3.1 to 10.6 GHZ and another monopole antenna centered at 5.45GHZ for broadband applications operates at (5.19-5.9GHZ).the antenna configuration is isolated by placing Stub and array of Split Ring Resonators (SRR) of different size and S-parameters and Envelope Correlation Coefficient (ECC) is computed for MIMO antenna with both Stub and Split Ring Resonator it is found that MIMO antenna with Stub and SRR provides better isolation |S_{12}|>20dB and is Envelope Correlation Coefficient of less than 0.0003.*

Keywords: **MIMO Antenna, Split-Ring-Resonator, Envelope Correlation Coefficient, Diversity Gain.**

1. INTRODUCTION

Today's generation there is a demand of faster data transmission and reception rate in cellular communication in that mainly multimedia communication as we can see the evolution of wireless communications since 1980,it started from 1st Generation –which involves transfer of voice signals from source to destination. Later 2nd generation cellular systems which provides transfer of voice and data signals with a rate of 50Kbps .next 3rd Generation cellular systems involves transfer of voice data and video which is also called multimedia communication with a data rate of 3.5 mbps to 20.9 mbps. Multiple-input Multiple-output (MIMO) technology is the key concept in 4th generation wireless communication systems which provides high data rate of up to 100Mbps.MIMO technology uses multiple antennas at both transmitter and receiver which results in increase in channel capacity as compared to other antenna systems. The MIMO technology involves design of multiple antennas inside a component to increase data rate and decrease in bit-error rate due to multipath propagation of a transmitted signal. The proposed antenna system operates in Ultra-Wide Band (UWB). When designing a MIMO antenna we need to take care of isolation between them, since space available to incorporating the antennas is very less and it leads in power flow from one antenna to other that decreases the efficiency of antennas.

This paper describes a novel method to increase isolation between the two different monopole antennas having different operational bandwidth. Two antennas are isolated by placing SRRs in between two antennas and metallic strip present in the ground plane.

2. LITERATURE SURVEY

There are many isolation techniques have been proposed for better antenna operation for higher antenna isolation and to increase antenna efficiency. Inverted -Y shaped stub [8] is used as isolation which is placed in between two antennas operates over a frequency band of 3.2-10.6GHZ which gives rise to isolation between antennas more than 15dB.another isolation technique such as sleeve coupled rectangle stepped impedance resonator (R-SIR)[4] which gives rise to isolation over 23dB.next The defected ground structure (DGS) [3] based isolation technique for multiple antennas; this technique is capable of improving the isolation of a dual band antenna especially for the low band(803-823MHz) and high band (2440-2980Mhz). The minimum isolation achieved for the low band and high band is 17dB and 9dB respectively. Later for two antennas operates at different bands which has been isolated by placing Split-Ring-Resonator (SRR) [5] type structures in between antennas which gives rise to better isolation and Envelope Correlation Coefficient(ECC).

3. ANTENNA DESIGN

The Proposed antenna system is designed using HFSS tool and the design composed of two antennas that is one circular monopole operates at UWB region (3.1-10.6GHZ) and other monopole operates at 5.45GHZ range designed in FR4 substrate of relative permittivity 4.4. This configuration is placed over a ground plane, and two antennas are separated by stub which is designed in ground plane. Isolation is further increased by placing four Split ring resonators of different sizes along with stub.

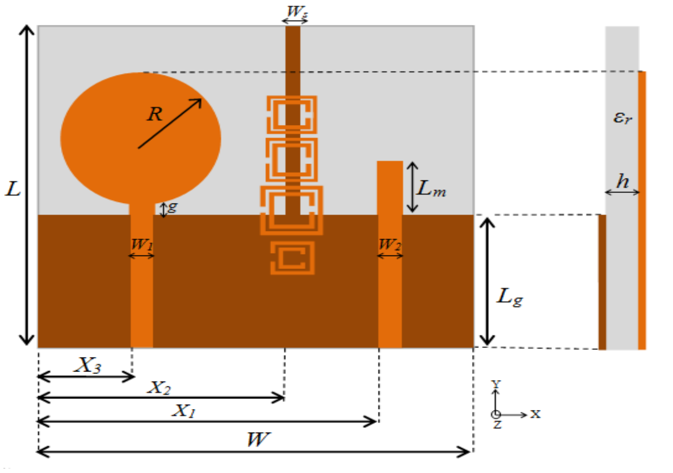

Fig3.1: MIMO Antenna System with SRR And Stub

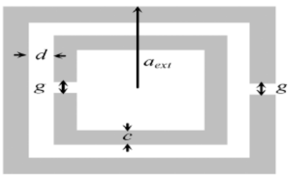

Fig3.2: Enlarged view of four Split Ring Resonators

The proposed antenna system is shown in above Fig 3.1 the design involves design of substrate(FR4) of relative permittivity εr =4.4 of size 52mm*50mm and substrate width is Ws=1.5mm.next is the design of ground plane of size 52mm*20mm.a circular monopole of Radius R=10mm is designed over a substrate and feed line width giving to that antenna is W1=2.6mm ,feed gap dimension is g=0.3mm.another $\lambda/4$ monopole is placed on substrate of length Lm=10.4mm and feed line of width is W2=2.7mm.the distance between two antennas is 20mm. the design parameters of four Split ring resonators is shown in below Table 1

Table 1 Design parameters of four SRRs

Design parametes	Dimensions in mm			
	SRR-1	SRR-2	SRR-3	SRR-4
a_{ext}	2.7	2.2	2.1	1.6
G	0.3	0.6	0.4	0.4
D	0.4	0.6	0.4	0.4
C	0.5	0.5	0.5	0.5

4. RESULTS

The proposed system is designed using HFSS (High Frequency Structural Simulator) which is based on finite element (FEM) method. Initially the MIMO antenna without isolation is designed and S-parameters are used to study the performance and S-parameters for MIMO antenna without isolation is shown in below fig 4.1 S-parameter S_{11} (Red line in below fig 4.1) represents return loss of circular monopole,S_{22} (black line in below fig 3.1)represents return loss of $\lambda/4$ monopole, and S_{12} or S_{21} (blue line fig 4.1)represents isolation between two monopoles. From the graph it can be observed that isolation between two antennas is more than that of -20db for frequency between 2to 10GHZ this is because of there is no isolation between antennas. S_{11}Return loss of antenna 1 that is circular monopole it is less than -10db except at frequency 2GHZ. However, the return loss and isolation between antennas can be improved by using isolation.

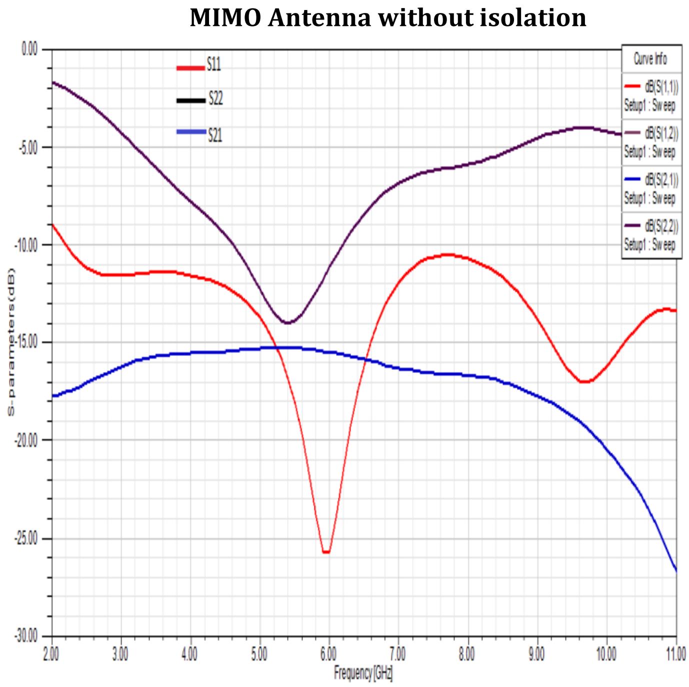

Fig 4.1: S-parameters of MIMO antenna without isolation

The correlation between antennas is determined by parameter called Envelope Correlation Coefficient (ECC) which uses S-parameters to compute ECC as shown in fig 4.2 which can be improved further by using array of four SRRs and stub is placed in between two antennas the Envelope Correlation Coefficient (ECC) is computed for different antenna configurations like MIMO antenna without isolation, MIMO antenna with Stub is placed in between two antennas ,MIMO antenna with Split Ring Resonator is placed in between two antennas and MIMO antenna with both Stub and SRR is placed in between them and in each case the S-parameters ,ECC and Diversity Gain is discussed .Envelope Correlation Coefficient (ECC) in terms of S-parameters is given by

$$\rho_e = \frac{(S_{11}^{*}\ S_{12} + S_{21}^{*}\ S_{22})*(S_{11}^{*}\ S_{12} + S_{21}^{*}\ S_{22})}{(1 - S_{11}^{2} - S_{22}^{2})*(1 - S_{22}^{2} - S_{12}^{2})}$$

For good diversity/MIMO performance the value of ECC Should be ρ_e<0.5.simulated value of ECC in this configuration is less than 0.07 (fig4.2) for entire frequency range of operation which is in good agreement with theoretical results.

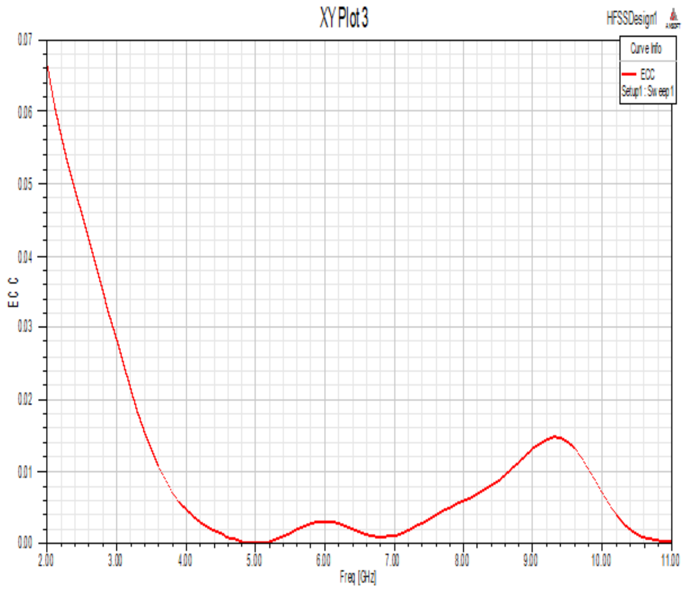

Fig 4.2: ECC of MIMO antenna without isolation

Diversity gain measures effect of diversity on communication channels It is defined as decrease in Signal to Noise Ratio (SNR) compared to a non-diversity receiver for a given performance factor. Diversity gain is calculated in terms of ECC.in MIMO antennas Diversity gain should be less than 10dB.computed values of DG is shown in below fig 4.3.

Diversity Gain =10*√1-ρe (dB)

Later Diversity gain can be improved by inserting Stub and Split Ring Resonator (SRR) which is discussed in later sections.

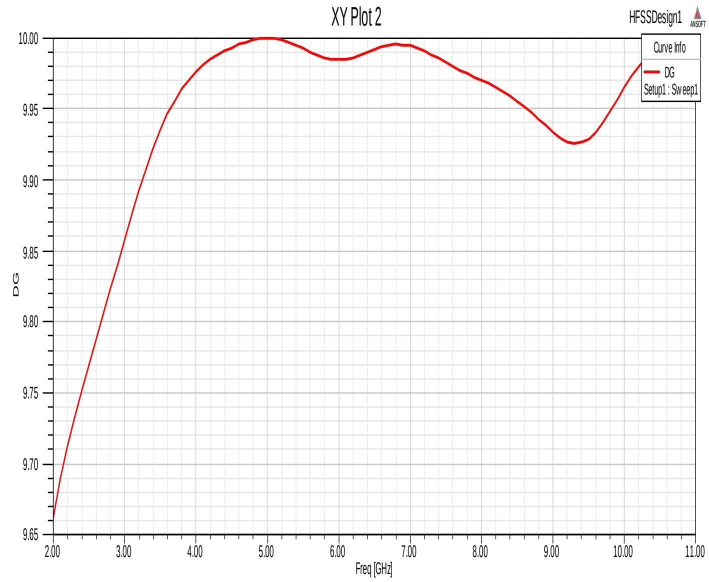

Fig 4.3: Diversity Gain of MIMO antenna without isolation

MIMO Antenna with Four SRRs and stub

Next MIMO antenna is isolated by four SRRs and a stub which gives high isolation results is better Error Correlation Coefficient (ECC).and isolation the S-parameters for MIMO antenna with Stub and SRR is shown in fig 4.4

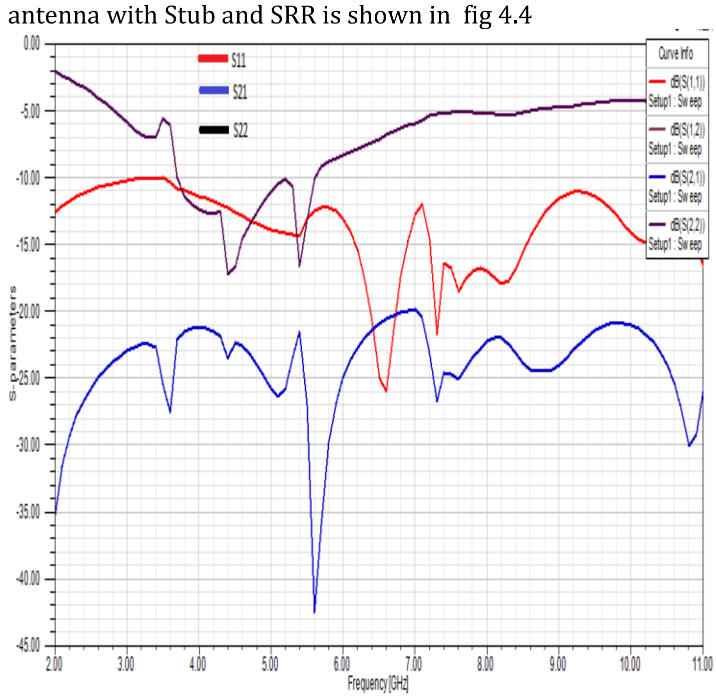

Fig -4.4: S-parameters of MIMO antenna with Stub and SRR

As from the fig 4.4 MIMO antenna configuration with high isolation the isolation achieved less than -20dB.the insertion loss for antenna 1 S11 is less than 10dB.S21<-20 dB for all frequencies and Envelope Correlation Coefficient (ECC) is less than 0.01 is shown in fig 4.5.

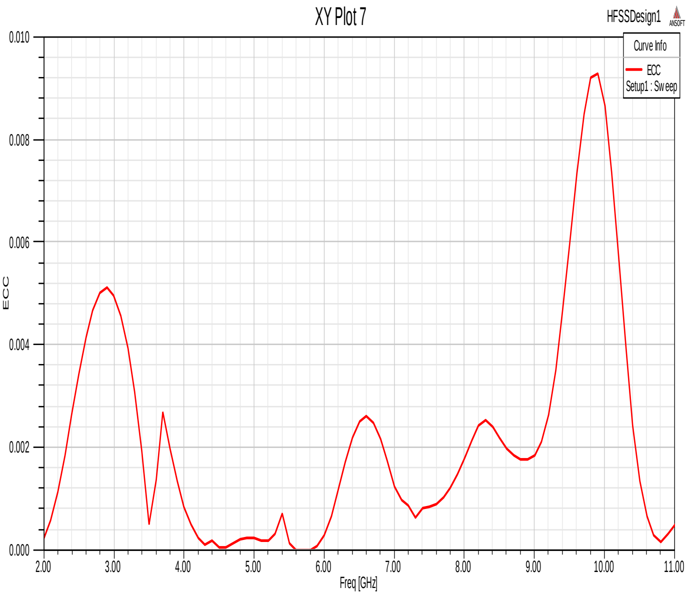

Fig 4.5: ECC of MIMO antenna with Stub and SRR

Table 2

Results Comparisons of different MIMO antenna configurations

Antenna configuration	ECC		Isolation	
	Value	% improvement	Value in dB	% improvement
MIMO without isolation	0.0638	none	-18.45	none
MIMO with stub	0.0007	98.9	-34.83	88.78
MIMO with Stub and SRR	0.0002	99.6	-35.89	94.52

As from the table 2 the results of different MIMO antenna configuration is shown above it can be observed that the MIMO antenna with stub and SRR is having better ECC and isolation between antennas as compared to MIMO without isolation and MIMO with Stub.

5. CONCLUSION

The designed MIMO antenna which operates at two frequencies is very use full for mobile applications and it is designed with very high isolation for efficient communication results in higher efficiency the MIMO antenna with stub as isolation results in less isolation as compared to MIMO with MIMO antenna with both Stub and Split Ring Resonator s which results is better isolation as compared to earlier MIMO with Stub the observed ECC (Envelope Correlation Coefficient) is very less in case of MIMO with Stub and SRR .

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