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Broadband MIMO Antenna with Parasitic Strip for Wireless Applications

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Abstract:

A Compact broadband Multiple input multiple output (MIMO) antenna is presented with a parasitic strip which are widely used in wireless applications. The antenna parameters such as Gain, directivity, Envelope correlation coefficient, efficiency, radiation pattern and isolation have been studied for our antenna design and then fabricated. The proposed antenna primarily consists of a meander dipole, a concave parabolic reflector and a parasitic strip to enhance better impedance matching. The antenna dimensions are minimized by the use of parabolic reflector and also the directivity is improved. Besides these components, a dipole is used to intensify the isolation and to increase the bandwidth. Four antenna elements are placed orthogonal to each other for miniaturized size. Experimental results indicate the proposed MIMO array achieves a broad impedance bandwidth of 26.9%

Keywords—miniaturized size, directive antenna, multiple-input–multiple-output (MIMO).

I. INTRODUCTION

High data rates with a large signal to noise ratio in wireless applications can be achieved by multiple input multiple output systems [1]. Multiple input multiple-output, or MIMO, is a radio communications technology or RF technology that is being mentioned and used in many new technologies these days. The MIMO technology has been used to improve wireless system performance because of high channel capacity and capability [4]. MIMO is effectively a radio antenna technology as it uses multiple antennas at the transmitter and receiver to enable a variety of signal paths to carry the data, choosing separate paths for each antenna to enable multiple signal paths to be used.

Fourth generation mobile networks or long term evolution (LTE) is based on MIMO technology. Multiple-Input-Multiple-Output (MIMO) technology deployed in 4G Long-Term Evolution (LTE), 5G networks, Wireless Local Area Network (WLAN) and World Interoperability for Microwave Access (WIMAX) significantly [8] improves the spectral efficiency. The proposed antenna operates in ku band (12 GHz) useful for satellite communication application. This band is split into multiple segments broken down into geographical regions, as the ITU (International Telecommunication Union) determines. The ku band cannot be used as it has a difficulty of rain fade and snow fade. The major issue in designing the antenna for wireless application is high propagation loss due to high frequency. The challenges faced while designing MIMO antenna are to minimize the dimensions of each element of MIMO antenna, to enhance isolation between the antenna elements and to reduce the mutual coupling [6]. Some commonly Used techniques for this purpose includes using a parasitic element, electronic band gap structures (EBG) and neutralizing line. Also high Front to Back Ratio (FBR) and directional radiation pattern.

In this letter, we design a compact broadband MIMO antenna with a size of 36 x 27 x 0.8 mm^3.The actual antenna element consist of a concave parabolic reflector, a meander dipole and a parasitic strip to improve return loss. A four element MIMO array is formed by using multiple single element antenna. Therefore our proposed MIMO array can be used for various wireless applications due to the obtained results.

II. SINGLE ANTENNA DESIGN

The designed antenna element is indicated in fig 1.The substrate used in the antenna construction is Rogers 4003C which has properties as follows: ξr=3.38 and tan Δ=0.027.The resulting antenna size is 36 x 27 x 0.8mm^3.Three major elements used in antenna design are 1.a dipole element 2.reflector and

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3.Metal strip which does the function of director. Besides these 3 elements we have also used parasitic strip. This strip is placed in between dipole and reflector element. The function of parasitic strip is to provide good impedance matching.

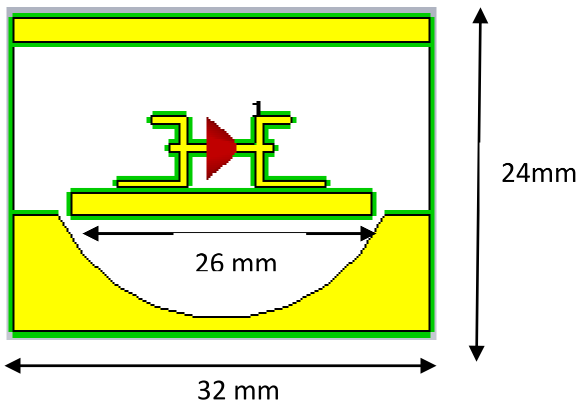
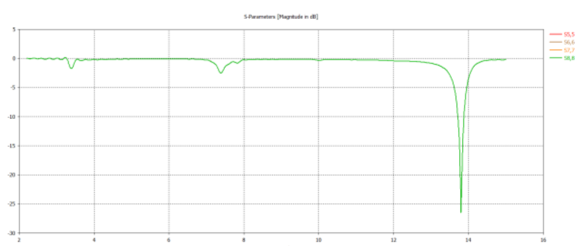


Fig 1. Single antenna element geometry

In order to obtain unidirectional radiation at the lower band reflector is used. In order to reduce the size of antenna without reducing the directivity a concave parabolic reflector is used. A 50 ohm coaxial cable is used for the purpose of feeding the antenna. The coaxial cable has two types of conductors: Inner and Outer conductors. These two conductors will be connected to two arms of meander dipole.



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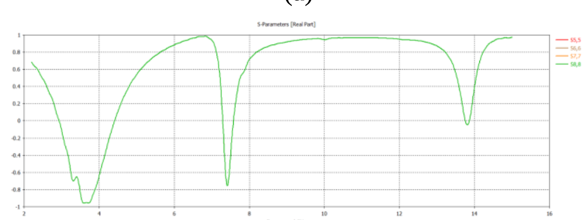

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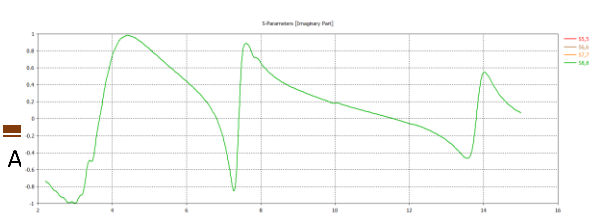

(c)

Fig. 2 Simulated results for antenna (a) S11 (b) Real and (c) Imaginary parts of the input impedance

Here a dipole antenna is used so as to reduce the antenna length. Director and reflector elements are used to minimize the back lobe and side lobe radiation and enhance directivity. Also a parabolic reflector is used to reduce the area of the antenna. Inductance exists in between the dipole element and parabolic reflector which reduces the return loss. This problem is overcome by using a parasitic strip that will act as capacitor and compensates the internal inductance effect. Thus improvement in return loss is achieved.

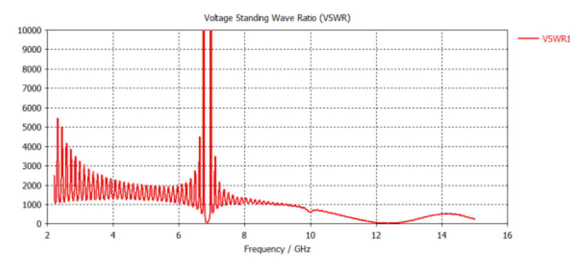

Fig.3. VSWR Measurement

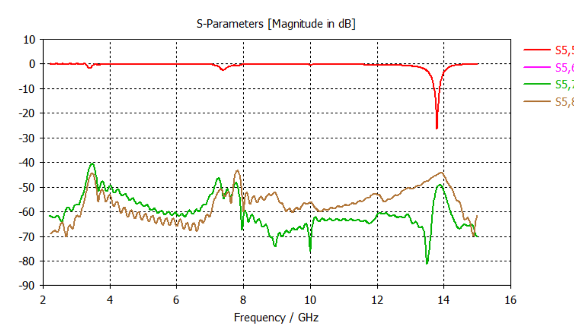

Fig.4. Simulated S-parameter of proposed antenna element

The frequency dip is obtained at 13.5 GHz. This can be varied by varying lengths l1, l2 and l3.The length and width of the parasitic strip are indicated byLp and Wp respectively. The impedance matching

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is adjusted by varying Lp. The strip could actually be considered as micro strip transmission line. This strip will strengthen the coupling between the dipole and the reflector. As a result more power could be coupled in between the driven dipole and the reflector. It is to be noted that the $|S_{11}|$ is lower than -15dB across band (12-14GHz).The folded dipole used in construction of the antenna in fig 1 is modified to obtain the frequency dip at 13.5 GHz which is key in satellite applications.

III. MIMO ARRAY DESIGN

The proposed antenna array has wide bandwidth and also good directivity. Such configuration is suitable to build MIMO array. It is important to maintain each antenna element in appropriate position in order to reducing coupling among various antenna elements. This ensures low signal correlation. Because of the square loop configuration of the designed array, the mutual coupling which would otherwise exist in between opposite element is very much reduced. And the overall size of the array is 85 x 85 mm^2.

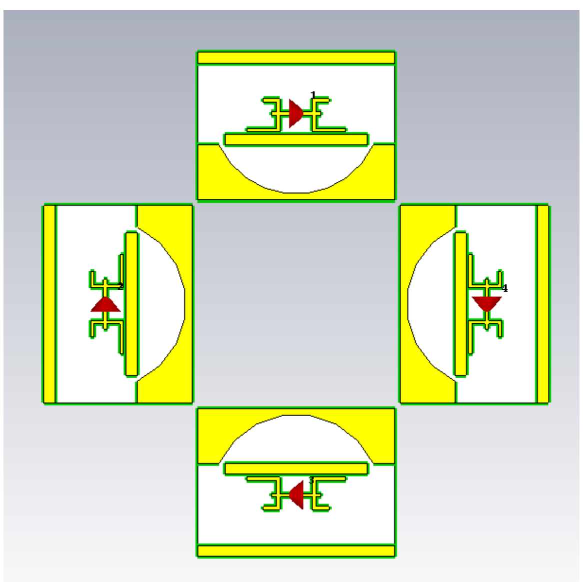


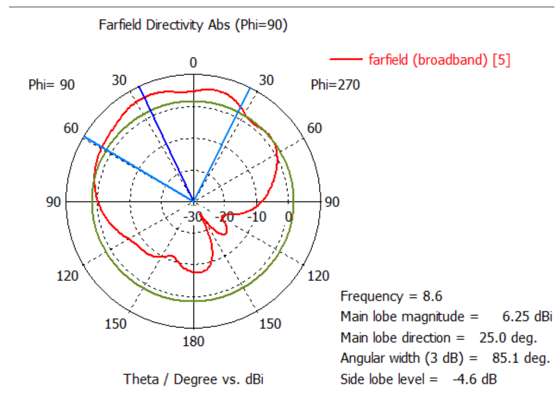
Fig. 5. Antenna Array Design

IV. SIMULATED AND MEASURED RESULTS

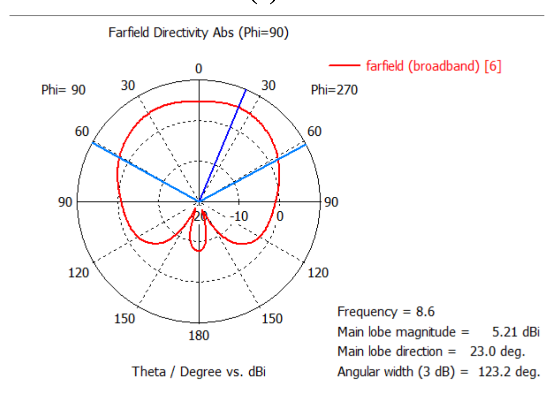
The Simulation was done using Computer Simulation Technology (CST) which is a three-dimensional electromagnetic simulator commercially used in recent times. A prototype of MIMO antenna is fabricated to verify the design of our proposed antenna. The S-parameters are measured by using Network Analyzer. Other parameters such as gain, Efficiency and radiation pattern are measured by the use of anechoic chamber.

TABLE I
COMPARISON OF DIRECTIVE ANTENNA ELEMENTS

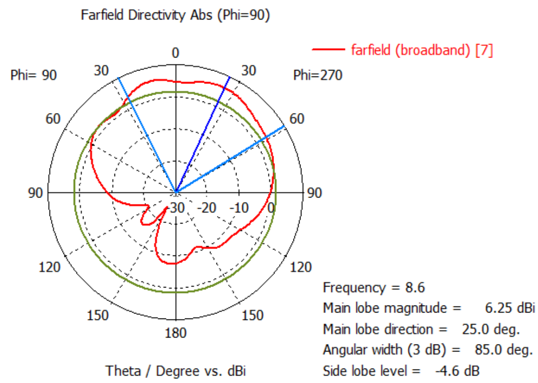
Ref	Size	Maximum FBR	R
[4]	$0.39\ \lambda_0 \times 0.39\ \lambda_0$	14 dB	92
[6]	$1.3\ \lambda_0 \times 1\ \lambda_0$	13 dB	10
[7]	$0.47\ \lambda_0 \times 0.47\ \lambda_0$	12.6 dB	57
Proposed	$0.26\ \lambda_0 \times 0.21\ \lambda_0$	**33.4 dB**	**543.51**



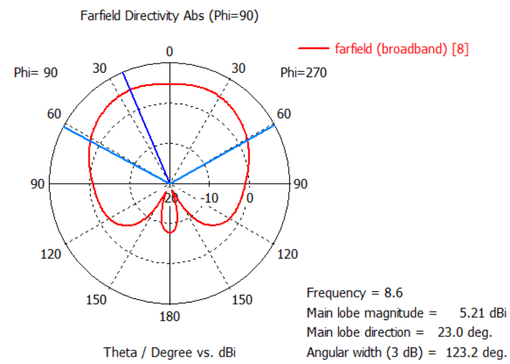
(a)



(b)



(c)



(d)

Fig.6. Far Field distribution of (a) 1st antenna (b) 2nd antenna (c) 3rd antenna (d) 4th antenna

A.S-Parameters

The return loss S_{11} represents how much power is reflected from the antenna, and hence is known as the reflection coefficient. It is measured and simulated. The results measured imply that the proposed antenna array meet the impedance matching and isolation requirements for wireless applications such as WIMAX, WLAN, LTE and so on.

TABLE II
COMPARISON OF MIMO ANTENNA ARRAYS

Ref	Gain
[4]	4 dBi
[6]	6 dBi
[8]	4.3 dBi
[9]	8 dBi
Proposed	**7.4 dBi**

B. Radiation Characteristics

The simulated and measured radiation pattern of the proposed MIMO antenna array in E-plane (xoy plane) and H-plane (yoz plane) are depicted. The antenna efficiency is also illustrated. It can be shown that the efficiency is improved better than the existing antenna design.

C. MIMO Performance

The low envelope correlation coefficient (ECC) is achieved with the proposed MIMO antenna design. A lower ECC implies that the design has a higher pattern diversity. The simulated and measured envelope correlation coefficient (ECC) of the proposed MIMO antenna array is presented in the picture. It can be seen that the design of the antenna has reduced dimensions when compared to the previous existing antenna designs. Also, it can be proven that it has achieved a greater gain to the existing systems.

V. CONCLUSION

A broadband planar MIMO antenna with compact size is proposed. By introducing parasitic strip between driven dipole and reflector, the impedance matching of the single element is greatly improved. Meanwhile, a metal director is also introduced to address the low gain at upper band and widen the operating bandwidth. By placing the antenna element in a right way, a four-element MIMO array is formed to obtain a wide band-width, low correlation, as well as compact size. The MIMO array has a compact size of 36 x 27 x 0.8 mm^3; hence, the low-profile planar structure and small footprint of the MIMO array are suitable for various wireless portable devices applications due to the obtained results.

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