

Compact MIMO Yagi-Uda Antenna with Parasitic Strip for LTE Application

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Abstract— An efficient LTE applications require increased data rate, high reliability and high gain antennas. Antennas used generally in LTE applications reliability and gain but for efficient performance an antenna with non- planar, wide band and better impedance matching is required. A Yagi -Uda antenna with a parasitic strip suitable for multiple input- multiple output (MIMO) applications is designed to achieve efficient performance. The parabolic reflector is utilized to reduce the dimension of the antenna. A parasitic strip is used to obtain a good impedance matching. The impedance matching can be obtained by adjusting the length of the parasitic strip. The purpose of a metal strip is to enhance the gain and widen the operation bandwidth. In this paper, a four-element MIMO yagi uda array is formed by placing the antenna elements orthogonal to each other. The elements are arranged in such a way that the coupling between them is reduced. Thereby a wide bandwidth and compact size can be achieved. The operating bandwidth of this MIMO array is 2.32-2.95GHz which makes it ideal for WLAN, WiMax and LTE applications.

Index Terms-directional antenna, low mutual coupling, impedance bandwidth, MIMO.

I.INTRODUCTION

Multiple Input Multiple Output (MIMO) technologies have several applications in recent years [1]. This technology could enhance the data transmission capacity and reduce multipath fading, resulting in improved data rate and reliability. To obtain good performance in MIMO system, multiple antennas are incorporated to achieve broad bandwidth and low mutual coupling. MIMO antenna plays a vital role in wireless communication such as WLAN (Wireless Local Area Network), WiMax (World Interoperability for Microwave Access), and LTE (Long Term Evolution). To reduce mutual coupling between antenna elements decoupling elements were used [2]. MIMO antenna element

should be directional so that the conventional method to design directive antenna is to use yagi antenna [3]. Landstorfer antenna also exhibit high gain [4]. The slot antenna inherently provide broad band characteristic and also used [5] and [6] to achieve high Front to back ratio (FBR) and directional radiation pattern. yagi uda antenna is simple to construct, cost effective and produce high gain so the elements are constructed by means of yagi uda elements.

II. DESIGN EQUATION

For designing a high performance array antenna, it is important to have the exact dimension of each patch element. A single antenna consists of four element, which is then formed into MIMO array which is used for LTE application.

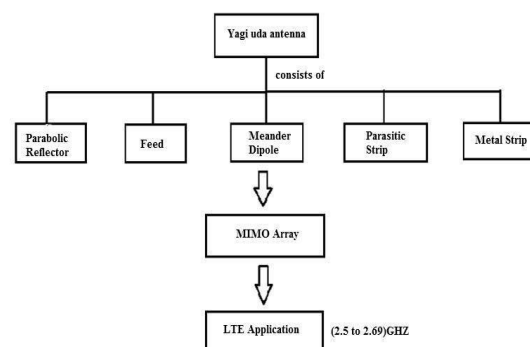


Fig. 1. Design flow of proposed antenna

In this section, the design of single element is described, followed by the array antenna design.

TABLE I. DESIGN SPECIFICATION

Parameter	Dimension
Substrate Type	FR4
Substrate Height	0.8mm
Dielectric Constant	4.4
Resonant Frequency	2.4GHz

The design specifications of single antenna are shown in Table 1.

A. Design Flow

$$\text{Width} = \frac{C_o}{2 * f_r} \sqrt{\frac{2}{\epsilon_{eff} + 1}}$$

$$\text{Length} = \frac{C_o}{2 * f_r \sqrt{\epsilon_{eff}}} - 2\Delta L$$

$$\epsilon_{eff} = \frac{(\epsilon_{eff} + 1)}{2} + \frac{(\epsilon_{eff} - 1)}{2} \left[1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}}$$

Feed Location X_f, Y_f , where, $X_f = \frac{L}{\sqrt{\epsilon_{eff}}}$ and

$$Y_f = \frac{W}{2}$$

Focal distance of reflector, $f = \frac{D^2}{16*d}$

B. Single Element Antenna Design

The proposed yagi-uda antenna elements are printed on a **FR4** substrate (dielectric constant, =4.4). The size of the proposed antenna is 36mm. The yagi uda antenna consists of a meander dipole, a reflector, a parasitic strip and a metal strip. The meander dipoles act as a driven element and operate at half wavelength mode, to reduce the length of the antenna. The concave parabolic reflector is used to enhance the directivity of the antenna at lower band. The parasitic strip is used to obtain good impedance matching. The metal strip is used to improve impedance matching and directivity of the antenna. The antenna is fed by a coaxial cable. The

inner and outer conductor of the cable is connected to the two arms of the meander dipole.

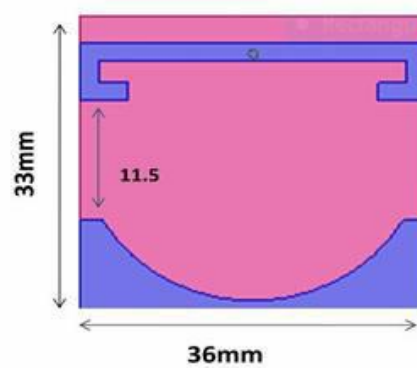


Fig. 2. Initial stage of single element design

In initial stage, the antenna design size is of $36*33*0.8 \text{ mm}^3$. First, a meander dipole that is placed above the reflector at a distance of $l_g = 11.5\text{mm}$. It provides a narrow impedance bandwidth, less FBR and has a large size, which is not suitable for the mobile communication.

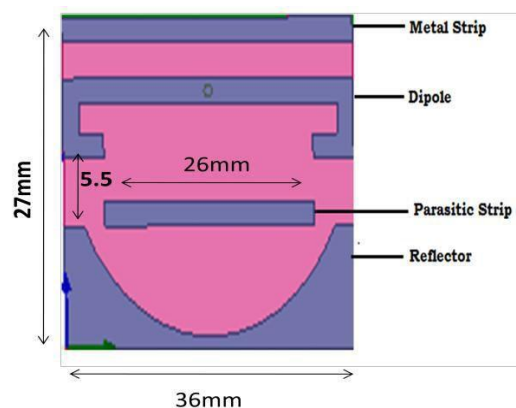


Fig. 3. Proposed design

In order to minimize the antenna size, Fig.3 is employed with $l_g = 5.5\text{mm}$. It deteriorated impedance matching when the distance l_g is reduced from 11.5mm to 5.5mm. If distance between antenna element is reduced, it will increase the input resistance and inductive reactance of antenna. The size of the proposed antenna is $36*27*0.8 \text{ mm}^3$.

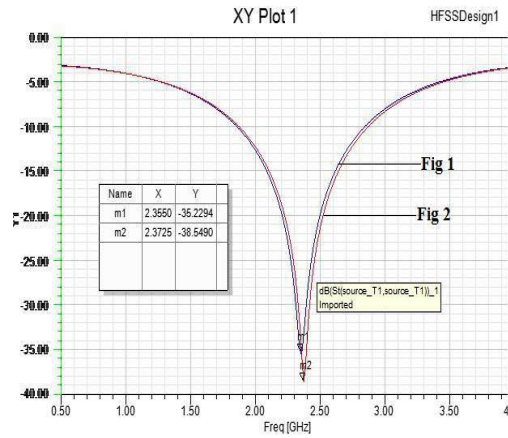


Fig. 4. Return loss plot

For the purpose of improving the impedance bandwidth, a parasitic strip is introduced between dipole and reflector, it provides capacitive coupling between dipole and reflector.

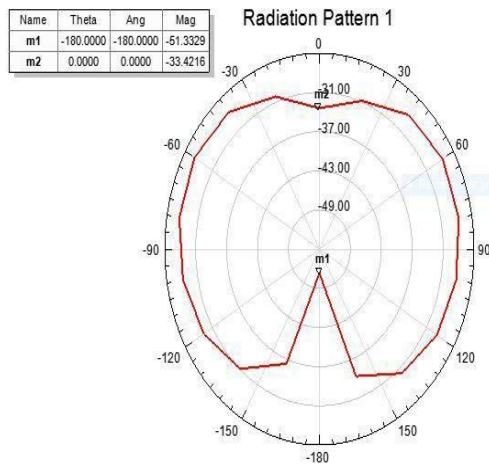


Fig. 5. Radiation pattern of proposed single element

To further widen the bandwidth and improve the directivity at upper band, a metal strip is placed at the upper side. Its vertical length is reduced about 18.2% compared to Fig 2

TABLE II. COMPARISON TABLE

Figure	Return Loss(dB)	VSWR
Fig 1(36*33)	-35.61	0.28
Fig 2(36*27)	-36.57	0.25

In order to get better return loss and VSWR, length of parasitic strip and width of dipole was adjusted. By varying the $lp=22$, better return loss of -38.54 dB (Table 3) was obtained compared to Fig 3.

TABLE III. ADJUSTING THE PARASITIC LENGTH

Length	R.L(dB)	VSWR
≤ 20	-34.54	0.32
22	-38.54	0.20
24	-37.54	0.23
26	-36.67	0.25
28	-34.62	0.32

In this figure 6, the width of dipole has been changed from 2 to 1.5, a return loss of -41.54dB and a VSWR of 0.17 was obtained.

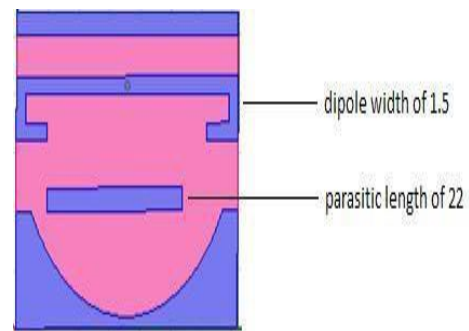


Fig. 6. Modified single element

The current distribution was simulated by ANSYS HFSS software. Current distribution is more where the feed is placed.

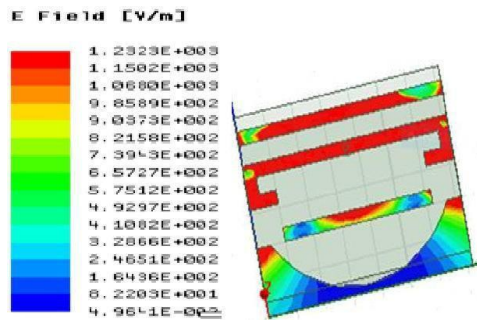


Fig. 7. Current distribution of single element

High voltage feed point is difficult to use so feed is placed at center where the impedance falls to its lowest value.

III. MIMO ARRAY DESIGN AND RESULTS

A good MIMO array have high transmission data rate, low mutual coupling, low signal correlation, wide bandwidth, good directivity, high efficiency.

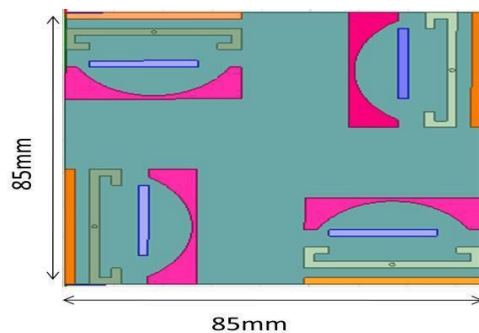


Fig. 8. MIMO Array 1(85mm*85mm)

A good MIMO array should have low mutual coupling between antenna elements. Therefore, each element should be arranged orthogonal to each other to reduce coupling. The distance between each element of MIMO array 1 is about 22mm.

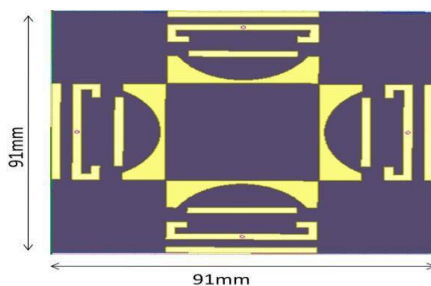


Fig. 9. MIMO Array 2 (91mm*91mm)

The distance between each element of MIMO array 2 is about 37mm. Moreover, the overall size of MIMO array1 show in Fig 8 is much reduced compared to the MIMO array2 show in Fig 9.

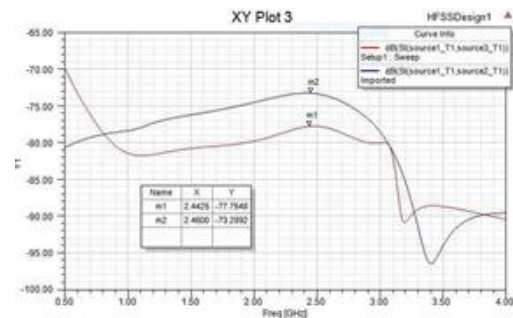


Fig. 10. Isolation loss of MIMO array1

Mutual coupling between adjacent element and opposite element is below -77.75dB and -73.28dB for MIMO array 1 is show in Fig 10.

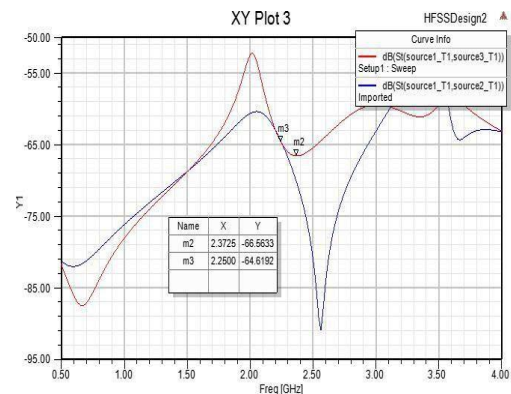


Fig. 11. Isolation loss of MIMO array2

Mutual coupling between adjacent element and opposite element is below -66.56dB and -64.61dB for MIMO array 2 is shown in Fig 11.

IV. CONCLUSION

A broadband planar MIMO antenna with compact size is proposed. By varying parasitic strip, the impedance matching of single element greatly improved. By placing antenna element in a right way, low mutual coupling as well as compact size is achieved. Due to the compactness and low mutual coupling, it is suitable for wireless portable device application.

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