ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 2, Issue 2, February 2013

# Performance analysis of Meandered loop and Top loaded monopole antenna for Wireless Applications

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*Abstract* — **This paper presents the design of multiple antennas for various wireless applications. In this paper the combination of top loaded monopole antenna and meandered loop antenna that operates on frequencies of 600MHz and 1100MHz. This gives good radiation pattern, return loss, effective bandwidth and diversity gain and enables high data rates in wireless applications. 600MHz and 1100MHz frequency of the proposed antenna has the application of LTE and GPS in mobile phones. Simulations are done by FEKO software.**

*Key words*: **MIMO, LTE, GPS**

## I. INTRODUCTION

The key advantage of MIMO is its potential to linearly increase channel capacity with the number of antennas at both the transmitter and receiver, without sacrificing additional frequency spectrum and transmitted power. However, implementing multiple antennas in compact terminal devices such as mobile phones is challenging, since it involves both practical and fundamental design. Nevertheless, most attention in the area has been on the fundamental aspect of closely spaced antennas resulting in an increase in spatial correlation and mutual coupling, which in turn degrade the performance of MIMO systems as measured by metrics such as efficiency, bandwidth, diversity gain and capacity.

The degree of current localization is controlled by the permittivity value of the monopole dielectric loading. Significant isolation enhancement is achieved with more localized currents. This technique improves the terminal's diversity and capacity performance both at the center frequency and over a given bandwidth [1].

The compactness of mobile terminals complicates the design of multiple antennas, since coupling among the antennas increases when they are placed in proximity of one another. It is possible to mitigate coupling between closely spaced antennas, a tradeoff in bandwidth is required [2].

In a novel internal meandered loop antenna with the meandered sections in the loop structure, the antenna's secondary resonant mode (1.5-wavelength mode) can be adjusted to be close to the prior resonant mode to achieve a wider upper band for DCS/PCS operation [5].

A multiband folded loop antenna with a symmetric loop pattern generates four resonance modes in the design bands. Using a pair of tuning elements near the feed port, the impedance bandwidth is broadened to cover GSM850/GSM900/DCS/PCS/UMTS bands [6].

The purpose of this paper is to provide a framework in understanding fundamental design of multiple antennas at dual frequency bands through antenna simulations.

When it comes in mobile application, implementing MIMO technology is a very complex task provided the space of the device. In cellular phone space required to implement more than one antenna are very less. So in this less space we need to accommodate the multiple antennas. However when antennas are closely packed, strong mutual coupling between them will degrade radiation patterns and decrease antenna efficiency.

## II. MULTIPLE INPUT MULTIPLE OUTPUT

MIMO (Multiple Input Multiple Output) technology uses multiple antennas at the transmitter and at the receiver, thus improving the capacity of the wireless link when operating in a dense multipath scattering environment. MIMO system can also be applied to provide a more reliable communication and a higher transmission rate than that of a single-input single-output system without additional radio resource requirements. Here MIMO antenna systems are used in modern wireless standards, including in IEEE 802.11n, 3GPP LTE, and mobile Wi-MAX systems.

Conventional systems use one transmit and one receive antenna. In MIMO terminology, this is called Single -Input Single- Output (SISO). According to Shannon, the capacity C of a radio channel is dependent on bandwidth B and the signal-to-noise ratio S/N. There are two major categories of MIMO – spatial diversity, in which the same data is transmitted over each of the multiple paths, and spatial multiplexing, in which each of the paths carries different data. In 2x2 MIMO with spatial diversity, for example, each of the two antennas is essentially transmitting and receiving the same data although the data is coded differently. This mode is primarily used to improve signal quality, or to increase the coverage area.

The system throughput can be increased linearly with the number of transmit antennas without using any additional spectrum resources. Given the, improving the spectral efficiency is a critical goal for improving the overall financial operating margins for the wireless operator. It is important to note that commercial MIMO systems switch dynamically between SISO, MIMO diversity, and MIMO multiplexing modes, depending on a variety of factors including the channel environment and signal quality. For example, if the signal quality is very high the system uses spatial multiplexing, and if not, it automatically switches to spatial diversity mode or even to SISO mode.

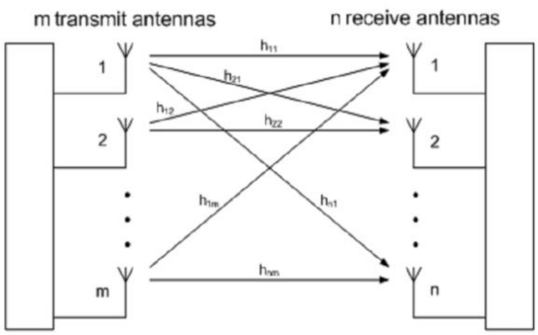
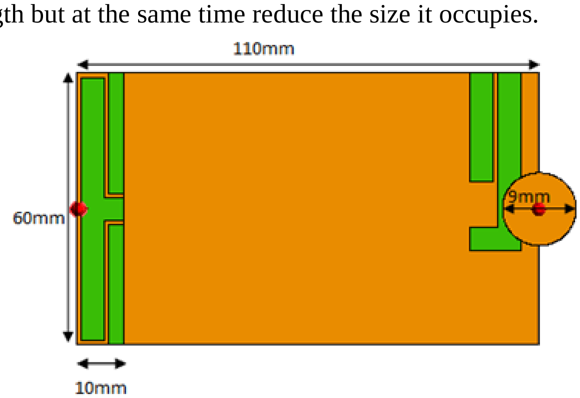



Fig 1.1 Multiple transmitter and receiver antenna

Spatial multiplexing is the mode that really takes advantage of the capacity improvement capabilities of MIMO. The system throughput can be increased linearly with the number of transmit antennas without using any additional spectrum resources. Given the, improving the spectral efficiency is a critical goal for improving the overall financial operating margins for the wireless operator. It is important to note that commercial MIMO systems switch dynamically between SISO, MIMO diversity, and MIMO multiplexing modes, depending on a variety of factors including the channel environment and signal quality.

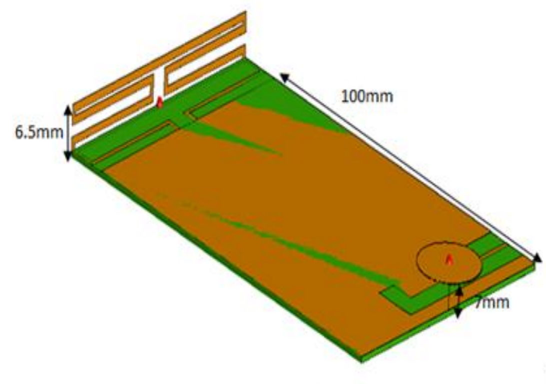
## III. ANTENNA DESIGN

In this paper the structure of the proposed antenna is the combination of top loaded monopole antenna and meandered loop antenna. The structure consist of a quarter wave-length top loaded monopole antenna in one edge and the meandered loop antenna at the other edge is placed above a FR4 substrate of thickness 0.8mm with relative permittivity 4.4. The top loaded monopole antenna consist of a ring shape structure above the substrate at the height of 7mm and radius of 9mm. Slots are etched in the substrate to increase the return loss and impedance matching. The meandered loop antenna consist of a loss tangent of 0.02, a folded loop strip and a capacitively-coupled feeding line mounted on the substrate. The loop pattern is meandered and folded to increase the electrical length but at the same time reduce the size it occupies.




(a)

Fig. 2(a) Top View of the proposed antenna




(b)

Fig. 2(b) Side View of the proposed antenna

Fig 2 (a) is the top view of the proposed antenna where the quarter wavelength top loaded monopole antenna is placed at the edge of the substrate and the meandered loop antenna is placed at the other edge of the substrate. Fig. 2(b) shows the side view of the proposed antenna. The design parameters used for simulation of the proposed antenna were set as in table.

Table I Dimensions of Proposed antenna

| PARAMETRES | DIMENSIONS |
|---|---|
| Substrate length | 110mm |
| Substrate width | 60mm |
| Substrate height | 0.8mm |
| Ground plane length | 100mm |
| Loop height | 6.5mm |
| Relative permittivity | 4.4 |
| Loss tangent | 0.02 |
| Radius of the ellipse | 9mm |
| Wire height | 7mm |
| Thickness of the ellipse | 0.1mm |

## IV ANTENNA SIMULATION RESULTS AND DISCUSSIONS

### a) Return Loss:

Fig.4 shows the S parameter of how much power is reflected from the antenna. The proposed antenna has a return loss of -12dB and -18dB. S11 is -12dB at 600MHz it is used for LTE application and S22 is -18dB at 1100MHz it is used for GPS application.

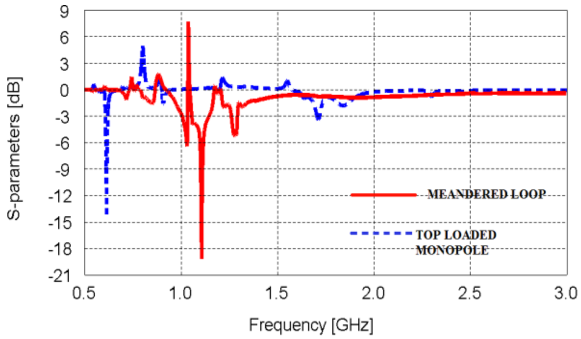



Fig.4 S parameter of the proposed antenna

## b) Gain and Radiation Pattern:

Fig.5 shows the gain of the proposed antenna at 600MHz and 1100MHz frequency. From the simulated result the gain obtained at the operating frequencies 600MHz and 1100MHz are 2.1dBi and 2.3dBi. The gain simulated from the proposed antenna is 2.2 for 600MHz and 2.6 for 1100MHz.

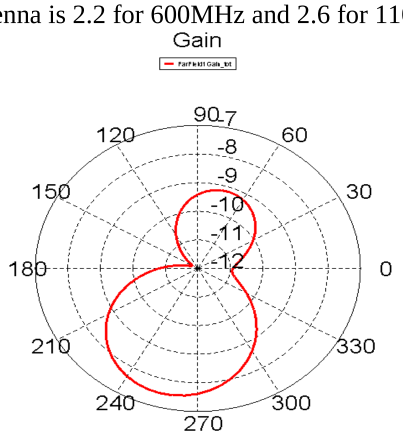



Fig.5 (a) Gain of the proposed antenna at 600MHz

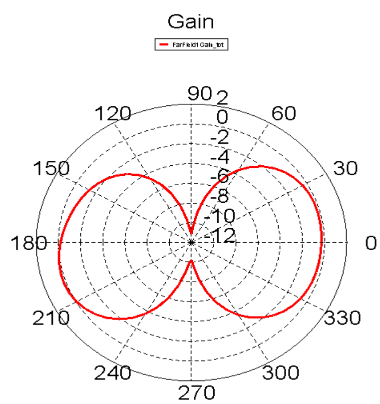
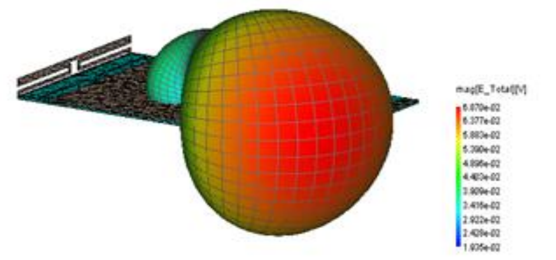


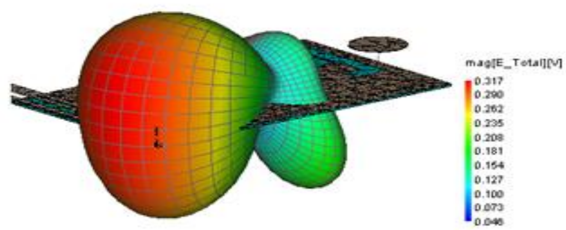

Fig.5 (b) Gain of the proposed antenna at 1100MHz

Fig. 6(a) and (b) shows the radiation pattern in which maximum power radiation is found at the loop antenna side at 1100MHz and at other edge at 600MHz.



(a)

Fig. 6(a) Radiation pattern of the proposed antenna at 600MHz



(b)

Fig. 6(b) Radiation pattern of the proposed antenna at 1100MHz

## c) Current Distribution:

. Current distribution is obtained when the proposed antenna is excited. Fig. 7(a) shows the current distribution of proposed antenna in which maximum current appears near loop antenna at 1100MHz and Fig. 7(b) shows the current distribution of the proposed antenna in which maximum current appears near the monopole antenna at 600MHz.

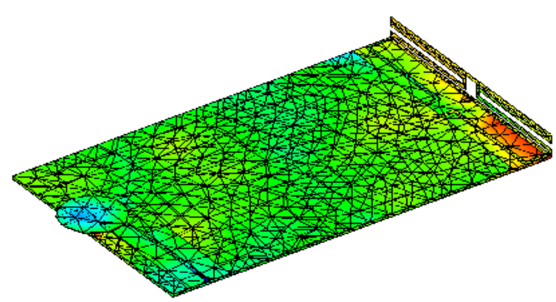


Fig 7(a) Current Distribution of the proposed antenna at 1100MHz

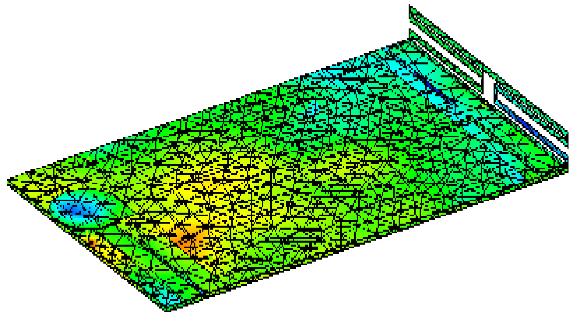


Fig. 7(b) Current distribution of the proposed antenna at 600MHz

d) Mutual Coupling:

The proposed antenna has the mutual coupling of -46dB for 600MHz frequency and -25dB for 1100MHz frequency. Fig.8. shows the mutual coupling of the proposed antenna. S21 varies depending on the permittivity of the dielectric substrate. The S21 values are the highest peak in the resonant band of frequency. From the simulated result, S21 values obtained resonating frequencies 600 MHz and 1100 MHz respectively.

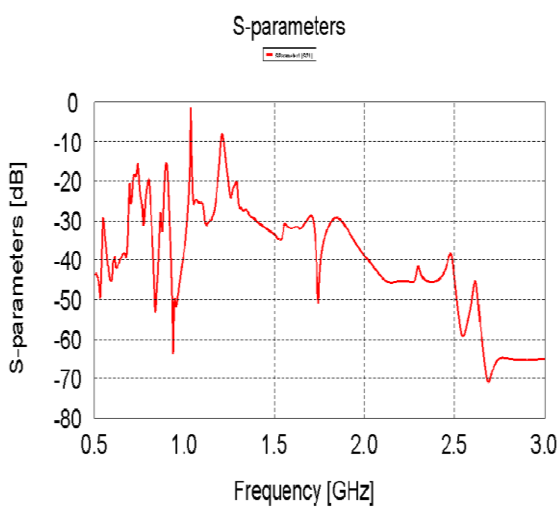



Fig.8 Mutual Coupling of the proposed antenna

e) Correlation:

The correlation of the proposed antenna is given by the formula

$$\rho = \frac{\left|S_{11}^{*}S_{12} + S_{21}^{*}S_{22}\right|^{2}}{(1-|S_{11}|^{2}-|S_{21}|^{2}(1-|S_{22}|^{2}-|S_{12}|^{2})}$$

and the calculated value is 0.512.

## V CONCLUSION

Thus the design of multiple antennas for various wireless applications is presented. The combination of top loaded monopole antenna and meandered loop antenna operates on different frequencies of 600MHz and 1100MHz. This gives good radiation pattern, good return loss, effective bandwidth and diversity gain. The meandered loop antenna has the application of GPS in mobile phone for and the monopole antenna has the application of LTE is simulated. This MIMO antenna enables high data rates in Long Term Evolution (LTE), Worldwide Interoperability for Microwave Access (Wi-MAX) and GPS.

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ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 2, Issue 2, February 2013

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