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Multiband Integrated Loop Antenna For Wireless Routers

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***Abstract*— The paper presents an internal loop antenna for access points and wireless routers. The antenna is a low profile and chip antenna. It uses the Multi Input Multi Output (MIMO) technology. The design has four meandered loop antennas integrated together on a single chip. Thus provides a multiband functionality. The antenna has return loss greater than -6 dB matching criterion. The antenna radiates omnidirectional covering the frequency bands of LTE- Long Term Evolution band (1.8-2.7) GHz, UMTS 3G mobile band (0.85-1.25) GHz, WiMAX bands of 2.5GHz and 3.3GHz and Wi-Fi/Wireless LAN bands of 2.5GHz and 5GHz.**

The design is in 1×2 MIMO configuration. It is a coplanar waveguide antenna of 150mm×150mm and the ground plane of 150×120 mm. The dielectric used is FR-4 material with permittivity or dielectric constant of 4.4. The prototype is fabricated, tested and measured.

Keywords- Loop antenna, MIMO (multi input-multi output), internal antenna, on chip antenna, meandered loop antenna

I. INTRODUCTION

Wireless communication has experienced a lot of advancements and sues to the growing technology a demand for high bandwidth and data rates are required. Even multi functionality is also expected. To fulfill the requirements a multi- input- multi- output antenna is presented. The antenna is capable of mitigating the multipath effect. The co-channel interference effect is also reduced to a great extent. Due to its link reliability MIMO antenna has become popular.

Wireless communications techniques employing spatial diversity have been developed using multiple transmit and receive antennas [1]. The antenna with a three antenna MIMO system is also embedded in wireless routers which are of low cost [2]. Shorted monopoles in MIMO configuration are used as conventional router antenna [3]. The existing antennas are for specific bands such as WLAN bands or for any specific application are presented. Recently, cellular providers have offered wireless broadband Internet Services as an alternative to those without landlines or wireless data plan for Internet access. For this purpose the presented antenna is capable of functioning in multiple bands. The coupling between the antennas is also reduced. The using of meandered loop antennas for mobile phones for multiband utilization [4][5][6].

II. AIM

The aim of the paper is to present an internal antenna that is used in the wireless routers and access points. Thus the antenna is capable of transmitting and receiving multiband. It is a four antenna system that can cover the following bands. The antenna operates for 3G Universal Mobile Telecommunication Service (UMTS) bands that include the Personal Communication Service (PCS) bands and Digital Cellular Services (DCS) bands. It also covers 4G Long Term Evolution (LTE) bands especially for band 12, 13, 14 and 17. It also operates for WiMAX, Worldwide Interoperability for Microwave Access and Wi-Fi Wireless Fidelity or WLAN bands.

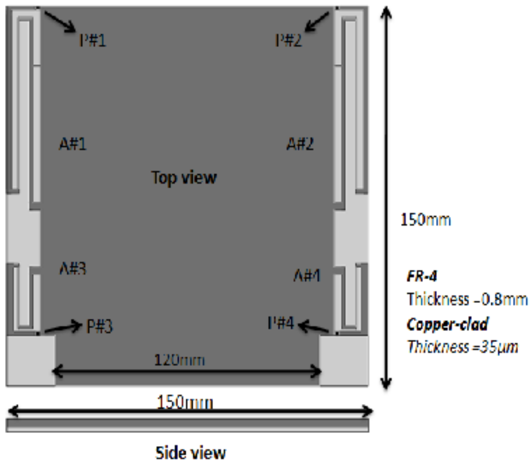

Fig1. Design of the proposed antenna

III. DESIGN GEOMETRY

The antenna that is presented is a rectangular loop antenna. The loops are in the form of strips of varying width from 0.5-3.0) mm. The proposed antenna structure is shown in fig.1.The antenna dimensions are given in millimeter. The antenna is in a meandered loop structure. The design is a printed antenna and thus the antenna has a substrate and a conducting material. The substrate that is used is a dielectric

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made of FR-4 material. The conductor that is printed on is copper material. In fig 1 the term A# and P# represents the antenna number and the feed points respectively.

The overall dimension of the design is (150×150) mm^2. The centre ground plane is of size (150×122) mm^2.On either side of the bottom of the board a gap of (20×14) mm^2 is left to accommodate the antenna and the rest of the board is for other antenna components. The ground plane isolates the antennas thus reduces the mutual coupling between the antennas. Fig 2 shows the trace dimensions.

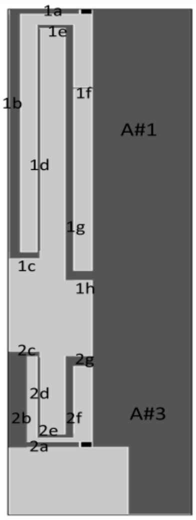

Fig 2 Design dimensions

Antenna 1 and 2 has same dimensions were as antenna 3 and 4 have same dimensions. Thus the design is 1×2 type in dimensions. The width and the path length of the trace is used to decides the operating frequency of the design. The path lengths for antenna 1 and 2 are each 225.55 mm full loop. The path lengths for antenna 3 and 4 are each 86.7853 mm. Shorting strip 1f is added to suppress the unwanted resonance and improves matching between the antennas. The space at the bottom of the board is used to increase the response.

IV. DIMENSIONS

The loop dimensions are calculated based on their response for the frequency bands. The length of the traces depend upon their λ/2 calculations. The below table 1 and 2 shows the measurement of the paths.

1a	1b	1c	1d
12×1.57	74.07×2	5.25×2	69.5×0.5
1e	**1f**	**1g**	**1f**
6.25×1.2	3×0.5	76×1.5	4.5×3

Table1 Antenna 1 and 2 dimensions

The above table shows the dimension of antenna 1 and 2.

2a	2b	2c	2d
12×1.57	25×3	5.25×1.37	22.431×0.5
2e	**2f**	**2g**	
6.25×1.2	20.099×1.5	4.5×3	

Table 2 Antenna 3 and 4 dimensions

Table 2 shows the dimensions of antenna 3 and 4.

The above tables show two different measurements for four antennas. As the design is of 1×2 type that is antenna 1 and 2 have same measurements and antenna 3 and 4 have same measurements. Thus the response of the same size antennas is relatively similar.

V. SIMULATED RESULTS

The antenna that is shown in fig 1 is simulated for their performance. The design is simulated using the RF microwave simulating software called Advanced Design System (ADS) software.

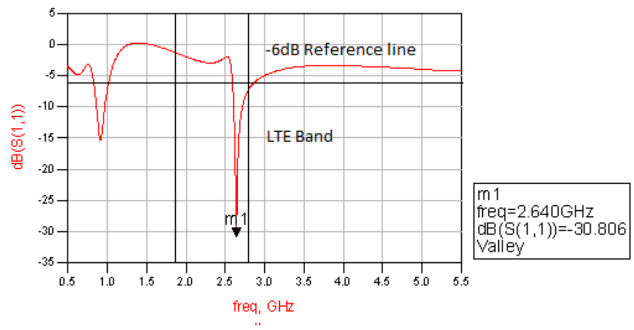

Fig 3 Return loss of Antenna 1 for LTE band

Fig 3 shows the scattering parameters of antenna 1. The LTE band covers a frequency of 1.8 GHz to 2.7 GHz. Antenna 1 responds at LTE band at a resonant frequency of 2.64 GHz. The antenna scattering parameter reaches -30.8 dB. The S_{11} parameter is again more than -6 dB. The antenna also interferes with the WLAN bands to some extent.

Fig 4 shows the scattering parameters of antenna 2. The UMTS band covers a frequency of 850 MHz to 1250 MHz band. But the antenna has a resonating frequency at 923 MHz frequency. The S_{22} parameter is more than -6 dB where it reaches a scattering parameter of -30.7 dB thus operating in UMTS band.

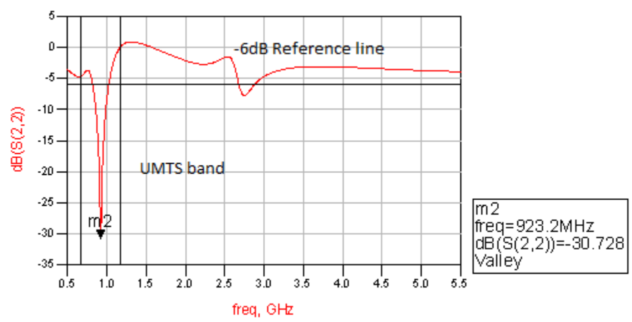

Fig 4 Return Loss of Antenna 2 for UMTS band

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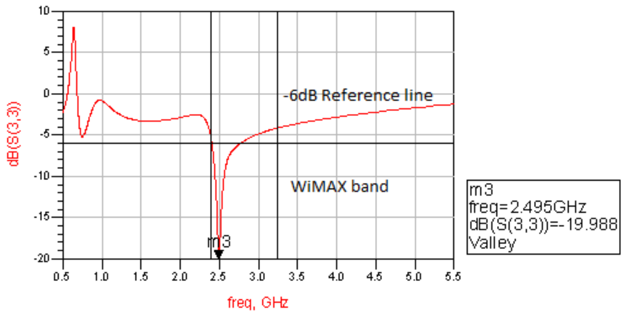


Fig 5 Return loss of Antenna 3 for WiMAX band

Fig 5 is the resonating frequency of antenna 3. Antenna 3 is designed to transmit and receive bands of frequency 2.4 GHz and 3.3 GHz, called WiMAX bands. The antenna is capable of operating in 2.5GHz. Although the effect of co-channel interference occurs, it is mitigated.

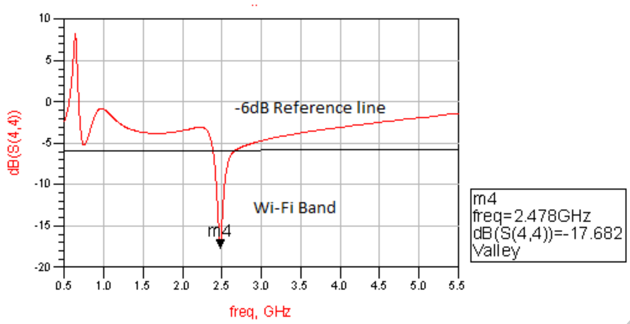


Fig 6 Return Loss of Antenna 4 for WLAN band

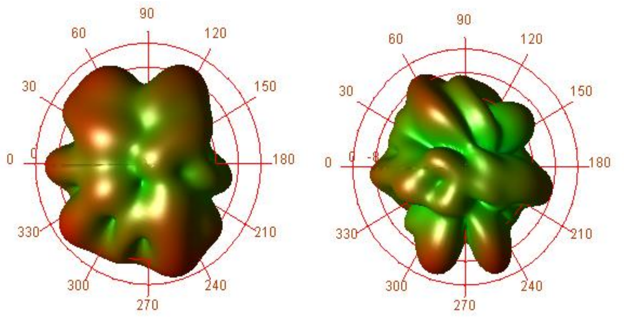
Fig 6 shows the antenna 4 scattering parameters and thus has an operating frequency of 2.4 GHz and 5 GHz depending on the bands.

UMTS band is a narrow band and LTE bands are covered by longer antennas. Thus antenna 1 and 2 covers low frequencies as shown in fig 3 and 4.

The short length antennas cover high frequency bands such as Wi-Fi and WiMAX bands. Thus the bandwidth of antenna 1 and 2 are less compared to antenna 3 and 4.

VI. Radiation Pattern

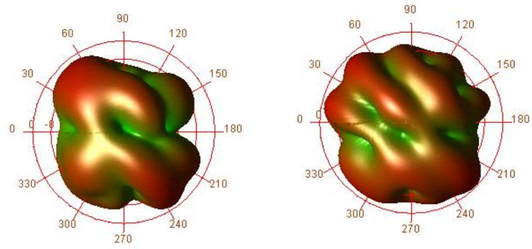
The fig 7 and8 shows the radiation pattern in 3D model. The patterns are near omnidirectional that have good matching criteria.



(a) (b)

Fig 7 Radiation pattern of Antenna 1(a) and 2(b)

Fig 7 (a) shows the radiation pattern for LTE band at frequency 923 MHz and fig 7 (b) shows the response of UMTS band for frequency 2.6 GHz.



(a) (b)

Fig 8 Radiation pattern of Antenna 3(a) and 4(b)

Fig 8 (a) shows the radiation pattern for WiMAX band for frequency 2.4 GHz and fig 8 (b) shows the pattern for WLAN band at frequency 2.5 GHz.

The patterns are presented for the corresponding frequency bands in fig 7. In MIMO systems, to preserve spatial diversity and channel independence, the mutual coupling between antenna elements must be low. Computing the envelope correlation coefficient (ECC) between antenna elements is one way to measure performance of the MIMO systems, which take mutual coupling into account. In industry, ECC less than 0.5 are considerable. The envelope correlation coefficient is calculated from radiation pattern or from the S- parameters.

High cross polarization can be advantageous for signal reception due to power radiating in all the directions regardless of the orientation. The antenna can be used in mobile phones. As a future enhancement the antenna can be reduced in size for the same operating frequencies.

VII. Conclusion

A printed on chip loop antenna is presented for wireless routers or access points. The antenna is capable of operating in four essential wireless communication bands such as UMTS band, LTE band, WiMAX band and Wireless LAN band. The antenna shows, near omnidirectional radiation pattern that minimizes the multipath effect, with low envelope correlation coefficient and efficient antenna parameters in all target bands.

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