Dual-Frequency Broadband Antenna for Mobile Device Applications

Ting Zhang, Ronglin Li
South China University of Technology
Guangzhou 510641, China
zt20041050063@126.com

Manos M. Tentzeris
Georgia Institute of Technology
Atlanta, GA 30308, USA
etentze@ece.gatech.edu

***Abstract*—This paper proposes a low profile monopole antenna which achieves a dual-frequency broadband operation at 900 MHz with a bandwidth of ~42% (790~1215) and at 1900 MHz with a bandwidth ~53% (1710~3000 MHz). The proposed antenna has an inverted F strip and a meandered strip directly fed by the microstrip line on the front side and has an S strip terminated at a ground plane. The lower sections of the inverted F strip and the S strip overlap and form a two-strip monopole. The mutual coupling of the two-strip lines has a significant effect on the bandwidth enhancement. The Antenna structure is described in detail and its performance is validated by experimental results.**

Keywords- Broadband antenna, dual-frequency antenna, mobile communications.

I. Introduction

Due to the rapid growth of wireless communications and the development of miniaturized smart phones, the need for multisystem operation in a mobile device has become a necessity. Therefore, multiband antennas equipped in mobile devices are widely demanded. The frequency bands for mobile communication are GSM850 (824~894), GSM900 (890~960 MHz), DCS1800 (1710~1880 MHz), PCS1900 (1850~1990 MHz), and UMTS (1920~2170MHz). With the development of the 4G technology, there is an increasing requirement to additionally cover LTE2300 (2305~2400MHz) and LTE2500 (2500~2690MHz) bands.

Recently, many antenna configurations have been proposed to overcome the difficulties in the design of multiband and small size antennas. Some of them have tried to achieve a small size of structure. However, these antennas failed to cover the whole frequency bands required, especially at the lower frequency bands [1], [2]. Antennas with sufficient bandwidth require either a considerable antenna thickness or a considerable antenna height, making them unsuitable for mobile devices [3].

In this paper, we propose a novel monopole antenna with dimensions of 15 mm×40 mm×0.5 mm. This antenna is capable of generating two wide operating bands to cover the GSM/UMTS/LTE operations in a mobile device. It is known that electromagnetic coupling and two-strip configurations are two effective methods for the bandwidth enhancement of a compact antenna structure [4], [5]. To achieve the wide bandwidth in the lower frequency, we design two electromagnetically-coupled strips that cover the lower band. An additional shorter meander branch is introduced for the 2.1 GHz operation. The mutual coupling among the three strips helps in the bandwidth enhancement for the higher band without significant effect on the performance for the lower band. There is no shorting via involved in the antenna structure. The configuration and performance of the dual-frequency monopole antenna is described in section II. Experimental results are presented in section III.

This work was supported by the NSFC (60871061), the GDSF (81510641010000085), the SRFDP (20080561), and the Oversea Distinguished Professor Program from the Ministry of Education of China.

II. Antenna Configuration and Performance

The configuration of the broadband antenna is illustrated in Fig. 1. The design of the antenna is based on a TLY-5 planar substrate that has a dielectric constant of ε_r =2.2 and a thickness of t=0.5 mm. The proposed antenna consists of a two-strip monopole for the 800 MHz band and a meandered strip for the 2 GHz band. The two-strip monopole is formed by an S strip and an inverted F strip. The meandered strip and the inverted strip are printed on the front side of the TLY substrate and fed by a 50Ω microstrip line. The S strip is etched on the backside of the substrate and terminated at a ground plane. The upper section of the inverted F strip is fitted into an area surrounded by the upper section of the S strip while the lower section of the inverted F strip overlaps with the lower section of the S strip, forming a two-strip line. The width (Wf) of the 50Ω feed line is 1.5 mm while the width (Wts) of the two-strip line is 1.2 mm to obtain a good impedance match. The meandered strip is connected to the feed line through a narrower microstrip line with its width (Wf2=1 mm) and length Lf2. The height (H) of the two-strip line is the same as the total height of the antenna which equals 15 mm.

The two-strip line is designed mainly to cover the lower band while its higher mode appears around 2.4 GHz. A meandered strip around 40 mm is added to generate a resonant mode around 1.9 GHz. As the configuration of the meander line is properly selected, good coupling among the three branches can enhance the bandwidth at the higher frequency without influence on the lower band.

To make the multi-band antenna have good impedance matching and sufficient bandwidth at the 900 MHz and 1.9 GHz bands, the geometric parameters of the antenna need to be optimized.

The optimization design was carried out with the help of an extensive numerical simulation. The optimized values for the geometric parameters are listed in TABLE I. In the rest of the paper, all geometric parameters assume the values in this table unless they are given specifically. Fig. 2 shows the result of return loss for the optimal dual-band antenna. It is found that the bandwidths for voltage standing wave ratio (VSWR) ⩽2.5 at the 900 MHz and 2 GHz bands are 36% (0.8 GHz~1.16 GHz) and 50% (1.70 GHz~2.83 GHz), respectively.

It is noticed that the mutual coupling between the inverted F strip line and the S strip line has considerable influence on the bandwidth enhancement at the lower frequency. It enables the antenna to cover an extremely wide bandwidth around the 800 MHz with a small size. The length of the inverted F strip is approximately 80 mm which is about 1/4 wavelengths around 930 MHz and the length of the coupling S strip line is approximately 120 mm which is about 1/4 wavelength around 830 MHz . The combination of the two strips generates two resonant modes close each other. When the distance and the length of the two branches are properly selected, the two modes can be well mutually coupled and enhance the input impedance matching.

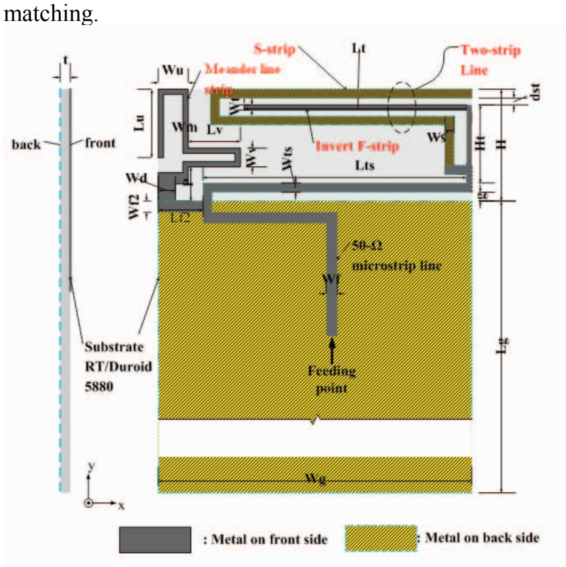


Fig. 1. Geometry of the dual-frequency broadband antenna.

TABLE I Optimized values for the geometric parameters of the dual-frequency broadband antenna.

parameter	value	parameter	value
H	15mm	Wu	4mm
Lts	36mm	Lu	9.2mm
Ht	10.5mm	Wv	2.5mm
Lt	30mm	Wm	0.7mm
Wt	0.7mm	Wd	2.3mm
g	1.2mm	p	4.6mm
t	0.5mm	Lv	7.5mm
Ws	1.2mm	Wf	1.5mm
Wf2	1mm	Wg	42mm
Lf2	6mm	Dst	0.7mm
Lg	100mm	Wts	1.2mm

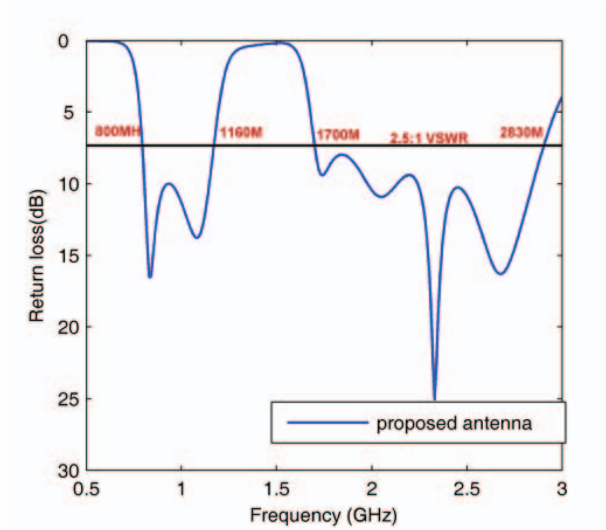


Fig. 2. Simulated return loss of the dual-frequency broadband antenna.

III. IEXPERIMENTAL RESULTS

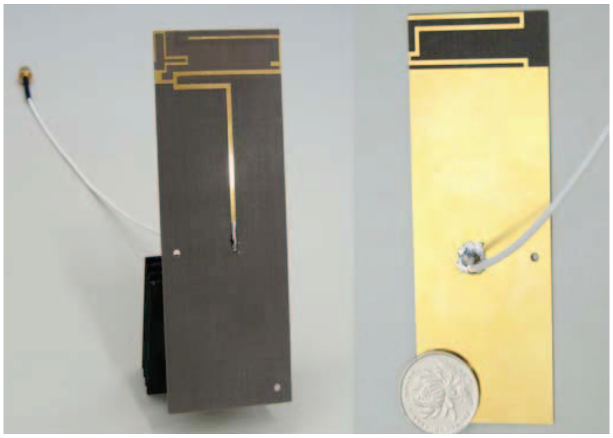
To verify the performance of the compact broadband planar antenna, a prototype was fabricated and measured. The antenna was fabricated on a 0.5mm TLY-5 substrate with 0.2 oz copper on both sides. Two photographs of the antenna prototype are displayed in Fig. 3 which shows the front view and the back view of the planar antenna. For the purpose of measurement, the antenna is connected to a coaxial cable in the middle section of the ground plane. The measured return loss (RL) is presented in Fig. 4. It is clearly seen that two wide operating bandwidths are obtained. The lower bandwidth, determined by 1: 2 VSWR, reaches 372 MHz (41%) and covers the GSM band (824~960 MHz). On the other hand, the upper band, determined by 1: 2.5 VSWR, has a bandwidth as large as 1275 MHz (53%) and covers the GSM 1800 (1710~1880), GSM1900 (1850~1990), UMTS (1920~2170), LTE2300 (2305~2400), LTE2500 (2500~2690MHz) bands. The measured result agrees with the simulated result. The radiation patterns of the proposed antenna at the center frequencies for the lower and high bands are plotted in Fig. 5. At 900 MHz, a radiation pattern with omni-directional radiation in the azimuthal plane (x-z plane) is obtained while at 1900 MHz, variation in the patterns is observed due to high-order modes. The proposed antenna in general has a monopole-like radiation pattern. The measured peak gains at the frequencies of 900, 1900, and 2600 MHz are approximately 1.4, 2.1, and 4.0 dBi, respectively.

IV. CONCLUSION

The lower band of the proposed planar monopole has a large enough bandwidth to cover the frequency range from 818 MHz to 1190 MHz for the GSM850/GSM900 operation. The upper band has an even larger bandwidth in order to cover the frequency range of 1710~3000 MHz for the GSM1800 (1710~1880), GSM1900 (1850~1990), UMTS (1920~2170), LTE2300 (2305~2400), LTE2500 (2500~2690MHz) bands with the VSWR=2.5:1. The wideband dual-frequency antenna can be realized on a thin substrate without via process, thus facilitating its easy integration with RF front-end circuits for mobile devices.

ACKNOWLEDGMENT

The authors thank to SPEED WIRELESS TECHNOLOGY Co., Ltd for pattern measurement.



(a) (b)

Fig. 3. Photographs of the dual-frequency broadband antenna with the optimized geometric parameters. (a) Front view. (b) Back view.

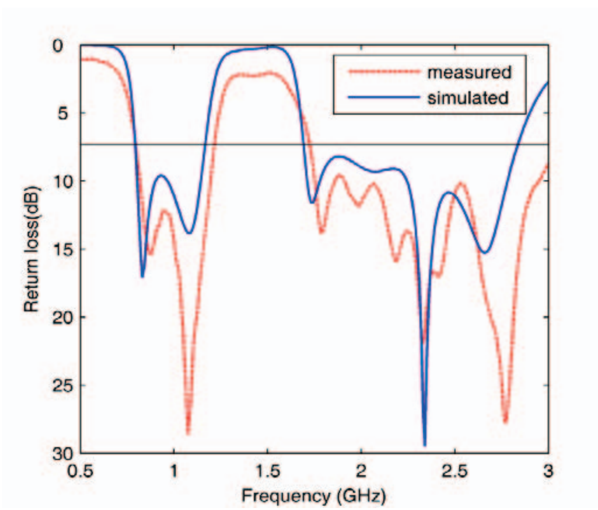
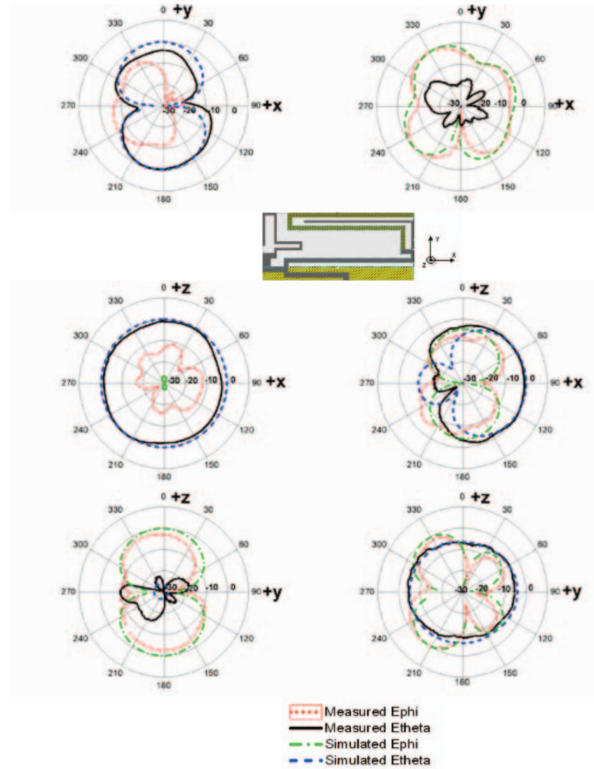


Fig. 4. Comparison of the measured and simulated result for return loss of the dual-frequency broadband antenna.



(a) (b)

Fig. 5. Radiation patterns for the proposed antenna at: (a) 900MHz, (b) 1900MHz

REFERENCES

[1] Yun-Wen Chi, Kin-Lu Wong. "Quarter-Wavelength Printed Loop Antenna with an Internal Printed Matching Circuit for GSM/DCS/PCS/UMTS Operation in The Mobile Phone," IEEE Transactions on Antennas and Propagation, Vol. 57, No. 9, pp. 2541-2547, September. 2009.

[2] Seokjin Hong, Wonseob Kim, Hoon Park, "Design of an Internal Multi Resonant Monopole Antenna for GSM900/DCS1800/US-PCS/S-DMB Operation," IEEE Transactions on Antennas and Propagation, Vol. 56, No. 5, pp. 1437-1443, May 2008.

[3] Shun-Yun Lin, "Multiband Folded Planar Monopole Antenna for Mobile Handset," IEEE Transactions on Antennas and Propagation, Vol. 52, No. 7, pp. 1790-1794, July 2004.

[4] RongLin Li, Bo Pan, Joy Laskar, and Manos M. Tentzeris, "A Compact Broadband Planar Antenna for GPS, DCS-1800, IMT-2000, and WLAN Applications," IEEE Antennas and Wireless Propagation Letters, Vol. 6, pp. 25-27, 2007.

[5] RongLin Li, Bo Pan, Joy Laskar, and Manos M. Tentzeris, "A Novel Low-Profile Broadband Dual-Frequency Planar Antenna for Wireless Handsets," IEEE Transactions on Antennas and Propagation, Vol. 56, No. 4, pp. 1155-1162, April 2008.