Monopole-type antenna with two coupled strips for mobile phone application

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***Abstract* – A seven-band WWAN/LTE mobile handset antenna is presented. The antenna structure is small and simple; its dimensions are 115x60x0.8 mm^3 where the antenna portion is 15x60 mm^2 and the ground portion is 100x60 mm^2. The proposed antenna is composed by a directed-fed monopole and two coupled strips. With the combination of the direct-fed monopole and two coupled strips, two wide operating bands for WWAM/LTE can be obtained. The first wideband obtained cover GSM850 (824-894 MHz), GSM900 (880-960 MHz) and is produced by the directed-fed monopole. The second wideband goes from 1710 MHz to 2690 MHz, covering DCS (1710-1880 MHz), PCS (1850-1990 MHz), UMTS (1920-2170 MHz), LTE2300 (2300-2400 MHz) and LTE2500 (2500-2690 MHz), is caused by the introduction of the coupled-fed strips on the antenna. The proposed antenna with simple structure and good performance is a good candidate of mobile phone antenna.**

***Index Terms* — Mobile handset antenna, coupled strips, directed-fed, monopole.**

I. INTRODUCTION

Due to the high demands required by users when using their mobile phones today, the main challenge of the design of a new mobile device is to reduce the dimension of the components as much as possible keeping the desired quality. Because of the requirements of the users, the most important services that the network should provide with the best possible quality are: (1) voice communication as the original phone was designed, and (2) Internet access. The communications through Internet are increasing nowadays for several kinds of services. Thus, small size and multi-function of the antenna is the mainstream of antenna design on a mobile phone device.

These days, the mobile phone technology has evolved and is currently operating in 2G (GSM, *Global System for Mobile communications*), 3G (UMTS, *Universal Mobile Telecommunications System*) [1] and in the emerging technology 4G (LTE, *Long-Term Evolution*) [2], therefore, the design of cell phone antennas[3-5] must cover all these bands, including LTE 700 (698-787 MHz) which is under supervision in some countries, GSM 850 (824-894), GSM 900 (880-960 MHz), GSM 1800 (1710-1880 MHz), GSM 1900 (1850-1990 MHz), UMTS (1920-2170 MHz), LTE 2300 (2305-2400 MHz) and LTE 2500 (2500-2690 MHz).

In this paper, a small and very easy to build antenna that covers 7 of the 8 bands represented above is proposed. This antenna, consists of a directed-fed monopole and two coupled strips, is to excite the desired frequencies to cover the requirement bands mention above.

II. ANTENNA CONFIGURATION

The geometry of the proposed antenna is shown in Fig 1. As it can be seen, the antenna is located in both sides of the substrate. At the front side of the substrate is located the directed-fed monopole, which excites the frequencies for GSM 850/900, and the microstrip line is to feed the antenna. At the back side of the substrate is located the two coupled strips connected to the system ground plane. Combined the directed-fed monopole and the two coupled strips is to excite the frequencies for DCS, PCS, UMTS and LTE 2300/2500; the central frequency that excites by the directed-fed monopole and the strip on the right side of the substrate is 2.1GHz and the one excited by the directed-fed monopole and the strip on the center of the substrate is 1.73 GHz.

The presented antenna dimensions are 115x60x0.8 mm^3. It is manufactured in a 0.8mm FR4 substrate, with relative permittivity constant of 4.4 and tangent of 0.0245 lost, which makes it perfect for using it as embedded antenna for smart phones.

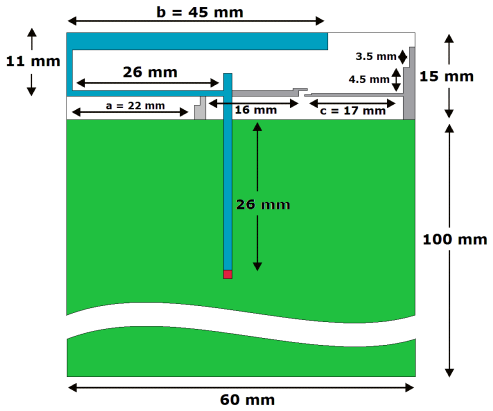

Fig. 1. Antenna geometry.

The distance between the coupled strips and their location is very important to obtain a good antenna operation. The adequate coupling between them lets the antenna get a huge

wide band on the high frequencies and do not affecting too much on the low band. On the other hand, the location of the directed-fed monopole has been chosen to avoid a ground coupling as much as possible. Additionally, its size affects directly to the central frequency that it excites.

III. Measured Results and Discussion

Simulated results have been implemented using the Ansoft HFSS software, delimiting the program results using standard for mobile phones applications VSWR (*Voltage Standing Wave Ratio*) 3:1 which in S parameter means -6dB. After observing the simulated results, we proceed to build the real antenna and carry out the measurements to compare how accurate were the results. These results can be seen on the Fig. 2.

Focusing on the measured values, the low band goes from 812 MHz to 990 MHz, covering GSM 850/900; and the high band goes from 1690 MHz to 2690 MHz, covering DCS, PCS, UMTS and LTE 2300/2500.

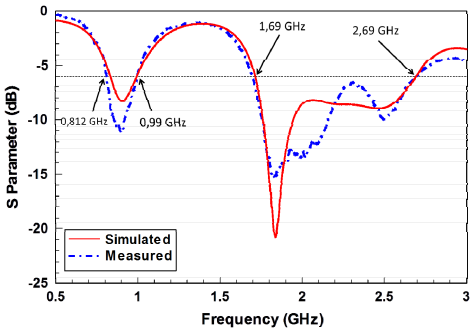

Fig. 2. Simulated and measured results of S parameters.

To further explore the study of the different strips that form the antenna, some of its characteristics are going to be modified to observe its behavior. First, has been modified the distance "a". As shown in Fig. 3, the more it reduces the distance "a" lower is the S parameter, and consequently, the lower the power of each of the modes. Modified the "b" strip the first frequency band shift to higher frequencies when is shorter, and shift towards lower frequencies when elongated, and the results can be seen in Fig. 4. By modifying the coupled strips, whole high frequency band is moved and altered because each depends on the other for proper operation of the proposed antenna; it can be observed the effect of different values of "c" in Fig. 5.

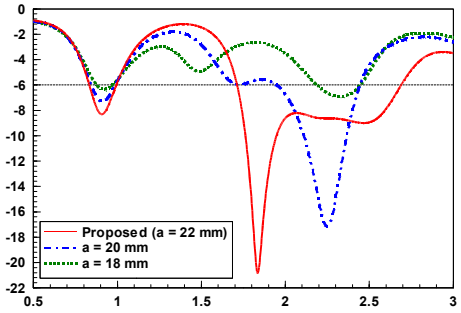

Fig. 3. Simulation of the S parameter for different values of "a".

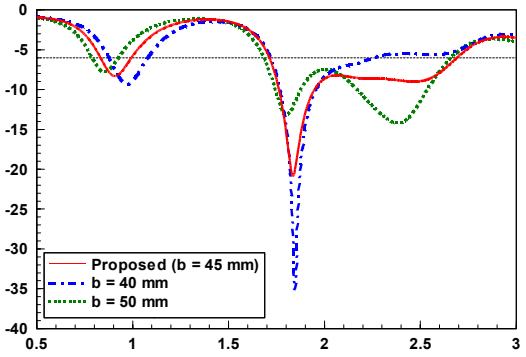

Fig. 4. Simulation of the S parameter for different values of "b".

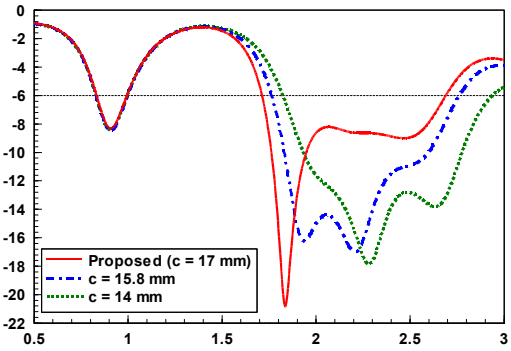

Fig. 5. Simulation of the S parameter S for different values of "c".

IV. Conclusion

The proposal antenna to be used in smartphones is able to cover 7 of the 8 band WWAN/LTE using a directed-fed monopole and two coupled strips, producing two huge wide bands (high band and low band). To be small, its total size is 115x60x0.8 mm^3 and simple, it is easy to manufacture. The design can be applied to mobile handset devices.

Acknowledgment

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References

[1] K.L. Wong, "Planar antennas for wireless communication," Wiley, New York, 2003.

[2] S. Sesia, I. Toufik, and M. Baker (Eds.), "LTE, the UMTS long term evolution: From theory to practice," Wiley, New York, 2009.

[3] Y.L. kuo And K.L. Wong, "Printed double-T monopole antenna for 2.4/5.2 GHz dual-band WLAN operations," *IEEE Trans. Antennas Propagat.*, vol. 51, pp. 2187-2192, Sep. 2003.

[4] S.H. Lee, K.J. Kim, J.K. Oh, and Y.J. Yoon, "Multi-band coupled feed loop antenna for mobile handset," *Asia Pacific on Microwave Conference 2009, APMC 200*, pp. 2703-2706, 2009.

[5] F.H. Chu and K.L Wong, "Planar Printed Strip Monopole with a closely-coupled parasitic shorted strip for eight-band LTE/GSM/UMTS mobile phone," *IEEE Trans. Antennas and Propag.* vol. 58, pp. 3462-3431, October 2010.