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Compact Multiband Planar Antenna for DVB-H, Mobile and Wireless Applications

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Abstract: **In this paper, a new multiband planar antenna with a compact size is designed and developed for mobile devices. The proposed antenna consists of a two-strip monopole and two meandered strip antenna which occupy a compact area of only 15 mm 42 mm. A meander monopole is added to the antenna to cover DVB-H and T-DMB for mobile broadcasting. A prototype of the antenna was fabricated using FR4 substrate. This paper proposes a new mobile handset antenna structure with low SAR and covers most of the mobile operating bands and other wireless applications. The covered bands are the DVB-H, T-DMB, GSM 900, DCS 1800, PCS 1900, UMTS 2100, and most of the LTE bands including the LTE 700 band. Furthermore, it covers the ISM, WIMAX and the WLAN bands. The SAR calculations are done using the CST 2016 commercial package. It is worth mentioning that the antenna has compact size, multiband operation including the low frequency bands, and low SAR radiation. The simulation results are compared to the experimental measurements and a good agreement is observed.**

Keywords: **Monopole, Digital Video Broadcasting Handheld (DVB-H), Terrestrial Digital multimedia Broadcasting (T-DMB), Long Term Evolution (LTE), Specific Absorption Rate (SAR).**

I. INTRODUCTION

As mobile communication systems support and enhance the multimedia functions, various demands have been expected and increased for mobile phone antenna design. Digital Video Broadcasting-Handheld (DVB-H) and the Terrestrial Digital Multimedia broadcasting (T-DMB) L-band reception are very attractive for many mobile users. Also, the fourth generation of mobile communications, the long term evolution (LTE), is expected to deliver multimedia services anywhere, anytime. The LTE standard is scheduled to operate in different frequency bands that range from 400 MHz to 4 GHz with bandwidths of 1.4 and 20 MHz [1-2]. Currently, the DVB-H service has made it possible to deliver digital broadcasting for a portable device, which operates in the portion of ultra-high-frequency (UHF) band (470 –702 MHz, relative bandwidth of 40%) [1]. Typically, the size of handset is much smaller than a quarter of a wavelength at (470-702) MHz. Thus, it is always challenging to design an antenna that covers all of the above-required bands with good impedance matching while integrating into a mobile handset.

Several studies have been performed to produce an antenna structure able to satisfy the demands of the DVB-H antenna for use in hand-held terminals [2-14]. Miniaturisation techniques with control circuits were introduced [2–5]; however, they had problems such as low antenna efficiency because of insertion loss in lumped elements, as well as an increased cost. Magneto-dielectric materials have primarily been used for the antenna miniaturisation method [6, 7]; however, they have certain disadvantages that cause high loss as well as low radiation efficiency and high cost in comparison with those of a general dielectric material [8].

In order to include DVB, Kim et al. [3] proposed a new compact antenna that consists of a printed rectangular monopole with a U-shaped slot, an extended ground stub and a folder-type chassis. The antenna occupies an area of only 50×27

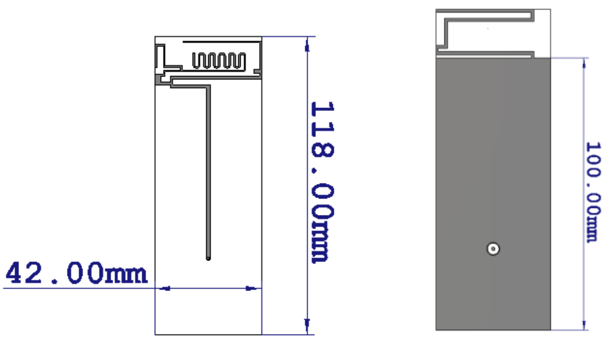
mm^2 to cover DVB-H, T-DMB, and GSM900. Other antennas were designed to include mobile bands with DVB, e.g. Liu et al. [12] introduced a compact multiband tunable PIFA system using a varactor as an active tuning component is presented to cover the mobile telephone bands (GSM850,900,1800,1900, UMTS) by controlling the value of the capacitance across the gap in the slotted PIFA and two broadcast bands, FM radio (76-108 MHz) & mobile television DVB-H (470 – 702 MHz) with size of 40×15×8 mm^3. Recently, Zuo et al. [13] proposed a new antenna that consists of a planar meander monopole. By using parasitic strips and a sleeve feed, wideband impedance characteristics are achieved from 440 to 1350 MHz. It is very suitable for DVB-H, LTE 13, GSM850, and GSM900 applications in the mobile phone with dimensions of 40x100 mm^2. Sultan et al. [14] introduce compact multiband internal antenna consisting of a monopole with three branch lines to cover the DVB, most bands of LTE, ISM, Wi-Max, WLAN and other wireless communication applications with dimensions of 28x38 mm^2.

In this paper, a novel internal antenna consisting of a two monopole with two meander lines to cover multibands including the DVB, LTE bands are introduced. The proposed antenna has a -6 dB bandwidth which means that it supports the following operating bands; GSM 900, DCS 1800, PCS 1900, UMTS 2100, ISM 2450, most LTE bands (FDD-LTE band 1-4, 7-12, 15-17, 23-25 and TDD-LTE band 33-41), WiMAX (2.3-2.4 GHz, 2.5-2.69 GHz, 5.1-5.7 GHz), and WLAN(2.4 -2.5 GHz, 4.8-5 GHz, and 4.825-5.515 GHz).

The paper is organized as follows: section II explains the antenna design, describes the antenna performance and shows the antenna performance together with a comparison between the simulated and the experimental results. In section III, the SAR results are introduced. Section IV presents the conclusions for this research. Finally, Section V introduces the acknowledgment.

II. ANTENNA DESIGN

The proposed antenna consists of a two-strip monopole and two meandered strip. The two-strip monopole includes an S-shaped strip and an Inverted-F strip. The inverted-F and the meandered strips are printed on the front side of the substrate and are fed by a 50- microstrip line while the S-shaped strip is etched on the backside of the substrate and terminated at a ground plane. The upper section of the inverted-F strip is printed inside the area surrounded by the upper section of the S-shaped strip, while the lower section of the inverted-F strip overlaps with the lower section of the S-shaped strip, forming a two-strip line. To achieve the wide bandwidth in the lower frequencies, we use two printed strips with appropriately optimized electromagnetic coupling. An additional shorter meander branch is added for the operation around 2.1 GHz and longer meander branch is added to operation around 0.5 GHz. The mutual coupling among the three strips significantly enhances the bandwidth around the higher frequency band, without affecting the performance in the lower frequency band. while the lower section of the Inverted-F strip overlaps with the lower section of the S-shaped strip, forming a two-strip line. The width of the 50- feed line is 1.5 mm while the width of the two-strip lines is 1.2 mm. The meander strip is connected to the feed line through a narrower microstrip line with a width of 1mm. The width of the strip line of each branch is optimized by simulation in order to achieve better impedance matching over the desired frequency ranges. The height (h) of the two-strip line is the same as the total height of the antenna which is equal to 15 mm. The antenna is designed over FR-4 substrate (εr=4.5) with 0.8 mm thickness and loss tangent of 0.025. the geometry of the proposed antenna and the all dimensions are shown in Fig. 1.



(a) Front (b) Back

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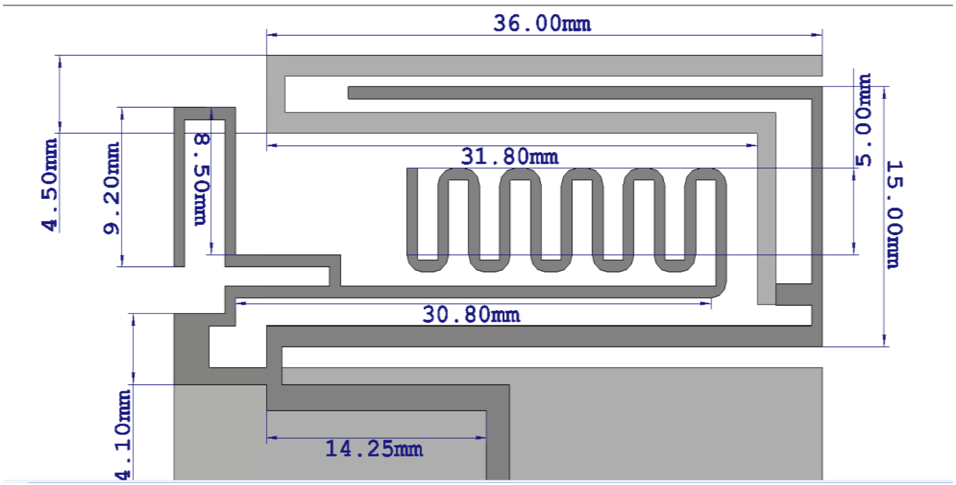
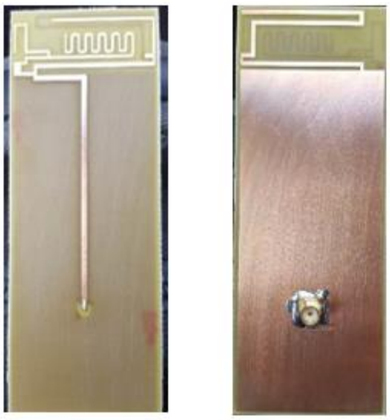


(c) Front and Back

Fig. 1 Antenna geometry

The antenna is fabricated on Fr-4 material using lithography technique and the return loss is measured using VNA. Fig. 2 shows the prototype of the proposed antenna. Fig. 3 shows the comparison between the measured and simulated return loss, there is a good agreement between the results.



(a)Front **(b)Back**

Fig. 2 Prototype of the antenna

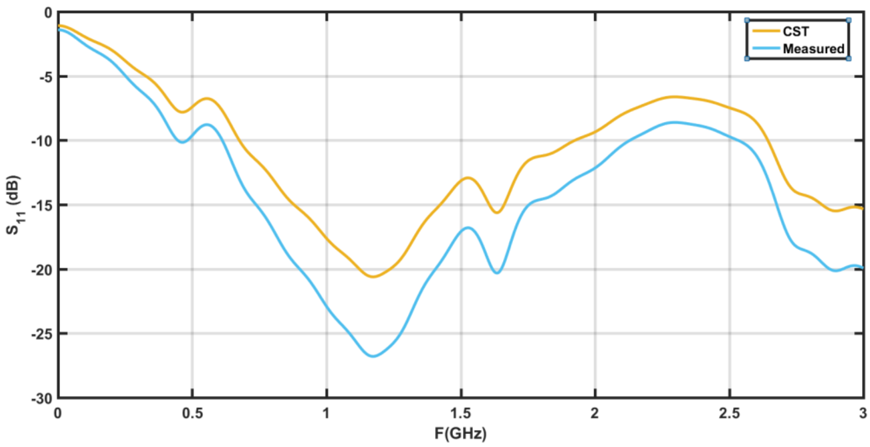


Fig. 3 Simulated and measured return loss of the proposed antenna.

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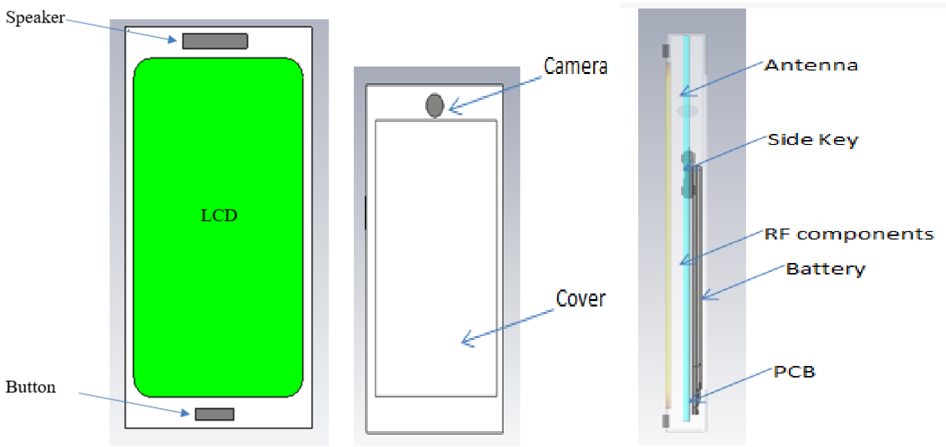
III. HANDSET MODELING

The smart phone has a number of components besides the system circuit board and the antenna. Fig. 4 shows smart phone with standard dimensions (151.1× 80.5 × 9.4) mm^3, the antenna is assembled with battery, camera, speaker, RF circuit, and touch screen LCD. The housing of the mobile is a polyvinyl chloride material (PVC) with permittivity of 2.8 and loss tangent of 0.019 where the total dimensions of the mobile are (151.1× 80.5 × 9.4) mm^3 and its wall thickness is 1 mm. the camera with 8.5 mm, and it is 6 mm thick. Opposite to the camera is a speaker with the dimensions of 20 mm length and 6 mm width, a battery with volume 90 × 60×3 mm^3 and a large touch LCD with size 130 × 70 × 2 mm^3 are located parallel with a spacing of 2 mm and are connected to the main circuit board via connectors. The comparison between the return loss in free space and in handset is shown in Fig. 5, the little shift between the results of the antenna with and without modeling but the antenna still covered all the bands. The all materials of mobile handset parts are shown in Table 1 according to [15].



(a) **(b)** **(c)**

Fig. 4. Structure of mobile (a) Front, (b) Back, and (c) Side view

Table 4.1 Characteristics of the Mobile Parts

Mobile parts	Material type	ε_r
LCD	LCD film	4.78
Battery	PEC	-
Rf circuit	PEC	-
side key, function keys	Rubber	3.5
Camera	PEC	-
Speaker	PEC	-
Casing (Housing)	PVC	2.8
PCB	FR4	4.5

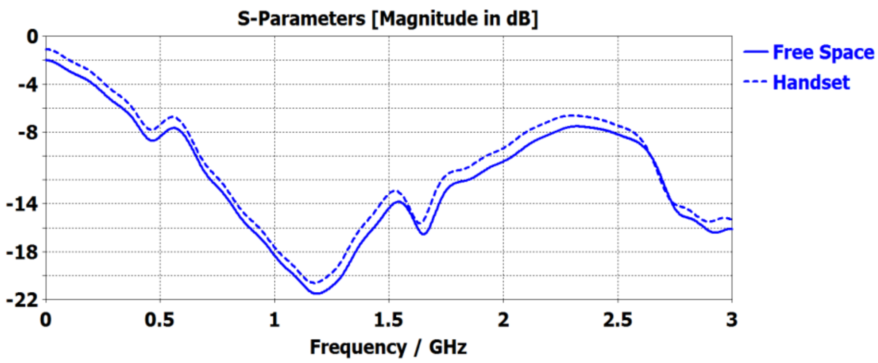


Fig. 5 Comparison of return loss of antenna in free space and handset

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IV. SAR CALCULATION

As the use of the mobile phone is increased, the research on the health risk due to the electromagnetic (EM) fields generated from wireless terminals is widely in progress. Many factors may affect the EM interaction while using cellular handset in close proximity to head and hand. One of the most widely used parameters for the evaluation of exposure is SAR, specific absorption rate. Therefore, some regulations and standards have been issued to limit the radiation exposure from the mobile handsets not only to decrease the SAR but also to increase the antenna systems efficiency. The SAR limit specified in IEEE C95.1: 2005 has been updated to 2 W/kg over any 10-g of tissue [16-17], which is comparable to the limit specified in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines [18].

In this paper, The SAR calculations on human head model are done in the presence of the antenna in the ZY plane as shown in Fig. 6. The SAR is tested at 0.5, 0.7, 0.9, 1.8 and 2.1 GHz when the antenna is close to the human head and the output power of the cellular phone is set to 500 mW. The SAR calculations are done using the CST 2016 commercial package with Hugo model CST Microwave Studio [19]; the tissues that are contained have relative permittivities and conductivities, according to [20]. The tissues frequency dispersive properties are taken into consideration. Table 2 shows the maximum SAR at the aforementioned operating frequencies when the antenna is close to the body.

Table 2 SAR values and the effects of human model on antenna properties.

F(GHz)	**0.5**	**0.7**	**0.9**	**1.8**	**2.1**
SAR (W/kg) 10g	1.01	0.93	0.87	0.72	0.6

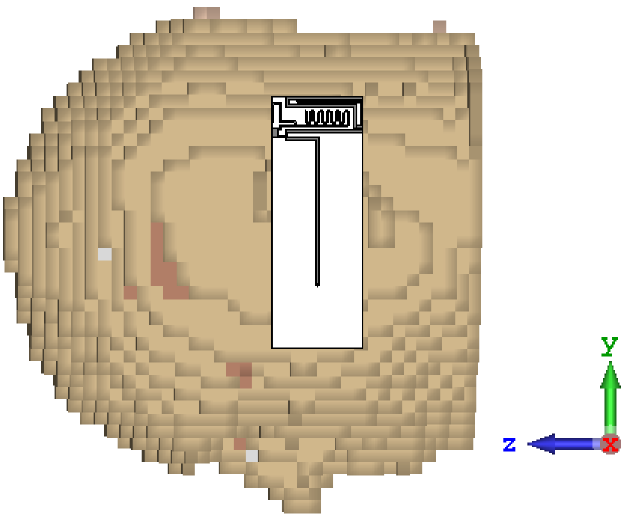

Fig. 6 Antenna structure with the human head model (Hugo voxel model)

REFERENCES

[1] DVB-H Implementation Guidelines, ETSI TR 102 377 V1.4.1, European Telecommunications Standards Institute, 2009.

[2] K. S. Sultan, H. H. Abdullah, E. A. Abdallah, and E. A. Hashish, “Low SAR, miniaturized printed antenna for mobile, ISM, and WLAN services” IEEE, Antennas and Wireless Propagation Letters, Vol. 12, pp. 1106-1109, 2013.

[3] J.P. Kim, G.H. Kim, W.M. Seong, and J.H. Choi, “A tunable internal antenna with an epsilon negative zeroth order resonator for DVB-H service’,IEEE Trans. Antennas Propag., Vol. 57, no. 12, pp. 4014– 4017, 2009

[4] K. S. Sultan, H. H. Abdullah, E. A. Abdallah, and E. A. Hashish, “Novel, compact and multiband antenna for mobile and wireless communication” PIERS, Stockholm, Sweden, Aug. 2013.

[5] K. S. Sultan, H. H. Abdullah, E. A. Abdallah, and E. A. Hashish, "Planar monopole antenna with three branch line for DVB-H/T-DMB/LTE/GSM900/DCS1800/PCS1900/UMTS2100/WLAN operation in the mobile phone" 2nd International Conference on New Paradigms in Electronics& Information Technology (PEIT'013), Egypt, Dec. 2013.

[6] H. Rhyu, C. Jung, and J. Nyun, "DVB-H antenna design using folder-type chassis and coupling element on a ferrite', IEEE Antenna Wirel. Propag. Lett., Vol. 8, pp. 453–456, 2009.

[7] Y. Deng, Q.X. Chu "A DVB-H antenna on organic magneto-dielectric substrate". Proc. Asia-Pacific Microwave Conf., pp. 1– 4, 2007.

[8] K.S. Min, and V.H. Tran, "Application of magneto-dielectric materials in antenna design" , J. Korea Electromagn. Eng. Soc., vol. 6, no. 3, pp. 165–170, , 2006.

[9] J.H. Jo, B. Yu, and K.H. Kong,"Multi-band internal antenna including DVB-H band'. Proc. IEEE AP-S Int. Symp. Dig., pp. 972–975, 2007.

[10] S.G. Jeon, K.W. Ryu, J.H. Choi, "A novel monopole antenna with parallel structure for DVB-H/SDMB applications", Micro. Opt. Technol. Lett., Vol. 50, no. 4, pp. 1054–1056, 2008.

[11] C.T. Lee, and K.L. Wong, "Broadband planar dipole antenna for DTV/ GSM operation', Micro. Opt. Technol. Lett., Vol. 50, no. 7, pp. 1900– 1905, 2008.

[12] L. Liu, J. Rigelsford, and R. Langley, "Tunable multiband handset antenna operating at VHF and UHF bands" IEEE Trans. Antenna and Propag. Vol. 61, No. 7, pp. 3790-3796, July 2013.

[13] S. L. Zuo, Z. Y. Zhang, and J. W. Yang, "Planar meander monopole antenna with parasitic strips and sleeve feed for DVB-H/LTE/GSM850/900 operation in the mobile phone", IEEE Antenna Wireless Propag. Lett., Vol. 12, pp. 27–30, 2013.

[14] K. S. Sultan, H. H. Abdullah, E. A. Abdallah, and E. A. Hashish , "Low SAR, planar monopole antenna with three branch lines for DVB, mobile, and WLAN" International Journal of Engineering and Technology IJET, Vol. 14, No. 1, pp. 70-74, Feb. 2014.

[15] K. S. Sultan, H. H. Abdullah, and E. A. Abdallah "Comprehensive study of printed antenna with the handset modeling" Microwave and Optical Technology Letters, Vol. 58, No. 4, pp. 974-980, April 2016.

[16] K. S. Sultan, and H. H. Abdullah, "Multiband Compact Low SAR Mobile Hand Held Antenna" PIER, Vol. 49, PP. 65-71, 2014.

[17] IEEE C95.1-2005, "IEEE standards for safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300GHz," Institute of Electrical and Electronics Engineers, New York, NY, 2005.

[18] International Non-Ionizing Radiation Committee of the International Radiation Protection Association, "Guidelines on limits on exposure to radio frequency electromagnetic fields in the frequency range from 100 kHz to 300 GHz," Health Physics, Vol. 54, no. 1, pp. 115-123, 1988.

[19] CST Microwave Studio Suite 2016 User's Manual, www.cst.com.

[20] K. S. Sultan, H. H. Abdullah, and Esmat A. Abdallah, "Low SAR, Simple Printed Compact Multiband Antenna for Mobile and Wireless Communication Applications" international journal of antenna and propagation, pp. 1-8, Aug. 2014.