A Dual Antenna Configuration for Multi-Standard Multifunction Handsets and Portable Computers

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***Abstract*— A novel dual antenna configuration has been developed for multi-standard multifunction mobile handsets and portable computers. Only two wideband antennas cover a frequency band from 470 MHz to 3.6 GHz, which is divided into two sub-bands; 470 - 960 MHz and 1.57 - 3.6 GHz. The new antennas are low-cost multi-polarized unbalanced resonant antennas that do not need matching circuits or any other components. Their overall sizes are very small and they do not require additional extended ground planes. They are made of a flexible material and hence they can be easily bent and/or folded in different forms in order to fit inside any mobile handset, laptop, notebook or palmtop computer.**

I. Introduction

The number of mobile wireless applications is continuously increasing. Mobile TV and mobile WiMax are examples of such new applications. As the number of mobile applications increases, the need for multifunction handsets and multifunction portable computers increases. Furthermore, most wireless applications have different standards with different frequency allocations worldwide. For example, WiMax has many frequency allocations such as 700 MHz, 2.5 GHz and 3.5 GHz. Hence, it is desirable to have multi-standard multifunction handsets and portable computers. In order to cover the frequency bands of all these applications, several antennas have to be used. The problem is that the frequency bands of some applications are very close to each other or even overlapping as in GSM (824-894 MHz) and UHF mobile TV "DVB-H" (470-862 MHz). As a result, there will be a severe interference between these antennas. Actually, this is one of the main challenges in developing multifunction multi-standard handsets and portable computers. Moreover, some applications such as UHF DVB-H require very wide frequency bandwidth that is not easy to cover with a single resonant antenna. Matching circuits are usually used to tune antennas for such wide bands and for even narrower bands [1]-[2]. Matching circuits increase the complexity of the antenna and reduce the efficiency. They also increase the overall size and the coasts of the antenna.

In this research, a novel dual antenna configuration is developed with an overall bandwidth ranges from 470 MHz to 3.6 GHz. The new antennas are resonant antennas that do not need matching circuits. Furthermore, they do not need an additional ground plane or any other components. Thus, they can be mounted anywhere inside or outside any communication equipment because the antennas do not use a part of the equipment as an extended ground plane as usually happens with internal antennas. Moreover, the new antennas are made of a flexible material and they can be bent and/or folded in different forms in order to fit any available space inside or outside any portable communication equipment. Actually, they can be used as internal, external or partially internal and partially external antennas.

The first (low-band) antenna of the dual antenna configuration resonates from 470 to 960 MHz and, hence, it can cover the bands of UHF mobile digital TV "DVB-H" (470-862 MHz), 700 MHz WiMax, CDMA / GSM800 (824-894 MHz) and E-GSM900 (880-960 MHz). The second (high-band) antenna of the dual antenna configuration resonates from 1.57 to 3.6 GHz and, thus, it can cover the bands of GPS (1575 MHz), GSM1800 (1710-1880 MHz), PCS1900 (1859-1990 MHz), UMTS (1900-2170 MHz), Bluetooth / WiFi (2.4 GHz), 2.4 WiMax (2.3-2.69 GHz) and 3.5 GHz WiMax (3.4-3.6 GHz). The bandwidths of these two antennas are 69% and 78%, respectively. There is an isolating frequency gap between the bands of the two antennas which helps in reducing the interference between them. It should be noted that linearly polarized antennas can be used with all the above applications including GPS, which is circularly polarized. This is because the advantages of using circularly polarized GPS antennas disappear in heavy multipath environments as it was experimentally verified in [3].

II. Geometry of the New Antennas

Fig.1 shows the geometry of the new wideband resonant antenna. It consists of two narrow printed metallic arms connected together by a short metallic strip. The two arms may be parallel to each other or they may have any angle between them. The length of the short arm is L_1 and its width is W_1 while the length of the long arm is L_2 and its width is W_2. The thickness of the antenna is T_a and the antenna is fed at a distance F_a from the shorted edge. Each arm has a set of slots having different shapes and locations, which are optimized in order to maximize the bandwidth of the antenna.

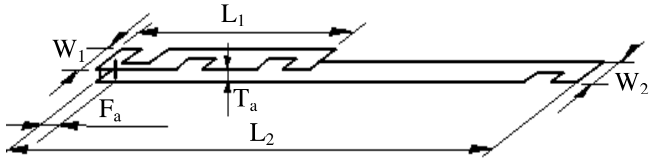


Fig. 1 Geometry of the new wideband resonant antenna

Two different prototypes of the new antenna have been designed and manufactured as shown in Fig.2. The dimensions of the first antenna are: L_1 =11.5 cm, L_2 = 25 cm, W_1 = 2.6 mm, W_2 =3.5 mm and T_a = 2 mm. Thus, the overall size of the low-band antenna is 25 x 0.35 x 0.2 = 1.75 cm^3. The dimensions of the second antenna are: L_1 =2.7 cm, L_2 = 6.6 cm, W_1 = 2 mm, W_2 =3.5 mm and T_a = 2 mm. Hence, the overall size of the high-band antenna is 6.6 x 0.35 x 0.2 = 0.462 cm^3. The return loss and radiation patterns of the new antennas are numerically calculated by a software packages that uses the moment method. They were also measured at IMST antenna labs in Germany [4]. The agreement between numerical and experimental results was acceptable and only experimental results will be presented. The return loss of both antennas is less than -5 dB over most of the two bands as will be shown in the next section. Fig.3 shows the peak gain of both antennas which is higher than 0 dBi over most of the two bands. This peak gain is much higher than MBRAI specifications of the UHF DVB-H mobile TV [5]. The efficiency of both antennas is shown in Fig.4. The average efficiency over the two sub-bands is more than 45%.

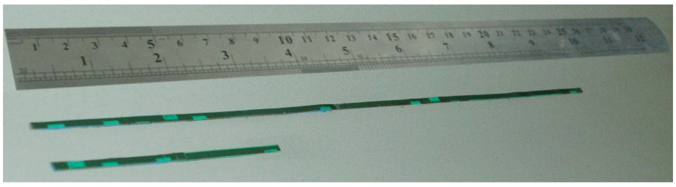


Fig.2 New low-band and high-band antennas

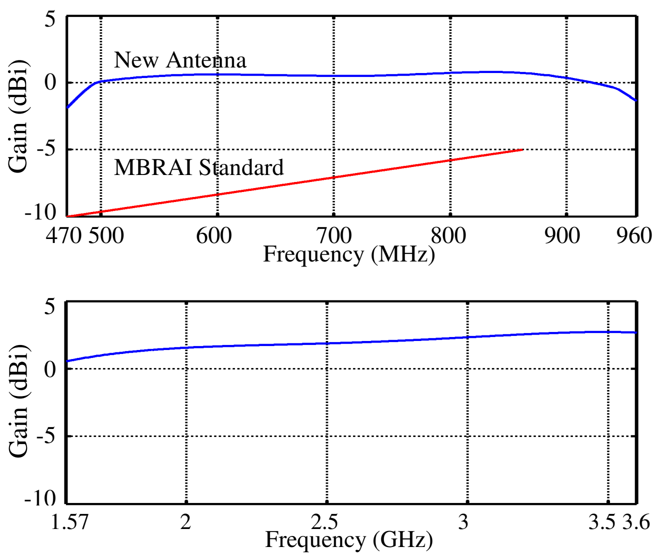


Fig.3 Measured peak gain of low-band and high-band antennas

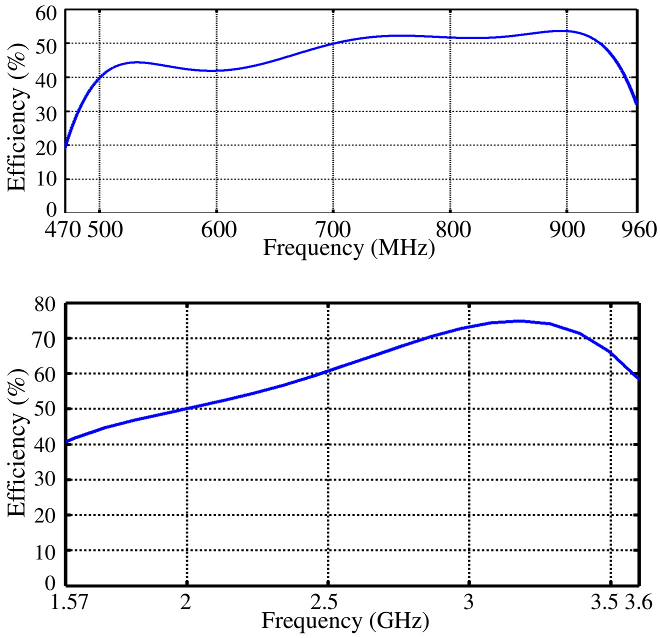


Fig.4 Measured efficiency of low-band and high-band antennas

III. Dual Antennas on Portable Computers

The two antenna prototypes were used together at different positions on various portable laptop, notebook and palmtop computers. One of the optimum configurations is shown in Fig.5 where the two antennas are mounted on the two upper corners of the display rim. In this configuration, both antennas have minimum blockage by the computer housing. This unique configuration is feasible with all portable computers because the widths of the new antennas can always be made narrower than the width of the display rim of any portable computer. Furthermore, the new antennas are made of a flexible material and, therefore, they are easy to fold around the 90^o corners of the display rim. Moreover, the new antennas can be mounted anywhere because they do not use a part of the computer as an extended ground plane as usually happens with internal antennas.

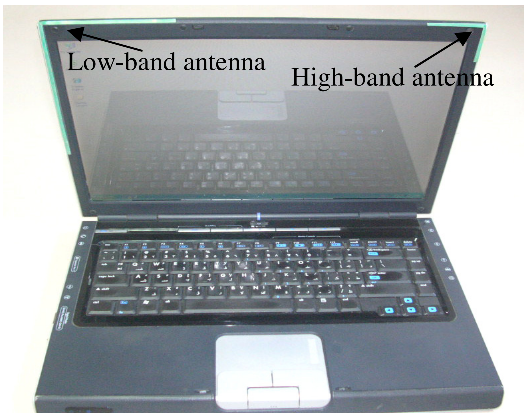


Fig.5 Optimum dual antenna configuration on the display rim of a portable laptop computer

The return losses of the two antennas with and without a laptop computer are shown in Fig.6. The effect of the computer housing on the return loss is negligible. On the other hand, bending each antenna by 90^{o} does not have any considerable effect on their overall efficiency. Fig.7 shows the measured radiation patterns of straight and bent antennas at 880 MHz. While the straight antenna is sensitive to only one polarization, the bent antenna is sensitive to two perpendicular polarizations. Using such dual polarized antennas is important in indoor applications where waves are randomly polarized because of multipath reflections. Moreover, bending the antennas by 90^{o} reduces the effect of the human body on them.

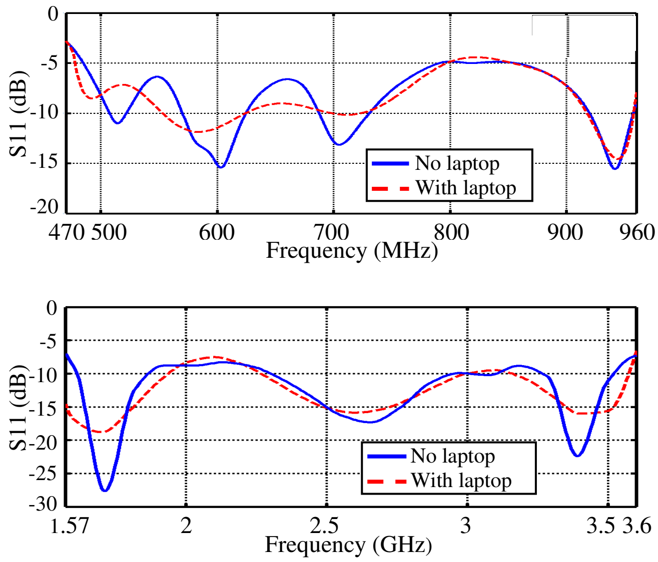
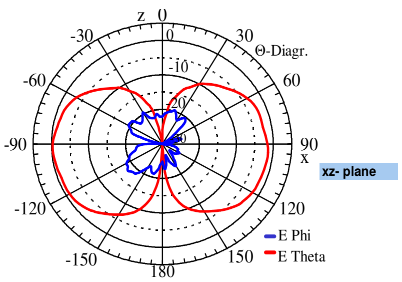
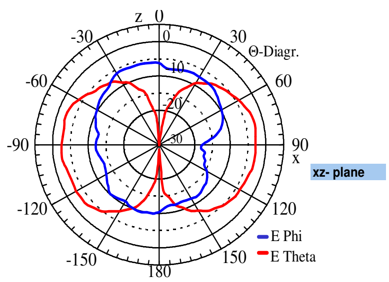


Fig.6 Measured return loss of the two antennas with and without a laptop



(a) a straight antenna



(b) a bent antenna

Fig.7 Radiation patterns of straight and bent antennas in the plane of bending at 880 MHz

IV. Dual Antennas on Mobile Handsets

The two antenna prototypes were also used together at different positions on various mobile handsets. One of the main differences between mobile handsets and portable computers is the available space inside the equipment. The small size of handsets may not allow the two antennas to be mounted in the same way as they were mounted on portable computers. The problem is the length of the low-band antenna which is 25 cm. However, there are different ways to overcome this problem. For example, the two ends of the low-band antenna can be folded as shown in Fig.8 where the length is reduced from 25 cm to 16 cm without a significant effect on the performance. This will allow the low-band and high-band antennas to be mounted on the handset as shown in Fig. 9. The performance of the reduced-length antenna is very close to that of the straight antenna and it is not presented because of space.

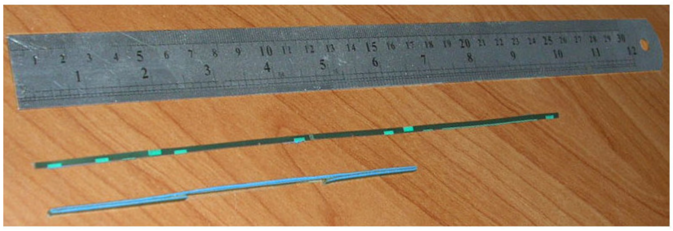


Fig.8 Straight and folded antennas

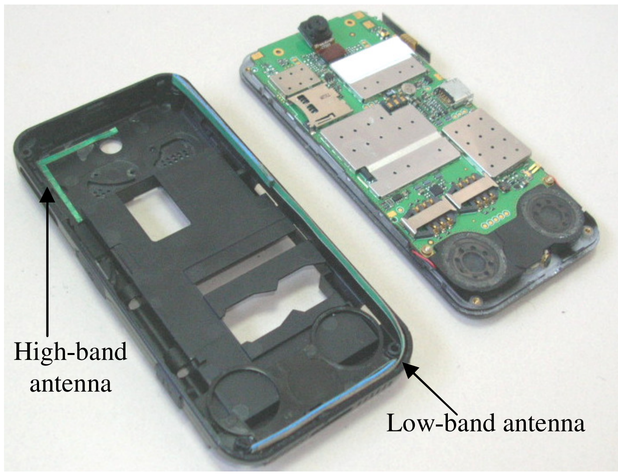
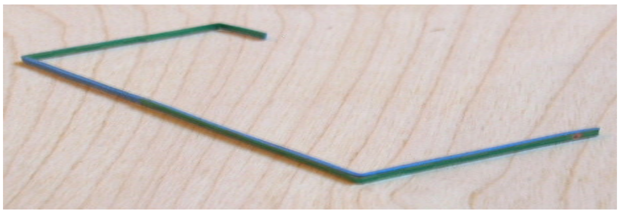
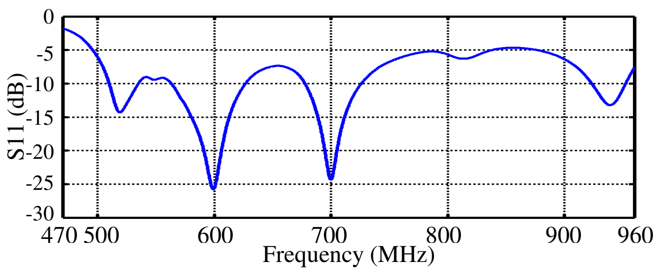


Fig.9 A dual antenna configuration embedded inside a mobile handset

On the other hand, the new antenna can be bent in two perpendicular directions to form a rectangle or a part of a rectangle as shown in Fig.10 (a). The dimensions of this rectangle can be adjusted to match the dimensions of any handset. The measured return loss of the bent antenna is shown in Fig. 10 (b). As was shown above, bent antennas are sensitive to two perpendicular polarizations. Of course, the optimum configuration for polarization diversity is to make the antenna sensitive to three perpendicular polarizations. This can be easily achieved by bending the new antenna in three perpendicular directions. Different mechanisms can be used in order to bend the new antenna in three perpendicular directions. One of these mechanisms is shown in Fig.11 where a part of the low-band antenna is embedded inside the handset while the other part is kept external. This also provides a good way to manage the length of the low-band antenna. The external part of the antenna is retractable and it is mechanically supported by a thin plastic rod in order to make it mechanically rigid. The external retractable part of the antenna may increase its sensitivity in low signal areas. Moreover, the external part of the antenna can be used as a mechanical support for the handset while it is used as a mobile TV as shown in Fig.11. It should be noted that the embedded parts of the antennas in Fig.11 are placed outside the handset just to clarify their locations and configurations.



(a) a bent antenna forming a part of a rectangle



(b) return loss

Fig.10 A bent antenna (a) and its measured return loss (b)

Fig.11 Bending the low-band antenna in three directions

V. Adjusting The Frequency Band of The Dual Antenna Configuration

The frequency band of the above dual antenna configuration can be adjusted according to the wireless applications that are needed to be covered by a mobile handset or a portable computer. However, the maximum bandwidth that can be covered by each antenna is about 80%. For example, if L2-GPS (1227.6 MHz) and L-band DVB-H (1452-1492 MHz) are required to be added to a mobile handset or a mobile computer while 3.5 GHz WiMax is not needed, the high-band antenna can be designed to resonate from 1.2 to 2.7 GHz instead of resonating from 1.57 to 3.6 GHz. The measured return loss of the modified high-band antenna is shown in Fig.12. On the other hand, if more wireless applications are needed to be added without removing any of the above applications, a third antenna can be utilized. For example, if 5.8 GHz WiMax is needed to be added to all the above applications, a triple antenna configuration can be used where the three antennas resonate at 470-960 MHz, 1.2-2.7 GHz and 3-6 GHz.

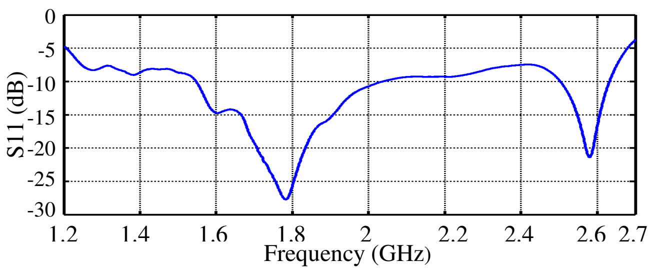


Fig.12 Measured return loss of the modified high-band antenna

VI. Conclusions

A novel dual antenna configuration was developed for multifunction multi-standard mobile handsets and portable computers. The first (low-band) antenna resonated from 470 to 960 MHz and the second (high-band) antenna resonated from 1.57 to 3.6 GHz. The new antennas were resonant antennas that did not need matching circuits. Furthermore, they were made of a flexible material and they could be bent and/or folded in different forms in order to fit any available space inside or outside any communication equipment.

Acknowledgment

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