A Novel Dual Resonant Antenna Configuration for Mobile Laptop, Notebook and Palmtop Computers

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I- Introduction:

There is a fast development and expansion of portable computer wireless systems. Cellular network radios are integrated into some modern laptop, notebook and palmtop computers in order to give the user access to the Internet in areas not covered by WLANs. Furthermore, computer manufacturers are now offering integrated WiMax as an option on some notebooks and laptops. Introduction of other applications such as GPS and digital TV, built into portable computers, is expected in the near future. On the other hand, most of these applications have different standards with different frequency allocations worldwide. For example, DVB-H mobile TV is designed to work in different bands such as UHF and L bands. Also, WiMax has many frequency allocations worldwide such as 700 MHz, 2.5 GHz and 3.5 GHz. Even GPS has different codes at different bands such as L_1 (1575.42 MHz) and L_2 (1227.6 MHz). In order to cover all these bands, several antennas have to be used. The problem is that the bands of some applications are very close to each other or even overlapping as in GSM and UHF digital TV. As a result, there will be a severe interference between these antennas.

Most of the above applications lie in a frequency band ranging from 470 to 2700 MHz, which can be divided into two sub-bands with an isolating frequency gap between them. The isolating frequency gap is not utilized by any important application. The first frequency sub-band is from 470 to 960 MHz and it covers: 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 frequency sub-band is from 1.2 to 2.7 GHz and it covers: L_2-GPS (1227.6 MHz), L-band DVB-H (1452-1492 MHz), L_1-GPS (1575 MHz), GSM1800 (1710-1880 MHz), PCS1900 (1859-1990 MHz), UMTS (1900-2170 MHz), Bluetooth/WiFi (2.4 GHz) and WiMax (2.3-2.69 GHz). The bandwidths of these two sub-bands are 69% and 77%, respectively. These are very wide bandwidths which are not easy to cover with resonant antennas. 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. In this research, a novel dual resonant antenna configuration that can cover these two wide sub-bands is developed. The new antennas do not need any matching circuits. The isolating gap between the two sub-bands helps in reducing the interference between the two antennas. It should be noted that linearly polarized antennas can be used with all the above applications. 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 wideband resonant antenna:

Fig.1 shows the geometry of the new wideband antenna. It consists of two narrow printed metallic arms connected together by a short metallic strip. 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.

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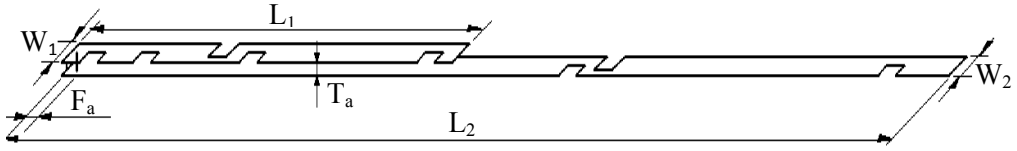


Fig. 1 Geometry of the new wideband resonant antenna

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 =3.7 cm, L_2 = 9.2 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 9.2 x 0.35 x 0.2 = 0.644 cm^3. The return loss and the radiation patterns of the two antennas are measured at IMST antenna labs in Germany [4]. The return loss is less than -5 dB over most of the two sub-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 sub-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%.

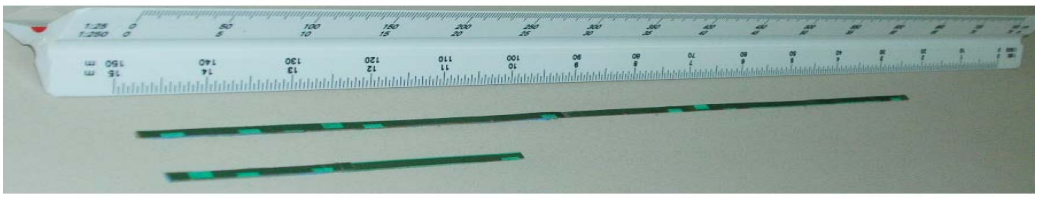


Fig.2 New low-band and high-band antennas

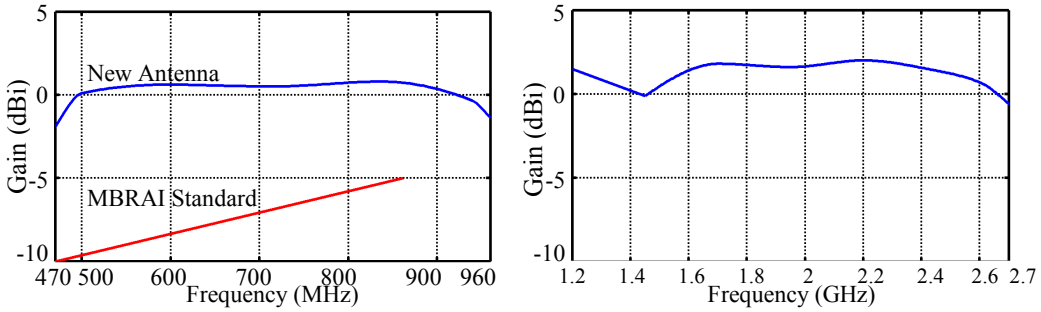


Fig.3 Measured peak gain of low-band and high-band antennas

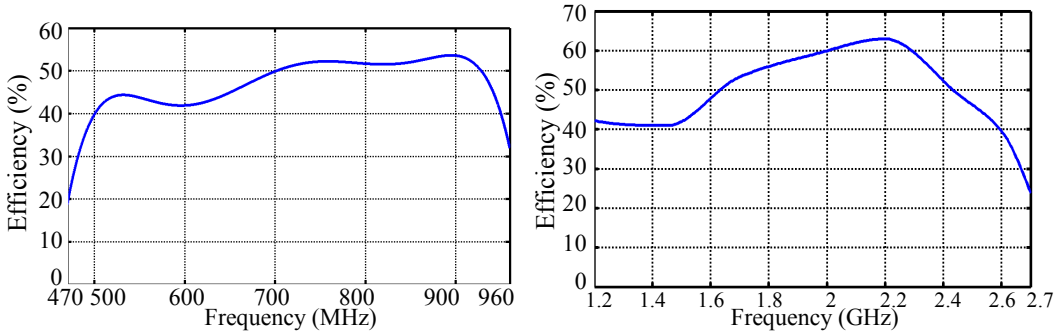


Fig.4 Measured efficiency of low-band and high-band antennas

III- Dual antenna configurations on portable computers:

The two antenna prototypes were used together at different positions on various portable computers. One of the best achieved 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 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.

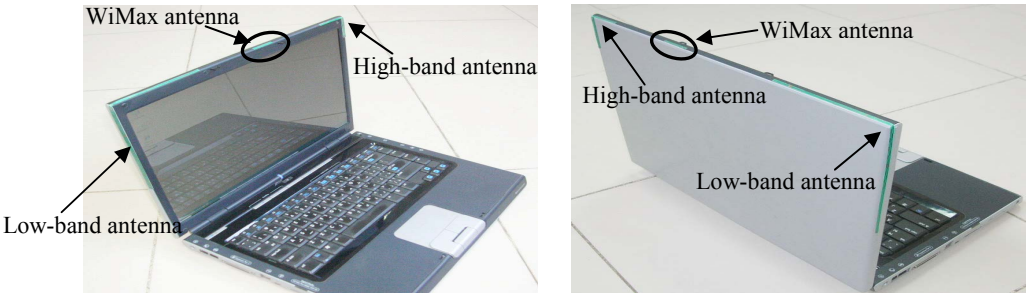


Fig.5 The optimum dual antenna configuration on the display rim

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. For example, 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.

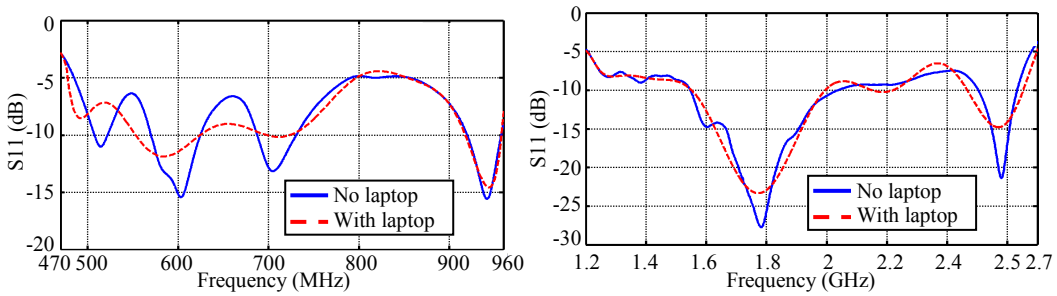
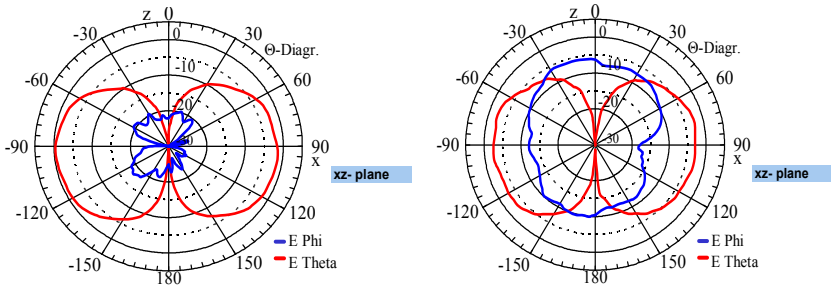


Fig.6 Measured return loss of the two antennas with and without a laptop



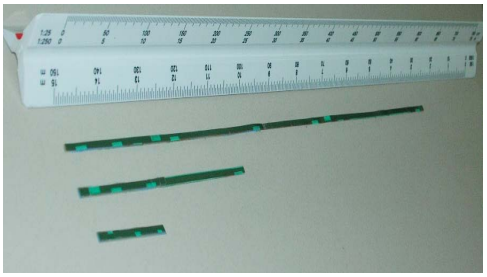
(a) a straight antenna (b) a bent antenna

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

IV-Adding more wireless applications to portable computers:

The above low-band and high-band antennas may be used together or only one of them may be required depending on the number of wireless applications in any laptop, notebook or palmtop computer. On the other hand, the frequency band of each antenna can be adjusted according to the wireless applications that are needed to be covered by the antenna. However, the maximum bandwidth that can be covered by each antenna is about 80%. For example, if L_2-GPS and L-band DVB-H are not required in a mobile computer, the high-band antenna can be designed to start from 1575 MHz instead of 1.2 GHz. This allows the high-band to be extended to 3.6 GHz (with 78% bandwidth) such that it can cover an additional WiMax band (3.5 GHz). This will also increase the gap between low-band and high-band antennas, which will further reduce the coupling between them.

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 3.5 GHz and 5.8 GHz WiMax bands are needed to be added, a third antenna can be used to operate from 3 GHz to more than 6 GHz. A prototype of this antenna is designed and manufactured. The length of the third antenna is 3.5 cm and its overall size is much smaller than the first two antennas as shown in Fig.8. Fig.8 also shows the return loss of the third antenna with and without a laptop computer. The configuration of the third antenna (WiMax antenna) mounted on the display rim of the laptop computer was included in Fig.5 with the first two antennas.



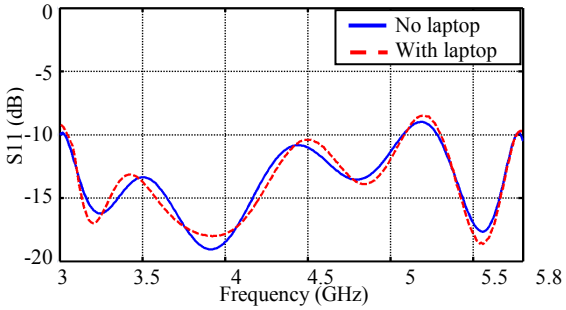


Fig.8 A triple antenna configuration and measured return loss of the third antenna

V- Conclusions:

A novel dual resonant internal antenna configuration was developed to cover all the important applications in multi-standard multifunction mobile laptop, notebook and palmtop computers. Only two wideband antennas covered the whole band from 470 MHz to 2.7 GHz, which was divided into two sub-bands. The low sub-band was from 470 to 960 MHz and the high sub-band was from 1.2 to 2.7 GHz. These frequency sub-bands could be adjusted according to the wireless applications that were needed to be covered. The two antennas might be utilized together or only one of them might be required depending on the number of wireless applications in the portable computer. Also, a triple antenna configuration might be used in order to add more applications.

References:

[1] Chi-Meng Chiang, Annie Yang and Chih-Cheng Chien, "Active Digital TV Antenna", US Patent No. 0066116, March 2008

[2] Fusao Sekiguchi and Kenichi Mitsugi, "Variable Tuning Antenna and Mobile Wireless Device", US Patent No. 0197711, September 2006

[3] V. Pathak, S. Thornwall, M. Krier, S. Rowson, G. Poilasne, and L.Desclos, "Mobile Handset System Performance Comparison of a Linearly Polarized GPS Internal Antenna with a Circularly Polarized Antenna," *IEEE APS Symposium*, Vol. 3, pp. 666–669, 2003.

[4] http://www.imst.com/en/home.php

[5] http://www.eicta.org/index.php?id=33&id_article=152